Whakawiriri Stream Hydraulic Modelling / Design Report

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Whakawiriwiri Stream - Hydraulic Modelling / Channel Design

Prepared by:	Reviewed by:	Approved by:
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Executive Summary

Introduction

A MIKE Flood model has been built of the Whakawiriwiri stream to determine the impacts of diverting water from the Tawaha Floodway into the stream at Barton's Lagoon and to also assist in the design for mitigating these effects.

The model has been built as a combined 1D/2D model using MIKE FLOOD software.

The model has been run with pre and post diversion flow scenarios to determine the impact of the extra water on the stream, as well as to assist with designing an upgrade to the channel in order to mitigate the effects of this extra water.

Summary of Design

The design is summarised as follows.

XS30 – Replace bridge (R. Bargh) and lower invert of culvert by 0.22 metres. Install wingwalls and reinstate

XS32 – Cross's Bridge (landowner – C. Cross) – remove vertical poles

XS34 – Bargh's Road Bridge (landowner – J. Bargh) – lower existing culvert by 0.47 metres, construct wingwalls and reinstate vehicle access.

XS37 – Hikinui Road Bridge (landowner – Hikinui Road Corridor)– Lower invert of culvert by 0.94 metres construct wingwalls and reinstate vehicle access.

XS39 – McCarthy's Bridge (landowner – J. Barton) – Lower Existing culvert by 0.34 metres, construct wingwalls and reinstate vehicle access.

XS47– Barton's Lagoon outlet (landowner – J. Barton), replace culvert with 0.9 m diameter culvert and lower to an invert of 11.8 metres.

The channel will be deepened and widened between section 30 and 39. The general design is for a trapezoidal channel shape with 2 metres base width and a side batter slope of 2:1. It should be noted that this may be adjusted upon final design to allow for environmental improvement work etc.

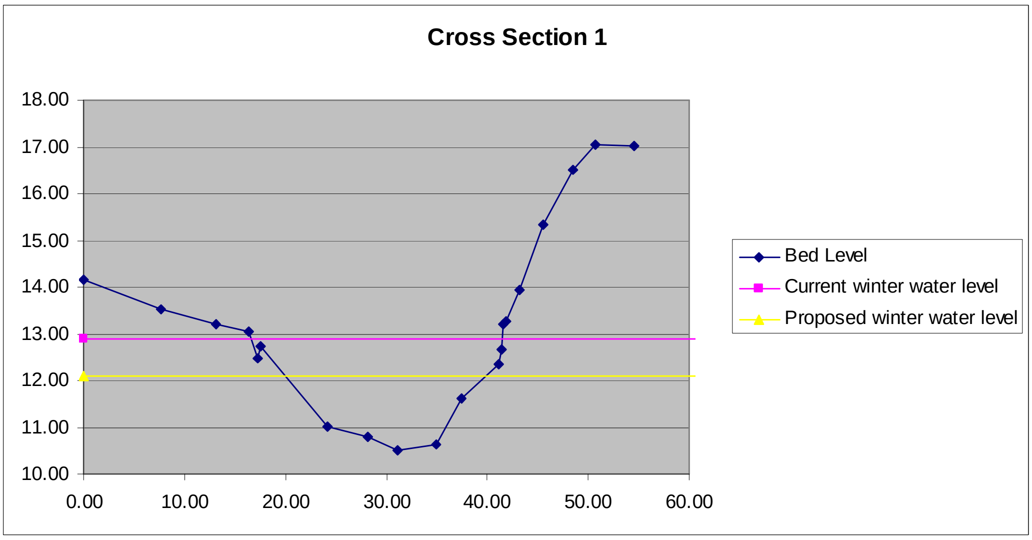
Key Conclusions

The current design which includes deepening and widening the stream as well as lowering culvert inverts, will mitigate the effects from adding extra water from the Tawaha floodway.

By upgrading the outlet culvert in Barton's Lagoon to a 900 mm diameter culvert, and lowering the outlet culvert to an invert of 11.8 metres, water levels should recede to below the weir crest in 10 hours following a flood event, providing there are no blockages in the culvert. The water levels will recede to base levels within 3 days.

Lowering the lagoon has no significant effect on the surface area, due to the steep gradient of the banks. The shallower depths are not expected to negatively impact on the environmental values of the lagoon.

Contents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Bed Level
Current winter water level
Proposed winter water level

1. Introduction

A MIKE Flood model has been built of the Whakawiriwiri stream to determine the impacts of diverting water from the Tawaha Floodway into the stream at Barton's Lagoon and to also assist in the design for mitigating these effects.

The Whakawiriwiri Stream is located in the Wairarapa; a location map of the stream downstream from Barton's lagoon is shown in Figure 1-1.

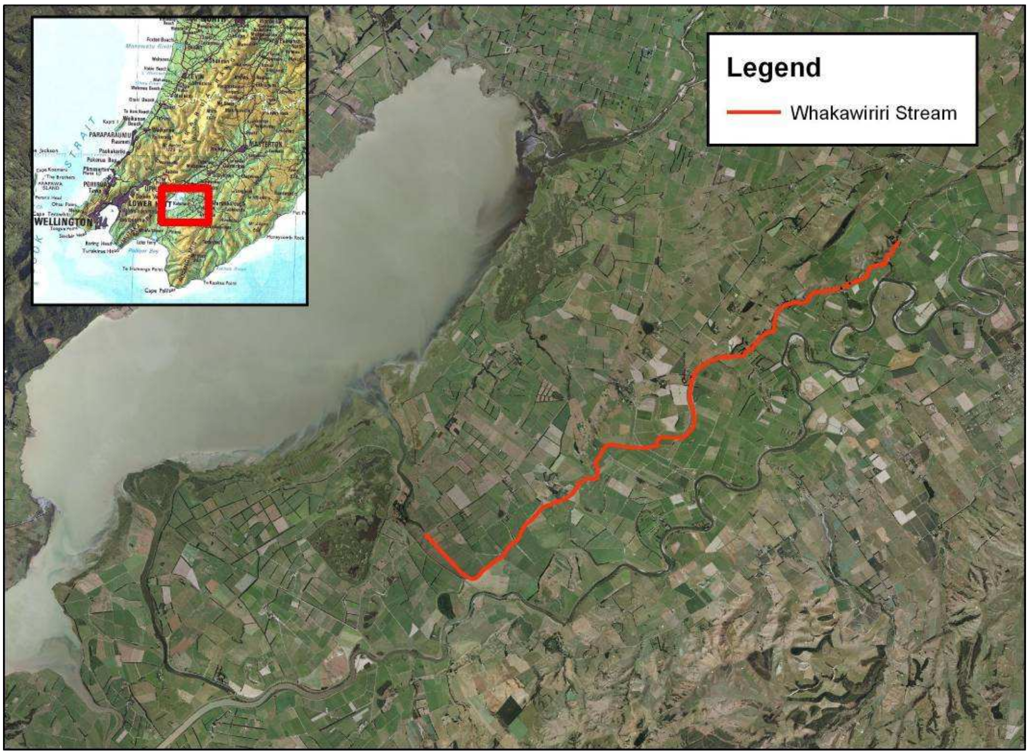

Figure 1-1 –Whakawiriwiri Stream Location Map

The history of stream and background to this investigation can be found in the Section 2 of the document titled Whakawiriwiri Stream – Flood Water Mitigation, Resource Consent Application and Assessment of Environmental Effects.

2. Survey and Data Collection

2.1 Topographic and Aerial Survey

In order to construct a MIKE FLOOD model (MIKE 11 / MIKE 21) of the Whakawiriwiri Stream, it was necessary to collect a large amount of topographic and aerial survey data.

LiDAR

LiDAR (**L**ight **D**etection **A**nd **R**anging aerial laser scanning) data was required to be used as the basis for the 2D terrain model. This data had already been flown and was readily available.

The LiDAR was flown between 7th and 14th October 2003, by Australian company AAM Hatch for GWRC. The data sheet containing a full description of the data acquisition and processing process for this job can be viewed in Appendix B

Topographic Survey

In order to accurately represent the hydraulics of the main stream channel and tributaries it is necessary to obtain detailed cross sectional data of the stream as well as details of bridges and culverts that have an impact in flows.

A detailed cross sectional survey of the Whakawiriwiri stream channel and carried out during August and September of 2011 by Adamson Shaw Ltd Surveyors. The survey picked up a total of 49 stream cross sections, 19 structures and also surveyed the stream invert at 10 metre intervals.

All surveyed data is reported to be within a tolerance of +/- 0.05 metres. The location of the surveyed cross sections and structures is shown in figure 2-1.

The raw survey data was converted into CAD (Computer Automated Design) drawings, showing stream long sections and profile views of structures by Philip Cook from Greater Wellington Regional Council. Copies of these drawings are filed in drawing set A1-10542.

2.2 Tidal Boundary

Due to the flat grade of the Whakawiriwiri Stream, the effect of the tidal boundary at Lake Wairarapa is profound in the lower reaches of the stream. The tidal boundary which has been used has been adopted based on discussions with Greater Wellington staff based in the Masterton Office. Several tidal boundary options have been considered including a high water level, extreme level as well as extreme plus climate change.

3. Hydraulic Model Setup

3.1 Introduction

A combined one dimensional (1D) channel model and a two dimensional (2D) floodplain model were constructed for the Whakawiriwiri Stream using the DHI software package MIKE FLOOD.

The advantage of modelling a river such as this as a combined 1D / 2D model is due to the fact that the main river channel and structures can be accurately represented with the assumptions necessary for a 1D model to a higher level of detail than is easily achievable with a 2D model. Modelling the floodplain in 2D also allows for a much more detailed representation than is possible in a traditional 1D model.

This brief for this project was to construct a model of the stream that could be used to determine the impact of diverting extra water into the stream and to also use the model to assist in re-grading the stream and altering / upgrading any structures.

3.2 MIKE 11 Model

The MIKE 11 channel model begins at the outlet of Barton's Lagoon and continues until the Kahutara road bridge. The extent of modelling can be clearly seen in figure 3-1.

3.2.1 Cross Sections

Cross section spacing in the model varies but is on average between 300 and 400 metres.

The maximum dx (i.e. the distance between computational H-points) was decreased to 10 metres, forcing the model to interpolate additional cross-sections at 10 metre intervals. This improves the linking between the 1D and the 2D components of the model.

Cross sections were based on a surveyed data and where necessary were extended with data extracted from LiDAR.

3.2.2 Bridges / Culverts

8 culverts and 7 bridges were included in the model. The bridges have been modelled using the bridge module available within MIKE 11.

There are a range of methods available within the bridge module in order to calculate the effects on flows through bridge structures. Due to the lack of calibration data for the bridges it was decided to adopt the energy equation, which is simplest methodology available for calculating the effects on flow through the structures. The MIKE 11 user manual describes this method as follows. "*The Energy Equation: A standard step method where a backwater surface profile is determination is used to calculate the discharge through the bridge. The method takes the contraction and expansion loss for bridges of arbitrary shape into account. The method assumes sub-critical flow and may default to critical flow for steep water surface gradients.*"

3.2.3 Channel Roughness

Initial values for bed roughnesses were assessed based on a visual inspection of photos at each section and a site walkover. The publication titled "Roughness Characteristics of New Zealand Rivers" by Hicks and Mason was used as a guide for assessing the roughness values and proved to be a very valuable resource in this exercise, as well as the reference tables for Manning's n values for Channels (Chow, 1959).

One of the problems with defining an appropriate 'manning's n' in a stream such as this is the variability in stream conditions with unpredictable amounts of weed growth and clearance. It was decided that an 'n' value of 0.045 would be applied to the entire stream length. Note: berm resistance values are included in the 2D model, refer to section 3.2.3.

3.2.4 Boundary Conditions

The downstream boundary condition for the stream is the water level in Lake Wairarapa. 2 boundary scenarios were used based on advice from staff based in the Wairarapa. These were a water level of 10.22 metres for a normal scenario and also a high water level of 10.7 metres assuming a blockage at the mouth of Lake Onoke. A climate change scenario has also been run with a level of 11.2 metres assuming 0.5 metres on top of the high water level scenario.

Flow scenarios have been based on historic design scenarios which have been used for this stream. These have been based on a constant drainage rate of 25mm/24hr period. The catchment for the stream has been split into subcatchments based on those used in the "Whakawiriwiri Stream 2005 Review" (Duncan, 2005). The subcatchments used are shown in figure 3-1. The Te Maire, Whaka 5 and Whaka 6 subcatchments have been added based on analysis of the topographic data.

Figure 3-1 – Subcatchments used for Hydrology

Flow rates for each subcatchment have been calculated based on this assumed drainage rate of 25 mm/24 hour and are specified below in Table 3-1.

Table 3-1 – Design peak flowrates for subcatchments

Subcatchment Name	Area (ha)	Flow (m^3/s)
Whaka 1	404.1	1.17
Whaka 2	80.8	0.2
Whaka 3	146.2	0.42
Whaka 4	105.6	0.31
Tawaha 1	117.8	0.34
Tawaha 2	122.2	0.35
Te Maire	863.3	2.50
Whaka 5	2272	6.57

Due to the lack of gauging information in the Whakawiriwiri Stream it was necessary to estimate a typical base flow in the winter months. In order to do this, I analysed the gauged flow information in the Parkvale Stream which has a well defined catchment area. Based on 10 years of flow during the winter months of June, July and August I estimated a typical wet base flow was approximately 1.3 m^3/s. Based on a catchment area of 11,770 hectares, this gives an average ratio of 0.11 m^3/s for every 1000 hectares of pasture. Based on this ratio, typical base flows for each sub-catchment are summarised in table 3-2.

Subcatchment Name	Winter Baseflow (m^3/s)
Whaka 1	0.04
Whaka 2	0.01
Whaka 3	0.02
Whaka 4	0.01
Tawaha 1	0.01
Tawaha 2	0.01
Te Maire	0.09
Whaka 5	0.25

Hydrographs were created based on these flows.

3.3 MIKE 21 Model

3.3.1 Digital Elevation Model

As discussed in Section 2.1, LiDAR has been used as the basis of the 2D terrain model. The raw LiDAR data has been converted into a Digital Elevation Model (DEM) using ArcGIS 3D analyst tools. It was decided that a 10 metre grid size would be appropriate to achieve the necessary resolution for flood mapping and to still allow for appropriate model run times.

3.3.2 LiDAR Accuracy

The accuracy of the LiDAR was checked by comparing levels with a range of surveyed cross sections in clear ground away from the river channel and thick vegetation. As a result of this it was found that on average the LiDAR data was approximately 0.18 metres higher than the survey data. In order to rectify this error, the final DEM that was used was lowered by this amount. Figures 3-2, 3-3 and 3-4 show 3 comparisons between the surveyed data and the LiDAR data at section 45, 44 and 25. Note that the LiDAR data does not read accurately beneath the water surface, nor through thick vegetation.

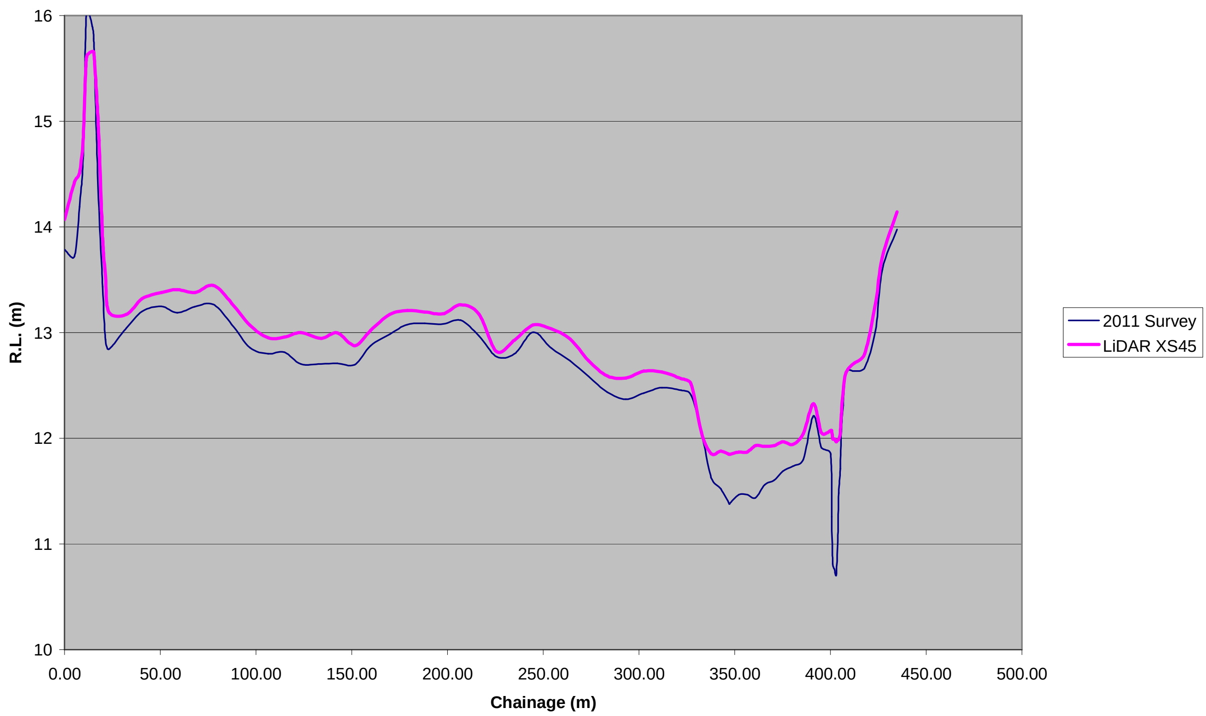

Figure 3-2 – Comparision of LiDAR and survey data at cross section 45

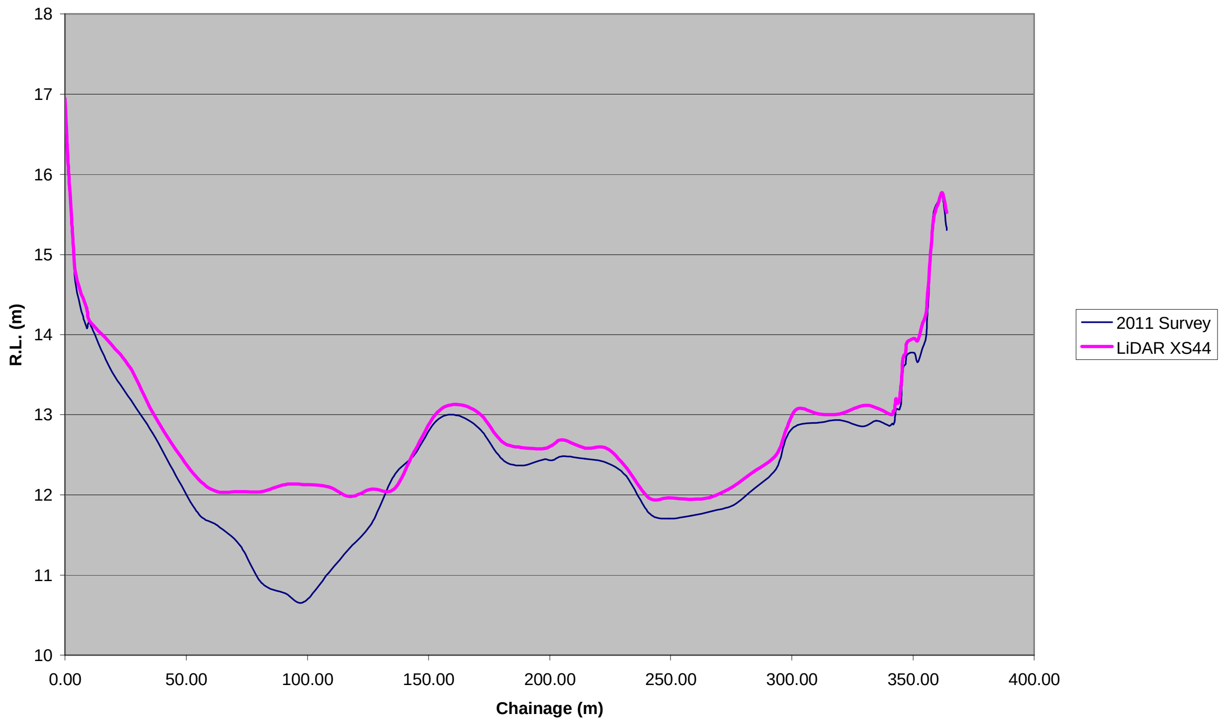

Figure 3-3 – Comparision of LiDAR and survey data at cross section 44

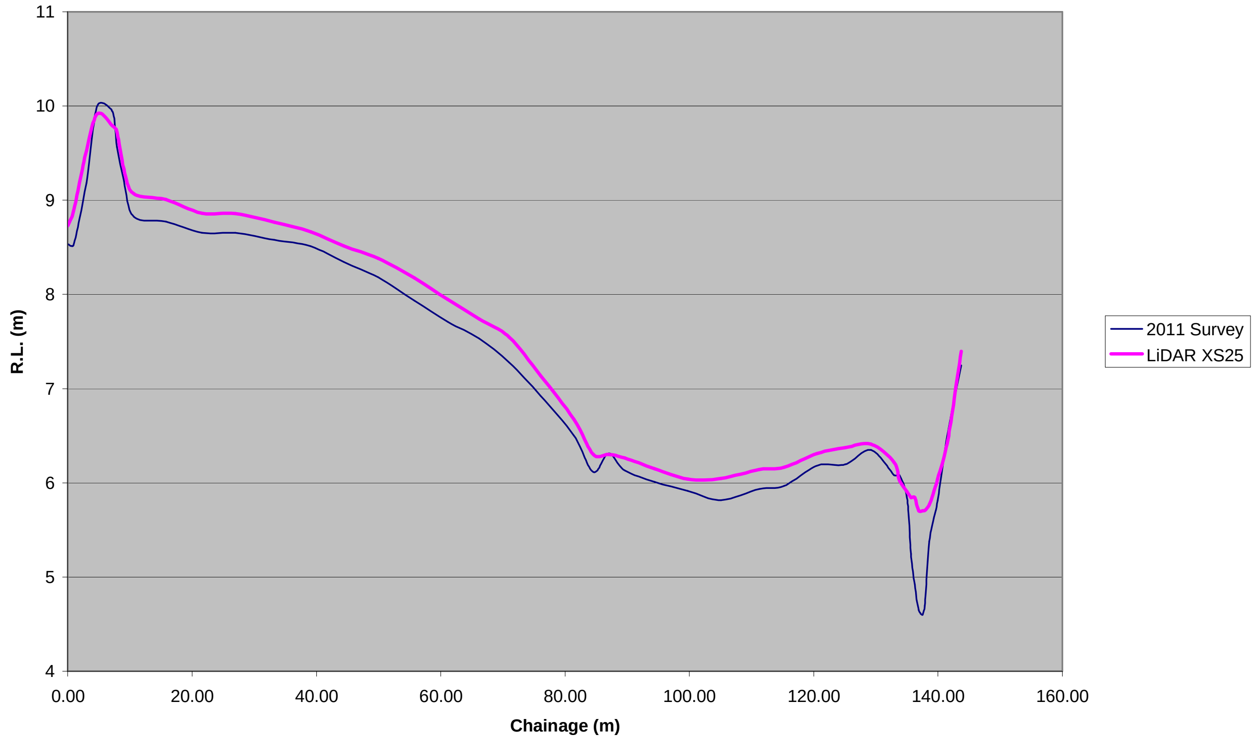

Figure 3-4 – Comparision of LiDAR and survey data at cross section 25

3.3.3 Modelling parameters

Due to the uniform nature of the area, floodplain and berm resistances were given an overall manning's n value of 0.033.

Flooding and drying depths have been taken as 0.02 and 0.01 respectively.

Eddy viscosity has been set at 0.1.

4. Design Runs

The primary purpose of the model is to determine the necessary works required to upgrade the stream in order to mitigate the effects of the additional flow from the diversion from the Tawaha Floodway into Barton’s Lagoon. As well as to determine the effects of the increased flows on flood levels in the stream.

Figure 4.1 outlines the inflows and outflows through the Barton’s lagoon as it is represented in the model. The model has been used to analyse 3 different flow scenarios, which look at varying amounts of flow from the Whakawiriwiri Stream, the Tawaha loop drain and an extra 1.6m^3/s being released over 8 hours from the Tawaha floodway.

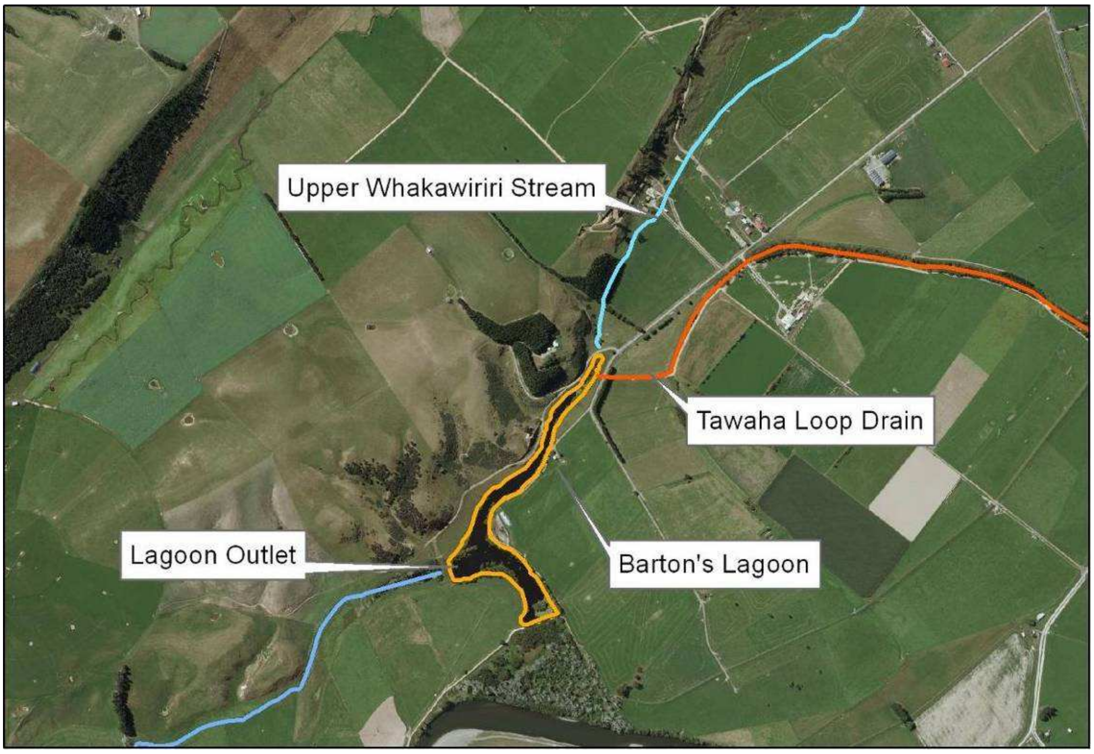

Figure 4-1 – Barton’s Lagoon flows.

Table 4-1 summarises the simulations used to design and assess the effectiveness of the proposed channel upgrade.

Table 4-1 – Summary of model runs

Run	Network	Cross Sections	Inflows	Notes
1	Original	Original	Whakawiriwiri Stream only	Models pre 1979 conditions
2	Original	Original	Whakawiriwiri and Tawaha	Models post 1979 conditions
3	Current	Current	Whakawiriwiri and Tawaha	Models current conditions (includes recent upgrade on Bartons property)
4	Current	Current	Whakawiriwiri and Tawaha + 1.6 m^{3s} floodwater release	Models current conditions with a flood flow from the tawaha floodway
*5	Upgraded	Upgraded	Whakawiriwiri and Tawaha + 1.6 m^{3s} floodwater release	Models the final design situation in a design flood

*Run 5 actually involved several iterations which involved modifying the bed levels, channel shape and culvert inverts in the stream to mitigate the effects of the diversion. The final iteration is presented in this report which is to be used for the final design. The final design is detailed in Appendix B.

Further runs have also been conducted which look into modifying the outlet culvert in Barton's lagoon to maximise the utilisation of the lagoon for storage, however not allowing the lagoon to remain at a high level for a lengthy period of time.

In order to determine the ideal configuration for the outlet culvert from Barton's lagoon, several factors need to be taken into consideration. These include:

- The ability for water to flow out of the lagoon (governed by downstream conditions)
- The ability for water to freely enter the lagoon without preventing drainage from upstream properties. (governed by lagoon water levels). The optimal water level has been decided as the invert of the inlet culvert which is approximately R.L 11.77 metres. However, it has also been assumed that if the culvert is flowing 1/3 full then that would be acceptable, therefore a water level 12.23 would be appropriate.
- The ability for the lagoon to be used as storage during a flood event, to prevent excessive volumes of water being sent downstream, adversely affecting downstream landowners.

The following lagoon configurations have been modelled. It should be noted that the results are sensitive to the base flow that is used, and it has been decided to adopt a baseflow that is 1.25 times greater than that which was estimated based on the flows in the Parkvale stream.

Table 4-2 summarises the options modelled for the culvert configuration.

Table 4-2 – Barton's Lagoon Culvert Configuration Runs

Run	Notes
6	Current culvert conditions (upstream invert 12.12m downstream invert 12.07 m)
7	0.45 culvert lowered to an invert of 12.0 metres
8	0.45 Culvert lowered to an invert of 11.8 metres
9	0.6 culvert at an invert of 11.8 metres
10	0.9 culvert at an invert of 11.8 metres
11	0.45 culvert lowered to an invert of 11.4 metres

4.1 Summary of upgraded channel design (run 5)

The following works have been included in the final upgraded design:

4.1.1 Structure Upgrades

XS30 – Replace bridge (R. Bargh) and lower invert of culvert by 0.22 metres. Install wingwalls and reinstate

XS32 – Cross's Bridge (landowner – C. Cross) – remove vertical poles

XS34 – Bargh's Road Bridge (landowner – J. Bargh) – lower existing culvert by 0.47 metres, construct wingwalls and reinstate vehicle access.

XS37 – Hikinui Road Bridge (landowner – Hikinui Road Corridor)– Lower invert of culvert by 0.94 metres construct wingwalls and reinstate vehicle access.

XS39 – McCarthy's Bridge (landowner – J. Barton) – Lower Existing culvert by 0.34 metres, construct wingwalls and reinstate vehicle access.

XS47– Barton's Lagoon outlet (landowner – J. Barton), replace culvert with 0.9 m diameter culvert and lower to an invert of 11.8 metres.

4.1.2 Channel Deepening / Widening

The channel will be deepened and widened between section 30 and 39 The general design is for a trapezoidal channel shape with 2 metres base width and a side batter slope of 2:1. It should be noted that this may be adjusted upon final design to allow for environmental improvement work etc.

5. Results

5.1 Stream and Floodplain water levels

In order to compare the results, we can compare both the water levels in the 1D channel model and the in 2D floodplain model. In order to determine the effectiveness of the upgrade to mitigate the effects of the increased flow due to the diversion from the Tawaha, it is critical to compare the differences in water level from runs 1 and 5.

First comparing the 1D model results, Figure 5-1 compares the water levels of the situation before the diversion took place, and the proposed upgrade.

Figure 5-2 looks at more detail at the water levels upstream of Pahautea Road Bridge which is where the works end.

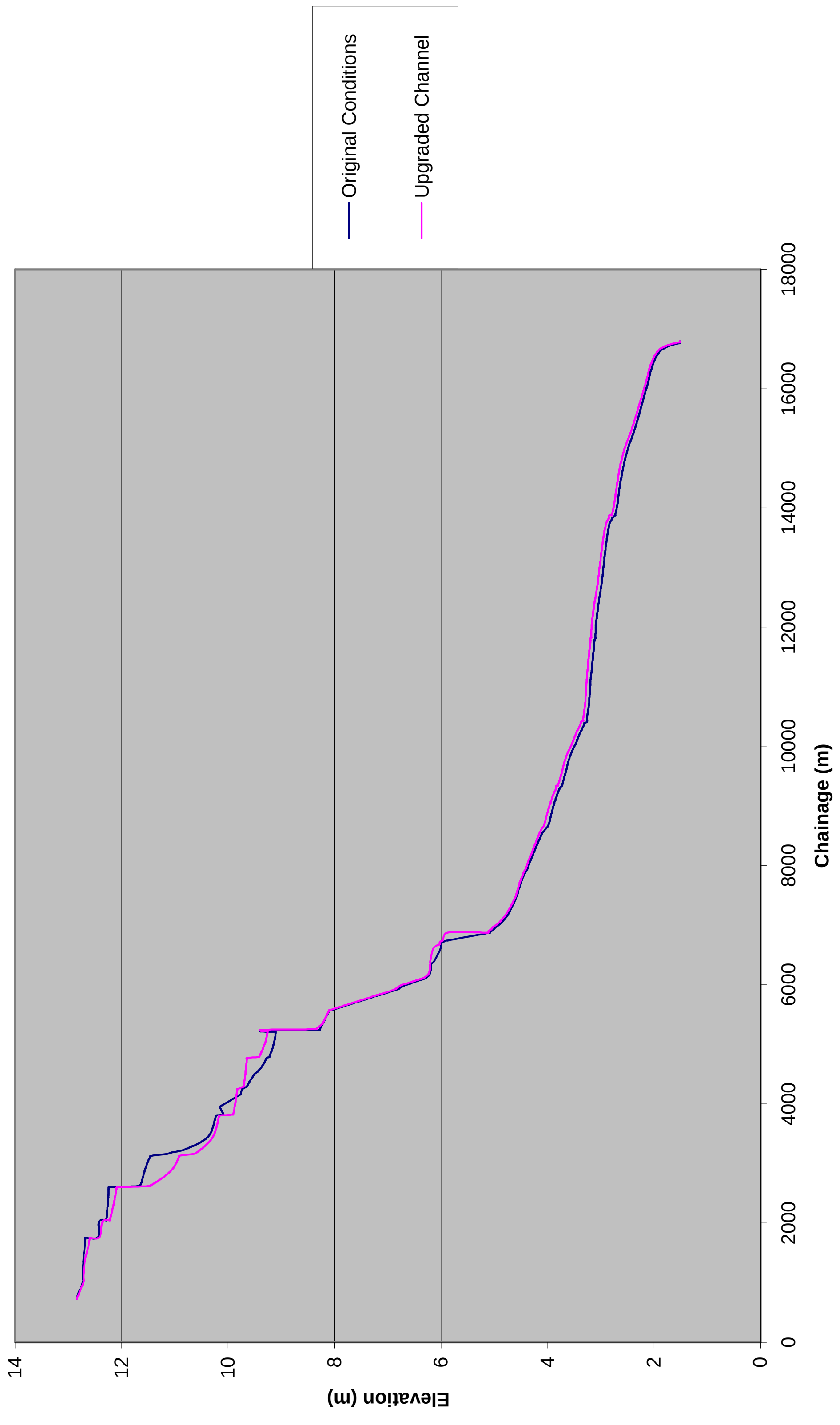

Figure 5-1 – Comparison of water levels with original conditions and after the upgrade with the diversion

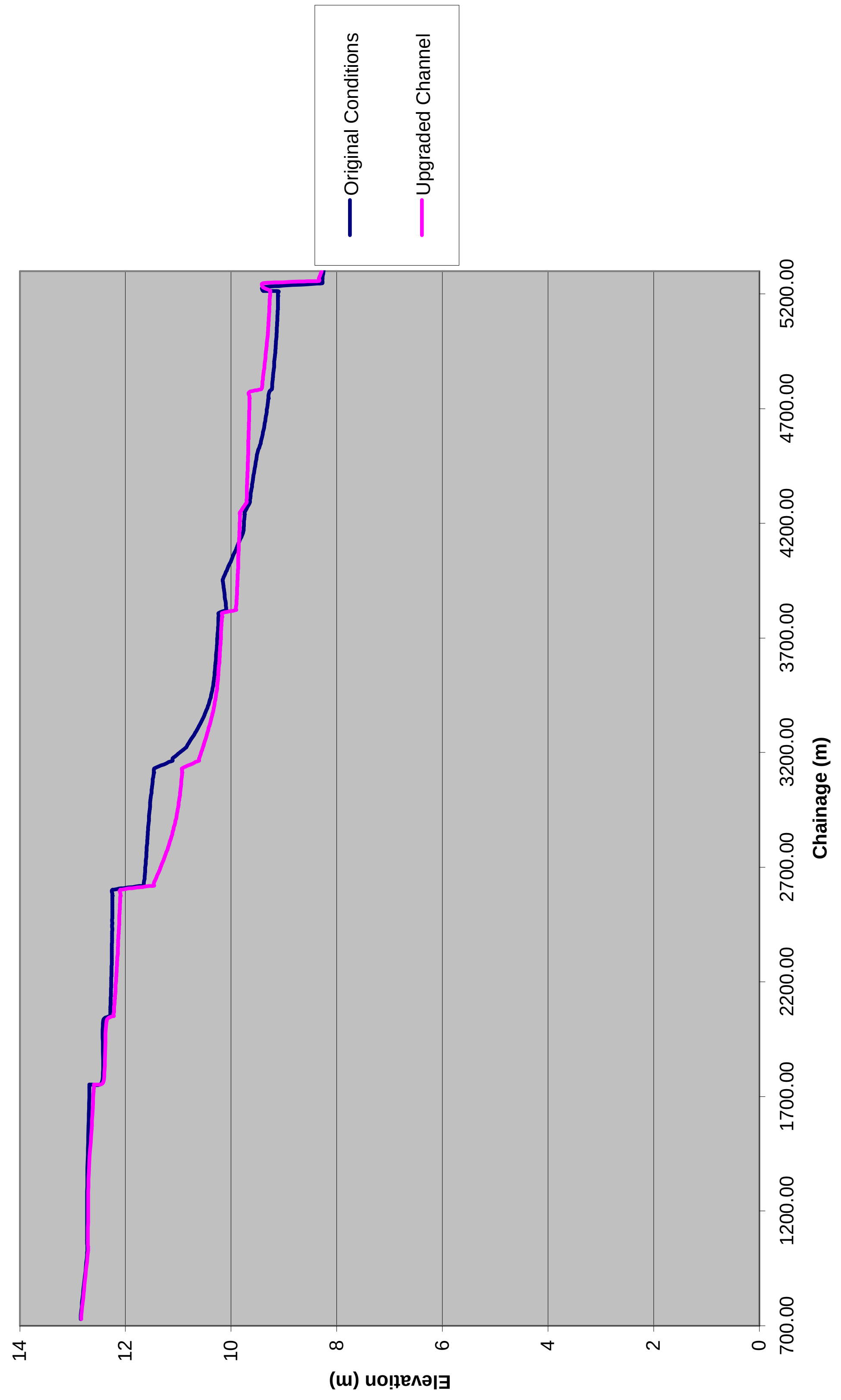

Figure 5-2 - Comparison of water levels with original conditions and after the upgrade with the diversion – upstream of Pahautea Road Bridge

It can be seen in this figure that immediately upstream of this bridge the water levels are raised by approximately 0.2m. This is due to the swale under the bridge blocking the flow. It has been assumed in this model that the small diameter culvert under this swale is completely blocked. Unless this swale is removed the water levels will not drop upstream from here, however this swale has been left there purposely to prevent the erosion downstream of this point getting any worse. However it can be seen when comparing the flood spread, that this has little impact on flood water levels.

It can be seen that downstream from chainage 2700 metres to approximately chainage 3200 metres, the water levels are significantly lower in the upgraded channel. In order to bring the pre and post water levels closer to each other in this reach it would be necessary to create a very steep slope further downstream, it was decided that maintaining an even grade would be more desirable and easier to construct as well as avoid the installation of energy dissipation devices.

Comparing the flood spread on the flood plain, figures 5-3, 5-4, show the flood spread upstream of the bridge, before and after the upgrade. Figure 5-5 shows the difference in water levels between the two runs.

It can be seen that the most significant increase in flood levels is in the area of Duffy's lagoon which is shown in yellow. This indicated an increase in flood levels of approximately between 0.05 and 0.1 metres. On closer inspections it can be found that this is closer to 0.08 metres increase in water levels from the extra flow from the Tawaha.

Sensitivity runs were also carried out with a raised downstream boundary level of 10.7 m (Wairarapa Datum). This is a typical water level if there is a mouth blockage at Lake Onoke. Figure 5-9 shows the difference in water levels downstream of Pahautea Road

Figure 5-3 – Flood extent with original conditions (Run 1), upstream of Pahautea Road

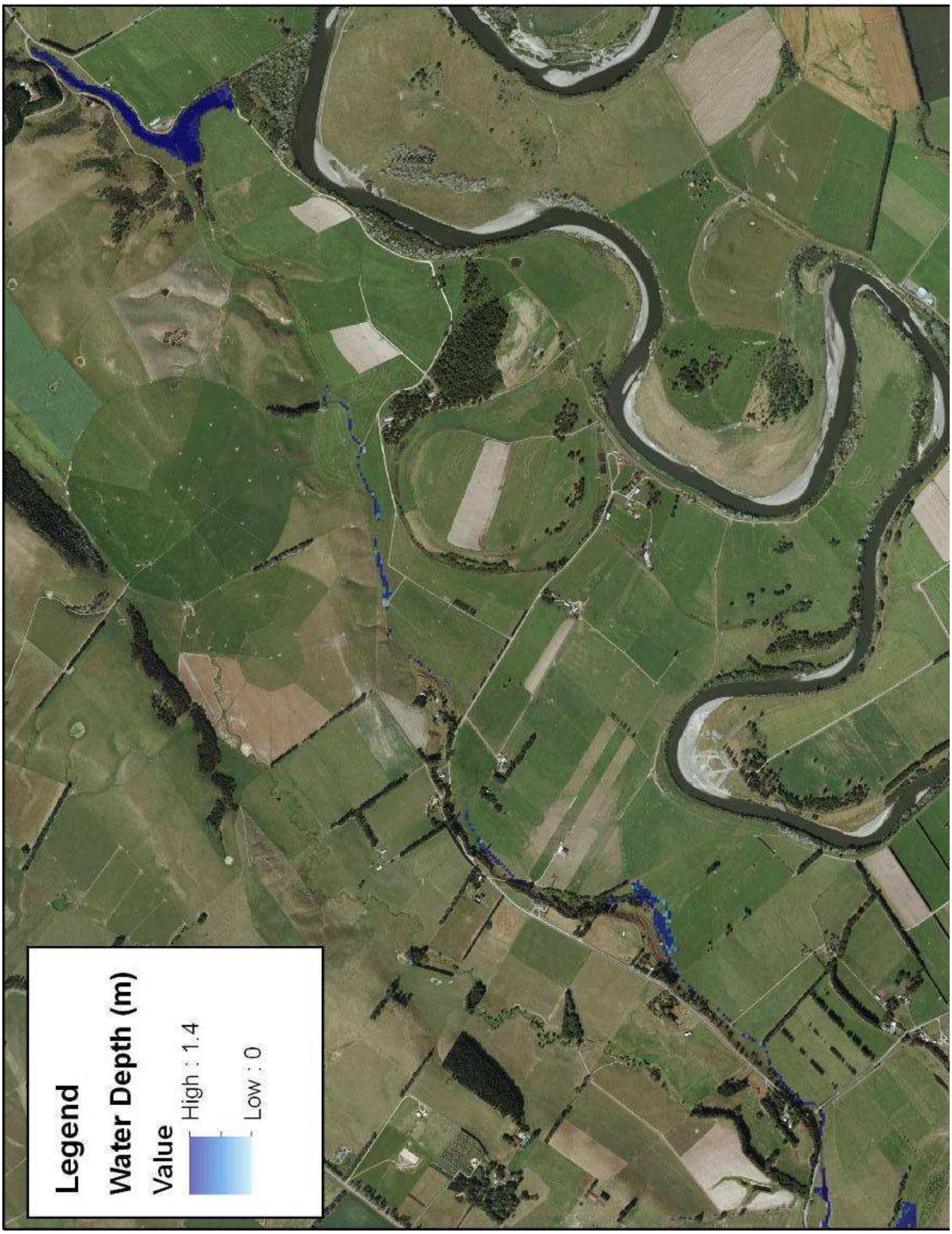

Figure 5-4 – Flood extent with upgraded conditions (Run 5), upstream of Pahautea Road

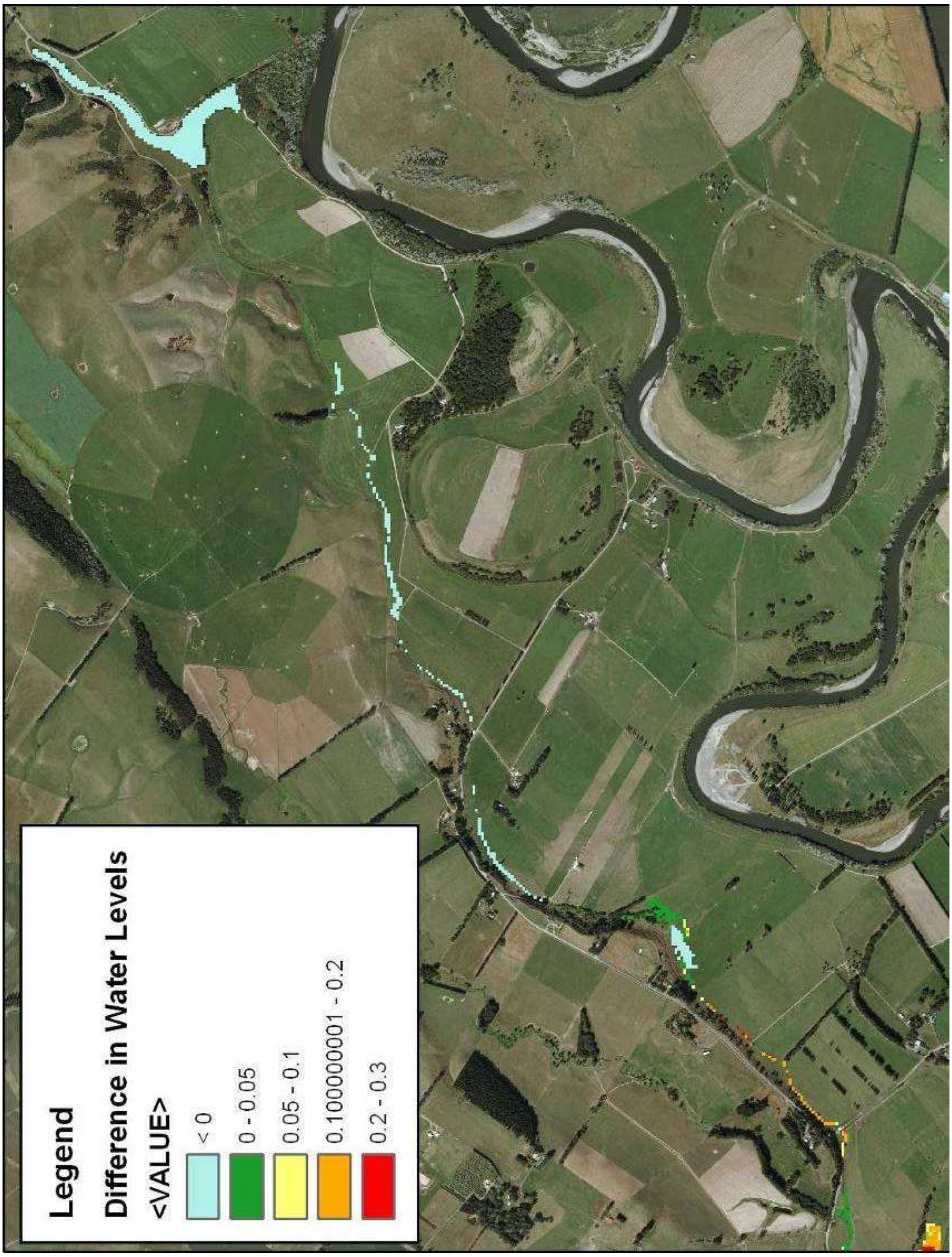

Figure 5-5 – Difference in flood levels with upgraded conditions, upstream of Pahautea Road

Figures 5-5, 5-6, show the flood spread downstream of the bridge, before and after the upgrade. Figure 5-7, shows the difference in water levels between the two runs.

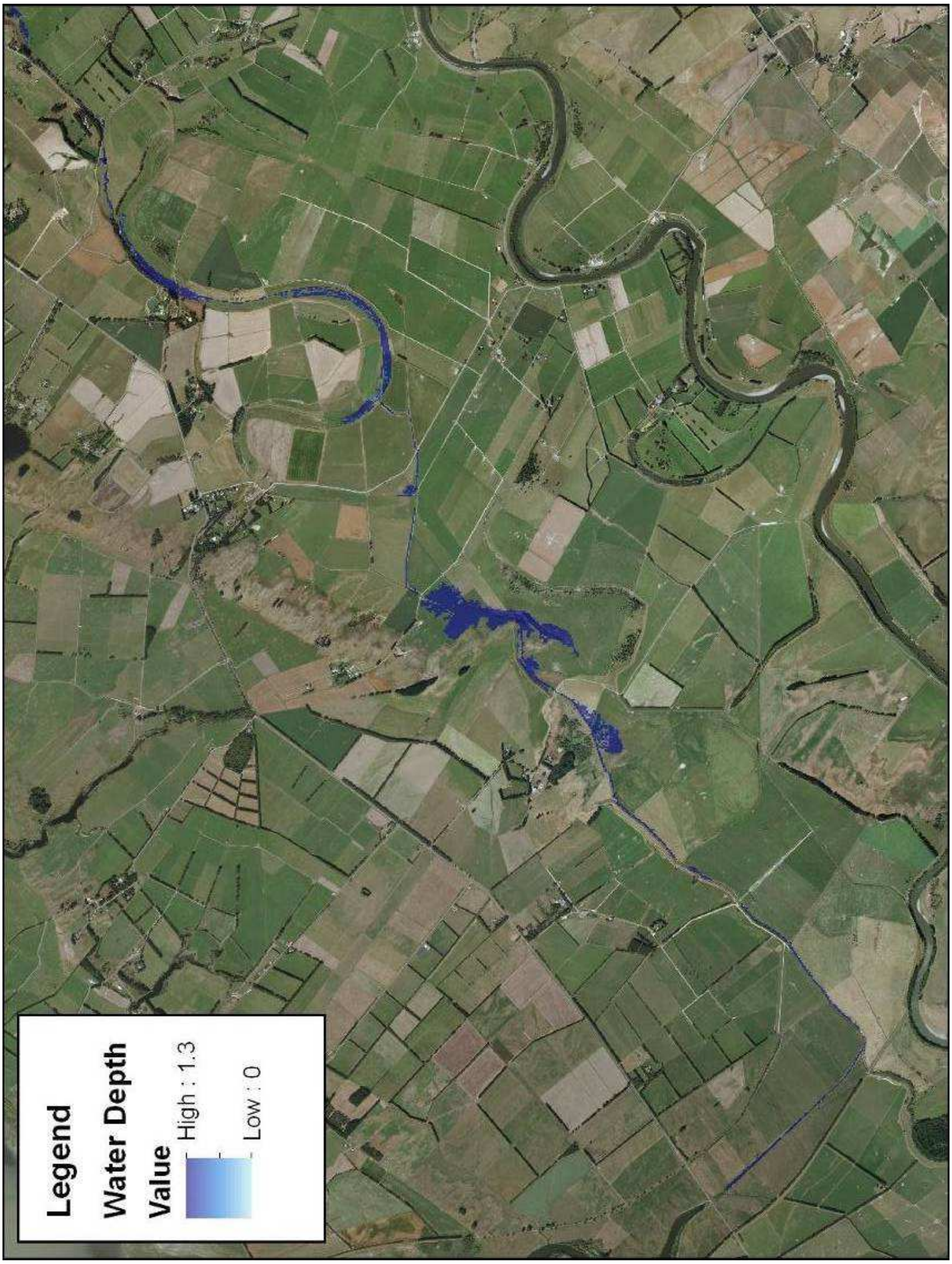

Figure 5-6 – Flood extent with original conditions (Run 1), downstream of Pahautea Road

Figure 5-7 – Flood extent with upgraded conditions (Run 5), downstream of Pahautea Road

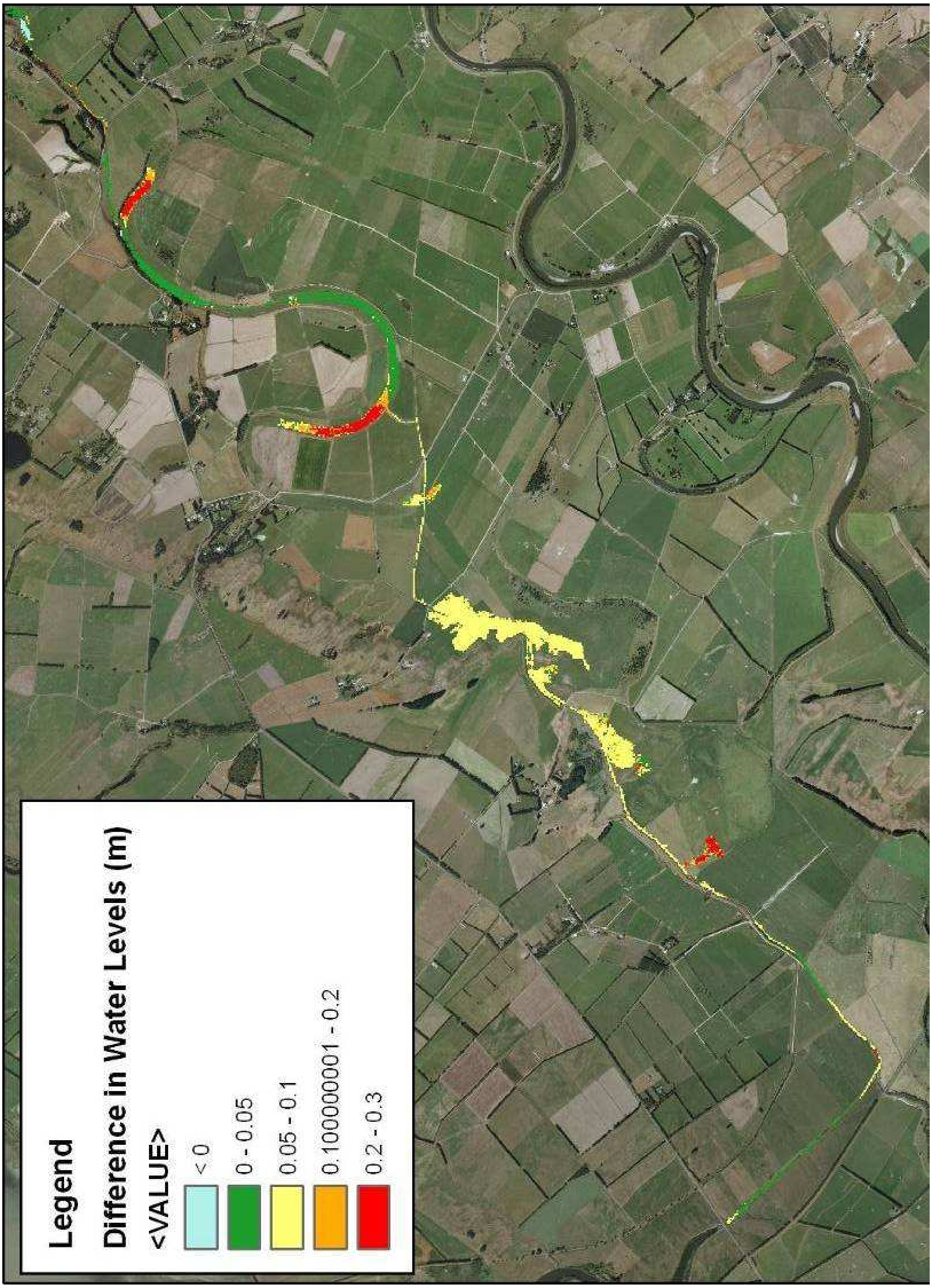

Figure 5-8 – Difference in flood levels with upgraded conditions, downstream of Pahautea Road

5.1.1 High tide and climate change sensitivity

Sensitivity runs were also carried out with several high tide scenarios to measure the impact of the tidal boundary on flood depths, particularly in the Duffys Lagoon vicinity. Sensitivity runs showed that increasing the tidal boundary had no significant impact on the flood depth or extent based on the flows in use.

5.2 Configuration of Barton's Lagoon Outlet Culvert

Figure 5-9, presents the results of the runs outlined in table 4-2. The figure shows three benchmark lines which are the recorded water level in August 2010, the invert of the inlet culvert, and also the water level at which the inlet culvert would be flowing 1/3 full. This level has been reported to be an acceptable operating level to upstream landowners.

Figure 5-9 shows the following key points:

- That simply clearing and maintaining the entrance to the outlet culvert will lower the water level in the lagoon by approximately 0.4 metres during normal winter baseflows.

- That further enlarging and lowering the culvert slight will also assist in lowering the water levels.

- That by enlarging and lowering the culvert to a diameter of 600 mm and an invert of 11.8 metres, the inlet culvert will be less than 1/3rd full during winter base flow conditions. This will lower the lagoon by approximately 0.7 metres from its current level, however only by 0.4 metres from its ideal level providing the outlet culvert was kept clear of any blockages.

- That the water level in the lagoon could potentially be lowered to below the invert of the inlet culvert if the outlet culvert was lowered to an invert of 11.4 metres. However it should be noted that the levels in the lower lagoon have not been simulated in this exercise, and I do not believe that the levels in this lagoon could be lowered to that level to realistically achieve this. The effects on the lagoon will also be very significant, and are likely to reduce the surface area significantly.

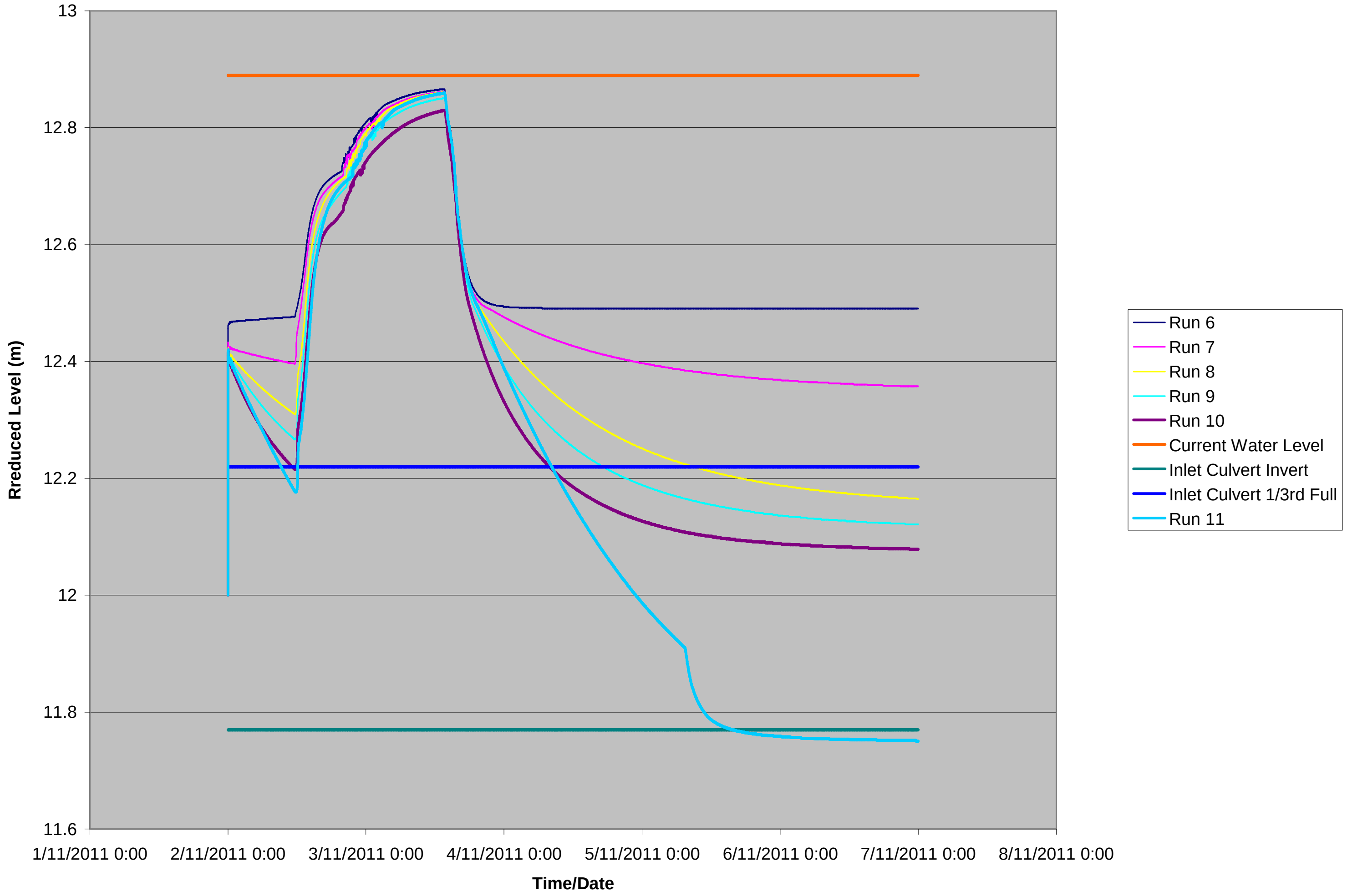

Figure 5-9 – Water levels in Barton's Lagoon

The impact on the lagoon from choosing run 10 are shown in the following figures.

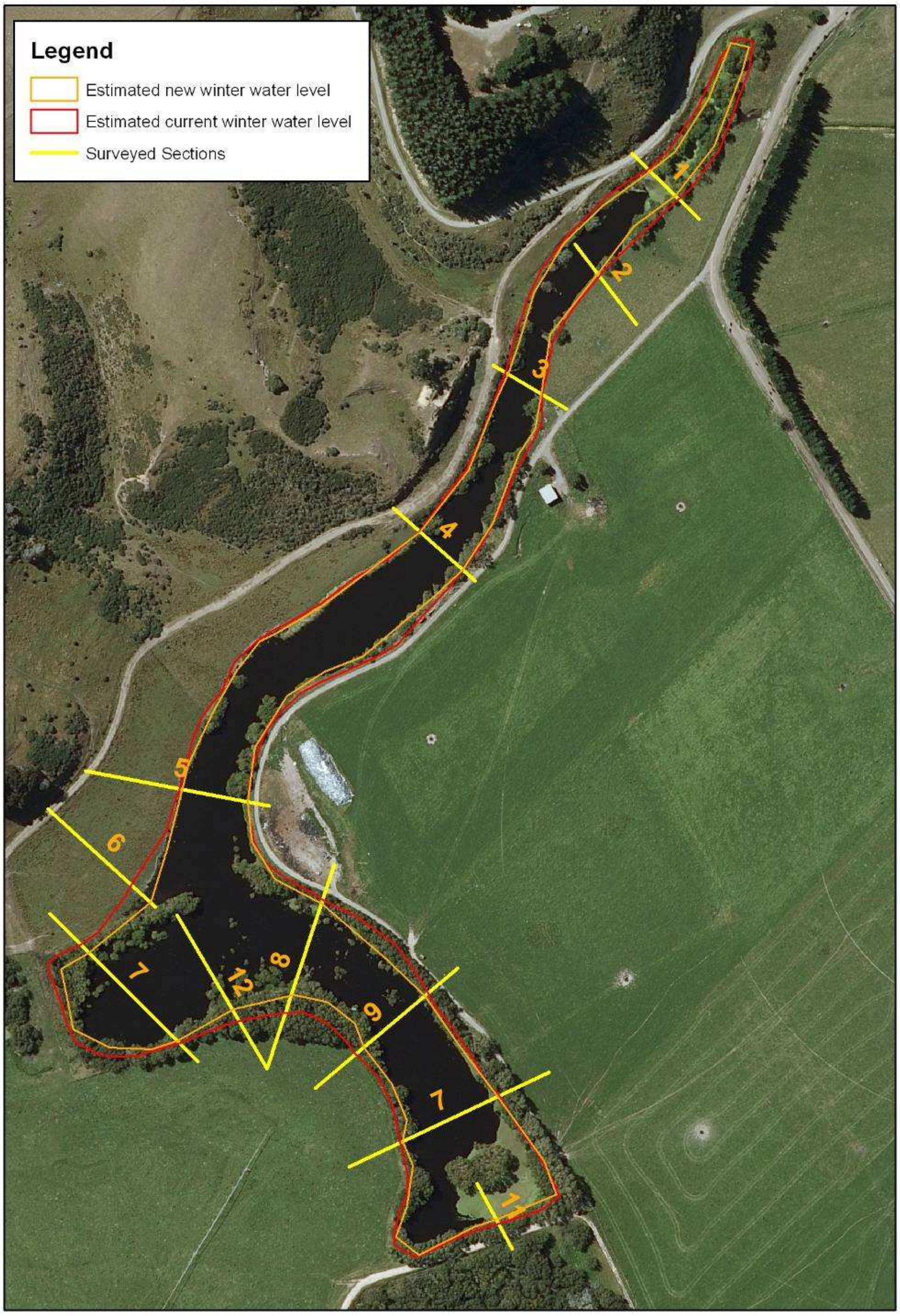

Figure 5-10 – Difference in areal extent of water level with lowering of outlet culvert

It can be seen from this figure that lowering the water level has minimal impact on the surface area of the lagoon. The impact on the depth at each cross section shown can be seen in Appendix D.

5.3 Bed erosion

Water velocities around 1 m/s are generally considered acceptable for a drain of this type. It should be noted that immediately downstream of Pahautea Road Bridge velocities reach approximately 1.2 m/s for the next 1 kilometre, where the gradient is much steeper than the rest of the stream. Some form of edge protection may need to be installed here to limit further erosion. The velocities are below 1 m/s for the rest of the stream.

6. Conclusions

Based on the results of the work outlined in this report, including historic investigations, the following conclusions can be made.

- The current stream is under capacity to take the extra volume of water and peak flows from the Tawaha floodway diversion.
- Previous studies have indicated that deepening/widening of the stream is the ideal solution. This report has solely focused on the required extent of works and associated impact of the works along the stream and the impact of flows and water levels in and around Barton's Lagoon.
- The new hydraulic modelling results for which now include whole stream reach as shown on drawing A1-10542 in Appendix B, confirm that the original design concepts of deepening and widening the stream as well as lowering culvert inverts provide the most cost effective solution to mitigate the effects from adding extra water from the Tawaha floodway.
- The engineering works required to mitigate the effects of the higher peak flows and volumes attributed to the Tawaha flood way diversion include deepening and widening of the stream to design bed levels and design cross sections , lowering of culverts, a larger culvert at the outlet of Barton's lagoon and lowering of the base level of Barton's lagoon .The full extent of the proposed works are detailed on plans A1-10542 in Appendix B.
- The hydraulic modelling results indicate that optimal solution for practical design and construction reasons, can be achieved by adopting variable grades, rather than one consistent grade along the length of the stream.
- Lowering the lagoon has no significant effect on the surface area, due to the steep gradient of the banks. The shallower depths are not expected to negatively impact on the environmental values of the lagoon. Refer to charts in Appendix C.
- Increasing the diameter of the Barton's Lagoon outlet culvert is likely to reduce the likelihood of blockages to increase the flow out of the lagoon and lower the water levels. It will also assist with lowering the raised levels in the lagoon more efficiently after a flood event.
- Based on the modelling results, by upgrading the outlet culvert in Barton's Lagoon to a 900 mm diameter culvert, and lowering the outlet culvert to an invert of 11.8 metres, water levels will recede to below the weir crest in 10 hours following a flood event, providing there are no blockages in the culvert. The water levels will recede to base levels within 3 days.

Appendix A - LiDAR Data Sheet

AAMHATCH
Incorporating Geoscan

DIGITAL DATA: DOCUMENTATION

THE GREATER WELLINGTON REGIONAL COUNCIL

AIRBORNE LASER SCANNING - WAIRARAPA

VOLUME 81021701NOB

Summary Data Description

Airborne Laser Scanning was captured over the Wairarapa region between 7th and 14th October 2003. The objective was to acquire a digital terrain model to a standard height error of 0.2m over the area known as option 2, encompassing 17137 hectares.

This volume contains gridded ground data with a spacing of 2.5m.

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Other Representatives: Sydney, Melbourne, Perth

1. PROJECT REPORT

Acquisition: Airborne Laser Scanning (ALS) data was acquired from a fixed wing aircraft between October 7th and 14th. Delays in acquiring the data were due to low cloud and flooding over the project area.

Ground Support: GPS base station support was provided by OPUS International Consultants without incident. The ground check points acquired by OPUS International Consultants allowed an assessment of the accuracy of the ALS data.

Data Processing: Reduction of the ALS data proceeded without any significant problems. Laser strikes were classified into ground and non-ground points using a single algorithm across the project area. Manual checking and editing of the data classification against intensity images and orthophotos provided by the client further improved the quality of the terrain model.

Further Processing: A digital terrain model was formed by triangulating the ALS ground strikes at every 2.5m interval.

Data Presentation: The data provided on this volume has been supplied in accordance with a specification agreed with the primary client. Subsequent users experiencing difficulties in handling the data should please contact AAMHatch to arrange a more appropriate data presentation.

Further Issues: There are no further issues to report.

2. DATA INSTALLATION

Data format	:	Space delimited ASCII
Number & type of media	:	One 700MB CD ROM
Media format	:	CD-ROM format
Number of files in dataset	:	77, corresponding to 2*2km mapsheets
Data formatted on	:	02.12.03
Disk volume	:	81021701NOB
AAMHatch Job Manager	:	Mr. D. Turton 07 3891 1033 Ms. P. Hyam 07 3891 1033

README FILE

This document (README.PDF) is provided as an Acrobat file in this volume.

To open the file, double click on the PDF file to activate Acrobat Reader Software. Adobe Acrobat Reader may be downloaded from:
http://www.adobe.com/products/acrobat/readstep2.html

FILE SIZES AND NAMES

Data is provided in tiles 2km by 2km to the following filenaming convention:

eg. W27146001.lat	W -	project abbreviation
	2714 -	coordinate easting (in thousands) of south west tile corner
	6001 -	coordinate northing (in thousands) of south west tile corner
	.lat -	Ground strikes triangulated into a 2.5m lattice

A list of the files contained on this volume is provided in Section 7.

SAMPLE LISTING

E	N	RL
2715425.000	6001000.000	59.620
2715427.500	6001000.000	59.170
2715430.000	6001000.000	59.020
2715432.500	6001000.000	58.710
2715435.000	6001000.000	57.820
2715437.500	6001000.000	56.920
2715440.000	6001000.000	56.030

etc.

3. ADDITIONAL SERVICES

AAMHatch can perform the following additional services on the data contained on this volume if required:

Change horizontal datum	:	to NZTM or other local grid
Alter geoid modeling	:	by transforming ALS data to fit orthometric survey heights
Improve data classification	:	by tailoring parameters to suit regional variations
Further classification	:	Assist building identification by further classifying non-ground strikes
Data thinning	:	to remove superfluous points not adding to the terrain definition
Data subset	:	by dividing the data into different tiles or polygons
Data presentation	:	by creating contours, profiles, perspectives, flythroughs, colour-coded height plots etc.
Ground truthing	:	by comparing the ALS terrain model with extra independent height data
Intensity Image	:	Greyscale image created from laser's intensity returns. (sample below)

4. METADATA

DATA CHARACTERISTICS

Characteristic	Description
Format	Space delimited ASCII
Size	28 million data points (approximate)
Captured terrain model	1.4m average point separation
Laser return	Last pulse
Laser footprint size	0.24m
Video	Captured over the project area (not supplied)

REFERENCE SYSTEMS

	Horizontal	Vertical
Datum	NZGD 1949	Unknown
Projection	NZMG	N/A
Geoid Model	N/A	EGM96
Reference Point	Pahautea Road (BAED) 5996183.67 N 2787789.02 E	Pahautea Road (BAED) 26.182 RL

SOURCE DATA

	Source	Description	Ref No	Date
Laser scanning	AAMHatch	25,000 Hz	810217	7-14.10.03
GPS base data	AAMHatch	Static GPS	810217	7-14.10.03
Base Stn coords	Opus International Consultants Ltd	Static GPS	810217	15.10.03
Test points	Opus International Consultants Ltd	RTK GPS	810217	15.10.03

ACCURACY

	Measured Point	Derived Point	Basis of Estimation
Vertical data		0.104	Comparison with 111 test pts
		0.15	Deductive estimate
Horizontal data	< 0.55		System specifications ($^{1}/_{2000}$ flying height)

ACCURACY NOTES:

- Values shown represent standard error (68% confidence level or 1 sigma), in metres
- "Derived points" are those interpolated from a terrain model.
- "Measured points" are those observed directly.

USE OF DATA

- Intended use : Creation of 0.5m contours

LIMITATIONS OF DATA

- The definition of the ground under trees may be less accurate.
- This data has not been field tested for completeness.

5. CONDITIONS OF SUPPLY

The data in this volume is provided to **THE GREATER WELLINGTON REGIONAL COUNCIL** under a license by which the data is not sold, lent or distributed to any other party; and used only for the project for which provided, subject to the following conditions:

1. This file (README.PDF) is always stored with the unaltered data contained in this volume.

2. The data is not altered in any way without the approval of AAMHatch. The data may be copied from this file to another.

3. The data is not used for purposes beyond that intended.

Any responsibility of AAMHatch is removed if any of these conditions is not observed.

4. AAMHatch maintains an archive copy of the data in this volume together with this README file for at least 7 years after delivery.

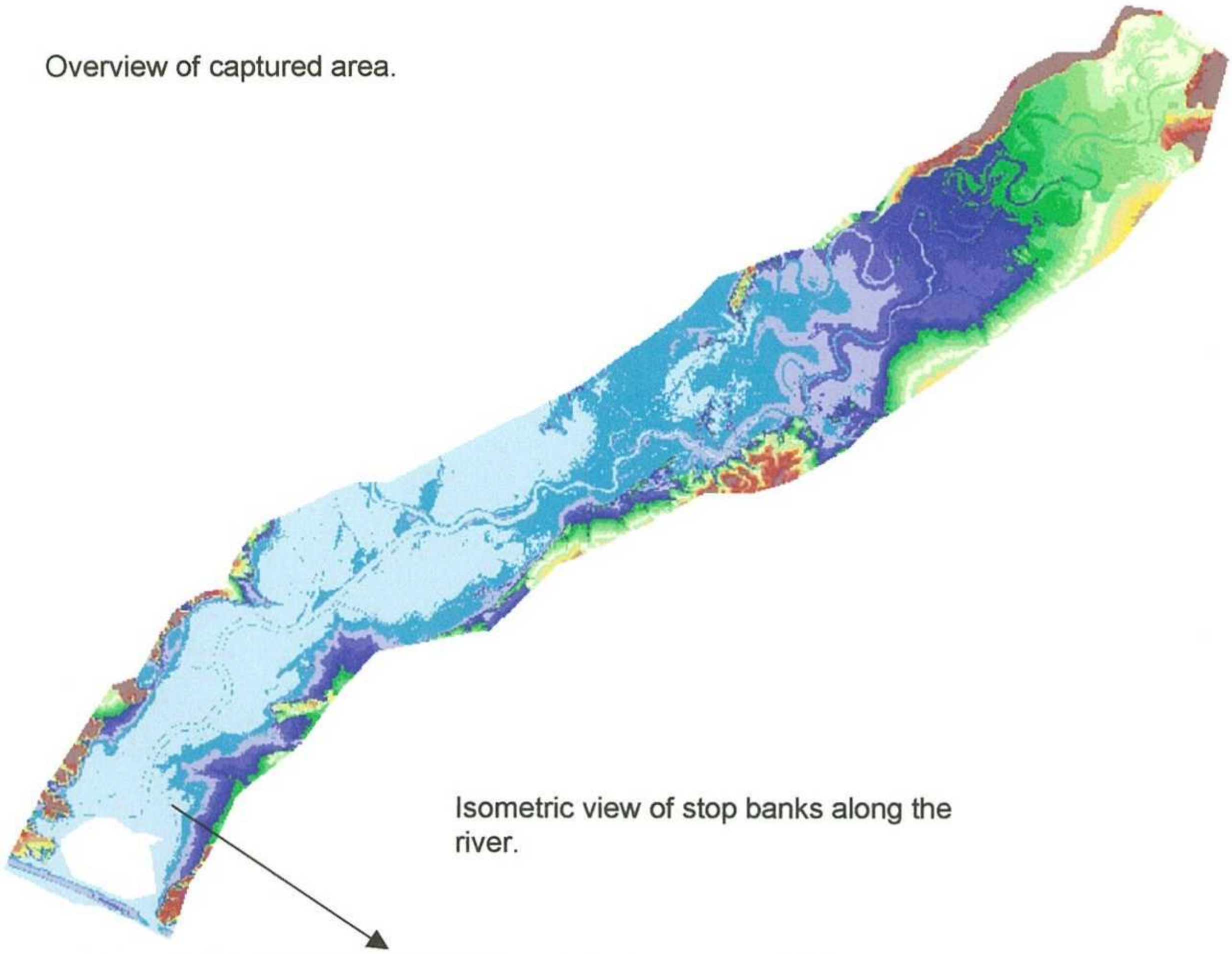
Any problems associated with the information in the data files contained in this volume should be reported to:

AAMHatch

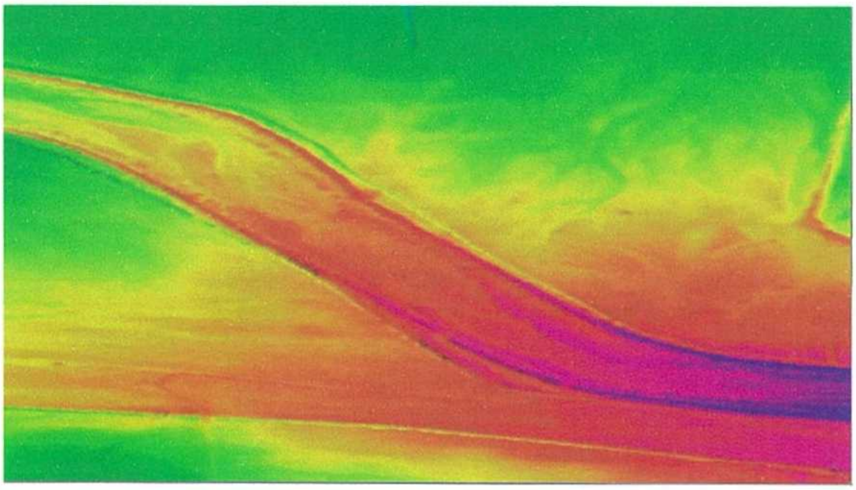
11 Wicklow Street
KANGAROO POINT
Queensland 4169
Australia
Telephone +61 7 3891 1033
Facsimile +61 7 3891 1050
Email info@aamhatch.com.au
Web www.aamhatch.com.au

6. VALIDATION PLOT

Overview of captured area.



Isometric view of stop banks along the river.



7. FILES SUPPLIED

Filename				Contents
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02/12/2003	02:15p	15,104,959	W26865979.lat	
02/12/2003	02:15p	6,680,537	W26865981.lat	
02/12/2003	02:14p	224	W26865983.lat	
02/12/2003	02:16p	2,860,252	W26885975.lat	
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02/12/2003	02:10p	18,736,672	W27165997.lat
02/12/2003	02:10p	19,931,648	W27165999.lat
02/12/2003	02:10p	2,890,208	W27166001.lat
02/12/2003	02:10p	348,960	W27185997.lat
02/12/2003	02:10p	2,847,415	W27185999.lat

DESPATCH NOTE

AAMHatch Pty Ltd, ABN 63 106 160 678

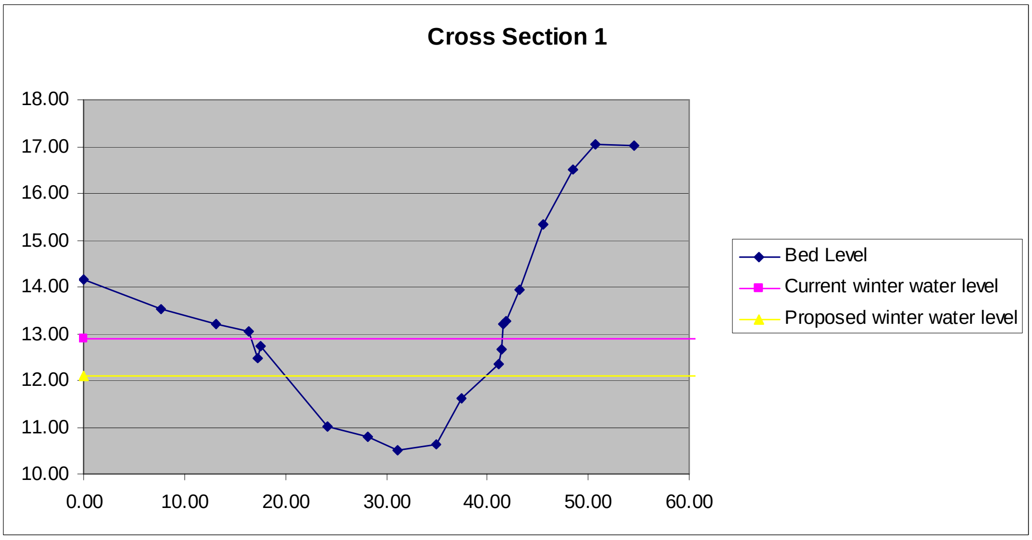
11 Wicklow St Kangaroo Point QLD 4169 Ph 07 3891 1033 Fax 07 3891 1050

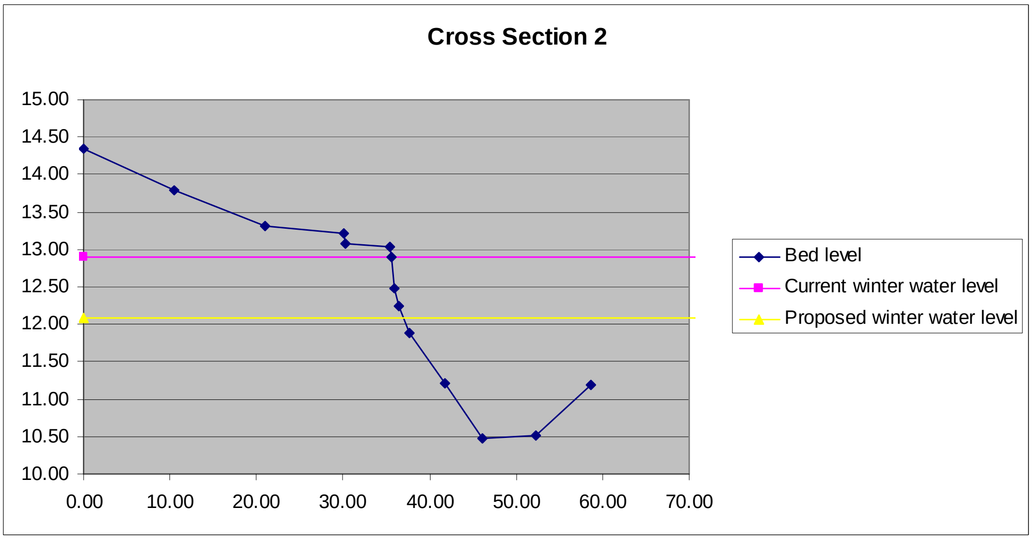
To Company:	**The Greater Wellington Regional Council**	Despatch Note No:	**DN_165**
		Date:	**03.12.2003**
Attention:	**Des Peterson**	Job Number:	**810217**
From:	**Peta Hyam**		
Subject:	**Wairarapa ALS Data**		

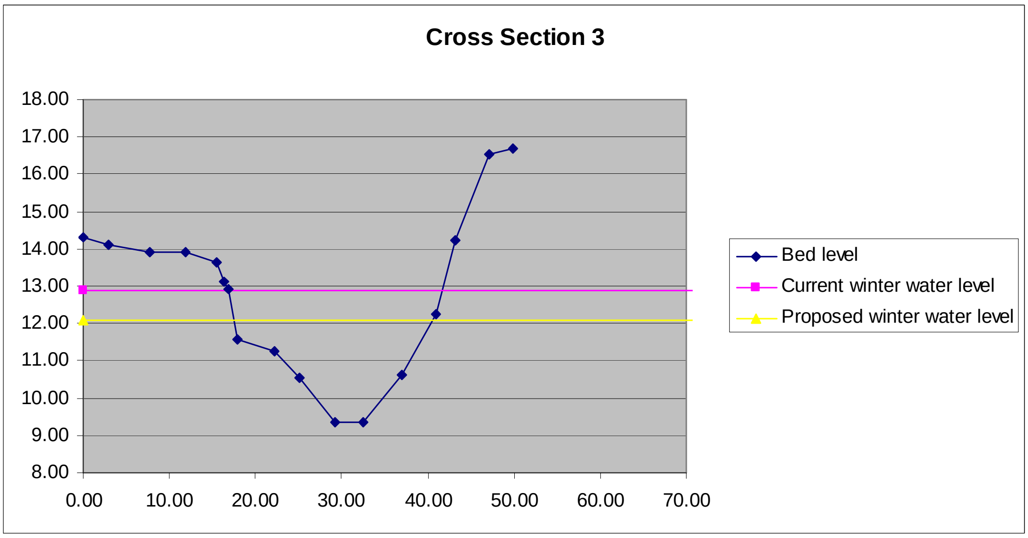
No.	To	From	Contents
1	D.Peterson	P.Hyam	2 x CD and metadata document

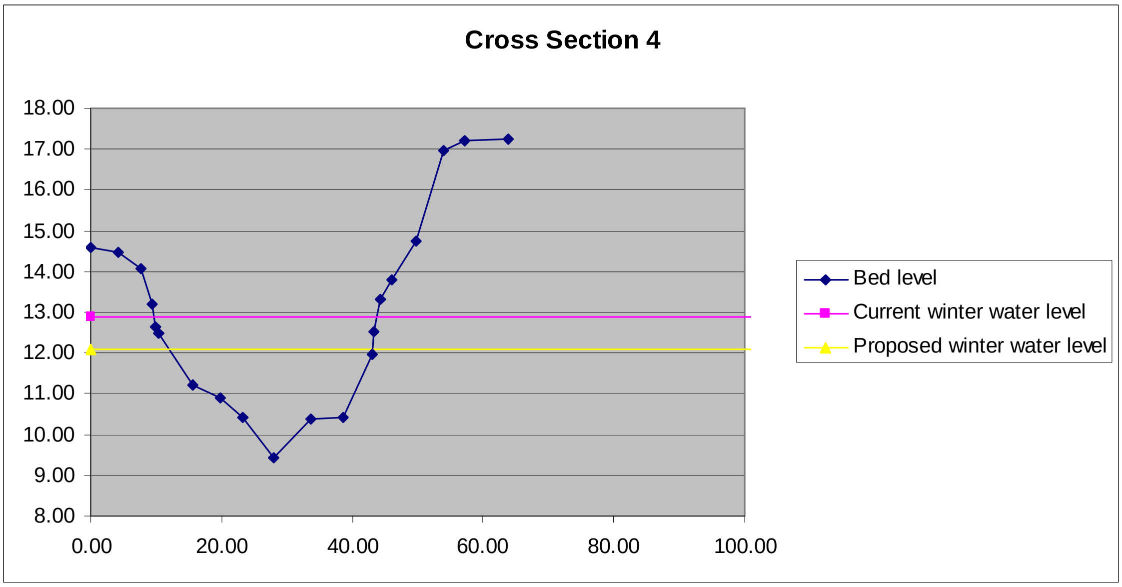
Appendix B – Final Design Drawings

Appendix C – Impact on lagoon depths





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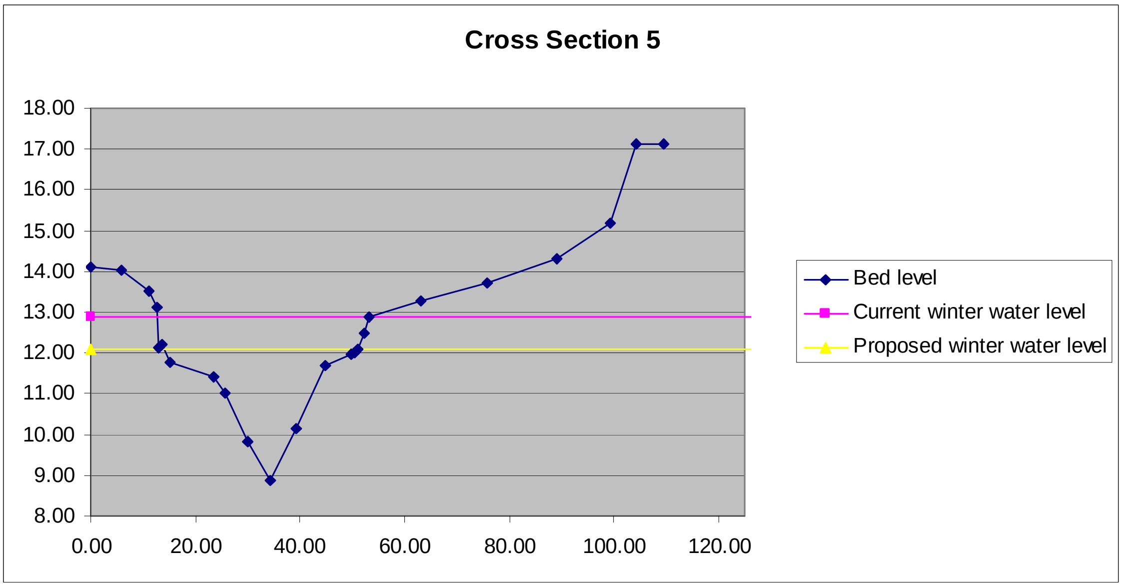
20.00
40.00
60.00
80.00
100.00
Bed level
Current winter water level
Proposed winter water level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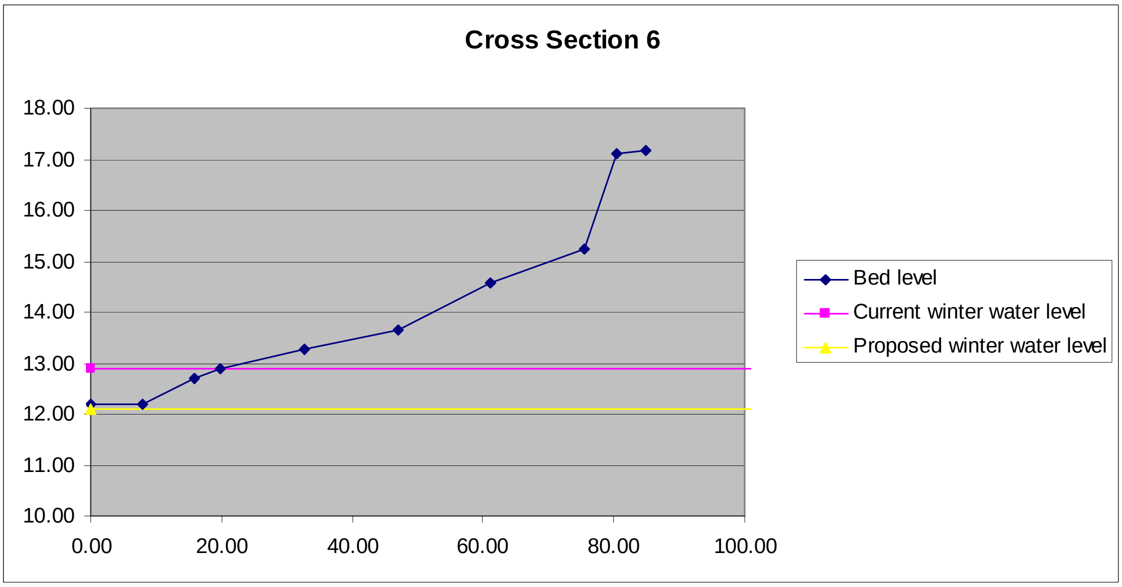
60.00
80.00
100.00
120.00
Bed level
Current winter water level
Proposed winter water level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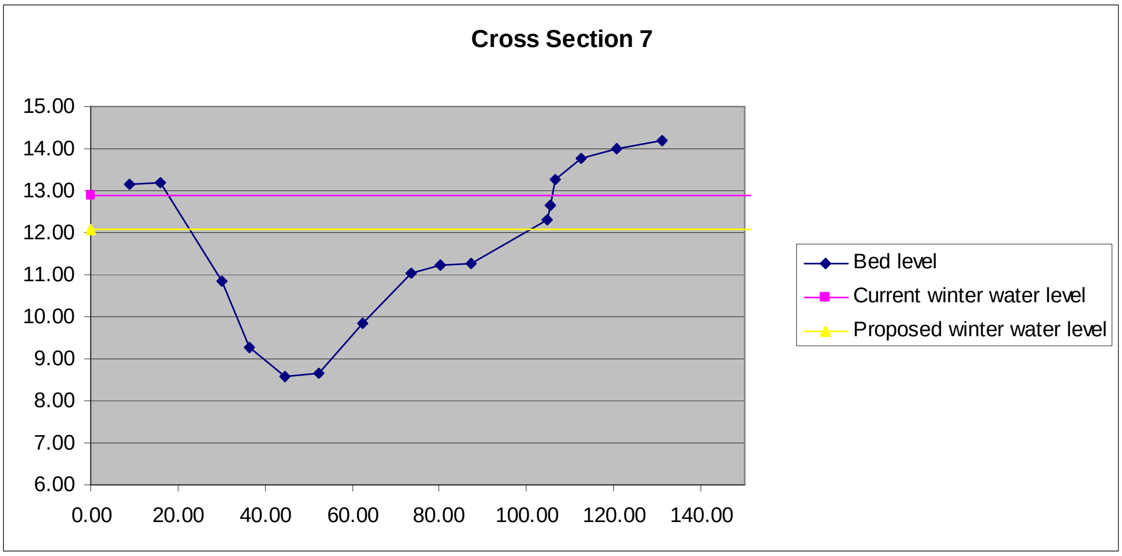
60.00
80.00
100.00
Bed level
Current winter water level
Proposed winter water level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9.00
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7.00
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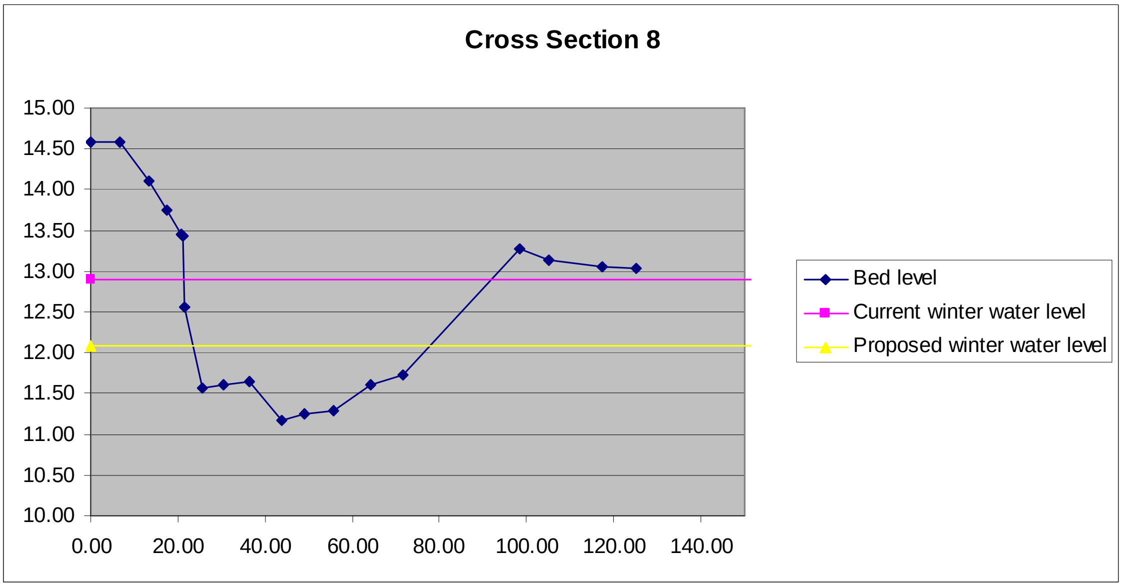
40.00
60.00
80.00
100.00
120.00
140.00
Bed level
Current winter water level
Proposed winter water level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11.00
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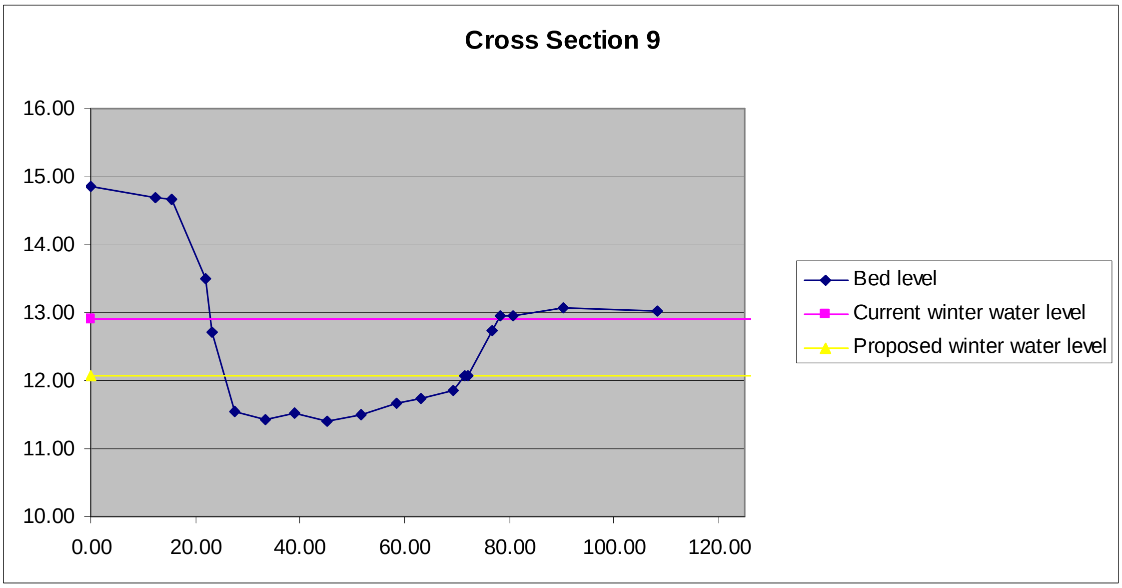
40.00
60.00
80.00
100.00
120.00
140.00
Bed level
Current winter water level
Proposed winter water level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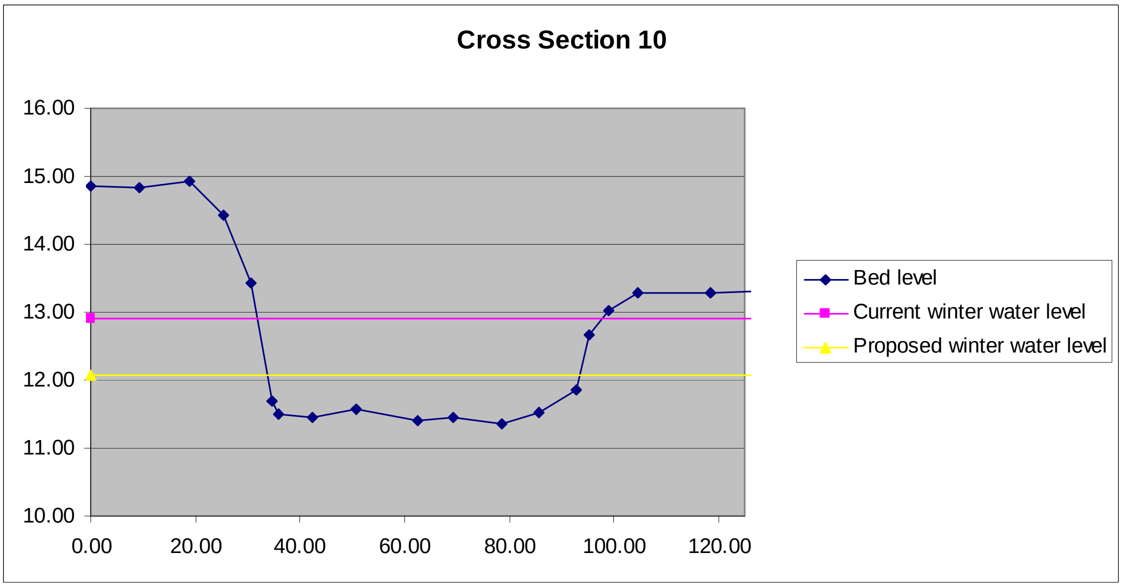
120.00
Bed level
Current winter water level
Proposed winter water level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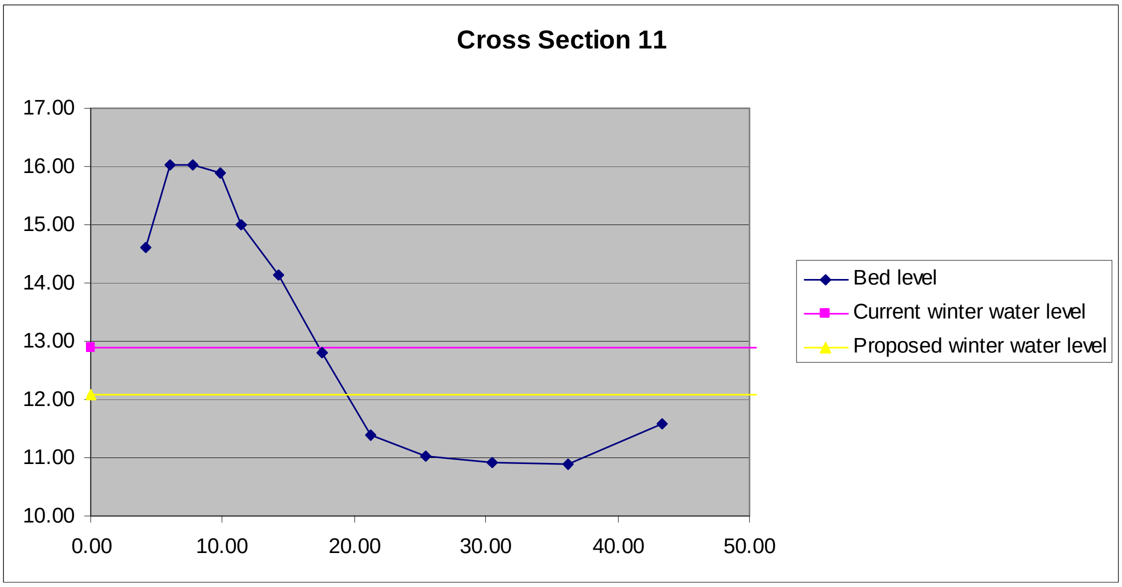
120.00
Bed level
Current winter water level
Proposed winter water level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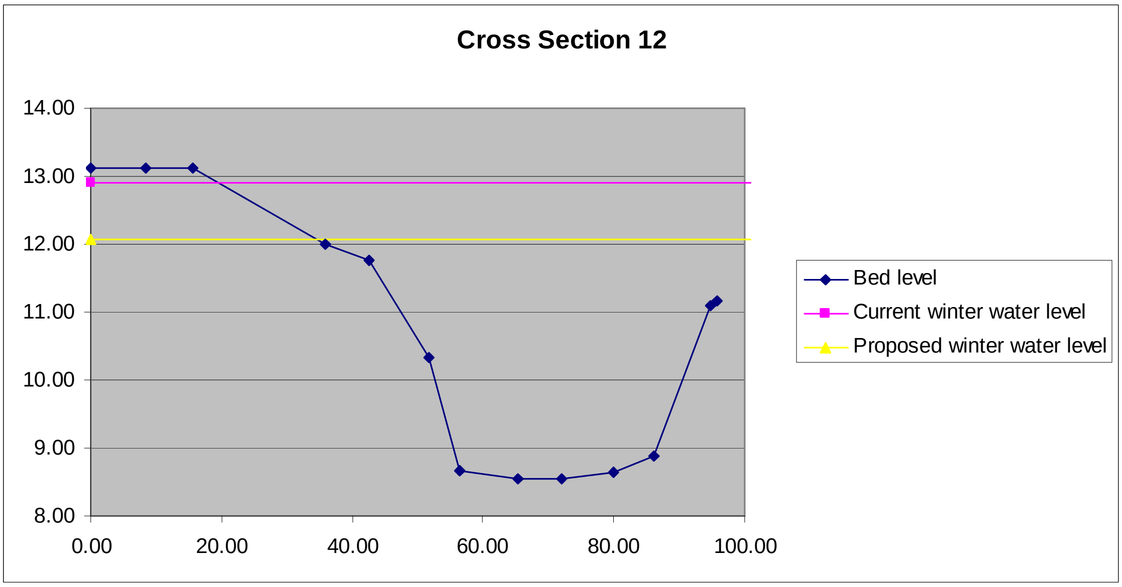
50.00
Bed level
Current winter water level
Proposed winter water level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0.00
20.00
40.00
60.00
80.00
100.00
Bed level
Current winter water level
Proposed winter water level

Appendix D – Landowner Database

Cross Section #	Cross Section Chainage u/s (m)	Property Owner	Description	GWRC Drawing Ref :
	0	Kahutara Road Corridor	Kahutara Road	
1	34	GWRC	Kahutara Road Bridge Elevation	A1-10542/11-RC
2	643	GWRC	S.M. Waka 2 - Stream Cross Section / Stopbank	A1-10542/17-RC
3	1140	GWRC	S.M. Waka 3 - Stream Cross Section	A1-10542/17-RC
4	1670	GWRC	S.M. Waka 4 - Stream Cross Section	A1-10542/17-RC
5	2650	GWRC + R.Bargh	S.M. Waka 5 - Stream Cross Section	A1-10542/17-RC
6	2977	GWRC	Awaroa Basin Road Bridge	A1-10542/11-RC
7	3159	GWRC + R.Bargh	Stream Cross Section	A1-10542/17-RC
8	3656	GWRC + LANDCORP	Stream Cross Section	A1-10542/17-RC
9	4164	GWRC + LANDCORP	S.M. Waka 9 - Stream Cross Section	A1-10542/18-RC
10	4677	GWRC + L. Taepa + LANDCORP	S.M. Waka 10 - Stream Cross Section	A1-10542/18-RC
11	5028	LANDCORP	S.M. Waka 11 - Elgar Road Bridge	A1-10542/12-RC
12	5174	LANDCORP	S.M. Waka 12 - Stream Cross Section	A1-10542/18-RC
13	5531	E. Cooke & N. Cole + LANDCORP	Stream Cross Section	A1-10542/19-RC
14	5863	E. Cooke & N. Cole	Stream Cross Section	A1-10542/19-RC
15	6208	E. Cooke & N. Cole	Stream Cross Section	A1-10542/19-RC
16	6423	E. Cooke & N. Cole	Farm Road Bridge	A1-10542/12-RC
17	6853	E. Cooke & N. Cole + R. Stout	Stream Cross Section	A1-10542/19-RC
18	7175	E. Cooke & N. Cole + R. Stout	Stream Cross Section	A1-10542/20-RC
19	7509	Pukio West Road Corridor	Pukio West Road Bridge	A1-10542/12-RC & A1-10542/20-RC
20	8033	R. Stout	Stream Cross Section	A1-10542/20-RC
21	8412	R. Stout & W + V Collins (c/ BF & J Bosch)	Stream Cross Section	A1-10542/21-RC

22	8860	R. Stout & W + V Collins (c/ BF & J Bosch)	Stream Cross Section	A1-10542/21-RC
23	9300	R. Stout & W + V Collins (c/ BF & J Bosch)	Stream Cross Section	A1-10542/21-RC
24	9825	R. Stout & W + V Collins (c/ BF & J Bosch)	Stream Cross Section	A1-10542/22-RC
u/s XS 24	10015	W & V Collins (c/ BF & CJ Bosch)	Movable Steel Bridge	A1-10542/13-RC
d/s XS 24.5	10034	W & V Collins (c/ BF & CJ Bosch)	825mm Nom. Dia. Culvert	A1-10542/13-RC
24.5	10121	L. Petrie	Collins Road Bridge	A1-10542/13-RC
25	10422	L. Petrie	Stream Cross Section	A1-10542/22-RC
26	10489	L. Petrie	Farm Road Bridge	A1-10542/13-RC
27	10738	L. Petrie	Stream Cross Section	A1-10542/22-RC
28	11595	Pahautea Road Corridor	Pahautea Road Bridge	A1-10542/14-RC
29	11825	A. Simmonds	Stream Cross Section	A1-10542/23-RC
30	12042	R. Bargh	Culvert	A1-10542/14-RC
31	12279	R. Bargh	Stream Cross Section	A1-10542/23-RC
32	12549	C. Cross	Cross's Bridge	A1-10542/14-RC
33	12869	J. Bargh	Stream Cross Section	A1-10542/23-RC
34	13012	J. Bargh	Bargh's Road Bridge	A1-10542/14-RC
35	13272	J. Hedley	Stream Cross Section	A1-10542/23-RC
36	13514	J. Hedley + Hikunui Road Corridor	Stream Cross Section	A1-10542/23-RC
37	13686	Hikunui Road Corridor	Hikunui Road Bridge	A1-10542/15-RC
38	13989	J. Barton	Stream Cross Section	A1-10542/23-RC
39	14219	J. Barton	Mcarthy's Bridge	A1-10542/15-RC
40	14488	J. Barton	Stream Cross Section	A1-10542/23-RC
41	14787	J. Barton	Culvert	A1-10542/15-RC
42	15058	J. Barton	Culvert	A1-10542/15-RC
43	15243	J. Barton	Stream Cross Section	A1-10542/23-RC
44	15433	J. Barton	Stream Cross Section	A1-10542/24-RC
45	15741	J. Barton	Stream Cross Section	A1-10542/25-RC

46	15823	J. Barton	Bund & 2 x Culverts	A1-10542/16-RC
47	16070	J. Barton	Spillway & Culvert	A1-10542/16-RC
48	16357	J. Barton	Barton's Lagoon	A1-10542/25-RC
49	16812	J. Barton	George Road Culvert	A1-10542/25-RC

Whakawiriwiri Stream - Hydraulic Modelling / Channel Design

Matthew Gardner

For more information, contact Greater Wellington:

Wellington
PO Box 11646

T 04 384 5708
F 04 385 6960
www.gw.govt.nz

January 2012

www.gw.govt.nz
info@gw.govt.nz

Contents

1. Introduction

A MIKE Flood model has been built of the Whakawiriwiri stream to determine the impacts of diverting water from the Tawaha Floodway into the stream at Barton’s Lagoon and to also assist in the design for mitigating these effects.

The Whakawiriwiri Stream is located in the Wairarapa; a location map of the stream downstream from Barton’s lagoon is shown in Figure 1-1.

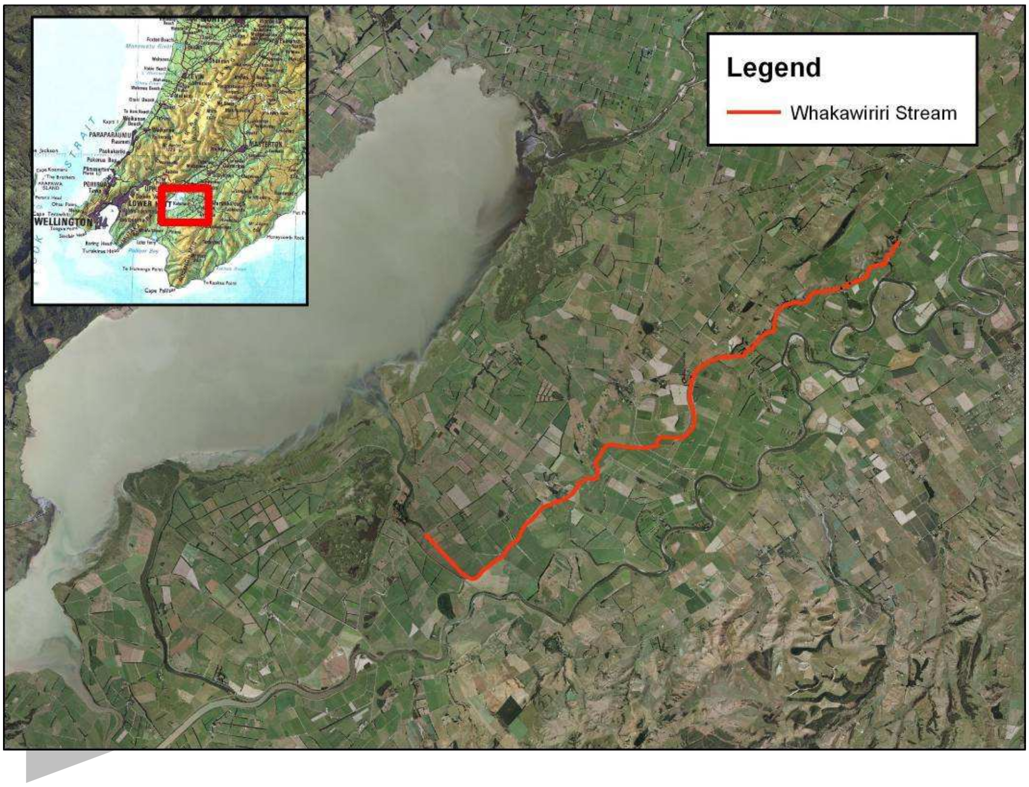

Figure 1-1 –Whakawiriwiri Stream Location Map

The history of stream and background to this investigation can be found in the background document titled Whakawiriwiri Stream, Detailed Design, AEE and Resource Consent Application, Implementation Brief – Project Plan which is included in Appendix A.

2. Survey and Data Collection

2.1 Topographic and Aerial Survey

In order to construct a MIKE FLOOD model (MIKE 11 / MIKE 21) of the Whakawiriwiri Stream, it was necessary to collect a large amount of topographic and aerial survey data.

LiDAR

LiDAR (**L**ight **D**etection **A**nd **R**anging aerial laser scanning) data was required to be used as the basis for the 2D terrain model. This data had already been flown and was readily available.

The LiDAR was flown by ???? for GWRC (WCC). The data sheet containing a full description of the data acquisition and processing process for this job can be viewed in Appendix B

Topographic Survey

In order to accurately represent the hydraulics of the main stream channel and tributaries it is necessary to obtain detailed cross sectional data of the stream as well as details of bridges and culverts that have an impact in flows.

A detailed cross sectional survey of the Whakawiriwiri stream channel and carried out during August and September of 2011 by Adamson Shaw Ltd Surveyors. The survey picked up a total of 49 stream cross sections, 19 structures and also surveyed the stream invert at 10 metre intervals.

All surveyed data is reported to be within a tolerance of +/- 0.05 metres. The location of the surveyed cross sections and structures is shown in figure 2-1.

The raw survey data was converted into CAD (Computer Automated Design) drawings, showing stream long sections and profile views of structures by Philip Cook from Greater Wellington Regional Council. Copies of these drawing are filed in drawing set A1-10542.

2.2 Tidal Boundary

Due to the flat grade of the Whakawiriri Stream, the effect of the tidal boundary at Lake Wairarapa is profound in the lower reaches of the stream. The tidal boundary which has been used has been adopted based on discussions with Greater Wellington staff based in the Masterton Office.

3. Hydraulic Model Setup

A combined one dimensional (1D) channel model and a two dimensional (2D) floodplain model were constructed for the Whakawiriwiri Stream using the DHI software package MIKE FLOOD.

The advantage of modelling a river such as this as a combined 1D / 2D model is due to the fact that the main river channel and structures can be accurately represented with the assumptions necessary for a 1D model to a higher level of detail than is easily achievable with a 2D model. Modelling the floodplain in 2D also allows for a much more detailed representation than is possible in a traditional 1D model.

This brief for this project was to construct a model of the stream that could be used to determine the impact of diverting extra water into the stream and to also use the model to assist in re-grading the stream and altering / upgrading any structures.

3.1 MIKE 11 Model

The MIKE 11 channel model begins at the outlet of Barton's Lagoon and continues until the Kahutara road bridge. The extent of modelling can be clearly seen in figure 3-1.

3.1.1 Cross Sections

Cross section spacing in the model varies but is on average between 300 and 400 metres.

The maximum dx (i.e. the distance between computational H-points) was decreased to 10 metres, forcing the model to interpolate additional cross-sections at 10 metre intervals. This improves the linking between the 1D and the 2D components of the model.

Cross sections were based on a surveyed data and where necessary were extended with data extracted from LiDAR.

3.1.2 Bridges / Culverts

8 culverts and 7 bridges were included in the model. The bridges have been modelled using the bridge module available within MIKE 11. The details of the bridges used in the model are summarised in Appendix C.

There are a range of methods available within the bridge module in order to calculate the effects on flows through bridge structures. Due to the lack of calibration data for the bridges it was decided to adopt the energy equation, which is simplest methodology available for calculating the effects on flow through the structures. The MIKE 11 user manual describes this method as follows. "*The Energy Equation: A standard step method where a backwater* *surface profile is determination is used to calculate the discharge through the bridge. The method takes the contraction and expansion loss for bridges of arbitrary shape into account. The method assumes sub-critical flow and may default to critical flow for steep water surface gradients.*"

3.1.3 Channel Roughness

Initial values for bed roughnesses were assessed based on a visual inspection of photos at each section and a site walkover. The publication titled "Roughness Characteristics of New Zealand Rivers" by Hicks and Mason was used as a guide for assessing the roughness values and proved to be a very valuable resource in this exercise, as well as the reference tables for Manning's n values for Channels (Chow, 1959).

One of the problems with defining an appropriate 'manning's n' in a stream such as this is the variability in stream conditions with unpredictable amounts of weed growth and clearance. It was decided that a fairly conservative 'n' value of 0.045 would be applied to the entire stream length.

3.1.4 Boundary Conditions

The downstream boundary condition for the stream is the water level in Lake Wainuiomata. A range of simulations with varying water levels were carried out based on advice from staff based in the Wairarapa.

Flow scenarios have been based on historic design scenarios which have been used for this stream. These have been based on a constant drainage rate of 25mm/24hr period. The catchment for the stream has been split into subcatchments based on those used in the "Whakawiriri Stream 2005 Review" (Duncan, 2005). The subcatchments used are shown in figure 3-1. The Te Maire, Whaka 5 and Whaka 6 subcatchments have been added based on analysis of the topographic data.

Figure 3-1 – Subcatchments used for Hydrology

Flow rates for each subcatchment have been calculated based on this assumed drainage rate of 25 mm/24 hour and are specified below in Table 3-1.

Table 3-1 – Design peak flowrates for subcatchments

Subcatchment Name	Area (ha)	Flow (m^3/s)
Whaka 1	404.1	1.17
Whaka 2	80.8	0.2
Whaka 3	146.2	0.42
Whaka 4	105.6	0.31
Tawaha 1	117.8	0.34
Tawaha 2	122.2	0.35
Te Maire	863.3	2.50
Whaka 5	2272	6.57

Due to the complete lack of any gauging information it was necessary to estimate a typical base flow in the winter months. In order to do this, I analysed the gauged flow information in the Parkvale Stream which has a well defined catchment area. Based on 10 years of flow during the winter months of June, July and August I estimated a typical wet base flow was approximately 1.3 m^3/s. Based on a catchment area of 11770 hectares, this gives an average ratio of 0.11 m^3/s for every 1000 hectares of pasture. Based on this ratio, typical base flows for each sub-catchment are summarised in table 3-2.

Subcatchment Name	Winter Baseflow (m^3/s)
Whaka 1	0.04
Whaka 2	0.01
Whaka 3	0.02
Whaka 4	0.01
Tawaha 1	0.01
Tawaha 2	0.01
Te Maire	0.09
Whaka 5	0.25

Hydropgraphs were created based on these flows. Baseflows were multiplied by 2.5 in order to ensure they were sufficiently conservative for some runs.

3.2 MIKE 21 Model

3.2.1 Digital Elevation Model

As discussed in Section 2.1, LiDAR has been used as the basis of the 2D terrain model. The raw LiDAR data has been converted into a Digital Elevation Model (DEM) using ArcGIS 3D analyst tools. It was decided that a 10 metre grid size would be appropriate to achieve the necessary resolution for flood mapping and to still allow for appropriate model run times.

3.2.2 LiDAR Accuracy

The accuracy of the LiDAR was checked by comparing levels with a range of surveyed cross sections in clear ground away from the river channel and thick vegetation. As a result of this it was found that on average the LiDAR data was approximately 0.18 metres higher than the survey data. In order to rectify this error, the final DEM that was used was lowered by this amount. Figures 3-2, 3-3 and 3-4 show 3 comparisons between the surveyed data and the LiDAR data at section 45, 44 and 25. Note that the LiDAR data does not read accurately beneath the water surface, nor through thick vegetation.

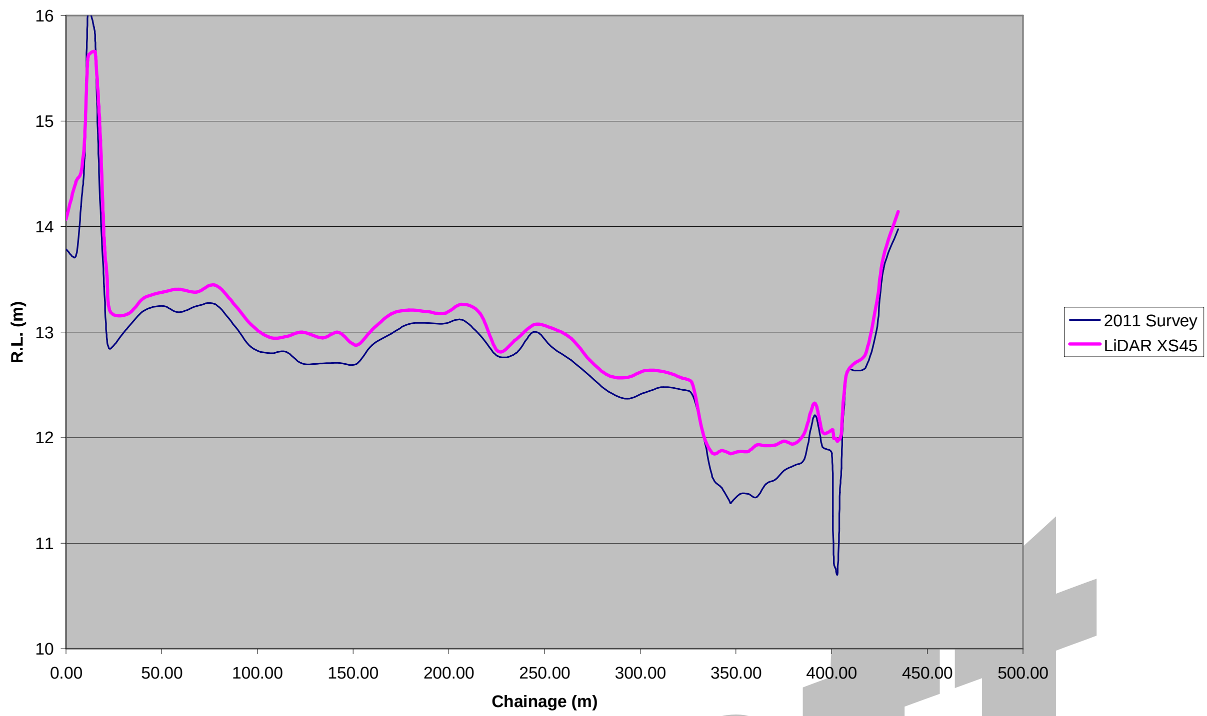

Figure 3-2 – Comparision of LiDAR and survey data at cross section 45

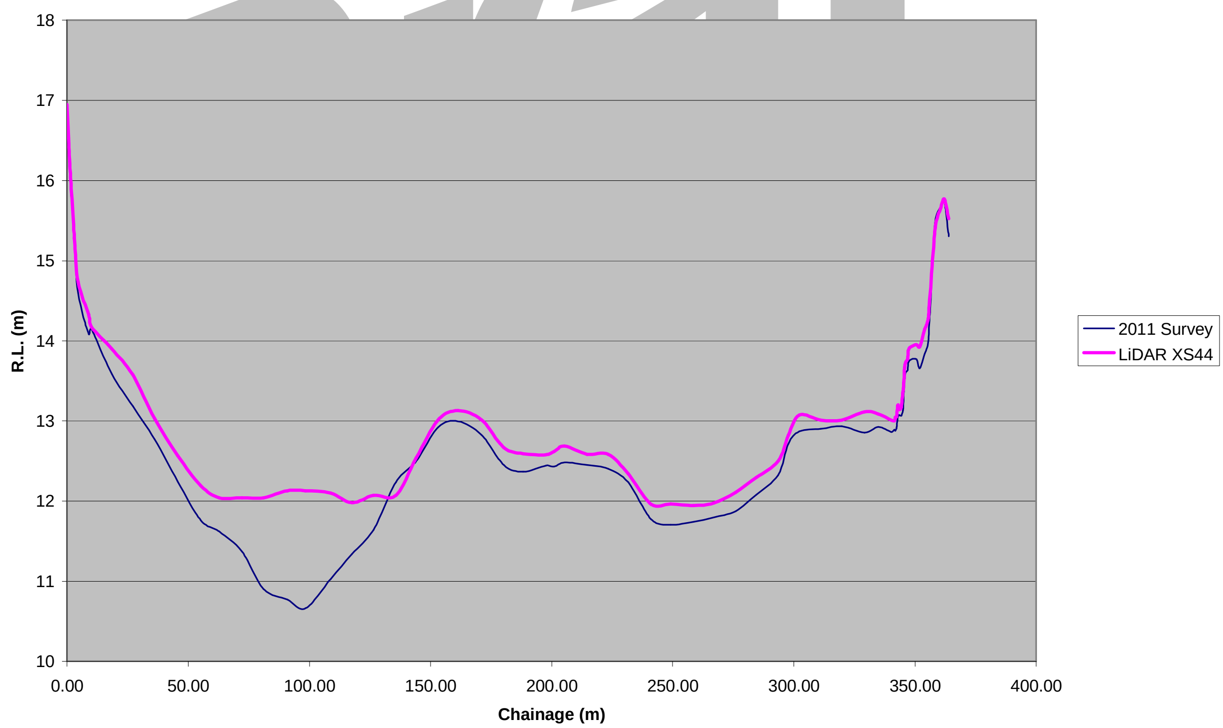

Figure 3-3 – Comparision of LiDAR and survey data at cross section 44

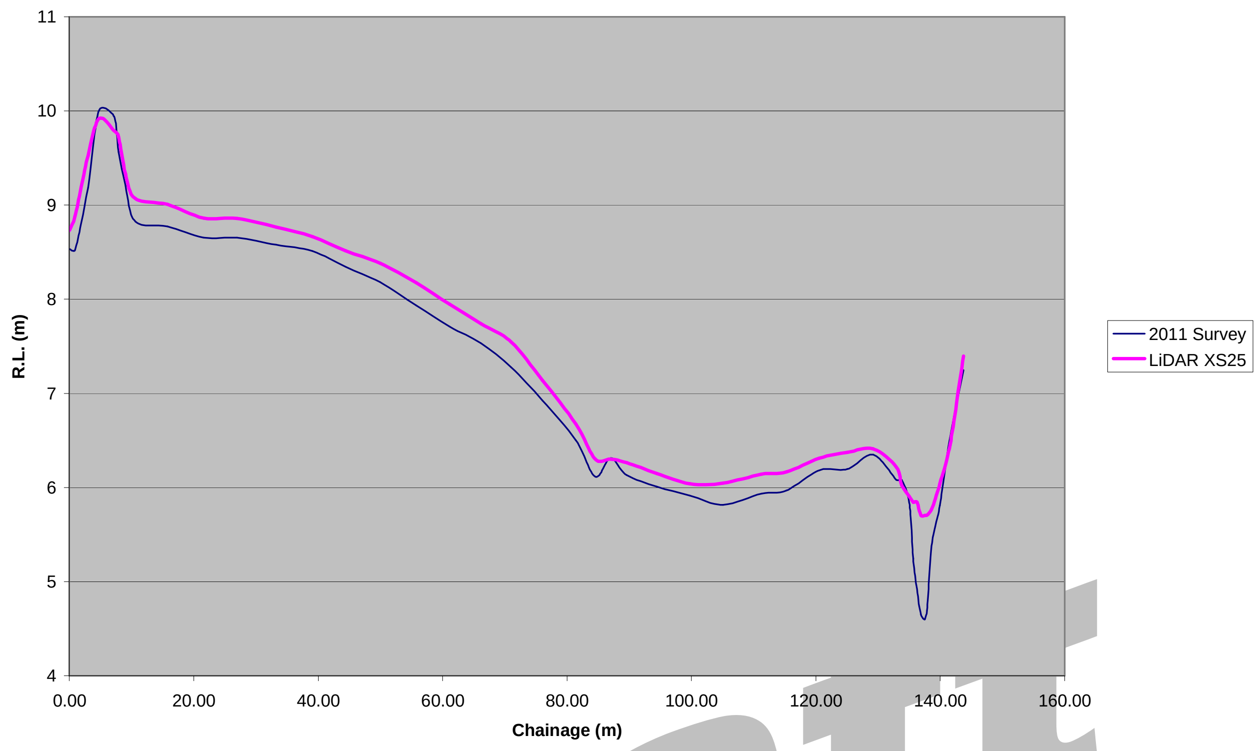

Figure 3-4 – Comparision of LiDAR and survey data at cross section 25

3.2.3 Modelling parameters

Due to the uniform nature of the area, floodplain and berm resistances were given an overall manning's n value of 0.033.

Flooding and drying depths have been taken as 0.02 and 0.01 respectively.

Eddy viscosity has been set at 0.1.

4. Design Runs

The primary purpose of the model is to determine the necessary works required to upgrade the stream in order to mitigate the effects of the additional flow from the diversion from the Tawaha Floodway into Barton's Lagoon. As well as to determine the effects of the increased flows on flood levels in the stream

Figure 4.1 outlines the inflows and outflows through the Barton's lagoon as it is represented in the model. The model has been used to analyse 3 different flow scenarios, which look at varying amounts of flow from the Whakawiriri Stream, the Tawaha loop drain and an extra 1.6m^3/s being released over 8 hours from the Tawaha floodway.

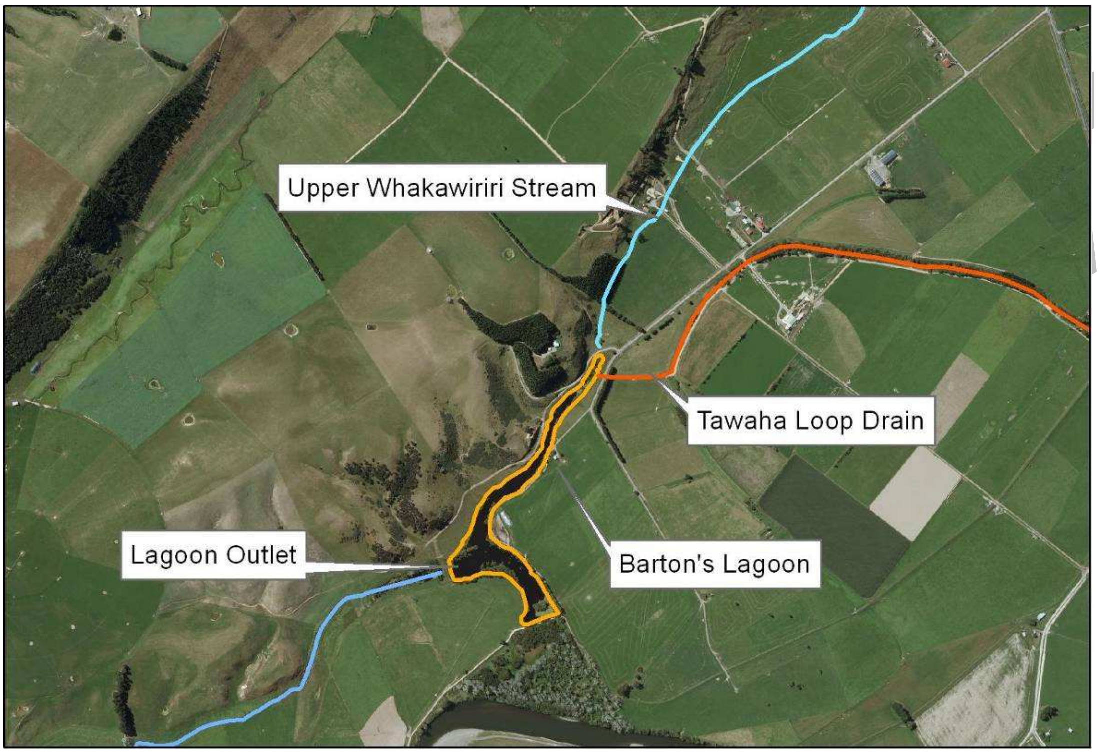

Figure 4-1 – Barton's Lagoon flows.

Table 4-1 summarises the simulations used to design and assess the effectiveness of the proposed channel upgrade.

Table 4-1 – Summary of model runs

Run	Network	Cross Sections	Inflows
1	Original	Original	Whakawiriri Stream only
2	Original	Original	Whakawiriri and Tawaha
3	Current	Current	Whakawiriri and Tawaha
4	Current	Current	Whakawiriri and Tawaha + 1.6 m^{3s} floodwater release
*5	Upgraded	Upgraded	Whakawiriri and Tawaha + 1.6 m^{3s} floodwater release

*Run 5 actually involved several iterations which involved modifying the bed levels, channel shape and culvert inverts in the stream to mitigate the effects of the diversion. The final iteration is presented in this report which is to be used for the final design. The final design is detailed in Appendix C

Further runs have also been conducted which look into modifying the outlet culvert in Barton's lagoon to maximise the utilisation of the lagoon for storage, however not allowing the lagoon to remain at a high level for a lengthy period of time. Table 4-2 summarises the options modelled for the culvert configuration.

Table 4-2 – Barton's Lagoon Culvert Configuration Runs

Run	Notes
6	Current culvert conditions (upstream invert 12.12m downstream invert 12.07 m)
7	Current culvert invert, upgraded to diameter of 0.45 metres
8	0.45 culvert lowered by 0.12 metres

5. Results

Stream and Floodplain water levels

In order to compare the results, we can compare both the water levels in the 1D channel model and the in 2D floodplain model. In order to determine the effectiveness of the upgrade to mitigate the effects of the increased flow due to the diversion from the Tawaha, it is critical to compare the differences in water level from runs 1 and 5.

First comparing the 1D model results, figure 5-1 compares the water levels of the situation before the diversion took place, and the proposed upgrade.

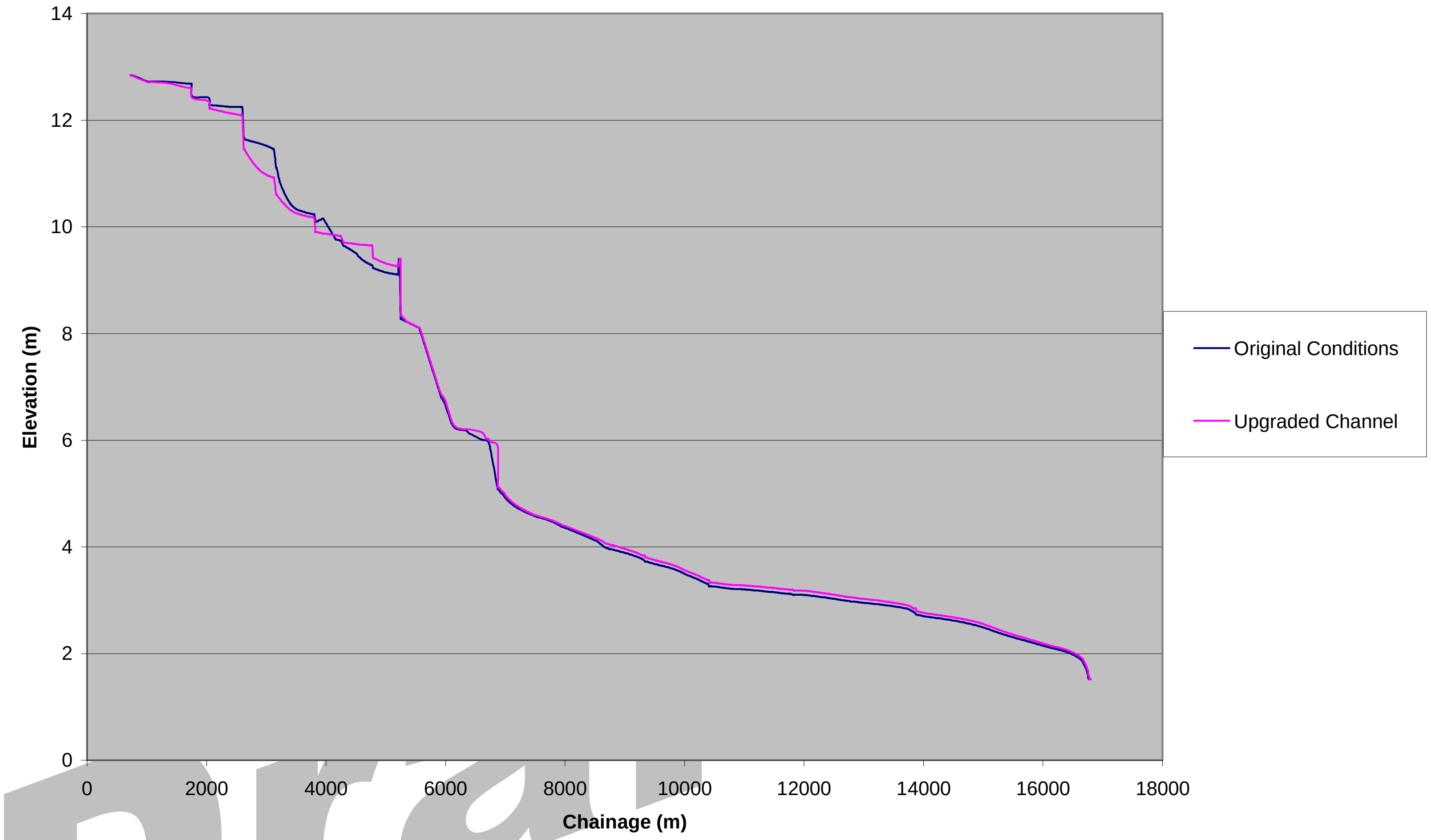

Figure 5-1 – Comparison of water levels with original conditions and after the upgrade with the diversion

Figure 5-2 looks at more detail at the water levels upstream of Pahautea Road Bridge which is where the works end.

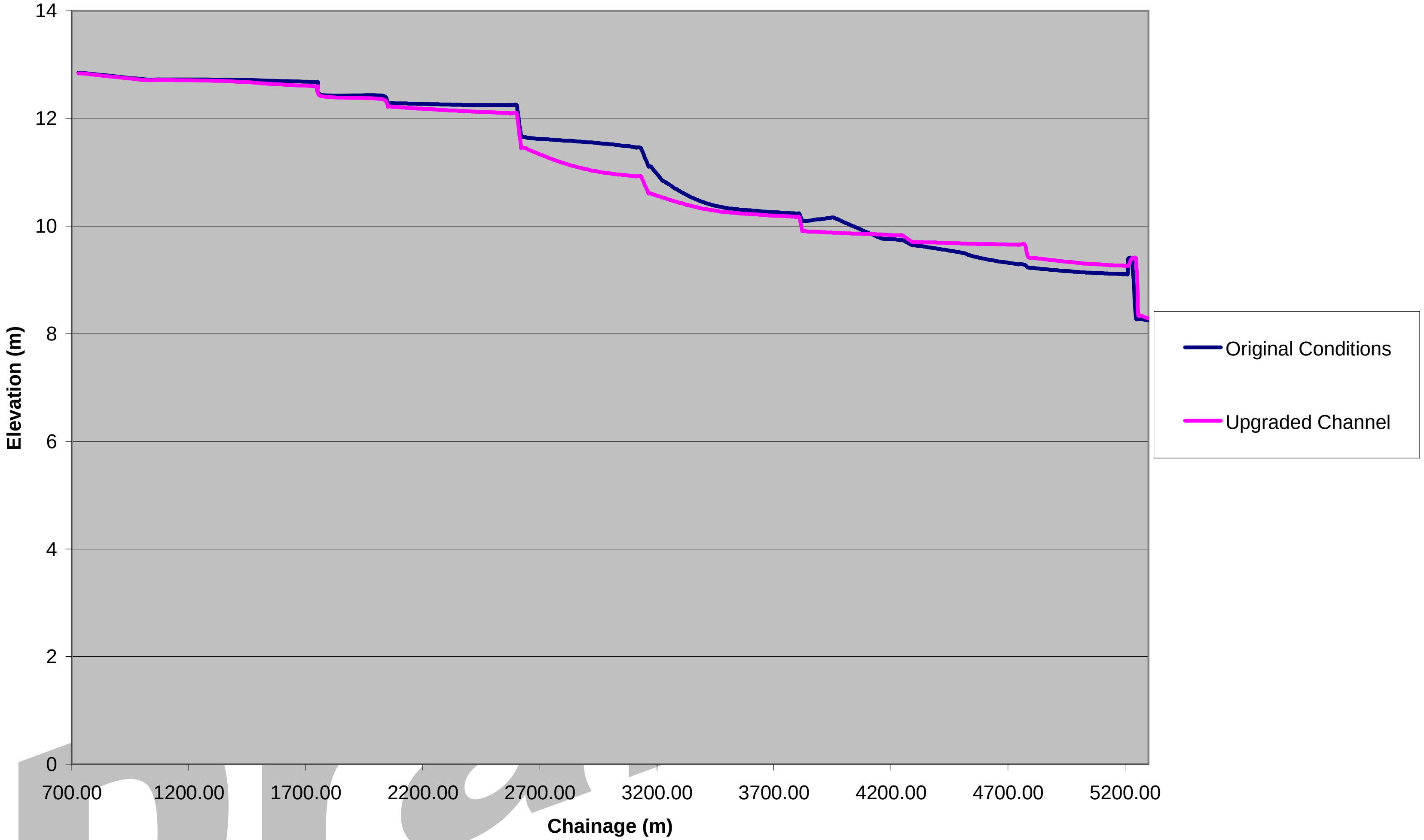

Figure 5-2 - Comparison of water levels with original conditions and after the upgrade with the diversion – upstream of Pahautea Road Bridge

It can be seen in this figure that immediately upstream of this bridge the water levels are raised by approximately 0.2m. This is due to the swale under the bridge blocking the flow. It has been assumed in this model that the small diameter culvert under this swale is completely blocked. Unless this swale is removed the water levels will not drop upstream from here, however this swale has been left there purposely to prevent the erosion downstream of this point getting any worse. However it can be seen when comparing the flood spread, that this has little impact on flood water levels.

It can be seen that downstream from chainage 2700 metres to approximately chainage 3200 metres, the water levels are significantly lower in the upgraded channel. In order to bring the pre and post water levels closer to each other in this reach it would be necessary to create a very steep slope further downstream, it was decided that maintaining an even grade would be more desirable and easier to construct as well as avoid the installation of energy dissipation devices.

Comparing the flood spread on the flood plain, figures 5-3, 5-4, show the flood spread upstream of the bridge, before and after the upgrade. Figure 5-5, shows the difference in water levels between the two runs.

Figure 5-3 – Flood extent with original conditions (Run 1), upstream of Pahautea Road

Figure 5-4 – Flood extent with upgraded conditions (Run 5), upstream of Pahautea Road

Figure 5-5 – Difference in flood levels with upgraded conditions, upstream of Pahautea Road

Figures 5-5, 5-6, show the flood spread downstream of the bridge, before and after the upgrade. Figure 5-7, shows the difference in water levels between the two runs.

Figure 5-6 – Flood extent with original conditions (Run 1), downstream of Pahautea Road

Figure 5-7 – Flood extent with upgraded conditions (Run 5), downstream of Pahautea Road

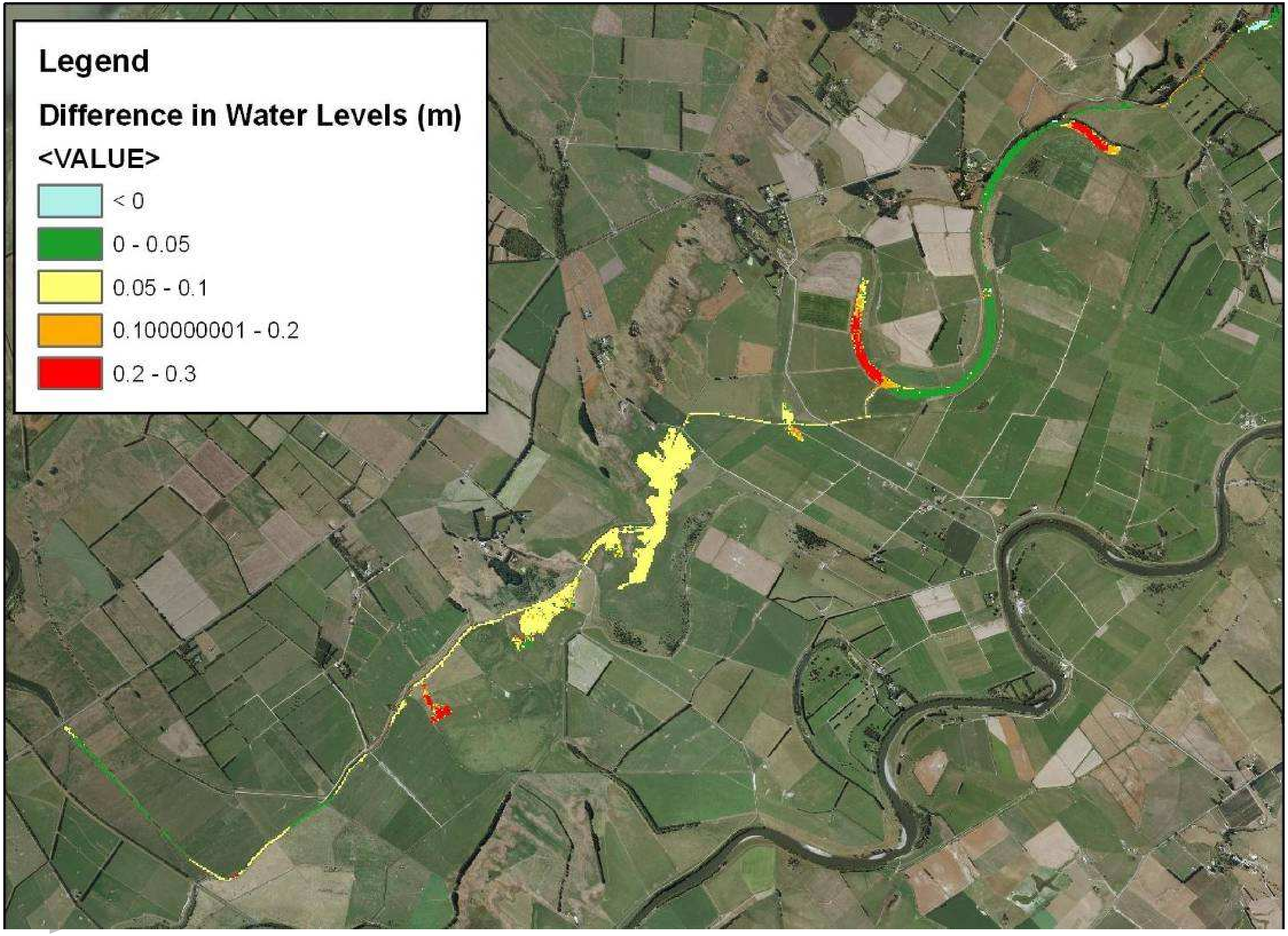

Figure 5-8 – Difference in flood levels with upgraded conditions, downstream of Pahautea Road

It can been seen that the most significant increase in flood levels is in the area of Duffy's lagoon which is shown in yellow. This indicated an increase in flood levels of approximately between 0.05 and 0.1 metres. On closer inspections it can be found that this is closer to 0.08 metres increase in water levels from the extra flow from the Tawaha.

Configuration of Barton's Lagoon Outlet Culvert

Several runs investigating the configuration of the outlet culvert have been carried out to determine if changing the size will improve anything. Lowering the culvert was considered however, due to the water levels in the lower lagoon it was observed that this is unlikely to improve the situation. The current culvert is 0.375 metres in diameter. Increasing the diameter of the culvert, will improve the inlet conditions and allow the water to more easily escape, it will also allow the water to drain slightly faster however, not significantly due to the lack of head. Once the rainfall has finished, it can be see in figure 5-9 that it takes approximately 10 hours for the water to fall below the crest of the weir (12.5 m), after that the water will slowly recede, however it cannot go much lower than the crest of the weir due to the invert of the culvert being above 12.0 m. Figure 5-9 shows how the water in the lagoon will rise and fall, with a .45 metre diameter culvert installed at the current invert, as well as at a lower invert.

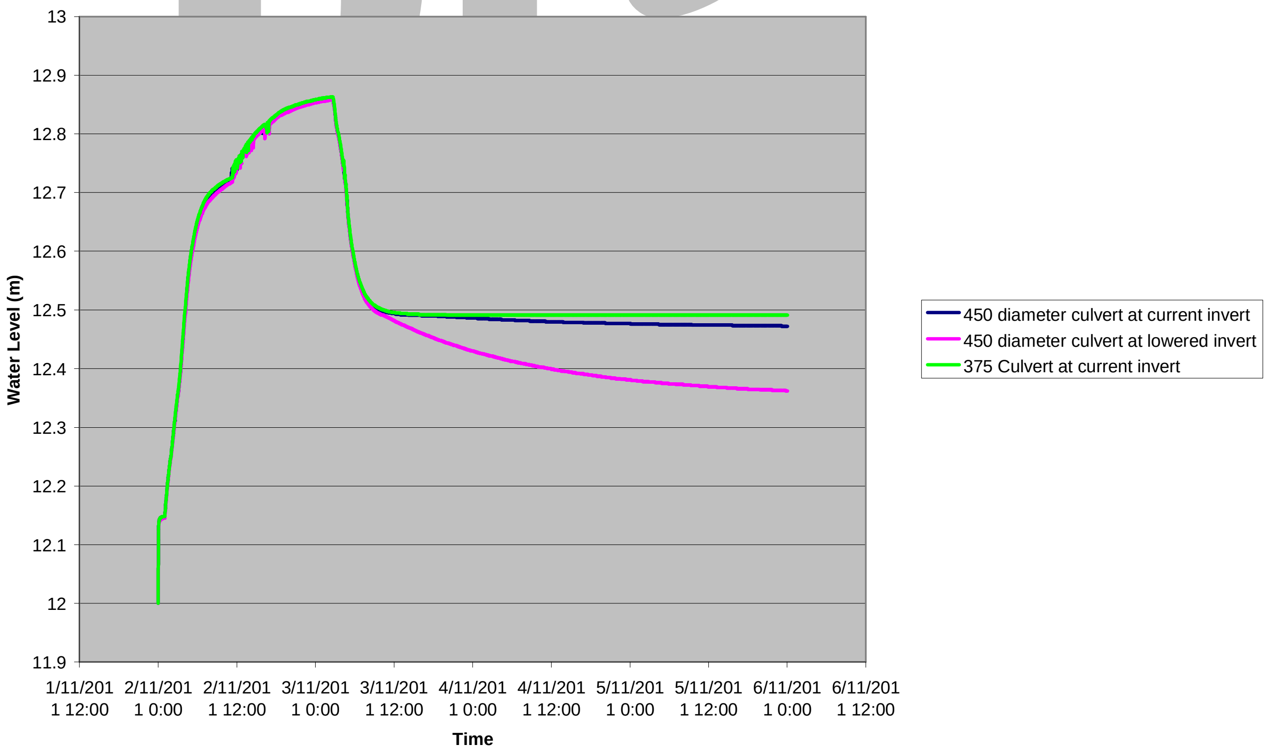

Figure 5-9 – Comparison of lagoon water levels with a 0.45 metre diameter culvert at current invert and with the invert lowered by 0.1 metres

It should be taken into account however, that if the water levels in the lower lagoon are raised after a flood event, lowering the culvert is unlikely to lower water levels as shown above.

Bed erosion

Water velocities around 1 m/s are generally considered acceptable for a drain of this type. It should be noted that immediately downstream of Pahautea Road Bridge velocities reach approximately 1.2 m/s for the next 1 kilometre, where the gradient is much steeper than the rest of the stream. The velocities are below 1 m/s for the rest of the stream

6. Conclusions

- The current design which includes deepening and widening the stream as well as lowering culvert inverts, will mitigate the effects from adding extra water from the Tawaha floodway.

- That increasing the diameter of the Barton's Lagoon outlet culvert is likely to reduce the likelihood of blockages to increase the flow out of the lagoon and lower the water levels. It will also assist with lowering the raised levels in the lagoon more efficiently after a flood event.

- By upgrading the outlet culvert in Barton's Lagoon to a 450 mm diameter culvert, water levels should recede to below the weir crest in 10 hours following a flood event, providing there are no blockages in the culvert.

- The design has included variable grades, rather than one consistent grade for practical design and construction reasons. Please refer to the final design drawings in Appendix C for details on gradients etc.

Appendix A - Background Information

Whakawiriwiri Stream

Detailed Design, AEE and Resource Consent Application

Implementation Brief – Project Plan

1. BACKGROUND

The review of the drainage from the Tawaha floodway was approved by the Catchment Committee in October 2010 (Report 09.378) following appeals by John Barton that improvements completed to the Whakawiriwiri Drain in 2000 hadn't improved matters sufficiently. The complaint is outlined in a letter dated 29 June 2008 with previously attached letters of 8 September 1995 and 20 August 1987 (to Wairarapa Catchment Board).

The Barton complaint essentially has three components:

- The diversion of the Tawaha drainage has caused flooding and ponding on low lying areas of his farm – Ongaha, and significant subsequent production losses.

- The drainage diversion is essentially illegal.

- Further improvements to the drain were necessary along the lines of the 1994 re-grade proposal.

Following receipt of the complaint some preliminary investigations were undertaken including site visits, further correspondence with Mr Barton and a preliminary review of the relevant files. Initial findings included:

- Low lying parts of the Barton property were certainly floodable during wet winter periods. How much was due to the low lying nature of the land and how much was due to the additional Tawaha drainage water was not clear.

- A visual inspection in winter of the flow at the Georges Road confluence of the Tawaha Drainage outlet and the Whaka Drain indicated an almost equal split in the base flows.

- The drain through the Barton property was in poor maintenance condition. The condition of the drain immediately downstream of Hikinui Road was also in less than ideal condition. The condition of the drain was clearly impacting on its flow capacity.

Advice was also sought from Council solicitors Oakley Moran about the Barton complaint, its substance and possible legal consequences. This advice is contained in the letter dated 21 April 2009 from John Tizard.

Following the legal advice a meeting was arranged between Mr Barton, the Council Chair, the Chair of the Catchment Committee and the Chief Executive to directly discus the complaint. The agreed outcome was discussions with immediate downstream neighbours and then report to the

Catchment Committee. The outcome of the Catchment Committee consideration was to investigate the matter including a technical review of the options.

2. BRIEF HISTORY

A thorough understanding of the history of this matter is necessary to form a view as to what further actions, if any, Council should take.

The history of this matter is pretty well covered in Council Report 09.378, a file note from Colin Wright dated 21 October 1999, in the legal advice from John Tizard of April 2009, and subsequent letter dated 21 April 2011.

Relevant resource consents: *940015 Full re-grade, 980083 J Bargh culvert re-placement, 990223 Replace three farm culverts in the Barton property* ***Relevant Council reports:*** *PE95.85W, PE96.102W, 97.94W, PE97.25W, PE98.11W, PE99.171, 09.378*

However a few key points are salient to this matter:

- Prior to the original 1979 floodway works and drainage diversion (via Campbell's cut) the only water feeding Barton lagoon was from the Whakawiriwiri Stream. In winter the stream caused the lagoon to rise (hence ephemeral nature) and in summer the stream would dry up completely, causing a substantial shrinkage in the lagoon size (was a single lagoon in those days).

- John Barton has advised that maintaining the drain pre 1982 was simple because the weeds could simply be grazed during the summer dry period. The new much larger drain now carries water throughout most of the year making maintenance of the aquatic weeds much harder.

- Prior to the 1979 floodway construction it is also clear that the Barton property had a flood risk from the Jenkins Dip area. It was believed the old horseshoe lagoon used to spill over the Campbell property (where the existing diversion cut is located) from as little as a 5 year return period flood event in the Ruamahanga River. This was discovered during the recent LWVDS review. Ian Gunn's draft summary of Barton issues for John Tizard includes a photo of the water spilling over in a 980 m^3/s event (as measured at Waihenga) in September 1977.

- The scheme has clearly substantially reduced the flood risk to the Barton property and in a way the periodic release of the residual flood waters from the current Tawaha floodway mimics what used to happen anyway, just in a controlled manner, much reduced in volume, and of only minor concern to downstream landowners.

- Following construction of the 1979 works the winter drainage on the Barton property would have been improved. Only a very small residual drain bypass was installed through the stopbank to retain some water in the Whaka Drain. The bulk of the water would have gone directly out to the river. This would have started the processes of drying up what is now known as the lower and ephemeral parts of the original lagoon.

- Following failure of the original floodway design the outlet from the Barton lagoon to the river was closed and this effectively completed the diversion of the Tawaha water into the Whaka system. While the floodway was rebuilt to as we see it today, no change was made to the diversion through what is known as Campbell's cut. The drainage catchment area was increased by 60% at what is now the upper Barton lagoon. In addition a gate valve was installed near Backwater Road so that the normal Tawaha drainage flow into the old horseshoe could be cut off during a flood event.

- The result of the additional drainage flows was a vastly increased extent of ponding and overflow onto pasture during wet winter conditions, both from the ephemeral lagoon and directly by side spill from the upper Barton lagoon. Evidence provided for the 1994 consent hearing indicated 14 ha of land subject to periodic inundation immediately adjacent to the Barton lagoons with a further 53 Ha of imperfect drainage between the lagoons and Hikinui Road.

- The additional inflows also raised the level of the Upper Barton lagoon so that in winter drainage was impeded on 36 Ha upstream from the Barton's lagoon (Steve Blakemore's evidence dated 28 January 1995)

- The initial remedial work was a heavy drain clean along the full length of the Whaka Drain in 1983, except in the reach from Hikinui Road to the downstream edge of the Cross property. In this reach the landowners objected to the diversion of the additional Tawaha water from the Catchment Board and wouldn't allow access for the work.

- The first complaint letter from Mr Barton found in the files was dated in 1987. In the early 1990's the Council got serious about mitigating the additional inflow and proposed a full re-grade and cross section enlargement of the Whaka Drain from the existing lower lagoon outlet to the downstream boundary of that owned by Cath Cross.

- There was however some significant objection to the 1994 proposal from a number of affected landowners including Mr Jim Hedley, Mr Bob Bargh and several landowners further downstream at what is called Duffy's lagoon. One of the key objections was that these landowners didn't accept the additional Tawaha water resulting from an 'illegal diversion".

- Jim Hedley appealed the 1994 consent granted for the work resulting in an out of Court agreement to get an independent engineer to review the matter, both parties to accept the reviewer's recommendation.

- The independent engineer (Brian Knowles, Royds Consulting) completed his report (two parts) in Feb 1997. The key recommendation was that the original re-grade should proceed. Mr Knowles also addressed development of a protocol for the floodway release, future maintenance, and culvert upgrades in the Barton property. Mr Knowles based his assessment of the capacity increase required in the drain on a design drainage coefficient of 25mm in 24 hours.

- Mr Hedley didn't accept the outcome of the independent review, and accordingly still refused access to his property for the work. It must also be said however that there were elements of the Council/Hedley agreement that Council was not able to honour. This was primarily the consent requirement to put in a water level control on the ephemeral lagoon within the Barton property. Council had no agreement from Mr Barton for this work, as it was contra to the drainage improvements he was seeking.

- In January 1998 Colin Wright recommended that Council consider using its compulsory powers to undertake the re-grade/widening work within the Hedley property – Report PE98.11W. Approval was given to issue a notice under Section 137 of the Soil Conservation and Rivers Control Act 1941.

- It is not known whether notice under Section 137 was ever formally given. It is known that Mr Hedley still adamantly opposed the drain upgrade in his property and it is clear that at this point that Council was looking for a compromise solution.

- Report PE99.171 proposed upgrade work within the Barton property only consisting of upgrade his three farm access culverts to 1200mm and widening the spillway from the Upper Lagoon to a 5m bottom width. The widening of the drain (to 2m bottom width) had already been completed under the 1994 consent which was subsequently surrendered on granting of the 1999 consent.

- The Hedley's (and other downstream neighbours) also objected to the 1999 consent application. One of the key points raised was the legality or otherwise of the original diversion (via Campbell's cut). This matter seems to have been only cursorily looked at as part of the 1990 application and no resolution reached.

3. ENGINEERING OPTIONS

In November Eastern Consulting Limited were engaged to look at the following options

Option 1 – New channel in floodway

Option 2 – Re-graded oxbow or horseshoe drain with new outlet to west of the existing Tawaha floodway.

Option 2A – Re-graded oxbow drain using original (pre Tawaha floodway) outlet.

Option 3 – New outlet from Barton's lagoon to the river.

Option 4 – Original Whaka Drain upgrade as proposed in the 1994 consent application, and shown on plan

The Eastern Consulting Limited report (dated 28 June 2010) was presented to the affected landowners group at a meeting on 1 July 2010. This was then followed by discussions with all affected landowners. The feedback from the combined and individual meetings resulted in the following decisions (see letter dated 7 September 2010):

- Options 1 and 2 to be considered no further. These options were considered expensive, very disruptive to the respective landowners and offered no additional benefits over the remaining options.

- To look more closely at Options 2A, 3 and 4

It also includes a "do minimum" option (Option 5) which only provides for some further cleaning and minor improvements to the existing Whaka Drain. Any consent granted for this option will almost certainly require a review and monitoring clause.

The key findings from this work were presented to the landowner group (with LWVDS Committee members in attendance) at a meeting on 5 October 2010. The notes from that meeting (Doc 848066) were mailed to all landowners.

A consensus could not be reached by all affected parties / landowners. The Lower Wairarapa Valley Drainages Scheme (LWVDS) Committee subsequently made the decision that Option 4 (extended) is the preferred option taking into consideration the following landowners comments:

- Preferred option of John Barton.
- Not acceptable to the Hedley's. Will likely lead to costly and drawn out consent/land access procedures. Old issues of the historic lagoon, Council/Hedley agreement will get re-litigated.
- There is nothing in this for the Hedley's. Resurrecting the concept of a control structure at the outlet to the historic lagoon is not feasible or sensible.
- Acceptable for landowners J Bargh to A Sims provided necessary channel upgrades completed.
- Initial indications from the 3 landowners who farm the low lying area near Duffy's lagoon is that they would react positively to a diversion application if the scheme would help to maintain the drain to a good standard.

3.1 OPTION 4 – A SUMMARY to date

3.1.1 Survey and preliminary improvement design

No additional survey or preliminary design for this option was undertaken for this options assessment.

The option is assumed to be more or less as per Plan A1 – D548/A, drawn in September 1994. This is the updated version of the plan showing typical cross sections and proposing that a duplicated 900mm diameter culvert be put under Hikinui Road at the new invert grade rather than attempting to lower the existing box culvert.

Option 4 wouldn't necessarily exactly follow the 1994 design invert. A practical new invert level that provides an even grade between the downstream 1200 Barton crossing to either the original Cross Bridge level or the upstream end of the J Bargh culvert should be considered. Some new survey would be required. Similarly the options of a new culvert on grade at Hikinui Road or the additional culvert (size checked) at grade should be determined as part of finalising a preliminary design for resource consent purposes.

The Option 4 improvement was modelled by Ian Heslop in 1996 using a HECRAS model for the reach proposed for the regarding - see his internal report dated 31 October 1996.

It is clear that the full re-grade proposal would provide a very good standard of drainage to the Barton property. Flow capacities in the Barton property would now be better than that modelled in 1996 following the upgrade of the three access culverts to 1200mm in 2000.

Capacity at Hikinui Road with the 900mm culvert duplication at full re-grade could be in the order of 3.5 – 4.0m3/sec with capacity restrictions now occurring further downstream at either the Cross/B Bargh access crossings or even at Pahautea Road. A preliminary Mike 11 has been designed that extends at as far downstream as the Pahautea Road culvert/weir based on historical survey data.

Estimates of existing channel capacity downstream of Pahautea Road were developed by Ian Heslop for the 1999 consent application.

3.1.2 Key Upgrade Components

- Re-grading the drain from the downstream 1200 mm access culverts in John Barton's down to the Cross Bridge (Plan A1 – D548/A), e.g. re-grade invert between the Barton culvert and J. Bargh culvert inlet

- The invert width of the improved drain from Hikinui Road down to Cross Bridge needs to be finalised but has initially been set as 1.5 – 2m

- The initial design was to construct an additional 900mm culvert at Hikinui Road to the new required invert level. The alternative is to put in a new 1350mm replacement culvert at the required grade

- Check the invert level of J. Bargh access (1350mm RRJC) pipe to ensure that this will not cause any detrimental affect to Hedley's property

This option would result in a culvert capacity at Hikinui Road of approximately 4 m^3/s; at minor paddock overtopping. The 1200mm culverts at the Barton's property would restrict the drainage capacity of the channel to approximately 2.5 - 3 m^3/s at a steeper grade. The assumption has been made that the new channel capacity from Hikinui Road to Pahautea Road would than be 3 m^3/s.

Under Option 4 the system can cope with either very wet winter conditions, 30mm in 24hrs 'drainage standard', or normal winter drainage conditions plus release of the residual Tawaha water without significantly flooding of the Barton property.

3.1.3 Initial Cost Estimate

The estimated cost for option 4 is $125,000 excluding engineering fees, consent costs and legal fees. The estimate includes provision for:

- An additional 600mm outfall pipe at the Barton lagoon.
- Additional 900mm culvert across Hikinui Road. Note may need to check whether a spill structure is required downstream of the existing 1200mm box culvert or indeed with simply upsizing the culvert is the way to go.
- Re-grading/widening /willow removal between Hikinui Road and Pahautea Road.
- Estimate includes no provision for a survey check or catch up maintenance of the Lower Whaka Drain.

3.1.4 Advantages / Disadvantages

Advantages

- Provides for a very good standard of drainage in Barton property and so will settle this dispute. Design will more than meet mitigation requirements for diversion for Barton property.

- John Barton will agree to lagoon lowering under this option.

- Easy to also upgrade drain channel capacity from Hikinui Road to Pahautea Road to match capacity in Barton property.

- Provides an outfall independent of Ruamahanga River levels.

- Cost is acceptable

Disadvantages

- Achieved drainage standard in Barton property may be better than what is currently the case in the Duffy's Lagoon area. Need to tread carefully so that these landowners don't object to the diversion consent (as was the case in 1994 and 1999) and require a further rethink.

4. ACTIVITIES

No.	Description	Assignment
1	Topographical Survey and Cross Sections	GWRC / Contractor
2	Hydraulic Model Update, calibration and review	GWRC / Consultant
3	Detailed Design, drawings and cost estimate, e.g. design grade downstream of the West Pukio Road culvert to Oporua Spillway, etc.	GWRC / Consultant
4	Assessment of Environmental Effects (AEE), e.g. land use, water quality, wetlands and habitat, fisheries value, Maori and cultural values, beneficial effects, effects on down stream properties, etc.	Consultant / GWRC
5	Review of current consents, conditions and appropriateness for adaptation of the project	GWRC / Consultant
6	Brief for Land Entry Permits – Jozsef Bognar	GWRC
7	Drafting of Resource Consent Application	GWRC / Consultant
8	Consultation of and application of Resource Consent	GWRC / Consultant
9	Preparation and develop a brief for a 'Hearing'	Consultant / GWRC
10	Prepare contract document for selection of contractor	GWRC

5. PROJECT IMPLEMENTATION TEAM

Project Management: Ranjan Cyril – GWRC

Design Lead / Support: Investigations, Strategy & Planning Team (Jan van der Vliet) – GWRC and Consultant

Resource Consent Application and AEE development: Tracy Berghan – GWRC and Consultant

Consultation Support: Mike Longworth, Colin Munn and Graeme Campbell - GWRC

Appendix B – LiDAR Data Sheet

Appendix C – Final Design Drawings