**West Coast Lifelines**

**Vulnerability and Interdependency Assessment**

# Supplement 9:

# Regional Flood Control Assets

**West Coast Civil Defence Emergency Management Group**

**August 2017**

**IMPORTANT NOTES**

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Hazard Maps

The hazard maps contained in this report are regional in scope and detail, and should not be considered as a substitute for site-specific investigations and/or geotechnical engineering assessments for any project. Qualified and experienced practitioners should assess the site-specific hazard potential, including the potential for damage, at a more detailed scale.

Cover Photo: Greymouth Floodwall, Grey River, Greymouth

# West Coast Lifelines
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# Regional Flood Control Assets

## 1 INTRODUCTION

### 1.1 West Coast Regional Council Assets

West Coast Regional Council (WCRC) water control assets include drainage assets, river control assets and coastal protection assets. A list of WCRC managed water control assets is presented in Table 1.1.

**Table 1.1: WCRC - Water Control Assets**

| Rating District | Location and Asset Type | | | |
|---|---|---|---|---|
| Karamea/Kongahu | Oparara River Control (Karamea rating district) | Karamea River Control (Karamea rating district) | Little Wanganui River Control (Karamea rating district) | Kongahu Drainage (Kongahu rating district) |
| Punakaiki | Punakaiki - Coastal Protection | | | |
| Nelson Creek | Nelson Creek - River Control | | | |
| Red Jacks Creek | Red Jacks Creek - River Control | | | |
| Coal Creek | Coal Creek - River Control | | | |
| Greymouth | Greymouth - River Control | | | |
| Taramakau | Taramakau Settlement - River Control | | | |
| Inchbonnie | Inchbonnie - River Control | | | |
| Southside Hokitika | Southside Hokitika - River Control | | | |
| Kaniere | Kaniere – River Control | | | |
| Raft Creek | Raft Creek – Drainage | | Whites Creek – Drainage | |
| Kowhitirangi | Kowhitirangi – River Control | | | |
| Vine Creek | Vine Creek – River Control | | | |
| Wanganui | Harihari flats – River Control | | Harihari and La Fontaine – Drainage | |
| Matanui | Matanui Creek – River Control | | | |
| Waitangitaona | Whataroa – River Control | | | |
| Lower Waiho | Franz Josef – River Control | | | |
| Canavans Knob | Franz Josef – River Control | | | |
| Okuru | Okuru – River Control and Coastal Projection | | | |

The WCRC water control assets are discussed in the following sections. Details provided include:

- A short description of each asset;
- Likely damage sustained in the event of a major natural disaster
- Likely recovery of the asset after an earthquake.

## 1.2 Water Control Assets Managed by Others

There are a number of other water control assets in the West Coast Region that are not operated by the WCRC, such as the Westland District Council stopbank at Hokitika and New Zealand Transport Agency (NZTA) assets which help protect farmland as well as the roads. These are considered in this report where we have information and they are relevant, but are not covered comprehensively.

## 1.3 Definitions

Structures that make up water control assets are defined as follows:

- ***Stopbanks*** – An embankment built to prevent the flooding of low lying land and damage from large ocean waves;
- ***Groynes***– A rock wall structure built out from a river bank or seashore to check erosion; and
- ***Rock work*** – Large stone (riprap) used to protect the bed or banks of a river from erosion.

# 2 VULNERABILITIES

## 2.1 Introduction

There are some observations that can be made in a general way on the West Coast flood control schemes. Many of them consist of simple earth fill banks along one or both banks of the rivers where the flood waters are being controlled. In some instances the flood banks are continuous; in others they are discontinuous according to the local topography. The bulk of the schemes protect farmland, some roads and some houses, but generally only a low population. Even the stopbanks in the Karamea area protect an area with a population of only 400 or so. Some others have much greater consequence if they are overtopped or fail, such as the Greymouth floodwall, the south bank of the Waiho River where SH 6 is several metres below the river level and failure would result in considerable damage to the road, or the stopbank by the Taramakau River at Inchbonnie where the river has a potential to avulse northwards into the Lake Brunner and the Grey River catchment.

Most of the stopbanks were designed and built several decades or more ago. The basis of design is not known, but those built within at least the last fifty years are likely to have had professional engineering design input following best New Zealand practice of the time[1]. Most will be constructed from a mixture of gravel and soil, but the comprehensiveness of geotechnical investigations and construction control is unknown. The integrity of the banks under loading from large floods may be questionable in some places, with possible potential for piping below the banks or batter instability on drawdown, although no stopbank failures are known of and the predominantly gravel fill and foundation subgrade

[1] Personal communication, R. Daniel, May 2017

make them relatively robust[2]. It is understood that backwater analyses would have been carried out to determine stopbank design heights. Most banks have probably been designed with freeboard at a 50-year return period flood and to contain a 100-year return period flood without overtopping[3]. Confidence in design flood flows is highly variable. The Buller and Grey Rivers have long periods of record and gauging sites close to the main towns, but the Hokitika River has a short record covering less than 60% of the catchment. Other catchments will have flood flows derived from flood estimation methods without in site-specific records. Changes in bed level over time and during floods add to the difficulty in estimating appropriate design flood levels. Climate change may also affect the return period of the design flood and hence the probability of overtopping.

Flood modelling has been carried out for the Karamea floodplain, Westport and Greymouth, and this also gives an idea of typical standards of flood protection. The Karamea stopbanks are predicted to overtop in a 50 year return period flood. Westport, despite being adjacent to the Buller River with the largest flood flow of any river in New Zealand has very limited flood protection structures. Much of the town is flooded to some degree with a 50-year flood. We have assumed that most flood protection schemes will be overtopped at floods of about a 100-year return period, although some may contain larger floods. The vulnerability-probing storm scenario used in this report is a roughly 500-year storm.

## 2.2 Earthquake

Strong earthquake shaking is expected to cause some damage to stopbanks, such as:

- Possible batter instability potential for slumping of the crest level, depending on the quality of the fill materials as well as construction, batter slopes and foundation conditions. Steeper and higher batters are more likely to be at risk. Many stopbanks of gravel fill and typical 2 to 1 batters should withstand even strong seismic shaking with limited damage.
- Dislodging of riprap; steeper and higher batters are more at risk
- Foundation movement with spreading of the earth fill, longitudinal cracking and slumping of the crest if there is liquefaction in the soils below the bank. Liquefaction is most likely in the coastal areas only, and even then is not universal as it requires loose saturated sand deposits to occur and the coastal soils are still gravel-dominated in most places.
- Rupture of the bank with horizontal and vertical offset if over a fault line which ruptures. Potential rupture is limited to the Taramakau stopbank at Inchbonnie and the stopbank on the Waiho River at Franz Josef, which both cross the Alpine Fault.

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[2] For example, the stopbank on the south bank of the Waiho River has been observed to have river water flowing from the batter along SH 6 with the river in flood 5m above, but without failure.

[3] Personal communication, R. Daniel, May 2017.

As well as direct damage, earthquakes can present longer term issues:

- Many landslides will occur in a large earthquake and some of these will collapse into river channels to form landslide dams. Although some remain long term, impounding lakes, many will breach at some time ranging between a few hours to many years after the earthquake. A landslide dam breach can result in a large "flash" flood, which can on occasions be larger than even a long return period flood from rainfall alone. The flood peaks will attenuate with distance downstream of the dam break, but in some instances could overtop flood protection banks.
- The landslides expected with a large earthquake generate large quantities of material which over time will enter the river system. Aggradation of the rivers is expected after a large earthquake, but again there will be a time delay, usually of some years, before the sediment load peaks and aggradation occurs in the lower reaches of the river. Aggradation, by raising the river bed, reduces the effective height of the flood structures and thus reduces the flood capacity of the schemes (a similar impact can occur on bridges).

Drainage systems may be impacted by slumping of steep banks or lateral spreading if over liquefiable ground, which may reduce the channel capacity. Aggradation of rivers clearly impacts on water levels within the channels and the ability for the system to drain as before, as well as possibly silting up the channels.

## 2.3 Extreme Storm

As discussed above, the river protection systems have a limited flood capacity before being overtopped. An extreme storm with high rainfall is expected to result in floods that exceed the capacity of the structures and stopbanks and result in overtopping, in at least some of the affected catchments. Breach of a stopbank can result in very high flow velocities sufficient to move buildings off foundations and scour the ground. There is also a potential for structural or piping failure leading to a breach.

Although the major impact of a bank failure would be on the downstream land and infrastructure that the structure was designed to protect, the structure itself would suffer damage needing repair.

## 2.4 Tsunami

None of the stopbanks on the West Coast provide any protection from tsunami[4] entering directly from the shore or estuaries, but they will contain surges within the river and limit flows sideways onto land from the rivers. In some instances, stopbanks may have an effect of funnelling tsunami flow further up a river than might otherwise occur. The lower extremity of stopbanks within perhaps 0.5km of the shore or estuary is likely to be completely inundated by a 500-year tsunami, and a longer length for larger tsunamis. Even without inundation, some scour and erosion damage of flood protection works must be expected for at least the lower 1 - 2km of the river due to waves and surging scouring the

[4] The sea wall at Punakaiki has been built to limit coastal erosion and will do little in a large tsunami

banks, even with smaller tsunami. Coastal drainage systems can also be expected to be damaged from surges along the channels from the outlet at the rivers, plus being obstructed with debris, sand and gravel. If within the inundation zone, they may be completely filled with material carried in with the tsunami waves.

# 3 WCRC WATER CONTROL ASSETS

The Flood Control assets managed by the West Coast Regional Council are briefly described and vulnerabilities outlined in the following sections, grouped according to each general district, in order from north to south. The locations are shown on Figures 3.1 to 3.7. The tables summarising the different schemes show a column on the right-hand side denoting relative likelihood of the damage vulnerability occurring. H denotes high probability, M is medium, and L is low probability.

## 3.1 Northern WCRC Water Control Assets

There are four WCRC Water Control Assets in the north of the West Coast Region (Figure 3.1):

- Oparara – River Control;
- Karamea – River Control;
- Little Wanganui – River Control; and
- Kongahu – Drainage

***(a) Oparara River***

| | | | |
|---|---|---|---|
| | Structures | Groynes and rockwork on both banks | |
| | Purpose | Flood protection to Oparara Rd and farmland on lower reaches | |
| | Earthquake | Liquefaction, shaking damage | M |
| | Extreme Storm | Overtopping, scour | H |
| | Tsunami | Lower 1.5km likely to be affected by surges, inundated in very large tsunami | M |

***(b) Karamea River***

| | | | |
|---|---|---|---|
| | Structures | Stopbanks, rockwork and groynes on both banks | |
| | Purpose | Flood protection to Karamea township, Umere, Maori Point & associated roads | |
| | Earthquake | Liquefaction, shaking damage (some banks steep sided and narrow) historic liquefaction and aggradation in 1929 | H |
| | Extreme Storm | Overtopping, scour. Flooding from river at Umere occurs at 20-yr flood; overtopping of sections of stopbank at 50-year flood. | H |
| | Tsunami | Lower 1.5km likely to be affected by surges, inundated in very large tsunami | M |

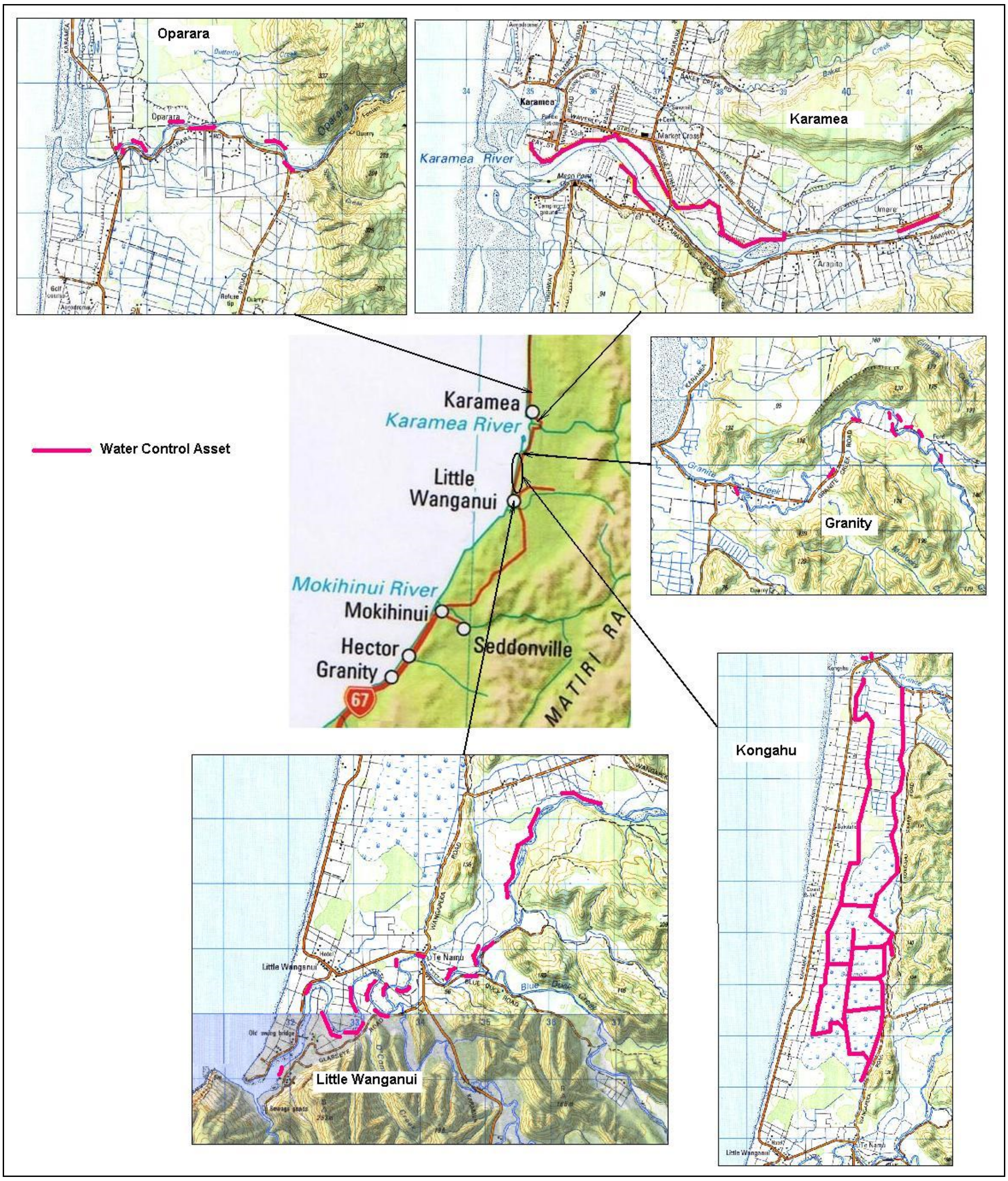


**Figure 3.1: Northern WCRC Water Control Assets**

***(c) Little Wanganui Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Groynes and rockworks on both banks | |
| | Purpose | Flood protection to roads and farmland in the Little Wanganui area as well as homes at the settlements of Te Namu and Little Wanganui | |
| | Earthquake | Liquefaction, shaking damage | M |
| | Extreme Storm | Overtopping, scour | H |
| | Tsunami | Lower 1.5km likely to be affected by surges, inundated in very large tsunami | M |

***(d) Kongahu Swamp Drainage Scheme***

| | | | |
|---|---|---|---|
| | Structures | Series of channels that drain the Kongahu Swamp | |
| | Purpose | Drainage of Kongahu Swamp for farmland | |
| | Earthquake | Liquefaction, bank slumping | M |
| | Extreme Storm | Flooding, possible scour and/or silting | M |
| | Tsunami | 500-year event likely to flood lower 0.5km of channels. Inundation with extreme event | M |

## 3.2 Lower Buller District & Upper Grey District - WCRC Water Control Assets

WCRC water control assets in the Lower Buller District and Upper Grey District are shown in Figure 3.2. There are three water control assets in the lower Buller District and upper Grey District:

- Punakaiki – Coastal Protection;
- Nelson Creek – River Control; and
- Red Jacks – River Control.

***Punakaiki Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbank and rockworks forming a seawall | |
| | Purpose | Protection to roads, homes and tourist accommodation at Punakaiki from sea erosion and sea flooding | |
| | Earthquake | Shaking damage | M |
| | Extreme Storm | Overtopping, scour, wave damage in a major storm. There is an ongoing shore erosion immediately north of the wall, and a large storm can be expected to cause some movement to the rockwork and potentially outflank the end with some loss of length | H |
| | Tsunami | Impacted by small – medium size with possible scour at toe; inundated with 500-yr tsunami. The action of a tsunami is different to storm waves with sustained flows over the wall inland and then draining back out to sea. Some damage must be expected with loss of rock from the face and top edge in particular, potential scour along the base and of the end. | H |

***Nelson Creek and Red Jacks Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbanks, rockworks and groynes | |
| | Purpose | Protection to farmland, roads and railway including bridge abutments of the SH 7 bridge and the rail bridge. | |
| | Earthquake | Shaking damage | M |
| | Extreme Storm | Overtopping, scour, erosion | H |
| | Tsunami | Nil | Nil |

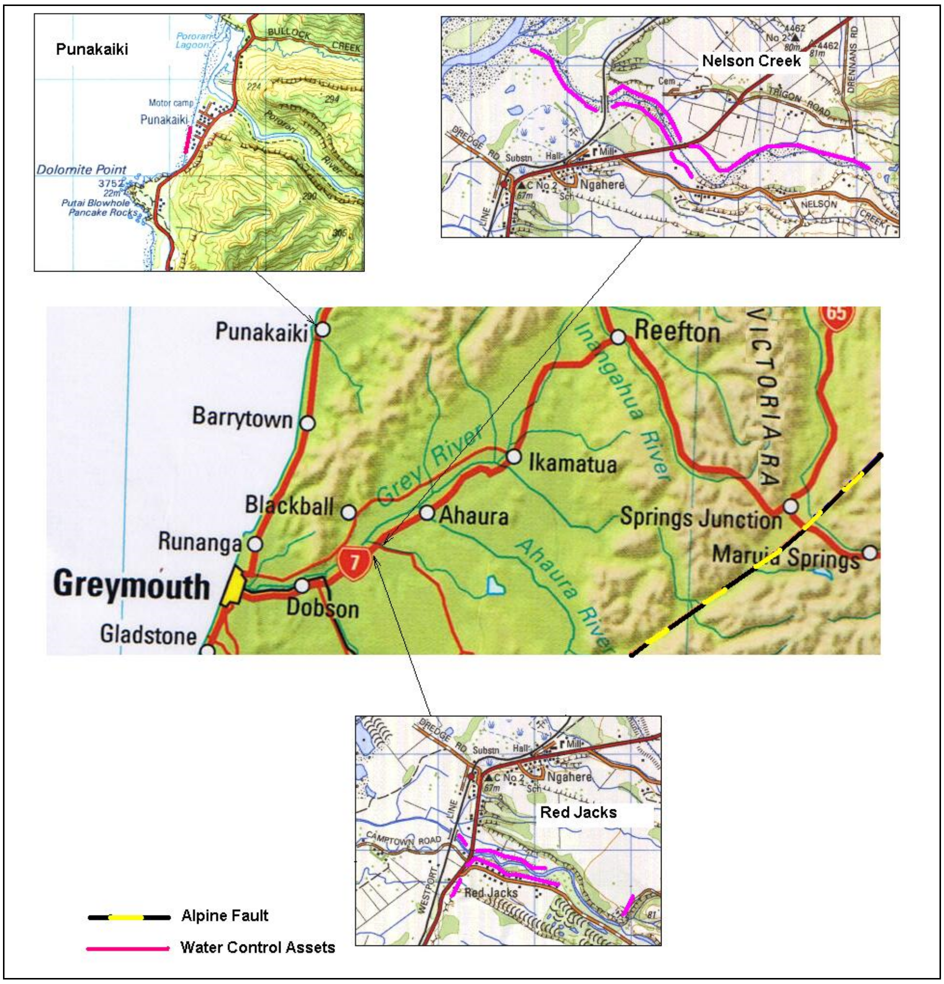


**Figure 3.2: Lower Buller District & Upper Grey District - WCRC Water Control Assets**

## 3.3 Grey River & Taramakau River - WCRC Water Control Assets

### *3.3.1 Description*

There are four WCRC water control assets on the Grey River and Taramakau River as listed here and shown on Figure 3.3:

- Coal Creek – River Control;
- Greymouth – River Control;

- Taramakau – River Control; and
- Inchbonnie – River Control.

Of these, the Greymouth Floodwall and the Inchbonnie stopbank are particularly important and are discussed in greater detail below.

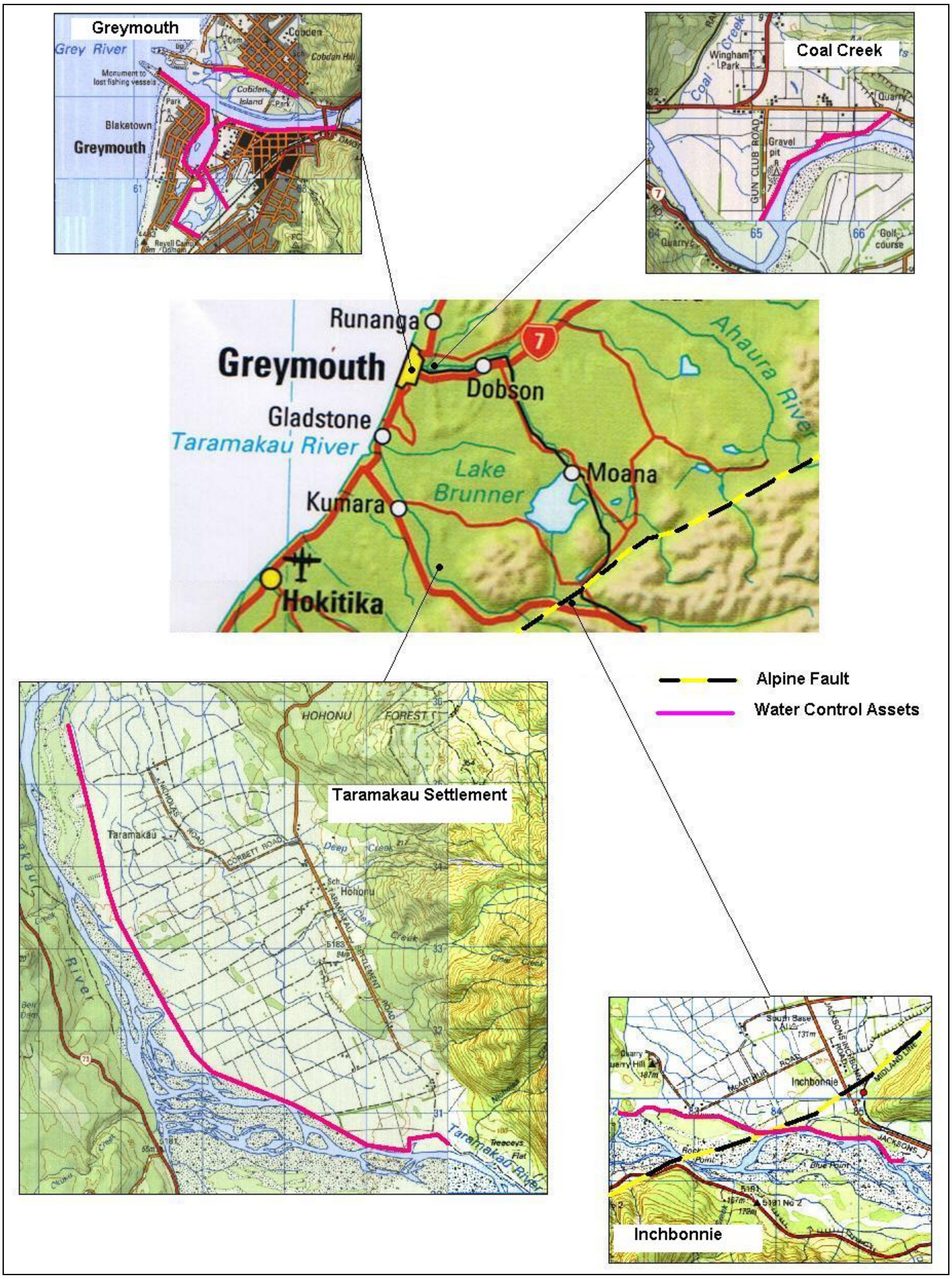


**Figure 3.3: Grey River & Taramakau River - WCRC Water Control Assets**

***Coal Creek Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbank and rockwork on the true right bank of the Grey River | |
| | Purpose | Flood protection to roads (Gun Club Rd, Taylorville Rd and SH 7), Runanga water supply intake and WTP, farmland and homes in the Coal Creek area. | |
| | Earthquake | Liquefaction, shaking damage | M |
| | Extreme Storm | Overtopping, erosion | H |
| | Tsunami | Nil | Nil |

***Greymouth Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbanks, rockwork, on both sides of the Grey River and around the Range Creek lagoon, Erua Moana Lagoon and Lake Karoro; concrete floodwalls and pump station on south side | |
| | Purpose | Flood protection to Greymouth and Cobden | |
| | Earthquake | See below | M |
| | Extreme Storm | See below | H |
| | Tsunami | See below | M |

***Taramakau Settlement Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbank, rockwork and groynes on the true right bank of the Taramakau River | |
| | Purpose | Flood protection to farmland and local roads in the Taramakau Settlement. | |
| | Earthquake | Shaking, aggradation long term | M |
| | Extreme Storm | Overtopping, erosion | H |
| | Tsunami | Nil | Nil |

***Inchbonnie Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbank, rockwork and groynes on the true right bank of the Taramakau River | |
| | Purpose | Flood protection to farmland in the immediate area at Inchbonnie, but more importantly, prevent the Taramakau River from avulsing to alternative river course into to Lake Brunner and the Grey River catchment. Consequence of failure could be very great | |
| | Earthquake | See below – fault rupture, shaking | M |
| | Extreme Storm | See below | H |
| | Tsunami | Nil | Nil |

### *3.3.2 Grey River Flood Protection*

*(a) Earthquake*

The protection works are vulnerable to a large earthquake in a couple of ways. There is historic evidence of liquefaction near portions of both the Greymouth (at the south end of Erua Moana Lagoon in particular) and Coal Creek water control assets. Some lengths of stopbanks and rockwork at both sites are likely to suffer damage from liquefaction and shaking. Where liquefaction does occur, it is likely to produce significant lateral spreading, slumping and settlement of the stopbanks producing longitudinal fissures in the stopbank, reducing the freeboard in places by as much as a metre. Major structures such as the pump stations at Newcastle Street in Cobden, and Johnston Street and Tarry Creek in Greymouth may tilt due to settlement caused by liquefaction, if this were to occur at these locations. The batters of the Greymouth stopbanks are steep and strong shaking could well dislodge rocks from the riprap, or even cause some batter failures. The stopbank at Coal Creek is likely to be similarly affected.

There could be some small aggradation in the Grey River in the years following the earthquake and additional works, such that increased dredging, might be required to maintain the desired level of flood protection.

*(b) Flooding*

The Greymouth floodwall has a design flood capacity of 6,600$m^3$/s (50 year return period), with 0.6m freeboard, although it is understood that some floodwall sections constructed since 2009 are designed for 7400$m^3$/s flow (150-year return period) with 0.6m freeboard. The capacity increases to about 8150$m^3$/s with no freeboard and larger floods will overtop the structures. This is about a 350-year return period flood. Failure of the floodwall could result in much of Greymouth and Cobden being flooded. In addition, because of the height of some sections, overtopping would be likely to result in scour of the inside batter and a breach of the structure, thus effectively creating a dam-break situation. Very high water velocities into a concentrated area would be likely for at least a period of time until tail water levels rose and the breach widened, and it is likely that structures immediately downstream of the breach would be severely damaged if not destroyed. Debris from damaged structures would increase damage levels in other structures further downstream.

*(c) Tsunami*

For medium sized tsunami, the floodwall is an essential protection against tsunami water flowing in from the river mouth and spilling out into the lower lying areas on either side of the river and at a lower level than the beach ridge along the shore. Some damage might occur from scour and erosion from the waves and strong currents within the river. For larger tsunami overtopping the beach ridge, the floodwall would be "attacked' from both sides. The lengths closest to the shore would be expected to be overtopped and extensive damage would be expected from scour and erosion with complete destruction of some sections likely. Further inland, the floodwall crest would remain above tsunami level but the batters would be subject to strong currents and scour. Pump stations would be likely to be damaged with saltwater inundation, blockage of screens and sumps with debris and sediment.

### 3.3.3 Taramakau Stopbank at Inchbonnie

The Inchbonnie assets are among the most important water control assets managed by WCRC because of the widespread effects that would be likely if they failed. Historically the Taramakau River has flowed in three directions from the point at which it crosses the Alpine Fault at Inchbonnie: west down its present course, north directly into Lake Brunner, and northeast through Lake Poerua past Rotomanu and into Lake Brunner at Crooked River. Inchbonnie is effectively the apex of an alluvial fan infilling these three valleys. If the Taramakau should change course it would significantly increase flow to Lake Brunner, the Arnold River and the Grey River. The increased flow would mean a small increase in the water level at Lake Brunner, and would significantly increase normal and flood flows in the Arnold River. This would have an impact both on bridges across the Arnold and Grey Rivers and some of its tributaries as well as on sections of road and railway. It would also impose greater loading and flood levels at the Arnold Power Station dam. Perhaps the most significant effect would be on the flood protection works at Coal Creek and Greymouth where the increased flood flow in the Grey River would effectively reduce the design capacity of the structures.

The Inchbonnie stopbank crosses the Alpine Fault. If the fault line ruptured through this location (it is not part of the AF8 scenario, but remains a possibility), the stopbank would be sheared with the section east of the fault moving in the order of 8m in a south-west direction with respect to the western section and rising in elevation by one metre. The geometry of these relative movements of the stopbank segments would, fortunately, minimise the exposure to the river of the rupture damage, as the shearing would make the upstream section higher and overlap the downstream section in such a way as to protect the downstream section, but a rupture would clearly cause a break in the bank with associated deformation and slumping as well as creation of flow paths within the bank. Being on the rupture, the bank would be severely shaken and likely to suffer batter failure, rock dislodgement, weakening of the structure and reduction of seepage path lengths. It would be important to get to the stopbank as soon as possible after an earthquake to assess the damage and arrange for the necessary repairs to ensure the Taramakau River remains within its present river course.

Aggradation would also threaten this stopbank by reducing its effective height, and ongoing work could be needed for some years following any major event causing large and numerous landslides in the catchment.

## 3.4 Hokitika River - Water Control Assets

There are several water control assets on the Hokitika River or in catchments that feed into the Hokitika River. Five are WCRC assets as follows, and as shown on Figure 3.4

- Southside Hokitika – River Control;
- Kaniere – River Control;
- Kowhitirangi – River Control;
- Vine Creek – River Control; and
- Raft Creek – Drainage.

There is also a WDC stopbank on the north side of the Hokitika River.

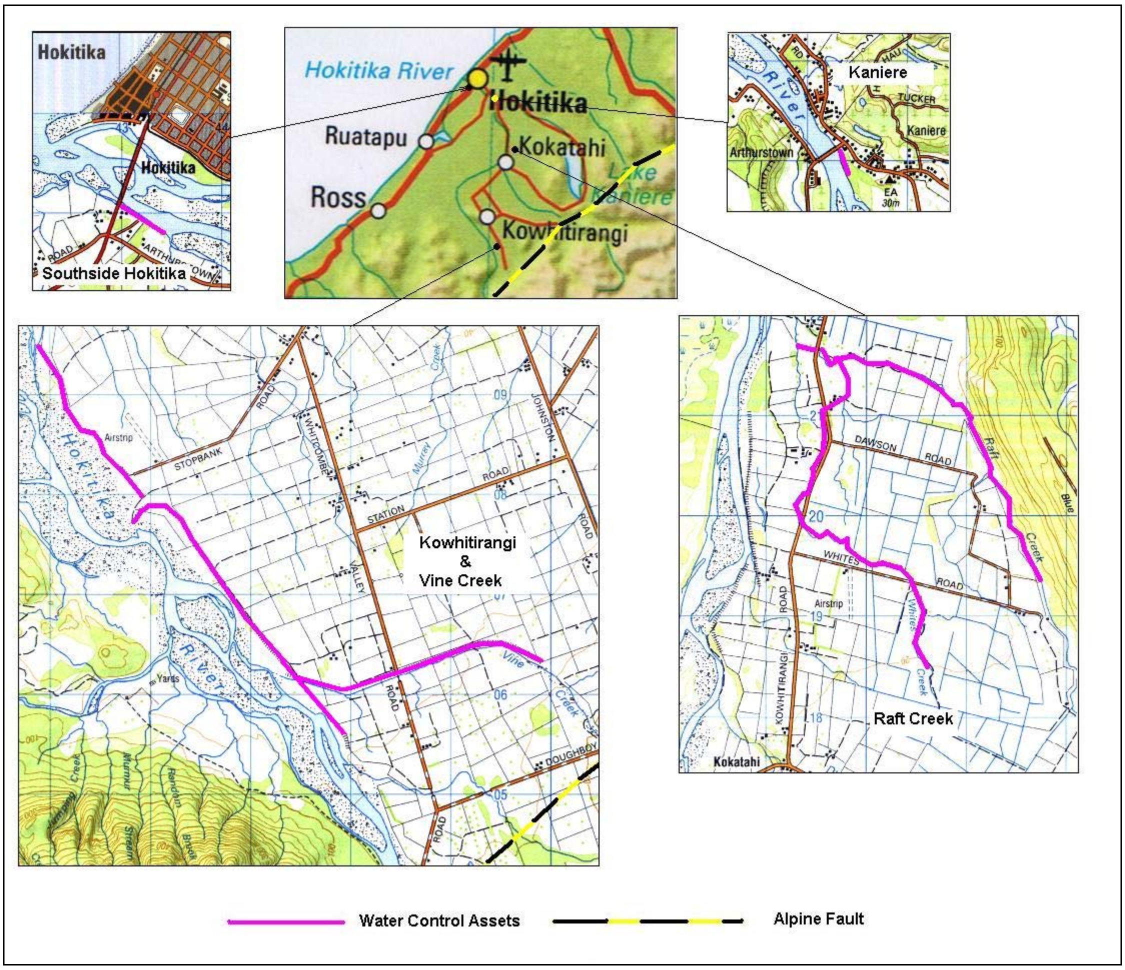


**Figure 3.4: Hokitika River - WCRC Water Control Assets**

***Northside Hokitika River - Hokitika, WDC***

| | | | |
|---|---|---|---|
| | Structures | Stopbank and some rockwork on the true right bank of the Hokitika River from close to the river mouth to upstream of the SH 6 bridge | |
| | Purpose | Protects Hokitika and SH 6 bridge abutments | |
| | Earthquake | Some liquefaction possible; shaking damage | M |
| | Extreme Storm | Erosion, scour, overtopping | H |
| | Tsunami | Surges for small to medium, overtopping with larger events; scour and erosion | H |

***Southside Hokitika Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Groynes and some rockwork on the true left bank of the Hokitika River upstream of the SH 6 bridge | |
| | Purpose | Prevents bank erosion and protects roads, SH 6 bridge abutments, and farmland. | |
| | Earthquake | Some liquefaction possible but not likely; shaking damage | M |
| | Extreme Storm | Erosion, scour, overtopping | H |
| | Tsunami | Surges for small to medium, overtopping with larger events; scour and erosion | M |

***Kaniere Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Groynes on the true right bank of the Hokitika River upstream of the bridge to Arthurstown. | |
| | Purpose | Prevents bank erosion and protects properties and roads at Kaniere and the bridge abutments | |
| | Earthquake | Shaking damage | M |
| | Extreme Storm | Overtopping, scour | H |
| | Tsunami | Nil | Nil |

***Kowhitirangi Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbank, rockwork and groynes on the true right bank of the Hokitika River | |
| | Purpose | Flood protection to farmland and roads in the Kowhitirangi area and prevent the Hokitika River from diverting to an old floodplain between Kowhitirangi (Mt Camelback) and Kokiraki (The Doughboy) into the Kokatahi River catchment. (1) | |
| | Earthquake | Strong shaking damage, long term aggradation | M |
| | Extreme Storm | Overtopping, scour | H |
| | Tsunami | Nil | Nil |

(1) Diversion of the Hokitika River into the Kokatahi River catchment would cause damage to farmland and houses as it establishes a new river course, would significantly increase flow in the Kokatahi River, and would potentially threaten the bridge over the Kokatahi River at Kokatahi.

The Kowhitirangi and Vine Creek stopbanks would be exposed to very strong shaking and although liquefaction would be unlikely the stopbanks would suffer batter failure, rock displacement and minor ground settlement. If a major flood occurred before repairs could be made to the stopbank, it is expected that there would be major breakouts. Significant repairs would be required to sustain the current level of flood protection.

***Vine Creek Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbank and rockwork on the true right bank of Vine Creek | |
| | Purpose | Flood protection to farmland and roads in the Whitcombe Valley Rd/Station Road area | |
| | Earthquake | Some slumping of banks; vulnerable to aggradation at outlet | M |
| | Extreme Storm | Overtopping, scour | H |
| | Tsunami | Nil | Nil |

***Raft Creek Drainage***

| | | | |
|---|---|---|---|
| | Structures | Utilises Raft Creek, White Creek and a series of channels | |
| | Purpose | To drain farmland in the area | |
| | Earthquake | Some slumping of banks; vulnerable to aggradation at outlet | L |
| | Extreme Storm | Scour / siltation of creeks and drains | M |
| | Tsunami | Nil | Nil |

The Raft Creek drainage system would probably have reduced drainage capacity due to slumping of steep batters. There is potential for ground settlement to cause changes in drain gradients. Continuing aggradation over a period of years would reduce drainage capacity in two ways; from an increase in fine sediment entering and building up in the drains, and from aggradation in the receiving waters (Hokitika River) that would raise the outlet water level and hence increase water levels in the drains.

## 3.5 Mid Westland - WCRC Water Control Assets

There are seven WCRC water control assets on the mid Westland area (Figure 3.5):

- La Fontaine and Harihari – Drainage
- Matainui Creek – River Control
- Franz Josef – River Control
- Lower Waiho – River Control
- Wanganui – River Control
- Waitangitaona – River Control
- Canavans Knob – River Control

***La Fontaine and Harihari Water Control Assets (Wanganui Rating District)***

| | | | |
|---|---|---|---|
| | Structures | Drainage system | |
| | Purpose | Drainage of farmland north of Harihari and in the La Fontaine stream area. | |
| | Earthquake | Shaking damage, possible bank failures, aggradation | M |
| | Extreme Storm | Flooding, scour/siltation | M |
| | Tsunami | Nil | Nil |

***Wanganui Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbanks, rockwork and groynes on the both banks of the Wanganui River | |
| | Purpose | Protect homes, farmland and roads on the Harihari flats north of Harihari and prevent Wanganui River from possible avulsion into Poerua River. | |
| | Earthquake | Shaking damage, fault rupture at upstream end | H |
| | Extreme Storm | Overtopping, scour | H |
| | Tsunami | Nil | Nil |

***Matainui Creek Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Channel re-alignment of Matainui Creek | |
| | Purpose | Prevent flooding of Whataroa. | |
| | Earthquake | Shaking damage, aggradation | M |
| | Extreme Storm | Overtopping, scour | H |
| | Tsunami | Nil | Nil |

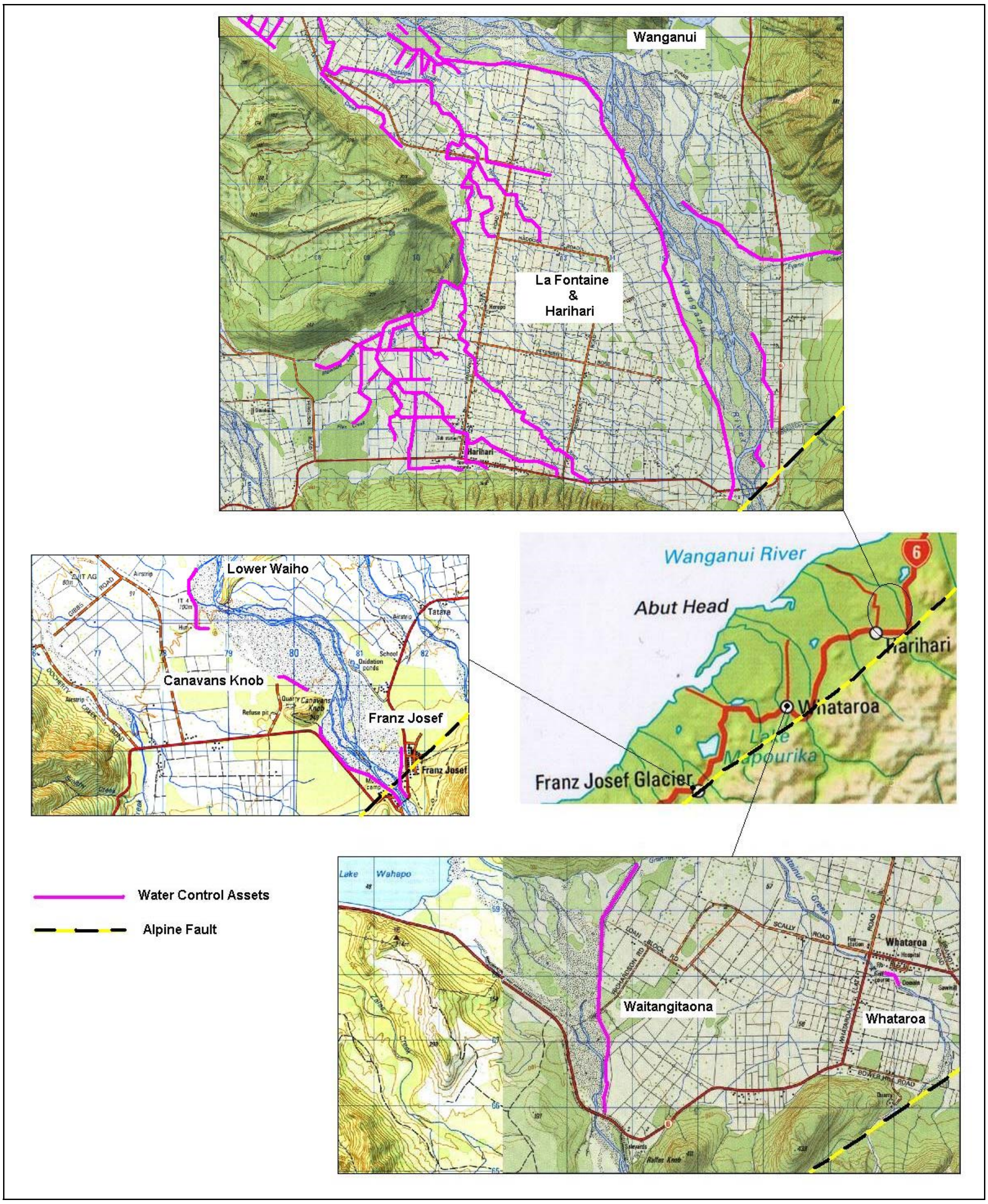


**Figure 3.5: Mid Westland - WCRC Water Control Assets**

***Waitangitaona Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbank, rockwork and groynes on the true right bank and additional NZTA stopbanks on true left bank protect SH 6 | |
| | Purpose | Protect farmland, roads and Whataroa township; prevents the Waitangitaona River returning into its pre-1980s course into the lower Waitangitaona River (1) | |
| | Earthquake | | M |
| | Extreme Storm | Overtopping, scour | H |
| | Tsunami | Nil | Nil |

(1) Prior to 1980s, the Waitangitaona flowed north east to a river mouth close to that of the Whataroa. A large slip and flood event changed the river course to flow northwest into Lake Wahapo and the Okarito River to Okarito Lagoon.

It is also noted that NZTA have some stopbanking structures related to SH 6. In particular there is a substantial stopbank between SH 6 and the Waitangitaona River, and a section of road embankment that serves as a stopbank (protecting more than just the road). St. Georges Creek, 2km east of Harihari, has a history of aggradation and NZTA works to keep the channel clear and open under the SH 6 bridge has resulted in substantial banks on either side of the creek. Assets managed by others are not listed or assessed in this section of the report.

***Franz Josef Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbanks, rockwork and groynes on the both banks of the Waiho River | |
| | Purpose | True right bank protect the Franz Josef township; true left bank protect accommodation buildings and SH 6 and prevent the Waiho River from diverting through farm land to Docherty Creek. | |
| | Earthquake | Fault rupture, shaking damage | H |
| | Extreme Storm | Overtopping, scour, aggradation | H |
| | Tsunami | Nil | Nil |

***Canavans Knob and Lower Waiho Water Control Assets***

| | | | |
|---|---|---|---|
| | Structures | Stopbanks, rockwork and groynes on the true left bank of the Waiho River | |
| | Purpose | Protect the Franz Josef aerodrome, farmland and roads, and prevent the Waiho River from migrating into Docherty Creek. | |
| | Earthquake | Shaking damage, aggradation | M |
| | Extreme Storm | Overtopping, scour | H |
| | Tsunami | Nil | Nil |

### *3.5.1 Wanganui – Harihari Assets*

All the mid Westland river control assets are within 15km of the Alpine Fault, all have part of the assets within 3km of the fault and the Waiho River flood control assets at Franz Josef cross the fault. It is anticipated that all the assets would be exposed to intensity MM IX shaking or greater with an Alpine Fault earthquake.

There is a possibility for some liquefaction in the area drained by the La Fontaine and Harihari drainage systems that could cause lateral spreading of the drain banks and reduce the drainage capacity. Ground settlement might also occur in some areas that could change the drain gradient sufficiently to reduce drainage capacity or even reverse the flow direction. Continuing aggradation over a period of years would reduce drainage capacity with an increase in sediment entering and accumulating in the drains and an increase in the bed level of the receiving waters (La Fontaine Stream and Wanganui River) reducing gradients and increasing water levels at the drainage outlet.
The Wanganui stopbanks would be exposed to very strong shaking and although the probability of liquefaction is low, the stopbanks would be likely to suffer batter failure, rock displacement and minor ground settlement. The upstream end of the stopbank is within 1km of the fault and would be likely to suffer the most damage. If a major flood occurred before repairs could be made to the stopbanks, there would be major breakouts. An outbreak or a number of outbreaks might lead to extensive flooding of parts of the Harihari flats, potentially causing parts of the La Fontaine and Harihari drainage systems to be buried and if serious enough might cause the Wanganui River to divert its course to the west of its current course.

### *3.5.2 Franz Josef*

*(a) Earthquake*

The Franz Josef stopbank crosses the Alpine Fault trace. The stopbank on the true right bank of the Waiho River would fail and break at the trace with the northern section of the stopbank moving (with respect to the southern section) in the order of 8m in a north-west direction and lowering in elevation by one metre. The relative movement of the stopbank sections would help to minimise the exposure of the ruptured section to the Waiho River on the Franz Josef township bank (refer Figure 3.6).

The stopbank on the true left bank of the Waiho River would fail and break in a similar way to the stopbank on the true right bank with an 8m relative horizontal movement in sections and lowering in elevation by one metre. However, as the Waiho riverbed level is already metres higher than SH 6, unless repair work was instigated very quickly the relative horizontal and vertical movements of the stopbank sections would result in the Waiho River breaking out through the damaged section over SH 6 and farmland and taking a new course to the south of Canavans Knob and down Docherty Creek (refer Figure 3.6) in the first flood that brought significant flow against this side of the riverbed.

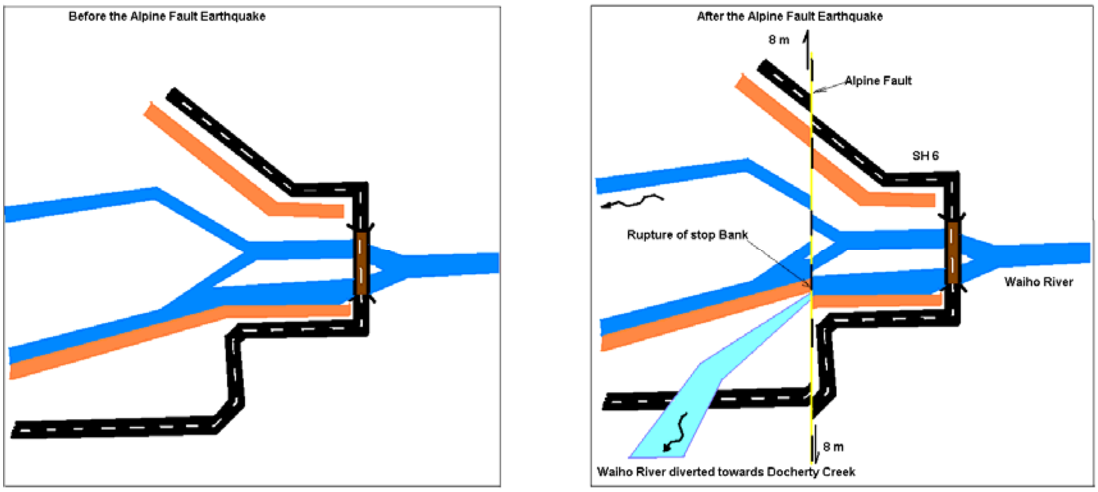


**Figure 3.6: Fault Rupture of the Waiho Stopbanks**

Aside from significant damage to the Franz Josef stopbank caused by the fault rupture, the remainder of the Franz Josef stopbank and the Canavans Knob and Lower Waiho stopbanks would be likely to suffer significant shaking damage with batter failure, rock displacement and some ground settlement.

Two other outcomes of the earthquake that could affect all the mid Westland stopbanks are dams caused by earthquake-induced landslides and aggradation of riverbeds and streambeds. A particular concern for potential landslide dam formation is the Callery River a tributary of the Waiho River just upstream of SH 6 and Franz Josef. It has very steep sides and there is evidence of previous landslide dams. A dam in the Callery River would be likely to have a catastrophic failure with the resultant large flood wave reaching the SH 6 Bridge on the Waiho River with little or no warning. Dams could also form in other parts of the Waiho River catchment and the catchments of the Wanganui River and Waitangitaona River. A sudden dam break and the resultant flood wave could overtop the downstream stopbanks even if the stopbanks were undamaged by the main quake.

The Waiho River at Franz Josef would be dynamic, changing dramatically for some years after the Alpine Fault earthquake event. The river would be likely to aggrade and could change course downstream of the SH 6 Bridge several times. It would be very difficult to re-establish roads while this process was underway and it would only be possible to undertake sensible planning after the event and after some understanding had been gained of the new dynamics of the area.

*(b) Extreme Storm*

The Waiho River has a history of bed instability, as a result of changes in the Franz Josef glacier. The river has aggraded many metres over the last century and the bridge has been raised twice to maintain the waterway. The bed is well above SH 6 on the south bank, and in 2016 floodwater ravaged hotel facilities and the town oxidation ponds on the north bank. In an extreme flood event, it is very likely that the river would break its banks either to south or north (or conceivably both) with large building and infrastructure damage as a result. Significant damage to the flood control structures would be expected with loss of stopbank, rockwork and groynes by scour as well as diminished effectiveness from aggradation.

## South Westland – WCRC Water Control Assets

There is one WCRC water control asset in the South Westland area: the Okuru water control asset (Figure 3.7). Three rivers drain into one estuary area and river mouth and there is a history of flooding.

***Okuru***

| | | | |
|---|---|---|---|
| | Structures | Two groynes on the true right bank of the Okuru River.<br>Sea wall made up of groynes and rockwork | |
| | Purpose | Protect the Okuru settlement from river and sea erosion | |
| | Earthquake | Liquefaction possibility, shaking damage | M |
| | Extreme Storm | Overtopping, scour, of both river groynes and sea wall | H |
| | Tsunami | Within inundation zone; overtopping erosion and scour of seawall, scour of groynes possible | H |

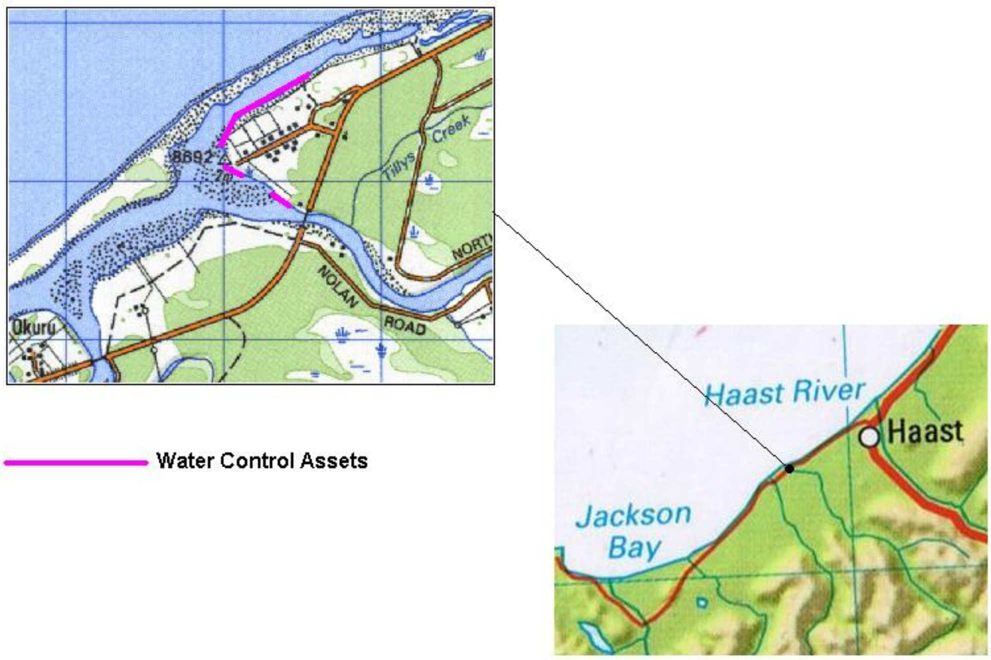


**Figure 3.7: South Westland - WCRC Water Control Assets**

# 4 UPGRADES AND IMPROVEMENTS – WCRC WATER CONTROL ASSETS

## 4.1 Summary

The WCRC water control assets are vulnerable to damage in severe storms, particularly if floods are greater than the design capacity, and to earthquakes. After an Alpine Fault earthquake WCRC would need to respond quickly to assess hazards. For example, the WCRC would need to identify landslide dams and assess the threat they posed to communities downstream of the dams. The WCRC would also need to assess stopbanks where there is a serious threat to life and/or property if a stopbank were to fail. The most important of these is probably the Inchbonnie stopbank where the Taramakau River could divert to the Grey River catchment significantly increasing flood flows in the Grey River and impacting on the Greymouth and Cobden water control assets. The WCRC would also needs to assess stopbanks at Kowhitirangi, Vine Creek, Wanganui River, Waitangitaona River, and Waiho River, where failure of a stopbank could also result in rivers diverting to new courses.

Assessment of the catchments and the stopbanks would require the use of helicopters and fuel, both of which would be likely to be in high demand and limited supply after an earthquake.

In many areas, particularly Franz Josef, it would not be possible to plan sensibly until after the earthquake event and after monitoring to gain a better understanding of the new dynamics of the environment. Only at that stage could an assessment be made and an appropriate balance achieved between on the one hand investment of resources in rebuilding or building new water control assets, and on the other the benefit of the protection provided. While changes at Franz Josef would probably be dramatic, changes at the location of other WCRC water control assets would probably return quickly to a more stable environment.

Of the water control assets in the West Coast Region, those managed by the WCRC are discussed above. However, there are an unknown number of water control assets managed by others. The New Zealand Transport Agency (NZTA), for example, has a number of water control assets associated with their road network. Water control assets managed by others are not listed or assessed in this report. It is possible that some of these assets fulfil a greater function than, for example, just supporting and protecting a road. An example is the section of the Waitangitaona stopbank beneath and adjacent to SH 6 that is managed by the NZTA, not the WCRC. Failure of this section of stopbank would have far greater consequences than just the loss of a small part of SH 6, as it could result in the Waitangitaona River reverting to its pre-1980s course into the Waitangiroto, lower Waitangitaona or Whataroa rivers, which all flow within a 3km wide valley for 12km to the sea. Such an outbreak would also threaten Whataroa Township and all houses in the diverted river's path.

Improvements to address vulnerabilities of WCRC water control assets identified in Sections 3.1 to 3.6 are presented in Table 4.1.

**Table 4.1: Improvement Schedule – WCRC Water Control Assets**

| Action | Responsible |
|---|---|
| ***General*** | |
| Work with CDEM before the Alpine Fault earthquake to determine an appropriate priority for catchment and stopbank assessment. This assessment will require helicopters and fuel which will both be in high demand and limited supply after the earthquake. | WCRC/CDEM |
| Prepare a complete map of all water control structure in the West Coast Region. Assess the vulnerabilities at each site and where appropriate, identify improvements to allow the structure to be more effective. | WCRC/other water control asset managers |
| Assessment of all main assets with respect to enhancing their robustness. Examples are placing additional fill to parts of the Karamea stopbank to increase their batter stability and reduce the effects of shaking and liquefaction. | |
| ***Greymouth*** | |
| Undertake a geotechnical and structural assessment of the pump stations and selected site on the stopbank to confirm and quantify earthquake risks and make recommendations on improvements to address these risks.<br><br>Consider where overtopping or a breach might be most likely, and consider planning or engineering that could go some way to reducing the impact in such an eventuality. | WCRC/GDC |
| ***Inchbonnie*** | |
| Develop strategies to allow the anticipated significant repair work to the Inchbonnie stopbank to be undertaken as soon after the Alpine Fault earthquake as possible.<br><br>Investigate possible mitigation to reduce the impact of fault rupture. This may be as simple as making the stopbank 15m wide across the fault so that even an 8m offset will leave a good width of bank remaining | WCRC |