WAIMAKARIRI
DISTRICT COUNCIL

Land and Water Committee

Agenda

Thursday 8 October 2020

9.30am

Function Room
Rangiora Town Hall
303 High Street
Rangiora

Members:

Councillor Sandra Stewart (Chairperson)
Deputy Mayor Neville Atkinson
Councillor Kirstyn Barnett
Councillor Al Blackie
Councillor Niki Mealings
Councillor Paul Williams
Mayor Dan Gordon (ex officio)

The Chairperson and Members
LAND AND WATER COMMITTEE

AGENDA OF THE LAND AND WATER COMMITTEE TO BE HELD IN THE FUNCTION ROOM, RANGIORA TOWN HALL, 303 HIGH STREET, RANGIORA ON THURSDAY 8 OCTOBER 2020 AT 9.30AM.

Recommendations in reports are not to be construed as Council policy until adopted by the Council

BUSINESS

Page No

1 APOLOGIES

2 CONFLICTS OF INTEREST

Conflicts of interest (if any) to be reported for minuting.

3 CONFIRMATION OF MINUTES

3.1 Minutes of a meeting of the Land and Water Committee held on Thursday 13 August 2020

4 - 7

RECOMMENDATION

THAT the Land and Water Committee:

(a) **Confirms** the circulated Minutes of a meeting of the Land and Water Committee held on 13 August 2020, as a true and accurate record.

4 MATTERS ARISING

5 DEPUTATION/PRESENTATIONS

5.1 Environmental programmes for the Long Term Plan 2021-31 – Sophie Allen (Water Environment Advisor) and Kate Steel (Ecologist Biodiversity)

S Allen and K Steel will be in attendance to introduce the Environmental Programmes to be presented as part of the 2021-31 Long Term Plan.

6 REPORTS

6.1 Kaiapoi River water quality and management – Sophie Allen (Water Environment Advisor)

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RECOMMENDATION

THAT the Land and Water Committee:

(a) **Receives** report No. 200918124023.

(b) **Notes** the water quality information available for the Kaiapoi River from Environment Canterbury monitoring, as well as proposed future management options.

(c) **Approves** the removal of the Adderley Terrace Wetland and the Smith Street Charles Street elbow bend realignment projects from the 2021-22 Kaiapoi River Rehabilitation Work Programme.

(d) **Endorses** the work programme detailed in Item 1.3 of the report (No.200918124023).

(e) **Endorses** that Environment Canterbury be requested to carry out continuous monitoring in the Kaiapoi River for nutrient, Chlorophyll-a and salinity levels in particular.

(f) **Notes** that no pigeon control will be undertaken for the Williams Street Bridge colony until it is confirmed whether the pigeons are a significant source of faecal bacteria to the waterway.

(g) **Notes** the suggestion for the Kaiapoi River Rehabilitation Work Programme to be combined into the Zone Implementation Programme Addendum (ZIPA) Work Programme in the 2021-31 Long Term Plan, primarily under recommendation 1.27.

(h) **Circulates** this report to the Waimakariri Water Zone Committee, the Rūnanga Liaison Group and the Kaiapoi-Tuahiwi Community Board.

7 QUESTIONS

8 URGENT GENERAL BUSINESS

NEXT MEETING

The next meeting of the Land and Water Committee is scheduled for 9:30am, Thursday 10 December 2020 in the Function Room, Rangiora Town Hall.

WAIMAKARIRI DISTRICT COUNCIL

MINUTES OF A MEETING OF THE LAND AND WATER COMMITTEE HELD IN THE FUNCTION ROOM AT THE RANGIORA TOWN HALL, 303 HIGH STREET, RANGIORA ON THURSDAY 13 AUGUST 2020 COMMENCING AT 9:30AM

PRESENT

Councillor S Stewart (Chairperson), N Atkinson, K Barnett, A Blackie, N Mealings, P Williams and Mayor D Gordon.

IN ATTENDANCE

C Brown (Manager Community and Recreation), K Simpson (3 Waters Manager) S Allen (Water Environment Officer), K Steel (Ecologist – Biodiversity), and T Kunkel (Governance Team Leader).

1 APOLOGIES

None

2 CONFLICTS OF INTEREST

There were no conflicts of interest.

3 CONFIRMATION OF MINUTES

3.1 Minutes of a meeting of the Land and Water Committee held on Thursday 11 June 2020

Moved Councillor A Blackie Seconded: Councillor P Williams

THAT the Land and Water Committee:

(a) **Confirms** the circulated Minutes of a meeting of the Land and Water Committee held on 11 June 2020, as a true and accurate record.

CARRIED

4 MATTERS ARISING

Councillor Barnett requested an update on the Nitrate limits for private wells. S Allen undertook to forward the report that served at the CWMS Waimakariri Zone Committee to the members of the Land and Water Committee.

5 DEPUTATION/PRESENTATIONS

None

6 REPORTS

6.1 Planting Proposal for Fernside Springs (Pinevale Farm)– S Allen (Water Environment Officer)

S Allen advised that the Cam River Enhancement provided an amount of $25,000 per annum over a five year period for habitat restoration in the Cam

River system. Funding was allocated to projects in September 2018 by the Cam River Enhancement Fund Subcommittee, which included funding for planting and maintenance for the springs in the Fernside area where Pinevale Farm was located.

S Allen reported that a staged approach was being proposed for the project at Pinevale Farm, where 1050 eco-sourced native riparian/ wetland plants would be planted over the two spring sites. There was also potential for further stages of works at other springs in the area. These areas were currently not able to be progressed with planting, as the landowner and lessee intend to carry out re-shaping works first, prior to fencing off the springs.

Councillor Atkinson enquired what measures the Council would put in place to ensure that the planting at the spring heads was maintained. S Allen explained that planting and maintenance for the first two years would be done by a contractor on behalf of the Council. After this initial period, the maintenance would be the responsibility of the landowner and the lessee. The Council was investigating the possibility of entering into a memorandum of understanding with the landowner regarding the maintenance, but this may be difficult to enforce.

Councillor Stewart tabled photos showing the area at Lehmans Road that had been fenced and would be planted. Councillor Williams noted that the fencing in the photos seemed to be a two hot wire fence, which would not be effective in keeping livestock out of the area. He therefore suggested that more substantial fencing should be erected.

Councillor Mealings agreed and stated that the fencing should include at least three hot wires, including the bottom wire to deter cattle from shoving their heads trough the fencing.

Councillor Blackie also agreed that proper fencing would be required, and suggested at least a five wire fence or cyclone netting to protect the plants. He stressed that it would be ill-advised to spent $14,000 on plating without proper protection.

Councillor Barnet sought clarity on why these two spring heads were selected for habitat restoration. K Simpson, explained that various hotspots around the Cam River catchment area were identified in Dr Henry Hudson's 2017 report, including these two spring heads. These two projects would hopefully get the ball rolling to identify more projects in the future.

Councillor Stewart advised that the Lehmans Road site was a major spring head that was known as major hotspot that needed protection since approximately 2007. Thus, the landowner had previously applied to the Cam River Enhancement Fund for fencing and articulation. C Brown concurred and stated that this was a historic application that the Council had been working on for a long time. More bio-diversity funding would be available in future for other landowners who wished to launch similar projects on their properties.

In response to questions, S Allen confirmed that the Council would consider the planting of trees near the spring heads at a later stage in the project.

Councillor Williams enquired if the gorse in the fenced area would be removed as it would overrun the other planting. S Allen advised that the Council would not be removing the gorse as this was the landowner's responsibility. There was however pros and cons to gorse, as it attracted various insects and birds and also leaked nitrates into waterways.

Councillor Mealings advised that, to her knowledge, farmers had to remove gorse along their boundaries, so the gorse in the area to be plated would have to be removed. Councillor Atkinson agreed that if current regulations stipulated

that the gorse should be removed, then the owner should be advised to remove the gorse.

Councillor Williams enquired who would be responsible for the actual maintenance work in the planting areas. S Allen advised that the Council had discussions with the landowner and was advised that the long term lessee would be doing the maintenance work such as gorse removal. However, it should be noted that the Council did not have the ability to enforce the gorse removal as this fell under the auspice of ECan.

C Brown enquired if some of the project funding could not be diverted to removing the gorse prior to planting. S Allen confirmed that the fencing upgrade and gorse removal could be funded from the Cam River Enhancement funding.

In response to questions from Councillor Barnett, S Allen advised that it was agreed with the landowner that a community planting day would not be ideal due to public health and safety concerns on the farm.

Moved: Councillor A Blackie Seconded: Councillor P Williams

THAT the Land and Water Committee,

(a) **Receives** report No. 200727094590.

(b) **Approves** the proposal for the planting and associated maintenance of springs at Pinevale Farm, estimated at a cost of $14,000, from the allocated budget of $33,100 from the Cam River Enhancement Fund.

(c) **That** the project proceeds on the condition that the area was fenced to the satisfaction of Council staff, prior to planting, to ensure livestock exclusion.

(d) **Circulates** a copy of this report to ECan, Fish and Game and the Rangiora-Ashley Community Board for their information.

CARRIED

Councillor Williams stated that the existing fencing was not adequate and it was important that suitable fencing be erected to protect the planting that would be funded by the public. Councillor Blackie supported the comments made by the previous speaker.

Councillor Stewart requested that an additional condition be added requesting that signage be erected at both sites advising the public that the planting was funded by the Cam River Enhancement Fund. However, Councillor Blackie raised a concern regarding the possible cost of proper signage.

Councillor Barnett stated that it was important to inform the public of projects that had been undertaken with public funding and to inspire members of the public to take care of waterways. It may also motivate other landowners to apply to the Cam River Enhancement Fund for similar projects.

Councillor Atkinson concurred and advised that the Council were regularly asked about the work it is doing with regard to climate change, sustainability and public-private partnerships. It was therefore important to inform the public of the work being done with visible signage. Councillor Mealings agreed that recognition of the project was important, but the signage should not be intrusive.

Moved: Councillor S Stewart Seconded: Councillor K Barnett

THAT the Land and Water Committee,

(e) **Approves** that signage to be erected at both sites to advise the public that the protected spring planting was funded by the Cam River

Enhancement Fund. The signage will be erected at a location to be determent by Council staff to ensure public visibility.

CARRIED

Councillor Atkinson stated that although it was imperative to ensure that public money was well spent, the importance of the rehabilitation and conservation work being done by the Council should be emphasised, and the public should be educated accordingly. Councillor Williams supported the erection of signage and hoped that it would stimulate similar projects.

Councillor Stewart advised that signage at these sites would be a signal to the farming public that the Council was willing to put public money towards this vital project. The signage may also ensure better monitoring and maintenance of these planting sites, as the public would make the Council aware of any neglect.

7 QUESTIONS

There were no questions.

8 URGENT GENERAL BUSINESS

There was no urgent general business.

NEXT MEETING

The next meeting of the Land and Water Committee is scheduled for 9:30am, on Thursday 8 October 2020 in the Function Room in the Rangiora Town Hall.

There being no further business, the meeting closed at 10.25am.

CONFIRMED

_____
Chairperson

_____
Date

Briefing (10:25am to 11:30am)

- Action for Healthy Waterways– *S Allen (Water Environment Advisor)*
- Long Term Plan – Environmental Projects - *S Allen (Water Environment Advisor)*
- Government Environmental Funding– *K Steel (Ecologist – Biodiversity)*
- Kaiapoi River Issues and Management – *S (Water Environment Advisor)*

WAIMAKARIRI DISTRICT COUNCIL

REPORT FOR DECISION

FILE NO and TRIM NO:	DRA-07 / 200918124023
REPORT TO:	Land and Water Committee
DATE OF MEETING:	8 October 2020
FROM:	Sophie Allen – Water Environment Advisor
SUBJECT:	Kaiapoi River water quality and management
SIGNED BY: **(for Reports to Council, Committees or Boards)**	Department Manager / Chief Executive

1. SUMMARY

1.1 This report summarises selective water quality information for the Kaiapoi River, and reviews management, including recommendations for the future of the Kaiapoi River Rehabilitation work programme.

1.2 Levels of contaminants monitored by Environment Canterbury, particularly *E. coli* (an indicator for faecal bacteria) and nitrate are of concern for the Kaiapoi River. These contaminants affect recreational activities and ecological health of the waterway.

1.3 WDC staff recommend the following actions for the Kaiapoi River Rehabilitation work programme for the next three years (2020-2023) and on-going:

a. Tidal planting of native wetland species that encourage passive creation of a two-stage channel, to increase flushing flows for sediment and absorb wave erosion.

b. Terrestrial planting along the riparian edge of the river with native species, potentially with on-going funds from Environment Canterbury of $10,000 per year for 3 years.

c. Progress with the creation of a gravel beach at elbow bend on the corner of Smith and Charles Streets in 2020-21. This will be planted with intertidal species to bind the gravel in place. Planting may proceed without gravel addition if considered to be detrimental to the popular fishing hole at the site.

d. Encourage passive establishment of native saltmarsh vegetation for coastal erosion prevention and biodiversity values.

e. Monitor inanga spawning area migration and plan for provision of suitable spawning habitat upstream.

f. Work with the Kaiapoi community to accommodate the Kaiapoi River as it transitions to a more estuarine environment, in conjunction with the WDC natural hazards workstream.

1.4 It is recommended by WDC staff to not proceed with the proposals of the Adderley Terrace wetland and Smith Street Charles Street elbow bend re-alignment within 2021-22, due to difficulty with consent timeframes, concerns raised about the projects around potential

effects on a popular fishing hole for the elbow bend realignment, difficulty with dredging methods, and clashes with other WDC projects for the Adderley Terrace wetland area.

1.5 WDC staff recommend that no pigeon control is undertaken for the Williams St bridge colony until confirmed whether the pigeons are a significant source of faecal bacteria to the waterway. Pigeon control was scoped out by WDC staff, however was complex to carry out underneath the bridge, and constraints were raised as an issue for an intend spend from the bridge maintenance budget.

1.6 In addition to continuation of the Kaiapoi River Rehabilitation programme, WDC staff recommend working on implementation of the Cam River Enhancement Fund, as well as stormwater contaminant and sediment control through the Kaiapoi, Woodend and Rangiora network discharge consents, resulting in stormwater improvements for water quality in the Kaiapoi River.

1.7 WDC will continue to work with Environment Canterbury and the Waimakariri Water Zone Committee on tree removal, nutrient reduction targets through the Canterbury Land and Water Regional Plan targets, and land management to treat at source for a 'ki uta ki tai / whole of catchment' approach.

1.8 If endorsed by the Land and Water Committee, WDC staff intend to request that continuous monitoring is carried out by Environment Canterbury in the Kaiapoi River for nutrient, chlorophyll-a and salinity levels in particular.

1.9 WDC staff recommend that on-going Kaiapoi River Rehabilitation works are incorporated into the Zone Implementation Programme Addendum (ZIPA) programme, under ZIPA recommendation 1.27 (with addition funding available under ZIPA recommendation 2.11), with a request for budget sought in the 2021-2031 Long Term Plan.

Attachments:

i. Kaiapoi River Rehabilitation sediment trap bank reshaping and drainage wetland design Tonkin and Taylor (160615056050)

2. RECOMMENDATION

THAT the Land and Water Committee:

(a) **Receives** report No. 200918124023.

(b) **Notes** the water quality information available for the Kaiapoi River from Environment Canterbury monitoring, as well as proposed future management options.

(c) **Approves** the removal of the Adderley Terrace Wetland and the Smith Street Charles Street elbow bend realignment projects from the 2021-22 Kaiapoi River Rehabilitation Work Programme.

(d) **Endorses** the work programme detailed in Item 1.3 of the report (No.200918124023).

(e) **Endorses** that Environment Canterbury be requested to carry out continuous monitoring in the Kaiapoi River for nutrient, Chlorophyll-a and salinity levels in particular.

(f) **Notes** that no pigeon control will be undertaken for the Williams Street Bridge colony until it is confirmed whether the pigeons are a significant source of faecal bacteria to the waterway.

(g) **Notes** the suggestion for the Kaiapoi River Rehabilitation Work Programme to be combined into the Zone Implementation Programme Addendum (ZIPA) Work Programme in the 2021-31 Long Term Plan, primarily under recommendation 1.27.

(h) **Circulates** this report to the Waimakariri Water Zone Committee, the Rūnanga Liaison Group and the Kaiapoi-Tuahiwi Community Board.

3. BACKGROUND

3.1 Many of the rivers in the Waimakariri Zone, particularly spring-fed streams such as the Kaiapoi River, exhibit unhealthy ecological communities, poor habitat conditions and degraded water quality. This condition reflects the high intensity land use in many parts of the zone. Without appropriate catchment scale management of nutrient losses and sediment inputs these impacted streams will continue to exhibit unhealthy aquatic communities.

3.2 A joint Waimakariri District Council and Environment Canterbury working group was established in 2014 at the request of the Kaiapoi-Tuahiwi Community Board, to scope future improvement actions for the lower Kaiapoi River. There were opportunities identified by the Board for improvements in the lower river, including to navigational safety, flood management, water quality, amenity and recreation. Dredging for navigational safety has been completed. The Kaiapoi River Rehabilitation Working Party was disestablished at the October 2019 Council election, with delegation transferred to the Land and Water Committee. There are on-going works proposed in this report for water quality, amenity and recreation.

3.3 The definition of Kaiapoi River in this report is from the confluence of the Ohoka Stream, Cust River and Silverstream to the sea, however takes a whole of catchment approach (ki uta ki tai) when considering management options.

4. ISSUES AND OPTIONS

Water quality

4.1. Environment Canterbury sample the Kaiapoi River near the Williams Street Bridge each summer season for *E.coli*, an indication of faecal contamination. The results have consistently resulted in a long-term grading of 'unsuitable for swimming' (see Figure 1), despite the use of the waterway by the community as a swimming area. Faecal source tracking by Environment Canterbury of the *E.coli* indicated a strong avian source. There are concerns that there is source of *E.coli* from tributaries of the Kaiapoi Rivers (Figure 2).

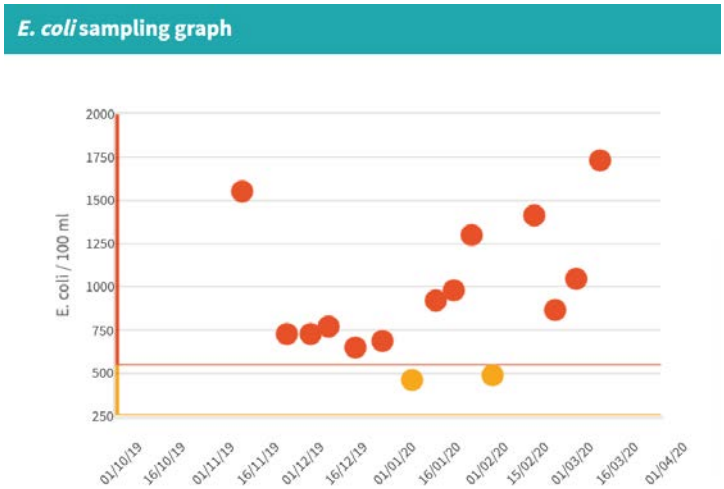

Figure 1: *E.coli* count per 100ml of water at the Kaiapoi boat ramp monitoring site. Yellow dots indicate above the 'alert' level, and red indicates above the 'action' level when 'unsuitable for swimming' signage is posted. Source: LAWA.org.nz

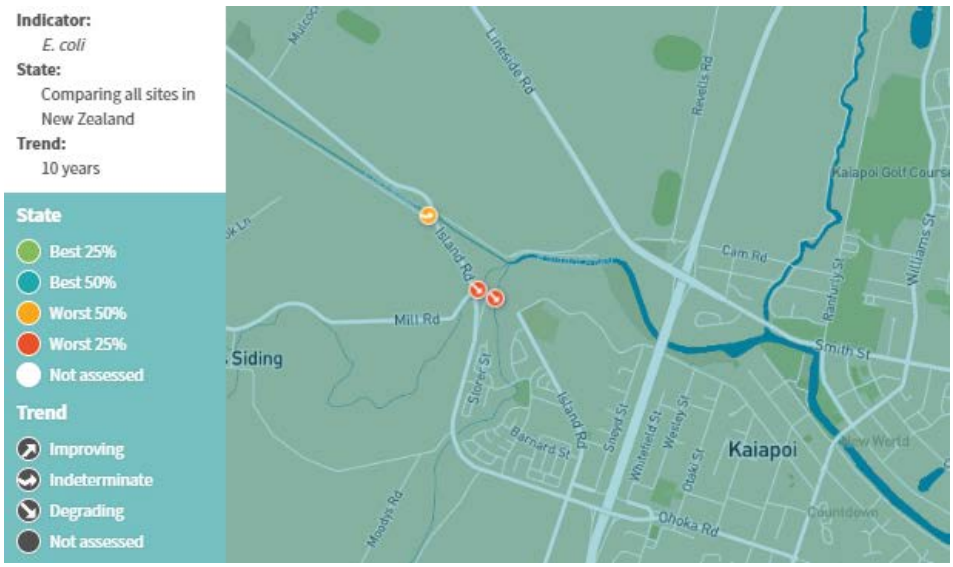

Figure 2: The state of the Kaiapoi River tributaries (Cust, Ohoka and Silverstream) for *E.coli* are either in the worst 50% or 25% of similar waterways in New Zealand, with an indeterminate or degrading trend observed in the past 10 years. Source: LAWA.org.nz

4.2. Nitrate levels in the key tributaries of the Kaiapoi River (the Cam River, Cust River, Ohoka Stream, Silverstream, South Brook, North Brook and Cam River) are monitored by Environment Canterbury (Figures 3 and 4). The state of these waterways are in the worst 25% or 50% of similar waterways nationally. The trend over 10 years is degrading for the most of the tributaries, except for the Ohoka Stream which is improving.

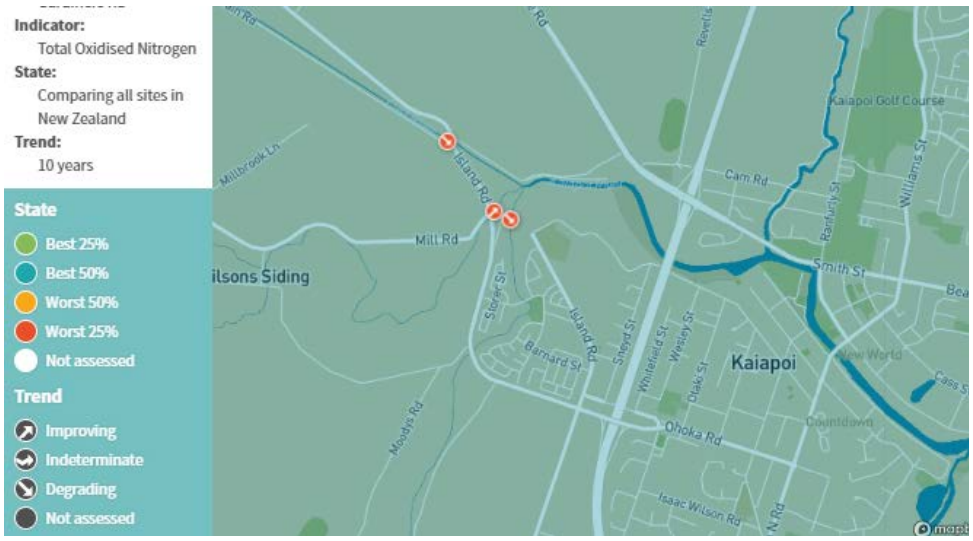

Figure 3: The state of Kaiapoi River tributaries (Cust, Ohoka and Silverstream) for Total Oxidised Nitrogen (nitrate and nitrite). Source: LAWA.org.nz

Figure 4:The state of Kaiapoi River tributaries (North Brook, South Brook and the Cam River) for Total Oxidised Nitrogen (nitrate and nitrite). Source: LAWA.org.nz

WDC work programme

4.3. An overall summary of approved Kaiapoi River Rehabilitation works still to be completed is presented in Table 1.

Project	2019-20	2020-21 Current year	2021-22	Funding Source	Comment
Intertidal planting	-	$10,000		ZIPA budget	Planting underway in late September
Terrestrial (riparian) planting	$10,000 (carried over)		-	Kaiapoi urban drainage account	Budget from Environment Canterbury confirmed. No longer require WDC budget
Intertidal planting – Coastguard to Courtenay	-	$10,000	-	Kaiapoi urban drainage account	Planned for November 2020 – February 2021
Stormwater outfall wetland, gravel beach and planting – Smith / Charles St	-	$10,000	-	Kaiapoi urban drainage account	Planned for November 2020 – February 2021. Gravel deposition depends on assessment of effect on fishing hole

Adderley Terrace Sediment trap / central island wetland and slow flow channel			$50,000	Kaiapoi urban drainage account	Proposed for removal or deferral to 2022-23. Requires resource consent and detailed design, plus confirmation of suitable dredging method. Final cost is uncertain.
Re-align Smith / Charles St elbow bend			$25,000	Kaiapoi urban drainage account	Proposed for removal or deferral to 2022-23. Requires resource consent, detailed design and further consultation with Fish and Game regarding the fishing hole. Final cost is uncertain.
TOTAL	**$10,000**	**$30,000**	**$75,000**		

Table 1: Kaiapoi River Rehabilitation approved budgets 2019-20 to 2021-22

4.4. WDC staff recommend the continuation of tidal planting of wetland species that encourage passive creation of a two-stage channel, to increase flushing flows for sediment and absorb wave erosion, as proposed by Dr. Henry Hudson in the 2011 rehabilitation plan for the waterway (130325021230[v2]). Planting will be focussed on establishment in new areas where there is bare river bed, and allow current wetland plants to spread and infill existing planted areas. WDC staff recommend an on-going budget of $10,000/yr for 3 years from 2021-24, which will be requested through an associated report.

4.5. The gravel beach creation project at the Smith Street Charles Street elbow bend, with associated wetland planting is still proposed to proceed in 2020-21, even if the associated elbow bend realignment project is removed. Gravel would only be added to the outer bend if there would not be a negative effect on the popular fishing hole. The gravel addition has been proposed to provide more access space for fishers.

4.6. WDC staff recommend the continuation of terrestrial planting along the riparian edge of the river with native species, potentially with on-going budget from Environment Canterbury of $10,000 for 3 years, following the comprehensive planting plan presented to the Land and Water Committee at the 13 August 2020 meeting. Initial discussions with the Environment Canterbury River Engineer - Northern indicate that this Environment Canterbury budget is confirmed in 2020-21, with project management by WDC staff.

Adderley Terrace Wetland

4.7. The Adderley Terrace wetland was originally proposed for amenity, to trap sediment, to create inanga and other species habitat, and mahinga kai opportunities among other reasons. It is recommended by WDC staff not proceed with the Adderley Terrace wetland. This is due to concerns raised, and anticipated consent timeframes for the project.

4.8. The former Drainage Asset Manager, Owen Davies, raised concerns over lack of suitable dredging methods available for the Adderley Terrace wetland area that could minimise

environmental impacts. The long distance from the banks to dredge (50+ m) would not be possible with a dragline, and a suction dredge barge would not be able to pass under the Mafeking footbridge.

4.9. There are also newer concerns that the Adderley Terrace wetland would clash with identified locations for canal boat in planning by the Business and Town Centres Team, and the 'Shovel-Ready' Kaiapoi drainage project for the Dudley and Parhams catchments, which entails works in the same area, and would possibly create scour for new plantings if an outfall is created in the area.

Smith Street Charles St elbow bend realignment

4.10. The Smith Street Charles St elbow bend realignment was proposed to reduce scour, and create more natural curvature that would allow wetland plants to establish on the outer bend. It is recommended by WDC staff not proceed at all with the Smith Street Charles Street elbow bend re-alignment. This is due to concerns raised, and anticipated consent objections timeframes for the project. Concerns were raised by North Canterbury Fish and Game and in public submission in 2017 that the popular fishing hole at the Smith Street Charles Street elbow bend would be degraded by realignment works.

4.11. Environment Canterbury is proposing works at the McIntosh Hole in 2020-22, which would restrict fishing access to that area downstream. WDC staff to do not recommend that works are carried out over the same period at the Smith Street Charles Street fishing hole, to allow for fisher access while McIntosh Hole has restricted access. The Smith Street Charles Street elbow bend realignment was proposed for scour protection reasons, however the Roading Manager, Stormwater Engineer and Wastewater Asset Manager do not see the project as required for protection of stormwater, road or wastewater pipe assets located near the bend. The Environment Canterbury River Engineer - Northern does not consider the project as necessary for stopbank protection.

William Street Bridge pigeon control

4.12. Control of the pigeon colony under the Williams St Bridge was proposed informally by WDC Councillors in 2019 to reduce faecal bacterial contamination to the Kaiapoi River. After investigations by WDC staff, it is recommended to not proceed with pigeon control for the Williams Street bridge colony until there is understanding whether the pigeons are a significant contribution to the faecal contamination load, and there is sufficient budget. The approach to not proceed with control of the pigeons was anecdotally supported by community members who attended a Kaiapoi Promotions Association event about Kaiapoi River water quality in August 2020.

Alignment with other WDC work programmes

4.13. Stormwater network discharge consent applications have been lodged for Kaiapoi, Rangiora and Woodend. All three of these urban areas have some tributaries that drain into the Kaiapoi River. As part of the proposed conditions of these consents, there will be water quality and stream health monitoring by WDC. This information will supplement monitoring by Environment Canterbury to understand the health of waterways and sources of urban contaminants, such as heavy metals. Stormwater improvement projects for the District, which will include a high number of projects for the Kaiapoi River Catchment, have been earmarked at a cost of $20 million in the Long Term Plan for the period 2025-2035.

4.14. Cam River Enhancement Fund projects are intended to be implemented 2020-22 to reduce sediment inputs into the Kaiapoi River. After the disbursement of the Fund, additional funding for Cam River water quality improvements, and maintenance of

sediment traps are recommended by WDC staff under the Zone Implementation Programme Addendum (ZIPA) budget for the Long Term Plan 2021-2031.

Environment Canterbury work programme

4.15. WDC staff will request that continuous monitoring is carried out by Environment Canterbury in the Kaiapoi River for nutrient, chlorophyll-a and salinity levels in particular. Monitoring will inform management options for mitigation of eutrophication that can cause excessive algal growth. Continuous (15-minute interval) monitoring is recommended because the tidal nature of the waterway means that there are regular fluctuations in these parameters, with less frequent monitoring not capturing this variation.

4.16. Environment Canterbury has indicated that they intend to continue with gradual tree removal to create light wells for planting, remove dying trees, and replace willows and other exotics with native species. There has been an allocation of $30,000 for this work by Environment Canterbury in 2020-21 and potentially on-going. WDC staff been offered a consultative role for which trees will be removed.

4.17. The Management Team have reviewed this report and support the recommendations.

5. COMMUNITY VIEWS

5.1. Groups and Organisations

5.1.1. The Kaiapoi River Rehabilitation Working Party approved the budget for the Adderley Terrace wetland and Smith Street Charles Street elbow bend realignment, however expressed concerns as well as support for these projects at the time of approval. Since the approval of these projects by the Working Party, additional concerns have been raised around the projects as well as consenting timeframes, that require reconsideration of these projects.

5.1.2. Environment Canterbury supports the continuation of Kaiapoi River rehabilitation works, such as exotic tree removal and native riparian planting. Environment Canterbury River Engineering does not object to the removal or deferral of the Smith / Charles St elbow bend alignment.

5.1.3. North Canterbury Fish and Game raised concerns that works at the Smith / Charles St elbow bend could degrade the quality of the well-known fishing hole at the site.

5.2. Wider Community

5.2.1. Consultation with the public was carried out in 2017 for Kaiapoi River rehabilitation work, which included the Adderley Terrace wetland and Smith Street Charles Street elbow bend realignment. The indication from this public consultation was that these works would be proceeding. However the following specific comment was raised in a submission from Mr Michael Bate on 2 May 2017 (TRIM 170804083394) "*the salmon fishing hole at the Smith Street corner has been used for many years by many veteran fishermen. If the corner is cut off then the hole will fill in which will destroy the present dynamics of this part of the river".*

5.2.2. A public talk was organised by the Kaiapoi Promotions Association in August 2020 about Kaiapoi River water quality and management, where staff from WDC and Environment Canterbury presented. Discussion about pigeon control under the Williams St Bridge was generally supportive of not carrying out these works, as the pigeons were not viewed as the primary source of faecal bacteria contamination. There was community concern about the progression of the Kaiapoi River to become more estuarine in the coming decades.

6. IMPLICATIONS AND RISKS

6.1. Financial Implications

6.1.1. The estimated cost of the Adderley Terrace island wetland is $50,000, which would be a saving to the Council if the project was removed from the programme, or could be higher if the project or methodology was changed. The cost of consenting, design and implementation could be significantly greater than this estimate, depending on the dredging method that is selected. The estimated cost of realignment of the Smith Street Charles St elbow bend is $25,000, which would be a saving to the Council if the project was removed from the programme.

6.1.2. WDC staff will be presenting funding under the LTP deliberation process for the Kaiapoi River Rehabilitation work programme. This information will be detailed in an associated report (200915122094[v2]).

6.2. Community Implications

6.2.1. The Kaiapoi River Rehabilitation work programme has a vision of an improved waterway for the local community across multiple values, such as biodiversity, swimming, boating and fishing.

6.3. Risk Management

6.3.1. Due to economic constraints created by the COVID- 19 pandemic in particular there is a need to minimise spend in 2020-2021. The removal of the Adderley Terrace wetland and Smith / Charles Street elbow bend realignment would help to manage the risk of rates inflation.

6.3.2. The is a risk, due to the sensitive cultural location of the Smith / Charles Street elbow bend as a historic confluence of the Cam River (Ruataniwha) that consent for the works may not be granted, or archaeological supervision may be required. There is a risk that North Canterbury Fish and Game or other local fishers could be identified as affected parties which could also delay the consenting process.

6.3.3. For the Adderley Terrace wetland to be dredged in its entirety as proposed there would be few feasible dredging methods due to the long distance from the shore to be dredged and the height of the Mafeking footbridge, which prevents a dredge from easily accessing the area. The Environment Canterbury dragline could access a distance up to 18m from shore, however the wetland is proposed to be at least 50m wide. It may not be feasible to use environmentally-friendly options for dredging, such as the suction-dredge technique used for the Kaiapoi marine precinct area, due to the access issues under the Mafeking footbridge. An option of a dredge on a barge could enable access to the area, however costs of this method would need to be investigated and could be significantly greater than the current project estimates.

6.4. Health and Safety

6.4.1. There are no specific Health and Safety considerations.

7. CONTEXT

7.1. Policy

7.1.1. This matter is not a matter of significance in terms of the Council's Significance and Engagement Policy.

7.2. Legislation

Resource Management Act (1991**)**

7.2.1. Consents would be required for the Adderley Terrace island wetland project and the Smith / Charles St elbow bend. These projects would likely require individual project consents, as they would not be covered by the Maintenance and Minor Works in Waterways consent for the Waimakariri District. The advice from the Utilities Planner is that these consent applications, if granted, would likely allow work to commence from late 2021-2022 at the earliest, or more likely in 2022-2023.

7.3. **Community Outcomes**

7.3.1. There is a healthy and sustainable environment for all

- Harm to the environment from the impacts of land use, use of water resources and air emissions is minimised.
- Cultural values relating to water are acknowledged and respected.

7.3.2. Public spaces and facilities are plentiful, accessible and high quality

- People enjoy clean water at our beaches, rivers and lakes.
- There are wide-ranging opportunities for people to enjoy the outdoors.

7.4. **Delegations**

7.4.1. The Land and Water Committee holds the delegation for the Kaiapoi River Rehabilitation work programme.

REPORT

TRIM Number: TBC

Environmental Management Associates Ltd

Tonkin+Taylor

Kaiapoi River Rehabilitation Stage 1A

Sediment trap, bank reshaping and drainage wetland design concepts

Prepared for

Waimakariri District Council | Kaiapoi River Rehabilitation Working Party

Prepared by

Environmental Management Associates Ltd

Tonkin & Taylor Ltd

Date

June 2016

Job Number

53720.001

Exceptional thinking together

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Waimakariri District Council | Kaiapoi River Rehabilitation Working Party	3 copies
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Abstract

This report builds on the concept development and assessment report for rehabilitation of Kaiapoi River Area A, which extends from the Mandeville Bridge upstream to the Ruataniwha/Cam floodgates (river chainage km ~2.4 to 3.0). Recommendations included extending rehabilitation upstream to excavate a sediment trap in the old meander bend of the realigned Kaiapoi River between the Motorway Bridge and Cam mouth (centred on river km 3.2); and modifying the elbow bend at the old mouth of the Cam River (centred on river km 2.75) by lowering the inner bend and infilling and planting the old Cam mouth as a drainage outfall wetland. This report is focused on these two recommendations.

Several options were evaluated for the sediment trap and elbow bend-wetland. In all cases, hydraulic modelling indicates there is negligible effect on the flood carrying capacity of the Kaiapoi River, primarily because the river is oversized. Over sizing relates to the fact that the Kaiapoi historically was the North Branch of the Waimakariri River, with considerably greater flow. Also, stopbanks on the Kaiapoi River are designed to contain flood backup from the Waimakariri River.

During normal river flows and small floods, conveyance is constrained to the main channel of the river and the velocities within the sediment trap area are minimal, facilitating settlement of fine particles. As edge vegetation is established, sediment would be stabilised in the trap area during large floods while the main channel is flushed clean to the gravel bottom. These effects will be enhanced with partial excavation of the trap. Planting recommended on the adjacent left bank of the Kaiapoi River, will further constrain the river and promote main channel flushing.

For flows less than 40 m^3/s, there is no apparent hydraulic effect from the proposed elbow bend modifications. In large flow events a slight reduction in flow velocities in the main channel and outside bends, and an increase in the inside bend velocities, is predicted. The outer bend drainage outfall wetland will be subject to moderate scour velocities during large flood events. As a result, stabilisation with coarse gravel-cobble material is recommended, rather than use of excavated material from the inner bend or sediment trap. To maintain channel capacity, and to reduce the risk of scour, it is recommended that the re-profiled inner bend is grassed. Planting of the outer bend is recommended to create the drainage outfall wetland.

An indicative methodology, for the construction and trial planting, is recommended. The latter was developed in consultation with Wai-Ora Forest Landscapes Ltd who are undertaking planting trials further downstream. Erosion and control measures are recommended.

Excavation of the sediment trap will partially restore the old meander loop that was cut off with channelisation of the Kaiapoi River to align with the new Northern Motorway Bridge (circa 1970). The meander loop was partially infilled during the channelisation, with net deposition of fine sediment averaging ~100 m^3/y in the intervening period. The excavation, and associated planting, is expected to increase sediment trap efficiency, and reduce the upstream and downstream flux of fine sediment that occurs on each tidal exchange. Trapping of Kaiapoi River flood flow sediment will also be enhanced; while flushing of fine sediment from the bed of the main channel will occur. Aquatic habitat will be enhanced with the exposure of a gravel bed in the reach as fine sediments are flushed from the main channel and with water clarity improvements.

Bank re-profiling will reduce the curvature and bank height of the inner bend and provide a more natural flow path, access, and integration with the planting proposed further downstream and on the outer bend drainage outfall wetland. The elbow bend drainage outfall wetland will be planted to trap and sediment and contaminants from the river and drainage outfall.

Planting in the reach has additional benefits including improved river habitat for aquatic life, mahinga kai, habitat and food for birds, lizards and insects, filtration and erosion control; and enhance the aesthetics of the river and river margins. This reach of river has the potential to provide inanga (whitebait) spawning and rearing habitat.

1 Introduction

The Kaiapoi River Rehabilitation Working Party (Working Party) adopted the recommendations of Hudson & Fletcher (2015) to investigate the utility of a cut off meander loop as a sediment trap; and naturalising an elbow bend at the historic Cam-Kaiapoi confluence to facilitate construction of a drainage outfall wetland on the outer bend (refer Figure 1.1 below).[1] On behalf of the Working Party, Waimakariri District Council (WDC), commissioned a joint project by Environmental Management Associates Limited (EMA) and Tonkin & Taylor Ltd (T+T) to undertake these investigations. The terms of reference are appended.[2]

These investigations are integral to a more holistic, catchment wide approach to rehabilitation. It is recognised that for rehabilitation of the Kaiapoi River to be successful, it is essential measures are taken to control the generation and delivery of sediment and contaminants from the catchment into the river, and to trap and treat sediment and contaminants that are in the Cam and Kaiapoi river system (Hudson 2010 & 2011). Catchment wide initiatives are underway in the Cam River system and are proposed for the Kaiapoi River system.

In terms of river corridor initiatives, the Working Party endorsed a "soft engineering" approach to rehabilitation of the upper Kaiapoi River (Hudson & Fletcher 2015). Planting trial are being undertaken to encourage the natural tendency of the river to development a sinuous low flow path, increase velocities to flush sediment from the river bed, and trap and treat sediment and contaminants along the planted channel margins that are frequently flooded. This planting, with resultant channel constriction, is likely to provide several environmental services, including improved river habitat for aquatic life, mahinga kai, habitat and food for birds, lizards and insects, filtration and erosion control; and enhance the aesthetics of the river and river margins.

The purpose of the sediment trap is to capture and stabilise suspended sediment mobilised during floods (in the Kaiapoi River catchment and Waimakariri River flood backflows) and during tidal action within the river (i.e. to capture sediment which would otherwise remobilise on the ingoing and outgoing tides but not leave the river system). Capture of this sediment is anticipated to improve the water clarity during non-flood periods by reducing the potential for sediment remobilisation (Hudson 1999, 2010). It was thought that this could be undertaken without adversely affecting river flood routing capacity of infrastructure integrity (Hudson & Fletcher 2015).

The purpose of the re-profiling is to reduce the curvature and bank height of the inner bend and provide a more natural flow path, access, and integration with the planting proposed further downstream and on the outer bend drainage outfall wetland (Hudson & Fletcher 2015). Realignment of the flow path to a more central course, coupled with a more natural inner and outer bank curvature, would facilitate establishment of vegetation on the outer bend. Planting of the beach on the outer bend is likely to enhance habitat values and trap and treat sediment and contaminants from the river and the drainage outfall. This area has the potential to be inanga (whitebait) spawning habitat as discussed in Hudson (2016).

[1] "*Kaiapoi River Rehabilitation Project Stage 1a – Variation Order (2) Drainage wetland and sediment trap indicative engineering and wetland concept development*" dated 15 October 2015. WDC Work order P0002026.

[2] T&T/EMA joint proposal titled "*Kaiapoi River Two Stage Meandering Flood Channel concept design – Stage 1 Engineering Services Proposal*" dated 03 February 2015. Job Ref: 53720. Work undertaken to WDC Purchase Order P0000798.

Figure 1.1 Kaiapoi River rehabilitation area Stage 1a – variation reach Jan 2016 (AP Google Earth)

2 Context

Historically the Kaiapoi River was the North Branch of the River Courtenay (now known as the Waimakariri River). The historic North Branch was largely dewatered as the result of a flour mill water race between the North Branch and South Branch avulsing and capturing most of the North Branch flow. The water race channel became the "new North Branch" in the 1860s; and the "old course North Branch" became the Kaiapoi River. Also, around this time, as part of major swamp drainage works, the Cust River was diverted into the Cust Main Drain and into the Kaiapoi River at river km 4.8. Large scale channelisation of the Waimakariri River in the 1930s isolated the North and South branches; and the braided river was confined into a progressively narrower channel over the lower 15 km to the sea (Hudson 2005).

In the late 1960s and early 1970s this section of the Kaiapoi River and lower Cam River were highly modified as part of the construction the Northern Motorway (State Highway 1) and for flood protection (Hudson 2010; 2011). Lower Cam River was shortened, widened, deepened and realigned so that it discharged into the Kaiapoi River about 275 m further upstream than previously (refer Figure 2.1 below). This produced an unnatural looking alluvial channel alignment (a 90 degree bend). Kaiapoi River was also realigned to flow under the new Northern Motorway Bridge, and the channel was straightened cutting off a meander loop (the sediment trap area marked in Figures 1.1 & 2.1).

These historic works resulted in degradation in the waterway's value with the enlarged and straightened river channel promoting sediment depositing and subsequent resuspension, and ebb and flow movements, of large quantities of fine sediment (Hudson 1999, 2010). As discussed earlier, Hudson & Fletcher (2015) proposed that wet edge[3] planting would accelerate development of a multi stage channel within the existing overall channel structure, by encouraging the natural tendency of the straightened, over widened and over deepened, river to develop a more natural cross section and sinuous low flow channel, with sediment flushing in the main channel, with deposition along the edges. The Working Party agreed that wet edge planting, and flow constriction,

[3] "Wet edge" planting was defined as the tidally flooded point bars and alternate side bars; and frequently flooded lower banks. The edge plantings are complimentary (not a replacement) to landscape plans for the upper river banks and river parks.

would provide several environmental services, including improved river habitat for aquatic life, mahinga kai, habitat and food for birds, lizards and insects, filtration and erosion control; and enhance the aesthetics of the river and river margins.

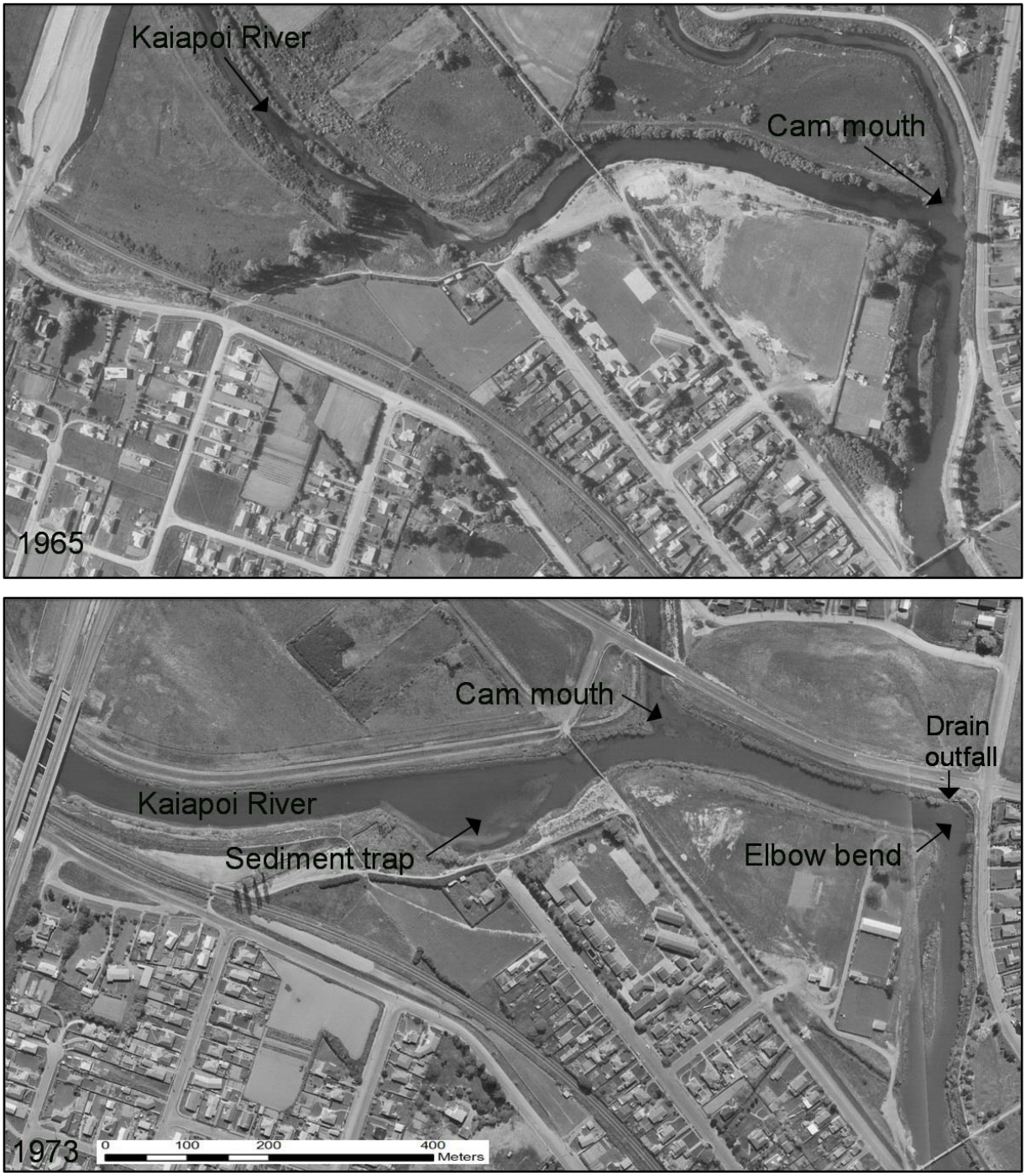

Figure 2.1 Historic aerial photographs (1965 & 1973) showing modifications to the Kaiapoi River in the Motorway to Mandeville swing bridge reach (AP Canterbury Maps/ECan)

3 Rehabilitation concepts

3.1 Sediment trap

The initial concept proposed for the sediment trap area was to excavate and remove the soft material deposited in the old bend of the Kaiapoi River (Figures 1.1, 2.1 & 3.1). Based on an assumed cross section (with a mean depth of 1.5 m) and the exposed surface area of the cut off meander bend, it was estimated approximately 10,000 m^3 of fine sediment would be removed. It was proposed that this excavation could be partially undertaken with the ECan dragline (which has a reach of 18 m)[4] with the remainder excavated from a barge. The quality or potential uses of this material were uncertain, which would have a bearing on uses or disposal costs. These estimates have been refined in this investigation by iterating different scenarios in the hydraulic modelling and other considerations.

Figure 3.1 View upstream to the proposed sediment trap near low tide

We have not been able to obtain before and after surveys of the old meander bend and new channel. Fortunately, ECan undertook cross section surveys in January 2016, in support of the Kaiapoi Rehabilitation initiative, which included probing to establish the thickness of fine sediment deposits overlying gravel. This information is critical to the development of the rehabilitation concepts and supply of this data by ECan is gratefully acknowledged. A summary of the supplied information is attached in Appendix B.

Based on the supplied cross-section information, the surveyed depth of soft sediment (i.e. difference between soft and hard bottom levels) within the proposed sediment trap area (plan area of approximately 7,800 m^2) varies up to ~1.0 m, with an average depth of approximately 0.58 m (Appendix B). The estimated volume of soft sediment within the trap area as of 20 January 2016 is 4,500 m^3. The fine sediment overlay has most likely accumulated since the river realignment works

[4] Brian McIndoe ECan (written comm. May 2015) estimated dragline and bank drop would cost ~$4 per m^3; but the ECan dragline has insufficient reach (18 m) with the greatest distance from the bank around 50 m.

undertaken as part of the northern motorway project in the early 1970's. This equates to roughly 100 m^3 per year net deposition.

The difference in the estimated depth of fine sediment is probably related to the partial infilling of the meander bend with the excavated material from the new channel. This view is based on Figure 3.2, which illustrates sediment in the area of the deepest part of the channel of the old meander bend shortly after channelisation (Figure 2.1). Also, the cross sections in Appendix B show that the hard bed is relatively level across the old meander loop.

Figure 3.2 Historic aerial photograph (1973) showing exposed bed material in the deepest part of the pre-cut off meander loop (AP Canterbury Maps/ECan)

It was thought that the excavated fine sediment could be used as hardfill and/or in the development of the drainage outfall wetland at the old Cam mouth. It is unlikely that the material is contaminated. This assessment is based on Hudson (1999) who examined sediment characteristics, and reported channel sediments were derived from catchment and river bank erosion, and backwash of the Waimakariri River. Because of its relatively fine texture, it has subsequently been determined that the material is not suitable for the drainage outfall wetland (it would easily erode); but would be suitable as soil for on-site or off-site use.

Various excavation scenarios were considered. The initial recommendation was to excavate from the true right bank with the ECan dragline which would create a channel about 18 m wide along the right bank where the deepest part of the original channel was. The remainder of the sediment trap could be excavated with hydraulic excavator mounted on a barge which has the ability to retain excavated material for subsequent disposal. While the dragline is cost effective ($4.00/$m^3$); the reach is too limited (18 m). Preliminary investigations of the barge mounted excavator indicate the

cost of excavation itself may be modest, but logistics are difficult and expensive.[5] The barge-excavator option may be viable for the sediment trap if excavation is coordinated with the proposed downstream navigation channel excavation.

A staged approach is recommended for the sediment trap. First, it is recommended that the inner portion of the sediment trap is excavated back to the gravel bed (refer Figure 3.3 below and Appendix B & C). This involves removal of fine sediment with an average thickness of ~0.60 m (ranging from a veneer to ~1.0 m) over an area of ~2,800 m^2 for a volume of ~1,700 m^3. Flows down the Kaiapoi River would enter the sediment trap from the existing upper end where the bed is already lower and by overtopping the "outer bank" at high flow (Figures 3.1 & 3.3). The downstream lead in excavation will promote water entry into the sediment trap for backflows from the Waimakariri River (Figure 3.3). The excavation will provide additional sediment trap capacity and a slow water wetland habitat off the main channel.

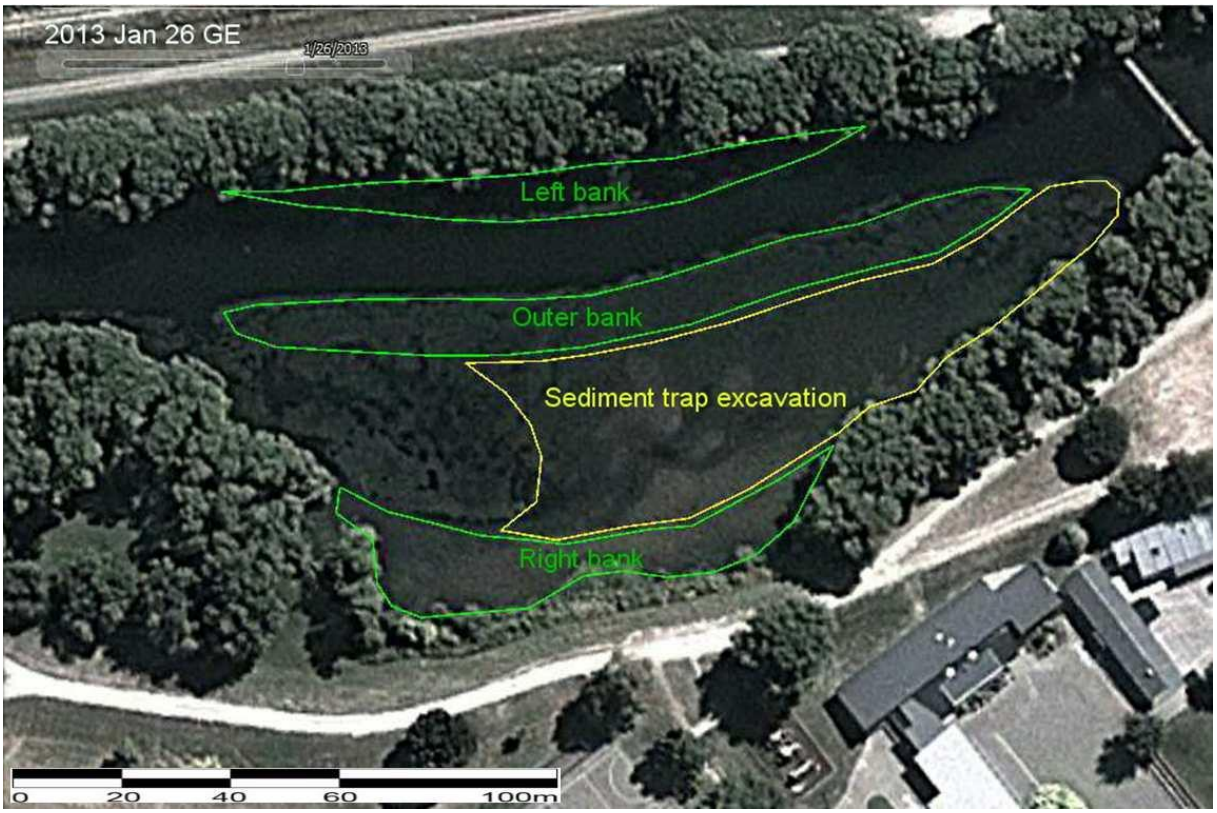

Figure 3.3 Proposed excavation and planting in the sediment trap wetland (AP Google Earth)

It is thought that the gravel infill in the old meander bed will support a front end loader, because it appears from historic aerial photographs to have been placed by machine. Hence, the excavation cost of the fine material is based on a dig and dump approach (refer Figure 3.4 below). Fine sediment would be removed from the bed over an area of ~2,800 m^2, temporarily stored on the adjacent bank for dewatering, and then removed for on site or off site use.

River bed sediments are of sufficient quality and value that a contractor may remove the ~1700 m^3 of material from the stockpile without charge. An alternative approach is to spread the fine sediment on the bank and to grass the levelled soil. The estimated cost to extract and stockpile is

[5] A suitable shallow draft barge has to be transported to site (probably from the North Island), assembled, used, disassembled, and returned to base. However, a cost estimate has not been finalised as at the time of writing.

~$4.00/m^3, hence ~$6,800. If the fine sediment was spread over an area of ~4,000 m^2 of lower ground near the site (based on the LIDAR elevations in Hudson & Fletcher 2015), the cost would be ~$2.00/m^2 for the levelling and $1.00/m^2 for hydroseeding, hence $12,000.

Figure 3.4 Front end loader removing wet river sediment (Google images unreferenced)

Planting of the right bank of the sediment trap is recommended as a second stage (Figure 3.3). The bed is firm enough for conventional planting (refer Figure 3.5 below). Planting would be undertaken in accordance with the recommendations from Hudson & Fletcher (2015) and the planting trials that are underway further downstream on the Kaiapoi River. However, to provide a cost guide, and perhaps trial another scheme, planting of raupō (*Typha orientalis*) at 1 m on centre, over an area of ~940 m^2 is proposed. This requires ~1,100 plants at $2.20 each planted cost hence ~$2,400. In addition, protection from grazing waterfowl may be probably required. This can be achieved with steel posts, wire and bird netting, but a cost has not been estimated.[6] Several alternatives, which appear to more cost effective (e.g. Mylar flags on stakes in the plant zone)[7] could be trialled if there is a problem.

[6] Jason Butt, Wai-Ora Forest Landscapes (WFL), telephone discussion 03 May 2016; written comm. 27 May 2016.

[7] http://icwdm.org/handbook/birds/Waterfowl.asp

Figure 3.5 The right bank edge of the sediment trap is a firm sandy-silt-gravel mix with an abrupt change to fine sediment

Raupō is recommended because it spreads, is self limiting (~1.5 m water depth), and historically this reach of the Kaiapoi River had extensive raupō along the river margin and extensive raupō swamps in the catchment (Hudson 2011). The proposed raupō planting would trap sediment and contaminants, and provide enhanced habitat and amenity values, including potential whitebait (inanga) spawning and rearing habitat (see discussion in Hudson 2016 on the latter).

Planting along the right bank would be enhanced with a band of plants in the frequently inundated area of the lower bank. Species used further downstream in Area 1a are recommended (Hudson & Fletcher 2015). These include *phormium tenax* (harakeke, flax), s*choenoplectus tabernaemontani* (Kāpūngāwhā, bulrush, club-rush) on the exposed channel edge and other species up the bank in the frequently flooded areas including cordyline australis (tī kōuka, cabbage tree), cortaderia richardii (toetoe, but commonly called toitoi), c*arex secta* and *carex virgata* **(**pukio, tussock sedge) and *coprosma propinqua* **(**mikimiki).

The additional area of planting would be ~70 m long and 5 m wide. As noted by Hudson & Fletcher (2015), costs vary by the assemblage of species with a likely range of \$5.50 to \$8.50/m^2 at this site.[8] For the proposed edge planting the estimated cost is ~\$2,000 to ~\$3,000.

The wet edge planting, and flow constriction (below), would provide several environmental services, including improved river habitat for aquatic life, mahinga kai, habitat and food for birds, lizards and insects, filtration and erosion control; and enhance the aesthetics of the river and river margins. The edge plantings are complimentary (not a replacement) to landscape plans for the river parks.

A third step is to plant the outer bank of the sediment trap with raupō, along the channel cut bank line, to create a backwater in the old meander bend replicating what occurs in nature with channel shifts (Figure 3.2). The flow constriction would be greater with planting of the left bank of the river (discussed below).

[8] Greg Bennett WDC (written comm. May 2015) & GSL written comm. May 2015)

Planting trials are recommended for the outer edge planting in the deep, soft, fine sediment. The bed is too soft for walking, thus it is proposed to insert weighted biodegradable bags[9] containing plants into the bed from a boat or platform. The bags would have a suitable substrate (e.g. 5-7 mm chip or crusher dust)[6] and would be driven into the soft bed with a plunger. Alternatively, plants could be tied to stakes which are driven into the bed.

Planting at a one metre interval over 1,300 m^3 requires about 1,500 plants at an estimated planted cost of $4.50 each, hence $6,750 for the biodegradable bag method or tethering to bamboo stakes with biodegradable rope (e.g. manila or sisal). If untreated pine stakes are used instead of bamboo, because they are potentially more biodegradable,[10] the cost per stake increases from around 20 cents to around $3.00, for an increase in cost of $4,200. Fewer plants may be required which would reduce costs.[11]

Other options are far more expensive (i.e. a barge mounted excavator as discussed earlier). Construction of a low berm from coarse aggregate (AP40) along the outer line of planting involves removal of fine sediment; and placement of the AP40; which could be undertaken with a hydraulic excavator and dump trucks. A construction sequence has been devised of progressive removal of fine sediment and placement of aggregate starting from the upstream bank. Removal of fine sediment is estimated to cost ~$6,000. The estimated cost of AP40 delivered to the site, is $34/$m^3$ (retail), hence more than $80,000. Placement would cost about ~$10,000, for a total cost of ~$90,000 ex GST.

The berm could be conventionally planted, perhaps with weed mat pins to secure plants. At one metre on centre, about 1,600 plants are required for the ~1,400 m^2 berm area. At $2.20 per plant, the estimated cost is ~$3,500, which includes the use of weed mat pins to secure the plants. An alternate planting scheme may reduce costs.

Finally, ~120 m of the left bank of the Kaiapoi River opposite the sediment trap could also be planted in raupō and bulrush on the side channel bar that is exposed at low tide (Figure 3.2). This will act to confine the channel and increase velocities in the main channel flushing sediment from the bed, and promoting deposition along the vegetated. At $2.20 per plant the cost for the ~700 m^2 area (~800 plants) is ~$1,800 ex GST.

3.2 Outfall wetland and bend reconfiguration

The initial concept proposed for the elbow bend at the old Cam mouth (Figures 1.1 and 2.1 previous) was to re-profile the right bank (refer Figure 3.6 below) and partially infill the left bank to develop a drainage outfall wetland in the bend with material from the upstream sediment trap and/or the bend excavation (refer Figure 3.7 below). The purpose of the right bank re-profiling is to reduce the curvature and bank height of the inner bend and provide a more natural flow path, access, and integration with the planting proposed further downstream; and to provide additional capacity for the outer bend drainage outfall wetland beach and planting (Hudson & Fletcher 2015). Planting of the shelf on the inner bend and outer bend is likely to enhance habitat values and trap and treat sediment and contaminants. This reach has the potential to be inanga (whitebait) spawning habitat as discussed in Hudson (2016).

[9] Biodegradable bags include sisal, hemp, jute or cotton (which have not been priced but may be quite expensive); and inexpensive (~10 cents per bag) vegetable based bio-plastic bags (e.g. http://www.insinc.co.nz/category/106601)

[10] http://www.bamboosupply.net/faq.htm

[11] The results of the planting trial being undertaken further downstream in the Kaiapoi River by Wai-Ora Forest Landscapes will be instructive.

These concepts were evaluated in this investigation by iterating different scenarios in the hydraulic modelling. The idea of using bed or bank material for the drainage outfall area was discounted because the hydraulic evaluation suggested the drainage outfall will be subjected to moderate scour velocities during large flood events. Stabilisation of this material with vegetation and/or use of large gravel for the fill material (i.e. D_{50} = 150 mm subject to design) was considered desirable. Also, the depth and area of fill is more limited that originally envisioned. A beach extending further into the main channel, to encourage a more central channel flow path, is likely to be subjected to high scour forces and would likely require engineering design (i.e. a graded riprap revetment type structure) with the associated costs. Therefore, it is recommended that the extent of backfill is limited to the area immediately around the drainage outlet to form a gravel beach (i.e. for fishing access and enhanced amenity) (refer Figure 3.7).

The proposed outfall beach wetland has an area of ~175 m^2 with ~1.0 m of granular fill (refer Figure 3.8 and Appendix C). The retail price for coarse granular fill (40 – 200 mm) delivered to site is \$34/m^3, hence ~\$6,000. The fill can be dumped onto the river bed and spread with a hydraulic excavator. The estimated cost of spreading the granular fill (\$500) is largely related to logistics. Planting of raupō on the beach, and harakeke (flax) and bulrush on the exposed channel edge, are recommended to trap and treat sediment and contaminants. The lower half of the beach would be planted with raupō, pinned to the bed, at a cost of \$2.20 per plant. At one meter on centre, raupō planting is estimated to cost ~\$220 for 100 plants. The upper beach planting at \$5.50 to \$8.50/m^2 is estimated to cost ~\$500 to ~\$750 ex GST.

Re-profiling of the inner elbow bend involves excavating the present bank and reinstating the cut with a grassed area (refer Figures 3.6 & 3.8; Appendix C). Reinstatement to grass is recommended because modelling indicates the hydraulic effect of excavating the bend was offset by the increased roughness of riparian planting, such that there was no identified hydraulic benefit. Further, the inside bend would be subject to relatively high velocities during large flood events. Establishment and maintaining a good grass cover would reduce the risk of scour, noting that some damage may still occur at this location in very large flood events. This is also in keeping with the adjacent grassed areas.

Top soil would be removed and stockpiled for use as the seedbed. Cut material would be levelled on adjacent land or removed from site. The total volume removed is 300 m^3 at a cost of \$4.00/m^3, for an estimated excavation cost of \$1,200. Levelling and hydroseeding of the ~380 m^2 excavation area, at \$3.00/m^2, is estimated to cost \$1,150 if undertaken in conjunction with the sediment trap levelling and planting. Excess spoil would have commercial value, hence may be removed from for by a contractor at no cost. Alternatively, it is likely that the stockpile excess could be used in the redevelopment of the adjacent land where buildings and car parks were removed. Spread over an area of ~4,500 m^2, the costs would consist of levelling (\$2.00/m^2) and hydroseeding (\$1.00), hence \$13,500 ex GST.

Figure 3.6 Right bank Kaiapoi River elbow bend re-profiling proposal

Figure 3.7 Left bank drainage outfall in the elbow bend of the Kaiapoi River

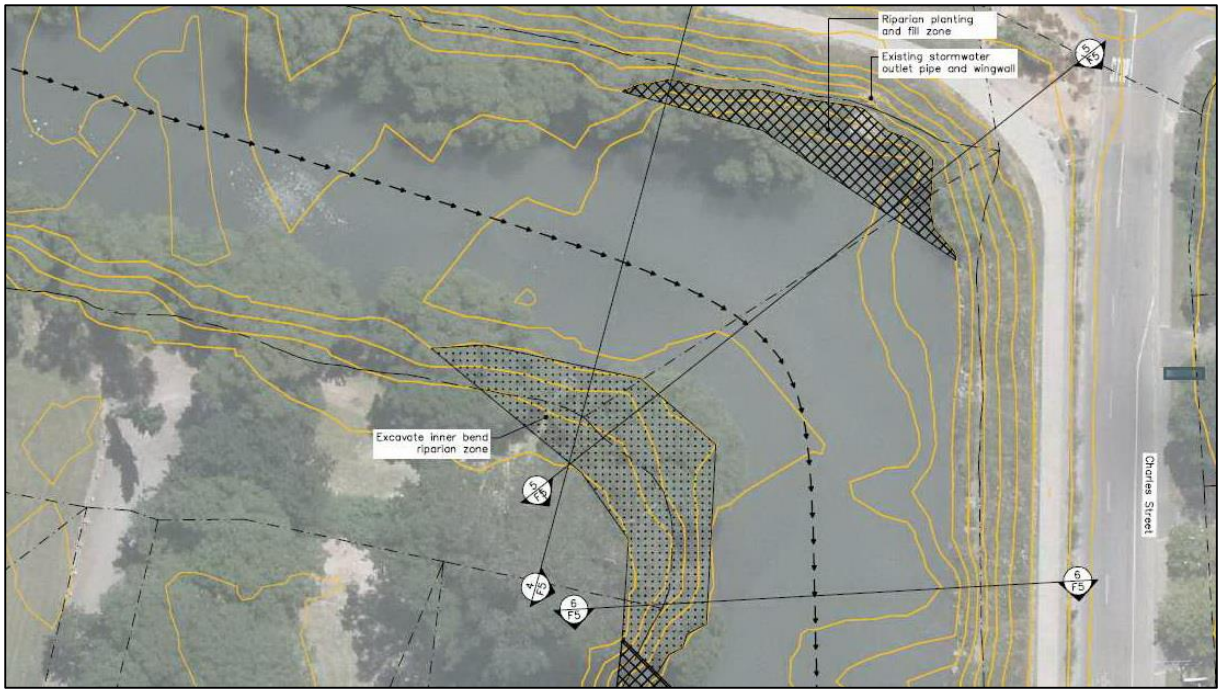

Figure 3.8 Elbow bend drainage outfall wetland and bank re-profiling (from Appendix C)

4 Hydraulic modelling

4.1 General

The additional survey cross-sections supplied by ECan were entered into the HEC-RAS software 1D hydraulic model previously developed for the Stage 1 concept development (Hudson & Fletcher 2015). This model was prepared for the assessment and comparison of the proposed rehabilitation concepts only, and is intended to be complementary to Mike 11 model developed by ECan for the Kaiapoi River (Boyle 2016).

The updated model was rerun with the additional cross sections for the previously assessed flood events (two estimates of the 2% AEP event 140 m^3/s and 270 m^3/s, and a low flow case of 10 m^3/s) and an additional intermediate flood event (40 m^3/s).

The boundary conditions applied to the model (refer Table 4.1 below) were the critical flow depth at the upstream extent of the model, and a set tidal level at the confluence with the Waimakariri River (previously estimated mean high water springs (MHWS) of 1.33 m and MLW of 0.03 m and revised low water estimate of -0.4 m RL based on survey and site observations). We note that other slightly different tidal boundary conditions have been adopted for recent modelling of the Kaiapoi River (i.e. ECan adopted a MHWS of 1.5 m (1.1 m + 0.4 m storm surge allowance)), and based on the supplied survey an apparent low tide level of - 0.3 to - 0.4 m was observed during our 2015 site visit (mud was exposed in sediment trap area which has a surveyed level of - 0.2 to - 0.5 m).

Table 4.1 Model inputs and boundary conditions

Kaiapoi River Flows		**Roughness Coefficients (Mannings' n) (2)**	**Upstream boundary condition**	**Tailwater conditions modelled (2)**
Upstream of Cam River (Sediment trap area)	**Downstream of Cam River (Bend area) (1)**			
10 m^3/s 40 m^3/s 140 m^3/s 270 m^3/s	10 m^3/s 40 m^3/s 140 m^3/s 270 m^3/s	0.020 for main channel (soft sediment base) 0.025 for proposed grassed areas 0.033 for riprap section of river bank 0.060 for currently vegetated river bank 0.100 for proposed planting areas	Critical depth	-0.40 m RL 0.03 m RL 1.33 m RL

(1) Assumes Cam River flood gates are closed, or for the low flow case assesses upstream and downstream flows as separate events (10 m^3/s in the Kaiapoi River, and 10 m^3/s from a combination of the Kaiapoi and Cam Rivers).

(2) Adopted roughness values in ECan model are n = 0.01667 for the soft sediment and n = 0.125 for vegetated areas (Boyle 2016) for comparison with the adopted values in this concept design.

(3) Tailwater conditions applied at the confluence of the Waimakariri and Kaiapoi Rivers. All levels are in terms of Lyttelton LVD MSL datum.

4.2 Sediment trap modelling

The sediment trap area was initially modelled by comparing the existing soft sediment profiles against a proposed scenario with the soft sediment excavated out (i.e. gravel surface exposed). The modelled effect of this excavation was to decrease the overall velocities within the wetted cross-sections and especially the main channel, which is counter to the objectives of the proposed sediment trap (to trap sediment off the main channel and enhance the flushing flows in the main channel).

Modelling suggested that the desired outcomes for this reach would be better achieved by stabilising the soft sediment in place along the "outer bank" and promoting sediment trapping in the

old meander bend (Figure 3.3). Sediment trapping would be promoted with vegetation and/or excavation of the old meander which becomes a sheltered no flow storage area. A staged approach was adopted.

The depth of flow under the usual tidal cycle (i.e. estimated range -0.4 to 1.1 m RL) is a key constraint for the establishment of water margin type vegetation (i.e. vegetation that is usually partially submerged such as reeds). The typical maximum usual water depth that can be utilised by these species is around 1.5 m, though higher water levels can be withstood for short periods. It is noted that the sediment trap area would be completely underwater (water depth more than 1.5 m) for relatively short durations (i.e. hours) during large floods and very high tidal conditions.

The surveyed river profile and sections suggest that the current river invert levels in the sediment trap area are just submerged at low tide (i.e. -0.4 m RL) such that mature reeds could be established along the margins. Planting/securing options for the perimeter plantings are covered in the Rehabilitation concepts section.

Three scenarios were modelled for the stabilising approach sediment trap (i.e. no excavation) to enable assessment of the potential effects with the proposed modifications. These three scenarios consisted of a current case (existing surveyed cross-sections to soft sediment profile), a short term case (representing perimeter planting only), and a longer term case (post establishment of vegetation over the entirety of the sediment trap area).

Modelling of the sediment trap area was based on 10 m wide strips of perimeter planting within the water margin zone from the left and right river banks and from the true right bank of the main channel. The perimeter planting adopted reed beds of up to 2 m high to act as a flow barrier between the main channel and the sediment trap area. Infill planting was assumed in the long term case (i.e. either artificially planted or naturally establishing) and a high hydraulic roughness factor was adopted in the infill areas for the long term scenario to reflect this. This outcome is probably decade's away (deposition since the cut off averaged ~100 m^3 per year).

The sediment trap area behind the perimeter planting was modelled as an ineffective flow area. This means that the area ponds water (i.e. is included in the hydraulic model storage calculations) but is not included as part of the active flow area (i.e. does not contribute to the flow conveyance) in normal flows. Once the water surface goes above the perimeter planting height of 2 m (i.e. 1.4 m RL), then the model assumed that the sediment trap area would contribute to the flow conveyance (as would be the case during large floods).

Figures 4.1 to 4.3 below show the modelled sections for each of the three scenarios described above. Figures 53720.001-F2 and F4 in Appendix B show the river cross-sections and concept design developed for the sediment trap area.

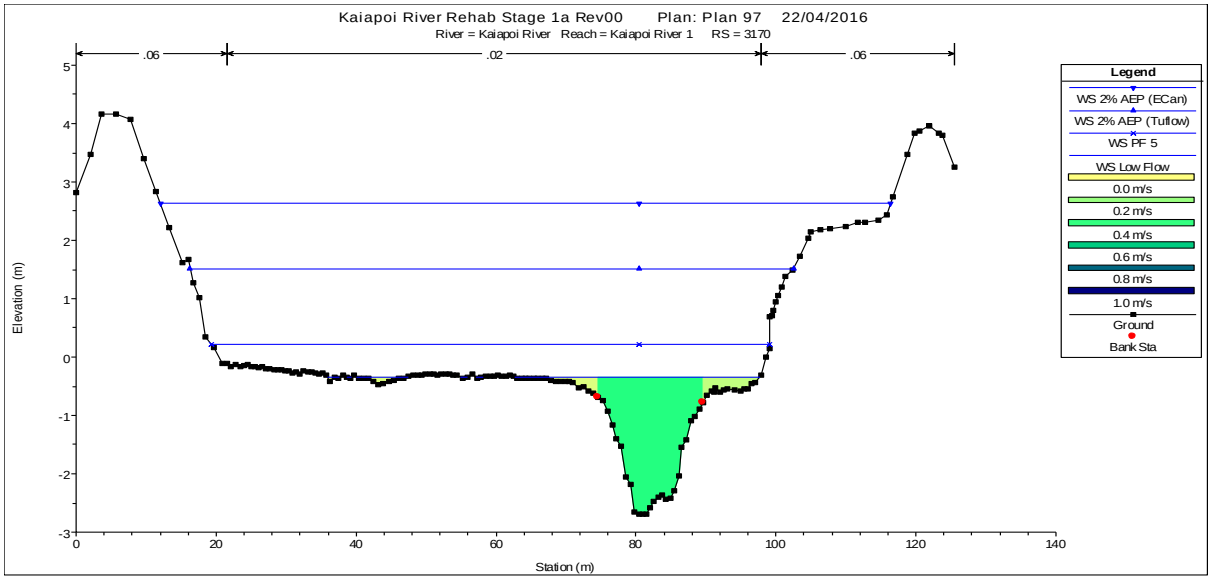

Figure 4.1 Model Section 3170 showing modelled flow profiles, water depths and velocity profile in the sediment trap area for the existing situation scenario (TWL = -0.4m RL shown).

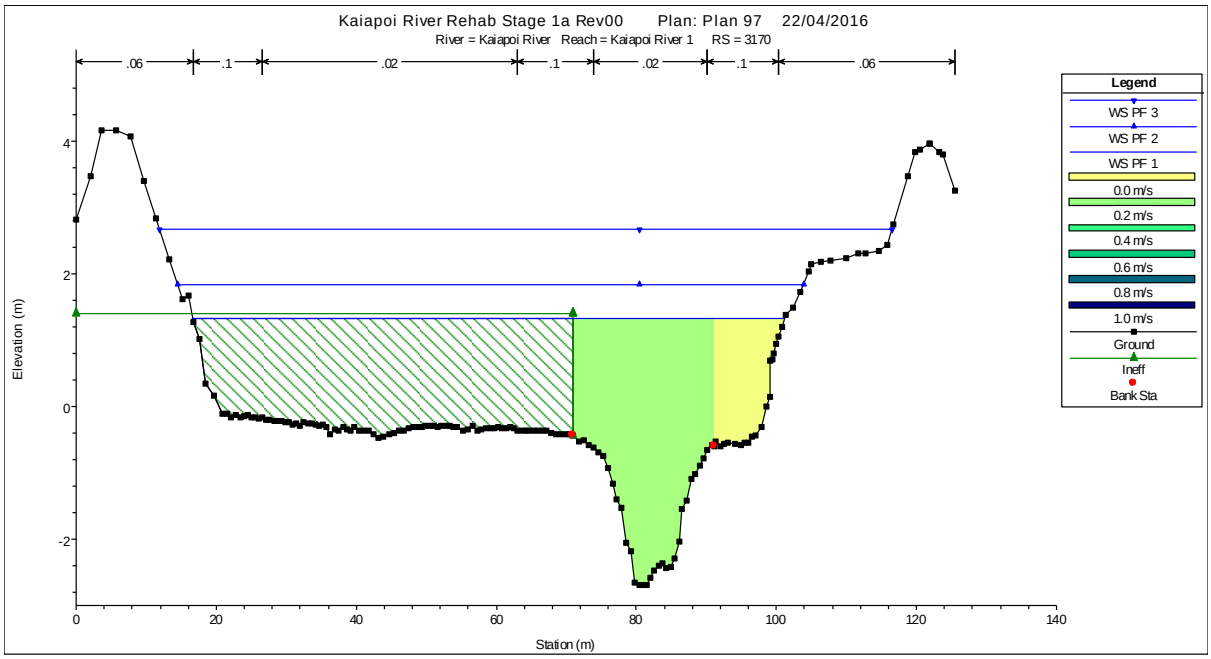

Figure 4.2 Model Section 3170 showing modelled flow profiles, water depths and velocity profile in the sediment trap area for the short term scenario (TWL = 1.33 m RL shown).

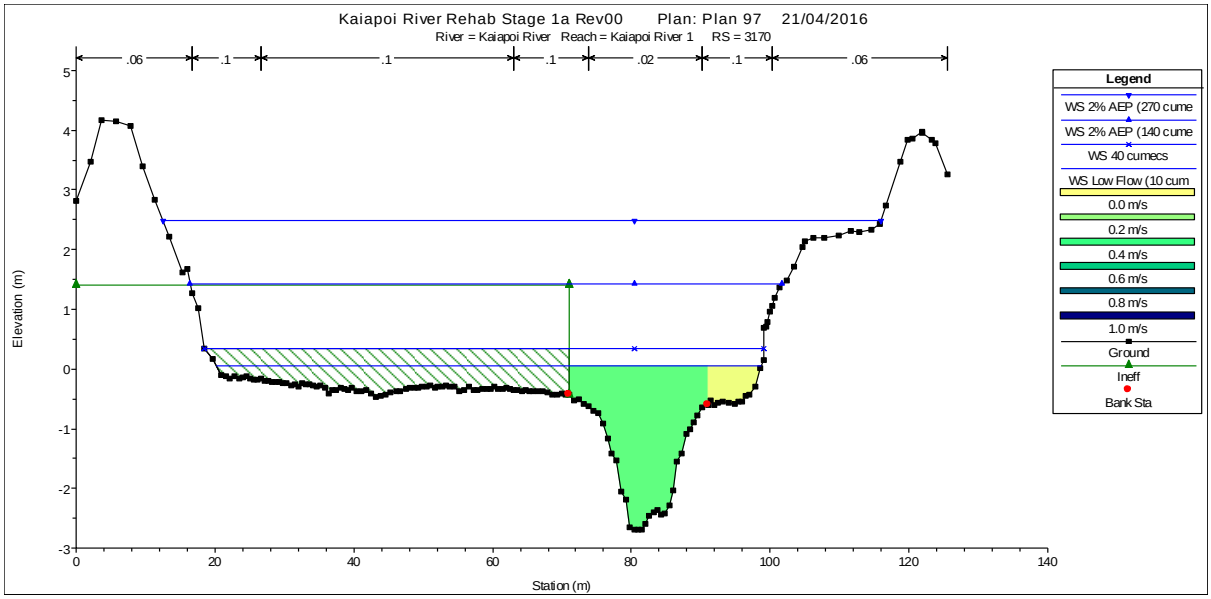

Figure 4.3 *Model Section 3170 showing modelled flow profiles, water depths and velocity profile for the long term scenario (TWL = 0.03 m RL shown).*

The results of the hydraulic modelling for the three scenarios with the tailwater and flow conditions are summarised in Table 4.2 below. The water levels and flow velocities were compared to assess the hydraulic effect of the proposed sediment trap.

Table 4.2 Sediment trap hydraulic modelling results

Scenario	Modelled flow m^3/s	Tailwater *m RL*	Water level *m RL*	Main channel velocity *m/s*	Sediment trap area velocity *m/s*	True left bank velocity *m/s*
Existing	10	-0.4	-0.33	0.3 - 0.4	< 0.1	0.1
		0.03	0.06	0.2 - 0.3	0.1	0.1
		1.33	1.33	0.07 - 0.08	< 0.1	< 0.1
	40	-0.4	0.23	0.6 - 0.9	0.3 – 0.4	0.3 – 0.4
		0.03	0.35	0.6 – 0.7	0.3	0.2 – 0.4
		1.33	1.38	0.3	0.2	0.1 – 0.2
	140	-0.4	1.53	0.9 - 1.0	0.6 - 0.7	0.4 - 0.7
		0.03	1.51	0.9 - 1.1	0.6 - 0.7	0.4 - 0.7
		1.3	1.86	0.8 - 0.9	0.5 - 0.6	0.3 - 0.6
	270	-0.4	2.65	1.1 -1.3	0.8 -0.9	0.4 - 0.7
		0.03	2.65			
		1.33	2.71			
Soft sediment stabilisation with riparian planting	10	-0.4	-0.33	0.3 - 0.4	< 0.1	< 0.1
		0.03	0.06	0.2 - 0.3	< 0.1	
		1.33	1.33	0.1 - 0.2	0	
	40	-0.4	0.2	0.9 – 1.2	0	0.1 – 0.3
		0.03	0.35	0.8 – 1.0		0.1 – 0.3

Scenario	Modelled flow *m^3/s*	Tailwater *m RL*	Water level *m RL*	Main channel velocity *m/s*	Sediment trap area velocity *m/s*	True left bank velocity *m/s*
(short term) (1)		1.33	1.38	0.5 – 0.7		0.1 – 0.2
	140	-0.4	1.52	1.0 - 1.2	0.6 - 0.7	0.1 - 0.3
		0.03	1.5	1.0 - 1.2	0.6 - 0.7	
		1.33	1.85	0.9 - 1.0	0.5 - 0.6	
	270	-0.4	2.62	1.2 - 1.4	0.8 - 0.9	0.2 - 0.4
		0.03	2.62			
		1.33	2.8			
Soft sediment stabilisation with riparian planting (long term) (2)	10	-0.4	-0.33	0.3 - 0.4	0	< 0.1
		0.03	0.06	0.3		< 0.1
		1.33	1.33	0.1 - 0.2		< 0.1
	40	-0.4	0.2	0.9 – 1.2	0	0.1 – 0.3
		0.03	0.35	0.8 – 1.0		0.1 – 0.3
		1.33	1.38	0.5 – 0.7		0.1 – 0.2
	140	-0.4	1.4 - 1.5	1.5 - 1.9	0.2 - 0.3	0.2 - 0.5
		0.03	1.4 - 1.5	1.5 - 1.9		
		1.33	1.84	1.3 - 1.6		
	270	-0.4	2.5 - 2.6	2.0 - 2.4	0.3 - 0.4	0.3 - 0.6
		0.03	2.5 - 2.6			
		1.33	2.6 - 2.7			

(1) Modelled assuming ineffective flow area applied to sediment trap area up to 1.4 m RL (above which area can convey flow as would occur during large floods) and area behind planted wet zone planting strip is left as vegetated soft sediment.

(2) Modelled assuming ineffective flow area applied to sediment trap area up to 1.4 m RL (above which area can convey flow as would occur during large floods) and entire area is planted out.

The hydraulic modelling results for the sediment trap area as presented in Table 4.2 suggest the following:

1 The proposed sediment trap has no identified adverse effects on the flood conveyance capacity or resulting water levels in the Kaiapoi River.

2 During normal river flows and small floods, the conveyance is constrained to the main channel of the river and the velocities within the sediment trap area are minimal, facilitating settlement of fine particles.

3 Higher tailwater levels result in lower overall velocities in lower flow and small flood cases. The modelled tailwater range has no effect on the river levels or velocities in the Stage 1a area during the 270 m^3/s flood.

4 In the short term scenario, where water levels exceed the perimeter strip vegetation height (i.e. during large floods), velocities within the sediment trap area of 0.5 – 1.0 m/s could occur and would result in scour to the soft sediment. This may also presented a scour risk to the perimeter strip.

5 In the long term scenario, where water levels exceed the perimeter strip vegetation height (i.e. during large floods), velocities within the planted sediment trap area of 0.2 – 0.4 m/s could occur and increases in the main channel velocities of between 0.5 – 1.0 m/s occur. This

means that the sediment would be stabilised with the trap area during large floods in the long term while the main channel is flushed clean to the gravel bottom.

4.3 Drainage outfall wetland and elbow bend area

The drainage outfall wetland and inside bend excavation (elbow bend) area was initially modelled including riparian planting on the inside bend down to water level and substantial filling of the outside bend around the stormwater/drainage outfall structure. The proposed concept was modified slightly followed this initial modelling to improve the hydraulic effectiveness of the concept and to account for flow uncertainties. These modifications were:

- The modelled effect of excavating the inside bend was offset by the increased roughness of planting the inside bend, such that there was no identified hydraulic benefit. In keeping with the adjacent grassed areas, the inside cut surface was modified to have grass cover only rather than riparian planting.
- The survey cross-sections show an approximately 2 m deep scour hole just downstream of the 90 deg bend. This is strong evidence of high hydraulic scour forces acting on the river bed due to the abrupt change in direction, and associated flow vortices. The 1 dimension model software package used for this concept modelling is unlikely to identify the extent of these scour forces or the flow conditions at this location.
- The original concept included filling of an area around the drainage outfall to form a beach and encourage flow towards the inside bend. The extent of this filling has been limited in the presented concept to the area immediately around the drainage outlet to from a gravel beach (i.e. as could be used for fishing access and enhanced amenity) rather than more extensive filling to achieve a hydraulic effect, which is likely to be subjected to high scour forces and would likely require engineering design (i.e. a graded riprap revetment type structure) with the associated costs.

Two scenarios were modelled for the bend area to enable assessment of the potential effects with the proposed modifications. The two scenarios consisted of a current case (existing surveyed cross-sections), and a modified case (post bank excavation and drainage outfall enhancement). Figures 4.4 and 4.5 below show the modelled sections for these two scenarios. Figures 53720.001-F3 and F5 in Appendix C show the river cross-sections and concept design developed for the drainage outfall wetland and elbow bend area.

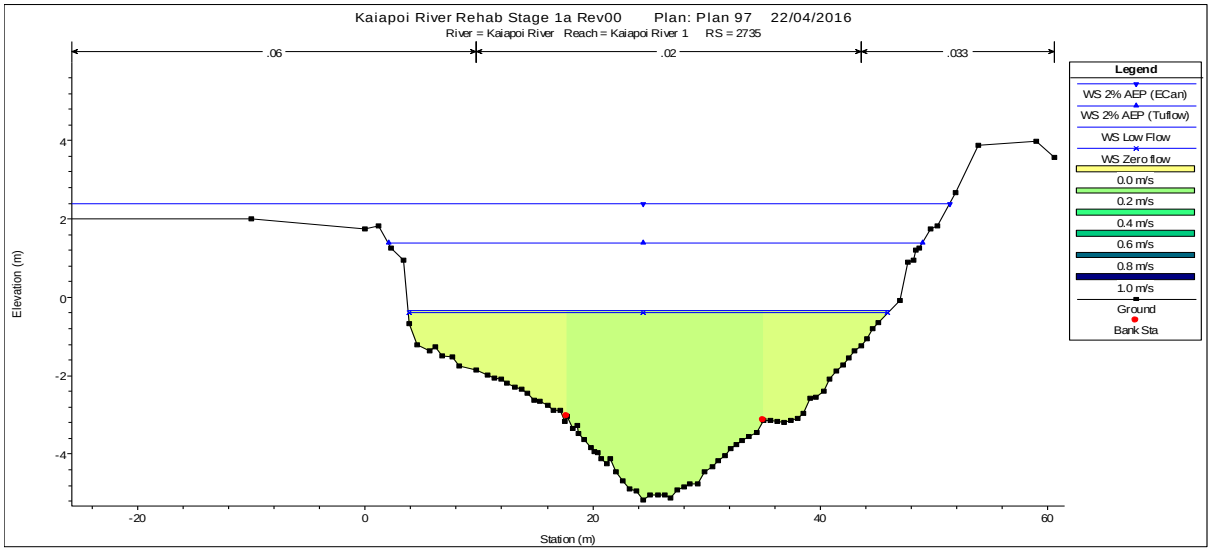

Figure 4.4 *Model Section 2735 showing modelled flow profiles, water depths and velocity profile for the existing scenario (TWL = -0.4 m RL shown).*

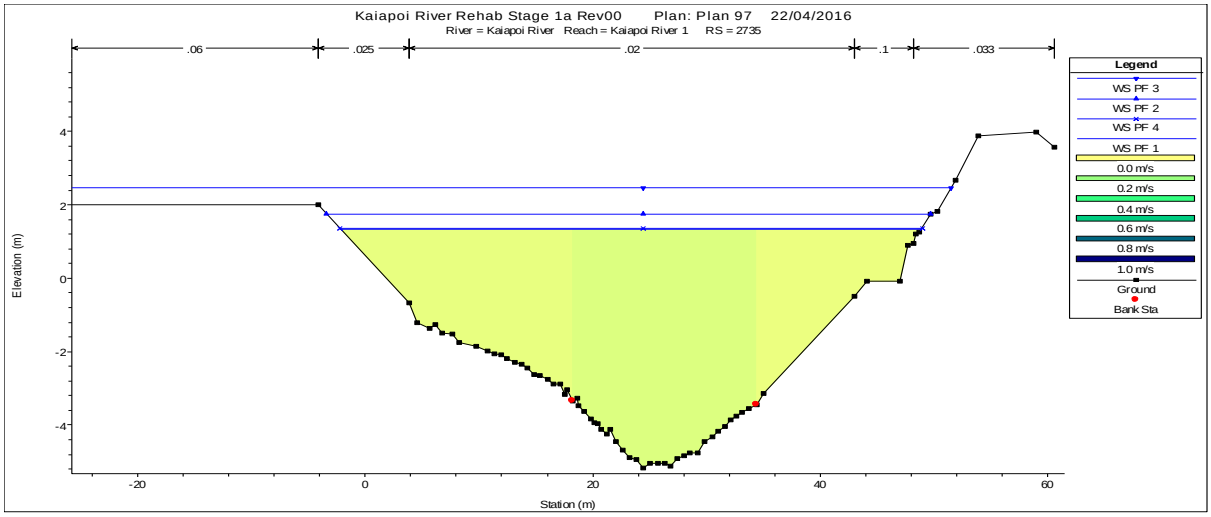

Figure 4.5 *Model Section 2735 showing modelled flow profiles, water depths and velocity profile for the modified scenario (TWL = 1.33 m RL shown).*

The results of the hydraulic modelling for the existing and modified scenarios with the adopted tailwater and flow conditions are summarised in Table 4.3 below. The water levels and flow velocities were compared to assess the hydraulic effect of the proposed modifications.

Table 4.3 Drainage outfall wetland and elbow bend hydraulic modelling results

Scenario	Modelled flow m^3/s	Tailwater m RL	Water level m RL	Main channel velocity m/s	Inside bend velocity m/s	Drainage outfall velocity m/s
Existing	10	-0.4	-0.35	0.1 – 0.2	<0.1	<0.1
		0.03	0.05	0.1 – 0.2		
		1.33	1.33	0.1		
	40	-0.4	0.16	0.4 – 0.6	<0.1 – 0.2	<0.1 – 0.2
		0.03	0.32	0.4 – 0.6		<0.1 – 0.2
		1.33	1.37	0.3 – 0.4		<0.1 – 0.1
	140	-0.4	1.38	0.9 – 1.4	0.1 – 0.5	0.1 – 0.6
		0.03	1.36	0.9 – 1.4		
		1.3	1.76	0.8 – 1.3		
	270	-0.4	2.2 – 2.4	1.4 – 2.2	0.2 – 0.4	0.2 – 1.0
		0.03	2.2 – 2.4	1.4 – 2.2	0.2 – 0.4	0.2 – 1.0
		1.33	2.3 – 2.5	1.4 – 2.1	0.1 – 0.4	0.2 – 0.9
Modified section with excavated bank and wetland	10	-0.4	-0.35	0.1 – 0.2	<0.1	<0.1
		0.03	0.05	0.1 – 0.2		
		1.33	1.33	0.1		
	40	-0.4	0.17	0.4 – 0.6	<0.1 – 0.2	0.1 – 0.2
		0.03	0.32	0.4 – 0.5		
		1.33	1.37	0.3 – 0.4		
	140	-0.4	1.37	0.9 – 1.3	0.4 – 0.6	0.1 – 0.5

Scenario	Modelled flow m^3/s	Tailwater m RL	Water level m RL	Main channel velocity m/s	Inside bend velocity m/s	Drainage outfall velocity m/s
		0.03	1.35	0.9 - 1.4		
		1.33	1.75	0.9 - 1.2		
	270	-0.4	2.2 – 2.4	1.4 – 2.0	0.6 – 1.0	0.2 – 0.8
		0.03	2.2 – 2.4		0.6 – 1.0	
		1.33	2.3 – 2.5		0.5 – 1.0	

The hydraulic modelling results for the drainage outfall and inner bend area as presented in Table 4.3 above suggest the following:

1 The proposed modifications have no identified adverse effects on the flood conveyance capacity or resulting water levels in the Kaiapoi River.

2 The effect of modifying the inner bend results in a slight reduction in flow velocities in the main channel and outside bends and an increase in the inside bend velocities (especially in the larger flood events).

3 During lower flow events (i.e. 40 m^3/s and lower), there is no apparent hydraulic effect from the proposed modifications.

4 The proposed filling at the drainage outfall will be subjected to moderate scour velocities during large flood events. Stabilisation of this material with vegetation and/or use of large gravel for the fill material (i.e. D_{50} = 150 mm subject to design) would be desirable.

5 The inside bend would be subject to relatively high velocities during large flood events. Establishment and maintaining a good grass cover would reduce the risk of scour, noting that some damage may still occur at this location in very large flood events.

5 Construction

5.1 Indicative methodology

Methods were discussed in the description of the proposed concepts. In brief, the recommended approach for excavating ~1,700 m^3 of fine sediment from the sediment trap is a front end loader because of their capacity to work in this environment and rapid back and forth motion from excavation face to stockpile. It is thought that the gravel infill in the old meander bed will support a front end loader, because it appears from historic aerial photographs to have been placed by machine. Hence, the excavation cost of the fine material is based on a dig and dump approach. The proposal is to excavate the fine sediment, and back up and dump on the bank for dewatering. Once the stockpiles are dewatered, the fine sediment can used as fill on site or trucked off site. A silt fence will be installed around the outer water edge of the sediment trap excavation (~200 m), and at the base of the dewatering stockpile (~30 m). Some remedial work around the site will probably be required (e.g. level-fill vehicle tracks and hydroseed)

Conventional planting of the right bank of the sediment trap and left bank of the Kaiapoi River is proposed. The sites are exposed at low tide and the bed is firm. Planting trials are recommended for the outer edge planting of the sediment trap where there is tidally flooded deep, fine sediment. At low tide, the bed is too soft for walking, thus it is proposed to plant in weighted biodegradable bags from a boat or platform. The bags would have a suitable substrate (e.g. 5 - 7 mm chip or crusher dust) and would be driven into the soft bed with a plunger. Alternatively, plants could be tied to stakes which are driven into the bed.

Re-profiling of the inner elbow bend is proposed to be undertaken with a hydraulic excavator. This will minimise disturbance of the river bank. The maximum width of the excavation is ~12 m, so the excavator can cut, turn and dump to stockpile or truck. Top soil would be retained for levelling and hydroseeding. Excess material would be temporarily stockpiled and removed by front end loader for adjacent site infill; or loaded for offsite use. A silt fence will be installed around the water edge of the excavation (~70 m)

Construction of a gravel-cobble beach on the outer elbow bend for the drainage outfall can be undertaken by directly dumping aggregate from a truck onto the river bed. The material would be spread with a hydraulic excavator operating from the bank or beach.

Conventional planting of the beach and lower bank is proposed. These procedures are well established, with novel approaches also being trialled further downstream in the Kaiapoi River by WDC and Wai-Ora Forest Landscapes. In this regard, and given the novel approaches recommended for the sediment trap outer bank planting, it is premature to specify planting plans. It would be more appropriate to wait for the trials to be completed and reported. Also, maintenance plans are premature. For example, the trials will show if plants such as raupō outcompete weeds, or require intervention. It is also uncertain if management of waterfowl is required. Some management measures have been recommended for trialling, but again it would be prudent to wait for a report on findings before guidelines are developed.

5.2 Sediment control and management

Sediment mobilisation will occur with the excavation of the old meander bend and there is an expectation that at times a plume of fine sediment will enter and flush down the Kaiapoi River. However, effects of such operations are considered to be minor in the context of constant sediment fluxes with each tidal exchange and high turbidity during flood flows. The long term benefit is that sediment flux will be reduced by enhanced trapping with the proposed works.

As noted in the next section, extraction from the Kaiapoi River for the Tuhoe berth did not require special sediment plume control measures. In the Avon River rehabilitation, silt fences were employed for many instream works, but the bulk removal of fine sediment from the bed was undertaken by hydraulic excavator from the bank or from within the channel (Figures 5.1 & 5.2).

The situation for the Kaiapoi sediment trap differs, because the sediment trap is “off-channel,” the trap can be isolated and excavation can occur in the dry or with minimal flow during slack tide. Nevertheless, sediment control measures will be implemented to minimise sediment flux downstream. Based on the ECan (2007) Erosion and sediment control guidelines, several measures are recommended:

- Excavation of the sediment trap will not be started if rain or high flows in the Kaiapoi River are forecast.
- Work will be undertaken in a timely fashion and excavated material will be removed from the dewatering stockpile in a timely manner (a few weeks at most).
- The dewatering stockpile will have a staked silt fence, weighted with sediment bags, around the base to prevent flux of dirty water back to the river.
- The stockpile site, and onsite infill areas, will be levelled and hydroseeded as soon as works are complete.
- A staked silt fence, or floating silt fence, will be installed around the outer edge of the sediment trap using a boat or platform. The flap of the silt fence would be weighted with sediment bags (sand or gravel filled) rather than placed in a trench.
- The silt fence will remain in place for the duration of the excavation.

- If possible, removal of the silt fence should coincide with a forecast of high flows. In this event, any resultant sediment plume would mix with the naturally high background levels of suspended sediment being flushed to the sea.

For the elbow bend excavation it is proposed to place a silt fence at the base of the bank (refer Figure 5.2 below). Excavation should be planned for a period of settled weather. Duration of exposure of excavated surfaces and stockpiles would be limited to minimise erosion risk. Soil levelling and hydroseeding should take place within days of excavation to control runoff and soil erosion.

No sediment control measures are proposed for the gravel – cobble beach construction of the outfall wetland because the aggregate contains few fines that can wash away. Any sediment plume would dissipate in a very short period (minutes, perhaps a few hours). This contrasts to major channel disturbance where a plume persists for the duration of works, with a diminishing plume over time a period of days after bed disturbance ceases (refer Figure 5.1 below).

Figure 5.1 Avon River silt removal (Sunday Star Times 4 May 2014)

Figure 5.2 Silt fence Avon River downstream of Montreal Street

5.3 Constraints and considerations

It is uncertain at this stage as to whether the proposed works can be undertaken under existing Regional and District council consents for drainage and river works. The proposed actions will be vetted by the appropriate authorities to establish the need, or not, for specific consents. In any event, historic dredging of the lower Kaiapoi River provides a precedent.

Resource consent was required for the dredging of the Tuhoe berth in the lower Kaiapoi River (ECan resource consent CRC070311). In the consent application a notable omission was the fact that dredging of the Kaiapoi River was undertaken for decades to maintain passage of coastal freighters using the Port of Kaiapoi. In any event, effects of such operations are considered to be no more than minor in the context. Erosion control measures were not required for the Tuhoe dredging other than stating "The consent holder shall use the best practical options to minimise the discharge of sediment laden water into the Kaiapoi River."

For the work proposed here, sediment control and management measures have been recommended based on the ECan Erosion and Sediment Control Guidelines (2007).

Public access (e.g. walking and fishing) will be restricted for the brief period of works for health and safety reasons (e.g. heavy equipment movements). Upon completion, there will be an improvement in fishing access with the re-profiling of the elbow bend and creation of a gravel-boulder beach at the drainage outfall wetland. The greatest gain for fishing will potentially be the improvement in fish habitat and the creation of considerably more spawning and rearing habitat for inanga (whitebait).

5.4 High level cost estimate summary

In the description of the rehabilitation concepts, initial and refined estimates were made of the area and volumes of materials to be excavated, infilled and relocated. Methods and costs based on these new estimates were outlined. Here these refined values are summarised.

Table 5.1 Indicative costs for proposed sediment trap concept

Item	Quantity	Unit	Unit rate	Cost estimate(1)(2)
Excavation to stockpile	1,700	cu.m	$4.00	$6,800
Level adjacent park[3]	4,000	sq.m	$2.00	$8,000
Hydroseed adjacent park[3]	4,000	sq.m	$1.00	$4,000
Remediation vehicle tracks & stockpile	500	sq.m	$3.00	$1,500
Right bank in-channel planting	1,100	plants	$2.20	$2,420
Right bank lower bank planting	350	sq.m	$5.50-$8.50	$1,925 - $2,975
Outer bank in-channel planting[4]	1,500	plants	$4.50	$6,750
Left bank in-channel planting	800	plants	$2.20	$1,760
Silt fence – outer bank	200	m	$8.50	$1,700
Silt fence – dewatering stockpile	30	m	$8.50	$255
Subtotal				$35,000 to $36,000
Contractor's Preliminary and General (~15%)				~$5,000
Total (excludes contingency and GST)				**~$40,000 to $41,000**

(1) Excludes additional costs associated with design, consenting and construction management.

(2) All costs exclude GST.

(3) Potentially lower cost if sediment is removed for offsite use.

(4) Using bags or bamboo stakes; untreated pine stakes $2.80 each extra, hence $4,200 extra.

Table 5.2 Indicative costs for proposed stormwater outfall wetland and inner bend widening

Item	Quantity	Unit	Unit rate	Cost estimate(1)(2)
Drainage Wetland				
Fill (gravel-cobbles)	175	cu.m	$34	$5,950
Spread fill on beach	1	LS	$500	$500
Lower beach planting	100	plants	$2.20	$220
Upper beach planting	90	sq.m	$5.50 - $8.50	$495 - $765
Bend re-profiling				
Excavation to stockpile	300	cu.m	$4.00	$1,200
Level and hydroseed bank	380	sq.m	$3.00	$1,140
Level and hydroseed adjacent park(3)	4,500	sq.m	$3.00	$13,500
Silt fence water edge	70	m	$8.50	$595
Remediation vehicle tracks & stockpile	350	sq.m	$3.00	$1,050
Subtotal				~$25,000
Contractor's Preliminary and General (~15%)				~$4,000
Total (excludes contingency and GST)				**~$29,000 ex GST**

(1) Excludes additional costs associated with design, consenting and construction management.

(2) All costs exclude GST.

(3) Potentially lower cost if sediment is removed for offsite use.

6 Conclusions

It is expected the proposed sediment trap will reduce fine sediment sloshing back and forth with tidal flows, and decreased downstream sediment flux from the Kaiapoi River when it is in flood. The recommended planting is expected to constrict the channel and promote flushing of fine sediment from the main channel, while trapping and treating sediment and contaminants along the channel margins. Water clarity should improve. The proposed sediment trap excavation will provide an extensive wetland habitat.

Re-profiling of the inner bank of the elbow bend will facilitate establishment of downstream wet edge planting, and development of the outer bend drain outfall wetland. The recommended planting, with resultant low flow channel constriction, is likely to provide several environmental services, including improved river habitat for aquatic life, mahinga kai, habitat and food for birds, lizards and insects, filtration and erosion control; and enhance the aesthetics of the river and river margins.

Indicative costs range from ~$40,000 to ~$70,000 ex GST (excluding contingency) if the excavations and all the recommended planting occur. Typically for cost estimates based on this level of design a minimum contingency of 30% is adopted and a 50% contingency is recommended (i.e. an additional $20,000 to $35,000 ex GST allowed for in budgets for this work).

The difference in cost estimates relates to the potential volume if sediment removed from the sediment trap and bank re-profiling. Costs are significantly greater if the project is assigned costs of disposal of excess material from stockpile. A logical use of the excess material is to infill adjacent low lying parkland. This requires extensive levelling and grassing. However, it is possible that stockpiled material may be removed by contractors for off-site use at no cost to the project; or costs of levelling of soil and grassing on low lying adjacent parkland is attributable to a non-project budget.

7 Applicability

This report has been prepared for the exclusive use of our client Waimakariri District Council | Kaiapoi River Rehabilitation Working Party, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Report prepared by:

Dominic Fletcher	Dr Henry Hudson
WATER RESOURCES ENGINEER	EMA PROJECT DIRECTOR
Authorised for EMA by:	Authorised for Tonkin & Taylor Ltd by:
.....	.....
Henry Hudson	Grant Lovell
EMA PROJECT DIRECTOR	T+T PROJECT DIRECTOR

DAF
p:\53720\53720.0010\workingmaterial\05 report\2016-06-07.daf.rpt.kaiapoi river rehab -stage 1a sediment trap and outfall wetland bend realignment concept report rev 03.docx

8 References

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Hudson HR, Fletcher D. 2015. Kaiapoi River Rehabilitation Stage 1A Sediment trap, bank reshaping and drainage wetland design concepts. Environmental Management Associates & Tonkin and Taylor Limited Report 53720 for Waimakariri District Council.

Appendix A: Scope

Drainage outfall wetland and bend realignment

The scope of work consists of preparing an engineered wetland design concept for a drainage outfall wetland at the old Cam River mouth, where a current discharge point from the WDC stormwater network exists; and modifications to the inner elbow bend on the true right bank of the river channel (refer Figure 1.1 previous). The following are addressed:

1 Prepare an engineered wetland concept to establish a drainage outfall wetland at the old Cam River mouth (where a current stormwater discharge pipe exists) and modify the inner elbow bend on the true right bank of the river channel. The concept will be developed in sufficient detail to enable indicative estimates of quantities and associated indicative construction costs to be estimated.

2 Refine estimated volumes of material to be excavated, infilled or relocated through the works with comparison to initial estimates as per project brief.

3 Concept design of any proposed protective barriers or materials required for the wetland edge and re-aligned inner elbow bend, such as rock/boulder edge protection and erosion control material or other measures that may be required.

4 The concept will be presented on Figures consisting of a site plan and sections and details. Dimensions, species recommendations and a planting/grassing plan for the wetland and inner elbow bend realignment.

5 Prepare a short concept design report describing the following (in conjunction with the sediment trap sections for the same 1x report):

   a The proposed concept and rationale including assessing the potential effects of the project on the environment, sediment management, water quality, habitat, mahinga kai and capacity/hydrology costs and benefits (with provision of information for verification by ECan with the Kaiapoi River model as per previous Stage 1 work).

   b Comment on potential options to use soil excavated during the inner elbow bend re-alignment as excavated material in the drainage wetland and potential associated cost offset.

   c An assessment on identified potential constraints and limitations of the proposed works (e.g. consent costs, impacts on public access and fishing, public safety, release of sediment during construction, etc.).

   d Provide a high level indicative estimate of all associated costs with creation of the outfall wetland and realignment of the inner elbow bend in terms of all options considered, noting detailed construction cost estimates are not covered in our scope.

6 Describe sediment control and management plan requirements for the works based on previous consent requirements for river works and drainage maintenance, and consent requirements for the lower river navigation channel.

7 Describe a wetland maintenance plan for future ongoing management based on planting guidelines and consultation with WDC staff.

Sediment trap

The scope of work consists of preparing an engineered sediment trap design concept in the old bend of the realigned Kaiapoi River between the Cam River mouth and motorway bridge (refer Figure 1.1 previous). The following are addressed:

1 Prepare an engineered sediment trap concept in the old bend of the realigned Kaiapoi River between the Cam River mouth and motorway bridge. The concept will be developed in sufficient detail to enable indicative estimates of quantities and associated indicative construction costs to be estimated. The concept will be presented on Figures consisting of a site plan and sections and details.

2 Development of concepts for the sediment trap and potential constructability is dependent on the extent and depth of soft sediment within the proposed sediment trap area. In order to provide a concept for the sediment trap, site investigation into the depth and strength of this material is required. We will undertake Scala penetrometer testing (4x tests proposed) as part of our scope to inform the concept development.

3 The short concept design report will describe the following:

   a The proposed concept and rationale including assessing the potential effects of the project on the environment, sediment management, water quality, habitat, mahinga kai and capacity/hydrology costs and benefits (with provision of information for verification by ECan with the Kaiapoi River model as per previous Stage 1 work).

   b The area of sediment trap and volume of material to be excavated.

   c Comment on the potential rate of re-sedimentation of the sediment trap.

   d Comment on potential assess constraints and limitations (e.g. consent costs, impacts on public access and fishing, public safety, release of sediment during construction, etc.).

   e Comment on potential methods for excavation at the site, including use of sludge pumps, the ECan drag line or a digger with barge. Testing to confirm the extent and depth of soft material in this zone will determine the likely requirements for equipment access. WDC and ECan will be consulted regarding downstream navigation dredging investigations.

   f Comment on options and pricing for disposal of excavated material, including:

      i Volume of material that could potentially be used as infill within the drainage outfall wetland, and indicative costs to relocate material to this area.

      ii Verify initial cost estimates for dredging the sediment trap

      iii Final costs of disposal of the balance of the excavated material to landfill based on rates advised by others.

4 Provide a high level indicative estimate of all associated costs with creation of the sediment trap in terms of all options considered, noting detailed construction cost estimates are not covered in this scope.

5 Describe sediment control and management plan requirements for the works based on previous consent requirements for river works and drainage maintenance, and consent requirements for the lower river navigation channel.

6 Describe a wetland maintenance plan for future ongoing management based on planting guidelines and consultation with WDC staff.

Information requirements

Additional cross sections and investigation of soft sediment depth, as discussed and agreed with WDC will be provided by ECan.

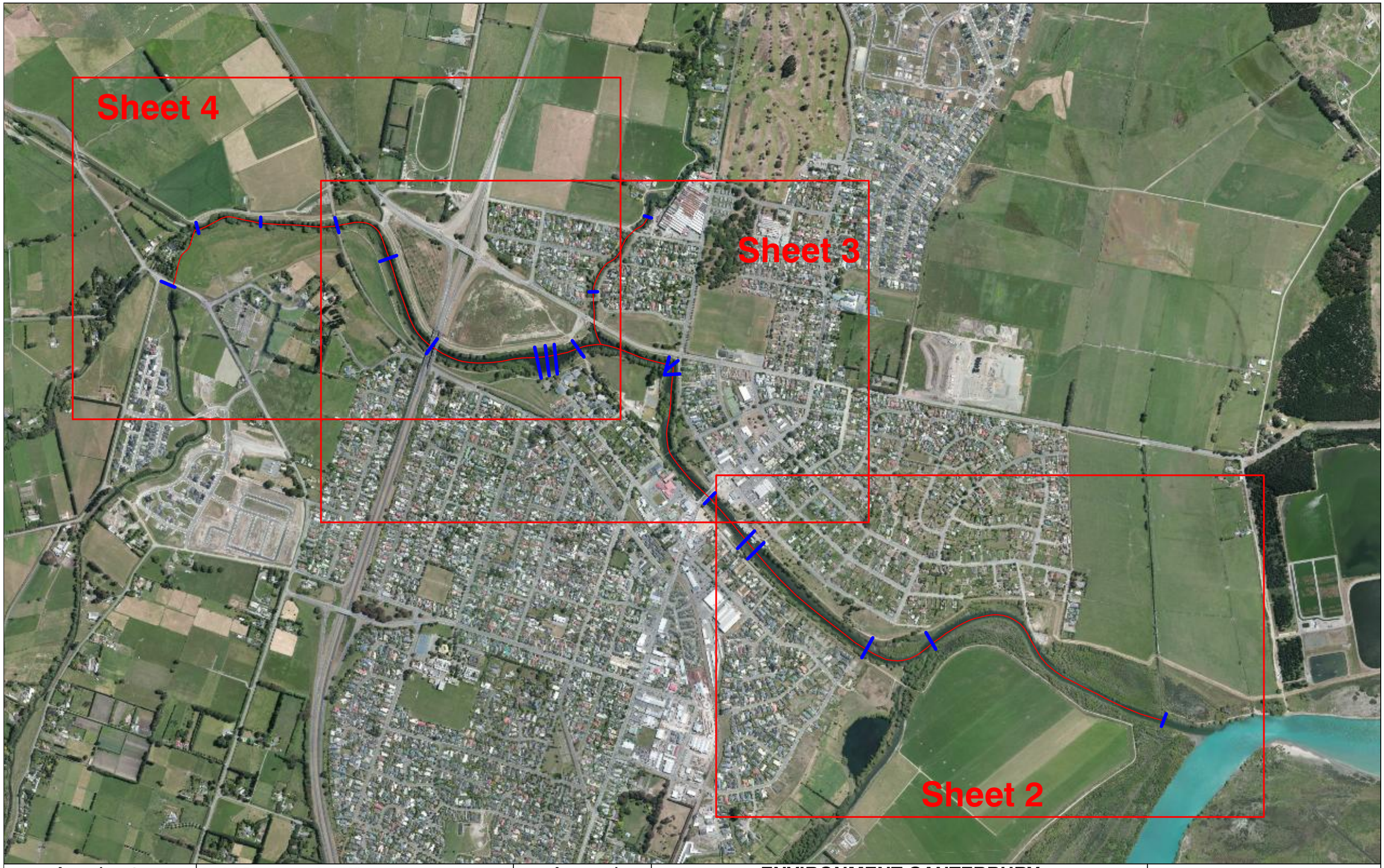
Cross section and hydraulic model parameters will be provided to enable ECan to undertake verification.

Outputs

Proposed concepts and draft figures will be developed for Working Party comment and discussion prior to proceeding with the report. A draft of the report with updated figures will be provided for comment prior to updating and finalising the report for issue.

One or both authors will attend two Working Party meetings to discuss draft concepts and present the final report and concepts as requested.

Appendix B: Survey data from ECan



Amendments 9 New Sections Dec 2015 Plans updated Jan 2015 WRM	**Aerial Photo** ArcGIS 2014 **Surveyed** W Mecchia Feb - Dec 2015 **Designed** **Compiled** W Mecchia Jan 2015 **Checked**	**Approved**	**ENVIRONMENT CANTERBURY** **Kaiapoi and Cam Rivers** **Cross Section Locations 2011 and 2015** **Overview**	Environment Canterbury Regional Council Kaunihera Taiao ki Waitaha **S15065 C3D**
Circuit TM 2000 Catch No. 6640400 Surv Data S16065 12d	Recommended Principal River Engineer	R J Vesey Regional Engineer	Original Scale: 1:12,500 Level Datum: Ortho Lytt 1937	**1 of 4**

Amendments			
Circuit TM 2000 Catch No. 6640400 Surv Data S16065 12d	**Aerial Photo** ArcGIS 2014 **Surveyed** W Mecchia Feb - Dec 2015 **Designed** **Compiled** W Mecchia Dec 2015 **Checked** Recommended Principal River Engineer	**Approved** R J Vesey Regional Engineer	**ENVIRONMENT CANTERBURY** **Kaiapoi and Cam River** **Cross Sections 2011 to Dec 2015** **Updated Control Dec 2015** Original Scale: 1:5,000 Level Datum: Ortho Lytt 1937

Environment Canterbury
Regional Council
Kaunihera Taiao ki Waitaha

S16065 C3D

2 of 4

Amendments		Approved	ENVIRONMENT CANTERBURY	Environment Canterbury Regional Council Kaunihera Taiao ki Waitaha
	Aerial Photo ArcGIS 2014 Surveyed W Mecchia Feb - Dec 2015 Designed Compiled W Mecchia Dec 2015 Checked		Kaiapoi and Cam River Cross Sections 2011 to Dec 2015 Updated Control Dec 2015	S16065 C3D
Circuit TM 2000 Catch No. 6640400 Surv Data S16065 12d	Recommended Principal River Engineer	R J Vesey Regional Engineer	Original Scale: 1:5,000 Level Datum: Ortho Lyt 1937	3 of 4

Amendments	**Aerial Photo** ArcGIS 2014 **Surveyed** W Mecchia Feb - Dec 2015 **Designed** **Compiled** W Mecchia Dec 2015 **Checked**	**Approved**	**ENVIRONMENT CANTERBURY** **Kaiapoi and Cam River** **Cross Sections 2011 to Dec 2015** **Updated Control Dec 2015**
Circuit TM 2000 Catch No. 6640400 Surv Data S16065 12d	Recommended Principal River Engineer	R J Vesey Regional Engineer	Original Scale: 1:5,000 Level Datum: Ortho Lytt 1937

Environment Canterbury
Regional Council
Kaunihera Taiao ki Waitaha

S16065 C3D

Site Name : Kaiapoi River

Site Number : 02735

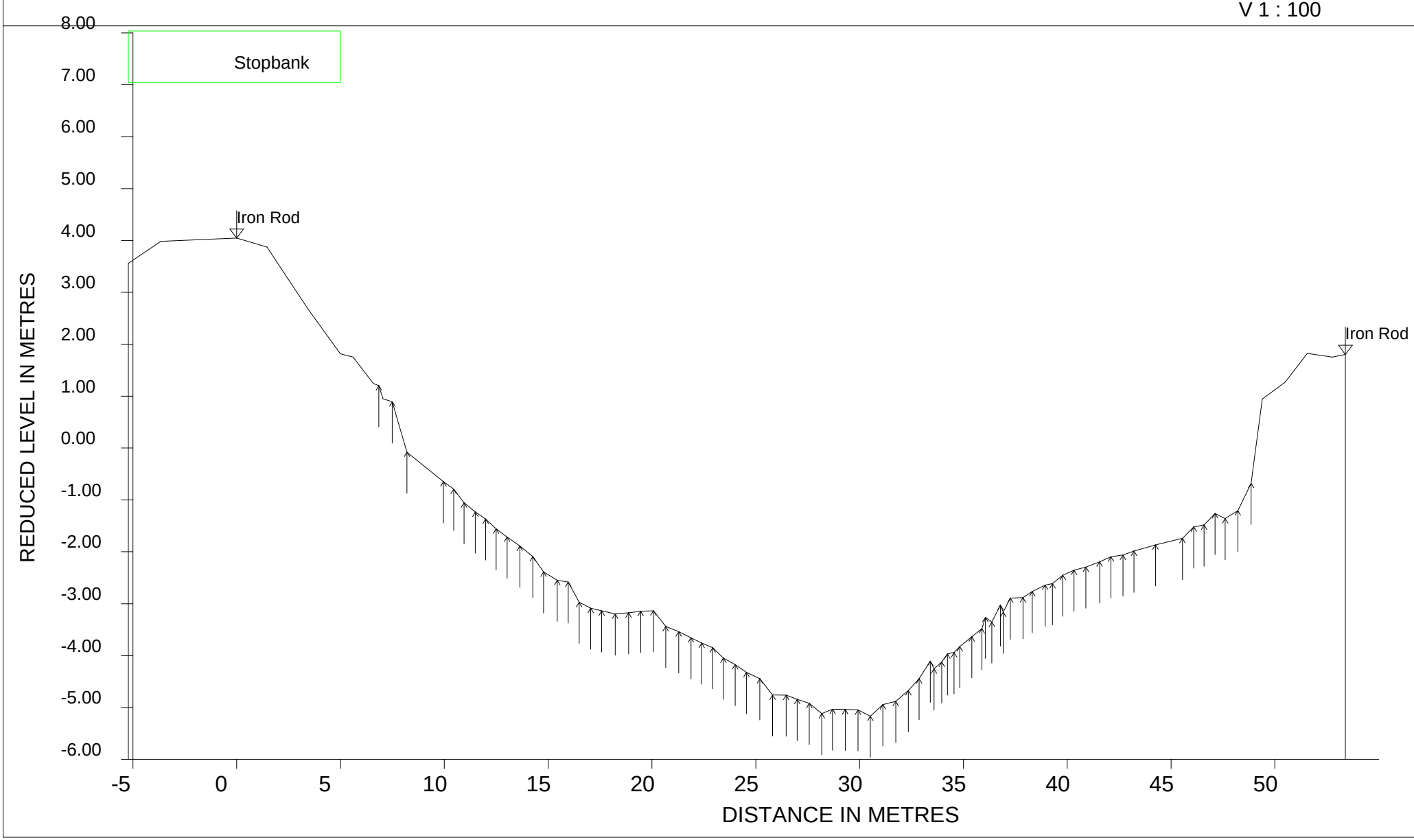
Survey Date : 20-Jan-2016

Site Distance : 2.735 km

29-Jan-2016 02:43 PM

Scale H 1 : 250

V 1 : 100



Site Name : Kaiapoi River

Site Number : 03170

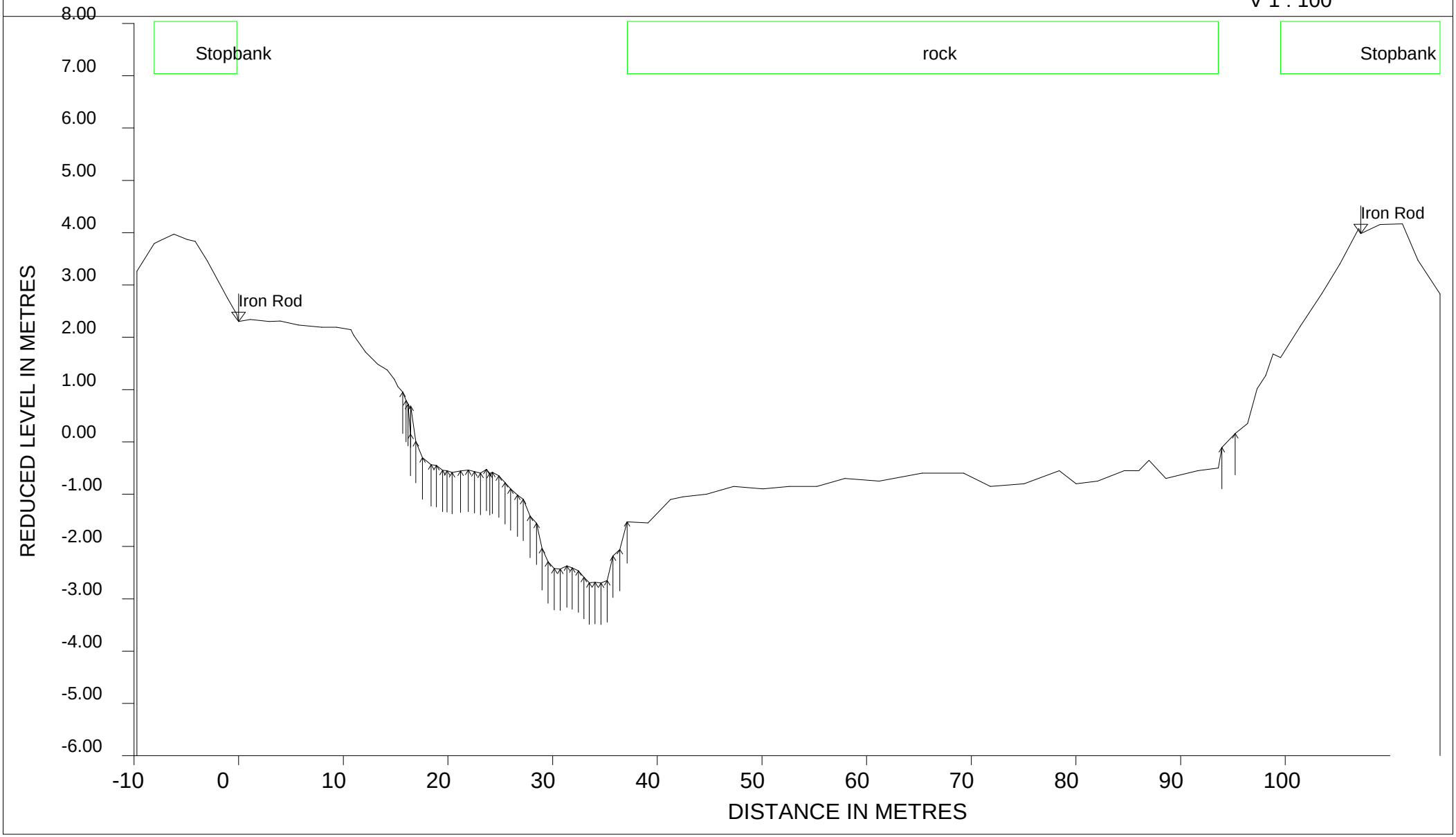
Survey Date : 20-Jan-2016

Site Distance : 3.170 km

29-Jan-2016 02:50 PM

Scale H 1 : 500

V 1 : 100



Site Name : Kaiapoi River

Site Number : 03170

Survey Date : 20-Jan-2016

Site Distance : 3.170 km

29-Jan-2016 02:49 PM

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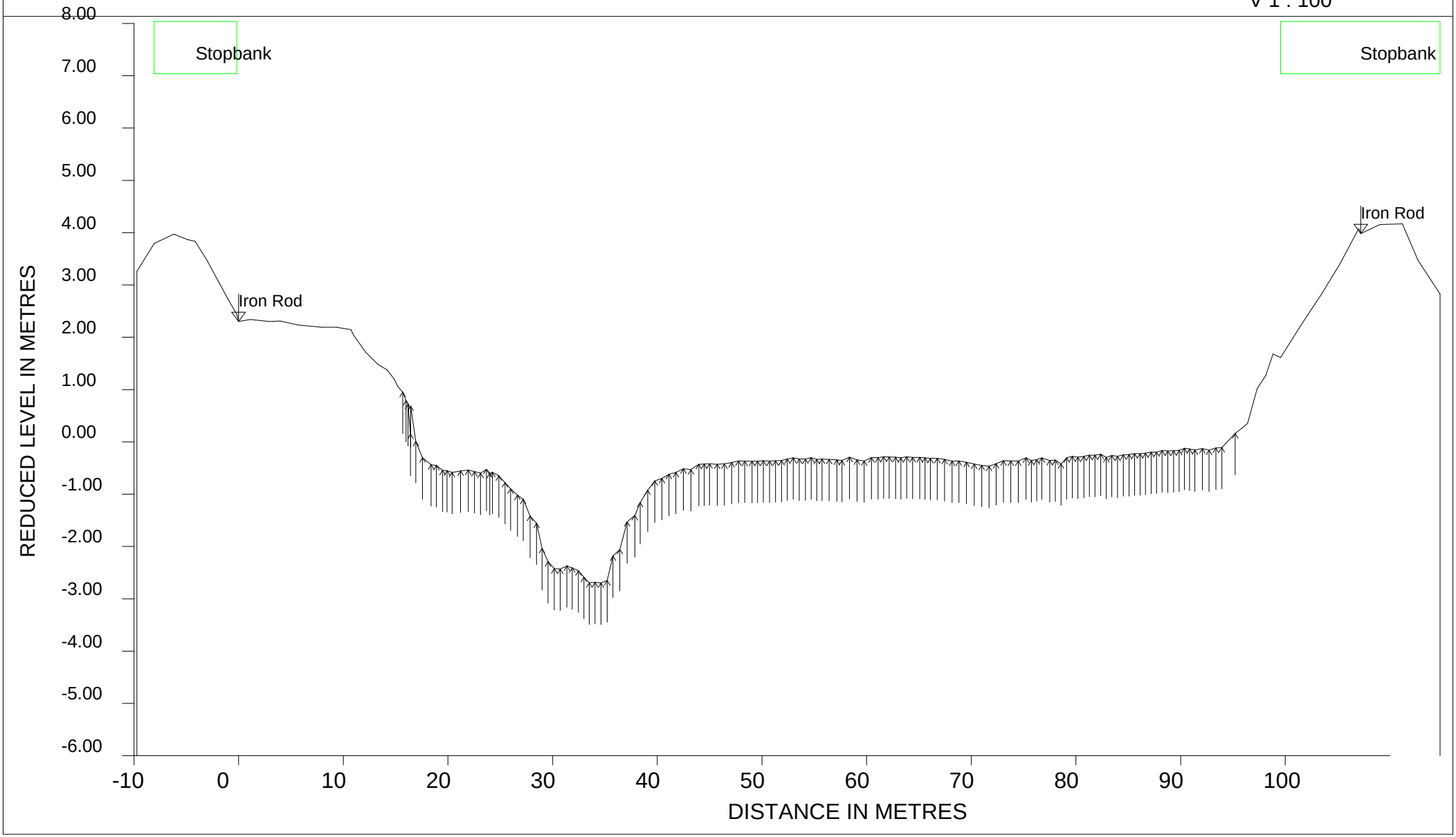
V 1 : 100



Kaiapoi River

XS ID	Distance	Type	Survey Date	Local Name
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03170	3.17	XS	20-Jan-2016	Est 2015

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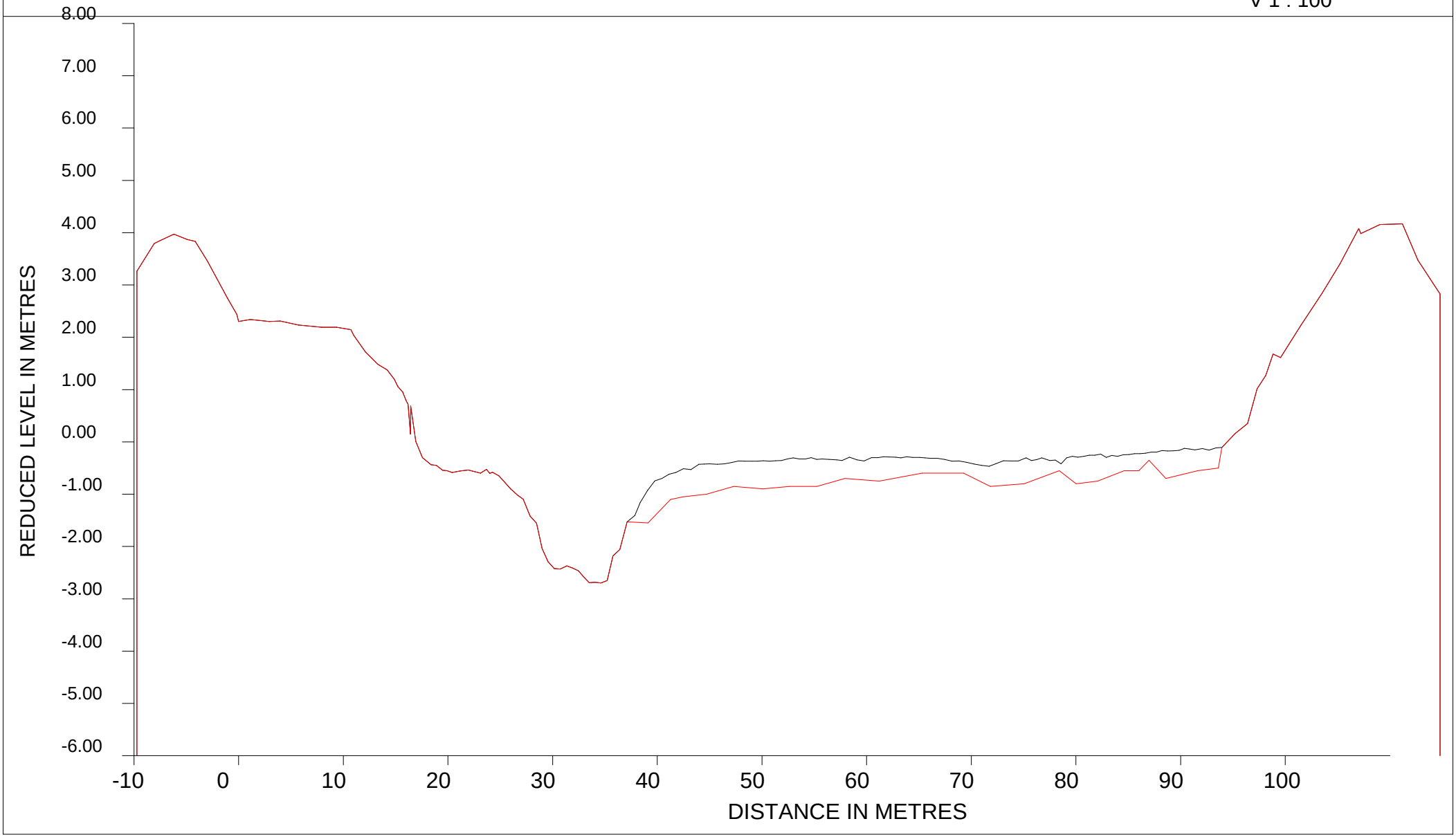
V 1 : 100



Site Name : Kaiapoi River

Site Number : 03205

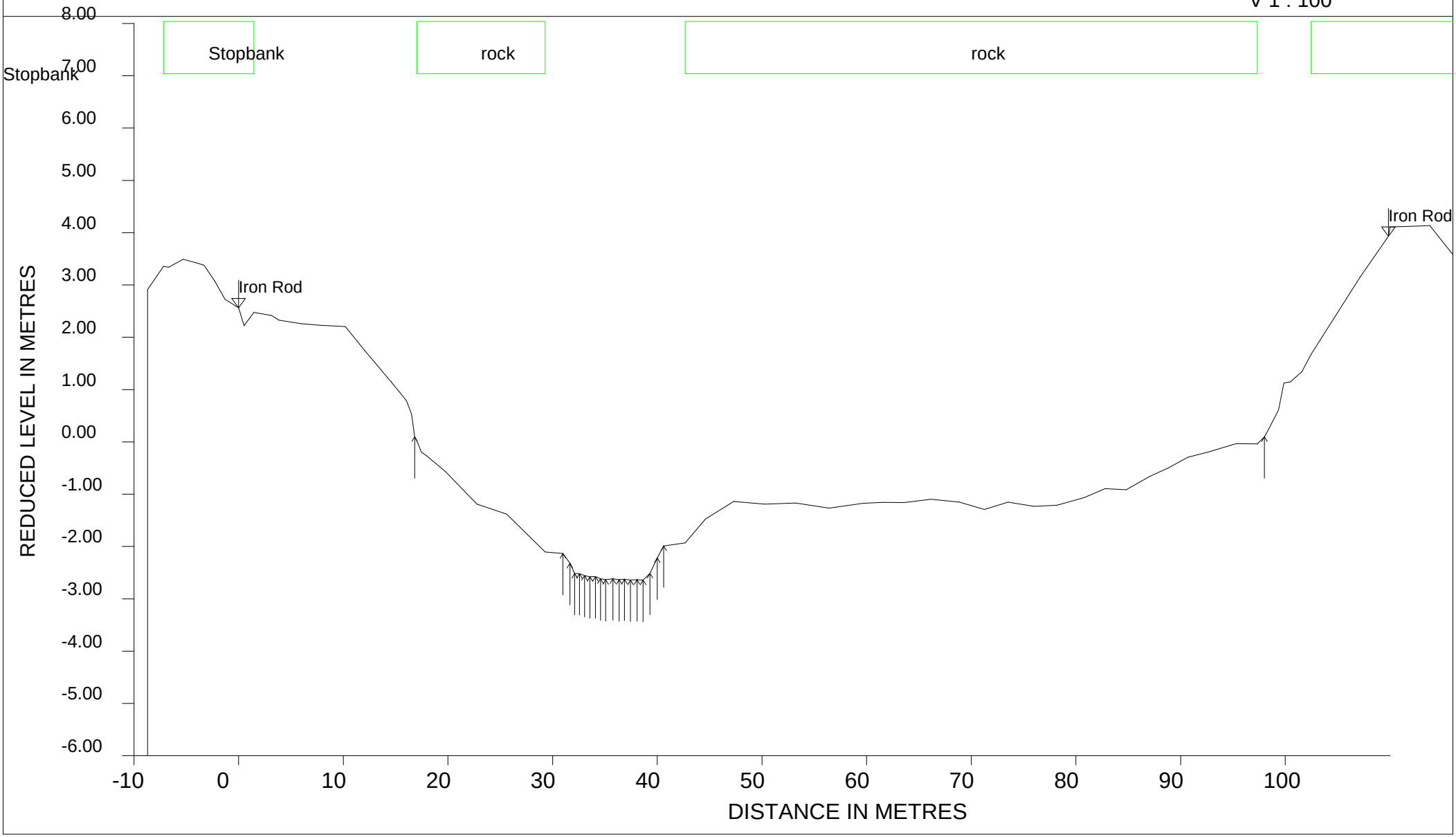
Survey Date : 20-Jan-2016

Site Distance : 3.205 km

29-Jan-2016 03:46 PM

Scale H 1 : 500

V 1 : 100



Site Name : Kaiapoi River

Site Number : 03205

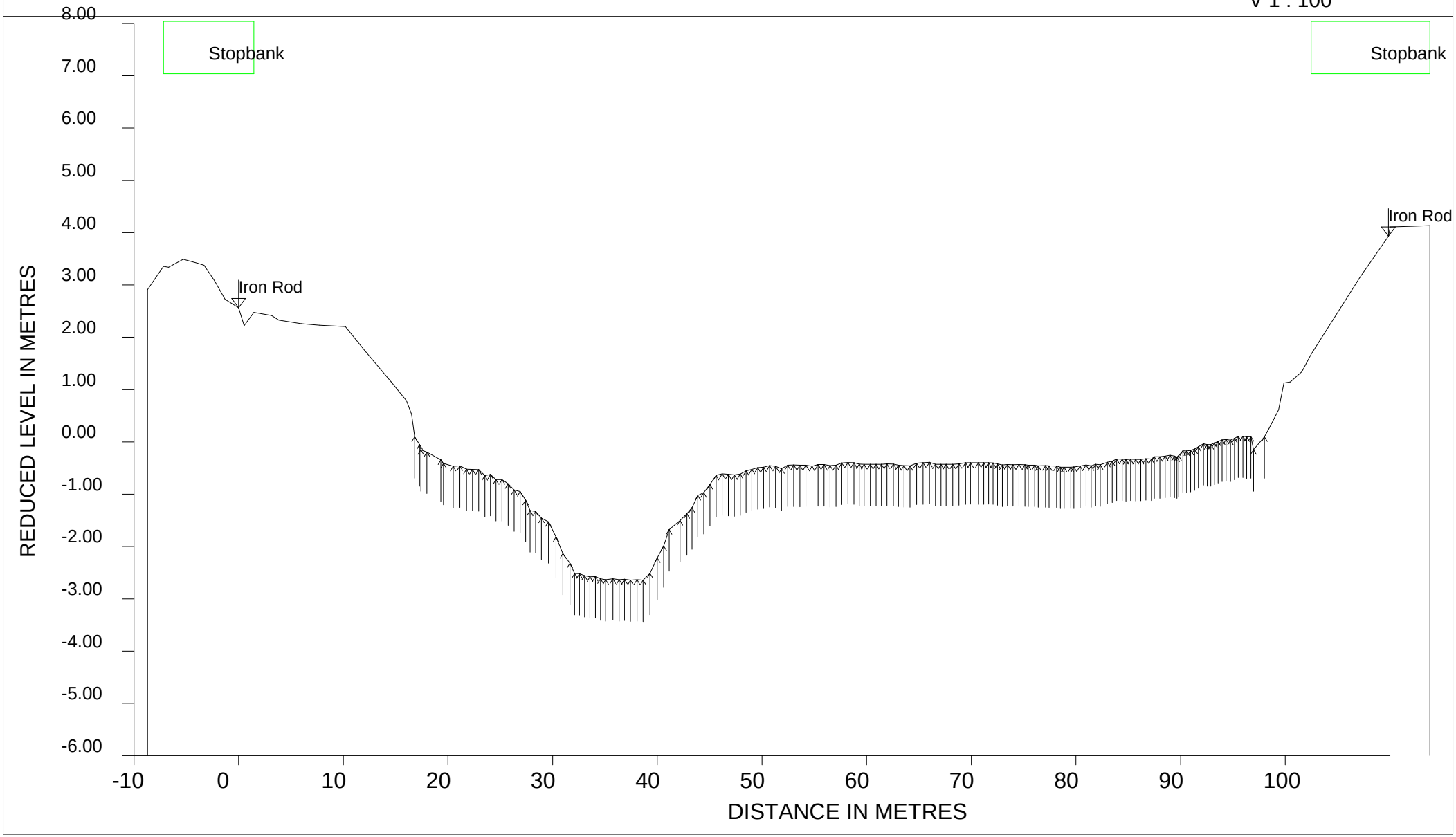
Survey Date : 20-Jan-2016

Site Distance : 3.205 km

29-Jan-2016 03:32 PM

Scale H 1 : 500

V 1 : 100



Kaiapoi River

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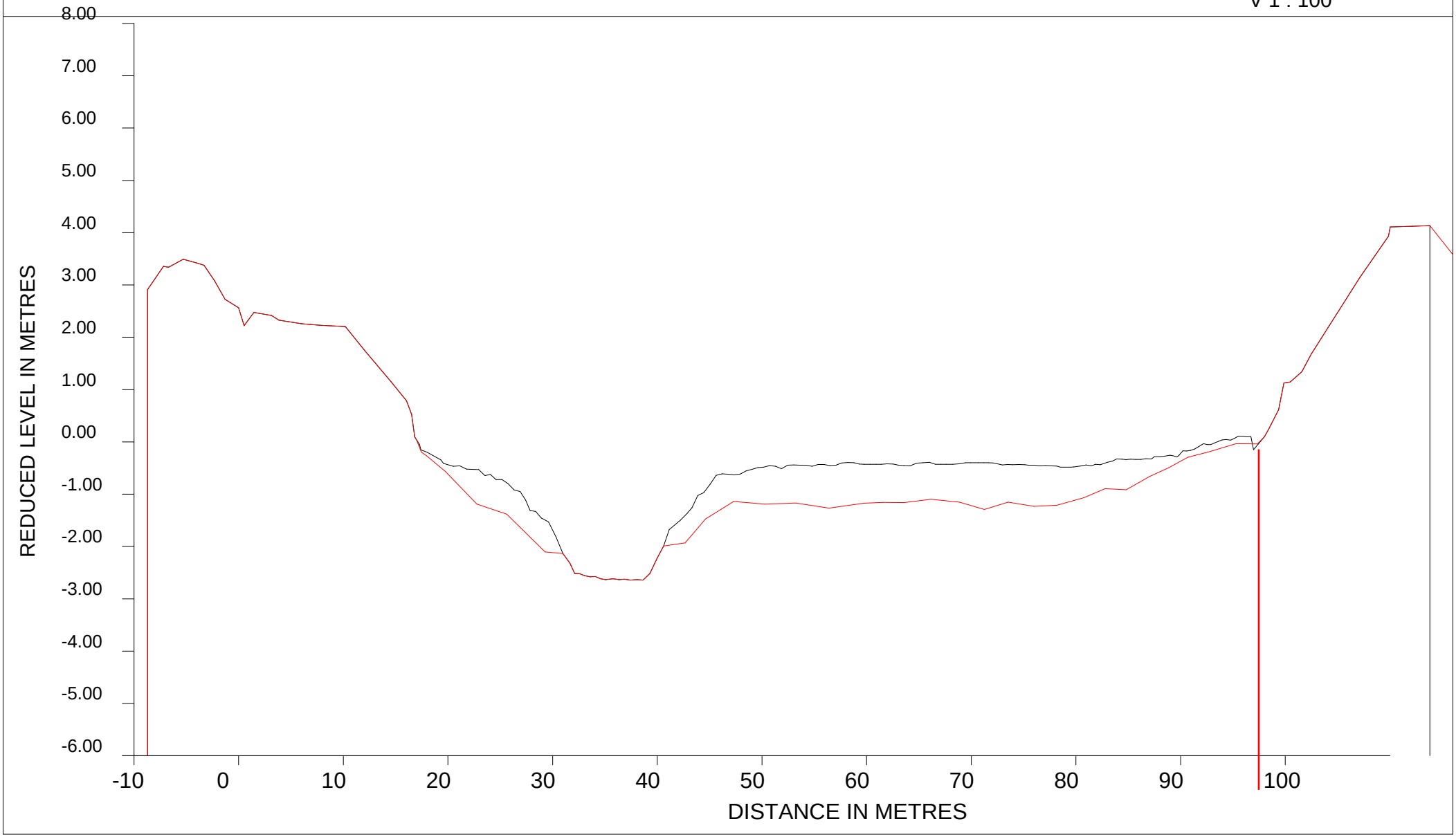
V 1 : 100



Site Name : Kaiapoi River

Site Number : 03240

Survey Date : 20-Jan-2016

Site Distance : 3.240 km

29-Jan-2016 04:00 PM

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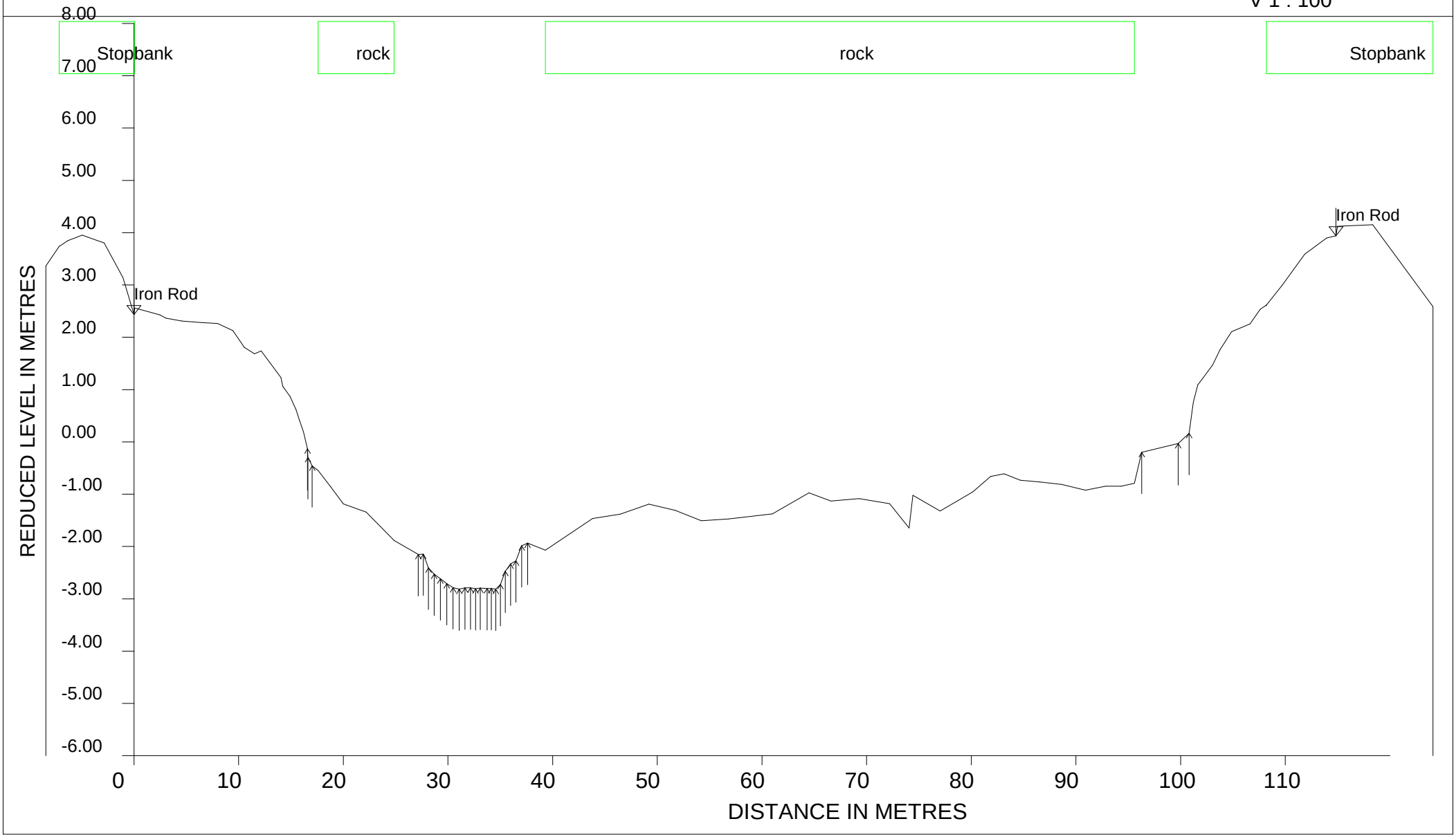
V 1 : 100



Site Name : Kaiapoi River

Site Number : 03240

Survey Date : 20-Jan-2016

Site Distance : 3.240 km

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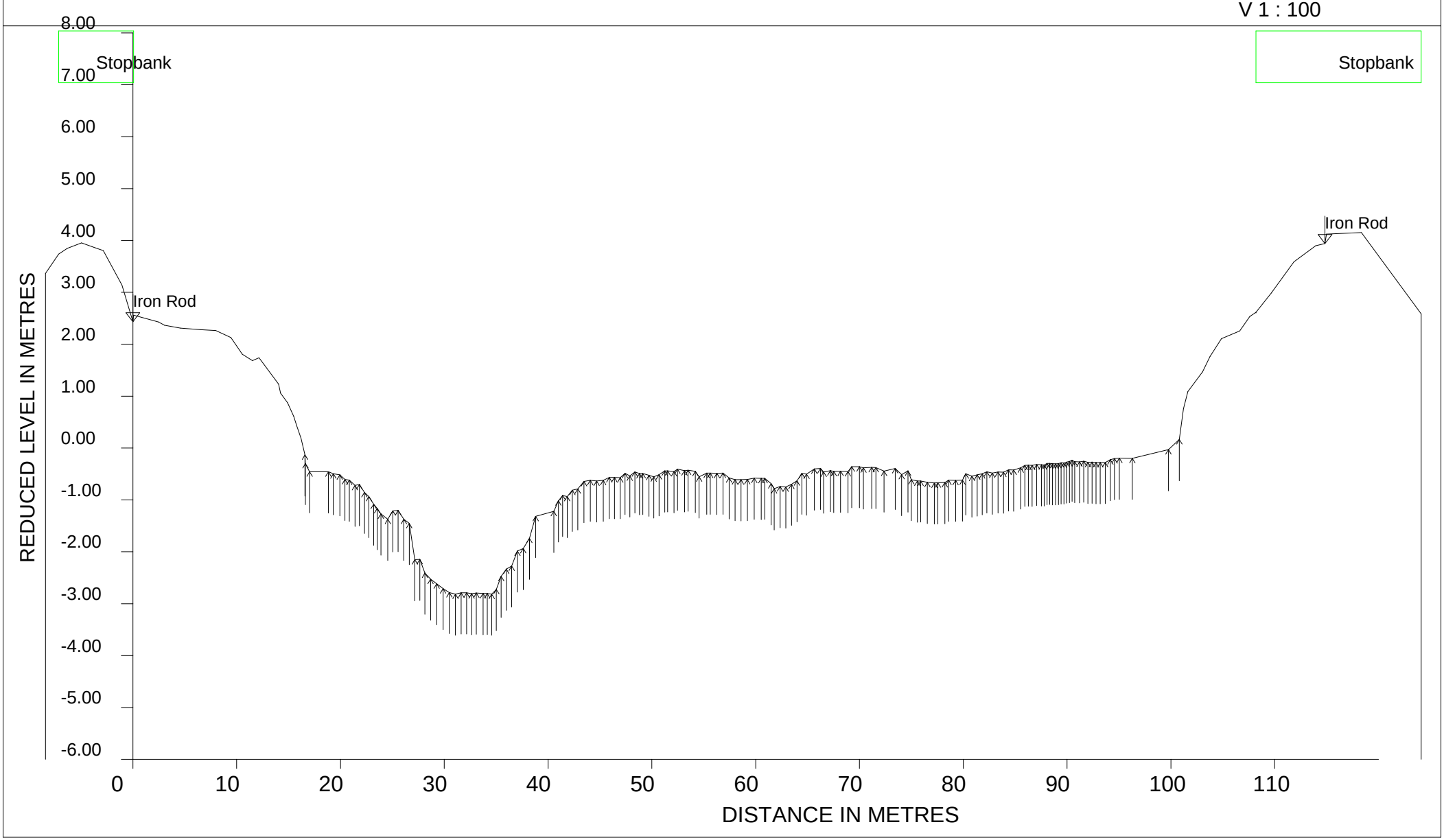
Scale H 1 : 500

V 1 : 100



Kaiapoi River

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29-Jan-2016 04:01 PM
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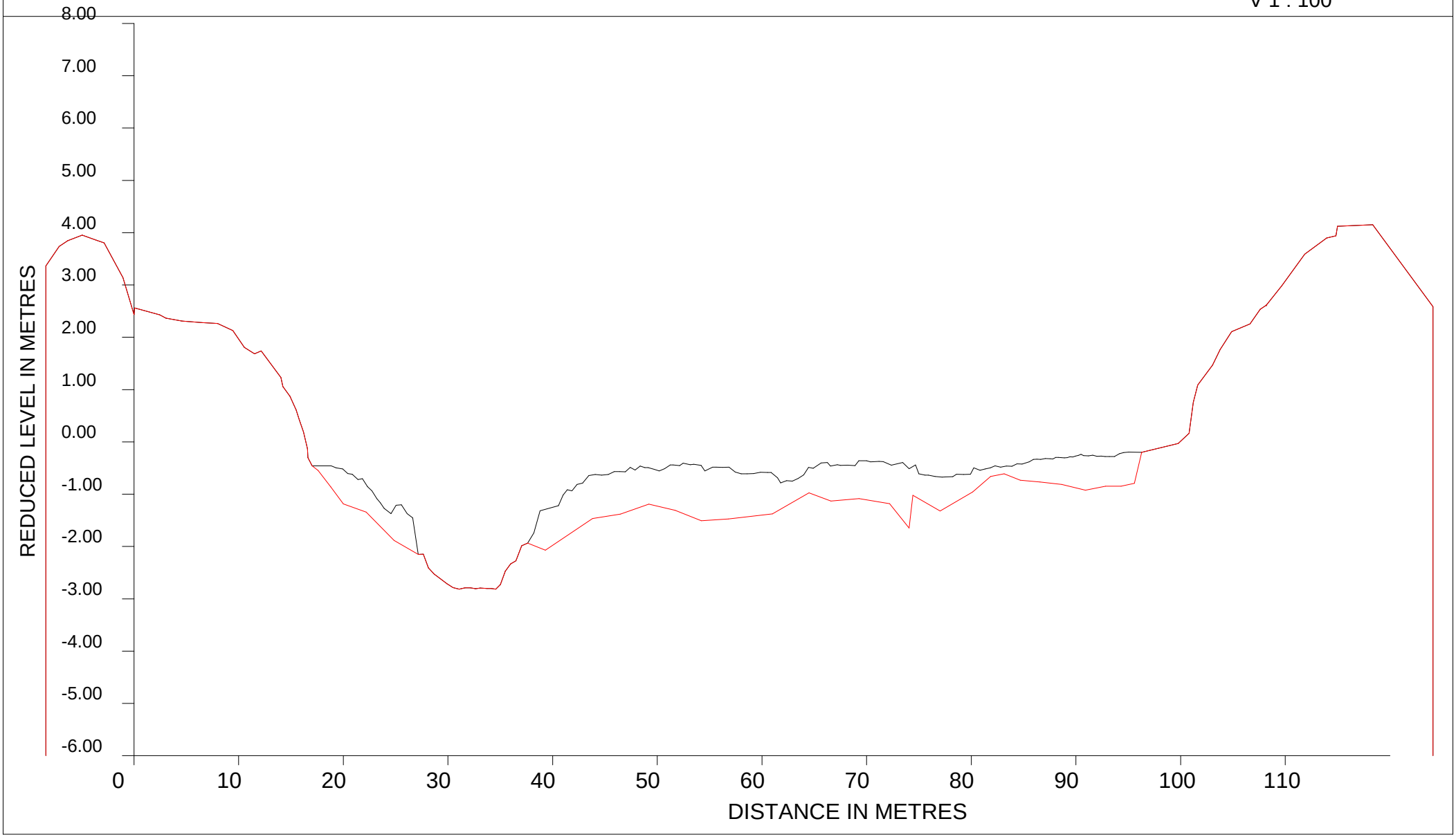
V 1 : 100



Site Name : Kaiapoi River

Site Number : 03635

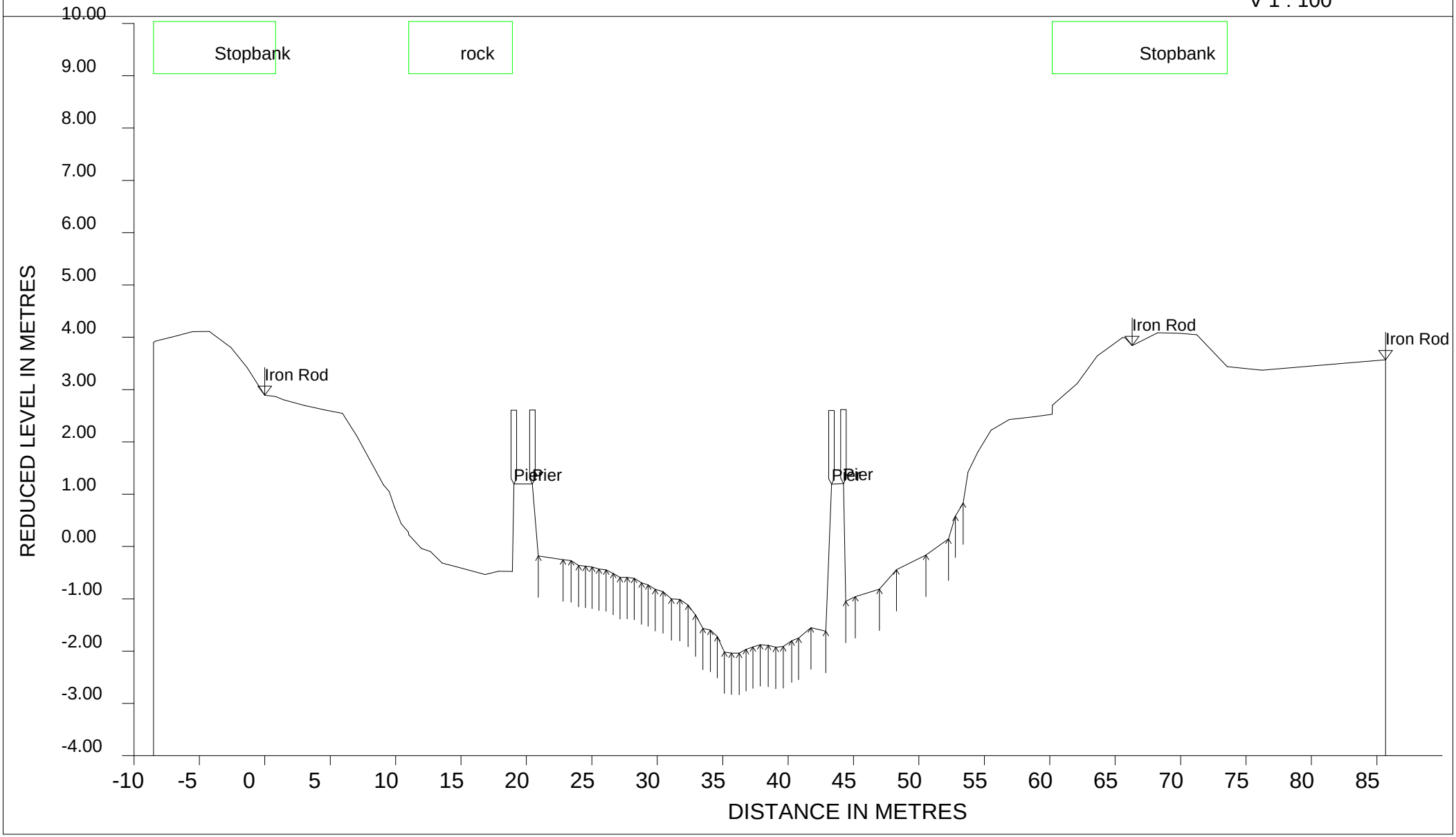
Survey Date : 20-Jan-2016

Site Distance : 3.635 km

03-Feb-2016 04:04 PM

Scale H 1 : 400

V 1 : 100



Site Name : Kaiapoi River

Site Number : 03635

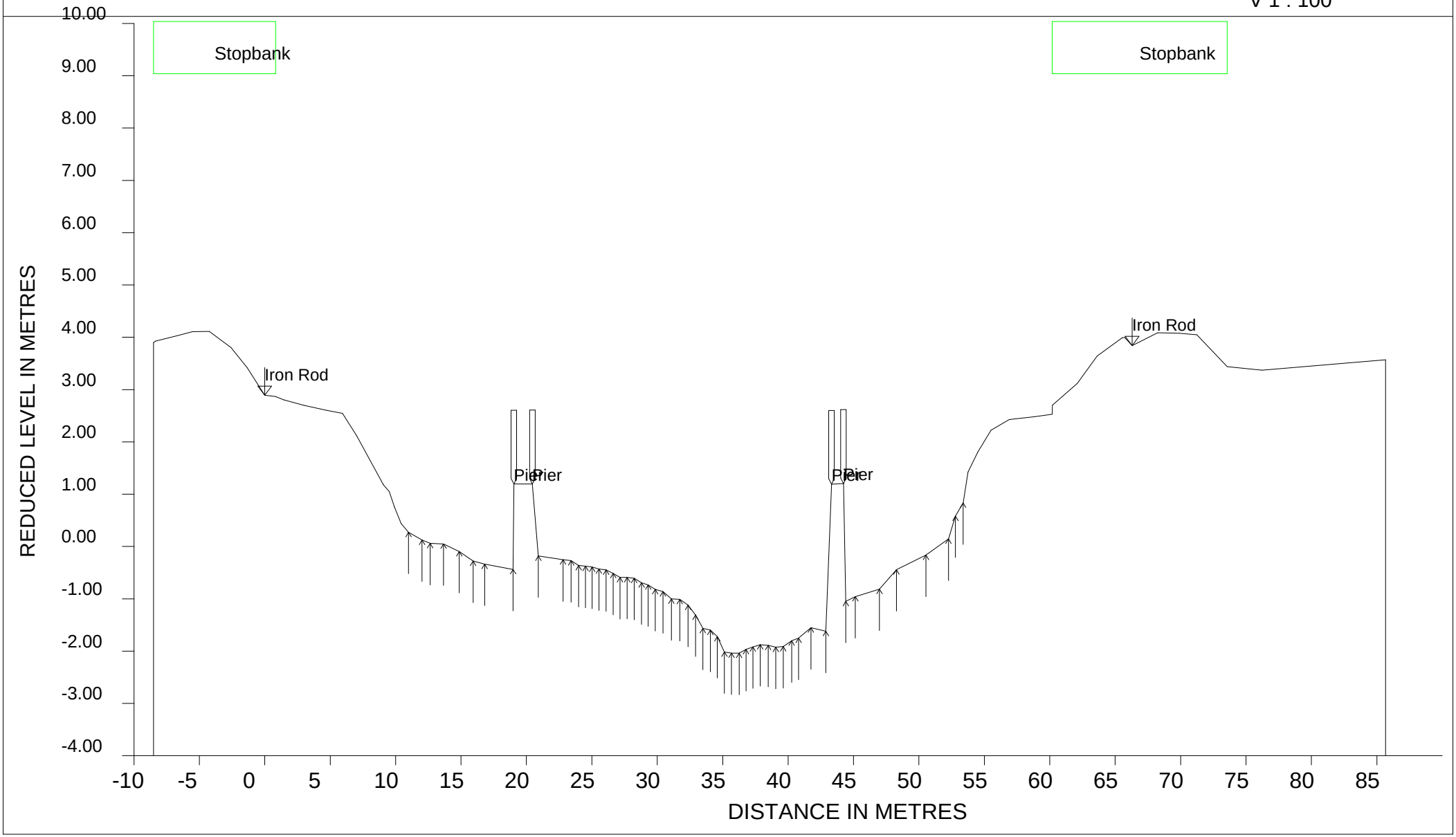
Survey Date : 20-Jan-2016

Site Distance : 3.635 km

03-Feb-2016 04:05 PM

Scale H 1 : 400

V 1 : 100



Kaiapoi River

XS ID	Distance	Type	Survey Date	Local Name
03635	3.64	XS	20-Jan-2016	MW Bridge 2015
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03-Feb-2016 04:01 PM
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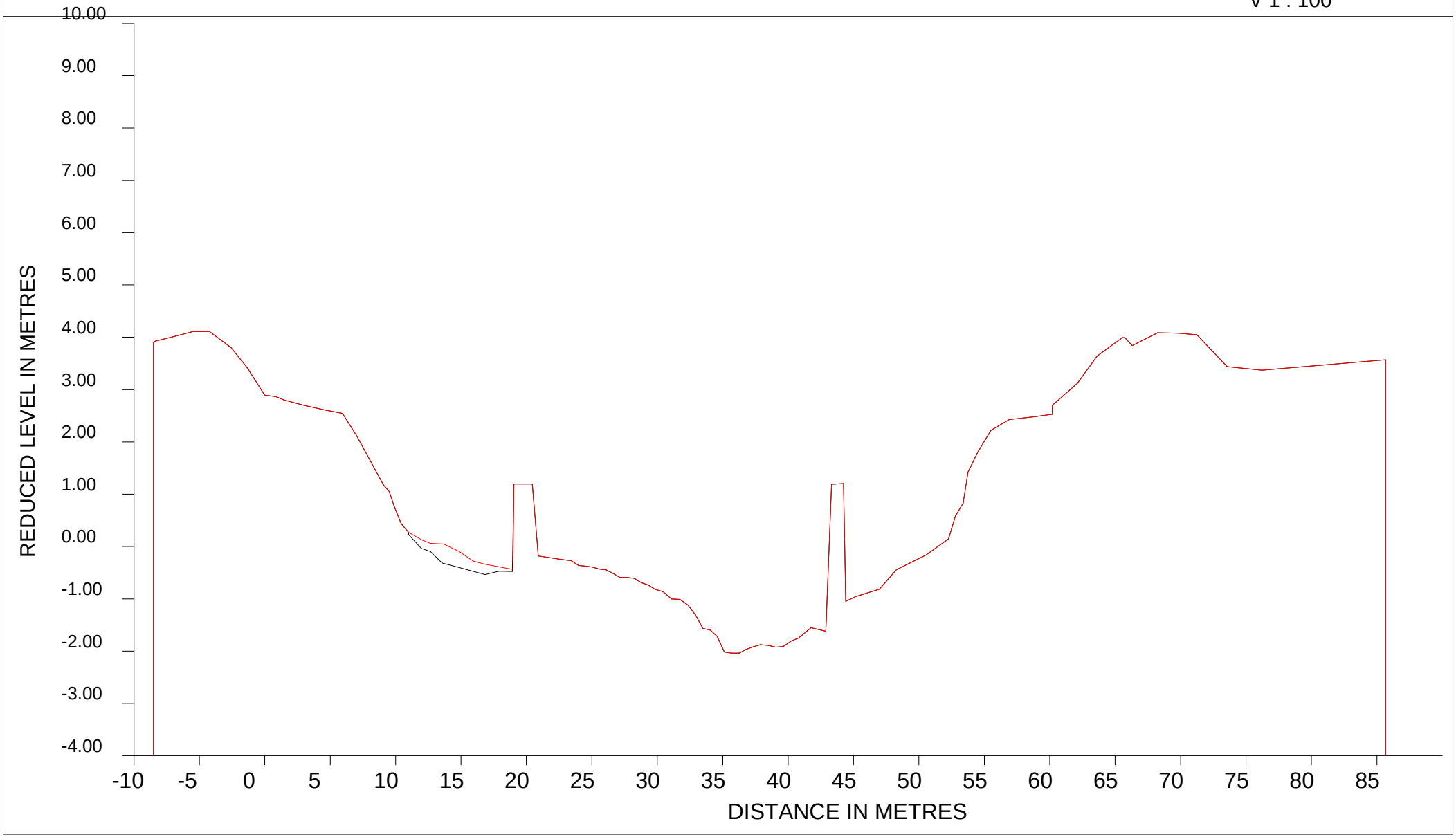
V 1 : 100



Site Name : Kaiapoi River

Site Number : 04000

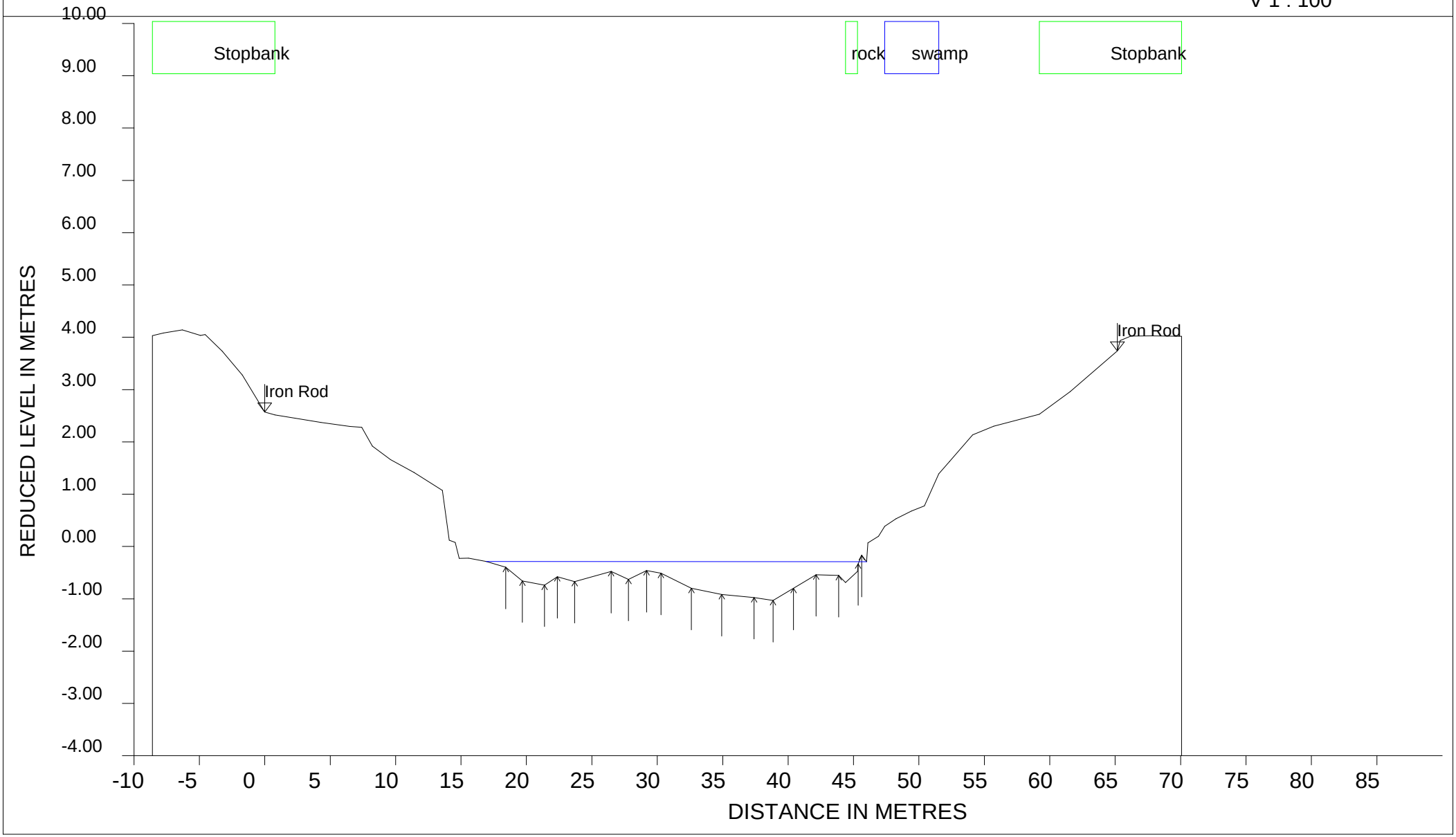
Survey Date : 14-Dec-2015

Site Distance : 4.000 km

03-Feb-2016 04:09 PM

Scale H 1 : 400

V 1 : 100



Site Name : Kaiapoi River

Site Number : 04000

Survey Date : 14-Dec-2015

Site Distance : 4.000 km

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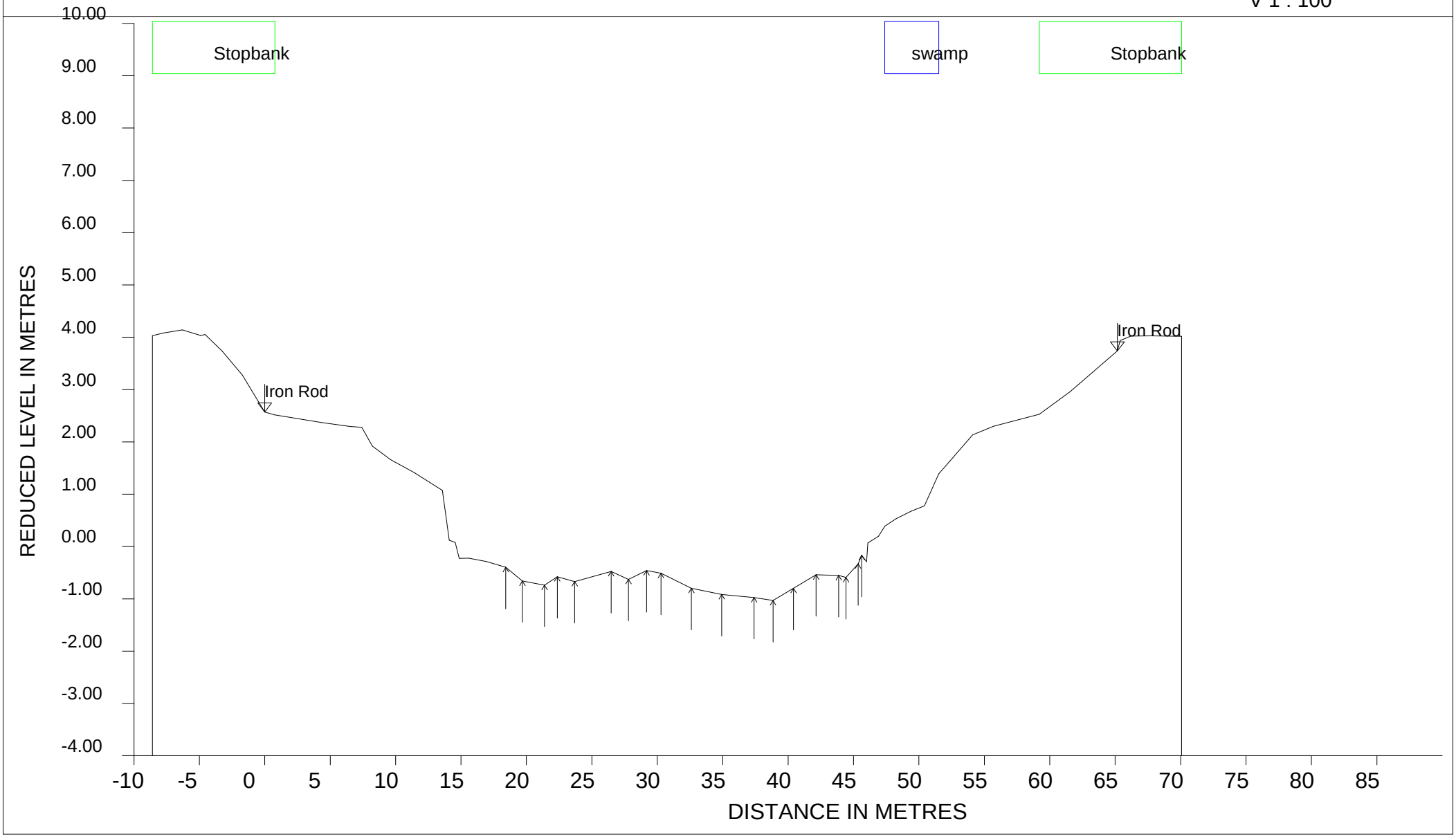
V 1 : 100



Kaiapoi River

XS ID	Distance	Type	Survey Date	Local Name
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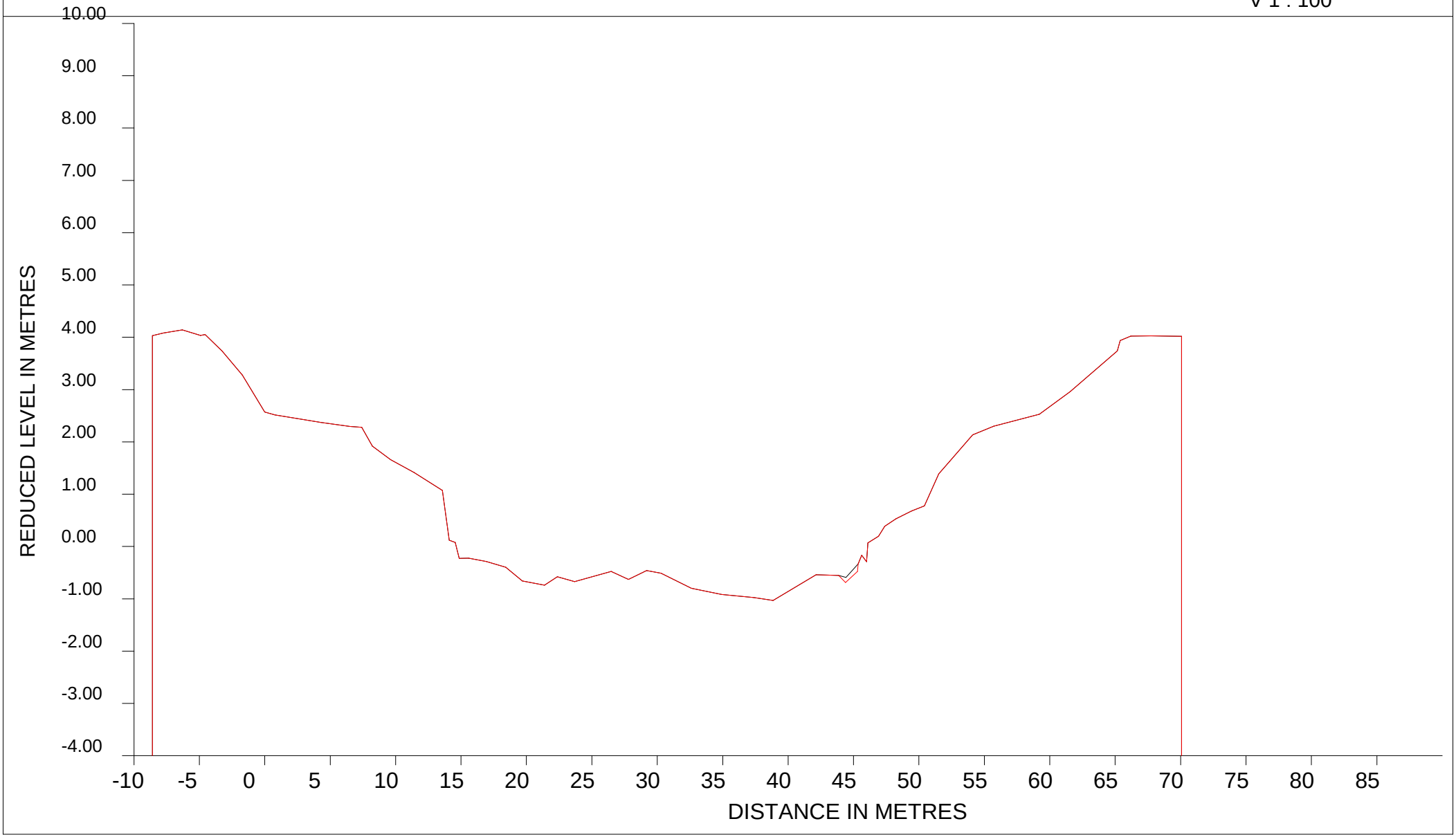

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Site Number : 04265

Survey Date : 14-Dec-2015

Site Distance : 4.265 km

03-Feb-2016 04:18 PM

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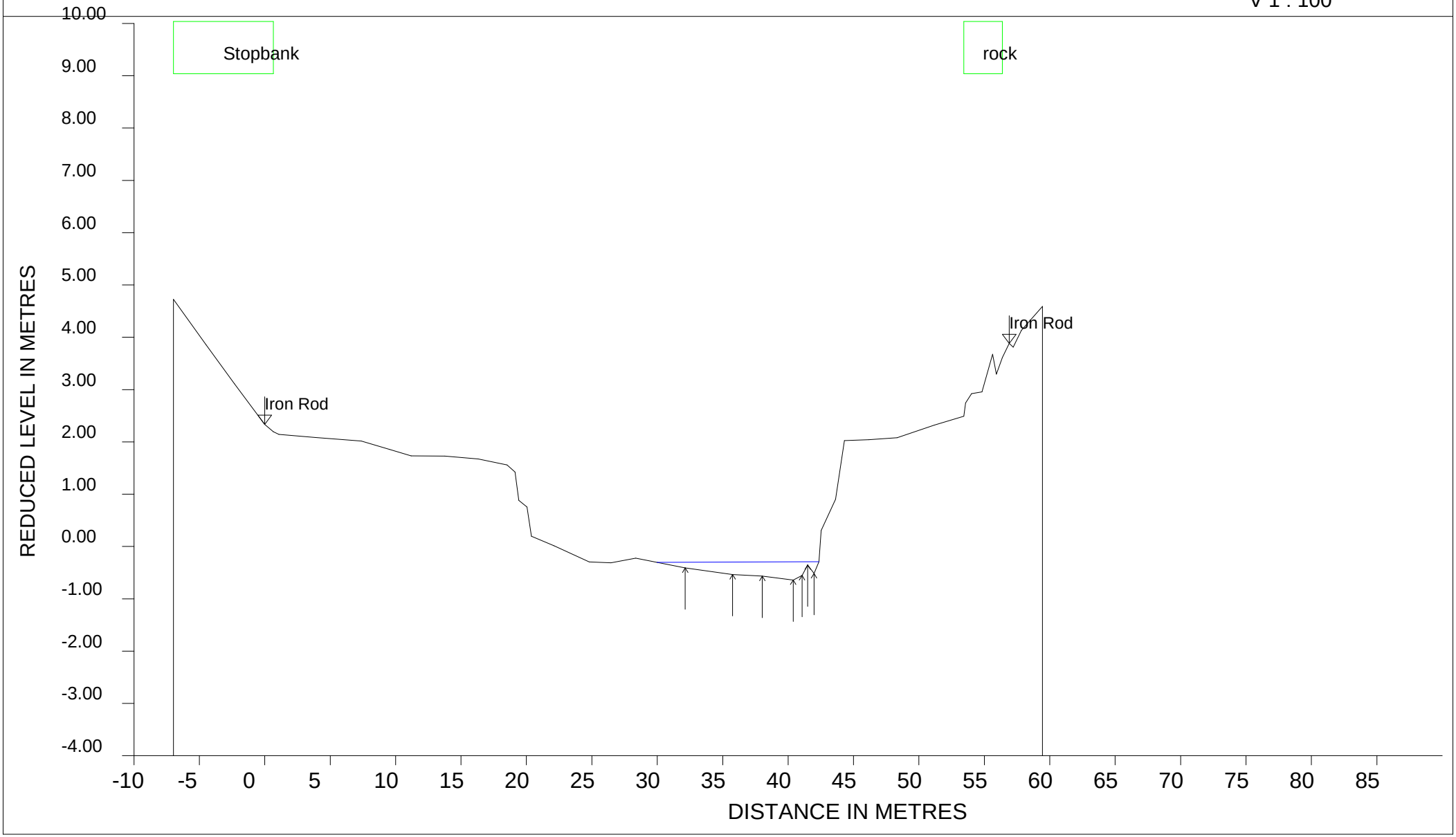
V 1 : 100



Site Name : Kaiapoi River

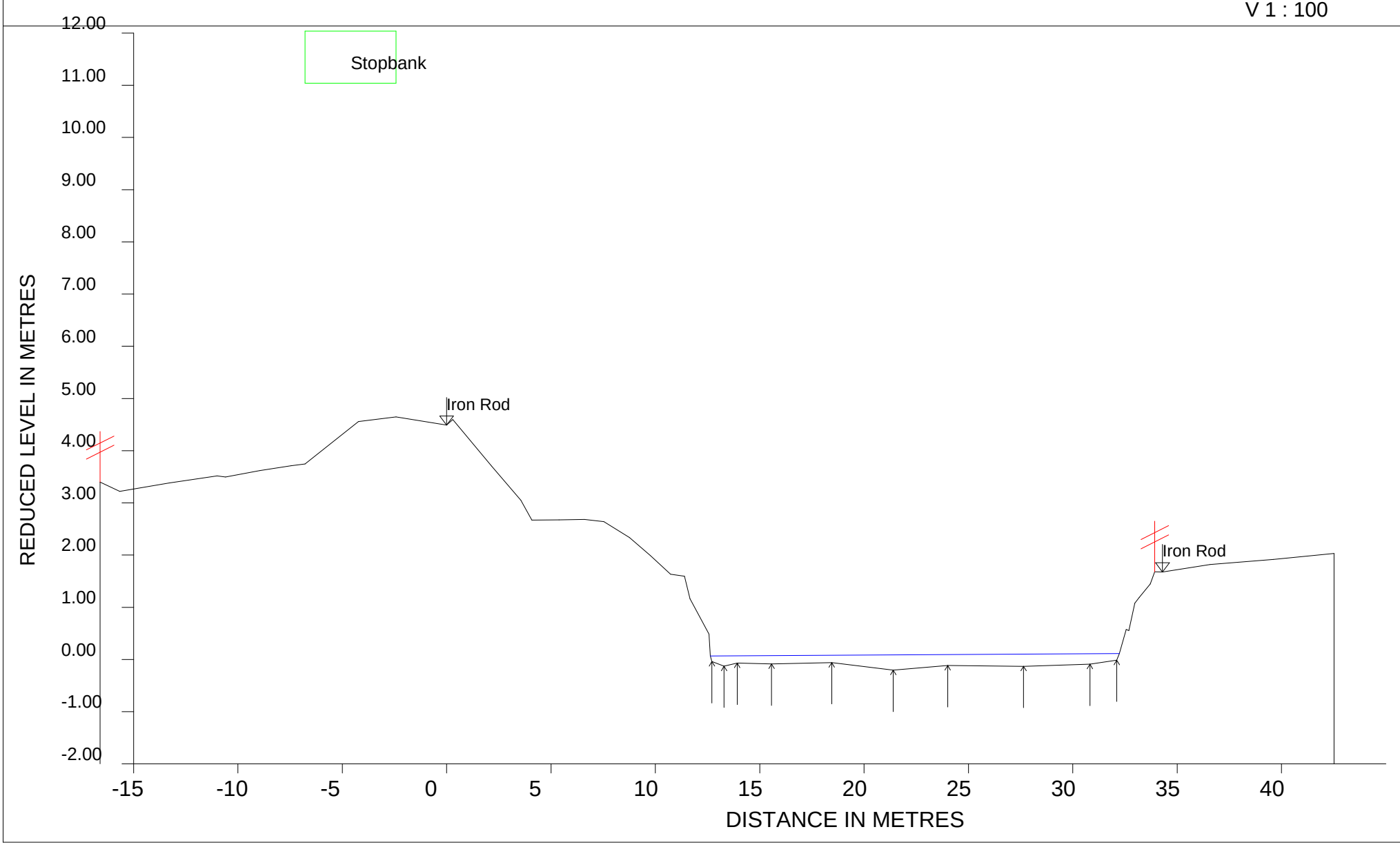
Site Number : 04545

Survey Date : 14-Dec-2015

Site Distance : 4.545 km

03-Feb-2016 04:22 PM

Scale H 1 : 250
V 1 : 100



Site Name : Kaiapoi River

Site Number : 04785

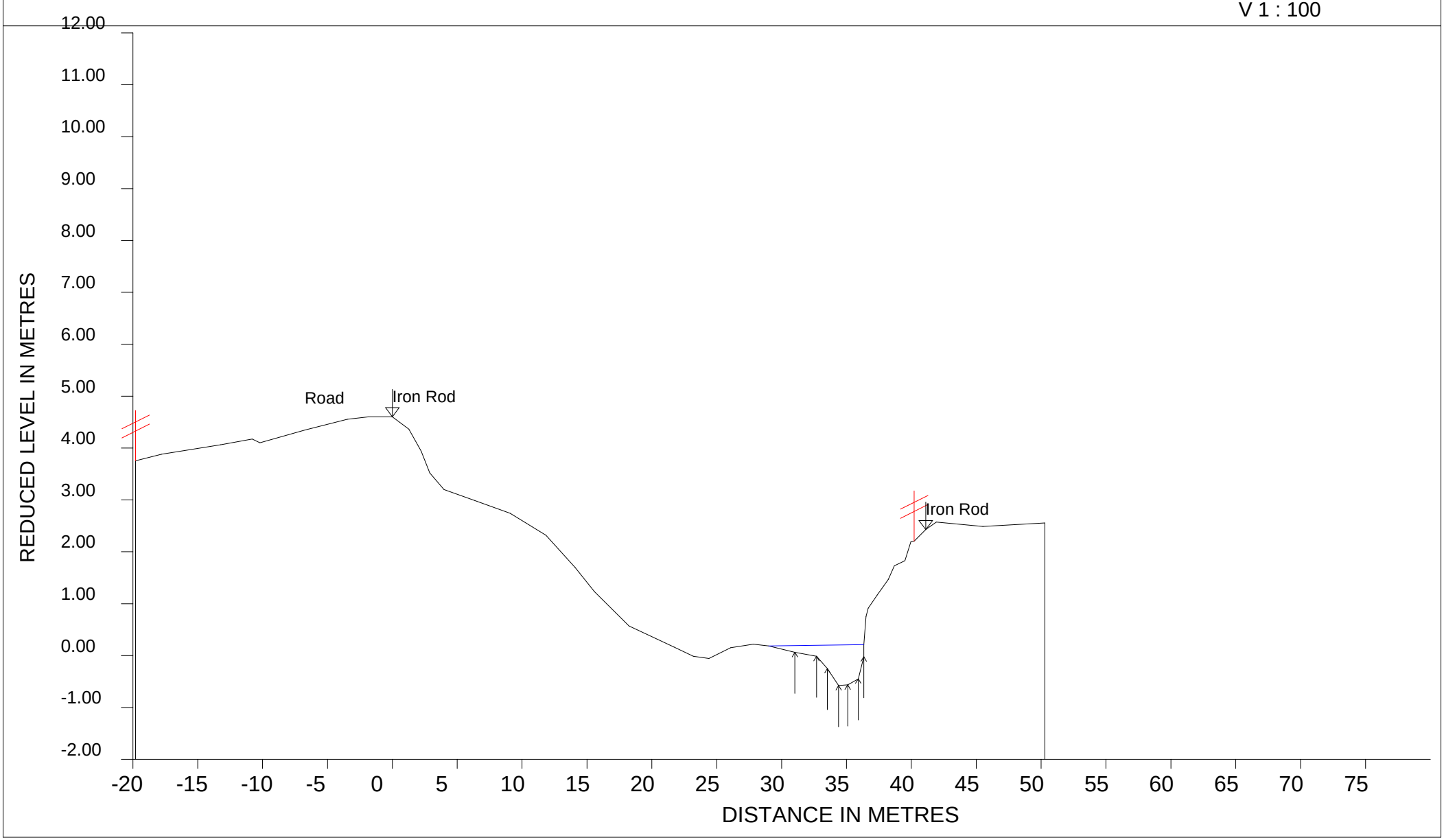
Survey Date : 14-Dec-2015

Site Distance : 4.785 km

03-Feb-2016 04:25 PM

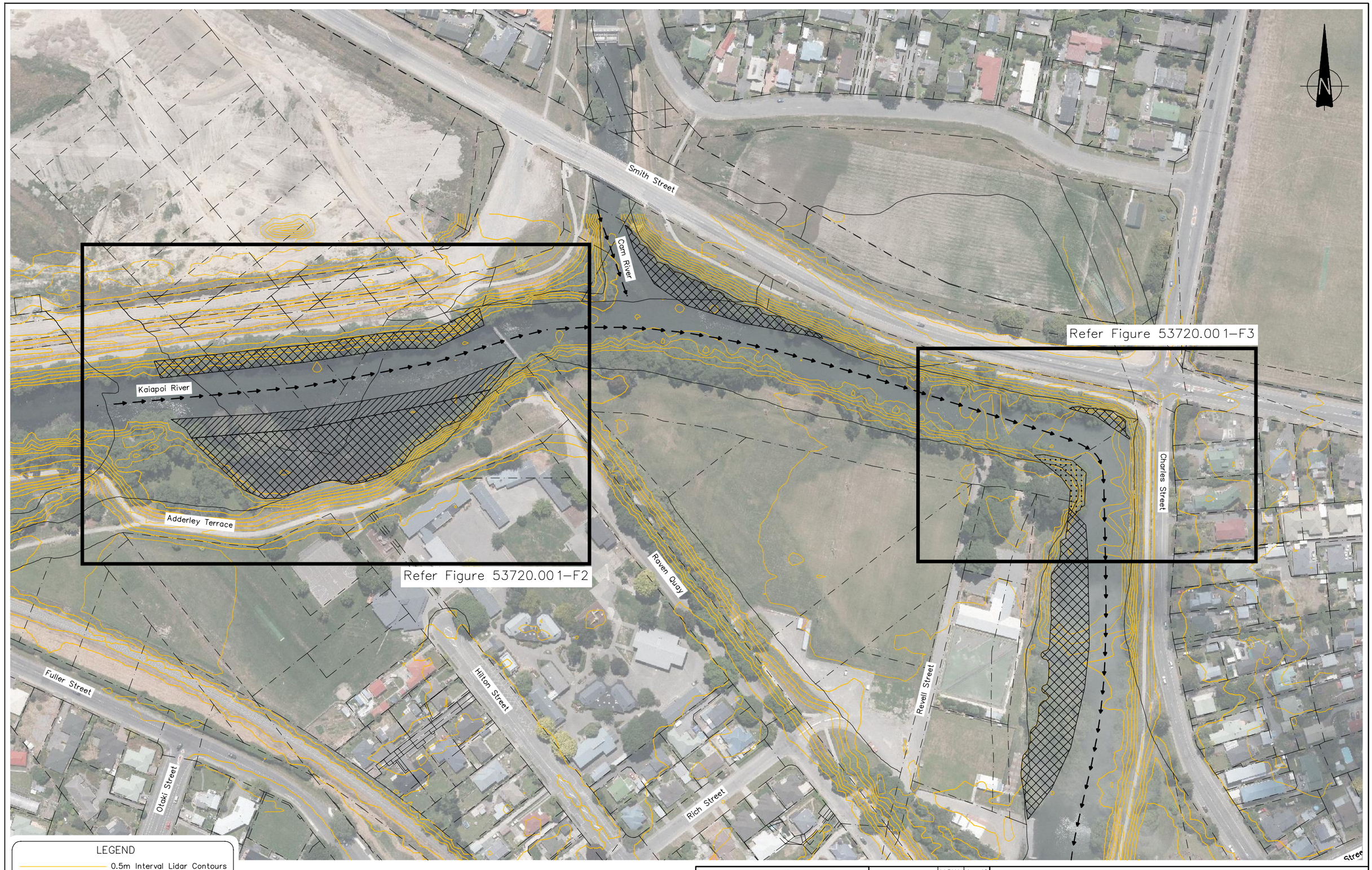
Scale H 1 : 400

V 1 : 100



Appendix C: Concept Figures

- **T+T Figures 53720.001-F1 to F6 Rev 0 and 1**



LEGEND

- 0.5m Interval Lidar Contours
- River flow direction
- Cadastral Boundaries
- Area of modification

A3 SCALE 1:2000

0 20 40 60 80 100 (m)

NOTES:
1. Aerial photo sourced from Land Information New Zealand data (Crown Copyright Reserved).
2. Contours sourced from LiDAR information from Waimakariri District Council (flown 2014)

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DRAWN	NSW	Apr. 16
DRAFTING CHECKED		
APPROVED		
CADFILE : \\53720.001–F1–F3.dwg		
SCALES (AT A3 SIZE) 1:2000		
PROJECT No. 53720.001		

KAIAPOI RIVER REHABILITATION WORKING PARTY

KAIAPOI RIVER REHABILITATION PROJECT STAGE 1A

KAIAPOI

Location Plan & Layouts

FIG. No. 53720.001–F1

REV. 0

Stopbank

Stopbank

Kaiapoi River

Dense riparian planting zone

Existing soft sediment deposits

Sediment trap area

Adderley Terrace

1/F4

2/F4

3/F4

N

LEGEND

- 0.5m Interval Lidar Contours
- River flow direction
- Cadastral Boundaries
- Area of fill/planting
- Area of dense riparian planting

A3 SCALE 1:750

0 5 10 15 20 25 30 35 40 (m)

NOTES:

1. Aerial photo sourced from Land Information New Zealand data (Crown Copyright Reserved).
2. Contours sourced from LiDAR information from Waimakariri District Council (flown 2014)

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DRAWN	SJK	Apr. 16
DRAFTING CHECKED		
APPROVED		
CADFILE : \\53720.001–F1–F3.dwg		
SCALES (AT A3 SIZE)	1:750	
PROJECT No.	53720.001	
FIG. No.	53720.001–F2	REV. 0

KAIAPOI RIVER REHABILITATION WORKING PARTY

KAIAPOI RIVER REHABILITATION PROJECT STAGE 1A

KAIAPOI

Sediment Trap Plan

Riparian planting and fill zone

Existing stormwater outlet pipe and wingwall

Excavate inner bend riparian zone

Area of proposed planting (Refer Stage 1 report)

Charles Street

4/F5

5/F5

6/F5

LEGEND

- 0.5m interval lidar contours
- River flow direction
- Cadastral boundaries
- Area of fill/planting
- Area of excavation

A3 SCALE 1:500

0 5 10 15 20 25 (m)

NOTES:
1. Aerial photo sourced from Land Information New Zealand data (Crown Copyright Reserved).
2. Contours sourced from LiDAR information from Waimakariri District Council (flown 2014)

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DRAWN	SJK	Apr. 16
DRAFTING CHECKED		
APPROVED		
CADFILE : \\53720.001–F1–F3.dwg		
SCALES (AT A3 SIZE) 1:500		
PROJECT No. 53720.001		

KAIAPOI RIVER REHABILITATION WORKING PARTY

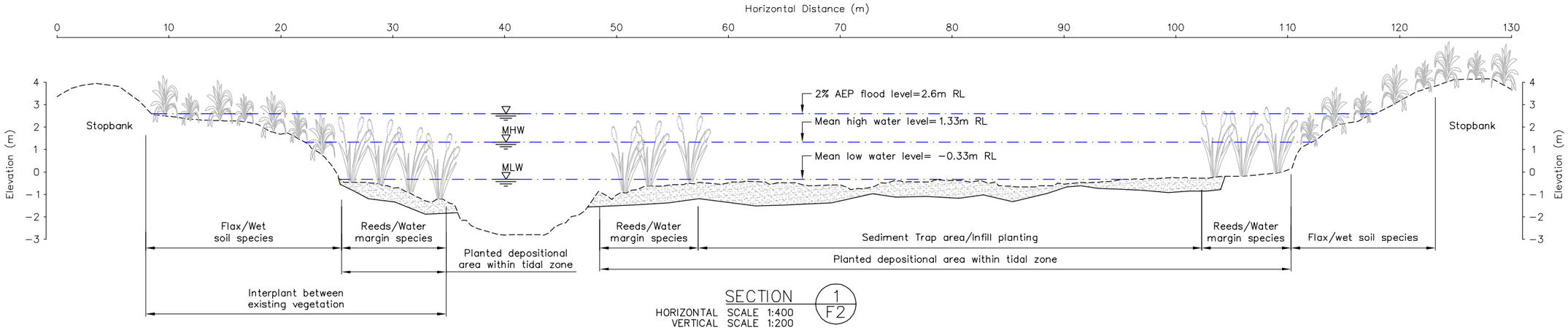
KAIAPOI RIVER REHABILITATION PROJECT STAGE 1A

KAIAPOI

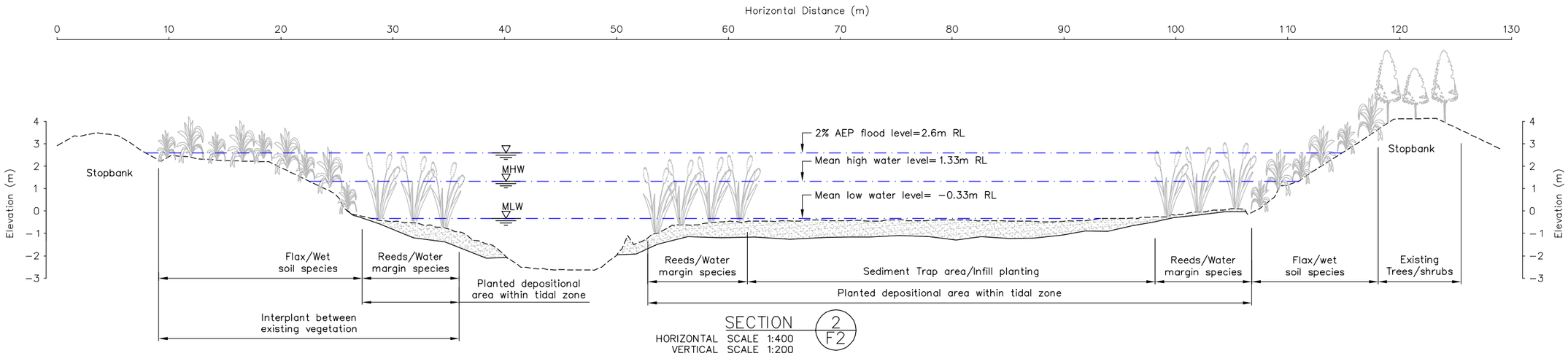
Elbow Bend Realignment

FIG. No. 53720.001–F3

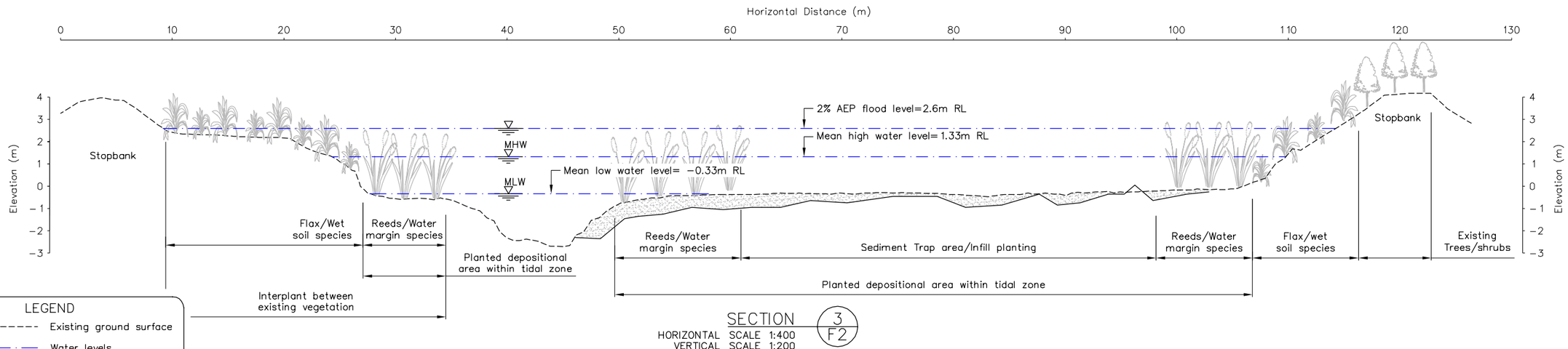
REV. 0



SECTION 1 / F2
HORIZONTAL SCALE 1:400
VERTICAL SCALE 1:200



SECTION 2 / F2
HORIZONTAL SCALE 1:400
VERTICAL SCALE 1:200



SECTION 3 / F2
HORIZONTAL SCALE 1:400
VERTICAL SCALE 1:200

LEGEND
- Existing ground surface
- Water levels
- Surveyed hard material interface

SCALE 1:400
0 4 8 12 16 20 (m)

A3 SCALE 1:200
0 2 4 6 8 10 (m)

NOTES:
1. Mean high water level refers to the approximated "peak spring tide" level in the Kaiapoi River.
2. Cross-sections and sediment depths taken & interpolated from ECan river cross-sections surveyed 2011, 2015 & 2016 provided to T&T by ECan March 2016.
3. Water levels during 50 year annual recurrence interval flood event derived from IFV study (refer report) flows.
4. All levels in terms of Lyttelton MSL datum.

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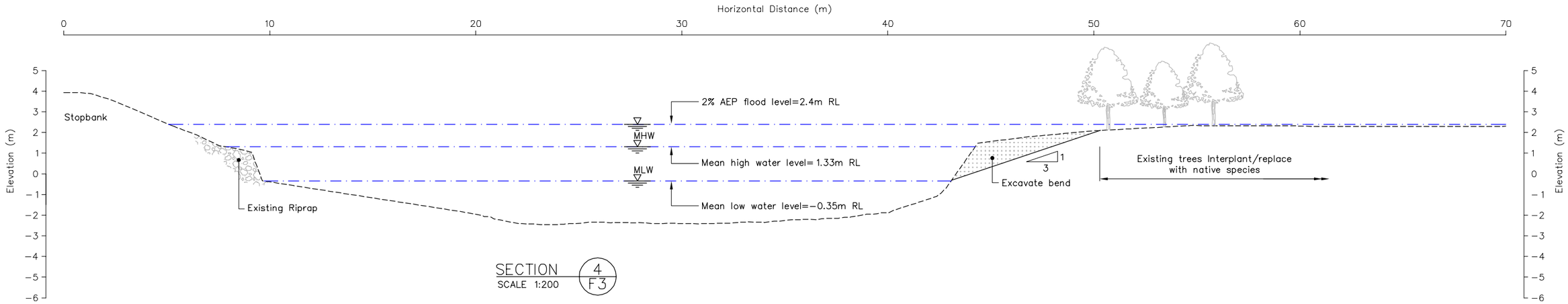
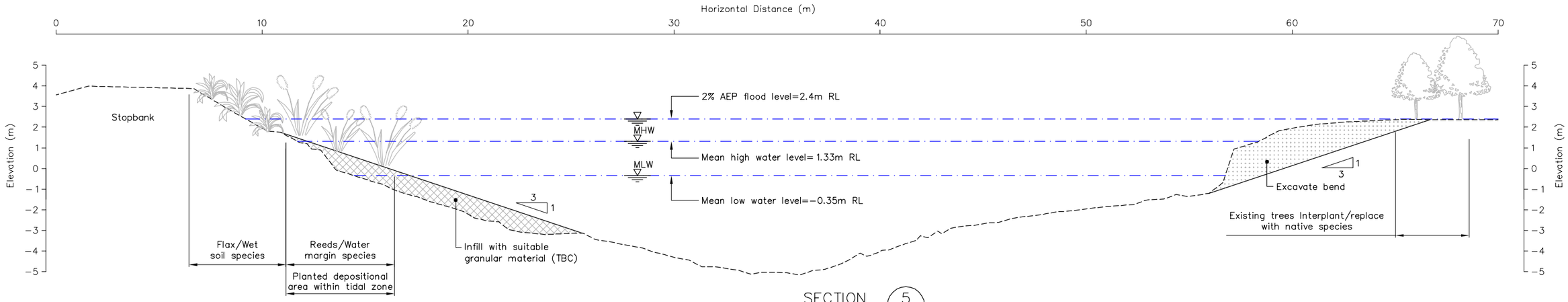
DRAWN	NSW	Apr. 16
DRAFTING CHECKED		
APPROVED		
CADFILE : \\53720.001-F4-F5.dwg		
SCALES (AT A3 SIZE) (H) 1:400 (V) 1:200		
PROJECT No. 53720.001		

KAIAPOI RIVER REHABILITATION WORKING PARTY
KAIAPOI RIVER REHABILITATION PROJECT STAGE 1A
KAIAPOI
Sediment Trap Concept Section (Sheet 1 of 2)

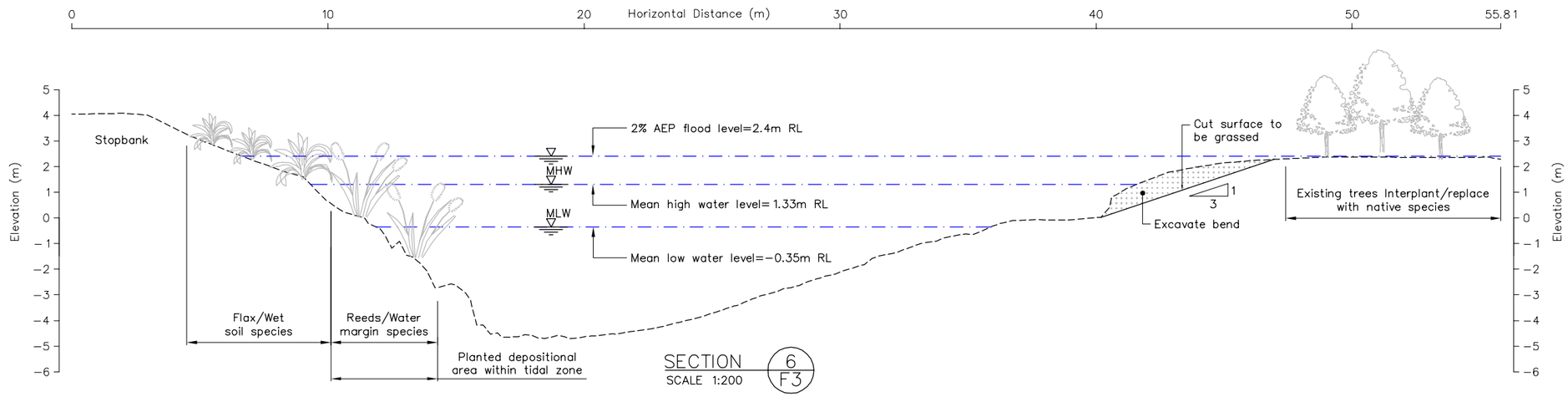
FIG. No. 53720.001-F4
REV. 0



SECTION 4
SCALE 1:200 F3



SECTION 5
SCALE 1:200 F3



SECTION 6
SCALE 1:200 F3

LEGEND

Existing ground surface

Water levels

A3 SCALE 1:200

0 2 4 6 8 10 (m)

NOTES:
1. Mean high water level refers to the approximated "peak spring tide" level in the Kaiapoi River.
2. Cross-sections and sediment depths taken & interpolated from ECan river cross-sections surveyed 2011, 2015 & 2016 provided to T&T by ECan March 2016.
3. Water levels during 50 year annual recurrence interval flood event derived from IFV study (refer report) flows.
4. All levels in terms of Lyttelton MSL datum.

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APPROVED		
CADFILE : \\53720.001-F4-F5.dwg		
SCALES (AT A3 SIZE)	1:200	
PROJECT No.	53720.001	

KAIAPOI RIVER REHABILITATION WORKING PARTY

KAIAPOI RIVER REHABILITATION PROJECT STAGE 1A
KAIAPOI

Sediment Trap Concept Section (Sheet 2 of 2)

FIG. No. 53720.001-F5

REV. 1

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