

PATTLE DELAMORE PARTNERS LTD

HWP Waitohi Irrigation and Hydro Scheme: Assessment of Sediment
Transport Effects

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∴ Prepared for
Hurunui Water Project (HWP)

∴ September 2011



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Limitations:

This report has been prepared on the basis of information on potential future land use assumed by the Hurunui Water Project Ltd and environmental conditions determined by other parties.

The report describes a numerical modelling simulation of a natural hydrological regime and approximate analysis of sediment transport processes. Due to the variability of natural processes, the modelling output and accuracy of the sediment transport analysis cannot be guaranteed.

The report has been prepared for Hurunui Water Project, according to their instructions, for the particular objectives described in the report. The information contained in the report should not be used by anyone else or for any other purposes.

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Executive Summary

This report provides an assessment of the effects that the proposed HWP Waitohi Irrigation and Hydro scheme (the scheme) will have on sediment transport processes in the Hurunui and Waitohi Rivers.

It is proposed that the scheme is developed in two stages with Stage 1 including two storage dams on the Waitohi River and two irrigation intakes, one on the Hurunui River and the other on the Waitohi River. Stage 2 increases the storage capacity of the scheme with two further dams on the Waitohi River as well as a second pumped intake on the Hurunui River.

The key impacts on sediment transport processes will be as a result of the trapping of sediment in the dams on the Waitohi River and a reduction in the sediment transport capacity of the Hurunui due to the abstraction of water. The reduction in flood flows in the Waitohi due to storage/routing in the dams will also have an impact on the sediment transport capacity of that river system.

The sediment being trapped in the dams on the Waitohi River will reduce the storage capacity of these dams and reduce the supply of sediment to the downstream river channel. The dams will also regulate flows and reduce the number of flood events that can move sediment in the downstream channel. The downstream channel is formed of coarse gravel and the process that is most likely to occur is bed level degradation (lowering) and armouring of the surface layer.

The Stage 1 dams on the Waitohi River are estimated to trap approximately 15,500 T/yr of fine sediment and 1,200 T/yr of coarse sediment in their upstream reservoirs. As a result of this the downstream Waitohi River Channel is estimated to degrade by approximately 0.065 m. The river channel will degrade over decades as finer material is washed out of the surface deposits and a coarse armour layer develops.

The Stage 1 water abstraction from the Hurunui River is estimated to result in approximately 6,100 Tonnes per year (T/yr) of fine sediment (suspended load) being removed from the system. This is around 1.4 % of the total annual suspended load (430,000 T/yr) of the Hurunui River at this location.

The Stage 1 water abstraction will also reduce the capacity of the Hurunui River to transport larger gravel material. It is estimated that this will reduce by approximately 700 T/yr. This is approximately 2% of the estimated annual bedload transported in this reach (35,000 T/yr). The river response to the reduced sediment transport capacity will most likely be minor aggradation (steepening). Over a period of 50 years this is unlikely to exceed a total of 20 mm.

Downstream of the Waitohi Confluence there will be the combined effects of the Waitohi dams/abstraction and the Hurunui abstraction. The reduction in the bedload sediment transport capacity downstream of the Waitohi Confluence is approximately 1400 T/yr. However, this is almost entirely offset by the reduction in bedload supply from the Waitohi

River due to the sediment trapped in the dams (1200 T/yr). The river downstream of the confluence may aggrade 10 mm over 50 years in response to this change.

The effects of Stage 1 on sediment transport are considered to be no more than minor.

The addition of the Stage 2 dams on the Waitohi River increases the sediment trapping to an estimated 15,900 T/yr of fine sediment and 1,300 T/yr of coarse sediment. The large upstream dam at Hurricane Gully will reduce flood flows in the downstream river and result in the degradation/armouring processes occurring more slowly. The extent of the channel degradation (0.065m) is not expected to change but it is likely to take longer to occur than if only the Stage 1 dams were developed.

There are two Stage 2 abstractions from the Hurunui River, an upstream pumped intake (Intake 3) and the enlarged Stage 1 intake (Intake 1) near the Mandamus River Confluence.

At Intake 3 there will be approximately 17,000 T/yr of fine sediment removed from the system. This is approximately 4% of the total annual suspended load in the Hurunui River. This will have a no more than minor impact on the river. The abstraction of water at Intake 3 will also reduce the capacity of the downstream channel to transport bedload by approximately 1,600 T/yr. This is estimated to result in channel aggradation of approximately 100 mm over 50 years. The effects of this are considered to be no more than minor.

At Intake 1 there will be approximately 23,000 T/yr of fine sediment removed from the system. This is approximately 5% of the total annual suspended load in the Hurunui River.

The abstraction of water at Intake 1 combined with the abstraction at Intake 3 will result in a reduction in the bedload transport capacity of 4,500 T/yr in this reach. This will likely result in channel aggradation of approximately 100 mm over approximately 50 years. The effects of this are considered to be no more than minor.

The removal of suspended sediment over both intakes is 40,000 T/yr and amounts to approximately 9% of the total suspended sediment load in this reach of the river. This will have a minor effect on the river.

On the Hurunui River, downstream of the Waitohi Confluence (SH7 Bridge) the capacity of the river to transport bedload is estimated to reduce by 6,100 T/yr. This is somewhat offset by the reduction in bedload supply as a result of the coarse sediment trapped in the Waitohi Dams (1400 T/yr). The net result is a reduction in bedload transport capacity of 4,700 T/yr in the reach downstream of the Waitohi Confluence. This could result in channel aggradation of approximately 200 mm over 50 years. This is considered to be a minor effect.

The reduction in suspended load at this point in the Hurunui River is 56,000 T/yr when taking account of the combined effects of the sediment trapped in the Waitohi Dams and that removed through the Hurunui intakes. This represents 11% of the total suspended load at this location in the Hurunui River and 1% of the suspended sediment load

supplied to the coast from the surrounding rivers. This could have a more than minor effect. Mitigation is suggested in the form of flushing the sediment deposited in the intakes back into the river during periods of high flow in winter. This will return suspended sediment to the system and will also enable larger bedload material to be moved through the system which will reduce the extent of the channel aggradation through all of the reaches considered. With this mitigation in place the effects of the Stage 2 development will be reduced to no more than minor.

Summary of River Sediment Effects

Components of Scheme	Changes to Waitohi River		Changes to Hurunui River				
	Sediment Trapping in Reservoir (T/year)	Degradation of Riverbed (mm over 50 + years)	Above Waitohi Confluence			Below Waitohi Confluence	
			Removal of Sediment via Water Abstraction (T/year)	Reduced Sediment Transport Capacity (T/year)	Aggradation of Riverbed (mm over 50 years)	Reduced Sediment Transport Capacity (T/year)	Aggradation of Riverbed (mm over 50 years)
Stage 1 * Seven Hills storage dam on Waitohi River * Inches Road storage dam on Waitohi River * Intake 1 on Hurunui River at Mandamus * Intake 2 on Waitohi River	15,500 (fine) 1,200 (coarse)	65	6,100	700	<20	1,400 (net decrease of 200)	<10
Stage 2 * Hurricane Gully storage dam on Waitohi River * Lower Gorge storage dam on Waitohi River * Intake 3 pumping water from Hurunui River * Enlargement of Intake 1 on Hurunui River	15,900 (fine) 1,400 (coarse)	65	40,000 (17,000 at Intake 3, 23,000 at Intake 1)	4,500 (1,600 from Intake 3, 2,900 from Intake 1)	100	6,100 (net decrease of 4,700)	200
Note: For comparison: * the assumed total suspended sediment load in the Hurunui River is approximately 430,000 T/year at Mandamus, 490,000 T/yr downstream of the Waitohi Confluence, 530,000 T/year whole Hurunui Catchment and the supply to the coastline including the Waiau and Waimakariri Rivers is 6,100,000 T/year; * the assumed bed load transport for the Hurunui River is 35,000 T/year at Mandamus.							

1.0 Introduction

Pattle Delamore Partners Limited (PDP) has been engaged by the Hurunui Water Project (HWP) to assess the sediment transport/river morphology effects that would arise from the proposed HWP Waitohi Irrigation and Hydro Scheme (the scheme).

It is proposed to develop the scheme in two stages. A full description of the elements of the both stages is provided in the Project Memorandum – Description of Waitohi Option Staging Rev 14 27/09/11 which is appended to this document (Appendix A). A brief summary of the scheme staging is provided below.

In Stage 1 two dams are proposed on the Waitohi River, one at Seven Hills the other at Inches Road. These dams would provide a total live storage volume of 11.2 Mm³. Stage 1 also has two river intakes; Intake 1 is on the Hurunui River at Mandamus and Intake 2 is on the Waitohi River.

In Stage 2 a further two dams are proposed for the Waitohi River increasing the total live storage volume to 221 Mm³, mainly through the Hurricane Gully dam which is 105 m high and has a total live storage volume of 209.5 Mm³. The other Stage 2 dam (Lower Gorge 1) is needed to divert water into the distribution canal. Both these dams will have hydro-generation infrastructure. In Stage 2 a pumped intake (Intake 3) is proposed to deliver water via a rising main into the Hurricane Gully dam and Intake 1 on the Hurunui is to be enlarged to take a greater volume of flow. A further feature of Stage 2 is the addition of hydro-generation infrastructure to the Seven Hills and Inches Road dams.

The key processes in terms of sediment transport and channel morphology are:

- ✦ Trapping of sediment upstream of dams on the Waitohi River;
- ✦ Trapping of suspended sediment in intake sediment ponds;
- ✦ Reduction in river flows reducing the capacity of the rivers to transport larger bedload sediment.

The suspended sediment load is made up of fine grained sand and silt material that is dispersed through the flow by turbulence and is transported in suspension. Larger material such as coarse sand, gravel, cobbles and boulders is too heavy to be transported in suspension and it rolls, slides, hops along the bed of the river. The river flow, and hence velocity, required to initiate and keep bedload in motion is far greater than that required for the suspended load. Also, during one flood event the smaller fractions of the suspended load may travel all the way through the river system out to sea whereas the bedload may only move a few hundred metres downstream.

These processes have been examined using sediment samples from the both rivers, reach scale hydraulic parameters, a suspended sediment rating curve, bedload rating curves, suspended sediment yield GIS tool, outputs from hydrological modelling and empirical relationships relating to river response. The analysis that has been undertaken is considered to be approximate only and provides an indication of the extent of the effects of the proposed scheme on a reach based scale.

2.0 Description of Environment

The description of the environment covers a broad catchment description and then a more specific description is provided on reaches of the Waitohi and Hurunui Rivers relevant to this study.

2.1 Catchment

The 2670 km² Hurunui River catchment originates on the eastern side of the Southern Alps in North Canterbury and flows in a westerly direction out to the coast just north of Sail Rock. The catchment is tectonically active with the underlying geology being predominantly greywacke. The annual rainfall of the catchment varies from 6000 mm in the headwaters down to 700 mm on the Amuri Plain. Catchment vegetation is a mixture of tussock grassland, gorse, broom and native forest. An important feature of the upper catchment is the glacial lakes, the largest being Lake Sumner. This previously glaciated valley is dammed by its terminal moraine and the resulting lake has trapped approximately ½ the sediment generated by the catchment in the proceeding years.

The Waitohi River is a major tributary of the Hurunui River with a catchment area of approximately 268 km². The Waitohi River drains the southern region of the Amuri plain extending from the low hill country of the Waitohi Downs up to the Puketeraki Range.

2.2 Specific Reaches

2.2.1 Hurunui River - Intake 3 to Intake 1

This reach of the Hurunui River includes the Hawarden Gorge which the river flows through just before being joined by the Mandamus River at the head of the Amuri Plain. The channel upstream of the gorge to the intake site is generally bordered by confining river terraces and hill country. The width is typically 50 m and the river channel is steep (1:200) with coarse gravel and boulders on the bed. The approximate particle size distribution of the bed material is provided in Appendix B.

2.2.2 Hurunui River - Intake 1 to SH7

The Hurunui River widens to approximately 400 m once it reaches the Amuri plain and takes on a braided form typical of other South Island gravel bed rivers. There is generally a main braid that takes a substantial portion of flow along with a number of minor braids taking the remaining flow. The slope remains steep at 1:200 and the river bed material has a similar particle size distribution to that of the upstream reach. The approximate particle size distribution is provided in Appendix B.

2.2.3 Hurunui River - SH7 to Lowry Peaks Gorge

This reach of the river is similar to the reach immediately upstream but is notable in terms of this study as the point from which the Waitohi River joins the Hurunui.

2.2.4 Hurunui River Lowry Peaks Gorge to the Sea

The Hurunui flows through the Lowry Peaks Gorge as a single thread before flowing out to sea via a small lagoon and barrier beach. The barrier beach closes infrequently due to the combined effects of severe low flows ($< 10 \text{ m}^3/\text{s}$ at Mandamus) and vigorous wave action. Seepage flows of $4 - 5 \text{ m}^3/\text{s}$ through the closed river beach barrier have been estimated by Docherty (1979).

2.2.5 Waitohi Upstream of Dams

The headwaters of the Waitohi are steep grazed farmland with patches of tussock and matagouri. The Waitohi River is a steep single thread channel approximately 15-20m wide in this reach and flows through a short gorge section before emerging onto the Amuri Plain.

2.2.6 Waitohi Downstream of Dams

The Waitohi River, like the Hurunui, widens significantly upon reaching the Amuri Plain. It increases to a width of approximately 125 m and takes the form of a small braided gravel bed river. It is also very steep (1:170) and has a bed made predominantly of medium/coarse gravel. The approximate particle size distribution is provided in Appendix B.

2.3 Sediment Transport

2.3.1 Suspended Load

The best information on suspended sediment for the Hurunui River is the sediment gaugings undertaken at Mandamus predominantly between 1965 and 1967. These 41 gaugings have been used to estimate sediment rating curves at Mandamus. By combining the suspended sediment rating curves with flow duration characteristics the annual suspended load can be estimated. The estimate for the suspended sediment flux at Mandamus based on this methodology is 480,000 T/yr to 550,000 T/yr. The suspended sediment rating curves, including the gauged points, are provided in Appendix C. The NIWA sediment yield GIS tool has also been used and provides a comparable figure of 430,000 T/yr at Mandamus, 490,000 T/yr downstream of the Waitohi Confluence and 530,000 T/yr for the whole catchment. It is also worth noting that the total supply to the coast in this region is 6,100,000 T/yr when including the two other major nearby rivers (3,200,000 T/yr – Waimakariri River and 2,400,000 T/yr - Waiau River).

2.3.2 Bedload

There are no surveyed river cross sections or bedload gauging data sets available for the Hurunui or Waitohi Rivers to allow an accurate bedload rating to be developed. Approximate bedload rating curves have been developed using the Parker (1990) surface based equations within the BAGS (bedload assessment in gravel-bedded streams) software package. Combining the bedload rating curves with the flow duration characteristics for the Hurunui River at Mandamus provides an approximate annual bedload transport rate of 35,000 T/yr. This represents 8% of the total sediment load which is within the expected range based on other South Island gravel bed river. The approximate bedload rating curves are provided in Appendix D.

3.0 Assessment of Potential Effects – Stage 1

3.1 Dam Sedimentation (Waitohi River)

The Inches Road and Seven Hills dams will trap almost all of the sediment generated by the upstream catchment. **Table 1** provides a summary of the annual sediment trapped in the reservoirs as well as an estimate of the loss in storage over a 50 year period assuming a deposited density of 1.4 T/m³. The analysis has been based on data from the NIWA sediment yield mapping tool and assuming that bedload makes up approximately 8% of the total load sediment yield. The sediment will deposit at the upstream extent of the reservoir and propagate downstream as more sediment is deposited. The effects on the reservoirs will no more than minor.

Dam	Live Storage (Mm³)	Suspended Sediment Trapped in Reservoir (T/yr)	Bedload Trapped in Reservoir (T/yr)	Total Sediment Trapped in Reservoir (T/yr)	Total Volume of Sediment After 50 years Mm³ (% of total storage)
Inches Road	3.9	3,022	263	3,285	0.1 (3%)
Seven Hills	7.3	12,423	1,067	13,490	0.5 (7%)
Total	11.2	15,445	1,330	16,775	0.6 (5%)

3.2 River Bed Armouring/Erosion (Waitohi River)

The sediment trapped in the dams will result in 'clear water' flows in the downstream river channel that will erode the finer gravel and sand making up the surface layer of the river. As this occurs coarse armour layer will develop on the surface. Following the 'Armouring Method' procedure described in Appendix A of Design of Small Dams (USBR 1987) yields a representative armour layer size of 19 mm and an armour layer thickness of 57 mm. Approximately 47 % of the bed material in the Waitohi River is larger than the representative armouring size and therefore the approximate depth of degradation to the armour layer is predicted to be 65 mm and this could take approximately 50 years to occur. This is considered to be no more than minor impact on Waitohi River.

3.3 Suspended Sediment Loading at Intake 1 (Hurunui River)

Using the worst case (highest annual yield) suspended sediment rating curve for the Hurunui at Mandamus and the output from the hydrological modelling for the 39 year simulation period results in an average suspended sediment loading of 6100 T/yr at Intake 1. If it is assumed that all of this sediment is permanently removed from the system (i.e. excavated from the sediment pond and disposed of out of the river catchment) this would equate to a loss of approximately 1.4% of the total suspended load. This is considered to be a no more than minor impact. Furthermore, it is likely that operationally it will be more practical to have an intake arrangement that allows most of this sediment to be flushed back into the river during periods of high flow. Having the flushing system operating during times of high flow will allow significant volumes of sediment to bypass the system while also flushing out sediment that has previously deposited in the sediment ponds. The abstraction of flow does result in a 'de-powering' in the downstream river channel but as the river is sufficiently steep so that the residual flow will still have greater than the required energy to keep the fine sand and silt sized particles in suspension. Approximate calculations indicate that even at minimum flows there would be sufficient shear stress for typical suspended sediment particles ($D_{50} = 0.014\text{mm}$ – South Island foothills greywacke and argillite) (Hicks et al 2004) to remain in suspension.

3.4 Deposition Downstream of Intake 1 (Hurunui River)

The abstraction of flow from the Hurunui River will impact on its ability to transport larger gravel material. The arrangement of the intake structure would normally prevent any significant inflow of bedload meaning that all of the bedload would have to be transported by the flow remaining in the river. Using the approximate bedload rating curve for the Hurunui River and the output from the hydrological modelling provides an estimated loss of sediment transport capacity of approximately 700 T/yr in the reach downstream of Intake 1. This represents a 2 % reduction in the bedload transport capacity within this reach. This reduction in capacity will likely result in sediment depositing in this reach as the channel adjusts to the modified hydrological regime. Assuming that 700 T/yr of sediment will be deposited in this reach results in aggradation of approximately 20 mm over a 50 year period.

3.5 Deposition Downstream of SH 7 (Hurunui River)

Downstream of SH7 and the confluence of Waitohi River the combined effects of the Waitohi Dams and the abstraction of water from the Hurunui will become evident. The reduction in bedload transporting capacity in this reach is estimated to be 1,400 T/yr but this is approximately balanced by the reduction in bedload from the Waitohi (1,342 T/yr) as a result of the sediment trapped in the dams. In terms of suspended load at this point the total annual supply is reduced by approximately 22,000 T making up 5 % of the 490,000 T/yr estimated for this reach of the river and a 0.4% reduction to the coastline. The

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overall impact of the scheme downstream of SH7, including the coastal area, is considered to be no more than minor.

The scheme will have a no more than minor impact on the river mouth opening as none of the intakes will be operating during low flow conditions ($< 12 - 15\text{m}^3/\text{s}$) when the mouth tends to close. Furthermore the scheme will not affect the occurrence of extreme wave conditions which are a significant contributing factor to mouth closure.

4.0 Assessment of Potential Effects – Stage 2

4.1 Dam Sedimentation (Waitohi River)

Following the same methodology as used in Stage 1 an assessment has been made of the sediment trapped in the dams on the Waitohi River. It has been assumed that the pumped inflows from the Hurunui River into Hurricane Gully are free of any substantial sediment load. Table 2 provides a summary of the results. The effects within the upstream reservoirs is considered to be no more than minor.

Dam	Live Storage (Mm³)	Suspended Sediment Trapped in Reservoir (T/yr)	Bedload Trapped in Reservoir (T/yr)	Total Sediment Trapped in Reservoir (T/yr)	Total Volume of Sediment After 50 years Mm³ (% of total storage)
Lower Gorge 1	0.4	427	37	464	0.016 (4%)
Inches Road	3.9	3,022	263	3,285	0.1 (3%)
Seven Hills	7.3	1,031	89	1,120	0.04 (0.5%)
Hurricane Gully	209.5	11,392	990	12,382	0.4 (0.2%)
Total	221.1	15,872	1,379	17,251	0.6 (0.3%)

4.2 River Bed Armouring/degradation (Waitohi River)

The impact of the Stage 2 dams in terms of the downstream armouring/degradation is the same as that predicted for the Stage 1 assessment. It is noted that the large Hurricane Gully reservoir will result in a reduction in flood flows in the Waitohi but this will just change the rate at which the armouring/degradation occurs and not the predicted extent. The assessment of the impact of the Stage 2 works is considered no more than minor for the Waitohi River.

4.3 Suspended Sediment Loading at Intake 3 (Hurunui River)

Following the previously described methodology the suspended sediment loading at Intake 3 will be approximately 17,000 T/yr. This represents approximately 4% of the total

suspended sediment load and its removal from the system will result in no more than a minor impact.

4.4 Deposition Downstream of Intake 3 (Hurunui River)

The bedload sediment transport capacity of the downstream reach will reduce by approximately 1,600 T/yr. If this material is assumed to now be deposited in this reach then channel aggradation of approximately 100 mm over a 50 year period is expected. This is considered to be a no more than minor impact within this reach.

4.5 Suspended Sediment Loading at Intake 1 (Hurunui River)

With Intake 1 enlarged to take the full design flow the suspended sediment loading increases to 23,000 T/yr. This in itself represents 5% of the total annual suspended sediment load and when added to the sediment removed at Intake 3 represents a total of 9% removed. It is considered that this change would have a minor effect. As previously mentioned it is likely that a flushing regime will be required to effectively maintain these intake structures and that if this is the case then sediment would be returned to the system. This is discussed further in Section 5.0.

4.6 Deposition Downstream of Intake 1 (Hurunui River)

The combined impact of both the abstractions is a reduction in the bedload sediment transport capacity of the downstream reach of 4,500 T/yr. Assuming this material deposits over an active channel of approximately 100m this results in approximate aggradation of 100 mm over a 50 year time period in the reach down to SH7. It is noted that the river may take 75 – 100 years to adjust to the change and that the rate of deposition would reduce over time. This level of aggradation is considered to be minor in this reach of the river. It should be noted that modified hydrological regime only reduces the occurrence of flows in excess of the mean annual flood by approximately 10% and that there will still be significant flow variability and events capable of shifting channel patterns and braids within the main floodway channel.

4.7 Deposition Downstream of SH 7 (Hurunui River)

The estimated reduction in the downstream bedload sediment transport capacity is 6,100 T/yr. However, this is offset by the bedload trapped in the Waitohi Dams (1,400 T/yr) and the overall deficit is considered to be 4,700 T/yr. Assuming that this deposits within the reach between SH7 and the Lowry Peaks Gorge the estimated channel aggradation over 50 years is 200 mm. This is considered to be a minor impact. The total reduction in suspended sediment load in this reach is 56,000 T/yr representing 11 % of the total suspended load for the Hurunui catchment and 1% of the total supplied to the coast from the surrounding rivers. It is considered that this could have a more than minor impact on the downstream channel and coastline. Mitigation is specifically discussed in the following section.

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The impact on the scheme on the opening of the river mouth is no more than minor as the scheme does not operate during extreme low flow conditions (12-15 m³/s).

5.0 Mitigation

The reduction in suspended sediment load downstream of SH7 in the Hurunui River as a result of the Stage 2 intakes and dams is considered to have a more than minor impact with 11% of the suspended sediment load being removed from this reach of the river and 1% being removed from the supply to the coastline in this area. It has already been discussed that the suspended sediment taken out of the river while abstracting flows at Intakes 3 and 1 could be returned to the system with a flushing regime incorporated as part of the operation/maintenance regime. This would involve shutting these intakes down during a period of high flow (of around 300 m³/s or greater) and allowing a flushing/bypass system to operate. This is considered to be an essential part of maintaining the intake sediment ponds in an operational condition whilst minimising the impact on the river. It is estimated that flows greater than 300 m³/s transport approximately 65% of the bedload and 50% of the suspended load in the Hurunui River.

The natural flushing would likely need to be supplemented with mechanical excavation which is unlikely to be practical during periods of high flow. It is suggested that the flushing arrangements should be designed to ensure at least 75% of the incoming suspended sediment can be naturally flushed back into the river during periods of high flow with the remaining 25 % being mechanically removed as required. It is also suggested that flushing is undertaken during winter months when higher flows are more likely and so there is minimal impact on the reliability of the scheme to meet both irrigation demand and environmental enhancement during low river flow conditions.

This shutdown/flushing regime would also provide greater flows in the Hurunui to move gravel bedload through the system and would mitigate some of the predicted aggradation.

With an effective flushing regime in place the amount of suspended sediment removed from the system will reduce to 26,000 T/yr being 5% of the total suspended load for the catchment and 0.4% of the total sediment supplied to the coast from the surrounding rivers. With this mitigation in place the effects of the Stage 2 development would be reduced to no more than minor.

The assessment of these estimated effects in terms of the relevant planning instruments is described in Appendix E.

6.0 Conclusions

- ∴ The Stage 1 development of the HWP Waitohi Irrigation and Hydro Scheme will have no more than minor effects on sediment transport and the morphology of the Waitohi and Hurunui Rivers.
- ∴ With the proposed mitigation in place the Stage 2 development will have a no more than minor effect on sediment transport and the morphology of the Waitohi and Hurunui Rivers.

7.0 References

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Appendix A Description of Waitohi Option Staging

HURUNUI WATER PROJECT PROJECT MEMORANDUM

TO: Amanda Loeffen – HWP; Heidi Crawford – HWP
FROM: Paul Rivett – RILEY
REVIEWED: Paul Morgan – RILEY
DATE: 27 September 2011
SUBJECT: Description of Waitohi Option Staging
ATTACHMENTS: RILEY DWGs 11841-10-R3 & 11-R4
RILEY REFERENCE: 11841-B **DATE:** 27.09.11 **REV:** 14

Stage 1:

Table 1: Stage 1 Intakes

Intake	Intake No. ⁽¹⁾	Water RL (m)	Max. Flow (m ³ /s)	Comment
Hurunui River (at Mandamus) ⁽²⁾	1	280.0 or 305.0	3.9	Required to supply first-stage water
Waitohi River	2	280.0 or 305.0	3.9	Required to supply first-stage water

Notes: (1) Refer to attached plan 11841-10-R3 for location. (2) This may also be a point of discharge from Waitohi Storage to supply irrigation to north of Hurunui River.

Table 2: Stage 1 Dams

Dam	Crest RL (m)	Water RL (m)	Dam Height (m)	Crest Length (m)	Drawdown (m)	Live Storage Volume (MCM)	Peak Outflow (m ³ /s)
Seven Hills	405	400	46	150	20	7.3	3.9
Inches Road	375	370	31	245	20	3.9	3.9
Total						11.2	

Construction

1. Main run-of-river intake from the Hurunui River (Intake 1). The take at this Stage will be 3.9 m³/s, however parts of the construction will be undertaken for the maximum flow of 26.1 m³/s at Stage 2.
2. Main canal from Intake 1 at RL305m to supply initial 8,600 ha of land (6,900 ha of net irrigable area). This canal will continue to Washpen Stream.
3. Seven Hills and Inches Road dams and water release structures to provide 11.2 MCM initial in-catchment irrigation water from the Waitohi catchment.

4. Spillway for Seven Hills dam will be required to safely pass PMF (probable maximum flood) inflows; spillway for Inches Road dam will be required to safely pass PMF routed through Seven Hills dam (ie. attenuation of flood in Seven Hills reservoir will reduce peak flow).
5. Intake from Waitohi River (Intake 2) located where the main canal will cross the Waitohi River. This intake will supply the main distribution canal originating at Intake 1. The take at this Stage will be $3.9 \text{ m}^3/\text{s}$.

Operation

1. Both dams operated to meet irrigation demand. This may include full drawdown to specified levels depending on irrigation demand and natural inflows.
2. No hydro-generation included at either dam, although provision provided for its later development.

Hydrology

1. B-block run-of-river water is available to supply the initial 6,900 ha of net irrigable area together with any 'left over' A-block water from the existing Balmoral Scheme
2. For the purposes of hydrology, it is assumed that existing irrigators in the Waitohi catchment will become part of Stage 1. It is assumed that HWP will operate in a water users group with existing consent holders and obtain the beneficial use of consented water when not taken by that existing consent holder. It is possible that HWP will be able to increase reliability for these users, but it is not included in the model at this stage.
3. It is proposed to set a minimum environmental flow release of 250 l/s at the outlet of Inches Road Reservoir.
4. In addition, the Waitohi River below the main canal will convey up to $3.9 \text{ m}^3/\text{s}$ for distribution which will provide a variable flow in the river from this point.
5. The Stage 1 irrigable area will have an irrigation application rate of 0.45 l/s/ha and a demand/supply ratio of 93%.

Stage 2:

Table 3: Stage 2 Intakes

Intake	Intake No. ⁽¹⁾	Water RL (m)	Max. Flow (m ³ /s)	Comment
Hurunui River (at Mandamus) ⁽²⁾	1	280 or 305	26.1 ⁽⁴⁾	To supply run-of-river water to the distribution system.
First Stage Waitohi River	2	n/a	n/a	The Stage 1 intake at this location will be decommissioned.
Hurunui River (at pump station)	3	383.5	17	To supply pumped water into the Waitohi catchment for irrigation storage and hydro-generation.
Hurunui River (Amuri Scheme) ⁽³⁾	4	unknown	8.5	To supply run-of-river water to the existing Balmoral Scheme and Balmoral Forest.
Waitohi River at Lower Gorge Dam	5	325.0 & 340	42.4	To supply the main distribution canal and other areas from Waitohi storage.

Notes: (1) Refer to attached plan 11841-11-R4 for location. (2) This intake will also act as a discharge point for stored Waitohi water. (3) The existing Amuri Scheme intake. (4) 3.8 m³/s to be abstracted from the mid- and lower-Hurunui River riparian area and Domett.

Table 4: Stage 2 Dams

Dam	Crest RL (m)	Water RL (m)	Dam Height (m)	Crest Length (m)	Drawdown (m)	Live Storage Volume (MCM)	Peak Inflow (m ³ /s)	Peak Generation Outflow ⁽²⁾ (m ³ /s)	Peak Irrigation Outflow ⁽²⁾ (m ³ /s)
Hurricane Gully	505	500	105	429	50	209.5	17 ⁽¹⁾	35	42
Seven Hills	405	400	46	150	20 ⁽³⁾	7.3	42	8	42
Inches Road	375	370	31	245	20	3.9	42	8	42
Lower Gorge 1	345	340	21	71	1	0.4	42	8	42
Total						221.1			

Notes: (1) Not including Waitohi natural inflows. (2) The difference between peak generation and irrigation flows is to maximise generation efficiency. During peak irrigation flows, generation will be at peak and the difference will be released via a bypass. (3) Operating range for re-regulation will be up to 10 m. Full drawdown will occur in extreme dry years (5 to 10 years).

Construction

1. Completion of Hurunui River intake (Intake 1) to its full 26.1 m³/s capacity.
2. Upgrade of existing Amuri intake at the Hurunui River to supply the existing Balmoral Scheme and Balmoral Forest to its full capacity of 8.5 m³/s (Intake 4).
3. Upper intake on the Hurunui River, pump station, rising main, and tunnel to convey water into the Waitohi catchment (Intake 3 on plan).
4. Hurricane Gully dam, including spillways designed to safely pass PMF inflows, and water-release and hydro-generation infrastructure.
5. Hydro-generation infrastructure on the Seven Hills and Inches Road.
6. Lower Gorge 1 dam, including spillways design to safely pass PMF routed through upstream dams, and water-release and hydro-generation infrastructure. A high-level intake will be required at RL340m (Intake 5 on plan); a low-level intake directly from the dam outlet structure will be constructed to divert water to the main distribution canal.
7. If Lower Gorge 1 dam is not constructed, then an intake at RL325m will be required to provide gravity-fed water to areas above RL305m (Intake 5 on plan).

Operation

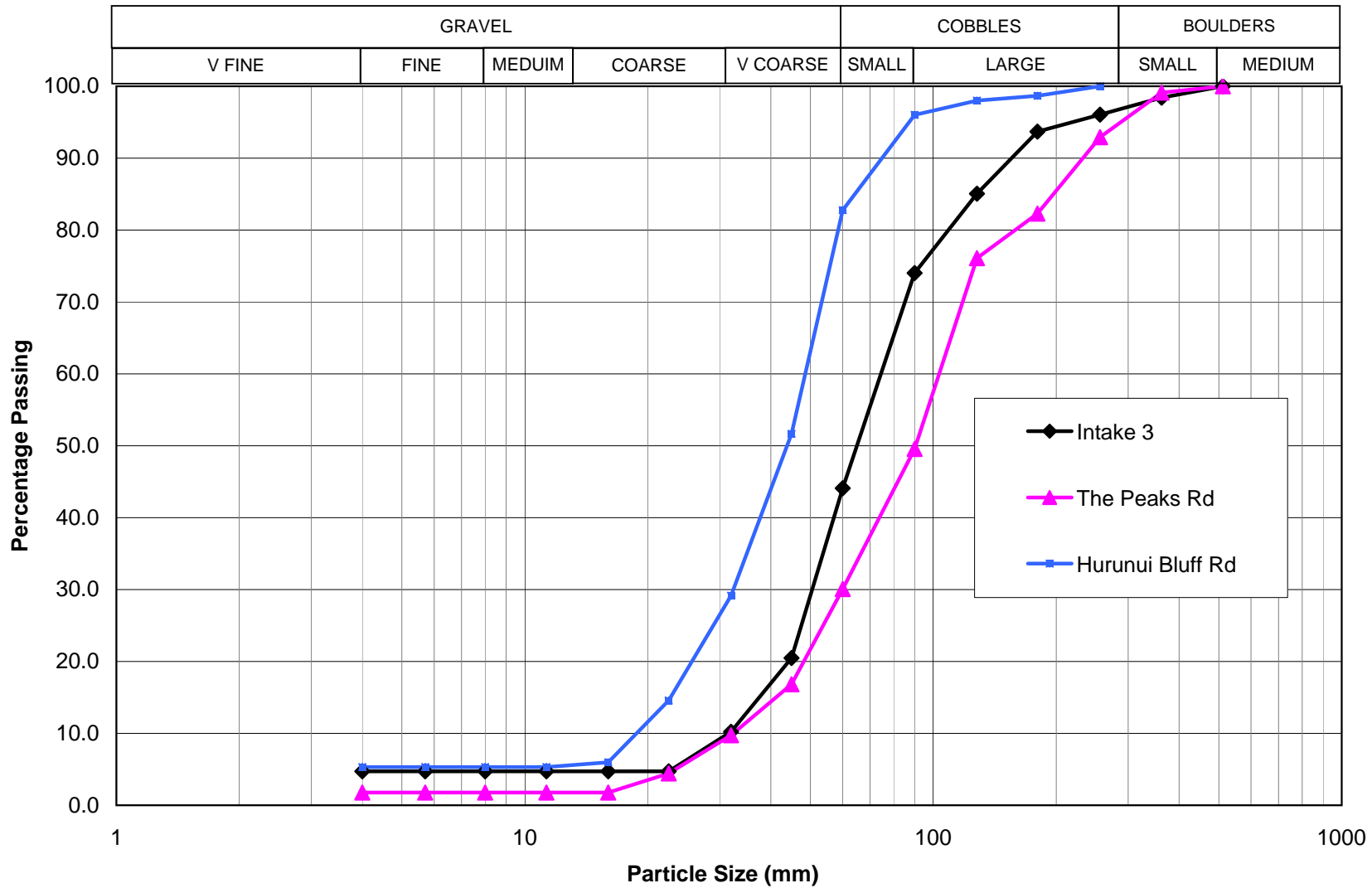
1. The upper Hurunui River intake (Intake 3) will divert and pump a maximum of 17 m³/s via rising main and tunnel into the Waitohi catchment.
2. Flows from the Hurricane Gully dam will be optimised for hydro-generation at a maximum flow-rate of 35 m³/s.
3. Seven Hills Reservoir is primarily used for re-regulation to attenuate hydro-generation flows generated by supplying electricity during peak demand periods. For the purpose of this simulation it is assumed that the reservoir will be drawn down in the weekends when the electricity demand is lower and therefore the release from Hurricane Gully is lower. This will result in a drawdown of up to 10 metres in the weekends. The water level will fluctuate throughout the day depending on electricity prices. This may result in water level fluctuations of up to 5 metres within one 24 hr period. Seven Hills dam will also be used for irrigation and be drawn down in extreme dry years. Peak inflows and outflows are presented in Table 4.
4. Inches Road dam will maintain a high reservoir level to maximise hydro-generation with normal operation being inflow = outflow but may be drawn down for irrigation in extreme dry years.
5. Lower Gorge 1 dam will maintain a high reservoir level to maximise hydro-generation with inflow = outflow.
6. The lower Hurunui River intake (Intake 1) will divert a maximum flow of 26.1 m³/s to the main distribution canal.
7. Waitohi intake (Intake 5) to divert a maximum flow of 42.4 m³/s to the main distribution canal.

Hydrology

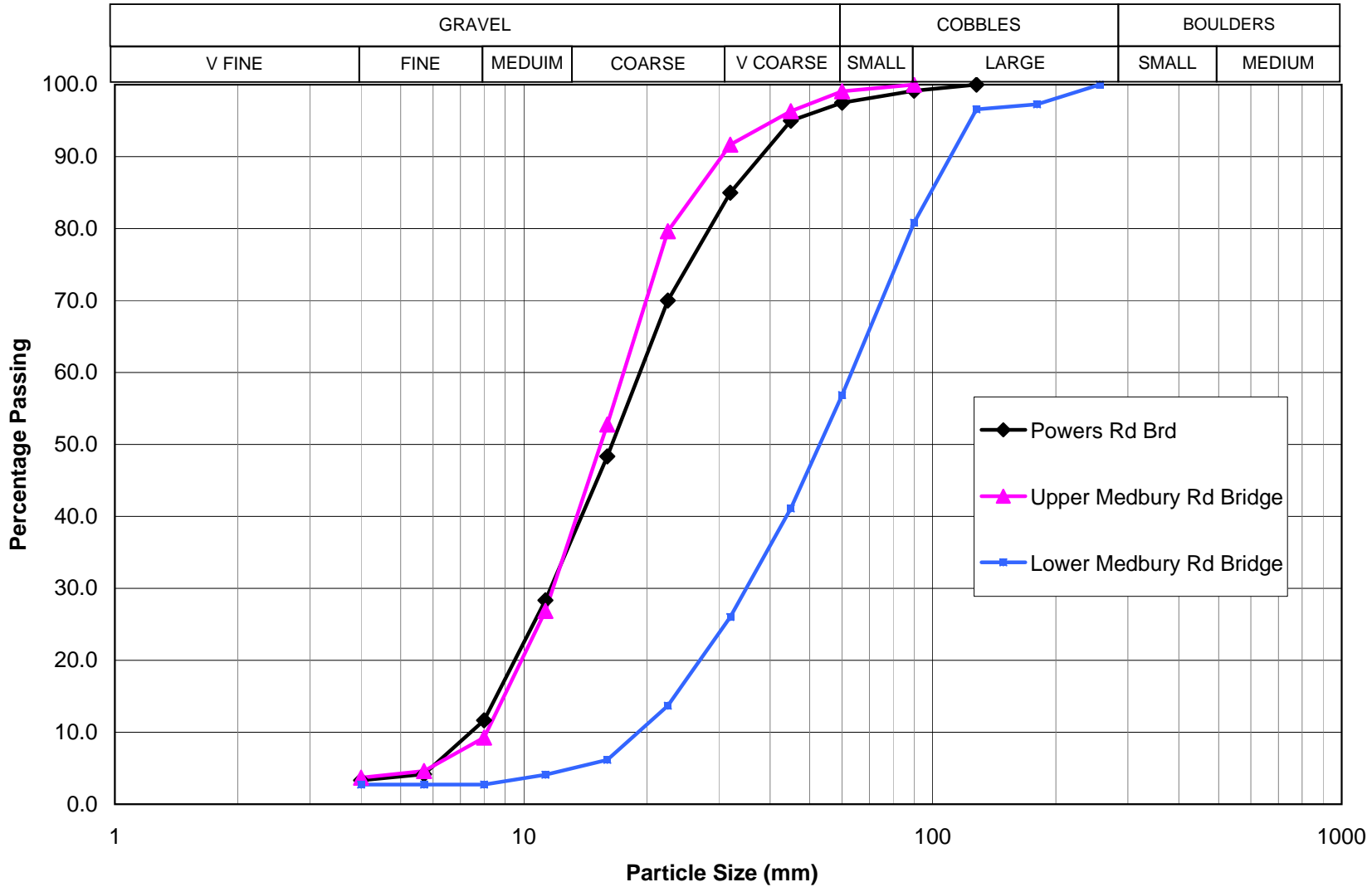
1. The existing A-block users in the relevant reaches of the Hurunui and Waitohi Rivers will be part of Stage 2, therefore A-, B- and C-block run-of-river water is available to supply the total net irrigable area of 58,500 ha.
2. The Stage 2 irrigable area will have an irrigation application rate of 0.6 l/s/ha and a demand/supply ratio of 98%.
3. It is proposed to set a minimum environmental flow release of 250 l/s at the outlet of Lower Gorge 1 reservoir.
4. Flows in the Waitohi River would be augmented by using the river for some of the distribution.

Appendix B Particle Size Distributions

Hurunui River Particle Size Distribution

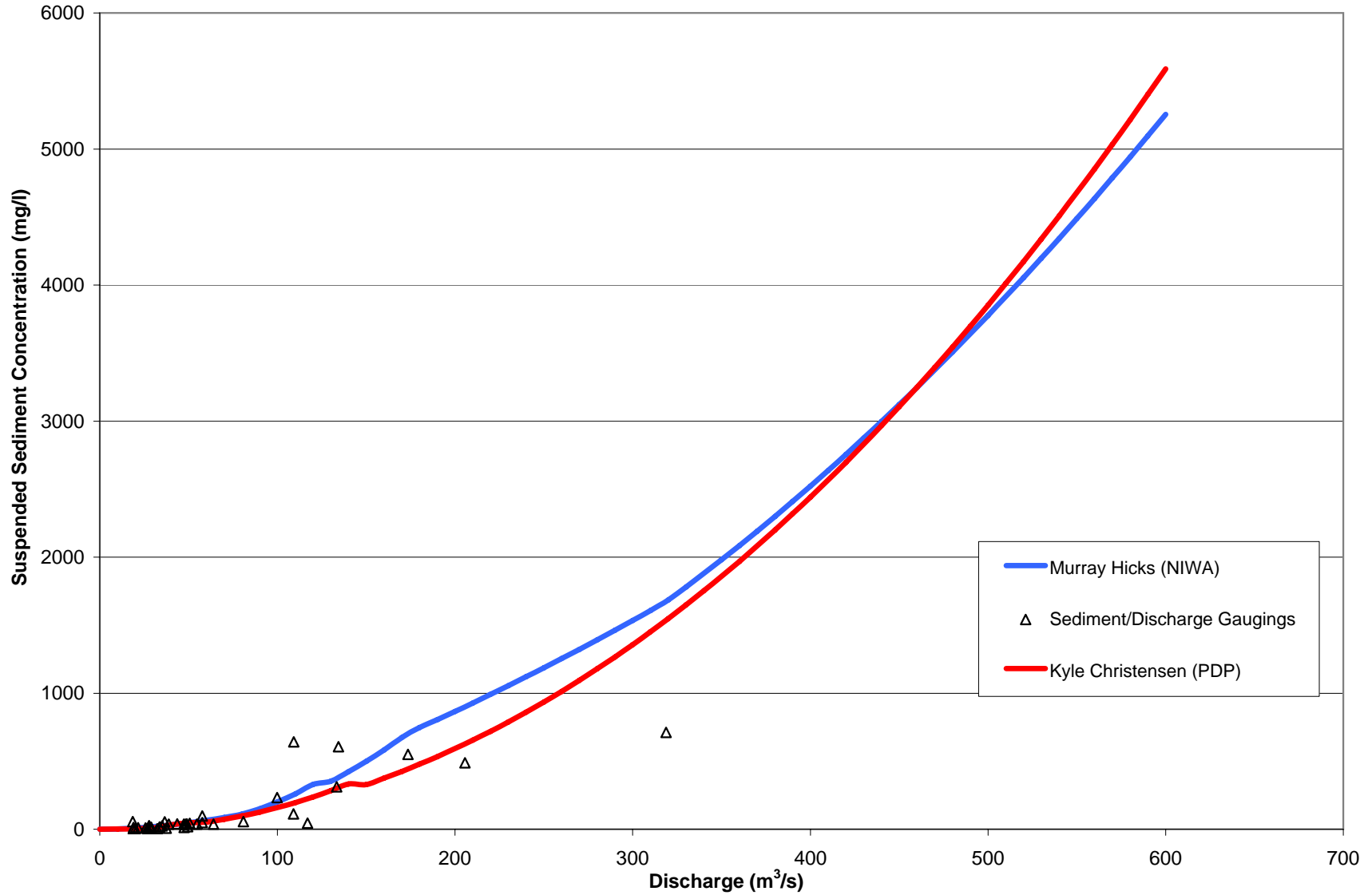


Waitohi River Particle Size Distribution



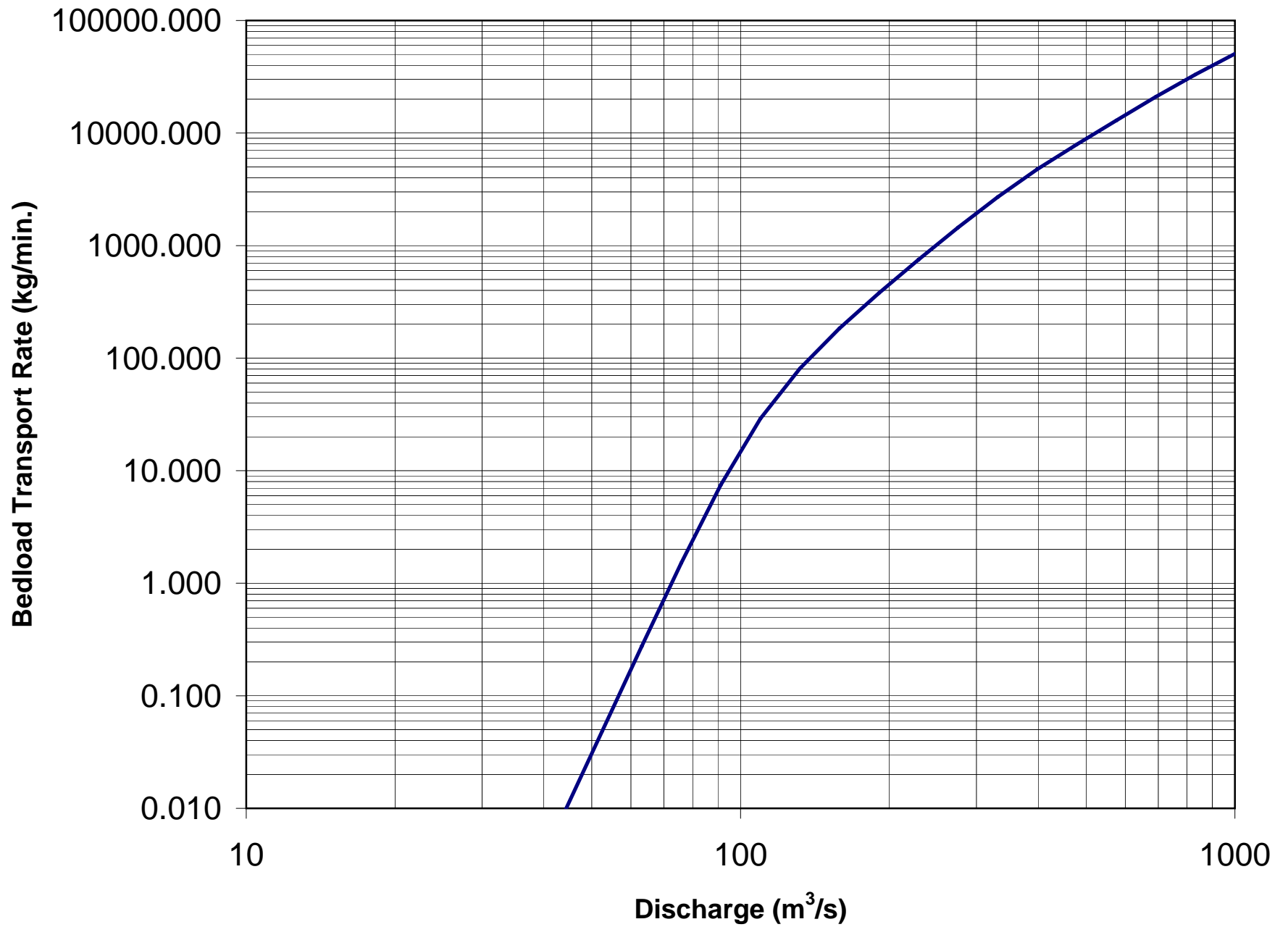
Appendix C Suspended Sediment Rating Curves

Suspended Sediment Rating Curves - Hurunui River at Mandamus

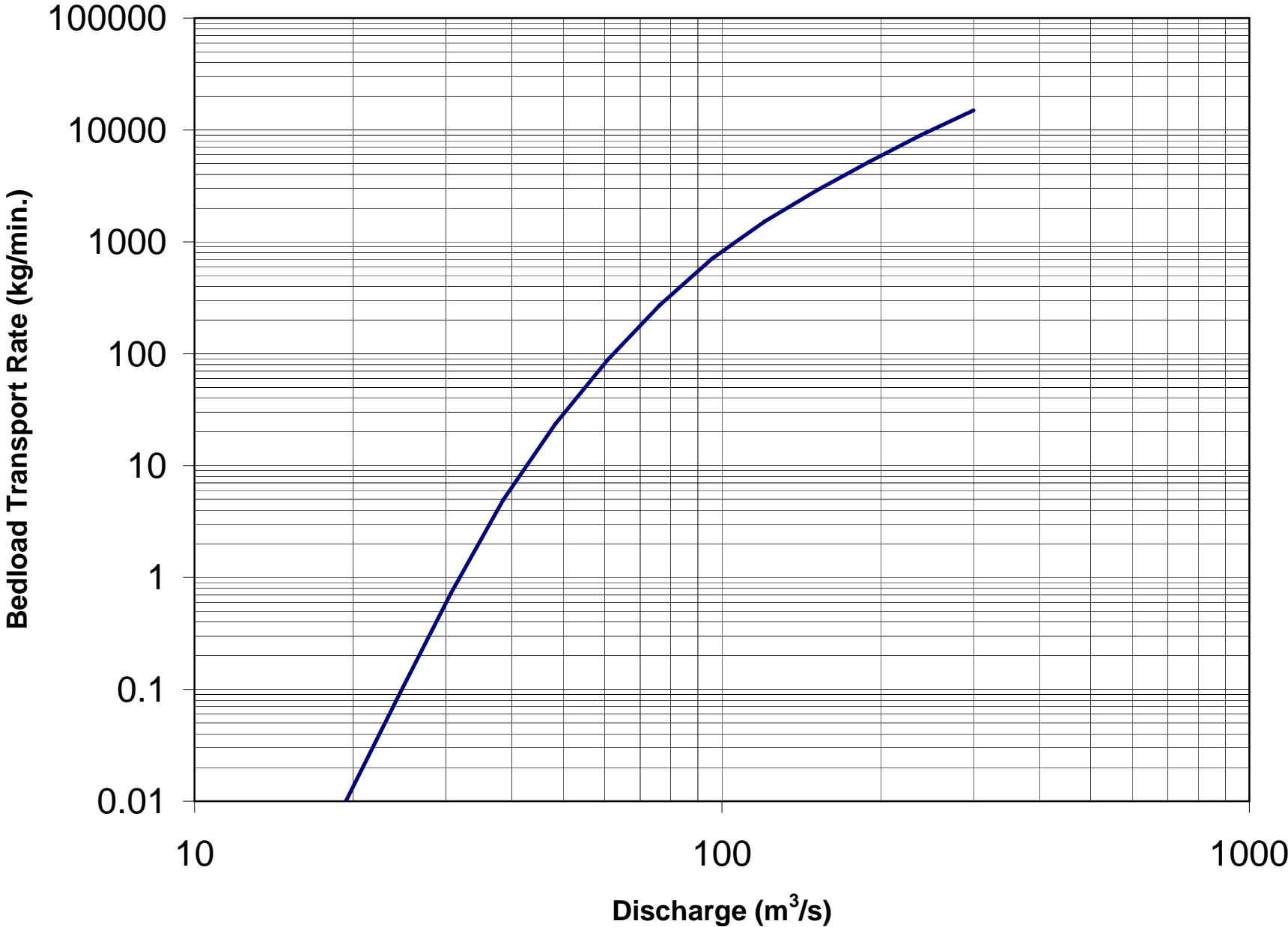


Appendix D Bedload Rating Curves

Hurunui River Bedload Rating Curve



Waitohi River Bedload Rating Curve



Appendix E Overview of Relevant Statutory Context

Resource consents are being sought for activities associated with the Hurunui Water Project. The key processes with respect to sediment transport and channel morphology arise from the damming and abstraction activities.

The project scope identified the most applicable rules under the Canterbury Regional Council Natural Resource Regional Plan (NRRP) and the Hurunui District Council District Plan. It is not the intent of this section to determine the applicable rules, but rather to assess how any changes to sediment transport or channel morphology arising from the proposed damming and abstraction activities may relate to the objectives and policies of relevant regulations and plans.

Section 104(1) of the Resource Management Act (the Act) states:

Subject to Part II, when considering an application for a resource consent and any submissions received, the consent authority shall have regard to -

- (a) Any actual and potential effects on the environment of allowing the activity; and*
- (b) Any relevant provisions of –*
 - (i) a national environmental standard:*
 - (ii) other regulations:*
 - (iii) a national policy statement:*
 - (iv) a New Zealand coastal policy statement:*
 - (v) a regional policy statement or proposed regional policy statement:*
 - (vi), a plan or proposed plan; and*
- (c) Any other matters the consent authority considers relevant and reasonably necessary to determine the application.*

Sections 3.0 and 4.0 of this report describe the actual and potential effects on the environment arising from the change in sediment transport as per Section 104(1) (a) of the Act.

In accordance with Section 104(1)(b) of the Act, the following sections discuss objectives and policies of relevant plans and how the proposed works as they relate to the change in sediment transport meet these objectives and policies. The relevant documents are the Canterbury Regional Policy Statement and Draft Regional Policy Statement, Canterbury Natural Resources Regional Plan and the Hurunui District Council District Plan.

As discussed in the assessment of potential effects in Sections 3.0 and 4.0, the extent of changes to the bed load and channel morphology arising from Stage 1 and Stage 2 of the project is localised and no more than minor in the context of the sediment supplied to

the coastal environment including the inputs from the adjacent Waimakariri and Waiau Rivers. Also, the impacts in terms of river mouth opening are no more than minor due to the scheme not operating during extreme low flow conditions when the mouth tends to close. Therefore, consideration of the coastal policy statement is not necessary.

Finally, Section E.5 briefly discusses how the changes to sediment transport and channel morphology arising from the proposed damming and abstraction activities relate to the Canterbury Water Management Strategy.

Part II matters are discussed in Section E.6 of this report.

E.1 Regional Policy Statement (RPS)

In accordance with Section 104(1)(b)(v), the consent authority is directed to have regard to the Regional Policy Statement (RPS). The RPS provides direction on resource management issues through the Canterbury region. The RPS became operative in 1998, and it establishes the frame work for integrated and sustainable management, and co-ordinates with other levels of legislation. This section identifies relevant objectives and policies contained in the RPS and provides a brief discussion as to how the change in sediment transport arising from the proposed activities relate to these objectives and policies.

Chapter 9 Water provides objectives and policies to ensure that the quality of water is protected. Objective 1 aims to achieve sufficient quantities of water to enable present and future generations to gain benefits from the water, while safeguarding valuable attributes of the waterways. Policy 1 seeks to have water flows, levels and allocation regimes set and managed such that adverse effects on the attributes of waterways are avoided or mitigated. Of relevance to this proposal, this policy specifically directs the consent authority to have particular regard to river bed morphology and substrate when considering allocation and/ or management of water quantity.

As described in Sections 3.0 and 4.0 of this report, under most circumstances, the flow regime proposed will have a no more than minor effect on the river bed morphology for a limited reach along the Waitohi and Hurunui Rivers. However, after Stage 2, the effect on the bed downstream of SH 7 as result of the combination of sediment trapping in the Waitohi River dams and the reduction in bedload capacity in the Hurunui River arising from the abstraction will be more than minor. Mitigation measures have been proposed (described in Section 5.0) which reduce the effect on the bed such that it is minor. Therefore, the proposed activities, when carried out with the proposed mitigation measures will be consistent with Policy 1.

Objective 3 within Chapter 9 Water aims to enable present and future generations to benefit from the water quality of Canterbury's water bodies while safeguarding the values and attributes of the waterbodies. Policy 9 strives to manage point and non-point sources discharges such that adverse effects on the existing surface water quality is avoided, remedied or mitigated. Sediment entrained in the abstracted water stored in

the dams will be deposited in the reservoirs, and will not be entrained in the flows to the Waitohi River, and therefore is consistent with Policy 9.

As described in Section 5.0, it is proposed to have an intake arrangement which allows the sediment to be flushed back into the Hurunui River during periods of high flow. As this material is originally sourced from the Hurunui River, and will not contain any other introduced contaminants, the proposed flushing and return of the sediment to the Hurunui River will also be consistent with Policy 9.

With respect to the sediment transport processes, the proposed damming and abstraction is consistent with the objectives and policies contained in Chapter 9 of the RPS.

Chapter 10 Bed of Rivers and Lakes and their Margins provides objectives and policies relating the land use and development of waterbodies. Objective 1 aims to protect, and where appropriate enhance, valuable aspects of the beds of rivers and lakes and their margins. Policy 1 seeks to avoid adverse effects arising from land use or development activities on the conservation values of rivers and their margins. As described in Sections 3.0 and 4.0 of this report, the effects to the channel morphology of the Waitohi and Hurunui Rivers from the damming and abstraction under Stages 1 and 2 will be localised and no more than minor, when carried out in accordance with the mitigation measures suggested.

Policy 2 seeks to ensure that any works or development will not adversely affect the flood-carrying capacity of the waterway or cause adverse effects of the performance or stability of essential structures. Given that the extent of any aggradation is extremely limited, the effects arising from the damming and abstraction will not have an adverse effect on the flood-carrying capacity of the Waitohi and Hurunui Rivers. Furthermore, the expected degradation arising from the works is minimal and therefore not expected to have any impact on the performance or stability of essential structures in the river. Therefore, with respect to sediment transport processes, the proposed activities are consistent with Policy 2.

Objective 2 of Chapter 10 Beds of Rivers and Lakes and their Margins aims to protect the flood-carrying capacity of the river from the adverse effects of land use within the beds and margins of the rivers, or the obstruction of waterways by the accumulation of bed material and vegetation. Policy 4 states that land use activities shall be undertaken in such a way that any adverse effects on the free passage of floodwaters within the beds should be avoided. As described in Section 5.0, mitigation measures have been proposed which will ensure that aggradation (which could potentially cause obstruction of waterways) is minimised such that it is no more than minor. Therefore Policy 4 is met.

Objective 3 of Chapter 10 Beds of Rivers and Lakes and their Margins is for the protection of the stability and performance of essential structures from the adverse effects of land use within the beds and margins of rivers. This assessment shows that the damming and abstraction of water, when carried out in accordance with the suggested mitigation measures will not adversely affect the stability and performance of essential structures and therefore is consistent with this objective.

With respect to the sediment transport processes, the proposed damming and abstraction is consistent with the objectives and policies contained in Chapter 10 of the RPS.

Chapter 11 Coastal provides objectives and policies to ensure that the coastal environment is protected. Objective 1 seeks to provide for the appropriate use and development of the coastal environment while protecting the life-supporting capacity of the coastal environment and significant coastal areas. Policy 1 strives to avoid, remedy or mitigate any direct or indirect effect from land use or activities which could impact on the coastal environment. With respect to changes in the sediment transport processes arising from the damming and abstraction of water, the activities, when carried out in accordance with the proposed mitigation measures are not expected to have any impact on the coastal environment, and therefore the proposed activity is consistent with the objectives and policies contained in Chapter 11.

Chapter 16 Natural Hazards deals with natural hazards within the Canterbury Environment. As discussed in Section 4.7, there may be some limited aggradation in the bed of the Hurunui River, however mitigation measures have been proposed to ensure that the extent of the aggradation within the river bed is minimised, and therefore does not contravene any objectives or policies contained within this chapter.

In summary, as demonstrated in the assessment of potential effects, and carried out in accordance with the proposed mitigation measures as described in Section 5.0, the activities as they relate to the sediment transport processes are consistent with the objectives and policies contained in the Regional Policy Statement (RPS).

E.2 Draft Regional Policy Statement (draft RPS)

In accordance with Section 104(1)(b)(v) of the Act the consent authority is also directed to have regard to any draft regional policy statements. An update to the 1998 RPS was developed, which incorporates the Canterbury Water Management Strategy. The draft RPS was released for review in September 2010. Public comment period on the draft RPS closed in November 2010, and it is anticipated that the updated RPS will be publicly notified in 2011. As with the 1998 RPS, this document provides direction on resource management issues throughout the Canterbury region. It establishes the framework for integrated and sustainable management and co—ordinate with other levels of legislation. The following objectives and policies contained in the draft RPS 2010 are considered relevant to this application.

Chapter 7 of the draft RPS deals with the Freshwater Resource. Objective 7.2.1 is for the sustainable management of Canterbury's fresh water resources, including the protection of the character of the resource. Policies have been included in this chapter which aims to achieve this objective. Policy 7.3.3 is to control the take and use of water or the discharge of contaminants which avoids adverse effects to freshwater. Subsection (1)(c) of this policy requires that the activities have regard to the dynamic processes of Canterbury's braided rivers. As demonstrated in Sections 3.0 and 4.0, the effects from the proposed activities, when carried out with the proposed mitigation measures are

limited in the extent and no more than minor, and therefore are consistent with this policy.

Chapter 8 provides the objectives and policies for the Coastal Environment. Objective 8.2.5 aims to protect the coastal water quality and associated values of the coastal environment from the significant adverse effects of point and non-point discharge of contaminants. The HWP activities do not occur directly on the coast, but occur inland quite a distance upstream from the coast line. HWP will undertake the activities in a manner which will not affect water quality of the coastal environment, nor will affect the visual amenity of the coast. Therefore the activities are consistent with this objective.

Chapter 10 of the draft RPS relates to the Beds of Rivers and Lakes and their Riparian Zones. Objective 10.2.1 enables development within riverbeds and their margin while protecting the values of the riverbed system. Objective 10.2.2 aims to maintain the flood-carrying capacity of the rivers while avoiding, mitigating or remedying any adverse effects arising from these activities. Objective 10.2.3 seeks to protect essential structures from activities in riverbeds which may undermine or adversely affect the essential structures.

Many of the policies contained in Chapter 10 relate to multiple objectives. Policy 10.3.1 seeks to provide for the activities within the riverbed while protecting the valuable attributes of the waterways. Policy 10.3.2 aims to protect and preserve the natural character of the waterway. Policy 10.3.3 provides for the management of the waterway for flood control and essential structures. Policy 10.3.4 allows for the removal of bed materials which may adversely affect the flood-carrying capability of the waterway.

As described in Sections 3.0 and 4.0, the effects arising from the damming and abstraction activities, when carried out in accordance with the proposed mitigation measures, are no more than minor and therefore, will meet the objective and policies of Chapter 10.

Chapter 11 addresses Natural Hazards in Canterbury. Objective 11.2.1 is to avoid or mitigate the impacts to the environment from natural hazards. Objective 11.2 is to avoid or mitigate the adverse effects to people and property from the methods used to manage the natural hazards. As described in Sections 3.0 and 4.0 of the report, the extent of any potential aggradation or degradation to the channel beds are limited, and no more than minor, and thus will not result in increased flooding. Therefore the proposed works are consistent with the objectives and policies of Chapter 11.

In summary, given the proposed consent conditions and mitigation measures, the activities described in this report are consistent with objectives and policies contained in the draft RPS 2010.

E.3 Natural Resource Regional Plan (NRRP)

In accordance with Section 104(1)(b)(vi), the consent authority is directed to have regard to the plan and any proposed plan.

On 11 June 2011, the Natural Resources Regional Plan became operative. This plan contains objectives and policies which are used to address issues that are significant on a regional basis. Chapters 4 (Water Quality), 5 (Water Quantity) and Chapter 6 (Beds of Lakes and Rivers) contain specific objectives and policies relevant to this application.

E.3.1 Chapter 4 Water Quality

Chapter 4 Water Quality contains the objectives and policies relating to the management of water quality within Canterbury.

Objective WQL1 provides for the water quality outcomes of rivers and lakes. Objective WQL1.1 relates to directly to rivers, and seeks to meet specific water quality outcomes, and where water quality outcomes are not being achieved, to progressively improve the existing quality of the water and the bed. Table WQL5 provides the water quality outcomes for rivers which are not in a natural state. The NRRP maps indicate that the Waitohi River is classed as hill-fed lower stream, while the Hurunui River at the point of intake and confluence is classed as Alpine-lower stream.

Policy WQL1 provides criteria for the point source discharges that may enter surface water.

As described in this report, sediment entrained in the abstracted water stored in the dams will be deposited in the reservoirs, and will not be entrained in the flows to the Waitohi River, and therefore adversely affect the water quality of the Waitohi River.

With respect to the Hurunui River, as described in Section 5.0, it is proposed to have an intake arrangement which allows the sediment to be flushed back into the Hurunui River during periods of high flow. As this material is originally sourced from the Hurunui River, and will not contain any other introduced contaminants, the proposed flushing and return of the sediment to the Hurunui River will also be consistent with Policy WQL1.

Policy WQL2 relates to the effects on water quality and the river bed caused by a change to the flow of a river. Sections 3.0 and 4.0 of this report provide an assessment on the impacts to the river bed arising from the change in flow regime. When carried out in accordance with the proposed mitigation measures (Section 5.0), the effect on the Hurunui River river bed from the abstraction is no more than minor. Therefore this policy is met.

Objective WQL3 aims to protect the water quality of community drinking water sources. Policy WQL13 strives to avoid the potential for contamination of community drinking water sources. There are no surface water community drinking water intakes on the Hurunui River, but there is an existing community water supply on the Waitohi River downstream of the reservoirs (Hurunui District Council Karaka Lower Waitohi Rural Water Supply 1464). Given that the sediment is trapped in the reservoirs, and any water to the Waitohi River is 'clear', there is no adverse effect to this surface water community drinking water intake and therefore the damming and abstraction will be consistent with this policy.

E.3.2 Chapter 5 Water Quantity

Chapter 5 contains the objectives and policies relating to the management of water quantity within Canterbury.

Objective WQN1 aims to enable present and future generations access the region's surface waters while ensuring that the critical values associated with the surface waters are maintained. Policy WQN1 relates to the high naturalness water bodies. While some of the proposed works is located on the Hurunui River and its tributaries, the works will be located downstream of Mandamus and therefore this policy is not directly applicable.

Policy WQN2 relates to the setting of flow and level regimes and also seeks to achieve Objectives WQN1 and WQL1.1. With respect to Objective WQN1, as the effects on sedimentation and channel morphology resulting from the proposed abstraction regime are no more than minor, and therefore meets Objective WQN1.

As described above the effect of the proposed abstraction regimes, with the proposed mitigation measures, will be consistent with Objective WQL1.1 when considering the effects to the water quality and bed morphology of the Waitohi and Hurunui Rivers. Therefore, from a sediment transport process perspective, the proposed abstraction flow regime is consistent with Policy WQN.

Policy WQN3 identifies the indicator instream values and matters to consider when assessing resource consent applications where there is no flow regime. Among the matters to be considered are the impacts of the flow regimes on the size and frequency of flows and the effect of these on processes need to remove the build-up of fine sediment and the processes needed to transport gravel and contribute to coastal sediment. As discussed in the assessment of potential effects sections of this report, the effects from the abstraction regime on the sediment transport process are no more than minor, when carried out in accordance to the proposed mitigate measures. Furthermore, any effects are quite limited in extent and there is no measurable effect on the coastal sediment processes.

Objective WQN8 is to enable the augmentation of water resources provided that it will be consistent with or better achieve provisions (a) to (h) of Objective WQN1 and the relevant provisions of Objective WQL1. Augmentation as defined by the NRRP is the improvement of water supplies and flows through storage of water in dams or out-of-river reservoirs, the transfer of water from one water body to another or the recharge of groundwater. The proposed HWP involves the use of storage reservoirs. Augmentation can result in adverse effects to the characteristics of the rivers such as the degradation or aggradation to the streambed, and could have direct impacts to the ecology or essential structures arising from the change in streambed.

Policy WQN20 seeks to manage the effects of augmentation. As demonstrated in Sections 3.0 and 4.0, the effect from the damming and storage activities on sediment

transport processes is no more than minor, and will not result in an adverse effect on the provisions contained in Objective WQN1 (a)–(h). Specifically, the reservoirs will trap sediment and the additional sediment will not be released into the Waitohi River system. The effect of degradation on downstream reaches of the Waitohi River is no more than minor, and the natural character of the Waitohi river bed will be maintained as specified in Objective WQN1 (e). Therefore Policy WQN20 is met.

E.3.3 Chapter 6 Beds of Lakes and Rivers

Chapter 6 Beds of Lakes and Rivers contains objectives and policies related to the management of the riverbeds, lakebed and their margins.

Objective BLR1 aims to allow for activities to be undertaken on the beds of rivers and margins while protecting valuable attributes such as the flood-carrying capacity, stability and integrity of existing structures and banks, protecting habitat, and avoiding or mitigating adverse effects from reductions in sediment transport to the coasts.

Policy BLR1 seeks to manage land use activities such that the effects from the activities do not compromise the attributes identified in Objective BLR1. As demonstrated in the assessment of potential effects, the effect to the riverbed morphology as a result of the damming or the abstraction is limited and is no more than minor, when carried out with the proposed mitigation measures, and therefore is consistent with Objective BLR1.

However, as the scheme is related strictly to the damming, diversion, take, storage and use of water, and therefore the assessment of effect provided is based only on effects arising from the damming and abstraction of water, and Policy BLR1 is not directly relevant.

However, it is important to recognise that should the water consents be obtained, the damming and abstracting will have a physical component which requires land use consent for works to occur on riverbed and their margins. This assessment does not address the potential impact of the works or infrastructure on this objective or policy, however it is acknowledged that the effects on these attributes can be mitigated or avoided by appropriate design and construction management.

E.3.4 Summary of NRRP

When considering the effects from the change in sediment transport processes arising from the proposed damming and abstraction activities, the relevant objectives and policies in Chapters 4, 5 and 6 of the NRRP are met, and are not compromised by the activities.

E.4 Hurunui District Plan

The current Hurunui District Council District Plan became operative on 7 August 2003. The District Plan's framework provides objectives, policies and methods to manage the

use and development of natural and physical resources to meet the purpose of the Resource Management Act 1991.

Part 1 of the Hurunui District Council District Plan identifies significant resource management issues for the district. Issue 14 relates to Natural Hazards. Objective 14 aims to avoid or mitigate the adverse effects of natural hazards on the environment, with priority on community protection.

Policy 14.3 seeks to ensure that new subdivision and development takes into account any risks from natural hazards. Policy 14.4 aims to establish special standards for land use activities proposed to locate in area of high potential risk. Policy 14.5 aims to encourage people to be prepared for the occurrence of hazardous events.

Sections 3.0 and 4.0 of this report assess the potential for adverse effects from changes in sediment transport processes associated with Stage 1 and Stage 2 of the HWP. The proposed changes in the bed levels arising from the damming and abstraction is no more than minor when constructed with the proposed mitigation measure. Consequently, it is expected that there will be no significant change to the flood-carrying capacity of the rivers, nor will the activities adversely affect any essential structures such as stopbanks. Accordingly, it is concluded that the changes in sediment transport regime will not increase the risk from Natural Hazards on the environment, and therefore the proposed activities are consistent with the objectives and policies in Chapter 14 of the Hurunui District Council District Plan.

E.5 Canterbury Water Management Strategy (CWMS)

Section 104(1)(c) of the RMA directs the consent authority to have regard to other matters. Of particular note is the Canterbury Water Management Strategy (2009), which forms the new framework for the management of the freshwater resources in Canterbury. The Environment Canterbury (Temporary Commissioners and Improved Water Management) Act 2010 requires the regional council to adopt and have regard for the CWMS with respect to the management of water resources.

While not providing specific detail, the CWMS seeks to allow the use and the development of Canterbury's water resources, while maintaining a variety of significant characteristics. The Targets Study 2010 supplements the CWMS and aims to provide more clear-cut goals for management of the water resources. Section 2 of the Target Study 2010 seeks to preserve the natural character, process and ecological health of braided rivers.

As demonstrated in Sections 3.0 and 4.0 of this report, the effects to the natural character of the river beds arising from the estimated changes to sediment movement arising from the proposed damming and abstraction activities are no more than minor, and are consistent with Section 2 of the Targets Study 2010.

E.6 Part II Matters

E.6.1 The Purpose of the Act

Section 5 (1) states that the purpose of the Act is to promote the sustainable management of natural and physical resources. Section 5 (2) defines “sustainable management” as *managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while -*

- (a) *Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
- (b) *Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and*
- (c) *Avoiding, remedying, or mitigating any adverse effects of activities on the environment.*

The effects from the changes in sediment transport processes arising from the proposed damming and abstraction activities are no more than minor when carried out in accordance with the proposed mitigation measures, and therefore represents sustainable management of natural and physical resources.

E.6.2 Matters of National Importance

Section 6 of the Act states:

In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall recognise and provide for the following matters of national importance:

- (a) *The preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development;*
- (b) *The protection of outstanding natural features and landscapes from inappropriate subdivision, use, and development;*
- (c) *The protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna;*
- (d) *The maintenance and enhancement of public access to and along the coastal marine area, lakes, and rivers;*
- (e) *The relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga.*

- (f) *The protection of historic heritage from inappropriate subdivision, use and development.*
- (g) *The protection of recognized customary activities.*

The assessment of potential effects (Sections 3.0 and 4.0) demonstrate that the changes in sediment transport processes arising from the proposed damming and abstraction activities will be no more than minor. Specifically, the effect on the bed of the rivers will be limited in extent and will be no more than minor when carried out with the proposed mitigation measures. This ensures that the natural character of the Waitohi and Hurunui Rivers (and their margins) is preserved [section (6)(a) of the Act].

Furthermore, the change in sediment transport will not compromise access along the rivers, margins or the coastal areas [section (6)(d) of the Act].

It is considered that there are no matters of national importance compromised by the changes in sediment transport arising from the proposed damming and abstraction activities.

E.6.3 Other Matters

Section 7 of the Act states:

In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall have particular regard to:

- (a) *Kaitiakitanga;*
- (aa) *the ethic of stewardship;*
- (b) *The efficient use and development of natural and physical resources;*
- (ba) *the efficiency of the end use of energy;*
- (c) *The maintenance and enhancement of amenity values;*
- (d) *Intrinsic values of ecosystems;*
- (e) *[Repealed]*
- (f) *Maintenance and enhancement of the quality of the environment;*
- (g) *Any finite characteristics of natural and physical resources;*
- (h) *The protection of the habitat of trout and salmon.*
- (i) *the effects of climate change;*
- (j) *the benefits to be derived from the use and development of renewable energy.*

The assessment of potential effects has demonstrated that any effects from the change in sediment transport processes arising from the proposed damming and abstraction is no more than minor, if constructed in accordance with the proposed mitigation measures. Specifically, the effects from changes to the river bed morphology are no more than minor, and consequently, will not have an adverse effect on maintenance and enhancement of the quality of the environment (f), or the finite characteristics of natural and physical resources (g). It is considered that there no matter set out in this section compromise, with respect to the sediment transport processes, by the proposed damming and abstraction activities.

E.6.4 Principles of the Treaty of Waitangi

Section 8 of the Act states:

In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall take into account the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).

The Court of Appeal has identified four principles, which form the basis of developing a relationship of partnership and communication. These are the Essential Bargain, Tribal Self-Regulation, The Treaty Relationship, and Active Protection. The third principle, the Treaty Relationship, accords Maori with special status as a Treaty Partner, distinct and separate from status as an "affected party."

In the preparation of this report, no consultation with Tangata Whenua has been undertaken regarding the potential effects arising from the changes in sediment transport processes. However, given that the changes are no more than minor, and do not change the overall character of the river bed, it is concluded that the effects on Tangata Whenua and associated interests, including mahinga kai and areas of cultural and historical significance, from the damming and abstraction will be no more than minor.

E.7 Summary

To conclude, a review of the relevant planning instruments has been undertaken to determine whether the effects from the changes in the sediment transport processes arising from the proposed damming and abstraction activities is consistent with the matters which have been identified in Section 104(1) of the Act.

This review has looked at the Canterbury Regional Policy Statement (RPS), the draft Canterbury Regional Policy Statement (2010), the Canterbury Natural Resource Regional Plan (NRRP), and the Hurunui District Council District Plan. The assessment of potential effects has demonstrated that the effects to the river bed morphology of the Waitohi and Hurunui Rivers and related attributes such as flood-carrying capacity or performance of essential structures, are limited and no more than minor when carried out in accordance with the proposed mitigation measures. With respect to the effects on the sediment

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transport regime, the damming and abstraction activities are consistent with the objectives and policies contained within these identified plans.

Furthermore, the effect of the proposed damming and abstraction on the sediment transport regime is limited and no more than minor, and is consistent with the Canterbury Water Management Study (2009) and the supplemental Target Study 2010, which seeks to preserve the natural character, process and ecological health of braided rivers.

Finally, a review of the effects from the proposed damming and abstraction on the sediment transport processes of the Waitohi and Hurunui Rivers has been considered with the sections contained in Part II Matter of the Act. When carried out in accordance with the proposed mitigation measures, the effects from the changes in sediment transport processes is no more than minor. The activities meet the sustainable management criteria as described in Section 5 of the Act. There are no matters of national importance as outlined in Section 6 of the Act compromised by the proposed activities. Likewise, there are no Other Matters as listed in Section 7 of the Act compromised by the proposed activities.