

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of a joint application for resource consent by the Ashburton Community Water Trust and the Central Plains Water Trust, and separate resource consent applications by the Ashburton Community Water Trust

FOR resource consent to take up to 40 cubic metres of water per second from the Rakaia River via the Ashburton Community Water Trust intake, and to use it for hydro electricity generation.

**SECOND STATEMENT OF EVIDENCE OF STEVEN WOODS
ON BEHALF OF THE ASHBURTON COMMUNITY WATER TRUST**

1 QUALIFICATIONS AND EXPERIENCE

- 1.1 My name is Steven Woods. I am employed as a Civil Engineer in the Christchurch office of MWH New Zealand Limited, and have been engaged by the applicant to provide Engineering evidence. I have approximately ten years of experience. I am a Chartered Professional Engineer in the Geotechnical and Civil practice areas and a member of the Institute of Professional Engineers New Zealand.
- 1.2 The evidence I will present today is within my area of expertise, except where I state that I am relying on information provided by another party. I have not knowingly omitted facts or information that might alter or detract from the opinions I express.

2 SCOPE OF EVIDENCE

- 2.1 I have been asked by the applicant to prepare evidence in relation to the following issues:
- A description of the engineering design and operation of the scheme.
 - A description of the management of river sediment by the scheme.
 - A description of the possible integration of the scheme with the Barrhill Chertsey Irrigation Scheme.
 - A description of the scheme construction and how potential environmental impacts would be managed.
 - Comment on submissions received.

3 SUMMARY OF THE PROPOSAL

- 3.1 An overview of the proposed scheme is shown on drawing C100. The scheme would be located approximately 10km north of Methven, on the south bank of the Rakaia River, approximately 5km downstream from the gorge. It would involve abstracting water from the Rakaia River, passing it through an intake structure, along a canal (for present purposes divided into two sections - the lower 'Highbank canal' and the upper 'Terrace Canal'), and returning it to the river approximately 14km downstream. The water would be dropped through two small power stations along the lower Highbank canal route before being transferred in the Terrace Canal where it will be returned to the river via a larger power station, hereafter referred to as the Barrhill Power station. The scheme is illustrated in photos 1, 2, 3 and 4.
- 3.2 The river intake structure would allow water to enter the scheme. It would also close the scheme from the river during floods. Water would flow through the intake into the settling pond allowing silt and sand sized particles to fall out of suspension and be trapped in the pond.
- 3.3 After flowing through the pond, water would enter the Highbank Canal. The first section of canal would be constructed up to 7m above ground level to the first drop structure, where it would drop below the existing ground level by approximately 7m.
- 3.4 The second section of the canal would start below ground level before eventually climbing above ground level and terminating at the second drop structure approximately 1.5km downstream. The maximum height of this section of the canal would also be approximately 7m above ground level.
- 3.5 Each of the proposed drop structures would include a generating station and a bypass spillway. The bypass spillway would allow water to pass around the station when the generating station is not operating.

- 3.6 Water from the second drop structure would flow through a tailrace canal, which would link into the existing Highbank Power station tailrace canal. The flow could then be combined with flows out of the Highbank Power station and taken into the next section of canal.
- 3.7 Downstream of the existing Highbank Power station, the Terrace Canal would be constructed by placing earthfill material at the base of the existing terrace for a distance of approximately 8km. The canal would gradually climb above the terrace face and reach a peak height of approximately 35m, where it would cross onto the top of the terrace.
- 3.8 The remaining 4.5km of canal would be constructed by excavating on the top of the river terrace. The canal would terminate in a headpond, feeding water into penstocks running down the terrace slope to the power station.
- 3.9 After passing through the final (Barrhill) power station water would be returned to the river via a tailrace formed in an excavated channel across the river flats.

4 SCHEME COMPONENTS

- 4.1 The proposed river intake site is shown on Photo 5. The river intake structure is shown in Illustration 1. The site is set back in from the line of the existing river bank. In the event of a flood the gates can be closed to isolate the scheme from flood waters. The river intake structure is designed to protect the scheme and surrounding land from floods in excess of a 1:1000 year event. From time to time work would be required in the river bed to maintain an adequate flow of water to the intake.
- 4.2 The settling pond would be formed by earthfill embankments typically 4 to 6m high. The embankments, as shown in Illustration 2 would be formed from locally available gravel soils and the pond would be lined to prevent seepage using locally available loess and gravel soils. Detailed design may enable a reduction in the extent of the settling pond and the height of the embankments.
- 4.3 Sediment that collects in the settling pond would be mechanically excavated and placed within the Sediment Disposal Area, shown on drawing C001, where it can be washed away during a series of natural flood events. Further discussion on this aspect is provided in Section 6.
- 4.4 A fish screen would be placed at the canal end of the pond. The fish screens prevent fish from leaving the settling pond and entering the remainder of the scheme. The fish screen structure is shown conceptually on Illustration 2. Fish in the pond can return to the river via the fish bypass structure. This would involve a concrete drop structure to return fish to the river bed level and then a small channel excavated across the river bed which connects to an active braid of the river.
- 4.5 Flows into the Highbank Canal would be controlled by a gated inlet structure. The canal would be formed by a combination of cut and fill earthworks to a maximum height of approximately 7m and maximum

depth of approximately 7m. While the application document stated that up to three drop structures would be used, more detailed optimisation indicates that two drop structures are preferable.

- 4.6 The two drop structures would each incorporate a generating station of up to 3 MW. The exact size of the stations is a matter of detailed engineering optimisation and it is possible that a smaller station may offer better economics. The likely scale of the generating station is shown on Illustration 3. Alongside each of the generating stations would be a bypass spillway. This will allow the scheme to pass flows in the event that a generating station is not in operation or if the maximum flow is not used for generation.
- 4.7 Approximately 500m upstream of Drop Structure 2 an emergency overflow section would be provided in the canal, as shown on drawing C002. The true left bank would be lowered so that in the unlikely (emergency) event that the bypass gate did not operate when required, water would preferentially overtop the canal in this location. The lowered section of canal bank would be approximately 100m long so that the velocity of water discharged across it would be low (approximately 1 m/s). Water discharged across this section would flow back to the river via an existing heavily vegetated gully at approximate chainage 2400m. I emphasise that this discharge would be extremely rare, requiring the failure of both primary and secondary control systems. Given the gradually sloping and heavily vegetated nature of the gully I would not expect there to be significant erosion damage or discharge of sediment to the river in this emergency situation.
- 4.8 Water discharged from Drop Structure 2 would flow through a new tailrace canal between the existing Highbank Powerhouse and the river. This area is illustrated on Photo 6. The new tailrace canal will be excavated up to 7m below existing ground level. The application indicated that a buried pipeline may be used rather than a canal; however, more detailed assessment has confirmed a canal as the preferred solution.

- 4.9 The new tailrace canal links with the existing Highbank tailrace canal approximately 150m downstream of the existing powerhouse. This is shown on Photos 7 and 8. To accommodate the combined flows of the existing Highbank station and the new scheme, the existing tailrace would need to be widened. The new Terrace Canal Intake would alter water levels in the tailrace which could have some impact on the operation of Highbank Power Station. Acceptable operating water level ranges would need to be agreed with TrustPower, who own and operate the station. Consent conditions addressing this matter are included in the proposed conditions of consent attached to Mr Dunning's evidence.
- 4.10 TrustPower have installed a fish barrier at the end of the tailrace to prevent migrating salmon attracted to tail water flows from becoming entrained in the tailrace. The barrier is shown on Photo 9. The existing tailrace currently discharges water back to the river via a river channel commonly referred to as the "unformed tailrace" shown in Photo 10.
- 4.11 The combined flows in the Highbank tailrace would be split so that up to 40 m³/s enters the Terrace Canal and the remainder is returned to the river. The means to achieve this is conceptually shown on Illustration 4. Gates would be used to control the flow into the Terrace Canal. Should there be more than 40 m³/s flowing into the modified tailrace, the additional water would pass over the primary spillway and through the existing salmon barrier. Under normal operating conditions, when water is flowing into the Terrace Canal, the flow through the salmon barrier would not exceed the flow which would currently flow through it and will generally be significantly reduced. Mr Borrie will discuss the changes in flow regime in more detail within his evidence. If the Terrace Canal was not operating then the flow in the Highbank Canal would be reduced so that the resulting flow over the primary spillway and through the barrier would not exceed the value currently consented by RDRML and Electricity Ashburton. An auxiliary spillway is provided so that in the event of a rapid and unexpected shutdown of the Terrace Canal, when the flow in the Highbank Canal is not controlled as described above, no more than the consented maximum is passed through the existing salmon barrier while the

remaining water is passed through the auxiliary spillway. This ensures that the screen will not be exposed to flows beyond that which would occur under existing consents, thereby minimising the potential for screen damage. I note that the potential for operation of the auxiliary spillway is very low as it would require a failure of the Terrace Canal Intake gates. It is noted that this would be an extremely rare event, perhaps occurring for a period of less than an hour every few years if at all.

- 4.12 In order to accommodate the Terrace Canal a section of the unformed tailrace approximately 300m long would need to be moved approximately 40m to the east of its current alignment.
- 4.13 Downstream of the Highbank tailrace the canal would be constructed both at the toe of the terrace and on top of the terrace. Typical cross sections are shown on Illustration 5. The canal carries water from the Highbank tailrace to a headpond located on top of the terrace.
- 4.14 The headpond only contains enough water for operational purposes rather than significant storage for generation purposes. As shown on Illustration 6, water would be taken from the pond by an intake structure and delivered to the power station via steel penstocks that would run down the terrace. A spillway (concrete chute) is also provided down the terrace so that, in the event of the station going offline, or “tripping”, water can be safely bypassed down the spillway to protect the canal. These features are shown on Photo 11.
- 4.15 The Barrhill Power station could generate approximately 16 MW and would be similar in overall physical scale to the existing Highbank Power station.
- 4.16 Water would be returned to the river via an excavated tailrace canal. This would be up to approximately 7m deep and would connect to an active braid of the river. Maintenance and repair of the channel with earthmoving equipment would be required from time to time, especially following large floods. Similarly ongoing work in the river may be necessary to maintain a connection with an active river braid,

should the braid pattern change over time. Such works would involve either the excavation of accumulated gravel deposits or the construction of small gravel bunds or weirs to direct flow back to a previously occupied channel. The tailrace site is shown on Photo 12.

- 4.17 Similar to the existing Highbank tailrace, adult migrating salmon are likely to be attracted to the new tailrace. It is proposed to adopt a barrier to prevent fish from entering the tailrace. This would be a “velocity barrier” where a physical drop and high velocity water are used to prevent fish from entering the tailrace. Mr Borrie will discuss this feature in more detail.

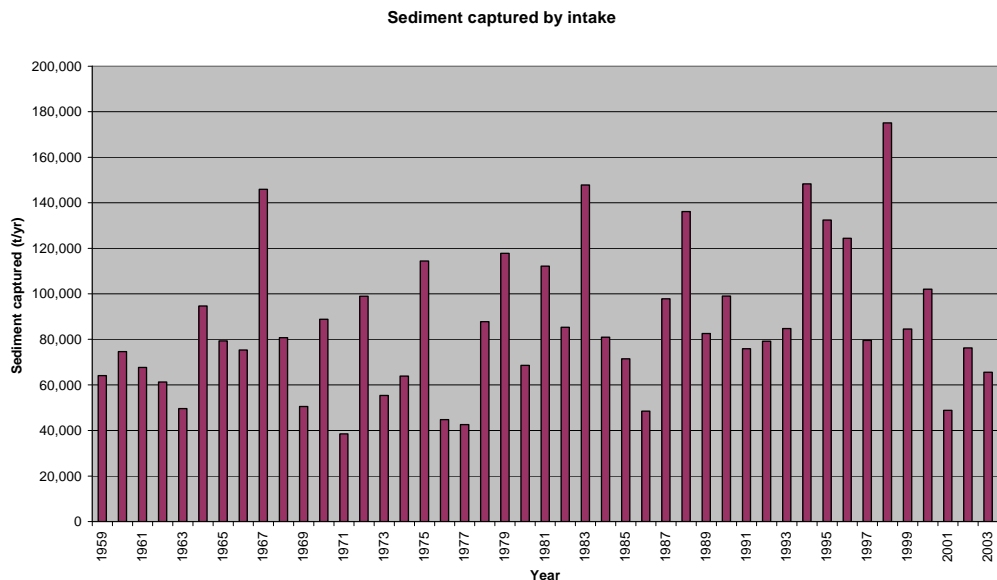
5 BARRHILL CHERTSEY AND ELECTRICITY ASHBURTON

- 5.1 Barrhill Chertsey Irrigation Ltd (BCI) and Electricity Ashburton (EA) hold resource consents to develop a hydro scheme with a significant amount of overlap with the ACWT scheme.
- 5.2 The point of take for both schemes is identical and both schemes feature Highbank Canals of the same alignment and form. The BCI/EA scheme finishes after discharging into the Highbank Tailrace and does not include the Terrace Canal. There are also minor differences in the layout of the scheme intakes.
- 5.3 There will need to be some rationalisation between the BCI/EA scheme and the ACWT scheme. The two parties are in regular communication and hold shared goals for the district. If the BCI/EA scheme was developed before the ACWT scheme then the intake could be upgraded from 17 m³/s (BCI) to 40 m³/s (ACWT) as shown on Illustration 7. This involves an enlargement of the river intake, an additional set of fish screens and enlargement of the on-land settling pond and channels.
- 5.4 The significant difference between the BCI/EA scheme and the ACWT scheme is the method with which sediment is dealt with. Under the ACWT scheme sediment is manually excavated from the settling pond

with the option of depositing this material back onto the river bed to be eroded and taken away under flood conditions. Under the BCI/EA scheme the majority of sediment is returned to the river by flushing or sluicing sediment, through an artificial channel, under flood conditions.

6 SEDIMENT MANAGEMENT

6.1 The Rakaia River carries significant sediment loads under elevated flow conditions. A proportion of this sediment will be entrained into the scheme intake and will settle in the settling pond. The quantity of sediment intercepted will vary from year as illustrated on the following graph, which summarises the results of a simulation of the sediment that would have accumulated in the settling pond each year over the last 50 years. This analysis assumes that all BCI water is taken through the intake all year and outside of the irrigation season all higher priority allocated water is taken when available. This presents the worst case for sediment volumes in the settling pond.



It can be seen that annual sediment volumes vary from approximately 40,000 tonnes per year to 180,000 tonnes per year with typical volumes of 80,000 tonnes per year. Approximately 40% of this sediment is associated with Barrhill Chertsey Irrigation water.

- 6.2 It is envisaged that the pond would be dewatered and cleaned out once per year using excavators and off road dump trucks. Given the large volume of storage available in the settling pond (1m depth equates to 350,000 m³ of storage) it would be possible to limit the sediment removed in a high sediment inflow year by keeping a proportion of the sediment in the pond.
- 6.3 The extent of the sediment disposal area suitable for placement of sediment will change from year to year depending on the nature of the river. The total sediment disposal area shown on drawing C001 (and C100) is approximately 75Ha. Of this a maximum of 20Ha in the riverbed would be used to place sediment. This means that sediment could be placed up to a maximum of approximately 700mm thick, but more typically half of this.
- 6.4 To provide context to the quantities of sediment placed within the disposal area, the following table provides estimates of natural sediment transport under a range of flow events. The estimates are based on a relationship developed by George Griffiths, which has been verified against total sediment yields in the river published by NIWA.

<i>Flow (m³/s)</i>	<i>Sediment Concentration (mg/l)</i>	<i>Sediment Flux (t/hr)</i>
100	7	2.5
200	41	29
300	117	126
500	444	799
1000	2694	9700

- 6.5 Material would be placed within the sediment disposal areas above the 300 m³/s flood level. The extent of the disposal area above this flood level would need to be re-assessed on a year by year basis to respond to changes in river morphology. The 300 m³/s flow has been selected as it is above the flow range where the river remains fishable (based on evidence presented by Mr Borrie at the 2000 Barrhill Chertsey Irrigation hearing) and as can be seen from the table in 6.4

above, natural suspended sediment levels are elevated beyond this flow. The most likely extent of sediment is shown on drawing C100.

- 6.6 In a flow of 300 m³/s water is expected to be confined largely to the main channels around and through the sediment disposal area. At a flow of 1000 m³/s water would be expected to inundate the non-vegetated portion of the disposal area. Illustration 8 shows the difference of the river running in baseflow conditions (in 2007) and 590 m³/s flood conditions (in 1982). Although the braid patterns through the disposal area are clearly different between the photos it can be seen that at 590 m³/s the flow is still largely carried by the primary channel on the true left bank and the sediment disposal area is not yet inundated.
- 6.7 It would take a significant flood, in excess of say 1000 m³/s, to inundate the sediment disposal area and remove all of the sediment in one event. Smaller floods will erode part of the sediment, however, they will only be able to erode sediment placed around the perimeter of primary channels. In a flood of 300 m³/s only a small amount of the sediment would be eroded. Based on the limited extent of the disposal area that would be inundated in a 300 m³/s flood, it is unlikely that more than a few thousand tonnes of sediment would be eroded in such an event. Based on flow records it is typical for flows to remain elevated above 300 m³/s for a day or more. If the example of a 300 m³/s flood lasting for 24 hours is used then the natural sediment moved in this event is predicted to be 3000 tonnes using the values in section 6.4. The amount of sediment eroded from the disposal area would be of the order of what is naturally being carried by the river – and obviously it needs to be recognised that the disposed sediment came from the river in the first place.
- 6.8 If the example of a 1000 m³/s flood lasting for 24 hours was considered, then the natural quantity of sediment transported would be 230,000 tonnes. Even if one year's sediment was eroded in such an event, the total eroded volume would be less than the natural volume of sediment carried. However by managing the amount of sediment

placed in the disposal area (by using the pond storage) the increase would be reduced to about one third of the natural volume. I note that in 42 of the last 50 years, there has been a flood event where the daily flow has averaged 1000 m³/s or more and it is likely that most of the sediment erosion will occur in these larger flood events.

6.9 Therefore during flood events of around 300 m³/s the erosion of sediment from the disposal area could increase natural sediment concentration levels in the order of 2 to 3 times. These increased concentrations would be well within the natural levels carried by the river in higher flow events. In larger flood events of around 1000 m³/s natural sediment concentrations would be increased typically less than one third even if it is assumed that all of the sediment is removed in one flood event.

6.10 Dr David Rowe has suggested a criteria that discharges of sediment into the Rakaia River should not increase the current frequency of sediment concentrations in excess of 2000 g m⁻³ (mg/l) for more than 24 hours during the time of year when juvenile chinook salmon are abundant in the river (i.e. October-February). I am of the opinion that the operation of the scheme could be managed to comply with this criteria. Concentrations of this order would only be possible during floods in the order of 1000 m³/s or larger. As discussed above, the impact of the disposal in floods of this size is expected to be an increase in suspended sediment concentrations by one third. Based on typical Rakaia flood hydrographs I would expect the erosion of sediment to occur within a 24 hour period, so that while suspended sediment levels would be artificially elevated above the 2000 mg/l criteria during a flood event of this magnitude, they would not be maintained for 24 hours or more. I acknowledge that there is some uncertainty regarding the rate at which sediment will be eroded from the disposal area and some operational experience will be required to refine the operation of the disposal area. A monitoring condition has been proposed, and is included with Mr Dunning's evidence. This will allow comparison of the operation of the sediment disposal area against expectations.

6.11 Consideration should be given to whether the river can carry artificially elevated suspended sediment loads, as I understand that deposition of sediment on the river bed could have negative environmental impacts. I note that additional sediment will only be introduced to the river in flows above 300 m³/s. Based on evidence presented by Mr Borrie, some movement of the gravel river bed would be expected at flows of 300 m³/s and beyond. Given that the river has sufficient power to move gravel sized particles in such a flood event I would expect it to comfortably be able to move the much finer sand and silt material placed in the disposal area. Furthermore the following table illustrates that other New Zealand rivers, with higher availability of sediment, carry higher sediment loads than the Rakaia River i.e. it would be expected that if more sediment were available the Rakaia River would carry a higher sediment load.

Suspended solids loads in the Rakaia River compared with other New Zealand rivers with high levels of suspended solids (data from Hicks et al. 2004).

River	Yield (t/km ² /a)	Median concentration (mg/l)	Mean concentration (mg/l)	Maximum concentration recorded (mg/l)
Waiapu	20520	-	1219	49,291
Waipaoa	6753	199	1687	36,814
Motu	2531	92	245	14,600
Rakaia	1680	26	173	5577
Waiau	1184	19	214	4688

I note that most sediment deposition occurs as a flood recedes, due to a reduction in water velocity and therefore energy in the river. As flows reduce and the water level drops, erosion of sediment from the sediment disposal area will decrease and eventually stop as the water recedes away from the sediment. Therefore during the most critical

phase of the flood for sediment deposition little, if any, additional sediment will be entrained in the flow.

I acknowledge that the prediction of sediment movement is extremely complex and providing a definitive model of sediment behaviour is highly unlikely to be possible. However, I note that in, what I consider to be, the unlikely event that changes in sediment deposition were to occur to the extent that it impacts on aquatic life in the river, then the proposed monitoring condition would provide a means of detecting and therefore being able to mitigate these events.

- 6.12 Increases in sediment concentration also have the potential to reduce river clarity. I have been unable to locate data on Rakaia River clarity, however, I will use Waimakariri River data to demonstrate the likely impact on clarity. The Waimakariri river has similar catchment geology to the Rakaia and can be expected to demonstrate similar characteristics. This similarity is supported by the similar sediment yields of the rivers (1669 t/km²/yr for Waimakariri vs 1641 t/km²/yr for Rakaia (from *Waters of New Zealand*))

The following table demonstrates the change in clarity in the Waimakariri River with flow (from evidence of John Hayes on behalf of the Canterbury Fish and Game Council)

Flow (m ³ /s)	Clarity (m)
25	2.7
50	1.2
75	0.5
100	0.2

The mean flow in the Waimakariri River is approximately 120 m³/s. It can be seen from the data above that, as flow approaches the mean, clarity reduces quickly and will exponentially reach a very low level.

The mean flow in the Rakaia River is approximately 200 m³/s and sediment discharges would not occur until flows reach 300 m³/s. By

this flow clarity levels would be very low and any changes as a result of sediment disposal would be very difficult to detect.

- 6.13 While the sediment is placed on the river bed it will be a potential source of dust. To mitigate against this the material will be “track rolled” with earthmoving machinery to form an undulating surface. This approach is supported by Environment Canterbury’s Erosion and Sediment Control Guideline 2007 which notes that roughening the soil to produce ridges perpendicular to the prevailing wind can reduce soil losses by 80%. My experience with river sediment placed in this manner is that a crust tends to form on the surface that will further enhance its resistance to wind erosion. It is inevitable that some small amounts of dust will be generated from the sediment, particularly in strong northwest winds, however, the area of approximately 20 Ha should be considered in the context of thousands of hectares of exposed river bed that naturally generates large quantities of dust.
- 6.14 Sediment would be placed on the river bed in late autumn or early winter. This is outside of what I understand is the bird nesting season and would minimise the exposure of sediment to hot dry conditions that would increase dust generation.
- 6.15 If the alternative modified EA/BCI intake was developed, the primary means of sediment disposal would be flushing back to the river via a sluice channel. With reference to Illustration 7, water in the modified EA/BCI scheme intake first flows down a diversion channel. Whilst travelling down this channel sand sized particles will fall out of suspension and be deposited in the diversion channel. Water will then flow into the settling pond which will remove finer silt sized particles. Most of the total captured sediment is predicted to be settled out in the diversion channel. Sediment in the diversion channel would be flushed back to the river via the sluice channel on days when river flows exceed 300 m³/s. Sediment in the settling pond would need to be mechanically excavated and placed on the river bed in the sediment disposal area.

- 6.16 Analysis of this sluicing system resulted in the following conclusions:
- Up to 5000 tonnes of sediment could be discharged in a single sluicing event, however, more typically less than 500 tonnes would be discharged.
 - The highest discharges of sediment almost always relate to high flow conditions during the sluicing event.
 - Deposition of sediment in the settling pond (10Ha surface area) is predicted to vary from 3,000 to 15,000 tonnes per year.
- 6.17 The total amount of sediment released during the sluicing operations is likely to be small compared to the natural sediment movement during the fresh or flood. For example if 500 tonnes of sediment is released to the river during a 300 m³/s flood that lasts 24 hours, then the additional sediment released is approximately one sixth of the natural movement of sediment down the river in that flood event. Over the expected two hour sluicing duration the average release of sediment from the scheme would be 250 tonnes per hour, compared to a natural movement of 126 tonnes per hour. Therefore over the two hour sluicing period, the concentration of sediment in the river is expected to be in the order of three times that which would exist under natural conditions.
- 6.18 If the analysis is repeated under higher flow conditions the impacts on the river would be reduced. To illustrate, if 5000 tonnes of sediment was released to the river over a two hour period during a 1000 m³/s flood the total movement of sediment during the flood event is estimated to be 230,000 m³, therefore I would not consider the additional 5000 tonnes deposited into the river by the sluice to be significant. Over the two hour sluicing period, the 2500 tonnes per hour released to the river compares to a natural flux of 9700 tonnes per hour, increasing the sediment concentration downstream of the intake by 25%.

7 MITIGATION OF CONSTRUCTION EFFECTS

- 7.1 Construction of the scheme will involve approximately 6 million cubic metres of earthworks together with the construction of a number of reinforced concrete structures. Such activities have the potential to cause adverse environmental effects if appropriate mitigation measures are not adopted. I am of the opinion that the most significant impacts to be mitigated are the generation of sediment, dust, noise and vibration from construction activities.
- 7.2 A range of mitigation measures have been proposed in the Mitigation of Construction Effects report appended to this evidence. It is intended that the measures outlined in this report are considered a baseline for compliance with the resource consent by the contractor. Should the eventual contractor for the project wish to use alternative methods, it is envisaged that they would present their proposal to the consenting authority for approval prior to construction commencing.
- 7.3 The primary reference document applicable to developing mitigation measures for sediment and dust nuisance is Environment Canterbury's Erosion and Sediment Guideline 2007 (ESCG).
- 7.4 I consider the site to be favourable in terms of the control of sediment during construction. Apart from the terrace faces, slopes are gently sloping and generally fall away from the Rakaia River. The construction site is not crossed by any permanent waterways and is underlain by permeable gravel soils which enable the disposal of stormwater to ground.
- 7.5 The first key principle of the ESCG is to control run-on water i.e. prevent water from off the construction site from entering the construction site. This would be achieved by forming topsoil bunds along the extent of the construction corridor as shown in Illustration 9. Water diverted by these bunds would either discharge to ground via infiltration or if necessary be assisted by soakage pits. Where concentrated flows could cross the alignment in high flow conditions

culverts would be provided so that water can flow beneath the construction site.

7.6 The second key principle is to separate “dirty” water from clean water. Water which falls within the construction zone needs to be collected and treated before being discharged back to the river system, without mixing with clean water from outside the construction zone. During initial stripping of surface soils (topsoil and loess) to expose gravels, soakage pits sized in accordance with the ESCG would be utilised to treat and dispose of water. As the surface soils are progressively removed more and more permeable gravel soils will be exposed forming a large natural soakage pit. Any water that can not be directed to the exposed gravel, for example the haul road in Illustration 9, would be directed to separate soakage pits sized in accordance with the ESCG.

7.7 The third key principle is the protection of the land surface from erosion. Most of the ground exposed during construction will be sandy gravel, which has a high natural resistance to erosion. After an initial layer of fine grained material is eroded from this type of material it naturally “self armours” as larger size particles are exposed on the surface. Combined with high natural infiltration rates, resulting in low run off, this material has a high natural resistance to surface erosion. Furthermore the ESCG section 6.2.2 identifies gravel surfacing as an effective surface erosion protection material. Therefore, surface erosion measures will target the topsoil and loess soils that will be disturbed along the alignment.

7.8 Small quantities of topsoil and loess will be exposed in the cut faces, however, they will be at their most vulnerable to erosion when stored in stockpiles. In order to manage these issues the following strategies would be adopted:

- Only topsoil required for re-vegetation of permanent slopes will be stored along the alignment. Topsoil which is surplus to these requirements will be taken to spoil disposal areas immediately.

- Spoil disposal areas will be re-vegetated progressively as material is placed. In practice this is likely to involve sowing areas in pastoral grasses in blocks of approximately 1 Ha, although dependent on weather or seasonal conditions and the quantities of material being moved at any particular time. While awaiting re-vegetation, topsoil surfaces will be roughened as recommended in the ESCG section 6.1.2.
- Loess not required for incorporation into the canal liner will be taken to the spoil sites immediately and covered in topsoil as discussed above.
- Loess required for incorporation into the liner will be delivered to a processing site in a progressive manner so that it can be treated and blended as required without the need for excessive stockpiling.
- As far as is practical, permanent slopes will be re-vegetated as soon as possible following formation.

7.9 The fourth key principle is to prevent sediment from leaving the site. Measures to prevent sediment from leaving the site due to erosive forces are discussed in the sections above. Consideration must also be given to movement of sediment from the site by vehicles leaving the site. Vehicles will only be able to enter and leave the site through controlled access points. In order to mitigate the transfer of sediment onto the public road system, the following measures will be implemented:

- Haul roads traversed by on road vehicles will be surfaced in gravel to form an “all weather” surface that will minimise the sediment that can be picked up by vehicles.
- Shaker ramps (cattle stop or similar) will be utilised at the formal exit points as outlined in section 7.1.4 of the ESCG to remove sediment before vehicles leave the site.
- Sweeping intersection points with public roads from time to time as required to keep them to a standard acceptable to the district council.

7.10 Special consideration needs to be given to sediment control during in-river works. All of the in-river works can be completed out of flowing

water, either due to their location or by temporarily diverting river braids by the use of gravel bunds and the like. Temporary coffer dams would be created around the works sites using gravel bunds so that any sediment generated can be collected and removed before flow was reactivated past the work-site. In the event of a significant flood occurring during construction, the temporary bunds would be overwhelmed and would need to be reinstated once the flood recedes. While it is possible that sediment will be released to the river in such an event, it would be during conditions when natural suspended sediment levels in the river are high and the impact on the river would be, in my opinion, minimal.

- 7.11 The key consideration for the control of dust generation is the limitation of disturbed areas from which soil particles can be detached. The same procedures outlined in paragraph 7.8 above for limiting erosion by water will be effective in limiting erosion by wind forces. Potential dust nuisance will be most prevalent during strong north west wind conditions and possibly during gusty southerly storms. When such conditions are encountered, construction activities that have high dust generating potential, such as stripping and spreading topsoil and loess, will be suspended. It is noted that during high wind conditions natural dust levels in the area are high due to the large area of exposed sediments in the Rakaia River bed. For health and safety reasons it may be necessary to stop work completely in particularly high wind conditions due to the high natural dust levels.

In order to minimise ground disturbance, construction traffic will be limited to designated and maintained haul roads within the site. Speeds will be limited to 70 kph on the haul roads, although lower speeds limits may be required in specific areas, such as in the vicinity of Highbank Powerstation, and under difficult weather conditions.

When conditions arise that generate larger amounts of dust than is tolerable, mitigation will be by the application of water from water carts as recommended in the ESCG section 6.1. Spray irrigation may also

be utilised to control dust generation from stockpiles and other areas that can not be trafficked by water carts.

7.12 Construction activities would generate noise that will have the potential to disrupt landowners in the vicinity of the canal. In order to assess the magnitude of this impact, NZS6803 can be used to provide guidance on the generation and attenuation of construction related noise.

7.13 Based on Annex C of NZS6803:1999 the majority of construction equipment to be used on the project will produce time averaged sound levels (L_{Aeq}) of 85 dBA or less within 10m of source. The attenuation of noise away from the source, calculated using Figure D2 of NZS6803, is summarised in the table below.

Noise Levels at distances from 85dBA source

Distance from source (m)	Predicted noise level, L_{Aeq} (dBA)
50	69
100	62
200	54
500	44
1000	37

The above calculations assume attenuation across cultivated land, with the sound source at the same level as the point of measurement. In reality significant vertical distances often exist between the source and receivers, which is likely to reduce noise levels by 10 dBA or more from the figures calculated above.

Some specific activities, such as driving of sheet piles, could generate greater sound levels than 85 dBA at source for short periods of time, however, they would be associated with works at the concrete structures of the scheme that are located generally several hundred metres from residential dwellings and therefore have far greater attenuation distances than the more common construction activities discussed above.

7.14 To provide context to the figures calculated in 7.13 above, the following table provides recommended upper limits for dwellings in rural areas.

NZS 6803 :1999 – Recommended Upper Limits for Noise Received In Dwelling in Rural Areas							
Time of Week	Time Period	Duration of Work					
		Typical (dBA)		Short Term (dBA)		Long-Term (dBA)	
		L _{eq}	L _{max}	L _{eq}	L _{max}	L _{eq}	L _{max}
Weekdays	0630-0730	60	75	65	75	55	75
	0730-1800	75	90	80	95	70	85
	1800-2000	70	85	75	90	65	80
	2000-0630	45	75	45	75	45	75
Saturdays	0630-0730	45	75	45	75	45	75
	0730-1800	75	90	80	95	70	85
	1800-2000	45	75	45	75	45	75
	2000-0630	45	75	45	75	45	75
Sundays & Public Holidays	0630-0730	45	75	45	75	45	75
	0730-1800	55	85	55	85	55	85
	1800-2000	45	75	45	75	45	75
	2000-0630	45	75	45	75	45	75

The closest residential dwellings are approximately 100m from the construction site and would therefore be expected to receive between 62 dBA if plant was operating at ground level. These values would be within the requirements of NZS6803 for weekdays between 0730 and 1800, Monday through Saturday.

The applicant proposes to comply with NZS6803 unless specific permission to exceed these levels is obtained from the affected landowners.

7.15 Construction plant also has the potential to generate vibration that could impact on surrounding properties. New Zealand does not currently have any established standards for the control of vibration, with the exception of NZS 4403:1976 “Code of Practice for the storage, handling and use of explosives”. However a number of international criteria are available to provide guidance on acceptable levels of vibration. For example:

- For short term vibration events (i.e those unlikely to cause resonance or fatigue), DIN 4150 offers a peak particle velocity criteria of 5 mm/s to avoid building damage to residential buildings.
- ISO 2631-2:1999 provides a “daytime annoyance” guideline of 0.55 mm/s. Norwegian standard NS8176.E:2005 suggests that vibration of 0.55 mm/s would be expected to cause annoyance to more than 10% of building occupants during daytime.
- The threshold of human sensitivity to vibration varies with frequency, but generally ranges from a peak particle velocity (ppv) of 0.1mm/s at low frequencies to 0.2mm/s at high frequencies.

7.16 The attenuation of vibration away from a source can be estimated using techniques such as discussed in the appended Mitigation of Construction Effects report. The expected vibration levels for typical construction equipment that would be used on the project are summarised in the following table.

Equipment	Source Vibration	Max vibration at 50m from source	Max vibration at 100m from source	Max vibration at 200m from source
	ppv v _a mm/ s			
Odex DTH Rig	5.00	0.96	0.39	0.09
50 T Excavator	1.00	0.23	0.11	0.04
20 T Excavator	0.20	0.05	0.02	0.01
30T ADT	0.70	0.16	0.08	0.03
Dozer D9	5.00	1.15	0.57	0.20
Scraper S24	0.80	0.18	0.09	0.03
Dump Truck Dumping Rock	0.78	0.18	0.09	0.03
21 T Vibrating Roller	2.00	0.46	0.23	0.08
7 T Vibrating Roller	1.00	0.23	0.12	0.04
50 T Crawler Crane	5.00	1.15	0.58	0.20
Road Truck 6 Wheeler	0.60	0.14	0.07	0.02
5T Drop Hammer (50,000 Joules)	8.00	4.65	3.12	2.00
Sheet Pile Vibro Hammer	12.00	2.77	1.38	0.48

7.17 Residential properties are located at least 100m from the proposed construction. From the table above, none of the likely range of construction activities would place these structures at risk from vibration induced damage. Human sensitivity to vibration is noted to begin at 0.1 to 0.2 mm/s and guideline “annoyance” values of 0.5 mm/s are proposed by international standards. It is noted that, apart

from pile driving (5T drop hammer and sheet pile vibro hammer) and the largest earthmoving machinery none of the activities would exceed 0.5 mm/s at a distance of 100m. It is further noted that pile driving activities are limited on the project, only being used for bridge foundations constructed near the river. Such structures are located approximately 1 kilometre from residential dwellings, and based on the calculation procedure above a setback of approximately 900m would reduce vibrations below 0.5 mm/s. I therefore conclude that provided appropriate choices for equipment operating near residential dwellings are made vibration generated by typical construction plant to be used on the project would generally be below annoyance levels at nearby residential dwellings and certainly below damage causing levels.

- 7.18 The applicant proposes to limit vibrations at residential dwellings to 0.5 mm/s unless an alternative standard can be negotiated with individual landowners. As a matter of good practice, condition assessments of all structures potentially affected by the works would be undertaken prior to and after construction to assess any damage that may have occurred during construction.
- 7.19 Special consideration should be given to the existing Highbank Power Station. Given the age of the structure and the sensitive equipment it houses, more stringent measures than a typical commercial building are warranted and myself and experienced contractors consider that the adoption of the residential guideline (5mm/s) is reasonable. Construction activities will take place within approximately 50m of the structure. From the table in 7.16 above it can be seen that all of the likely construction activities will be within the 5mm/s guideline value. Given that the station is unmanned I do not consider that vibration values above the perception limits unacceptable. Specific conditions of consent including monitoring provisions have been proposed to address vibration induced building damage at this structure.

8 ISSUES RAISED IN SUBMISSIONS

8.1 I consider the main issues raised in opposing submissions relate to:

- The standard of fish screening at the scheme intake.
- The impact construction effects may have on the Rakaia River.
- The impact of sediment disposal on the river.
- The impact that the canal may have on stability of the terrace.
- The use of a pipeline as an alternative to a canal.
- Operational noise from the Barrhill Powerstation on the nearby “Corwar” property.

I will discuss each of these issues in the following sections.

8.2 The application indicates that the fish screens for the scheme will match the requirements of the BCI Scheme on the basis that this would be the minimum standard acceptable if BCI water were to be taken through the intake. The BCI consents dictate the approach velocity to the screens (and therefore their area) and the screen mesh opening size (3.8 to 5mm depending on the time of year). Since the application was made, NIWA has released *Fish Screening: good practice guidelines for Canterbury*. Compared to the BCI fish screens these guidelines recommend the same approach velocity and a screen mesh size of 3mm (or 2mm slot screen) and the applicant has elected to adopt these guidelines for the design of fish screens. These guidelines were developed primarily to address game fish but also discuss native species and generally concludes that the 3mm screen size will offer a significant level of protection or the consequences of entrainment are not severe. The guidelines note that “*DOC’S review of screening requirements for native fish (Charteris 2006) concluded that implementing screens to protect salmon fry would protect the majority of native species*”. I am therefore of the opinion that adoption of these best practice guidelines as the basis of fish screen design will adequately address fish entrainment into the scheme.

- 8.3 A number of submitters have raised the impact of construction activities on the Rakaia River as a significant issue. As noted in section 7, I consider the site to be favourable with respect to the management of erosion and sediment and provided the requirements of ECan's Erosion and Sediment Control Guidelines are implemented as outlined in the appended Mitigation of Construction Effects report, I consider that any potential effects on the river can be mitigated.
- 8.4 In section 6 of this evidence I discuss the return of sediment to the river by either deposition within the proposed sediment disposal area or sluicing back to the river. Based on the high natural volumes of sediment that are transported down the river, and the release of sediment to the river only in conditions of high natural turbidity, I am of the opinion that effects of sediment discharge to the river will be significantly mitigated. Furthermore a monitoring condition is proposed to assess actual performance against expectations.
- 8.5 The potential for construction of the canal to destabilise the terrace face has been raised by some submitters. My observations of the existing terrace face is that areas of instability are associated with erosion from water running down the face. Where the canal is constructed at the toe of the terrace it will not change the stability of the upper portion of the terrace. The canal will improve the stability of the lower portion of the terrace by buttressing the existing terrace face. Drainage works associated with the canal will collect water flowing off the faces above and discharge it in a controlled manner. Control of water in this manner will ensure that the formed slopes of the canal are likely more stable than the existing slopes. Where the canal is constructed by excavating at the top of the terrace, provided sufficient setback is provided to the edge of the terrace and leakage from the canal is controlled to very low levels I would expect no adverse impacts on the terrace stability. These issues would need to be analysed in detail during the final design of the scheme using dam engineering principles. Conditions of consent have been proposed to

address dam safety issues and ensure the appropriate level of engineering design and supervision.

8.6 The potential for a pipeline rather than a canal has been raised as an alternative design. If water was to be transferred through a pipeline it would need to flow much faster than if it were travelling in a canal. If water is flowing faster it uses up more energy and requires more elevation difference between two points to drive the water. If the elevation is being used to drive water it is not available at the end of the pipeline for use to generate power. It is therefore a less efficient use of the water.

8.7 The Campion's, who live approximately 500m downstream of the Barrhill Power Station, have raised the issue of operational noise from the Power Station. Guidance on the dissipation of noise can be taken from measurements undertaken by Marshall Day during Project Aqua. Based on measurements from the Power Atations in the Waitaki scheme they concluded that:

- Turbine noise would be negligible at distances over approximately 150m.
- Old "noisy" transformers would be essentially inaudible at a distance of 500m while newer transformers would be essentially inaudible at a distance of approximately 100m.

These comments are consistent with my observations of noise generated during the operation of the existing Highbank Power Station.

More noticeable noise levels could be generated if water was flowing down the spillway, which may be audible at a distance of 500m. This would only happen for a few hours per year, if that, so would represent a very low nuisance value.

9 SUMMARY

- 9.1 I have presented an overview of the proposed components of the Rakaia Terrace Hydro Scheme. The way in which water flows through the scheme is described along with the scale and operation of each component.
- 9.2 I have discussed how the scheme may be integrated with the Barrhill Chertsey Irrigation Scheme, if that scheme were developed before the Ashburton Community Water Trust scheme.
- 9.3 I have discussed the means by which sediment would be managed under two alternative intake configurations. Based on the natural characteristics of the river I conclude that the river will be able to carry increased sediment loads and meet environmental criteria. I acknowledge uncertainty in these assessments but am of the opinion that proposed monitoring conditions can address this uncertainty.
- 9.4 I have discussed the strategies that would be implemented to mitigate the potential adverse impacts of the construction activities that will be required for the project. I consider that the site is favourable with respect to the management of erosion and sediment provided mitigation measures described in this evidence and based on Environment Canterbury's Erosion and Sediment Control Guideline are implemented. I am also of the opinion that effects from dust, noise and vibration can be mitigated using the methodologies described in this evidence.
- 9.5 I am of the opinion that entrainment of fish into the scheme intake can be mitigated by adoption of the recommendations of *Fish Screening: good practice guidelines for Canterbury*, published by NIWA, for the design of fish screens.

Dated: 8/9/08

Name: Steven Woods

Title: Civil Engineer

MWH New Zealand Limited