Canterbury 2021 Flood Recovery Update 1

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Executive summary

Purpose:

This report documents the significance of the May 2021 Canterbury Flood event and its impact on the Canterbury Region, particularly Environment Canterbury (ECan) infrastructure. It provides an estimate of response costs to the end of July 2021 and an initial estimate of the costs to replace lost ECan infrastructure with like-for-like asset replacement.

It is intended that this report be used to support the initial ECan claim to the National Emergency Management Agency (NEMA) for eligible flood response costs, and to provide NEMA with an initial estimate of the overall like-for-like replacement of assets lost as a result of the flood.

Background:

The significant rainfall event of 28-31 May 2021 over much of Canterbury, resulted in wide-spread flooding across the region. A region-wide state of emergency was declared on 30 May 2021. The largest 72-hour rainfall totals on record were recorded at 28 of Canterbury's 84 rain gauges. The event was most significant in the foothills area, with the Mount Somers rain gauge recording 546 mm in 72 hours, more than double the previously recorded maximum for 72 hours. Fifteen of ECan's 155 water level recorder sites reported the largest floods on record.

Flood damage as a result of the exceptional rainfall was significant and widespread across the region. Many rivers across Canterbury burst their banks or experienced out of river flows, damaging community infrastructure, public and private property and damaging or destroying significant ECan flood protection assets.

Progress to date: Response and Recovery

Immediate response focused on protecting community infrastructure and dwellings with temporary flood protection works. Follow up work has included further temporary works and assessment and prioritisation of permanent flood recovery works based on risk.

Helicopter overflights were an essential part of the damage assessment and provided post-flood aerial imagery for comparison with recent pre-flood aerial images for flood damage assessment. Some 500 locations of flood damage were identified and included in the ECan Flood Damage data base.

Financial Status:

Total costs to the end of July 2021 for flood response are $2.9 Million. The initial estimate for total flood recovery is $19.7 Million. This includes the estimated cost to replace lost assets with like-for like assets.

Application can be made to the National Emergency Management Agency (NEMA) for a 60% central government contribution to eligible costs above a threshold for like-for-like asset replacement. The threshold for Environment Canterbury is approximately $4.1 Million.

Claims to NEMA are assessed on completion of both the temporary and permanent flood damage repairs. This report is being provided to NEMA to give an indication of the likely magnitude of the overall claim for government assistance. The indicative funding mix based on initial cost estimates is a likely claim to central government for a contribution of $7.5 Million towards Flood Recovery with the remaining $12.2 Million to be funded by ECan (refer to table 5-5).

Next Steps:

Providing some form of ongoing flood protection through temporary repairs remains ECan's highest priority. In the next few months it is anticipated that response works will start to taper off and permanent repairs will commence once ground conditions are suitable.

Prioritisation of permanent flood damage repairs to replace like-for-like assets is the next priority. Prior to commencing permanent repairs, there will be consideration as to whether or not betterment or improvement on what was previously in place is required. Improvement may be needed to account for climate change and the likelihood of increased frequency and more intense rainfall events. Improvement

could take the form of creating more room for rivers in fairways that have already been widened by the flood. There may also be the opportunity to undertake cost effective repairs to infrastructure in the vicinity of flood damaged assets, while contractors are working in the area. Betterment is not eligible for the 60% NEMA subsidy.

Consideration of Climate Change:

The immediate response / temporary works that have been undertaken have a very low level of resilience and are expected to fail in even moderate flood events. The opportunity to consider modifications incorporating the predicted effects of climate change will come in the future as betterment opportunities are explored. These will not be eligible for the 60% NEMA subsidy.

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1 Introduction

This report is the first report documenting the May 2021 Canterbury flood to be provided to the National Emergency Management Agency (NEMA). It provides background to the flood and initial cost estimates for like-for-like flood damage repairs to Ecan's flood protection assets. It presents the summary of flood response costs and estimated flood recovery costs as at the end of July 2021. Response efforts are still underway and assessment of flood damage still being refined, so these initial estimates will change.

The flood of 28-31 May is summarised below, followed by a description of the response activities to date. Flood damage has been assessed across the region and initial estimates of costs presented in the financials section with further detail provided in Appendix 1.

Until flood damage repairs are implemented, there remains an increased risk of flooding to the community. An initial assessment of risk is presented.

Communication and community engagement is an essential part of undertaking flood recovery. Efforts to date are summarised.

2 Flood Event 28-31 May 2021

On 28 May MetService issued a red alert for the Canterbury region forecasting 200-300 millimetres of rain in the high country which they warned could cause dangerous river conditions and significant flooding.

What followed was an extreme rainfall event, both in terms of volume and duration of rainfall. It caused wide-spread out-of-river flooding and resulted in the declaration of a region-wide state of emergency from 30 May to 10 June.

This was the largest 24-hour event on record for most of the foothills rain gauges (e.g. Ashburton, Opuha, Mt Somers, Rangitata, Ashley, Selwyn and Waimakariri). The rain gauge at Mt Somers recorded its largest 48-hour rainfall ever, at 526mm.

Waimakariri District

Flooding in the Waimakariri scheme was moderate with a peak flow in the Waimakariri River of about 2500 cumecs, which is about half of the design capacity of the stopbank system. That is because the upper catchment of the Waimakariri, within the Southern Alps, was largely unaffected by this rainfall.

Both the Eyre and the Cust Rivers were flowing at 'bank-full' levels through this event and at risk parts of this community were advised to evacuate. A significant amount of bank erosion has been observed and will require repair.

The Ashley River reached a peak level that was within 1m of the top of the stopbanks above Rangiora. This peak flow coincided with the flow gauges in the upper catchment not functioning due to extreme water levels and a conservative decision was made to evacuate an at risk part of the community. Fortunately no stopbanks in the Ashley scheme were breached but there has been damage to berm vegetation and groynes within the scheme.

Selwyn District

The Selwyn River and tributaries rose to high flood levels through this event. Significant out of river flows were experienced. One major stopbank breach occurred near the downstream end of the flood protection scheme.

Notably, considerable damage occurred both with the river channel and on adjacent properties in the upper part of the catchment which is not part of ECan's rating district. This damage is therefore ineligible for NEMA co-funding.

Ashburton District

It is within the Ashburton District that the flood damage is concentrated. River flows significantly exceeded design capacities in a number of reaches of the rivers in the catchment as shown in Figure 2-1 below. Estimated peak flows are shown in green and the design capacities of different reaches are shown in red and blue. At State Highway 1, this was the biggest flood on record for the Ashburton River.

The damage to ECan assets within the Ashburton catchment is widespread and large scale. Stopbanks have been breached, many kilometres of erosion control vegetation has been completely destroyed.

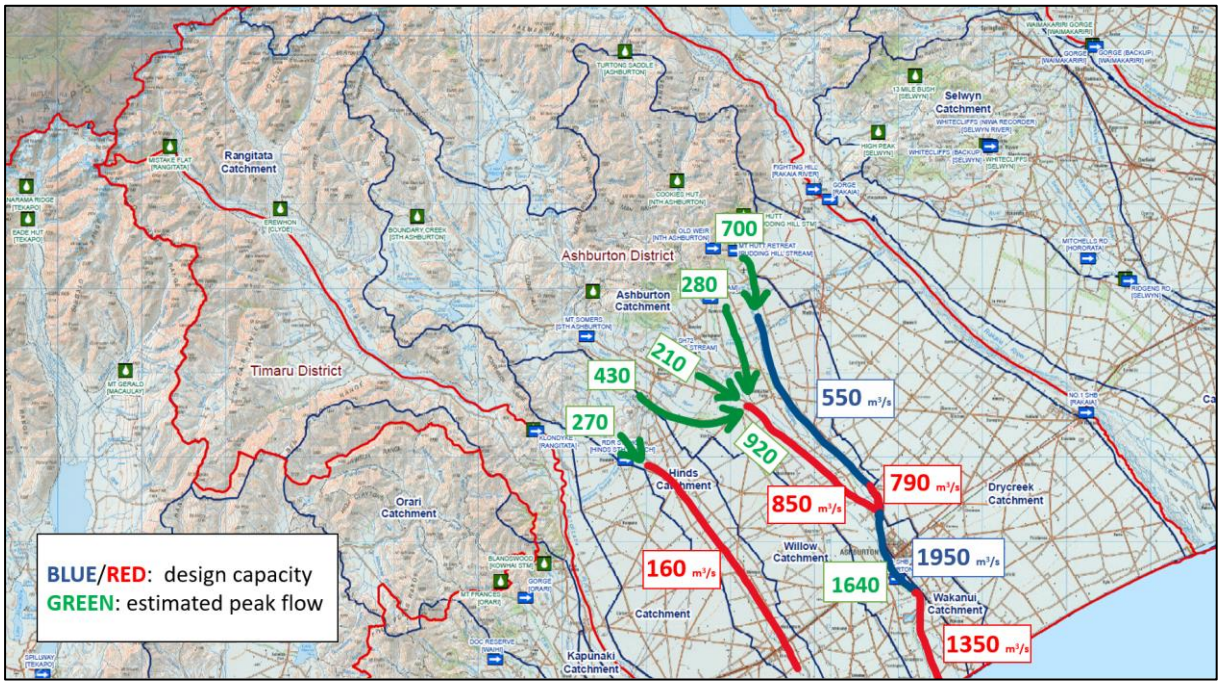

Figure 2-1: Preliminary peak river flow data for the Ashburton area.

Timaru and Mackenzie Districts

These two districts have been combined for this summary as the catchments of these rivers span both districts.

For the Orari River, this was the second highest flood on record. Damage to ECan assets includes several stopbank breaches and extensive erosion control vegetation loss.

Damage within the Opihi / Opuha catchment is also severe but was significantly reduced due to the fortunate situation of Lake Opuha being at very low levels prior to the rainfall starting.

Estimated peak flows are shown in green and the design capacities of different reaches are shown in red and blue on Figure 2-2 below.

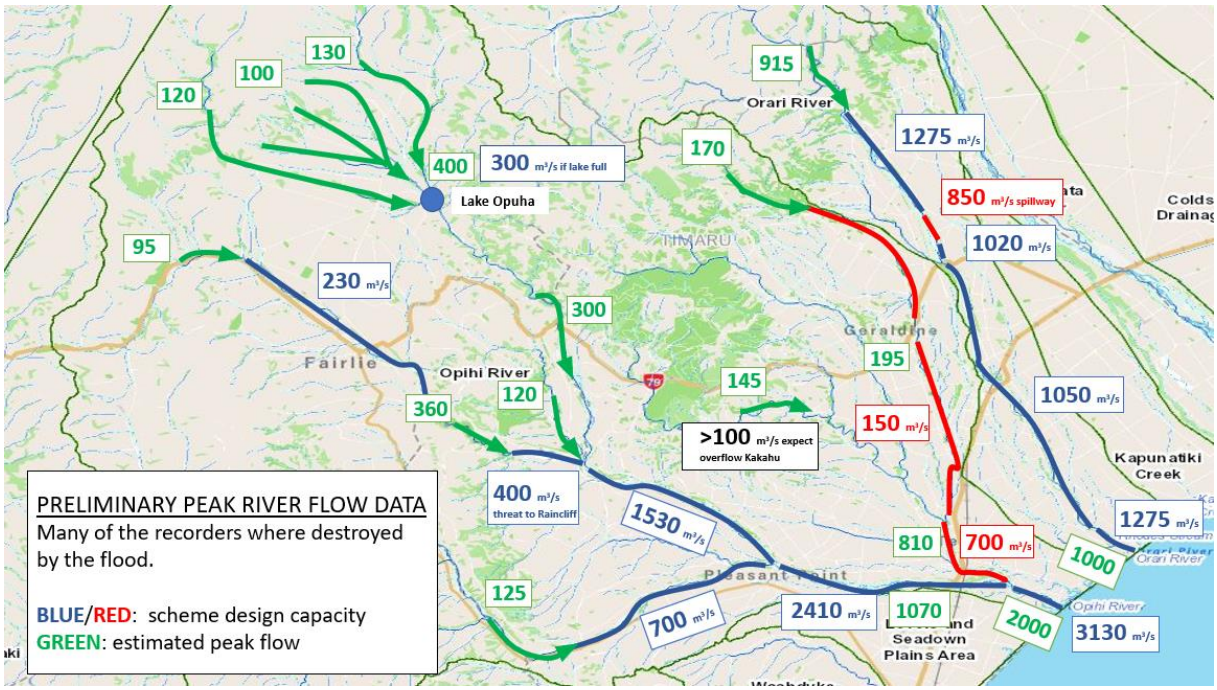

Figure 2-2: Preliminary peak river flow data for the Timaru and Mackenzie area.

3 Temporary Repairs (Response)

The focus since the beginning of June has been on undertaking temporary repairs to maintain the rivers either within or close to their original channels to prevent further damage to property and to minimise ongoing risk to the community.

Temporary repairs have included:

- Temporary erosion control and overflow reduction though temporary bunding,
- River fairway, channel and bridge clearing to re-establish flow paths,
- Urgent erosion repairs,
- Re-establishing anchored tree protection in areas where tree edge protection has blown out, and
- Providing temporary rock protection in places where urgent river edge protection is required.

An example of temporary repairs is provided in Appendix 3.

Response work including undertaking temporary repairs is ongoing. The importance of continuing temporary repairs was emphasised by the recent rains of 17 July. Although repairs breached in several locations of previous breakthrough, most of the temporary repairs held up and prevented more wide-spread flooding and further damage to ECan assets. It is noted that this was a relatively low volume rainfall event with the peak flow in the Ashburton River at SH1 only reaching 430 cumecs.

Looking ahead, it is expected that further temporary work will be required. This will be in response to braid formations eroding existing temporary structures, and for new temporary works that are required for the implementation of permanent works.

Expenditure to the end of July 2021 on flood response is included in the Financials section.

4 Damage Assessment and Prioritisation of Permanent Repairs (Recovery)

ECan staff, contractors and staff from other councils were mobilised immediately following the flood to identify all the locations of flood damage throughout the region. 473 damage sites had been identified by the end of June and recorded within ECan's asset management database which included details of the type and severity of damage, together with location and other relevant information. These are displayed on Figure 4-1 below. Aerial images from helicopter overflights, taken soon after the floods, were also loaded to the same data base, providing before and after flood aerial imagery. Drones have been utilised on a site specific basis once the overall scoping of damage by helicopter was complete.

ECan's flood protection assets (stopbanks, tree edge protection, groynes, rock protection, culverts etc) are all available within the ECan asset management and GIS system. This has facilitated the checking of each identified site against the asset register.

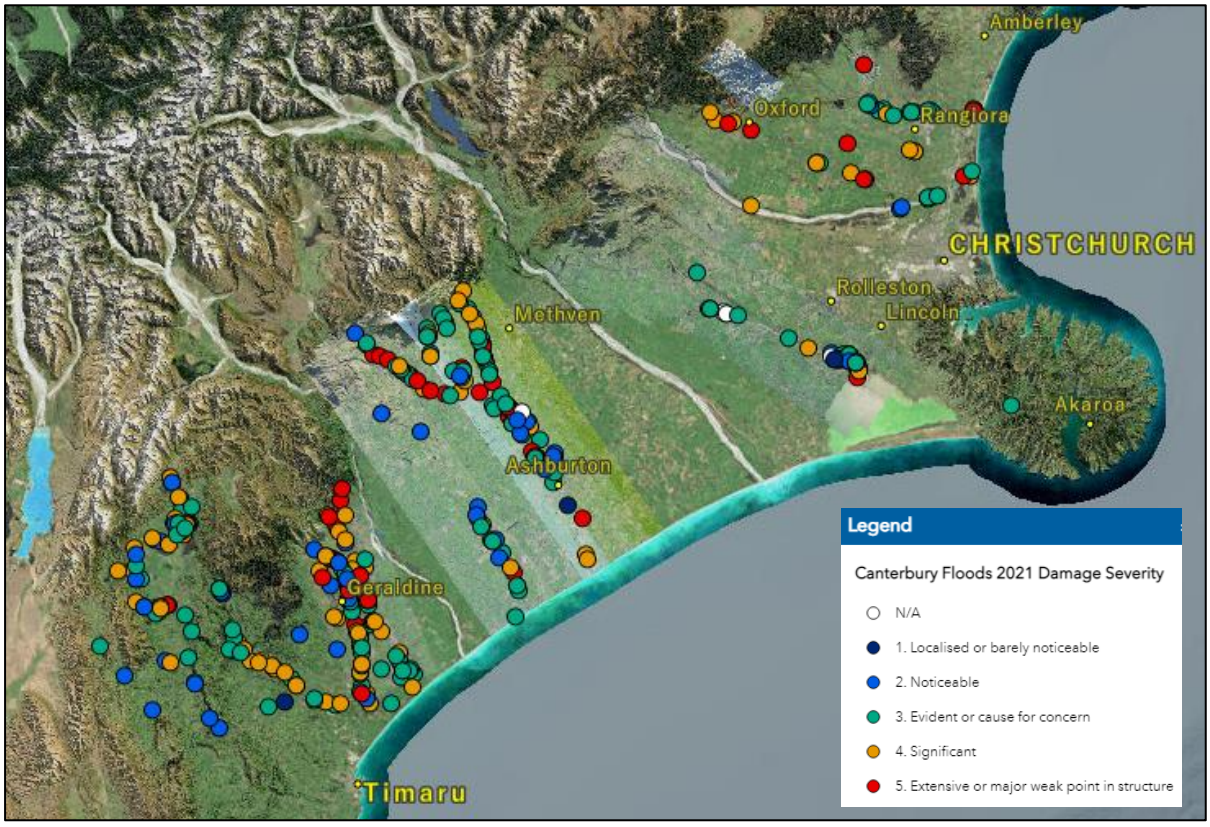

Figure 4-1: Mapped Environment Canterbury Asset Damage Sites

Damage assessment

At each site, damage has been assessed as whether it is to an ECan asset and the cost for permanent like for like repair and replacement estimated. Where betterment or partial betterment is required this has been noted.

A risk-based approach was used to prioritise flood damage repair using following the matrix below. This risk-based approach has been applied to both temporary (response) and permanent (recovery) works.

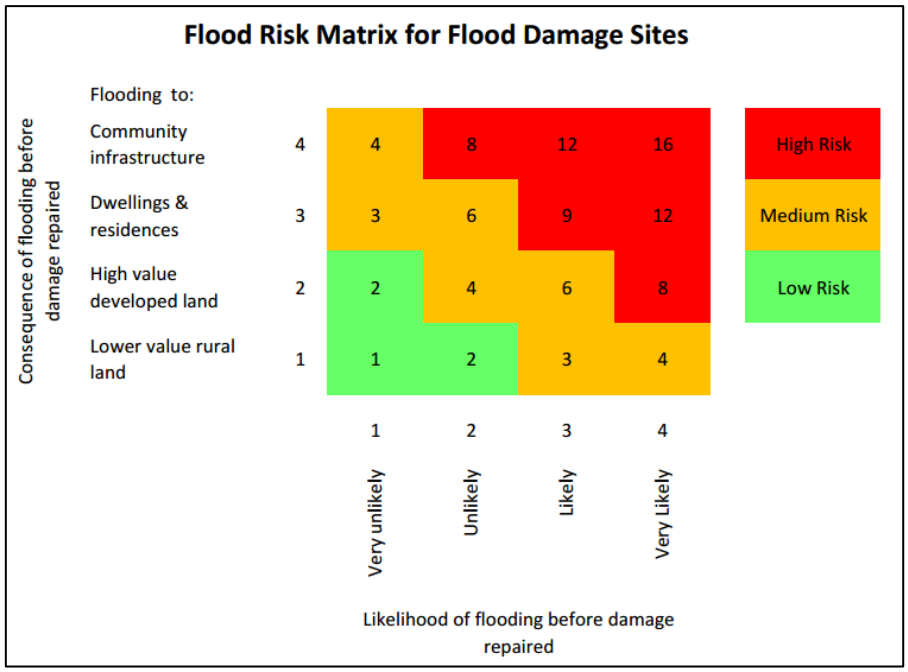

Figure 4-2: Flood Damage Risk Assessment Matrix

Of all the flood damage sites identified, 281 sites have been assessed as requiring permanent repairs. For replacement of river edge tree protection, tree loss has been grouped into a single repair for several sites along reaches of rivers. Of the sites requiring permanent repair, 23% were deemed high risk 51% medium risk and 26% low risk. Repairs will be prioritised accordingly.

Response work is still required or already underway at 68 locations in addition to the sites identified for permanent repairs. Permanent repairs have been completed at 22 sites already.

Repairs have been summarised according to the type of work in Table 4-1 below. Replacement of tree edge protection is by far the biggest component of permanent flood damage repair, required at 148 sites or groups of sites over 42km across the region. Stopbank replacement or repair is required at 46 locations requiring 5km of stopbank reinstatement. Cost estimates for permanent repairs are included in the financials section.

Table 4-1: Flood Damage Summary by Type

Type of Work	Number of sites	Length of repair
Tree Replacement	148	42 km
Stopbank repair	46	5 km
Erosion repair	52	475 m
Fairway clearing	15	
Rock Protection	9	200 m
Groyne repair	7	
Culvert Repair	4	
Total	**281**	

5 Financials

Flood Response

Flood response costs to the end of July 2021 are $2.9 million as summarised in Table 5-1 below. Costs are subdivided into the affected flood rating districts. Of these costs, ECan has assessed that approximately $750,000 are non-NEMA eligible costs (subject to NEMA confirmation).

Flood monitoring costs include external goods and services such as post flood surveys and inspection flights, and external contractor on ground services not specified into a particular rating district. The non-eligible monitoring costs include ECan staff costs, staff travel, vehicle use and administrative charges.

Flood repairs costs for each of the affected rating districts relate to costs for contractors to undertake temporary repair works (to be confirmed by NEMA).

Table 5-1: Canterbury 2021 Flood Response Costs at 31 July 2021

Description	Total Costs To Date	Est. Non-Eligible Costs	Est. Eligible Costs
Flood monitoring costs	286,513	187,453	99,060
Selwyn 2021 Flood Repair	6,952	6,652	300
Ashburton 2021 Flood Repair	1,730,850	99,795	1,631,055
OWT 2021 Flood Repair	217,827	54,897	162,930
Opihi 2021 Flood Repair	9,279	5,154	4,125
Ashley 2021 Flood Repair	62,942	8,843	54,100
WEC 2021 Flood Repair	83,593	17,016	66,577
Upper Hinds 2021 Flood Repair	2,156	2,156	-
Lower Hinds 2021 Flood Repair	6,929	1,409	5,520
Little River 2021 Flood Repair	4,487	1,753	2,734
	2,411,528	385,127	2,026,401
CD Emergencies - Weather Event May 21	341,932	294,180	47,752
Flood Recovery Advisory Group	1,468	1,468	-
Other Cost Codes	178,374	68,433	109,941
	2,933,302	749,208	2,184,094

Flood Recovery

An estimate of the NEMA eligible Flood Recovery repair costs is included in Table 5-2 below. This has been summarised by rating districts for compatibility with the flood response costs to date.

Replacement of tree edge protection is estimated to be by far the most expensive flood damage repair at approximately $6.7 Million. Tree edge protection is included in the ECan asset register as it forms a major part of the ECan flood protection and erosion control defences.

In addition to the estimate of costs per rating district for physical works repairs, ECan will require consultant assistance with Flood Recovery project management, assessment of repair solutions, detailed design, engineer to contract and project oversight for many of the repairs. Rather than attribute this to individual rating districts, this is estimated as 10% of the estimated flood damage repair costs.

Table 5-2: Canterbury 2021 Flood - Estimated NEMA Eligible Flood Recovery Costs

Rating District	Type of Flood Damage Repair								Estimated Eligible Cost ($)
	Response	Tree Replace-ment	Stopbank Repair	Rock Protection	Erosion Repair	Culvert Repair	Groyne Repair	Fairway clearing	
Selwyn		157,000	75,000		50,000			0	282,000
Ashburton Rivers	18,000	3,475,000	910,000				170,000	0	4,573,000
Orari-Waihi-Temuka	24,000	1,972,700	3,527,900		454,500		15,000	10,000	6,004,100
Opihi	150,000	206,000	30,000		10,000			13,000	409,000
Ashley River		55,000	25,000		82,000		107,500	0	269,500
Waimakariri-Eyre-Cust		87,000		216,000	113,000	20,000		5,000	441,000
Waimakariri Flood Protection Project		35,000	10,000	225,000					270,000
Ashburton Hinds Drainage					1,000	10,000			11,000
Upper Hinds River		391,000					10,000	1,000	402,000
Lower Hinds River	20,000	358,000	95,000						473,000
Saltwater Creek SA						15,000			15,000
Estimated Eligible Repair Cost ($)	**212,000**	**6,736,700**	**4,672,900**	**441,000**	**710,500**	**45,000**	**302,500**	**29,000**	**13,149,600**
Consultant Assistance (10%) **Includes Flood Recovery project management, assessment of repair solutions, design and engineer to contract oversight**									**1,314,960**
Total Estimated NEMA Eligible Flood Recovery Costs									**14,464,560**

An estimate of non-NEMA eligible costs for flood recovery is provided in Table 5-3 below for completeness of cost estimation for Council. These costs include internal ECan staff costs and possible land acquisition to make room for the river. Betterment costs have not yet been determined, however would also be included as non-NEMA eligible costs.

Table 5-3: Canterbury 2021 Flood Estimated Non-Eligible Recovery Costs

Non-Eligible Recovery Costs	Estimated Cost ($)
Staff - Design Costs (5%)	657,480
Staff - Supervision (5%)	657,480
Subtotal of ECan non-eligible costs	**1,314,960**

Land Acquisition - indicative estimate	**1,000,000**

The total cost estimate including response costs to date and future eligible and non-eligible costs are presented in Table 5-4 below.

Table 5-4: Canterbury 2021 Flood – Overall Recovery Costs

2021 Flood Recovery Cost Estimates	Cost ($)
Response Costs to Date (includes approx. $750k not eligible)	2,933,302
NEMA Eligible Flood Recovery Costs	14,464,560
ECan non-Eligible Flood Recovery Costs	1,314,960
Land Acquisition - indicative estimate	1,000,000
Overall Flood Recovery Cost Estimate	**19,712,822**

NEMA Eligible Costs

Government policy[1] is to reimburse 60 percent of the combined eligible costs (response and essential infrastructure costs above 0.002 percent of the net capital value in the case of regional councils. For environment Canterbury the threshold has been determined to be $4,113,817 as follows:

Table 5-3: Environment Canterbury threshold for response and recovery claim to government

Rateable value of Environment Canterbury infrastructure assets (1 June 2021)	$205,690,827,124
Threshold Rate	0.002%
Threshold Value (Rateable Value * Threshold Rate)	$4,113,817

Based on the initial estimate of flood response and recovery costs the initial estimate of a likely overall claim to NEMA for flood recovery is approximately $7.5 Million (see Table 5-4). The overall cost to Environment Canterbury is estimated to be approximately $11.6 Million. It is stressed that these are initial cost estimates which will be updated and modified through the flood recovery project based on actual costs and NEMA agreement on eligible costs.

Table 5-5: Initial Estimate of ECan & NEMA funding model

Estimated Costs	**Million $**
Response Costs to date	$ 2.9
Estimated Eligible Flood Recovery Costs	$14.5
Estimated Non Eligible Future Costs	$ 2.3
Total Flood Response & Recovery Estimate	**$19.7**
Estimated non-Eligible Recovery Costs	-$ 3.1
ECan Threshold for NEMA claim	-$ 4.1
Eligible for 60% government subsidy (NEMA)	**$12.5**
Estimated Funding Mix	**Million $**
ECan initial threshold	$4.1
ECan – Non Eligible Costs	$3.1
ECan – 40% of Eligible Costs	$5.0
NEMA – 60% of Eligible Costs	$7.5
Total	**$19.7**
Total ECan Estimated Cost	**$12.2**

6 Risks

Due to the extent of flood damage and the number of break-outs and breaks through flood protection infrastructure, the risk of further inundation remains high until permanent repairs can be implemented.

The following table provides a summary of residual risk and ongoing risks to the flood recovery programme together with mitigation actions to reduce the likelihood of the risks becoming issues.

[1] Section 33 of the Guide to the National CDEM Plan, 2015.

Table 6-1: Residual and Flood Recovery Project Risks

Risk	Description	Mitigation Action
Further Floods	Severe weather may cause further flooding before or during flood damage repairs. This could increase the flood damage.	Undertake temporary repairs as soon as possible. Communicate elevated residual risk to the community, especially in areas where river break-out has occurred.
Spring thaw	High spring flows in the rivers when snowmelt occurs could pose further flood risk.	Assess most likely locations of high flows following spring thaws. Undertake priority temporary repairs in these areas.
Funding	Security of funding	Ongoing communication with ECan Councillors is needed to keep them aware of funding needs from Council Reserves and potential risks. Work closely with NEMA to maximize NEMA contributions and flood recovery. Closely monitor contractor and materials cost. Follow council procurement processes. Public tender for large works.
Material availability	The availability of material, particularly to undertake tree replacement. Both heavy and light anchored bank protection requires significant lengths of cable and anchors (typically concrete blocks).	Councils around the country have been made aware of ECan's need for cable. Alternative sources are being investigated. Contingencies may need to be considered, including the use of higher cost rock protection where material availability limits the reinstatement of anchored tree protection.
Tree growth time	The time for re-establishment of tree edge protection poses a risk until trees can be established.	In critical areas of high risk, alternatives, particularly rock protection, may need to be considered to mitigate risk. As far as is practicable, live trees are being salvaged from the river fairways and being utilised in repair works. Many of these large trees will resprout and form the future erosion protection.
Staff Resource	Staff resources are limited to undertake oversight and coordination of significant flood damage repairs.	Consider additional contract resource for flood damage assessment, prioritisation and works and on-site works supervision that cannot be delivered in-house.
Programme length	Property owners want works associated with their property undertaken first.	Prioritise flood damage repairs based on risk, and develop and implement a communications plan. Communicate directly with property owners, and with the community as a whole keeping them informed of works priorities.
Ground conditions	River levels from time to time will restrict access and be generally unsuitable to undertake large scale works.	Monitor river levels and plan works for drier months if possible. Communicate this risk to directly affected landowners.

7 Communications and Community Engagement

The Environment Canterbury Flood Recovery web page is the primary means of communicating information regarding the flood and flood recovery efforts. It is located at:

https://www.ecan.govt.nz/your-region/your-environment/river-and-drain-management/canterbury-flood-recovery/

This web site includes information on what happened in the flood itself, flood recovery updates, recent temporary repairs, answers to frequently asked questions and links to information to specifically help the rural community.

Significant one-on-one communication has been undertaken with affected landowners. This has provided an opportunity to listen to their concerns, communicate ECan's priorities, and has been needed in order to implement temporary works.

A number of Community engagement meetings have been held including several site visits to view damaged areas. These include:

- Selwyn and Waimakariri field trips
- Community meetings: Ashburton, South Canterbury, Okuku

A flood recovery hui was also recently held on 6 August, at which Mayors, Territorial Authority Recovery managers, Rural Leaders, Local Iwi and others gathered to receive an update and discuss regional recovery. This meeting was coordinated by ECan and facilitated by an external facilitator.

8 Betterment Opportunities

The future state of Canterbury's braided rivers may well look different to the pre-flood state, particularly when referencing overall river width, indigenous biodiversity, mahinga kai, recreation and other values. It is no secret that many reaches of these rivers have been squeezed over the last 50 years. In many cases it will not be acceptable to simply build back 'like for like'. This is particularly so when the effects felt in this event

The reality is that there is a balance to be found between (for example):

- Providing an acceptable level of flood protection and erosion control, incorporating climate change.
- Both the tangible and intangible benefits of a strong river ecosystem, ki uta ki tai. Incorporating te mana a te wai.
- Allowing the river more room to be a river.
- The cost or affordability to ratepayers of capital works for new infrastructure, maintenance, land acquisition.
- Existing land use and ownership expectations – allowing these to continue or providing a fair and reasonable transition pathway for change.

The engineering challenges here are actually quite solvable. Our biggest challenge is matching community expectations in the broadest sense with affordability, short and long term. This becomes an exercise of public communication. Currently, there is no long term (say 100yr) vision for what these rivers could or should look like. Prior to these floods, Environment Canterbury had a project budgeted in the Long Term Plan to develop a 'Braided River Strategy'. This is now more important than ever.

There are some obvious locations however that will be investigated thoroughly as part of this flood recovery effort, regardless of a long term vision being in place. For example:

- The North Ashburton narrows from around 300m between stopbanks at Thompsons Track to 100m between stopbanks at Shearers Road.
- The width of the Orari River narrows from around 650m between stopbanks and a clear fairway of 200m near Geraldine to around 250m and 100m respectively near the coast.

In addition to these betterment opportunities, there may be some inadvertent betterment. This includes the need to replace the function of an asset with a different asset that performs the same function. For example there may be certain locations where it is necessary to replace tree river edge protection with rock protection because of the level of risk, and the time limitations to establish replacement tree edge protection. These opportunities will require discussion with NEMA as to the government co-funding eligibility.

Appendix 1: Estimated Recovery Costs for Physical Works by River

Sum of Cost Est LocationCode	Type of Wo Response	Tree Replacement	Stopbank repair	Culvert Repair	Erosion repair	Rock Protection	Groyne repair	Fairway clearing	Grand Total
Ashburton Main Stem		182,000					170,000		352,000
Ashburton North Branch	18,000	1,164,000	590,000						1,772,000
Ashburton River North Branch (S)		66,000							66,000
Ashburton South Branch		1,182,000	320,000					0	1,502,000
Ashburton-Hinds Drainage				10,000	1,000				11,000
Ashley River		55,000	25,000		82,000		107,500	0	269,500
Bowyers Stream		222,600							222,600
Clandeboye Drains					2,000		5,000		7,000
Cust				20,000	60,000			5,000	85,000
Eyre		87,000			53,000	191,000			331,000
Hinds main stem			20,000				10,000		30,000
Lower Hinds River	20,000	358,000	75,000						453,000
Lower Opihi		187,000	30,000						217,000
Opihi Tributaries	0				10,000			10,000	20,000
Opuha Tributaries	150,000	5,000							155,000
Orari River	0	1,153,500	2,444,900		0				3,598,400
Orari Tributaries			0		150,000			10,000	160,000
Pudding Hill Stream		136,000							136,000
Selwyn		157,000	75,000		50,000			0	282,000
South Branch Upper Hinds River		98,200						1,000	99,200
Taylors Stream		522,400							522,400
Temuka River	0	52,000	0						52,000
Tengawai River		14,000						2,000	16,000
Upper Opihi								1,000	1,000
Waihi River	24,000	767,200	1,083,000		272,500		10,000		2,156,700
Waihi Tributaries					30,000				30,000
Waimakariri Flood Protection Project		35,000	5,000			10,000			50,000
Waimakariri River			5,000	0		215,000			220,000
WEC other						25,000			25,000
Saltwater Creek SA				15,000					15,000
North Branch Upper Hinds River		292,800							292,800
Grand Total	**212,000**	**6,736,700**	**4,672,900**	**45,000**	**710,500**	**441,000**	**302,500**	**29,000**	**13,149,600**

Appendix 2: Types of Flood Damage and Temporary Repairs

River edge protection – tree loss.

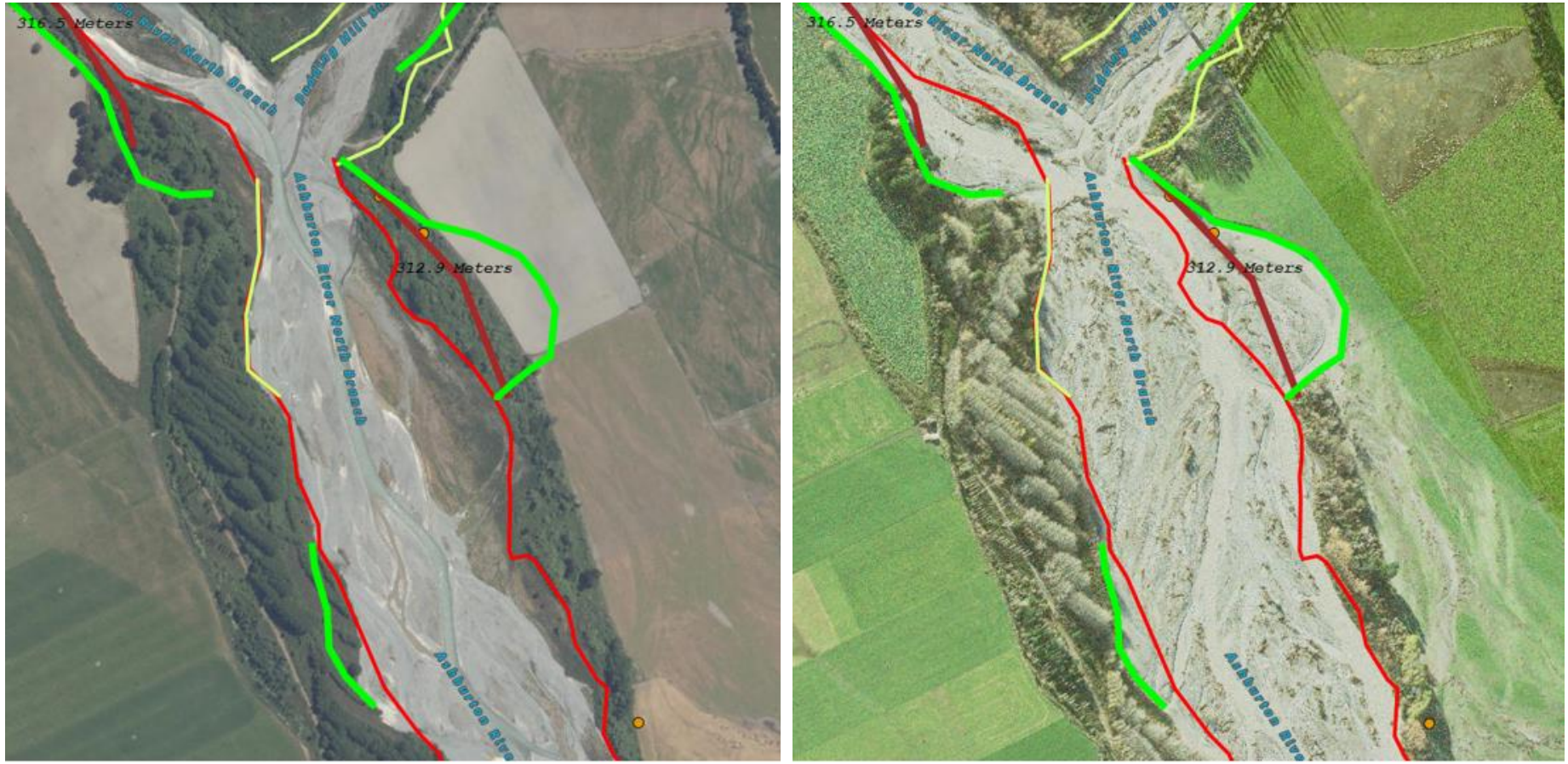

Figure A2-1: Ashburton River North Branch downstream of Pudding Hill Stream confluence. Tree loss and river blow-out on true left bank. Aerial image before flood (left) and after flood (right)

Figure A2-2: Aerial view of Ashburton River North Branch downstream of Pudding Hill Stream after flood. Note loss of tree edge protection on true left bank and some temporary bunding

Stopbank Loss (Orari River example)

Figure A2-3:Upper Orari River. Stopbank Asset before flood (above) and loss of stopbank asset after flood (below).

Stopbank Loss (Orari River example)

Figure A2-4:Upper Orari River. Stopbank breakthrough during flood (above) and estimate of river edge protection and stopbank asset loss (below).

Temporary Repair Bunding (Ashburton River at River Road example).

Figure A2-5: Temporary repair at River Road, Ashburton River on 9 June 2021 (above) and 27 July 2021 (below).