Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

Selwyn River / Waikirikiri capacity – Issues and options

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1 Summary

An objective of the Selwyn River scheme is to contain the river in flows up to 560 cumecs.

The current capacity of the stopbanked section of the river is about 400 cumecs in the lower 3 km, rising to 500 cumecs near the Upper Selwyn Huts and 560 cumecs upstream of the Upper Selwyn Huts to Ellesmere Traffic Bridge

Although the upper river begins to overflow and spill into the Irwell Creek at a lower flow threshold, as flows increase, the overflows are insufficient to ensure the lower river capacity is not exceeded. For example in a 400 cumec event, 40 cumecs is estimated to overflow to the Irwell River; while in an 800 cumec event, about 220 cumecs is estimated to overflow, leaving 580 cumecs to flow to the lower river.

Issue 1*: Maintenance has been sufficient to maintain a fairway and attend to bank erosion, but has not been sufficient to maintain channel and stopbank flood capacity.*

Issue 2*: Flood risk on the floodplain has been increasing (because of bed aggradation) and is likely to continue to increase (because of a combination of aggradation and climate change). Gravel extraction may help to limit the increase.*

Issue 3*: An aggrading river is liable to course change as well as more frequent flood overflows.*

The scheme is not meeting the objective of maintaining a flow capacity of 560 cumecs in the Selwyn River, which is increasing the risk of flooding on the floodplain.

Key question: Is the community prepared to accept that the risk of outflows will increase, or is it prepared to pay the cost of halting the increase in risk or restoring the capacity of the Selwyn River?

The flow capacity objective of the scheme needs to be reviewed.

Issue 4: *A changing river capacity means changes in the balance of risk and benefit*

If the flow capacity objective of the scheme is changed, the rating classification should be reviewed from time to time to ensure it reflects the benefits and disbenefits the scheme provides and creates.

A floodplain investigation is being undertaken by Environment Canterbury (Hazards Section) this year, which will provide further information about the current risks on the floodplain.

2 Background

2.1 Introduction

The Selwyn River / Waikirikiri has had a stop-start history of flood control works to a variety of standards (see Table 2-1). It also has a long term bed aggradation trend. The aggradation has only recently been quantified, and is now known to apply throughout the River Scheme area (i.e. downstream of Gillanders Rd/ Waianiwaniwa confluence). It is not just an issue near Lake Ellesmere.

Table 2-1: Timeline of significance to flood control works

	Flood capacity (cumecs)	Decisions/ comments
1947	425	First classification, works started 1947. Govt subsidy 3:1. Overspent by 1951. Stopbanks from Lake to Ellesmere Bridge.
1956	849 + 600 freeboard proposed	Increased design not supported by ratepayers.
1958-63	560 + 800 freeboard	Investigations, scheme adopted 1962. Later shown to be uneconomic.
1965	560 + 800 freeboard	Maintain assets but abandon further works and investigations. A few works later built by individuals subsidised by scheme/govt to same standard.
1987-90	**560**	Govt subsidies discontinued. Reclassification, restatement of objectives.
1995	560, zero freeboard	Aggradation in the lower reaches identified limited capacity, proposals to raise stopbanks rejected.
2010	Gravel report – Initial overflow at 190? Several overflows at 320?	Aggradation identified throughout system: 1.1 million cubic metres since 1950 (19,000m^3/yr)
2011	**Stopbank capacity about 400-500 cumecs**, zero freeboard (see section 3.3)	Based on 1999 survey of river channel – needs to be updated when survey available (programmed in 2011/12). Refer attached graphs.

2.2 Freeboard

Freeboard is a term used to describe an allowance for a stopbank or structure capacity to be built above the design water level, and gives a margin of safety to allow for uncertainties in the design level. There are several variables that contribute to uncertainties in level. Some important ones include:

- Velocity of water – the model calculates an average water level across a cross-section, but the kinetic energy embodied in the flow of water can be translated into an additional build-up of water, e.g. at bends and in eddies. The equivalent "velocity head" can be calculated to estimate the likely additional build-up.
- Topography – the model is made up of cross-sections that are assumed to be representative of a length of channel, but the cross-sections cannot account for every change in cross-section shape.
- Roughness – the model relies on an accurate estimate of roughness. The accuracy of the estimate can be improved if flood flow and level data is available for calibration and verification
- Model layout and connections – in 1D models, discrete links connect the channel and floodplains – these may not accurately represent the flow exchanges.
- Downstream (Lake Ellesmere) level (with and without sea level rise).
- Flow rate (with and without climate change).

In the upper part of the Selwyn River / Waikirikiri where it is wide, a small increase in water level or freeboard represents a relatively large increase in flow or capacity. Conversely, a small increase in bed level can markedly decrease the capacity. In the narrower, stopbanked lower reaches where the velocity is slower, a relatively small increase in flow corresponds to relatively large level changes.

The stopbanks on the Selwyn River / Waikirikiri were originally designed with 800 mm freeboard, which is a relatively generous freeboard in the context of other Canterbury rivers. This is a reasonable design standard given the uncertainties above. However, discussions of flood capacity on unstopbanked sections (of which there are many in the Selwyn River / Waikirikiri) generally exclude freeboard. In the context of the Selwyn River / Waikirikiri, rather than have a robust, secure, unfailing design standard for the limited lengths of stopbank, it is more important to have reasonable equity in different parts of the scheme. On this basis it is considered more useful to compare different parts of the scheme without including freeboard.

It could be argued that the benefits of the scheme are reflected in the classification, and that the Class A land behind the stopbanks receives a greater level of protection. However the rating differential between Class A and B land is small, suggesting that this difference is perhaps that there will need to be greater maintenance expenditure on the stopbanked parts of the scheme than a recognition that the flood risk (without stopbanks) is greater. The capacity of the stopbanks has gradually deteriorated in the lower reaches, but the river capacity has also reduced in the upper reaches. A large proportion of the rates come from the Irwell Creek catchment. On balance, it *is* most useful to **compare different parts of the scheme without including freeboard.**

3 Issues

3.1 Scheme objectives and maintenance

The objectives of the scheme are:

a) To prevent overflows from the Selwyn River / Waikirikiri in floods up to a discharge of 560 cumecs.
b) To maintain the riverbed downstream from the Hororata River confluence clear of vegetation and obstructions (trees and brushweeds) which would have the effect of impeding or diverting flows.
c) Maintenance of fairway edge erosion control works and berm planting to protect the stopbank system or to control or reduce flood overflows onto the floodplain.

Objectives b) and c) have been followed, but the ability to achieve objective a) has deteriorated with time due to gradual bed aggradation. One can imagine the Selwyn River / Waikirikiri to be a natural sediment trap, given that it has a gravel bed through much of its length, but flattens out and carries only sand and fine material into Lake Ellesmere.

In 1988, the policy adopted was to fund:

a) Maintenance of a clear river channel from the Hororata confluence to Lake Ellesmere;
b) Maintain the stopbanks;
c) Essential erosion control to restrict flood overflows, i.e. erosion control works to protect the stopbanks or where continued erosion would lead to overflows beyond natural terraces;
d) Subsidise other erosion control works, the level of subsidy set each year. This item was later deleted.

These policies have been followed. Maintenance of the stopbanks has included keeping them clear of gorse, broom and other weeds, but has not extended to ensuring their flood capacity is maintained. The 1995 decision to not raise the stopbanks downstream of 4.5 km was an illustration of this.

Current flow capacity is discussed in section 3.3.

Issue 1: Maintenance has been sufficient to maintain a fairway and attend to bank erosion, but has not been sufficient to maintain channel and stopbank flood capacity.

The 1995 decision appears to have led to an understanding amongst staff that the stopbanks downstream of 4.5 km are not as important as the other stopbanks, and that any maintenance there should be the absolute minimum. A section of bank in this area was repaired following the Sept 4 earthquake, to the level of the adjacent sections of bank. This section of bank needs to be included as part of a wider discussion about the future standard of the scheme. The description of the rating class that includes the Lower and Upper Selwyn Huts is "severe flood risk". The Lower Huts pay a reduced rate because they receive a significantly lower level of protection (they can flood directly from Lake Ellesmere).

Also of note is a 1987 staff report which included the following recommendations:

1) Develop a works programme for the rating district with provision for review;
   a) Short term 0-5 yrs: Concentrate resources on maintenance works, particularly channel clearance with some protection works,
   b) Medium term 5-10 yrs: Having established reasonable fairways, maintenance works will be reduced and increases in the extent of protection possible,
   c) Long term 10-20 yrs: Further strategic stopbanks – and consideration given to establishing a flood fund. Maintenance and protection works to continue.
2) Define control lines for the river – Define the width required by the river to carry the defined flow (560 cumecs), draw the control lines irrespective of land tenure, and manage the river to within those lines.
3) Reclassify the rating district.

Items 1a and 3 were carried out in the short term. Item 1b was worked on for a number of years, and is essentially how the scheme has been operating recently. Item 2 has been carried out recently, and is fairly consistent with how the scheme is currently operating. Only 1c remains – it was envisaged at the time that strategic stopbanking may eventually become a priority for the scheme.

3.2 Flood history and flood frequency

3.2.1 Flood history

Significant floods recorded at Ellesmere Traffic Bridge or Coes Ford include:
(from a 1963 report, quoted as significant floods since April 1932):

January 1953	580 cumecs
April 1959	400 cumecs
May 1959	310 cumecs
July 1961	650 cumecs
July 1963	*620 cumecs – estimate superseded below*
(from more recent records):	
July 1963	570 cumecs
1978	
1979	
March 1986	400 cumecs
August 1986	307 cumecs
July 1994	502 cumecs
August 2000	674 cumecs *plus estimated 125 cumecs overflow*
Jan 2002	341 cumecs
August 2008	385 cumecs

3.2.2 Flood frequency

Estimates of flood frequency when scheme standards were considered (1947, 1956, & 1962) would have been based on a limited flood record. There is now sufficient flood record to obtain a reasonable understanding of flood frequency, however, this is tempered by the additional uncertainties that climate change may introduce. It is sensible to design a system to an agreed flood flow rate, with some understanding of the flood frequency and the residual risk of flooding, rather than try and work to the moving target of a particular flood frequency (e.g. a "50 year return period").

Assuming the flood frequency has not decreased (and there is no evidence of that), the residual risk of flooding on the floodplain has been gradually increasing as the bed level of the river has built up. It is likely to continue to increase (refer to Appendix 1 for discussion on climate change implications for the Selwyn River / Waikirikiri). A sensitivity run with an 800 m^3/s peak flow has been modelled, which represents a 40% increase on the current design flow of 560 m^3/s. Compared to the 560 m^3/s flow, in the narrow lower reaches (lower 5 km) it adds up to 0.7 m in water level. It adds about 0.5 m in the 6-7 km reach and about 0.3 m in the 8-14 km reach. It typically adds only 0.1-0.2 m upstream of there.

Current estimates of flood frequency for the Hawkins to Coes Ford reach (including overflows) are:

Flow rate (cumecs)	Return period	Probability of flooding in any one year	Probability of flooding in any 10 year period	Probability of flooding in any 30 year period	Probability of flooding in any 70 year period
83	2yr	50%			
140	Mean annual flood	33%			
260	5yr	20%			
430	10yr	10%	1 in 1.5	1 in 1	
600	20yr	5%	1 in 2.5	1 in 1.3	1 in 1
820	50yr	2%	1 in 5	1 in 2	1 in 1.3
985	100yr	1%	1 in 10	1 in 4	1 in 2

The current objective of containing a 560 cumec event equates to around an 18 year return period, with around a 6% chance of being exceeded in any year.

3.2.3 Lake Ellesmere level

The 1962 design considered a lake level of 1.20 m approx. The 2010 Aurecon modelling considered a lake level of 1.13 m, the winter opening level. Lake levels are frequently higher than the opening level, as it can take some weeks to open the lake in unfavourable sea conditions. The average opening level has been 1.27 m. The lake reached 1.41 m in 2010 following six weeks of attempted openings. Considering the potential sea level rise (refer Appendix 1), levels of up to 2 m may need to be considered over the longer term (2090s). Sensitivity to lake level has been modelled – because of the gradient of the river, lake levels only affect flood capacity in the lower reaches (downstream of the Upper Selwyn Huts).

3.2.4 Gravel extraction

Gravel extraction has the potential to counter the effects of aggradation. Aggradation has exceeded gravel extraction by an average of around 19,000 m^3/yr over the last 60 years; about 1.1 million cubic metres has built up in the river bed and berms since 1946/52.

There is the potential for large scale gravel extraction on the Selwyn River / Waikirikiri to alleviate some of the flood risk, for example if the gravel is used for construction of the Christchurch Southern Motorway and/or Christchurch Earthquake Recovery. However, the use of the gravel depends to a large extent on availability of alternative sources, and the economics involved in their transport to works sites.

Issue 2: Flood risk on the floodplain has been increasing (because of aggradation) and is likely to continue to increase (because of a combination of aggradation and climate change). Gravel extraction may help to limit the increase.

3.3 Current flow capacity

Appendix 2 shows a longsection of the stopbanks downstream of the Ellesmere Traffic Bridge (11.5 km) in relation to flows of 560 and 400 cumecs (without freeboard).

The estimated flow capacity is about 400 cumecs at some locations downstream of 3 km from Lake Ellesmere. It is about 500 cumecs in the reach from 3 to 4.6 km past the Upper Selwyn Huts. It is generally greater than 560 cumecs on the left bank from 4.6 km to 8.5 km and on the right bank from 4.6 km to 11.5 km (Ellesmere Traffic Bridge). The terrace on the left bank upstream of 8.5 km (Goulds Rd) appears to have a capacity of less than 400 cumecs but may not flood large areas – overflows in this area may be collected by a bank parallel to Curries Rd and returned to the river at Coes Ford.

Upstream of the Ellesmere Traffic Bridge, overflow locations are summarised in a series of plans produced by Aurecon in 2009. There are many locations identified as possible overflow locations, but many of these would be very shallow in a 560 cumec event.

The main overflow sites to the south include:
- Downstream of Westenras Rd
- Near Old South Rd
- Near Highfield Rd
- Downstream of SH1 towards Boundary Creek Rd
- Opposite Swamp Rd towards Lake Rd South

The first four of these would augment the Irwell River (or for the Highfield Rd area, may return to the Selwyn River). The last would discharge to Wood Creek.
Overflows to the north are possible around Ashley Dene Rd.
Minor overflows may be possible in flows as low as 190 cumecs, with overflows likely in several locations from about 300 cumecs.

Indicative overflows for 400, 560 and 800 cumec events are tabulated in Appendix 2. Potential flows into the Irwell River for these three events are estimated at roughly 40, 110 and 220 cumecs respectively.

A floodplain investigation is being undertaken by Environment Canterbury (Hazards Section) this year, which will provide more detailed information about the current risks on the floodplain.

3.4 River morphology

The climate of the Canterbury foothills setting of the Selwyn River / Waikirikiri offers a partial explanation for continued aggradation of the river – as floods pass across a relatively dry floodplain, there are considerable losses to groundwater. While the river slope is fairly consistent down the main part of the plains, this loss to groundwater will mean the river is less able to transport gravel the further downstream it travels.

Sites of outflow are also places where gravel transport capacity can reduce. Where outflows do not return to the river (e.g. go down Irwell Creek), the transport capacity is lost to the rest of the main river. Deposition immediately downstream of these outflow sites is liable to exacerbate the outflow and can lead to course change (avulsion) of the whole river. The outflow itself starts off free of gravel, but if it becomes large enough can become erosive and start to create its own channel.

Issue 3: An aggrading river is liable to course change as well as more frequent flood overflows.

The Selwyn River / Waikirikiri is not in equilibrium, and is in the process of slowly building its fan. In order to live on the fan in relative safety, a degree of management is necessary.

Because the transport capacity of the river reduces in the downstream direction, deposition of gravel is inevitable. One strategy to manage this gravel is to give the river as much room as practical in order to limit the rate of rise of the bed (a narrower course will fill more quickly).

When discussing the capacity of the system, overflow thresholds in the upper river need to be treated carefully. The river may start spilling at, say, 400 cumecs, but the outflow at 600 cumecs might only be 60 cumecs, leaving 540 cumecs in the river for the system downstream to cope with.

3.4.1 Earthquake effects

4 September Earthquake

The main fault scarp passed through the upper end of the scheme area at Greendale, with a downdrop of about 1 m on the north side of the fault. The Hororata River appears to be more likely to have flood overflows join the Selwyn River upstream of its normal confluence. The fault crosses the Selwyn River at Gillanders Rd. Upstream of this point, there is likely to be more aggradation than normal and the River position may become more unstable. There may be changes to overflows from the Hawkins River near Shipleys Rd, where flows are now more likely to head east and reach the Selwyn River further downstream than normal.

These are localised changes and do not affect the scheme objectives. Some erosion protection work may emerge as desirable in due course.

Stopbanks in the lower river were damaged in a few locations. A 50 m section with large cracks in and adjacent to the stopbanks near Lower Selwyn Huts was repaired promptly. Other minor cracks were identified and are being monitored. No further work is proposed at this stage.

22 February Earthquake

No additional damage was reported on the Selwyn River.

3.5 Equitable treatment

As the capacity in both the upper and the lower reaches has reduced, the risk of overflows in different areas has changed. In particular, the risk of overflows into the Irwell River from the upper reaches has increased over time. Because of this, despite losing capacity, the likelihood of overflows of the stopbanks in the lower reaches does not appear to have changed substantially. This is obviously not a fair situation if this trend is to continue.

Issue 4: A changing river capacity means changes in the balance of risk and benefit

This is illustrated by the events of 1986. The 1965 decision to “maintain assets but abandon further works and investigations” led to no fewer than 5 breakouts upstream of SH1 in 1986, substantially influenced by channel congestion upstream of SH1. The largest flow in 1986 was 307 cumecs. The congestion was rectified by adopting new policies in 1988 (section 3.1) and implementing them in subsequent years.

Even if restoring a 560 cumec capacity throughout the river is regarded as too costly, it would be fairer to stabilise the capacity of the river (at, say, 450 cumecs) than to continue to allow the capacity to change.

Economically, it makes more sense to reduce overflows in the upper part of the scheme because these affect the widest area. But again, this may not be fair to those downstream, and the adverse effects on those downstream need to be avoided, remedied, or mitigated. Restoring a capacity of up to 560 cumecs would restore something close to the situation prevalent in the 1960s – perhaps works would be justifiable up to this level. But if a greater capacity was desired (e.g. as a response to climate change), it would be necessary to start work at the downstream end of the scheme and work upstream to avoid transferring an unfair risk to those downstream.

The economics of protecting the lower 2 km of river are difficult to justify, particularly on the south bank, as the banks protect only a narrow strip of low-lying land. Works in this area, (and to a lesser extent on the north bank), can only be justified in terms of equitable treatment and avoidance of adverse effects.

The 1995 decision not to restore the capacity of the lower 4.6 km of river has led to a de facto inequitable treatment of different areas. If this is to continue, this should perhaps be reflected in a revision of the scheme classification. It is 24 years since the scheme was reviewed. In the absence of a commitment to a stabilisation of the capacity of the scheme, a review of the rating classification should be undertaken in the next year or two, and perhaps 20 yearly after that.

4 Tactics and options

4.1 Possible tactics

Encourage gravel extraction – extraction of around 20,000 m^3/yr at the right locations will tend to encourage stability of the system. Further extraction reversing the aggradation of the last 60 years is probably also desirable provided there is sufficient flood capacity downstream of the extraction area. New, low level stopbanks are likely to be a cheaper solution than removing and stockpiling gravel, but either would need to be ongoing to keep up with aggradation. Where commercial extraction is viable economically, it can benefit flood capacity, but would need to be spread out and targeted to be of maximum benefit.

Move stopbanks in the narrow reach (0-4.6 km) to create additional capacity in the lower reaches. Costly, especially as land purchase or compensation would be required. There is no obvious route without substantial disruption to several properties.

Abandon the stopbanks on the south side downstream of Upper Selwyn Huts and remove that area from rating classification. One landowner adversely affected for benefit of many.

Lower the stopbanks on the south side downstream of Upper Selwyn Huts so that area acts as a flood relief channel. More controlled than abandonment and improves flood capacity past Upper Huts to 4.6 km. One landowner adversely affected for benefit of many.

Shorten the route to Lake Ellesmere. Costly. One landowner adversely affected for benefit of many. What are the consequences for Lake Ellesmere?

Create new stopbanks (at known overflow locations) in the upper reaches to contain overflows and return them to the river

Create gravel traps. Still need to stockpile or find market for gravel. Withells Ford has effectively been acting as a gravel trap for many years. Targeted extraction is more effective at optimising capacity.

Further develop and maintain Irwell River as a flood channel. Controlling vegetation in the Irwell channel and adjacent overflow areas may reduce damage in some events. However, the length of channel involved is large, and the gain in flood capacity would be minor. It could be more cost effective to limit overflows from the Selwyn River (with low stopbanks or buffers of trees).

Adopt private banks upstream of SH1. Overflows to the Irwell are sensitive to some existing private banks e.g. along Westenras Rd. It may be in the community interest for the rating district to control and maintain these banks.

Berm management. Berm and buffer zone planting helps prevent flood overflows, prevents movement of flood debris onto the floodplain, and reduces the risk of river course change.

4.2 Options/ ideas for discussion

Option	Consequences	Modelling shows…	Comment	Cost
Abandon the scheme	Significantly increased likelihood of course change		Unacceptable to many?	0
Status quo – maintain fairway, edges and stopbanks at current levels. Abandon capacity standard.	Gradual deterioration of capacity of scheme – gradual increase in likelihood of course change		Unacceptable long term? Balance of benefits will change over time.	$
Status quo plus gravel extraction 20,000 m^3/yr	Stabilisation of scheme capacity – perhaps 400 cumecs		Is this acceptable to those in Irwell Creek?	$$
Gravel extraction 20,000 m^3/yr plus minor bank work	Stabilisation of scheme capacity – perhaps 500 cumecs			$$$
Gravel extraction 20,000 m^3/yr, remove south bank at 2 km (shorten flood route to Ellesmere)	One area loses flood protection for wider benefit. Effects on Ellesmere?	Reduces flood level up to 0.8 m, 0.2 m at 4.6 km, 0.1 m at 5.6 km	Could achieve 540 cumec capacity with minor bank works	$$$
Gravel extraction 20,000 m^3/yr, new channel from 2 km (shorten route to Ellesmere)	One area loses flood protection for wider benefit. Effects on Ellesmere?	Reduces flood level up to 1.3 m, 0.3 m at 4.6 km, 0.1 m at 6 km	Could restore 560 cumecs with minor bank works	$$$$
Gravel extraction 20,000 m^3/yr, & greater capacity in stopbanked section by dredging	Stabilisation of scheme capacity – e.g. 400 cumecs upper, 560 cumecs lower	Dredged 30 m wide -3 m to 4.6 km: Flood levels reduced 0.9 m at 4 km, 0.2 m at 6 km	Capacity can be restored but would require ongoing dredging to maintain capacity. Long term more costly than raising banks.	$$$$
New stopbanks in upper river where overflows likely, encourage gravel extraction, minor bank work to plug gaps in lower river to 4 km	Return to 560 cumecs (zero freeboard) to 4 km, 500 cumecs in lower 4 km.		Risk of sending too much to lower river. But is this worse than letting too much down the Irwell?	$$$
Widen distance between stopbanks downstream of 4.5 km			Unacceptable cost?	$$$$$
Remove willows downstream of 4.5 km		Reduces flood level 0. 1 m at 4.6 km	Not sufficient to restore capacity.	$$

Alternative schemes to restore a 560 cumec capacity with adjustments near Lake Ellesmere (e.g. shortening the route) would not be markedly different in cost. They may reduce (e.g. weir) or eliminate (e.g. new channel) the need for upgrading approximately 3.4 km of stopbank in the lower reaches.

Removing some of the existing stopbank is likely to be sufficient to give enough relief to the threat of overflows to the Upper and Lower Huts without a significant upgrade of the stopbanks being necessary. Removal of 60 m of the south bank was modelled and found to give close to 560 cumecs capacity in this reach. This is a much simpler option than a new channel.

5 Conclusion

The scheme is not meeting the objective of maintaining a flow capacity of 560 cumecs in the Selwyn River, which is increasing the risk of flooding on the floodplain.

Key question: Is the community prepared to accept that the risk of outflows will increase, or is it prepared to pay the cost of halting the increase in risk or restoring the capacity of the Selwyn River?

The flow capacity objective of the scheme needs to be reviewed.

If the flow capacity objective of the scheme is reviewed, the rating classification should be reviewed from time to time to ensure it reflects the benefits and disbenefits the scheme provides and creates.

Appendix 1 - Climate change – sea level rise and flood frequency

Sea level rise and beach erosion

The implications of climate change on Lake Ellesmere levels and therefore the downstream level of the Selwyn River / Waikirikiri are not yet clear. A rise in sea level would likely initially lead to more frequent openings at the same level (and closing at a higher level) than now, until the cost of opening became uneconomic. For the immediate future (10 years), there is no need to consider the implications for the Selwyn River / Waikirikiri. However, a sea level rise of more than about 0.3 m is likely to translate into substantial difficulty in the opening of Lake Ellesmere, so could impact on the lower Selwyn River / Waikirikiri over the longer term.

"Erosion of the coast between the Rakaia River and Taumutu has occurred at rates of about 1m/yr…" (Single, Timaru and Banks Peninsula Coastal Report, Appendix W of Regional Gravel Management Report, 2006). While erosion at this rate would marginally reduce the volume of Lake Ellesmere (for a given lake level), it is not likely that a landward movement of the beach barrier of, say, 100 m would in any way affect the opening and closing level of the lake. Beach erosion is not likely to be a significant factor in the future of the Selwyn River / Waikirikiri.

The Ministry for the Environment (MfE) has produced a series of reports and guidance manuals to summarise and interpret the Fourth Assessment of the International Panel on Climate Change in the New Zealand context.

With regard to planning for sea level rise, the MfE publication *Coastal Hazards and Climate Change: A Guidance Manual for Local Government in New Zealand* states:

> "To provide some guidance on this assessment process, this Guidance Manual recommends for planning and decision timeframes out to the 2090s (2090–2099):
>
> 1. a base value sea-level rise of 0.5 m relative to the 1980–1999 average should be used, along with
>
> 2. an assessment of the potential consequences from a range of possible higher sea-level rises (particularly where impacts are likely to have high consequence or where additional future adaptation options are limited). At the very least, all assessments should consider the consequences of a mean sea-level rise of at least 0.8 m relative to the 1980–1999 average."

MfE describe the confidence in the prediction of an increase in sea level of "at least 18 to 59 cm" as "very confident" it will occur.

Modelling indicates a rise in peak Lake Ellesmere levels of 0.8 m translates to a rise in peak levels of about 0.3 m 2 km up the Selwyn River and 0.1 m 4 km up the Selwyn River. This sort of rise could be fairly easily accommodated in raised stopbank levels. The areas benefitting from the Selwyn River scheme downstream of 2 km would be severely affected by a Lake Ellesmere level of, say, 2 m so there would be little gained in maintaining a high flow capacity beyond that point (unless perhaps there is wholesale raising of ground levels). The scheme does not therefore need to consider sea level rise to any great extent, but it is a particular issue for the Lower Selwyn Huts.

Flood frequency

There is considerable uncertainty in the recorded flood flow estimates and therefore the estimated flood flow frequency relationship for the Selwyn River / Waikirikiri. Nonetheless, a practical design flow can be chosen. Future changes in climate may mean that floods of the chosen size happen more often.

The MfE publication *Preparing for climate change: A guide for Local Government in New Zealand* includes a "screening method" for assessing the likely impacts of climate change on flood frequency estimates. It also describes more detailed quantitative assessments as being most likely to be required for, for example,

- whenever infrastructure is upgraded, or major developments are undertaken
- if some infrastructure and developments have a lifetime of more than 30 years

Any significant upgrade of the Selwyn River / Waikirikiri stopbanks would fit these criteria. However, there is enough uncertainty in the existing estimate of the flood frequency relationship that a more detailed quantitative assessment of the impacts of climate change on flood frequency is not warranted for this catchment at this stage.

In a series of general statements, the publication indicates that extreme rainfall is likely to become heavier, particularly where annual rainfall is likely to increase. It indicates, with a "moderate confidence" that extreme rainfalls are likely to be within the range of: "No change through to halving of heavy rainfall return period by 2040; no change through to fourfold reduction in return period by 2090."

The MfE report *Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand* screening method for Canterbury indicates that:

- the mid-range estimates for temperature rise are 0.9 °C by 2040 to 2.0 °C by 2090, with some minor seasonal variation. Extreme rainfalls are anticipated to increase in intensity by 8% per degree of warming (mid-range estimate).
- the mid-range estimate for annual precipitation in Christchurch is a marginal 1% reduction by 2040 and 2% by 2090, with less rainfall in winter and spring but more in summer and autumn, while the mid-range estimate for Tekapo is an increase of 4% by 2040 and 8% by 2090, particularly in winter and spring.

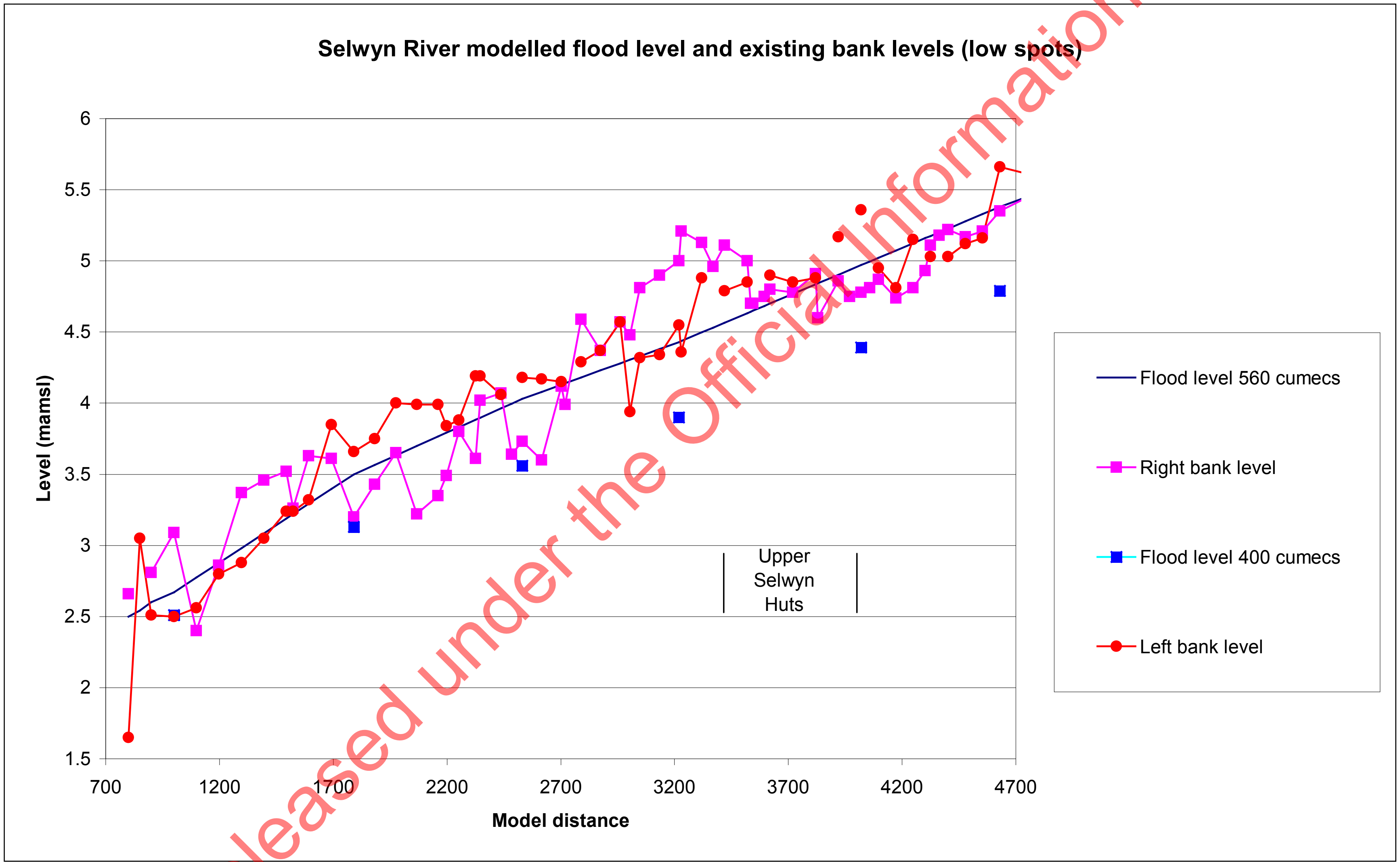
The MfE publications describe the confidence in the prediction of an increase in mean temperature as "very confident", while having "moderate confidence" in the broad quantity of the change in temperature and in the likelihood that this would lead to increased rainfall intensity.

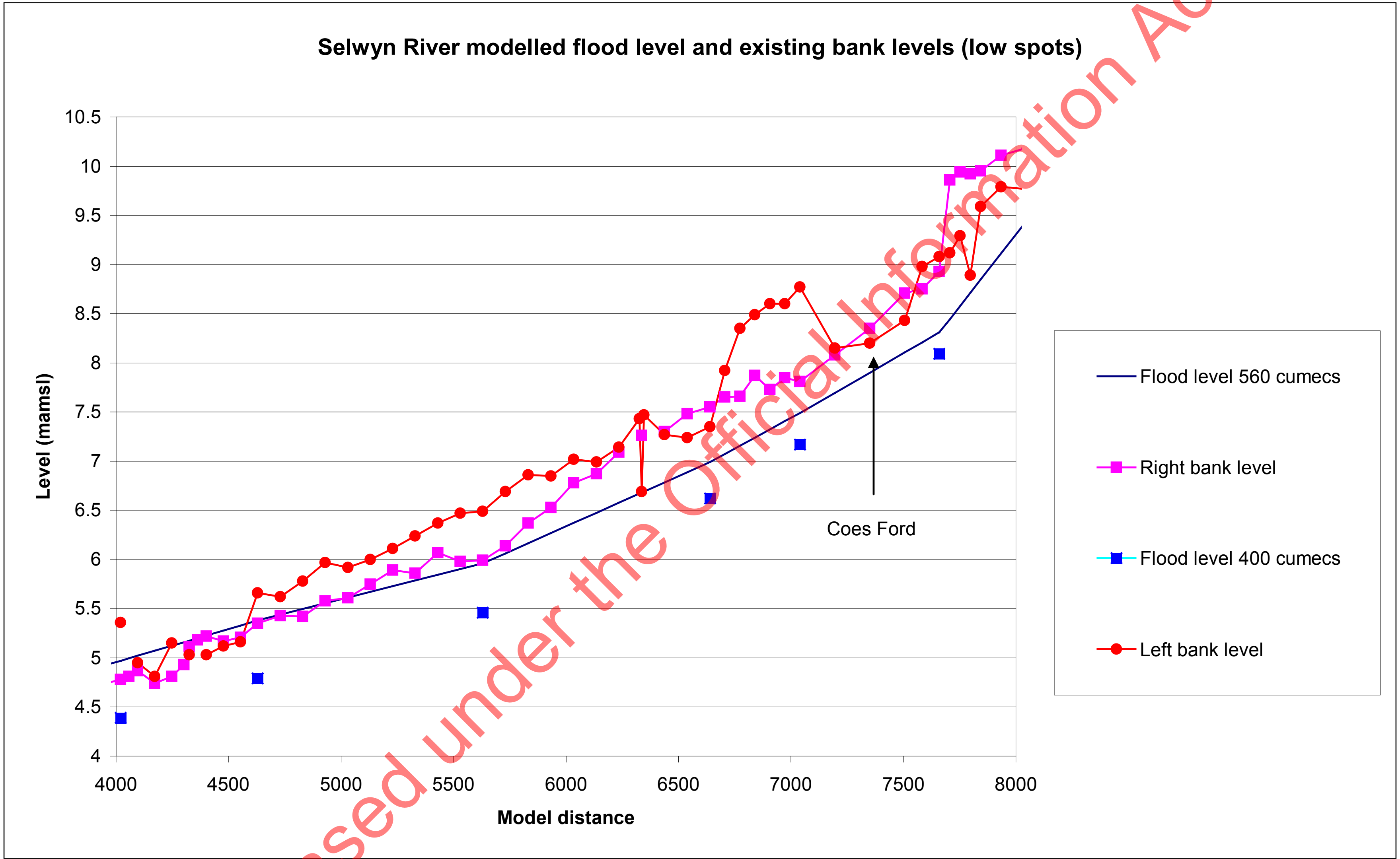
For the Selwyn/Waikirikiri catchment, it appears that changes in mean annual (and seasonal) rainfall are not likely to be particularly large, but that extreme rainfall intensities are liable to increase. Increases in rainfall intensities of 8% by 2040 and 16% by 2090 would be consistent with approximately doubling (2040) and quadrupling (2090) the frequency of a given extreme rainfall. We could therefore expect the frequency of a given flood flow rate to be exceeded about twice as often by 2040 and four times as often by 2090.

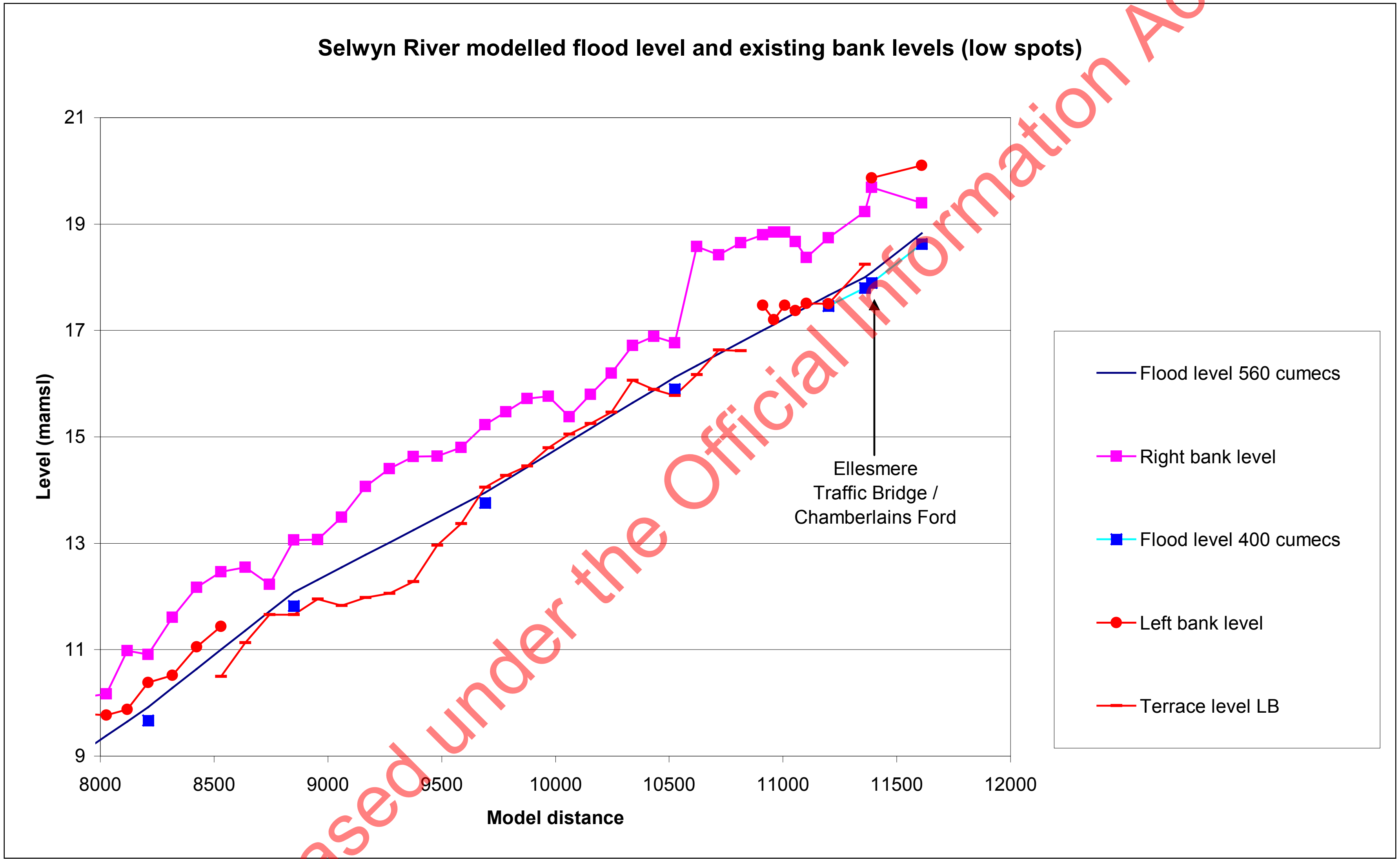
In other words, what we now might describe as about a 100 year event could become about a 50 year event by 2040 and about a 20-30 year event by 2090. In terms of flow rates, this could mean increases of the order of 20% by 2040 and 50% by 2090. In order to cater for a flood frequency corresponding to the current design flow of 560 m^3/s, we may need to design for a flow of 840 m^3/s by 2090.

More sophisticated techniques for estimating the impact of more intense rainfall (such as those described in *Tools for Estimating the Effects of Climate Change on Flood Flow: A Guidance Manual for Local Government in New Zealand)* have not been applied at this stage.

Appendix 2 – Longsection of main stopbanked section of Selwyn River




Selwyn River modelled flood level and existing bank levels (low spots)
Level (mamsl)
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
4000
4500
5000
5500
6000
6500
7000
7500
8000
Model distance
Coes Ford
Flood level 560 cumecs
Right bank level
Flood level 400 cumecs
Left bank level


Selwyn River modelled flood level and existing bank levels (low spots)
Level (mamsl)
21
19
17
15
13
11
9
8000
8500
9000
9500
10000
10500
11000
11500
12000
Model distance
Ellesmere
Traffic Bridge /
Chamberlains Ford
Flood level 560 cumecs
Right bank level
Flood level 400 cumecs
Left bank level
Terrace level LB

Appendix 3 – Indicative main overflow locations

Selwyn river -significant overflow locations 400 cumecs

Irwell flow	Outflow south	Location south bank	River distance (km)	River width	Remaining Flow	Max overflow depth (560 cumecs)	Length (km)	Location north bank	Outflow north	
		Westenras Rd			400			Greendale Golf Course		
5	5			900	395	1	1.1			
10	5	Old South Rd		700	390	0.5	1.5			
15	10	Highfield Rd		550	385	0.6	3			
40	25	d/s SH1 towards Boundary Creek Rd		500	360	0.5	1.5			
				350	360	insufficient info	0.7	Corbetts/Ashley Dene Rd	?	Returns?
	0	opp Swamp Rd towards Lake Rd South	14.0	550	360	0.5	0.2			
			8.8	300	360	1	1.9	u/s Goulds Rd	?	Returns(?) at Coes Ford
	0	Selwyn Lake Rd	4.6	80	360	0.5	1.1			
			4.3	80	360	0.3	0.5	u/s Upper Selwyn huts	0	
			3.2	80	360	0.3	0.2	d/s Upper Selwyn Huts	0	
	0	Last corner	2.5	80	360	0.5	1			
	0		1	80	360	0.2	0.6	Lower Selwyn huts		

Selwyn river -significant overflow locations 560 cumecs

Irwell flow	Outflow south	Location south bank	River distance (km)	River width	Remaining Flow	Max overflow depth (560 cumecs)	Length (km)	Location north bank	Outflow north	
		Westenras Rd			560			Greendale Golf Course		
20	20			900	540	1	1.1			
40	20	Old South Rd		700	520	0.5	1.5			
60	40	Highfield Rd		550	500	0.6	3			
110	50	d/s SH1 towards Boundary Creek Rd		500	450	0.5	1.5			
				350	450	insufficient info	0.7	Corbetts/Ashley Dene Rd	20?	Returns?
	10	opp Swamp Rd towards Lake Rd South	14.0	550	440	0.5	0.2			
			8.8	300	440	1	1.9	u/s Goulds Rd	?	Returns(?) at Coes Ford
	0	Selwyn Lake Rd	4.6	80	440	0.5	1.1			
			4.3	80	440	0.3	0.5	u/s Upper Selwyn huts	0	
			3.2	80	440	0.3	0.2	d/s Upper Selwyn Huts	0	
	10	Last corner	2.5	80	430	0.5	1			
	0		1	80	430	0.2	0.6	Lower Selwyn huts		

Selwyn river -significant overflow locations 800 cumecs

Irwell flow	Outflow south	Location south bank	River distance (km)	River width (m)	Remaining Flow	Max overflow depth (560 cumecs)	Length (km)	Location north bank	Outflow north	
		Westenras Rd			800			Greendale Golf Course		
50	50			900	750	1	1.1			
100	50	Old South Rd		700	700	0.5	1.5			
140	80	Highfield Rd		550	660	0.6	3			
220	80	d/s SH1 towards Boundary Creek Rd		500	580	0.5	1.5			
				350	580	insufficient info	0.7	Corbetts/Ashley Dene Rd	50?	Returns?
	50	opp Swamp Rd towards Lake Rd South	14.0	550	530	0.5	0.2			
			8.8	300	530	1	1.9	u/s Goulds Rd	?	Returns(?) at Coes Ford
	20	Selwyn Lake Rd	4.6	80	510	0.5	1.1			
			4.3	80	500	0.3	0.5	u/s Upper Selwyn Huts	10	
			3.2	80	495	0.3	0.2	d/s Upper Selwyn Huts	5	
	40	Last corner	2.5	80	455	0.5	1			
			1	80	445	0.2	0.6	Lower Selwyn Huts	10	

Environment Canterbury
Regional Council
Kaunihera Taiao ki Waitaha

Everything is connected

Promoting quality of life through balanced resource management

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