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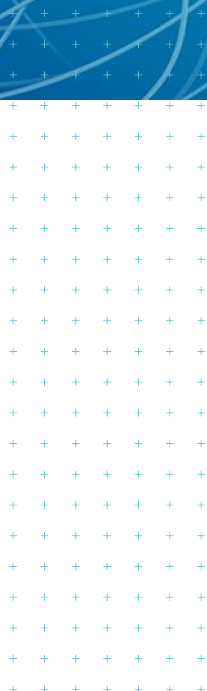
An overview of current practices, national benefits and future challenges of our flood protection, river control and land drainage schemes

Prepared for
River Managers' Special Interest Group

Prepared by
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Executive summary

Water management has become a pressing concern for many New Zealanders from grassroots level through to our national political dialogue.

In recent years, conversations about water management have tended towards how our communities can be better provisioned by resilient 'three waters' services, and the limits of our regulatory approaches on maintaining an acceptable amount and quality of water within our lakes, streams and rivers.

Flooding is the most common natural hazard that New Zealanders face. The role that a low profile and separate layer of infrastructure – the vast network of critical flood protection, river control and land drainage schemes – plays within water management has generally been absent from these conversations.

Over 100 towns and cities across the country have been built alongside rivers or on flood plains. Between the 1930s and 1980s, billions of dollars were spent building stopbanks, pump stations and related assets to protect our citizens and lifeline infrastructure, and enable regional economic stability by preventing regular flooding of our communities and productive land.

New Zealand has come to rely on the protection provided by over 350 flood protection, river control and land drainage systems. The effectiveness of these systems combined with the low frequency, high impact nature of flooding keeps public awareness of flood risk to life, property, livelihoods and the economy low – until there's a failure – and flood risk is expected to increase as society anticipates more extreme weather events and sea level rise.

This has prompted New Zealand's river managers – the stewards of these critical assets – to stop and think about how well their current practices will serve future generations of New Zealanders.

Environmental engineers, Tonkin + Taylor, and resource economists, Covec, were commissioned to conduct this national assessment of current practices, quantify benefits at a national level and identify future challenges associated with the flood protection, river control and land drainage schemes managed by regional councils.

This national assessment is intended to raise the profile of this hidden infrastructure and its importance. It has not been possible to fully explore all of the issues and challenges identified in this report. It is expected that this report will serve as a starting point for more detailed assessments of these issues.

Takeaway messages

This national assessment has found that, regional councils appear to have, overall, adopted an appropriate level of asset management, renewal and upgrade processes. However, the methods used by councils to understand, interpret and approach both technical and non-technical river management issues are inconsistent, and this variability may unknowingly expose some New Zealand communities to a greater likelihood of asset failure and its consequences.

These infrastructure assets are vital in protecting and supporting New Zealand communities and economic development. These assets protect around 1.5 million hectares of land – including highly productive primary production land, and many urban areas. This report does not cover the effect that historic and current land use practices have had on our water ways, which undoubtedly have a place in water management conversations.

All of these assets have a combined capital and operational value of \$3.6 billion, and in aggregate for every dollar of invested there is some \$55 of avoided losses on average. These assets provide \$13 billion in benefits to New Zealand every year.

Many technical and non-technical challenges face the sector tasked with managing our river management infrastructure. This river management sector is relatively small, with limited capacity and capability to address these challenges. Therefore the sector will need to work together across organisational boundaries, and in collaboration with external parties to adequately face these challenges and serve future generations of New Zealanders.

Key findings

Survey data. Data for this assessment was gathered from over 350 flood protection, river control and land drainage schemes managed by regional councils throughout New Zealand. These schemes directly protect some 1.5 million hectares of land which comprises about 5.5% of New Zealand's land mass, and includes highly productive primary production land, and both small and large urban areas.

Scheme funding. Funding is generally provided through targeted rates on rateable land that either directly or indirectly benefits from the schemes. The schemes also protect or provide a benefit to non-rateable land (Crown estate), regionally significant public utilities – such as three waters infrastructure – and nationally significant infrastructure such as roading and rail networks, and energy and telecommunication links. Current funding practices impact on how councils manage and deliver flood protection, river control and land drainage infrastructure and services.

Scheme management. Indicators of how well the schemes are being managed include infrastructure asset condition, criticality, and performance. Our assessment of asset condition scores for river management infrastructure indicates that, on the whole, regional councils appear to have adopted appropriate levels of asset management, renewal and upgrade processes for various asset types. However, documented asset management practices are variable between councils, and do not generally describe asset criticality and asset performance.

Asset value. The infrastructure assets comprising the schemes – stopbanks, dams, river structures, flood gates, drains, pump stations, and the like – have a collective replacement value of \$2.3 billion. In comparison to other publically owned infrastructure, the national value of this infrastructure is small.

Cost benefits. The schemes included in our assessment provide an estimated Net Present Benefit of \$198 billion (\$NZD at 2016), over \$11 billion each year. These benefits includes the wider social and economic benefits of the schemes. The Net Present Cost to operate, maintain and rebuild the schemes total an estimated \$3.6 billion (\$NZD at 2016).

Consistency. Variability in how councils understand, interpret and approach both technical and non-technical flood protection and land drainage issues was found throughout this assessment. Nationally consistent methodologies in how flood protection and land drainage infrastructure are managed and delivered would assist in ensuring an appropriate level of investment in this infrastructure and associated services to New Zealand communities. We would also expect this to deliver financial efficiencies for ratepayers.

Communication. Many councils describe large flood events to their stakeholders in terms of occurrence probabilities, which has limitations due to the uncertainties associated with estimating these probabilities. It would be useful for the river management sector to reframe these community discussions with a primary focus on event consequences with less emphasis on event probabilities. This is in line with the risk based approach now prescribed in the Resource Management Act. These discussions may be most effective when they include data and illustrative scenarios which convey the consequences and residual risks of events, and community and scheme vulnerabilities.

Technical and non-technical challenges. Many technical and non-technical challenges face the river management sector. These challenges include understanding the impact of more frequent extreme rainfall events, involving much wider stakeholder groups in decision making, scheme funding and affordability, and how environmental, social and cultural values are considered in river management

activities. Many of the challenge themes are similar to those that councils face in the delivery of other infrastructure and services, but the specific challenges facing the river management sector and how it may respond to them are unique.

Given the relatively small and distributed nature of the asset base managed by the sector, a coordinated response from river managers and collaboration with external parties is required to address these challenges. For this to happen effectively, there needs to be further standardisation of whole-of-life asset management and resilience planning methodologies across councils, and development of an enabling environment which supports knowledge sharing and knowledge transfer. Inter-organisational transfers and collective staff training would help staff to work effectively across organisational boundaries. Consideration should be given to how these types of cross-organisational activities are collectively funded.

We've identified a number of areas for further work which will help the river management sector to better address issues and challenges that it faces. **Our recommendations** are to work across the following themes:

Working together across the sector

- a Provide resources to river managers to enable and support a step change in professional collaboration and development across regional council river managers and with external organisations, so that the sector as a whole can proactively respond to the challenges identified in this national assessment.

Communication and enabling environment

- b Communicate as 'one voice' the state of the river management sector and the outstanding value the schemes provide to New Zealand as identified in this assessment.
- c Proactively engage as 'one voice' in discussions about potential changes to the regulatory environment (for example, managing natural hazards under the RMA, development of National Disaster Resilience Strategy, other RMA reforms, etc) so the views of the river management sector are understood by central government.
- d Develop methodologies and programmes to enable river managers to effectively engage with stakeholders on the schemes, and their benefits, including how the schemes work and help manage flood risk.

Quality people

- e Increase the capacity and capability of the sector to deliver future-focused, successful community outcomes, which may include formal graduate intake and professional development programmes.
- f Partner with tangata whenua to bring new skills, networks, and views into the river management sector.

Practices, methodologies and standards

- g Benchmark each regional council against key metrics including staffing levels, service levels, funding levels, and the like.
- h Prepare nationally consistent asset management methodologies, metadata standards, targeted asset management maturity levels, funding and payment metrics, reporting frameworks (e.g. AMPs), and level of service standards.
- i Assess on a scheme by scheme basis asset criticality and performance against asset condition, to better understand how well infrastructure assets are being managed including how river structures integrate with flood protection schemes, and identify where key vulnerabilities lie.

- j Compile a technical body of knowledge to establish best practice, and identify knowledge gaps or uncertainties, and research needs (e.g. water quality, risk communication, climate change, river geomorphology).
- k Carry out an assessment of cultural and environmental values of the schemes and take them into account when assessing the schemes' benefits and costs.
- l Develop a river management resilience framework and supporting decision making tools to enable regional councils to better inform and position communities so they respond to shocks and stressors with minimum disruption, and to formally include environmental, social, cultural and economic values into projects.
- m Understand the financial viability of the schemes and common funding issues (asset revaluation, depreciation and renewal expenditure, borrowing, etc) on a national scale and their implications on future affordability of the schemes, and what the impacts of removing protection or decreasing a level of protection may be.
- n Investigate alternative funding rationales and strategies, for example, to avoid a higher proportion of scheme costs sitting with fewer ratepayers and to recognise the wider benefits of the schemes.

1 Introduction

In conjunction with Tonkin + Taylor and Covec, regional councils have combined forces to carry out a national assessment of river control, flood protection and land drainage schemes (collectively, ‘the schemes’, or ‘river management activities’) that are managed by regional councils. The River Managers’ Special Interest Group, which reports to the Regional Council CEO Special Interest Group, has overseen this project. Specifically through this project we have sought to identify at a national level:

- The location and state of the schemes’ infrastructure assets
- The benefit they provide in protecting and developing communities and economies
- The quality of asset management and ability to deliver community agreed service levels
- The present and future opportunities and challenges associated with river control, flood protection and land drainage

The outcomes from the project will enable the river management sector to:

- Understand the current state of the schemes in New Zealand
- Communicate the nation’s reliance on and value of investment in river control, flood protection and drainage schemes
- Quantify the investment in the schemes’ infrastructure by regional councils and their predecessors
- Quantify annual maintenance/renewal expenditure in maintaining agreed levels of service defined in asset management plans
- Quantify the benefits of these schemes to the community
- Understand the extent to which work or plans are in place to meet increasing expectations of communities which benefit from them, including the predicted implications of climate change on the schemes
- Identify strengths and weaknesses in current institutional performance of the river management sector

1.1 Background

Regional councils have been responsible for the construction, maintenance and improvement of river control, flood protection and land drainage scheme infrastructure since 1989. This is when the powers of catchment boards under the Soil Conservation and Rivers Control Act 1941 Act were vested in regional councils and unitary authorities. Prior to 1989 this infrastructure was developed and managed by catchment authorities — often working in partnership with central government who helped fund this infrastructure.

In the absence of seeing this infrastructure tested in significant rainfall or flood events, communities may well forget the purpose, and therefore the importance and value, of this infrastructure. By its very nature, over time this infrastructure simply becomes part of the landscape.

The lack of widespread awareness of the role, state and value of this infrastructure to New Zealand may have contributed to its general omission from the National Infrastructure Unit’s *Thirty Year New Zealand Infrastructure Plan 2015*.

1.2 Methodology

Tonkin + Taylor conducted a review of spatial (GIS-based) information provided by regional councils of their river control, flood protection, and drainage schemes to identify the areas that benefit from the schemes' infrastructure assets.

With this spatial information we undertook a high level analysis of the economic benefit afforded by the schemes. The cost benefit analysis was carried out by our project partner Covec, a company specialising in natural resource economics. In carrying out this analysis, Covec undertook an international literature review of flood protection economic evaluation methods to inform their analysis.

We also received detailed responses from the river manager at each regional council in the form of a written questionnaire. Questions and responses covered factors that influence how river management services are delivered. Topics were categorised under the broad headings of People, Equipment, Environment, Processes, Organisation, and External (PEEPOE framework). The questionnaire is included in Appendix C.

The matters raised by river managers, and the outcomes of our analyses were discussed with the river managers' project steering group in three workshops held throughout the course of this project.

Our research covered the way councils manage delivery of other infrastructure assets in NZ, the difference between delivery of river management infrastructure to other infrastructure, and how the history of river management in NZ has influenced the sector we have today. Where appropriate, we've drawn on our knowledge and experience of working within the river management sector.

1.3 Limitations

This project has relied on information provided to us by river managers and regional councils. Most of this information was provided via Asset Management Plans, councils' GIS and ratings databases, and through responses by river managers to the PEEPOE questionnaire. Data was also gathered through follow up questions and workshops with the river managers' project steering group.

Information provided to us has been taken at face value, with data anomalies queried and checked with relevant river managers. A detailed review of all information provided is outside the scope of the project. Based on our experience and understanding, we consider that the results of our analysis represent a reasonable overview of NZ's state of management of river control, drainage and flood control schemes, and their value. Limitations include:

- Data was provided by all regional councils and unitary authorities with the exception of Nelson and Marlborough
- Data provided by Otago Regional Council had some gaps in asset value that could not be resolved within the constraints of this project
- Schemes managed by territorial local authorities — such as Christchurch City Council — are outside the scope of this project¹
- The economic assessment and cost benefit analysis are based on 2016 costs
- The cost benefit analysis does not attempt to fully account for all environmental, social, and cultural benefits and costs of the schemes as discussed in Section 5.3 Exclusions on page 19.

¹ The scope of this survey included regional councils and the regional council functions of unitary authorities.

2 The nature of river management and land drainage activities

River control and flood protection activities exist to reduce the severity of impacts on communities from low frequency, large flooding events. Land drainage activities allow the use of low lying land predominantly for agricultural production or improve the productivity of agricultural land. These activities provide communities with greater security from substantially mitigated flooding risks and confidence from better knowledge of how frequently their land may be inundated. This has enabled economic growth through increased productivity of land.

Ironically, the success of these schemes, particularly in reducing the impacts of flooding, has resulted in a low awareness of these activities amongst the wider community. Failure of this infrastructure to provide a particular level of service – or even recognition that the infrastructure exists – is often not immediately apparent.

The relatively infrequent nature of these events stands in contrast to other infrastructure assets — for example, the wastewater, stormwater, or transport links that are utilised on a near daily basis. While many of those assets, such as underground pipes, are unseen and taken for granted by the general public, it quickly becomes apparent when a council doesn't deliver these services to the standard expected by the community. Feedback to councils and agencies responsible for managing these assets is often immediate and very clear. However, similar feedback is infrequently available for river management activities because a scheme's performance may only be tested once or twice within a generation.

A combination of event infrequency and subsequent lack of performance feedback presents many challenges to the river management sector. Not least, are communities' engagement and understanding of their infrastructure needs, and the ability of managers to secure and maintain funding for scheme assets. These challenges are discussed further in this report.

3 Brief history of river management and land drainage in New Zealand

The economic, social, and cultural development of New Zealand is intricately linked with human interventions to manage the direction of rivers to protect people and property from flooding, and to drain low-lying land for productive use.

Settlement in New Zealand has primarily occurred on and around the coastal alluvial flats near rivers and streams. In locating settlements on flat land adjacent to rivers and surrounding land, Maori and European settlers were able to use the rivers to their advantage. Fertile soils, drinking water, and transportation links were afforded by these waterways. Conversely, this also exposed them to the hazards of flooding, erosion and sedimentation, and water borne diseases.

Early activities and legislation (1850s-1900s)

By the mid-19th century, settlers had initiated various river management and land drainage works on an ad hoc basis in an attempt to guard against the hazards posed by the rivers. Although various pieces of legislation were enacted to formalise river management and land drainage activities (notably the River Boards and Land Drainage Acts of 1908), a fairly piecemeal and localised approach to these activities continued until the late 1930s. By this time soil erosion and its impact on waterways had become prevalent issues in catchments nationwide. These issues, and the Esk Valley floods of 1938, prompted a response from central government that resulted in the passing of the Soil Conservation and Rivers Control Act 1941.

Formation of the Soil Conservation and Rivers Control Council (1941)

The 1941 Act established the Soil Conservation and Rivers Control Council (SCRCC), which centralised soil conservation, river management and land drainage activities under the Ministry of Works and Development, and gave rise to a formal, interventionist approach to river management and land drainage activities. During this time central government subsidised capital river management works of between 30% and 87.5% of the capital cost of the works. Higher subsidies were provided for larger, nationally important schemes, and lower subsidies provided for smaller, locally important schemes. Although most of the works were subsidised in the order of 70% to 75%, the local funding contribution engendered a sense of ownership among communities that benefitted from the works.

The 1941 Act also established Catchment Boards (or Commissions) and made them responsible for river functions and objectives. These included controlling or regulating water flows into and out of watercourses, preventing or lessening the likelihood of overflow and associated damage from watercourses, preventing or lessening erosion, and promoting soil conservation.

To achieve these objectives Catchment Boards were given powers to compulsorily acquire land, make by-laws, control land use, undertake river management and land drainage activities, and recover their costs from communities. However instead of acting unilaterally with these powers, the Catchment Boards endeavoured to take a collaborative approach with communities, who in many instances were financially assisted to undertake works at the direction of Catchment Board staff.

It was under this regulatory regime, with some later amendments², that most of the country's now existing river control, flood protection, and land drainage infrastructure was planned, designed and constructed.

² Notably the Water Pollution Act 1953, the Water and Soil Conservation Act 1967 (which also created the National Water and Soil Conservation Authority), the Town and Country Planning Acts of 1953 and 1977, and the Local Government Act 1974.

The rise of environmental awareness and an understanding of the interconnection between land use and water quality in the 1960s and 1970s led to a raft of regulatory changes. Most notable was the Water and Soil Conservation Act 1967. This created the National Water and Soil Conservation Authority (NWASCA) and generally resulted in the morphing of catchment boards and commissions into regional water boards. Boards were charged with responsibility for regulating any significant uses of water through a water rights system.

Local government reforms (1980s-current)

The major state sector and local government reforms³ of the 1980s essentially completed the transition of river management and associated soil conservation functions to regional authorities. These reforms included the dissolution of NWASCA and the allocation of its responsibilities and those of the Catchment Boards to regional councils. Central government retained a limited transfer policy and monitoring role through the Ministry for the Environment.

These reforms also eliminated central government funding of capital and maintenance works for river control, flood protection, and land drainage activities. Prior to NWASCA's abolition, central government's servicing department (the Ministry of Works and Development) typically applied a funding vote of more than \$40 million per annum to support these functions. These are now largely paid for through rates levied by regional councils.

Transitioning from a position of very substantial Government funding support to total reliance on local and regional funding sources posed many political and technical challenges. In general, however, that transition has been successfully made, albeit with some community-negotiated changes to protection service levels, both upwards and downwards.

Regional councils are now the organisations primarily responsible for soil conservation, maintenance and enhancement of water quality, water quantity, aquatic ecosystems, and the avoidance or mitigation of natural hazards. But whereas the primary consideration of most river management infrastructure built during the mid-20th century was safety and economic growth – social, cultural, and environmental values of water resources are now prominent policy and activity drivers. This can be seen in the start of freshwater co-management with tangata whenua, more collaborative engagement on freshwater issues from statutory and industry organisations, and the National Policy Statement for Freshwater Management.

River management activities supporting safety and economic growth still remain vitally important to the communities and primary industry sector that directly benefit from them, as well as their supporting infrastructure, such as the nationally important transport and telecommunications links that underpin the functioning of modern society.

³ Including the Local Government Act 1989 and the Resource Management Act 1991.

4 An overview of New Zealand schemes

So what do New Zealand flood protection and land drainage schemes look like? This section provides a snapshot of river control, flood protection, and land drainage schemes. It covers what's included and excluded from a scheme, the extent and quantity of the schemes nationally, and the state of the infrastructure assets within schemes.



Figure 4.1: Stopbanks protected Palmerston North from inundation during the 2004 Manawatu River flood event. Source: teara.govt.nz

4.1 Schemes – what's in and what's out?

The river management activities undertaken by regional councils generally deal with the management of rainfall runoff on a catchment scale, and are broadly classed into four scheme types based on the nature of their benefit as follows:

- Land drainage – getting water off the land into a stream or river
- Flood protection – keeping water in the river and off land
- River management – keeping the river where it is
- Tidal inundation – keeping sea water off land

Each regional council classifies schemes and their infrastructure assets into these four broad types. This publicly available information has been used in this assessment.

What is not covered under these schemes and is excluded from this assessment is the management of stormwater runoff in urban or semi-urban settings by city and district councils. The management of some flood control and coastal protection schemes by city and district councils such as the Avon-Heathcote River in Christchurch or the Maitai River in Nelson is also excluded⁴.

Additionally, regional councils undertake soil conservation activities to reduce soil erosion and in some instances these are key elements of flood protection schemes. Although these soil conservation activities are important to water quality and overall catchment health, assessing the state and value of them is beyond the scope of this assessment.



Figure 4.2: Surface flooding on productive land served by land drainage scheme, Waikato 2008. Source: Waikato Regional Council.

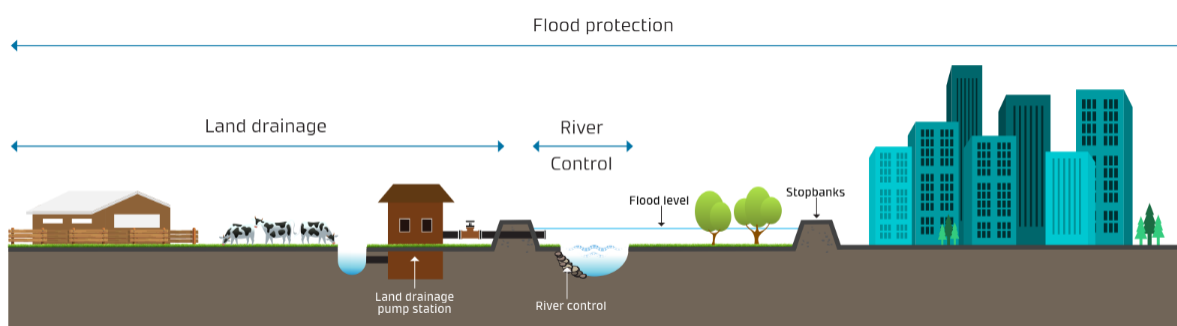


Figure 4.3: Schematic of flood protection, river control and land drainage services

4.2 Scheme extents

The geographic coverage of river control, flood protection and land drainage schemes can be described as follows:

- **Infrastructure assets** – physical structures which protect land from being inundated by water, for example, stopbanks, flood gates, pump stations, and river training works

Capital and operational expenditure associated with these assets are generally funded by rates from the following areas:

- **Direct benefit areas** – areas of land which are immediately protected from flooding by infrastructure assets and would otherwise be subject to flooding during storm events up to and including the size of a design event
- **Indirect benefit areas** – areas of land which sit outside the direct benefit area and receive a 'community good' from protection afforded by the infrastructure assets

⁴ The scope of this survey included regional councils and the regional council functions of unitary authorities.

- **Exacerbator areas** – upper areas of land in a catchment that contribute runoff to low-lying portions of a catchment and contribute to drainage or flooding issues experienced in these lower lying areas

The direct benefit areas for all scheme types across New Zealand is shown in Figure 4.4, below.



Figure 4.4: Extent of direct benefit areas

4.3 Number of schemes

There are around 364 river control, flood protection, and land drainage schemes administered by regional councils across New Zealand that have been included in this assessment.

A breakdown of the number of scheme types by region is given in Table 4.1 below. We found that how the nature of scheme benefit is described varies depending on the scheme. Specifically, some schemes provide a single benefit type only, while other schemes provide multiple benefits. For those schemes that provide multiple benefit types, the available data was insufficient to understand the proportion of benefit type.

For example, there are a large number of schemes in the Waikato that are identified as only providing drainage benefit. This is contrasted with the Kaituna scheme in the Bay of Plenty that provides flood protection for an event having a 1% Annual Exceedance Probability (AEP) and drainage protection for events up to 20% AEP.

Schemes with multiple benefit types were most common for regional councils in the Bay of Plenty, Hawkes Bay, Manawatu, and West Coast. Future data analysis would be made easier if the schemes or their constituent parts were able to be classed under a single benefit, though we recognise this may be difficult.

Table 4.1: Number of scheme types by region

Council	Benefit Type Flood	Drainage	River Management	Tidal	Mixed Benefit	Total Schemes
Northland	2	0	0	0	1	3
Auckland ¹	-	-	-	-	-	-
Waikato ²	3	86	0	0	5	94
Bay of Plenty	0	1	0	0	4	5
Gisborne DC	2	17	0	0	0	19
Hawkes Bay	2	0	2	0	21	25
Taranaki	0	0	0	0	2	2
Manawatu	7	6	6	0	15	34
Wellington	51	15	0	0	0	66
Marlborough DC	-	-	-	-	-	-
Nelson CC	-	-	-	-	-	-
Tasman DC	0	0	16	0	6	22
West Coast	3	1	2	1	13	20
Canterbury	15	13	28	0	4	60
Otago	3	3	1	0	1	8
Southland	6	0	0	0	0	6
Grand Total	94	142	55	1	72	364

Notes:

1. Council reported it does not have any relevant schemes under management.
2. No data was provided for schemes protecting urban settlements in Taupo and Thames – Coromandel Districts.

4.4 What schemes protect

The 364 schemes for which data is available provide direct benefit to some 1.5 million hectares of land (about 5.6% of New Zealand's land area). As noted previously, schemes provide benefit beyond the areas of direct benefit. Regional councils recognise this through the identification of indirect benefit areas and exacerbator areas for the purposes of striking a rate to fund the schemes.

In addition to the rateable areas of benefit that schemes protect — or otherwise provide a 'community good' — schemes also protect non-rateable land and regionally and nationally significant infrastructure, including transportation, energy and telecommunication links. For example, State Highway 1, the North Island Main Trunk Line, and a trunk fibre optic cable are protected by the Lower Waikato scheme. Social and cultural infrastructure, for example, the Hutt Hospital and numerous schools, marae, libraries and churches, are protected by the Hutt Valley scheme.

The available scheme rating databases from each region were combined to prepare Figure 4.5, below. This figure shows the four benefit types relative to each other for rateable land area, rateable land value, and rateable capital improvements (capital value less land value).

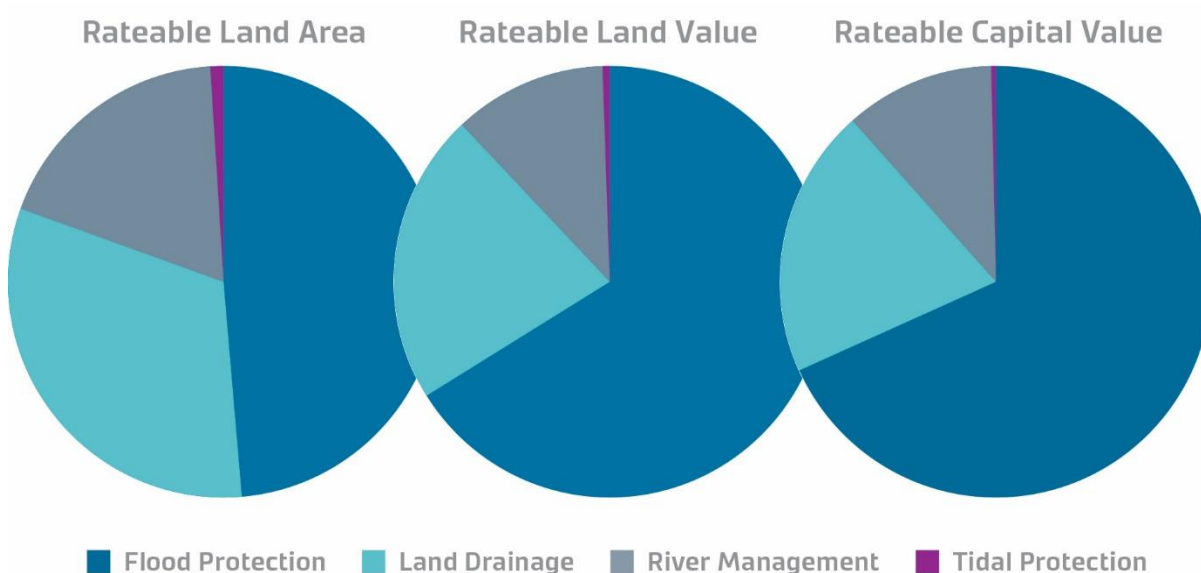


Figure 4.5: Comparison of benefit proportions for rateable area, land value, and improvements value by scheme type based on available data

4.4.1 Discussion

As illustrated in the pie charts, flood protection schemes protect an increasingly greater proportion of rateable land area, land value and capital value compared to other scheme types. This indicates that flood schemes may protect a greater portion of urban land — with capital improvements — than other scheme types.

Land drainage schemes comprise approximately half of the total number of schemes in this assessment. However, they protect a disproportionately small amount of rateable land area, and a diminishing proportion of rateable land value and capital improvements. This is indicative of the more rural nature (primary industry production) of land protected by these schemes.

The same diminishing proportion of rateable land area, value, and capital improvements are observed for tidal protection schemes. Again this is indicative of the rural nature (primary industry production) of land protected by these schemes. For example, the area protected from tidal

inundation in lower Piako River is the largest area of tidal protection benefit, as this scheme covers an extended area of low-lying farmland near or below sea level.

A diminishing proportion of rateable land area, value, and capital improvements is also observed for river management structures. However, these structures are often integral to flood protection schemes. The data does not clearly illustrate a linkage between these structures and the type of land they benefit. Further work would be required to demonstrate this link at a national or regional level.

4.5 Infrastructure assets

4.5.1 Asset value

The total replacement value⁵ of river control, flood protection and land drainage infrastructure assets is approximately \$2.3 billion. This is about 4.5% of the estimated \$45 billion replacement value of assets for three waters infrastructure (drinking water, waste water, and stormwater) as stated in Treasury's Thirty Year NZ Infrastructure Plan 2015-45.

The total replacement value of infrastructure assets (about \$2.3 billion) is broken out by asset type in Figure 4.6, below.

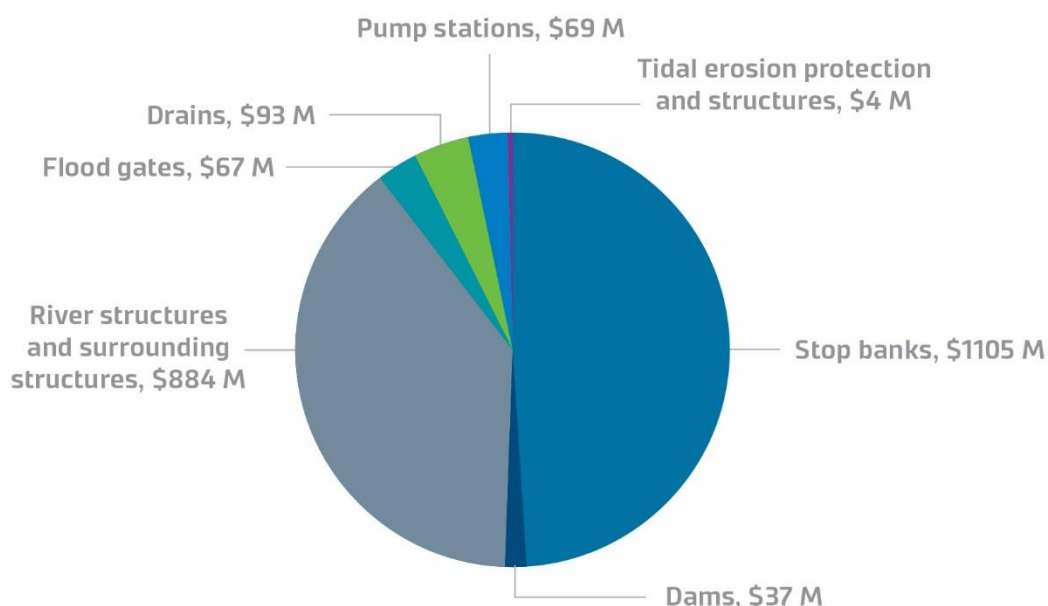


Figure 4.6: Summary of total replacement value by asset type for provided data

Flood protection is generally provided by stopbanks and dams. Across the assessed councils, these assets make up about half of the capital investment but provide almost three quarters of the capital value protected. In other words the capital value of land protected by stopbanks and dams is disproportionately higher than the asset value.

The same pattern can be seen for assets including pump stations, floodgates and drains which provide land drainage. These assets make up about a tenth of the total capital investment and from this provide benefit to around a fifth of the capital value protected.

River structures, such as groynes, rockwork and other armouring, training banks, weirs, and trees/vegetation, are associated with both flood protection and river management as noted above.

⁵ Total replacement value of the infrastructure assets is based on the valuations published in the asset management plans available for this assessment.

However, based on the data provided it is difficult to apportion value of these assets to those benefit types. We note that river structures are often capital intensive and integral to flood protection schemes, and the river structures themselves may not directly relate to a large area of benefit.

Further work is needed to better understand how river structures integrate with flood protection schemes, and how the river structure capital and economic values could be apportioned to discrete benefit types.

4.5.2 Asset condition

A fundamental aspect of asset management is the systematic inspection and recording of asset condition. The International Infrastructure Management Manual (IIMM) 2015⁶ uses a five point scale for asset management scoring. For the purposes of this assessment we have used the IIMM qualitative descriptors (Excellent/Good/Average/Poor/Failed) instead of a one to five scale.

Based on the data available for this assessment, it appears all regional councils use the NAMS scale. However, there is little, if any, asset condition assessment standardisation across the councils or even within a council. In our experience, the way asset condition is assessed can vary depending on who undertakes the assessment and when the assessment is carried out. For example, staff who are very familiar with an asset can become complacent with its condition and overlook some shortcomings. Additionally, in absence of condition scoring guidance staff departures can result in new staff using a different reference point to score asset condition.

The sector has recognised that standardisation in asset condition scoring is important, and has recently developed a stopbank condition assessment framework that all councils should adopt. Development of further assessment frameworks for assets such as for pump stations, floodgates and the like, is beneficial and should be considered by river managers.

The overall condition of river control, flood protection and land drainage infrastructure assets is summarised in Table 4.2, below. Data is based on conditions published in the asset management plans made available for this assessment.

Table 4.2: Asset condition summary

Infrastructure asset type	Condition (qualitative descriptor)
Stopbanks	Average or better
Floodgates	Average or better
Drains	Good or better, some Average
Dams	Average or better
Pump stations	Average to Good, some Poor
River structures	Good, some Poor to Average

At an overview level, the asset condition scores suggest regional councils have adopted an appropriate level of asset management, renewal and upgrade according to asset type. Scores also reflect councils' general asset management approach of maintaining stopbanks in perpetuity while river and mechanical structures are worn and then replaced, hence the latter group having a wider range of condition. A summary of regional asset condition by type is included in Appendix A.

The condition of an infrastructure asset does not tell the whole story of how well that asset is being managed. Asset condition needs to be assessed in conjunction with asset criticality and performance

⁶ The IIMM 2015 is identified by the New Zealand Asset Management Support Organisation as best practice in asset management.

to understand if and when maintenance or renewal work needs to be carried out. Asset criticality and performance are generally not well documented by regional councils, and an assessment of these criteria is beyond the scope of this report. Further work to assess these factors against asset condition would require a more in depth scheme by scheme review.

4.6 Regional breakdown

A regional breakdown of the number of schemes by type is given in Figure 4.7, below. There is significant variation between councils in terms of the size and make up of schemes. Figure 4.7 is ordered by total value of each councils’ scheme assets with two cohorts emerging. One is a cohort of councils — Canterbury, Manawatu, Waikato, Greater Wellington, Bay of Plenty and Hawkes Bay — covering a significant overall proportion of asset value. The other, a cohort of councils collectively making up a smaller proportion of the asset value.

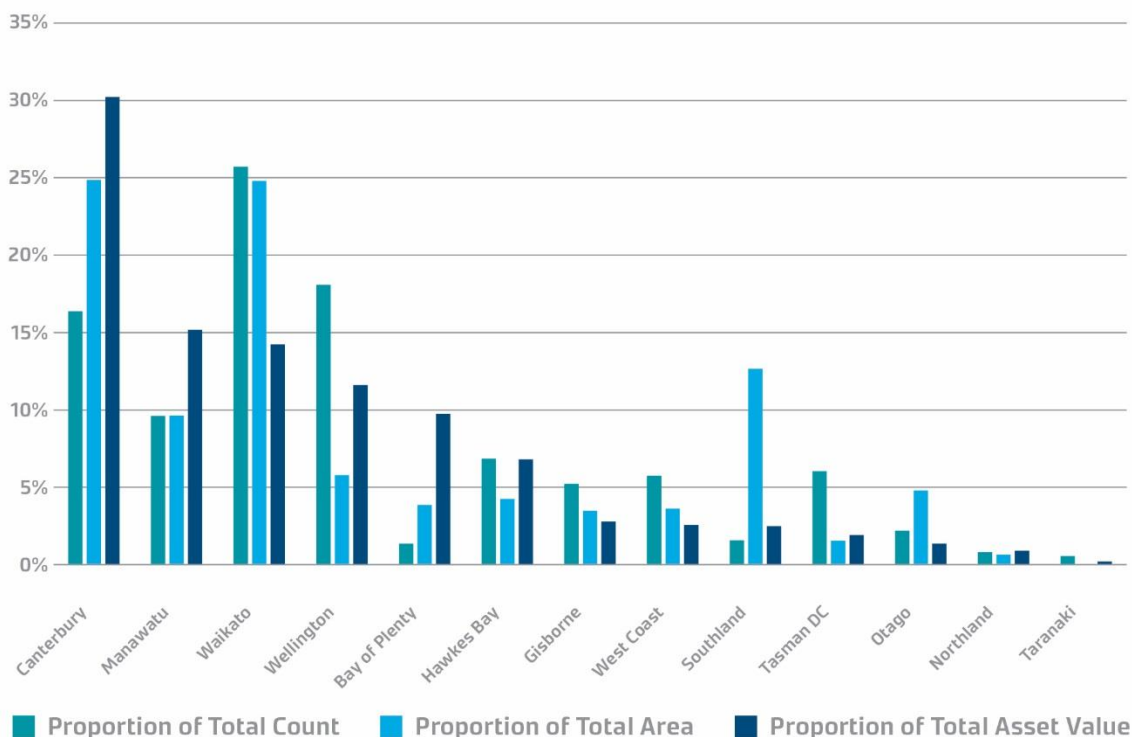


Figure 4.7: Scheme attributes as proportion of assessed total

5 Economic value of the schemes to New Zealand

A cost benefit analysis was undertaken by economic consultants, Covec, to help define the total economic value of the schemes included in this assessment. Covec's report is attached in Appendix E and its analysis is summarised in this section.

Covec estimates that the river control, flood protection, and land drainage schemes included in this assessment provide a Net Present Benefit of \$198 billion (\$NZD at 2016). Using the sum of the regional councils' published infrastructure asset replacement values and operational expenditure of \$3.6 billion (\$NZD at 2016), the average Benefit Cost Ratio (BCR) of these schemes to New Zealand is approximately 55:1. For comparison, large infrastructure projects in New Zealand, such as those for the NZ Transport Agency, are considered economically viable if the BCR is greater than 1:1⁷. As such, with an average BCR of 55:1, these schemes provide outstanding value for money to New Zealand.

5.1 Methodology

A cost benefit analysis (CBA) of the schemes was undertaken by adding all of the estimated benefits of the schemes and subtracting estimated operational and maintenance costs. To undertake CBA, two scenarios were assessed:

- The factual case – that is the overall benefit to the community with the schemes in place, and
- A counterfactual case – that is the overall benefit to the community where there are no schemes in place

Covec considered three different situations for the counterfactual case, and evaluated situations in terms of the assumptions needed to define them, the analytical problems arising from these approaches, and whether and to what degree any approach adopted is consistent with best practice for CBA.

The counterfactual approach that was used for this analysis assumes that to continue to receive the current scheme benefits, the community is willing to pay an amount equal to value of assets and land currently protected by the schemes. This assumption, which is further described in Covec's report attached in Appendix E, is made on the basis that the owner of the scheme could otherwise remove these assets.

The approach used to evaluate the benefits to the community was predominantly based on the value of damage to residential and other buildings, and the valuation of various land use types that are protected by the schemes. These are described in detail by Covec, and summarised in Table 5.1.

⁷ Economic evaluation manual, New Zealand Transport Agency, January 2016.

Table 5.1: Valuation approach by land use and scheme type (Covec 2017)

Land use/ land type	Flood protection	Tidal protection	Drainage	River management
Built-up areas (residential and other buildings)	NPV of avoided damage	Value of improvements plus difference in value of land uses	Value of improvements plus difference in value of land uses	Value of improvements plus difference in value of land uses
Other land uses	Greater of NPV of avoided damage or Difference in value of land uses possible with/ without flood protection	Difference in value of land uses possible with/without tidal protection	Difference in value of land uses possible with/ without drainage	Difference in value of land uses possible with/ without river management

For flood protection, the Net Present Value of avoided damage was estimated through the development of flood risk density curves, whereby the annual average damage for an area of land can be determined with and without a scheme in place, as shown in Figure 5.1 below. For the purposes of estimating annual average damages, data from the NZ Insurance Council for floods between 1976 and 2016 was used.

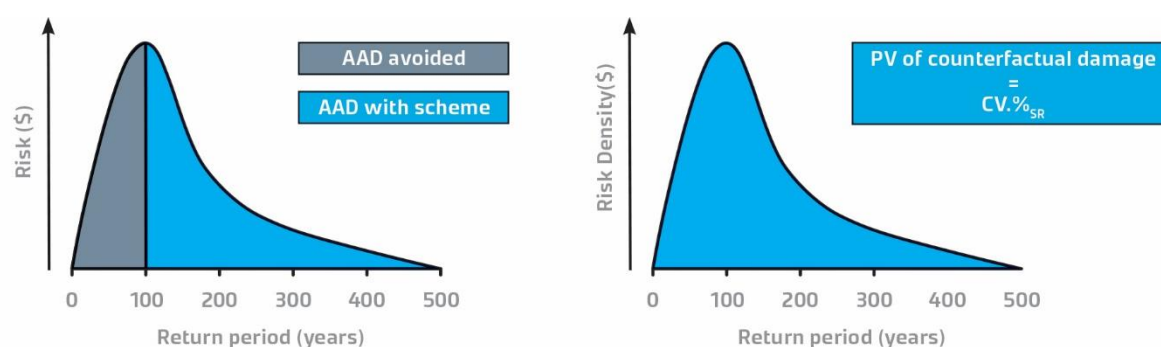


Figure 5.1: Annual Average Flood Damage (AAD), and Average Annual Damage avoided with a flood control scheme in place that has a 100 year return period level of service. The counterfactual is also shown.

Finally, the level of flood damage avoided was modified based on each scheme's benefit rating, as set out in their relevant asset management plans.

For differences in land use, Covec used the difference in value of land based on the current use, and counterfactual use assuming that no scheme was in place.

Covec reviewed potential non-market values such as insurance costs, emergency cost multipliers and health impacts on the community. Based on work carried out for the Greater Wellington Regional Council, Covec adopted a value of 100% of direct damage costs to take account of a range of non-market costs associated with flooding in urban areas. This cost was allocated on a pro rata basis for non-urban areas based on average population densities for rural areas in NZ.

The data used by Covec for this analysis is outlined in their report. It included:

- The flood level of service for the schemes used in this assessment
- The capital value of land within the scheme's benefit area
- The land value within the scheme's benefit area

- The level of benefit provided (low, medium, high)
- Land cover descriptions.

5.2 Results

The results are presented across all schemes assessed and separated into scheme types, and are summarised in Table 5.2 below.

Overall the benefits of the schemes are significant with a Net Present Benefit of approximately \$198 billion (\$NZD at 2016) at an average Benefit Cost Ratio (BCR) of 55:1. The highest benefits come from flood control, drainage, and mixed benefit schemes followed by tidal and river control schemes.

The annual benefit of over \$11 billion provided by the schemes is nearly five times their published infrastructure replacement value. .

Due to the project steering group's concerns of the significantly large difference in benefit calculated for Canterbury region compared with other regions, we reviewed the input data for Canterbury and Wellington regions and performed a few sensitivity checks. In this review we found some differences in how these regions supplied their data and rate their schemes.

However, the differences between Canterbury and Wellington appear to be overshadowed by the relatively large areas of direct benefit, and population within these areas. Using the latest census meshblock information Canterbury has about 350,000 normally resident population in direct benefit areas compared to 75,000 for Wellington's Hutt Valley.

Table 5.2: Estimated benefit (2016 \$ million) of flood control, drainage, river management, tidal and multiple schemes

Protection type	Land type	Estimated benefit (PV) (\$m)	Annual benefit (at 6% Discount Rate) (\$m)
Flood control	Built-up area	\$134,601	\$7,619
	Other land use type	\$12,553	\$711
	Total	\$147,154	\$8,329
Drainage	Built-up area	\$12,796	\$724
	Other land use type	\$629	\$36
	Total	\$13,424	\$760
River Management	Built-up area	\$2,167	\$123
	Other land use type	\$83	\$5
	Total	\$2,250	\$127
Multiple types	Built-up area	\$34,631	\$1,960
	Other land use type	\$895	\$51
	Total	\$35,526	\$2,011
Total		\$198,354	\$11,228

It should be evident that built-up areas that are protected by these schemes represent the greatest benefit, which together represent over \$184 billion NPV or over \$10 billion of annual benefit, compared with over \$14 billion NPV or an annual benefit nearly \$1 billion for other land use types protected by these schemes.

While not all councils are represented in this analysis we consider that the information is sufficient for an evaluation of the benefits of the schemes to be made at a national level. It is expected that inclusion of schemes not included in our analysis would return a similar, outstanding BCR.

Figure 5.2 depicts the cost and benefit of the schemes for each region in our assessment.

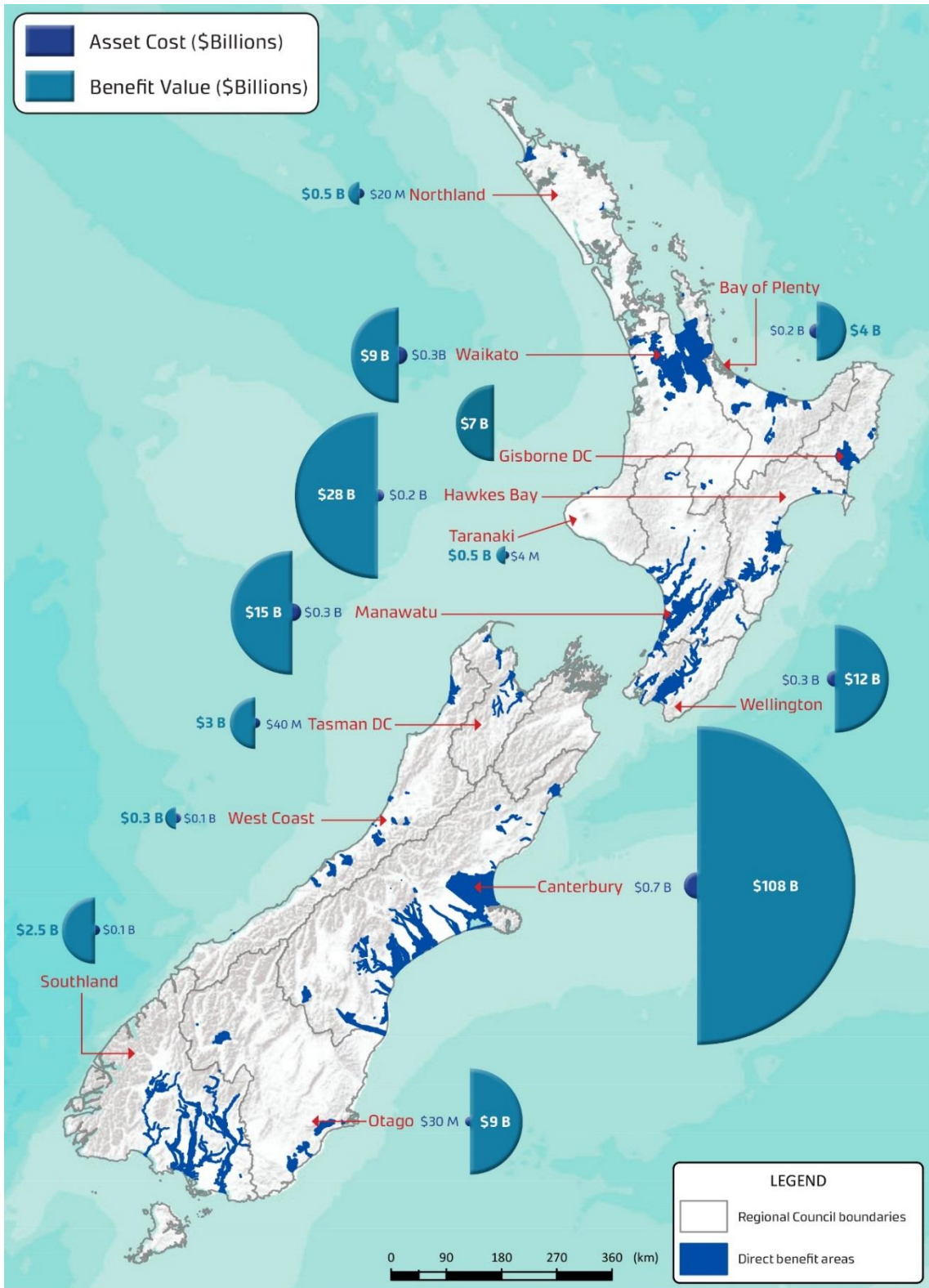


Figure 5.2: NPV of scheme benefits and capex + opex costs by region (values indicated where available, subject to rounding)

Figure 5.3 below shows the combined benefit and the benefit cost ratio for each region. This clearly shows the significant benefit derived from the protection provided in various locations throughout New Zealand, at various scales, and with different land use types being protected.

Figure 5.3 shows that the Canterbury region has a very high BCR. This is because virtually all of the Christchurch urban area receives flood protection benefit from the Waimakariri Flood Protection Scheme. We note that parts of Christchurch are protected by Christchurch City Council’s flood protection schemes. The costs of these schemes have not been incorporated into our analysis and if incorporated would reduce the BCR for the Canterbury Region. However, given the small scale of the city’s schemes relative to the direct benefit area for all of the Canterbury schemes, we would expect little change to our overall findings, i.e. flood protection schemes in Canterbury provide outstanding value for money.

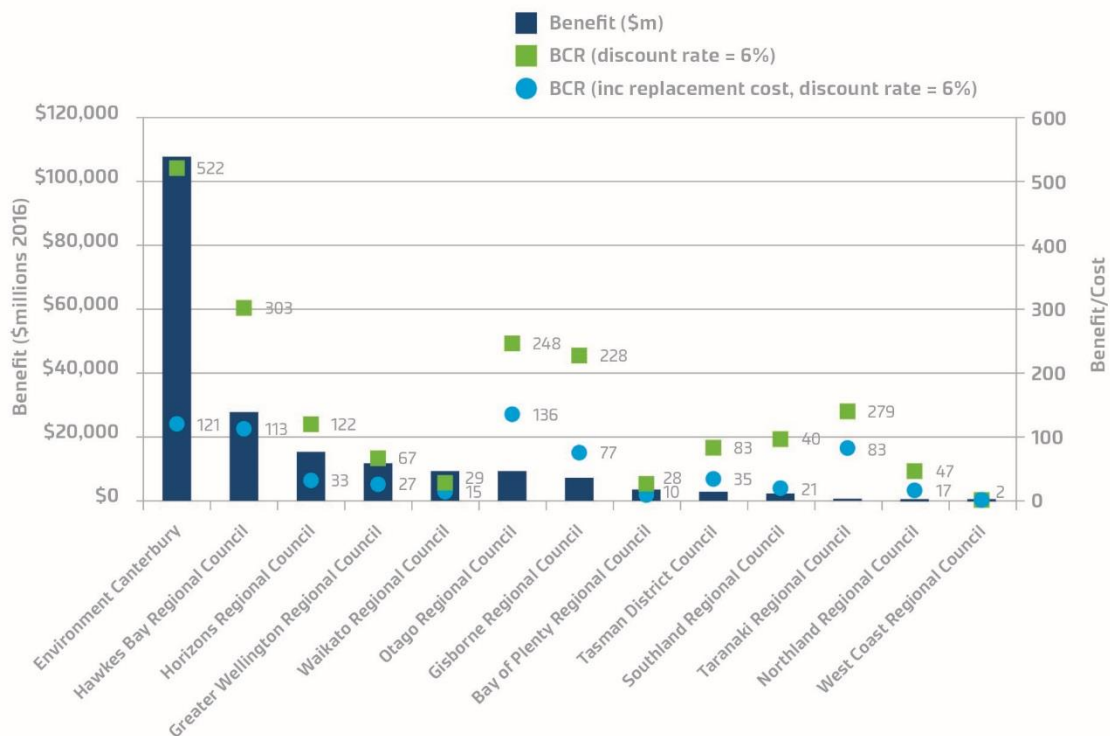


Figure 5.3: Benefit, costs and benefit cost ratios for schemes included in this assessment

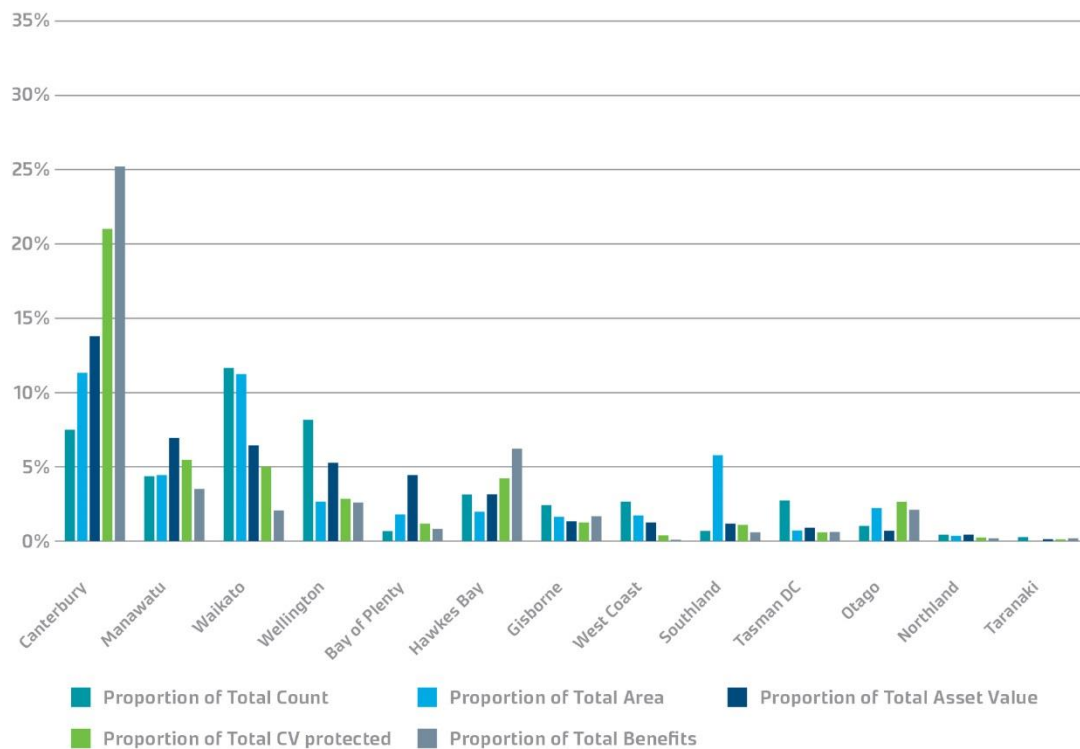


Figure 5.4: Scheme attributes as proportion of national total including economic information

5.3 Exclusions

The economic assessment included in this assessment represents a snapshot of economic benefits and costs as at 2016. A longitudinal study of how these benefits and costs have changed historically and might change in the future was excluded from the scope of this review. We would expect that given the increase in New Zealand GDP and land prices over the past two decades the benefit provided by the schemes is likely to have increased over this period as a result. However, we are less certain on how scheme costs and their cost benefit ratios may have changed over that period. Special care would need to be taken in selecting time periods for such a longitudinal assessment so the results are not overly influenced by selection bias.

The economic assessment included in this assessment is traditional in that a factor was applied to the economic analysis to account for wider social and economic benefits of the schemes. This analysis excluded a formal assessment of the cultural and environmental costs and benefits given its overview nature and the complexities associated with assessing these values on such a large scale. We would expect that the calculated BCR would change if these values were included in a cost benefit analysis. We would also expect that if these values were included, the schemes overall would still provide a net benefit to New Zealand given the large economic BCR calculated in this assessment. Further detailed analyses of individual schemes or portions of schemes may reveal that some are not economic.

Further work would be required to address these exclusions as well as understand infrastructure asset valuation practices and outcomes, and forecast how the benefits and costs of the schemes might change in the future.

6 Management of the schemes

6.1 Asset management maturity

Asset management plans (AMPs) are the central documents for describing the purpose and performance of a scheme and outlining how the scheme is managed.

Councils are required to prepare AMPs for flood protection assets under s101B of the Local Government Act 2002. AMPs are optional for assets that deliver benefits to other areas — for example, drainage, river management, and tidal protection.

We assessed the maturity of the asset management plans provided by regional councils using the Asset Management Maturity Methodology published by Treasury⁸. Assessment was based on an evaluation of a small selection of AMPs from each council. Treasury's framework and our asset management maturity assessment is included in Appendix B.

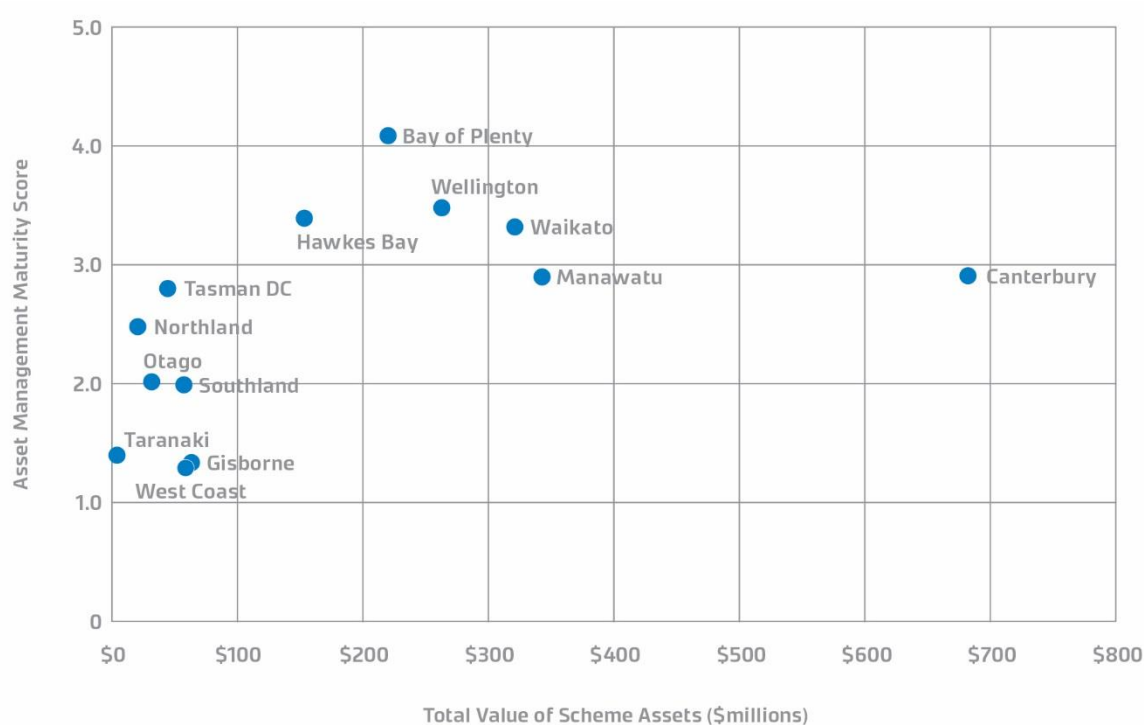


Figure 6.1: Asset management maturity by council

As seen in Figure 6.1 there is some variation in asset management maturity amongst the cohort of councils managing a larger asset base (greater than \$150M replacement value). Although all were assessed as meeting or nearly meeting a 'core' level of overall asset management maturity (an asset management maturity score of three). Canterbury and Manawatu fell just short of reaching a 'core' level, indicating that some aspects of asset management weren't well described in the AMPs reviewed.

Amongst the cohort of councils managing smaller asset bases (less than \$100M replacement value) asset management maturity scores varied more widely, with Tasman being the only council to nearly achieve a 'core' rating. We expect this is due to their broader asset management responsibilities for

⁸ <http://www.treasury.govt.nz/statesector/investmentmanagement/review/icr/information/assetmgmt>, accessed 27 May 2017

areas such as three waters and transport, which has helped them develop a stronger internal capability to document their activities in AMPs.

It should be noted that AMPs may not reflect actual management practice. This is because some river managers reported that they carried out the necessary asset management activities but did not document it in their AMPs. This feedback predominantly came from managers of smaller schemes.

6.2 Providing a level of service

One of the fundamental metrics across all of the schemes is the level of service that the schemes deliver to their benefit areas. Using a broad sample of asset management plans provided, we reviewed the approach regional councils have taken and the levels of protection offered by schemes⁹.

6.2.1 Ways of measuring the level of service

We found that councils generally adopted one of three methods for determining the level of service provided by a scheme:

- Agreeing on a scope of physical works with the community without reference to a target capacity or return period
- Providing physical works with a level of performance provided in terms of a target capacity — for example, stating a maximum channel flow
- Providing physical works with a level of performance in terms of a target return period — for example, referring to a 1 in 100 year event

The proportion of these three levels of service methods across the schemes in this assessment is shown in Figure 6.2.

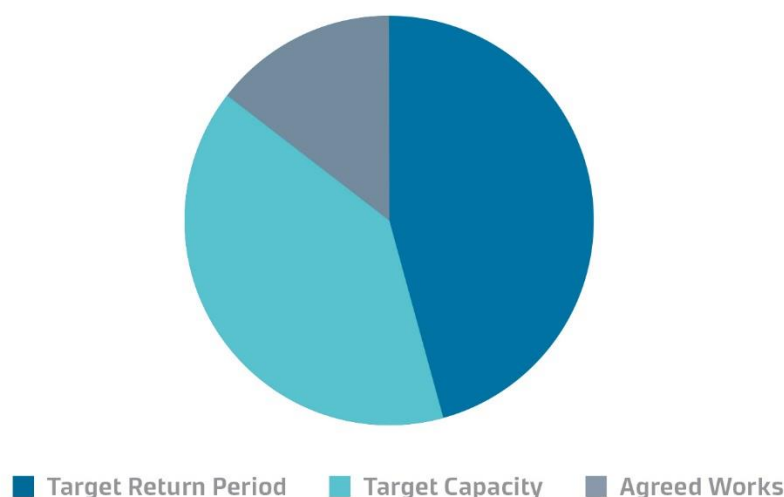


Figure 6.2: Proportions of level of service methods weighted by asset value

⁹ The terms level of protection, level of service, and service level are used interchangeably in this document.

Asset management maturity at district councils

Although asset management maturity scores that district councils target vary depending on the asset class, a 'core' level of maturity is considered the minimum acceptable score.

Some asset classes — for example, roading — have higher minimum acceptable scores. NZ Transport Agency funding for roads drives better asset management practices in the transport sector and an 'intermediate' level of maturity is required.

It is our view that regional councils should agree on a nationally consistent minimum level of asset management maturity. We would expect that at a minimum, regional councils should target a score of 'core', though a higher level of maturity may be desired.

6.2.1.1 Agreed works

The level of service provided by ‘agreed works’ schemes is defined by their performance during past flood or rainfall events. For many of these schemes, both council staff and the community agree that the scheme size does not justify the cost of detailed analysis. However, there are some documented instances where council staff recommended technical analysis that did not proceed due to community resistance to cost. With the scheme performance undefined, councils are only able to track their service delivery through measures around maintenance works programmes or a general description of channel condition.

6.2.1.2 Target capacity

The level of service provided by ‘target capacity’ was most common in mid-sized schemes. An example of ‘target capacity’ flood scheme channel capacity with a flowrate of 900 m³/s or a pumping rate in a drainage scheme of 7 mm/day. This type of service level provision focuses on managing the natural processes and asset lifecycle issues that reduce the capacity below the target, and the integrity of the scheme over time. Meaningful comparisons and conclusions between schemes and councils with ‘target capacity’ levels of service cannot be made as their service level is specific to each scheme.

Many of New Zealand’s hydraulic and hydrologic record lengths are relatively short – in the vicinity of 40 to 60 years. As time passes and these record lengths increase, the frequency that a scheme’s ‘target capacity’ occurs will change. This phenomenon, combined with climate change will likely cause the ‘target capacity’ of a scheme to be exceeded more frequently in the future. Climate change is widely acknowledged to likely lead to more frequent high intensity storms and may result in increased flood damages and poorer community outcomes if left unmanaged.

6.2.1.3 Target return period

The larger schemes have a level of service based on a ‘target return period’ or ‘target AEP’, for example protection from events up to a 50 year return period or 2% AEP. For flood schemes, rural return periods ranged from 5 years (20% AEP) to 100 years (1% AEP), with the return periods for urban schemes ranging from 100 years (1% AEP) to 500 years (0.2% AEP).

Under a ‘target return period’ level of service, the notional level of service – say 2% AEP – will stay the same over a given period until the agreed level of service is changed. However, the actual size of the design event, such as flow and water level, will vary as the length of hydrologic record grows. In addition, as environmental changes — ranging from land use change within the catchment, sea level rise, and increased frequency of high intensity rainfall events to river channel aggradation or degradation — take place, the frequency of a flood of a particular size will vary.

Given this, schemes that use a ‘target return period’ rather than a ‘target capacity’ to set the level of service for a scheme need regular and detailed technical analysis to quantify the size of the design event. Also, these schemes may require physical works to ensure the agreed level of service is maintained. Schemes using a ‘target capacity’ approach will also require periodic technical analysis, though on the face of it this should be more straightforward than that carried out for a ‘target return period’ approach.

6.2.1.4 Discussion

Each of the three methods for determining the level of service currently in use may be suitable for a given scheme, provided that information about event likelihood, scheme and property vulnerability, potential consequences, and residual risk to the community are well understood and communicated. Each of the three methods may also be suitable for a class of schemes. For example, the ‘agreed

works' method may be suitable for low risk schemes, the 'target capacity' method for medium risk schemes, and the 'target return period' method for high risk schemes.

In addition, a 'target return period' may be more effectively communicated in terms of cumulative probability rather than a return period or annual probability. For example, what is commonly known as a 100 year flood is technically an event having a 1% probability of exceedance annually. People regularly dismiss this risk believing there is a low probability of it occurring in their lifetime.

But statistically, a 1% AEP event has a 26% chance of occurring during the life of a 30 year mortgage, and a 39% chance of occurring during a 50 year design life of a standard building¹⁰.

Providing this and other contextual information may assist in increasing the public's understanding of a 'target return period' level of protection.

This approach, however, does not consider the uncertainty associated with event likelihood given New Zealand's relatively short record periods. These short record periods mean that any estimate of rainfall or flood events larger than one having a 10 to 20 year average recurrence interval (or a 10% to 5% annual exceedance probability) is potentially unreliable. A summary of the length of historical record required to reliably estimate return period events is presented in Table 6.1.

Table 6.1: Length of historical record required to reliably estimate return period events

Average recurrence interval (ARI, years)	Annual exceedance probability (AEP which is the inverse of ARI, %)	Length of record required to reliably estimate return period events (years)	
		95% reliable estimate	80% reliable estimate
2.33	43%	40	25
10	10%	90	38
25	4%	105	75
50	2%	110	90
100	1%	115	100

Source: *Landslide risk assessment*, Lee E.M. and Jones, D.K.C., Thomas Telford, 2004.

6.3 Changing the level of service

Changes to a scheme's targeted levels of service typically do not happen very often. As noted above, schemes using the 'target return period' and 'target capacity' methods of providing a level of service will require periodic technical analysis to quantify the size of the design event, and possibly physical works upgrades to ensure a scheme continues to provide the target level of service. There is not the same need to review the underlying technical analysis of schemes where the 'agreed works' approach is adopted.

Even though most schemes would benefit from a level of service review, the scale of investment required to improve service levels and the longevity of the associated infrastructure assets mean there are long periods between planned reviews. By not having a regular programme of level of service reviews, there is a risk that a scheme may not actually deliver on the community's expectations of performance.

¹⁰ Rather than using event AEP as a design basis, the New Zealand structural loadings code uses cumulative probability language such as "an event having a 10% chance of occurring over 50 years". This equates to a 475 year return period, and approximately a 0.2% AEP.

For example, the Heretaunga Plains Flood Control Scheme was 30 years old before undergoing its first level of service review. Events that exceed a targeted level of service, for example the Whanganui River floods of 2015, may also trigger a service review. However, these large scale events are infrequent and any review is therefore on an ad hoc basis.

Regional councils generally undertake incremental reviews of scheme performance on an ongoing or revolving basis. For example, the Waikato Regional Council has a programme of works to update each of their hydraulic models on a 10 year rolling basis. The way this works is that a proportion of their models are updated each year so that by the end of a 10 year period all models have been updated. These reviews may identify changes in actual performance, for example, a reduction in channel capacity. Or, they may identify changes in the understanding of actual performance, for example, from an improved scheme model. These incremental reviews may produce updated works programmes requiring consultation with the community.

Further work is required to standardise the timing and frequency of a level of service review across the sector. This could be undertaken as part of the package of work described above to provide a framework for determining the level of service by scheme class, and how risk is understood and communicated.

6.3.1 Adequacy of existing levels of service

A comparison of the large economic BCR of the schemes and the relatively low performance standards of schemes when compared with other hazards¹¹, suggests that, on the whole, the schemes may be under-designed for what they protect and enable. Further work would be required to understand if the existing levels of service are appropriate and sufficiently in line with best practice.

We would expect this conversation to be informed by a better understanding and communication of flood risk information. This includes data on probability and likelihoods, scheme vulnerability and that of protected properties, consequences, and residual risks, as well as the physical works and associated costs required to provide a higher level of service. In our experience, the magnitude of a 200 year flood event is not twice that of a 100 year flood event even though the former is statistically twice as rare as the latter. Further, we would expect the marginal cost of providing protection from a 200 year event to be less than the cost of providing protection from a 100 year event. Nonetheless, current pressures on scheme funding and affordability would need to be considered in opting for a higher level of service. These pressures are further discussed in Section 6.6 of this report.

6.4 Community consultation

The requirements, processes, and techniques for effective community consultation on river management activities can largely be classed into routine and non-routine matters.

6.4.1 Existing practices

Consultation on routine operational and maintenance matters including annual renewal programmes, annual plans and the like are reported by river managers to be generally relatively easy and straightforward to carry out. Consultation is reported by river managers to be effective for smaller schemes and where stakeholders are direct beneficiaries.

¹¹ The Reserve Bank of New Zealand's solvency standards require insurers to be solvent after a 0.1% AEP (1 in 1,000 year) earthquake, and after other events (e.g. storms and floods) with an AEP of 0.4% (1 in 250 year). The New Zealand structural loadings code is designed to provide buildings that do not endanger human life during a 0.2% AEP equivalent (1 in 475 year) earthquake, while many flood protection schemes are designed to protect from events up to 1% AEP (1 in 100 year).

A summary of consultation methods used by councils is given in Table 6.2, below. All councils report using liaison committees which are comprised of stakeholders, although on some very small schemes, the number of stakeholders is so small that the council deals directly with ratepayers.

Table 6.2: Consultation methods employed by councils

Council	Consultation methods				
	Long term plan	Liaison committee	Direct consultation (ie no committee)	Annual ratepayer meeting	Survey
Canterbury	✓	✓			
Manawatu	✓	✓	✓	✓	
Waikato	✓	✓			
Wellington	✓	✓			
Bay of Plenty	✓	✓			
Hawkes Bay	✓	✓	✓		✓
West Coast	✓	✓	✓		
Southland	✓	✓			
Tasman DC	✓	✓			✓
Otago	✓	✓	✓	✓	
Northland	✓	✓			
Taranaki	✓	✓			
Gisborne DC	✓	✓			

Consultation on non-routine matters is generally more difficult as these matters represent a significant change to scheme operation or level of service. For these issues, a unique consultation strategy is required for each change or issue. This typically requires educating various stakeholders about an issue, then gathering key stakeholders around a table to develop a consultation strategy before finally consulting more widely. This process is reported to generally provide a better chance of successful consultation on a major issue but doesn't guarantee its outcome.

6.4.2 Willingness to pay

River managers also reported that communities are generally more willing to pay for tangible measures of protection, such as stopbanks rather than soft responses – for example, land use controls or managed retreat. Also, that communities often opt for a larger capital outlay in the near term rather than an adaptive response carried out over many decades. These two incidences were reported by Greater Wellington as results of their public consultation regarding the recent Hutt Valley scheme upgrade for a future state of 2115.

6.4.3 Effective engagement

The ability to conduct effective stakeholder communications will be vital if communities are to understand the rationale for, and gain the potential benefits – such as cost savings and improved quality – from soft or adaptive approaches to flood hazard management. Especially as these approaches are often controversial. For example, managed retreat may be the best long term option for some communities. But this approach will require greater collaboration, and a willingness to consider alternative strategies that provide a similar outcome to physical works – such as providing safety and security from flooding.

Given the uncertain level of impact surrounding many of the sector challenges outlined in Section 7, river managers will need to be collaborative and engage early with stakeholders to deliver successful outcomes for the community. This early engagement process may challenge river managers who the community potentially perceives as having a vested interest in the ongoing maintenance of a particular intervention. It may also challenge asset managers to consider whether and how the community may respond to an event – such as flooding— and to then tailor their communication appropriately at an early stage.

6.4.4 Risk communication

The importance of how well risk information — probability or likelihood, vulnerability, consequences, and residual risk — is communicated to stakeholders cannot be emphasised enough¹². Reframing by the river management sector of the risk discussion to one of consequences first and cumulative probability and uncertainty second may be a good first step towards better risk communication with stakeholders.

Understanding and building a national picture of flood risk vulnerability and consequences, underpinned by development of a nationally consistent methodology for understanding and documenting asset criticality, performance, and level of service, would be a useful foundation for communicating this risk to communities and stakeholders.

6.5 Council staffing

Recruiting, retaining, and developing great staff is fundamental to the success of any organisation. Current river management staffing levels are just sufficient to carry out day to day activities, and staff often have a narrow technical skill set or limited understanding of river management in a New Zealand context. Staffing issues that inhibit regional councils from producing successful river management activities and community outcomes include:

- A chronic shortage of versatile, multi-faceted engineers with an understanding of the broader non–engineering aspects of river management activities
- A lack of visibility of a professional river management career by university students
- No formal, sector-wide graduate engineer intake or development programme
- Lack of awareness of the regional council business by the wider public, and a lack of positive news stories about regional council activities in the mainstream media

¹² This approach is effected through a risk-based approach to natural hazards under the 2017 amendment to the Resource Management Act, see <http://www.mfe.govt.nz/publications/rma/resource-legislation-amendments-2017-fact-sheet-series>, Fact Sheet 10, accessed 27 May 2017.

- Unstructured in-house and sector professional development programmes that are geared towards future issues facing the sector
- A lack of sophisticated employee transfer arrangements between councils and with other organisations

Addressing these staffing challenges is critical, and the ability of river managers to resolve them individually is constrained by several factors, including the current level of funding at each council, and level of coordination amongst regional councils.

Partnership and collaboration is essential to addressing staff and resource challenges successfully. This could take the form of working with an existing organisation (e.g. IPENZ or LGNZ) or the formation of a new pan-sector partnership to promote the river engineering sector. Activities by this group of sector professionals could include:

- Guest lecturing at engineering schools in New Zealand universities
- Establishing a chair in river engineering and management at a New Zealand university
- Developing a formal graduate intake and development process
- Creating a river management continuing education framework and supporting coursework
- Facilitating movement of staff within and among regional councils, and with similar organisations overseas

Case study – Development of River Management Asset Performance Assessment Code of Practice

New Zealand's river managers have already recognised the importance of greater consistency in assessing the condition and performance of river management infrastructure. Development of a guidance document for this purpose was recently developed by Greater Wellington RC, and endorsed by other river managers.

However, we understand that uptake of the Code of Practice has not been uniform across the regional councils. We would expect that implementation of the methodologies outlined in the document would require each river manager to affect change within their council. Achieving this in a timely manner across all regional councils may be difficult depending on the priorities of each council.

Additionally, development of this document by a single regional council in the current working environment raises some questions about how it may be revised and updated. We could see each council using the document as a starting point, with individual councils modifying it to suit their context in isolation from others.

Clearly this is not what was intended when the document was developed, though it appears a real possibility given the current working environment within NZ's river management sector.

6.6 Scheme funding

As noted in Section 2, schemes were heavily subsidised via central government between 1941 when the SCRCC was formed and 1987 when NWASCA was disbanded. The Local Government Act 2002 now provides councils with tools for fair and equitable allocation of rates according to benefit received.

6.6.1 Funding sources

All regional councils generally use targeted rates as the primary funding source for the schemes¹³. These rates are typically banded into benefit levels to reflect spatial variation in the benefit received from a scheme. For example, a property on the second terrace of a flood plain will not receive the same benefit from a flood control scheme as a property lower down and immediately adjacent to the river.

¹³ A notable exception to this is Greater Wellington's move towards funding schemes on the Kapiti Coast through a general rate on properties in that sub-region.

Some councils incorporate all relevant benefits into a single targeted rate, where others separate out different costs and benefits as separate rating bases. In one instance 11 different targeted rates overlapped. Obviously councils need to balance transparency, administrative practicality and efficiency, fairness and accuracy when funding these schemes.

Some councils also use either a targeted or uniform rate for indirect benefit to provide part funding of scheme costs by the wider community. This is restricted to schemes that are large enough to have a clear benefit for the wider (or entire) region – either as an individual scheme or the cumulative benefit from a number of schemes.

Overall, we found that each of the rating schemes was developed in its own context and provenance, so even among schemes with simple rating areas it is difficult to use the rating information as a basis for compiling and comparing scheme funding data. Future national data analysis would be enabled by a consistent rating methodology and regional councils should consider if this would be valuable and achievable.

6.6.2 Funding issues

Funding affects many aspects of a regional council's river management business including:

- The future affordability of the schemes and their renewal programmes
- Whether a scheme's level of service can be maintained, upgraded or may need to be downgraded
- The ability of councils to employ, retain and develop, appropriately trained people to effectively deliver work programmes
- The ability of councils to share information and experiences with other river managers
- Their success in educating the community about the value of schemes, what they protect and the residual risks that the communities face

In our assessment we found a number of issues relating to funding and operational expenditure pressures on river management activities including:

- Desire of some communities to control rate increases at the expense of infrastructure asset investment or renewal
- The general expectation to do more for less
- Changing community expectations, the widening of stakeholder groups, and how environmental, social and cultural values manifest themselves in river management activities, including but not limited to:
 - National Policy Statement for Freshwater Management 2014
 - Health and Safety at Work Act 2015
 - Co-governance commitments through Treaty of Waitangi settlements
- A greater incidence of non-rateable properties (and corresponding decline in rating base) within areas of benefit from the schemes — for example through construction of new state highways
- How asset condition is measured (discussed in Section 4.5.2 above), and how this informs asset revaluation practices
- An increase in actual costs to renew or replace infrastructure above the planned expenditure and / or asset book value. This can result from a variety of factors including poor financial and asset management planning, a change in community expectations or legislative environment, and construction costs increasing faster than general inflation

- The way operational and maintenance activities are funded. For example, depreciating asset book value and renewal expenditure, borrowing, and the resulting balance of payments

These issues and downward pressures on funding levels for river management activities discourage best practice, and force staff to 'make do' by cutting expenditure elsewhere. This is particularly relevant for unplanned additional expenditures. For example, on a recent capital works project on the Lower Waikato scheme, the Waikato Regional Council decided to use more costly mechanical components to provide better environmental outcomes while still providing the same level of service, and had to trim budgets elsewhere to accommodate this unplanned expenditure.

Many of these issues are common across the regional councils, though how councils record, report and manage them varies considerably. Further work would be required, for example, to better understand the balance of operational payments on a national scale and its implications on future affordability of the schemes. Standardisation in operational expenditure reporting would make this assessment easier. As with other challenges, this appears to be one that would benefit from greater cross-council collaboration.

As previously discussed, property rates paid to regional councils are the backbone of funding river management activities. Ratepayers, however, are generally unable to offset a property rates increase through increased productivity (i.e. income generation) from their land, and cannot release their property's capital value until it is sold. This creates a challenging situation where communities may not be willing to pay for river management infrastructure upgrades and renewals despite professional advice from river management experts. It is our view that alternative funding strategies should be explored so that regional councils can deliver a better river management service to their communities.

Willingness to pay – a West Coast Regional Council case study

The West Coast Regional Council (WCRC) has low population growth and GDP per resident close to the national average. Many of the flood protection schemes WCRC is responsible for benefit, and are funded by, a small local community.

Council staff sought to better understand changes to the risk posed by the Matanui Creek through a flood study. When council staff approached the community to gauge support for this work, the community declined to spend the money, preferring to leave the current performance of the scheme unknown.

6.6.3 Environmental, social and cultural context of scheme funding

It is our view that to meet changing community expectations and make investment decisions transparently, developing a framework that formally accounts for environmental, social, cultural, and economic outcomes of council projects and schemes would be beneficial. We expect that this framework would be supplemented by a decision support tool, such as that recently developed for NZ Transport Agency¹⁴. This would enable councils to be more proactive in responding to or adapting to stressors or shocks on their infrastructure assets within a timeframe and to a cost that is acceptable to the community.

In April 2017, the International Public Sector Accounting Standards Board (IPSASB) published a consultation paper on Financial Reporting for Heritage in the Public Sector. In this context 'heritage' includes 'natural heritage', that is, the environment. NZ takes its accounting standards from the IPSASB and the inclusion of environmental outcomes into this formal financial framework represents a significant change in public sector accounting.

This may require regional councils to quantify in their financial reports the natural environment as assets, and costs associated with maintaining the environment as liabilities. Further professional

¹⁴ *Establishing the value of resilience*, New Zealand Transport Agency research report 614, Money C. et al, 2017.

advice would be required to understand how the consultation paper and subsequent standards may affect the river management sector.

6.7 Regulatory environment

The regulatory environment relevant to river management in New Zealand is in a state of flux with changes to the Resource Management Act (RMA), and the National Policy Statement for Freshwater Management, the development of a National Policy Statement for Natural Hazards, funding of emergency response / recovery under the Guide to the National CDEM Plan – Section 33 Government Financial Support, and development of a National Disaster Resilience Strategy.

In addition to the overarching national legislation and guidance, each river manager negotiates a different regional regulatory environment, which has been developed in response to their communities' needs and desires and their own physical settings.

The following subsections outlined details of legislation as relevant to river management activities.

6.7.1 Soil Conservation and Rivers Control Act 1941

The 1941 Soil Conservation and Rivers Control Act (SCRCA) was a key piece of legislation that enabled construction of many of the flood protection, river control, and land drainage schemes in New Zealand. Key elements of this Act that continue to enable river managers to carry out their work include:

- Section 2 - The breadth of the definition of “defence against water”
- Section 10 - Objectives of the Act (c) the prevention of damage by floods and (d) the utilisation of lands in such a manner as will tend towards the attainment of the said objects
- Part 7 Powers and Duties of (Catchment) Boards
 - Section 126 (2) - General powers to construct, reconstruct, alter, repair and maintain works and do other acts to fulfil function to minimise and prevent damage. These powers are important to carry out river management activities. However, given their breadth and reasonably unfettered nature, we note they could be subject to challenge in a legislative review process
 - Section 131 - Public Works Act 1981 to apply to construction works. This power is also conferred to regional councils under the Local Government Act 2002
 - Section 132 - Powers to enter for assessment and investigation
 - Section 133 - Maintenance and improvement of watercourses and defences against water
 - Section 135 - Incidental powers, including the ability to acquire land under the Public Works Act, enter & use land to take materials, access and load/unload materials and establish work areas
 - Section 137 - Notice in respect of works on private land. This could be subject to challenge in a legislative review process
 - Section 138 - Apportioning costs of works with owners of land
 - Section 139 - Land can be purchased on system of time payment
 - Section 140 - Leasing powers
 - Section 143 - Supervision of drainage works and river works
 - Section 146 & 147 - Ability of Board to pay for private works and purchase land injuriously affected
 - Section 148 - Liability for damages arising from neglect

The objectives of the Act are indirectly encompassed in the purpose and principles of the RMA, with some powers under the Act included in the Local Government Act 2002. Should any repeal of the Act, or parts of it, be proposed river managers should carefully consider how these changes may affect the functions and powers they currently have to enable their river management activities.

To access and maintain their assets some councils rely on good relationships with private landowners and the provisions of the SCRCA. This, however, is variable as some councils own many of their assets, or at least maintain easements over private land.

The ability of regional councils to own the land beneath their assets, or at least maintain an easement across private land would remove some of the concerns river managers have around getting to and protecting their scheme assets. It must be noted that requiring regional councils to buy land or negotiate easements would substantially increase their costs.

Many of the aspects of the Soil Conservation and Rivers Control Act (SCRCA), along with other pertinent legislation have been repealed. A broad based, blue skies review covering key pieces of legislation, including *inter alia* the Resource Management Act 1991 (RMA) and Local Government Act 2002, has been suggested by several organisations including Local Government New Zealand and the Productivity Commission. Should such a review occur, there is a potential threat to regional councils that the remaining residual provisions of the SCRCA, which enable river management activities and are described above, could be inadvertently repealed.

Repeal of these remaining provisions would affect the ability for regional councils to develop new schemes, manage and maintain existing schemes and, potentially, to upgrade schemes to respond to the effects of climate change. Should a blue skies legislative review occur, how these activities are enabled needs to be considered. Not only in the context of the way that these schemes have been historically developed, but in light of current and likely future environmental and societal expectations. This represents a significant challenge, not only to ensure that legislation allows regional councils to effectively fulfil their obligations, but also to understand how those obligations may change.

Additionally, there is a potential for significant additional cost on communities should these powers be inadvertently removed. Costs could arise from:

- Councils being unable to maintain schemes if access is denied by land owners
- Legal costs associated with maintaining access rights
- Costs of land or easement purchase.

6.7.2 Resource Management Act 1991

The RMA affects river management and land drainage activities, which means river managers can be both applicants and potentially affected parties under the Act. The way in which river managers undertake their works and activities, and the ease of doing so, largely comes down to how the effects of these activities are provided for through regional and other plans.

Provisions in Regional Plans are variable across the regional councils. Some plans have policies that explicitly recognise some scheme structures as natural and physical resources and have specific provisions that enable river managers to undertake a range of activities. For example in Hawkes Bay and Taranaki a range of river management tasks can be undertaken as permitted activities (subject to terms and conditions in the plan), or in some instances compliance with a Code of Practice or similar document. Other regional plans, such as Greater Wellington Regional Council's, are much more restrictive and require resource consents to be obtained for nearly all works and activities that river managers may need to undertake.

Some plans and council practices identify scheme asset managers as potentially affected parties, enabling them to be consulted on resource consent applications that may affect them – other plans and council practices don't. Those managers have reported they have little influence on decisions that may impact on their infrastructure or their ability to deliver services to their communities.

Some regional councils use river management staff as experts in the evaluation of consent applications — which raises potential conflict of interest issues — whereas others would tend to use people from other parts of the organisation or commission this advice from an independent expert.

How these elements play out in any regional council — along with the size or value of assets under management by a regional council — may affect the ability of councils to meet their obligations to the community effectively and efficiently. In some circumstances these elements may affect the councils' ability to retain river management staff.

The river management sector could benefit significantly from a nationally consistent approach to managing the effects of their schemes under the RMA. This approach would allow for more effective collaboration and sharing of resources across councils because staff wouldn't have to learn how to work in a new regulatory setting. This would likely have a wide ranging and significant impact, including providing further consistency in the delivery of services across the sector, normalising compliance costs, expediting processes, and standardising expected outcomes.

6.7.3 Local Government Act 2002

River managers report that the Local Government Act 2002 generally enables and supports their activities, and identified the following provisions as notably important to their activities:

- Ability to have targeted rates
- Use of the special consultative procedure
- Development of infrastructure management strategy
- Use of long term and annual planning processes to implement their infrastructure strategies.

6.7.4 Civil Defence and Emergency Management Act 2002

River managers also have a good connection to the Civil Defence and Emergency Management Act 2002 and see this as integral to their activities. Specifically in areas of emergency management planning, providing advice to emergency controllers, and managing residual risk to communities.

The Ministry of Civil Defence and Emergency Management is currently developing a new National Disaster Resilience Strategy that will replace the current National Civil Defence Emergency Management Strategy¹⁵.

The Ministry has prioritised the following areas for improvement:

- Understanding disaster risk
- Strengthening disaster risk governance to manage disaster risk
- Investing in disaster risk reduction for resilience

¹⁵ This is in response to international best practice that suggests a shift in focus from 'managing disasters' to 'managing risk' will improve the resilience of our communities. New Zealand is also signatory to the Sendai Framework which seeks: *a substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.*

- Enhancing disaster preparedness for effective response, and to “Build Back Better” in recovery, rehabilitation and reconstruction.

6.7.5 Summary

The regulatory environment relevant to river management in New Zealand is complex and varies from region to region. Key powers given to river managers under legislation such as the SCRCA may inadvertently be removed under a ‘blue skies’ legislative review. As these potential issues affect the sector as a whole, the sector would benefit from better collaboration to create ‘one voice’ and assist in the development of policy and law on these issues.

7 Resilience challenges for river management

Many of the challenges facing river management activities have been outlined in the preceding sections and in this section we describe the concept of resilience. Many organisations understand resilience in the context of natural hazards, however it also relates to other technical and non-technical challenges. Many challenges facing the river management sector fit within the resilience concept.

7.1 Resilience – in concept and practice

The concept of resilience is often simply thought of in terms of how a community responds to a large earthquake or other natural disaster – how quickly will the community return to normal? Resilience is much more than that.

Definitions and themes of resilience include understanding, communicating, and managing risk through lenses as diverse as governance and leadership; health, wellbeing, stability and security for individuals, families and communities; and the built and natural environment.

Central government and many of its agencies recognise the value that adopting a multi-faceted resilience framework brings to their ability to deliver successful outcomes to their communities. As noted above in Section 6.7, the Ministry of Civil Defence and Emergency Management is developing a new National Disaster Resilience Strategy in line with the Sendai Framework for Disaster Risk Reduction, of which New Zealand is a signatory. The NZ Transport Agency has a national resilience programme and recently proposed a definition¹⁶ of resilience as: ***the ability of systems (including infrastructure, government, business and communities) to proactively resist, absorb, recover from, or adapt to, disruption within a timeframe which is tolerable from a social, economic, cultural and environmental perspective.***

In practical terms, if river management activities among regional councils were resilient one would see a sector that, among other things:

- Values business continuity, and performs effectively in a crisis
- Is resourced in terms of capability and capacity to respond to known and unknown changes relevant to the sector —including climate change or funding pressures
- Understands and effectively communicates risk information — event probability or likelihood, vulnerability, consequences and residual risk
- Proactively engages with diverse stakeholder groups, and has the ability to measure the environmental, social, cultural, and economic value of the services it provides
- Builds and maintains infrastructure assets that are robust and have spare capacity to accommodate disruption and uncertainty
- Can adopt alternative strategies to continue to provide an agreed outcome — including safety and security from flooding — to the community

Some regional councils are carrying out aspects of resilience without the benefit of working within a systematic framework. In this assessment we've found that some councils may be better than others at some aspects of resilience. These practices are not widely adopted, however, and are carried out on an *ad hoc* basis without a vision or strategy of making our communities more resilient. Cross-sector collaboration is needed to develop a river management resilience framework and associated decision making tools to enable all regional councils to respond to their common challenges with minimum disruption to their communities.

¹⁶ Money C. et al, 2017.

7.2 Challenges as shocks and stressors

The challenges facing river management in New Zealand threaten the ability of regional councils to effectively deliver their agreed services to the communities they protect. Challenges can be classed as either shocks or stressors, depending on their nature. Shocks occur suddenly, often without warning, test an organisation's resilience, and can precipitate a crisis. Stressors are issues that persist over a long time or recur frequently, and inhibit the capacity and capability of an organisation to deliver its service or respond effectively during a crisis.

7.2.1 Potential shocks

The findings of this assessment indicate the main potential shocks facing the river management sector include:

- Large flooding events, including infrastructure asset failure during a design event and over design events
- Earthquakes, which can damage infrastructure assets and deplete council and/or insurance reserves
- Future changes to how central government financially supports local authorities during emergencies
- Changes to the regulatory framework that enables river management activities
- Implementation of new policies or standards that may make it difficult for river managers to meet their consent compliance obligations. Refer Appendix D for a discussion on national metadata standards.

Due to the complex systems and environments where river management is practiced in New Zealand, the occurrence of a potential shock can have an impact far beyond the immediate community that receives direct benefit from the scheme. Examples include:

- The March 2016 flooding of the Franz Josef township and closure of State Highway 6. This highlighted that the failure of flood protection in a small settlement on the West Coast can have a disproportionately large impact on national and economically important tourism opportunities and connectivity
- The September 2010 Darfield earthquake, which severely damaged infrastructure assets in Canterbury's Waimakariri scheme. Urgent and timely repairs were undertaken and completed just days before the December 2010 flood event in the Waimakariri River thereby protecting the surrounding community from flooding
- Insurance claims from Christchurch City and Waimakariri District Councils to cover infrastructure damage from the September 2010 and February 2011 Canterbury earthquake sequence. Claims exhausted the reserves of the Local Authority Protection Programme Disaster Fund, which placed other participating councils at risk of not having insurance coverage for their infrastructure assets.

Insuring for Maximum Probable Loss

Following insurance claims resulting from the 2010-11 Canterbury Earthquake Sequence, the reserves in the Local Authority Protection Programme Disaster Fund were depleted.

As a result of this, and other changes to disaster recovery funding for councils, many councils are considering alternative insurance mechanisms. As part of this, councils estimate their Maximum Probable Loss during a natural hazard event, then seek insurance for this amount.

There are a few consultancies operating in the New Zealand loss estimation marketplace, each with their own estimation methodology. Hawkes Bay RC and Greater Wellington RC are two regional councils known to have carried out this exercise, and each have used a different consultant / methodology.

Regional councils should consider carrying out this beneficial exercise for each of their portfolios. Before doing so it would be prudent to compare the usefulness of methodologies available, and consider whether a consistent methodology across the councils is preferred.

7.2.2 Potential stressors

The findings of this assessment indicate the main potential stressors and their implications facing the river management sector include:

- A lack of effective collaboration prevents regional councils from presenting themselves as ‘one voice’
- Inconsistent data gathering and reporting prevents regional councils from easily identifying issues common to the sector
- Different regional regulatory environments which result in inconsistent outcomes across the regions and inhibits collaboration between councils

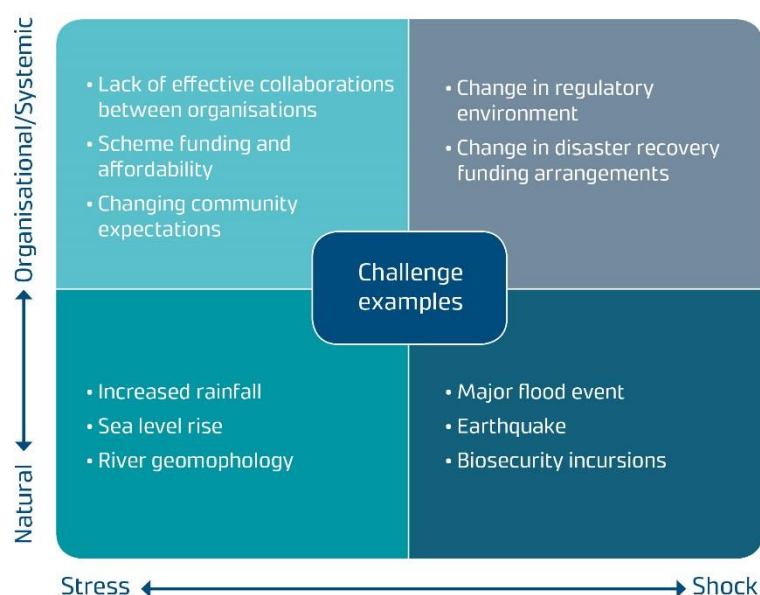


Figure 7.1: Example challenges facing river management sector as shocks and stressors

- A varied understanding of flood risk information —probability or likelihood, vulnerability, consequences, and residual risk — which inhibits effective communication with the community on these key concepts
- Staffing issues as discussed in Section 6.5 which inhibit regional councils from producing successful river management activities and community outcomes
- Funding and scheme affordability issues as discussed in Section 6.6 activities which discourage best practice river management practices, and force staff to ‘make do’ by cutting expenditure elsewhere
- The rate of change in current policies and procedures which are not keeping up with changing community expectations, the implications of wider stakeholder groups, and how environmental, social and cultural values manifest themselves in river management activities
- Land use change (increased urbanisation) may lead to increased consequences of infrastructure asset failure during an event or of larger-than-design events
- Climate change which may result in:
 - More frequent high intensity rainfall events
 - Higher peak river flows during large rainfall events
 - Increased erosion and sediment discharge into watercourses leading to changes in river geomorphology
 - Increased instances of flood flows transitioning to debris flow (as at Matata, Bay of Plenty, 2005)
 - Increased likelihood of existing infrastructure not meeting agreed levels of service
 - More frequent drought periods, and lower low flows in river channels leading to changes in river geomorphology as low flow channels are infilled by sediment

- Increased likelihood of existing infrastructure assets not meeting agreed levels of service if low flow channels infilled or river course changed
- Sea level rise, causing an increase in water levels during flood events in tidally affected areas; and an increased likelihood of existing infrastructure assets not meeting agreed levels of service
- Active river geomorphology may require an increased width of river management corridors that will likely encroach on what is currently private land, and a change in river management philosophy, including type and location of river controls
- Biosecurity incursions —for example, the willow sawfly in 1999 and giant willow aphid identified in 2013 resulted in destruction of some river management structures leading to increased risk of river alignment changes during more routine flood events
- Peat settlement, which can cause existing infrastructure assets to become redundant when ground levels shrink, and a lowering of the level of service provided by the asset

7.3 Responding to challenges – mitigation or adaptation

Understanding the implications of each of the above shocks and stressors is a significant gap in the current New Zealand river management body of knowledge. Closing this gap and development of appropriate response strategies will be important for river managers and is a large piece of work in its own right.

Once implications of shocks and stressors are well understood a response strategy can be developed. Response strategies are either one of mitigation – finding ways to reduce the impact – or adaptation – the process of preparing for and adjusting to new conditions to minimise disruption and take advantage of opportunities that these new conditions provide.

In developing these strategies, regional councils would benefit from a coordinated approach that is flexible enough to accommodate the diverse scale, range, and criticality of river control, flood protection and land drainage schemes. These strategies can include controls from one of more of the types listed in Figure 7.2.

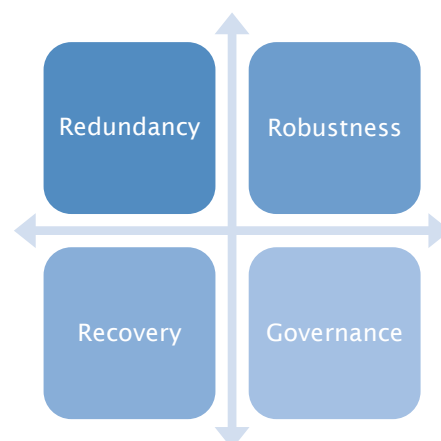


Figure 7.2: Control types to increase resilience of response strategies

Response strategy – adaptation to climate change

An example of an adaptation response to climate change is Greater Wellington Regional Council's policy decision to make allowances for sea level rise and an increased flow in its rivers over a 100 year planning horizon when infrastructure assets are designed or a design review is undertaken.

This response required leadership and governance by policy makers, and accounts for uncertainty through robust design assumption. This response is a good start to building resilient infrastructure, and could be further improved by creating design features to manage uncertainty, and improving the ability of a community to recover after a catastrophic flood event.

8 Delivery of infrastructure in New Zealand

In recent years a considerable amount of work has been done by central government agencies and some sector organisations to improve the delivery of infrastructure services in New Zealand. This has involved work by the Department of Internal Affairs, the National Infrastructure Unit (NIU) of Treasury, the Office of the Auditor General and Local Government NZ. This section presents a broad review of the work that these agencies have carried out.

8.1 Department of Internal Affairs

The Department of Internal Affairs (DIA) is responsible for implementation of the Better Local Government programme announced by Government in 2012. This broad improvement programme included improvement in infrastructure delivery and asset management practices in local government. Among other things, the local government improvement programme:

- Placed greater emphasis on quality asset management planning
- Instituted mandatory timeframes for a review on the cost effectiveness of infrastructure service delivery
- Directed the development of thirty-year infrastructure strategies
- Introduced an expectation that councils should actively seek to collaborate and cooperate to improve effectiveness and efficiency

8.2 National Infrastructure Unit of Treasury

Central to much of the work to improve delivery of infrastructure services is the development of the Thirty Year New Zealand Infrastructure Plan by the NIU, which comprised a critical assessment of New Zealand infrastructural needs, including the provision of water, wastewater, and stormwater services and infrastructure. Within this context the management of flooding is recognised fleetingly in the context of urban stormwater, and there is no comment on the provision of flood control and land drainage infrastructure or services in NZ.

Despite this, several themes have emerged from NIU that are common to the provision of river management infrastructure. These have been recognised in this assessment and the most notable among them include:

- Networks continue to operate without widespread service failures, but concerns about aging infrastructure and asset deterioration are increasing
- Larger authorities with capacity and capability generally better manage their infrastructure, while small provincial councils with static or declining populations and ratings bases face potentially significant servicing issues
- There is no national data framework, standards or benchmarks to understand how infrastructure is being managed nationally
- Councils have generally poor information regarding the condition of their infrastructure assets
- In general, three waters infrastructure is generally less well managed than other council assets (such as roads)

The NIU identified key challenges facing the infrastructure sector as:

- Aging infrastructure, and the corresponding need to invest in renewals and replacement
- Infrastructure affordability in the face of demographic changes

- The role of technology in the provision of infrastructure services
- Climate change, and how this may affect infrastructure assets

8.3 Office of the Auditor General

In response to the development of Long Term Plans by local authorities as required under the Local Government Act, the Office of the Auditor General (OAG) summarised the issues and matters arising from its review of councils' 2015-25 Long Term Plans.

The OAG found that although councils were planning to look after their major assets, there has been a recent shift towards meeting additional demand, renewals and replacement of assets at the expense of improving the level of service.

The OAG identified a close match between depreciation and renewal and replacement expenditure for road and footpath assets, and found that replacement and renewal expenditure of water, wastewater and stormwater assets is well below the level of depreciation. Depreciation on flood protection assets is significantly lower than other assets, which the OAG considers is a result of flood protection expenditure being on land that is not depreciating.

The OAG was unable to draw conclusions about whether the level of infrastructure funding will be sufficient, or that depreciation has been adequately addressed. The generally low level of planned expenditure across the three water assets could indicate a similarly low level of expenditure on flood control and drainage assets. The OAG also noted a decrease in spending to improve levels of service and a corresponding increase in spending on renewal and replacing existing assets.

The OAG noted that almost half of the local authorities identified the need to collect better information about their assets, and a smaller number were actually putting in place programmes to capture better data. While most councils had reasonable information regarding their aboveground assets, they understood less about the condition of underground assets. Additionally, there was little discussion on the risks and implications associated with a lack of reliable asset information.

Finally, the OAG reported that many councils did not adequately address financial sustainability and affordability of expenditure throughout the full life-cycle of infrastructure assets.

8.4 Response by Local Government New Zealand

In response to these concerns, Local Government New Zealand (LGNZ) has put in place a programme to improve New Zealand's water, wastewater and stormwater sector. LGNZ acknowledges the challenges associated with increased levels of infrastructure reliability, quality, and resilience while maintaining its affordability.

As part of this programme, LGNZ identified the priority outcomes for the three waters sector as:

- Performance transparency and performance improvement over time
- High quality asset information which improves asset management practices
- Resolving competing interests during decision making processes

Additionally, LGNZ recognised the characteristics of a strong sector performance as:

- Understanding customer needs and expectations
- Effectively managing and investing in physical assets
- Effectively recovering costs
- Promoting efficient use
- Continuing to learn and grow

To achieve these outcomes LGNZ considered three ways to effect change. These include minor modifications to existing practices, a strong, sector-led approach, and economic regulation. LGNZ identified the preferred way forward as a strong, sector-led approach.

8.5 Comparison with river management sector

Our assessment of New Zealand's flood protection, river control and land drainage activities managed by regional councils has identified many of the same issues raised by several government agencies in relation to infrastructure delivered by district councils, unitary authorities and utility providers. This should not be surprising given the overall regulatory context, demographic changes and their impact on infrastructure funding, and historic infrastructure investment patterns.

However, there is a real concern that given the relatively small size of the river management sector, the needs of river managers could be overlooked through any programme of reform. We believe there is a real need for the river management sector to speak as a united voice to communicate the challenges and opportunities, and ensure the sector is identified as a key stakeholder and recognised as an expert advisor in any reform process.

9 Conclusions and recommendations

This national assessment of river control, flood protection and land drainage schemes was carried out at a high level across the river management sector of New Zealand's regional councils. Overall we have found that NZ's flood protection, river control and land drainage schemes deliver significant benefits and effective, widespread communication of these benefits should be a priority. Our conclusions are outlined below, followed by recommendations for areas and actions that will address specific challenges and opportunities in the river management sector.

9.1 State of the schemes

Approximately 364 river control, flood protection, and land drainage schemes for which regional councils are responsible were included in this assessment. These 'schemes' directly protect some 1.5 million hectares of land (about 5.5% of New Zealand's land mass), including highly productive primary production land and both small and large urban centres. The 'schemes' also protect or otherwise provide a benefit to non-rateable land (Crown estate) and nationally significant infrastructure including roading and rail networks, and energy and telecommunication links. Funding for the schemes is generally provided through targeted rates on rateable land that either directly or indirectly benefits from the schemes.

9.2 Economic value of the schemes

The schemes included in this assessment provide an estimated Net Present Benefit of \$198 billion (\$NZD at 2016). This Net Present Benefit includes the wider social and economic benefits of the schemes by way of applying a factor to the calculated direct economic benefit. Costs for the schemes if they were constructed today are given by the sum of the regional councils' published infrastructure asset replacement values and capitalised annual operational expenditure, and provide an estimated Net Present Cost of \$3.6 billion (\$NZD at 2016). Thus the average Benefit Cost Ratio (BCR) of the schemes to New Zealand is approximately 55:1.

Costs and benefits will obviously vary from scheme to scheme and a more detailed analysis of individual schemes or their elements may find that some are uneconomic. Further work is required to include cultural and environmental capitals of the schemes into a broader cost benefit analysis. One of the most compelling findings of this assessment was the annual benefit of over \$11 billion provided by the schemes is nearly five times their published infrastructure replacement value.

9.3 Management of the schemes

Scheme management is informed by the state of infrastructure asset condition, criticality, and performance. Our assessment of asset condition scores for river management infrastructure indicates that, on the whole, regional councils appear to have adopted an appropriate level of asset management, renewal and upgrade processes for various asset types. However, documented asset management practices are variable between councils, and do not generally describe asset criticality and asset performance.

9.4 Challenges facing the river management sector

Various challenges face those responsible for river management. Challenges facing the sector come from both external and internal sources and can be classed as natural or systemic stressors and shocks. Given the distributed nature of the asset base managed by a relatively small sector, a coordinated response from river managers and collaboration across regional councils and with external parties will be required to address these challenges efficiently and comprehensively in the future.

To deal with some of the internal challenges that the sector faces, an enabling environment will need to be created to support further standardisation across councils. A formal process or Memorandum of Understanding should be developed to support council staff working across organisational boundaries. This would also position the river management sector to effectively address external challenges. Consideration should be given to how these cross-organisational activities are collectively funded.

9.5 Recommendations

This assessment has identified a number of areas that need further work to better understand and address issues and challenges. We recommend the river management sector work on areas that encompass the following themes: cross sector collaboration, practices and standards, people, and environment.

Working together across the sector

- a Provide resources to river managers to enable and support a step change in professional collaboration and development across regional council river managers and with external organisations, so that the sector as a whole can proactively respond to the challenges identified in this national assessment.

Communication and enabling environment

- b Communicate as 'one voice' the state of the river management sector and the outstanding value the schemes provide to New Zealand as identified in this assessment.
- c Proactively engage as 'one voice' in discussions about potential changes to the regulatory environment (for example, managing natural hazards under the RMA, development of National Disaster Resilience Strategy, other RMA reforms, etc) so the views of the river management sector are understood by central government.
- d Develop methodologies and programmes to enable river managers to effectively engage with stakeholders on the schemes, and their benefits, including how the schemes work and help manage flood risk.

Quality people

- e Increase the capacity and capability of the sector to deliver future-focused, successful community outcomes, which may include formal graduate intake and professional development programmes.
- f Partner with tangata whenua to bring new skills, networks, and views into the river management sector.

Practices, methodologies and standards

- g Benchmark each regional council against key metrics including staffing levels, service levels, funding levels, and the like.
- h Prepare nationally consistent asset management methodologies, metadata standards, targeted asset management maturity levels, funding and payment metrics, reporting frameworks (e.g. AMPs), and level of service standards.
- i Assess on a scheme by scheme basis asset criticality and performance against asset condition, to better understand how well infrastructure assets are being managed including how river structures integrate with flood protection schemes, and identify where key vulnerabilities lie.
- j Compile a technical body of knowledge to establish best practice, and identify knowledge gaps or uncertainties, and research needs (e.g. water quality, risk communication, climate change, river geomorphology).

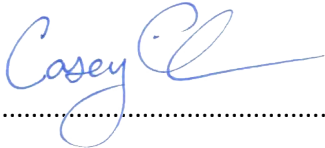
- k Carry out an assessment of cultural and environmental values of the schemes and take them into account when assessing the schemes' benefits and costs.
- l Develop a river management resilience framework and supporting decision making tools to enable regional councils to better inform and position communities so they respond to shocks and stressors with minimum disruption, and to formally include environmental, social, cultural and economic values into projects.
- m Understand the financial viability of the schemes and common funding issues (asset revaluation, depreciation and renewal expenditure, borrowing, etc) on a national scale and their implications on future affordability of the schemes, and what the impacts of removing protection or decreasing a level of protection may be.
- n Investigate alternative funding rationales and strategies, for example, to avoid a higher proportion of scheme costs sitting with fewer ratepayers and to recognise the wider benefits of the schemes.

10 Applicability

This report has been prepared for the exclusive use of our client River Managers' Special Interest Group, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

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Appendix A: Regional Scheme Information

- **Regional asset replacement costs by asset group**
- **Regional asset condition by asset group**
- **Regional total benefit areas by benefit type, and combined total area**
- **Regional total protected rateable capital value by benefit type, and combined total**
- **Regional opex budgets**

Table: Area of rateable land receiving each type of benefit (multiple benefit not double counted in total)

Council	Flood Area (Ha)	Drainage Area	River Management Area	Tidal Area	Total Area (Ha)
Canterbury	252,772	59,372	48,965		333,738
Manawatu	58,522	56,792	47,112		128,822
Waikato	197,904	200,834	43,151	16,360	332,522
Wellington	76,659	6,914			77,571
Bay of Plenty	31,187	43,209			51,866
Hawkes Bay	57,056	32,790	29,989		57,318
West Coast	47,314	1907.933885	42,042		48,201
Southland	57,903	62,901	66,093		169,582
Tasman DC	4,922		20,614		20,614
Otago	33,688	28987.89724	20,331		64,635
Northland	8,909	5457.893029	1,104		8,909
Taranaki	156		156		156
Gisborne	7,952	45,963			46,549
Grand Total	834,944	545,128	319,557	16,360	1,340,482

Table: Average total annual operating budget for flood, drainage and river management schemes, by region

Council	Average Annual Opex (2015 dollars)	Source notes
Waikato*	\$18,800,000	10 year budgets with general categories
Canterbury	\$12,400,000	10 year budgets with general categories
Wellington	\$10,400,000	10 year budgets with general categories
Bay of Plenty	\$7,700,000	10 year budgets with detailed categories
Manawatu	\$7,540,000	10 year budgets with detailed categories
West Coast	\$6,500,000	10 year budgets with general categories
Hawkes Bay	\$5,480,000	10 year budgets with general categories
Southland**	\$3,760,000	2 year budgets with detailed categories
Otago	\$2,260,000	8 year budgets with general categories
Tasman DC	\$1,930,000	1 year budget with general categories
Gisborne DC	\$1,910,000	1 year budget with general categories
Northland	\$676,000	1 year budget with general categories
Taranaki	\$99,900	1 year budget with general categories

* excludes drainage scheme budgets
**2014 dollars

Table: Capital value of rateable land receiving each type of benefit (multiple benefit not double counted in total)

Council	Flood CV	Drainage CV	River Management CV	Tidal CV	Total CV
Canterbury	\$92,117,897,443	\$4,872,626,678	\$1,507,987,123		\$94,900,694,209
Manawatu	\$21,348,006,898	\$2,827,208,051	\$1,771,452,604		\$24,247,119,010
Waikato	\$10,947,337,410	\$14,847,392,427	\$2,148,707,206	\$893,323,497	\$22,288,051,017
Wellington	\$12,859,154,551	\$193,811,052			\$12,894,929,020
Bay of Plenty	\$4,194,110,972	\$2,613,341,778			\$5,136,727,022
Hawkes Bay	\$18,950,570,109	\$18,199,541,111	\$18,227,580,628		\$18,988,072,729
West Coast	\$1,366,713,912	\$41,646,617	\$1,365,060,055		\$1,367,695,612
Southland	\$2,581,229,504	\$1,678,071,118	\$1,214,075,692		\$4,853,170,098
Tasman DC	\$1,430,733,661		\$2,551,668,407		\$2,551,668,407
Otago	\$10,302,073,156	\$1,562,577,629	\$175,163,851		\$11,560,204,481
Northland	\$911,566,113	\$185,178,412	\$26,335,712		\$911,566,113
Taranaki	\$239,456,163		\$239,456,163		\$239,456,163
Gisborne	\$785,513,485	\$5,344,567,327			\$5,394,058,373
Grand Total	\$178,034,363,379	\$52,365,962,200	\$29,227,487,439	\$893,323,497	\$205,333,412,253

Appendix B: Asset Management Maturity Framework and Results

- **IIMM2011 Asset Maturity Framework**
- **Assessment results by Council**

Appendix XX: Asset management maturity scores using the IIMM maturity framework.

Asset Management Category	Canterbury	Manawatu	Wellington	Bay of Plenty	Hawkes Bay	West Coast	Southland	Otago	Northland	Taranaki	Tasman DC	Waikato	Gisborne DC
1 AM Policy and Strategy	45	60	55	55	50	0	25	20	45	20	55	45	5
2 Levels of Service and Performance Management	80	95	90	90	90	45	25	60	80	40	45	80	45
3 Demand Forecasting	40	45	65	95	50	0	30	10	35	20	45	50	25
4 Asset Register Data	65	75	90	80	80	21	40	60	75	40	60	80	40
5 Asset Condition Assessment	60	60	85	100	60	40	45	40	55	40	40	65	25
6 Risk Management	60	45	45	100	95	10	20	25	60	40	65	85	10
7 Decision Making	60	55	60	40	60	35	40	35	45	25	60	60	25
8 Operational Planning and Reporting	45	80	50	95	65	35	40	45	40	35	60	80	40
9 Maintenance Planning	45	50	55	70	65	35	50	40	45	45	45	65	35
10 Capital Investment Strategies	45	30	75	80	75	25	25	40	40	20	65	50	25
11 Financial and Funding Strategies	80	70	50	80	65	25	50	40	40	25	60	70	25
12 Asset Management Teams	60	60	85	90	60	34	60	55	70	30	70	55	25
13 AM Plans	60	40	75	80	75	25	55	40	40	25	60	80	35
14 Information Systems	60	60	55	80	55	36	55	60	80	40	65	70	25
15 Service Delivery Models	40	40	40	80	40	31	52	25	40	25	65	45	15
16 Quality Management	65	55	75	55	50	25	40	35	35	25	70	40	25
17 Improvement Planning	50	35	75	60	70	19	25	55	20	0	60	75	25

Source for this data: T:\Hamilton\Projects\62067\62067.0010\WorkingMaterial\JYC Graphs.xlsx

Reference	Question	Section	Questions	Why	Maturity Levels				
					Aware	Minimum	Core	Intermediate	Advanced
					0-20	25-40	45-60	65-80	85-100
Understanding and Defining Requirements									
IIMM 2.1	1	AM Policy and Strategy	To what extent has your organisation's AM Policy and AM Strategy been articulated, approved, communicated and acted on? How consistent is this policy and strategy with current government policies?	The AM Policy supports an organisation's strategic objectives. It articulates the principles, requirements and responsibilities for asset management (AM). It articulates the objectives, practices and action plans for AM improvement, audit and review processes. The AM Policy and Strategy may be incorporated into the AM Plan.	The Organisation is aware of the need to develop an AM Policy, but hasn't yet completed this work.	Corporate expectations are expressed informally and simply, e.g. "all departments must update AMPs every three years".	There are defined policy statements for all significant business activities. There is a clear linkage to corporate goals. AM Policy is supported by high level action plans with defined responsibilities for delivery.	Expectations of each business activity are supported by detailed action plans, resources, responsibilities and timeframes. AM Policy and Strategy is reviewed and adopted by Executive Team each year.	AM Policy and Strategy is fully integrated into the organisation's business processes and subject to defined audit, review and updating procedures.
IIMM 2.2	2	Levels of Service and Performance Management	How does your organisation determine what is the appropriate level of service for its customers and then ensure that asset performance is appropriate to those service levels?	Levels of service are the cornerstone of asset management and provide the platform for all lifecycle decision making. Levels of service are the outputs a customer receives from the organisation, and are supported by performance measures. One of the first steps in developing asset management plans or processes is to find out what levels of service customers are prepared to pay for, then understand asset performance and capability to deliver those requirements.	The organisation recognises the benefits of defining levels of service but has yet to implement guidelines for development of these.	Basic levels of service have been defined and agreed, along with the contribution of asset performance to the organisation's objectives.	Customer Groups have been defined and requirements understood. Levels of service and performance measures are in place covering a range of service attributes. There is annual reporting against targets.	Customer Group needs have been analysed and costs of delivering alternate levels of service have been assessed. Customers are consulted on significant service levels and options.	There is formal consultation over levels of service. Customer levels of service and technical (ie asset performance) levels of service are an integral part of to decision making and business planning.
IIMM 2.3	3	Demand Forecasting	How robust is the approach your organisation uses to forecast demand for its services and the possible impact on its asset portfolios?	This AM activity involves estimating demand for the service over the life of the AM plan or the life of the asset. Demand is a measure of how much customers consume the services provided by the assets. The ability to predict demand enables an organisation to plan ahead and meet that demand, or manage risks of not meeting demand.	The organisation recognises the benefits of demand forecasting but has yet to implement processes to forecast demand.	Demand forecasts are derived by experienced staff (rather than data models), taking account of past demand trends and likely future growth patterns.	Demand Forecasts are based on robust projections of a single primary demand factor (e.g. population growth) and extrapolation of historic trends. Risk associated with changes in demand is broadly understood and documented.	Demand forecasts are based on mathematical analysis of past trends and primary demand factors. A range of demand scenarios is developed (e.g.: high/medium/ low).	As for intermediate, plus there is an assessment of risks associated with different demand scenarios, and mitigation actions are identified.
IIMM 2.4	4	Asset Register Data	What sort of asset-related information does the organisation collect, and how does it ensure the information has the requisite quality (accuracy, consistency, reliability)?	Asset data is the foundation for enabling most AM functions. Planning for asset renewal and maintenance activities cannot proceed until organisations know exactly what assets they own or operate and where they are located	The organisation recognises the benefits of capturing asset data but has yet to implement systems to capture the data.	Basic physical information recorded in a spread sheet or similar (e.g. location, size, type), but may be based on broad assumptions or not complete.	Sufficient information to complete asset valuation – as above plus replacement cost and asset age/ life. Asset hierarchy, asset identification and asset attribute systems documented.	A reliable register of physical and financial attributes recorded in an information system with data analysis and reporting functionality. Systematic and documented data collection process in place. High level of confidence in critical asset data.	Information on work history type and cost, condition, performance, etc. recorded at asset component level. Systematic and fully optimised data collection programme. Complete data-base for critical assets; minimal assumptions for noncritical assets.
IIMM 2.5	5	Asset Condition Assessment	How does the organisation measure and manage the condition of its assets?	Timely and complete condition information supports risk management, lifecycle decision-making and financial / performance reporting.	The organisation recognises the need for monitoring asset condition but has not developed a coherent approach. Measures are incomplete, predominantly reactive. There is no linkage to asset management objectives.	Condition assessment at asset group level ('top-down). Supports minimum requirements for managing critical assets and statutory requirements (e.g. safety).	Condition assessment programme in place for major asset types, prioritised based on asset risk. Data supports asset life assessment. Data management standards and processes documented. Programme for data improvement developed.	Condition assessment programme derived from benefit- cost analysis of options. A good range of condition data for all asset types (may be sampling- based). Data management processes fully integrated into business processes. Data validation process in place.	The quality and completeness of condition information supports risk management, lifecycle decision-making and financial / performance reporting. The organisation conducts periodic reviews of the suitability of its condition assessment programme.
IIMM 2.6	6	Risk Management	How does your organisation manage the interplay between business risks and asset-related risks?	Risk management helps identify higher risks, and identify actions to mitigate those risks. This process reduces the organisation's exposure to asset related risk, especially around critical assets, and drives renewal and rehabilitation programmes and decision making.	The organisation recognises the benefits of risk management but has yet to implement processes for development of these.	Critical assets understood by staff involved in maintenance / renewal decisions.	Risk framework developed. Critical assets and high risks identified. Documented risk management strategies for critical assets and high risks.	Systematic risk analysis to assist key decision-making. Risk register regularly monitored and reported. Risk managed consistently across the organisation.	A formal risk management policy in place. Risk is quantified and risk mitigation options evaluated. Risk is integrated into all aspects of decision making.

Reference	Question	Section	Questions	Why	Maturity Levels				
					Aware	Minimum	Core	Intermediate	Advanced
					0-20	25-40	45-60	65-80	85-100
Lifecycle Decision Making									
IIMM 3.1	7	Decision Making	How does your organisation go about making decisions on the replacement or refurbishment of existing assets or investment in new ones?	Decision techniques provide the best value for money form an organisation's expenditure programmes. These techniques reveal strategic choices, and balance the trade off between levels of service, cost and risk. ODM is a formal process to identify and prioritise all potential asset and non-asset solutions with consideration of financial viability, social and environmental responsibility and cultural outcomes.	The organisation recognises the benefits of optimised decision making but has yet to implement processes.	AM decisions are based largely on staff judgement and agreed corporate priorities.	Formal decision making techniques (eg using BCA) are applied to major projects and programmes.	Formal decision making and prioritisation techniques are applied to all operational and capital asset programmes within each main budget category/business unit. Formal decision making techniques (eg BCA) are applied to major projects and programmes. Critical assumptions and estimates are tested for sensitivity to results.	As for Intermediate, plus the decision making framework enables projects and programmes to be optimised across the whole business. Formal risk-based sensitivity analysis is carried out.
IIMM 3.2	8	Operational Planning and Reporting	How does your organisation manage the cost effective performance of its key business assets over time (e.g. in terms of utilisation, availability, fitness for purpose)?	Effective operational strategies can mitigate risk, defer the need for asset renewals and minimise service downtime following asset failures. Planning for business continuity and full utilisation of assets are key factors in good asset management processes.	The organisation recognises the benefits of operational planning and asset performance reporting but has yet to implement processes to implement these.	Operational responses are understood by key staff, but plans aren't well-documented, or are mainly reactive in nature. Asset performance is measured for some key assets but is not routinely analysed.	Emergency response plan is developed. Demand management is considered in major asset planning. Asset performance is measured for critical asset groups and is routinely analysed.	Emergency response plans and business continuity plans are routinely developed and tested. Demand management is a component of all operational decision making. Asset performance is measured and analysed for most asset groups.	Operational plans are routinely analysed, tested and improved. Formal debriefs occur after incidents. Asset performance is measured in real-time and cost-effectiveness is analysed across all asset groups. Operational programmes are optimised using benefit-cost and risk analysis.
IIMM 3.3	9	Maintenance Planning	How does the organisation plan and manage its maintenance activity?	Maintenance is "all actions necessary for retaining an asset as near as practicable to its original condition, but excluding rehabilitation or renewal". Maintenance slows deterioration: it is mechanism to ensure assets continue to deliver performance associated with the required level of service. A major challenge for the asset manager is striking the appropriate balance between planned maintenance (inspections and scheduled maintenance etc.) and unplanned maintenance (arising from unexpected failures)	The organisation recognises the benefits of maintenance planning but has yet to implement such processes.	Managers and operators understand how asset functions support organisational objectives. Processes comply with legislation and regulations. Maintenance records are maintained. Critical assets have been identified.	Asset criticality considered in response, fault tracking and closure processes. There is a strategy for prescriptive vs. performance-based maintenance. Key maintenance objectives have been established, measured and reported on.	Contingency plans exist for all maintenance activities. Asset failure modes are understood. Timing and frequency of major preventative maintenance is optimised using benefit-cost analysis. Maintenance management software is being applied appropriately.	Forensic root cause analysis is conducted for major faults. All reactive and planned programmes are optimised with respect to renewal planning. Different procurement models have been fully explored. Maintenance operations represent value for money.
IIMM 3.4	10	Capital Investment Strategies	What processes and practices does the organisation have in place to plan and prioritise capital expenditure?	Capital investment include the upgrade, creation or purchase of new assets, typically to address growth or changes in levels of service requirements, or for the periodic renewal of existing assets, to maintain service levels. Agencies need to plan for the long term asset requirements relative to future levels of service. The decision on whether to create a new asset is typically the time when there is the most opportunity to impact on the potential cost and level of service. Cabinet expects all capital-intensive agencies to disclose 10 year capital intentions and make appropriate use of the better business cases methodology for programmes and individual investment proposals.	The organisation recognises the benefits of capital planning, but has yet to implement such processes.	There is a schedule of proposed capital projects and associated costs, based on staff judgement of future requirements.	Projects have been collated from a wide range of sources such as business unit planning processes and corporate risk processes. Capital projects for the next three years are fully scoped and estimated.	As for core, plus formal options analysis has been completed for major projects that need to be bought into service within the next 5 years. Capital intentions reports identify all major capital projects for the next 10 or more years with broad estimates of the costs and benefits of those projects or programmes.	Long -term capital investment programmes are developed using advanced decision techniques, such as predictive renewal modelling. The organisation has a reliable and approved 10 year view of its future capital requirements and the strategic choices available to meet changing fiscal or level of service requirements.
IIMM 3.5	11	Financial and Funding Strategies	How does your organisation plan for the funding of its future capital expenditure and asset-related costs?	Poor financial management can lead to higher long run life cycle costs, inequitable fees and charges, and financial "shocks". Good collaboration between financial and asset managers is important, especially in relation to long term financial forecasts and asset revaluations. Asset valuation is required by International Accounting Standards, and can be used in lifecycle decision making. Robust financial budgets are a key output of any asset management planning process.	The organisation recognises the benefits of developing medium to long term financial and funding strategies, but does yet have any in place. The organisational focus is on the operating statement rather than the balance sheet.	Financial forecasts are based on extrapolation of past trends and broad assumptions about the future. Assets are re-valued in accordance with NZ International Accounting Standards (NZ IFRS).	Ten year+ financial forecasts based on current AMP outputs. The quality of forecasts meets NZ IFRS requirements. Significant assumptions are specific and well reasoned. Expenditure captured at a level useful for AM analysis.	Ten year+ financial forecasts are based on current and comprehensive AMP's with detailed supporting assumptions / reliability factors. Asset expenditure information is linked with asset performance information.	The organisation publishes reliable ten year+ financial forecasts based on comprehensive, advanced AMPs with detailed underlying assumptions and high confidence in accuracy. Advanced financial modelling provides sensitivity analysis, evidence-based whole of life costs and cost analysis for level of service options.

Reference	Question	Section	Questions	Why	Maturity Levels				
					Aware	Minimum	Core	Intermediate	Advanced
					0-20	25-40	45-60	65-80	85-100
Asset Management Enablers									
IIMM 4.1	12	Asset Management Teams	<p>What is the level of organisational commitment to asset management?</p> <p>How is this reflected in existing organisation structure, responsibilities and resourcing of AM competencies?</p>	Effective asset management requires a committed and coordinated effort across all sections of an organisation.	The organisation recognises the benefits of an asset management function within the organisation, but has yet to implement a structure to support it.	Asset Management functions are performed by a small number of people with AM experience.	An organisation-wide Steering Group or Committee coordinates all capital asset management activity. There is relevant training for key AM staff. The Executive Team have considered options for AM functions and structures.	All staff in the organisation understand their role in relation to AM, it is defined in their job descriptions, and they receive training aligned to their roles. A person on the Executive Team has responsibility for delivering the AM policy and strategy.	There is strong leadership of the AM functions across the organisation. There is a formal AM capability management programme. The cost effectiveness of the AM structure has been formally reviewed.
IIMM 4.2	13	AM Plans	How does your organisation develop, communicate, resource and action its asset management plans?	An asset management plan is a written representation of intended capital and operational programmes for its new and existing infrastructure, based on the organisations understanding of demand, customer requirements and its own network of assets.	The organisation recognises the benefits of asset management plan(s), but has not yet developed any.	The AM Plan contains basic information on assets, service levels, planned works and financial forecasts up to 5 years, and future AM improvement actions.	As for minimum plus a description of services and key / critical assets, future demand forecasts, description of supporting AM processes, 10 year financial forecasts, 3 year AM improvement plan.	As for core, plus analysis of asset condition and performance trends (past / future), effective customer engagement in setting LoS, ODM / risk techniques applied to major programmes.	As for intermediate plus evidence of programmes driven by comprehensive ODM techniques, risk management programmes and level of service / cost trade-off analysis. Improvement programmes are largely complete. There is a focus on maintaining appropriate practices.
IIMM 4.3	14	Information Systems	How does your organisation meet the information needs of those responsible for various aspects of asset management?	AM systems have become an essential tool for the management of assets in order to effectively deal with the extent of analysis required.	The organisation recognises the benefits of using an asset management system, but does not have one in place.	Asset register records core asset attributes - size, location, age, etc. Asset information reports can be manually generated for AMP input.	Asset register enables hierarchal reporting (from component level to whole-of-facility level). There are systems for tracking customer service requests and for planning maintenance activity. System enables manual reports to be generated for valuation, renewal forecasting.	More automated asset performance reporting on a wider range of information. Key operations, unplanned maintenance and condition information held.	Financial, asset and customer service systems are integrated and enable advanced AM functions. There is optimised forecasting of renewal expenditure.
IIMM 4.4	15	Service Delivery Models	<p>How does your organisation procure asset-related services like maintenance and consumables for different classes of assets?</p> <p>How does the organisation exercise control over any outsourced asset management services?</p>	The effectiveness of asset management planning is proven in the efficient and effective delivery of services at an operational level.	The organisation recognises the benefits of defining services delivery mechanisms and functions, but has yet to define these.	Service delivery roles are clear. Allocation of roles (internal and external) generally follows past procurement preferences.	Core functions defined. Contracts in place for external service providers. Tendering / contracting policy in place. Competitive tendering practices applied.	As for core, plus internal service level agreements in place with internal service providers. Contracting approaches have been reviewed to identify best value delivery mechanism.	All potential service delivery mechanisms have been reviewed and formal analysis carried out. Risks, benefits and costs of various outsourcing options have been considered and the best value arrangement has been or is being implemented.
IIMM 4.5	16	Quality Management	How does your organisation ensure that its asset management processes and practices are appropriate and effective?	When AM processes are part of a Quality Management system the organisation is able to operate consistent and reliable processes,, provide evidence that what was planned was delivered, and ensure that knowledge is shared. In short, that processes are appropriate and consistently applied and understood.	The organisation recognises the benefits of quality assurance processes, but has yet to implement processes for these.	Simple process documentation in place for service-critical activities.	There is a clear quality policy and basic quality management system. All critical AM activity processes are documented.	Process documentation has been implemented in accordance with the Quality Management System plan. All processes documented to appropriate level detail.	Quality certification has been achieved. Surveillance audits demonstrate the quality management system is operating satisfactorily.
IIMM 4.6	17	Improvement Planning	How does your organisation ensure that it continues to develop its asset management capability towards an appropriate level of maturity?	Well performing agencies give careful consideration of the value that can be obtained from improving AM information, processes, systems and capability. The focus is on ensuring AM practices are "appropriate" to the business objectives and government requirements.	The organisation recognises the benefits of improving asset management processes and practises, but has yet to develop an improvement plan.	Improvement actions have been identified and allocated to appropriate staff.	Current and future AM performance has been assessed and improvement actions identified to close the gaps. Improvement plans identify objectives, timeframes, deliverables, resource requirements and responsibilities.	There is formal monitoring and reporting on the improvement programme to the Executive Team. Project briefs have been developed for all key improvement actions. Resources have been allocated to the improvement actions.	There is evidence that agreed improvement plans have delivered the expected business benefits.

Appendix C: River Manager Survey

- **Survey Questionnaire**
- **Survey Results**

River managers questionnaire in PEEPOE framework

			Score				
			Aware	Minimum	Core	Intermediate	Advanced
Section		Questions	0	1	2	3	4
<p>This questionnaire seeks to understand the factors that are helping or hindering your RC from delivering a high performing land drainage, river control, and flood protection service with the following objectives:</p> <ul style="list-style-type: none"> - Water drains quickly - Farms stay productive - Design floods are prevented - Over-design is managed - Businesses stay open - Roads stay open - People stay safe. 							
People	How well do your people enable delivery of a high performing flood protection, river control and land drainage service?	Rate your staffing levels in the following areas	Majority of our staff are graduates / inexperienced		Some of the staff have good experience however there are still some skill sets missing in the team.		We have specialised staff in these areas who have been doing this work for at least 10 years.
		-Engineering -Planning -Operations -Management					
		How much do you rely on consultants to deliver your services?	Majority of our staff are consultants seconded for their services.		We rely on consultants for some of our core services.		We use consultants occasionally for specialised projects.
		-Engineering -Planning -Operations -Management					
		How would you rate staff retention?	Most staff have been here less than four years		We have a mix of long serving and new staff		Majority of our staff have a 10 year celebration under their belt.
		Is it easy to find suitable candidates for your vacancies?	We struggle to find suitable applicants, positions may be open for more than 6 months.		We can usually find a suitable person in the first round of applicants		We have people coming in enquiring about vacant positions in the organisation.
		My staff know and understand our assets.	Staff have only a rudimentary understanding of the assets relating to their role.		Most of the team have a good understanding of assets but some are still learning.		Everyone has a good working knowledge of the scheme assets relevant to their role
		How much institutional knowledge does your staff retain?	When key staff leave, we have to rebuild their knowledge from scratch		More than one person are familiar with most of the our procedures or schedules for most of our responsibilities.		When someone leaves it is a smooth transition for the new person.
		How well does your council plan for succession of staff?	We'll cross that bridge when we get there		We have a template in place for staff to drive their own development.		We have procedures and team in place to look at staff development.
		Describe the level of training and development provided to staff.	Staff only have access to essential training (eg H&S)		Staff typically attend a conference or course each year for professional development.		We help staff prepare professional development plans and support them to achieve these.
What needed skill sets does your council lack? (free form)							

River managers questionnaire in PEEPOE framework

			Score				
			Aware	Minimum	Core	Intermediate	Advanced
Section		Questions	0	1	2	3	4
Environment	Does the physical environment in which you work make it easy to deliver a high performing service?	The river and floodplain environment we work in makes it difficult to deliver: -Land drainage -River control -Flood protection Please explain the nature of your rivers and the reasons for your score - free text.	The rivers are unpredictable (big, braided, high energy). Extensive flood prone areas are adjacent.		Either rivers are predictable or surrounding lands allow natural protection for low lying towns.		Our rivers are quite consistent and predictable. Low lying towns are protected by surrounding hills.
		Our relationships with landowners make it difficult to deliver: -Land drainage -River control -Flood protection	We inform them of our work proposal in the mail. Relationship is poor when we try to dialogue.		We consult with the community and achieve reasonable engagement.		We have a strong working relationship with the community, working together on important decisions.
		We understand and document risks associated with our assets	Staff understand the risk associated with assets however there are no documentation in place yet.		We have risk descriptions for the assets we own.		We have a risk framework (quantify our risk) developed for our assets.
		We understand the residual risks associated with our schemes	We have not considered residual risks associated with our schemes.		We understand the residual risks however this has not been quantified.		We have quantified all major risks for our schemes.
		The residual risks of our schemes are appropriate for their context	We have not considered residual risks associated with our schemes.		We have identified inappropriate risks and have a plan to address them.		We have assessed our residual risks and any unacceptable risks have been addressed.
		We understand and document consequences of our assets failing	We have not considered the consequences of our assets failing		Partial documentation. Some people have good understanding of failure consequences for each scheme.		We have fully documented the consequences of asset failure at a level appropriate to each scheme.
		We clearly communicate risks and failure consequences to our community	We display flood risks on our website. Open to any interested users.		We send pamphlets to the community to inform them of risks and flood consequences.		The community understands the risks and what the plan is if there is a major asset failure.
		Urbanisation of areas protected by our assets is adequately managed	There is little management of development on the floodplain with respect to the scheme		Some planning or management is in place for growth, but issues are not full addressed		Coordinated planning in place for current growth with forecasts and budgets to address future growth.
		Free form to identify schemes where urbanisation is a problem					
		Free form to identify which schemes protect NZTA or other central government assets (e.g. schools)					
		Free form to identify schemes that protect other regional or national significant infrastructure					

River managers questionnaire in PEEPOE framework

			Score				
			Aware	Minimum	Core	Intermediate	Advanced
Section		Questions	0	1	2	3	4
Equipment	Do you have adequate equipment/tools to deliver a high performing service?	Our network of rain and river gauges enables us to -Monitor and manage flood events -update hydraulic models	We have engineers that go out in the field after the storm event to measure the flood levels.		We have flood models in place, and inspections after flood events to verify them.		We have systems in place that monitor flood levels during flood event.
		We have adequate tools to monitor flood events in real time	We rely on staff in the field for information		Sufficient gauges in place. If there are models, some key calibration points are available.		All critical scheme are monitored. Models can forecast levels on larger schemes based on gauge info.
		We have accurate models of our schemes -Land drainage -River control -Flood protection	We rely on historic events to estimate scheme performance		Most of our schemes have been modelled but some of these are getting a bit old.		Most schemes have mature models with improvement iterations and we have confidence in the results.
		We know what level of protection (e.g. 1% AEP flood) is actually provided for: -Land drainage -River control -Flood protection	We are satisfied if none of the protections have failed (i.e. LoS based on historic/initial).		Currently completing survey and modelling. Current LoS is still based on historic/initial.		Current level of protection determined and modelled from survey undertaken and reviewed x-yearly.
		We understand historic flood levels in the context of the level of protection currently provided	We describe the level of protection provided in terms of historic events		We have assessed the return period of historic events in terms of current ARI		We describe return period for historic events (current weather), and the current scheme LoS.
		We have appropriate knowledge of the following: -Functionality of M & E equipment -LiDAR coverage -Channel or river cross section surveys -flood hazard maps -field communications -telemetry -information management systems	We do not have this data, even though it is appropriate to deliver our services.		We mostly have this data, although some of it is out of date.		We have the data we need, it is up to date, and we have forward budget to keep it so.
		We have up to date hydraulic models and software to run them.	We don't have models in place.		We have models and software in place however have not been updated (i.e. not the latest version)		We have a team in place which collects, builds and collates information for these systems and updates them utilising latest cross section data.

River managers questionnaire in PEEPOE framework

			Score				
			Aware	Minimum	Core	Intermediate	Advanced
Section		Questions	0	1	2	3	4
Procedures	Do you have adequate procedures to enable delivery of a high performing service?	Do you have adequate procedures to enable delivery of a high performing service?	Our procurement processes are a significant handbrake or do not give good value.		We can achieve the outcomes we need but there is room for improvement in our procurement		Our procurement processes are streamlined and encourage best value.
		We have adopted Flood Protection Assets Performance Assessment Code of Practice, March 2015, in development of our procedures.	We have not adopted the Code of Practice.		We have adopted the Code of Practice for some schemes, and looking to do so for other schemes.		We have adopted the Code of Practice for all of our schemes.
		We have other written procedures on: - Asset condition monitoring - Flood warning - Data collection to enable better analyses - Demand forecasting - climate change - land use - other future planning	Staff understand how we do things but procedures generally aren't written down.		We mostly have written procedures in place but there is no review/update process.		We have a policy in place for these procedures and we review them in on a regular basis.
		Channel capacity monitoring or river cross section surveys - Updating river design flows and/or levels of protection - Sediment management - Stopbank condition and alignment	Generally, we do not monitor this on our schemes		We have this information for most of our schemes but it is mixed quality		We have a procedure in place for field surveys at appropriate frequencies.
		Our annual and long term planning rounds are effective in establishing a framework for our operations.	AM recognised in annual and long term planning but does not affect AM operations.		AM planning is crucial for decisions made in the long term planning.		AM planning is crucial for decisions made in both annual and long term planning.
		There are good linkages between asset management planning objectives and financial provisions included within LTPs and Annual Plans.	There is no realistic way that we can fund our planned objectives.		We can fund our planned objectives but often we sacrifice or delay some due to funding restrictions.		We are able to reliably fund and complete our planned objectives.
		We are proactive in programming and executing our annual maintenance programme.	Our annual maintenance spend is largely reactionary, and priorities change throughout a given year.		Most of our work carried out to a programme, but some gets deferred for emergency works.		All works delivered to a programme and emergency works doesn't affect our programme.
		We have procedures to update our knowledge of - changes in hydrology - changes in river shape/alignment - changes in design flows	We made assumptions which means there are no changes for the next 10 years.		We review and update information regularly.		We review and update information, including making future improvements and timing.
		We have procedures to assess and review the economic and community impact of our services	No procedures in place for assessment but we are aware of the impacts of our services.		We have written procedures in place, however there haven't been any updates/reviews recently.		We review and update procedures every x years.

River managers questionnaire in PEEPOE framework

			Score				
			Aware	Minimum	Core	Intermediate	Advanced
Section		Questions	0	1	2	3	4
Organisation	Does your organisation make it easy to deliver a high performing service?	How enabling is your regional plan to your operations?	The regional plan creates inappropriate constraints on our schemes		The regional plan doesn't have much impact on the scheme.		The regional plan supports the operation and goals of the scheme
		How well is land use planning informed by department's knowledge of flood related hazards?	Land use planning largely happens in isolation of departmental knowledge		All planning staff understand and make some major decisions.		We work closely with the land use planners to incorporate our knowledge of flood hazards
		How well do your global consents enable your operations?	We generally don't have global consents		Our global consents generally work for us		Our global consents work really well
		How well do Codes of Practice enable your operations?	We don't have Codes of Practice for the operations we have.		We have Codes of Practice for all the operations and we implement some of them for the operations.		We have Codes of Practice for all the operations and we implement them for all the operations.
		How well does your organisation deliver - operational programme - capital improvement works -AMP improvement tasks	We are always behind, and core services remain undelivered.		We are consistently able to deliver our core services		We deliver all of our services and are able to tackle 'nice to have' items
		Our communities understand: -what we do -what level of protection they receive -Free form to list challenges and strengths in consulting with our communities	The community has a poor level of understanding		We have achieved good consultation in the past on key topics.		We have an ongoing programme to maintain awareness that achieves good results
		How well do the following groups know and understand your operations: -council staff not in your department - upper management in your department - managers outside your department - CE level	This group doesn't know or haven't heard of our operations.		This group understands the general gist of our major operations.		This group is part of the decision making for our operations.
		What regular reporting procedures do you undertake to your elected representatives?	We report through standard budget review processes.		We report against budgets and mandatory measures, and provide some narrative to current issues.		Dashboard system of mandatory measures and management priorities. Covers issues and risks.
		How well do the following groups support your operations: -council staff not in your department - upper management in your department - managers outside your department - CE level - elected councillors	This group doesn't have any connections to our operations.		This group provides support when we request it.		This group provides support on an ongoing basis.

River managers questionnaire in PEEPOE framework

			Score				
			Aware	Minimum	Core	Intermediate	Advanced
Section		Questions	0	1	2	3	4
		How well do the following groups enable retention of institutional knowledge - council staff in your department - council staff not in your department - upper management in your department - managers outside your department - CE level - elected councillors	Often difficult to find someone in the team who knows their stuff		It's usually not a problem to find someone who can give good advice on an issue		Solid understanding of the context and issues for relevant topics, backed up by supporting docs.
		How well does your organisation understand its maximum probable loss from natural hazards?	We only worry about likely damage, not the maximum probable loss.		We have considered maximum probable loss for some of our largest schemes.		We have a risk framework in place that considers this.
		How does your organisation determine asset valuation for insurance purposes?	Book value (depreciated)		Estimated replacement cost		Estimated replacement cost, plus allowance for cost of repairs following failure or partial failure.
		How does your organisation financially plan for disaster recovery (for your assets)?	We have some money set aside in our reserves		We have a formal self insurance and risk assessment programme		We use LAPP or other 3rd party insurance
		Our department is adequately funded for: - routine asset maintenance - asset renewal/replacement - river system changes - disaster response and recovery	We are always behind, and core services remain undelivered.		We are consistently able to deliver our core services		We deliver all of our services and are able to tackle 'nice to have' items

River managers questionnaire in PEEPOE framework

			Score				
			Aware	Minimum	Core	Intermediate	Advanced
Section		Questions	0	1	2	3	4
External	Do external factors or organisations make it easy to deliver a high performing service?	Legal and regulatory factors make our job easy	We struggle to work with this		We are generally OK but sometimes run into challenges		We find strong alignment between our responsibilities and these requirements
		<ul style="list-style-type: none"> - Local Govt Act - RMA consenting - Recreational - Biodiversity - Cultural (eg co-management) 					
		We have strong relationships with special interest departments/groups	The relationship is non-existent / unhelpful.		We have a contact in the team who could help us.		Long standing relationship with them (directly contact them). We are comfortable working together.
		The communities of benefit we service are able to pay for these services.	Rely heavily on some form of subsidy. Affordable LoS are significantly lower than appropriate.		Financial constraints limit some aspects of the service we consider would be appropriate practice.		Financial constraints do not prevent us from providing appropriate services and protection
Other	Free form field to solicit feedback on any other significant issues that have the potential to impact adversely on scheme performance or maintenance.						

	Questions		No Ans	1	2	3	4	5	Weighted average
30	We have other written procedures on:	Asset condition monitoring	2		1	3	4	3	3.8
		Flood warning	2			4	3	4	4.0
		Data collection to enable better analyses	2		2	4	4	1	3.4
		Demand forecasting (climate change)	3		4	4		2	3.0
		Demand forecasting (land use)	3		4	3	1	2	3.1
		Demand forecasting (others)	3		5	2	1	2	3.0
31	Channel capacity monitoring or river cross section surveys:	Updating river design flows and/or levels of protection	3		1	2	2	5	4.1
		Sediment management	3	1	1	3	2	3	3.5
		Stopbank condition and alignment	3		1	3	2	4	3.9
32	Our annual and long term planning rounds are effective in establishing a framework for our operations.		2		1	4	1	5	3.9
33	There are good linkages between asset management planning objectives and financial provisions included within LTPs and Annual Plans.		2		2	1	4	4	3.9
34	We are proactive in programming and executing our annual maintenance programme.		2		1	2	6	2	3.8
35	We have procedures to update our knowledge of:	Changes in hydrology	2		2	5	2	2	3.4
		Changes in river shape/alignment	2		2	5	3	1	3.3
		Changes in design flows	2	2		5	3	1	3.1
36	We have procedures to assess and review the economic and community impact of our services		2	2	3	4	2		2.5
37	How enabling is your regional plan to your operations?		3	1	3	3		3	3.1
38	How well is land use planning informed by department's knowledge of flood related hazards?		3		1	3	2	4	3.9
39	How well do your global consents enable your operations?		3	2	1	4	1	2	3.0
40	How well do Codes of Practice enable your operations?		3	1	3	4	1	1	2.8
41	How well does your organisation deliver:	Operational programme	4			7	1	1	3.3
		Capital improvement works	4		1	5	2	1	3.3
		AMP improvement tasks	4		1	7		1	3.1
42	Our communities understand:	What we do	3	1		6	1	2	3.3
		What level of protection they receive	3		1	7		2	3.3

Appendix D: Data Standards

- Discussion of national metadata standards

Data standards

Land Information New Zealand, in conjunction with the Ministry of Building Innovation and Employment and Treasury, are currently developing metadata standards (how data should be captured, described and stored) for the three waters sector. It is our view that development of similar standards would benefit the river management sector, and lead to improved asset management practices.

The National Environmental Monitoring Standards (NEMS) are a suite of non-regulatory technical documents prescribing technical standards, methods and other requirements associated with the continuous monitoring, recording and processing of environmental parameters (e.g. water level, rainfall, open channel flow, ratings, etc) that were first published in June 2013. Since then, a number of these documents have been reviewed and rereleased, and many others are planned or under development. Whilst they are entitled 'standards', they are considered best practice and not ascribed a formal status in this regard by Standards New Zealand or our legislative environment.

The NEMS documents set out a generic framework ascribing a level of data quality. This is developed based on a range of factors including but not limited to:

- Whether and how the data are processed
- If an empirical relationship is used to derive the data
- The equipment used for data collection, including processes around its selection, installation, verification and calibration

The generic NEMS quality framework is included here as Figure D.1.

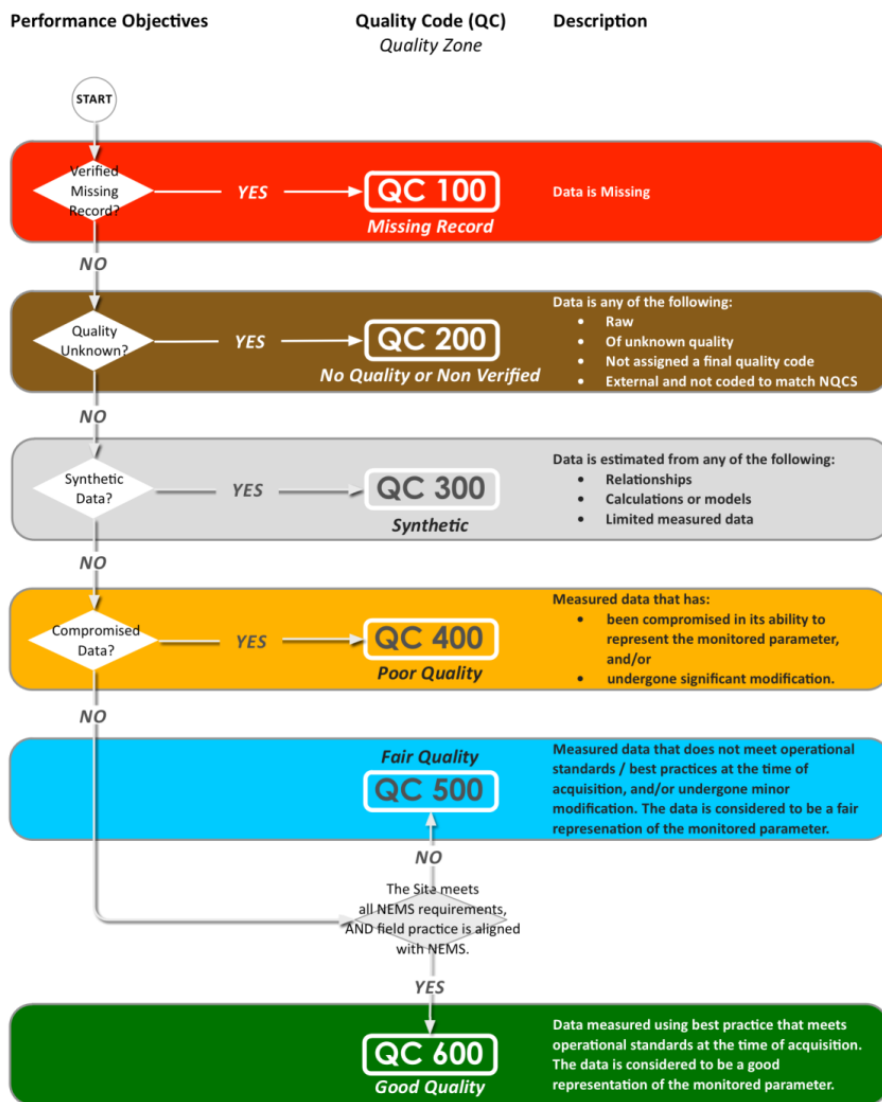


Figure D.1: NEMS generic quality flow chart

In our experience, data of ‘fair’ quality (QC 500) appears to be a reasonable balance between data accuracy and price tag – ‘good’ quality (QC 600) data is often associated with expensive installations which may be unaffordable if deployed *en masse*. We would expect that ‘fair’ quality (QC 500) data would provide enough confidence for regional councils to engage with the National Policy Statement on Freshwater Management and other regulatory processes.

A review of council data acquisition and management processes was outside the scope of this assessment. Further work is required to confirm to which NEMS quality code the river management sector should target, understand each regional council’s current data quality codes and what, if any, changes to existing data acquisition and management processes are needed to meet the agreed target NEMS quality code.

Appendix E: Economic Analysis

- **Full report on the analysis of economic benefits**

Economic value of river control, flood protection and drainage (RCFPD) schemes in New Zealand

Tim Denne and Louis Wright

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1 Introduction

1.1 The Purpose of this Report

This report aims to define the total economic value of river control, flood protection and drainage (RCFPD) schemes in New Zealand. This is a forward-looking examination of value; it examines the benefits that will flow from the ongoing existence of the RCFPD schemes, net of any future costs. The study aims to demonstrate and communicate the value of these schemes to the communities that depend on them.

1.2 Approach to Analysis

The analysis aims to establish the total value of the RCFPD schemes. It evaluates the impacts on the total wellbeing of New Zealanders in aggregate. Wellbeing is not easily defined, but it represents the sum of the outcomes that people (as individuals or as groups) would regard as positive, less the sum of those they regard as negative. Overall changes in wellbeing (also referred to as welfare or utility) are measured using cost benefit analysis (CBA), rather than more narrowly-focused economic valuations tools, such as economic impact analysis (EIA) which measures contributions to GDP. We explain the differences between these concepts below.

As with all valuation exercises, measuring the economic value of RCFPD schemes requires the comparison of two scenarios. In this case, the situation with RCFPD schemes in place (the factual) is compared with a scenario (the counterfactual) in which there are no RCFPD schemes. We discuss the complexities of such an analysis below.

1.3 Valuation Concepts: CBA vs EIA

1.3.1 Cost Benefit Analysis

Cost benefit analysis (CBA) is an analytical approach that springs from welfare theory; it defines the best decision outcome in any circumstance as that which results in the maximum net gain in wellbeing for the community as a whole. Aggregate wellbeing gains to the community are estimated by adding all the estimated benefits (wellbeing gains) and subtracting all estimated costs (wellbeing reductions), taking account of their timing and adjusted by discounting.

Consistent with NZ Treasury CBA guidance,¹ we do not include distributional impacts. For example, we do not examine whether schemes have tended to provide greater benefits to people in particular income categories. Rather we assume that the benefits are widely distributed across the community.

CBA measures changes in wellbeing using monetary values. This is for convenience only. Money is already a currency for exchanging many kinds of goods, and it can be used, usefully, to measure relative wellbeing. This assumes that, in broad terms, patterns of monetary expenditure reflect relative preferences amongst consumption options. Monetary valuation is extended to things (or preferences) which are not normally measured in money terms so they can be compared on the basis of relative preferences.

1.3.2 Economic Impact Assessment

Economic Impact Assessment (EIA) typically measures impacts on Gross Domestic product (GDP) or regional equivalents, which is a measure of total economic activity in a country (or region). GDP is usually measured as total expenditure in a given year on final goods² or as total income. It measures

¹ The Treasury (2015) Guide to Social Cost Benefit Analysis.

² Final goods are those that are ultimately consumed rather than used in the production of other goods.

different things from a CBA. For example, it does not count the value of things that produce wellbeing but which are not bought and sold in a market, and it measures only the market price of a good and not any additional benefit (the consumer surplus, which is the difference between price paid and willingness to pay). Of relevance to this project, it would count the value of flood control protection of buildings but not the avoidance of indirect costs such as the stress of those experiencing a flood. GDP also tends to count expenditure as a benefit, eg GDP increases as a result of flood damage followed by rebuilding.

The Treasury notes that EIA can provide useful contextual information for decision-makers, but it is not suitable as a tool for measuring the balance of costs and benefits of a decision to society.³ We agree. We use the CBA approach in this report as the basis for assessing the economic value of river control, flood protection and drainage schemes.

1.4 CBA Concepts

1.4.1 Defining Costs and Benefits

Costs are defined as opportunity costs. CBA assumes efficient markets which means that the prices of all goods and services are assumed to reflect their opportunity costs of supply. The opportunity cost of allocating a resource to any particular use is that the resource is not available for the next highest value use. This includes opportunity costs of capital (it could have been invested to create a return in some other venture), resources (they could have been used as inputs to some other industry) and labour (workers could be employed elsewhere). Effectively using an opportunity cost approach is the same as comparing the benefits of any given project with those of some other project or set of projects in which the inputs are all used productively.

Benefits are measured as the value that individuals place on the output. This includes any value paid in a market and any additional surplus that is based on what someone would be willing to pay, ie the value of any change in outcome is equal to what people would be willing to give up to obtain it. This is applied to effects or values that are not normally specified in a market, including the impacts on the environment. Such effects are measured using a mix of stated and revealed preference techniques.

1.4.2 CBA Outputs

The results of a CBA of an investment can be summarised in several ways.

- **Net present value (NPV)** – the sum of benefits minus the sum of costs over the lifetime of the investment, with all costs and benefits discounted to take account of their timing. A positive NPV means the investment will provide net wellbeing benefits.
- **Benefit cost ratio (BCR)** – the sum of discounted benefits divided by the sum of discounted costs. A BCR that is greater than 1 means that the investment is worthwhile and will produce net wellbeing benefits.
- **Internal rate of return (IRR)** – the discount rate which would produce an NPV of zero. IRRs can be used to rank investment options, with the project with the highest IRR being favoured. An IRR can also be used to compare with a hurdle (or targeted) rate of return.

The net present value (NPV) is usually the favoured indicator, and it is providing information that is closest to the interests of this project. It measures the sum of benefits minus the sum of costs over

³ The Treasury (2015) Guide to Social Cost Benefit Analysis.

the lifetime of the project(s), with all costs and benefits discounted to take account of their timing. This can be used to estimate the total value of RCFPD schemes, rather than estimated returns on investment, which are largely historical. The benefit cost ratio (BCR) or internal rate of return (IRR) might be used to estimate returns on future costs, eg the value of maintaining (or expanding) existing infrastructure, but this is addressing a different question from the valuation question.

We use NPV analysis in this report. However, we also transform the values into annualised values (or equivalent annual value, EAV) to enable better comparison of projects which have different durations (see below). An EAV is an amount which, if spread equally over the lifetime of a project would result in the same NPV as the actual project costs and benefits. The formula for an EAV is:

$$EAV = \frac{r \cdot PV}{1 - (1 + r)^{-n}}$$

Where: EAV = equivalent annual value
 r = discount rate
 PV = present value of project (or NPV)
 n = project duration in years

It is estimated using the PMT function in excel.

1.4.3 Project Lifetime

Projects should be evaluated over the length of the project. This is until the end of the economic life of the capital invested, eg to a time when there is a need for a significant reinvestment. When comparing projects with different time frames, the NPV results should be converted into EAVs as discussed above.

1.4.4 Discounting

Discounting in the context of a CBA is a way to measure the time value of consumption. Two broad approaches are used: the social rate of time preference and the social opportunity cost of capital.

Social Rate of Time Preference

The social rate of time preference (SRTP) assumes that the primary interest of policy makers is in the timing of consumption and that public policy (or investment) decisions can affect that timing. The Ramsey equation is a standard formula for determining the SRTP. It includes two elements:⁴

- the time preference of people, ie the extent to which there is a preference for consumption earlier in time; and
- the relative value of consumption in different time periods because of changing income, ie an additional unit (eg dollar) of consumption is valued less when income is higher.

The SRTP is applied to wellbeing effects more generally by assuming that people would be willing to sacrifice present wellbeing in favour of greater future wellbeing at the same rate of time preference as evidenced in saving behaviour (saving forsakes current consumption in favour of greater future consumption).

⁴ Ramsey FP (1928) A Mathematical Theory of Saving. *Economic Journal*, 38: 543–559.

The SRTP approach attempts to have wide applicability to the timing of all impacts on wellbeing, eg whether we would prefer to face the stress of a flood this year or next year.

Estimates of the SRTP for New Zealand include an estimate of 4.4% by the Ministry of Economic Development (now MBIE) in the context of the 2006 NZ Energy Strategy,⁵ and a recommended rate of 4% by Auckland Council.⁶

Social Opportunity Cost of Capital

NZ Treasury emphasises the social opportunity cost of capital (SOC) concept, ie that government decisions are displacing private investments which would have yielded a rate of return. In its 2015 *Guide to Social Cost Benefit Analysis*, the Treasury states that “*the public policy objective must be to maximise the return that is obtained from the tax payer’s dollar*” and that “*a useful way to think about the discount rate is as a hurdle rate of return.*”⁷ Based on this argument, the guide recommends the rate of return in the share market is the next best, or most convenient, alternative investment, that could be used as an opportunity cost of capital-based discount rate.

Although the Treasury authors assume a wide view of possible effects (by ‘return’ they mean “*the net total of the social and economic impacts of a project, or the benefits net of the costs, all valued at their opportunity costs*”), they take a narrow assumption on initial costs (taxpayer funds). Their argument is that “*Assuming that all benefits have been valued correctly, we should be indifferent between one kind of benefit and another, if their value is the same.*”

Treasury’s estimate of the opportunity cost of capital for public decisions is 7% in real terms.⁸

Recommended Discount Rate

Some approaches to discounting combine the two approaches, eg by isolating the investment items and using the SOC to estimate a shadow price of capital. All effects are then discounted using the SRTP.⁹ In this study, we are not examining new investments but the value of existing investments which are sunk costs. The consumption effects are being valued.

For analysis in this study we use a discount rate of 6%, consistent with NZ Treasury, but with sensitivity analysis using 4%.

2 Avoided Flood Damage

2.1 Economic cost categories

A review of economic analyses of floods and other natural disasters suggests that costs (which are avoided as a result of RCFPD schemes) are often categorised as:¹⁰

- tangible and intangible damages – those that are readily measurable in monetary terms and those that are not; and

⁵ MED (2006) Choice of Discount Rate for the New Zealand Energy Strategy. POL/1/39/1/1

⁶ Auckland Council (2013) Auckland Council Cost Benefit Analysis Primer.

⁷ NZ Treasury (2015) Guide to Social Cost Benefit Analysis, p35

⁸ <http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/currentdiscountrates>

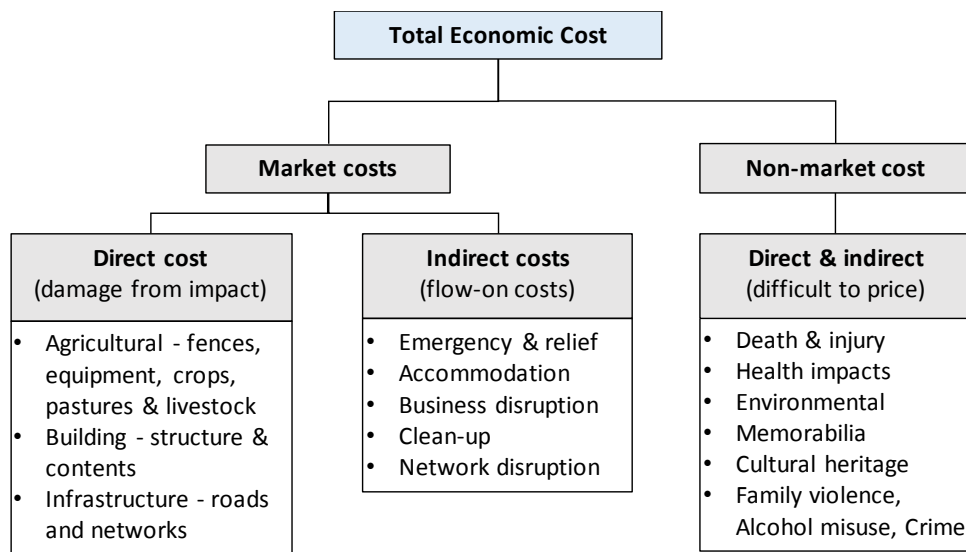
⁹ Young L (2002) Determining the Discount Rate for Government Projects. New Zealand Treasury Working Paper 02/21

¹⁰ Department of Infrastructure, Planning and Natural Resources (2005) Floodplain Development Manual the management of flood liable land. New South Wales Government. Appendix M Flood Damages

- direct and indirect damages – those that result from the direct contact with water and those that are secondary to this.

Figure 1 summarises cost categories building on a selection of Australian and New Zealand flood defence CBAs.¹¹ For clarity we use market and non-market values as categories rather than tangible/untangible; the market values category is split into direct and indirect reflecting whether the costs are directly attributable to the actions of water. Market costs (those for which there are market values) tend to be more tangible and their values somewhat more easily determined. Direct costs are generally damages caused by the flood, whereas indirect costs are inconveniences incurred as consequence of the event. Costs that fall under the ‘non-market’ category are generally less tangible and more difficult to value. Some indirect or ‘flow-on’ costs, such as network disruption, can also be classified as a non-market cost.

Figure 1 Summary of avoided costs in flood defence CBAs



Although the classification of avoided costs is based largely on flood defence projects, the set of categories is more widely applicable to river control and drainage schemes. The categories are developed to ensure that a comprehensive set of effects is taken into account, including those which are more or less easily estimated. The classification is similar to that used in defining Total Economic Value (TEV)¹² which is used to ensure that all values are incorporated in a CBA, particularly those relating to the environment.

In this study we have considerable data limitations. Nevertheless, we examine ways in which the widest set of values possible can be included in the analysis. Tonkin + Taylor (2014) reviewed the quality of the data that are available to describe flood damages and found it to be highly variable.¹³ The best quality data are for tangible-direct damages and then, in order of decreasing quality, tangible-indirect, intangible-direct and intangible-indirect damages. The analysis in this study

¹¹ Bureau of Transport [BTE] (2001) Economic costs of natural disasters in Australia, report 103; Deloitte & Access Economics (2013) Building our nation’s resilience to natural disasters. Australian Business Roundtable for Disaster Resilience and Safer Communities; Deloitte & Access Economics (2016) The economic cost of the social impact of natural disasters. Australian Business Roundtable for Disaster Resilience & Safer Communities; Wyatt S (2015) Flood, drainage and erosion protection benefits of Lower Wairarapa Valley Development Scheme. Report prepared for Greater Wellington Regional Council

¹² European Environment Agency (2010) Scaling up ecosystem benefits A contribution to The Economics of Ecosystems and Biodiversity (TEEB) study. EEA Report No 4/2010.

¹³ Tonkin & Taylor (2014) Flood Damage Assessment methodology. Report Prepared for Auckland Council.

concentrates on the components of value that are most readily measured at an aggregate (national) level.

2.2 Treatment of Insurance

Insurance provides a means for households and businesses to pass on their risks to others. In a fully competitive insurance market with perfect information, the level of premium would reflect the risk and associated damage. In such a theoretical competitive world, if measures were taken to reduce the risk of flooding, this would be reflected in reduced insurance premiums and the total amount paid in premiums would reflect the total expected pay-out (damage times risk). In the short run, and at the margin, ie for the valuation of individual RCFPD schemes, premiums may not adjust efficiently with risk levels. This matters, because most insurance companies operating in New Zealand are foreign-owned. Risk reduction that was not met by reductions in premiums would largely result in benefits for insurance companies, and these benefits would be expatriated.

However, for this analysis, which assesses the effects of investments made over a significant period of time, spread widely across the country, we assume that the industry is relatively efficient and that premiums are reflective of risk. We thus ignore insurance payments (premiums and pay-outs) in estimating (avoided) damage costs.

2.3 International Experience

In this section, we briefly review international examples of CBAs used to evaluate flood defence schemes. Of particular interest to this study, the examples are used to examine how others have approached:

- the inclusion of the full range of effects; and
- the development of a counterfactual against which value is determined.

The findings below suggest that, over time, CBAs have taken account of an increasing number of effects, particularly as approaches to valuation have improved and monetary values have been published. Also, CBAs of flood defence have, in general, been used to analyse new schemes, rather than existing schemes. In that context, the counterfactual definition is generally “doing nothing in addition to what is there already”, rather than “the removal of existing schemes”.

2.3.1 USA

The 1936 Flood Control Act in the US is often cited as the first significant example of government-required use of CBA for decision making.¹⁴ As a result, federal agencies adopted a damages-avoided method for flood control benefit assessment. This included the cost of replacing and repairing property that could be damaged and the foregone income from agricultural land (lost sales and/or increased production costs); the damages for each possible flood event were multiplied by the probability of each flood occurring and the impact was estimated as the difference between the with and without project scenarios.

Over time there was increasing criticism of the avoided damages approach because it tended towards a narrow focus on property damage.¹⁵ Approaches shifted towards those that measured the willingness to pay (WTP) of beneficiaries for avoided flood damage. This would include assessment of the full range of effects.

¹⁴ Shabman L (1997) Making benefit estimation useful: lessons from flood control experience. Water Resources Update [Universities Council on Water Resources], 109: 19-24.

¹⁵ Shabman (*op cit*)

Since 1983, direction has been provided to Federal agencies in the form of the Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies (PR&G). They provide advice when evaluating and selecting major water projects, including projects related to navigation, storm resilience, wetland restoration, and flood prevention.¹⁶ The PR&G were finalised in 2014; they include a requirement for evaluation of the costs and benefits of alternatives, in addition to performance relative to a set of guiding principles¹⁷ and formulation criteria.¹⁸ The cost benefit analysis requirements include monetisation wherever possible, consistent with federal guidance;¹⁹ impacts that cannot be monetised are to be described.

2.3.2 Australia

Over the early 2000s, the Australian government carried out a long-term research project to better understand the costs and benefits of flood mitigation expenditure. The first report by the Bureau of Transport Economics (BTE) analysed the past impacts of natural disasters in Australia to develop a model for costing future events.²⁰ Costing methods relied heavily on findings from past studies and insurance data to estimate total economic costs.

BTRE (2002)²¹ used BTE methodologies to analyse five flood mitigation interventions (case studies) in Australia. The damage observed after a flood and with a specific intervention in place, was compared with the estimated damage without it (the counterfactual). Where feasible, damage avoided benefits were estimated as the reduced average annual damage (AAD) due to mitigation. The counterfactual was defined simply, eg flood damage observed in a nearby industrial zone was used to estimate the counterfactual damage to the Tamworth CBD, had its existing flood levee not been built. No detailed scenarios were developed of possible different types of development in the absence of flooding.

Cost estimation methods developed by BTE continue to provide methodologies and inputs for Australian flood protection analysis. However, recent research has recognised the lack of attention previously given to those less tangible, social costs of natural disasters. Impacts that are typically overlooked include damage to health and wellbeing of people and communities. These effects have been included in a recent study for the Australian Business Roundtable for Disaster Resilience & Safer Communities²² (see below).

2.3.3 UK

In the UK, although chiefly for England, there are a number of documents that provide guidance on the evaluation of projects that would enhance current levels of flood protection or erosion risk. Consistent with a set of principles set out in a Defra policy statement on a appraisal of flood and coastal erosion risk management (FCERM),²³ all publicly-funded FCERM strategies and projects developed by operating authorities must complete a FCERM appraisal. FCERM Appraisal Guidance (FCERM-AG) sets out methods to be used.²⁴ This includes guidance on:

¹⁶ Council on Environmental Quality: Updated Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies. Retrieved from <https://obamawhitehouse.archives.gov/administration/eop/ceq/initiatives/PandG>

¹⁷ These principles are: (1) healthy & resilient ecosystems, (2) sustainable economic development, (3) floodplains (ie avoiding floodplain development), (4) public safety, (5) environmental justice, and (6) a watershed approach.

¹⁸ The formulation criteria are completeness, effectiveness, efficiency and acceptability.

¹⁹ Office of Management and Budget (OMB) Circulars A-94 and A-4

²⁰ Bureau of Transport Economics [BTE] (2001) Economic costs of natural disasters in Australia.

²¹ Bureau of Transport and Regional Economics [BTRE] (2002) Benefits of Flood Mitigation in Australia.

²² Deloitte Access Economics (2016) The economic cost of the social impact of natural disasters. Prepared for the Australian Business Roundtable for Disaster Resilience & Safer Communities

²³ Defra (2009) Appraisal of flood and coastal erosion risk management A Defra policy statement

²⁴ Environment Agency (2010) Flood and Coastal Erosion Risk Management appraisal guidance FCERM-AG

- setting a baseline for appraisal. This is defined as do-nothing, ie walk-away with no further intervention. This is forward looking and includes an assessment of how risks will change over time, eg as a result of climate change. The do-nothing baseline should set out a story on what is expected to happen in the future in terms of:
 - deterioration, failure/loss and time to failure of structures such as defences, coast protection works and pumping stations;
 - how the frequency of erosion and flooding events will change and whether or not there are existing structures or management activities; and
 - the impacts (positive and negative) that occur as a result.
- measuring costs and benefits. The main guidance is provided by the Green Book,²⁵ which is Treasury Guidance on cost benefit analysis. The FCERM-AG includes some guidance on the types of costs and benefits to be considered, with additional guidance provided in a separate handbook on environmental valuation.

The handbook on valuing environmental effects in the context of flood evaluation²⁶ includes default values for a number of impacts, while noting that these are “*best estimates of the likely levels of benefits*” but that new valuation studies should be used when the impacts are significant or likely to be contested. Table 1 shows some default values in £/ha/year for different ecosystem types; they are used to value habitat creation as a result of managed retreat.

Table 1 Range of indicative economic values (“default values”) for different habitats (£/ha/yr, 2008 prices)

Habitat & ecosystem service provision	Indicative value	Range
Inland marsh: water quality improvement, recreation (non-consumptive), biodiversity, aesthetic amenity	~£1300	£200 - £4,300
Saltmarsh: water quality improvement, recreation (non-consumptive), biodiversity, aesthetic amenity	~£1400	£200 - £4,500
Intertidal mudflat: water quality improvement, recreation (non-consumptive), biodiversity, aesthetic amenity	~£1300	£200 - £4,300
Peat bog: water quality improvement, recreation (non-consumptive), biodiversity, aesthetic amenity	~£300	£0 - £1,000

Source: Eftec (2010) Flood and Coastal Erosion Risk Management: Economic Valuation of Environmental Effects HANDBOOK for the Environment Agency for England and Wales.

The values were derived from a number of studies, particularly that of Brander *et al*²⁷ which included techniques for scaling up data from individual studies to an aggregate national (or European) level, including taking account of:

- distance-decay functions in which the willingness to pay (WTP) for a particular improvement would decrease with distance from the valued ecosystem;
- taking account of substitutability, eg if benefit transfer is performed between landscapes that vary in level of ecosystem services (from poor to rich), WTP values are likely to be overestimated;²⁸

²⁵ HM Treasury (2003) The Green Book. Appraisal and Evaluation in Central Government (minor updates in 2011)

²⁶ Eftec (2010) Flood and Coastal Erosion Risk Management: Economic Valuation of Environmental Effects HANDBOOK for the Environment Agency for England and Wales

²⁷ Brander LM, Ghermandi A, Kulk O, Markandya A, Nunes P, Schaafsma M and Wagtenonk A (2008) Scaling up ecosystem services values: methodology, applicability and a case study. Report to European Environment Agency.

²⁸ They note: “For instance, respondents in an area with several lakes whose water quality is polluted will value cleaning up the first lake more than cleaning up the second lake, because (1) the first lake can be a substitute for the second lake, and (2) the respondent has a budget limitation which reduces the money available for cleaning up the second lake. Valuing goods separately and then adding up the values will overstate the true value, as every respondent will treat the ecosystem under study as if it were the first good.” (Brander *et al* 2008, p7)

- differences in socio-economic factors (eg income and demographics) between the study site and the policy site; and
- differences in contextual factors that explain WTP, including (a) the spatial pattern of the social, demographic and psychological characteristics of the affected population and (b) the physical characteristics of the goods and services under valuation.

The handbook also included values relating to the value of recreation, but this is also translated into average values per hectare. The valuation approach focussed on developing an average annual damage (AAD), as discussed above. Additional guidance is provided on multi-criteria methodologies for effects that are difficult to measure in monetary terms.²⁹

3 Evaluation of NZ Schemes

3.1 Defining the counterfactual

Any analysis of costs and benefits requires the comparison of two scenarios –with or without some action. In this case it is comparing a factual scenario (the current set of RCFPD schemes) with a counterfactual (no RCFPD schemes). This differs from most CBAs of flood defence schemes which have examined the costs and benefits of new investments or enhancements; typically, they have compared new investment and expenditure to a do-nothing counterfactual (no additional investment).³⁰ This cannot be used here because the interest is in valuing the existing stock.

There are different ways in which the counterfactual might be specified to answer the question that this study addresses. We outline three options below.

1. New Zealand with no RCFPD schemes

This scenario would postulate a situation in which no RCFPD schemes had ever been put in place. It might be equivalent to imagining that no one in New Zealand had ever discovered or been aware of these techniques and technologies. This might lead to the need for a complex assessment of how New Zealand would have developed differently, including significant differences in land use activity and the location of economic activity, towns and cities. Such an analysis is both complex and highly speculative. For example, if a flood defence scheme protects an urban area from flooding, eg the Hutt Valley, it is likely that, in the absence of the schemes, the people and activities would have located elsewhere, away from the risk of flooding. Defining this counterfactual scenario might require an analysis of:

- alternative locations for the residents, including whether this would be through expanding other urban areas at the same density, or through more intensive development; and
- alternative economic activities and, potentially, a different economic structure, ie a different set of industries in New Zealand.

2. No coordinated RCFPD schemes

Instead of assuming there are no RCFPD schemes, this scenario would assume there are no coordinated, community-developed schemes and that the schemes that exist are developed

²⁹ Environment Agency (2010) Flood and Coastal Erosion Risk Management appraisal guidance. Guidance on applying the scoring and weighting methodology.

³⁰ Middlesex University Flood Hazard Research Centre (2014) A common framework of flood risk management cost benefit analysis features; Deloitte Access Economics (2013) Building our nation's resilience to natural disasters. Australian Business Roundtable for Disaster Resilience and Safer Communities;

privately by individual landowners or small groups of them. This would require speculation on whether or not landowners would have coordinated their activities in a way which resulted in similar schemes to those that currently exist. The analysis would be of the value of coordination (or of public intervention) rather than of the schemes themselves.

3. Removal

The third approach examines the value of what is currently protected by the existing RCFPD schemes, equivalent to asking the current community for its willingness to pay (WTP) for the continued provision of protection on the assumption that the (private) owner of the schemes could somehow remove them. Although this scenario is not realistic (the existing schemes would not be removed), it provides a basis for estimating the value of the existing schemes to the current communities protected by them.

The third option is the approach adopted in this study. It is consistent with the study's aim to identify the current value of existing schemes.

3.2 Analytical Approach

3.2.1 Counterfactual Application

Building on the discussion above, we have defined the analytical question as:

the estimated maximum willingness to pay by the relevant communities for the continued provision of protection and value by the river control, flood protection and drainage schemes, on the assumption that these schemes were removable such that their benefits were no longer available.

The approach to valuation will differ with the land use or land type, and with the nature of the scheme. We set out the proposed approaches in Table 2. In all cases our interest is in estimating the present value of the change in scenario; this is the discounted sum of future costs. We discuss time frames for analysis below (Section 3.2.2).

Table 2 Valuation approach by land use and scheme type

Land use/ land type	Flood protection	Tidal protection	Drainage	River management
Built-up areas (residential and other buildings)	NPV of avoided damage	Value of improvements plus difference in value of land uses	Value of improvements plus difference in value of land uses	Value of improvements plus difference in value of land uses
Other land uses	Greater of: <ul style="list-style-type: none"> NPV of avoided damage or Difference in value of land uses possible with/without flood protection 	Difference in value of land uses possible with/without tidal protection	Difference in value of land uses possible with/without drainage	Difference in value of land uses possible with/without river management

Built-up areas are characterised by the presence of buildings. These are capital assets for which there is a risk of:

- physical damage in the case of floods or tidal inundation; or
- land unsuitability, ie in the case of drainage or river management, the counterfactual would be that it would be too wet for the buildings.

The maximum WTP of communities protected by the existing schemes would be equal to the expected damage costs following removal of the existing schemes. For buildings, expected costs

would be equal to:

- floods or coastal inundation: the change in risk level (risk of damage) times the cost of damage were it to occur, including market and non-market costs. Normally risks are expressed as annual risks so that the annual change in risks has to be converted to an NPV; or
- drainage or river management: the value of the buildings as these would be expected to be lost in the counterfactual scenario.

For land, including in built-up areas and **other land uses** elsewhere, the expected costs are the expected changes in land values, based on the change in the potential use of the land. Land values are equivalent to the present value of future benefits from the use of the land (or the value of the next best use where there is a competitive land supply market), so that they are already expressed in NPV terms.

We explore the approach to measuring expected costs below.

3.2.2 Expected Costs – Flood Damage to Built-up Areas

Approaches to flood risk analysis can vary according to differences in the counterfactual assumptions, the number of analysis sites (ie single-site or many sites) and availability of relevant data. However, all flood risk assessments require the following key factors to be considered:³¹

- flood hazard – the probability and magnitude of flooding;
- exposure – the economic value of assets vulnerable to flood hazard;
- vulnerability – the relationship between flood hazard and economic loss; and
- performance – the effectiveness of flood protection that modifies the above factors

The UK Flood Estimation Handbook (FEH) flood estimation methodology is internationally recognised as best practice. The FEH method uses flood frequency curves to define a relationship between the magnitude of a flood (peak flow) and the return period (expected frequency of occurrence). Box 1 defines probability terms often used in flood analysis.

Box 1 Definition of flood probability

Flood probability is generally expressed as a return period (T) or an annual exceedance probability (AEP). A return period is the average interval of time between floods that equal or exceed a particular magnitude. The AEP is the probability of exceeding a specified flood level in any year (the inverse of the return period). For example, a flood return period of 50 years will have an AEP of 0.02 or 2%.

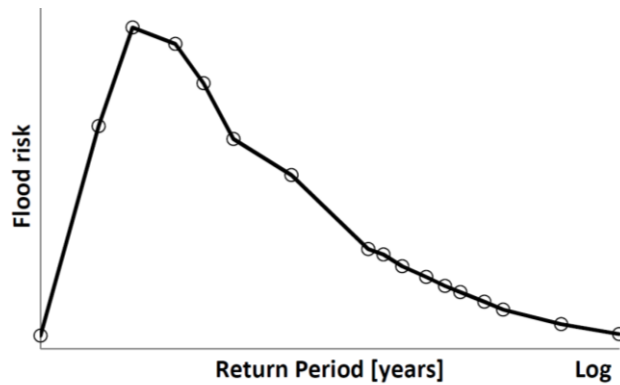
The FEH method requires historical data on the maximum flood each year for several consecutive years.³² Flood data must be specific to the site, or to a site of similar characteristics. However, even if sufficient peak flow data are available, this method is infeasible given the large number and diversity of sites in our base data; we are trying to estimate an avoided cost of floods as an aggregate for New Zealand as a whole, without undertaking detailed analysis of each individual flood-prone site. Thus, we take an alternative approach and use historical insurance data and flood damage relationships observed in past studies to determine the association between flood return period and flood damage.

³¹ National Research Council (2015) Tying flood insurance to flood risk for low-lying structures in the floodplain. Chapter: 3 methods for assessing flood risk. ISBN: 978-0-309-37166-7

³² Environment Agency (2010) Fluvial Design Guide – Chapter 2.4.1 Probability and return period. Retrieved from <http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide/Chapter2.aspx?pagenum=4>

We adopt a flood risk estimation method demonstrated in Morita (2014)³³ and Olsen *et al* (2015),³⁴ in which the average annual damage (AAD) or expected annual damage (EAD) for a location is defined by the total area under its flood risk density curve (RDC). A flood RDC illustrates the risk (in dollar amounts) of a flood along a range of return periods. Using flood damage and return period data from Denmark, Figure 2 shows the RDC as a typical relationship between return period and annual flood risk. Although damage costs increase with return period, risk (or expected annual cost) approaches zero for larger events because of their low probability of occurrence.³⁵

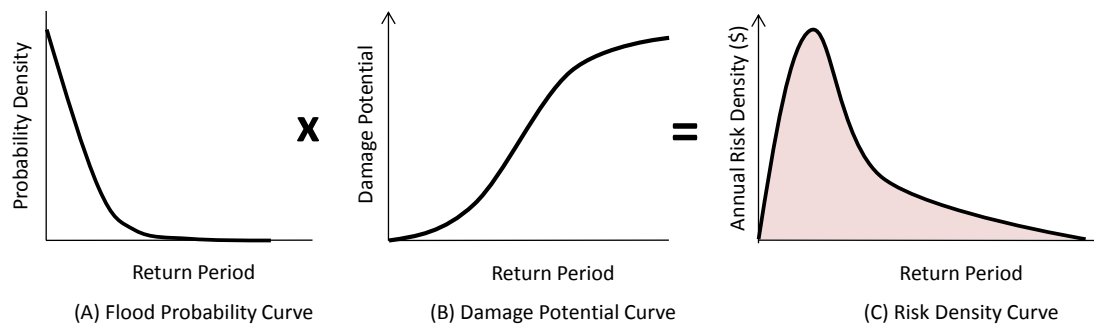
Figure 2 Flood Risk Density Curve



Source: Olsen *et al.* (2015)³⁶

The RDC is the product of damage potential and event probability, as seen in Figure 3. Each point along the RDC represents the damage corresponding to a return period (Figure 3B), weighted by its exact annual occurrence probability (Figure 3A). The sum of these probability-weighted damages, ie the area under the RDC, equals the annual average damage (AAD) for a site.

Figure 3 Flood Probability, Damage and Risk Curves



Source: Modified from Morita (2014)³⁷

Our approach assumes the entire area underneath the RDC is equivalent to a location's AAD without flood defence, ie the counterfactual AAD. We then assume AAD avoided, ie the flood benefit provided to a location, is determined by a scheme's level of service. For example, a scheme with a 100-year level of service will fully avoid damages up to a 100-year flood (Figure 4).

³³ Morita M (2014) Flood Risk Impact Factor for Comparatively Evaluating the Main Causes that Contribute to Flood Risk in Urban Drainage Areas. *Water* 2014, 6 (2): 253-270; doi:10.3390/w6020253

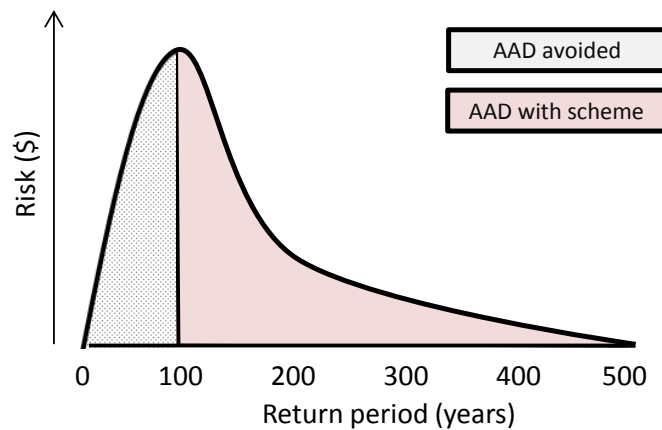
³⁴ Olsen AS, Zhou Q, Linde JJ & Arnbjerg-Nielsen K (2015) Comparing methods of calculating expected annual damage in urban pluvial flood risk assessments. *Water*, 7(1): 255-270.

³⁵ *ibid*

³⁶ *ibid*

³⁷ Morita M (2014) Flood Risk Impact Factor for Comparatively Evaluating the Main Causes that Contribute to Flood Risk in Urban Drainage Areas. *Water* 2014, 6, 253-270; doi:10.3390/w6020253

Figure 4 AAD with a 40-year flood protection level of service



Therefore, annual average damage (AAD) avoided because of flood mitigation can be denoted as:

$$AAD\ avoided = counterfactual\ AAD - AAD\ with\ scheme$$

We take the following steps to estimate the value of damage avoided for sites protected by flood defence:

1. Calculate the **flood probability curve** (see Figure 3A)
2. Calculate a **flood damage curve** (see Figure 3B)
3. Calculate a **risk density curve** (RDC) (see Figure 3C). The purpose of this step is to determine how flood damage changes with a scheme's level of service.
4. Estimate site specific **counterfactual flood damage**. This is done by combing counterfactual assumptions with base data information, eg site capital value and scheme rating.
5. Calculate site-specific **damage avoided** using level of service data.

We set out these steps in more detail below.

Step 1: Calculating the Flood Probability Curve

The flood probability curve used in the derivation of the RDC (Figure 3) is not the same as the annual exceedance probability (AEP). The AEP defines the probability of a flood exceeding a specific magnitude. Therefore it is the probability that a flood of a specific return period or greater occurs within a given year. In contrast, the flood probability curve uses the probability associated with each individual return period. This is referred to as the probability density of a return period (Figure 3A). Intuitively, a return period's probability density will always be lower than its AEP, except for return periods of 1, where the AEP and probability density is also equal to 1.

Flood probability density can be defined as a function of the return period. This equation is known as the flood probability density function (PDF). Mathematically, a PDF is equal to the derivative of the corresponding cumulative distribution function (CDF).³⁸ In flood analysis, the CDF is equal to 1-AEP, ie it is the annual probability that a flood of a given return period or less will occur:

$$CDF = P = 1 - \frac{1}{T}$$

Where: P = the cumulative probability
T = the return period in years

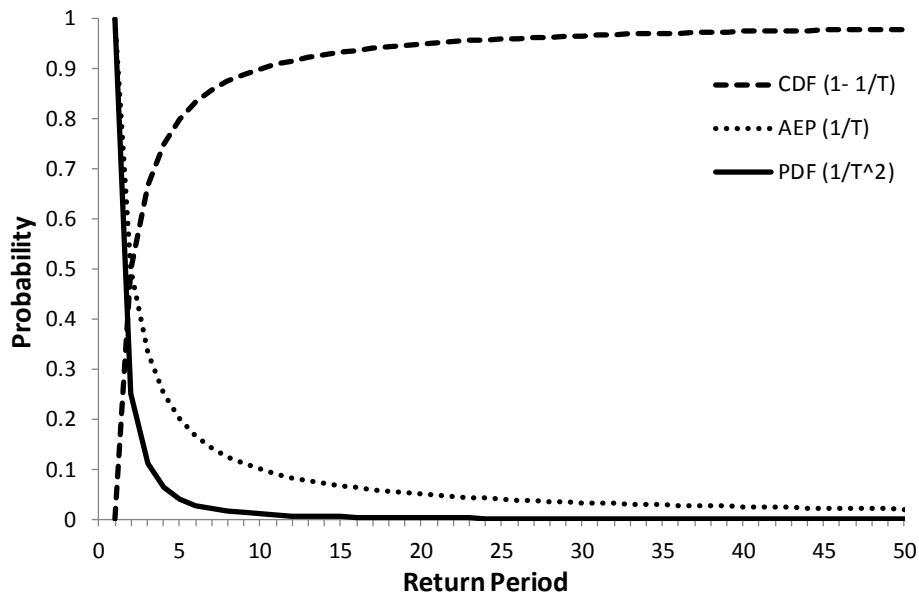
³⁸ Morita M (2014) Flood Risk Impact Factor for Comparatively Evaluating the Main Causes that Contribute to Flood Risk in Urban Drainage Areas. Water 2014, 6, 253-270; doi:10.3390/w6020253

Using calculus, we can calculate the derivative of the CDF to obtain the PDF, the probability for an exact return period (T):

$$PDF = \frac{dP}{dT} = \frac{1}{T^2}$$

Figure 5 illustrates these three key probability equations with respect to flood return period.

Figure 5 Different types of probability for flood return periods



Flood PDF is the probability curve (Figure 3A) used in our analysis. This same probability curve applies to all locations in the base data.

Step 2: Calculate the Damage Potential Curve

Damage potential curves define the expected damage for a range of return periods. We take two approaches to estimate damage potential:

- A. Use historical insurance data to estimate the relationship between return period and flood damage.
- B. Use numbers regarding the observed relationship between flood damage and return period in the UK.

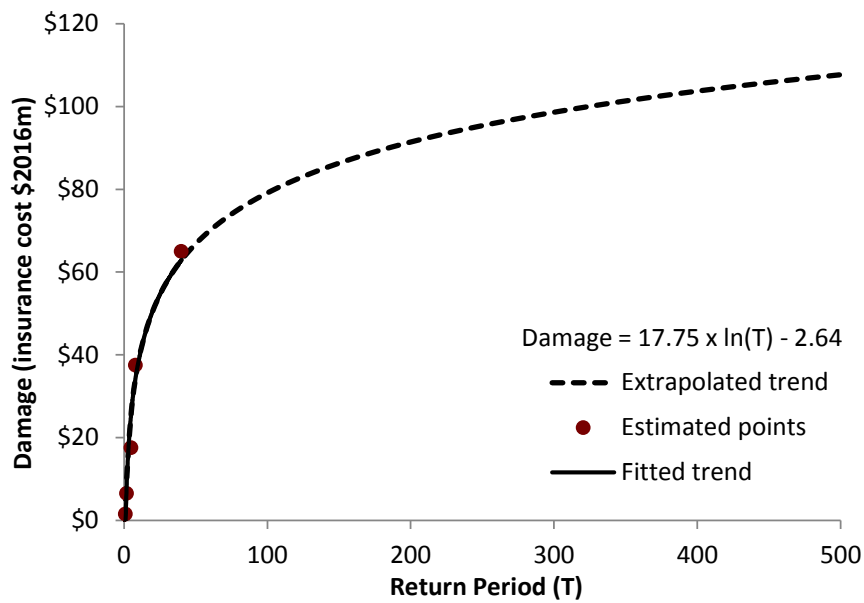
These methodologies are explained below.

A) Damage potential curve: NZ insurance data

The Insurance Council of New Zealand (ICNZ) has published a table of insurance costs which have occurred in New Zealand since 1968.³⁹ ICNZ data contain 77 flood events from 1976 to 2016. After adjusting insurance costs to 2016 prices, we count the number of floods within specified cost ranges: \$0-2.9m, \$3-9.9m, \$10-\$24.9m, \$25-49.9m, \$50-80m. To find the return period associated with each cost category, we divide the analysis period (40 years) by the number of flood events within a given cost category. For example, there were 8 floods within the \$10-25m range, therefore we estimate a 5 year flood (40 years/ 8 floods) would cost \$17.5m (median of \$10-25m). We plot these data and fit a regression line to estimate the relationship between insurance cost and return period (Figure 6). The dotted line of Figure 6 is an extrapolation of this trend out to 500 years.

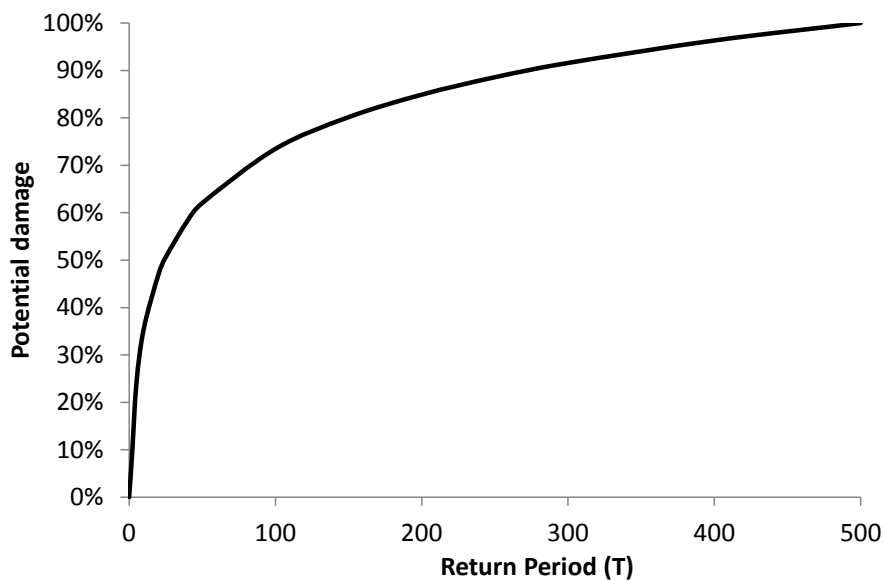
³⁹ <http://www.icnz.org.nz/statistics-data/cost-of-disaster-events-in-new-zealand/>

Figure 6 Insurance cost and return period



The insurance cost-return period relationship from Figure 6 serves as a proxy for the relationship between direct damage and return period. Under the assumption that a 500-year flood will incur the maximum flood damage, we can then calculate a damage potential curve, ie damage as percentage of that expected in a 500-year flood (Figure 7).

Figure 7 Potential Damage Curve: NZ data



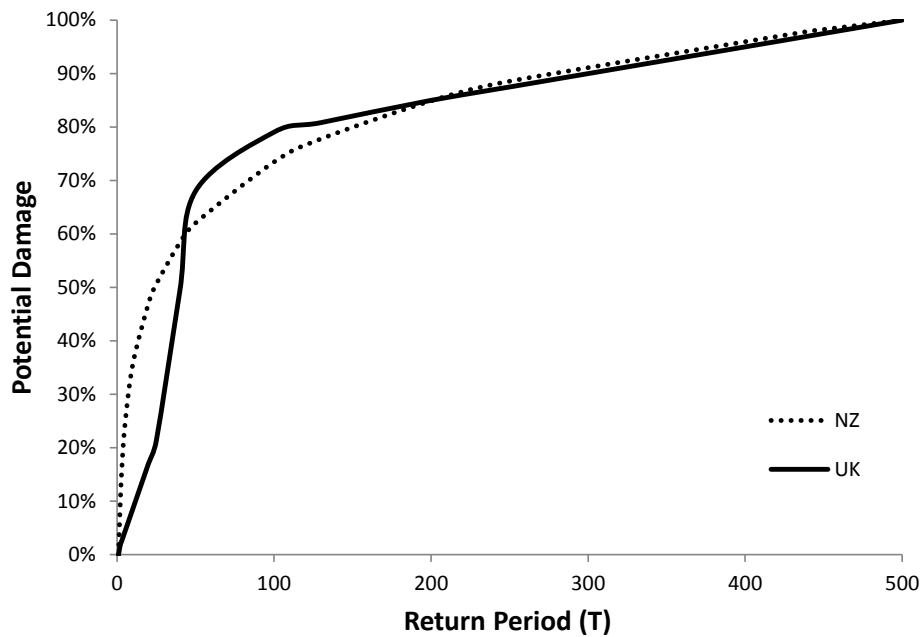
B) Damage potential curve: UK data

The Middlesex University Flood Hazard Centre (2014)⁴⁰ used UK data to estimate the percentage of properties affected (relative to a 200 year flood) by different floods. Using “percentage of properties affected” as a proxy for “damage potential” we can construct a second potential damage curve (Figure 8). To estimate UK damage potential as a percentage of a 500-year flood, we multiply these values by a factor of 0.85, which is equal to 200-year damage as a proportion of 500-year damage

⁴⁰ Middlesex University Flood Hazard Centre (2014) A common framework of flood risk management cost benefit analysis features. Version 3.

found in the NZ data (eg the average insurance costs of a 200-year and 500-year flood were estimated to be \$91m and \$107m, respectively).

Figure 8 Potential Damage Curve: UK vs NZ



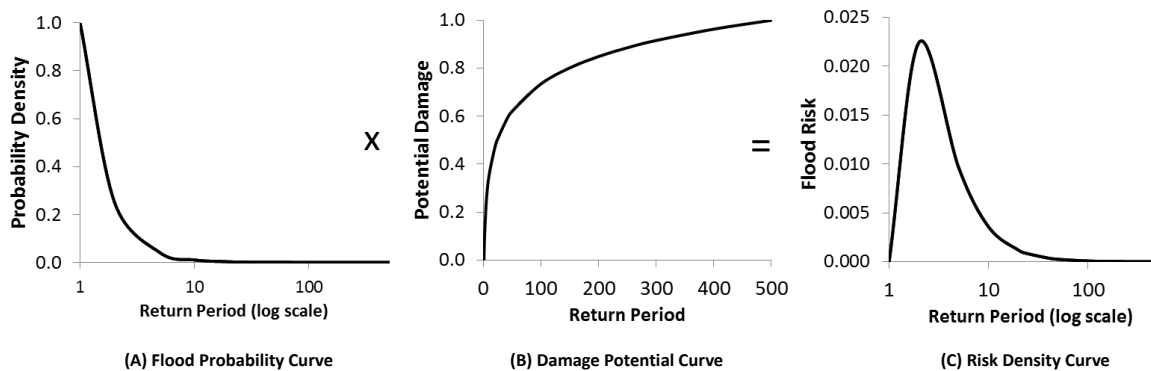
Source : Middlesex University Flood Hazard Centre (2014)

In comparison to the curve derived from NZ data, the UK-derived curve increases at a slower rate up to a return period of 20 years, and at a greater rate over return periods 20-50 years, after which the NZ and UK curves converge.

Step 3: Calculate the RDC

To calculate the RDC (flood risk), we apply the method shown in Figure 3 and combine the flood probability and potential damage curves (NZ or UK curve). Figure 9 illustrates this step using the damage curve estimated via NZ insurance data. Potential damages in the middle chart of Figure 9 are expressed as a proportion of the maximum damage (and not actual damage values as in Figure 3B); they are multiplied by the probability density to produce a flood risk density curve (RDC). To estimate damage in monetary terms they must be multiplied by the estimate of maximum flood damage (in monetary terms) for the specific area (Step 4).

Figure 9 Construction of the RDC



Step 4: Estimate site-specific counterfactual AAD

The objective of this step is to multiply the previously estimated RDC (specified as a proportion of maximum damage - Figure 9C) by the maximum expected flood damage for a given site. The RDC is expressed as an annual flood risk so needs to be multiplied by the maximum annual damage. We make the standard assumption that a property’s capital value (CV) is equal to the present value of the string of future annual returns (to infinity) from use of the land. Thus the maximum expected damage for a given year is estimated by calculating an annuity from the CV. When calculating a constant annuity to infinity, it is equal to the discount rate (r) multiplied by the capital value (CV). Therefore, a site’s counterfactual AAD, ie with flood defence removed, is the total area under the RDC, and is equal to the capital value multiplied by the discount rate. The difference between the factual (with flood defence) and counterfactual (no flood defence) is estimated as some proportion of this area based on the Level of Service (LoS) of the flood defence scheme (see Step 5 below). However, flood defence schemes are also classified in terms of the level of benefit, as high, medium or low. We assume that this is a measure of the vulnerability of the area to flooding and we use this to adjust the counterfactual AAD. For example, a flood defence scheme defined as providing a low level of benefit, is assumed to provide protection of a small proportion of the total counterfactual AAD (CV.r).

In the absence of data, we assume the counterfactual damage for schemes rated high, medium and low is 75%, 50% and 20% of the maximum counterfactual damage (Table 3).

Table 3 Assumptions for Scheme Rating Percentage

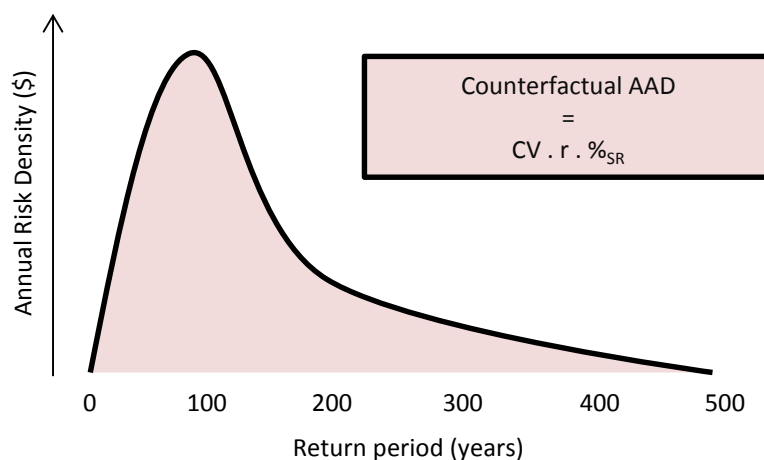
Council Scheme Benefit Rating	Scheme Rating Percentage (% _{SR})
High	75%
Medium	50%
Low	20%

Actual counterfactual AAD can then be expressed by the following equation and as the area under the RDC (Figure 10):

$$\text{Counterfactual AAD} = CV \cdot r \cdot \%_{SR}$$

Where %_{SR} is the scheme rating percentage as shown in Table 3.

Figure 10 Site specific RDC (annual form)



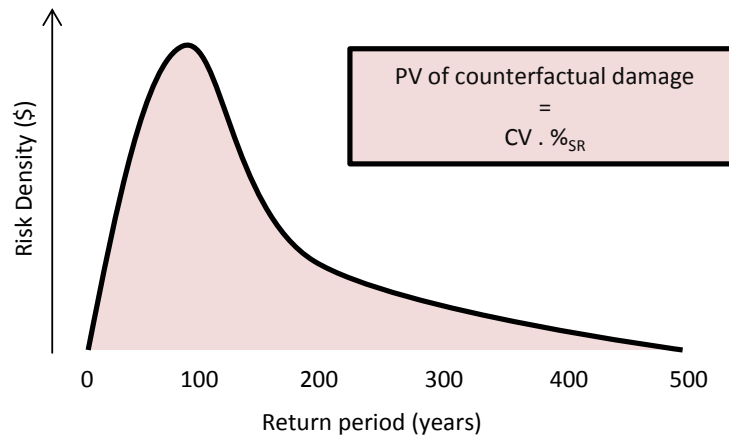
By definition, AAD is an annualised value of flood damage. To find the present value (PV) of counterfactual flood damage, we divide the AAD by the discount rate (r). The PV of a site’s

counterfactual damage can be simplified to its capital value multiplied by its scheme rating percentage:

$$PV \text{ of counterfactual AAD} = \frac{\text{counterfactual AAD}}{r} = \frac{\%_{SR} \cdot CV \cdot r}{r} = \%_{SR} \cdot CV$$

For example, with flood protection removed, a \$500,000 site with a low scheme rating would incur \$500,000 x 20% = \$100,000 worth of damages. The annual RDC can be scaled to represent risk in PV form (Figure 11). The area under this curve represents the present value of counterfactual damage to a specific site.

Figure 11 Site specific RDC (PV form)

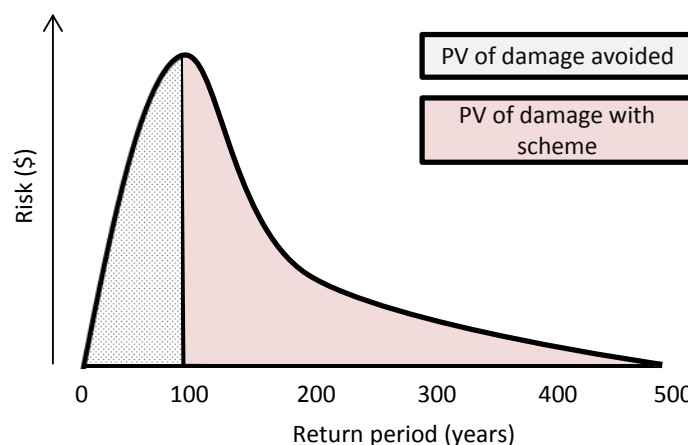


This methodology assumes landowners do not take account of the expected duration of the RCFPD schemes themselves. For example, if a high value land use is occurring that is only possible because of the RCFPD scheme, the landowners assume that the RCFPD scheme will always be in place. Under this assumption, the capital value = discounted annual benefits to infinity, rather than the value incorporating some risk that the scheme might depreciate (physically) over time and that, at some future date, the high value land use could not occur.

Step 5: Calculate damage avoided

A scheme’s level of service is used in conjunction with the RDC to calculate the portion of the counterfactual flood damage that is now avoided. The key assumption here is that a scheme provides full protection from flood damage up to the level of service specified in the base data. Figure 12 gives illustrates the change in flood damage for a site protected by a scheme with a 100 year level of service.

Figure 12 Site specific avoided damages (PV form)



A specific level of service can be represented by a percentage (%_{LOS}) that is equivalent to the left hand-side proportion of the total area under the RDC, ie damage avoided as a percentage of the counterfactual damage. To find the PV of damage avoided for a given site, this percentage is simply multiplied by a site’s CV and scheme rating percentage:

$$PV \text{ of damage avoided} = \%_{SR} \cdot CV \cdot \%_{LOS}$$

These classifications and assumptions are combined to produce the following assumptions regarding the benefit of a flood protection scheme (Table 4). The matrix of percentages represents the flood benefit as a proportion of a site’s capital value, given the level of service and scheme rating.

Table 4 Flood damage avoided as a percentage of site capital value

Level of service	Counterfactual damage avoided ¹ (% _{LOS})	Perceived flood benefit		
		High	Med	Low
		Counterfactual damage as % of maximum flood damage (% _{SR})		
		75%	50%	20%
10	62% (36%)	47%	31%	12%
50	90% (67%)	67%	45%	18%
100	95% (85%)	71%	48%	19%
200	98% (94%)	73%	49%	20%
500	100% (100%)	75%	50%	20%

Note: ¹ UK expected damages as a percentage of a 500 year flood in brackets

3.2.3 Difference in land value

For differences in land use we examine the difference in value between current use and the alternative use under the assumption of no protection or no drainage. Table 5 sets out our counterfactual land use assumptions. It shows, for each land use, the assumption on the land use (or vegetation cover) that would exist if the protection was not there. For forestry and low value land uses, it is assumed that there is no change in land use. But for some, higher value land uses, alternatives are required.

The raw data distinguishes between ‘high producing exotic grassland’ and ‘low producing grassland’. For some areas represented within the data, low producing grassland is more valuable (per hectare) than high producing grassland. This is unintuitive and becomes problematic when low producing grassland is used as the counterfactual land use for the high producing grassland. In other words, the data implies that high producing exotic grassland would be more valuable in absence of protection. To avoid this confusion, we have merged these two categories into a single land use (see Table 5).

Table 5 Counterfactual land use type by protection type and current land use

Simplified land use type	Counterfactual land use type
Depleted Grassland	Depleted Grassland
Exotic Forest	Exotic Forest
High or Low Producing Grassland	Non-productive land
Non-productive land	Non-productive land
Orchard, Vineyard or Other Perennial Crop	Non-productive land
Short-rotation Cropland	Non-productive land
Tall Tussock Grassland	Tall Tussock Grassland

3.2.4 Adjustments for Population and Economic Changes

It is common for flood defence CBAs to inflate future avoided costs to account for the increasing risk exposure of a growing economy and population.⁴¹ Data on natural disaster costs from Australia support the application of this costing method.⁴² However, in this analysis, we are using land prices as a proxy for the value of activity on the land. Land prices would be expected to incorporate future expected value of activities, discounted to the present day. Given this assumption, we do not adjust values further.

3.2.5 Inclusion of Wider Economic Benefits (Multiplier Effects)

Current communities that are protected by RCFPD schemes have economic connections beyond the geographical area in which they are based. This includes businesses and other organisations providing services to the community that would be affected by the flooding and which might suffer financially if the community did not exist.

However, to include these wider economic activities involves two questionable assumptions.

1. The counterfactual would need to be further refined to one in which, in the absence of flood protection, the people currently located in the flood prone area would move to somewhere completely different, such that they could no longer use those services. If they were simply located close by, they might continue to use the services.
2. The inclusion of wider benefits would assume that the out-of-area services are not being provided efficiently, ie that the prices paid by the community for goods and services from outside the flood-prone area do not reflect the costs of their provision.

To assume point 1 is to start to shift back towards a scenario in which we speculate on how New Zealand might develop differently in the absence of flood defence. This would raise the problems associated with counterfactual option 1 (see discussion in Section 3.1 above).

Point 2 refers to efficient provision of goods and services and pricing at opportunity costs of supply (costs to providers would fall in addition to revenues). This is the standard approach to CBA. To adopt an approach in which these wider benefits are taken into account is to shift towards EIA. This can be used to measure the value of wider economic activity *associated with* a region, but it cannot be used in this simple way to speculate on what the loss of economic activity would be as a result of change in current demand. The resources currently used to provide goods and services to the existing flood-protected community would be reallocated to different things. There may be some overall reduction in economic activity (and economic value) but we do not know how large it would be. To count the full amount from using, eg regional multipliers, would be to grossly over-estimate the value.

3.3 Non-market Values

Section 2.1 above discussed the different cost categories and the need to include a wide set of costs of flooding, beyond simple estimates of damage to buildings and land uses. However, many of these damages are highly localised and the estimates of costs are site-specific. Rather than analyse each scheme in terms of local characteristics, in this section we explore the extent to which generalised ratios of market to non-market (tangible to intangible) costs can be identified from studies elsewhere and which might be used to estimate avoided damage costs in New Zealand.

⁴¹ DeLoitte & Access Economics (2016) The economic cost of the social impact of natural disasters. Australian Business Roundtable for Disaster Resilience & Safer Communities.

⁴² Risk Frontiers (2010) Bushfire Penetration into Urban Areas in Australia: A Spatial Analysis.

3.3.1 Non-market cost estimation

A review of “a small selection of existing literature” by Wyatt for an analysis of a lower Wairarapa Valley development scheme,⁴³ led her to adopt an assumption that human impacts (including risk to life, injury, disruption and worry) are equal to direct damage to property, but only in cases where the access to the dwelling is affected by flood.” Wyatt noted that, following a review of other schemes in New Zealand and overseas, a report by Greater Wellington Regional Council assumed that intangibles would be equal to the direct damage to urban and rural buildings (structural and contents damage associated with floodwaters entering properties).⁴⁴

These values might provide a useful basis for scaling up the initial assessment of damages avoided.

3.3.2 Insurance to economic costs

In Australia, Joy (1991)⁴⁵ used historical data to approximate ‘insurance costs to total costs’ multipliers for each disaster type. Floods were estimated to cost around 10 times the value of insured costs incurred. BTE notes that these estimates do not include intangible cost, and probably contain a large degree of error due to their simplicity.⁴⁶ Still, they have been used by a number of studies, including BTE, to roughly estimate the total tangible costs of natural disasters. Deloitte & Access Economics estimate the flood multiplier (total economic losses to insured losses) to be around 18 when intangible costs are included.⁴⁷

3.3.3 Emergency costs multiplier

Middlesex University researchers observed that flood incidents in the UK in 2000 were accompanied by significant emergency costs.⁴⁸ These costs were quantified to be around 11% of property damages. Therefore, property damages could be multiplied by 1.1 to estimate this cost if better data are unavailable. Studies of flooding in the UK in 2007 showed proportionately lower emergency costs, around 5.6% of total property damage. These floods were more localised rather than geographically dispersed flooding.

In Australia, Deloitte Access Economics (2013) found that, on average, emergency costs are 4% of the insured natural disaster costs.⁴⁹

3.3.4 Health impacts

Alderman *et al.*⁵⁰ assessed the effects of the 2011 Brisbane floods on residents’ physical and mental health. Their results are presented in odds ratios (ORs), which represent the association between an exposure and an outcome. A statistically significant OR greater than 1 means exposure (ie being affected by a flood) is positively associated with a given outcome. The larger the OR, the greater the association between exposure and an outcome. Using regression analysis, and controlling for as

⁴³ Wyatt S (2015) Flood, drainage and erosion protection benefits of Lower Wairarapa Valley Development Scheme. Report prepared for Greater Wellington Regional Council. Sapere Research Group.

⁴⁴ Greater Wellington Regional Council (2014) in Wyatt (*op cit*), p16

⁴⁵ Joy CS (1991) The cost of natural disasters in Australia. Climate Change Impacts and Adaptation Workshop, Climatic Impacts Centre, Macquarie University, New South Wales, Australia, 13–15 May.

⁴⁶ Bureau of Transport [BTE] (2001) Economic costs of natural disasters in Australia, report 103.

⁴⁷ Deloitte Access Economics (2016) The economic cost of the social impact of natural disasters. Australian Business Roundtable for Disaster Resilience & Safer Communities

⁴⁸ Middlesex University Flood Hazard Research Centre (2014) A Common framework of flood risk management cost benefit analysis features.

⁴⁹ Deloitte Access Economics (2013) Building our nation’s resilience to natural disasters. Australian Business Roundtable for Disaster Resilience and Safer Communities

⁵⁰ Alderman, K., Turner, L. R., & Tong, S. (2013). Assessment of the health impacts of the 2011 summer floods in Brisbane. Disaster medicine and public health preparedness, 7(04), 380-386.

many factors as possible, they found residents whose households were directly affected by flooding were:

- 5.3 times more likely to report poorer health than those not affected by the floods;
- 2.3 times more likely to report respiratory issues;
- 1.9 times more likely to report psychological distress;
- 2.3 times more likely to report poor sleep quality; and
- 2.3 times more likely to have probable post-traumatic stress disorder (PTSD).

These probabilities could be matched with New Zealand statistics to estimate the number of additional health issues attributed to a given flood. We assume the magnitude of human health impacts from a flood is proportional to the population size of the affected area. As monetising different health impacts would be difficult and impractical, we take a simplified approach and include health impacts as part of the wider non-market/ intangible costs of flooding (see section 4.5.2).

4 Economic Analysis

4.1 Introduction

Table 6 lists the key components of the analysis used to derive scheme values. All involve the comparison of factual (with schemes) and counterfactual (no schemes) scenarios. The valuation of flood protection schemes in urban areas, where buildings are important, involves estimating the difference in expected flood damage with and without the flood protection schemes, using the analytical approaches discussed in section 3.2 above. This will vary with the level of service (return period protected against) and the scheme rating (high, medium or low levels of protection). In rural areas, the approach taken depends on whether buildings are significant; the values are estimated as the greater of the results using this same approach and a simpler method which compares current capital values of the areas protected with values under some counterfactual scenario of a different land use.

Table 6 Key elements used in scheme valuation

Scheme type	Flood	Flood	Other	Other
Land use type	Urban	Non-urban	Urban	Non-urban
Approach	Damages avoided	Greater of damages avoided or difference in land value	Improvement value	Difference in land value
Factual	Damages expected with flood protection	Land value with flood protection	Capital value with flood protection	Land value with flood protection
Counterfactual	Damages expected without flood protection	Land value without flood protection	Current land value	Land value without flood protection
Data required	<ul style="list-style-type: none"> • Capital value • Level of service • Council scheme rating 	<ul style="list-style-type: none"> • Land value (LV) • Average LV/Ha by land use type 	<ul style="list-style-type: none"> • Capital value • Land value 	<ul style="list-style-type: none"> • Land value (LV) • Average LV/Ha by land use type

A simpler valuation method is used for river control, tidal protection and drainage schemes, because the analysis does not involve estimating factual and counterfactual damage levels. The analysis is examining the difference in land value between the factual and counterfactual scenarios. For urban areas, scheme value is estimated to equal a location's improvement value (i.e. the difference between land and capital value). For non-urban areas, protection value is estimated in the same way

as for non-urban flood protection schemes: the difference in land values between current use and the expected use in the counterfactual (no scheme) scenario.

The analysis has been undertaken for each of the council areas listed in Box 2.

Box 2 Regions/ Council areas analysed

Bay of Plenty Regional Council	Otago Regional Council
Environment Canterbury	Southland Regional Council
Gisborne District Council	Taranaki Regional Council
Greater Wellington Regional Council	Tasman District Council
Horizons Regional Council	Waikato Regional Council
Northland Regional Council	West Coast Regional Council

4.2 Raw Data

The data given to us includes a list of land areas, the type of scheme, the level of benefit (including flood return period), land use, and land and capital values (Table 7).

Table 7 Raw data variables and definitions

Data variable	Definition
Identification number	Identification number for land area
Council	Region in which area is located
Scheme	Name of scheme
Flood Level of Service	The approximate return period for flood protection schemes (in years)
Flood Benefit	Level of flood benefit for a property (high, medium or low)
Drainage Benefit	Level of drainage benefit for a property (high, medium or low)
River Benefit	Level of river management benefit for a property (high, medium or low)
Tidal Benefit	Level of tidal benefit for a property (high, medium or low)
CV Prorated	Capital value of land area. Prorated as rows refer to only part of a property.
LV Prorated	Land value of area.
LCDB Name 2012	The detailed land cover descriptions
LCDB Simplified Class	Simplified land cover description
MB 2016	Census meshblock number
MB Percent	The percent of the meshblock for the row
UA 2016	Census Area Unit number
UA Name	Census Area Unit name
Hwy Number	State Highway number for any SH intersecting the area covered by this row
Hwy Length	The length (m) of SH intersecting this row
Area HA	Area in hectares
Area m2	Area in metres squared

4.3 Flood Protection Schemes

For flood protection, we have valued the benefit provided for each land area using one of two methods (see Table 2).

- For built-up areas (with residential and other buildings) – the NPV of avoided damages; and
- For other areas – the difference in land values possible with and without protection.

4.3.1 NPV of avoided damages

This method is used to value flood schemes in urban areas. It assumes that floods would damage the existing buildings and land uses. Calculation of avoided damages requires an estimate of damage without flood protection (counterfactual damage) and the proportion of this damage that would be avoided with flood defence.

According to the theory set out in Section 3.2.2, we estimate the counterfactual level of damage as a percentage of the capital value ($\%_{SR}$); this percentage is determined by the scheme rating as specified by councils (eg high, medium or low). We use the scheme's level of service to determine the proportion of this damage that is avoided ($\%_{level\ of\ service}$). These calculations can be summarised by the following equation:

$$PV\ of\ EAD = CV \cdot \%_{SR} \cdot \%_{LoS}$$

Where:

PV of EAD	=	Present value of expected annual damage
CV	=	Capital value
$\%_{SR}$	=	Scheme Rating Percentage (see Table 3)
$\%_{LoS}$	=	Percentage of the counterfactual damage avoided

The two percentage values used in the avoided damage calculation ($\%_{benefit}$ and $\%_{level\ of\ service}$) can be condensed into a single percentage value, the flood defence value percentage (FDVP), which is the product of $\%_{SR}$ and $\%_{LoS}$, as demonstrated in Section 3.2.2 such that:

$$PV\ of\ EAD = CV \cdot FDVP$$

Table 4 contains FDVPs corresponding to each combination of scheme benefit and level of service. Each land area identified in the base data is assigned a FDVP based on the scheme benefit and the level of service specified. These FDVPs are then multiplied by the land area's capital value to calculate the value of flood defence. For example, an area with a capital value of \$110,000, protected by a high benefit flood scheme with a 100-year level of service, will have a FDVP of 71% (Table 4) and a flood protection value of \$78,100 (71% x \$110,000). To find the total value of flood defence in urban areas, we sum all flood defence valuations and filter out all non-urban areas from this calculation.

4.3.2 Difference in land value, with and without protection

This method is used to value all schemes in non-urban areas, and for valuing drainage, tidal and river management schemes in urban areas. It is assumed that, in the absence of RCFPD schemes, all land uses would change from those used currently. The maximum WTP of existing landowners to avoid this is equal to the difference in value between the current land value and the average value of some assumed alternative land use. The alternative land use assumptions used are those shown in Table 5 on page 19.

To obtain the difference in land value, with and without protection, we subtract the counterfactual land value per hectare from the current land value per hectare and multiply the result by the corresponding area (in hectares).

A number of corrections have to be made:

- Some current land values are estimated as zero in the base data. We assign a land value to these areas, according to their respective regional average value per hectare and land use type, before the difference in land value calculation is applied.

- In some cases, the counterfactual land values are estimated to be higher than the current land values. As this is implausible, we assign a \$0 difference in land values for such cases.

To obtain the total value of protection, we filter out all urban areas and sum the remaining values by protection type.

4.4 Other Schemes

Schemes other than flood protection schemes, ie river control, tidal protection and drainage schemes, do not have a level of service concept. The analysis assumes that the schemes have a binary effect so that their presence enables different land uses and thus an improvement in land value. The approach taken differs between rural and built-up areas.

- Built-up areas – the benefits are measured as the land and improvement value attributable to scheme; and
- Other areas – the difference in land values possible with and without protection.

4.4.1 Land and improvement value attributable to scheme

This method is used to value drainage, tidal and river management schemes in urban areas. The assumption is that, in the absence of drainage, tidal and river management, the current improvements (buildings) would not be present and that there would be different land uses. We calculate these effects separately.

An area's improvement value is its capital value less the land value. We assume that this total value is lost if the drainage, tidal or river management schemes are removed in urban areas. We calculate and sum the improvement values for every individual urban land area in the data set.

4.4.2 Difference in land value, with and without protection

This is the same approach as used for flood protection schemes and is discussed above.

4.5 Other Components

4.5.1 Avoiding Double Counting

Many of the individual areas within the raw data receive a benefit from more than one type of protection. To avoid double counting of scheme benefits, we only use the maximum relevant scheme value in such cases. For example, an urban area is protected by a flood protection and a river management scheme; we attribute the combined value of protection to be the greater of the NPV of damage avoided and the improvement value.

4.5.2 Accounting for non-market/intangible costs

Section 3.3 sets out assumptions used in past studies to factor in damages that cannot be easily quantified. We follow the assumptions used by both Wyatt⁵¹ and the Greater Wellington Regional Council⁵² and assume that for urban areas, intangible loss is 100% of the direct damage estimate. As the magnitude of intangible loss is proportionate to the population affected by a flood, we use a

⁵¹ Wyatt S (2015) Flood, drainage and erosion protection benefits of Lower Wairarapa Valley Development Scheme. Report prepared for Greater Wellington Regional Council. Sapere Research Group.

⁵² Greater Wellington Regional Council (2014) in Wyatt (*op cit*), p16

smaller direct cost multiplier for non-urban areas. Statistics NZ⁵³ report the average population density of independent urban areas is 265.9 people per square kilometre. For rural areas, this value is 6.5 per square kilometre. Given this difference in population density, we scale up direct damage costs by 2.4% (6.5/265.9) to account for intangible loss in non-urban areas.

4.6 Summary of Results

The overall results are shown in Table 8. Flood protection schemes have the greatest total value, followed by areas with multiple schemes, drainage schemes, river management schemes and tidal management schemes. This is partly explained by the respective capital value protected by each scheme type: flood protection only (\$143b), mixed protection (\$35.1b), drainage only (\$21.8), and river management only (\$5.51). There are no areas subject to tidal protection only.

Table 8 Summary of Gross Benefits (2016\$ millions)

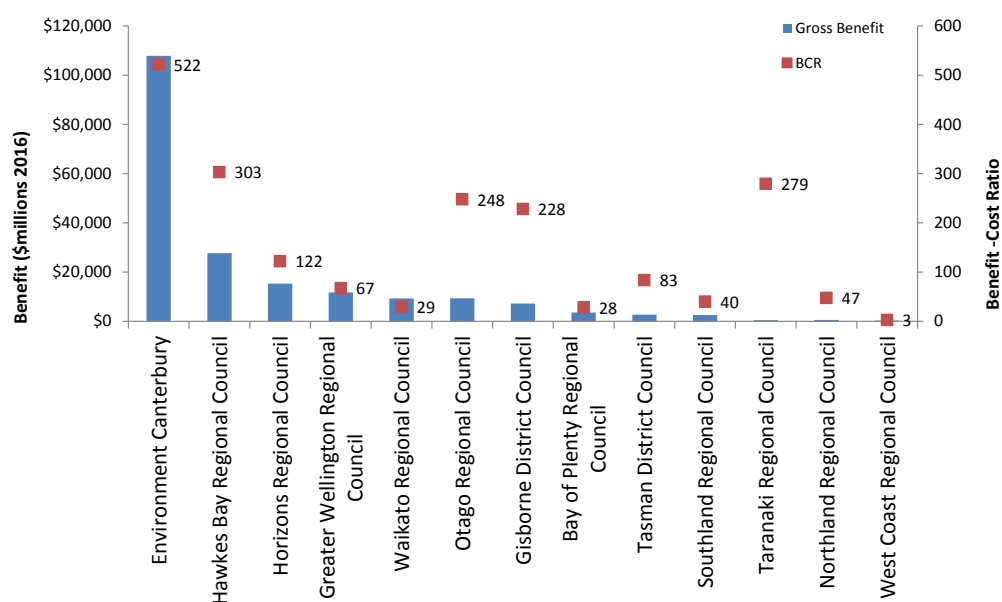
Protection type	Land type	Estimated benefit (PV)	Annual benefit	
			4% DR	6% DR
Flood only	Built-up area	\$134,601	\$5,177	\$7,619
	Other land use type	\$12,553	\$483	\$711
	Total	\$147,154	\$5,660	\$8,329
Drainage only	Built-up area	\$12,796	\$492	\$724
	Other land use type	\$629	\$24	\$36
	Total	\$13,424	\$516	\$760
River Management only	Built-up area	\$2,167	\$83	\$123
	Other land use type	\$83	\$3	\$5
	Total	\$2,250	\$87	\$127
Multiple types	Built-up area	\$34,631	\$1,332	\$1,960
	Other land use type	\$895	\$34	\$51
	Total	\$35,526	\$1,366	\$2,011
Total		\$198,354	\$7,629	\$11,228

Note: DR = discount rate

Figure 13 shows a regional breakdown of total flood benefits and benefit-cost ratios (BCRs). Costs used in the BCRs are the present value of a council's stated annual operating expenditure on flood defence. The treasury's preferred discount rate of 6% is used for these calculations. Environment Canterbury has the greatest total flood benefit (\$108b) and BCR (552). Values in other regions range significantly, for example, the West Coast region is estimated to benefit \$0.27b and has BCR of 3, while the Hawkes Bay has a total benefit of \$28b and a BCR of 303.

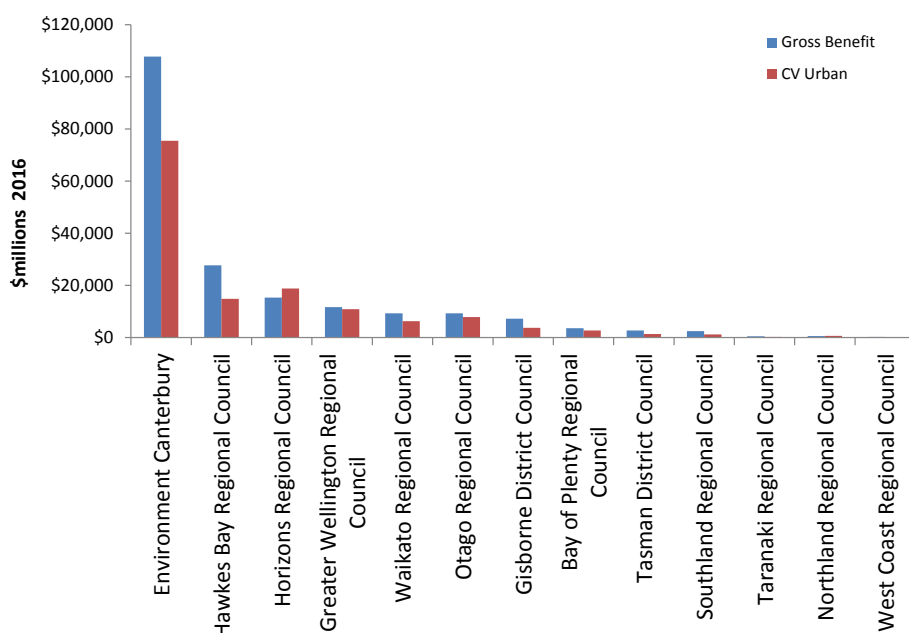
⁵³ Statistics NZ (2001) New Zealand: Urban/Rural Profile. Retrieved from http://www.stats.govt.nz/browse_for_stats/Maps_and_geography/Geographic-areas/urban-rural-profile/main-urban-areas/people.aspx

Figure 13 Flood benefit (\$millions) and BCR by region



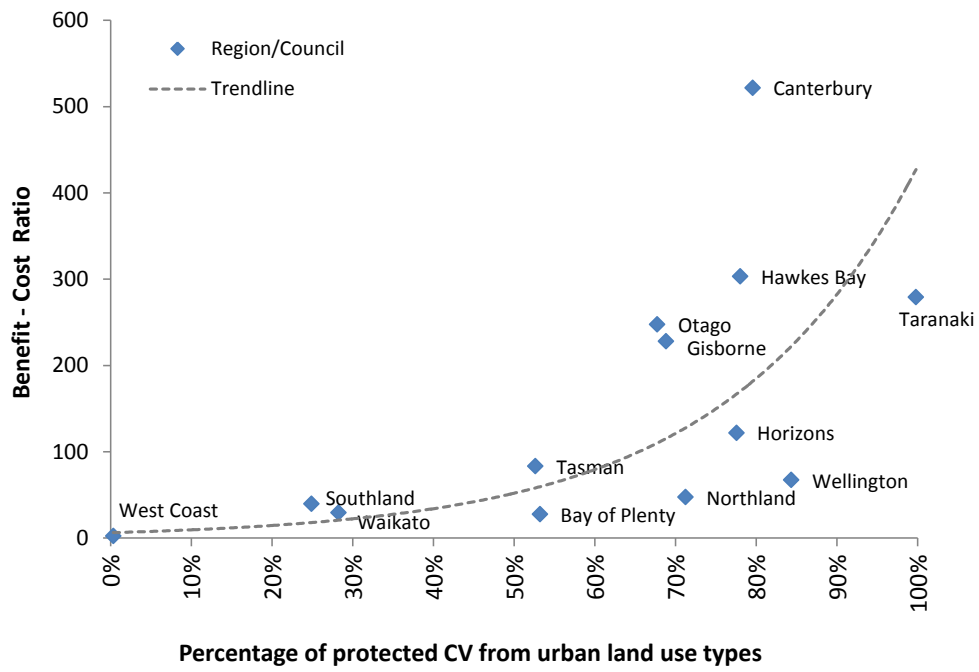
Regional variation of flood benefit values is largely explained by the differences in the amount of urban land protected, as illustrated in Figure 14. The significant non-market value associated with protecting urban land (such as the value of human life) means that regions with a large amount of urban land protected will yield greater benefits from flood defence.

Figure 14 Flood benefit (\$millions) and CV of urban land by region



Similarly, differences in BCRs by council are largely attributable to the protected land's composition of urban and non-urban land use types. Figure 15 shows that regions which owe most of their protected land CV to urban land use types tend to have higher BCRs. Again, this is due to the high non-market inflation factor given to urban land use, as we would expect more damage to human life and health (the main components of non-market costs) in such areas in the event of a flood.

Figure 15 Relationship between BCR and non-urban land by region



Appendix F: Regional Benefit Tables

Regional Benefit Tables

- *Estimated benefit = PVform*
- *4% and 7% = discount rate for annualised values*
- *All values are \$millions*

Bay of Plenty Regional Council				
Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area	\$2,177	\$84	\$142
	Other land use type	\$176	\$7	\$11
	Total	\$2,353	\$90	\$154
Drainage only	Built-up area	\$301	\$12	\$20
	Other land use type	\$49	\$2	\$3
	Total	\$351	\$13	\$23
River Management only	Built-up area			
	Other land use type			
	Total			
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$785	\$30	\$51
	Other land use type	\$67	\$3	\$4
	Total	\$852	\$33	\$56
Total		\$3,556	\$137	\$233

Environment Canterbury				
Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area	\$96,989	\$3,730	\$6,345
	Other land use type	\$7,716	\$297	\$505
	Total	\$104,705	\$4,027	\$6,850
Drainage only	Built-up area	\$198	\$8	\$13
	Other land use type	\$11	\$0	\$1
	Total	\$209	\$8	\$14
River Management only	Built-up area	\$183	\$7	\$12
	Other land use type	\$25	\$1	\$2
	Total	\$208	\$8	\$14
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$2,537	\$98	\$166
	Other land use type	\$174	\$7	\$11
	Total	\$2,712	\$104	\$177
Total		\$107,834	\$4,147	\$7,055

(see end of document for EC
excluding Christchurch city data)

Gisborne District Council

Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area	\$27	\$1	\$2
	Other land use type	\$16	\$1	\$1
	Total	\$42	\$2	\$3
Drainage only	Built-up area	\$6,939	\$267	\$454
	Other land use type	\$63	\$2	\$4
	Total	\$7,002	\$269	\$458
River Management only	Built-up area			
	Other land use type			
	Total			
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$166	\$6	\$11
	Other land use type	\$26	\$1	\$2
	Total	\$192	\$7	\$13
Total		\$7,236	\$278	\$473

Greater Wellington Regional Council

Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area	\$10,803	\$416	\$707
	Other land use type	\$904	\$35	\$59
	Total	\$11,708	\$450	\$766
Drainage only	Built-up area	\$0.00	\$0.00	\$0.00
	Other land use type	\$0.06	\$0.00	\$0.00
	Total	\$0.06	\$0.00	\$0.00
River Management only	Built-up area			
	Other land use type			
	Total			
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area			
	Other land use type	\$0.27	\$0.01	\$0.02
	Total	\$0.27	\$0.01	\$0.02
Total		\$11,708	\$450	\$766

Hawkes Bay Regional Council

Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area	\$169	\$6	\$11
	Other land use type	\$280	\$11	\$18
	Total	\$448	\$17	\$29
Drainage only	Built-up area			
	Other land use type			
	Total			
River Management only	Built-up area	\$45	\$2	\$3
	Other land use type	\$5	\$0	\$0
	Total	\$50	\$2	\$3
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$26,968	\$1,037	\$1,764
	Other land use type	\$221	\$9	\$14
	Total	\$27,190	\$1,046	\$1,779
Total		\$27,688	\$1,065	\$1,811

Horizons Regional Council

Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area	\$13,532	\$520	\$885
	Other land use type	\$576	\$22	\$38
	Total	\$14,108	\$543	\$923
Drainage only	Built-up area	\$78	\$3	\$5
	Other land use type	\$38	\$1	\$2
	Total	\$116	\$4	\$8
River Management only	Built-up area	\$792	\$30	\$52
	Other land use type	\$7	\$0	\$0
	Total	\$799	\$31	\$52
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$266	\$10	\$17
	Other land use type	\$16	\$1	\$1
	Total	\$282	\$11	\$18
Total		\$15,305	\$589	\$1,001

Northland Regional Council

Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area	\$422	\$16	\$28
	Other land use type	\$31	\$1	\$2
	Total	\$453	\$17	\$30
Drainage only	Built-up area			
	Other land use type			
	Total			
River Management only	Built-up area			
	Other land use type			
	Total			
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$72	\$3	\$5
	Other land use type	\$9	\$0	\$1
	Total	\$81	\$3	\$5
Total		\$534	\$21	\$35

Otago Regional Council

Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area	\$6,926	\$266	\$453
	Other land use type	\$1,292	\$50	\$84
	Total	\$8,218	\$316	\$538
Drainage only	Built-up area	\$1,066	\$41	\$70
	Other land use type	\$8	\$0	\$1
	Total	\$1,074	\$41	\$70
River Management only	Built-up area	\$10	\$0	\$1
	Other land use type	\$0	\$0	\$0
	Total	\$10	\$0	\$1
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$19	\$1	\$1
	Other land use type	\$2	\$0	\$0
	Total	\$21	\$1	\$1
Total		\$9,322	\$359	\$610

Southland Regional Council

Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area	\$1,346	\$52	\$88
	Other land use type	\$592	\$23	\$39
	Total	\$1,938	\$75	\$127
Drainage only	Built-up area	\$44	\$2	\$3
	Other land use type	\$14	\$1	\$1
	Total	\$58	\$2	\$4
River Management only	Built-up area	\$239	\$9	\$16
	Other land use type	\$11	\$0	\$1
	Total	\$250	\$10	\$16
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$240	\$9	\$16
	Other land use type	\$9	\$0	\$1
	Total	\$249	\$10	\$16
Total		\$2,495	\$96	\$163

Taranaki Regional Council

Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area			
	Other land use type			
	Total			
Drainage only	Built-up area			
	Other land use type			
	Total			
River Management only	Built-up area			
	Other land use type			
	Total			
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$465	\$18	\$30
	Other land use type	\$0	\$0	\$0
	Total	\$465	\$18	\$30
Total		\$465	\$18	\$30

Tasman District Council

Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area			
	Other land use type			
	Total			
Drainage only	Built-up area			
	Other land use type			
	Total			
River Management only	Built-up area	\$842	\$32	\$55
	Other land use type	\$35	\$1	\$2
	Total	\$877	\$34	\$57
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$1,770	\$68	\$116
	Other land use type	\$35	\$1	\$2
	Total	\$1,804	\$69	\$118
Total		\$2,681	\$103	\$175

Waikato Regional Council

Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area	\$2,210	\$85	\$145
	Other land use type	\$972	\$37	\$64
	Total	\$3,182	\$122	\$208
Drainage only	Built-up area	\$4,170	\$160	\$273
	Other land use type	\$445	\$17	\$29
	Total	\$4,615	\$178	\$302
River Management only	Built-up area	\$55	\$2	\$4
	Other land use type	\$1	\$0	\$0
	Total	\$55	\$2	\$4
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$1,337	\$51	\$87
	Other land use type	\$70	\$3	\$5
	Total	\$1,407	\$54	\$92
Total		\$9,259	\$356	\$606

West Coast Regional Council

Protection type	Land type	Estimated benefit	4%	7%
Flood only	Built-up area			
	Other land use type			
	Total			
Drainage only	Built-up area			
	Other land use type			
	Total			
River Management only	Built-up area			
	Other land use type			
	Total			
Tidal	Built-up area			
	Other land use type			
	Total			
Multiple types	Built-up area	\$6	\$0	\$0
	Other land use type	\$265	\$10	\$17
	Total	\$271	\$10	\$18
Total		\$271	\$10	\$18

