APPENDIX S.

Economic Assessment Report

South Rockhampton Flood Levee Implementation

Rockhampton Regional Council

29-Apr-2019

Doc No. 60589157:REP-022

South Rockhampton Flood Levee

Cost Benefit Analysis - 2019 Update

South Rockhampton Flood Levee

Cost Benefit Analysis - 2019 Update

Client: Rockhampton Regional Council

ABN: 59 923 523 766

Prepared by

AECOM Australia Pty Ltd
Level 1, 130 Victoria Parade, PO Box 1049, Rockhampton QLD 4700, Australia
T +61 7 4927 5541 F +61 7 4927 1333 www.aecom.com
ABN 20 093 846 925

29-Apr-2019

Job No.: 60589157

AECOM in Australia and New Zealand is certified to ISO9001, ISO14001 AS/NZS4801 and OHSAS18001.

Table of Contents

Executive Summary

E1 Overview

In October 2018, Rockhampton Regional Council (RRC) engaged AECOM Australia Pty Ltd (AECOM) to deliver concept / detailed design updates and support Statutory Approvals for the South Rockhampton Flood Levee (SRFL) project.

The primary objective of the SRFL is to protect residential and commercial properties within areas of Port Curtis, Depot Hill and the Rockhampton CBD against Fitzroy River flooding. These areas are to be protected up to and including the 1% Annual Exceedance Probability (AEP), which has been adopted as the Defined Flood Event for the project. The levee is approximately 8.74km long generally consisting of earthfill embankment, with portions being crib wall, vertical flood walls and temporary flood barrier systems.

E2 Update to the 2014 Economic Assessment

AECOM has updated a 2014 cost-benefit analysis (CBA) for the project. This report outlines the methodology and results of the CBA. The CBA results have been presented for 'direct' only benefits, and a combination of the 'direct' and 'indirect' benefits.

E3 Project Costs

Two cost streams for the flood levee were included in the economic analysis, including:

- Capital Expenditure: The 2018 cost estimate update was used in the economic analysis. The total capital cost is $80.36m, which equates to $72.70m in present value terms.
- Operational Maintenance Expenditure: Operational expenditure relating to maintaining the levee is estimated to be $450,000 per annum.

E4 Project Benefits

Investments in flood mitigation infrastructure such as flood levees can provide a cost effective and proven means of reducing the community's long term exposure to the risk of floods.

The CBA has separated out the benefits of reducing future insurance premiums and property valuations as there is some contention in the economic literature regarding inclusion of indirect benefits as it may lead to double counting. Insurance premiums and property values effectively capitalise the benefits of reducing the prevailing risk of extreme weather events.

Eight benefit streams were included in the economic analysis, including:

Direct benefits

- Reduced Flood Damages: Detailed numerical hydraulic modelling has been undertaken for the project and used to estimate average annual flood damages. The methodology and results have been documented in the Flood Damage Assessment Report for the base case and project case. The analysis found that the levee is expected to avoid $1.74m in damages each year.
- Reduced Social Impacts: In addition to the damages to existing infrastructure and asset damage which results from a flood, there is a significant social burden associated with a major flood event. An analysis of the 2010 Queensland floods found that social impacts accounted for slightly more than the direct flood damages. The ratio of social costs to flood damage costs is 52:48.
- Disaster Management Costs: A study conducted by Rolf et al (2014) for the SRFL estimated that the project will reduce disaster management costs in a major flood between $2.03m - $2.38m.
- Avoiding the upgrade of Lower Dawson Road: The Fitzroy River Floodplain and Road Planning Study (AECOM, 2011) presented an Implementation Programme for upgrades to the Bruce Highway and North Coast Rail line to meet the transport needs of the Rockhampton region to 2031 and beyond. Stage 6 – Lower Dawson Road Flood Immunity Upgrade is scheduled for 2021

and is expected to cost approximately $70m (2019 dollars). The SRFL will protect Lower Dawson Road from flooding up to a 1% AEP magnitude and therefore makes the investment redundant and the ensuing savings are treated as a benefit.

- Residual Value: The residual value captures the benefit associated with the useful life of the project extending beyond the evaluation period. AECOM estimate a useful life of 50 years, resulting in 25 years of life remaining at the end of the evaluation.

Indirect benefits

- Reduced Insurance Premiums: As the probability of a property flooding declines, the insurance premium paid is also expected to fall. A study undertaken by Rolf et al (2014) suggests an insurance premium saving of $0.2m to $0.94m per annum is achievable.
- Improved Property Values: A study by Rolf et al (2014) estimated that the SRFL would improve property values within the protected area over time by lowering the probability of flood damages. It is estimated that there might be an improvement in property values between $16m and $32m in total. However this would be a once-off improvement in values, and would take some years to be recognised fully. It is assumed this will be a gradual process over 12 years, with equal amounts per year.
- Reduced Business Interruptions and Losses: Interruptions to business operations are a major cost of flood events. There are currently three locations where businesses are impacted by local flooding and where the benefits of the levee would be most relevant: Depot Hill; Port Curtis and at Allenstown, along the Lower Dawson Road and Gladstone Rd. The loss of business production within the area to be protected by the proposed levee has been estimated in a study by Rolf et al (2014) using estimates of the labour force in the area. Estimated losses in GRP are $9.49m (low), $11.39m (medium) and $13.29m (high).

E5 CBA Results

Costs and benefits quantified in the analysis are summarised in Table E1.

Table E1 Headline Cost and Benefit Inputs - 7% discount rate, 25 years of benefits

Item	Direct Benefits Only	Direct and Indirect Benefits
COSTS		
Capital Expenditure	$72.7m	
Operational Expenditure	$4.6m	
Residual Value	-$6.5m	
Total Costs	**$70.8m**	
BENEFITS		
Reduced Flood Damages	$17.7m	$17.7m
Reduced Social Impacts	$19.5m	$19.5m
Reduced Disaster Management	$1.1m	$1.1m
Avoiding Lower Dawson Road Upgrade	$57.1m	$57.1m
Direct Benefits Subtotal	**$95.4m**	**$95.4m**
Reduced Insurance Premiums	N/A	$5.2m
Improved Property Values	N/A	$13.9m
Reduced Business Interruptions	N/A	$5.8m
Indirect Benefits Subtotal	**$0.0m**	**$24.9m**
Total Benefits	**$95.4m**	**$120.3m**

Based on the inputs, the project delivers a positive net economic benefit at the 7% discount rate for both the ‘direct’ and ‘direct plus indirect’ benefits are included (refer to Table E2).

The project is expected to produce a positive economic return mainly driven by the direct cost of flood damage and the avoidance of the Lower Dawson Road Upgrade with a BCR of 1.70 and a net present value (NPV) of $49.5m. The BCR with ‘direct’ only benefits is 1.35 and the NPV is $24.6m.

Table E2 Headline CBA Results - 7% discount rate, 25 years of benefits

Item	Direct Only Benefits	Direct and Indirect Benefits
BCR	1.35	1.70
NPV	$24.6m	$49.5m
FYRR	82.3%	85.8%
NPV/I	0.37:1	0.75:1

The CBA highlights that:

- the investment has economic merit and will contribute to effectively reducing the town’s ongoing exposure to flood risk;
- a major component of the potential benefits of the levee involves avoiding significant costs of upgrading other infrastructure assets; and
- there is considerable protective benefit from the flood levee, particularly in terms of avoiding damage to the built environment and minimising disruption to economic activity.

E6 Sensitivity Analysis

The headline results have been tested for variations to the underlying assumptions in the CBA, including changes to capital costs, operating costs, benefits and discount rate. A summary of sensitivity tests are provided below:

- Low Scenario for Benefits
- High Scenario for Benefits
- Capital Cost + 20%
- Capital Cost - 20%
- Annual Maintenance $1m per annum
- Social Impacts Reduced to 30%
- Lower Dawson Road Benefit Removed

Under all tests, the NPV and BCR remained well above the usual hurdle rates, noting that the removal of the Lower Dawson Road avoidance benefit brings the BCR below 1.0.

E7 Discount Rate Testing

The results of the CBA have been presented at different discount rates in accordance with guidance from Infrastructure Australia. While the 7% discount rate was used as the main assumption, given the current rates of interest in Australia (e.g. government bonds) there is an argument that a discount rate lower than 7% may be more appropriate.

These results show that the project is viable for both the ‘direct’ and ‘direct plus indirect’ benefit scenarios across the range of discount rates assessed.

Table E3 BCR at Various Discount Rates

BCR	4%	6%	7%	10%
Direct Only Benefits	1.70	1.44	1.35	1.15
Direct and Indirect Benefits	2.19	1.83	1.70	1.43

1.0 Introduction

1.1 Overview

In October 2018, Rockhampton Regional Council (RRC) engaged AECOM Australia Pty Ltd (AECOM) to deliver concept, detailed design updates and support Statutory Approvals for the South Rockhampton Flood Levee (SRFL) project.

1.2 Location and Context

Rockhampton is a large regional city located on the Fitzroy River approximately 640 kilometres north of Brisbane. The Rockhampton Regional Council area has a population of some 80,000 people and is a major service centre for the wider Central Queensland region. In addition to serving a range of industries including agriculture and mining, Rockhampton provides a full range of retail, education, health, social, government and professional services to a broad catchment.

The wider Central Queensland region that Rockhampton services and supports is experiencing continuing growth in mining and resources sectors, including Liquid Natural Gas and coal mining in particular. As a consequence, interruptions to logistics and services resulting from flooding in Rockhampton impact to varying degrees on the broader region and its industries.

The Central Queensland region is a world ranked producer and exporter of black coal and a major centre for mineral processing. The region hosts the coal-bearing Bowen and Galilee basins and also produces gold, silver, limestone, coal seam gas, magnesite and gemstones. There are currently 50 coal mines, 25 mineral mines and 30 medium to large (>50 000 tonnes per year) extractive quarries operating in Central Queensland.

1.3 Flooding from Fitzroy River Events

The Fitzroy River, which flows through the city of Rockhampton in the state of Queensland, drains a catchment of approximately 142,000 km^2 and is one of the largest catchments on the east coast of Australia. The catchment extends from the Carnarvon Gorge National Park in the West to Rockhampton on the central Queensland coast and is predominantly dominated by agriculture (grazing, dry land cropping, irrigated cotton and horticulture) and by mining (coal, magnesite, nickel and historically gold and silver).

Due to its immense size and fan-like shape, the Fitzroy River catchment is capable of producing severe flooding following heavy rainfall events in any of its major tributaries. These tributaries are the Dawson, Nogoa-Mackenzie and Connors-Isaacs Rivers which rise in the eastern coastal ranges and the Great Dividing Range and join together about 100 kilometres west of Rockhampton. Major floods can result from either the Dawson or the Connors-Mackenzie River catchments. Significant flooding in the Rockhampton area can also occur from heavy rain in the local area below Riverslea.

Rockhampton is the largest urban centre in Central Queensland and is located approximately 60 kilometres from the mouth of the Fitzroy River at Keppel Bay. The Fitzroy River at Rockhampton and adjacent townships has a long and well documented history of flooding with flood records dating back to 1859. The highest recorded flood occurred in January 1918 and reached 10.11 metres on the Rockhampton flood gauge (8.65m AHD).

It must be noted that extensive social and economic impacts are also experienced in more frequent, minor flood events. As examples:

- Low lying areas of Port Curtis and Depot Hill are inundated at a gauge height of 7.0m which is equivalent to the Minor Classification given by BOM.
- The Depot Hill community is isolated at a gauge height of 7.5m which is equivalent to the Moderate Classification given by BOM.
- The Bruce Highway at Lower Dawson Road is cut at a gauge height of approximately 8.4m.
- Low lying areas of Allenstown are inundated at a gauge height of 8.5m which is equivalent to the Major Classification given by BOM.

- Depot Hill and Port Curtis have been impacted by 33 historical flood events over 7.0m in gauge height since records commenced in 1859.
- There have been 17 historical flood events over a gauge height of 8.0m in which the Bruce Highway (Lower Dawson Road) has been cut.

1.4 The South Rockhampton Flood Levee

The SRFL project represents one of the most significant regional flood mitigation projects currently proposed in Queensland. The SRFL was identified as a Priority 1 Structural Mitigation Measure in the 1992 Rockhampton Flood Management Study (CMPS&F, 1992). Construction of the levee will significantly reduce flood damage and social impacts for a large portion of the urban area in South Rockhampton.

The SRFL will be approximately 8.74km long, running from the Rockhampton CBD in the north (Fitzroy Street and Quay Street), to Jellicoe Street and Port Curtis Road in the south, and Upper Dawson Road (Yeppen North) in the west (refer to Figure 1). It will consist of sections of earth embankment, crib wall, vertical flood wall and temporary demountable levee structures (component lengths are summarised in Table 1).

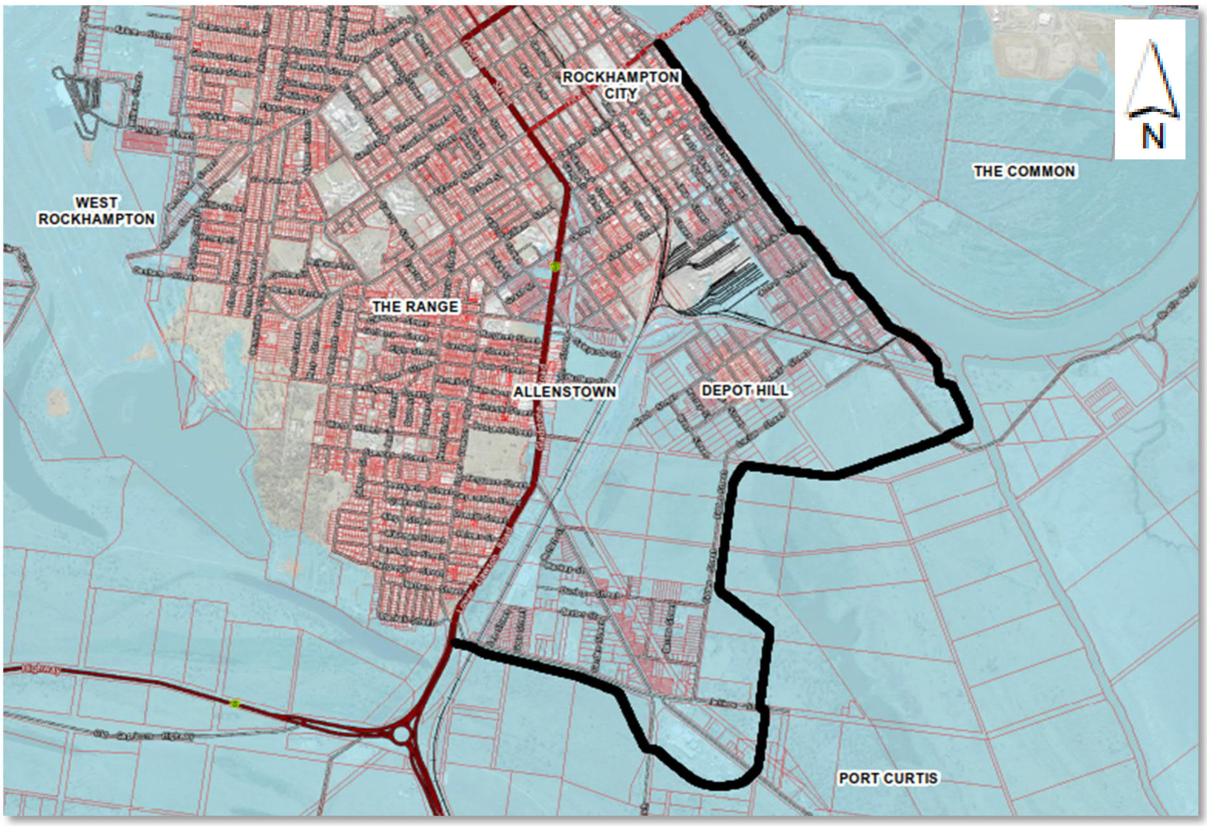

Figure 1 Location of the Proposed SRFL (Baseline Fitzroy River 1% AEP Flood Extents Shown)

The levee will be constructed to 1% Average Exceedance Probability (AEP) or 100 year Average Recurrence Interval (ARI) flood immunity with 600 mm freeboard. This will be equivalent to a 9.89 m gauge level (post SRFL construction).

The levee will incorporate flood gates on the major drainage channels and existing piped drainage networks that discharge outside the levee will be fitted with non-return devices to prevent river back-up. A system of landside drainage channels and three interior pump stations will discharge local catchment runoff should local rainfall events coincide with a regional Fitzroy River flood event.

Table 1 SRFL Component Lengths

Levee Type	Length (m)
Temporary Fully Demountable Wall	732
Composite Demountable / Permanent Levee Wall	967
Levee Emergency Spillway	420
Earth Embankment (incl. road ramps and gates)	5,892
Crib Retaining Wall	729
Total Levee Length	**8,740**

1.5 Project Delivery

The SRFL project is being delivered in two distinct stages, as detailed below.

1.5.1 Stage 1: Early Works (Pre-construction services)

Prior to construction starting on the SRFL project, early works will be completed. The works include land acquisition, stormwater, water and sewage relocations, river bank protection works and drainage works. Early works are anticipated to commence in 2019, and will be undertaken progressively throughout the year.

1.5.2 Stage 2: Main Contract

Council is committed to finalising the consultation, environmental and planning approvals, technical investigations and design of the SRFL project, to facilitate tendering and construction. The SRFL construction works are anticipated to start in late 2019.

The SRFL project has been declared a prescribed project by the Minister for State Development, Manufacturing, Infrastructure and Planning. Approvals for the project are yet to be obtained, and will be facilitated through the Infrastructure Designation process under the *Planning Act 2016*. This will include the preparation and exhibition of an Environment Assessment Report (EAR).

1.6 Scope of Works

The purpose of this report is to provide a detailed economic appraisal to support the Rockhampton Regional Council in its funding submission for the South Rockhampton Flood Levee.

The report brings together a range of direct and indirect costs and benefits pertaining to the project. It also brings together cost and benefit estimates from a number of specialist sources.

The project is expected to provide a level of protection against flood events which have recently and historically affected the township and surrounding area. Each of the previous events has caused considerable damage, social and logistic dislocation, economic hardship and many other adverse impacts.

1.7 Report Structure

- Section 2.0 discusses the approach taken in the cost-benefit analysis.
- Section 3.0 details the costs of the project, both capital and maintenance.
- Section 4.0 describes the quantified benefits of the analysis.
- Section 5.0 concludes the report by summarising the economic results.
- Section **Error! Reference source not found.** provides a brief summary
- Section 6.0 summarises references used in undertaking the assessment.

2.0 Cost Benefit Analysis Approach

2.1 Overview

A cost-benefit analysis (CBA) compares the costs and benefits of a project, program or option in monetary times across its useful life. The outputs of the analysis provide policy makers with sufficient information to make an investment decision on a project based on the net benefit (or dis-benefit) to society. Unlike financial analysis, economic cost-benefit analysis incorporates non-financial benefits and costs such as social impacts.

The approach undertaken in the CBA is shown in Figure 2.

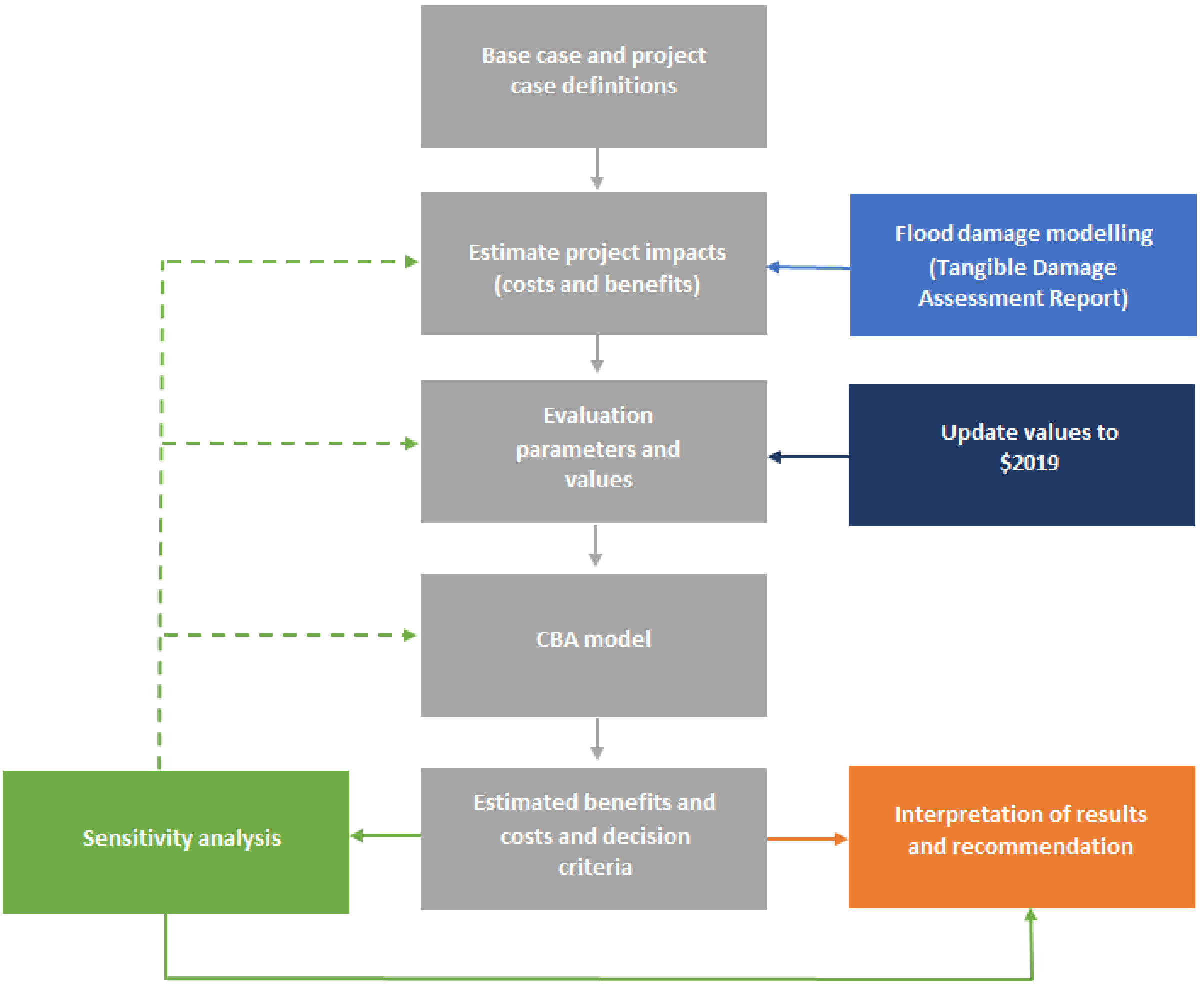

Figure 2 Approach to cost-benefit Analysis

2.2 Key Components of the CBA

2.2.1 Base and project case

The CBA is an incremental analysis between two scenarios, one "without the project" (base case) and one "with the project" (project case). The benefits in the CBA concern the avoided damage from floods, social hardship and secondary impacts. The objective of most flood related projects is to lower the impact flooding has on the community. The costs considered in the CBA relate to the capital costs required to build the levee. Other costs such as maintenance are also included.

In the CBA, the base case is defined as the current situation, i.e. no levee. The project case is defined as the installation of the SRFL.

2.2.2 Discount rate

In economics, the discount rate is used to convert future benefit and costs streams to a present value (i.e. today's value). Costs and benefits in the future are valued less highly than those incurred today due to the time preference of money. For example, you would prefer to receive $100 today than receive $100 in five years as you have the opportunity to invest the money today to return a higher dollar value in the future.

Based on the Infrastructure Australia guidelines, a discount rate of 7% was used as the main assumption. This is assumed to be a 'real' discount rate. Sensitivity testing of the CBA under different discount rates was undertaken and is presented in the results section of the report.

2.2.3 Evaluation period

The first year of the evaluation is 2019. The capital expenditure period is for a total of two years with commissioning mid-2021. Benefits are then calculated for a period of 25 years from commissioning. As such, the costs and benefits between 2019 and 2046 (inclusive) are included in the CBA. The evaluation period used in the CBA is shown in Table 3.

Table 2 SRFL Evaluation Period

	Years	Total Years
Capital Expenditure Period	2019 to 2021	2
Commissioning	Mid 2021	-
Benefit Period	2021 to 2046	25
Total	2019 to 2046	27 (includes overlap of commissioning and finalisation of capital)

2.2.4 Inflation and Price Year

The CBA is undertaken in constant 2019 prices. Costs and benefits were assumed to increase at the same rate. The CBA was thereby undertaken in real terms or "inflation neutral".

2.2.5 Prices

In economic analysis, costs are valued in resource prices (as opposed to market values), as taxes are viewed as transfer costs that distort economic behaviour. Where relevant, the GST component was excluded.

2.2.6 Indexation of Unit Parameters (escalation)

The data used in the CBA are sourced from a range of previous work. These reports have been conducted at various points in time for different purposes. To update these reports to current dollars, Consumer Price Indices (CPI) from the Australian Bureau of Statistics (ABS) have been used for the relevant years.

2.2.7 Explanation of Economic Criteria

Five measures of the economic worth were calculated including the Net Present Value (NPV), Benefit Cost Ratio (BCR), Net Present Value Index (NPVI), First Year Rate of Return (FYRR) and the Internal Rate of Return (IRR). NPV is the difference between the Present Value (PV) of project benefits (PV (B)) discounted at the chosen discount rate minus the PV of costs (PV (Capital, K + Other costs, C)):

- $NPV = PV(B) - PV(K + C)$

The proposed project may be considered worthwhile if the NPV is greater than zero. The Benefit Cost Ratio (BCR) is the ratio of the present value of benefits to the present value of costs:

- $BCR = PV(B) / PV(K + C)$

The project is potentially worthwhile if the BCR is greater than 1. In the presence of funding constraints, the BCR provides a way of ranking the project against other projects. The BCR enables projects to be ranked in terms of the economic benefit per dollar of economic cost.

The NPVI is the net present value per capital dollar invested. This is also known as the capital efficiency ratio. The formula is:

- *NPV/I = PV (B) / PV (K)*

The FYRR measures the rate of return in the first year of operations. It is a useful measure to determine project timing. If the FYRR is greater than the discount rate then immediate construction of the project is warranted, while a FYRR lower than the discount rate may justify a delay in construction.

The formula is:

- *FYRR = PV (Bt1) / PV (K + Ct1)*

The economic internal rate of return is the discount rate at which the NPV is equal to zero. The project is potentially worthwhile if the IRR is greater than the test discount rate of 7%.

3.0 Project Costs

3.1 Overview

There are two components to the costs of the project - capital and ongoing costs. Capital expenditure will be required in order to build the levee. This expenditure relates to the initial cost of building the levee and includes risk and contingency. In the economic analysis, escalation has been removed from the capital costs. Secondly, additional maintenance costs were included in the project case relating to the upkeep of the levee.

The remainder of this section describes the method of calculation for the capital and ongoing expenditure.

3.2 Capital costs

The estimated capital costs associated with the SRFL were estimated in 2014 and updated in 2019 based on updated market rates and escalation from 2014 to 2019. It is noted that a refined cost estimate for the project will be completed following obtainment of final statutory approvals and completion of the design.

The 2019 costs are tabled below.

Table 3 Project Capital Costs

Item Code	Item	Est. Cost ($)
1000	Site Establishment & Contractor Preliminaries	3,164,000
2000	Provision for Traffic Management	1,001,000
3000	Environmental Management	1,321,000
4000	Levee Structures	39,062,000
5000	Levee Crossings	3,428,000
6000	Drainage Works	1,702,000
7000	Pump Stations	4,094,000
8000	Existing Services	1,098,000
9000	Borrow Pit Works	1,222,000
10000	Principal's Costs and Obligations including Contingency	11,024,000
-	2018/19 Design Inclusions and Updates	9,670,000
-	Market Escalation (accounting for buoyant market conditions)	3,600,000
	Project Total Cost	**$80,386,000**

For the purposes of the economic analysis, escalation has been excluded from the capital costs. Escalation beyond 2019 is excluded to ensure the costs are in "real" economic prices.

The development of the project is forecast to take 2 years starting in mid-2019 and ending mid-2021. The capital costs are provided in Table 4. It is assumed cost and construction is shared equally over the two years.

Table 4 Project Capital Costs ($m) – 7% discount rate

	Undiscounted cost ($m)	Discounted cost ($m)
Total	$80.39m	$72.67m

3.3 Ongoing costs

Ongoing costs were estimated by AECOM. It has been assumed that the levees will cost approximately $450,000 per annum to maintain. This has been assumed to occur in each year of the evaluation period post project completion.

Operation and maintenance costs estimates will be updated with completion of the detail design and Operation and Maintenance Manual.

4.0 Project Benefits

4.1 Benefits overview

The project has the potential to reduce flood damages in the South Rockhampton region during a range of different flood magnitudes. The levee is expected to provide protection for floods up to a 1% AEP Fitzroy River flood event.

The benefits quantified in this assessment draw from economic analysis completed in 2014 – refer Economic Analysis Report (AECOM, 2014). As such, each of the benefit categories have been carried over from the previous analysis. The breakdown of benefits is displayed in the figure below.

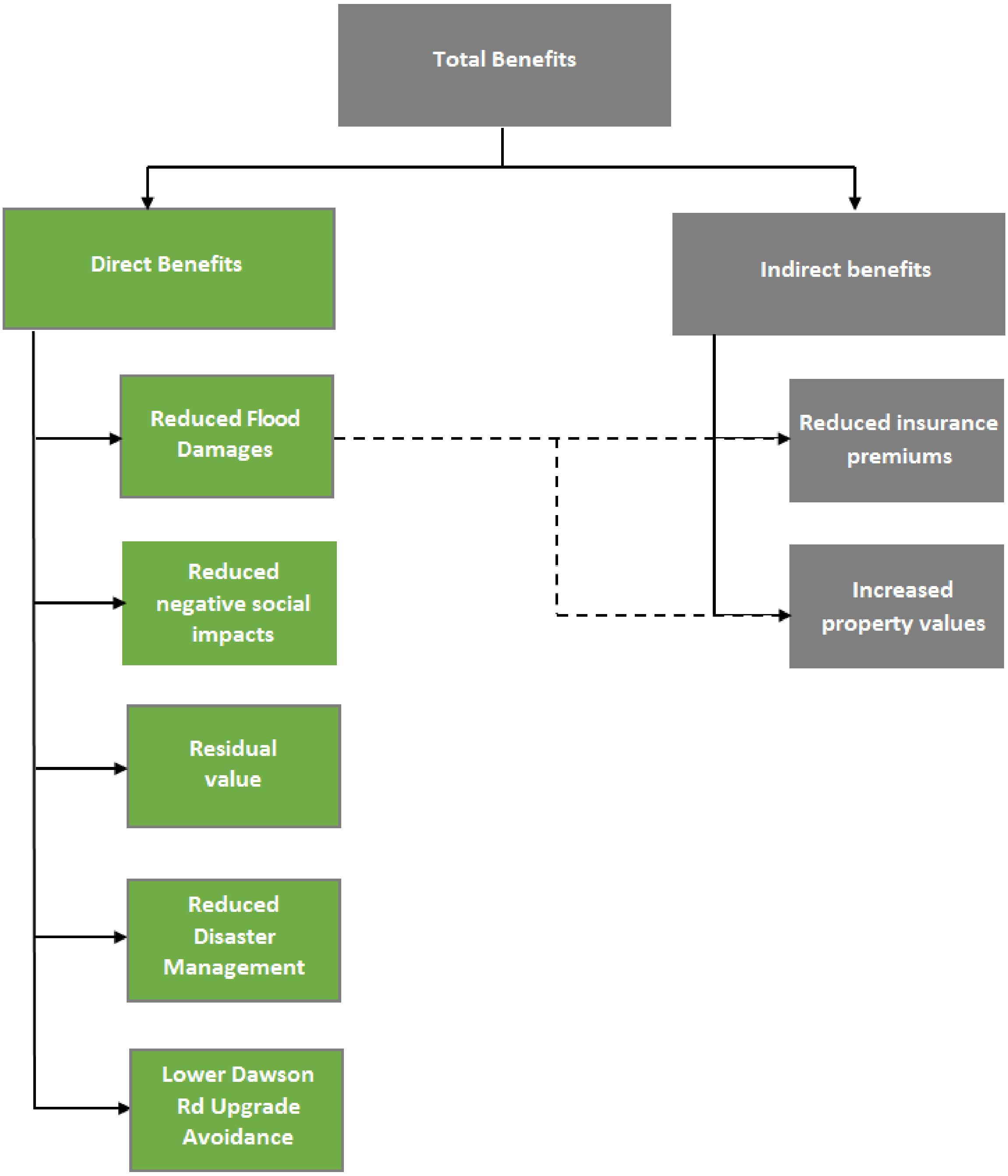

Figure 3 Direct and Indirect Benefits

The inclusion of "indirect" benefits, such as the reduced insurance premiums and improved property values may lead to double counting. From an individual's perspective, the value of flood damage is compensated when they are insured and the insurance premiums represent the annualised cost of this compensation. The reduction in the cost of insurance can be seen as another estimate of expected reduction in flood damage associated with the levee. However, because not everyone (or everything) is insured, this figure will always be less than the total cost of flood damage.

Similarly, changes in property value are excluded from the direct benefits because the higher property values capture the reduced risk of damage from flooding, people are willing to pay more for properties which are less likely to flood because of the reduced value of expected flood damages. To avoid any double counting issues, the benefits have been broken into two streams, "direct" and "indirect", with the CBA results presented using both streams and direct only.

The remainder of this section describes the benefits that were quantified as part of the CBA.

4.2 Direct Benefits

As part of the economic analysis, five direct benefit streams have been quantified. These primarily relate to the avoidance of the economic costs associated with a flood event. The five quantified direct benefits include:

- Reduction in flood related damages to residential and commercial premises.
- Reduced negative social impacts which arise as a result of a flood event.
- Reduced disaster management costs.
- Avoidance of Lower Dawson Road Upgrade.
- A residual value.

These benefits are described in the sub-sections below.

4.2.1 Reduced Flood Damages

AECOM have undertaken an updated Tangible Flood Damages Assessment Report (AECOM, 2019) for the SRFL project. This report determines the likely reductions in tangible flood damage for levee concept design alignments. Flood damages have been calculated based on the residential and commercial land parcels, property information (property area, type, size and use of building), floor level data (actual survey, or estimated by other means), flood level data for a range of flood events and various stage-damage curves (often depending on building type, use and area). Property information, floor and flood level data are compared using Geographic Information System (GIS) techniques with stage-damage relationships applied to each property and building. The sum of the individual property damages is then aggregated to give the total damage.

Based on guidance from the Department of Natural Resources and Mines (DNRM), the flood damage calculation is divided into two basic divisions: tangible costs (both direct and indirect) and intangible costs. Tangible costs are those that can be measured directly in monetary terms with the direct cost component being those costs that occur immediately and as a direct exposure to floodwater. Indirect costs are consequential to the flood itself. Intangible costs are viewed as unable to be quantified in monetary terms and, as such, are excluded from the damage estimations.

Tangible damages are financial in nature and are assessed by determining the damage or loss caused by floodwater. They include two sub-categories:

- Tangible (direct) damages caused by the wetting of items and assets as either equal to the cost of repairs and loss of value, or the replacement cost of the item.
- Tangible (indirect) damages are the additional financial losses caused by a flood, such as the extra cost of accommodation, loss of wages, loss of production and opportunity cost to the public causes by the closure or limited operation of public facilities.

The average annual damage (AAD) is able to be calculated for the base case (no levee) and the project case (construction of a levee) based on the flood damage curves of various flood event types.

These costs are then annualised based on the expected cost of the flood type and the respective probability that a flood of that nature occurs. AAD has been assessed for two separate assessment methods and has been treated as an upper and lower bounds for the project. For the purposes of this report the base scenario is taken as the average of the upper and lower estimates.

Table 5 Reduced Flood Damage Benefits

Damage Curve	Average Annual Damages				
	Existing	Proposed	Decrease	Increase	Net Change
WRM	$5,586,362	$3,909,050	-$1,747,161	$69,849	-$1,677,312
O2 Environmental	$8,278,544	$6,473,100	-$1,889,090	$83,646	-$1,805,444
Average (Adopted)	**$6,932,453**	**$5,191,075**	**-$1,818,126**	**$76,748**	**-$1,741,378**

4.2.2 Reduced Social Impacts

Social impacts of severe natural disasters such as floods include:

- Mental health and psychological distress.
- Family violence.
- Alcohol and drug misuse.
- Increase in crime rates.

To supplement the reduced flood damage benefits, an estimate of the social impact associated with a flood has been calculated. To include these social impacts, a review of the relevant literature was undertaken in the absence of time and data availability to conduct primary research. A recent study by Deloitte Access Economics (2015) reviewed the economic cost of the social impact of natural disasters, including an analysis of the 2010 Queensland floods[1]. In these floods, intangible costs exceeded the value of the direct tangible flood damage costs.

Estimates of total tangible flood damages for the 2010 Queensland floods are approximately $6.7 billion. However, the intangible costs represent an additional $7.4 billion for a total of $14.1 billion. This suggests that intangible flood costs are 110% of the tangible costs. This is shown in the figure below.

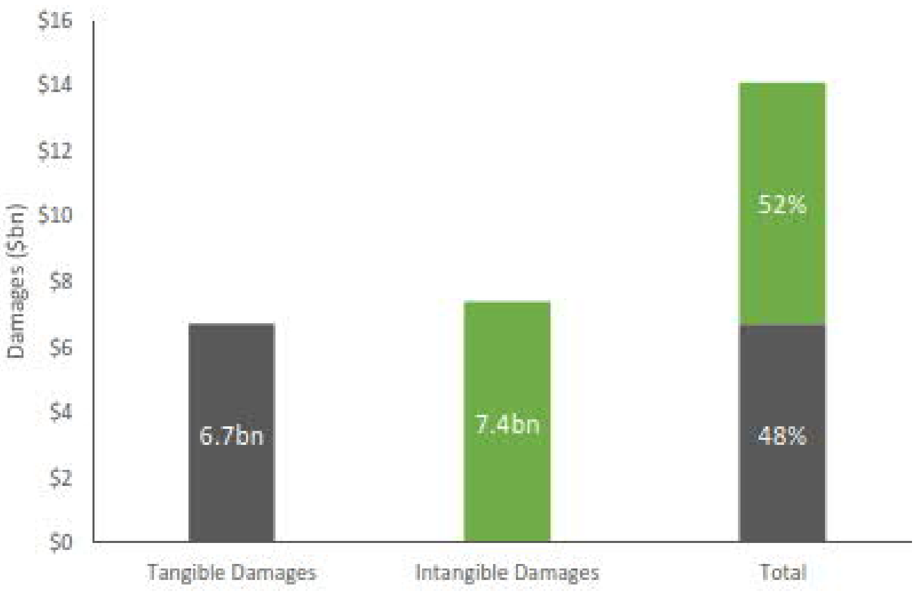

Figure 4 Tangible and Intangible Impacts of the 2010/11 Floods (source: Deloitte Access Economics)

[1] Deloitte Access Economics (2015), 'The economic cost of the social impact of natural disasters', Australian Business Roundtable for Disaster Resilience and Safer Communities.

For the purposes of the CBA, the 52:48 split between intangible and tangible flood damages has been adopted as it includes the wide range of flood related social impacts. This is applied to the AAD from the Tangible Damage Assessment Report. The table below presents the calculations used to establish the social impact.

Table 6 Calculation of Social Impact from Direct Impact – 2018 AAD Figures

Item	Values
Tangible Damages – Base Case	$6.93m
Tangible Damages – Project Case (average)	$5.19m
Tangible Flood Damages – Benefit	**$1.74m**
Social Multiplier (tangible to intangible)	*110%*
Social Flood Damages – Base Case	$7.62m
Social Flood Damages – Project Case	$5.71m
Social Damages – Benefit	**$1.91m**
Total Flood Benefit – Tangible and Social (intangible)	**$3.65m**

4.2.3 Residual Value

The residual value captures the benefit of the asset life extending significantly beyond the end of the appraisal period used in the cost-benefit analysis. The straight-line depreciation method was adopted.

The asset life is 50 years, with the evaluation period being 25 years. As such, half of the capital cost with escalation removed has been included in the final year of the evaluation.

4.2.4 Reduced Disaster Management

This benefit section is sourced from work undertaken by Rolfe et al (2014)[2]. To quote:

Floods involve substantial coordination and investment of public and community services. The level of investment has risen in recent decades as state and local governments assume more responsibility to minimise adverse and risky impacts. Three levels of response could be identified from the 2011 and 2013 floods:

- *Local government services: Estimates of the disaster management costs incurred by the Rockhampton Regional Council in the 2011 flood event have been reported at $1.5 million.*
- *State level services: Front line services are largely provided by the Queensland State Emergency Service and the Queensland Police Service, with other departments. For the purpose of this report, it is assumed that the disaster management costs of the Queensland Government departments and agencies was equivalent to the costs incurred by the Rockhampton regional council.*
- *Voluntary services: These costs were mainly associated with self evacuation and the evacuation centre. The economic cost of evacuation was estimated at $630,000, ranging from $530,000 to $880,000.*

On this basis, total disaster management costs for a major flood in the proposed levee protected area are $2.13 million, ranging from $2.03m to $2.38m.

The analysis undertaken by AECOM is based on the median estimate (escalated to 2019 dollars) but the low and high estimates have been included for sensitivity testing.

---

[2] Rolfe, J., Windle, J. and Small, G. 2014. *Assessment of the economic and social benefits of a South Rockhampton Flood Levee.* Report Prepared for the Rockhampton Regional Council. CQ University

4.2.5 Avoidance of Lower Dawson Road Upgrade

The federally funded Fitzroy River Floodplain and Road Planning Study investigated long term solutions for existing and forecast Bruce Highway and North Coast Rail Line flooding, freight and road transport impacts in and around the city of Rockhampton.

The centrepiece of the strategy is the Western Combined Road and Rail Corridor, comprising the Western Road Corridor and the Western Rail Corridor. The strategy recommends the staged implementation of the western combined road and rail infrastructure to provide for the strategic transport needs of Rockhampton and Central Queensland to 2031 and beyond. Individual components of the implementation program were determined for road and rail.

Stage 6 (Bruce Highway Lower Dawson Road Flood Improvements) was anticipated to cost $40M in 2011 dollars. Through recent discussions with the Department of Transport and Main Roads (TMR), the project is expected to cost $70M in 2019 dollars due to escalation, design updates and market conditions. The project is scheduled for 2021 if required. This stage is necessary to prevent Bruce Highway traffic being diverted to Upper Dawson Road in Fitzroy River flood events – a local road with potential safety and geometric limitations.

The SRFL would make the investment redundant and the ensuing savings are treated as a benefit.

4.3 Indirect Benefits

Three indirect benefits have been quantified in the economic analysis. As mentioned earlier, there are issues surrounding the inclusion of these benefits as they may lead to some double counting. They have been included, however, for consistency with the "Preliminary Evaluation". The three indirect benefits quantified are:

- Reduced business interruptions and losses.
- Reduction in insurance premiums for people in the leveed area.
- Increase in property values for residents in the leveed area.

These indirect benefits are quantified in the sub-sections below.

4.3.1 Reduced Business Interruptions and Losses

This benefit section is sourced from work undertaken by Rolfe et al (2014). To quote:

Interruptions to business operations are a major cost of flood events. Losses can occur through impacts on property and stock, the loss of staff wages during downtime, inability to trade, and impacts on the supply chain. It is difficult to identify the costs of flood interruptions on businesses in the area of interest with any degree of precision.

There are currently three locations where businesses are impacted by local flooding and where the benefits of the levee would be most relevant: Depot Hill; Port Curtis and at Allenstown, along the Lower Dawson Road and Gladstone Rd.

The loss of business production within the area to be protected by the proposed levee has been allocated using estimates of the labour force in the area. Assuming that businesses would be closed in the relevant area for two weeks in a major flood generates an estimate of $11.39 million in lost production. Reductions in business turnover would be higher, while the estimated loss in working time was estimated at $6.54 million. A sensitivity analysis using employment levels of 2,500 and 3,500 employees have also been modelled.

Estimated losses in GRP are $9.49m (low), $11.39m (medium) and $13.29m (high).

4.3.2 Reduced Insurance Premiums

The benefits in this section are sourced from work undertaken by Rolfe et al (2014).

To quote:

Construction of the SRFL is estimated to protect 1000 dwellings from flooding which will reduce the cost of flood insurance premiums. This will be a reduction in annual costs that is dependent on the size of the premium reduction and the number of households that take out flood insurance.

Information is available from the 2011 floods about the insurance claims made in Rockhampton which can be applied to this case study.

Annual values for reduced flood insurance range from a low of $207,033 to a high of $940,330. The medium estimate is $515,507.

The analysis undertaken by AECOM is based on the medium estimate (escalated to 2019 dollars) but the low and high estimates have been included in the sensitivity testing.

4.3.3 Improved Property Values

This benefit section is sourced from work undertaken by Rolfe et al (2014). To quote:

Housing in the flood effected area of Depot Hill sells at a major price discount relative to similar suburbs in Rockhampton. The current median price of housing in Depot Hill is $162,000 compared to Wandal at $299,000 (values sourced from RPData).

In Depot Hill and other areas protected by the levee it is likely that flood mitigation work will improve perceived amenity, and the currently substantial value blight will begin to dissolve once flooding is known to be no longer a threat. In terms of likely timing, there will be three periods to consider as follows:

1) *From announcement to actual commissioning of flood mitigation: Due to speculative expectations part of the eventual benefit will likely accrue to the flood affected properties. An increase of 10% to 20% could be expected. This would lift the median price of properties in Depot Hill to between $180,000 and $194,000.*
2) *Following the completion of flood mitigation works: Once there was no risk concerning flooding in Depot Hill price growth of between 40% and 50% could be expected, or eventual prices in the range $225,000 to $245,000. This growth may require two to 10 years to be fully realised, but would be offset by the private investment in property to bring housing up to a comparable standard to other parts of Rockhampton. This would still leave Depot Hill at a discount to comparable parts of Wandal of 20% to 25%, largely due to social preferences between the two localities.*
3) *Gentrification: This will be a long term factor that will rely on a different profile of resident moving into Depot Hill, initially on the basis of its low cost and high amenity. These new residents will likely have the resources to redevelop their properties, forming highly desirable neighbourhoods and this will produce a subsequent momentum effect that will propel values higher. Gentrification is an uncertain possibility that may be realised over the longer term and would require substantial private and public investment.*

It is estimated that there might be an improvement in property values net of any private investment of between $16,000 and $32,000 per property, or between $16 and $32 million in total. However some other private and public costs may be involved. It would be a once-off improvement in values, and would take some years to be recognised fully.

AECOM's analysis is based on the medium estimate (escalated to 2019 dollars) but the low and high estimates have been included for sensitivity testing. Further, given the length of time for the ramp up in property values, it is assumed this is a gradual process over 12 years, with equal amounts per year.

4.4 Summary of Benefits

The direct benefits of the SRFL project are summarised in Table 7.

Table 7 Discounted Direct Project Benefits ($million)

Discount Rate	4%	6%	7%	8%	10%	% at 7%
Disaster Management Cost	1.5	1.2	1.1	1.0	0.8	*1.1%*
Flood Damage	25.1	19.8	17.7	15.9	13.1	*18.6%*
Reduced Social Impacts	27.6	21.7	19.4	17.5	14.3	*20.4%*
Avoid Lower Dawson Road Upgrade	62.2	58.8	57.1	55.6	52.6	*59.9%*
Total	**116.5**	**101.5**	**95.4**	**90.0**	**80.8**	***100%***

A summary of direct and indirect benefits is provided in Table 8.

Table 8 Discounted Direct and Indirect Project Benefits ($million)

Discount Rate	4%	6%	7%	8%	10%	% at 7%
Disaster Management Cost	1.5	1.2	1.1	1.0	0.8	*0.9%*
Flood Damage	25.1	19.8	17.7	15.9	13.1	*14.7%*
Reduced Social Impacts	27.6	21.7	19.4	17.5	14.3	*16.2%*
Avoid Lower Dawson Road Upgrade	62.2	58.8	57.1	55.6	52.6	*47.5%*
Reduced Insurance Premiums	7.4	5.9	5.2	4.7	3.9	*4.4%*
Improved Property Values	17.4	14.9	13.9	12.9	11.3	*11.5%*
Reduced Business Interruptions and Losses	8.2	6.5	5.8	5.2	4.3	*4.8%*
Total	**149.5**	**128.8**	**120.3**	**112.8**	**100.2**	***100%***

5.0 Results

5.1 Overview

The aggregated results and headline results are presented to provide sufficient information to decision makers on the economic merit of the project. Similarly, the results of the sensitivity analysis are presented which provide an overview of how different assumptions influence the results. A brief overview of the limitations of the CBA is also provided.

The CBA results have been presented for “direct” only benefits, and a combination of the “direct” and “indirect” benefits. There is some contention in the economic literature regarding inclusion of “indirect” benefits (i.e. property values and changes in insurance premiums) as it may lead to double counting.

5.2 CBA Results

Based on the costs and benefits quantified in the analysis, the project delivers a positive net economic benefit at the 7% discount rate for both the ‘direct’ and ‘direct plus indirect’ benefits are included.

The project is expected to produce a positive economic return mainly driven by the direct cost of flood damage and the avoidance of the Lower Dawson Road Upgrade with a BCR of 1.70 and a net present value (NPV) of $49.5m. The BCR with ‘direct’ only benefits is 1.35 and the NPV is $24.6m.

The CBA highlights that:

- the investment has economic merit and will contribute to effectively reducing the town’s ongoing exposure to flood risk;
- a major component of the potential benefits of the levee involves avoiding significant costs of upgrading other infrastructure assets; and
- there is considerable protective benefit from the flood levee, particularly in terms of avoiding damage to the built environment and minimising disruption to economic activity.

Table 9 Headline CBA Results - 7% discount rate, 25 years of benefits

Item	Direct Benefits Only	Direct and Indirect Benefits
COSTS		
Capital Expenditure	$72.7m	
Operational Expenditure	$4.6m	
Residual Value	-$6.5m	
Total Costs	**$70.8m**	
BENEFITS		
Reduced Flood Damages	$17.7m	$17.7m
Reduced Social Impacts	$19.5m	$19.5m
Reduced Disaster Management	$1.1m	$1.1m
Avoiding Lower Dawson Road Upgrade	$57.1m	$57.1m
Direct Benefits Subtotal	**$95.4m**	**$95.4m**
Reduced Insurance Premiums	N/A	$5.2m
Improved Property Values	N/A	$13.9m
Reduced Business Interruptions	N/A	$5.8m
Indirect Benefits Subtotal	**$0.0m**	**$24.9m**
Total Benefits	**$95.4m**	**$120.3m**

Item	Direct Benefits Only	Direct and Indirect Benefits
CBA RESULTS		
BCR	**1.35**	**1.70**
NPV	**$24.6m**	**$49.5m**
FYRR	**82.3%**	**85.8%**
NPV/I	**0.37:1**	**0.75:1**

The FYRR is a useful way to optimise the timing of projects. If the FYRR is greater than the discount rate, the project should proceed immediately. If the FYRR is less than the discount rate, but still viable, then the project should be deferred until the FYRR equals the discount rate. Based on the range of discount rates tested, the project should commence immediately.

5.3 Sensitivity Testing

The headline results are tested for variations to the underlying assumptions in the CBA, including changes to capital costs, operating costs, benefits and discount rate.

The overall results of the sensitivity analysis for the 'direct' and 'indirect' benefits are shown in Table 10. Under all tests the NPV and BCR remained well above the usual hurdle rates, noting that the removal of the Lower Dawson Road avoidance benefit brings the BCR just below 1.0.

An increase to capital costs by 20% only reduces the BCR to 1.43. Variations in ongoing costs are not significant to the overall results with limited changes to the NPV or BCR. The benefit assumptions have a more significant impact on the results. When the upper bound benefits are used, the NPV increases by 23%. NPV reduces by 19% when the lower bound benefits are adopted.

Testing at different discount rates does not alter the accept/reject decision rule on the project. At the 10% discount rate the NPV is still positive at $30.1m.

Table 10 Sensitivity Analysis Results - Direct and Indirect Benefits

Sensitivity Test	NPV		BCR	
	Value	Change (%)	Ratio	Change (%)
Main Case	**$49.5m**	**-**	**1.70**	**-**
4% Discount Rate	$81.2m	64%	2.19	29%
6% Discount Rate	$58.3m	18%	1.83	8%
10% Discount Rate	$30.1m	-39%	1.43	-16%
Low Scenario for Benefits	$40.1m	-19%	1.57	-8%
High Scenario for Benefits	$60.7m	23%	1.86	9%
Capital Cost + 20%	$36.3m	-27%	1.43	-16%
Capital Cost - 20%	$62.8m	27%	2.09	23%
Annual Maintenance $1m per annum	$43.9m	-11%	1.58	-7%
Social Impacts Reduced to 30%	$35.9m	-27%	1.51	-11%
Lower Dawson Road Benefit Removed	-$7.6m	-115%	0.89	-48%

Where relevant, the same sensitivity tests were conducted for the 'direct' only benefits result. These are presented in Table 11. Under all tests, the BCR remains positive, with the exception of the scenario removing the Lower Dawson Road avoidance benefit.

Table 11 Sensitivity Analysis Results - Direct Only

Sensitivity Test	NPV		BCR	
	Value	Change (%)	Ratio	Change (%)
Main Case	**$24.6m**	**-**	**1.35**	**-**
4% Discount Rate	$48.1m	96%	1.70	26%
6% Discount Rate	$31.1m	26%	1.44	7%
10% Discount Rate	$10.7m	-57%	1.15	-15%
Low Scenario for Benefits	$23.3m	-5%	1.33	-1%
High Scenario for Benefits	$26.2m	7%	1.37	1%
Capital Cost + 20%	$11.4m	-54%	1.14	-16%
Capital Cost - 20%	$37.9m	54%	1.66	23%
Annual Maintenance $1m per annum	$19.0m	-23%	1.25	-7%
Social Impacts Reduced to 30%	$11.0m	-55%	1.16	-14%
No Lower Dawson Road Benefit	-$32.5m	-232%	0.54	-60%

5.4 Discount Rate Testing

While 7% discount rate has been used as the main assumption, there is a strong argument for adoption of a lower discount rate. Overseas, discount rates have fallen over the last 15 years as shown in the figure below (years indicate when discount rate was lowered). By comparison Australia has a relatively high discount rate of 7%. An unnecessarily high discount rate will result in an underestimation of future project benefits due to a higher discounting effect when compared to the initial investment costs. It is worth noting that that the *Building Up and Moving Out* report (Commonwealth of Australia, 2018) tabled in Parliament in September 2018, recommended the adoption of a 4% discount rate for the appraisal of Commonwealth infrastructure projects.

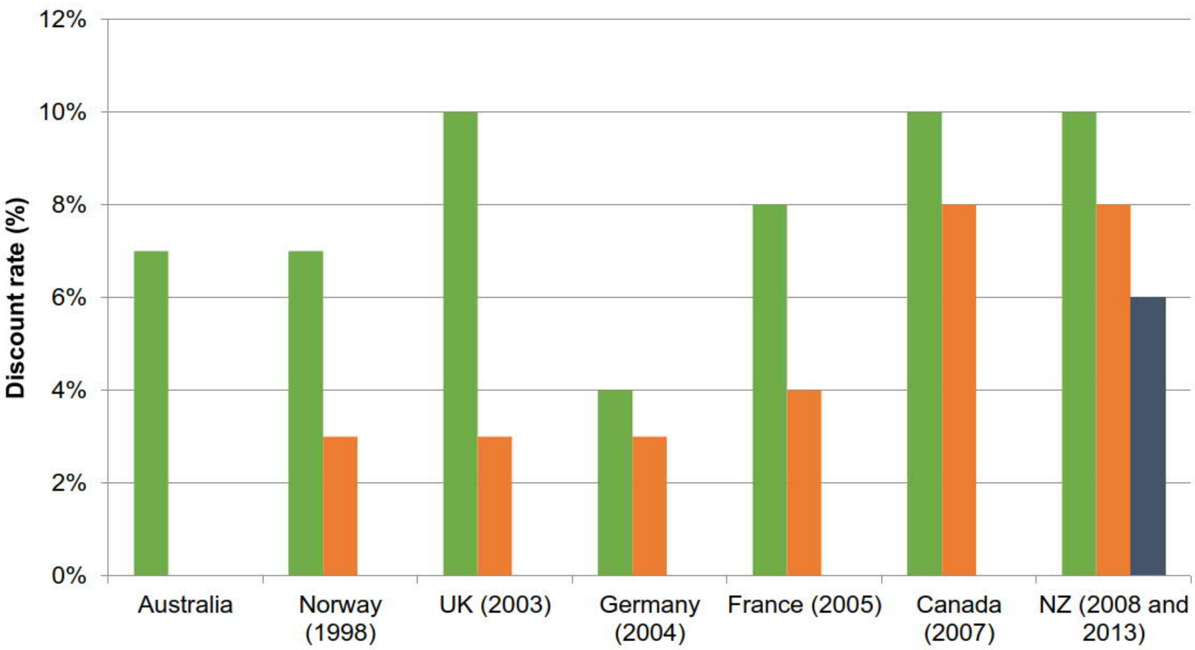

Figure 5 Discount Rates in Australia and Overseas

The results of the CBA are presented at different discount rates in accordance with guidance from Infrastructure Australia. While the 7% discount rate was used as the main assumption, given the current rates of interest in Australia (e.g. government bonds) there is an argument that a discount rate lower than 7% may be more appropriate.

These results show that the project is viable for both the ‘direct’ and ‘direct plus indirect’ benefit scenarios across the range of discount rates assessed.

Table 12 BCR at Various Discount Rates

BCR	4%	6%	7%	10%
Direct Only Benefits	1.70	1.44	1.35	1.15
Direct and Indirect Benefits	2.19	1.83	1.70	1.43

5.5 Limitations

The benefit stream is dependent on the final height of the levee. Flood damage estimates contain a significant number of sub-benefits which are difficult to separate from the total. These can include items such as emergency response and flood management, disruptions to business and losses, lost wages and productivity, etc. It may be that some of these benefits are conservatively estimated and the actual benefits could potentially be higher. On the other hand, the estimation of social costs is made by applying a factor that was estimated in another study. The use of this factor was a proxy in the absence of any specific information for Rockhampton.

The results of the CBA have been aggregated into ‘direct’ and ‘indirect’ benefits. The BCR is then calculated using “direct” only benefit and also using both ‘direct’ and ‘indirect.’ This is to ensure that there is transparency in the results and that any views on double counting of benefits can be addressed.

A few issues in relation to the possibility of ‘double counting’ benefits should be noted”

- First, the risk of natural disasters and avoided damages from mitigation are not always fully reflected in the pricing of insurance premiums. Business and public assets, in particular, may be uninsured or self-insured, and residential insurance pricing is often unable to be tailored to individual properties.
- Second, in a related sense, reductions in premiums for residential insurance products can also extend well beyond the more direct protective influence of levee assets — effectively enhancing accessibility of coverage and providing more wholesale benefits for local townships and immediate surrounds
- These issues mean that avoided infrastructure damage or residential pricing reductions can often be somewhat incomplete measures of the potential economic gains from levee investments, especially in more localised settings such as those examined in this study.

Given these inherent limitations, readers of this report should consider the results of the sensitivity and scenario testing and also whether the BCR should include ‘direct’ only benefits or both the ‘direct’ and ‘indirect’ benefits.

6.0 References

Rolfe, J., Windle, J. and Small, G. 2014. *Assessment of the economic and social benefits of a South Rockhampton Flood Levee*. Report Prepared for the Rockhampton Regional Council. CQ University

Aither 2013 *Flood Plain Management Economic Appraisal Guidelines* Draft Report for Department of Environment and Primary Industries

ATC, 2006, *National Guidelines for Transport System Management in Australia Volume 5: Background Material,* Commonwealth of Australia Section 1.10.4

Interim Cost Estimate Report, South Rockhampton Flood Levee (AECOM, 2019).

South Rockhampton Flood Levee Tangible Flood Damages Assessment Report (AECOM, 2019).

Building Up & Moving Out - Inquiry into the Australian Government's role in the development of cities prepared by the House of Representatives Standing Committee on Infrastructure, Transport and Cities (Commonwealth of Australia, 2018)