CHAPTER THREE

Economic & Financial Feasibility

Contents

Appendices

The Hells Gates Dam feasibility study was instigated by the Australian Government in 2016 in response to initiatives driven by the Developing Northern Australia and Agricultural Competitiveness white papers. The study was added to the National Water Infrastructure Development Fund (NWIDF) program by the Commonwealth Department of Infrastructure, Regional Development and Cities for administration by the Queensland Department of Natural Resources, Mines & Energy (DNRME). The study was not part of the competitive round of funding run by the Australian Government to gain access to the NWIDF feasibility study funds. It is also noted that this project is a feasibility study of a specified proposal rather than a business case to assess options to meet an identified demand for water. This differentiates this study from many of the other NWIDF feasibility studies.

Townsville Enterprise Limited (TEL) has managed the delivery of this feasibility study into the proposed Hells Gates Dam, with a consortium led by SMEC delivering the works. Townsville Enterprise Limited and SMEC have instituted significant stakeholder consultation throughout the investigation and final delivery processes across all three levels of government as well as the community, landholders, traditional owners, environmental interest groups and numerous other stakeholders. From this consultation, a range of important stakeholder views and technical/economic items have been considered in this study.

It is acknowledged that the scale of the report could make it difficult for readers to identify some of the critical caveats, assumptions and clarifications. This statement is intended to bring many of those key items into a consolidated location that allows an objective view in the context of the study's terms of reference.

Townsville Enterprise Limited acknowledges the positive approach from DNRME and the study's Project Leadership Group (comprising Charters Towers Regional Council, Townsville City Council and members of the TEL Board) in guiding the Project Directors through a complex project that has taken over a year and comprises almost all engineering disciplines as well as economic, environmental and cultural heritage elements. DNRME has contributed multiple rounds of review, commentary and feedback that have led to several contextual considerations being identified during the technical and economic phases of work.

This section provides an outline to the limitations of the scope and the approach taken to address some of these, providing context to the assumptions that were made for the purpose of the assessment and relevant commentary resultant of the final review of the final Hells Gates Dam feasibility study. This section should be read in conjunction with the whole report.

Townsville Enterprise Limited and SMEC note it is critical to keep the following items in mind when considering the technical and economic outcomes of this study:

- While this feasibility study was delivered through the Australian Government's NWIDF program, it is not a business case as would be expected under the Building Queensland (BQ) Project Assessment Framework (PAF). While many of the PAF guiding principals have been utilised by the project team, as a feasibility study it is not as definitive in many of the economic requirements of PAF.
  - For example, the assessment identifies the potential opportunities associated with suitable soils and irrigation potential in the vicinity of Hells Gates Dam rather than including specific needs analysis to assess the demand for water from the proposal informed for example by market testing and analysis.
  - In addition, there is no assessment and shortlisting of other potential water supply options that could meet the identified needs and/or opportunities, i.e. consideration of water supply infrastructure other than Hells Gates Dam.
- There is no current project proponent, either from a government or private sector source that could participate in project development from this point. It seems logical that further de-risking work is needed before a project proponent could invest confidently in the project, especially given the scale of development, long term infrastructure investment outlook needed and the multi-billion-dollar construction cost.
- A risk of the project outcomes is that the Burdekin Water Plan, administered by the Queensland DNRME and due for review in 2019, currently does not allow for Hells Gates Dam and hence construction of the dam does not comply with the Plan. To enable a major dam to be built at the Hells Gates site, the Water Plan would need to be altered to make additional water resource allocations available. Such an alteration will require public consultation as part of the Burdekin Water Plan review in the future, and considered along with other competing interests and development options for water resources in the area as well as any impacts to existing users and the environment. The project

team has identified this in the report, however, the Water Plan is critical to future development and this report could and should form part of the input to the Water Plan review.

- The Project Directors also acknowledge that:
  - it is likely that commencement of construction of the Hells Gates Dam and major irrigation network may not occur for the best part of a decade given the investigative works needed to determine its viability.
  - significant additional technical (field investigations and design development), social (cultural heritage), environmental (EIS) and commercial (economic modelling) de-risking is required to advance this project. These would be undertaken during a subsequent Business Case that would align with the BQ PAF.
  - the level of technical investigations undertaken to date has allowed the development of a concept design for the inundation area, dam and irrigation scheme components as well as the supporting infrastructure. Further investigations may see changes to the scale of the inundation area, type of dam used, and the components of the irrigations scheme once technical inputs are included – for example assessments of geology, geotechnical drilling, environmental and cultural heritage investigations amongst others. These changes and refinements could have material effects on the cost of development and scale of the irrigation network, will allow the removal of risk and contingency elements in the project cost estimate and thus could positively or negatively affect the economic outcomes and viability.
  - a deliberately non-prescriptive approach has been used when identifying the crops within the cropping assessments and economic assessment. This non-prescriptive approach was taken to ensure that real market forces drive cropping at the time of the irrigated agricultural development, responding to demands for agricultural produce that cannot be accurately defined at this point in time.
  - an assumption of the economic modelling is therefore, that this product driven demand will ensure that single crops that could over supply the markets in which they will be sold will not be developed, thereby driving down prices
  - the cropping yields and crop values that are used have been sourced from public data and can be interpreted in several ways, especially given the extensive development timeline for this project. The assumptions include some subjective views and, in most cases, were chosen based on a high level of take up of agricultural best practices to maximise the effectiveness and efficiency of the irrigated agriculture. Different subjective views could affect the economic model outcomes.
  - while the scale of Hells Gates Dam and the associated irrigation scheme represents some 30% of the Federal Government's target of doubling Australia's agriculture output, it should not be considered as "instead of" a range of other proposals. To meet the Government's goal, Hells Gates Dam plus numerous other irrigation schemes could be needed.
  - Hells Gates Dam cannot be considered a competing potable water source to either Stage 1 (duplication of the Haughton Pipeline) or Stage 2 (extension of the 1.8 metre diameter pipeline to Clare) of Townsville City Council's water security plan. Any potential town water supply from Hells Gates Dam to Townsville is likely to be in the extreme long term.
  - there has been no consideration of the pumped hydro project past a desktop assessment. As a result, no revenue or cost elements of a large scale pumped hydro project have been included in the economic assessments. Future investigations need to technically de-risk this element of the project and firm up the economic effects to allow the positive or negative effect to be included in the modelling and Benefit Cost Ratio.

In addition, the main risks to the project are articulated in the report and include issues such as costs of water likely to restrict the viable cropping opportunities, the absence of a water allocation or allowance under the Water Plan and the capacity of markets to absorb significant additional horticultural production. However, the recommended assessments and further work proposed by the report focus on detailed engineering and environmental assessments that don't appear to substantially mitigate all the major risks identified in the report.

Abbreviations

Abbreviation / Acronym	Description
ASEAN	Association of South East Asian Nations
BCR	Benefit-Cost Ratio
BHWSS	Burdekin-Haughton Water Supply Scheme
CAPEX	Capital Expenditure
CBA	Cost-Benefit Assessment
CV	Construction Value
DTMR	Department of Transport and Main Roads
EIA	Economic Impact Assessment
FTE	Full Time Equivalent
GRP	Gross Regional Product
HP	High Priority Water
IRR	Internal Rate of Return
kWh	kiloWatthour
LGC	Large-Scale Generation Certificate
MP	Medium Priority Water
MW	MegaWatt
NEM	National Electricity Market
NPV	Net Present Value
OPEX	Operational Expenditure
PV	Present Value
WACC	Weighted Average Cost of Capital

1. Executive Summary

1.1. Background and Purpose

The Hells Gates Dam Feasibility Study is investigating options to develop a large-scale irrigation district in the Upper Burdekin catchment that will be supplied by a new dam to be constructed at Hells Gates, north of Charters Towers.

This report provides a financial and economic analysis of the 2,100 GL storage dam and an agricultural district of up to 50,000 ha, as identified in Milestone 4 – Technical Feasibility. The report provides estimates of water pricing, agricultural capacity to pay, and return on investment, given the identified timings and capital requirements for development.

An Economic Impact Assessment (EIA) was undertaken to evaluate the potential direct and flow-on economic impacts the proposed development will provide. A Cost-Benefit Assessment (CBA) was also undertaken to estimate the net socio-economic benefits of the proposed development.

This analysis analyses two cropping scenarios to evaluate the potential opportunities that will be generated by the proposed scheme:

- Mixed cropping scenario – 50,000 ha under irrigation with a mix of annual and perennial horticultural, and broadacre cropping.
- Perennial cropping scenario – 30,000 ha under irrigation, using high-reliability water for permanent cropping. Under the perennial cropping scenario, only two of the three potential irrigation areas would be developed. The high water consumption and security requirements of perennial crops reduces the potential area under irrigation from 50,000 ha to 30,000 ha.

1.2. Key Findings

1.2.1. Financial Analysis

To determine the commercial viability of the dam and associated distribution infrastructure, a building block approach to identifying water charge revenue was adopted. The approach included examination of labour, goods and services expenditure, depreciation, and a commercial return on capital. A series of pricing methodologies were applied, ranging from full commercial cost recovery to depreciation, operation and maintenance costs only.

Key findings arising from the financial analysis, include:

- A high-level pricing analysis was undertaken of supplying up to 65,000 ML/annum of urban water to Ross Dam in Townsville. The results indicate water could be delivered at a levelised ($2018) cost of just over $600/ML, including variable pumping costs of approximately $190/ML. The relative merits of the pipeline should be compared on a whole-of-life basis with alternative long term water supply options, including additional connections to the Burdekin Haughton Water Supply Scheme
- Levelised medium priority (MP) annual water charges for agriculture range from $258/ML (cost recovery over the potential life of assets, no return on capital) to $559/ML (cost recovery and return on capital over 40 years) across the scheme, depending on the cost recovery method and level of subsidy
- High priority (HP) annual water allocation prices (for Type 2 perennial crops) range from $433/ML (cost recovery over the potential life of assets, no return on capital) to $1,034/ML (cost recovery and return on capital over 40 years). Under the perennial cropping scenario, these costs reduce to $352/ML to $756/ML
- Modelled annual water charges are considerably higher than existing Burdekin-Haughton Water Supply Scheme (and other Queensland and interstate schemes) charges of $12/ML to $67/ML (MP)
- These costs represent a major constraint on agricultural production to sustainably support the cost of infrastructure, particularly for broadacre cropping – all broadacre crops assessed would require good growing conditions and an increase of at least 20% in grower returns to support the modelled water

prices at the lowest modelled water costs. Amongst the broadacre crops, cotton, chickpeas and mung beans returned the strongest results

- Some higher-value crops are potentially viable at the proposed water prices (avocados, citrus, capsicum), however market constraints would restrict the volume which could be grown economically without significant new export markets to support a 30,000 ha – 50,000 ha scheme
- Modelled water costs vary significantly across the three cropping areas, with areas close to the Burdekin River (approximately 5,000 ha identified) substantially more cost-effective to irrigate under the assumptions used in the pricing analysis (due to the reduction in distribution / pumping costs).

1.2.2. Economic Impact Assessment

Construction of the proposed Hells Gates Dam development has the potential to support substantial economic activity for North Queensland. During construction (excluding the PHES and Townsville Pipeline), the project is estimated to support:

- $5.7 billion in total output (including $3.7 billion directly)
- A $2.3 billion contribution to gross regional product (GRP) (including $1.4 billion directly)
- $1.0 billion in income for local workers (including $474 million directly)
- 10,855 FTE jobs (including 4,607 direct FTE positions).

On an annual basis, the agricultural precinct (once fully-operational and assuming a mix of horticultural and broadacre cropping) is modelled to provide:

- $1.5 billion in total industry output (including $1.2 billion directly)
- A $823.4 million contribution to GRP (including $669.5 million directly)
- $341.0 million in income for households (including $273.9 million in direct wages and salaries)
- FTE employment totalling 5,564 jobs (including 4,565 direct FTE positions).

Agricultural activity supported under the perennial cropping scenario will significantly increase the estimated impacts to North Queensland, providing:

- $1.9 billion per annum in output (including $1.5 billion directly)
- $1.1 billion per annum to GRP (including $901 million directly)
- $427.4 million in wages and salaries (including $343.4 million directly)
- 6,975 FTE jobs (including 5,720 direct FTE jobs).

Flow-on impacts to the state and national economies are estimated to be even larger.

A key assumption of the assessment is that the scheme can be developed on a sustainable basis, with growers able to afford the required water costs and horticultural production based at the site not significantly impacting upon existing producers. This is a challenging assumption under current market conditions. Such outcomes, however, will become more likely going forward, given the timeframes for development and macro outlook of rising long-term demand for agricultural production.

1.2.3. Cost-Benefit Assessment (CBA)

The CBA examined the construction and ongoing costs and benefits associated with the project over a 30-year timeframe. Specifically, the following costs and benefits were assessed:

- Costs:
  - Water storage capital costs
  - Water storage operational costs
  - On-farm capital costs
- Benefits:

- Agricultural net revenues
- Operational wages
- Local recreational amenity
- Asset residual value.

The CBA considered the identified costs and benefits associated with the project between the financial year ending June 2027 and the financial year ending June 2056, at discount rates of 4%, 7%, and 10%. The CBA modelling at the discount rate of 7% produced the following results:

- **Mixed Cropping Scenario** – net present value (NPV) of -$1.5 billion, benefit-cost ratio (BCR) of 0.70, and internal rate of return (IRR) of 4.3%
- **Perennial Cropping Scenario** – NPV of $1.5 billion, BCR of 1.33, and IRR of 9.3%.

The CBA identified that, at a 7% discount rate and under the perennial cropping scenario, the proposed development would be deemed economically **desirable** (benefits outweigh costs), assuming that the required water price levels are affordable. The mixed cropping scenario is not economically desirable at a 4%-10% discount rate.

Project outcomes are highly sensitive to agricultural costs / revenues, and capital cost estimates. Other factors not captured within the CBA include those outlined below.

Costs

- **Reduced economic activity from beef cattle production** – New irrigated agricultural production is largely expected to replace existing dryland cattle grazing (much of the proposed development area has a low carrying capacity). The proposed water storage component may provide improvement / intensification of other areas of cattle production, helping to offset these economic losses.
- **Environmental impacts due to increased agricultural irrigation** – Additional irrigated agriculture could increase the levels of agri-pollutants (such as nutrients, pesticides and sediment) in the Great Barrier Reef and downstream catchments including the Bowling Green Bay Ramsar. These impacts could negatively affect the achievement of the Australian Government's Reef 2050 Long-Term Sustainability Plan. While the engineering design of the scheme aims to collect sediment, and allow settlement of pollutants in sediment control weirs, there remains a risk of higher agri-pollutant discharge to the Great Barrier Reef. However, it has been assumed that all appropriate environmental mitigation and management techniques would be employed prior to the project being approved to reduce these impacts to the extent possible.
  - Increased irrigation may also result in environmental risks associated with rising salinity, which has been a significant issue experienced in parts of the Lower Burdekin.
- **Decreased market prices for existing Queensland horticultural producers** – Deep domestic and /or established export markets exist for the major broadacre crops included in the analysis. Perennial and annual horticultural production crops, however, currently have a strong reliance on supplying the domestic market (up to 90%+). This is due to a range of factors, including trade barriers to exporting fresh produce, the perishability of horticultural produce, and the intensity of production of these crops which decreases the advantage of the scale provided by Australia's available land.

Benefits

- **Increased water security for urban and industrial users** – Increased water security for urban and industrial users – The proposed development has the potential to support increased urban water supply to both Townsville and Charters Towers, as well as future industrial and mining developments. Due to the long timeframes and uncertainty regarding urban water uptake from Hells Gates, these benefits have not been modelled in the CBA analysis. Nevertheless, water security represents a critical catalyst to support economic development and population growth and has been a key issue for North Queensland in recent years.
- **Economic activity from flow-on development** – The CBA includes economic activity arising from direct scheme and agricultural operations only. However, a plethora of flow on opportunities exist throughout the supply chain, including in downstream processing, marketing and transport / logistics.

- **Enhanced infrastructure development (roads and energy)** – Major infrastructure developed for the scheme will generate substantial flow-on benefits to the wider community / economy through improved access, which will provide economies of scale and increase access and utilisation.
- **Supporting strategic direction** – The proposed scheme will support key state and federal initiatives to develop the mining and agricultural industries and increase the development of northern Australia. Few opportunities offer the same scale of irrigation development potential as the proposed Hells Gates Dam development.
- **Improved flexibility and efficiency of water management** – The operation of water resources will be significantly improved through the coordinated operation of the Burdekin Falls Dam and the Hells Gates Dam by maximising collective system yield and reliability (GHD, 2014; SMEC, 2018).

The impacts of these costs and benefits, were they able to be quantified may have a significant impact upon the results of the CBA.

1.3. Overall Feasibility

The development of the proposed Hells Gates Dam is a challenging investment proposition, given its nation-building scale and the likely ramp-up time for production of high value tree crops. It is the opportunity of a lifetime to develop a large tract of highly viable land, create 5,000+ jobs and inject up to $1.1 billion of annual GRP into the North Queensland economy. Modelled water costs are well above established irrigation areas and viable economic scenarios for broadacre crops. Further the modelled water costs are higher than those of established horticulture areas such as the Murray-Darling Basin.

It is pertinent to note that the delivery of an attractive investment proposition requires expansion of export quantities to the ASEAN, Middle Eastern, and European markets for high value crops, and/or a substantial increase in grower returns for traditional broadacre cropping.

Levels of horticultural production modelled in this study are very significant relative to current national production, a failure to access sufficient additional international markets (as per the current industry structure) would make these levels of production clearly unsustainable.

The Hells Gates irrigation scheme needs to be set up to maximise a mosaic of high value produce of both perennial and annual crop mixes for the export market. There is room for broadacre farming of crops such as cotton, but these lower value crops would not form the core investment return for the scheme.

The proposed Hells Gates Dam project represents a significant opportunity for the development of northern Australia. The identified scheme has unique scale, at up to 50,000 ha, providing significant synergies in the development of new and existing markets. Furthermore, the potential to provide high-security water allows for the development of a broad range of high-value crops. There are early signs of substantial export growth in perennial horticulture which may continue to develop over time. These benefits are not fully captured in the financial and economic appraisals conducted as part of this study.

The economic and financial analysis has identified that (currently), given the capital cost of the scheme and subsequent cost of water, there are limited viable agricultural cropping options available. Based on prevailing agricultural production, price and consumption trends, it is conceivable that within a 10–15-year window, a number of the crops assessed would become viable under the proposed scheme.

No detailed geotechnical studies have been conducted on the site and, as a result, the estimated capital cost is conservative. It is highly unlikely the information captured via drilling and other geotechnical studies (when they are conducted) will result in an increase in dam construction costs. Depending on the reduction in capital cost, it is conceivable that a number of commodities may be potentially viable for production in the immediate or short-term.

The timeframes for development allow for positive macroeconomic trends, including rising emerging market demand for agricultural produce. Significant production lands have been identified in close proximity to the Burdekin River which, subject to further evaluation, show promise as being commercially viable under current market conditions at a reduced water storage scale. Critical to the success of a smaller scale initial stage development is the trade-off between cost of irrigation, market capacity (for horticultural crop options) and the economies of scale provided by the proposed 30,000 ha – 50,000 ha scheme (roads, power, logistics).

Key steps to support and de-risk the proposed Hells Gates Dam development include:

- Marketing the development to identify suitable proponents to take the scheme through to final investment.
- Supporting trial cropping to de-risk production on a significant scale – this could include releasing water allocations for development and irrigation of lands next to the Burdekin River, potentially in conjunction with weir storage. Beginning irrigation work by focusing on the lowest cost areas will provide greater market transparency and insight for when larger scale water infrastructure is provided.
- Detailed engineering works to refine the capital costs applied in this analysis.
- Gaining environmental approvals, including an Environmental Impacts Statement (EIS), to reduce risk and timeframes for future proponents.
- Securing public financial support for the development, including through avenues such as the National Water Infrastructure Loan Facility and the Northern Australia Infrastructure Facility.

2. Introduction

2.1. Background and Purpose

The Hells Gates Dam Feasibility Study is investigating options to develop a large irrigation district in the Upper Burdekin catchment that will be supplied by a new dam to be constructed at Hells Gates, north of Charters Towers.

The objective of the proposed Hells Gates Dam project is to develop biomass, ethanol, energy and agricultural opportunities in the region by providing sustainable and integrated irrigation.

The technical outcomes of Milestone 4 of this study have produced a concept for the development of a 2,100 GL storage dam in the Upper Burdekin, which could be the catalyst for:

- Staged development of infrastructure to support 50,000 ha of irrigated horticulture, including fruit, vegetables, pulses / legumes, and broad-scale agriculture of both perennial and annual crops
- Upgrades to the local road network to handle freight and tourism traffic
- Economic development opportunities in food processing in Charters Towers and the Townsville State Development Area
- Export opportunities for fresh foods and processed foods through the Port of Townsville and Townsville
- Increased freight to south-east Asia and southern Australian cities
- Implementation of a pumped hydroelectric scheme, with an output of up to 1,200 MW
- Construction of a 20 MW solar farm and 15 MW run-of-river hydro facility at the toe of the dam
- Major upgrades to the power network in the Charters Towers region to allow development of on-farm water pumping and food processing
- Long-term water security for the City of Townsville, post-2035 (from Hells Gates Dam)
- Long-term water security for Charters Towers Regional Council
- Recreational (fishing, water sports) and tourism (caravan parks, gourmet foods) activities on a dam with more capacity than the current largest dam in Queensland (Burdekin Falls) within 2.5 hours of Townsville.

This report provides a financial and economic analysis of the 2,100 GL storage dam and 50,000 ha agricultural precinct identified in Milestone 4 – Technical Feasibility. It includes estimates of water pricing, agricultural capacity to pay and return on investment, and net socio-economic benefits of the proposed development for the North Queensland community and the State of Queensland.

2.2. Report Structure

The report is structured as follows:

- Section 3 presents an overview of the water storage and agricultural development proposed in Milestone 4, including infrastructure works and crop options
- Section 4 presents an overview of the market assessments undertaken for candidate cropping options
- Section 5 delivers a financial analysis of the proposed development, including water pricing and agricultural capacity to pay / return on investment
- Section 6 applies input-output modelling to assess the economic impacts of the development on the regional, state, and national economies during construction and operation
- Section 7 provides a Cost Benefit Assessment (CBA) which examines the net socio-economic benefits to the State of Queensland over a 30-year period
- Section 8 provides a summary of study findings and next steps.

3. Hells Gates Dam Development Concept

This section provides a brief overview of the key findings of Milestone 4 – Technical Feasibility, relevant to the financial and economic analysis.

3.1. Study Area

The proposed Hells Gates Dam area is north of Charters Towers, to the west of the Burdekin River, straddling the Basalt River in the Upper Burdekin catchment (see Figure 1). The objective of the Hells Gates Dam Feasibility Study is to develop biomass, ethanol, energy and agricultural opportunities in the region by providing sustainable and integrated irrigation.

Figure 1: The Burdekin Catchment (outlined in red) and Upper Burdekin Sub-Catchment (shaded in red)

3.2. Proposed Crop Mix

The land and crop suitability assessment recommend targeting an irrigation area of up to 50,000 ha across three irrigation areas (North, Middle, and South – see Figure 2), with production focusing on the high-value cropping options across three broad soil types:

- **Soil Type 1: Red and yellow sands and red basalt** – trafficable under all farming conditions
- **Soil Type 2: Fragile bleached grey sands** – highly-erodible and more suited to permanent planting, where erosion control measures can be used
- **Soil Type 3: Clays / vertisols that are not trafficable when wet** – best suited to broadacre crops with greater leeway when it comes to management and harvest timing.

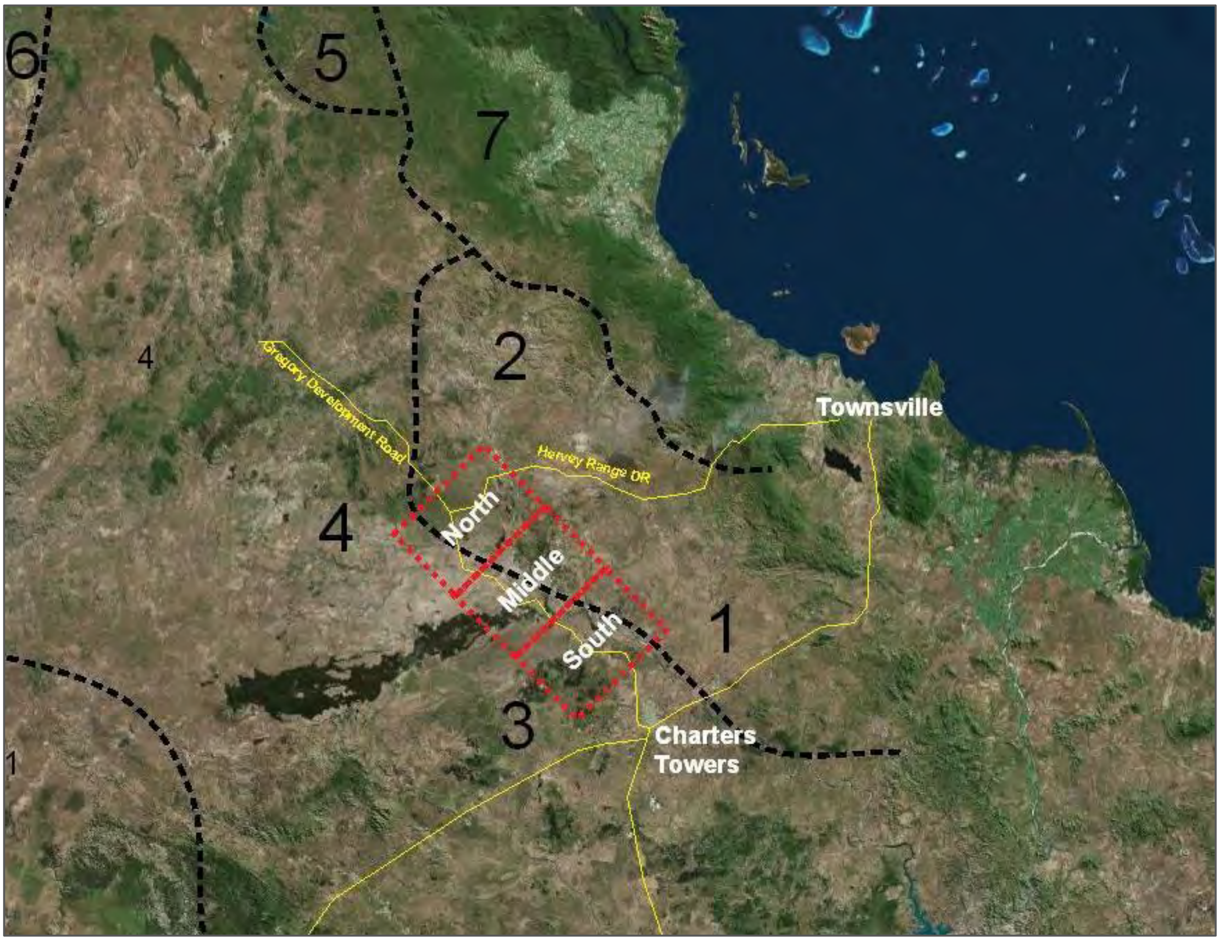


Figure 2: Cropping Precincts

Each of the irrigation areas includes a share of suitable lands that can have water pumped directly from the Burdekin River, and areas requiring development of distribution channel infrastructure. Following the economic modelling documented in this report, an additional "zone" has been nominated as the Burdekin Zone, covering roughly 5000 ha of land that is absolutely contiguous to the river.

Irrigation requirements were modelled for each crop and are presented in Table 1. Water security for crops planted on Soil Types 1 and 3 are modelled at 70% reliability (henceforth medium priority (MP) water). Type 2 soil type crops (perennial horticulture) require 100% reliability, though an acceptable reduction to 80% was made for exceptionally dry (1 in 60) years (henceforth referred as high priority (HP) water). Conversion between HP and MP water is estimated at a rate of 0.58:1.

Soil and crop mixes for each irrigation area are presented in the tables below. For comparative purposes, two potential production scenarios have been considered in this report:

- **Mixed cropping scenario** – 50,000 ha under irrigation, with a mix of MP and HP water, as per Chapter 2 Technical Feasibility. Refer to Table 1 below.

- **Perennial cropping scenario** – 30,000 ha under irrigation, using HP (100% reliability water, see Table 2) – under perennial cropping, only the North and South irrigation areas would be developed.

Table 1: Mixed Cropping Scenario: Proposed Crop and Soil Mix

Region	Hectares of Each Crop Group			Water Requirement (ML)
	Type 1 Rockmelon Watermelon Capsicum & Chilli Pumpkins	Type 2 Avocado Citrus Orange Citrus Lemon Table Grapes	Type 3 Mung Beans* Chick Pea Grain Sorghum Cotton	
Away from Burdekin River				
North	6,650	4,480	3,900	128,710
Middle	320	1,770	14,800	157,303
South	2,740	7,320	2,570	139,135
Sub-Total (ha)	**9,710**	**13,570**	**21,270**	**425,149**
Close to Burdekin River				
North	910	0	1,460	17,105
Middle	190	540	2,200	27,967
South	0	0	150	1,325
Sub-Total (ha)	**1,100**	**540**	**3,810**	**46,397**
Grand Total	**10,810**	**14,110**	**25,080**	**471,546**

Table 2: Mixed Cropping Scenario Area and Average Irrigation Requirements

Crop	Total Area (ha)	Average Irrigation Requirement (ML/ha)
Type I		
Rockmelon	2,702	6.3
Watermelon	2,702	3.5
Capsicum & Chilli	2,702	4.7
Pumpkin	2,702	4
Type II		
Avocado	3,528	15
Citrus Orange	3,528	17.7
Citrus Lemon	3,528	17.7
Table Grapes	3,528	6.3
Type III		
Chick Pea	8,360	4.6
Grain Sorghum	8,360	7.9
Cotton	8,360	8.6
Mung Beans*	12,540	3.6
Total	**50,000**	**9.4**

Note: [1] Utilised as a fallow / rotation crop. [2] Totals do not sum due to rotational cropping of Type 3 crops.

Table 3: Perennial Cropping Scenario – Proposed Crop and Soil Mix

Region	Type 2 Avocado Citrus Orange Citrus Lemon Table Grapes	Water Requirement (ML)
Away from Burdekin River		
North	12,962	184,060
South	13,117	186,255
Sub Total (ha)	**26,079**	**370,315**
Close to Burdekin River		
North	2,370	33,654
South	150	2,130
Sub Total (ha)	**2,520**	**35,784**
Grand Total	**28,599**	**406,099**

Table 4: Perennial Cropping Scenario Area and Average Irrigation Requirements

Crop	Total Area (ha)	Avg. Water Requirement (ML/ha)
Avocado	*7,150*	15.0
Citrus Orange	*7,150*	17.7
Citrus Lemon	*7,150*	17.7
Table Grapes	*7,150*	6.3
Total	**28,599**	**14.2**

3.3. Other Works

The following components identified in Milestone 4, are also relevant to this assessment:

- **Energy generation** – A 20 MW solar farm and 15 MW run-of-river hydro facility at the toe of the dam to help support the energy requirements of the irrigation area and supply renewable energy to the National Electricity Market (NEM).
- **Major upgrades to the power network in the Charters Towers region** – Allowing development of on-farm water pumping and food processing.
- **Consideration of long-term connection of urban water supply to Townsville** – Construction of a 140 km pipeline from Hells Gates Dam to Townsville. Milestone 4 – Technical Feasibility noted the proposed Hells Gates Dam has no role to play in any short or medium-term solutions for Townsville. Any consideration of using the Hells Gates Dam for water supply to Townsville can only be relevant past 2035, when the city's population has grown significantly, stretching the capacity of the upgraded Burdekin-Haughton Water Supply Scheme (BHWSS) currently under development. Given the given the long timeframes for urban demand and level of uncertainty regarding this aspect of the project, the pipeline has been excluded from the base case for the economic and financial analysis. High level estimates including the Townsville pipeline have been included as breakout sections throughout the analysis.

3.4. Infrastructure Requirements

Infrastructure costings have been developed by Project Support, totalling $5.4 billion (based on the specifications identified in Milestone 4 – Technical Feasibility). These are summarised in Table 5. These costs include approximately $1.0 billion (including contingency) for an urban water connection to Townsville which is not required for the development of the base agricultural project.

Table 5: Capital Cost Estimates

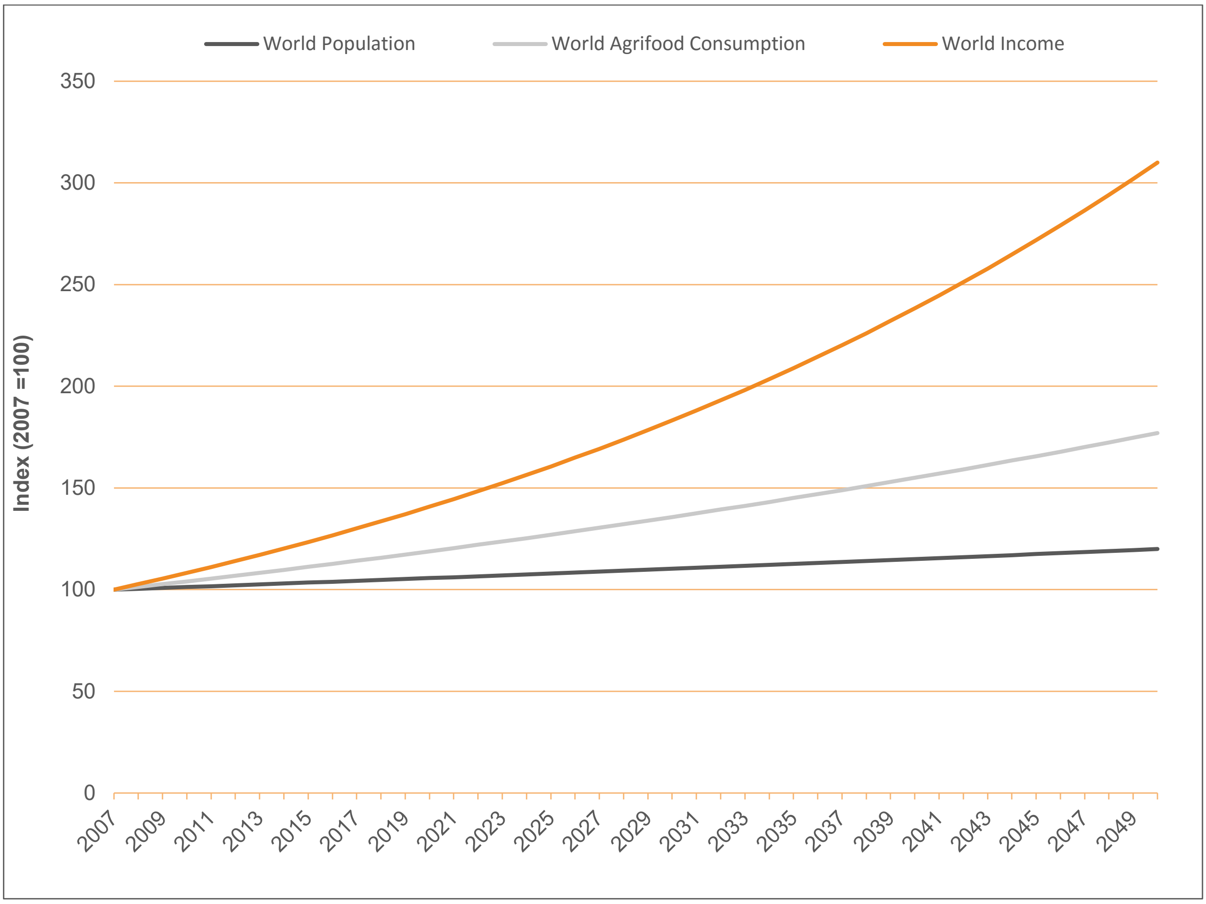
No.	Description	Value ($M)
1	**Construction Costs**	
1.1	RCC Dam	$645.2
1.2	TCC Pipeline (Optional)	$696.4
1.3	Irrigation	$1,482.7
1.4	Transport (Roads)	$608.9
1.5	Electrical and Hydropower	$220.9
	Sub Total Construction Costs	**$3,654.0**
2	**Owner's Costs**	
2.1	Resumption – Mount Fox Road Realignment	$8.1
2.2	Resumption – Dam Access Road	$0.9
2.3	Resumption – Minor Sealed Roads	$55.1
2.4	Environmental – Hells Gates Dam	$7.6
2.5	Design Costs – 5.0% of Construction Value (CV)	$182.7
2.6	Owner's Insurance Costs – 1.0% of CV	$36.5
2.7	Cultural Heritage Consultation – 0.1% of CV	$3.7
2.8	Environmental Approvals – 0.1% of CV	$3.7
2.9	Community Consultation – 0.5% of CV	$18.3
2.10	Development Costs – 0.5% of CV	$18.3
2.11	Project Management (ALL) – 5.0% of CV	$182.7
2.12	Services Relocation – 0.5% of CV	$18.3
	Sub Total Owner's Costs	**$535.8**
	Total Base Estimate	**$4,268.2**
3	**Contingency**	
3.1	Contingency for Dam	$258.1
3.2	Contingency for Pipeline	$208.9
3.3	Contingency for Irrigation	$444.8
3.4	Contingency for Transport (Roads)	$182.7
3.5	Contingency for Electrical and Hydropower	$66.3
	Sub Total Contingency	**$1,160.7**
	Total Estimated Project Cost (Feb 2018)	**$5,350.5**

4. Market Assessments

This section provides an overview of the market outlook and dynamic for the identified crop options considered in this assessment (assessments for each crop are presented in Appendix A). A broad range of opportunities are available for future proponents, beyond the small sample considered in this study. The intent of this analysis, however, is to understand the broad market potential and key risks based on established crop options, not to exclude potential opportunities for production.

4.1. The Macro Opportunity

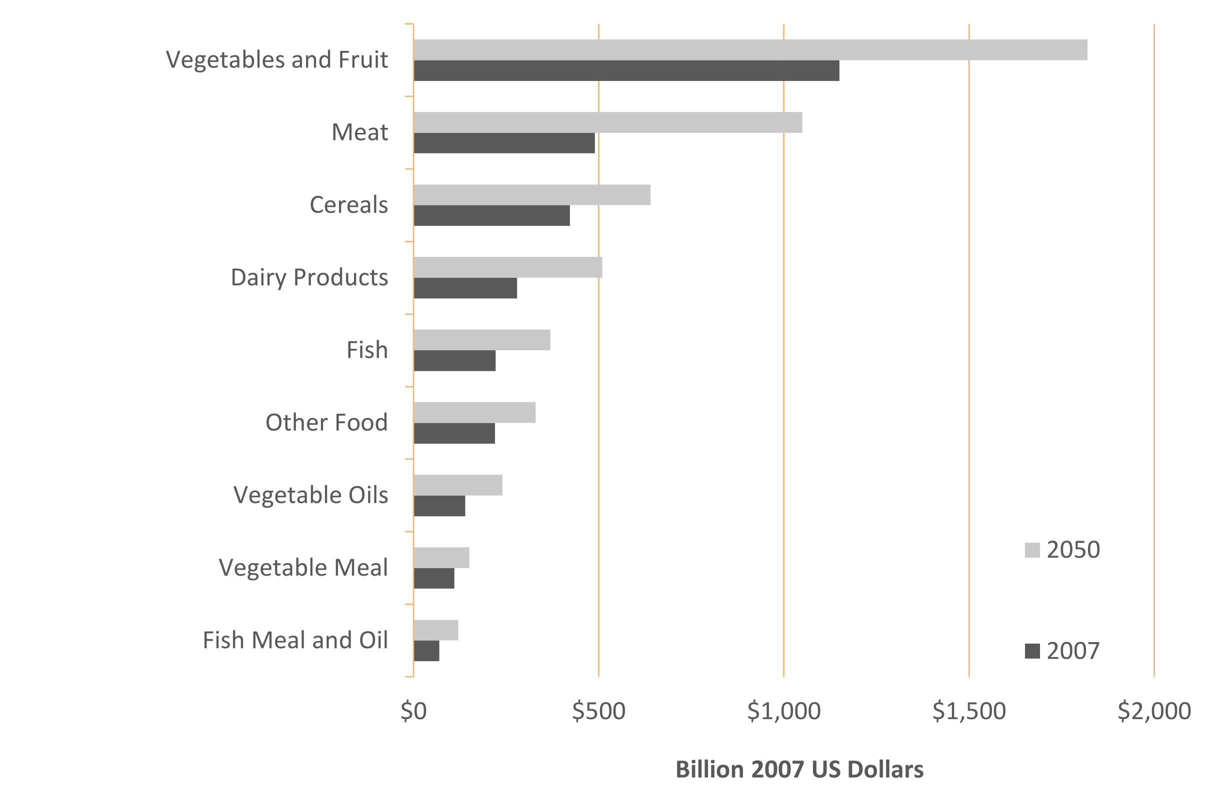
World demand for agrifood products is expected to increase significantly to 2050 driven by ongoing population and income growth, particularly in Asian and other emerging economies. Food consumption patterns continue to shift from traditional diets oriented around starchy staples to more varied diets with greater quantities of higher-value and higher-protein foods (particularly meat and dairy products) (Ash et al., 2014 p. 35.).



Source: Ash et al. (2014)

Figure 3: World Population, Income and Agrifood Consumption

Consumption of fruits and vegetables, cereals and vegetable oils is also projected to increase significantly, with China, India and the Association of South East Asian Nations (ASEAN) projected to experience substantial growth across dairy products, meat, sugar, fruits and vegetables.



Source: ABARES (2013)

Figure 4: Projected Food Demand – 2050

This rising demand combined with increasing competition for land use due to urbanisation is expected to create a substantial rise in demand for food exports over the medium to longer term. Asia has accounted for 50% of global agricultural production growth in recent decades through improvements in productivity. However, resource constraints and other challenges may slow Asia's future growth rates in agricultural production. Projections indicate that increases in food production in Asia will not be sufficient to meet growth in food consumption for many commodities.

For example:

- China, a net exporter of fruit in 2007, is projected to be a small net importer by 2050
- China's expanding domestic livestock production is expected to drive import demand for feed grains, such as sorghum and maize
- Growth in demand for fruit and vegetables is projected to result in India becoming a significant net importer of horticulture products by 2050
- In Association of South East Asian Nations (ASEAN) countries:
  - Imports of wheat are projected to rise by 40% between 2007 and 2050 (no significant amount of wheat is currently produced in the region)
  - Net imports of fruit and vegetables are also projected to increase strongly over the longer term
  - Growth in consumption of beef and dairy products is also expected to be largely met by increased net imports.

The long-term trends described above provide substantial opportunities for expanded irrigation in northern Australia and the Hells Gates site specifically, due to its potential scale and proximity to Asian markets.

4.2. Key Challenges

4.2.1. International Market

Growing economies in the Asian region do not necessarily guarantee business success for northern Australian agriculture. There has been little growth in exports to Asia from northern Australia in the last decade outside of the resources and cattle sectors (Boston Consulting Group, 2012).

Key challenges facing expanded agricultural development include:

- Sourcing the capital investment to support the high cost of 'greenfield' development
- Cost-effectively and sustainably growing crops in the northern environment and transporting to international markets via efficient supply chains
- Establishing new and viable export markets for crops that are not a natural part of the global commodities trade such as high-value, perishable fruit and vegetable products with seasonality of supplies.

Rising export demand will provide support for the development over the longer term, however competition from alternative low-cost export destinations including Chile, Brazil, Asia and Mexico mean the site will have to be to cost competitive to capitalise on the opportunities higher global demand will provide.

4.2.2. Domestic Market

Broadacre (Type 3) crops feature deep international markets for which Australia is an established and competitive exporter (see Appendix A). However, the potential for increased horticultural production from the study area to be absorbed by the domestic market has significant limits. Expansion in production that exceeds growth in demand may result in oversupply. This would place downward pressure on prices and returns across the industry.

Horticultural production at the study site is not assessed as having significant production window or transport cost advantages to the local market compared to established domestic producers. Each of the commodities assessed for Hells Gates have alternative growing locations and many of these locations have opportunities for significant growth at least to meet projected domestic demand.

For Perennial crops, areas including Lakelands, Mareeba Dimbulah, Western Australia and the Burnett can produce at overlapping or the same seasonal window. Type I crops can be produced during the same season in the Burdekin, Bowen and many other areas.

While some potential exists for import replacement and through domestic population and consumption growth, the scale and proximity of the Hells Gates scheme to the Port of Townsville suggest the primary target of new production will be through the export market.

4.3. Market Assessments

4.3.1. Key Implications of Market Assessments

A summary of the market assessment outcomes is presented in Table 6, with additional detailed provided as Appendix A. Key outcomes of note for this study can be summarised by broad crop type as follows:

- Type 1 crops, annual horticulture (pumpkins, capsicums, melons):
  - Strengths:
    - High value (capacity to pay for water, refer to section 5.3.3 for high level estimates of capacity to pay)
    - Low irrigation requirements (4 ML/ha – 6 ML/ha)
  - Weaknesses:
    - Limited market depth, particularly in the domestic market (90%+ currently produced for the domestic market) – Australia has a well-supplied and finely balanced domestic market, particularly during peak production seasons, however prices are highly volatile and

  - susceptible to oversupply, and demand (for vegetables in particular) is generally inelastic (Clements & Si, 2015)
  - Production risk – the identified horticultural production options are highly volatile and susceptible to weather events, pests and diseases

- Type 2 crops, perennial horticulture (avocado, citrus, table grapes):
  - Strengths:
    - High value (capacity to pay for water, refer to section 5.3.3)
    - Potential to produce on a broad range of soil types (Type 2 crops are also able to be produced on Type 3 and Type 1 soils)
  - Weaknesses:
    - Modest market depth: (between 2% and 60% of Type 2 crops are currently exported) with a finely balanced domestic market, particularly during peak production seasons – the export profile of perennial horticulture is generally stronger than annual crops, with the notable exception of avocados, which is are a relatively new crop within Australia and have yet to establish a substantial export presence
    - Long turnarounds for investment – Perennial crops can take 5–10 years to reach full production – this can be reduced significantly through higher density planting methods (near full production in 3–5 years), though these methods result in higher upfront and ongoing (orchard thinning) costs
    - Production risk – the high up front costs and long investment timeframes create substantial risks should production fail – Type 2 crops require full water security to maintain production and ensure the survival of the trees/vines for future years
- Type 3 crops, broadacre agriculture (sugar, cotton, chickpea, mung beans):
  - Strengths:
    - Deep global markets (Australia is an established and competitive exporter, with around 80%+ of produce exported for major commodities)
    - Generally lower capital / production requirements and risk compared to horticultural production – price fluctuations for broadacre crops typically occur over a longer time period than horticulture (ABARES, 2013).
  - Weaknesses:
    - Modest capacity to pay for water (modest production value means that broadacre cropping is more sensitive to water prices, refer to section 5.3.3)
    - Significant scale requirements: Lower production intensity means scale requirements for viable broadacre production are significantly higher than horticulture. This is particularly true where local processing is required (e.g. sugarcane 30,000ha + to support a mill, cotton 8,000 ha – 10,000+ ha to support a gin). The location of existing processing (Burdekin/Hinchinbrook sugar mills (200+ km) and Emerald cotton gin (approximately 500 km) increases the cost of production substantially for these crops[1].

4.3.2. Summary of Market Overview

Table 6 contains a summary of the market assessments outlined in Appendix A, including consideration of each crop, the key markets they are suitable to access, competitors, prevailing trade barriers, and specific market opportunities.

[1] Small volumes of cotton are transported from the Burdekin to Emerald, a further distance by road than the study area.

Table 6: Market Assessment Overviews

Crop	Key Markets	Key Competitors	Trade Barriers	Market Opportunities
Type 1				
Pumpkins Melons Capsicum	Production is focused on domestic market – less than 2% of pumpkin production and less than 10%–15% of melons are exported. The largest overseas market for pumpkins is Singapore. For melons / capsicum, it is New Zealand.	Established producers in Northern and south-east Queensland	New Zealand, Singapore and UAE apply zero tariffs. Exports attract 5% tariff in Indonesia.	**Domestic:** Rising nutritional awareness is expected to continue to have a positive impact on consumption of vegetables. **International:** Over the medium to longer term, exports have the potential to benefit from increased consumption in Asia.
Type 2				
Citrus	Production is predominately focused on fresh fruit for the domestic market. However, exports to Asia represent a rapidly growing market segment.	Established producers, predominately Sunraysia	The 2015 China-Australia Free Trade Agreement (FTA) has resulted in a gradual reduction in tariffs.	**Domestic:** Limited market potential, with established growers swapping production from Valencia to Navel orange varieties due to competition from imported juice. **International:** Exports to China have averaged annual growth of 133% between Apr–Jun ‘11 and Apr–Jun ’17.

Crop	Key Markets	Key Competitors	Trade Barriers	Market Opportunities
Avocado	Australian production is largely focused on domestic market. Small volumes are exported to Singapore, Thailand, Malaysia, Hong Kong and the UAE.	Australia is a net importer – most imports are from New Zealand. Major global exporters include Mexico, Chile, and Peru.	Australian avocado exports are currently subject to few tariff barriers.	**Domestic:** Domestic demand for avocados is currently growing rapidly due to high prices, however domestic supply is likely to increase substantially within the timeframes for development of the study site. **International:** Avocados are transported to Singapore and Malaysia from Australia by air in 8 hours, compared with imports from Mexico, which can take up to 30 days
Table Grapes	Rapidly growing exports into Asia. Total exports have grown four-fold since 2011.	Exporters face considerable competition from lower-cost producing countries, particularly Chile	Gradual removal of tariffs under the Australia - China FTA has been a major driver of recent export growth.	Table grapes represent a growing industry sector which is not heavily constrained by the domestic market. Prices are currently weak. However, solid projected growth suggests opportunities to support increased production into the future.

Crop	Key Markets	Key Competitors	Trade Barriers	Market Opportunities
Type 3				
Grain Sorghum	Used by Australian intensive livestock industries – feedlot cattle, pigs and poultry. Also used in ethanol production. Production has become more export oriented in recent years (around 50%) – major markets are Japan, China, New Zealand and South Africa.	United States Argentina	Exports face either zero or low tariffs in Australia's main export destinations. Japan applies 0% tariff, while China has removed the previous 2% tariff under the China – Australia FTA.	**Domestic:** Generally strong outlook for the livestock, pig and poultry sectors should underpin domestic demand. **International:** The dominant market for Australian exports is Japan, although the Chinese market is projected to grow substantially. Historically, China used sorghum in the manufacture of hard liquor, and livestock feed was a less significant use. However, feed use in China is expected to increase over the medium to longer term.
Chick Peas	The vast majority of Australia's production is. Main export markets are India, Pakistan, and Bangladesh. The Middle East and Turkey are also important markets.	Australia is world's largest exporter. Competitors are India, Russian Federation, Canada, Argentina, Mexico and Turkey.	Pakistan, Bangladesh and India currently apply zero tariffs. India provides a domestic minimum support price that exceeds international prices.	**Domestic:** Demand growth is expected to come from the large South Asian and Middle Eastern migrant communities in Australia. **International:** Continuing growth in demand from South Asia is likely, given projections of population growth and the largely vegetarian diet.

Crop	Key Markets	Key Competitors	Trade Barriers	Market Opportunities
Cotton	Around 95% of Australian cotton production is exported. China accounts for around two thirds of total cotton exports.	Main competitors into Asian markets are India, the United States, Uzbekistan and Brazil.	China's bound and applied tariffs are 40%, for both raw cotton and semi-processed.	**Domestic:** There is expected to be very limited additional demand for ginned cotton in Australia. **International:** Demand from ASEAN countries such as Cambodia and Vietnam is projected to grow over the medium term.
Mung Beans	Currently, Australian mung bean production is largely destined for export – India and Indonesia are the most important markets for Australian export	Myanmar and China are world's largest exporters. While India is one of the largest producers, its exports are small.	Australian mung bean exports typically face low tariff barriers. India's bound tariff rate is 30%, but zero rate is applied.	**Domestic:** Modest opportunities to market mung beans to domestic food manufacturers. **International:** Continued growth from ASEAN countries and India.

Source: Ash et al. (2014), AEC

5. Financial Analysis

This section presents a high-level financial analysis of the proposed development concept. The analysis identifies the range of water price points at which the scheme is potentially commercially viable (from the operator's point of view) and provides insight into the capacity of industry to support the required infrastructure development.

5.1. Price Setting Approach

5.1.1. Adopted Cost Recovery Method

A building block approach to identifying water charge revenue was adopted. The approach included examination of labour, goods and services expenditure, depreciation (return of capital), and a commercial return on capital. Initial water allocation sales are offset against the capital investment cost of the dam infrastructure for pricing purposes, effectively reducing the return on capital and depreciation requirements using the asset offset (rather than the revenue offset) approach.

Ongoing charges are costed on a take or pay basis with a fixed and variable component.

5.1.2. Labour, Goods, and Services Expenditure

Labour, goods, and services expenditure covers estimated costs associated with the dam, labour, administration, and other operating costs (excluding depreciation and interest). Estimates for fixed operating expenditure (OPEX) have been based on previous studies and existing schemes and are summarised in Table 7.

Works on state roads (Gregory Development Road, Hervey's Range Road and Mount Fox Road realignment) have been assumed to be gifted to the Department of Transport and Main Roads (DTMR) to be maintained, and have therefore been excluded from the operating cost estimates[2].

Table 7: Annual Fixed Operating Cost Assumptions

Cost Allocated To	Item	Fixed Labour, Goods and Services Expenditure ($M)
All Demands[1]	Dam	$4.0
	Roads	$1.7
	Hydropower and Solar Farm	$2.1
North Area	Distribution	$6.9
	Electrical	$0.9
South Area	Distribution	$7.7
	Electrical	$0.2
Middle Area[2]	Distribution	$8.2
	Electrical	$0.2
	Total Agriculture	**$31.9**
TCC Pipeline	Pipeline	$10.7
	Total Inc. TCC Pipeline	**$42.6**

Note: [1] Production close to the Burdekin River is only allocated the costs noted as all demands.

[2] However, these capital items still incur a return on capital and depreciation (return of capital to the scheme investor) expense where appropriate under the cost recovery methodology. The exclusion of operating costs assumes ongoing costs to DTMR are not increased due to the associated development works. Where this is the case, an NPV payment of the additional costs would be made by the scheme operator to DTMR.

Source: McKellar et al. (2013), GHD (2014), AEC

Estimated fixed costs total just under 1% of applicable capital expenditure[3], which are broadly in line with existing schemes, such as SunWater.

Table 8: Water Scheme Operating Cost Benchmarks

Agency	Operation, Maintenance & Administration (% of Capital Replacement Cost)
Hells Gates Estimate	0.97%
SunWater – River Regulation	0.69%
State Water	0.95%
Sun Water - Aggregated Service Provider	1.01%
Goulburn-Murray Water - Regulated River	1.91%
Goulburn-Murray Water Aggregated Service Provider	2.48%

Source: Queensland Competition Authority (2012)

Based on the benchmarks identified in Table 8, the distribution of scheme fixed operating costs (excluding the TCC pipeline) has been estimated as follows:

- Labour costs – $10.5 million per annum
- Maintenance costs – $10.0 million per annum
- Administration and other costs – $11.4 million per annum.

In addition to fixed costs, a variable pumping cost of $1.05/ML/metre of head has been included, based on 3.5 kWh at 30 cents/kWh (estimates for pumping head requirements for each project area are presented in Table 9).

Table 9: Pumping Head Estimates

Irrigation Area	Static Head (m)	Pipeline Length (m)	Vol (m^3/s)	Diameter (mm)	Friction Loss (m)	Total Dynamic Head (m)
Agriculture						
North Area	37	6,000	24	2,000	73.9	111
South Area	58	14,500	20	2,000	84.3	175
Middle Area	48	14,500	16	2,000	127.4	142
Urban						
TCC Pipeline (Interim)	90	140,000	2.7	1,800	76.4	166
TCC Pipeline (Duplication)	90	140,000	1.8	1,500	96.9	187

5.1.3. Depreciation (Return of Capital)

Depreciation charges are applied over the useful life of the asset, as the shorter of:

- **Potential operating life** – the total operating life of the asset without the need for replacement/renewal
- **Economic life** – if an asset with no resale (or relocatable) value is installed to provide dedicated supply to a particular user or users, then the life of the 'in use' agreement will reflect the period over which the capital invested in the asset will need to be recouped (i.e. its economic life).

[3] Noting that operating expenditure for main roads was excluded.

For the purposes of this financial and pricing assessment, the following two approaches have been applied to derive a range of potential pricing requirements:

- **Adoption of individual asset lives of 30–100 years** to reflect the potential operating life of all scheme infrastructure, assuming that infrastructure components can be utilised beyond any individual supply agreements in all locations (McKellar et. Al, 2013; ATAP, 2018, AEC):
  - Dams – 100 years
  - Roads – 30 years
  - Land acquisition – indefinite
  - Pipelines / channels – 80 years
  - Other infrastructure – 40 years
- **Adoption of an average economic life of 40 years** across all infrastructure components (excluding land) as a proxy of the average life of supply contract / agreements.

5.1.4. Return on Capital

Return on capital has been derived at a high level by applying a targeted real, pre-tax Weighted Average Cost of Capital (WACC) of 4.4% (reflecting a nominal rate of approximately 7%), based on an assumed financing structure consisting of both debt and equity[4] and AEC's experience with similar projects.

5.2. Other Modelling Assumptions

The assumptions identified below have been applied in developing the financial projections (all costs in real $2018).

Capital Costs

Infrastructure costs applied for each of the scenarios / components as per the cost and timing outlined in Table 10. Agricultural development has been assumed as taking place in the following sequence:

1. North Area (2027–2029)
2. South Area (2030–2032)
3. Middle Area (2033–2035).

Table 10: Capital Cost Estimates

Cost Allocated To	Item	Cost Inc. Contingency and Owner's Costs($M)	Timing
All Demands	Dam	$991.8	2027–2029
	Land Resumption	$64.1	2027–2029
	Roads	$869.1	2027–2029
	Hydropower and Solar Farm	$188.1	2027–2029
North Area	Distribution	$639.6	2027–2029
	Electrical	$87.7	2027–2029
South Area	Distribution	$716.8	2030–2032
	Electrical	$21.5	2030–2032
Middle Area[1]	Distribution	$759.9	2033–2035
	Electrical	$18.0	2033–2035
	Total Agriculture	**$4,356.6**	**2027-2035**

[4] Regulatory pricing determinations adopt an optimal financing structure when determining the appropriate WACC to be applied, rather than taking into account actual debt and equity funding.

Cost Allocated To	Item	Cost Inc. Contingency and Owner's Costs($M)	Timing
Townsville Pipeline	Pipeline	$994.0	2033–2035
	Total Incl. TCC Pipeline	**$5,350.5**	**2027–2035**

Note: [1]Not developed under the perennial cropping scenario

Revenue

Sale of water allocations at $500/ML (MP equivalent) have been assumed in the year before production begins. The assumed allocation sale price is higher than current sales for the Burdekin, but below alternative schemes such as Mareeba Dimbula, and the Murray Darling, which have reached $1,800+/ML.

Energy generation (55,000 MWh/annum from hydropower and 36,000 MWh/annum from the solar farm) has been modelled at an average price of $80/MWh, including energy and large scale generation certificates (LGCs), which have been offset against the cost of dam operation. Refer to Milestone 4: Technical Feasibility Report for further detail regarding the energy generation assumptions.

Impact of Subsidy

A subsidy option has been included in the analysis alongside the base commercial pricing assessments to identify the potential impact on grower prices. Under the option, the scheme operator would forego return on capital (cost recovery only allows for operating costs and depreciation). This cost is the minimum allowed under Queensland Treasury Corporation requirements and leaves the initial capital costs ($5.3 billion including the pipeline connection to Townsville) unfunded.

5.3. Results

Townsville Urban Water

Assessing the financial feasibility of the Townsville urban water supply concept is particularly challenging, given:

- The extended time period for development (post-2035)
- Absence of detailed demand modelling which would clarify the required timing for the proposed interim and final solutions
- Ongoing annual demand that could be supported from the pipelines. Townsville's current and connection to the BHWSS is only used intermittently when supplies in the Ross Rover Dam fall below 20%

Due to these factors, the connection has not been included in the financial assessments. However, a high-level analysis (assuming no return on capital) indicated the final pipeline could supply 65,000 ML/annum at a levelised ($2018) cost of just over $600/ML, including variable costs of approximately $185/ML. The relative merits of the pipeline should be compared with alternative long-term water supply options (including additional connections to the BHWSS) on a whole-of-life basis.

5.3.1. Required Water Prices – Agriculture

A pricing assessment has been undertaken for the first 30 years of supply to each area. Levelised real ($2018) water prices for medium priority (MP) and high priority (HP) water required to achieve cost recovery are presented in Table 11.

Reported prices represent an ongoing levelised estimate, costs are typically charged on a two-tier fixed and variable basis (with pumping costs representing the variable component, see Table 9).

Table 11: Levelised Ongoing Costs per ML (30 Years of Operations, Mixed Cropping Scenario)

Cost Recovery Method	Agreement Life (40 years)		Potential Life		Potential Life (No Return On Capital)	
	MP	HP	MP	HP	MP	HP
Away from the Burdekin River						
North Area	$812	$1,315	$767	$1,238	$361	$538
South Area	$538	$787	$516	$748	$285	$352
Middle Area	$657	$1,032	$641	$1,005	$284	$390
Next to the Burdekin River						
North Area	$315	N/A	$294	N/A	$53	N/A
South Area	$183	N/A	$176	N/A	$40	N/A
Middle Area	$149	$257	$147	$253	$38	$65
Whole of Scheme	**$613**	**$1,034**	**$584**	**$979**	**$277**	**$433**
Whole of Scheme (Perennial Cropping Scenario)	**N/A**	**$756**	**N/A**	**$719**	**N/A**	**$352**

The following should be noted:

- Levelised MP water charges range from $258/ML to $559/ML per annum across the scheme, depending on the cost recovery method and level of subsidy
- HP water allocation prices for Type 2 perennial crops range from $433/ML to $1,034/ML per annum. Under the perennial cropping scenario, these costs reduce to $352ML to $756/ML
- Costs vary significantly across the three cropping areas, with areas close to the Burdekin River substantially more cost-effective to irrigate (as they exclude distribution costs). Average ongoing water charges are considerably higher than existing BHWSS scheme charges of $13/ML to $67/ML (for comparison purposes, water charges for selected existing schemes are presented in Table 12).

Table 12: Ongoing Water Costs Selected Schemes (Sum of Take or Pay Plus Variable Components)

Scheme	Annual Charge ($/ML of MP Water)
Burdekin	
Burdekin River	$12.60
Burdekin Channel	$67.10
Werribee and Bacchus Marsh Irrigation Districts	
Werribee and Bacchus Marsh Irrigation Districts	$62.00
Mareeba Dimbulah	
River (Tinaroo / Barron)	$30.60
Channel – Relift	$118.90
Lower Fitzroy	
River	$14.20

Source: SunWater (2018), Southern Rural Water (2018), SEQ Water (2018)

Table 13 highlights the relative contribution to total water prices from each building block under the mixed cropping scenario. The return on capital component comprises the majority of the costs to be recouped.

Table 13: Contribution of Cost Components to Price Outcomes (Potential Life, Return on Capital)

Cost Input	Whole-of-Scheme
Pumping Costs	19.4%
Other Labour, Goods and Services Expenditure	8.0%
Depreciation (Return of Capital)	25.9%
Return on Capital	46.7%

5.3.2. Agricultural Capacity to Pay

To evaluate the capacity of agricultural production to support the required water costs (whole-of-scheme), prices have been compared with the identified gross margins for potential crop options developed in the market assessment for (see Table 14 and Appendix B). Transport costs are estimated at a high level predominately based on export via Townsville[5].

The gross margins enable the identification of a maximum capacity to pay for water, whereby producers can still contribute to fixed costs under the whole-of-scheme levelised costs.

Table 14: Agricultural Gross Margins and Capacity to Pay for Water ($2018)

Crop Type	Revenue /ha	Variable Costs /ha	Gross Margin /ha	Avg. Irrigation (ML/ha)	Max Capacity to Pay ($/ML)	Capacity to Pay (Levelised Ongoing Water Charges, Whole of Scheme)	
						Agreement Life (Return on Capital) $613 MP/ $1,034 HP	Potential Life (No Return on Capital) $277 MP/ $433 HP
Type 1							
Rockmelon	$28,000	$22,608	$5,976	6.3	$1,182	Yes	Yes
Watermelon	$24,000	$17,685	$5,611	3.5	$1,603	Yes	Yes
Capsicum & Chilli	$48,000	$31,989	$18,263	4.7	$4,566	Yes	Yes
Pumpkins	$12,000	$10,408	$1,592	4.0	$398	No	Yes
Type 2							
Avocados	$79,200	$14,292	$64,905	15.0	$4,327	Yes	Yes
Citrus Oranges	$47,500	$18,083	$28,679	17.7	$1,621	Yes	Yes
Citrus Lemons	$62,500	$20,940	$41,560	17.7	$2,348	Yes	Yes
Table Grapes	$24,000	$23,087	$913	6.3	$145	No	No
Type 3							
Mung Beans	$2,440	$775	$1,665	3.6	$463	No	Yes
Chick Peas	$2,880	$851	$2,029	4.6	$441	No	Yes

[5] Some crops with very limited current export intensity are modelled based on transport to Brisbane, though it is hoped that in time, these crops will also develop a more substantial export profile.

Crop Type	Revenue /ha	Variable Costs /ha	Gross Margin /ha	Avg. Irrigation (ML/ha)	Max Capacity to Pay ($/ML)	Capacity to Pay (Levelised Ongoing Water Charges, Whole of Scheme)	
						Agreement Life (Return on Capital) $613 MP/ $1,034 HP	Potential Life (No Return on Capital) $277 MP/ $433 HP
Grain Sorghum	$2,200	$1,445	$755	7.9	$96	No	No
Cotton	$6,444	$2,864	$3,580	8.6	$416	No	No

Source: McKellar et. Al. (2013), DAF (2016, 2018), NSW DPI (2013), ABARES (2017a), AEC

The following should be noted:

- Higher value horticultural crop options (Types 1 and 2) are identified as providing the capacity to pay for water at the whole-of-scheme average price levels, with the notable exception of table grapes. However, the relatively high risks and modest market depth for horticultural cropping options may limit uptake in the absence of new export markets
- Identified water costs exceed the maximum capacity to pay for grain sorghum and cotton. Water prices exceed the capacity to pay of all Type III crops under the agreement life pricing methodology.

To extend evaluation of capacity to pay, a whole-of-farm analysis has been undertaken for a period of 20 years. Fixed and capital cost assumptions are defined in Table 15 below (refer to Appendix B for more detail regarding on-farm production cost assumptions). The estimates have been adapted from published benchmarks and are for illustrative purposes only. In practice, overhead and capital cost structures will vary widely, depending on a range of factors such as farm size, operating structure, production methods, and crop options.

Table 15: Whole-of-Farm Cost Assumptions

Factor	Avg. Type 1 Crops ($/ha)	Type 2 Crops ($/ha)			Avg. Type 3 Crops ($/ha)
		Avocado	Citrus	Table Grapes	
Farm Size (ha)	**200**	**200**	**200**	**200**	**500**
Capital Costs ($/ha)	**$26,000**	**$45,000**	**$30,000**	**$55,000**	**$17,000[1]**
Fixed Costs					
Fixed Labour	$1,000	$1,000	$1,000	$1,000	$300
Fixed Repairs / Maintenance	$200	$400	$400	$400	$100
Administration	$250	$250	$250	$250	$80
Land Rent	$100	$100	$100	$100	$100
Other	$150	$300	$300	$300	$70
Total	**$1,700**	**$2,050**	**$2,050**	**$2,050**	**$650[1]**

[1]Capital costs are excluded, and fixed costs reduced to $350/ha for mung beans as a rotational crop option
Source: McKellar et. al. (2013), ABARES (2017), GHD (2014), Dee & Ghose (2015), Citrus Australia (2015), AEC

Returns have been assessed at a modest real discount rate of 7% over 20 years of operation[6], with the net present value (NPV) and internal rate of return (IRR) presented in Table 16 below. For simplicity, and to consider a minimum hurdle for viability, results have been modelled based on the whole of scheme water prices (full cost recovery agreement life and no return on capital potential life) identified in Section 5.3.1 with

[6] A shorter timeframe than undertaken for water storage reflecting the investment span of individual growers.

100% of allocations available each year. Initial water allocation purchase costs have been included in Year 1 of the analysis at $500/ML MP ($863/ML HP).

Results of the analysis are presented in Table 16 below. Key findings include:

- Type 1 crops return a mix of negative and positive NPVs, with high-value capsicum / chilli crops showing a strong NPV under the assumptions used in the analysis.
- Type 2 crops provide the strongest returns under the assumptions applied, although all crops – excluding avocados – return a negative NPV when depreciation and return on capital charges are incorporated.
- Type 3 crops do not return a positive NPV under any of the water prices analysed, except for mung beans which have been included as a rotational cropping option (and exclude up-front capital costs). Among the crops assessed, cotton and chickpeas return the smallest NPV losses (cotton would require an increase of around 25% in grower returns at the lower bound pricing). A rotation of these crops appears to be the strongest broadacre cropping option of those assessed.

Ultimately, the viability of crop options will vary from year to year, based on seasonal, production, and market factors. The options available to potential growers extend well beyond those considered in this study. However, the results indicate that the cost of water under the proposed scheme will likely limit the cropping options available to growers, particularly in areas away from the Burdekin River.

Estimates for some crops, such as avocados, are based on a strong current market dynamic, though others such as table grapes are based on relatively weak returns. Thus, all of the crops have been retained within the respective scenarios. Alternative broadacre crops such as sugarcane have some potential in the study area, though would require significant scale to support local processing[7].

Market dynamics will change over time, and the long-term outlook for agriculture is positive. Projecting price changes over a long timeframe, however, is highly challenging and likely subject to significant error. Projected real price growth over the next five years (ABARES, 2017b – see Appendix A) for the selected commodities does not materially change the outcomes of the analysis.

Table 16: NPV Outcomes, 20 Years of Operations (7% Real Discount Rate)

Crop	Indicator	Water Costs ($/ML Ongoing)	
Type 1		**$613**	**$277**
Pumpkins	NPV ($M)	-$12.9	-$8.8
	IRR	N/A	N/A
Rockmelon	NPV ($M)	-$5.8	-$1.7
	IRR	N/A	2.5%
Watermelon	NPV ($M)	-$0.4	$1.9
	IRR	5.9%	11.5%
Capsicums	NPV ($M)	$16.8	$19.8
	IRR	40.3%	45.9%
Type 2		**$1,034**	**$433**
Avocados	NPV ($M)	$34.6	$52.0
	IRR	18.7%	25.3%
Citrus Oranges	NPV ($M)	-$22.3	-$1.8
	IRR	-5.8%	6.1%
Citrus Lemons	NPV ($M)	-$4.9	$15.6

[7] GHD (2014) found that such a scenario would require 100,000 ha (10 million tonnes per annum) to be potentially commercially viable.

Crop	Indicator	Water Costs ($/ML Ongoing)	
	IRR	4.8%	14.1%
Table Grapes	NPV ($M)	-$30.3	-$23.0
	IRR	N/A	N/A
Type 3		**$613**	**$277**
Mung Beans	NPV ($M)	-$5.1	$0.7
	IRR	N/A	15.7%
Chick Peas	NPV ($M)	-$16.7	-$8.5
	IRR	N/A	-16.6%
Grain Sorghum	NPV ($M)	-$33.1	-$20.3
	IRR	N/A	N/A
Cotton	NPV ($M)	-$2.2	-$0.8
	IRR	N/A	-6.7%

5.4. Scheme Net Present Value

This section assesses the proposed scheme (as a whole) on an NPV basis over a period of 30 years. The analysis assumes no transfer pricing between the water storage operator and farming operations. A return at whole-of-scheme level represents the lowest investment hurdle for viability, with returns for individuals (growers, scheme operators, processors) determined through commercial negotiation. Noting the results of the previous section, it is unlikely that a return on capital would be recovered by the scheme operator.

The analysis is based on the assumptions applied in Sections 5.2–5.3.2, with the following inclusions (at real discount rates of 4%, 7%, and 10%):

- A salvage value for water infrastructure assets at the end of the analysis period[8]
- Incorporation of water restrictions on MP water, based on modelling provided over 30 years by SMEC (unpublished) – water restrictions affect pumping and variable on-farm costs, based on the percentage of MP allocations available
- Capital renewal for on-farm infrastructure equal to 25% of initial costs required after 20 years of operation (with the remainder due outside of the analysis period)
- Allowances for varying levels of capital subsidy, specifically:
  - Funding for main roads
  - 50% subsidisation of scheme capital
  - 100% subsidisation of scheme capital.

The following should be noted:

- The mixed cropping scenario returns a negative NPV at all the discount rates assessed, with an IRR equal to 2.2%. A subsidisation of 50% of scheme capital costs returns a positive NPV at a discount rate of 4%, and 100% subsidisation returns a positive NPV at a discount rate of 10%.
- The perennial cropping scenario returns a positive NPV at discount rates of 4% or 7% and a negative NPV at a discount rate of 10%. The scenario returns an IRR of 7.1%, indicating that perennial cropping options have some potential to support the scheme, given the costs and revenues assumed in this

[8] Using straight line depreciation and the asset lives identified in Section 5.1.3, applying a terminal value approach using the lowest cost recovery method (potential life, no return on capital) reduces the NPV by approximately $230 million for the mixed cropping scenario and $160 million for the perennial cropping scenario at a 7% discount rate.

analysis (where additional production does not impact significantly upon market prices). Inclusion of scheme capital subsidies improves the position of the NPV analysis significantly.

Table 17: NPV Outcomes

Real Discount Rate	Mixed Cropping ($M)	Perennial Cropping ($M)
Including Capital Costs		
4%	-$1,420	$2,854
7%	-$2,558	$40
10%	-$2,959	-$1,324
IRR	2.2%	7.1%
Excluding Capital Costs (Main Roads)		
4%	-$925	$3,349
7%	-$2,090	$508
10%	-$2,515	-$880
IRR	2.7%	7.9%
Excluding Capital Costs (50% of Scheme Capital)		
4%	$482	$4,471
7%	-$825	$1,546
10%	-$1,370	$83
IRR	4.8%	10.3%
Excluding Capital Costs (100% of Scheme Capital)		
4%	$2,383	$6,088
7%	$907	$3,052
10%	$219	$1,491
IRR	11.8%	18.7%

5.5. Sensitivity Testing

Sensitivity testing was undertaken using a Monte Carlo analysis, which assigns a probability distribution for each input parameter in the model and then examines multiple iterations. This distribution is then used to identify the effect of the input parameter on the decision criteria (i.e. NPV). It reflects the 'probability' of achieving the key dependent output across the following key assumptions used in the economic analysis modelling (including the base assumptions outlined in Sections 5.2–5.3.2):

- Costs:
  - Water storage capital costs (including environmental offsets)
  - On-farm costs
  - Scheme operating costs[9]
- Revenues:
  - Agricultural production revenues
  - Scheme salvage value.

Each of the above assumptions was tested in isolation, with all other inputs maintained. The results were reported in terms of the modelled change in NPV resulting from the variance in the base assumptions at a

[9] Scheme operating costs have been reduced to allow for energy generation revenues/cost savings.

discount rate of 7%. Table 19 shows each assumption simultaneously to provide a 'combined' or overall sensitivity of the model findings to the assumptions used. Table 19 also outlines the distribution used, allowing for:

- A 50% confidence interval, with the '25%' and '75%' representing a 50% probability that the distribution and NPV will be within the range outlined in the table.
- The 50th percentile result, indicating the NPV at which 50% of values will be equal to or greater than.

The ranges tested for each input variable are presented in the table below.

Table 18: Monte Carlo Simulation Results (7% Discount Rate)

Variable	Key Risks	Distribution Applied
Costs		
Scheme Capital Expenditure	Costs exceed modelled estimates Cost and availability of finance	Maximum 50% higher and 40% lower than the base values used.
Scheme Operating costs	Costs exceed estimates	Maximum 50% higher and 40% lower than the base values used.
On-Farm Capital Costs	Costs exceed estimates Cost and availability of finance	Maximum 50% higher and 40% lower than the base values used.
Revenues		
Farm Net Revenues	Capacity to pay for water Crop failures (disease, pests, weather events) Market depth to support horticultural cropping	Maximum 40% higher and 150% lower than the base values used.
Scheme Residual Value	Reliability of scheme value outside of the analysis period	Maximum 40% higher and 50% lower than the base values used.

Results of the Monte Carlo simulation indicate:

- The mixed cropping scenario returns a 50% probability of an NPV between -$4.1 billion and -$2.5 billion, returning a positive NPV in none of the 5,000 iterations of the Monte Carlo simulation
- The perennial cropping scenario returns a 50% probability of an NPV between -$2.9 billion and $293 million, returning a positive NPV in 30.4% of the iterations of the Monte Carlo simulation.

Both scenarios are most strongly impacted by the assumptions relating to capital expenditure and agricultural production. In particular the scenarios are acutely sensitive to agricultural risks such as market depth, price volatility and crop failures.

Table 19: Monte Carlo Simulation Results (7% Discount Rate)

Variable	Variable Distribution		
	25%	50%	75%
Mixed Cropping Scenario			
Costs			
Capital Expenditure	-$3.0 billion	-$2.6 billion	-$2.2 billion
Scheme Operating costs	-$2.6 billion	-$2.6 billion	-$2.5 billion
On-Farm Capital Costs	-$2.7 billion	-$2.6 billion	-$2.5 billion

Variable	Variable Distribution		
	25%	50%	75%
Revenues			
Farm Net Revenues	-$3.9 billion	-$3.1 billion	-$2.4 billion
Scheme Residual Value	-$2.6 billion	-$2.5 billion	-$2.5 billion
Combined	**-$4.1 billion**	**-$3.3 billion**	**-$2.5 billion**
Perennial Cropping Scenario			
Costs			
Capital Expenditure	-$396 million	$0.5 million	$366 million
Scheme Operating Costs	-$34 million	$35 million	$100 million
On Farm Costs	-$92 million	$28 million	$146 million
Revenues			
Farm Net Revenues	-$2.7 billion	-$1.1 billion	$161 million
Scheme Residual Value	-$8 million	$38 million	$68 million
Combined	**-$2.9 billion**	**-$1.2 billion**	**$293 million**

6. Economic Impact Assessment

Modelling in this section estimates the economic activity supported by construction and ongoing activities associated with the mixed cropping scenario, with agricultural production also assessed under the perennial cropping scenario. Input-output modelling was used to examine the direct and flow-on[10] activity expected to support the regional economy (the geography examined is outlined in Section 6.1). Modelling drivers used in the assessment are described in Section 6.1. A description of the input-output modelling framework is provided in Appendix C.

Input-output modelling in this report describes economic activity by examining four types of impacts:

- **Output** – the gross value of goods and services transacted, including the cost of goods and services used in the development and provision of the final product. Output typically overstates the economic impacts as it counts all goods and services used in one stage of production as an input to later stages of production, hence counting their contribution more than once.
- **Gross product** – the value of output after deducting the cost of goods and services inputs in the production process. Gross product (e.g. gross regional product) defines a true net economic contribution and is therefore the preferred measure for assessing economic impacts.
- **Income** – measures the level of wages and salaries paid to employees of the industry and to other industries benefiting from the project.
- **Employment** – the part-time and full-time employment positions generated by the economic stimulus, both directly and indirectly through flow-on activity, expressed in full-time equivalent (FTE) positions[11].

6.1. Geographic Scope

The assessment examines the economic impacts across three catchments (with commentary focused on the North Queensland region):

- North Queensland (Northern Statistical Area Level 4)
- Queensland
- Australia.

6.2. Model Drivers

6.2.1. Construction Phase

Scheme Development

The irrigation scheme has total construction activity worth $4.4 billion excluding the TCC pipeline option[12]. The timing will ultimately be subject to market demand, but for the purposes of this assessment has been assumed to occur from 2027-2035.

For modelling purposes, the capital outlay for the project was disaggregated into relevant industries represented in the input-output model (based on the Australian and New Zealand Standard Industrial Classification (ANZSIC) categories). A summary of expenditure for development of the project is outlined in the table below, broken down by relevant industry. Some items were excluded and assumed to represent a transfer of financial benefits rather than a driver of economic activity.

[10] Within this report Type I flow-on multipliers are reported only as Type II multipliers are generally considered to overstate economic activity.

[11] Where one FTE is equivalent to one person working full-time for a period of one year.

[12] Construction estimates associated with the TCC pipeline have been assessed separately.

Table 20: Construction Costs (Incl. Contingency)

Description	Value Incl. Contingency ($M)	ANZSIC
Construction Costs		
RCC Dam	$903.3	Heavy and Civil Engineering Construction
Irrigation	$1,927.5	Heavy and Civil Engineering Construction
Transport (Roads)	$791.5	Heavy and Civil Engineering Construction
Hydropower and Electrical	$287.1	Heavy and Civil Engineering Construction
Sub Total Construction Costs	**$3,909.4**	
Owner's Costs		
Resumption – Mount Fox Road Realignment	$8.1	Excluded
Resumption – Dam Access Road	$0.9	Excluded
Resumption – Minor Sealed Roads	$55.1	Excluded
Environmental – Hells Gates Dam	$7.6	80% Excluded 20% Arts and Recreation Services (subsector Nature Reserves and Conservation Parks Operation)
Design Costs	$147.9	Professional, Scientific and Technical Services
Owner's Insurance Costs	$29.6	Insurance and Superannuation Funds
Cultural heritage Consultation	$3.0	Professional, Scientific and Technical Services
Environmental Approvals	$3.0	Professional, Scientific and Technical Services
Community Consultation	$14.8	Professional, Scientific and Technical Services
Development Costs	$14.8	Construction Services
Project Management	$147.9	Professional, Scientific and Technical Services
Services Relocation	$14.8	Heavy and Civil Engineering Construction
Sub Total Owner's Costs	**$447.3**	
Total	**$4,356.7**	

On-Farm Capital Expenditure

In addition to direct development of the scheme, the project will facilitate substantial on-farm construction activity, a summary of which is presented in Table 21 (broken down by ANZSIC sector).

Table 21: On-Farm Capital Assumptions

Factor	Avg. Type 1 Crops ($/ha)	Avg. Type 2 Crops ($/ha)	Avg. Type 3 Crops ($/ha)	Total Investment ($M)	ANZSIC
Total Area	**10,810 ha**	**14,110 ha**	**25,080 ha**	**50,000 ha**	
Land Clearing	$2,000	$2,000	$2,000	$100	Heavy and Civil Engineering Construction
Irrigation Capital (On Farm)	$8,000	$8,000	$4,500	$312	Heavy and Civil Engineering Construction
Irrigation Capital (Connection to Channel)	$10,000	$10,000	$10,000	$500	Heavy and Civil Engineering Construction
Other costs (sheds / workshops, machinery & equipment, wind breaks, trellis, etc.)	$6,000	$23,333	$1,500	$432	• Non-Residential Building Construction (20%) • Construction Services (20%) • Specialised and other Machinery and Equipment Manufacturing (40%) • Motor Vehicles and Parts; Other Transport Equipment Manufacturing (20%)
Total	**$26,000**	**$43,333**	**$18,000**	**$1,344**	

Of the above capital outlay, not all activity will be undertaken within the local or regional economy. For example, some professional services activities will likely be sourced from major capital cities or overseas. Table 22 outlines assumptions used in the modelling to identify where relevant activity is anticipated.

Table 22: Location of Construction Phase Activity by Industry

Industry	North Queensland	Queensland	Australia
Heavy and Civil Engineering Construction	100%	100%	100%
Construction Services	100%	100%	100%
Professional, Scientific and Technical Services	50%	85%	100%
Specialised and other Machinery and Equipment Manufacturing	20%	35%	45%

Industry	North Queensland	Queensland	Australia
Motor Vehicles and Parts; Other Transport Equipment Manufacturing	20%	35%	45%
Arts and Recreation Services	100%	100%	100%
Insurance and Superannuation Funds	30%	70%	100%

In interpreting Table 22, it is important to recognise that work locations may not be the same as locations used to source labour or services to undertake the work. For example, construction activity will (effectively) all occur on-site. However, some labour and services may reside outside of the catchment area. Table 23 outlines the assumptions used in modelling with respect to sourcing goods and services.

Table 23: Source of Construction Phase Activity by Industry

Industry	Northern / Central Queensland	Queensland	Australia
Heavy and Civil Engineering Construction	70%	85%	100%
Construction Services	70%	85%	100%
Professional, Scientific and Technical Services	50%	85%	75%
Specialised and other Machinery and Equipment Manufacturing	20%	35%	45%
Motor Vehicles and Parts; Other Transport Equipment Manufacturing	20%	35%	45%
Arts and Recreation Services	100%	100%	100%
Insurance and Superannuation Funds	30%	70%	100%

In undertaking economic modelling, construction phase activities have been based on the location of activities (as described in Table 22), rather than based on the source of labour (as described in Table 23). However, the amount of activity retained in the local economy is best considered in terms of the sources of labour, goods, and services. This refers to a 'retention' of income and profits within an economy and reflects that labour and companies sourced from outside the catchment area economy are more likely to spend income within their own local area, rather than within the catchment area.

For the purpose of modelling, it has been assumed construction companies and sub-contractors sourced from outside the catchment area will contribute approximately one-quarter (25%) of the level of Type I (production induced) flow-on activity within the economy that a locally-sourced company would. This reflects that companies working on-site but sourced from outside the catchment area will contribute to local supply chains through sourcing some goods and services locally.

6.2.2. Operational Phase

Once operational, the proposed development will predominantly generate economic activity through two avenues:

- Direct operational activity associated with water supply
- Additional agricultural production.

Activities associated with each of these drivers have been modelled separately to avoid double-counting (direct and flow-on) economic activity.

Water Supply Operations

Water supply operations have been modelled, based on the operating and revenue assumptions identified in Section 4, excluding the potential urban water pipeline to Townsville and assuming that the required water prices can be afforded. Revenues have been modelled based on the (real $2018) annual average from 2035, using the potential life (no return on capital) pricing methodology:

- Operating turnover of $132.7 million per annum (assuming no return on capital)
- Operating costs (excluding labour) of $77.8 million per annum
- Average direct labour costs of $10.5 million per annum.

For modelling purposes, revenues were allocated to the water supply, sewerage and drainage services ($125.4 million) and electricity generation ($7.3 million) sectors respectively.

Agricultural Production

New agricultural production has been modelled for the proposed cropping mix, as per the table below (refer to Appendix B for detailed production assumptions). Turnover was allocated to the sheep, grains, beef and dairy cattle (grain sorghum) and the other agriculture sectors represented in the input-output model.

Estimates of direct employment have been developed based on ABARES (2017) estimates and the published gross margin budgets adapted for this study:

- Type 1 Crops – average one direct FTE per 8 ha
- Type 2 Crops – average one direct FTE per 5 ha
- Type 3 Crops – average one direct FTE per 80 ha (reduced 50% for mung beans due to rotational cropping).

Wages are estimated at an average rate of $60,000/FTE.

Table 24: Agricultural Production Assumptions

Crop Type	Area (ha)	Revenue ($/ha)	Employment (FTE)
Type 1			
Rockmelon	2,702	$28,000	338
Watermelon	2,702	$24,000	338
Capsicum & Chilli	2,702	$48,000	338
Pumpkins	2,702	$12,000	338
Type 2			
Avocados	3,528	$79,200	706
Citrus Oranges	3,528	$47,500	706
Citrus Lemons	3,528	$62,500	706
Table Grapes	3,528	$24,000	706
Type 3			
Mung Beans	12,540	$2,440	78
Chick Peas	8,360	$2,880	105
Grain Sorghum	8,360	$2,200	105
Cotton	8,360	$6,444	105
Total	**50,000**	**$1,182 million**	**4,565**

6.3. Model Results

6.3.1. Construction

Should the proposed Hells Gates Dam development proceed, associated construction activity would make a substantial contribution to the North Queensland economy during the 10-year construction period. Overall, the construction phase between 2027 and 2035 (including water scheme and on-farm expenditure) is estimated to support:

- $5.7 billion in total output (including $3.7 billion directly)
- A $2.3 billion contribution to gross regional product (GRP) (including $1.4 billion directly)
- $1.0 billion in income for local workers (including $474 million directly)
- 10,855 FTE jobs (including 4,607 direct FTE positions).

Flow-on benefits to the Queensland and national economies are expected to be even greater, as per Table 25 below.

TCC Pipeline

Economic activity supported through construction of an urban water pipeline to Townsville also has the potential to be significant. Estimated impacts to North Queensland in total during construction for the interim plus final solutions include:

- $1.0 billion in output (including $677.9 million directly)
- $419.5 million per annum to GRP (including $259.4 million directly)
- $184.0 million in wages and salaries (including $87.0 million directly)
- 1,916 FTE jobs (including 783 direct jobs supported).

Table 25: Construction Phase Impacts (Total $2018)

Impact	Output ($M)	Gross Product ($M)	Income ($M)	Employment (FTE)
North Queensland				
Direct Impact	$3,737.2	$1,413.4	$473.7	4,607
Indirect Impact	$1,968.1	$882.1	$533.3	6,248
Total Impact	**$5,705.3**	**$2,295.5**	**$1,007.0**	**10,855**
Queensland				
Direct Impact	$4,652.3	$1,768.0	$609.4	6,014
Indirect Impact	$2,824.7	$1,290.6	$767.6	8,831
Total Impact	**$7,477.0**	**$3,058.5**	**$1,377.0**	**14,845**
Australia				
Direct Impact	$5,486.7	$2,085.0	$719.9	7,103
Indirect Impact	$3,756.3	$1,736.0	$1,026.5	11,798
Total Impact	**$9,243.0**	**$3,821.0**	**$1,746.4**	**18,901**

Note: Totals may not sum due to rounding

Table 26: Construction Phase Impacts (Average Annual 2027–2035, $2018)

Impact	Output ($M)	Gross Product ($M)	Income ($M)	Employment (FTE)
North Queensland				
Direct Impact	$467.2	$176.7	$59.2	576
Indirect Impact	$246.0	$110.3	$66.7	781
Total Impact	**$713.2**	**$286.9**	**$125.9**	**1,357**

Impact	Output ($M)	Gross Product ($M)	Income ($M)	Employment (FTE)
Queensland				
Direct Impact	$581.5	$221.0	$76.2	752
Indirect Impact	$353.1	$161.3	$96.0	1,104
Total Impact	**$934.6**	**$382.3**	**$172.1**	**1,856**
Australia				
Direct Impact	$685.8	$260.6	$90.0	888
Indirect Impact	$469.5	$217.0	$128.3	1,475
Total Impact	**$1,155.4**	**$477.6**	**$218.3**	**2,363**

Note: Totals may not sum due to rounding

Industries within North Queensland which are expected to benefit substantially form the construction phase of the proposed development include:

- Construction (direct and flow-on GRP of $1.4 billion during construction)
- Professional, scientific, and technical services (direct and flow-on of GRP of $277.0 million)
- Manufacturing (direct and flow-on of GRP of $164.6 million).

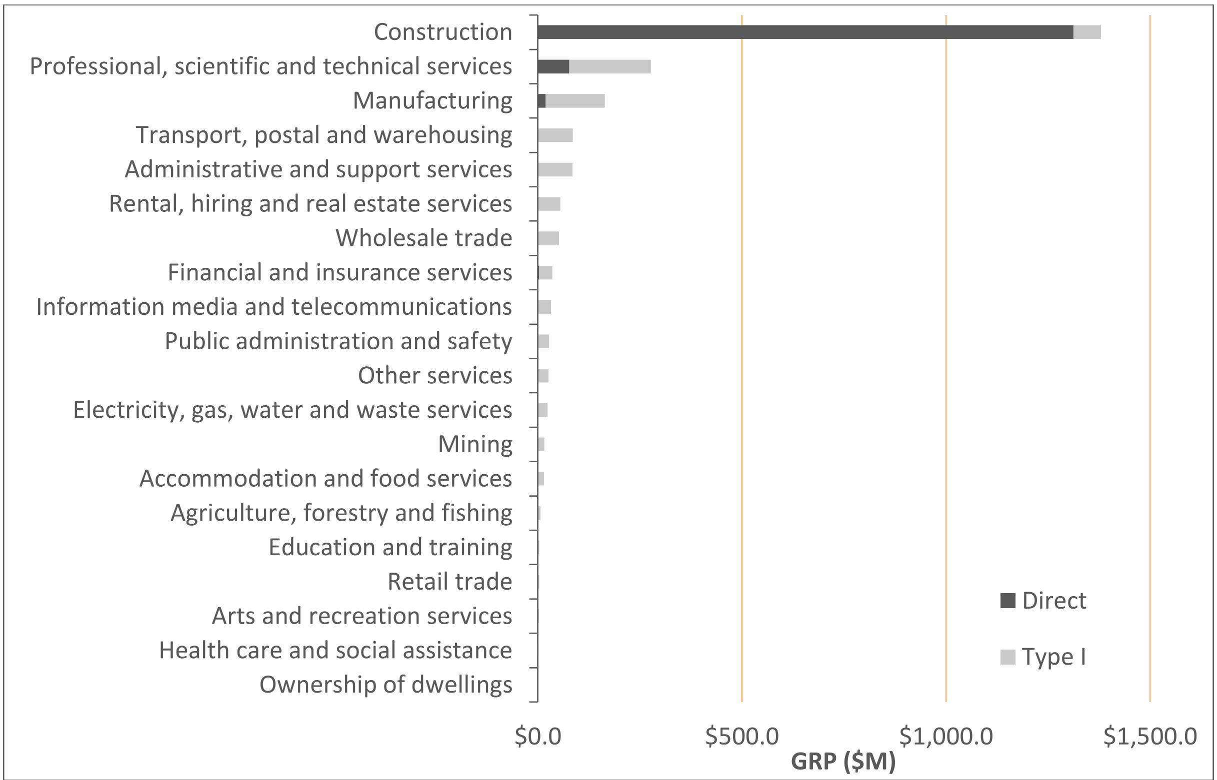


Figure 5: GRP Impacts by Industry (North Queensland Region)

6.4. Operations

Water Supply Activity

Once operational, the Hells Gates Dam and water distribution networks would make a substantial contribution to the North Queensland economy. Average annual operational activity from full production is estimated at:

- $211.9 million in total industry output (including $132.7 million directly)

- $90.6 million in annual contribution to GRP (including $51.3 million directly)
- $29.7 million in income for households (including $10.5 million in direct wages and salaries)
- FTE employment totalling 353 jobs (including 131 direct FTE positions).

Flow-on impacts are even greater for the state and national economies, as presented in Table 27.

Table 27: Economic Activity Supported by Operations, Ongoing Annual 2028+ ($2018)

Impact	Output ($M)	Gross Product ($M)	Income ($M)	Employment (FTE)
North Queensland				
Direct Impact	$132.7	$51.3	$10.5	131
Indirect Impact	$79.2	$39.3	$19.2	222
Total Impact	**$211.9**	**$90.6**	**$29.7**	**353**
Queensland				
Direct Impact	$132.7	$51.3	$10.5	131
Indirect Impact	$94.2	$47.1	$22.8	250
Total Impact	**$226.9**	**$98.4**	**$33.3**	**381**
Australia				
Direct Impact	$132.7	$51.3	$10.5	131
Indirect Impact	$110.4	$56.9	$27.1	288
Total Impact	**$243.1**	**$108.2**	**$37.6**	**420**

Note: Totals may not sum due to rounding

Industries within North Queensland which are expected to benefit substantially from water scheme operations include:

- Electricity, gas, water and waste services (direct and flow-on GRP of $58.2 million per annum)
- Financial and insurance services (direct and flow-on GRP of $9.7 million per annum)
- Construction (direct and flow-on GRP of $4.4 million per annum).

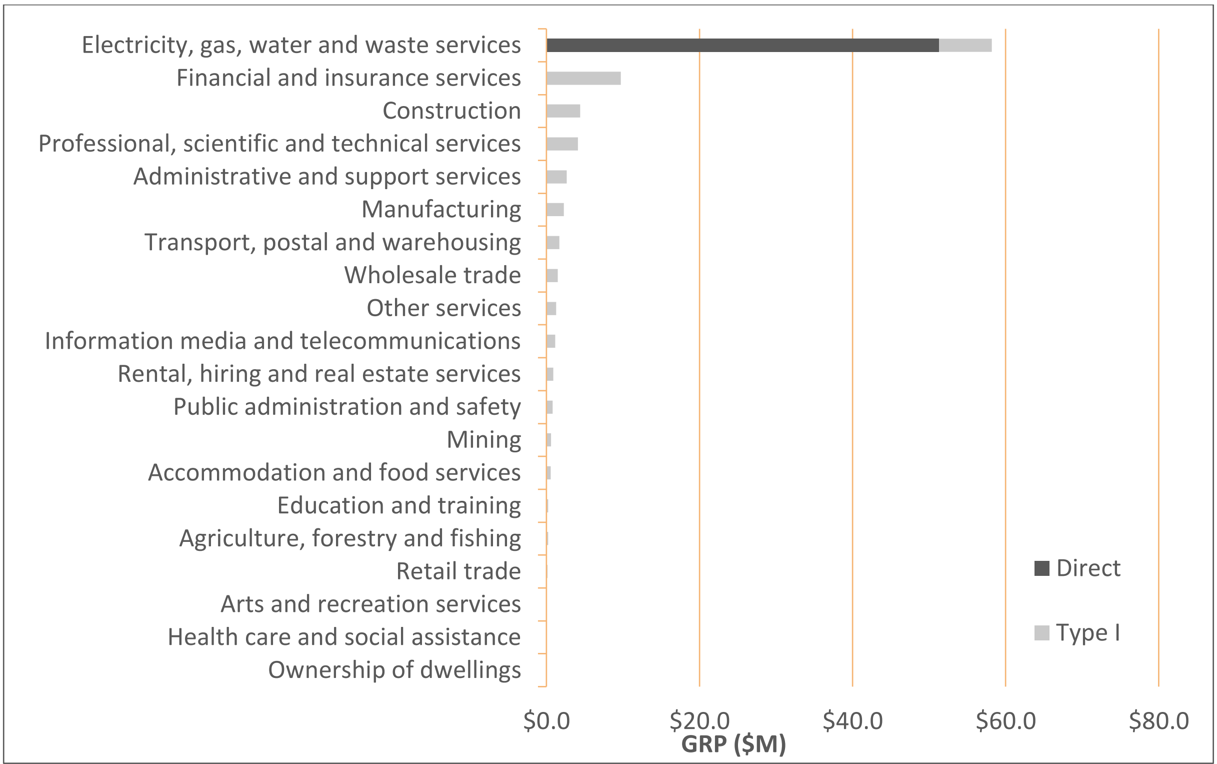


Figure 6: Water Operations GRP by Industry (North Queensland Region)

Agricultural Production

Increased agricultural production is estimated to make a significant contribution to the regional economy. Once full agricultural production is achieved, the new industry is estimated to support, on an ongoing annual basis (assuming full allocations):

- $1.5 billion in total industry output (including $1.2 billion directly)
- A $823.4 million contribution to GRP (including $669.5 million directly)
- $341.0 million in income for households (including $273.9 million in direct wages and salaries)
- FTE employment totalling 5,564 jobs (including 4,565 direct FTE positions).

Flow-on impacts are even greater for the state and national economies, as presented in Table 28.

Perennial Cropping Scenario

Agricultural activity supported under the Perennial Cropping scenario increases significantly, estimated impacts to North Queensland include:

- $1.9 billion per annum in output (including $1.5 billion directly)
- $1.1 billion per annum to GRP (including $901 million directly)
- $427.4 million in wages and salaries (including $343.4 million directly)
- 6,975 FTE jobs (including 5,720 direct FTE jobs).

Table 28: Economic Activity Supported by Agricultural Operations, Ongoing Annual 2035+ ($2018)

Impact	Output ($M)	Gross Product ($M)	Income ($M)	Employment (FTE)
North Queensland				
Direct Impact	$1,181.7	$669.5	$273.9	4,565
Indirect Impact	$326.3	$153.9	$67.1	999

Impact	Output ($M)	Gross Product ($M)	Income ($M)	Employment (FTE)
Total Impact	**$1,508.0**	**$823.4**	**$341.0**	**5,564**
Queensland				
Direct Impact	$1,181.7	$669.5	$273.9	4,565
Indirect Impact	$481.7	$227.9	$100.4	1,344
Total Impact	**$1,663.4**	**$897.4**	**$374.4**	**5,910**
Australia				
Direct Impact	$1,181.7	$694.4	$273.9	4,645
Indirect Impact	$621.5	$298.6	$135.4	1,740
Total Impact	**$1,803.2**	**$993.0**	**$409.3**	**6,384**

Note: Totals may not sum due to rounding

Industries in North Queensland which are expected to benefit substantially from agricultural operations include:

- Agriculture, forestry, and fishing (direct and flow-on GRP of $733.7 million per annum)
- Financial and insurance services (flow-on GRP of $12.9 million per annum)
- Electricity, gas, water and waste services (flow-on GRP of $11.8 million per annum).

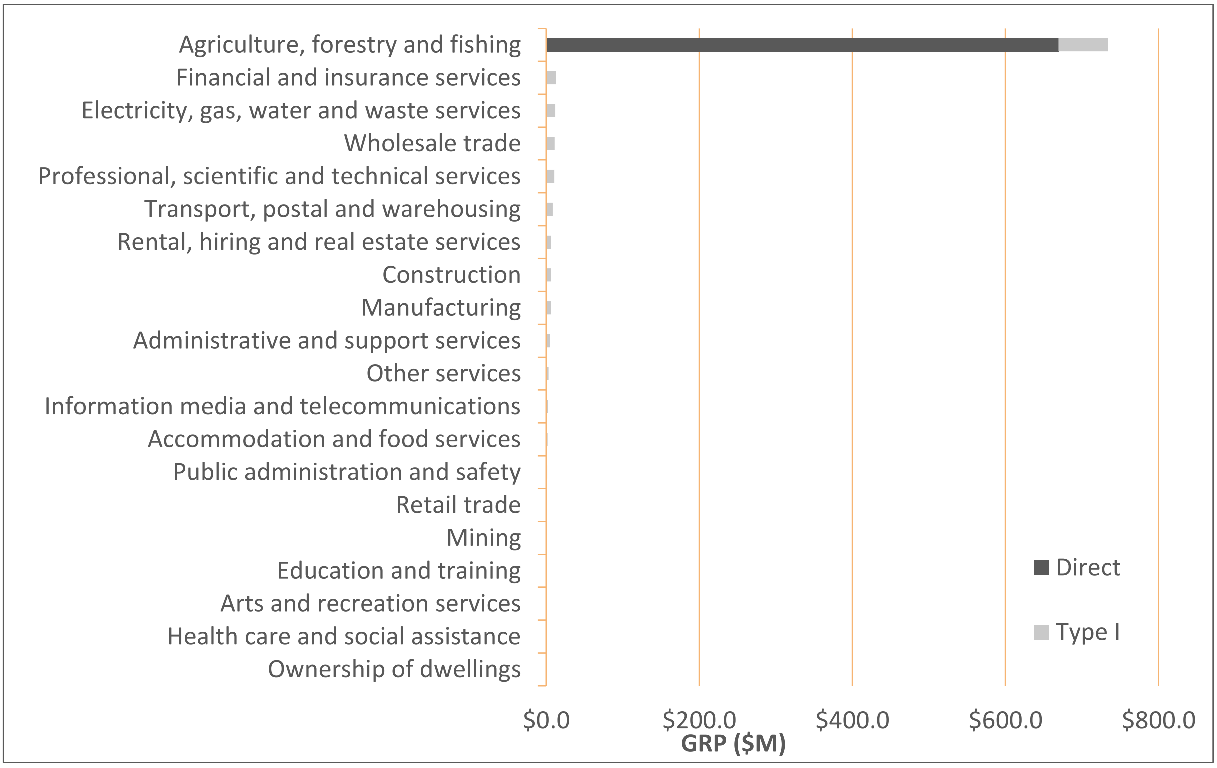


Figure 7: GRP impacts by Industry Agricultural Production (North Queensland Region)

6.5. Opportunities for Indigenous Employment

North Queensland features a 7.9% Indigenous population, significantly higher than the Queensland (4.0%) and Australian averages (2.8%) (ABS, 2017a). In the absence of more detailed procurement information, the proportion of local Indigenous employment by industry (place of work) has been applied to the project employment estimates to provide a high-level indication of potential Indigenous employment levels (approximately 2%–4% of direct and indirect employment). Estimates of potential Indigenous employment are shown in Table 29.

Opportunities for Indigenous employment quotas, partnering with traditional owners during development and operations, and suitable training and upskilling in areas likely to benefit from project works (trades and construction, agriculture / horticulture, transport) could see the share of potential Indigenous employment increase significantly.

Table 29: Indigenous Employment Estimates

ANZSIC	Project Employment (FTE)		Project Indigenous Employment (FTE)		
	Direct	Indirect	% of North Queensland Indigenous Employment (PoW)	Direct	Indirect
Construction					
Mining	0	98	3.8%	0	3.7
Electricity, gas, water and waste services	0	95	2.9%	0	2.8
Agriculture, forestry and fishing	0	48	1.9%	0	0.9
Arts and recreation services	7	36	4.4%	0	1.6
Financial and insurance services	17	101	2.1%	0	2.1
Public administration and safety	0	312	5.6%	0	17.5
Information media and telecommunications	0	157	3.4%	0	5.3
Rental, hiring and real estate services	0	296	2.2%	0	6.5
Wholesale trade	0	347	2.6%	0	9.0
Administrative and support services	0	746	5.8%	0	43.3
Transport, postal and warehousing	0	631	3.3%	0	20.8
Education and training	0	41	4.7%	0	1.9
Other Services	0	422	4.0%	0	16.9
Health care and social assistance	0	11	5.1%	0	0.6
Manufacturing	175	953	3.1%	5	29.5
Accommodation and food services	0	255	4.4%	0	11.2
Retail trade	0	54	3.3%	0	1.8
Professional, scientific and technical services	784	1915	2.1%	16	40.2
Construction	4,350	796	3.8%	165	30.2
Total	**5,333**	**7,314**	**3.4%**	**188**	**246**
Agricultural Operations					
Mining	0	2	3.8%	0.0	0.1
Public administration and safety	0	11	5.6%	0.0	0.6
Arts and recreation services	0	1	4.4%	0.0	0.1

ANZSIC	Project Employment (FTE)		Project Indigenous Employment (FTE)		
	Direct	Indirect	% of North Queensland Indigenous Employment (PoW)	Direct	Indirect
Information media and telecommunications	0	9	3.4%	0.0	0.3
Rental, hiring and real estate services	0	27	2.2%	0.0	0.6
Electricity, gas, water and waste services	0	32	2.9%	0.0	0.9
Financial and insurance services	0	33	2.1%	0.0	0.7
Construction	0	55	3.8%	0.0	2.1
Administrative and support services	0	42	5.8%	0.0	2.4
Manufacturing	0	28	3.1%	0.0	0.9
Wholesale trade	0	64	2.6%	0.0	1.7
Transport, postal and warehousing	0	59	3.3%	0.0	2.0
Professional, scientific and technical services	0	87	2.1%	0.0	1.8
Education and training	0	2	4.7%	0.0	0.1
Other services	0	44	4.0%	0.0	1.8
Health care and social assistance	0	1	5.1%	0.0	0.1
Accommodation and food services	0	29	4.4%	0.0	1.3
Retail trade	0	13	3.3%	0.0	0.4
Agriculture, forestry and fishing	**4,565**	**456**	**1.9%**	**86.7**	**8.7**
Total	**4,565**	**999**	**2.0%**	**87**	**26**

Note: Totals may not sum due to rounding
Source: ABS (2017a), AEC

6.6. Recreational and Tourism Opportunities

Opportunities for investment will exist in the recreational and tourism areas at the dam site itself. This will likely include opportunities for caravan parks, camping, eateries, fishing, boating, and other similar recreational activities that will directly create full-time employment for local residents, businesses and vendors in the area. The ability to cater for these recreational facilities will likely promote growth in the region's tourism industry.

7. Cost-Benefit Assessment (CBA)

7.1. Method and Approach

The CBA provides an overview of the net economic costs and benefits associated with the proposed development between the financial years ending 30 June 2027 and 30 June 2056.

All years presented in the CBA are for financial years ending in June. The costs and benefits have been assessed against three real discount rates (4%, 7%, and 10%), with the focus primarily on the standard 7% discount rate[13].

The geographical impact area is the state of Queensland, in line with Building Queensland guidelines. Costs and benefits assessed in this analysis relate to this catchment.

Scenarios compared in this assessment include:

- **The Base Case** – assumes the project does not proceed and regional irrigation development is constrained without the Hells Gates Dam development. Agricultural production in Queensland continues in line with current trends.
- **Mixed Cropping Scenario** – assumes the proposed development proceeds under the mixed cropping scenario, supporting a mix of agricultural and horticultural development.
- **Perennial Cropping Scenario** – assumes the proposed development proceeds under the perennial cropping scenario, supporting high-value permanent crops.

The CBA provides guidance on the net impact of the project cases against the base case. **Due to the timeframes (2035+) and uncertainty of the TCC pipeline connection, it has been excluded from the CBA scenarios.**

Decision Criteria

The NPV and benefit-cost ratio (BCR) are the primary decision criteria for the economic appraisal. The NPV of a project expresses the difference between the present value (PV) of future benefits and PV of future costs, (i.e. NPV = PV benefits – PV costs). The BCR provides the ratio between the PV of benefits and PV of costs (i.e. BCR = PV benefits / PV costs).

Where the economic appraisal results in a:

- Positive NPV and BCR above 1, the project will be deemed as desirable
- NPV is equal to zero and BCR of 1, the project will be deemed neutral (i.e. neither desirable nor undesirable)
- Negative NPV and BCR below 1, the project will be deemed undesirable.

The IRR, which indicates the discount rate which would return an NPV of $0 and a BCR of 1, is also reported.

Additional details on the approach taken for this CBA are presented in Appendix D.

7.2. Quantification and Valuation of Costs and Benefits

7.2.1. Costs

Water Storage Capital Costs

Capital costs have been applied (see Table 30), including environmental offsets. Land resumption costs have been included in the analysis as a representation of part of the opportunity cost of developing the scheme.

[13] It should be noted that the social discount rate applied for the CBA differs from the WACC rate applied for cost recovery of scheme infrastructure in Chapter 5.

Table 30: Capital Cost Estimates

Item	Cost inc. Contingency and Owner's Costs ($M)	Timing
Dam (includes $7.6 M Environmental Offsets)	$991.8	2027–2029
Land Resumption	$64.1	2027–2029
Roads	$869.1	2027–2029
Hydropower and Solar Farm	$188.1	2027–2029
Distribution (North)	$639.6	2027–2029
Electrical (North)	$87.7	2027–2029
Distribution (South)	$716.8	2030–2032
Electrical (South)	$21.5	2030–2032
Distribution (Middle)	$759.9	2033–2035
Electrical (Middle)	$18.0	2033–2035
Total	**$4,356.5**	**2027–2035**

Source: Project Support (2018), AEC

Capital residual values have been included at the end of the analysis, based on their remaining useful lives and applying straight line depreciation:

- Dams – 100 years
- Roads – 30 years
- Land resumption – indefinite
- Pipelines / channels – 80 years
- Other infrastructure – average 40 years.

On-Farm Capital Costs

Estimates for scenario on-farm capital costs are presented in Table 31 (refer to Section 5.3.2 for additional information). Costs are assumed the year before production begins across the North, South, and Middle Irrigation Areas, with each irrigation area established over the three years following completion of water infrastructure (see Table 30).

Some on-farm capital costs will likely require renewal within the analysis period. An allowance of 25% of initial capital costs has been included after 20 years of operations, with the remainder assumed as required outside of the analysis period.

Table 31: On-Farm Capital Costs

Factor	Avg. Type 1 Crops	Avg. Type 2 Crops	Avg. Type 3 Crops	Total
Average Cost/ha	**$23,800**	**$42,239**	**$17,000**	
Development Size				
Mixed Cropping Scenario (ha)	10,810	14,110	25,080	50,000
Perennial Cropping Scenario (ha)	Nil	27,965	Nil	27,965
Total On-Farm Capital Costs				
Mixed Cropping Scenario ($M)	$257	$596	$426	$1,280
Perennial Cropping Scenario ($M)	Nil	$1,181	Nil	$1,181

Source: McKellar et. al. (2013), ABARES (2017a), GHD (2014), SMEC (2018), AEC

Water Storage Operating Costs

Estimates for ongoing operating costs have been applied as per the financial assessment in Section 5, and are summarised in Table 32. In addition to the costs below, a variable pumping cost of $1.05/ML per metre of head has been included (based on 3.5 kWh/ML per metre of head at 30 cents/KWh.

Electricity revenues arising from solar and hydropower sources have been included in the CBA as an offset against scheme operating costs. However, LGC revenues ($40/MWh) have been treated as transfers between individuals, not benefits to society, and excluded from the CBA.

Table 32: Operating Cost Assumptions

Item	Annual Fixed Labour, Goods and Services Expenditure ($M)
Dam	$4.0
Roads	$1.7
Hydro and Solar Farm	$1.2
Distribution (North)	$6.9
Electrical (North)	0.9
Distribution (South)	$7.7
Electrical (South)	$0.2
Distribution (Middle)	$8.2
Electrical (Middle)	$0.2
Total	**$31.9**

Source: McKellar et al. (2013), GHD (2014), AEC

7.2.2. Benefits

Net Revenues from Agricultural Production

The proposed Hells Gates Dam development has the potential to support increased agricultural production and economic activity. This has been captured using the assumptions outlined Table 33. A detailed breakdown of on-farm assumptions is presented in Appendix B.

The agricultural revenues have been reduced to account for production costs and are presented as a net benefit stream in Table 33. The agricultural revenues have been reduced to account for production costs and are presented as a net benefit stream. Production levels are assumed to vary with MP water availability based on 30 years of historical modelling provided by SMEC (Unpublished).

Revenue generated from local sales (i.e. within Queensland), may result in a transfer of benefits (between consumers or from existing growers) within the catchment. For this assessment revenues are explicitly assumed to occur from outside of the catchment (e.g. national/international sales and thus do not result in a transfer impact.

Table 33: Agricultural Operating Assumptions (Excl. Water Costs)

Crop	Area (ha)	Revenue /ha @ Full Production	Variable Costs/ha @ Full production	Fixed Costs /ha	Net Revenue /ha	Net Benefit @ Full Production ($M)
Mixed Cropping Scenario						
Type 1						
Rockmelon	2,702	$28,000	$22,608	$1,700	$3,692	$10.0
Watermelon	2,702	$24,000	$17,685	$1,700	$4,615	$12.5

Crop	Area (ha)	Revenue /ha @ Full Production	Variable Costs/ha @ Full production	Fixed Costs /ha	Net Revenue /ha	Net Benefit @ Full Production ($M)
Capsicum & Chilli	2,702	$48,000	$31,989	$1,700	$14,311	$38.7
Pumpkins	2,702	$12,000	$10,408	$1,700	-$108	-$0.3
Type 2						
Avocados	3,528	$79,200	$14,292	$2,050	$62,818	$221.8
Citrus Oranges	3,528	$47,500	$18,803	$2,050	$26,291	$94.0
Citrus Lemons	3,528	$62,500	$20,940	$2,050	$32,450	$139.4
Table Grapes	3,528	$24,000	$23,087	$2,050	-$1,137	-$4.0
Type 3						
Mung Beans	12,540	$2,440	$775	$350	$1,315	$16.5
Chick Peas	8,360	$2,880	$851	$650	$1,379	$11.5
Grain Sorghum	8,360	$2,200	$1,445	$650	$105	$0.9
Cotton	8,360	$6,444	$2,864	$650	$2,930	$24.5
Perennial Cropping Scenario						
Type 2						
Avocados	7,150	$79,200	$14,292	$2,050	$62,818	$449.1
Citrus Oranges	7,150	$47,500	$19,159	$2,050	$26,291	$188.0
Citrus Lemons	7,150	$62,500	$28,000	$2,050	$32,450	$232.0
Table Grapes	7,150	$24,000	$23,087	$2,050	-$1,137	-$8.1

Operational Wages

Development of the proposed Hells Gates Dam is expected to provide significant direct employment through operation of the water scheme and on-farm agricultural production (see Section 6). This assessment includes 50% of direct operational wages as representing a net benefit to Queensland, reflecting the fact that not all those employed on the project would be otherwise unemployed, and that those who are unemployed would still contribute to economic activity.

Wages are assumed to scale with production over the development, declining proportionally in years of low MP allocations.

Recreational Amenity

The dam construction will significantly improve resident leisure / recreational opportunities, resulting in an increase in local amenity particularly for residents of Charters Towers. The site will also have notable potential as a tourism attraction, however a tourism value has not been assigned as the dam is unlikely to significantly impact visitation at a State of Queensland level. Likewise, residents within the broader Queensland catchment are also likely to visit the site, however their amenity values have been excluded given the presence of alternative sites such as Burdekin Falls Dam in the absence of the project proceeding.

For modelling purposes, an estimated benefit of $35 per person per visit has been applied. The estimate is adapted from coastal North Queensland residents' visitation to beaches valued at approximately $40 (in $2018) by Rolfe and Greg (2012)[14]. The results are similar to studies for recreational dams and lakes as shown in the table below.

Table 34: Summary of Recreational Amenity Values

Study	Value per person/visit ($2018)	Asset Valued
Rolfe and Greg (2012)	$40	Recreational value of beach visits North Queensland
Acil Tasman (2006)	$10 -$27	The value of recreation at Logue Brook Dam, WZ
SEQ Water (2013)	$65	Value of a recreational visit to a South East Queensland Lake

Source: Rolfe and Greg (2012), Acil Tasman (2006), SEQ Water (2013)

An average 12 visits per resident per year or one visit per month has been assumed (far less than coastal residents visit the beach, estimated at 26–70 times per annum on average by Rolfe and Greg (2012)). Population has been projected over the analysis period using Queensland Government Statistician's Office (QGSO, 2015) medium series population projections for the Charters Towers LGA[15].

Development of such a large project offers the potential to increase population growth well beyond QGSO (2015) estimates, which project only modest population growth (averaging just 0.3% per annum). However, additional benefits arising from higher population growth due to the development has been excluded from the CBA, leading to a conservative assessment of recreational amenity.

7.2.3. Costs and Benefits Not Included

In addition to the quantified benefits outlined above, the proposed development will provide a range of other potential costs and benefits. These are outlined below. Due to data limitations, no estimates of these impacts have been included in the base CBA.

Costs

- **Reduced economic activity from beef cattle production** – New irrigated agricultural production is largely expected to replace existing dryland cattle grazing (much of the proposed development area has a low carrying capacity). The proposed water storage component may provide improvement / intensification of other areas of cattle production, helping to offset these economic losses. Land lease rates included in the agricultural operating cost assumptions help to account for the opportunity cost of beef cattle production.
- **Environmental impacts due to increased agricultural irrigation** – Additional irrigated agriculture could increase the levels of agri-pollutants in the Great Barrier Reef and down stream catchments including the Bowling Green Bay Ramsar. These impacts could negatively affecting the achievement of the Australian Government's *Reef 2050 Long-Term Sustainability Plan*. Agricultural producers must be held to the following standards (which have been incorporated into the on-farm financial analysis):
  - Irrigated sugarcane (applicable to other Type 3 crops):
    - Optimising fertiliser and pesticide application rates placement and timing
    - Optimising irrigation systems and scheduling to reduce run-off and deep drainage
    - Conjunctive-use irrigation
    - Improving water recycling capability

[14] The travel cost method study applied by Rolfe and Greg (2012) incorporated additional recreational benefits (e.g. camping, night life, shopping) which are not applicable to the project. A value reduction of $5/visit has been applied to allow for these deficiencies.
[15] Projections beyond 2036 have been assumed at the average annual growth between 2031 and 2036.

        - Reducing tillage and erosion
    - Horticulture (applicable to Type 1 and 2 crops):
        - Optimising fertiliser and pesticide application rates placement and timing
        - Optimising irrigation systems and scheduling
        - Improving water recycling capability
        - Managing fallow crops.

- **Decreased market prices for existing Queensland horticultural producers** – Deep domestic and /or established export markets exist for the major broadacre (Type 3) crops included in this analysis. Horticultural production crops (Types 1 and 2), however, have a strong reliance on supplying the domestic market (see Appendix A). This is due to a range of factors, including trade barriers, the perishability of horticultural produce, and the intensity of production of these crops which decreases the advantage of the scale provided by Australia's available land compared to countries with lower operating costs. In the absence of sufficient growth in the domestic market or gaining greater access to international markets, new production may result in lower income for all Queensland producers.
- **Additional supply chain development costs** – Developing the proposed scheme will require significant investment in downstream processing and logistics, depending on the ultimate crop mix this could include additional refrigerated export capabilities via sea and air, value-add processing (e.g. cotton ginning) which have not been included in this assessment.. If the supply chain is not able to accommodate increased agricultural production, the net benefits associated with this project would not eventuate or be significantly limited. Refer to Milestone 4 Technical Feasibility Report for detailed discussion of supply chain infrastructure requirements.
- **Social Infrastructure** – The establishment of the proposed Hells Gates Dam development will likely see a substantial increase in population and employment between Charters Towers and Townsville through flow-on supply chain activity. The proposed increase in population will require supporting investment in social infrastructure (schools, health care, public amenity) to support the development and quality of life of the existing regional population.

Benefits

- **Increased water security for urban and industrial users** – The proposed development has the potential to support increased urban water supply to both Townsville and Charters Towers, as well as future industrial and mining developments. Due to the long timeframes and uncertainty regarding urban water uptake from Hells Gates, these benefits have not been modelled in the CBA analysis. Nevertheless, water security represents a critical catalyst to support economic development and population growth and has been a key issue for North Queensland in recent years.
- **Economic activity arising from flow-on development** – The CBA included analysis of economic activity arising from direct scheme and agricultural operations only, however numerous flow-on opportunities exist throughout the supply chain.
- **Enhanced infrastructure development (roads and energy)** – Major infrastructure developed for the scheme will generate substantial flow-on benefits to the wider community / economy through improved access, which will provide economies of scale and increase access and utilisation.
- **Improved flexibility and efficiency of water management** – The operation of water resources is significantly improved through the coordinated operation of the Burdekin Falls Dam and the proposed Hells Gates Dam by increasing the potential to maximise collective system yield and reliability and mitigating environmental impacts (GHD, 2014, p. 122).
- **Increase in land values** – The ability to economically irrigate an agricultural property can increase the price by over 5,000 per cent (GHD, 2014). The uplift in land values has not been included in the CBA as this is reprehensive of the change in productive capacity of land (agricultural net revenues benefit stream). Appendix E presents a high level analysis of the potential change in land values and associated benefits for stakeholders.
- **Supporting strategic direction** – The proposed scheme will support key state and federal initiatives to develop the mining and agricultural industries and increase the development of northern Australia, including *The Coalition's 2030 Vision for Developing Northern Australia*:

– Developing a food bowl, including premium produce, which could help to double Australia's agricultural output.
– Growing the Tourist economy in the North to two million international tourists annually.
– Building an energy export industry worth $150 billion to the economy, with a focus on clean and efficient energy, providing major increases to resource exports.

Few opportunities offer the potential scale of irrigation development that the proposed Hells Gates Dam development does.

The impacts of these costs and benefits, were they able to be quantified may have a significant impact upon the results of the CBA.

7.3. Cost-Benefit Assessment

Table 35 outlines the present value (PV) of the identified costs and benefits between the financial year ending June 2027 and the financial year ending June 2056, at discount rates of 4%, 7%, and 10%.

The CBA modelling at the discount rate of 7% produced the following results:

- **Mixed Cropping Scenario** – NPV of -$1.5 billion, BCR of 0.70, and IRR of 4.3%
- **Perennial Cropping Scenario** – NPV of $1.5 billion, BCR of 1.33, and IRR of 9.3%.

The CBA identified that, at a 7% discount rate, the perennial cropping scenario would be deemed economically **desirable** (benefits outweigh costs), assuming that the required water price levels are affordable and that horticultural production can be absorbed. The mixed cropping scenario would be deemed economically desirable at a 4% discount rate.

Table 35: Summary of Cost Benefit Analysis Results, 2027 to 2056 (Financial Year Ended June)

Real Discount Rate	PV Costs ($M)	PV Benefits ($M)	NPV ($M)	BCR
Mixed Cropping Scenario				
4%	$5,956.6	$6,206.5	$250.0	1.04
7%	**$5,014.3**	**$3,514.2**	**-$1,500.1**	**0.70**
10%	$4,349.1	$2,094.0	-$2,255.1	0.48
Perennial Cropping Scenario				
4%	$5,262.8	$10,353.6	$5,090.8	1.97
7%	**$4,509.2**	**$5,994.2**	**$1,485.0**	**1.33**
10%	$3,975.8	$3,631.5	-$344.3	0.91

Note: Totals presented in the table may not equal the sum of costs and benefits due to rounding

Table 36: Costs and Benefits

Impact	Total Value ($M)	PV ($M) – 4% Discount Rate	PV ($M) – 7% Discount Rate	PV ($M) – 10% Discount Rate
Mixed Cropping Scenario				
Costs				
Water Storage Capital Costs	$4,356.5	$3,803.2	$3,465.3	$3,178.3
Water Storage Operational Costs	$2,058.8	$1,007.9	$627.7	$410.0
On-Farm CAPEX	$1,635.5	$1,145.4	$921.3	$760.9
Total Costs	$8,050.8	$5,956.6	$5,014.3	$4,349.1
Benefits				

Impact	Total Value ($M)	PV ($M) – 4% Discount Rate	PV ($M) – 7% Discount Rate	PV ($M) – 10% Discount Rate
Net Revenues from Agricultural Production	$8,580.2	$3,742.7	$2,104.8	$1,227.3
Operating Wages	$3,297.5	$1,645.4	$1,041.7	$692.3
Recreational Amenity	$144.7	$77.4	$51.9	$36.7
Asset Residual	$2,403.6	$741.1	$315.8	$137.7
Total Benefits	**$14,426.0**	**$6,206.5**	**$3,514.2**	**$2,094.0**
NPV	**$6,375.2**	**$250.0**	**-$1,500.1**	**-$2,255.1**
Perennial Cropping Scenario				
Costs				
Water Storage Capital Costs	$3,578.6	$3,234.5	$3,011.9	$2,814.3
Water Storage Operational Costs	$1,823.0	$912.7	$578.8	$385.0
On-Farm CAPEX	$1,549.1	$1,115.6	$918.5	$776.4
Total Costs	***$6,950.8***	***$5,262.8***	***$4,509.2***	***$3,975.8***
Benefits				
Net Revenues from Agricultural Production	$16,887.7	$7,497.9	$4,272.7	$2,521.6
Operating Wages	$4,325.7	$2,212.6	$1,428.6	$968.0
Recreational Amenity	$144.7	$77.4	$51.9	$36.7
Asset Residual	$1,834.6	$565.6	$241.0	$105.1
Total Benefits	***$23,192.7***	***$10,353.6***	***$5,994.2***	***$3,631.5***
NPV	**$16,242.0**	**$5,090.8**	**$1,485.0**	**-$344.3**

Note: Totals may not sum due to rounding.

7.4. Sensitivity Analysis

This section examines the sensitivity of the proposed development to other key model inputs and assumptions used in the CBA. Sensitivity analysis was undertaken using a Monte Carlo analysis, which assigns a probability distribution for each input parameter in the model and then examines multiple iterations. This distribution is then used to identify the effect of the input parameter on the decision criteria (i.e. NPV). It reflects the 'probability' of achieving the key dependent output (see Appendix D for more details on Monte Carlo analysis) across the following key assumptions used in the economic analysis modelling (including the base assumptions outlined in Section 7.2):

- Costs:
  - Water storage capital costs
  - Water storage operational costs
  - On-farm capital costs
- Benefits:
  - Agricultural net revenues
  - Operational wages
  - Recreational amenity value
  - Asset residual value.

Each of the above assumptions was tested in isolation, with all other inputs maintained. The results were reported in terms of the modelled change in NPV resulting from the variance in the base assumptions at a discount rate of 7%. Table 38 shows each assumption simultaneously to provide a 'combined' or overall sensitivity of the model findings to the assumptions used.

Each of the above assumptions was tested in isolation, with all other inputs maintained. The results were reported in terms of the modelled change in NPV resulting from the variance in the base assumptions at a discount rate of 7%. Table 19 38 shows each assumption simultaneously to provide a 'combined' or overall sensitivity of the model findings to the assumptions used. Table 19 also outlines the distribution used, allowing for:

- A 50% confidence interval, with the '25%' and '75%' representing a 50% probability that the distribution and NPV will be within the range outlined in the table.
- The 50th percentile result, indicating the NPV at which 50% of values will be equal to or greater than.

The ranges tested for each input variable are presented in the table below.

Table 37: Monte Carlo Simulation Results (7% Discount Rate)

Variable	Key Risks	Distribution Applied
Costs		
Scheme Capital Expenditure	Costs exceed modelled estimates Cost and availability of finance	Maximum 50% higher and 40% lower than the base values used.
Scheme Operating costs	Costs exceed estimates	Maximum 50% higher and 40% lower than the base values used.
On-Farm Capital Costs	Costs exceed estimates Cost and availability of finance	Maximum 50% higher and 40% lower than the base values used.
Revenues		
Farm Net Revenues	Capacity to pay for water Crop failures (disease, pests, weather events) Market depth to support horticultural cropping	Maximum 40% higher and 150% lower than the base values used.
Agricultural Wages	Increased automation replacing on farm labour Labour and skills availability	Maximum 40% higher and 50% lower than the base values used.
Recreational Amenity	Local usage and recreation value of the dam may be lower than modelled	Maximum 40% higher and 50% lower than the base values used.
Scheme Residual Value	Reliability of scheme value outside of the analysis period	Maximum 40% higher and 50% lower than the base values used.

Table 38: Sensitivity Analysis Summary, Discount Rate 7%

Variable	Net Present Value ($M)		
	25th percentile	50%th percentile	75%th percentile
Mixed Cropping Scenario			

Variable	Net Present Value ($M)		
	25th percentile	50%th percentile	75%th percentile
Costs			
Water Storage Capital Costs	-$1,992	-$1,562	-$1,125
Water Storage Operational Costs	-$1,588	-$1,508	-$1,433
On-Farm Capital Costs	-$1,626	-$1,509	-$1,398
Benefits			
Agricultural Net Revenues	-$2,898	-$2,070	-$1,449
Operational Wages	-$1,641	-$1,514	-$1,387
Recreational Amenity	-$1,508	-$1,501	-$1,494
Asset Residual	-$1,544	-$1,504	-$1,465
Combined	**-$3,091**	**-$2,231**	**-$1,479**
Perennial Cropping Scenario			
Costs			
Water Storage Capital Costs	$1,053.1	$1,443.2	$1,828.0
Water Storage Operational Costs	$1,402.3	$1,477.1	$1,548.1
On-Farm Capital Costs	$1,350.6	$1,474.2	$1,587.8
Benefits			
Agricultural Net Revenues	-$1,250.8	$327.3	$1,609.0
Operational Wages	$1,287.5	$1,467.2	$1,643.5
Recreational Amenity	$1,477.6	$1,484.1	$1,490.7
Asset Residual	$1,450.8	$1,482.2	$1,511.6
Combined	**-$1,476.8**	**$225.5**	**$1,544.8**

The table shows that, at a discount rate of 7%, there is a 50% probability the:

- Mixed cropping scenario will provide an NPV of between -$3.0 billion and -$1.4 billion. Sensitivity testing returned a positive NPV on 1% of the iterations run in the simulation.
- The perennial cropping scenario will provide an NPV of between -$1.5 billion and $1.5 billion. Sensitivity testing returned a positive NPV on 54% of the iterations run in the simulation.

Both scenarios are most strongly impacted by the assumptions relating to capital expenditure and agricultural production, in particular agricultural risks such as market depth, price volatility and crop failures.

8. Creating a Development Pathway

8.1. Summary of Findings

The development of the proposed Hells Gates Dam is a challenging investment proposition. Modelled water costs are well above established irrigation areas and viable economic scenarios, requiring a combination of significant capital subsidy, significant expansion of horticultural export markets, and / or a substantial increase in grower returns for traditional broadacre cropping.

Despite these challenges, the scheme represents a significant opportunity for the development of northern Australia. The identified scheme has unique scale, at up to 50,000 ha, providing significant synergies in the development of new and existing markets, where such markets can be developed without trade or oversupply limitations. Furthermore, the potential to provide high-security water allows for the development of a broad range of high-value crops. There are early signs of substantial export growth in perennial horticulture which may continue to develop over time. These benefits are not fully captured in the financial and economic appraisals conducted as part of this study.

The economic and financial analysis has identified that (currently), given the capital cost of the dam and subsequent cost of water, there are limited viable agricultural cropping options available. Based on prevailing agricultural production, price and consumption trends, it is conceivable that within a 10–15-year window, a number of the crops assessed would become viable under the proposed scheme. The key constraint to the feasibility is the cost of the dam infrastructure and the subsequent impact on the price of water.

No detailed geotechnical studies have been conducted on the site. Future information captured via drilling and other geotechnical studies (when they are conducted) may result in a significant reduciton in construction costs. Where this is the case, it is conceivable that a number of commodities may be potentially viable for production in the immediate or short-term.

The timeframes for development allow for positive macroeconomic trends, including rising emerging market demand for agricultural produce. Significant production lands have been identified in close proximity to the Burdekin River which, subject to further evaluation, show promise as being commercially viable under current market conditions. Critical to the success of a smaller scale initial stage development is the trade-off between cost of irrigation, market capacity (for horticultural crop options) and the economies of scale provided by the proposed 30,000 ha – 50,000 ha scheme (roads, power, logistics).

Key steps to support and de-risk the proposed Hells Gates Dam development include:

- Marketing the development to identify suitable proponents to take the scheme through to final investment.
- Supporting trial cropping to de-risk production on a significant scale – this could include releasing water allocations for development and irrigation of lands next to the Burdekin River, potentially in conjunction with weir storage. Beginning irrigation work by focusing on the lowest cost areas will provide greater market transparency and insight for when larger scale water infrastructure is provided.
- Detailed engineering works to refine the capital costs applied in this analysis.
- Gaining environmental approvals, including an Environmental Impacts Statement (EIS), to reduce risk and timeframes for future proponents.
- Securing public financial support for the development, including through avenues such as the National Water Infrastructure Loan Facility and the Northern Australia Infrastructure Facility.

8.2. Key Risks

Creating a pathway to development for the proposed Hells Gates Dam project is a challenging proposition which will require commitment and support from key regional stakeholders, the private sector, and all levels of government. The proposed development has substantial potential to increase the agricultural output of northern Australia, as modelled within this study. It is, however, subject to a number of key risks which need to be eliminated or mitigated. These are summarised in Table 39.

Table 39: Development Risks

Risk	Description	Mitigation Measures
Cost of water	The modelled water costs greatly restrict the viable cropping opportunities, particularly export-intensive broadacre cropping.	Detailed engineering assessment to reduce the required costings and contingency levels. Identification of opportunities for staging development, in favour of lowest coast areas (such as next to the Burdekin River) developed in the initial stage. Securing financial support for the project including concession.
Crop failures	Financial viability is highly susceptible to on farm returns, particularly in the early years of development. Crop failures may occur due to a range of reasons, including water restrictions, weather events and management failure.	Establishment of trial cropping, potentially through Big Rocks Weir or release of allocation close to the Burdekin River. Achieving viable production on a smaller scale will de-risk investment for larger proponents.
Market depth	The market capacity to absorb significant additional horticultural production is limited in the absence of greatly increased export.	Establishment of market access and suitable contractual arrangements prior to committing significant capital expenditure.
Cost and availability of finance	While capital costs are currently at record lows, availability of finance for such a large greenfield project, and future increases in the cost of capital have a substantial impact on the viability of the project.	Securing concessional finance agreements for both scheme and farm development will reduce the risk for proponents. Opportunities include: • The $2 billion National Water Infrastructure Loan Facility • $2 billion in Commonwealth farm business concessional loans through the Regional Investment Corporation. Such support is critical to de-risk the early years of development and support the long investment turnaround for perennial cropping.
Environmental impacts and approvals	Lack of environmental approvals creates significant risks for proponent's given the level of time, cost and risk.	Works to secure Environmental Impact Statement (EIS) approval in order to de-risk the project for investment.
Timing for Irrigation Uptake	The timeframes for development of such a large scheme presents substantial risks. A slow uptake results in infrastructure costs being borne by a relatively small amount of production.	Develop a detailed staging plan based on identified demand, focussing on low cost development areas for the initial stages. Secure formal, prior commitment (on a take or pay basis) for a significant share of available allocations.

Risks are further outlined in the Risk Register, attached in Appendix F.

8.3. Pathways to Development

Based on the feasibility of the project and key identified risks, various pathways to development have been identified, as outlined in Figure 8 and Table 40.

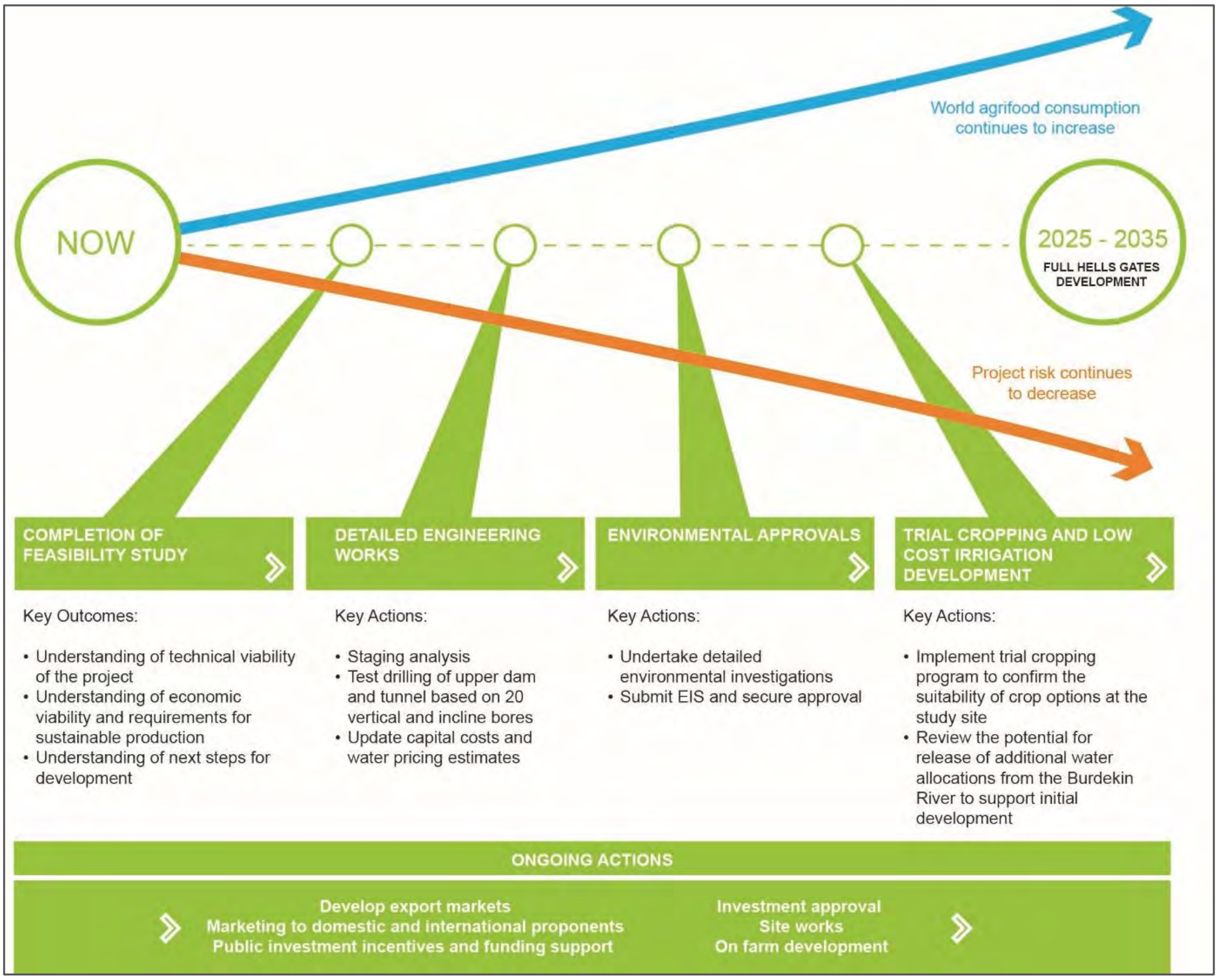


Figure 8: Future Steps for Project Development

Table 40: Development Pathway

Action	Need	Actions	Timeframe	Responsible Stakeholders	KPI
Detailed Engineering Analysis	Detailed site investigations are needed to confirm the cost of capital and ensure economically viable irrigation	Investigate the potential for greater staging of the investment, with lowest cost irrigation areas developed as a first stage Test drilling of upper dam and tunnel based on 20 vertical and incline bores Update capital costs and water pricing estimates	+12–18 months	Townsville Enterprise Limited (TEL)	Consultants appointed Detailed Feasibility Study Completed
Marketing and Proponent Identification	The Hells Gates project does not currently have an identified proponent to take the project through to financial close for either scheme or agricultural operations. Securing an investor/proponent(s) is a critical hurdle to the success of the project	Develop project investment materials: • Investor Memorandum • Investment video Approach potential investors: • SunWater • Large Australian agricultural businesses • International investors Support identified proponents seeking financial/government approval, and community support as required	Ongoing as required	TEL Charters Towers Regional Council	Proponent secured
Environmental Impact Statement (EIS) Approvals	Lack of environmental approvals creates significant risks for proponent's given the level of time, cost and risk. Obtaining EIS approval will support the acquisition of private investment.	Secure funding for EIS works Undertake detailed environmental investigations Submit EIS and secure approval	+3 Years	Project proponent State Government	EIS Approval Granted

Action	Need	Actions	Timeframe	Responsible Stakeholders	KPI
Support Trial Cropping and Low Cost Irrigation	This study has identified significant lands in close proximity to the Burdekin River which are potentially suitable for low cost irrigation. Enabling greater uptake of irrigation will de-risk larger scale production and provide evidence to de-risk greater investment.	Implement a program of trial cropping to confirm the suitability of crop options at the study site Review the potential for release of additional water allocations from the Burdekin River to support initial development	+12-18 months, ongoing as required.	Project proponent DAF Landholders Research Organisations	Trial Cropping Established Growing data and risks captured
Funding Support	Given the identified capital and operating costs, it is likely the project will require significant public funding to support viable public investment.	Securing public funding incentives to support water infrastructure and on farm development	Ongoing as required	TEL Charters Towers Regional Council State Government Commonwealth Government	Funding incentives secured
Export Market Development	A number of the viable cropping opportunities identified in this study are currently constrained by the Australian domestic market. The opening up of new export avenues will support expanded production for the Hells Gates site	Identify and approach potential export market stakeholders to consider opportunities associated with the site Liaise with key industry bodies to support awareness of production opportunities for the Hells Gates site	+ 2 years Ongoing as Required	TEL Charters Towers Regional Council State Government Commonwealth Government	Future markets identified

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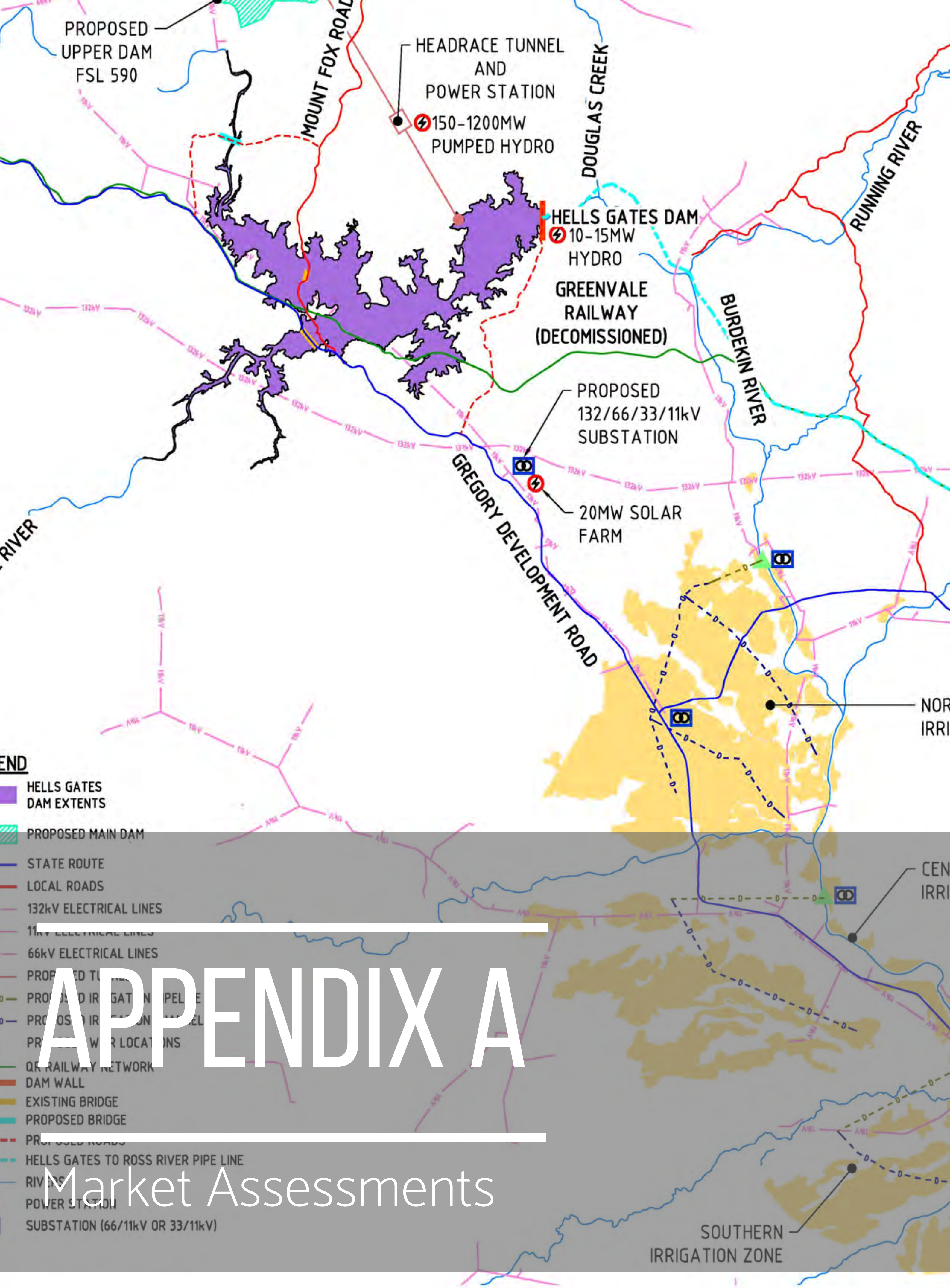


APPENDIX A

Market Assessments

Appendix A – Market Assessments

Table A.1: Melons Market Assessment

Factor	Melons
Price ($AU/t)	Around $850/t (ABS, 2017b; 2017c) with differences between varieties (predominantly watermelon, honeydew and rockmelon). Prices vary significantly between and within growing seasons.
Projected Industry Growth – 2023	4.7% per annum based on fruit and tree nuts (excl. grapes) ABARES (2017b)
Market Demand Levels	Finely balanced domestic market, with peak Queensland production occurring from autumn to spring and southern states producing during summer. Rockmelons and honeydews are usually sold in the Brisbane, Sydney or Melbourne wholesale markets through an agent or merchant.
Competition Levels	High price-based competition.
Key Current Producers	Queensland (approximately 50% of production): • Burdekin/Bowen • Atherton Tablelands • Darling Downs • Bundaberg New South Wales (approximately 20% of production): • North Coast • Hunter Valley • Riverina Western Australia (approximately 15% of production): • Carnarvon • Kununurra
Yield (t/ha)	30
Labour Requirements	One person can manage the growing of 10 ha of melons with casual labour for the laying of plastic mulch and trickle tape, planting and early weed control. Approximately four people are needed to harvest and pack each hectare of melons.
Australian Production (ha, 2016)	6,148
Australian Production (tonnes, 2016)	239,146
Export Intensity (% of Production)	15%
World Production (2016) tonnes	31,166,896
Australia Est % Global Production	0.2%
Key Export Markets	• Singapore (33% of exports) • Hong Kong (33% of exports) • New Zealand (28% of exports)
Production Risk	High
Market Risk	High
Key Trends	• Australian industry targeting export growth to Japan with rules for market access agreed in 2016
Overall Feasibility	Melons represent a high value/high-risk crop option for production within the study area. Market depth constraints and seasonal growing limitations represent the major barriers to industry development.

Source: DAF (2017), HIA (2017), AEC

Table A.2: Capsicums / Chilies Market Assessment

Factor	Capsicums/Chillies
Price ($AU/t)	Around $1,800/t (ABS, 2017b; 2017c) with differences between varieties (chilies, capsicums). Prices vary significantly between and within growing seasons.
Projected Industry Growth – 2023	2.1% per annum based on vegetables sector (ABARES, 2017b)
Market Demand Levels	Finely balanced domestic market, Bowen-Burdekin production occurs mainly in late autumn, winter and spring. Bundaberg produces from autumn to early summer, while Stanthorpe and the Lockyer harvest through summer.
Competition Levels	High price-based competition.
Key Current Producers	Queensland (approximately 70% of production): • Bowen/Burdekin • Bundaberg • Lockyer Valley and Stanthorpe
Yield (t/ha)	25
Labour Requirements	Two field workers could grow 20 ha of capsicums or chilies to the harvesting stage. The main labour requirement is for harvesting and packing. A standard picking rate for capsicums is about 30-50 cartons per person per hour, depending on whether hand-picking into buckets or using a harvest aid, amount of fruit set, harvesting method and colour of fruit being harvested. A standard grading and packing rate is about 25 cartons per person per hour, but this depends on fruit quality and the equipment being used. Chilies take much longer to pick and pack. Growers often pay a contract rate rather than an hourly rate for picking and packing chilies. For the larger chilies, an average picking rate would be about 20 kg per hour, while for the small types the rate would be about 6 kg per hour.
Australian Production (ha, 2016)	2,080 ha capsicums and 222 ha chilies – production has been flat since 2012 with significant variation between growing seasons
Australian Production (tonnes, 2016)	72,533 tonnes capsicums and 2,165 tonnes chilies
Export Intensity (% of Production)	1%
World Production (2016) tonnes	34,497,462, world production has grown strongly averaging 2.8% per annum since 2012
Australia Est % Global Production	0.1%
Key Export Markets	New Zealand (approximately 75% of exports)
Production Risk	High
Market Risk	High
Key Trends	• Increasing undercover (protected cropping) production in southern States. Undercover crops can be harvested for much longer (up to 6 months) and produce much higher yields per plant. Additionally, crop damage and losses from environmental factors such as rain are dramatically reduced.
Overall Feasibility	Capsicums / chilies represent a high value/high-risk crop option for production within the study area. Market depth constraints and seasonal growing limitations represent the major barriers to industry development.

Source: DAF (2017), HIA (2017), AEC

Table A.3: Pumpkins Market Assessment

Factor	Pumpkins
Price ($AU/t)	Around $500/t (ABS, 2017b; 2017c) with differences between varieties (Japanese, jarradhale, butternut). Prices vary significantly between and within growing seasons.
Projected Industry growth – 2023	2.1% per annum based on vegetables sector (ABARES, 2017b)
Market Demand Levels	Finely balanced domestic market, Bowen-Burdekin production occurs mainly in late autumn, winter and spring. Bundaberg produces from autumn to early summer, while Stanthorpe and the Lockyer harvest through summer.
Competition Levels	High price-based competition. Pumpkins are often grown by broadacre farmers as an opportunity horticultural crop.
Key Current Producers	Pumpkins are grown commercially in every state and territory in Australia (except the Australian Capital Territory) with the majority of production in New South Wales, and Queensland followed by Western Australia.
Yield (t/ha)	Pumpkins yield from 12 to 40t/ha. Jarrahdale is usually the highest yielding, followed by Japanese, and butternuts.
Labour Requirements	Pumpkins typically do not require as much labour as other vegetable crops, as the crop can also be harvested at one time and stored for many months.
Australian Production (ha, 2016)	5,090
Australian Production (tonnes, 2016)	94,482
Export Intensity (% of Production)	3%
World Production (2016) tonnes	26,486,616
Australia Est % Global Production	0.4%
Key Export Markets	Singapore (approximately 50% of exports)
Production Risk	Medium-High
Market Risk	High
Key Trends	• Pumpkin production has been falling on average since 2008-09 • Growers' on average, have experienced annual losses between 2007-08 and 2011-12
Overall Feasibility	Pumpkins represent a moderately high-value crop option for the study area. Lower production risks and production costs need to be offset against the potential for oversupply.

Source: DAF (2017), HIA (2017), AusVeg (2017), AEC

Table A.4: Avocados Market Assessment

Factor	Avocados
Price ($AU/t)	Around $4,800/t (ABS, 2017b; 2017c) with differences between varieties (Hass fruit are most common at approximately 80-85% of production followed by Shepard's, Reed's, and Wurtz).
Projected Industry Growth – 2023	4.7% per annum based on gross value fruit and tree nuts (excl. grapes) (ABARES 2017b)
Market Demand Levels	Finely balanced domestic market, Australia is able to produce avocados all year round due to the range of growing climates. The Shepard variety is only produced in Queensland from February to April and is the dominant variety in the market at this time.
Competition Levels	High price-based competition.
Key Current Producers	Queensland (approximately 50% of production): • Atherton Tablelands • Bundaberg-Childers district Western Australia (approximately 40% of production) • Gingin • Carabooda • Busselton • Manjimup • Pemberton International: • Mexico (45% of production) • Chille
Yield (t/ha)	Around 14-20t/ha at full production. Trees take ~8 years to reach maturity.
Labour Requirements	Two people can manage up to around 7ha of mature trees. Significant casual labour is required for harvesting, packing and injecting for root control.
Australian Production (ha, 2016)	6,000
Australian Production (tonnes, 2016)	67,600
Export Intensity (% of Production)	2%
World Production (2014) tonnes	5,431,844
Australia Est % Global Production	1.2%
Key Export Markets	• Singapore (approximately 50% of exports) • Malaysia (approximately 40% of exports)
Production Risk	High
Market Risk	High
Key Trends	• Australian avocado consumption has been increasing strongly over time, from around 1kg/capita in the late 1990s to just over 3kg/capita in 2015-16 and is projected to continue to grow strongly over the next 10 years • Consumption growth driven by avocado's status as a 'super food' with the fruit nutrient-dense ranking number one per kg among all fruits for folate, potassium, vitamin E and magnesium. Avocados are also high in fibre and healthy fats • Prices in the short term are projected to fall in response to growing supply
Overall Feasibility	• Avocados present a strong growth opportunity for the study area, with potentially high returns and a solid market outlook • Key risks revolve around the long turn around between planting and full production at around eight years

Source: DAF (2001, 2017), HIA (2017), AEC

Table A.5: Citrus Market Assessment

Factor	Citrus
Price ($AU/t)	Around $900/t (ABS, 2017b; 2017c) with differences between varieties (most common being oranges, lemons, mandarins, limes, grapefruits)
Projected Industry Growth – 2023	4.7% per annum based on gross value fruit and tree nuts (excl. grapes) (ABARES 2017b)
Market Demand Levels	Avg. consumption in Australia of 12.7kg/capita. Finely balanced domestic market with growing export opportunities. Oranges represent around two thirds to Citrus exports, predominantly to Asia. Queensland production is harvested from about January to October with the bulk of the crop picked between March and July. Most of the fresh fruit produced is marketed in the major metropolitan wholesale markets of Brisbane, Sydney and Melbourne, but a large and increasing amount of the mandarin and orange crop is being exported.
Competition Levels	High price-based competition.
Key Current Producers	Queensland: • Middle Burnett • Emerald • Mareeba New South Wales: • Riverina • Murray Valley South Australia: • Riverland Region Australian citrus faces strong competition from the US and South Africa for Asian export markets.
Yield (t/ha)	Up to around 50t/ha trees take around eight years to reach full production.
Labour Requirements	Two people can manage up to around 7ha of mature trees. Significant casual labour is required for harvesting, packing and injecting for root control.
Australian Production (ha, 2016)	28,000
Australian Production (tonnes, 2016)	714,207
Export Intensity (% of Production)	32%
World Production (2014) tonnes	5,028,756
Australia Est % Global Production	1.3%
Key Export Markets	• China (approximately 25% of exports) • Japan (approximately 20% of exports)
Production Risk	High
Market Risk	High
Key Trends	• Exports to China posted an average annual growth of 133% between Apr-Jun 11 and Apr-Jun 17, after the China-Australia Free Trade Agreement was signed in December 2015, which resulted in a gradual reduction in tariffs • Local producers switching from Valencia to Navel orange production due to increasing juice imports
Overall Feasibility	• Citrus provides a solid combination of high returns, market depth and export potential within the study area • Key risks revolve around the long turn around between planting and full production

Source: DAF (2017), HIA (2017), AEC

Table A.6: Table Grapes Market Assessment

Factor	Table Grapes
Price ($AU/t)	Around $2,5000-$3,500/t with differences between varieties (most common being Menindee, Thompson, Crimson, Flame and Globe)
Projected Real Price Growth – 2023	6.2% per annum (ABARES, 2017b)
Market Demand Levels	Australian consumption per capita of 3.4kg, has remained flat over the past three years. Australian production occurs between December and May with product imported during the off season.
Competition Levels	High price-based competition.
Key Current Producers	Victoria (approximately 70% of Australian production): • Murray Valley • Sunraysia Imports during the Australian off season predominately from the US. Australian production competes with Chile and Peru in the US in Asian export markets.
Yield (t/ha)	7-8t/ha, crops take around 5 years to reach consistent production
Labour Requirements	Labour needs per acre during the first and second years include planting (30 hours), training (30 hours), and maintenance (24 hours). A fruiting vineyard will require vine and trellis maintenance (80 hours) along with spraying and mowing operations (48 hours). Harvest will require approximately 48 hours per acre. It is advantageous to have one full-time vineyard manager to scout for diseases, provide canopy management, and spray the vineyard. Grapevines need daily attention.
Australian Production (ha, 2016)	25,000
Australian Production (tonnes, 2016)	178,595
Export Intensity (% of Production)	60%
World Production (2014) tonnes	74,499,859
Australia Est % Global Production	0.2%
Key Export Markets	• China (approximately 25% of exports) • Indonesia (approximately 15% of exports) • Hong Kong (approximately 12% of exports)
Production Risk	High
Market Risk	High
Key Trends	• Rapidly growing exports into Asia. Total exports have grown rapidly since2011-12 • Exporters are expected to face considerable competition from lower-cost producing countries, particularly Chile
Overall Feasibility	• Table grapes represent a growing industry sector which is not heavily constrained by the domestic market. A solid growth profile suggests opportunities to support increased production into the future. • Key risks revolve around the long turn around between planting and full production

Source: DAF (2017), HIA (2017), AEC

Table A.7: Mung Beans Market Assessment

Factor	Mung Beans
Price ($AU/t)	$1,100/t first grade
Projected Industry Growth to 2023	Not available
Market Demand Levels	Deep international market with several major producers.
Competition Levels	High price-based competition as a commodity product, mung beans have numerous uses in processing including as a starch, flour or paste.
Key Current Producers	Domestic: South-east Queensland and northern New South Wales International: India, Burma, Thailand and Indonesia produce almost 90% of the world's mungbean crops, however these are largely used for domestic consumption. Major exporting countries include China and Myanmar, which both exported over 100,000 tonnes in 2016.
Yield (t/ha)	3t/ha
Labour Requirements	Mung beans have a relatively short season (90–110 days) though are management intensive (Agrifutures Australia, 2017).
Australian Production (ha, 2016)	130,190
Australian Production (tonnes, 2016)	122,953
Export Intensity (% of Production)	95%
Key Export Markets	• India (50% of exports) • ASEAN (22% of exports)
Production Risk	Moderate
Market Risk	Moderate
Key Trends	• Increasing demand from India and broader ASEAN should underpin growth in mung bean production. • Commonly used as a rotational broadacre crop alongside cotton or sugar cane.
Overall Feasibility	• Mung beans and similar crops (soy, dolichos) have substantial potential as a rotational broadacre crop alongside higher value options such as cotton/sugarcane

Source: DAF (2017), HIA (2017), AEC

Table A.8: Sugarcane Market Assessment

Factor	Sugarcane
Price ($AU/t)	$435/tonne sugar (approximately $42/tonne cane)
Projected Real Price Growth – 2023	1.1% per annum (ABARES, 2017b)
Market Demand Levels	Deep international market with several major suppliers.
Competition Levels	High price-based competition as a commodity product, significant cane production used for biofuel internationally.
Key Current Producers	Queensland: • Burdekin • Hinchinbrook • Far North Queensland • Bundaberg International: • Brazil • Thailand • India
Yield (t/ha)	Irrigated production around 140t/ha (McKellar et. al., 2013)
Labour Requirements	Industry benchmark around 1 FTE per 15,000 tonnes (around 130ha including fallow) with additional contract labour for planting and harvest.
Australian Production (ha, 2016)	447,204
Australian Production (tonnes, 2016)	34.4 million tonnes
Export Intensity (% of Production)	80%
World Production (2014) tonnes	1.89 billion tonnes
Australia Est % Global Production	1.8%
Key Export Markets	• South Korea • Indonesia • Japan • Malaysia
Production Risk	Moderate-low
Market Risk	Moderate
Key Trends	• Australian production has decreased since the 1990s with increasing international competition from large producers such as Brazil and Thailand • Rising health concerns (particularly in developed countries) are a threat to global sugar demand as consumption of sugar is associated with diabetes, obesity and tooth decay. Concerns about health effects may lead to the reduced use of sugar alongside continued growth in alternative sweeteners • Consumption growth in emerging markets is expected to remain robust for some time, helping to underpin Australia's production and exports • Strong trend towards industry consolidation, with larger often corporate growers purchasing smaller family farms and the takeover of Australian milling assets by multinational companies such as Singapore's Wilmar International, Thailand's Mitr Phol and China's COFCO
Overall Feasibility	• Sugarcane represents a proven crop option for the study area with a deep international market • Key risks include modest capacity to pay for water and significant scale requirements to support processing infrastructure (e.g. sugar/bio-fuel), estimated at a minimum of 30,000 ha (Ash et al. 2014)

Source: DAF (2017), AgriFutures Australia (2017), AEC

Table A.9: Cotton Market Assessment

Factor	Cotton
Price ($AU/t)	$540/t
Projected Real Price Growth – 2023	1% per annum (ABARES, 2017b)
Market Demand Levels	Deep international market with several major suppliers.
Competition Levels	High price-based competition internationally.
Key Current Producers	Queensland: • Darling Downs • St George • Dirranbandi • Macintyre Valley • Emerald • Central and north-west New South Wales International: • USA • India • Uzbekistan
Yield (t/ha)	Irrigated production around 11 bales per ha (approx. 2.2t)
Labour Requirements	Industry benchmark around 1 FTE per 75 hectares (Cotton Australia, 2016)
Australian Production (ha, 2016)	280,422
Australian Production (million bales, 2016–2017)	4.1
Export Intensity (% of Production)	99%
World Production (million bales, 2016–2017)	106.8
Australia Est % Global Production	3.8%
Key Export Markets	• China (around two-thirds of exports) • Indonesia • Thailand
Production Risk	Moderate-low
Market Risk	Moderate
Key Trends	• The cotton industry has endured extreme revenue volatility and fluctuating profit margins over the past five years, with a range of external factors influencing industry performance (drought and poor growing seasons) • Global cotton consumption is expected to rise over the next five years, due to economic and population growth, particularly across the Asia-Pacific. Furthermore, the development of textile industries in Asia is anticipated to boost the volume of cotton exported from Australia
Overall Feasibility	• Cotton represents a significant crop option for the study area with a deep international market • Key risks include modest capacity to pay for water and significant scale requirements to support processing infrastructure such as cotton ginning

Source: DAF (2017), AgriFutures Australia (2017), AEC

Table A.10: Chickpeas Assessment

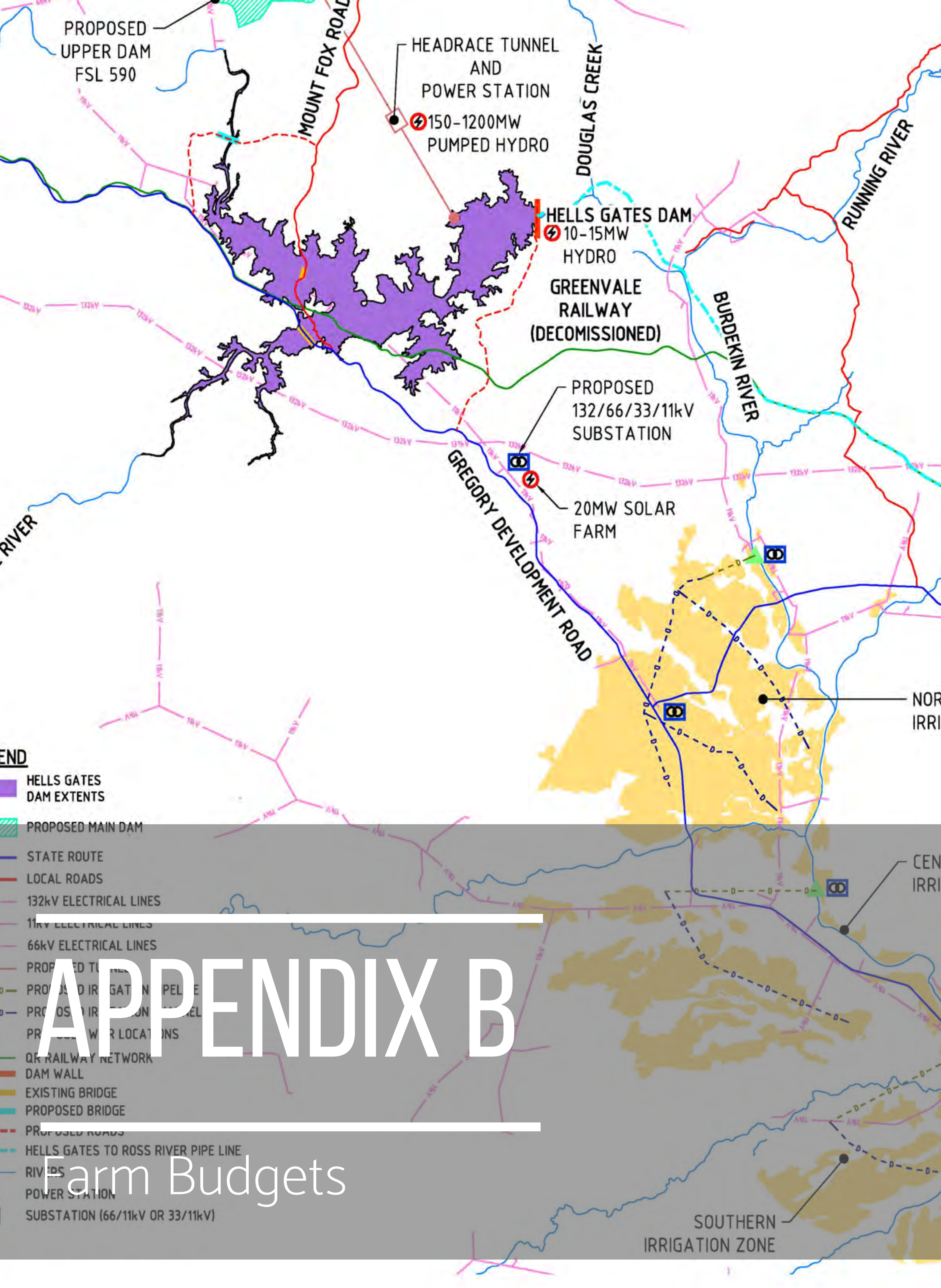
Factor	Chickpea
Price ($AU/t)	$600/t – $900/t – chickpeas have shown strong price growth over recent years
Market Demand Levels	Growing international market, particularly in India.
Competition Levels	Significant price-based competition, however Australia has a dominant export market position.
Key Current Producers	Queensland and Northern New South Wales International: • India (around 75% of world production) • Key export nations include Russia, Mexico, Canada and Argentina, each exporting over 100,000 tonnes in 2016
Yield (t/ha)	Irrigated production around 2t/ha
Labour Requirements	Low direct labour requirements (0.6 hours/ha for dryland production, NSW DPI (2013), increases substantially with irrigation.
Australian Production (ha, 2016)	677,444
Australian Production (tonnes, 2016)	874,593
Export Intensity (% of Production)	80%
World Production (2016) tonnes	12,092,950
Australia Est % Global Production	7.2%
Key Export Markets	• India (around 40% of exports) • Bangladesh (around 30% of exports)
Production Risk	Moderate-low
Market Risk	Moderate
Key Trends	• Australian chickpea production has grown five-fold since 2005, driven by growing demand and poor production seasons in India – Indian consumption of chickpeas is over 12kg per capita (ABARES, 2013) • Demand is expected to continue to increase over the coming years, with chickpeas a key high-protein ingredient in vegetarian and vegan diets
Overall Feasibility	• Chickpeas represent a solid rotational crop option for the study area with a growing international market • Key risks include modest capacity to pay for water to support infrastructure development

Source: DAF (2017), AgriFutures Australia (2017), AEC

Table A.11: Sorghum Market Assessment

Factor	Sorghum
Price ($AU/t)	$200/t – $300/t crop has numerous uses for various markets, is predominately sold as livestock feed and for biofuel production.
Projected Real Price Growth – 2023	-2.4% per annum (ABARES, 2017b)
Market Demand Levels	Increasing demand from livestock producers domestically and internationally.
Competition Levels	High price and quality considerations
Key Current Producers	Domestic: • Southern Queensland • Northern New South Wales International: • United States • Argentina • Nigeria
Yield (t/ha)	Approximately 8t/ha irrigated
Labour Requirements	Varies with operating structure and irrigation.
Australian Production (ha, 2016)	520,527
Australian Production (tonnes, 2016)	1.8 million
Export Intensity	The Australian sorghum industry is becoming increasingly export-oriented (approximately 50% of production), with key markets including Japan and more recently China.
World Production (2016) tonnes	57.9 million
Australia Est % Global Production	3.1%
Key Export Markets	• China (95% of exports) • Japan
Production Risk	Moderate, sorghum is highly drought tolerant, but responds well to rainfall, especially during head forming and grain fill stages.
Market Risk	Highly volatile from year to year.
Key Trends	• Increasing trend towards electric vehicles reduces the outlook for biofuels which is a key driver for sorghum production • Increasing share of exports driven by intensive livestock production in Asia
Overall Feasibility	• Sorghum has limited potential has limited potential within the subject site due to the low capacity to pay for water.

Source: AgriFutures Australia (2017), AEC



APPENDIX B

Farm Budgets

Appendix B – Farm Budgets

Table B.1: Rockmelon Gross Margin Budget

Input	$/ha
Income	
Rockmelon (2,000 Cartons @ $14/carton)	$28,000
Total Income	**$28,000**
Variable Costs	
Fuel	$429
Planting	$1,321
Nutrition	$1,265
Chemicals	$547
Irrigation Pumping Costs (6.3 ML/ha)	$441
Packaging Materials	$4,600
Harvesting	$3,413
Cartage	$4,060
Commission/Levies	$4,200
Other Costs	$2,332
Total Variable Costs	**$22,608**
Gross Margin	***$5,392***
Gross Margin/ML	**$856**

Source: DAF (2018), NSW DPI (2013)

Table B.2: Watermelon Gross Margin Budget

Input	$/ha
Income	
Watermelon: 30t/ha @ $800/t	$24,000
Total Income	**$24,000**
Variable Costs	
Seed and Plants	$3,116
Fertiliser	$1,488
Fuel	$346
Chemicals	$1,304
Irrigation Pumping Costs	$245
Labour	$1,621
Packaging	$1,286
Cartage	$3,480
Other Costs	$4,800
Total Costs	**$17,685**
Gross Margin	***$6,315***
Gross Margin /ML	**$1,804**

Source: DAF (2018), NSW DPI (2013)

Table B.3: Capsicum Gross Margin Budget

Input	$/ha
Income	
Capsicums (3,000 Cartons/ha @ $16/Carton)	$48,000
Total Income	**$48,000**
Variable Costs	
Fuel	$427
Planting	$5,285
Fertiliser	$1,464
Chemicals	$822
Irrigation Pumping Costs	$329
Packaging Materials	$5,073
Labour	$6,205
Cartage	$2,784
Other Costs (levies, commission, bin hire, drip tape)	$9,600
Total Variable Costs	**$31,989**
Gross Margin	***$16,011***
Gross Margin /ML	**$3,407**

Source: NSW DPI (2013), AEC

Table B.4: Pumpkin Gross Margin Budget

Input	$/ha
Income	
Pumpkin: Jap (30t/ha @ $400/t)	$12,000
Total Income:	**$12,000**
Variable Costs	
Preparation	$120
Planting	$465
Nutrition	$901
Irrigation Pumping Costs	$280
Crop Protection	$531
Packaging	$1,286
Harvesting	$1,545
Cartage	$3,480
Commission/Levies	$1,800
Total Costs	**$10,408**
Gross Margin	***$1,592***
Gross Margin/ML	**$398**

Source: DAF (2018), AEC

Table B.5: Type I Crop Fixed and Capital Cost Assumptions

Factor	Avg. Type 1 Crops ($/ha)
Farm Size (ha)	**200**
Capital Costs	
Land Clearing	$1,700
Irrigation Capital (On Farm)	$8,500
Irrigation Capital (Connection to Channel)	$10,000
Other costs (sheds/workshops, machinery and equipment, etc.)	$6,000
Total	**$26,200**
Fixed Costs	
Fixed Labour	$1,000
Fixed Repairs/Maint.	$200
Admin.	$250
Land Rent	$100
Other	$150
Total	**$1,700**

Source: McKellar Et At. (2013), ABARES (2017a), AEC

Table B.6: Avocados Gross Margin Budget

Year	1	2	3	4	5	6	7	8+
Irrigation Requirement (ML)	2.8	2.8	8.4	8.4	11.3	13.1	15.0	15.0
Yield (Tonnes/ha)	-	0.6	2.4	5.9	8.3	11.8	14.1	16.5
Revenues @$4,800/t	**$0**	**$2,829**	**$11,314**	**$28,286**	**$39,600**	**$56,571**	**$67,886**	**$79,200**
Variable Costs ($/ha)								
Pruning, mowing & operating	$22	$41	$278	$578	$752	$726	$1,097	$1,097
Pest & disease control	$279	$307	$403	$816	$1,153	$1,566	$1,623	$1,681
Fertiliser & testing	$2,704	$153	$2,829	$545	$3,784	$2,064	$2,064	$2,064
Irrigation Pumping Costs	$197	$197	$591	$591	$788	$919	$1,050	$1,050
Harvest	$0	$181	$722	$1,805	$2,527	$3,610	$4,332	$5,054
Management & consultant costs	$488	$173	$765	$775	$1,476	$1,499	$1,719	$1,864
Other costs	$50	$278	$278	$833	$833	$1,111	$1,296	$1,481
Total Variable Costs	**$3,740**	**$1,330**	**$5,865**	**$5,943**	**$11,313**	**$11,496**	**$13,182**	**$14,292**
Gross Margin	**-$3,740**	**$1,499**	**$5,449**	**$22,342**	**$28,287**	**$45,076**	**$54,703**	**$64,908**
Gross Margin/ML	**-**	**$533**	**$646**	**$2,648**	**$2,514**	**$3,434**	**$3,647**	**$4,327**

Source: Dee and Chose (2015), DAF (2016), AEC

Table B.7: Oranges Gross Margin Budget

Year	1	2	3	4	5	6	7	8	9	10	11+
Irrigation (ML/ha)	0	7.1	8.9	12.4	15.9	17.7	17.7	17.7	17.7	17.7	17.7
Yield T/ha	0	0	0	3	9	16	23	31	40	46	50
Revenue @ $950/t	**$0**	**$0**	**$0**	**$2,714**	**$8,143**	**$14,929**	**$21,714**	**$29,857**	**$38,000**	**$43,429**	**$47,500**
Variable Costs ($/t)											
Pruning & Hand Thinning	$1,555	$390	$465	$545	$620	$700	$775	$775	$775	$775	$775
Wages Spraying / Slashing	$180	$180	$220	$255	$290	$325	$365	$365	$365	$365	$365
Irrigation Pumping Costs	$0	$499	$624	$865	$1,114	$1,239	$1,239	$1,239	$1,239	$1,239	$1,239
Wages Irrigation / Drainage / Fertiliser	$155	$155	$185	$220	$250	$280	$310	$310	$310	$310	$310
Fuel & Electricity Costs	$570	$570	$685	$800	$910	$1,025	$1,140	$1,140	$1,140	$1,140	$1,140
Contract Pest services	$50	$50	$60	$75	$85	$95	$105	$105	$105	$105	$105
Fertiliser	$285	$285	$340	$400	$455	$515	$570	$570	$570	$570	$570
Fungicide / Insecticide	$155	$155	$185	$220	$250	$280	$310	$310	$310	$310	$310
Crop Regulation	$130	$130	$155	$180	$205	$235	$260	$260	$260	$260	$260
Weed Control	$50	$50	$60	$75	$85	$95	$105	$105	$105	$105	$105
General R&M	$105	$105	$125	$145	$165	$185	$205	$205	$205	$205	$205
Harvesting	$0	$0	$0	$361	$1,084	$1,988	$2,891	$3,976	$5,060	$5,783	$6,325
Levies & Other	$0	$0	$0	$405	$1,216	$2,229	$3,243	$4,459	$5,675	$6,486	$7,094
Total Variable Costs	**$3,235**	**$2,569**	**$3,104**	**$4,546**	**$6,730**	**$9,191**	**$11,518**	**$13,819**	**$16,119**	**$17,653**	**$18,803**
Gross Margin	***-$3,235***	***-$2,569***	***-$3,104***	***-$1,832***	***$1,413***	***$5,737***	***$10,196***	***$16,039***	***$21,881***	***$25,776***	***$28,697***
Gross Margin/ML		**-$360**	**-$348**	**-$148**	**$89**	**$324**	**$576**	**$906**	**$1,236**	**$1,456**	**$1,621**

Source: Citrus Australia (2015), AEC

Table B.8: Lemons Gross Margin Budget

Year	1	2	3	4	5	6	7	8	9	10+
Irrigation (ML/ha)	0	7.1	8.9	12.4	15.9	17.7	17.7	17.7	17.7	17.7
Yield T/ha	-	-	2.9	8.6	15.7	22.9	31.4	40.0	45.7	50.0
Revenue @ $1,250/t	**$0**	**$0**	**$3,571**	**$10,714**	**$19,643**	**$28,571**	**$39,286**	**$50,000**	**$57,143**	**$62,500**
Variable Costs ($/t)										
Pruning & Hand Thinning	$1,555	$390	$465	$545	$620	$700	$775	$775	$775	$775
Wages Spraying / Slashing	$180	$180	$220	$255	$290	$325	$365	$365	$365	$365
Irrigation Pumping Costs	$0	$499	$624	$865	$1,114	$1,239	$1,239	$1,239	$1,239	$1,239
Wages Irrigation / Drainage / Fertiliser	$155	$155	$185	$220	$250	$280	$310	$310	$310	$310
Fuel & Electricity Costs	$570	$570	$685	$800	$910	$1,025	$1,140	$1,140	$1,140	$1,140
Contract Pest services	$50	$50	$60	$75	$85	$95	$105	$105	$105	$105
Fertiliser	$285	$285	$340	$400	$455	$515	$570	$570	$570	$570
Fungicide / Insecticide	$155	$155	$185	$220	$250	$280	$310	$310	$310	$310
Crop Regulation	$130	$130	$155	$180	$205	$235	$260	$260	$260	$260
Weed Control	$50	$50	$60	$75	$85	$95	$105	$105	$105	$105
General R&M	$105	$105	$125	$145	$165	$185	$205	$205	$205	$205
Harvesting	$0	$0	$361	$1,084	$1,988	$2,891	$3,976	$5,060	$5,783	$6,325
Levies & Other	$0	$0	$528	$1,583	$2,901	$4,220	$5,803	$7,385	$8,440	$9,231
Total Variable Costs	**$3,235**	**$2,569**	**$3,993**	**$6,446**	**$9,318**	**$12,085**	**$15,162**	**$17,829**	**$19,607**	**$20,940**
Gross Margin	***-$3,235***	***-$2,569***	***-$421***	***$4,268***	***$10,325***	***$16,486***	***$24,124***	***$32,171***	***$37,536***	***$41,560***
Gross Margin/ML		**-$360**	**-$47**	**$346**	**$649**	**$931**	**$1,363**	**$1,818**	**$2,121**	**$2,348**

Source: Citrus Australia (2015), AEC

Table B.9: Table Grapes Gross Margin Budget

Year	1	2	3	4	5	6+
Irrigation Requirement (ML/ha)	1.9	2.5	3.0	4.5	5	6.3
Yield (t/ha)	0	0	2.4	4	4.8	8
Revenue @ $3,000/t	**$0**	**$0**	**$8,400**	**$14,000**	**$16,800**	**$28,000**
Variable Costs ($/t)						
Vine Management	$4,782	$5,702	$7,663	$8,277	$8,890	$9,564
Crop Protection	$208	$248	$333	$360	$387	$416
Nutrition	$39	$47	$63	$68	$73	$78
Irrigation Pumping Costs	$133	$175	$210	$315	$350	$441
Harvesting	$0	$0	$2,775	$4,626	$5,551	$9,251
Cartage	$0	$0	$281	$469	$562	$937
Levies/Commission	$0	$0	$720	$1,200	$1,440	$2,400
Total Variable Costs	**$5,162**	**$6,171**	**$12,046**	**$15,313**	**$17,252**	**$23,087**
Gross Margin	***-$5,162***	***-$6,171***	***-$4,846***	***-$3,313***	***-$2,852***	***$913***
Gross Margin/ML	**-$2,716.8**	**-$2,468.4**	**-$1,615.3**	**-$736.3**	**-$570.4**	**$145**

Source: DAF (2016, 2018), AEC

Table B.10: Type II Crops Capital and Fixed Operating Cost Assumptions

Factor	Citrus	Avocado	Table Grapes
Farm Size (ha)	**200**		
Capital Costs ($/ha)			
Land Clearing	$2,000		
Irrigation Capital (On Farm)	$8,500		
Irrigation Capital (Connection to Channel)	$10,000		
Other costs (trees & planting, sheds/workshops, machinery and equipment, etc.)	$10,000	$25,000	$35,000
Total	**$30,000**	**$45,000**	**$55,000**
Fixed Costs			
Fixed Labour	$1,000		
Fixed Repairs / Maintenance	$400		
Administration	$250		
Land Rent	$100		
Other	$300		
Total	**$2,050**		

Table B.11: Mung Beans Gross Margin Budget

Input	Amount ($/ha)
Income	
No1 Processing (2 tonnes @ $1100/tonne)	**$2,200**
Gradings (1.2 tonnes @ $200/tonne)	$240
Total Income	**$2,440**
Variable Costs	
Irrigation Pumping Costs (Overhead, 3.6ML)	$252
Fallow Management	$25
Planting	$73
Nutrition	$45
Crop Protection	$43
Harvesting	$67
Post-Harvest	$217
Other	$53
Total Costs	**$775**
Gross Margin	***$1,665***
Gross Margin/ML	**$463**

Source: DAF (2018), AEC

Table B.12: Cotton Gross Margin Budget

Input	Amount ($/ha)
Income	
Lint (12bales @ $480/bale)	$5,760
Seed (3.6t @ $190/tonne)	$684
Total Income	**$6,444**
Variable Costs	
Fallow Management	$82
Planting	$487
Nutrition	$357
Crop Protection	$125
Irrigation Pumping Costs (Overhead, 8.6ML)	$602
Harvesting	$265
Other	$188
Post-Harvest	$758
Total Costs	**$2,864**
Gross Margin	***$3,580***
Gross Margin/ML	**$416**

Source: DAF (2018), AEC

Table B.13: Sorghum Gross Margin Budget

Input	Amount ($/ha)
Income	
Sorghum (8t @ $275/tonne)	$2,200
Total Income	**$2,200**
Variable Costs	
Fallow Management	$31
Planting	$51
Nutrition	$315
Crop Protection	$107
Irrigation Pumping Costs (Overhead, 7.9ML)	$553
Harvesting	$56
Post-Harvest	$292
Other	$40
Total Costs	**$1,445**
Gross Margin	***$755***
Gross Margin/ML	**$96**

Source: DAF (2018), AEC

Table B.14: Chickpea Gross Margin Budget

Input	Amount ($/ha)
Income	
Grain (3.2tonnes @ $900/tonne)	$2,880
Total Income	**$2,880**
Variable Costs	
Fallow Management	$43
Planting	$84
Nutrition	$44
Crop Protection	$131
Irrigation Pumping Costs (Overhead, 4.6 ML)	$322
Harvesting	$44
Post-Harvest	$117
Other	$66
Total Costs	**$851**
Gross Margin	***$2,029***
Gross Margin/ML	**$441**

Source: DAF (2018), AEC

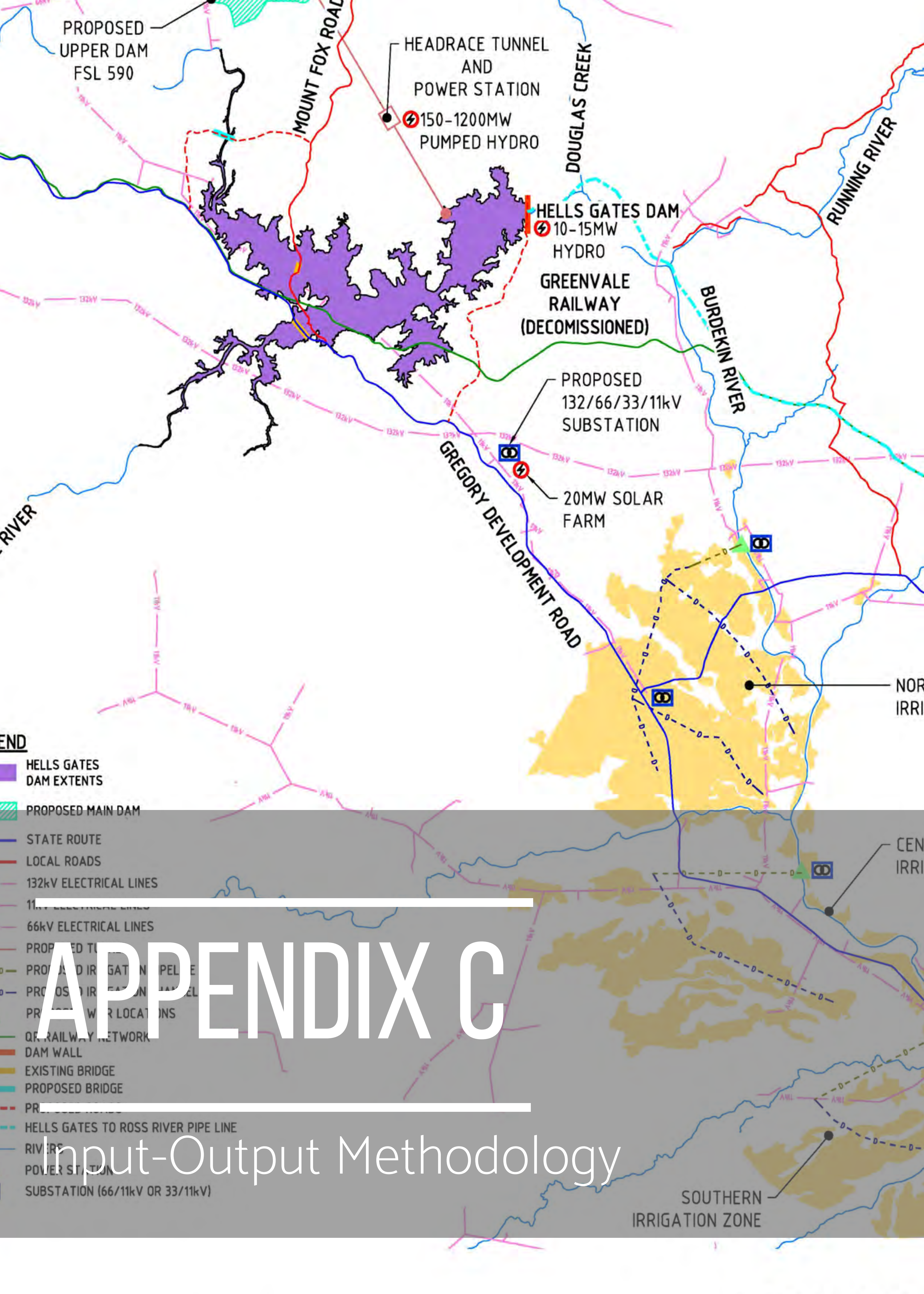
Table B.15: Type 3 Crops Fixed and Capital Cost Assumptions

Factor	Avg. Type 3 Crops
Farm Size (ha)	**500**
Capital Costs ($/ha)	
Land Clearing	$2,000
Irrigation Capital (On Farm)	$4,500
Irrigation Capital (Connection to Channel)	$10,000
Other costs (sheds/workshops, machinery and equipment, etc.)	$1,500
Total	**$18,000**
Fixed Costs	
Fixed Labour	$300
Fixed Repairs / Maintenance	$100
Administration	$80
Land Rent	$100
Other	$70
Total	**$650**

Source: McKellar et al. (2013), AEC

APPENDIX C

Input-Output Methodology



Appendix C – Input-Output Methodology

Input-Output Model Overview

Input-output analysis demonstrates inter-industry relationships in an economy, depicting how the output of one industry is purchased by other industries, households, the government and external parties (i.e. exports), as well as expenditure on other factors of production such as labour, capital and imports. Input-Output analysis shows the direct and indirect (flow-on) effects of one sector on other sectors and the general economy. As such, input-output modelling can be used to demonstrate the economic contribution of a sector on the overall economy and how much the economy relies on this sector or to examine a change in final demand of any one sector and the resultant change in activity of its supporting sectors.

The economic contribution can be traced through the economic system via:

- **Direct impacts**, which are the first round of effects from direct operational expenditure on goods and services.
- **Flow-on impacts**, which comprise the second and subsequent round effects of increased purchases by suppliers in response to increased sales. Flow-on impacts can be disaggregated to:
  - **Industry Support Effects (Type I)**, which represent the production induced support activity because of additional expenditure by the industry experiencing the stimulus on goods and services in the intermediate usage quadrant, and subsequent round effects of increased purchases by suppliers in response to increased sales.
  - **Household Consumption Effects (Type II)**, which represent the consumption induced activity from additional household expenditure on goods and services resulting from additional wages and salaries being paid within the economic system.

These effects can be identified through the examination of four types of impacts:

- **Output**: Refers to the gross value of goods and services transacted, including the costs of goods and services used in the development and provision of the final product. Output typically overstates the economic impacts as it counts all goods and services used in one stage of production as an input to later stages of production, hence counting their contribution more than once.
- **Gross Product**: Refers to the value of output after deducting the cost of goods and services inputs in the production process. Gross product defines the true net contribution and is subsequently the preferred measure for assessing economic impacts.
- **Income**: Measures the level of wages and salaries paid to employees of the industry under consideration and to other industries benefiting from the project.
- **Employment**: Refers to the part-time and full-time employment positions generated by the economic shock, both directly and indirectly through flow-on activity, and is expressed in terms of full-time equivalent (FTE) positions.

Input-output multipliers can be derived from open (Type I) input-output models or closed (Type II) models. Open models show the direct effects of spending in an industry as well as the indirect or flow-on (industrial support) effects of additional activities undertaken by industries increasing their activity in response to the direct spending.

Closed models re-circulate the labour income earned because of the initial spending through other industry and commodity groups to estimate consumption induced effects (or impacts from increased household consumption).

Model Development

Multipliers used in this assessment are derived from sub-regional transaction tables developed specifically for this project. The process of developing a sub-regional transaction table involves developing regional estimates of gross production and purchasing patterns based on a parent table, in this case, the 2014-15 Australian transaction table (ABS, 2017a).

Estimates of gross production (by industry) in the study area were developed based on the percent contribution to employment (by place of work) of the study area to the Australian economy (ABS, 2017b), and applied to Australian gross output identified in the 2014-15 Australian table.

Industry purchasing patterns within the study area were estimated using a process of cross-industry location quotients and demand-supply pool production functions as described in West (1993).

Where appropriate, values were rebased from 2014-15 (as used in the Australian national Input-Output transaction tables) to current values using the Consumer Price Index (ABS, 2017c).

Modelling Assumptions

The key assumptions and limitations of input-output analysis include:

- **Lack of supply-side constraints**: The most significant limitation of economic impact analysis using input-output multipliers is the implicit assumption that the economy has no supply-side constraints, so the supply of each good is perfectly elastic. That is, it is assumed that extra output can be produced in one area without taking resources away from other activities, thus overstating economic impacts. The actual impact is likely to be dependent on the extent to which the economy is operating at or near capacity.
- **Fixed prices**: Constraints on the availability of inputs, such as skilled labour, require prices to act as a rationing device. In assessments using Input-Output multipliers, where factors of production are assumed to be limitless, this rationing response is assumed not to occur. The system is in equilibrium at given prices, and prices are assumed to be unaffected by policy and any crowding out effects are not captured. This is not the case in an economic system subject to external influences.
- **Fixed ratios for intermediate inputs and production (linear production function)**: Economic impact analysis using input-output multipliers implicitly assumes that there is a fixed input structure in each industry and fixed ratios for production. That is, the input function is generally assumed linear and homogenous of degree one (which implies constant returns to scale and no substitution between inputs). As such, impact analysis using input-output multipliers can be seen to describe average effects, not marginal effects. For example, increased demand for a product is assumed to imply an equal increase in production for that product. In reality, however, it may be more efficient to increase imports or divert some exports to local consumption rather than increasing local production by the full amount. Further, it is assumed each commodity (or group of commodities) is supplied by a single industry or sector of production. This implies there is only one method used to produce each commodity and that each sector has only one primary output.
- **No allowance for economies of scope**: The total effect of carrying on several types of production is the sum of the separate effects. This rules out external economies and diseconomies and is known simply as the “additivity assumption”. This generally does not reflect real world operations.
- **No allowance for purchasers’ marginal responses to change**: Economic impact analysis using multipliers assumes that households consume goods and services in exact proportions to their initial budget shares. For example, the household budget share of some goods might increase as household income increases. This equally applies to industrial consumption of intermediate inputs and factors of production.
- **Absence of budget constraints**: Assessments of economic impacts using multipliers that consider consumption induced effects (type two multipliers) implicitly assume that household and government consumption is not subject to budget constraints.

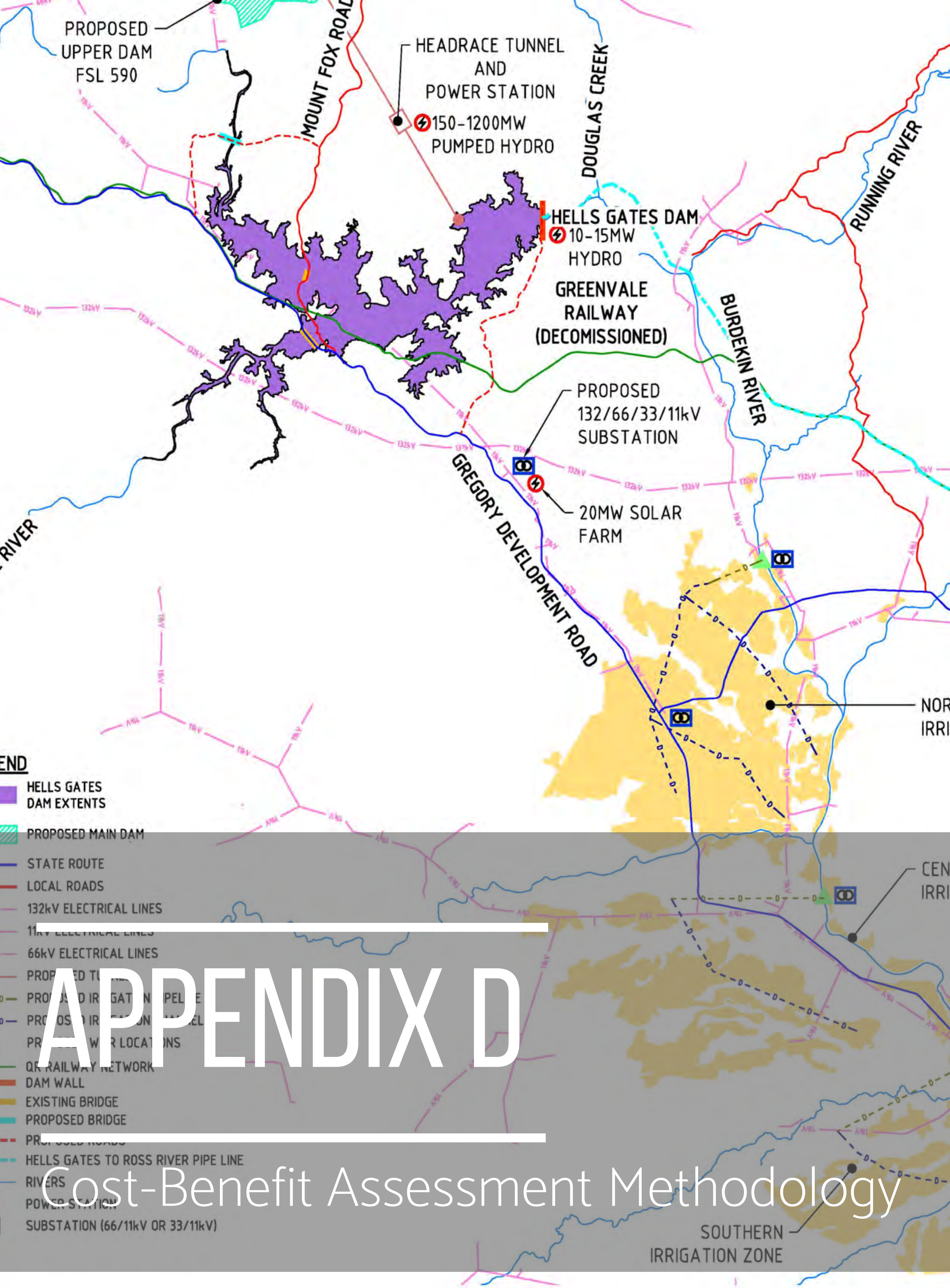
Given the above limitations, input-output has the potential to overstate the level of economic activity, particularly in instances where significant capacity constraints exist within the economy (such as a tight labour market), potential for substitution between capital and labour, or substantial efficiencies from economies of scale.

Despite these limitations, input-output techniques provide a solid approach for taking account of the inter-relationships between the various sectors of the economy in the short-term and provide useful insight into the quantum of final demand for goods and services, both directly and indirectly, likely to be generated by a project.

In addition to the general limitations of input-output analysis, there are two other factors that need to be considered when assessing the outputs of sub-regional transaction table developed using this approach, namely:

- It is assumed the sub-region has similar technology and demand / consumption patterns as the parent (Australia) table (e.g. the ratio of employee compensation to employees for each industry is held constant).

Intra-regional cross-industry purchasing patterns for a given sector vary from the national tables depending on the prominence of the sector in the regional economy compared to its input sectors. Typically, sectors that are more prominent in the region (compared to the national economy) will be assessed as purchasing a higher proportion of imports from input sectors than at the national level, and vice versa.



APPENDIX D

Cost-Benefit Assessment Methodology

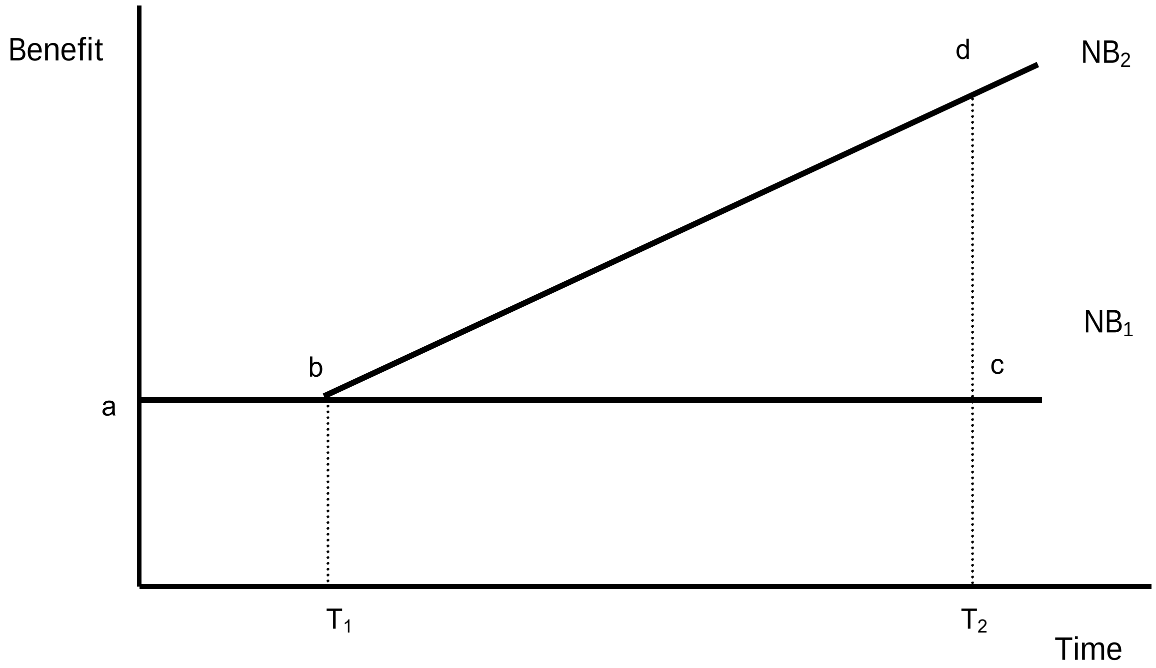
Appendix D – Cost-Benefit Assessment (CBA) Methodology

Step 1: Define the Scope and Boundary

To enable a robust determination of the net benefits of undertaking a given project, it is necessary to specify base case and alternative case scenarios. The base case scenario represents the 'without project' scenario and the alternative or 'with project' scenario examines the impact with the project in place.

The base case (without) scenario is represented by line NB_1 (bc) over time T_1 to T_2 in the figure below. The investment in the project at time T_1 is likely to generate a benefit, which is represented by line NB_2 (bd). Therefore the net benefit flowing from investment in the project is identified by calculating the area (bcd) between NB_1 and NB_2.

Figure D.1. With and Without Scenarios



Step 2: Identify Costs and Benefits

A comprehensive quantitative specification of the benefits and costs included in the evaluation and their various timings is required and includes a clear outline of all major underlying assumptions. These impacts, both positive and negative, are then tabulated and where possible valued in dollar terms.

Some impacts may not be quantifiable. Where this occurs the impacts and their respective magnitudes will be examined qualitatively for consideration in the overall analysis.

Financing costs are not included in a CBA. As a method of project appraisal, CBA examines a project's profitability independently of the terms on which debt finance is arranged. This does not mean, however, that the cost of capital is not considered in CBA, as the capital expenses are included in the year in which the transaction occurs, and the discount rate (discussed below in Step 5) should be selected to provide a good indication of the opportunity cost of funds, as determined by the capital market.

Step 3: Quantify and Value Costs and Benefits

CBA attempts to measure the value of all costs and benefits that are expected to result from the activity in economic terms. It includes estimating costs and benefits that are 'unpriced' and not the subject of normal market transactions but which nevertheless entail the use of real resources. These attributes are referred to as 'non-market' goods or impacts. In each of these cases, quantification of the effects in money terms is an important part of the evaluation.

However, projects frequently have non-market impacts that are difficult to quantify. Where the impact does not have a readily identifiable dollar value, proxies and other measures should be developed as these issues represent real costs and benefits.

One commonly used method of approximating values for non-market impacts is 'benefit transfer'. Benefit transfer (BT) means taking already calculated values from previously conducted studies and applying them to different study sites and situations. In light of the significant costs and technical skills needed in using the methodologies outlined in the table above, for many policy makers utilising BT techniques can provide an adequate solution.

Context is extremely important when deciding which values to transfer and from where. Factors such as population, number of households, and regional characteristics should be considered when undertaking benefit transfer. For example, as population density increases over time, individual households may value nearby open space and parks more highly. Other factors to be considered include, depending on the location of the original study, utilising foreign exchange rates, demographic data, and respective inflation rates.

Benefit transfer should only be regarded as an approximation. Transferring values from similar regions with similar markets is important, and results can be misleading if values are transferred between countries that have starkly different economies (for example a benefit transfer from the Solomon Islands to Vancouver would likely have only limited applicability). However, sometimes only an indicative value for environmental assets is all that is required.

Step 4: Tabulate Annual Costs and Benefits

All identified and quantified benefits and costs are tabulated to identify where and how often they occur. Tabulation provides an easy method for checking that all the issues and outcomes identified have been addressed and provides a picture of the flow of costs, benefits and their sources.

Step 5: Calculate the Net Benefit in Dollar Terms

As costs and benefits are specified over time it is necessary to reduce the stream of benefits and costs to present values. The present value concept is based on the time value of money – the idea that a dollar received today is worth more than a dollar to be received in the future. The present value of a cash flow is the equivalent value of the future cashflow should the entire cashflow be received today. The time value of money is determined by the given discount rate to enable the comparison of options by a common measure.

The selection of appropriate discount rates is of particular importance because they apply to much of the decision criteria and consequently the interpretation of results. The higher the discount rate, the less weight or importance is placed on future cash flows.

The choice of discount rates should reflect the weighted average cost of capital (WACC). For this analysis, a base discount rate of 6% has been used to represent the minimum rate of return, in line with Australian Government guidelines. As all values used in the CBA are in real terms, the discount rate does not incorporate inflation (i.e., it is a real discount rate, as opposed to a nominal discount rate).

To assess the sensitivity of the project to the discount rate used, discount rates either side of the base discount rate (6%) have also been examined (4% and 8%).

The formula for determining the present value is:

$$PV = \frac{FV_n}{(1+r)^n}$$

Where:

PV = present value today

FV = future value n periods from now

r = discount rate per period

n = number of periods

Extending this to a series of cash flows the present value is calculated as:

$$PV = \frac{FV_1}{(1+r)^1} + \frac{FV_2}{(1+r)^2} + \cdots + \frac{FV_n}{(1+r)^n}$$

Once the stream of costs and benefits have been reduced to their present values the Net Present Value (NPV) can be calculated as the difference between the present value of benefits and present value of costs. If the present value of benefits is greater than the present value of costs then the option or project would have a net economic benefit.

In addition to the NPV, the internal rate of return (IRR) and benefit-cost ratio (BCR) can provide useful information regarding the attractiveness of a project. The IRR provides an estimate of the discount rate at which the NPV of the project equals zero, i.e., it represents the maximum WACC at which the project would be deemed desirable. However, in terms of whether a project is considered desirable or not, the IRR and BCR will always return the same result as the NPV decision criterion.

Step 6: Sensitivity Analysis

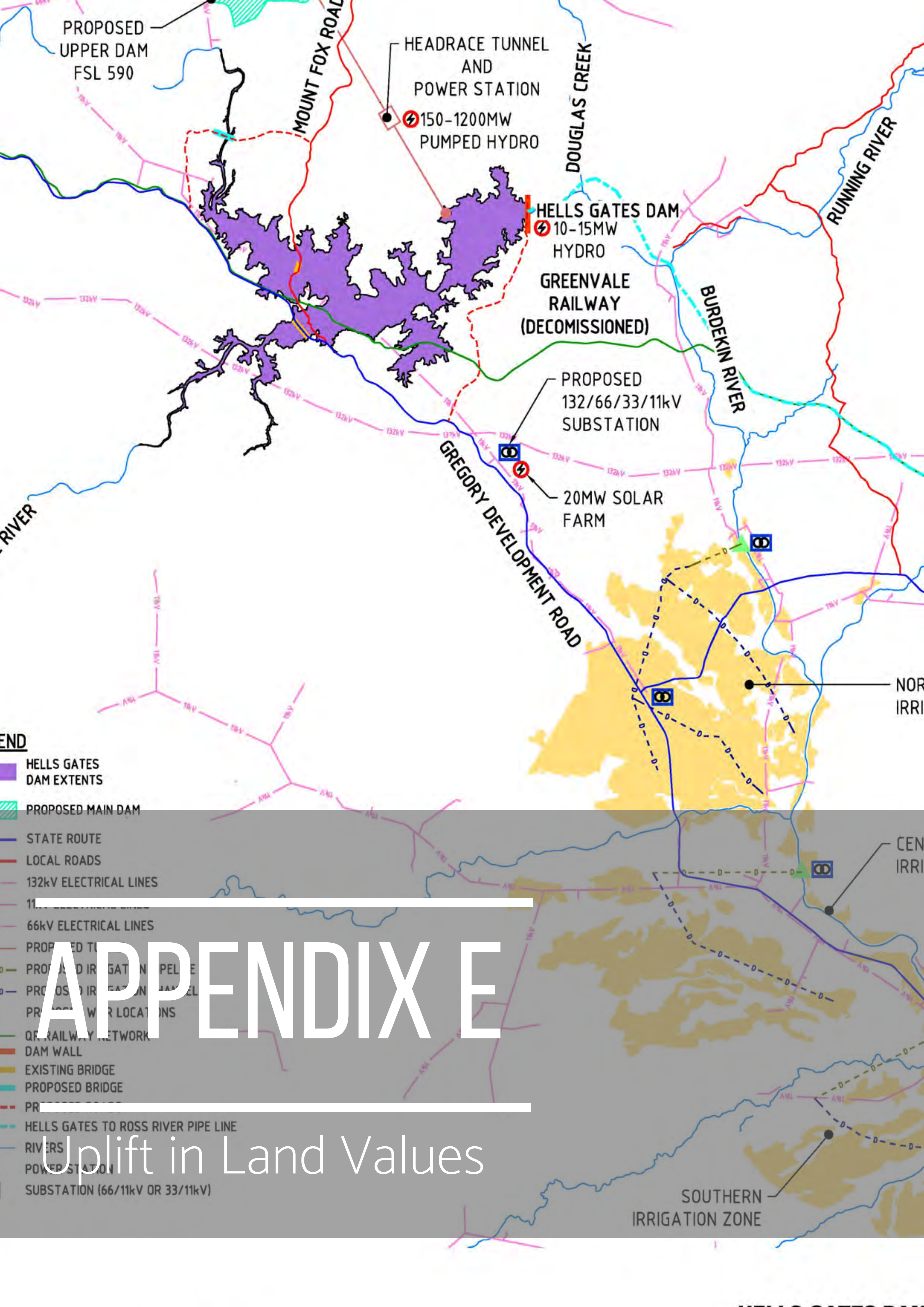
Sensitivity analysis allows for the testing of the key assumptions and the identification of the critical variables within the analysis to gain greater insight into the drivers to the case being examined.

A series of Monte Carlo analyses has been conducted in order to test the sensitivity of the model outputs to changes in key variables. Monte Carlo simulation is a computerised technique that provides decision-makers with a range of possible outcomes and the probabilities they will occur for any choice of action. Monte Carlo simulation works by building models of possible results by substituting a range of values – the probability distribution – for any factor that has inherent uncertainty. It then calculates results over and over, each time using a different set of random values from the probability functions. The outputs from Monte Carlo simulation are distributions of possible outcome values.

During a Monte Carlo simulation, values are sampled at random from the input probability distributions. Each set of samples is called an iteration, and the resulting outcome from that sample is recorded. Monte Carlo simulation does this hundreds or thousands of times, and the result is a probability distribution of possible outcomes. In this way, Monte Carlo simulation provides a comprehensive view of what may happen. It describes what could happen and how likely it is to happen.

APPENDIX E

Uplift in Land Values



Appendix E – Uplift in Land Values

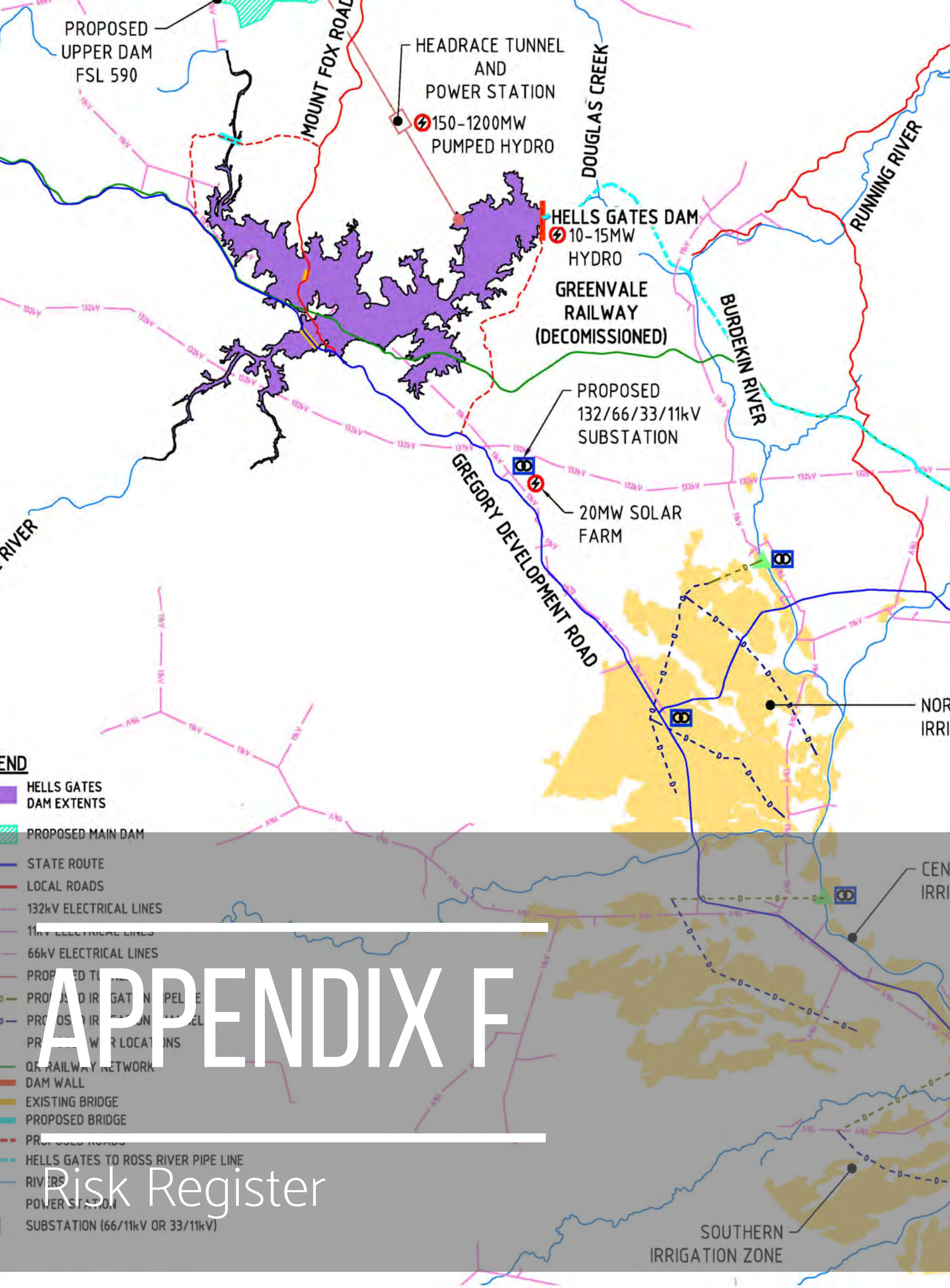
This section provides a high-level assessment of the benefits flowing from the uplift in land values and economic activity associated with the development. The assessment assumes an uplift from $120 to $3,800/ha based on a review of land valuations within the study area and in the Burdekin. Results include:

- $184 million uplift in land values
- Potential for up to $14.8 million in stamp duty
- $39.1 million in annual income tax paid
- $84.4 million in company taxes per annum (agricultural operations)
- Up to $13.6 million in annual payroll tax
- $36.8 million in potential capital gains tax.

Table E.1: Uplift Calculations

Factor	Input
Land Value /ha (Pre Project)	$120
Land Value /ha (Post Project)	$3,800
Land Uplift/ha	$3,680
Total Ha	$50,000
Total Uplift $M	$184
Capital Gains ($M) 50% discount @ 40% Marginal Tax Rate	$36.8
Total Land Value ($M)	$190
Stamp Duty (Per 500ha)	$147,750
Total Stamp Duty (50,000ha) ($M)	$14.8
Increase in General Rate @ $0.0051 per dollar ($M)	$0.94
Total Direct Employment	4,728
Total Direct Income ($M)	$286
Average Income	$60,817
Tax on Income	$11,312
Less Average Deduction	$3,041
Income Tax Per Annum/FTE	$8,271
Total Income Tax Paid Per Annum ($M)	$39.1
Total Payroll Tax Paid ($M) @ 4.75%	$13.6
Company Tax (Agriculture @ 15% after deductions)	$84.4

Source: Charters Towers Regional Council (2017), AEC



APPENDIX F

Risk Register

Member of the Surbana Jurong Group

Project No: 30031890 - Hells Gates Dam Feasibility Study | Developed | KN | 14/09/2018

Risk Identification			Risk Analysis					Risk Management Plan					
Nature of Risk	Identified Risk / Hazard (opportunities & threats)	Leading to . . .	Existing Controls of Identified Risk / Hazard (If any)	Likelihood (1 - 5) *	Consequence (1 - 5) *	Risk Rating	Is the Risk Significant? Yes ≥8 No <8	Treatment / Action	Responsibility	Timing	Residual Likelihood (1 - 5)	Residual Consequence (1 - 5)	Residual Risk Rating
Project Delivery	Political and Social Impact	Scope changes following stakeholder involvement or change in political decision.	Media announcements and Stakeholder meetings/townhalls in planning to set expectations	3	3	9	YES	Management of stakeholder expectations and delivery outcomes. Management of relationships with political members.	TEL	Ongoing	2	2	4
Project Delivery	Delay in project funding (Specific to the Hells Gates Dam Feasibility Study)	Sufficient funding is not available due to other project priority ahead, or conflict with current planning by funding authorities.	DEWS has bankroleld the project funding to alleviate issues from the Commonwealth post-delivery funding	1	4	4	NO	Maintain ongoing communications between TEL and the funding agencies. Ensure the delivery of milestones within expected timeframes.	TEL/SMEC	Ongoing	1	4	4
Project Delivery	Political pressure to bring project timeframes forwards	Pressure form the local communities and political members to bring deliver project quickly. Pressure due to the growing urgency for water supply to the communities (Townsville and Charters Towers)	Contract dates are specific	1	5	5	NO	Contract mitigates this risk completely	TEL	Ongoing	1	2	2
Project Delivery	Unidentified risks that will be identified during gap analysis	Increased need for data sourcing or field testing	Gap analysis report	5	2	10	YES	Deliver gap analysis and develop mitigation strategies	SMEC	30/06/2017	1	2	2
Project Delivery	Delivery of project objectives not to clients satisfaction	Increased pressure for re-working and re-analysing information.	Ongoing discussion with PM at TEL to monitor	2	4	8	YES	Utilisation of suitably qualified and experiences personnel originally engaged to the project	TEL	Ongoing	1	2	2
Technical	Soil Suitability	Previous studies did not cover the entire catchment with soil suitability mapping and assumed Hillgrove soils were suited to sugar cane	Gap analysis report	4	4	16	YES	Soil mapping for crop suitablility will require investigation as part of this study to determine suitable crops and farming vaiability.	SMEC	Ongoing	4	1	4
Technical/Project Design	Soil study reveals that the viable vertasols soils are the highest value soils, and are a long narrow strip close to the river	Change of philosophy from a broad scale farming concept as envisaged by the 2014 GHD report	Nil	3	3	9	YES	Techncial Feasibility study refocuses on mosaic high value crops and multiple weirs with a droughtproofing storage dam	SMEC	July-Dec 17	3	1	3
Technical/Soil Study	Soil study shows broad acre farming soils identified by GHD 2014, such as Hillgrove soils, are unsuitable for irrigated farming	Much reduced irrigation zone from 100,000Ha to less than 20,000 Ha	Nil	4	5	20	YES	Techncial Feasibility study refocuses on mosaic high value crops (tree crops, vegetables, high value cattle)	SMEC	July-Dec 17	4	1	4
Technical/Dams	Multiple water retentions and storages required to service irrigation zone	Different technical solutions required to have distributed storages rather than one large dam	Nil	3	5	15	YES	Techncial Feasibility study refocuses on multiple weirs with a droughtproofing storage dam	SMEC	July-Dec 17	3	1	3
Technical/Agronomy	Cropping analysis identifies crops that have a history of biosecurity issues such as table grapes/Phyloxera	Potential high biosecurity compliance costs	Nil	2	5	10	YES	Techncial feasibility needs to address how regional "clean zones" can be declared and what mitigations and critical mass are needed to do so	SMEC	July-Dec 17	2	1	2
Technical/Agronomy	Soil study reveals a mosaic of high value crops is more beneficial than broad acre irrigatied farming	More varieties of crops rather than a small number of large production crops	Nil	3	3	9	YES	Technical Feasibility study refocuses on mosaic high value crops (tree crops, vegetables, high value cattle)	SMEC	July-Dec 17	3	1	3
Stakeholder/Community Perception	A small number of large landholders become the beneficiary of the dam and irrigation scheme works	Potential issues around managing community expectations and carving the land uop into smaller parcels with more landholders	Nil	4	4	16	YES	Consult with State and Commonwealth Governemnt of the likely political consequences and amy mitigations or considerations needed to make the solution mopre palateable for future stages of the project to deal with	TEL	July-Dec 17	4	2	8
Technical//Soils	Soil analysis reveals highly erodable soils in the irrigation zone	Potential for significant land degradation on disturbed soils during high afflux periods	Nil	4	4	16	YES	Particular care exercised in soil suitability assessment to ensure flat lands and suitable soil conditions are present to reduce erosion risks	SMEC	July-Dec 17	4	1	4
Technical/Environment	Soils suitability assessment identified heavily vegetated areas are best suited to irrigated agriculture	Significant clearing of native vegetation	Nil	4	4	16	YES	Environmental investigations during Milestone 3 and 4 identify pathways forward to reduce regulatory risk of the vegetation clearing	SMEC	July-Dec 17	4	2	8
Technical/Agronomy	Crop specific water demand assessment for 10th, 50th and 90th percentile rainfall years will need input from the water resource assessment to develop crop specific water demand which will impact suitable land requirements	Sub optimal cropping results if water resource is not large enough	Nil	4	4	16	YES	Water Resources assessment to inform Agronomy works during Milestone 3 - these works will be jointly performed. Leads Jim Kelly and Ian Varley will need to coordinate efforts and share early results	SMEC	July-Dec 17	1	4	4
Technical/Agronomy	Water resource allocation to Upper Burdekin is insufficient to meet irrigation needs of this scheme	irrigation scheme unduly restricted in size	Nil	4	4	16	YES	Negotiate with DNRM during Milestones 3 and 4 to increase allocations or have the ability to do so	SMEC	July-Dec 17	1	4	4
Technical/Agronomy	No approvals to undertake the soil and landscape resource audit from landholders	No access to target lands to assess cropping potential	CTRC to provide contacts	4	4	16	YES	Jim Kelly to contact farmers and Cr Roma Bailey to assist in making contacts	SMEC	Jul-17	1	4	4
Technical/Agronomy	No current approvals to undertake the soil and landscape resource audit where any digging is required in undisturbed locations	Stakeholder concerns from TLO Groups	TLO consultation	4	4	16	YES	M Bird & SMEC PM to organise early discussions with both TLO Groups in the target area to brief them on activites and assure them of nil-impact	SMEC	Jul-17	1	4	4
Technical/Agronomy	Local indigenous approval to dig	Sub optimal cost outcomes	Early interaction between agronomy and irrigation network teams to assess best approach	2	2	4	NO	Team leads for agronomy (Jim Kelly) and Irrigation Systems (Mani Maivasakan) to consult in early July	SMEC	Jul-17	1	1	1
Technical/Agronomy	No LiDAR data available to allow irrigation channels and extensive slope/drainage analysis for soils	Poor concept designs	Fly LiDAR early in July.	4	2	8	YES	Obtain survey data available. Fly LiDAR in the subsequent stages of the project	SMEC	Jul-17	4	2	8
Technical/Agronomy	Future climate change will affect cropping assessment	Reduced productivity over time of the irrigation network and the need to change crops	Nil	2	4	8	YES	Within Milestone 3 this will be addressed during the cropping assessment	SMEC	July-Sept 17	1	4	4
Technical/Agronomy	Test pitting in "pristine" areas that are subject to native title claims or could be in future	Breach of obligations under native title or other acts, significant stakeholder disturbance, poor publicity	Engagement with TLO groups in the region through Michele Bird.	3	5	15	YES	Care to schedule all possible test pitting and shovel orks only in previously disturbed areas. Engagement being scheduled for July	SMEC	July-Dec 17	1	1	1
Technical/Irrigation	Detailed contour information not provided by GHD from their 2014 report dataset	Lack of viable data to assess the channel route on the east or west side of the river for irrigation distribution	Data requested from GHD via TEL	3	3	9	YES	Obtain survey data available. Fly LiDAR in the subsequent stages of the project	SMEC	Jul-17	1	1	1
Technical/Irrigation	River modelling data not provided by GHD from their 2014 report dataset	Lack of viable data to assess using the river as a distribution channell below the dam for water transport purposes	Data requested from GHD via TEL	3	3	9	YES	If unavailable or not supplied for other reasons, SMEC will make documented assumptions and include this as an item to be addressed by future studies	SMEC	Jul-17	2	3	6
Technical/Defence Overlay	Potential for either inundation or irrigation zone lands to overlay with Defence land acquisition for ADF/SAF expansion of TFTA	Inability to access land for irrigation or competition with Defence	Work closely with Sean Hawkins of Defence to confirm land target overlays, if any	2	5	10	YES	Meet with Sean Hawkins in late June/Early July once initial selection of agrionomy areas is complete in Milestone 3 (underway 21/6/17)	SMEC	Jul-17	1	1	1
Technical/Electrical/Carry forward of assumptions from previous reports	GHD North & Northwest Queensland Sustainable Resource Feasibility Studies (2014) assumptions around sugar crops may not translate	Lack of power generation capacity in the irrigation zone that may cause power supply capacity issues for water pumping	Technical feasibility to address	4	3	12	YES	Technical feasibility of the cropping, irrigation network and water resourcing will determine pumping loads and potential bagasse/biomass availability for self generation	SMEC	30/11/2017	3	2	6
Technical/Electrical/Future development of Pentland Bioenergy project	Electrical supply capacity of the Charters Towers Grid may be increased as a result of a major new generation site establishing through Millchester substation	Ability to further power irrigation systems from electrical mains	Nil	3	3	9	YES	Consultation with RDA (proponent) by SMEC to confirm progress and likelihood of direct effects	SMEC	30/11/2017	1	2	2
Technical/Electrical/Future Feasibility on establishing Burdekin Falls Hydro generator	May open up injection and electrical capacity into the national grid, or may use all injection capacity	Ability to further power irrigation networks and dispatch generation (positive risk) or potential for all injection capacity to be consumed (negative risk)	Nil	2	4	8	YES	Consultation with successful consultant undertaking transmission line feasibility during technical studies	SMEC	30/11/2017	2	2	4
Technical/Electrical/Future Feasibility on Transmission Line	May open up injection and electrical capacity into the national grid	Ability to further power irrigation networks and dispatch generation (positive risk)	Nil	1	4	4	NO	Consultation with successful consultant undertaking transmission line feasibility during technical studies	SMEC	30/11/2017	1	2	2
Technical/Electrical/Grid Capacity	Electrical supply capacity of the Charters Towers Grid ini ts current state to handle irrigation loads	Inability to power irrigation systems from electrical mains	Technical feasibility to identify pumping loads and grid capacity	3	3	9	YES	Technical feasibility of irrigation systems and pump stations to supply crop needs will determine pumping loads along with consultation with Ergon Energy to determine line capacities	SMEC	30/11/2017	1	2	2
Technical/Electrical/Grid Capacity	Electrical supply capacity of the Charters Towers Grid as a result of other loads and generators (Asolar, Bpower projects)	Inability to power irrigation systems from electrical mains	Technical feasibility to address	3	3	9	YES	Consultation with Ergon Eenrgy during technical feasibility essential to mitigate or define risk better	SMEC	30/11/2017	1	2	2
Technical/Hydropower/Grid Capacity	Electrical capacity of the Kidston 132kV line taken up as a result of other projects (Genex, NSF especially)	Inability to connect hydropower generation to the grid	Technical feasibility to address	4	2	8	YES	Consultation with Ergon Energy during technical feasibility essential to mitigate or define risk better	SMEC	30/11/2017	4	1	4
Technical/Hydropower/Grid Capacity	Electrical injection capacity of the Charters Towers Grid	Inability to connect hydropower generation to the grid	Technical feasibility to address	4	2	8	YES	Consultation with Ergon Energy during technical feasibility essential to mitigate or define risk better	SMEC	30/11/2017	1	2	2
Technical	Selection of storage volume	Irrigation needs may not be met in all years without reductions in allocations being implemented. Impact to project NPV.	Water resource study	2	4	8	YES	Reliability criteria will be set to achieve project risk objectives. Management of low water yield years established in concept design phase and communicated to irrigators.	SMEC and TEL	Ongoing	2	3	6
Technical	Unfavourable site conditions	Cost estimates increase in later project stages affecting project viability	Detailed geological mapping is not in scope but previous studies will be reviewed in detail	2	4	8	YES	High level assessment for this stage of the project. Scope for future stages will be developed to address any areas of uncertainty.	SMEC	Ongoing			0

Technical	Background Data	Limited past knowleadge data gaps	Handover of all past studies and review during gap analysis	2	4	8	YES	Undertake workshop forums for multiple stakeholders to canvas all interest parties early on in the process	SMEC	Ongoing			0
Technical	Water distribution requires significant pumping	CAPEX and OPEX impacts affecting project viability	Technical studies	2	3	6	NO	Thorough assessment of distribution to suit agricultural land	SMEC	Ongoing	1	3	3
Technical/Roads	Poor transportation networks (roads)	Inaccessibility to critical areas of the scheme. Leading to increased capital costs. Inundation of Gregory Developmental Road/Clarke River Bridge via dam inundation.	Development of critical networks between farms, dams and weirs.	3	3	9	YES	Assessment and provision of critical road network to critical infrastructures (farms, dams, weirs, substations). Utilisation of existing road network to minimise capital expenditures. Provision of flooding immunity to Clarke River Bridge and allow for road closures.	SMEC	Milestone 4	1	3	3
Legislative	Fish passage	Fish passage requirements lead to increased capex	Environmental assessment	2	4	8	YES	Early consolation with fisheries and review of existing fish way reports during concept design.	SMEC	Ongoing	1	4	4
Legislative	Land rights	Additional consents, land rights, approvals required	Native title assessment	2	4	8	YES	Early identification of approvals will allow mitigation of impacts	SMEC	Ongoing	1	4	4
Legislative	Planning approvals	Potential to be referred to federal government for approval	Planning assessment	2	2	4	NO	Early identification of approvals will allow addressing or mitigation of impacts	SMEC	Ongoing	1	4	4
Legislative	Water Resources Plan (Water Plan)	Current Water Plan does not support or cater for the water allocation for Hells Gates Dam	Allocation Demand and support DNRME	5	5	25	YES	Development of this feasibility study to feed into the new Water Plan to support the Hells Gates Dam allocation	DNRME	Ongoing	2	5	10
Financial	Sensitivity to commodity market fluctuations and exchange rates	Agribusiness less profitable and impacting on viability of scheme	Agronomy assessment	3	3	9	YES	Sensitivity analyses to be undertaken for key parameters	SMEC	Milestone 3	2	3	6
Financial	Over-production of single crop types	Over-supply into constrained markets thereby leading to price reductions and low ROI	Mixed cropping scenarious considered	4	4	16	YES	Market analysis around capacity to absorb additional horticulture. Strategic assessment of a mixed cropping scenario of both annual and perennial agriculture targeting internation markets. This both improves local production and GDP, whilst mitigating over-supply locally	SMEC	Milestone 5	2	3	6
Risks Identified During Project That Will Need Mitigation In Later Stages Of Development													
Financial	Late commitment from irrigators	Difficulty securing financial close	Not a deliverable of this project, but needs to be recognised as an overall risk	2	4	8	YES	Not an action for this project	TBA	Later project stages	2	3	6
Financial	Securing of investment	Unable to finance project or unacceptable controls placed on project	Range of financing options will be evaluated	2	4	8	YES	If project is shown to be viable - Early engagement with financiers or investors depending on preferred funding arrangement.	TBA	Later project stages	2	3	6
Financial	Cost share between potable and irrigation water demand.	Townsville Water's inability to contribute to project if water pricing is set too high due to irrigation demand.		3	4	12	YES	Early pricing agreement with Townsville water to set prising arrangements with irrigators.	TBA	Later project stages	2	2	4
Financial	high cost of water likely to impact viability of scheme	High water cost will make affordability unviable. Direct competition with other cheaper schemes.	High value high return crop mixes considered in the development	3	5	15	YES	Crop matrix in the district to ensure utilisation of high ROI type crops to cater for capacity to pay. Optimisation in the staging of the overal scheme to ensure minimisation of front-loading of capital expenditures.	SMEC and TEL	Later project stages	2	3	6
Financial	Environmental offset costs	Increased or unexpected changes to project capex at late stage	Early investigation into environmental offset requirements is included in scope.	2	4	8	YES	Test sensitivity of capex/opex to a range of offset requirements. Incorporate into financial models if overall impact is significant.	SMEC	Later project stages	1	4	4
Financial	Land acquisition costs, pipeline easement acquisition,	Land acquisition cost may vary significantly if land costs adjust to reflect irrigation. Eg. $100/ha currently but could rise to $300+/ha if significant irrigation water available.		2	4	8	YES	Early acquisition of key parcels of land		Later project stages	2	2	4
Financial	Delays in financial close	Significant delays due to reviews and re-reviews. Can add 1 to 2 years to program as we have seen at Ruataniwha		3	5	15	YES	Early engagement with financiers and expert review panel such that the final design does not need significant rework to achieve approval and financing.	TEL	Later project stages	2	4	8
Financial	Discontinuous irrigator commitments	Gaps in irrigation area result in a need to drop customers who have committed, design modifications, irrigator buy in cost and project cost impacts.		3	5	15	YES	Early engagement with irrigators and assessment of price sensitivity to inform project staging	Project proponent	Later project stages	2	4	8
Financial	Impacts on scheme viability due to extreme weather events	Irrigators reconsider buy into scheme due to extreme weather impacts on cropping		2	3	6	NO	Early engagement with irrigators to sell benefits of scheme, target early commitments from irrigators.	TEL	Later project stages	1	3	3
Financial	Uptake profile not met	Assumed uptake used in financial model and business case is not met, condition precedent not met and financial close delayed		3	5	15	YES	Continued focussed efforts, marketing, open houses. Staging options assessed and sensitivity analyses carried out	SMEC and TEL	Later project stages	2	4	8
Financial	Investor interest	Lack of investor interest in scheme leading to inability to attract funding		3	5	15	YES	Identify areas to optimise scheme to maximise viability. Close out uncertainty by testing sensitivity.	SMEC	Later project stages	2	5	10
Financial	O&M forecasts exceed estimates	Changes viability of scheme		2	3	6	NO	Testing of sensitivity. Benchmarking to recent projects by SMEC and others	SMEC	Later project stages	2	2	4
Financial	Business case indicates the project is not feasible	Project does not proceed to next stage.		2	3	6	NO	Prepared in accordance with the BQ guidelines. Manage high risk items identified in this risk register to focus study on high impact items	SMEC	Later project stages	2	2	4
Financial	Market volatility and demand	market cannot handle the new injection of produce		3	5	15	YES	Indepth market analysis and assess new international markets such as ASEAN markets. Utilisation of current published and acceptable market data	SMEC	Later project stages	2	2	4
Legislative	Community legal issues	Community groups oppose project and present legal challenges such as Traveston Crossing Dam		2	4	8	YES	Early engagement with stakeholders vital to formulate the project approach.	SMEC and TEL	Later project stages	1	4	4
Water	Water losses	Underestimation of losses from the system leads to lack of water availability.	Apply best practice to arrive at accurate estimates. Carry out sensitivity analyses.	3	4	12	YES	Conservative estimates to be undertaken or better definition of losses required during design. Detailed investigation at later design stages	SMEC and TEL	Later project stages			0
Water	Integration with other Burdekin River water rights	Inability to source Sufficient water	Staging of scheme to be assessed to mitigate impacts should water not be shown to be available.	3	2	6	NO	None identified		Later project stages			0
Water	Environmental water flows impact on available supply	Environmental flow conditions imposed during approvals process impact on availability of water		3	4	12	YES	Staging of scheme important to mitigate impact from unforeseen changes to flow requirements.	SMEC	Later project stages	3	4	12
Technical/Environment	New land clearing and new agricultural development	Nutrient and chemical runoff into natural rivers and water courses/streams from agricultural land	Provision of sedimentation control weir at Big Rocks Weir	4	4	16	YES	Development of an EIS and nutrient distribution model. Assessment and incorporation of the legislative requirements for appropriate farming practises within the Business Case	SMEC	Ongoing	2	4	8
Operational	Operational philosophy	Operator and owner of scheme is unclear leading to underestimated operational costs		2	3	6	NO	Assumptions clearly stated, updated following review of ownership options.	SMEC	Later project stages	1	3	3
Technical	Dam failure during construction	Construction delays and delay to project commencement. HSE Risks	Consideration of diversion design during evaluation of dam sites	3	5	15	YES	Construction program to consider diversion risks. Diversion designed to appropriate standards during detailed design.	SMEC	Ongoing	2	5	10
Technical/Dams	Geotechnical issues at spillway outlet	Selection of flip bucket arrangement liekly to promote scouring and undermining issues	Geological assessment of the area and investigation around future geotechnical scope (completed)	3	5	15	YES	Conduct detailed geotechnical assessment of the outlet areas to inform the design on the optimum selection of dam foundation, spillway type and stilling basin if/as required.	SMEC	Ongoing	2	2	4
Technical	Material availability	Sufficient quantity and quality of material not available at site. Impacts chosen dam type and escalation of construction costs.		3	5	15	YES	Develop detailed geological model based on geological mapping, desktop studies, previous investigations etc. Prepare a geotechnical scope for next stage of the project.	SMEC	Ongoing	1	5	5
Technical	Survey accuracy	Impacts on the design of the distribution network due to coarse contour intervals. Potential redesign at later project stages once detailed survey available		2	4	8	YES	Source highest accuracy survey data available from publically available sources. Procure additional survey for partular sites after gap ananlysis an preliminary investigations.	SMEC	Ongoing	1	4	4
Technical	Ancillary infrastructure	Unforeseen commodity distribution costs or restrictions negatively impact project NPV		3	3	9	YES	Agribusiness studies will consider infrastructure associated with getting commodities to market.	SMEC	Ongoing	1	3	3
Technical	Dpeth of Alluvium valley at Mt Foxton	Incorrect footing design for dam wall. Under mining.		2	4	8	YES	Investment in understanding geolocgical profile more accurately	SMEC	Ongoing	2	3	6
Legislative	Approvals risk	Significant changes to project assumptions change viability of scheme.		3	5	15	YES	Early engagement with government agencies	SMEC	Ongoing	2	3	6
Legislative	Approvals risk	Opposition to project during approvals and consultation process		3	4	12	YES	Early consultation with stakeholders	SMEC and TEL	Ongoing	2	3	6

SMEC
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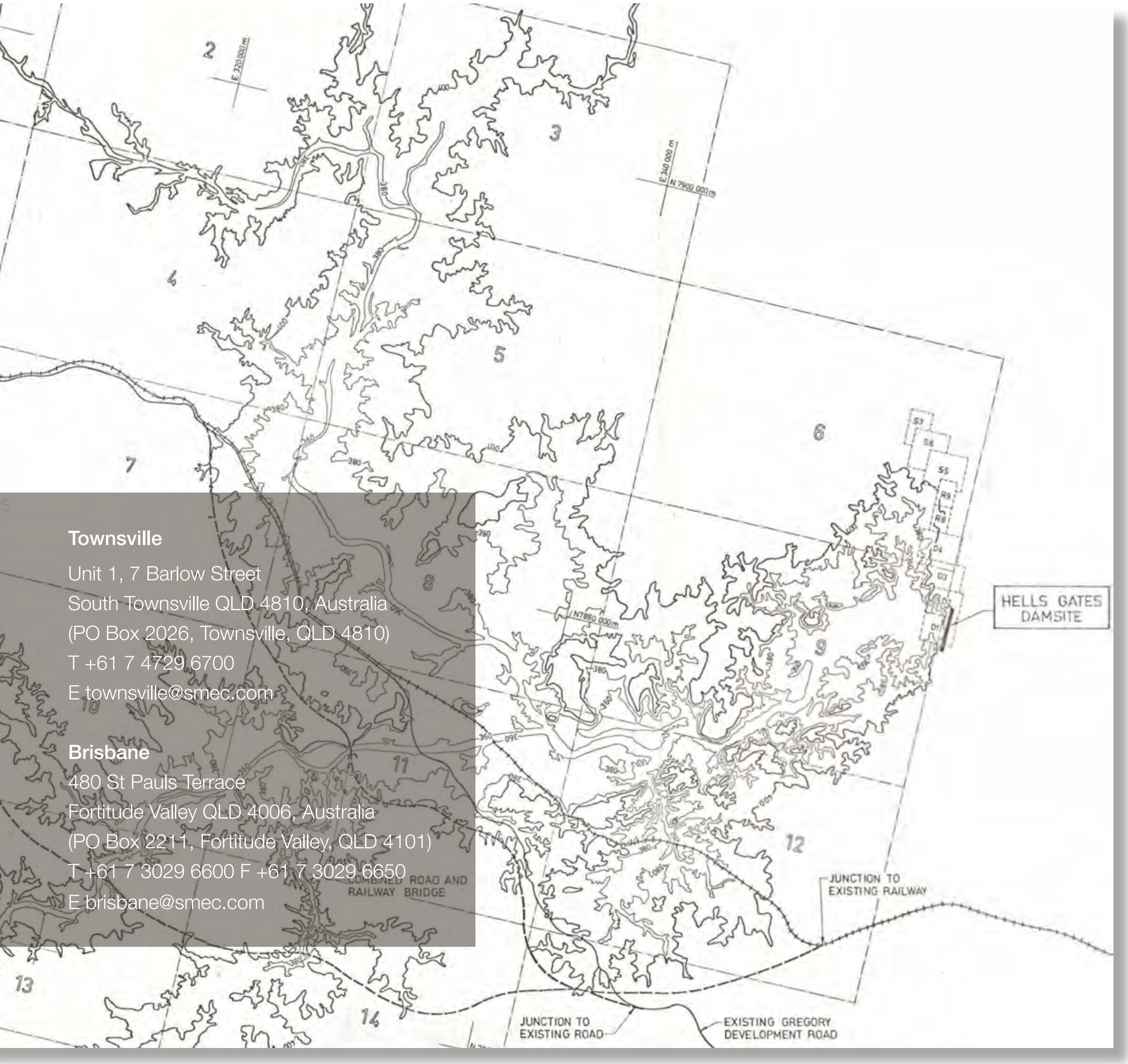

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