Economic Assessment of Flood and Drainage Schemes

Report to Otago Regional Council

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Acronyms and Abbreviations

Cumecs	Cubic metres per second
NPV	Net Present Value
ORC	Otago Regional Council
SH	State Highway
TLA	Territorial Local Authority

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Executive Summary

Otago Regional Council (ORC) operates five flood and drainage schemes that manage water levels in the Taieri Plain and the areas surrounding Clutha River.

A targeted rate is levied on beneficiaries of the scheme. The rate is based on the level of service provided in terms of water flows avoided on their properties.

The current benefit assessment finds that most benefits are to those within the scheme's boundaries ("private benefits") and identifies some small benefits (less than five percent) for those located outside of the scheme who do not directly benefit from avoided water flows ("public benefits").

The ORC now wishes to reassess what those public benefits are, if any, and what proportion of the overall benefits of the scheme they might be.

This report provides an economic assessment of the public-private benefit shares for the flood and drainage schemes.

There are varying levels of public benefit shares in the five schemes

There are public benefits from the existence of the schemes. However, in all the schemes, the private benefits make up a larger proportion of the overall benefits from the schemes. Table E.1 shows the estimate for the benefit shares for the five schemes;

Table E.1: Public Benefit Proportions for 5 Schemes

Scheme	Public-private benefit ratio
Lower Taieri flood	17:83
West Taieri drainage	8:92
East Taieri drainage	8:92
Lower Clutha flood	16:84
Lower Clutha drainage	6:94

We used a counterfactual test to assess the benefit splits

There are a range of possible methods for determining the public benefits. We have used a counterfactual approach, where we consider the situation if the infrastructure does not exist and flooding and rainfall events occur as they naturally would. The costs that would be faced in those circumstances are assumed to be proportional to the benefit received from the scheme.

We first assess all costs qualitatively to identify material costs. Then we quantify the costs that are identified as material. A 100-year sample of expected flood events is used and the net present value of the costs from the expected floods in that period is assessed. The ratio of in-scheme versus out-of-scheme costs is used to determine the ratio of public and private benefits.

There are some key reasons for the benefit splits

The majority of benefits are enjoyed by the local residents and businesses inside the scheme, as expected. However, small frequent events have a higher proportion of private benefits whereas larger, more severe and less frequent events would have region-wide impacts. By avoiding these costs, the schemes provide region-wide benefits.

The public benefits are above zero primarily because:

- Some of the schemes have important regional infrastructure within them including airports, state highways and railway lines, and disruption to these would have impacts that are widely felt by people and businesses throughout the region
- The economic activity that the schemes underpin also underpins related and dependent businesses even if they do not avoid water flows as a result of the schemes. This includes the economic activity enabled by the drainage schemes on a daily basis.
- Public services such as civil defence and emergency services, and highway operations benefit from a reduction in flood events both at the Territorial Local Authority level and the regional level.

There is some uncertainty to the results

Determining public and private benefit splits has a degree of uncertainty associated with it. This is partly a result of the fact that the future cannot be known with certainty and the projections of expected costs must make assumptions about what would happen over a long period of time. The reality is that much of the built environment is the way it is because of the scheme. The method employed here therefore should be seen as one way to make a reasonable assessment of the benefit splits.

We have tested the sensitivity range of benefit splits by varying key assumptions including the discount rate, the proportion of lost business inside (and therefore outside) the scheme, and the frequency of severe flood events. We find that the benefit shares are largely robust to changes in these key variables.

Applying high and low scenarios of these assumptions we find the sensitivity ranges for public-private ratios (listed in Table E.2).

Table E.2: Sensitivity Ranges for Public-Private Benefit Ratios

Scheme	Public-private benefit ratio	Sensitivity range	
		Low end	High end
Lower Taieri flood	17:83	13:87	24:76
West Taieri drainage	8:92	3:97	20:80
East Taieri drainage	8:92	3:97	19:81
Lower Clutha flood	16:84	13:87	21:79
Lower Clutha drainage	6:94	2:98	14:86

Applying this analysis to targeted rate levels and general rate levels

Some landowners are exempt from rates within the schemes. The options to recover funds from these properties is not available to the ORC. The available options are to either increase the targeted rate, increase the general rate, or some combination. Increasing the general rate is preferable from an efficiency perspective as the economic distortions are minimised by distributing this cost broadly in the manner of a tax.

If changes to the rates were contemplated, the public benefits could be recovered from general ratepayers or from a new targeted rate on a subset of regional ratepayers. A district wide targeted rate would be likely to capture the majority of public benefits. There are some exceptions to this, including road and rail assets that connect regional

networks. The efficiency differences between a district rate and a regional rate would be small. Additional administrative costs could be incurred by new targeted rates.

Table E.3 illustrates the distribution of out-of-scheme benefits at a district and regional level. Generally, the district benefits make up most of the public benefit proportion. The exception to this is the Lower Clutha flood protection scheme, where the regional benefit is driven by avoiding the costs of reduced road and rail access, and emergency response costs.

Table E.3: Distribution of Benefits

Scheme	Private benefit (%)	Public benefit	
		District (%)	Regional (%)
Lower Taieri flood	83	13	4
West Taieri drainage	92	8	0
East Taieri drainage	92	8	0
Lower Clutha flood	85	4	12
Lower Clutha drainage	94	6	0

1 Introduction

The geography of the Otago region lends itself to flood and drainage schemes that manage water levels to protect communities and enable the productive use of land. There are five such schemes in the Taieri Plain and the area surrounding the southern end of the Clutha River.

The costs of the schemes are allocated to different parties based on who is thought to benefit from the schemes. Costs are targeted based on the proportion of benefits to those inside the scheme ("private benefits"), while costs are spread across the district or region based on the proportion of benefits to those outside of the scheme ("public benefits").[1] Otago Regional Council (ORC) has engaged Castalia to review the split between public and private benefits for flood and drainage schemes in the region.

We provide some background on the schemes directly and then describe the role and structure of this paper.

Background

Otago Regional Council operates five flood and drainage schemes that manage water levels in the Taieri Plain and Lower Clutha. Flood protection schemes protect against large storms up to a certain level of severity. Drainage schemes are designed to handle lighter, more frequent rainfall, therefore providing continuous benefits.

The ORC is responsible for constructing and maintaining the flood banks and spillways that make up the schemes.[2] These schemes enable the residents, businesses, the public and government agencies in these areas to carry out their day-to-day activities, and provide protection in the event of severe rainfall or snowmelt.

The areas covered by the schemes are largely used for agricultural purposes and rural residences.[3] Sheep and beef, and dairy are the main productive uses of farmland. In the Taieri Plain, the schemes include significant transport infrastructure including Dunedin International Airport, state highways, and railway lines. The Lower Clutha flood and drainage schemes cover State Highway 1 and rail infrastructure. Both schemes include towns and communities that services the surrounding farming businesses. These are Mosgiel and Outram in the Taieri Plain, and Balclutha in Lower Clutha.

Figure 1.1 shows the location of flood and drainage infrastructure in the Otago region.

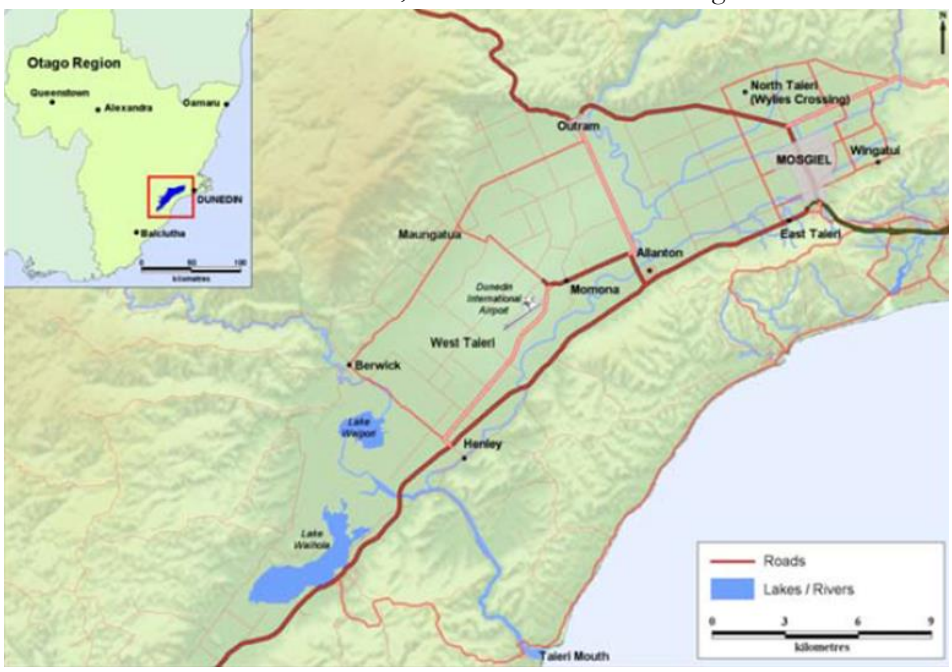
[1] We note that this interpretation differs from the economic definitions for public and private benefits.

[2] See p.77, http://www.orc.govt.nz/Documents/Publications/Corporate/Long%20Term%20Plan%202015/Long%20Term%20Plan%202015-25.pdf.

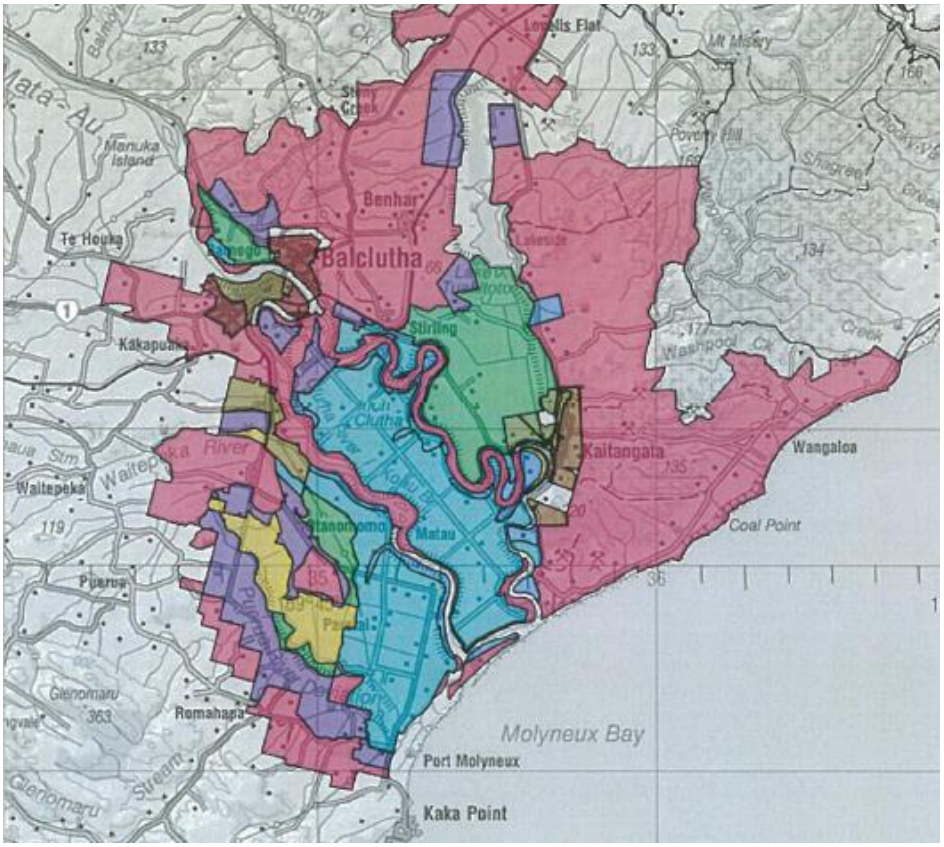
[3] See http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/Hazards%20on%20the%20Taieri%20Plains/Taieri%20Report%20-%20Introduction.pdf.

Figure 1.1: Location of Flood Protection and Drainage Schemes

Lower Taieri Flood Scheme, and West and East Drainage Schemes [1]



Lower Clutha (coloured area is the scheme) [2]



Source: [1] ORC, Natural Hazards on the Taieri Plains, Otago, July 2012.

[2] ORC, Request for Proposal- Economic Assessment of Otago Regional Council's flood and drainage schemes, September 2015

Currently, land owners living within the boundaries of the flood protection and drainage schemes bear all, or most of, the costs of maintaining the schemes. This is achieved through targeted rates that are levied on land owners. For some schemes, a small proportion of the costs are also shared across a wider group. The current targeted rates are based on an assessment of direct benefits received in flood protection by those in the scheme's defined area. Direct benefits are currently measured by reduced water flows as a result of the schemes.

Table 1.1 summarises current funding arrangements across the five schemes in the Otago region.

Table 1.1: Current Funding Policies for Flooding and Drainage Schemes

Area	Scheme	Percent of funding from targeted rates	Percent of funding from wider funding sources
Lower Taieri	Flood protection	96%	▪ 2% general rates at regional level ▪ 2% general rates from Dunedin City
West Taieri	Drainage	100%	
East Taieri	Drainage	100%	
Lower Clutha	Flood protection	98%	2% general rates from Clutha district
	Drainage	100%	

Source: ORC, Long Term Plan 2015-2025, p.50.

Purpose of this paper

In this study we assess the economic benefits of the schemes including all benefits to those inside and outside the flood protection schemes. Then we assess what public-private cost-sharing arrangement would accurately reflect how benefits from the flood and drainage are shared between ratepayers inside and outside the schemes.

This assessment was informed by feedback from the public in Taieri and Balclutha. A summary of their feedback is attached in Appendix A.

We carry out the economic assessment in three steps (Section 2 describes these in greater detail):

- Determine a counterfactual and identify the types of costs (that is the benefits of the scheme) that would be incurred (Section 3)
- Qualitatively assess the benefits to find material benefits (Section 4)
- Quantify the material benefits for each scheme (Section 5)

We are then able to identify the ratio of public to private benefit for each of the schemes, and highlight issues to consider if the rating policy is changed to reflect these ratios (Section 6).

2 Methodology

The three steps in our economic assessment of benefits from the flood and drainage schemes are:

1. Determine a counterfactual and identify the types of costs that would be incurred

The economic benefits of the schemes are considered to be the avoidance of the costs that would be incurred in the absence of the schemes. To understand this, we pose a counterfactual whereby the schemes do not exist and flooding occurs as it naturally would. This requires the consideration of expected rainfall, flooding inundation levels and frequencies.

The frequency is expressed as a '1 in 5' year event and a '1 in 20' year event and so on to describe the frequency (and severity) of a particular level of flood event.

In the counterfactual scenario there would be a range of types of costs expected. We identify and describe the direct and indirect costs that are faced by those inside and outside the schemes. These impacts (the benefits of the scheme) are described in Table 2.1:

Table 2.1: Impact Categories

Impact	Description
Loss of life	Deaths that occur as a result of the flood event
Impaired health	Injuries and illnesses caused by the flood event
Damage to non-commercial property	Structural and contents damage to residential homes as a result of flooding
Loss of land or output on farms or businesses	Damage to farm infrastructure and lost productive output on farmland, and the flow-on impacts on local and regional businesses
The cost of the emergency response and repairs	The costs of evacuation, immediate welfare needs for those affected by the event, support and advisory services
Reduced access via roads	The disruption to users of road infrastructure (individuals and businesses)
Reduced access via rail	The disruption to users of rail infrastructure (businesses only)
Reduced access via the airport	The disruption to users of the airport (individuals) and the regional businesses that rely on passenger arrivals (e.g. regional tourism)

2. Qualitatively assess the benefits to find material benefits of the schemes

Before quantifying the impacts of a flood event, the impacts are assessed based on their materiality, so that quantification efforts are focused on the impacts that best reflect the overall public-private benefit ratio.

The impacts are assessed using a qualitative assessment framework in four levels: negligible, low, moderate and high. These assessments consider the likelihood of the impact, the number of parties affected, the scale of the impact to those parties. The definitions are described in Table 2.2:

Table 2.2: Qualitative Cost Assessment Guide

Assessment	Description
Negligible	The impact is managed by a small number of residents, farms or businesses without noticeable flow on effects
Low	The impact is noticeable through the community where the event occurred but not beyond
Moderate	The impact is felt throughout the community including those not directly affected by flood waters and there is a detectable impact within the region
High	Significant impacts are detected across the region and/or beyond the region and the effects of the event are felt for some time after

3. Quantify the material costs and determine the ratio of in-scheme to out-of-scheme costs

To focus on the most material impacts, those that are assessed as moderate or high are quantified.

These impacts are individually quantified for each scheme, given that the costs of an event will differ in different areas as a result of the built and natural environment and the linkages with the rest of the region. We use appropriate methods for each specific cost across the schemes. These methods are summarised in Table 2.3:

Table 2.3: Quantification Methods

Impact	Quantification Methods
Damage to non-commercial property	Apply damage-depth curves for different levels of flood inundation for non-commercial properties
Loss of land or output on farms or businesses	▪ Estimate infrastructure losses on farms ▪ Estimate production losses on farms by assessing the extent of effective hectares lost, and multiple by the average value per effective hectare ▪ Assume amount of farms' expenses no longer spent in service towns (e.g Mosgiel and Balclutha), with losses inside and outside of the scheme
The cost of the emergency response and repairs	Apply evacuation costs based on past flood events by the number of people evacuated
Loss of access: Road	Apply costs of additional journey time and fuel cost from having to take alternative routes when roads are inaccessible, or the wider implications to the regional economy when roads are inaccessible and no alternatives are available
Loss of access: Rail	▪ Estimate the lost wages and salaries for those working on the rail line ▪ Estimate the lost value of key products being sent to Port Chalmers due to delays on rail line
Loss of access: Airport	▪ Estimate the lost revenue to the airport company ▪ Estimate the lost revenue to the region from fewer arrivals ▪ Apply costs of additional journey time and fuel cost from some passengers taking alternative routes when airport is inaccessible

Impacts are measured for each expected flood event severity and frequency over a 100-year sample period. The benefits of flood and drainage schemes are therefore the avoided costs of an event, multiplied by the events' expected frequency without the scheme. Total costs are measured using a net present value (NPV) analysis of the costs over the period. The NPV model is set with a discount rate of 7.5 percent. Other rates are also tested for sensitivity.

These assessments are uncertain

The assessment of costs and the resulting ratios are subject to a degree of uncertainty that is a result of several factors. These factors include:

- Predicting the timing, severity and coverage of flooding events
- Predicting the costs of flooding events.

This economic assessment deals with this uncertainty in two ways:

- While the total amount of expected cost remains uncertain, this uncertainty would be expected to affect both sides of the ratio (the pubic and the private impact). This means that while the overall cost of an event might be uncertain the ratio is less uncertain
- Remaining uncertainty is dealt with by altering assumptions made in our quantitative assessment, using different scenarios of expected outcomes to understand a range of possibilities.

3 Categories of Benefits

In the event of a flood without the flood and drainage schemes in place, there would be a range of costs incurred. For both flood and drainage schemes, the benefits of the infrastructure are the costs avoided from events that would be incurred without the infrastructure.

Given that drainage schemes essentially manage very small flooding events; they have the same categories of benefits as flood schemes. However, the level of significance of some of these benefits will differ between flood and drainage schemes.

Infrastructure can protect land from events up to a certain severity. For example, parts of the flood protection schemes in Taieri are built to handle up to and including 1 in 100 year floods.[4] This means that an event more severe than a '1 in 100' year event may still breach the infrastructure protection levels and flood the land causing damage.

Similarly, the drainage systems are designed to drain between 8mm to 18mm of rainfall within a 24-hour period, depending on the part of the scheme.[5] Under the counterfactual, there would be no drainage system to manage the typical rainfall and ponding in the scheme area. For the purpose of finding the public-private benefit ratio, we use annual and 3-year events to calculate the benefits from drainage schemes. In reality, drainage benefits will be more frequent, which would increase the absolute value of the benefits, but the public-private ratio would remain unchanged.

We define the counterfactual using rainfall and flood events of differing levels of frequency and severity. Table 3.1 illustrates how we define the characteristics of each event, which provide the framework for identifying the impacts of events. These characteristics are our interpretation of the hazard information produced by ORC.[6] Characteristics such as inundation and flooding duration are difficult to predict as they vary based on the event, and specific locations in the scheme, and can be influenced by local features such as embankments and buildings.[7] Where assumptions have been necessary, these were generally informed by past events in the schemes, or similar sized flood events.

[4] Communication with ORC.

[5] Communication with ORC.

[6] See http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/2015/Flood%20hazard%20on%20the%20Taieri%20Plain%20Revision%20One%20WEB.pdf, http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/Hazards%20on%20the%20Taieri%20Plains/2013/Intro.pdf, and http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/FRH%203%20upper%20lower%20Clutha.pdf.

[7] See http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/2015/Flood%20hazard%20on%20the%20Taieri%20Plain%20Revision%20One%20WEB.pdf.

Table 3.1: Characteristics of Rainfall and Flood Events in the Taieri Plain

Return Period	Rainfall[8]/River Flow (cubic metres per second (cumecs))	Inundation (metres above floor level)	Flooding duration
Annual	▪ 6mm/day	-0.5m	Up to a few hours
3-year	▪ East: 8mm/day to 18mm/day[9] ▪ West: 10mm/day[10]	-0.5m to -0.1m	Few hours
5-year	▪ Taieri at Outram: 825 cumecs ▪ Silver Stream: 112 cumecs	0m	Few days
10-year	▪ Taieri at Outram: 1,100 cumecs ▪ Silver Stream: 140 cumecs	0m	Few days
20-year	▪ Taieri at Outram: 1,430 cumecs ▪ Silver Stream: 170 cumecs	0.5m	Few days to a week
50-year	▪ Taieri at Outram: 1,950 cumecs ▪ Silver Stream: 220 cumecs	0.5m	Around a week
100-year	▪ Taieri at Outram: 2,500 cumecs ▪ Silver Stream: 260 cumecs	0.5m above floor level	Up to a few weeks

Source: ORC, Memorandum: Updated flow return periods for Taieri and Silver Stream (used for flows of flood events (5-year events and larger)).

Table 3.2: Characteristics of Rainfall and Flood Events in Lower Clutha

Return Period	Rainfall[11]/River Flow (cubic metres per second (cumecs))	Inundation (metres above floor level)	Flooding duration
Annual	5mm/day	-0.5m	Up to a few hours
3-year	Between 7.5mm/day (Kaitangata) and 10mm/day (Paretai)	-0.5m to -0.1m	Few hours
5-year	2,200 cumecs[12]	0m	1 day
10-year	2,850 cumecs	0m	1-2 days
20-year	3,400 cumecs	0.5m	Few days
50-year	4,300 cumecs	0.5m[13]	Few days

[8] Amount of excess rainfall that needs to be drained away within a 24-hour period.

[9] ORC, Long Term Plan 2015-2025, p.80. See http://www.orc.govt.nz/Documents/Publications/Corporate/Long%20Term%20Plan%202015/Long%20Term%20Plan%202015-25.pdf.

[10] ORC, Long Term Plan 2015-2025, p.81.

[11] Amount of excess rainfall that needs to be drained away within a 24-hour period.

[12] Communication with ORC

[13] Flood levels between 0.3 metres to 3 metres (depending on the area) forecast in the event of a 50-year flood. See p.31 http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/FRH%203%20upper%20lower%20Clutha.pdf.

100-year	5,200 cumecs[14]	0.5m	Over a week

Source: ORC, Flood Management on the Lower Clutha Delta, November 2000 (used for flows of flood events (5-year events and larger) unless otherwise stated).

3.1 Categories of Benefits from Flood Protection Schemes

The cost impacts are grouped into six categories and then assessed according to the unique circumstances in each scheme. We describe these categories and identify the parties that will be affected, whether they are inside or outside of the scheme area.

Loss of life

This impact includes the deaths that occur as a result of the flood event.

Those inside the scheme at the time of the event (residents and visitors) will be at risk. In contrast, the physical distance between those outside the scheme and the flooded area will largely ensure residents outside the scheme are not at risk of this impact.

Impaired health

This impact covers injuries and illness caused by the flood event. Illnesses can be caused where residents' health is impaired by:

- Lack of access to healthcare
- Farm drainage overflowing into residential areas, and contaminating water/vegetable gardens
- Stagnant water
- Overflows in the stormwater and wastewater systems.

Those inside the scheme will largely bear the costs of injuries. However, given that the costs of the stormwater and wastewater systems are spread across the district, the costs from system overflows will be borne by the wider community as well.

Damage to non-commercial property

This includes the results of flooding of residential homes, including structural and contents damage.

These costs will be borne by landowners and residents in the scheme area, rather than those outside.

Loss of land or output on farms or businesses

On-farm impacts include damage to farm infrastructure (fences, tracks etc.) and the lost production value from the loss (or reduced health) of stock or crops, or ability to support stock or crops.

On-farm impacts then have flow-on effects to local businesses that serve rural communities.

These impacts are felt by those farmers inside the scheme that suffer damage and revenue losses. Businesses that service the affected area would lose business—these can be inside or outside of the scheme.

[14] Estimated based on a 200-year flood having a flow of 5,600 cumecs. ORC, Flood Management on the Lower Clutha Delta, November 2000.

Costs of the emergency response and repairs

These are the costs of evacuation, immediate welfare needs for those affected by the storm, support and advisory services.

Those outside the scheme would bear these costs, where co-ordinated emergency management is called on. The groups bearing these costs may be at a local, regional or national level.[15]

Reduced access via roads

The costs of this impact are the travel time costs to residents using roads, and the cost to businesses using road for freight. Costs to businesses can be through either lost or delayed business, or the additional cost using alternative route.

These costs are borne by those who would normally use the roads in the scheme. These users can be from inside or outside of the scheme.

Reduced access via rail

The costs of this impact are felt by the rail business including those using rail for freight purposes. This impact can be lost or delayed business, or the additional cost using alternative routes. There are also costs to the rail company from the delays.

Similar to roads, these costs are borne by the usual users of the rail. Given the dominance of road freight in the region,[16] and the small size of the scheme areas, we assume that rail users are from outside of the scheme. Similarly, rail employees are considered to be based outside of the scheme.

Reduced access via the airport

This covers the disruption to the usual operation of the airport through reduced arrivals, the additional costs to arrivals that instead choose a more expensive alternative route, and the losses to the businesses through the region that rely on passenger arrivals.

Where the airport is located within the scheme, the lost revenue to the airport is a direct cost of a flood event. The costs to passengers that use an alternative route, and the flow-on impacts of fewer tourists are both considered to be borne by those outside of the scheme.

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[15] In accordance with the National Civil Defence Emergency Management Plan, local authorities can request government financial assistance for response and recovery costs for civil defence emergencies. See http://www.civildefence.govt.nz/cdem-sector/cdem-framework/guide-to-the-national-civil-defence-emergency-management-plan/.

[16] See http://www.orc.govt.nz/Documents/Publications/Transport/Pressures%20and%20issues%20facing%20land%20transport%20in%20Otago_web.pdf.

4 Identifying Material Benefits

Using the categories identified under Section 3, we identify which benefits are material for each scheme. These judgements are based on the nature of the flood and rainfall events in the scheme areas.

We rank the materiality of benefits using a four-point scale:

- **Negligible**: The impact is managed by a small number of residents, farms or businesses without noticeable flow on effects
- **Low**: The impact is noticeable through the community where the event occurred but not beyond
- **Moderate**: The impact is felt throughout the community including those not directly affected by flood waters and there is a detectable impact within the region
- **High**: Significant impacts are detected across the region and/or beyond the region and the effects of the event are felt for some time after.

These assessments consider the likelihood of the impact, the number of parties affected, and the scale of the impact to those parties. Judgements are informed by scientific and engineering information,[17] and interviews with ratepayers in Outram and Balclutha.

We assess the two flood schemes and the three drainage schemes together given that similar factors determine the size of the impact within these categories.

4.1 Flood Protection Schemes

Table 4.1 assesses the impacts of floods in Taieri and Lower Clutha against the counterfactual, where the schemes would not exist.

Table 4.1: Assessment of Impacts of Flood Events without Existing Infrastructure

Type of Impact	Assessment for Lower Taieri Flood Scheme	Assessment for Lower Clutha Flood Scheme
Loss of life	Net impact assessment: **Low** ▪ The risk to lives is low in the event of a small flood ▪ The risk to lives is higher in the event of a large flood rather than in a small event (in the absence of the infrastructure). For instance, in a recent flood in Wellington (a 1 in 50-year event), there was one fatality ▪ While the cost of losing lives is high, its low probability means the overall impact is low	
Impaired health	Net impact assessment: **Low** ▪ Injuries and illness from flooding events are likely to affect several people in the scheme, which will be increased the longer that the flooding persists	

[17] See http://www.orc.govt.nz/Publications-and-Reports/Natural-Hazards/Natural-Hazards/Dunedin-City-District/ and http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/FRH%203%20upper%20lower%20Clutha.pdf.

Type of Impact	Assessment for Lower Taieri Flood Scheme	Assessment for Lower Clutha Flood Scheme
Damage to non-commercial property	Net impact assessment: **High** ▪ May suffer aesthetic damage ▪ Given the extent of property (residential and farms) in the Taieri area, damage to this property is likely to be widespread (and severe in a large event) within the scheme	Net impact assessment: **Moderate to High** ▪ Given that parts of Balclutha are on higher ground, property damage is more likely to be felt in higher level events, but would affect a large number of people
Loss of land or output on farms or businesses	Net impact assessment: **High** ▪ Damage to stock and ability to support them for several weeks (possibly longer, if the recovery time after the event is taken into account) ▪ Ability to support certain stock, crops or businesses in the area would be undermined ▪ Lost business to those reliant on expenditure by farms. Significant impact given multiple service towns in schemes	
The cost of the emergency response and repairs	Net impact assessment: **Moderate to High** ▪ A large flooding event would cause a high cost of response and subsequent reparation works ▪ Direct costs would be moderate in low level events as they require relatively little response (partly due to the ability to give some prior warning about the likelihood of flooding) and some reparation costs ▪ Cost to evacuate, house and provide welfare for residents in major event would be significant	
Loss of access via roads	Net impact assessment: **Moderate to High** ▪ The 'flood free' section of State Highway 1 will not to be affected ▪ The section of State Highway 1 protected by the scheme (south of Henley turn off) will face delays and loss of access in large events ▪ Residents and businesses (in- and out-of-scheme) using road infrastructure in scheme (State Highway 86 and State Highway 87) would face delays and costs from taking alternative routes	Net impact assessment: **Moderate to High** ▪ Residents and businesses (in- and out-of-scheme) using State Highway 1 would face delays and costs from taking alternative routes
Loss of access via rail	Net impact assessment: **Moderate** ▪ Businesses using rail infrastructure in scheme (Main South Trunk Line) would face delays and costs from lost business ▪ Given lenient characteristics of rail freight, businesses are more likely to bear cost of delays than use more expensive alternatives such as road freight	

Type of Impact	Assessment for Lower Taieri Flood Scheme	Assessment for Lower Clutha Flood Scheme
Loss of access via airport	Net impact assessment: **High** ▪ Revenue losses within scheme (to the airport company) and outside (to tourism-related businesses) ▪ Travel time costs from passengers taking alternative routes	Net impact assessment: **Negligible** ▪ With a peak of 11 aircraft movements per month since December 2010,[18] and one small crop-dusting business using the facility, very few people would be affected by not being able to access the Balclutha aerodrome

4.2 Drainage Schemes

Table 4.2 assesses the impacts of no drainage in West and East Taieri, and Lower Clutha, based on the counterfactual, where the schemes would not exist.

Table 4.2: Assessment of Impacts Without Drainage Schemes

Type of Impact	Assessment		
	West Taieri	**East Taieri**	**Lower Clutha**
Loss of life	Net impact assessment: **Negligible** ▪ There is a low risk of deaths as a result of heavy rainfall		
Damage to residents' health	Net impact assessment: **Low** ▪ Possibility of pooling of stagnant water given similar landscape and proximity of residential areas to farmland		Net impact assessment: **Negligible to Low** ▪ Populated areas on relatively higher land compared to farmland
Damage to non-commercial property	Net impact assessment: **Moderate** ▪ Possibility of damage from pooling of stagnant water		
Loss of land or output on farms or businesses	Net impact assessment: **Moderate** ▪ Cost per event is likely to be lower (re-seeding land etc), but large number of events could mean these costs make living or farming in the area does not make economic sense ▪ Farms and businesses inside the scheme would likely be unable to support certain stock, crops or businesses in the area would be undermined		
The cost of the emergency response and repairs	Net impact assessment: **Negligible** ▪ Without much cause for rescue operations, these costs are likely to remain low		
Loss of access via roads	Net impact assessment: **Low** ▪ Low levels of surface flooding may occur, but are unlikely to cause major delays or force users to take alternative routes		
Loss of access via	Net impact assessment: **Low** ▪ Low levels of surface flooding may occur, but are unlikely to cause major		

[18] See http://www.vatnz.net/airspace/airport/NZBA.

Type of Impact	Assessment		
	West Taieri	**East Taieri**	**Lower Clutha**
rail	delays		
Loss of access via airport	Net impact assessment: **Low** ▪ Low levels of surface flooding may occur, but are unlikely to cause major delays or prevent passenger arrivals		Net impact assessment: **Negligible** ▪ Low levels of surface flooding may occur, but volume of operations at aerodrome also mean that any costs of disruption are likely to be low

5 Quantifying Material Benefits

Quantifying the material benefits of the schemes will enable an assessment of the split between public and private benefits. Here we quantify the moderate and high impacts from Section 3. Costs of the impacts are allocated according to whether they would be borne publicly (that is by those across the region) in the event or privately (that is by those in the schemes).

The costs are modelled over a 100-year timeframe. We quantify impacts that are annual, 3-year, 5-year, 10-year, 20-year, 50-year and 100-year events. Annual and 3-year events are helped by the drainage schemes, but not considered to be flood events requiring flood infrastructure. Larger events are grouped under benefits of the flood protection schemes. We recognise that this is a limitation of this analysis as drainage schemes assist with water levels management in flood events.

We also recognise that in reality, drainage benefits will be more frequent as schemes provide a benefit by enabling agricultural land-use. If this reality was reflected in the model, the absolute value of the benefits from drainage would be higher. However, the ratio of public and private benefits from drainage would remain unchanged. For the purposes of finding the public-private ratio, our most frequent events occur annually. The list of quantified benefits is not exhaustive. We focus on calculating the material costs, which are likely to determine the public-private benefit ratio.

5.1 Benefits of the Lower Taieri Flood Protection Scheme

In the Taieri Plain, the material costs avoided by the flood protection scheme (the scheme's benefits) were damages to non-commercial property, losses on productive land, the cost of the emergency response and repairs, and reduced access via roads, rail and the airport.

Damage to non-commercial property

Damage to non-commercial property was determined by applying the expected damage per property (based on flood inundation levels) to the number of properties.

The expected damage per property was based on the depth-damage curves developed for the Macquarie floodplain in New South Wales, Australia. These curves calculate the cost per individual residence for flooding level above floor level (ranging from 5 metres under the floor level to 5 metres above floor level).[19] Given the differences in residential homes built in Australia and New Zealand, we have only applied the costs associated with single-storey slab/low set properties to non-commercial properties in the Taieri Plain.

We assumed that for moderately large events (5-year and 10-year events) the flood level was assumed to be at floor level, with dozens of properties affected. Large events (20-year, 50-year and 100-year events) assume that flood levels get up to 0.5 metres above the floor level, and affect over 100 properties. Table 5.1 summarises the public and private benefits of the scheme based on the avoided costs of damages to non-commercial property.

Table 5.1: Benefits from Avoided Damage to Non-Commercial Property

Costs ($000)	5-Year	10-Year	20-Year	50-Year	100-Year

[19] Bewsher Consulting Pty Ltd, Macquarie Park FRMS&P Final Report, February 2011. The costs for each level of flooding were converted from 2007 Australia dollars using the exchange rate for 1 September 2007 and adjusted for inflation.

Private	3,107	3,773	10,279	11,307	12,335
Public	0	0	0	0	0

Loss of land or output on farms or businesses

This impact was quantified by calculating the direct infrastructure and production loss on farmland, and the losses (both public and private) to businesses supporting farming businesses.

Impacts on farms include the immediate infrastructure losses (broken fences, tracks, silt-removal etc). Across the scheme we assume infrastructure losses vary from $2.5 million to around $40 million depending on the event.[20]

Production losses are the production that would have otherwise occurred without the flood or rainfall taking place. To find these losses, we multiplied the expected loss in effective hectares (excludes support blocks) by the value of the output that the hectares could have been used for. We assume that around 80 percent of the Taieri Plain are effective hectares.

The value of the output that would have been produced was based on the adjusted value of dairy output per effective hectare.[21] This value was adjusted to take account of the other farming activities on the Taieri Plain before being multiplied by the loss of effective hectares (ranges from 1 percent to 50 percent depending on the event). We note that these production losses can last for a number of years after a significant event has passed.

Losses to farm businesses have a further impact as farms will reduce their expenditure in the local economy, particularly rural service towns such as Mosgiel and Outram. We assume that the reduction in farm expenditure will be 50 percent of the lost production value. This will impact businesses located in and outside of the scheme. We assume that around 70 percent of the lost business would be to those inside the scheme, and 30 percent of lost business is to businesses outside of the scheme. Given the importance of this assumption, we alter this assumption in our sensitivity analysis in Section 6.

Table 5.2 summarises the public and private benefits of the scheme based on the avoided losses to farms and businesses.

Table 5.2: Benefits from Avoided Losses to Farms and Businesses

Costs ($000)	5-Year	10-Year	20-Year	50-Year	100-Year
Private	13,200	17,375	27,063	48,438	120,252
Public	1,189	1,486	2,229	3,715	8,917

The cost of the emergency response and repairs

The costs of the emergency response and repairs are based on the costs ($90 million) to central government incurred during the 2004 floods in Manawatu-Whanganui.[22] This was

[20] The June 2015 Taranaki and Horizons Regions flood had an estimated $43 million infrastructure damage, with up to 800 rural properties impacted. The return period on the flood varied from 70 years to 100 years on the three rivers that flooded. Ministry for Primary Industries, June 2015 Taranaki and Horizons Regions Storm: Primary Sector Impact Assessment. MPI Technical Paper No. 2015/28, 31 August 2015.

[21] The value of dairy output per effective hectare was calculated by multiplying the average dairy company payout over 10 years by the average milksolids per effective hectare produced in the Dunedin City district. See p. 19 http://www.dairynz.co.nz/media/1327583/nz-dairy-statistics-2013-2014-web.pdf.

[22] Horizons Regional Council, 'Storm', Civil Emergency, Storm and Flood Report, February 2004. Available at https://www.horizons.govt.nz/assets/publications/keeping-people-safe-publications/Civil-Emergency-Storm-and-Flood-Report-February-2004.pdf.

approximately $97,000 per person evacuated during those floods. We apply this rate to the number of people that would evacuated in an event in the Taieri Plain—ranging from 2 people for 5-year events to 100 people in 100-year events. While not all of these costs will be tied to evacuation costs, applying costs based on the number of evacuees helps link the costs with the magnitude of the event.

Table 5.3 summarises the public and private benefits of the scheme based on the avoided costs of emergency response and repairs.

Table 5.3: Benefits from Avoided Costs of Emergency Response and Repairs

Costs ($000)	5-Year	10-Year	20-Year	50-Year	100-Year
Private	0	0	0	0	0
Public	196	489	978	2,446	9,783

Reduced access via roads

The costs of reduced road access are based on the number of delays that main roads would not be accessible and road users would bear the costs of using alternative routes (fuel and time). For the purpose of estimating material costs, we focus on the most used roads in the area. The three state highways in the area are State Highway 1, State Highway 86 and State Highway 87.

State Highway 1

Most of State Highway 1 is on an embankment that is not part of the flood scheme. This section of the State Highway, the 'flood free' section, is not expected to be affected by any event.

However, there is a section of the State Highway (south of the turn off to Henley) that is not on the embankment, and therefore benefits from flood protection in the Lower Taieri. This section ('the protected section') is still elevated above the ground (average height is approximately 1.7 metres above mean sea level).[23] As a result, we consider that only relatively large events (20-, 50- and 100-year events) would impact the protected section of the state highway.

The height of the protected section also suggests that in the 20-year and 50-year events the traffic disruption on the State Highway is likely to be resolved quickly. The costs of not being able to access the protected section are based on the time and fuel costs from having to take an alternative route to access the 'flood free' section from the south. These calculations take into account that around 12 percent of traffic along State Highway 1 is from heavy vehicles.[24]

In a 100-year event, alternative routes to State Highway 1 may also be unavailable. We assume that the protected section may be completely inaccessible for 5 days. Given that State Highway 1 is part of a national network, losing access to just one section can have repercussions for the regional economy. Most industries affected would bear the costs of having to defer operations until the State Highway re-opens. A smaller group of businesses would bear greater costs from losing business or production during this time. Combining business interruptions and losses, we assume that for each day the protected

[23] Communication with ORC.

[24] Recorded at South Allanton, after Stack Street. See https://www.nzta.govt.nz/assets/resources/state-highway-traffic-volumes/docs/SHTV-2010-2014.pdf.

section is inaccessible, 5 percent of the average daily regional GDP would be forgone. This assumption is a low percent of regional GDP because not all businesses will rely on the use of State Highway 1, or may be unaffected by this particular section being flooded. The actual size of the impact will also depend on its timing relative to key agricultural seasons.

There are few estimates of the wider costs of traffic delays following disasters as they are difficult to calculate even after, let alone before, the event.[25] However, we find that our estimate of wider costs is in line with the gross output impacts from transport disruption in Wellington after a storm in June 2013. This storm cut off commuter rail lines between the Hutt Valley and Wellington City for 6 days. The regional economic impacts of the disruption were estimated at $21.5 million (or $3.6 million per day without access, which is approximately 5% of the average daily regional GDP of the Wellington region).[26]

State Highway 86

In moderate and large events, other major roads in the area could be affected. The costs of not being able to access State Highway 86 are based on the time and fuel costs from having to take an alternative route using State Highway 87. We assume that a third of the vehicles that would normally use State Highway 86 would be from inside the scheme.

State Highway 87

Similarly, State Highway 87 could be inaccessible in a flood event. This road appears to be important for the movement of locals given that the number of vehicles using State Highway 87 reduces significantly between Mosgiel and Outram.[27] We assume that the costs of having to use local roads instead of the state highway will be the same as the fuel and time costs of using alternative routes to State Highway 86. However, for State Highway 87 these costs are all allocated as private costs, due to the large use of the road by those inside the scheme.

Table 5.4 summarises the public and private benefits of the scheme based on the avoided costs of reduced road access.

Table 5.4: Benefits from Avoided Costs of Reduced Road Access

Costs ($000)	5-Year	10-Year	20-Year	50-Year	100-Year
Private	26	53	91	231	1,603
Public	13	26	63	186	4,299

Reduced access via rail

The South Island Main Trunk Railway crosses part of the Taieri Plain.[28] In large flood events delays on this line would result in lost wages for employees in the rail sector that

[25] Bureau of Transport Economics, "Economic Costs of Natural Disasters in Australia," Report 103, 2001, pp.79-80. Available at https://bitre.gov.au/publications/2001/files/report_103.pdf.

[26] Ministry of Transport, NZTA, KiwiRail & Greater Wellington Regional Council, "The Transport Impacts of The 20 June 2013 Storm," November 2013, p. 17. Available at http://www.transport.govt.nz/assets/Uploads/News/Documents/Transport-impacts-in-Wellington-storm-June-2013.pdf.

[27] Through Mosgiel, State Highway 87 carries 13,400 vehicles every day, reducing to 2,700 at Outram. See p.18, http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/Hazards%20on%20the%20Taieri%20Plains/2013/Intro.pdf.

[28] See p.13. http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/Hazards%20on%20the%20Taieri%20Plains/2013/Intro.pdf.

would otherwise be working, and would affect the businesses using rail freight. The lost business from delays or closures is estimated to be around a 1 percent loss in the (daily average) value of dairy, animal and meat products[29] transported to Port Chalmers by rail. We assume that rail workers, and those using rail for freight are located outside of the scheme, so costs from rail line delays are categorised as public costs.[30]

Table 5.5 summarises the public and private benefits of the scheme based on the avoided costs of reduced rail access.

Table 5.5: Benefits from Avoided Costs of Reduced Rail Access

Costs ($000)	5-Year	10-Year	20-Year	50-Year	100-Year
Private	0	0	0	0	0
Public	0	0	188	313	438

Reduced access via airport

Dunedin International Airport is located in West Taieri and has around 850,000 passengers every year.[31] In moderate and large events, there would be direct losses to the airport's revenue depending on how many days the airport is inoperable. While these revenue losses are counted as private benefits below, in reality ORC cannot rate the airport runway. If the ORC chooses to use this analysis to inform its rating policy, this portion of benefits should be treated as a tax and funded through the widest rating base available to minimise distortionary impacts.

There are also public costs from lost tourism-related business. An average spend of $246 per passenger[32] is applied to the number of passengers (based on the average passengers per day) that would not be able to enter the region through the airport. We assume that of the passengers that would not be able to enter Otago, approximately 10 percent would choose to travel through Queenstown Airport, and bear the additional fuel and travel time costs.

Table 5.6 summarises the public and private benefits of the scheme based on the avoided costs of reduced access to the airport.

Table 5.6: Benefits from Avoided Costs of Reduced Airport Access

Costs ($000)	5-Year	10-Year	20-Year	50-Year	100-Year
Private	16	66	165	659	1,647
Public	275	1,100	2,751	11,003	27,507

[29] This includes dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included, and meat and edible meat offal (around 80 percent of the exports at Port Chalmers).

[30] Lost wages are based on the median hourly wage for employees in the transport, postal and warehousing sector (both sexes and all age groups). Statistics New Zealand, 'Earnings from main wage and salary job by industry (ANZSIC2006), sex, and broad age groups (2009 onwards)'.

[31] See http://www.dunedinairport.co.nz/companyinfo.php.

[32] See p.5 http://www.dunedinairport.co.nz/userfiles/file/Annual%20Report%202011%20full%20-%20electronic%20version.pdf.

5.2 Benefits of the Lower Clutha Flood Protection Scheme

In the Lower Clutha flood protection and drainage scheme, the material costs avoided by the scheme (the scheme's benefits) were damages to non-commercial property, losses on productive land, the cost of the emergency response and repairs, and reduced access via roads and rail.

Damage to non-commercial property

Damage to non-commercial property in Lower Clutha was determined using the same approach as in Taieri: applying the expected damage per property (based on flood inundation levels) to the number of properties.

We used the same assumptions for flood-level inundations for different levels of severity of events. However, fewer properties are expected to be affected in 5-year, 10-year and 20-year events, as most residential properties are situated at higher elevation levels. However, for 50-year and 100-year events, this assumption is changed, based on the inundation expected around Kaitangata and properties south of Balclutha.[33]

Similar to Taieri, these costs would be borne by those inside the scheme at the time of the event—there are no public costs from this damage.

Table 5.7 summarises the public and private benefits of the scheme based on the avoided costs of damages to non-commercial property.

Table 5.7: Benefits from Avoided Damage to Non-Commercial Property

Costs ($000)	5-Year	10-Year	20-Year	50-Year	100-Year
Private	332	2,220	7,709	10,279	20,558
Public	0	0	0	0	0

Loss of land or output on farms or businesses

The losses to farms are calculated as the immediate damage to infrastructure and the production losses.

Immediate infrastructure losses were estimated to vary from $1 million in a 5-year event to $10 million in a 100-year event. This is smaller than the losses in the Taieri due to the smaller area covered by the Lower Clutha scheme.

Production losses are the number of day's land would not be able to be used to produce output. We assume that 90 percent of the land in Lower Clutha is productive land. The value of the output that would have been produced was based on the adjusted value of dairy output per effective hectare.[34] We adjust this value to take account of the other farming activities in Lower Clutha. However, given the greater dominance of dairy in Lower Clutha (compared to the Taieri Plain)[35] this is a relatively small adjustment (5

[33] See Figure 10 http://www.orc.govt.nz/Documents/Publications/Natural%20Hazards/FRH%203%20upper%20lower%20Clutha.pdf.

[34] The value of dairy output per effective hectare was calculated by multiplying the average dairy company payout over ten years by the average milk solids per effective hectare produced in the Clutha district. See p.19, http://www.dairynz.co.nz/media/1327583/nz-dairy-statistics-2013-2014-web.pdf.

[35] Agricultural Census, 2012, 'Farms by farm type (ANZSIC06) and territorial authority'. Just under 20 percent of farms in Clutha district were dairy compared to around 11 percent in Dunedin City District (where the Taieri Plain is located).

percent). The adjusted value is then multiplied by the loss of effective hectares (ranges from 0.1 percent to 20 percent depending on the event).

Total losses to businesses in the area and beyond are assumed to be around 50 percent of the lost production value on farms. The key businesses that would be affected (in Balclutha, Stirling milk processing plant and Finegand freezing works) are all within the scheme. We therefore assume that 70 percent of the total losses to businesses are felt within scheme, with the remaining 30 percent allocated as public costs.

Table 5.8 summarises the public and private benefits of the scheme based on the avoided losses to farms and businesses.

Table 5.8: Benefits from Avoided Losses to Farms and Businesses

Costs ($000)	5-Year	10-Year	20-Year	50-Year	100-Year
Private	3,073	5,455	11,911	17,366	23,821
Public	230	384	768	1,152	1,536

The cost of the emergency response and repairs

The costs of the emergency response in Lower Clutha are also based on the costs (around $97,000 per evacuee) to central government incurred during the 2004 floods in Manawatu.[36] We apply this rate to the number of people that would evacuated in an event in Lower Clutha—ranging from 1 for 5-year events to 75 in 100-year events.

Table 5.9 summarises the public and private benefits of the scheme based on the avoided costs of emergency response and repairs.

Table 5.9: Benefits from Avoided Costs of Emergency Response and Repairs

Costs ($000)	5-Year	10-Year	20-Year	50-Year	100-Year
Private	0	0	0	0	0
Public	98	783	2,446	4,891	7,337

Reduced access via roads

The costs of reduced road access are based on the number of das that State Highway 1 would be inaccessible, where road users would bear the costs of using alternative routes (fuel and time).

The flood's impact on State Highway 1 depends on the severity of the event. In 5-year events, State Highway 1 may be delayed or inaccessible for half a day. In this event, the number of vehicles using State Highway 1 at Balclutha (average annual daily traffic of 11,264)[37] could instead travel through Clydevale (an extra 4 minutes and 3.5 kilometres).

In larger events, the alternative route through Clydevale may also be inaccessible due to its proximity to the Clutha River. For larger events, the costs of vehicles having to use alternative routes are instead based on using State Highway 98 and State Highway 8 (an extra 39 minutes and 32 kilometres). In allocating private and public costs, we assume that 30 percent of the state highway's users are from inside the scheme.

[36] Horizons Regional Council, 'Storm', Civil Emergency, Storm and Flood Report, February 2004.

[37] Recorded at Balclutha Bridge. See https://www.nzta.govt.nz/assets/resources/state-highway-traffic-volumes/docs/SHTV-2010-2014.pdf.

Table 5.10 summarises the public and private benefits of the scheme based on the avoided costs of reduced road access.

Table 5.10: Benefits from Avoided Costs of Reduced Road Access

Costs ($000)	5-Year	10-Year	20-Year	50-Year	100-Year
Private	6	56	55	164	766
Public	14	65	132	392	1,828

Reduced access via rail

The costs of impeded access to rail are estimated as the lost wages to rail workers, and lost business for those using rail freight. These impacts are estimated to occur in 20-year events and larger. The lost wages are calculated for 10 workers, multiplied by the number of days the rail line is inaccessible. The lost business from delays or closures is estimated to be around a 0.5 percent loss in the (daily average) value of dairy, animal and meat products[38] transported to Port Chalmers by rail. Similar to Taieri, rail workers, and those using rail for freight are assumed to be outside of the scheme, and costs from rail line delays are counted as public costs.

Table 5.11 summarises the public and private benefits of the scheme based on the avoided costs of reduced rail access.

Table 5.11: Benefits from Avoided Costs of Reduced Rail Access

Costs ($000)	5-Year	10-Year	20-Year	50-Year	100-Year
Private	0	0	0	0	0
Public	0	0	32	97	225

5.3 Benefits of the West Taieri Drainage Scheme

The material costs avoided by the West Taieri drainage scheme are the damage to non-commercial property and the losses to farms and businesses.

The avoided damage to non-commercial property is determined by depth-damage curves (the same approach as for the flood schemes). For annual and 3-year events, we assume that houses will be flooded up to a maximum of 0.10 below floor level.

For farm losses, annual and 3-year rainfalls are expected to have some infrastructure damage on farms (such as, washing out tracks and silt removal). Production losses are also expected where 1 percent (annual event) or 4 percent (3-year event) of effective hectares would be affected by a lack of drainage infrastructure.

These on-farm losses are expected to reduce the expenditure at farming-related businesses. For West Taieri, we assume that 70 percent of the lost business will be to those within the scheme.

Table 5.12 summarises the public and private benefits of the scheme.

[38] This includes dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included, and meat and edible meat offal (around 80 percent of the exports at Port Chalmers).

Table 5.12: Benefits from the West Taieri Drainage Scheme

Costs ($000)	Annual		3-Year	
	Private	Public	Private	Public
Damage to non-commercial property	332	0	798	0
Loss of land or output on farms or businesses	1,413	149	5,500	594

5.4 Benefits of the East Taieri Drainage Scheme

The material costs avoided by the East Taieri drainage scheme are the damage to non-commercial property and the losses to farms and businesses.

To find the benefits of the drainage scheme in East Taieri, we generally apply the same assumptions used for West Taieri. For example, we consider that the same percent of lost business (70 percent) would be felt inside the scheme. While part of Mosgiel is not rated for the drainage scheme, this area is largely residential and is not thought to impact the proportion of business inside or outside of the scheme.

East Taieri is different to West Taieri in that more land is used for rural-residential, residential and industrial purposes. As a result, we assumed 60 percent of East Taieri land is effective hectares (compared to 80 percent in West Taieri).

Table 5.13 shows how the benefits of the scheme are shared between those inside and outside of the scheme.

Table 5.13: Benefits from the East Taieri Drainage Scheme

Costs ($000)	Annual		3-Year	
	Private	Public	Private	Public
Damage to non-commercial property	332	0	798	0
Loss of land or output on farms or businesses	1,078	111	4,163	446

5.5 Benefits of the Lower Clutha Drainage Scheme

The material costs avoided by the Lower Clutha drainage scheme are the damage to non-commercial property and the losses to farms and businesses.

Damages to non-commercial property are determined by depth-damage curves. Compared to West and East Taieri, fewer properties are expected to be affected in Lower Clutha, due to the tendency for residential homes to be built on higher ground.

On-farm losses are also comparatively smaller, due to the smaller area covered by the Lower Clutha scheme. With Balclutha included in the scheme, we assume that 70 percent of the business lost from reduced farm expenditure affects those inside the scheme.

Table 5.14 summarises the public and private benefits of the scheme.

Table 5.14: Benefits from the Lower Clutha Drainage Scheme

Costs ($000)	Annual		3-Year	
	Private	Public	Private	Public
Damage to non-commercial property	0	0	40	0
Loss of land or output on farms or businesses	69	8	646	38

6 Public-Private Benefit Ratios

The proportion of public benefits from the flood schemes are between 15 percent and 20 percent, whereas the in drainage schemes benefits are concentrated more within the scheme boundaries. The ratios for each scheme are described in Table 6.1.

Table 6.1: Public-Private Benefit Ratios per Scheme

Scheme	Total costs to those outside of scheme ($m NPV)	Total costs to those in the scheme ($m NPV)	Public-Private Benefit Ratio
Lower Taieri flood	142	701	17:83
West Taieri drainage	9	99	8:92
East Taieri drainage	7	79	8:92
Lower Clutha flood	47	255	16:84
Lower Clutha drainage	0.6	9	6:94

Results are sensitive to the location of lost business and more frequent severe floods

Estimating expected public benefit ratios is uncertain. To manage this uncertainty, we test some key assumptions made in our assessment (referred to as the medium scenario) to produce the sensitivity range for the ratio.

One key assumption is the discount rate used (7.5 percent). The public-private benefit ratios change by a maximum of 1 percentage point by varying the discount rate to 6 percent or to 9 percent.

We also test the sensitivity of the public-private benefits ratios by changing our assumptions about the percent of lost business inside the scheme's area (70 percent in the medium scenario), and adjusting for more frequent, severe events. These are tested under the following scenarios:

- **Integrated local economy:** Thirty percent of lost business would be inside of the scheme (that is 70 percent would be outside the scheme)
- **Insular local economy:** Ninety percent of lost business would be inside the scheme (that is 10 percent would be outside the scheme)
- **More frequent severe events:** High-cost events happen more frequently, where the costs of 50-year floods are felt every 20 years, and the costs of 100-year floods are felt every 50 years.

Table 6.2 summarises how the ratios change under each of these scenarios. These results show that the ratios are sensitive to assumptions about the location of lost business in the event of a flood. Across the schemes, there is a 10 to 15 percentage point range that ratios could be plausibly set.

Table 6.2: Sensitivity Analysis Based on Key Assumptions

Scheme	Public-private ratio under different scenarios			
	Medium scenario	Integrated local economy	Insular local economy	More frequent severe events
Lower Taieri flood	17:83	24:76	13:87	21:79
West Taieri drainage	8:92	20:80	3:97	8:92
East Taieri drainage	8:92	19:81	3:97	8:92
Lower Clutha flood	16:84	21:79	13:87	17:83
Lower Clutha drainage	6:94	14:86	2:98	6:94

These ratios largely align with the ratios used in other areas and schemes, and in flood hazard literature. For example, four of the flood protection schemes for areas in the Bay of Plenty fund the schemes through 80 percent contribution from targeted rates and the remaining 20 percent from general rates.[39] Similarly, investigations into the relative sizes of direct losses (private benefits) and indirect losses (public benefits) from floods have found that in most cases, indirect losses were less than 25 percent, sometimes less than 10 percent.[40]

Considerations when applying this assessment

When implementing this assessment, ORC must make further rating decisions on how to distribute the public share across districts to reflect their benefit from the schemes.

In reality, the benefits of the schemes will not follow the boundaries of the TLAs. However, to give an initial sense of the spread of the public benefits across the Otago region, we grouped the public benefits into district or region benefits (as shown in Table 6.3).

Table 6.3: Allocation of Public Benefits

Public benefit category	Allocated to		Comment
	District	Region	
Lost businesses as a result of impacts on farms	✔		Significant proportion of business likely to be in district
The cost of the emergency response and repairs		✔	Local authorities bearing these costs can apply for central government

[39] See http://www.boprc.govt.nz/media/414639/04-Draft-Revenue-and-Financing-Policy-for-the-Long-Term-Plan-2015-2025.pdf.

[40] See http://www.victoria.ac.nz/sgees/research-centres/documents/riskscape-flood-fragility-methodology.pdf

			financial assistance (i.e. benefit higher than district level)
Reduced access via roads		✔	Part of regional road network
Reduced access via rail		✔	Part of regional rail network
Reduced access via the airport	✔		Residents in other districts have greater access to alternative airports (Queenstown, Christchurch, Invercargill)

Given these allocations, we generally find that the benefits to the district make up most of the public benefits. This is particularly the case for drainage schemes, where the only public benefits are from avoiding lost business to the local area. For the Lower Taieri flood scheme, avoiding lost business and reduced or lost access to airport means that around 13.5 percent of the total benefits are to the Dunedin City District (where the flood protection scheme is located). The exception to this trend is the Lower Clutha flood protection scheme, where the emergency response costs dominate the public benefits.

Table 6.4: Distribution of Benefits

Scheme	Private benefit (%)	Public benefit	
		District (%)	Regional (%)
Lower Taieri flood	83	13	4
West Taieri drainage	92	8	0
East Taieri drainage	92	8	0
Lower Clutha flood	84	4	12
Lower Clutha drainage	94	6	0

Appendix A: Feedback from Public Consultation

7 December 2015

A.1 Introduction

Currently, Otago residents living within the boundaries of the flood protection and drainage schemes in Lower Clutha and the Taieri Plain bear all, or most of, the costs of maintaining the schemes through targeted rates. For some schemes, a small proportion of the costs are shared across a wider group. For example, the Lower Taieri flood protection scheme is funded through general regional rates (2 percent), Dunedin City general rates (2 percent) and targeted rates in the scheme (96 percent).[41] The current targeted rates are based on an assessment of direct benefits received in flood protection by those in the 'zone'.

In response to a request from the ratepayers, Otago Regional Council (ORC) has engaged Castalia to determine whether the current rates arrangements accurately reflect the proportion of benefits received by in-zone residents (the private benefit) compared to out-of-zone residents and the wider Otago region (the public benefit).

The first step in the economic assessment is to identify the types of benefits that the infrastructure provides, and who receives these benefits. We have consulted ratepayers on these issues through two channels:

- An online survey available through the ORC website
- Two drop-in sessions in Balclutha and Outram on 11 November 2015, where residents met with Castalia and could also fill out surveys in paper

This note describes who we heard from, and summarises the feedback received through both of these channels. We found that residents overwhelmingly felt that the current private-public benefit split did not reflect that there are several parties outside of the scheme's current boundaries that benefit from the schemes.

We will use the feedback from this consultation process to help identify the main benefits from the schemes, and quantify these to identify the private to public benefit ratio.

A.2 Who Participated in the Consultation Process?

Residents were able to participate in the public consultation through either drop-in sessions or by filling out the online survey.

Approximately 10 residents attended drop-in sessions in Balclutha, and more than 30 attended in Outram, and we received 78 survey responses in total. Most surveys (63 percent) were completed online, while 37 percent were completed in the Outram drop-in session. We did not receive any survey responses from the Balclutha drop-in session.

Most survey respondents (online and in paper) were in the West and East Taieri drainage schemes (66 percent), with only 9 percent of survey respondents in the Lower Clutha flood and drainage scheme. Around 6 percent of survey respondents were out-of-zone residents, while 9 percent were unsure which zone they are in.

[41] These funding sources are used after receipt of rental income from land owned by the schemes.

Just under half of the survey respondents owned a farm or a lifestyle block (32 percent and 17 percent respectively), while 36 percent of survey respondents were business owners.

This consultation is primarily a qualitative assessment of issues with some quantitative aspects. We note that some opinions may be over-emphasized in this summary of feedback. This could occur if feedback was received both in person at drop-in sessions (and filled out a survey in person) as well as surveys filled in online.

A.3 Key Themes from Public Consultation

The feedback in surveys and at drop-in sessions included several repeating concerns or comments. We have grouped our observations under five themes:

- Some residents take issue with the design of the current schemes
- There was a general consensus that in-zone residents benefit from the scheme
- Particular groups and organisations outside of the schemes were repeatedly identified as beneficiaries
- Natural and man-made factors are changing the nature of drainage and floods
- Beneficiaries pay does not represent all factors affecting flood and drainage.

Some residents take issue with the design of the current schemes

Several residents noted that the boundaries of the scheme are not reflective of who benefits and who doesn't. A common example was that of Mosgiel. Residents noted that the centre of Mosgiel is not rated for drainage, but would not be able to be in that location without the drainage scheme.

There were also comments from residents that the schemes were redundant, or that there were no floods until the schemes were constructed or developed. Several residents in Balclutha also noted that the schemes needed to be built to better specifications, or to a quality that best fits the scheme's purpose, and that the infrastructure suffered from poor maintenance.

There was a general consensus that in-zone residents benefit from the scheme

The majority of residents who filled out surveys and attended drop-in sessions were those from within the schemes, and bore most of the cost of the schemes. These residents largely acknowledged that they, and other residents inside the zone, are the main beneficiaries of the schemes.

Survey respondents ranked residents inside the scheme as the party receiving the greatest benefit from the scheme, followed by farms and businesses inside the scheme. Some respondents made the argument that while flood events create unliveable residential houses and stranded businesses, they have less of an impact on farms, as stock can be moved, and there are limited impacts on the land.

Where survey respondents were asked to rank the risks and impacts of a flood event, respondents ranked personal safety, loss of essential services, and property and housing the highest. Risks that received a lower ranking included productive land capability, access to necessary amenities and loss of business. Survey respondents also identified risks to residents' health, stock, and the value of property as other impacts from a flood event.

Respondents' estimates of the loss of property varied from $0 to $1.75 million, with an average of $370,000 (median = $250,000). Fewer estimates were given for the lost

business sales, which ranged from $0 to $500,000, with an average of $55,000 (median = $8,000). Some respondents noted that estimates were too difficult to produce, or varied depending on the size of the event. Survey respondents also noted other costs from the time, materials and effort required to repair any damage, including to farms and residential homes.

Particular groups and organisations outside of the schemes were repeatedly identified as beneficiaries

Residents also identified several parties outside of the zone that also benefit from the schemes. Of those outside the scheme, people, farms and businesses outside the scheme were thought to get the greatest benefit, rather than government agencies and institutions, and other groups. In particular, out-of-zone residents and businesses benefit from the services and infrastructure provided in the areas protected or drained by the schemes. Other groups of beneficiaries identified (by both survey respondents and residents) included:

- Dunedin International Airport, and the residents and businesses using it
- Dunedin City residents
- Mosgiel residents
- Road users (such as, those using State Highway 1 and State Highway 87)
- KiwiRail
- Fonterra
- Property developers
- Recreational and sporting organisations outside of the zone.

Most survey respondents identified that, in the event of a flood, the costs faced from those outside the scheme would be in trying to access services and amenities within the scheme. Survey respondents also identified that loss of business would also be a cost faced by those outside of the scheme. Loss of environmental amenity values was ranked lower, followed by other costs, which included:

- The lack of a rail line, airport, or roads
- Insurance cover and premiums changing due to reassessment of risk
- Mental health of those affected by the event (from loss of stock, property, income).

Natural and man-made factors are changing the nature of drainage and floods

The need for flood and drainage schemes has typically been driven by prolonged rain and snow melts in spring. Some residents noted that the nature of these environmental events (such as their frequency, speed and severity) were changing due to climate change.

Manmade practices are also affecting the demand for flood and drainage schemes, particularly in the way they affect the volume of water being handled by the schemes. For instance, the speed at which water enters the Lower Clutha scheme has increased following changes in farming practices (where water is discharged quickly from farms) upstream of scheme. As a result, that there is less time to warn residents of a flood event. This reduces the time where residents can evacuate to safer areas, or to move stock to minimise the damage of an event.

A similar issue was picked up by Taieri residents, who noted that the drainage system was under greater pressure as natural drainage in green areas has been reduced development increasing the number and area of concrete spaces. Mosgiel was used as an example of this, with residents noting that the stormwater in Mosgiel contributes to the water being managed by the flood and drainage schemes. As a result of these developments, floodwater now sits around for several weeks rather than days, prolonging the disruption to lives and businesses.

Beneficiaries pay does not represent all factors affecting flood and drainage

Residents also noted that there were parties who contributed to the demand for the schemes, and therefore the costs of the schemes, but were not necessarily 'beneficiaries' of the scheme. These parties were particularly those who exacerbated the problem by adding additional water to the scheme, and were able to use the scheme to remove their unwanted water.

If the beneficiaries of the scheme are considerably distinct from the 'exacerbators', then the beneficiaries are bearing the costs of schemes that are being driven by a different party. This undermines the efficiency of having a beneficiary pays system in the first place (those bearing the cost will try to minimise the costs of the scheme). This suggests that targeted rate's focus on beneficiary pays may be too narrow.

Additional material from residents

In addition to verbal feedback, we received supporting written material from some residents, which included:

- A comparison to five other flood and drainage schemes in New Zealand, which found that the targeted contribution in Taieri was much higher than the targeted contribution in other schemes
- A ratepayer's letter to ORC's chief executive explaining that their rates have increased by $35,000 over ten years
- A suggested rate split based on analysis of direct and indirect benefits in the Taieri area
- A submission by Waipori Holdings Limited Partnership on the ORC's Long Term Regional Plan, describing rates increases since 2006 and suggesting the development of rating areas currently outside of the scheme, and
- A comparison of the cost sharing in the Lower Taieri flood protection and the West Taieri drainage schemes, and the Leith flood protection scheme (7 percent from general rates, 46.5 percent indirect benefit zone, 46.5 percent from targeted rate in direct benefit zone).