BEFORE THE CANTERBURY REGIONAL COUNCIL
AND ASHBURTON DISTRICT COUNCIL

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of resource consent applications by Rangitata Diversion Race Management Ltd to the Canterbury Regional Council and Ashburton District Council for resource consents for the construction, operation and maintenance of the Klondyke Water Storage Facility, its associated water takes from and discharges to the Rangitata River, and all associated activities

---

STATEMENT OF EVIDENCE OF PAUL KELVIN MORGAN ON BEHALF OF RANGITATA DIVERSION RACE MANAGEMENT LTD

UPDATED 12 APRIL 2018

Introduction

1. My name is PAUL KELVIN MORGAN and I am a Director of Riley Consultants Ltd (RILEY). My qualifications are a BE (honours) in civil engineering from University of Auckland 1997 and a BSc from University of Otago 1990. I am a Chartered Professional Engineer CPEng (civil) and Member of IPENZ (MIPENZ). I have 20 years' experience in civil and water resource engineering and in particular this includes expertise in Water Resources, hydro power, irrigation and river management.

2. I have particular experience in the development of hydro power and irrigation schemes which include storage dams, canals, intakes, fish screens, pump stations and pipelines. I was project manager and undertook design of the intake and pump station for irrigation at Highbank for Trustpower (Ltd) which was completed in 2010 and for the South Ashburton fish screen for the Rangitata Diversion Race intake 1998. I have also undertaken engineering work for Hurunui Water Project, Barrhill Chertsey Irrigation and Central Plains Irrigation in recent years.

3. I provide the following statement of evidence in support of the resource consent applications lodged by the Rangitata Diversion Race Management Ltd (RDRML) for the proposed Klondyke Storage Facility (the 'Project'). I have read the Code of Conduct contained in the Environment Court's Practice Notes for Expert Witnesses and agree to comply with it.

4. In my evidence I will cover the following components of the proposed project. This includes:

   4.1 Canal Modifications between Rangitata River intake and intake to Klondyke Storage Facility.

   4.2 Fish Screen.

   4.3 White Water Course at outlet of Klondyke Storage Facility.

5. This evidence will include the following aspects of the engineering for the three components of the scheme:

   5.1 Description of the component of the scheme and explanation of how it will operate.

   5.2 Details of investigations that have been undertaken in developing each component.

   5.3 Design standards and guidelines that have been followed in the analysis and development of each component.

   5.4 Proposed construction works, the effects of the construction and mitigations that will be undertaken.

   5.5 Consideration of dam safety for the canal modifications.

6. Please note that the following three reports provide more details of the three components of the project that I discuss:

   6.1 RILEY 11835-A (February 2016). Klondyke Water Storage Proposal – Canal Modification Engineering Report

   6.2 RILEY 150975-C (November 2017). Rangitata Diversion Race Fish Screen Concept Report.

6.3 RILEY 11835/3-A (July 2016). White Water Course Engineering Report.

7. I have provided review and contribution to the following Management Plans undertaken by MWH and Ryder in regard to the canal modifications, fish screen and WWC:

- Construction Management Plan
- Erosion and Sediment Control Plan
- Dam Safety Management System
- Emergency Action Plan

7.1 I support these plans as being robust and according with the applicable legislation and guidelines, and that there finalisation and implementation will ensure that any effects from the WWC, RDR Mods and fish screen will be avoided, remedied or mitigated to an extent whereby there are minimal (and, appropriate, in my opinion and experience with similar projects)

7.2 I have also assisted with the production of the conditions of consent that have been developed by RDRML and that are attached to the evidence of Mr Greaves. The focus of my input has been on conditions for the fish screen, canal modification and white water course, which fall within the ambit of my expertise and my role in this project. I am of the opinion that these proposed conditions are appropriate and will follow accepted and best practice.

Executive Summary

8. This evidence provides an overview of the engineering work associated with the canal modifications, fish screen and kayak course. The key findings presented in the evidence are as follows:

Canal Modifications

8.1 The additional 10m^3/s increases water levels by approximately 0.5m which requires modification to parts of the canal between the intake and the Klondyke Storage Facility. The modifications will mostly require bank raising with a section of the canal also requiring widening. Three of the existing bridges will also require raising. The proposed rotary cylinder fish screens will also result in a further approximately 0.2m rise in water levels upstream of the fish screen (i.e. 0.7m in total upstream increase). However the existing bank levels between the intake and the location of the fish screen are already sufficiently high as to not require any modifications to accommodate the additional flows and fish screen.

8.2 An initial dam break assessment has been undertaken by RILEY for the canal between the intake and the Klondyke Pond and indicated that there are three areas along the race that have been constructed in fill which require consideration. The assessment has indicated that the Potential Impact Category (PIC) is low. Compliance with the design standards that apply as a consequence of this PIC will ensure that any risk of an uncontrolled release from the modified sections of the canal will be low, and in accordance with the applicable guidelines. .

8.3 The main construction activity will be earthworks with a total of approximately 34,000m^3.

Fish Screen

8.4 The proposed new fish screen will comprise a rotary cylinder screen located upstream of the sand trap. The last rotary cylinder screen may be replaced with a flat screen of some kind depending on the available flows for the fish bypass.

8.5 Feedback from consultation with Fish & Game (F&G), Department of Conservation (DOC) and Environment Canterbury (ECan) was considered and changes to original concepts were then included.

8.6 The fish screen is designed based on the fish screen guidelines and on international practice, particularly the standards that apply in the USA. The design will achieve the guidelines in regard to approach velocity and the sweep velocity.

8.7 The fish bypass will meet the guidelines and follow the feedback from consultation. The outlet will be located upstream of the existing fish bypass.

8.8 Maintenance will be required periodically but can be undertaken while the scheme operates below maximum flow conditions when it will be possible to raise a screen out of the water for work to be undertaken.

8.9 The main construction activity will occur offline from the existing canal and will involve excavation of a new channel and construction of concrete walls and the fish screens.

White Water Course

8.10 It is proposed to construct a White Water Course (WWC) at the outlet of the proposed Klondyke Storage Facility. The WWC is off-line from the MHIS race to allow the control of flows into the course, thereby maximising its potential usage. All flows above the design inflow will bypass the gate and continue as normal to the MHIS race.

8.11 The construction of the kayak course will include control gates, earthworks in the kayak course, a car park and toilet/change facilities.

Involvement in Project

9. I have been involved in work on the Rangitata Diversion Race (RDR) since 2007 which has included work on improvements to the existing Bio Acoustic Fish Fence (BAFF), design and construction of intakes, and ponds and all work undertaken by RILEY for the current project on the canal, white water course and fish screen.

Canal Modification

10. The Klondyke Water Storage Proposal – Canal Modification Engineering Report[1] includes details of the proposed work required to modify the canal between the Rangitata River intake and the Klondyke Pond.

11. The current intake diverts a total of 35.7m^3/s from the Rangitata River. This is inclusive of 30.7m^3/s for the RDR to supply to the various irrigation companies, 3.0m^3/s for the fish bypass, 0.5m^3/s (MAR trial water on loan from ADC), and 1.5m^3/s for a farm located immediately downstream of the sand trap. The key objective of the canal modification is to facilitate an additional 10m^3/s to be conveyed in the canal at times of high river flow and an additional 2m^3/s for fish bypass (to take total to 5m^3/s), which results in 47.7m^3/s at the intake and 40.7m^3/s in the canal to the pond diversion point at the current MHIS turnout.

---

[1] RILEY 11835-A (February 2016). Klondyke Water Storage Proposal – Canal Modification Engineering Report

12. **Hydraulic Modelling of Canal:** I was the author and reviewer of previous work undertaken by RILEY which included a preliminary hydraulic assessment of the canal in 2011 which is included in Appendix A of the Klondyke Water Storage Proposal – Canal Modification Engineering Report[1]. The other RILEY engineers involved in this work were Paul Rivett, Director, BE, CPEng who has over 14 years' experience in civil engineering, Nadeesha Senarath-Angus BE who has 6 years' experience as a civil engineer also assisted with this work. The preliminary study developed a hydraulic model to assess the effects on canal freeboard caused by any increase in flow into the RDR. A number of potential operational scenarios were modelled including the additional inflow of $10m^3/s$, and the implications on the remaining freeboard to the top-of-bank and to the underside of the existing bridges. The modelled results are presented in RILEY Dwg: 11835/2-1 (Annexure A).

13. **Freeboard:** A freeboard of 0.5m has been selected as it is consistent with the current freeboard. Module 3 Section 4.5.3 of the New Zealand Dam Safety Guidelines 2015 (NZDSG) prepared by the New Zealand Society on Large Dams (NZSOLD) recommends freeboard requirements for new dams, but provides no guidance for the modification of existing dams. Therefore, I have referred to the following standards:

- United State Bureau of Reclamation (USBR) Design Standard No.13 Embankment Dams (2012).

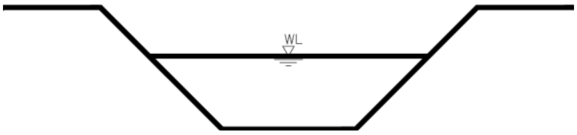
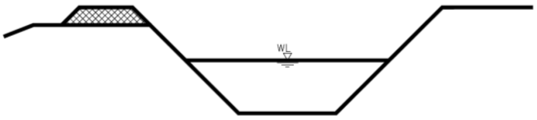
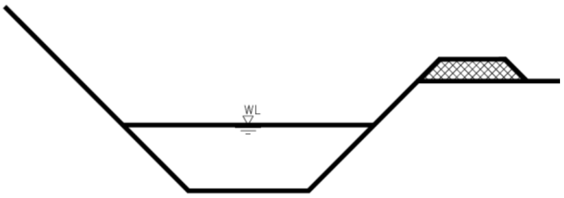
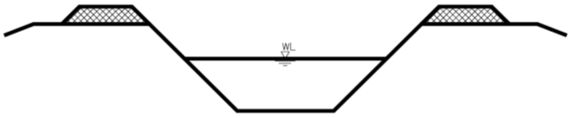
- USBR Design Standard No.14 Appurtenant Structures for Dams (Spillways and Outlet Works) (2014).

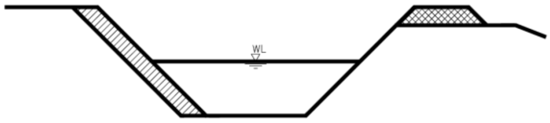
Given that the majority of the uncertainties outlined by the USBR are not relevant in the RDR context, I believe that the nominated 0.5m freeboard used in this preliminary assessment is adequate and appropriate.

Effects on Canal and Proposed Modifications

14. To achieve the required 0.5m freeboard involves different canal upgrade solutions along the length of canal. The construction process can be split into five indicative cross-sections as presented below (and on RILEY Dwgs: 11835/2-1 and 11835/2-2 at Annexure A). For indicative cross sections 2, 3 and 4 the canal will be in full service whilst the works are undertaken, and no de-watering of the canal will be required. For cross section 5, the canal will need to be dewatered for approximately two to six weeks to allow access for construction machinery. This will coincide with a planned shutdown period with works also being undertaken at the

sand trap over this period. The final construction methodology and details will be dependent on the detailed design and the selection of constructors and their construction planning.

Typical Cross-Section and Description of Canal Modification	Proposed Construction Works
Typical Cross-Section 1  Freeboard level adequate for increase in water levels. Hence no modification required.	No action required.
Typical Cross-Section 2  True-right bank has sufficient freeboard. True-left requires bank elevation.	Raising of Embankment: • Strip approximately 0.2m of topsoil with suitable excavator. • Backfill with imported/reusable aggregate. • Compact in appropriate layers. • Match existing topsoil and re-grass. • Excavate the batter within the canal to increase canal width and match with existing profile.
Typical Cross-Section 3  True-left bank has sufficient freeboard. True-right requires bank elevation.	
Typical Cross-Section 4  True-left and right banks do not have sufficient freeboard. Both banks require elevation.	

Typical Cross-Section 5	<u>Widening of Canal:</u> • Dewater canal. • Construct temporary coffer dam at both ends of the worksite so stormwater does not enter. • Excavate required canal bank width. Dispose of or reuse material as appropriate. <u>Filling of Embankment:</u> • Strip approximately 0.2m of topsoil with 20 tonne excavator. • Backfill with imported/reusable aggregate. • Compact in appropriate layers. • Match existing topsoil and landscaping details at surface.
 This section of canal width identified as narrower than other sections and widening will be required. True-left has sufficient freeboard. True-right requires bank elevation.	

15. The total stripping area is approximately 50,000m^2, the total volume of material to be removed is approximately 10,000m^3, and the total volume of material to be imported is approximately 24,000m^3. The removal and replacement of material will be undertaken in discrete sections to allow effective stormwater management controls to be implemented.

Effects on Bridges and Proposed Modifications

16. There are five bridges along the length of the canal that is to be modified by the Proposal (I understand that there are 63 bridges across the full length of the RDR). RILEY Dwg 11835/2-1 includes a plan showing the location of the bridges (see Annexure A). The hydraulic model identifies the requirement to raise Bridges 3, 4, and 5 to prevent constant submergence of the bridge deck upon increasing the flow and water level within the canal. A new bridge has recently been constructed across the canal between Bridge 4 and 5, which meets the new freeboard requirements and does not require further modification. The design of a new bridge is expected to be a single span pre-cast bridge deck, supported by abutments at both canal banks. The final arrangement will be determined during detailed design, including the abutment foundation type.

Dam Break Flood Hazard and Consequences Assessment

17. For the canal modifications the potential impact of the dam in the hypothetical event of a dam breach has been assessed by RILEY and reported in the Klondyke Water Storage Proposal – Canal Modification Engineering Report[1]. The consequence of such a dam breach and the associated Potential Impact Category (PIC) of the dam determine the loadings and standards required for design, as well as post-construction operation and maintenance requirements. As the size and storage volume of the canal increases, the potential breach volume and peak flow rate also increases, with a potential increased risk to any downstream population and/or infrastructure. The assessment of the consequences of a dam breach is also an expected component in the future applications for building consent.

18. The NZDSG outlines a dam-break flood hazard and consequence assessment process. The Guidelines outline three levels of assessment that depend on the anticipated level of consequence of the potential dam-break hazard. The consequence is predominantly determined by assessing the Population at Risk (PAR), but includes other issues such as the amount of downstream development and the severity of flooding.

Embankments and Appurtenant Structures

19. The Building Act 2004 defines a large dam as a dam that has a height of 4 or more metres and holds 20,000 or more cubic metres volume of water. For a canal, the height of a dam is measured from the invert of the canal. The modifications to the existing RDR mean that that height requirement is met, and given the large volume of water, the RDR meets the definition of a large dam in the Building Act. Given there are a number of areas where the canal is in cut the true height of 4m is better reflected by the height difference between the crest and downstream toe of the embankment. There are three distinct sections of the RDR embankments that would classify as fill embankments in this context (as presented in RILEY Dwg: 11835/2-5):

    - Fill Zone 1: From the sand trap to Bridge 3 (approximately 3000m).

    - Fill Zone 2: A short length of approximately 450m between Bridges 4 and 5.

    - Fill Zone 3: The length of approximately 1100m immediately upstream of the Mayfield Hinds Irrigation Scheme intake.

20. The scheme includes (from upstream to downstream) the following key components that have been identified as critical to dam safety, and are therefore appurtenant to the RDR embankment:

- Rangitata River intake gate.
- Overflow spillway at the sand trap.
- Montalto power station bypass gate.

Initial Dam Break Flood Hazard Assessment

21. RILEY Dwg: 11835/2-5 (Attachment A) presents the embankments that have been identified with significant fill. The entire zone between the RDR and Rangitata River is comprised of modified farmland and there are two residential houses at Teradale, and no commercial buildings, across this zone. The only structure within this zone is a farm pond located immediately east of the Sand Trap; this pond draws 1.5m^3/s directly from the RDR.

RDR Embankments

22. To assess the PAR and subsequently the PIC, an assessment of the likely peak dam breach flow and inundation area for each section needs to be made. A range of empirical methods exist for estimation of dam breach parameters. For the current assessment RILEY has undertaken a conservative approach by assuming a breach width three times the depth of water in the RDR (from USBR 1988), and assuming that there is an instantaneous breach of the canal at the normal maximum operating level.

23. Based on the geometry of the canal, the theoretical peak discharge is approximately 175m^3/s (and 240m^3/s at embankment crest), with an actual discharge less than this due to the following mitigating factors: (1) the canal water level will drop quickly as there is no reservoir upstream to provide a large source of water; and (2) the formation of a breach is unlikely to occur instantaneously. RILEY Dwg: 11835/2-5 presents the theoretical flood inundation zones for the identified sections of the RDR for all areas. It is important to note that a single breach would be confined to a considerably smaller area than that presented in the drawing.

Appurtenant Structures

24. **Control Gate at Rangitata River Intake:** Water is diverted from the Rangitata River to the RDR via the Rangitata River intake. A radial control gate is located downstream of the intake structure and its dam and reservoir safety function is to control the diversion inflow into the RDR. Failure of the control gate to operate will allow uncontrolled flow to enter the RDR. The volume of uncontrolled flow is unknown, but given the dimensions of the upstream culvert and gate, there will be significant choking of the flow. An uncontrolled release would be safely attenuated over the spillway and not result in an overtopping of the RDR given the restrictions to flow at the intake structures and the capacity of the emergency spillway. Ben Curry has reported that this event has occurred in the past when the gates have incorrectly opened fully and the spillway has successfully operated to avoid overtopping of the canal.

25. **Spillway at the Sand Trap:** The spillway is located upstream of the Sand Trap and consists of a lowering of the crest to allow spill flow to spill back to the Rangitata River. The dam and reservoir safety function of the spillway is to safely divert inflows that cannot be accommodated within the RDR if the Rangitata River intake gate malfunctions open. The canal at this point is in cut and the only credible failure mode for the spillway is if its capacity is exceeded by the inflows into the RDR. The spillway is unlikely to become blocked and there are no mechanical items of plant that could fail. If the spillway capacity is exceeded the water level in the RDR could increase and ultimately lead to overtopping of the embankment.

26. **Montalto Bypass Structure:** The bypass gate is incorporated into the Montalto power station. The dam and reservoir safety function of the bypass gate is to open automatically when the RDR level upstream of Montalto level exceeds a pre-set maximum level. The gate can also be used to dewater the RDR in the event of an upstream dam safety event. Failure of the bypass gate to operate at its pre-set levels will result in an increase in RDR level and potential overtopping of the embankment.

Initial Dam Break Consequence Assessment

27. **Assessment of Damage Level.** NZSOLD Guidelines (Table 2.2 in Guideline) outlines the key criteria for consideration relating to the damage level. The categories that need to be considered are Residential houses, critical or major infrastructure, natural environment and community recovery time.

- **Residential houses:** There are no residential houses in zones 1 and 2. There is a house in zone 3 which is 600m from the RDR and the ground contours suggest it is unlikely that the inundation area would include the residence.

- **Critical or major infrastructure:** The infrastructure associated with the RDR is considered to be of national significance based on the area of irrigation and hydro power generation components and therefore the RDR should be considered as Critical Infrastructure. The damage to the RDR embankment caused by a single breach should be readily repaired and the Time to Restore to Operation should be less than three months which would categorise the damage level as Moderate

- **Natural Environment:** The inundation zone potentially floods the riparian margins of the Rangitata River and modified farmland. Only short-term damage would occur due to the breach flows spreading out and the relatively short duration due to limited volumes contained within the canal as there is no upstream storage.

- **Community Recovery Time:** There will be no notable impacts on the community given the location of breach zones and therefore recovery times are assessed to be no more than days or weeks which corresponds to Minimal Damage Level in Table 2.2 of the Guidelines.

28. Three of the above categories are assessed as Minimal Damage but due to the Time to Restore to Operation for Critical Infrastructure being less than three months, the assessment damage level is assessed as Moderate.

Assessment of Potential Impact Category

29. The assessment of PIC is based on Table 1 which is reproduced from the NZDSG. There are no residential houses or commercial facilities within the inundation zone. The only potential PAR will be farm workers tending to their normal farming duties and fishermen on the banks of the Rangitata River. A conservative assessment based on Table 4 is that the PAR will be between 1 to 10 and that no lives are highly likely to be lost. A cascade failure of the small farm pond downslope of the RDR will not increase the PAR. Given it is unlikely that a dam-break at inundation zone 3 will cause flooding to a depth of 0.5m, then no PAR is triggered for a dam-break at this location.

Table 1: Determination of Potential Impact Category (PIC) – reproduced from Table 3.1 of the NZSOLD Guidelines 2015 (NZSOLD 2015)

Assessed Damage Level	Population at risk (PAR)			
	0	1 to 10	11 to 100	More than 100
Catastrophic	High potential impact	High	High	High
Major	Medium potential impact	Medium/High (see note 4)	High	High
Moderate	Low potential impact	Low/Medium/High (see notes 3, and 4)	Medium/High (see note 4)	Medium/High (see notes 2 and 4)
Minimal	Low potential impact	Low/Medium/High (see notes 1, 3, and 4)	Low/Medium/High (see notes 1, 3, and 4)	Low/Medium/High (see notes 1, 3, and 4)

Notes:

1. With a PAR of five or more people, it is unlikely that the potential impact will be low.
2. With a PAR of more than 100 people, it is unlikely that the potential impact will be medium.
3. Use a medium classification if it is highly likely that a life will be lost.
4. Use a high classification if it is highly likely that two or more lives will be lost.

30. The assessed PIC for all RDR embankments is: low. The assessed PIC each of the appurtenant structures is: low.

Summary of Dam Break and Consequence Assessment (Section 17 – 30)

31. The assessment process has followed the NZDSG approach. Three sections of the RDR canal and three appurtenant structures are assessed to be critical to dam safety and have been included in the assessment. An initial dam break flood hazard assessment was undertaken which shows there is no infrastructure within potential areas of inundation from a dam breach other than a farm pond. The three Appurtenant Structures have been considered in regard to the failure modes that should be applied. The damage level from a dam break using Table 2.2 in NZDSG is assessed as moderate due to importance of the RDR infrastructure and time to repair. The PIC is assessed as Low based on the combination of assessed damage and Population at risk. The PIC of the dam determine the loadings and standards required for design, as well as post-construction operation and maintenance requirements.

Dam Safety Management System

32. MWH have prepared a Dam Safety Management System for Klondyke Pond which has been assessed as having a High PIC. The NZSOLD Dam Safety Guidelines (2015) does not require a Dam Safety Management System or an EAP for a Low PIC dam which the canal has been assessed to be. Given this, and contrary to the suggestion in the report of Ms Ford, I am of the opinion that a Dam Safety Management System is not needed for the proposed modifications to the RDR.

33. I recommend that the following two mitigations are provided in regard to safety of the canal:

33.1 Maintain an emergency overflow spillway for the canal. The current spillway is located immediately upstream of the BAFF screen but may need some modifications in regard to level and width for any additional flows into the race.

33.2 The three fill areas of the canal highlighted in the dam break assessment are visually inspected as part of existing routine monitoring of the RDR canal.

These two mitigation recommendations have been included in the consent conditions as proposed in Mr Greaves' evidence.

Construction Activities

34. The approach to the construction of the canal modifications will need to account for impacts on existing RDR water users to minimise the impacts on operation and in particular as far as possible limiting the time when water is not available. The timing of work will be programmed to coincide with shutdowns for other required maintenance work. As the RDR water has a dual purpose for irrigation and hydro power generation the critical periods for these main two groups occurs at different times and historically shutdowns have occurred in the "shoulder season" when there is the transition from predominantly one use to the other. Where possible work will be undertaken in a manner to enable existing operation to continue and shutdowns will be used for critical periods when the tasks that can only be undertaken after dewatering are required to occur. I note that condition Disruption of Water Supplies 15.0 and 15.1 of the ADC conditions that are attached to the evidence of Mr Greaves seeks to ensure that the construction of the proposal, including the canal modifications, does not detract from the reliability of the water that is supplied to third parties from the RDR. I support the retention of these conditions.

35. **Temporary Works Area:** At the start of construction many activities are scheduled as part of mobilisation. The works associated with the canal modifications are part of a larger programme of works, including the construction of the Klondyke Water Storage Facility. Temporary areas will be required for the canal modification, including the following:

- Establishment of temporary work areas at each bridge site. As the main area will be at the Klondyke depot, the area required will be small around 0.2ha.

- No specific temporary works area will be required for the canal modifications as they are occurring along the length of the canal and it is expected that the temporary area at the bridges could be used for secure storage of material and plant.

36. **Site Clearing:** The full length of the canal that requires modification is free from vegetation. The true-right crest contains the access track for the full length, while the true-left crest either has no vegetation or is an existing large cut bank. The only clearing that will be required will be the stripping of the canal crests to design level. An estimate of the total stripping area is 50,000m^2; with a stripping depth of 200mm the estimate for material requiring disposal is 10,000m^3.

37. **Disposal Area:** All material will be disposed of at the approved disposal areas associated with the Klondyke Storage Facility.

38. **Material and Equipment Requirements:** I have assumed that the contractor will adopt a conservative approach to construction using standard construction equipment with some specialist selections where necessary. I have also assumed that all major construction-related administration and storage activities will be operated from the primary depots planned for the Klondyke Storage Facility as presented by MWH. Furthermore, the plant that will be used for the canal modifications will be the same plant involved in the construction of the Klondyke Storage Facility. These assumptions are, in my opinion and experience, reasonable as the work required on the canals is only a very small percentage of the total work on the project. I have made this assumption as the canal work is close to the major work site of Klondyke Storage Pond and for the client and contractor and therefore I expect combing the works will result in in cost efficiencies.

39. **Construction Quantities:** Table 2 presents an estimate of the major quantities of materials required for construction. It also estimates the number of vehicle movements that will be required to transport these materials to the site.

Table 2: Summary of Construction Quantities

Activity	Quantity	Approximate Vehicle Movements	Vehicle Type
Disposal of material	10,000m^3	1,000	Truck and trailer
Importing of material	24,000m^3	4,800	Truck and trailer
Steel pile casing	10 tonnes	6	Truck
Reinforcing Steel	1 tonne	6	Truck

Concrete for pile abutments	40m^3	12	Concrete truck
Bridge decks	3 off	6	Truck

40. **Environmental Effects Control:** The canal modifications are an extension of the works associated with the construction of the Klondyke Storage Facility. Therefore, the Construction Management Plan (CMP)[2] will be implemented in the works associated with the canal modifications. The plan describes how the Contractor will manage both the day-to-day work activities and the effects of the construction activities. I have worked with MWH on the CMP providing inputs related to the canal modifications, fish screen and white water course. The CMP follows industry standard practice for construction and the implementation of these plans will address potential effects of construction to an acceptable degree. The modifications to the canal in general only require relatively minor earthworks of cut and fill and therefore the effects of the work will be contained mostly within the existing RDR canal.

41. In comparison to the earthworks associated with the Klondyke Water Storage Facility, the earthworks for the canal modifications will involve a small amount of cut material requiring disposal, which will be replaced by imported material to locally raise the crest level. The key Erosion and Sediment Control principles as described in Section 5 to Section 8 of the Klondyke Storage Pond - Erosion and Sediment Control Plan[3] (ESCP) and in the erosion and sediment control plan requirements of the applicable CRC resource consent conditions will apply as follows:

- To control run-on water.

- To separate clean from dirty water.

- To protect the land surface from erosion.

- To prevent sediment from leaving the site.

42. The first two of these principles, and by implication the final principle, have been discussed above (refer Section 11 for the canal modifications and Section 13 for the bridges). The third principle will be effectively mitigated by the sandy gravel material that will be excavated and left exposed, which has a high natural resistance to erosion, and the small work areas that will

---

[2] MWH (December 2016) Klondyke Storage Pond Construction Management Plan
[3] MWH (December 2016) Klondyke Storage Pond Erosion and Sediment Control Plan

be left open and the ease at which erosion control measures can be installed and maintained. The key issue for protecting the land from erosion is ensuring the re-vegetation and seeding of permanent slopes is completed as soon as possible following their formation.

Fish Screen

43. The RDR constructed a Bio Acoustic Fish Fence (BAFF) in 2008 "for the purpose of diverting as far as practicable migrating salmon smolt to the Rangitata River" which is a condition of Resource Consent CRC011237 (condition 5(a)). There have been challenges in the operation of the BAFF, and RDR have made a number of modifications over recent years in an attempt to improve the performance of the screen. It has therefore proposed an alternative. The Rangitata Diversion Race Fish Screen Concept Report[4] includes details of the proposed new fish screen.

Basis for Design of the Fish Screen

44. The design shall take into consideration regional and national guidelines in relation to fish screens. The consent conditions for the Fish Screen include a list of the criteria in condition 7 which are based upon the guidelines. The most relevant documents are NIWA: Good Practice Guidelines for Fish Screening in Canterbury[5] and Canterbury Land and Water Regional Plan (CLWRP[6]) Schedule 2. The NIWA fish screen guidelines outline key design requirements for fish screens. The key aspects of the design are:

- Velocity of the flow into the screen (approach velocity), measured in front of the screen.
- Velocity of the flow past the screen (sweep velocity).
- Mesh size of screen.
- Fish bypass geometry and design.

In considering the fish screen location and fish screen type these key factors need to be considered. The other considerations in the selection relate to sediment, ease of operation/maintenance, construction costs and operating costs.

---

[4] RILEY (November 2017) Rangitata Diversion Race Fish Screen Concept Report.

[5] Jamieson, D., Bonnett, M., Jellyman, D., & Unwin, M. (2005). Fish Screening: good practice guidelines for Canterbury. NIWA, Auckland, 70pp.

[6] Canterbury Land and Water Regional Plan. Schedule 2 Fish Screen Standards and Guidelines. (December 2016)

45. For one of the most critical parameters in the design of the screen (velocity of water into the screen) these two guidelines are different in what flow is used. The CLWRP uses the through-screen velocity rather than the approach velocity as the basis of design. For a mesh screen, the proportion of openings between the mesh is typically around 50% of the total area based on 2mm screens. Therefore, if through-screen velocity is used for the design it will result in screens needing to be twice as large in comparison to approach velocity. The infrastructure costs for a mesh screen that meets the NIWA guidelines are very high. It is likely that a mesh screen designed to be compliant with the CLWRP will not be economically feasible given it will be in the order of twice the cost of meeting the NIWA guidelines.

46. RDRML has, in my presence, discussed this issue with Environment Canterbury representatives and the basis of the design of the proposed RDR screen is the approach velocity as outlined in the NIWA guidelines. These guidelines are based upon international experience and good practice and the consent conditions specify the screen should meet NIWA guidelines and/or CLWRP. I note that the fish screen design has been peer reviewed by Senior Fisheries Biologist Dr Dana Schmidt (Golder Associates, Canada) who concludes that the design is consistent with International Standards and has a high probability of meeting the defined objectives and the stated best practices as defined by Jamieson et al (2007) if final designs, constructions and operations are consistent with concepts presented (peer review attached as Annexure B).

Potential Fish Screen Type

47. There are a number of different types of fish screen that have been considered in the assessment of options by RDRML and RILEY. The NIWA fish screen guidelines[5] includes a summary of several different types of screens. The screens considered as potentially appropriate for the RDR Based on the flows, previous trials on physical screens, results from recent testing of screens and the design of recent fish screens are:

- Permeable bund or infiltration galley screen.
- Rotary cylinder screen.
- Travelling flat screen.

Fish screens located upstream of the sand trap need to be suitable for a much higher sediment load and therefore a rock bund or gallery are not considered to be suitable in that location.

Options for Location of the Fish Screen

48. I have considered the following potential locations for a new fish screen:

- At the river intake.
- Between the river intake and sand trap.
- Immediately downstream of the sand trap.
- At the intake to the proposed Klondyke Pond.

49. The options for a fish screen located at the river intake and at Klondyke pond have been discounted as not feasible for engineering issues at the intake and consent issues for Klondyke pond relating to distance of fish return being beyond Water Conservation Order requirements.

50. At the river intake the screens would be exposed to the river and the debris it conveys. The existing intake openings would need to be significantly enlarged to meet the approach velocity requirements. Therefore, I have concluded there are no feasible options for a fish screen at the river intake without very significant changes to the existing configuration of the intake.

51. A fish screen at the Klondkye Pond would not meet the criteria of locating the fish screen as close as possible, the fish bypass would need to be of a very significant length and be a number of kilometres further downstream than the WCO. As a consequence, it is not be best practicable option, in my opinion, and is therefore not recommended in this location.

Proposed option for Location and type of Fish Screen

52. From an assessment of the different options RDRML have decided to proceed with a rotary cylinder screen located upstream of the sand trap (approximately 1400m downstream of the intake gates). Figure 1 shows the approximate location of the proposed fish screen. The canal is close to the river at this location and therefore only a relatively short distance for a fish bypass back to the river. The new fish screen can be constructed offline with flows maintained in the existing canal until the new fish screen is ready to connect to the existing canal.

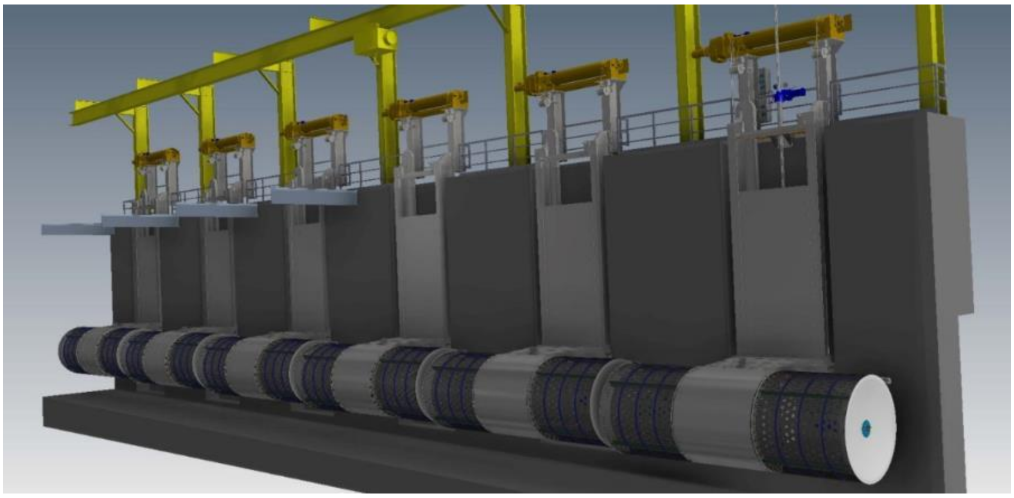
53. From an initial assessment of the hydraulics associated with the proposed configuration, and in particular the sweep velocity, which is important for both fish exclusion and sediment management, it is difficult to maintain the design velocity at the downstream end with a rotary

cylinder screen due to the geometry of the fish screen and need for reduced canal width to maintain the sweep velocity. To maintain the sweep velocity for the proposed rotary cylinder screens would require approximately 10m^3/s fish bypass flow for a rectangular shaped canal. Therefore, it is likely, in my opinion, that the last rotary cylinder screen may be replaced with a flat screen of some type as this screen type can fit within a much more narrow channel and will meet the sweep velocity requirements. During the detailed design of the fish screen the aim will be to achieve the required conditions with rotary cylinder screens only and therefore the flat screen at the downstream end is included as a potential solution. A number of fish screen installations in the United States observed have mostly rotary screens with the final section using flat screens which relates to the limitations of available bypass flow.

Rotary Cylinder Fish Screen

54. As Mr Curry notes in his evidence, a group including representatives from RDRML, RILEY, Ryder Consulting Limited, North Canterbury Fish and Game and ECan travelled to California and Washington State in April 2017 to visit fish screen manufactures and sites where fish screens have been installed. A number of cylinder screens were observed, which along with vertical travel screens, appear to be the preferred screen type being installed in those two States. These screens were, in my experience, very different than common rotary screens previously constructed in New Zealand. These screens are rotated by a motor and have either bush cleaning system or water jets. Figure 1 shows an example of a design for an installation in the United States of these cylinder screens (Intake Screens Inc.).

Figure 1: Cylinder screen design in United States (Intake Screens, Inc. Sacramento USA)



The rotary cylinder screens in Figure 1 are orientated at a small angle to the flow (almost parallel to screens flowing left to right along this figure) which results in high sweep velocities past the screens.

Travelling Screens

55. Travelling screens are mechanical screens installed vertically. The screens operate by rotating around a drum at the top and bottom of the screen with the motors all above the water level. The screens are self-cleaning through air or water jets at the top of the screen. Like the rotary cylinder screen they are widely used in the United States. Figure 2 shows an example of a screen from Hydrolox and located at Fall River in the United States. The main reason for including a short section of travelling screen at the downstream end of the rotary cylinder screens is to enable the channel to be narrower to maintain the design sweep velocities. The screens will be in the order of 10m to 15m long and 4m high to replace one of the rotary cylinder screens.

Figure 2: Example of travelling screen (Fall River, Hydolox screen)

Fish Screen Design

56. Figure 4 shows the proposed location for the new the RDR fish screen. This concept enables the fish screen and bypass to be constructed offline and flows maintained in existing race during construction. The fish screen requires a widened channel and concrete structure for the fish screens to be positioned at a small angle (Less than 10 degrees) to the flow. Figure 3 shows a schematic of the fish screen. The schematic shows the flows along the channel and progressively flows will enter through the cylinder screens into the downstream channel. The

red arrows give some examples of the flow paths into the fish screens and to the downstream canal. The pink arrows show the downstream flow through the channel leading to the fish bypass. This channel progressively narrows to maintain the velocities to the fish bypass channel.

Figure 3: Schematic layout of fish screen and bypass channel (blue box shown in Figure 4)

57. The layout of the fish screen will result in high flow velocities past the screens (sweep velocity) towards the fish bypass. The average velocity of the flow in the channel past the screen will be approximately 1.0m/s. The mesh screens will have openings of approximately 2mm and may either be a mesh or wedge wire.

58. Only sediment that is smaller than 2mm will get through the screen so all other sediment greater than 2mm will flow down the fish bypass and back to the river. Previous analysis of sediment deposited within the RDR canal downstream has found that very little of the sediment was larger than 2mm. Most of the samples have between 0 to 5% of the sediment greater than 2mm. RDRML are currently undertaking sediment measurements. This monitoring will provide information on the quantities of sediment and also the distribution of sediment size but is currently not yet complete. The operation of a fish screen will reduce the

quantity of sediment in the canal upstream of the sand trap but based on current information from sediment sampling downstream there will only be a small percentage increase (less than 10% increase) in sediment discharged back to the river via the fish bypass as the majority of this sediment is less than 2mm in size and is expected to continue downstream of the screens in the canal.

Hydraulics of the Rotary Cylinder Screens and Travelling Screens

59. The geometry of the cylinder screen requires baffles inside the screen to even out the flows and velocities in the screen. Intake Screens Incorporated (ISI), based in Sacramento, California, who are the designers and manufacturers of the proposed fish screens have provided RDRML with a copy of a modelling report for the design of their screens for a river intake constructed for the Stanislaus Power Tunnel Fish Screen. This is located on the Stanislaus River near Sonora California. This is for a flow of approximately 15m^3/s and was constructed and then commissioned in 2015. We understand that hydraulic performance evaluation of the screens were undertaken in June 2016 and approach and sweep velocities were found to be consistent with the original design and consent requirements.

60. The Travelling Screen has a simple geometry as it is a flat surface against the side of the channel. Therefore it will have less of an effect on the flows in the channel and therefore it~~s~~ will be easier to maintain consistent flow velocities.

61. For the RDR proposed screen, modelling as part of the detailed design stage will be required to refine the screens to ensure that the approach velocities are relatively consistent to achieve the guidelines. Modelling will also be required to consider sweep velocity and sediment transport through the screen and down the bypass to avoid any significant deposition near the screens. The channel at the fish screen down to the fish bypass is likely to need to be concrete lined as a smooth surface is required to reduce the risk of sediment build-up. This area of the race currently does not result in any significant deposition of sediment which is due to the canal being in a straight section and velocities of 0.8m/s to 1.0m/s, which if replicated should ensure the sediment remains mobilised within the flow.

62. RDR commissioned AWMA who are a company based in Australia who are working with ISI to manufacture the fish screens to undertake Computational Fluid Dynamics (CFD) modelling of the proposed Fish Screen. GHD in Australia who have significant expertise in CFD modelling have undertaken this work for AWMA. This work is currently still being progressed. The modelling will assess compliance with the guidelines for the rotary screens. The results from an initial modelling run found that for the majority of the screen areas the approach and sweep

velocities meet the requirements of the guidelines. Further work is currently being undertaken to improve upon the initial results and GHD will then provide the results in a format that measures directly against the requirements of the fish screen guidelines.

Consultation with Stakeholders

63. RDR have consulted with Environment Canterbury (ECan), Central South Island Fish & Game (F&G), Department of Conservation (DOC) and Forest & Bird (F&B) in regard to the proposed fish screen concept. The following are the changes made to the design following feedback from these groups:

- The change in design from a rock bund fish screen to a rotary cylinder fish screen.
- The fish bypass will be constructed as an open channel.
- The entry from the race into the bypass will be open and light with flow controls further downstream in the bypass.

Proposed Operation of the Fish Screen

64. Dr Ryder has previously prepared a Fish Screen Verification Monitoring Plan His view is that this plan is no longer required due to the appropriateness of the consent conditions.

65. The basis of the design is to ensure the recommendations from the NIWA Fish Screen Guidelines[5] are met which in particular are the velocities at the screen and the fish bypass location and geometry.

66. **Approach Velocity:** The fish screen guidelines recommend an approach velocity of less than 0.12 m/s. The rotary cylinder fish screen will be designed to achieve average approach velocity of less than 0.12m/s. The design approach is to have a lower average velocity than 0.12m/s to allow for the variations that will occur to ensure the maximum flows are less than 0.12m/s for as much as the screen as possible. During detailed design modelling of the fish screen will be undertaken to enable any changes to the baffles within the screen to even out the approach velocities. The baffles are within the screen and ISI have undertaken previous design work to provide best location and size of these to even out the distribution of flow. During the detailed design phase there are a number of opportunities to make changes to improve both the approach and sweep velocities which include:

- Changes to the dimensions and locations of the holes in the internal baffle within each screen.

- Adjustment of the downstream openings for each screen to adjust flow rates between screens.

- Angle of the screens to the flow.

- Dimensions and shape of the main channel.

- External baffles, vanes etc.

67. **Sweep Velocity:** A sweep velocity provides environmental input to control fish behaviour and ensure that fish do not accumulate upstream of the screen. The sweep velocity directs fish across the fish screen and also directs toward a bypass leading them back into the Rangitata River. The average sweep velocity will be approximately 1.0m/s. While there is no specific magnitude of sweep velocity outlined in the NIWA Guidelines other than being greater than the approach velocity, RDR have sought to achieve the highest sweep velocity as possible in the design that is recommended. In addition to fish screen requirements the velocity is also required to reduce the risk of sediment deposition and is similar to existing flow velocities in the canal. During detailed design the sweep velocity will be modelled to ensure that as much as possible it achieves the 1.0m/s average and at the screens is firstly higher than the approach velocity but with design goal to maximise this as much as possible. Due to the hydraulics around the fish screens I expect there will be areas of reduced sweep velocity and the modelling will check that the sweep velocity exceeds the NIWA guidelines. Adjustments to the design (Potential options listed in above paragraph for Approach Velocity) will be undertaken to resolve any areas of the screen that require improvements to achieve the guidelines.

68. **Fish Bypass:** A fish bypass is required to return fish to the river, and should include a non-return function so that fish are unable to approach the screen from the bypass, or return to the bypass once a fish has been drawn into the bypass. Following consultation with Fish and Game New Zealand (F&G), I have indicated that the bypass will mostly be constructed as an open channel and a hydraulic control structure be constructed well downstream of the start of the bypass. Any control gate will need to enable flow through the full height of the water column and therefore a horizontal slide gate is likely to be best option to achieve that. The fish bypass will convey $3m^3/s$ for flows up to current consent limits. A flow of $5m^3/s$ will apply when the additional $10m^3/s$ of flow is taken. For the design of the fish screen higher bypass

flows are of benefit but this has been balanced with potential effects on river flows between the river intake and the discharge back to the river from the bypass.

69. **Maintenance:** A key advantage of the rotary cylinder screens is that they can individually be raised above the water for maintenance work to be undertaken while the scheme is still operating. The screens have a cleaning system using brushes which will operate as required during operation to remove any build-up of sediment and debris on the screens.

The travelling vertical screens have the motors and other key components above the water. Most of the maintenance of these screens can be undertaken during operation. For more major maintenance works it is likely a stop log system would be required or programming of work during a shutdown of the RDR.

Construction Activities and Schedules

70. The approach to the construction of the fish screen will need to account for impacts on existing RDR water users to minimise the impacts on operation and in particular as far as possible limiting the time when water is not available. As the proposed screen can be constructed offline there is only a relatively short period of construction required with the scheme shutdown. The timing of work will be programmed to coincide with shutdowns for other required maintenance work which will result in minimal effects on existing water users.

71. The Rangitata Diversion Race Fish Screen Concept Report[4] includes details of the construction sequence. This new concept will reduce the period of time that a shutdown is required to 2 to 4 weeks. The shutdown will be required for the construction of the upstream and downstream connection. This will be able to be completed during a period of shutdown require for routine maintenance or other construction work and therefore not result in any additional effects.

72. **Decommission Existing Fish Screen and Bypass:** The BAFF can continue to operate during initial work on construction of the new fish screen until dewatering. Then following dewatering to enable construction of the new fish screen the BAFF can be removed.

73. **Erosion and Sediment Controls:** The erosion and settlement controls used during the construction of the fish screen, and the bypass, will be adopted from the Klondyke Storage Facility construction methodology, and are discussed in detail in the ESCP[3]. Due to nature of the construction site being offline and in cut, it is very unlikely that construction sediments will be freely conveyed to the Rangitata River. This is because the majority of the earthworks are

being undertaken in cut and there is no stormwater runoff onto the site other than from rainfall that falls directly on the site. Stormwater runoff from the site will be treated onsite using standard sediment control techniques. This approach is using methods of collection and soakage as the basis for avoiding sediment getting down to the river. For the fish bypass channel the minor nature of the works would suggest that simple approaches like silt fencing located downslope of the work should be sufficient as outlined in the ESCP[3]. The new fish screen will be linked to the existing canal during a RDR shutdown period and any sediment within the newly constructed canal and fish screen will be removed so that on commissioning there is not any sediment to be transported downstream into the canal or fish bypass.

74. **Excavation:** Excavators will be used to construct the new fish screen channel offline from the existing canal. This activity will require the removal of approximately 60,000m^3 of excavated materials to be disposed by truck and trailer unit at an approved disposal area. Excavation will also be required to construct the fish bypass. The open channel for the bypass will require excavation and appropriate disposal of approximately 25,000m^3 of soils at the approved disposal area.

75. **Fish Screen civil works:** Some of the new channel at the fish screen will be lined with concrete and the main structure that the screens will be placed on will be constructed of concrete. It is likely that most of this will be constructed as precast units and shipped to site. Steel work to support the fish screens and gantry crane system will also be constructed off site.

76. **Construction of Fish Bypass:** A fish bypass conveying up to 5m^3/s over a distance of 200m will be primarily constructed as an open channel, with a non-return hydraulic feature located downstream of the bypass inlet. The outlet to the river will be framed by rocks and other material similar to the gravels found in the main river fairway. The fish bypass will include a gate near the start of the bypass and the outlet to the river will require erosion protection in the form of rocks. A weir to enable monitoring of the bypass will be located between the gate and river outlet.

77. **Construction Quantities:** Table 3 presents an estimated summary of the major quantities of materials required for construction. It also estimates the number of vehicle movements that will be required to transport these materials to the site.

Table 3: Summary of Construction Quantities

Activity	Quantity	Approximate Vehicle Movements	Vehicle Type
Excavation of Canal	60,000m^3	6,000	Truck and trailer
Importing of rock	25000m^3	2,500	Truck and trailer

Pre cast concrete	TBC	TBC	Truck
Concrete (site concrete)	TBC	TBC	Concrete Truck
Steel work	TBC	TBC	Truck
fish screens	10 screens	10	Truck

78. **Construction Programme:** The construction phase for the fish screen and bypass is estimated to take approximately four to eight months to complete. A lot of work will be undertaken off site for the construction of the rotary screens, steel work and pre cast concrete. The proposed location means most of the work is being undertaken offline and will only require a shutdown of the RDR to link the new fish screen to the existing canal and that is expected to take two to four weeks and would be undertaken during a planned shutdown for other work.

Kayak Course

79. The White Water Course Engineering Report[7] includes details of the proposed new fish screen.

80. It is proposed to construct a White Water Course (WWC) at the outlet of the proposed Klondyke Storage Facility. The WWC will provide recreational use when water is released to the Mayfield Hinds Irrigation Scheme (MHIS). The storage facilities, disposal areas, and erosion control measures already in place for the storage pond are available for the construction of the WWC. There is potential for the WWC to be added to in the future, and the course described herein is potentially the first in a cascade of courses that could be developed between the outlet and the existing irrigation race. RILEY Dwg: 11835/3-01 presents the proposed layout of the WWC and the possible areas for future expansion.

Available Flow from Storage

81. The outflows from the proposed Klondyke Storage Facility have been modelled by PDP which is presented in White Water Course Engineering Report[7]. This modelling has been completed for the following two periods:

- December to February: this is the peak period for use of the WWC, and is when most releases from storage would occur during the driest period of the irrigation season. In addition, PDP has modelled the following for this period:

---

[7] RILEY (July 2016) White Water Course Engineering Report.

  - Average irrigation demand (1973/1974).
  - Low irrigation demand (2004/2005).
  - High irrigation demand (2000/2001).
- November to April: this longer period is the typical irrigation season when outflows would be expected from storage. The period outside December to February often has irregular irrigation demand.

82. The analysis by PDP[7] shows that there are two potential design flows that the WWC could operate over that would provide suitable design parameters for the final configuration of the WWC: 4-11m^3/s and 13-20m^3/s. Table 4 summarises the percentage of time available for both these ranges during the peak December to February period.

Table 4: Flow Availability for Different Irrigation Demand (December to February)

Period of Irrigation Demand	**Design Flows**	
	4-11m3/s	**13-20m3/s**
Average	67%	48%
Low	36%	35%
High	85%	70%

Description of the Proposed White Water Course

83. The following sections describe the key components of the WWC from the Klondyke Storage Facility outlet to the return to the Mayfield Hinds race. The WWC is off-line from the MHIS race to allow the control of flows into the course, thereby maximising its potential usage. All flows above the design inflow will bypass the gate and continue as normal to the MHIS race. The components discussed below are presented on RILEY Dwg: 11835/3-02.

84. **Control Gate and Weir:** The control gate will be a concrete structure with a single gate to allow water released from the Klondyke Storage Facility to be diverted into the WWC. The gate will operate across the full range of WWC operational flows to ensure the design flow can be continuously provided. Erosion protection through a concrete slab and/or rock rip-rap will be installed immediately downstream of the gate to ensure that diverted flows do not erode the invert of the downstream channel. A weir will be provided in the Klondyke Storage Facility outlet channel downstream of the control gate to provide a stable water elevation at all flows to facilitate the diversion. This point will also be a flow monitoring point for discharge from storage into the MHIS race.

85. **Upstream Staging Area and Drop-In Zone:** The drop-in zone is located immediately downstream of the control gate, with the staging area situated along the northern bank of the drop-in zone. The drop-in zone will operate as a relatively slack water environment allowing users to control their entrance to the wave located downstream. If required to provide a non-slip, impermeable bed liner, the drop in zone may be lined with a shallow bed of river gravels underlain with a geosynthetic clay liner.

Transition to Wave: The transition to the wave is a hydraulic feature that transforms the subcritical flow (lower velocity) of the drop-in zone into a supercritical state (higher velocity), creating the upstream conditions required to form a hydraulic jump. There is an increase in the bed elevation with a downslope transition to the toe of the wave. The transition area will be lined with cement stabilised rip rap to armour the subgrade and prevent erosion by the higher energy supercritical flow. To ensure the safety of WWC users, the cement stabilised rip rap will be smoothed and no inclusions of rock will protrude above the surface of the smoothed finish.

86. **Wave:** A hydraulic jump is created by a subcritical state at the toe of the transition. An increase in flows will move the wave downslope, and likewise decreases in flow will move the wave upstream. To stabilise the location of the wave, a rise in the bed elevation is constructed at the desired wave location. The geometry of this feature is critical for the shape of the wave and is subject to design, and potentially, ongoing adjustment. As with the transition immediately upslope of the wave, the area of the WWC supporting the standing wave will be lined with a smoothed cement stabilised rip rap to ensure both erosion control and safety of WWC users. An additional feature of the wave zone will include a second staging area located immediately adjacent to the standing wave. It is envisaged that swimmers, surfers, and body-boarders are able to access the wave from this location, bypassing the transitional run in used by kayakers. As such, the precise location and design of this feature will be subject to the hydraulic design of the wave.

87. **Downstream Take-Out Zone:** The take-out zone is located immediately downstream of the wave. This area will have the same controlled calm water conditions as described for the drop-in pool and will allow users to safely exit the WWC. The take-out zone may be lined in the same manner described for the lining of the drop-in zone.

88. **Control Weir to Mayfield Hinds Race:** A control weir will be located at the downstream boundary of the take-out pool. This feature returns the water from the WWC to the MHIS race in a controlled manner. The weir will stabilise the water level in the take-out zone and allow

for flow monitoring of flows through the WWC, and can be adjusted to calibrate design flows through the WWC.

Ancillary Facilities

89. **Car Park:** The WWC will be accessed via the proposed Klondyke Water Storage Facility maintenance access road, and will require sufficient space to allow for users of the WWC to park vehicles. While the demand of the WWC is currently unknown, the proposed carpark will allow for up to 30 vehicles. I note that provision will be included to allow for expansion of a car park as the possibility of events and/or expansion of the WWC may increase the demand for vehicle parks for an additional 30 vehicles.

90. **Toilet Facilities:** Toilet and changing facilities will also be provided at the site with the proposed location shown on RILEY Dwg: 11835/3-01. The configuration of these facilities will be confirmed during detailed design.

Construction Activities and Schedules

91. **Erosion and Sediment Controls:** These controls are discussed in detail in the ESCP[3]. All controls associated with the WWC will be consistent with those used for the adjacent construction works. The predominant means of disposal of stormwater is through its capture in swales and discharged to ground via soakage pits.

92. **Vegetation Clearance:** All vegetation in the construction corridor that has not previously been cleared for the Klondyke Storage Facility will be removed, and unsuitable material will be hauled to the approved disposal areas, as per methods outlined in the Klondyke Storage Facility construction methodology.

93. **Excavation:** An excavator will be used to form the grade WWC and approximately 2,000m^3 of excavated materials will be transported by truck to be disposed at an approved disposal area.

94. **Structures:** A control gate will be constructed off-site and transported to the site. The superstructure supporting the control gate will be constructed from reinforced concrete, and will require formwork, reinforcing steel, and imported concrete. Material volumes are subject to specific engineering design, but the preliminary estimate of concrete volume is 50 to 100m^3.

95. Hydraulic controls (transitions and wave area) will be constructed from cement stabilised rip rap, or concrete. Construction will involve installing formwork and the delivery of concrete (and rebar if required) to the site. Based on concept design, it is estimated that 200m^3 of concrete and rock will be required to construct the transition and wave area.

96. Two weirs will control WWC flows. The weirs will be constructed from reinforced concrete. These will require formwork and deliveries of concrete and reinforcing steel to the site. Volumes of material are subject to specific engineering design, but each weir is expected to consist of 25 to 50m^3 of concrete.

Ancillary works

97. A car park of approximately 1,000 to 2,000m^2 will be constructed with AP40 and AP60 on grade. Stripped earth will be transported and disposed at the identified disposal area.

98. The amenity building will be located adjacent to the car park. This will initially include a small structure for changing facilities and toilets. The construction works will include vegetation stripping of a small area (which would be included as part of the car park stripping) and constructing the buildings from timber or masonry.

99. Table 5 presents an estimated summary of the major quantities of materials required for construction. It also estimates the number of vehicle movements that will be required to transport these materials to the site.

Table 5: Summary of Construction Quantities

Activity	Quantity	Approximate Vehicle Movements	Vehicle Type
Disposal of material	2,000m^3	200	Truck and trailer
Importing of rock	60m^3	6	Truck and trailer
Reinforcing Steel	0.15 tonne	1	Truck
Concrete	100 to 200m^3	15-30	Concrete truck

100. **Temporary Works Area:** A small temporary area will be required at the location of the WWC to allow general construction requirements such as heavy vehicle turning radii and short-term material storage. Typically, vehicles excluding the excavator will be stored at the primary Klondike Storage Facility. The excavator will be stored on-site for the duration of the construction works.

101. **Construction Programme:** The construction phase for the WWC is estimated to take three months to complete, however, there may be opportunities to advance construction by establishing a refined construction programme.

102. **Operation of MHIS Race:** The proposed WWC will be constructed entirely off-line from the existing MHIS race and there will be no effects on the operation of the race.

Submissions

103. There are 27 submissions that relate to fish screen. Sixteen of the submissions oppose the consent application and eleven support it. In general the submissions want the RDR to install a fish screen that works as a number of submissions raise concern over effectiveness of the existing BAFF.

104. **Efficiency of Fish Screen:** A number of the submissions indicate the importance of the efficiency rate of the fish screen in regard to the exclusion of fish and in a few cases a rate is suggested which are between 85% to 95%. A significant problem with applying an absolute efficiency is how it is accurately measured. The current best practice for measuring the effectiveness of a fish screen is using live fish released and then captured in the fish bypass. There are significant errors with this methodology due to the fish being hatchery fish and not from the wild, difficulty in trapping fish with large flows, risks of fish remaining in the channel and not being trapped downstream. The trials undertaken on the BAFF have resulted in very large differences in results which has highlighted the limitations of this approach for the RDR. Given this, I recommend that the Committee carefully consider what monitoring is needed to confirm the effectiveness of the proposed fish screen. I note, for completeness, that I rely on the evidence of Dr Ryder as to what is the appropriate manner in which to monitor the effectiveness of the proposed fish screen.

105. **Fish Screen Guidelines:** The NIWA Fish Screen guidelines[5] (2007) along with the studies undertaken by NIWA and Fish & Game in 2014 are considered the current best practice guidelines. In the Submission by Fish & Game they highlighted that the NIWA guidelines were for intakes up to 10m^3/s. There is no obvious reason why the guidelines cannot be applied for intakes with flows greater than that and with recent consents such as Central Plains Water which also exceeds those flows they were used as the basis for best practice and in the application of consent conditions.

106. **Maintenance:** Questions on what maintenance would be undertaken on the fish screen was raised in submissions. Section 69 include comment on the maintenance of the fish screen.

Effective operation of the sand trap will reduce the sediment that is transported to the fish screen and therefore reduces the frequency of the maintenance.

107. **Testing of fish screen:** A number of the submissions have indicated the need for testing of the screen. RDR have proposed in the draft conditions to include testing of the velocities to compare against guideline requirements and also the efficiency of the fish screen in conveying fish back to the river.

108. **Fish Bypass:** The proposed fish bypass has been modified based on consultation with Fish & Game, DOC and ECan. Section 68 includes a discussion on the fish bypass which will be designed to include an open channel for the most part with only a piped section where it crosses the sand trap sluice channel. The sizing of the channel or pipe has not yet been specified but will be designed to ensure the velocities are suitable for a bypass structure.

Section 42A Officer's Report

109. The most relevant issues are covered in paragraph 366 of the CRC Section 42A Officer's Report which include the recommended consent conditions. The consent conditions for CRC182542 (change of conditions to CRC0011237) state that the fish screen shall be designed to comply with the design specifications as defined in NIWA (2007) Fish Screening: Good Practice Guidelines[5] for Canterbury and/or Schedule 2 of the Canterbury Land and Water Regional Plan[6] or subsequent amendments. As previously noted RDRML proposes to follow the NIWA guidelines[5] which is consistent with the recommendation from the Section 42A Officer's Report.

110. Condition 7 of CRC182542 (change of conditions to CRC0011237) sets out 8 design specifications listed (labelled a-h) which the fish screen will comply with. I agree with this condition with the minor amendments contained in the conditions in Mr Greaves' evidence.

111. CRC's Principal Surface Water Quality Scientist Dr Adrian Meredith has audited the proposed Rotary Fish Screen design and his conclusion is that it complies very well with the "design criteria" approach promoted by the Canterbury Fish Screen Working Party, and embraced in the NIWA guidelines[5] and CLWRP[6] Schedule 2, and as generally used internationally. I agree with the overall conclusions of this review. In regard to the approach and sweep velocities I note that RDRML proposes to comply with the NIWA guidelines[5] which are consistent with the consent conditions relating to these velocities.

Submissions

112. There are a number of submissions relating to the Fish Screen. In general they are in support of the proposal but most have indicated need for RDRML to provide initial testing and ongoing monitoring of the fish screen operation. The following issues have been raised within these submissions:

- Testing and monitoring program to prove effective operation of the fish screen in preventing loss of fish.
- Need for the fish screen to be 100% effective or to have a close to 100% exclusion of fish safely back to the river.
- Comments that length of lapse period for fish screen consent of 5 years is too long.
- Concerns of sediment discharge from the new screen during initial commissioning.
- Risk of maintenance works resulting in additional sediment discharges to the river.
- Some submissions were concerned about the additional flows proposed for the fish bypass. CSIF&G indicated a preference for the 5m^3/s bypass to apply in all flow conditions and not just during times of taking additional 10m^3/s flow from the river.

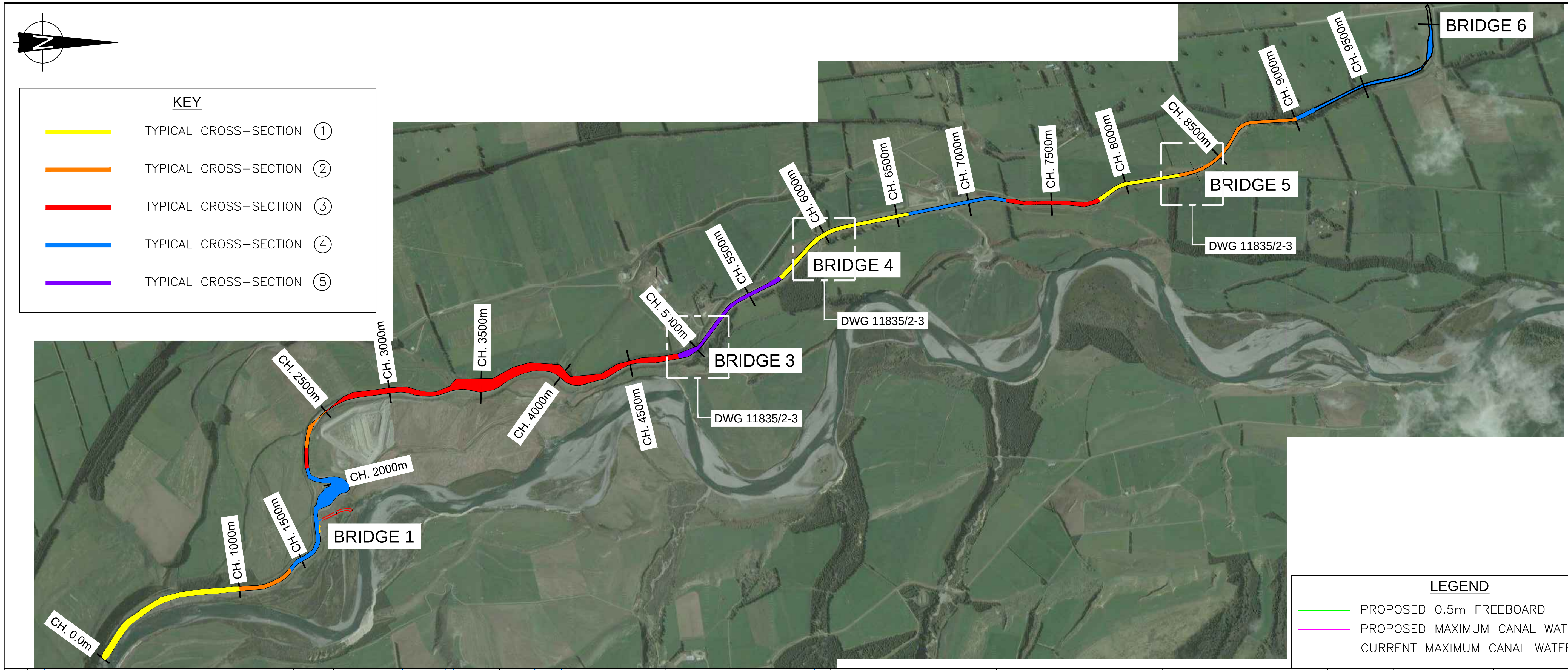
113. I note that I have addressed the matters raised by the submissions in this statement, or they are addressed by others. In this regard, the testing; monitoring; effectiveness of the fish screen; and bypass flows are addressed in the Section: "Proposed Operation of the Fish Screen". The length of the lapse period is discussed by Mr Greaves. The sediment issues are addressed in Section: "Construction Activities and Schedule".

Summary

114. This evidence provides an overview of the engineering work associated with the canal modifications, fish screen and kayak course. Three reports associated with the development of these components are included in the application and referenced within this evidence. These three components have been advanced in accordance with engineering best practice, with appropriate regard being given to formal guidelines and the input of other organisations. The site is appropriate to the types of works that are proposed as it involves the modification of existing infrastructure and/or improvements which the new fish screen and white water course provide. Through the conditions of consent and management plans, the effects associated with the construction of these aspects of the proposal can be minimised to the point that they are less than minor, and acceptable in my opinion.

Annexure A

Drawings

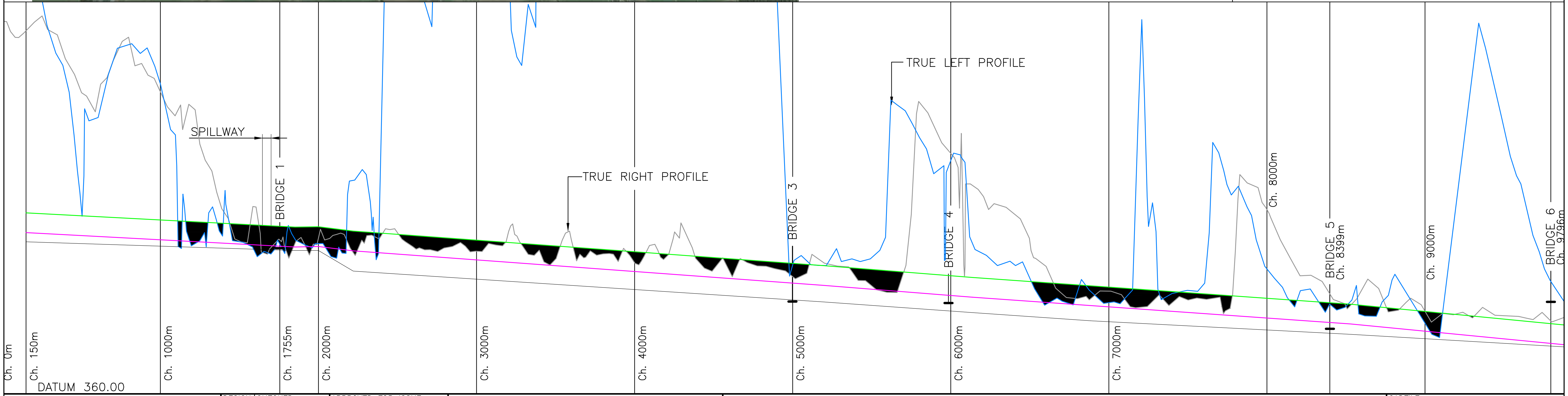


KEY

🟨	TYPICAL CROSS–SECTION ①
🟧	TYPICAL CROSS–SECTION ②
🟥	TYPICAL CROSS–SECTION ③
🟦	TYPICAL CROSS–SECTION ④
🟪	TYPICAL CROSS–SECTION ⑤

LEGEND

—	PROPOSED 0.5m FREEBOARD
—	PROPOSED MAXIMUM CANAL WATER LEVEL
—	CURRENT MAXIMUM CANAL WATER LEVEL



REV	DESCRIPTION	BY	DATE
0	FIRST ISSUE		

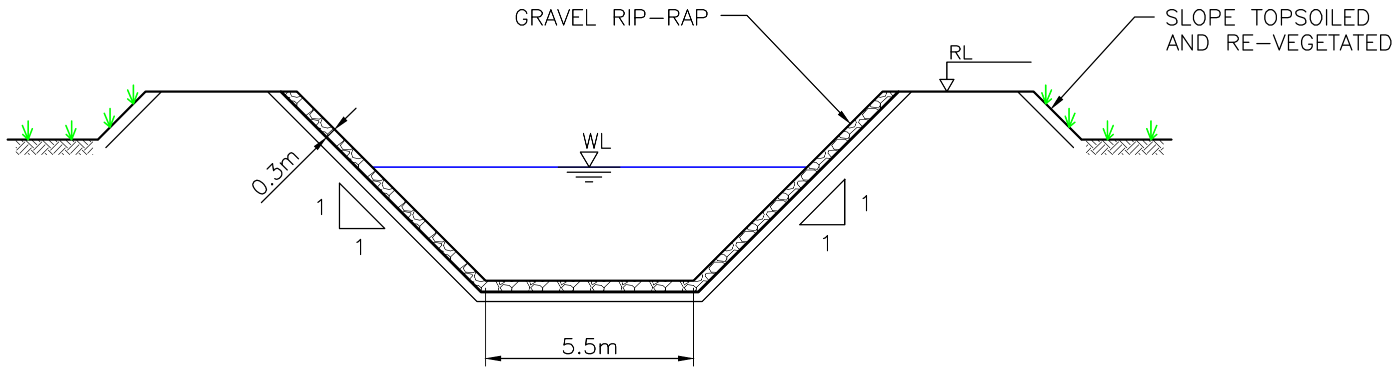
DESIGN NS CHECKED
DRAWN HN CHECKED
DATE DRAWN 27 AUG 2015

APPROVED FOR ISSUE:
DATE: / /

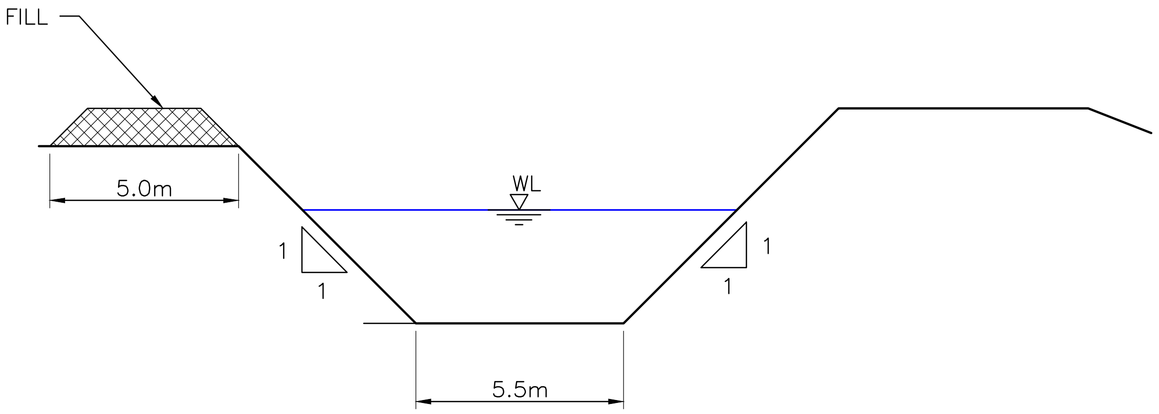
RILEY CONSULTANTS
P.O.BOX 4355
CHRISTCHURCH
TEL. 03–3794402
FAX. 03–3794403

TITLE
RANGITATA DIVERSION RACE MANAGEMENT LTD
RANGITATA DIVERSION RACE (RDR)
CANAL MODIFICATION - PLAN AND LONG SECTION

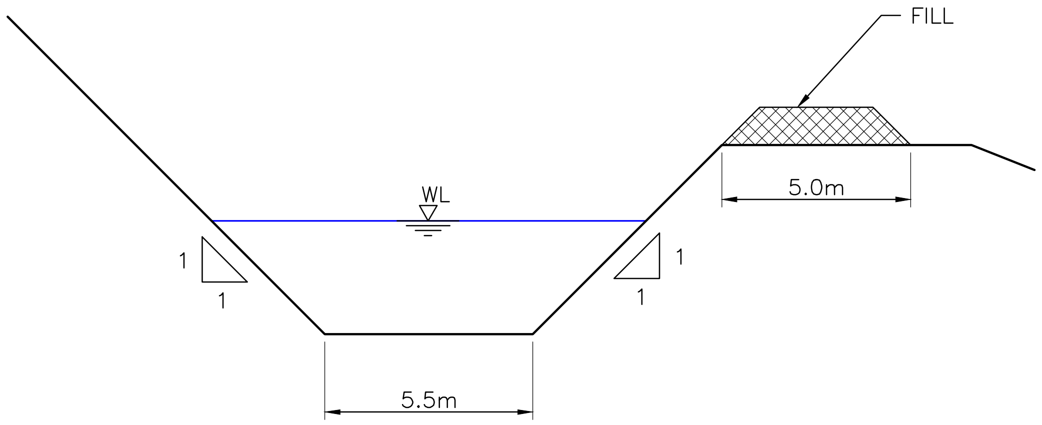
CADFILE 11835_2–1
SCALES (A3) 1:2500
ACENZ
DRAWING No. 11835/2-1
REV. 0



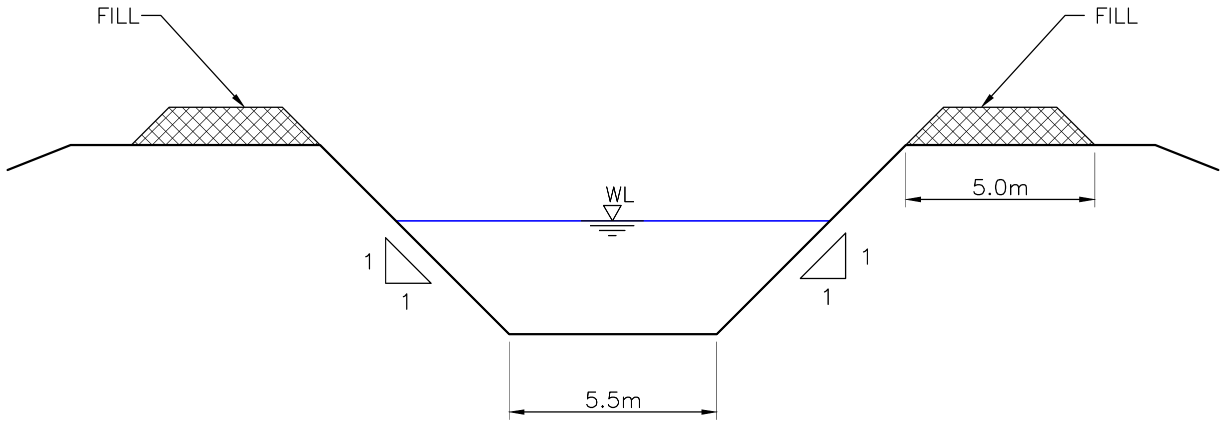
TYPICAL CROSS SECTION ①
SCALE 1:200



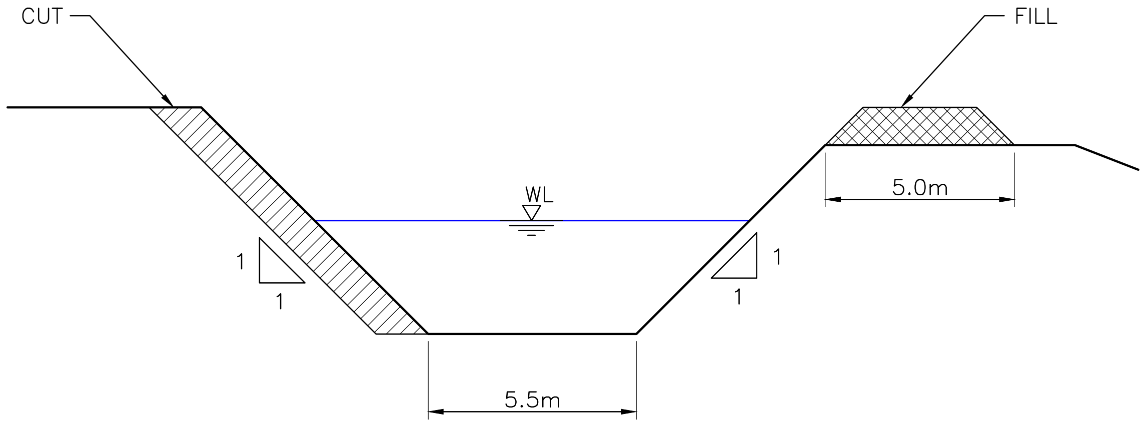
TYPICAL CROSS SECTION ②
SCALE 1:200



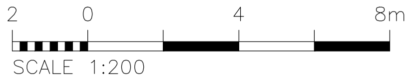
TYPICAL CROSS SECTION ③
SCALE 1:200



TYPICAL CROSS SECTION ④
SCALE 1:200



TYPICAL CROSS SECTION ⑤
SCALE 1:200



NOT FOR CONSTRUCTION

0 FIRST ISSUE
REV DESCRIPTION BY DATE

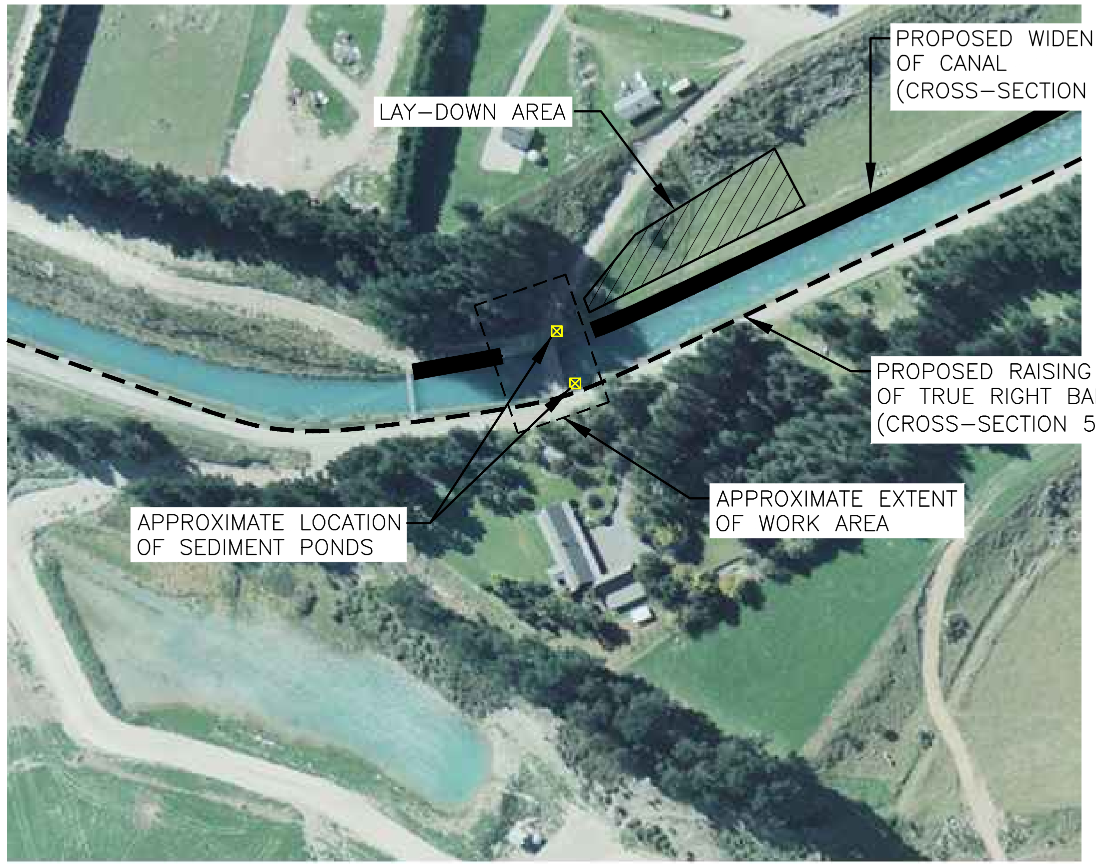
DESIGN NS
CHECKED
DRAWN HN
CHECKED
DATE DRAWN 27 AUG 2015

APPROVED FOR ISSUE:
DRAFT
DATE: / /

RILEY CONSULTANTS
P.O.BOX 4355
CHRISTCHURCH
TEL. 03–3794402
FAX. 03–3794403

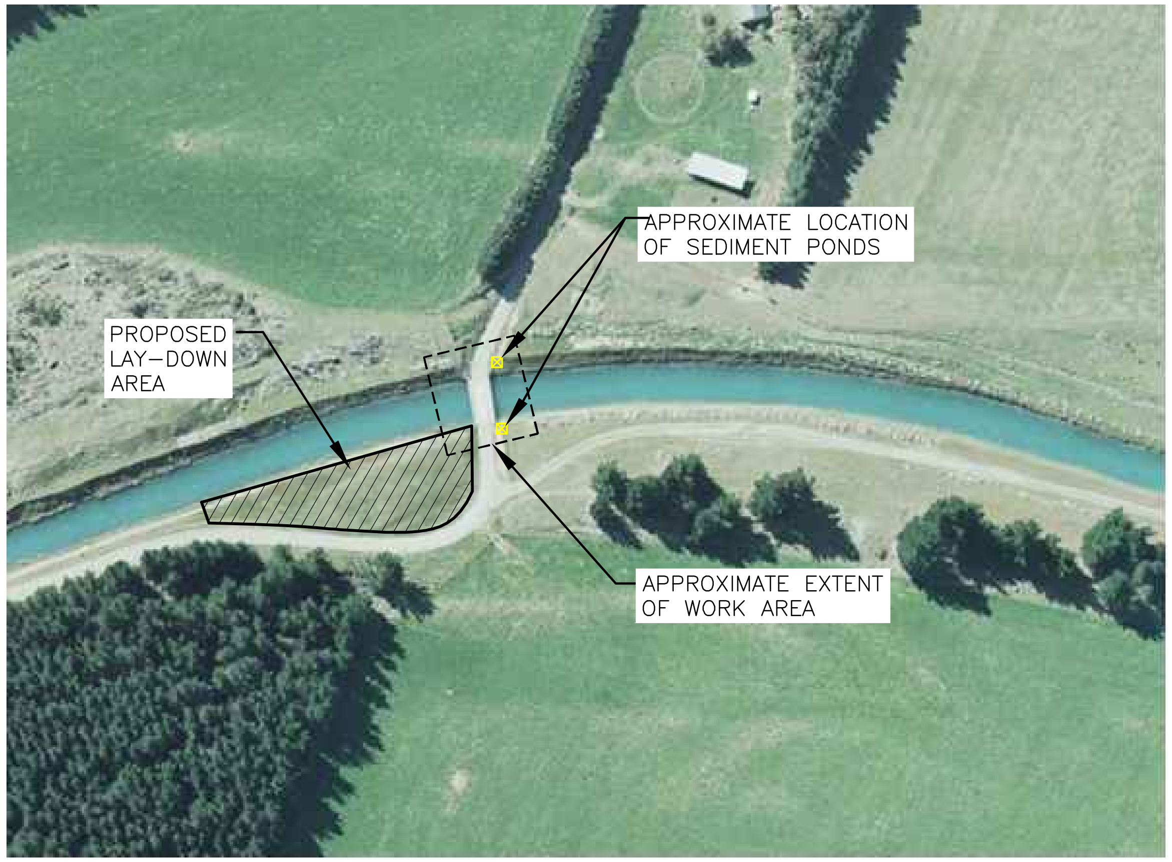
TITLE
RDRML
RANGITATA DIVERSION RACE (RDR)
CANAL MODIFICATION - TYPICAL SECTIONS

CADFILE 11835_2–2
SCALES (A3) AS SHOWN
ACENZ
DRAWING No. 11835/2-2
REV. 0



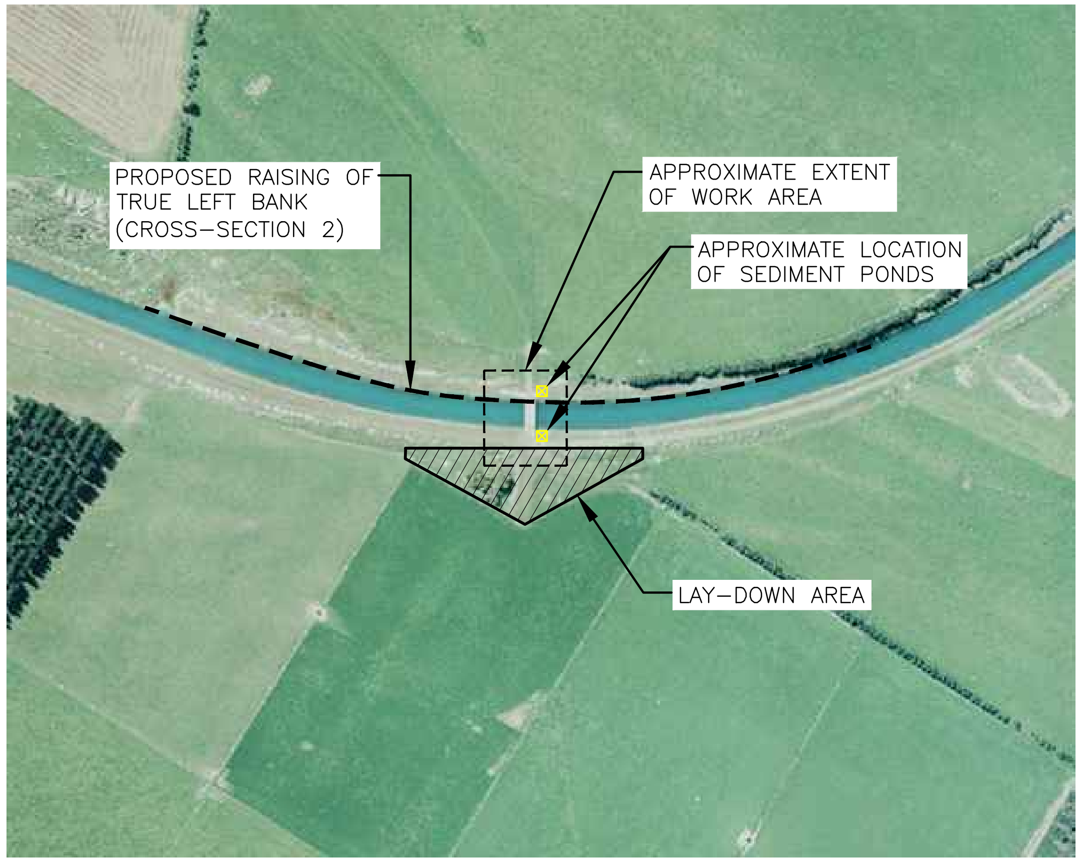
BRIDGE 3

SCALE N.T.S.



BRIDGE 4

SCALE N.T.S.



BRIDGE 5

SCALE N.T.S.

NOT FOR CONSTRUCTION

REV	DESCRIPTION	BY	DATE
1	SEDIMENT PONDS ADDED	HN	29.10.15
0	FIRST ISSUE		

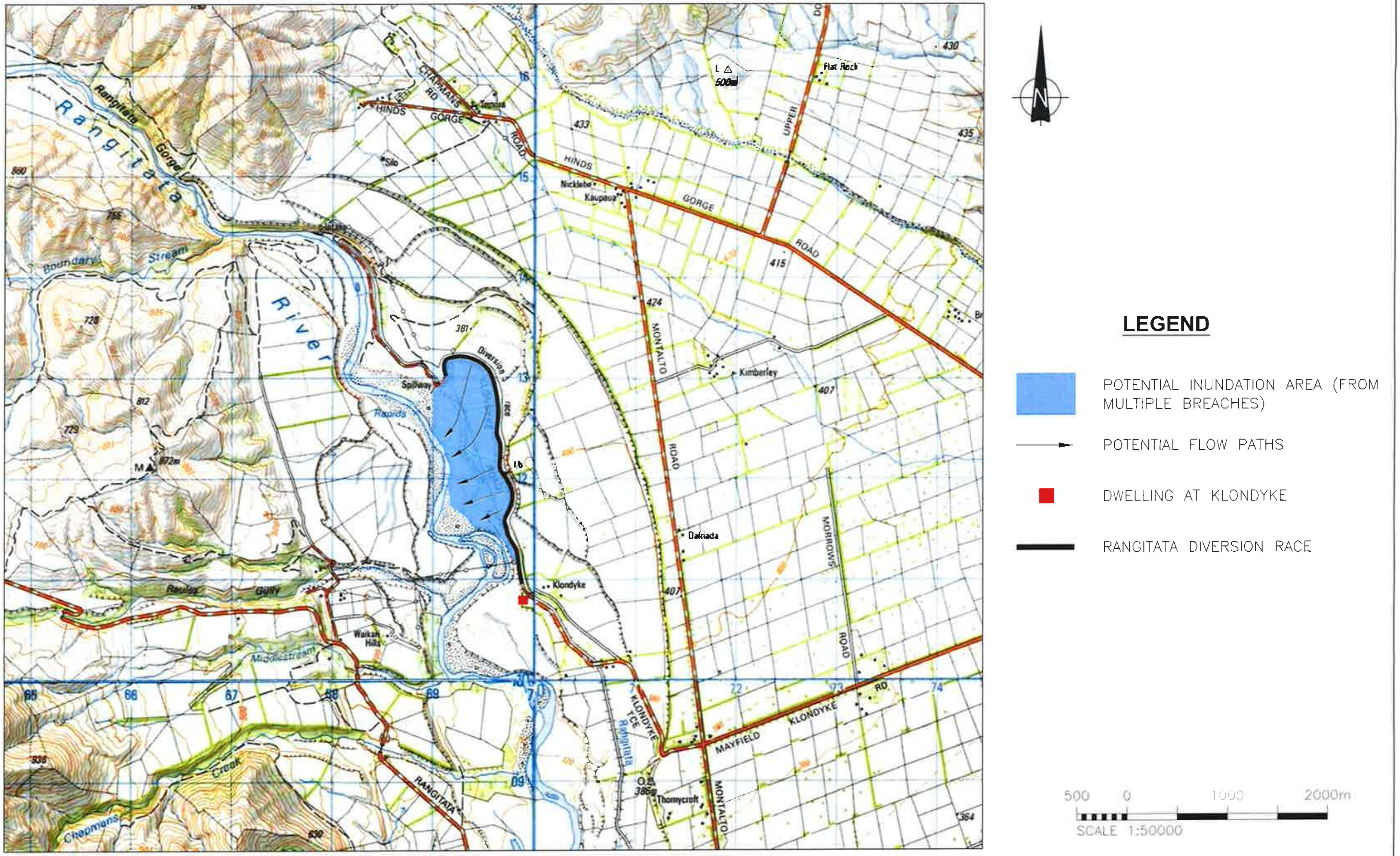
DESIGN NS
CHECKED
DRAWN HN
CHECKED
DATE DRAWN 4 SEPT 2015

APPROVED FOR ISSUE:
DRAFT
DATE: / /

RILEY CONSULTANTS
P.O.BOX 4355
CHRISTCHURCH
TEL. 03–3794402
FAX. 03–3794403

TITLE
RANGITATA DIVERSION RACE MANAGEMENT LTD
RANGITATA DIVERSION RACE (RDR)
CANAL MODIFICATION AERIALS - BRIDGES 3, 4 AND 5

CADFILE 11835_2–3
SCALES (A3) AS SHOWN
ACENZ
DRAWING No. 11835/2-3
REV. 1



DESIGNED
PFR

DRAWN
HN

CHECKED

RILEY CONSULTANTS
○ AUCKLAND
● CHRISTCHURCH

RANGITATA DIVERSION RACE MANAGEMENT LTD

RANGITATA DIVERSION RACE (RDR)

DAM-BREAK FLOOD HAZARD AND CONSEQUENCE ASSESSMENT

CADFILE
11835_2-5

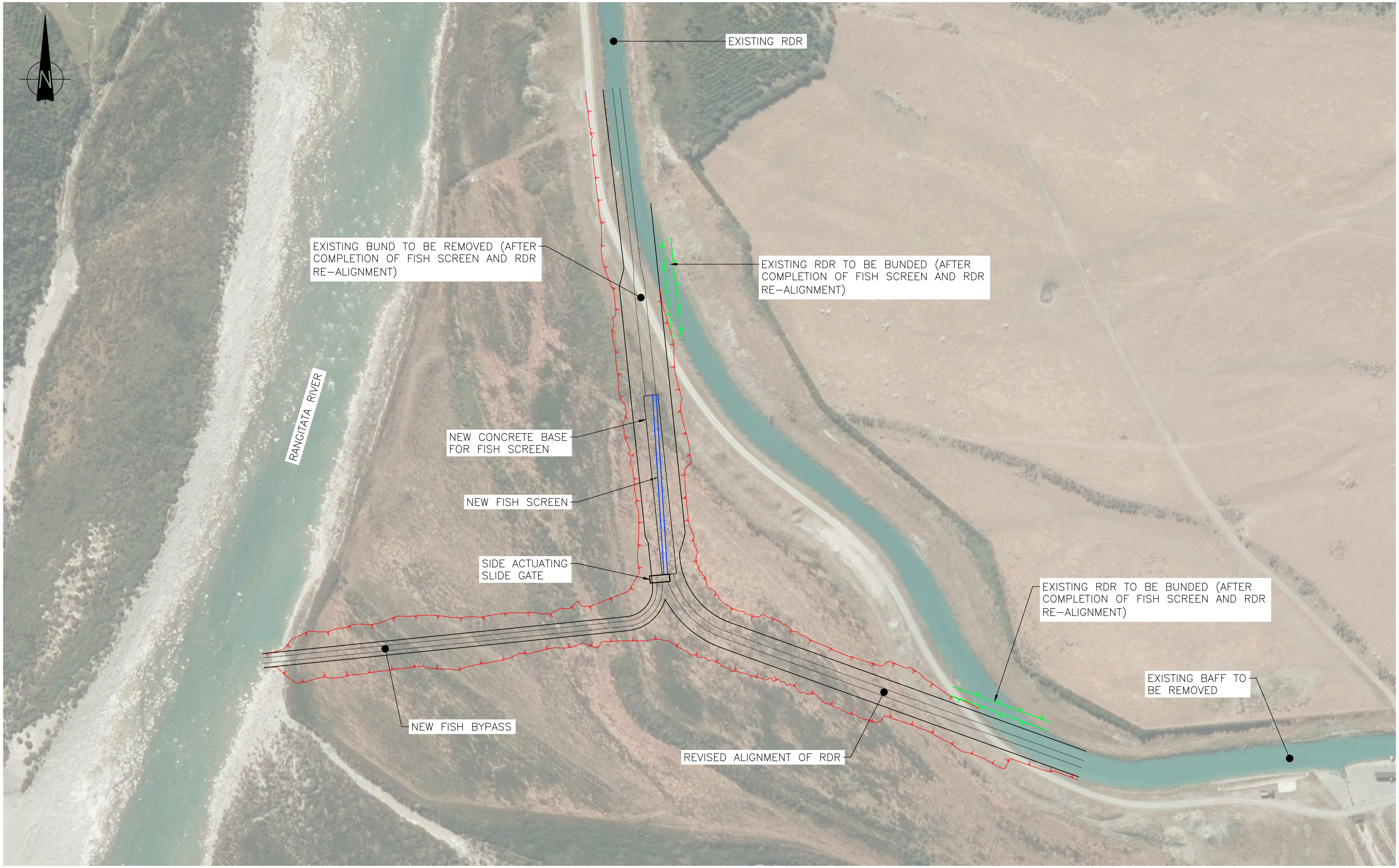
DATE
14 OCT 2015

SCALES (A4)
AS SHOWN

ACENZ

DRAWING No.
11835/2-5

REV.
0



20 0 40 80m

SCALE 1:2000

NOTES:

1. PHOTO SOURCED FROM LINZ (DEC 2011).

FOR INFORMATION ONLY

REV	DESCRIPTION	BY	DATE
1	FOR INFORMATION		

DESIGN BEA | CHECKED

DRAWN PO | CHECKED

DATE DRAWN OCTOBER 2017

APPROVED FOR ISSUE:

DRAFT

DATE: / /

RILEY CONSULTANTS

P.O.BOX 4355
CHRISTCHURCH

TEL. 03-3794402
FAX. 03-3794403

RDR
Rangitata Diversion Race Management Limited

TITLE

RANGITATA DIVERSION RACE MANAGEMENT LTD

RDR SAND TRAP AND FISH SCREEN

FISH SCREEN CONCEPT PLAN

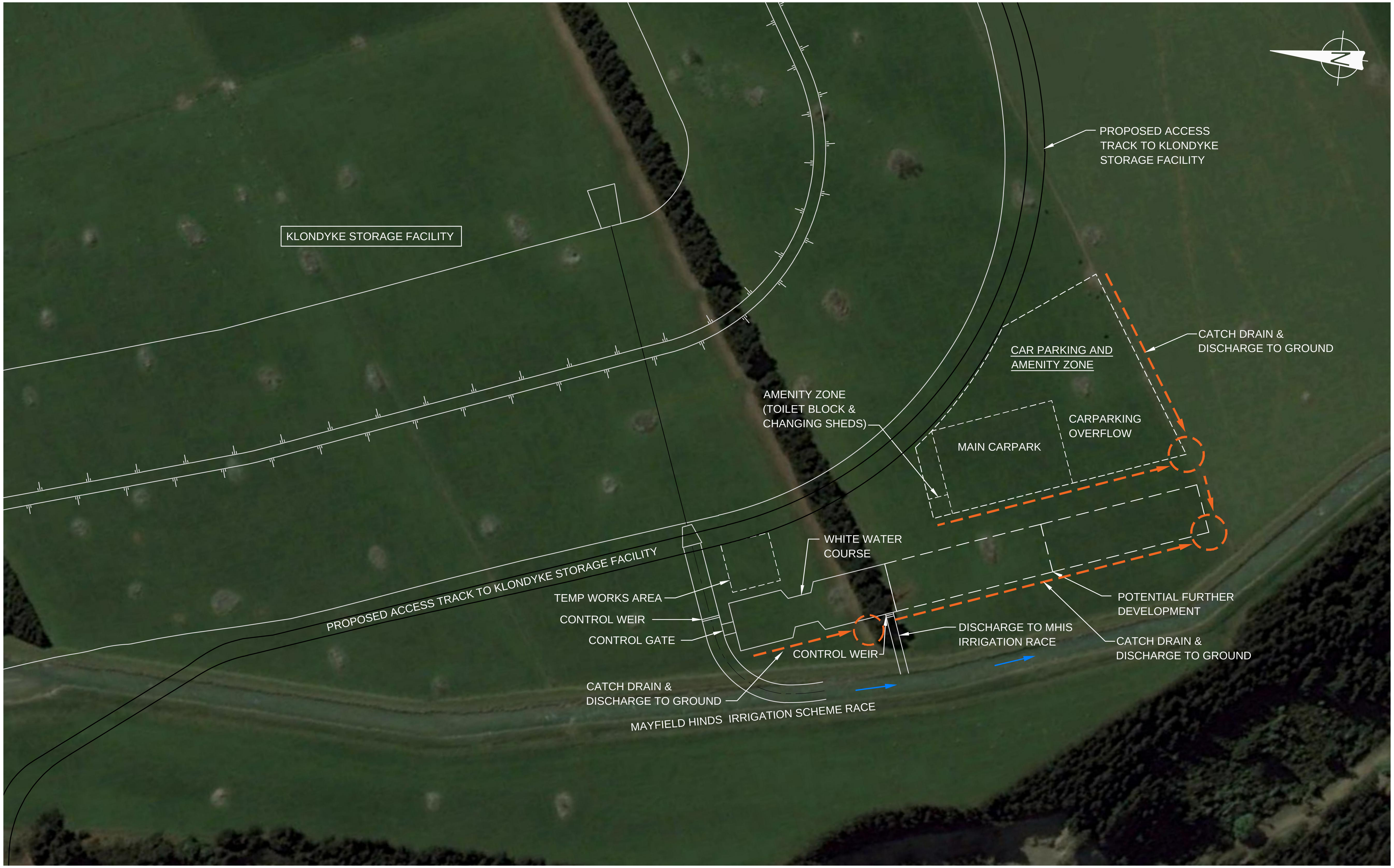
CADFILE 150975-3

SCALES (A3) 1:2000

DRAWING No. 150975-3

REV. 1

ACENZ



20 0 40 80m

SCALE 1:2000

NOT FOR CONSTRUCTION

0	FIRST ISSUE		
REV	DESCRIPTION	BY	DATE

DESIGN GML
CHECKED
DRAWN RBT
CHECKED
DATE DRAWN 20 NOV 2015

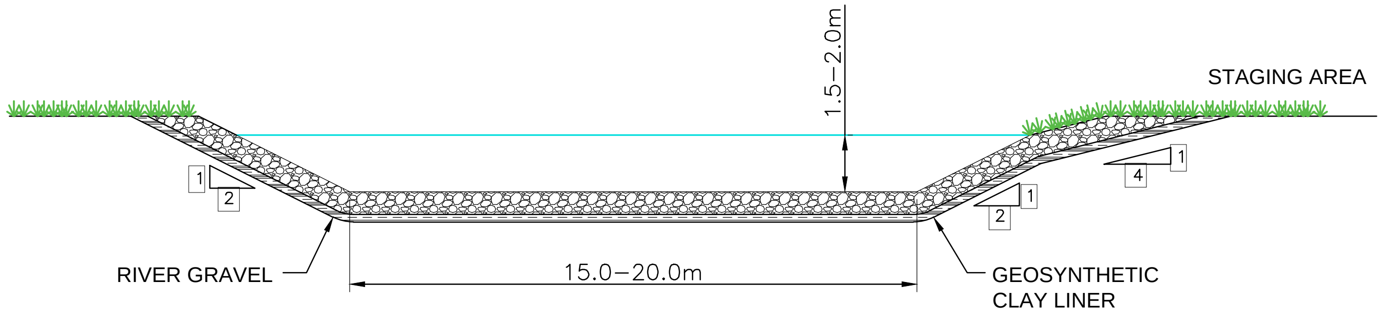
APPROVED FOR ISSUE:
DRAFT
DATE: / /

RILEY CONSULTANTS
P.O.BOX 4355
CHRISTCHURCH
TEL. 03-3794402
FAX. 03-3794403

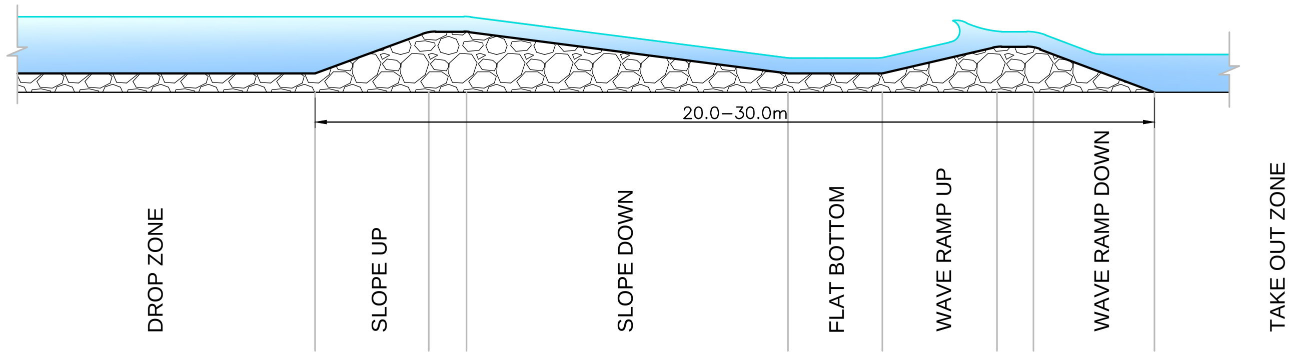
RDR
Rangitata Diversion Race Management Limited

TITLE
RANGITATA DIVERSION RACE MANAGEMENT LTD
WHITE WATER COURSE
OVERALL LAYOUT

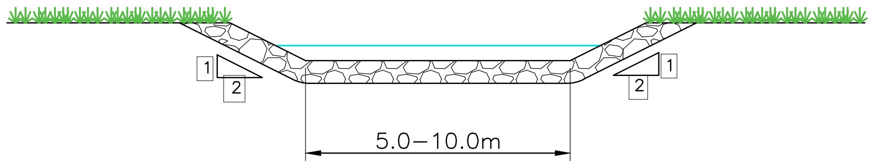
CADFILE 11835/3-01
SCALES (A3) AS SHOWN
DRAWING No. 11835/3-01
REV. 0
ACENZ



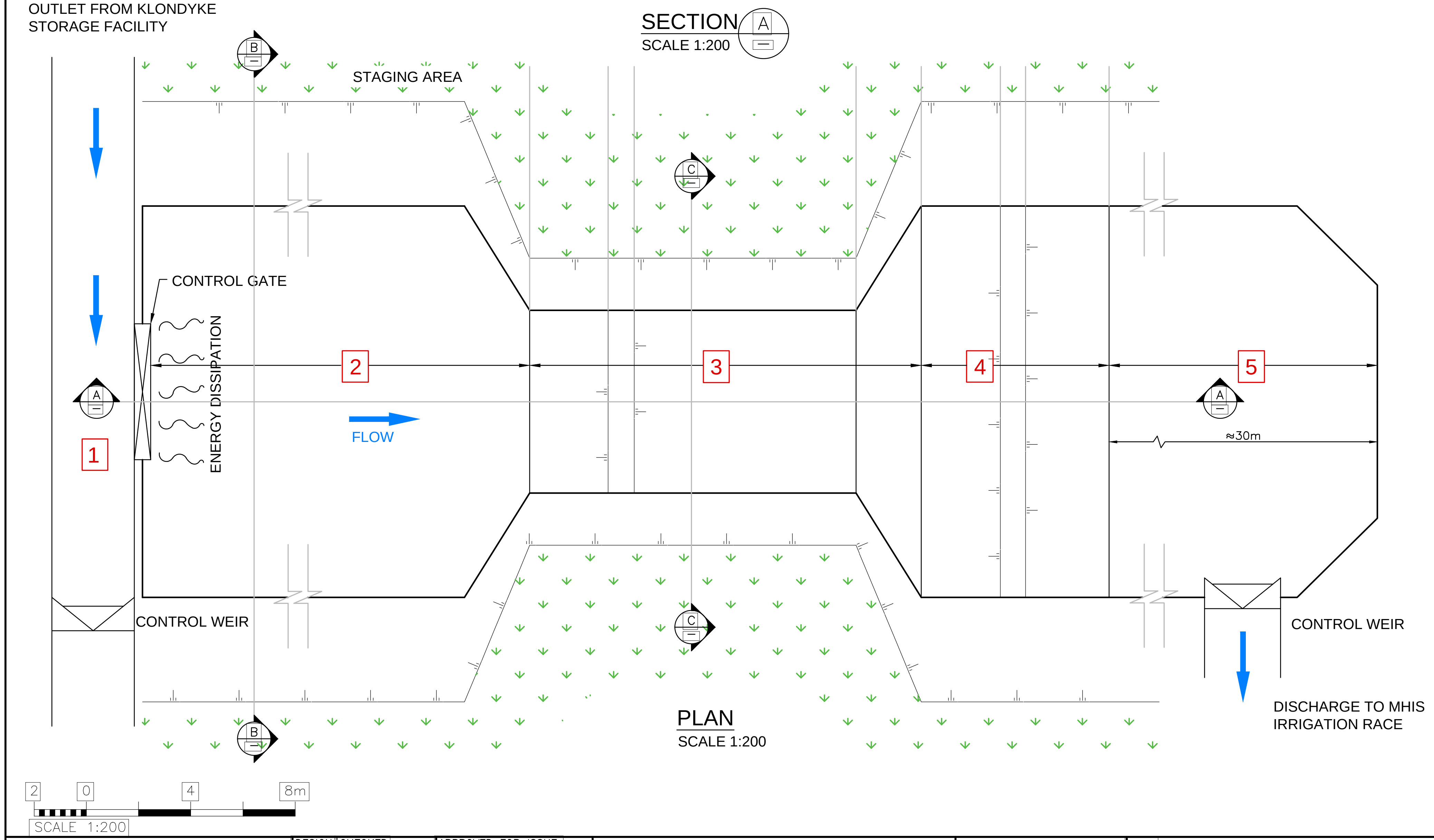
SECTION B
SCALE 1:200



SECTION A
SCALE 1:200



SECTION C
SCALE 1:200



PLAN
SCALE 1:200

NOTES:

- ALL DIMENSIONS SUBJECT TO SPECIFIC ENGINEERING DESIGN

1	CONTROL GATE AND WEIR
2	UPSTREAM STAGING AREA AND DROP-IN ZONE
3	TRANSITION TO WAVE
4	WAVE ZONE
5	DOWNSTREAM TAKE-OUT ZONE

NOT FOR CONSTRUCTION

REV	DESCRIPTION	BY	DATE
0	FIRST ISSUE		

DESIGN GML CHECKED
DRAWN RBT CHECKED
DATE DRAWN 20 NOV 2015

APPROVED FOR ISSUE:
DRAFT
DATE: / /

RILEY CONSULTANTS
P.O.BOX 4355
CHRISTCHURCH
TEL. 03-3794402
FAX. 03-3794403

RDR
Rangitata Diversion Race Management Limited

TITLE
RANGITATA DIVERSION RACE MANAGEMENT LTD
WHITE WATER COURSE
LAYOUT AND SECTIONS

CADFILE 11835/3-02
SCALES (A3) AS SHOWN
ACENZ
DRAWING No. 11835/3-02
REV. 0

Annexure B

Peer Review

GOLDER

21 March 2018

1898089-002-L-Rev0

Ben Curry, CEO
Rangitata Diversion Race Management Ltd. (RDRML)
18 Kermode Street
PO Box 61, Ashburton 7740
New Zealand

ben@rdrml.co.nz
Ph. 03 307 8320
Fx. 03 307 8321

RE: PEER REVIEW OF TASK 1. REPORT 2: RANGITATA DIVERSION RACE FISH SCREEN CONCEPT REPORT, RILEY CONSULTANTS LTD., NOV. 2017.

Dear Ben,

This letter provides a general assessment of the following document under Task 1 of our contract. This is the second of three reviews to be provided under this agreement and is sent prior to the final to give you and the authors time to review and comment and undertake any editing deemed necessary for the document under review. The original document is provided with embedded comments and suggested editing that can be viewed using Track Changes in MS Word. The document was converted from the PDF format to enable editing and line by line comments.

Rangitata Diversion Race Fish Screen Concept Report, Riley Consultants Ltd., Nov. 2017.

General:

The reviewed document provides a concept report on a proposed fish screen design. My comments and review are limited to compliance of the design with the required objectives stated in Jamieson et al. (2007) under best practices for fish screens of this type. Some other minor editorial comments are included in the mark-up attached copy of the original document.

The screen type proposed and specifications are consistent with the objectives of Jamieson et al. (2007) and conforms to International Standards (see NMFS 2007 for example) for positive fish exclusion devices that are used for diversion of migrating and rearing juvenile salmonids in North America. I suggest that both approach velocities and sweep velocities, which will be targeted in the design, are more clearly specified, such as average approach/sweep velocities and proposed allowance for variability in measured values along the face of both rotating drum screens and flat screens.

Although this design concept does not have specific details for meeting all concerns for successful operations, such as ability to handle sediment loads that occur under expected extremes, these issues have been defined and the data collection needed for further design refinement have been identified.

The concept proposed is consistent with International Standards and has a high probability of meeting the defined objectives and the stated best practices as defined by Jamieson et al. (2007) if final designs, construction and operations are consistent with concepts presented.

Golder Associates Ltd.

Dana Schmidt, PhD, Author
Senior Fisheries Biologist

Shawn Redden, RPBio, Golder Internal Senior Reviewer
Associate, Senior Fisheries Biologist

DS/SR/cmc

References:

Jamieson, D., Bonnett, M., Jellyman, D., and Unwin, M. 2007. Fish screening: good practice guidelines for Canterbury. Prepared for the Fish Screen Working Party by NIWA. NIWA Client Report: CHC2007-092, October 2007.

NMFS (National Marine Fisheries Service).1997. Fish Screening Criteria for .Anadromous Salmonids. U.S. National Marine Fisheries Service, Southwest Region, Long Beach, CA.

Report Limitations

This Report/Document has been provided by Golder Associates (GAL) Limited ("Golder") subject to the following limitations:

i) This Report/Document has been prepared for the particular purpose outlined in Golder's proposal and no responsibility is accepted for the use of this Report/Document, in whole or in part, in other contexts or for any other purpose.

ii) The scope and the period of Golder's Services are as described in Golder's proposal, and are subject to restrictions and limitations. Golder did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Report/Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Golder in regards to it.

iii) Conditions may exist which were undetectable given the limited nature of the enquiry Golder was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Report/Document. Accordingly, if information in addition to that contained in this report is sought, additional studies and actions may be required.

iv) The passage of time affects the information and assessment provided in this Report/Document. Golder's opinions are based upon provided information that existed at the time of the production of the Report/Document. The Services provided allowed Golder to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

v) Any assessments, designs and advice made in this Report/Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Report/Document.

vi) Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Golder for incomplete or inaccurate data supplied by others.

vii) The Client acknowledges that Golder may have retained subconsultants affiliated with Golder to provide Services for the benefit of Golder. Golder will be fully responsible to the Client for the Services and work done by all of its subconsultants and subcontractors. The Client agrees that it will only assert claims against and seek to recover losses, damages or other liabilities from Golder and not Golder's affiliated companies. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any legal recourse, and waives any expense, loss, claim, demand, or cause of action, against Golder's affiliated companies, and their employees, officers and directors.

viii) This Report/Document is provided for sole use by the Client and is confidential to it. No responsibility whatsoever for the contents of this Report/Document will be accepted to any person other than the Client. Any use which a third party makes of this Report/Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Report/Document.