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Waiomu flood protection scheme design report

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Te Kaunihera ā Rohe o Waikato

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Executive summary

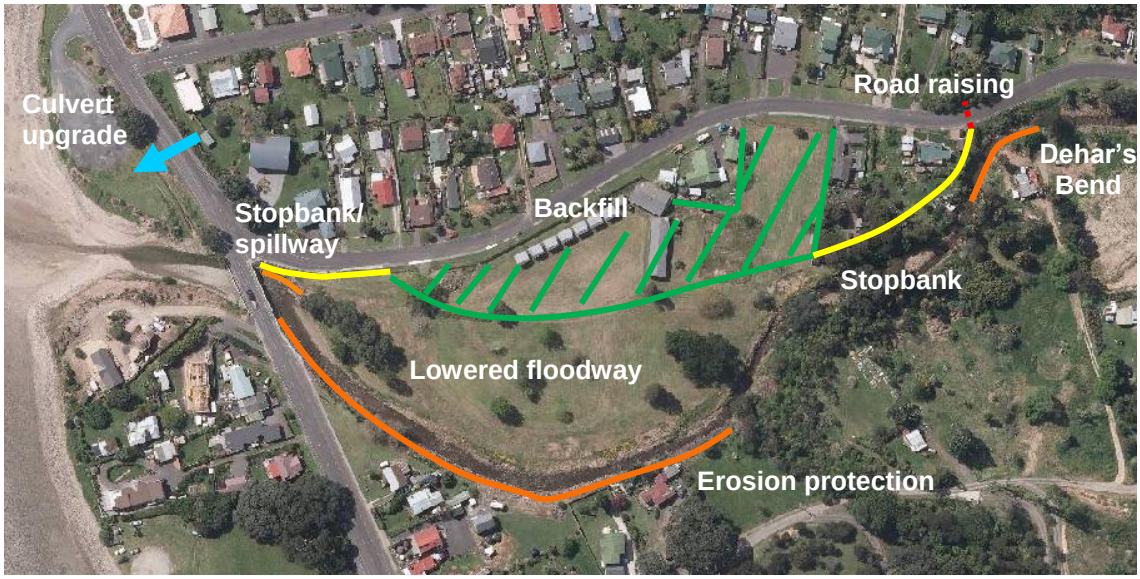
The Waiomu community is located on the west coast of the Coromandel Peninsula, thirteen kilometres north of Thames on State Highway 25. In response to the severe floods generated by the "Weather Bomb 2002", Waikato Regional Council established the Peninsula Project to address river and catchment issues across the Peninsula through soil conservation, river management, animal pest control and flood protection measures. The work included risk assessment, technical investigations, a business case to Central Government, community consultation and establishment of a funding system to provide for undertaking flood mitigation works.

Waiomu is one of the five priority communities identified as having a very high risk to life and property, requiring actions that address these risks. Since the introduction of the Peninsula Project in 2004, Waikato Regional Council and Thames Coromandel District Council, worked with the Waiomu community to develop a flood mitigation strategy to address the Waiomu Stream flood hazard. A completed interim flood protection scheme has been completed for the Waiomu community, the details of which are provided in this Design Report.

For the success of this project it was essential that the community was involved with the development of the project. A flood working group was set up with members of the Waiomu Community and representation from TCDC, DOC and the local Iwi. The working group met at regular intervals to scope the issues, discuss options and to work together to implement the project.

The flood protection scheme developed for Waiomu, focussed on providing a clear floodway free of obstructions to give Waiomu Stream room within which to flood. In 2006, with the assistance of funds received from Central Government, Waikato Regional Council and Thames Coromandel District Council jointly purchased the former Waiomu Holiday Park and the adjacent property for flood protection purposes. These two properties were low-lying and were considered to be very vulnerable to flood hazards from the Waiomu Stream. The intention of purchasing these two properties was to remove dwellings from high flood hazard areas and to provide an efficient and safe floodway within the town. The lower ground adjacent to Waiomu Stream would be reshaped and retained for floodway management purposes and it was proposed that the remaining high ground be sold. The sale of this land would enable the recovery of part of its cost, reducing the financial burden on the local community.

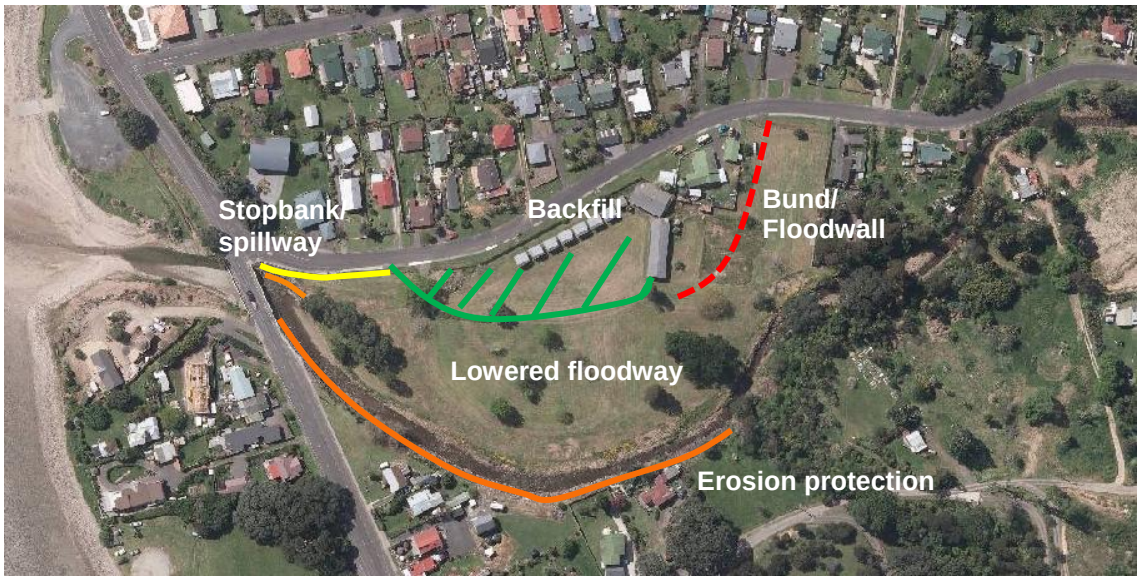
In addition to lowering of the floodway and filling of a portion of the former holiday park for disposal, the original concept for the flood protection scheme included works at Dehar's Bend to keep flood flows in the channel and the provision of a stopbank/spillway from Dehar's Bend to the former holiday park to protect properties on the north side of Waiomu Valley Road. The concept also included New Zealand Transport Agency upgrading the State Highway 25 (SH25) Bridge and SH25 culvert. The concept is summarised on the figure below.



Proposed engineering works

The concept aims at achieving security and safety against flooding by avoidance first and secondly by reduction and/or mitigation of the risks through engineering works. Planning controls such as designations, property retirement, building set back lines and other land use planning tools form an important part of this concept. Where protection could not be practically achieved by such planning controls, engineering works up to specific design standard and with clear definition of the residual risks was proposed.

During the design process, certain components of the scheme became unfeasible to implement hence a revised scheme was implemented. The figure below illustrates the completed works at Waiomu.



Completed engineering works

The full flood protection scheme has not been constructed at Waiomu, hence some properties are still vulnerable to flood hazard from Waiomu Stream. If at a future date it is decided to complete the flood protection scheme, then a proposed scheme upgrade has been developed that has evolved from the original scheme design to take into account the feedback received from adjacent landowners.

The proposed scheme upgrade comprises raising 18, 20 and 22 Waiomu Valley Road hence the remainder of the former holiday park (18A Waiomu Valley Road) could be filled and some additional items, as illustrated on the figure below.

Proposed future works

There is a remaining portion of land (0.2714ha) that council still owns (18A Waiomu Valley Road, Lot 2, CT SA882/86) that does not comprise part of the floodway and hence is surplus to Waikato Regional Council's requirements and can be sold. This portion of land has not been raised, hence if it was to be sold it is essential that the potential purchaser/s understand the flood hazard that exists at the property from Waiomu Stream and the limitations on activities that can be undertaken at the site.

At this stage no further capital works are proposed to protect the Waiomu community from flood hazard. If at some point in the future the community decides it requires additional protection, and is able to fund the works, then council would look to extend the works further upstream.

Catchment management and soil conservation works programmes have also been established in the Waiomu Stream catchment to complement the flood mitigation works undertaken.

The main channel of the Waiomu Stream is monitored and periodically maintained by the Waikato Regional Council to remove accumulated sediment and debris. This work maintains the capacity of the Waiomu Stream and reduces the risk to adjacent land that would otherwise be inundated more frequently.

'Residual flood risk' is a term used to describe a river flood risk that exists due to the potential for 'greater than design' flood events to occur. Residual flood risk applies to the Waiomu community from factors such as the incomplete nature of the works, the greater than the design event, the impact of debris flow during a flood event and that the model excludes obstructions such as buildings and walls which may have localised effects. Based on the flood hazard status of land in the community, TCDC has various planning controls in place via the Thames Coromandel District Plan, that restrict what land use activities can be undertaken. Refer to the Thames Coromandel District Plan and TCDC staff for details.

The flood mitigation scheme for the Waiomu community should be reviewed in accordance with the Coromandel Zone Management Plan. In addition if there are any significant changes in land use within the Waiomu settlement/Township, the scheme would need to be reviewed. Due to funding constraints the full flood mitigation scheme was not constructed. If feedback from the community indicates that the community wants to increase their level of protection and are able to fund the works, then the scheme would be reviewed and completed following normal Council Community processes.

1 Introduction

1.1 Background

The Waiomu community is located on the west coast of the Coromandel Peninsula, thirteen kilometres north of Thames on State Highway 25.

In response to the severe floods generated by the "Weather Bomb 2002", Waikato Regional Council established the Peninsula Project to address river and catchment issues across the Peninsula through soil conservation, river management, animal pest control and flood protection measures.

Under the Peninsula Project WRC and Thames Coromandel District Council (TCDC) worked together on flood mitigation plans for five Thames Coast communities. The work included risk assessments, technical investigations, development of risk mitigation options, development of a business case to central government for funding support and establishment of rating mechanisms. There was extensive community consultation on plans for these Thames Coast communities.

Waiomu is one of the five priority communities identified as having a very high risk to life and property, requiring actions that address these risks. A critical area of risk that was identified within the Waiomu community was the former Waiomu Bay Holiday Park. Since the introduction of the Peninsula Project in 2004, Waikato Regional Council and Thames Coromandel District Council, worked with the Waiomu community to develop a flood mitigation strategy to address the Waiomu Stream flood hazard. A completed interim flood protection scheme has been completed for the Waiomu community, the details of which are provided in this Design Report.

1.2 Scope of report

The purpose of this Design Report is to provide a summary of the Waiomu flood protection scheme, including the rationale behind the scheme development, the agreed levels of service, the design details, as built information, the operation and maintenance requirements associated with the scheme, the flood hazard and residual risk of the scheme and the scheme review requirements.

The Design Report includes the following sections:

- Catchment overview
- Hydrological assessment
- Hydraulic model development
- Flood protection scheme
- Agreed levels of service
- Operation and maintenance
- Flood hazard assessment
- Residual flood risk
- Planning controls, and
- Scheme review.

2 Catchment overview

2.1 Catchment description

The Waiomu community is located on the west coast of the Coromandel Peninsula, thirteen kilometres north of Thames on State Highway 25 (SH25), refer to Figure 1 below.

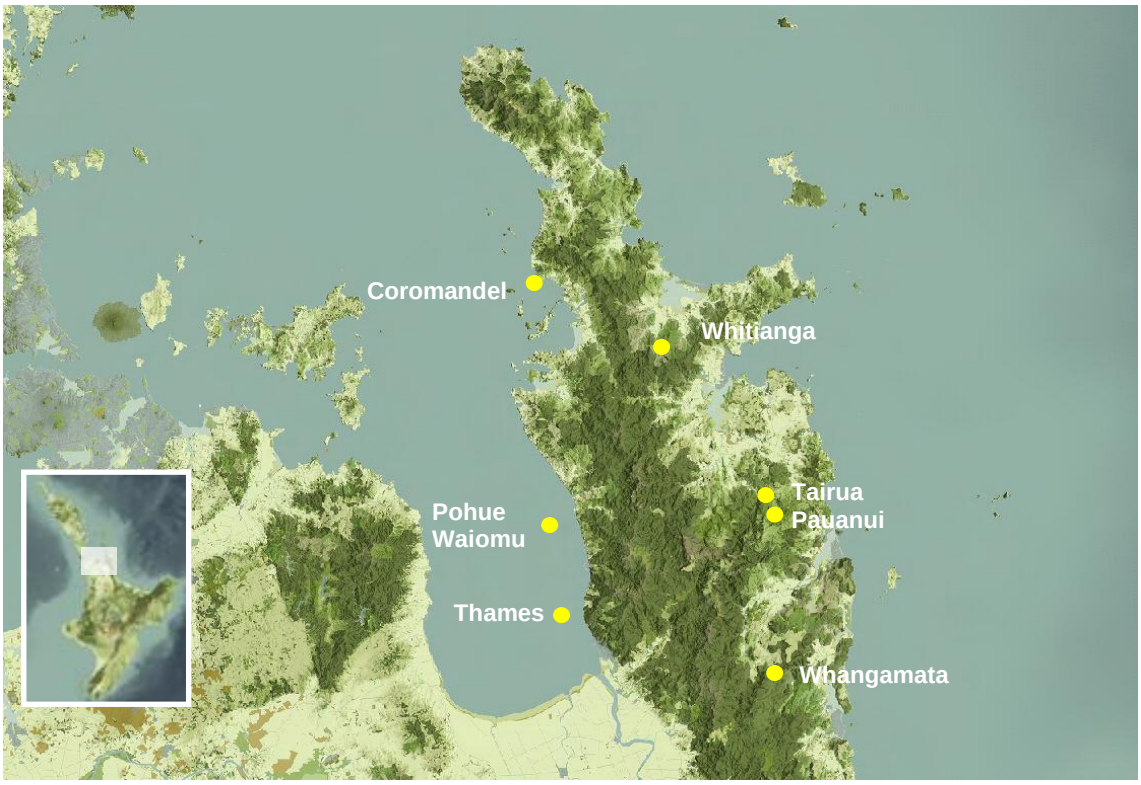


Figure 1 Thames-Coromandel district

The Waiomu Stream has a 10.4 km^2 catchment that originates in the western Coromandel Ranges, refer to the following figure.

Figure 2 Waiomu Stream catchment

The total area of the Waiomu catchment equals 1,038 hectares (or 10.4 square kilometres). Around 97 percent of the catchment is covered by native forest while only 1.3 percent is in farmland. About 83 percent of the catchment is managed by the Department of Conservation. The Waiomu community makes up just 1.5 percent of the total catchment.

This catchment is relatively steep and covered in regenerating native vegetation and scrub. It is also susceptible to short duration but high intensity rainfall events that cause flash flooding and debris flows in the Waiomu Stream with little or no warning.

2.2 Waiomu Stream

The Waiomu Stream flows out of the Coromandel Ranges and through the Waiomu community before discharging to the Firth of Thames. The Waiomu Stream drains a steep, hilly area. It is fed by approximately 15 smaller tributary streams and during periods of heavy rain it takes about 45 minutes for water to get from the top of the catchment to the bottom.

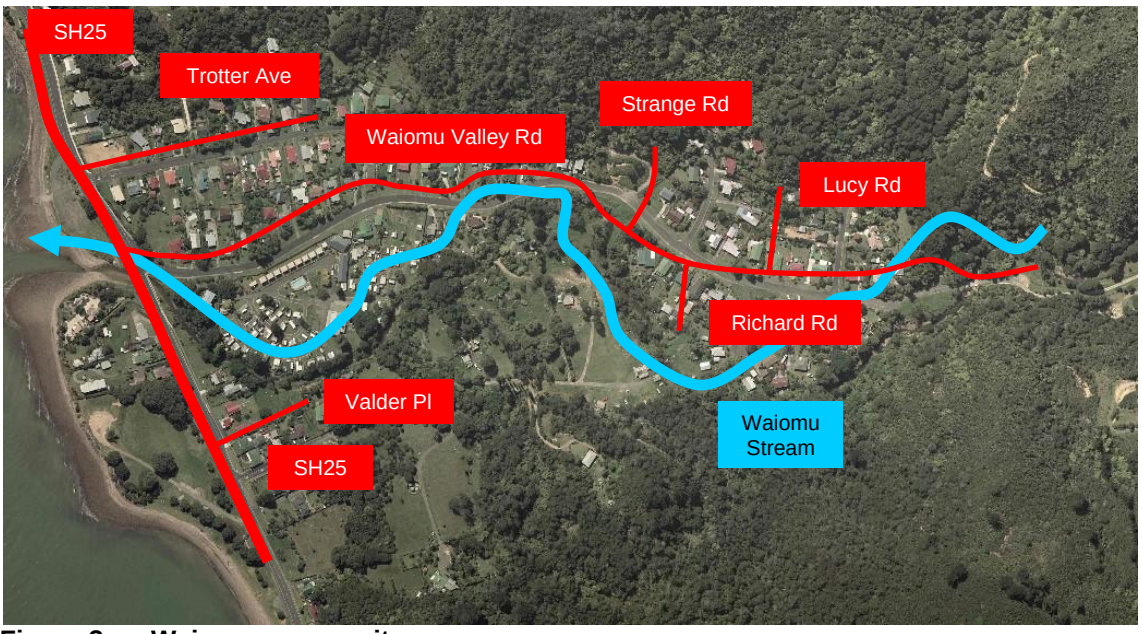


Figure 3 Waiomu community

Parts of the Waiomu community are located on the floodplain and sediment/debris fan created by the Waiomu Stream (refer to Figure 4 and Figure 5).

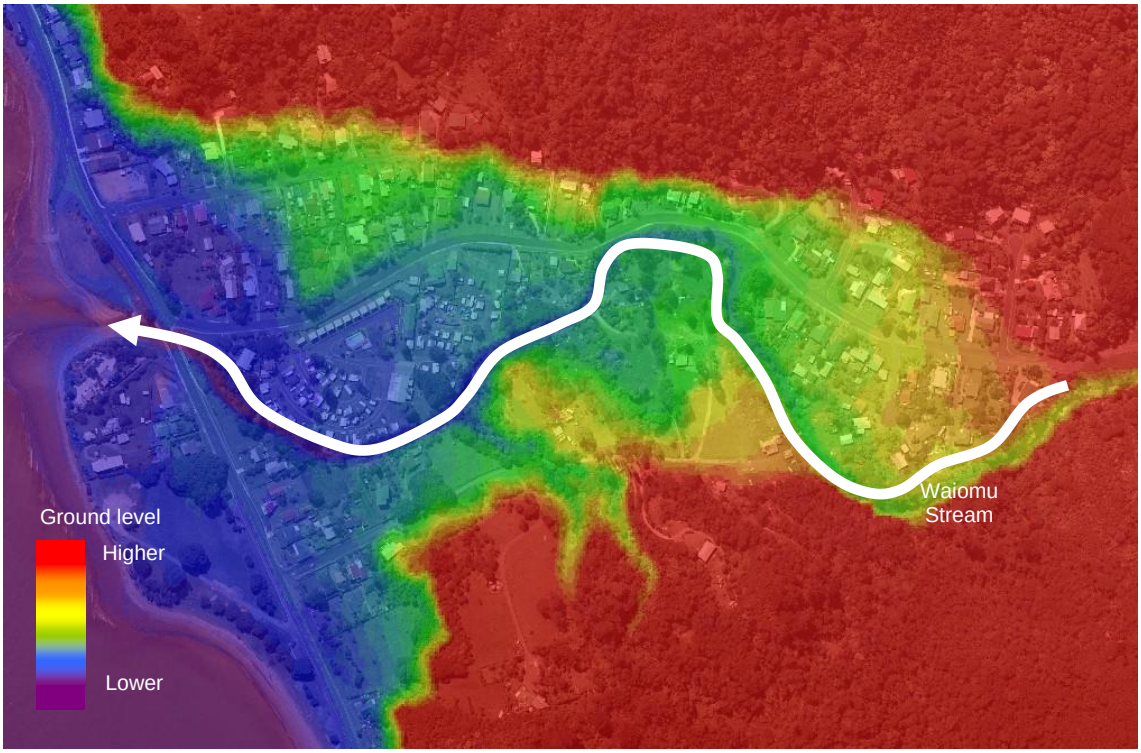


Figure 4 Ground level around the Waiomu community

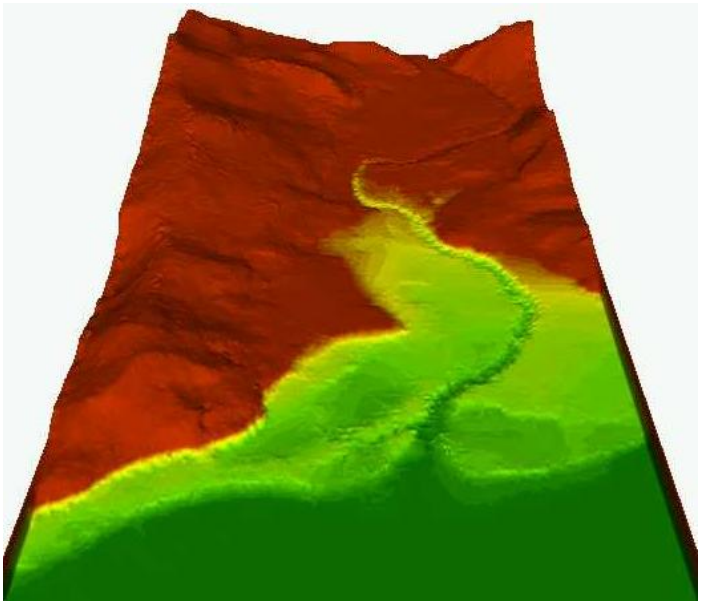


Figure 5 Waiomu Stream coastal alluvial fan (looking inland from the Firth of Thames)

2.3 Flood history

The presence of the Waiomu community on the floodplain of the Waiomu Stream means that there is risk that people and property will be affected by flood events in the Waiomu Stream. The Waiomu catchment is susceptible to short duration but high intensity rainfall events causing flash flooding and debris flow in Waiomu Stream with little or no warning.

Historically during significant flood events in the Waiomu Stream, overland flow occurred across the meander where the former Waiomu Bay Holiday Park was established. A proportion of this overland flow would re-enter the Waiomu Stream upstream of the SH25 Bridge. The remainder would pond behind SH25 in the vicinity of Trotter Avenue. Minor overland flow also occurred downstream of the Waiomu Creek Road Ford. Damage to properties within the Waiomu community was focused on those properties on the true right bank of the Waiomu Stream in the lower reaches

of the catchment between Dehar's Bend and the SH25 Bridge. Figure 6 below illustrates the predominant flooding mechanism.

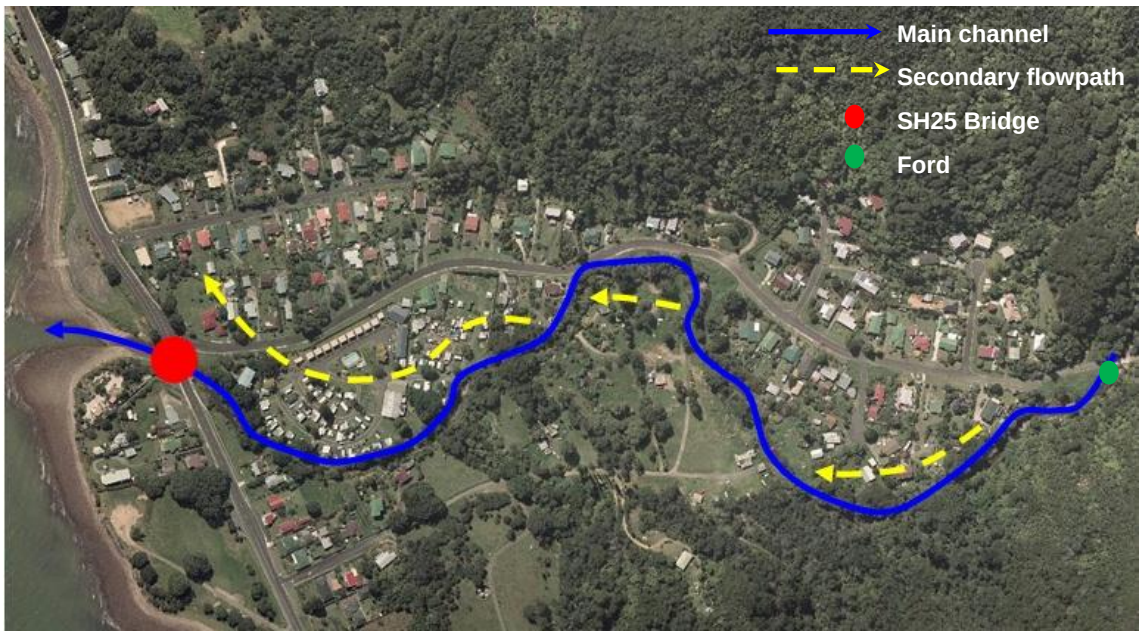


Figure 6 Predominant flooding mechanism at Waiomu

Figure 7 below illustrates the predicted flood extents at Waiomu for the 1% Annual Exceedance Probability (AEP) event with an allowance for predicted climate change.

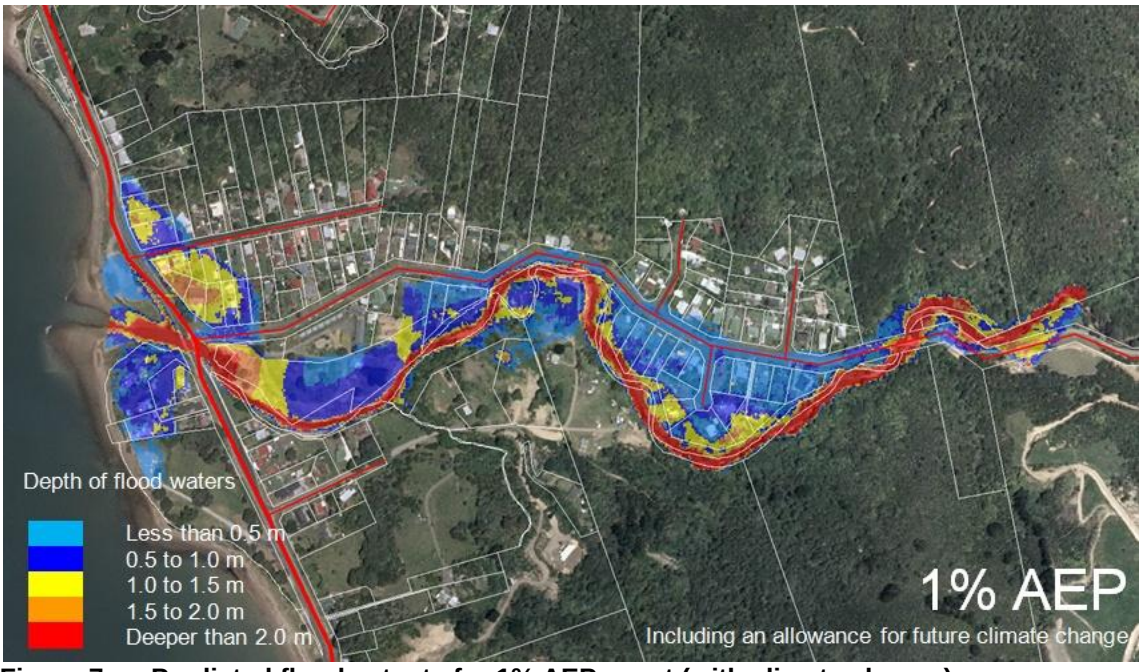


Figure 7 Predicted flood extents for 1% AEP event (with climate change)

The significance of the flood hazard to the Waiomu community was demonstrated during the storm event that occurred on June 21, 2002 (also referred to as the 'Weather Bomb'). This event brought torrential rainfall to the Coromandel Peninsula (with unconfirmed intensities of up to 125 mm in 25 minutes) and caused widespread damage across the Thames-Coromandel and South Waikato Districts (Munro, 2002). The Waiomu community sustained significant damage during this event, including a loss of life.

Damage to properties within the Waiomu community from the Weather Bomb was focused on those properties immediately adjacent to the Waiomu Stream and those that were within the secondary flow paths and ponding areas. Figure 8 below

illustrates the property damage that occurred within the Waiomu community following the 'Weather Bomb'.

Figure 8 Property damage within the Waiomu community during the 'Weather Bomb'

Following the 'Weather Bomb', the Waikato Regional Council and Thames Coromandel District Council initiated the Peninsula Project to better understand the river flooding issues that affect the communities on the Thames Coast. This project also involved the identification of works to mitigate the impact of river flooding on people and property along the Thames Coast.

The Peninsula Project focused on the five most vulnerable communities that were identified as being worst affected by both the weather bomb and historical flood events, which included the Waiomu community.

2.4 Flood hazards

Waikato Regional Council undertook a scoping exercise to identify the flood hazards for the Waiomu community now and in the long term to ensure that council's objectives were met in terms of providing sustainable outcomes into the future.

The flood hazards within the Waiomu area could be briefly described as follows:

- **Flooding**: Pre-scheme the Waiomu Stream had a capacity of approximately 80m^3/s and overland flow occurred upstream of the State Highway 25 Bridge through the former Holiday Park and gradually rose to cover all other low-lying areas. The extent of flooding covered adjacent developed floodplains.

- **Ponding**: Part of the residential area north of Waiomu Valley Road is low lying and flood waters pond for approximately 10 hours following floods as the existing drainage culvert under SH25 is sized for local drainage only.

- **Channel stability**: The Waiomu Stream channel has a gravel bed and vegetated banks, is relatively deep upstream of the ford culvert (refer to Figure 6 above for the location of the ford) and becomes wider and shallower through the Waiomu community. Natural, slow erosion of the bed and banks is ongoing with significant erosion occurring during flood events, especially at bends.

- **Channel infilling**: Floods bring significant amounts of gravel and bed load material from the upper catchment, which cause infilling of the active channel, reducing its capacity, raising its bed and flood levels.

- **Floating debris**: A characteristic of the Waiomu Stream floods is that it carries a significant amount of logs and debris that cause higher water levels, blockages in culverts and bridges, and damage to property. Debris becomes a significant hazard in events exceeding the 2% AEP event.

- **Climate change effects**: Based on Ministry for the Environment guidelines (MfE, 2004), the effects of global warming are expected to be increased rainfall and higher sea levels. Effectively, this means that what is assessed as a 1% Annual Exceedance Probability (AEP) flood flow today might have a higher probability of occurring in the future. The MfE guidelines suggest that the average annual temperature within the Waikato region is likely to increase by 1.4 ^{0}C in 2030 and 3.8 ^{0}C in 2080. This change is likely to increase rainfall by approximately 7.5% per degree temperature rise.

Based on the above, a long term vision to address flood hazards for the Waiomu community was developed as outlined in this report.

3 Hydrological assessment

3.1 Technical information

During the development of the Peninsula Project, WRC collected a significant amount of technical information covering the Waiomu Stream catchment. This information is presented in WRC's Technical Report 2004/13 and includes:

- Historical research
- Catchment hydrology
- Lower channel hydraulics (1 dimensional)
- Floodplain hydraulics (2 dimensional)
- Flood hazard analysis (including extent and severity).

Some of the key data sources and findings that have informed technical investigations are summarised below.

Table 1 Summary of technical reports covering flood events on the Thames Coast

Flood event	Technical reports
April 1981	HCB Report 109 and 123 (Sep 1981 and June 1982)
February 1985	HCB Report 190 (October 1985)
Cyclone Bola	No technical reports located
Cyclone Drena	No technical reports located
January 2002	No technical reports located
June 2002	EW Report 2002/10 (July 2002)

Table 2 Technical reports covering flood mitigation and management at Waiomu

Community	Previously completed technical investigations
Waiomu	No technical investigations previously completed

Table 3 Summary of completed flood mitigation works at Waiomu

Community	Previously completed works
Waiomu	Channel improvement works were completed privately during 2002. These works involved installing erosion protection (rock rip rap) along the true left bank of the lower Waiomu Stream (opposite the Waiomu Bay Campground).

Longsection information for Waiomu Stream (pre-scheme) has been detailed in a WRC document number WRC DM# 912047.

This longsection includes the following information:

- Bed level
- Top-of-bank level
- Design flood level for a variety of flood events
- Levels associated with proposed works (e.g. floodwalls)

The existing channel performance prior to the scheme works being implemented was assessed to be the following for Waiomu:

- Upstream of Dehar's Bend 1% AEP (100 year ARI) event
- Dehar's Bend < 50% AEP (2 year ARI) event
- Downstream of Dehar's Bend < 50% AEP (2 year ARI) event

3.2 Catchment characteristics

The Waiomu Stream catchment is located on the steep western slopes of the Coromandel Ranges. The catchment is covered with regenerating native forests and dense scrub. The catchment area and characteristics used to develop a hydraulic model for the catchment are described below.

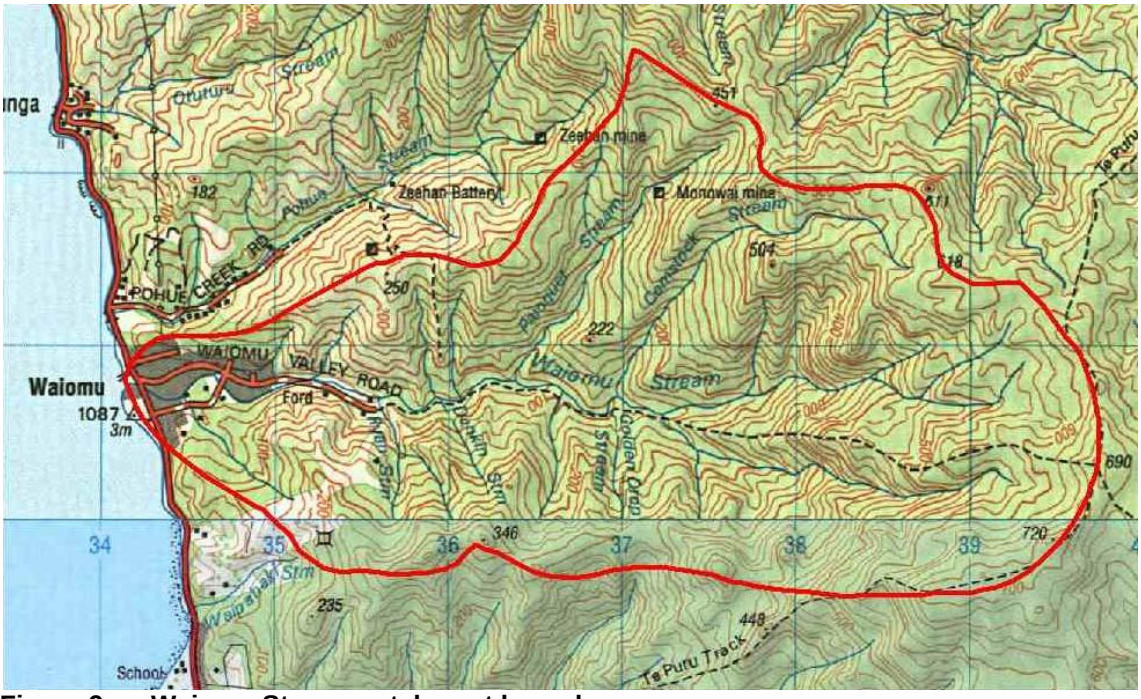


Figure 9 Waiomu Stream catchment boundary

Table 4 Waiomu Stream catchment summary

Catchment area	10.4 km^2
% urban	Low
% indigenous forest/ scrub	High
Channel slope	10%
Time of concentration	45 minutes

3.3 Rainfall

Rainfall data was taken from NIWA's High Intensity Rainfall Design System (HIRDS) Version 2 (the most current version of HIRDS at the time of the model development). The standard error was added to the rainfall depth to give a conservative rainfall estimate and is shown below.

Table 5 Waiomu Stream catchment predicted rainfall intensities (existing)

	Rainfall summary 45 minute duration event					
Annual exceedance probability (AEP) event	50%	20%	10%	5%	2%	1%
Predicted rainfall intensity (mm/hr)	32	38	45	52	67	80

Climate change effects have been estimated following the methods outlined by the Ministry for the Environment guidelines (MfE, May 2004 – the most current guidelines at the time of the assessment). The guidelines predict that the temperature within the Waikato Region will rise by up to 1.4^{0}C by 2030 and up to 3.8^{0}C by the year 2080. The guidelines also suggest that rainfall intensity will increase 7% to 8% per degree ^{0}C increase. Based on the above the rainfall intensities were estimated as outlined in the following table.

Table 6 Waiomu Stream catchment predicted rainfall intensities (future)

	Rainfall summary 45 minute duration event					
AEP event	50%	20%	10%	5%	2%	1%
Predicted rainfall intensity 2030 (mm/hr)	35	42	50	58	74	88
Predicted rainfall intensity 2080 (mm/hr)	40	49	58	67	86	103

3.4 Flow estimates

The peak inflow for Waiomu Stream including an allowance for climate change has been determined using several methods; the Rational Method, Relative Rational Method, and the Revised Regional Flood Estimation Method. The results have been compared with previous reports and historic events.

Table 7 Waiomu Stream peak flow estimates

	Peak flows estimates					
AEP event	50%	20%	10%	5%	2%	1%
Existing peak flow - 2006 (m^3/s)	61	74	105	124	143	157
Future peak flow - 2030 (m^3/s)	68	82	116	137	158	174
Future peak flow - 2080 (m^3/s)	78	95	135	159	184	202

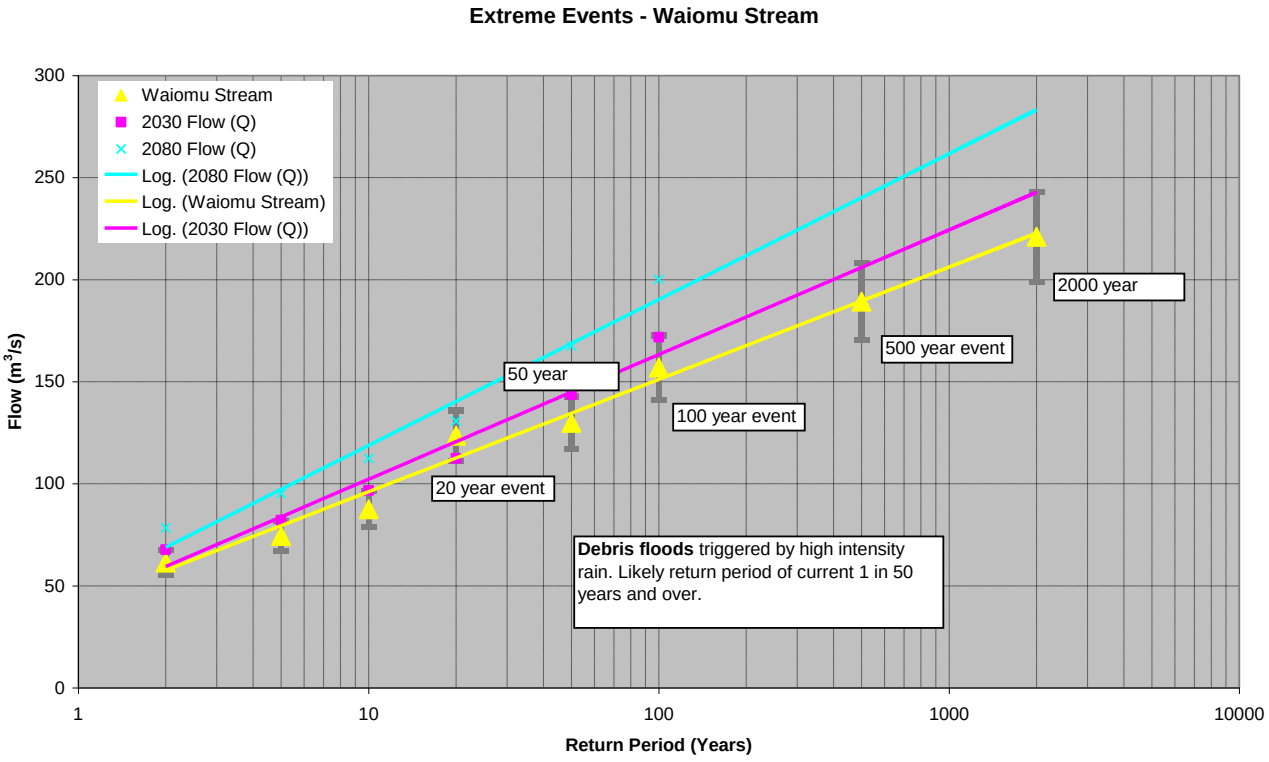


Figure 10 Waiomu Stream hydrological summary

From this assessment, the existing 1% AEP event flood flow for Waiomu Stream is estimated to be 157m^3/s and the future 1% AEP event flow is estimated to be approximately 188m^3/s.

3.5 Hydrograph

To allow realistic modelling it was necessary to create a hydrograph to input flows into the model. A dimensionless unit hydrograph was created by examining five historic floods recorded on the Kauaeranga River at Smiths (WRC recording site 9301). The dimensionless hydrograph used is shown below.

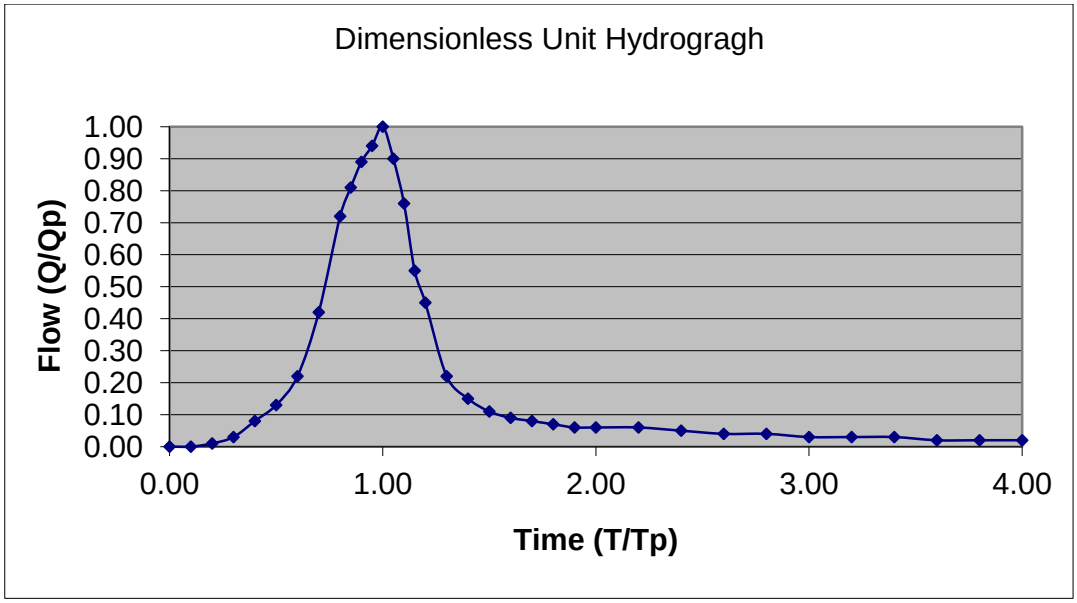


Figure 11 Dimensionless unit hydrograph

This was used to produce a unit hydrograph for the Waiomu catchment. Where Tp used is the time of concentration and Qp is the peak flow.

4 Hydraulic model development

The Waiomu Stream and surrounding area was modelled using an unsteady state, two-dimensional computational hydraulic model using the MIKE-21 software. This model provides detailed information in regard to extent, depth and velocity of flooding. This section outlines the development of the hydraulic model.

4.1 Model inputs

4.1.1 Ground contour

A digital terrain model (DTM) based on ground survey (LiDAR) was used in the hydraulic model to represent the ground contours of the study area. The DTM was based on a 2m by 2m grid of the whole stream and flood plain with an accuracy of +/- 0.15m.

4.1.2 Upper boundary condition

The upper boundary of the hydraulic model consists of an inflow hydrograph to represent the peak flow for the catchment for the 1% AEP event. The derivation of the hydrograph is discussed in Section 3 above.

The design flow for the 1% AEP event for the existing climatic conditions is 157m^3/s.

The design flow for the 1% AEP event for the future climatic conditions is 188m^3/s.

4.1.3 Lower boundary conditions

The lower boundary of the Waiomu Stream is the Firth of Thames. The spring high tide level was used to replicate the backwater effect at the lower end of the stream. The current spring high tide is RL2.3m (LiDAR datum - the datum used in the hydraulic model). This was used for the model runs for the existing climatic conditions.

Sea level is predicted to rise 0.5m by the end of the century according to MfE guidelines (MfE, May 2004). Hence the lower boundary condition used to simulate future climatic conditions was RL2.8m (LiDAR datum).

4.1.4 Resistance

The variation in resistance across the flood plains has been taken into account. In MIKE-21 a separate resistance file has been created. In this file the resistance for different areas is assigned. MIKE-21 uses Manning's M to represent roughness, which is the inverse of Manning's n value. In the hydraulic model the resistance was assigned as follows:

Stream/river/sea	= 25
Land	= 15

Note that the resistance values are assigned with only limited accuracy based on the aerial photographs for the study area. This is considered an appropriate level of detail in hydraulic modeling practice.

4.1.5 Model location

The MIKE-21 hydraulic model is located on the WRC system in the following folder:

G:\RCS\Technical Services\Projects\Coromandel Zone\Waiomu\Hydraulics\MIKE 21

4.2 Model validation

The river flood maps prepared as part of this assessment were compared with observations made during previous flood events in the Waiomu Stream. This

comparison, which included the review of several Hauraki Catchment Board and Waikato Regional Council reports, showed that the maps were a reasonable representation of flooding in the Waiomu Stream (refer to Figure 12).

Figure 12 Comparison of modelled and observed flood extents

4.3 Model assumptions and limitations

The following outlines the assumptions made when building the hydraulic model and model limitations:

- The modelling work has been undertaken for the current catchment characteristics. Any significant alteration to the catchment will affect the hydrology which will then affect the extent and magnitude of the flood hazard risk. Alterations to the catchment that may affect the hydrology significantly include, land use changes, deforestation and development. Following significant alterations to the catchment the hydrology should be reviewed and possible adjustments should be made to the flood hazard.

- The modelling work has been undertaken for the current floodplain topography. Aerial survey data (LiDAR) is taken and converted into 2 metre cell Digital Terrain Model (DTM). The DTM incorporates ground levels but excludes

features such as fences, trees and buildings. Water is allowed to flow across the DTM to determine the extent and magnitude of the flood hazard risk.

- The DTM was also used to model flows through the culvert under State Highway 25. The accuracy was limited by the 2 metre cell spacing and improvements in the modelling of the culvert are possible. However as the results from this assessment appeared to match historical events it was decided that for at this concept stage the results were acceptable.

- The flood modelling work is for the Waiomu Stream only. Coastal hazards have not been included as part of the modelling work.

- All flood modelling has been undertaken for clear freely flowing water and does not model actual debris and sediment movement. However the derivation of the peak flows has been undertaken using methods derived from actual events. Actual events typically have elements of debris and sedimentation movement. While the model does not include these elements specifically, the derivation of the flows used in the hydraulic model does. Therefore the modelling result capture the effects of debris and sediment load in a way similar to that experienced historically.

- While the model results capture typical debris and sediment movement effects, the results do not represent larger debris flows or blockages. Such occurrences are considered greater than design events and are considered a residual risk which is described in Section 10.

5 Flood protection scheme

5.1 Long term vision

Addressing flood risks within Waiomu needed to be considered within the context of a long term flood risk management plan incorporating a range of the options, including planning controls, flood warning and response, floodway designations and flood protection works. These in conjunction with appropriate catchment management practices, such as pest control and native bush regeneration, can achieve the best community outcomes.

The long term vision to protect the Waiomu community from flood hazard is for the:

- Floodway of the Waiomu Stream to be well defined with no buildings or obstructions in it, so as to provide sufficient capacity to pass the flood flows for up to the future 1% AEP event.

- Floodway capacity to be sufficient to account for debris and bed load that is characteristic of flood events in the Coromandel Peninsula, and also for tidal/coastal flooding arising from sea surge and wave action.

- All houses and sections to be located outside of the designated floodway and to be raised above the future 1% AEP flood level.

- SH25 Bridge capacity to be increased to provide for the future 1% AEP event with sufficient freeboard. At present the SH25 Bridge is estimated to be able to convey up to the 2% AEP event.

This long term vision was considered when developing a flood protection strategy for the Waiomu community; however the actual design concept needed to take into account existing constraints which are discussed in the sections below.

5.2 Scheme development

5.2.1 Community input

For the success of this project it was essential that the community was involved with the development of the project. A flood working group was set up with members of the Waiomu Community and representation from TCDC, DOC and the local Iwi. The working group met at regular intervals to scope the issues, discuss options and to work together to implement the project.

5.2.2 Design concept

The Waiomu community is small and due to the topography of the lower reaches of the catchment only a limited number of properties receive betterment from the flood protection scheme. Waikato Regional Council has been mindful of this issue and has tried to develop a proposal that is affordable to the community.

In 2006, with the assistance of funds received from Central Government, Waikato Regional Council and Thames Coromandel District Council jointly purchased the former Waiomu Holiday Park and the adjacent property (2 Waiomu Valley Road) for flood protection purposes. These two properties were low-lying and located on the floodplain of the Waiomu Stream and were considered to be very vulnerable to flood hazards from the Waiomu Stream. These two strategic property purchases formed the heart of the Waiomu flood protection scheme.

The intention of purchasing these two properties was to remove dwellings from high flood hazard areas and to provide an efficient and safe floodway within the town. The

lower ground adjacent to Waiomu Stream would be reshaped and retained for floodway management purposes and it was proposed that the remaining high ground be sold. The sale of this land would enable the recovery of part of its cost, reducing the financial burden on the local community.

In addition to lowering of the floodway and filling of a portion of the former holiday park for disposal, the original concept for the flood protection scheme included New Zealand Transport Agency (NZTA) upgrading the SH25 Bridge and SH25 culvert, works at Dehar's Bend to keep flood flows in the channel, and the provision of a stopbank/spillway from Dehar's Bend to the former holiday park to protect properties on the north side of Waiomu Valley Road. The original concept is summarised below and a schematic is provided in Figure 13:

- Definition of the natural floodway and works to ensure it has sufficient capacity to pass future 1% AEP flood flows.
- NZTA upgrading the SH25 Bridge and the SH25 culvert.
- Channel works to provide a stable channel, predominantly on the left bank at Dehar's Bend and upstream of the SH25 Bridge.
- Protection of the existing development on the right bank by a combination of road raising, construction of a stopbank upstream of the former holiday park, and the construction of a stopbank/spillway on the section downstream of the former holiday park.
- Protection of future development on the former holiday park by raising the portion of the property that is to be sold, above the expected flood levels of the future 1% AEP event.
- Land use planning controls.

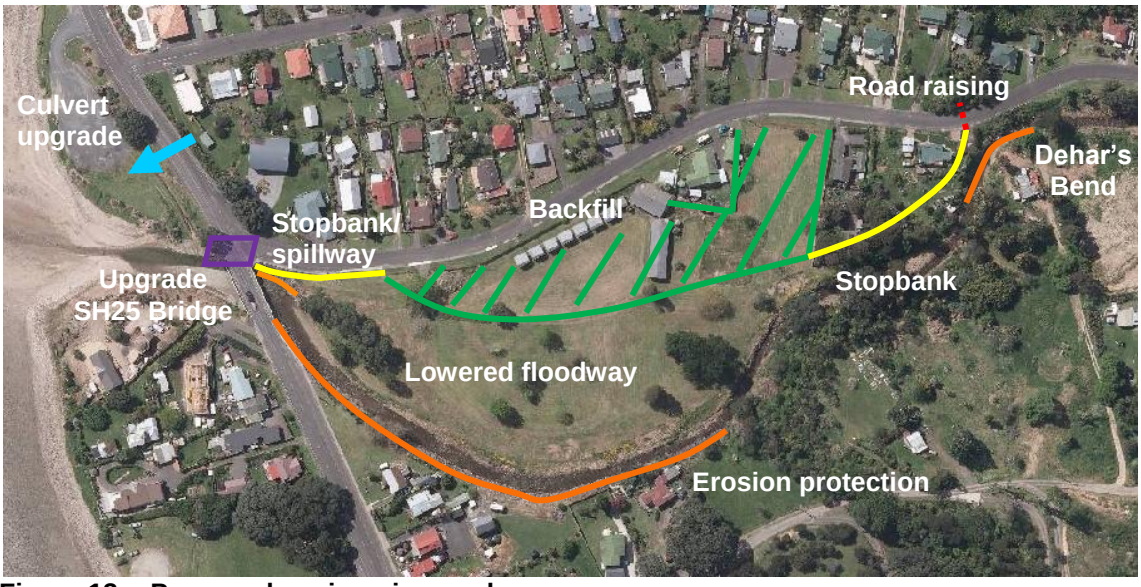


Figure 13 Proposed engineering works

The concept aimed at achieving security and safety against flooding by avoidance first and secondly by reduction and/or mitigation of the risks through engineering works. Planning controls such as designations, property retirement, building set back lines and other land use planning form an important part of this concept. However, where protection could not be practically achieved by such controls, engineering works up to specific design standards associated with clear definition of the residual risks along with a risk management plan was proposed. The concept incorporates the following elements:

- Adequate floodway
- Stable channel
- Protection along the right bank by way of stopbanks/floodwalls/road raising, and

- Appropriate planning controls to address the residual risks.

5.2.3 Scheme evolution

Various properties are referred to in the following sections. For ease of reference the following figure illustrates the property locations at Waiomu that are referred to.

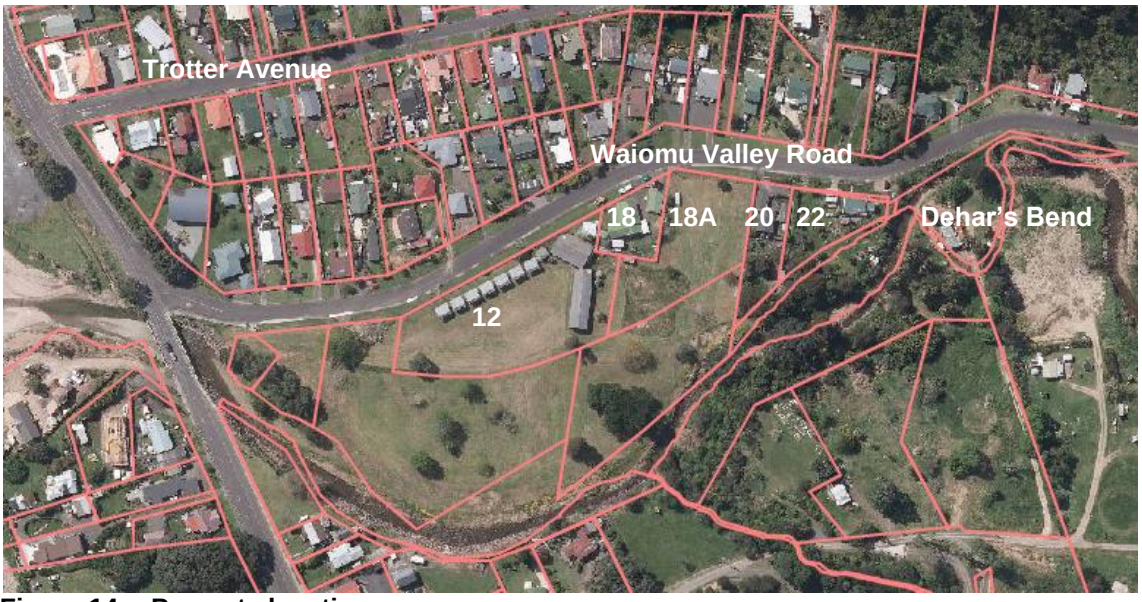


Figure 14 Property locations

The flood protection scheme for Waiomu was designed to retain as much of flood flows as possible in the Waiomu Stream floodway. In general, schemes are designed to cater for the 1% AEP event, however this was not possible at Waiomu due to the limited capacity of the SH25 Bridge (bridge capacity is estimated to convey the 2% AEP event).

Upgrading the SH25 Bridge to convey the future 1% AEP flood flows with sufficient freeboard was identified as part of the total solution to reduce flood hazard to the Waiomu community. At the time of scoping this project (2006), the SH25 Bridge upgrade could not be included within the New Zealand Transport Authority's 10-year plan; hence a staged approach was taken in providing flood protection for Waiomu until the SH25 Bridge could be replaced/upgraded.

Prior to WRC's implementation of the flood protection scheme at Waiomu, overland flow occurred over Waiomu Valley Road (between the downstream end of the former holiday park and the SH25 Bridge) in 10% to 5% AEP events causing flooding and ponding within the properties to the north of Waiomu Valley Road. A stopbank/spillway was proposed in this reach (refer Figure 15) providing protection to this area in up to the 2% AEP event. In greater than a 2% AEP event, the stopbank/spillway would act as a controlled spillway into this area. If the SH25 Bridge is upgraded then the stopbank/spillway would be upgraded to provide protection to the 1% AEP event.

The floodway was proposed to be lowered and reshaped to convey the future 1% AEP flood flows. The land on the left bank was already elevated sufficiently to contain flows, however the land on the right bank (a portion of the former holiday park) needed to be raised to contain the flood flows and to ensure sufficient definition of the floodway to ensure velocities could be achieved to limit the deposition of materials within the floodway. The land was proposed to be raised to the future 1% AEP event (allowing for climate change).

During the consultation process associated with undertaking fill at the former holiday park, adjacent landowners expressed concerns about the total fill proposal in terms of the fill height and the potential effects of the fill proposal on local drainage. A concept that included drainage channels down either side of the proposed fill to provide for local

drainage was developed, however the adjacent landowners were still not comfortable with the fill proposal. As a result, it was decided that only the western half of the former holiday park (12 Waiomu Valley Road) would be filled, with the remainder of the former holiday park (18A Waiomu Valley Road) remaining at existing ground levels.

Without the entire fill proposal being undertaken it was necessary to construct a bund (with a small section of flood wall) through 18A Waiomu Valley Road to provide protection to 18 Waiomu Valley Road and the existing buildings retained at the former holiday park. This bund has designed to the height of the future 1% AEP event flood level.

During the project it was also decided that it was not feasible to locate a stopbank in the back gardens of the two properties upstream of the former holiday park (20 and 22 Waiomu Valley Road) as due to site topography the stopbank would be located midway through the properties, which would cut off a significant portion of the properties from their houses. The preferred option to manage flood hazard to these two properties is to raise the upper halves of the sections and houses, however this was not able to be progressed due to funding and implementation issues.

The scheme included proposed works at Dehar's Bend as at this location there is a bend in the stream and during flood events water can come out of channel and flow through residential properties and down Waiomu Valley Road. The proposed works comprised bank stabilisation and the construction of a flood wall on the right bank along the property boundary of 22 Waiomu Valley Road, to deflect the flows around the bend and to keep the water in the stream channel. Road raising was also proposed at this location to tie into the flood wall to keep the water in the stream channel. During consultation the residents at this property would not agree to the proposed works being constructed on their land hence these components of the scheme were not constructed.

Figure 15 below illustrates the completed works at Waiomu.

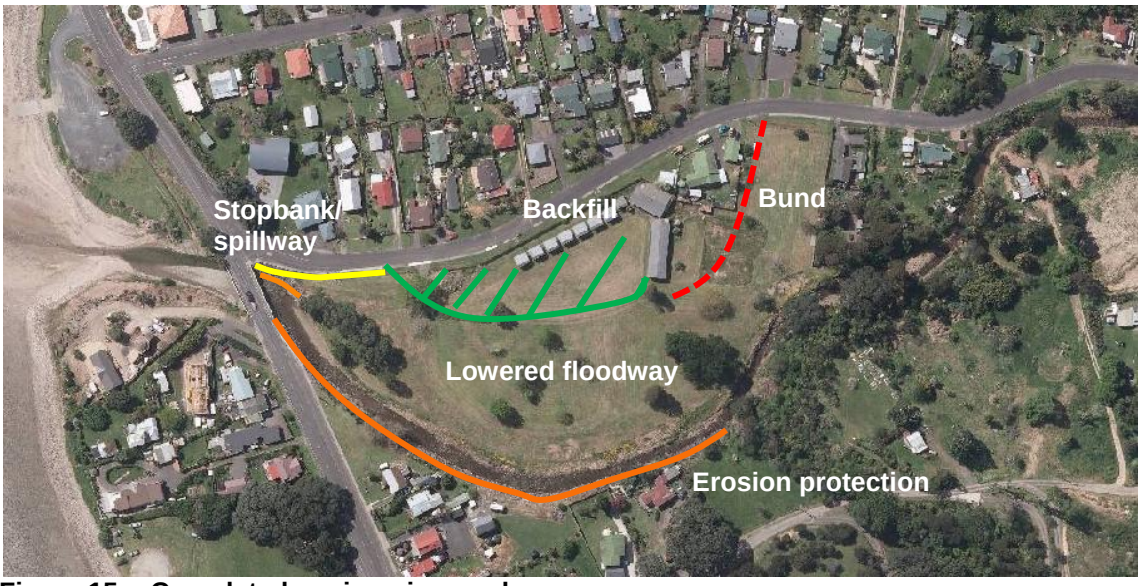


Figure 15 Completed engineering works

Based on the completed works, parts of the community are still subject to flood hazard from the Waiomu Stream, as described below and illustrated in the flood hazard maps in Section 9.2:

- 20 and 22 Waiomu Valley Road are below the future 1% AEP flood level and are subject to low to medium flood hazard in the vicinity of the buildings and high flood hazard in the lower part of their sections, however there is no change to their pre-scheme flood hazard status.

- The eastern portion of the former holiday park (18A Waiomu Valley Road) is below the future 1% AEP flood level and is subject to low to medium flood hazard, and high flood hazard adjacent to the floodway. The western portion of the property is protected by the bund.

- Flood waters can come out of channel at Dehar's Bend and flow down Waiomu Valley Road and into the properties to the north of Waiomu Valley Road, as per pre-scheme conditions.

- Properties to the north of Waiomu Valley Road have an improved level of protection; however they will be inundated in greater than the 2% AEP event. It is predicted that up to 25m^3/s may flow over the spillway across Waiomu Valley Road and into this residential area in a 1% AEP event.

- The capacity of the existing SH25 culvert draining the ponding area to the north of Waiomu Valley Road is designed for local drainage only hence the SH25 embankment acts as a dam behind which flood waters pond in residential properties around Trotter Ave. This area will flood less frequently than pre-scheme, however once it floods the conditions are the same as pre-scheme in terms of draining times.

5.3 Design details

5.3.1 Design parameters

The design parameters of the different elements of the proposed works were derived from the computer hydraulic models for different scenarios of floods under a range of boundary conditions. The details used to build the hydraulic model are discussed in Section 4 above and are summarised below:

- All models assume that the upper catchment will remain in its current form and no future development will occur in this area.

- All models assume a stable channel (no change in bed and bank level) within the reach extending between the ford culvert and SH25 Bridge.

- The flows are assumed to be steady and have the following discharges:

Parameter	Current (2004)	Future (2080)
2% AEP flood flow	130 m^3/s	
1% AEP flood flow	157 m^3/s	188 m^3/s
Mean high water springs*	RL 2.3 m	RL 2.8

*In terms of LiDAR datum

- The flows are for clear water with no floating debris or bed material included.

The different flood profiles resulting from the different hydraulic modelling scenarios are shown in the following figures.

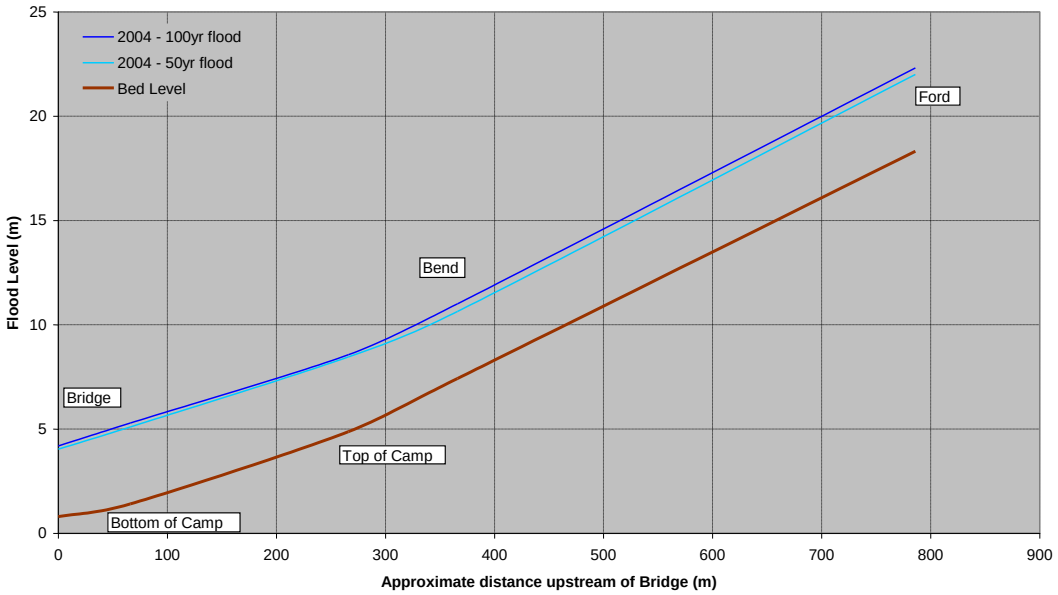


Figure 16 Existing flood levels

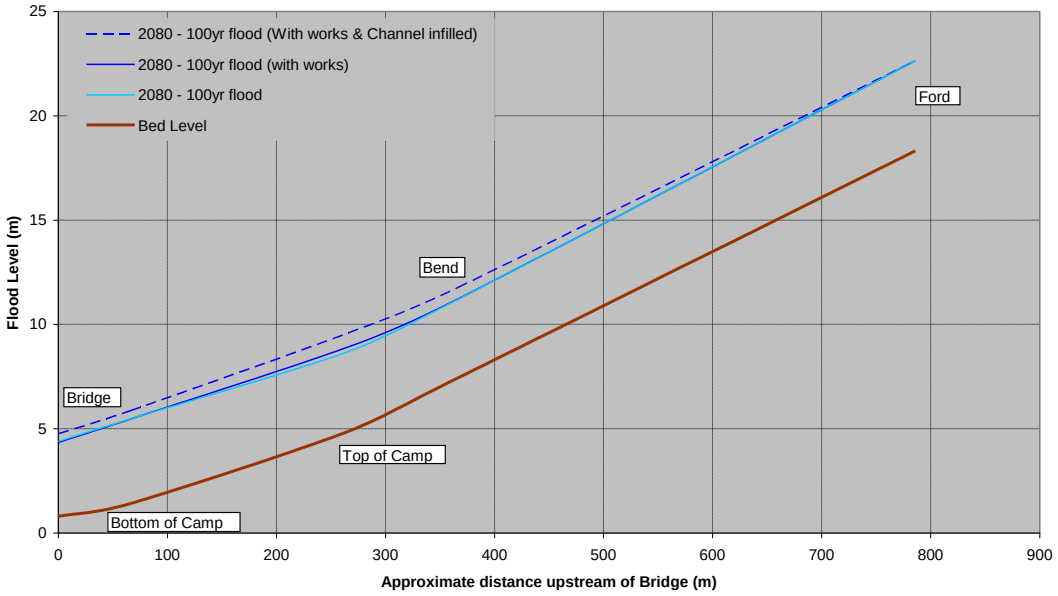


Figure 17 Predicted future flood levels

5.3.2 Design standards

In defining the flood protection design standard for a community, a number of factors are considered including the natural hydrological, hydraulic and morphological characteristics of the catchment and stream, the tidal influences, the infrastructural limitations and the feasibility of protection in technical and economic terms. Another important consideration is the sustainability of protection in the long term and the versatility of the works to accommodate future upgrades to cope with future changes in weather patterns. Generally, protection against a 1% AEP flood event is considered to be an acceptable standard within urban areas in New Zealand.

Within the Waiomu community, it is proposed to provide the following flood protection design standards in a staged manner.

- A stable stream channel along the whole reach extending from the ford culvert upstream of the settlement to the sea.

- A stable floodway to accommodate the current and future 1% AEP flood flows.

- Protection of the residential area along the right bank (north) of the stream against floods up to the existing 1% AEP event with adequate freeboard to accommodate uncertainties. This is to be provided in a staged approach that is linked to the SH25 Bridge upgrade. Prior to the SH25 Bridge upgrade protection to the 2% AEP event is to be provided. Once the SH25 Bridge is upgraded this level of protection will be increased to the 1% AEP event design standard.

- Appropriate planning and landuse controls to ensure that greater than design events would pass safely through the settlement with minimal damage.

In setting the design standard, it is understood and accepted that there remains a level of residual risk arising from "greater than design" flood events, debris, channel infilling and other uncertainties. Hence the need to understand the full continuum of flood events, the implications of these on the community and to identify appropriate measures to ensure the safety of the community under such events. Residual risk is discussed further in Section 10 of this report.

5.3.3 Stopbank/spillway

A stopbank/spillway has been constructed on the right bank of Waiomu Stream, immediately upstream of the SH25 Bridge to provide protection to the houses on the north side of Waiomu Valley Road to the 2% AEP design standard, as illustrated on Figure 18 below.

A stopbank was proposed in this reach to the 1% AEP design standard; however this could not be achieved due to the restricted SH25 Bridge capacity at the time of project implementation (bridge capacity estimated to be the 2% AEP event flows). Hence a spillway was constructed to the 2% AEP design standard, which will be raised to the full protection level following replacement or upgrade of the SH25 Bridge.

Figure 18 Constructed stopbank/spillway

The first section of the stopbank/spillway structure comprises a 20 metre length of flood wall, this has been constructed to abut the footpath and to a height of the 1% AEP flood level plus 500mm freeboard. A design drawing for this section of flood wall and the associated erosion protection is provided in Appendix 1. The next section of the structure comprises the spillway section formed from clay and earth. This section has been designed to be 50 metres long and to the height of the 2% AEP flood level, refer to the profile drawing in Appendix 1 for design details included the design levels. The spillway is then bounded on the upstream edge by the raised land at 12 Waiomu Valley

Road. The design details for the when the stopbank/spillway is upgraded (once the SH25 Bridge is upgraded) are also provided on the drawing in Appendix 1.

5.3.4 Floodway

The flood protection scheme includes the provision of a floodway on the right bank of the Waiomu Stream within the land owned by council. The purpose of the floodway is to provide room for the stream to flood and come out of bank without impacting on property.

The criteria for designing the floodway and defining its boundaries included the elements below.

- Adequately sized and hydraulically efficient geometry along with a gradient consistent with that of the channel to ensure gradual change in depth and velocity to occur with minimum turbulence during the design event.

- The ability of the floodway to transport sediment and bed load material. While a wide floodway can carry higher flows, it normally reduces the flow velocity and leads to significant deposits of sediment, especially on side inactive pockets, which eventually would require removal at high costs. Hence, the need for confining the floodway within the geometric design parameters to ensure sufficient depth and velocity is maintained across the floodway. This was proposed to be achieved by raising the land along the floodway boundaries, which would also help to prevent overland flows across the campground into the residential area to the north of Waiomu Valley Road.

The floodway is approximately 380m long with varying widths (35m to 80m) across the site and has been recontoured to increase the capacity for conveying flood flows. Refer to the drawings in Appendix 2 illustrating the Concept Plan and Floodway Map for Waiomu. A 10-20m wide strip along the stream bank within the floodway has been lowered and ground levels were graded in both east to west (flow) direction along the stream channel and north to south (perpendicular to flow) direction sloping down toward the channel. This work included an average cut of 0.4m across the site, most of which was closer to the channel. The volume of stripped material was estimated to be approximately 2500m^3, some of which was used to form the spillway and raise the ground level at 12 Waiomu Valley Road. Figure 19 below illustrates the Waiomu floodway and shows the section of stream berm that was to be lowered.

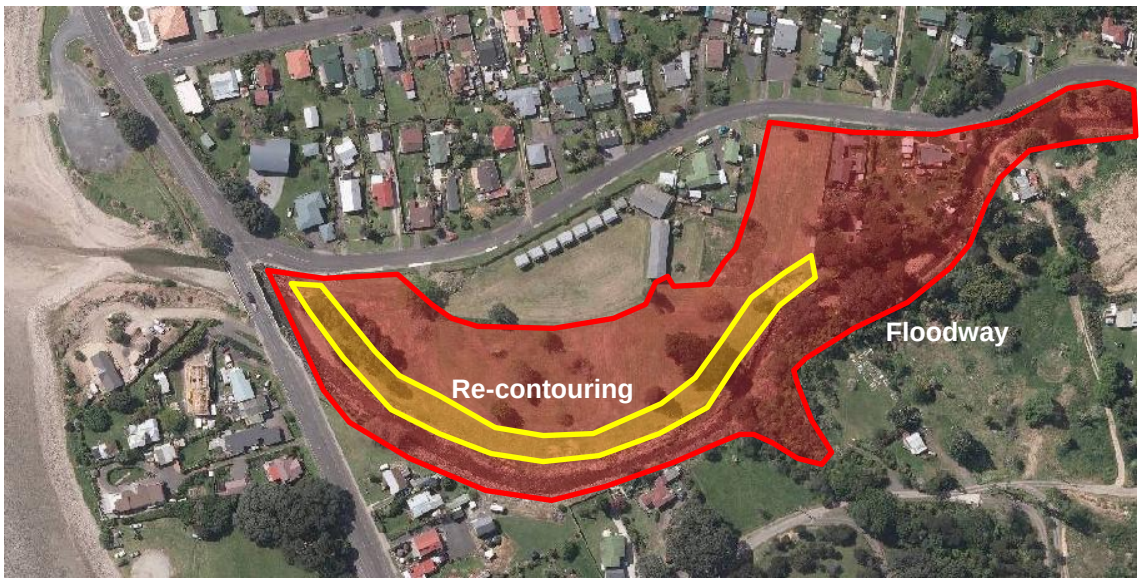


Figure 19 Proposed floodway

Two dimensional computer models of different floodway configurations with and without the proposed works were established and run for different flood scenarios to define the

appropriate size of the floodway and appropriateness of raising the remainder of the campground property. The results confirmed that restricting the 1% AEP flows within the proposed floodway would not cause an increase in flood levels above those currently experienced, and that the raised property could be developed for residential or commercial use.

An approximately 70m length of the right bank stream berm has not yet been lowered as there was no location where scraped material could be stored, refer Figure 20. This is an item of works still to be completed when practicable.

Figure 20 Section of floodway still to be lowered

5.3.5 Infill at 12 Waiomu Valley Road

12 Waiomu Valley Road has been raised to the future 1% AEP flood level. A profile showing the ground level pre and post fill, along the boundary of 12 Waiomu Valley Road, is provided in Appendix 2. The depth of fill above existing ground level along this alignment ranges from 0.5 metres to 1.0 metres. Refer to WRC DM# 1207670 for the design details for the fill.

To ensure the safety and protection of any future development on this land, modelling of different existing and future scenarios was undertaken. The resulting flood profiles were plotted against the natural ground levels. The results are shown in the following figures (refer to WRC DM#1101440 for the assessment that informed the following graphs).

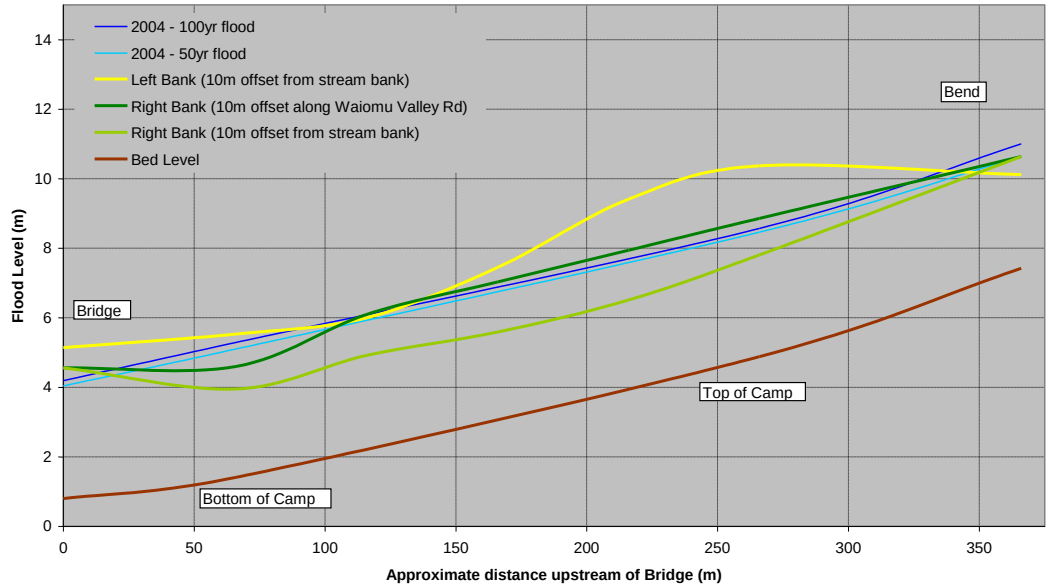


Figure 21 Ground levels and existing flood levels along the floodway

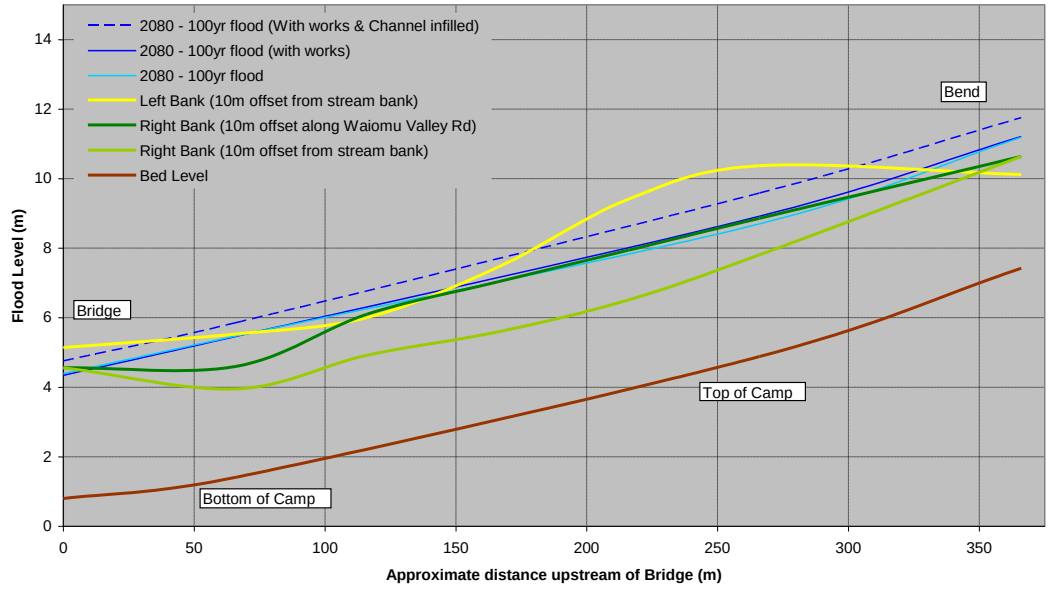


Figure 22 Ground levels and future flood levels along the floodway

The following can be determined from these graphs.

- Other than two short sections upstream of the former holiday park and the lower part closer to the SH25 Bridge, the strip of 12 and 18A Waiomu Valley Roads along Waiomu Valley Road is higher than existing and predicted future flood levels. However the ground level gradually falls to stream bank level which is approximately 1.5 m lower than the design flood, especially in the lower terrace of the floodway.

- The left bank of the stream is high for most of its length opposite the floodway down to the bridge.

- Raising the land at 12 and 18A Waiomu Valley Road to establish safe building platforms will have less than a minor effect on the floodway capacity, especially with the re-contouring of the floodway.

- Infilling of the stream up to full bank height would increase flood levels by 500 mm on average.

To ensure the safety of the raised property against flooding in the long term various planning controls have been developed for the site which are discussed in Section 11.

5.3.6 Existing buildings at 12 Waiomu Valley Road

Several buildings have been retained on site at 12 Waiomu Valley Road, including Cabins 2 – 8, a house and a motel unit (refer to Figure 23 for building locations).

Figure 23 Existing buildings retained on site

The following table provides a comparison of the floor levels of the existing buildings to the future 1% AEP flood levels:

Table 8 Comparison of floor levels to flood levels

Building	Floor level (mRL)	Future 1% AEP flood level – with works (mRL)	Freeboard (mm)
Cabin 8	6.44	5.62	820
Cabin 5	6.79	6.15	640
Cabin 2	7.18	6.78	400
House	7.52	7.15	370
Motel unit	7.18	6.98	200

NOTE: Levels are in LiDAR datum

This information demonstrates that the buildings retained on the property are above the future 1% AEP flood level with varying levels of freeboard. Section 11 outlines the planning controls for this property, including the condition that building floor levels should be a minimum 800mm above the future 1% AEP flood level.

The buildings retained at 12 Waiomu Valley Road have existing use rights, however to ensure the site is safe into the future, it is necessary to place a timeframe within which the buildings with less than 800mm freeboard can be used. These buildings can be used until 2030, after this date the buildings will need to be removed or raised to the appropriate floor level.

When the buildings are removed /refurbished, the adjacent land would need to be raised to the future 1% AEP flood level to tie in with the adjacent infilled portion of 12 Waiomu Valley Road and the bund/flood wall that has been constructed in 18A

Waiomu Valley Road. The building platforms and floor levels of any new buildings would need to comply with the planning controls outlined in Section 11 below.

If this area was raised and the eastern portion of 18A Waiomu Valley Road had been filled, adequate provisions would need to be made to ensure drainage for 18 Waiomu Valley Road and the local drainage area was maintained.

5.3.7 Bund at 18A Waiomu Valley Road

The eastern portion of 18A Waiomu Valley Road has not been raised, and the majority of this area is below the future 1% AEP flood level. A bund has been constructed through this site to protect the existing residential dwelling at 18 Waiomu Valley Road and the existing buildings located at 12 Waiomu Valley Road. The bund crest level is set to the future 1% AEP flood level. Figure 24 below illustrates the indicative alignment of the bund.

Figure 24 Indicative alignment for bund/flood wall

The bund originates at the edge of the floodway boundary (within Lot 1, 12 Waiomu Valley Road) in line with the eastern corner of the existing motel block with a short section of floodwall due to limited space. There is a gap between the end of the existing fill at 12 Waiomu Valley Road and the origin of the bund to enable the unfilled land behind the proposed bund to drain freely (this includes 18 Waiomu Valley Road). The bund runs in a northeast direction across 18A Waiomu Valley Road to tie into high ground at Waiomu Valley Road. The bund is approximately 104 metres long.

An indicative alignment and a profile showing the bund design height and the ground level along the indicative alignment are provided in Appendix 3, also refer to WRC DM#1207670 for design levels. The height of the bund above existing ground level along this alignment ranges from 0.25 to 1.35 metres and is on average about 1.0 metres high. Material from floodway lowering was used to form the bund, with additional clay used as required. The bund profile was designed to have a 3 metre crest width, and 1V:3H batter slopes so that it is mowable, and was topsoiled and grass seeded after construction.

The gap between the bund and the raised land at 12 Waiomu Valley Road means that the existing motel block will be exposed to ponded flood waters during flood events. This design scenario was tested using the hydraulic model developed for Waiomu. The floor level of the motel block is RL7.18m (LiDAR datum) and the predicted ponding level for the future 1% AEP event is RL6.5m (LiDAR datum). This information demonstrates that the existing motel building will have at least 680mm freeboard above the ponded water level for the future 1% AEP event, which is considered to be acceptable.

5.3.8 Erosion protection

The Waiomu Stream is characterised by a relatively wide gravel bed and meandering low flow channel within the bed. Large quantities of gravel mobilise during flood events and these are mainly deposited in the vicinity of the SH25 Bridge. Channel clearing is undertaken regularly by WRC, such to maintenance is necessary to maintain adequate channel capacity. It is important that when the channel is cleared, the low flow meandering channel is retained to ensure quick re-establishment of the habitat and ecosystem.

The left bank of the stream along the floodway and downstream to the SH25 Bridge was experiencing severe erosion. The re-contoured floodway would help to reduce the pressure on the left bank; however the toe of the bank was likely to be eroded further, eventually undermining the bank. Waikato Regional Council employed Tonkin & Taylor Consultants to investigate the bank stability and design appropriate measures to address this issue. The design included rock fill (rip-rap) protection over filter cloth along a length of approximately 150 metre linking with rock protection works undertaken by NZTA upstream of the bridge as illustrated in Figure 25 below.

Figure 25 Erosion protection

The works aim at stabilising the toe of the bank with the rest of the bank protected by vegetation and plant. Tonkin & Taylor's design letter report is provided in Appendix 4.

Other reaches of the channel also require attention especially the bends upstream of the former holiday park (Dehar's Bend); this work has not been undertaken.

6 Future works

6.1 Proposed scheme upgrade

As discussed above the full flood protection scheme has not been constructed at Waiomu, hence some properties are still vulnerable to flood hazard from Waiomu Stream. The Waiomu community is small and only a limited number of properties receive betterment from the flood protection scheme. All general feedback from the community in terms of rating has been that they are not prepared to pay more. With this feedback in mind, no further works are to be undertaken at Waiomu until such time as the community indicates that they want an increased level of flood protection.

If at a future date it is decided to complete the scheme and increase the level of protection to the 1% AEP flood event (subject to NZTA upgrading the SH25 Bridge), then a proposed scheme upgrade has been developed that has evolved from the original scheme design to take into account the feedback received from adjacent landowners.

The proposed scheme upgrade comprises raising 18, 20 and 22 Waiomu Valley Road hence the remainder of the former holiday park (18A Waiomu Valley Road) could be filled. This option would also include the following items illustrated in Figure 26 below. These items are in addition to the works that have already been completed that are illustrated in Figure 15.

- 18, 20, 22 Waiomu Valley Road raised to the future 1% AEP flood level and buildings raised to appropriate floor levels (as per TCDC specifications).
- 18A Waiomu Valley Road filled to the future 1% AEP flood level.
- Road raising in Waiomu Valley Road to tie into raising of 22 Waiomu Valley Road.
- Local drainage would need to be provided to convey flows from the local catchment into the floodway.
- Culvert under SH25 upgraded to drain ponding area to the north of Waiomu Valley Road.
- Complete floodway lowering.

Figure 26 Preferred total option for future works

The main disadvantage of this option is that there would be a localised increase in flood levels at the Dehar's property (the property located on the left bank at Dehar's Bend); this would need to be further assessed if this option was to be progressed. The Dehar's property is located within the floodway, however this property was not considered for flood protection in the original scheme and business case to Central Government as it is in the middle of the floodway, hence is difficult to protect without impacting on the conveyance of flood flows. There is currently no legal structure on this property and any intensification of this property should be dealt with by TCDC planning controls.

6.2 Priority works

One of the items discussed above is deemed to be the most urgent of the proposed future upgrade works, the upgrading of the SH25 culvert. The residential area to the north of Waiomu Valley Road is low lying and is bound by SH25 to the west, refer to Figure 27. While the constructed stopbank/spillway (upstream of the SH25 Bridge) protects this area up to a 2% AEP event, it is expected that up to 25m^3/s will still flow over the bank across Waiomu Valley Road and into this residential area in a 1% AEP event.

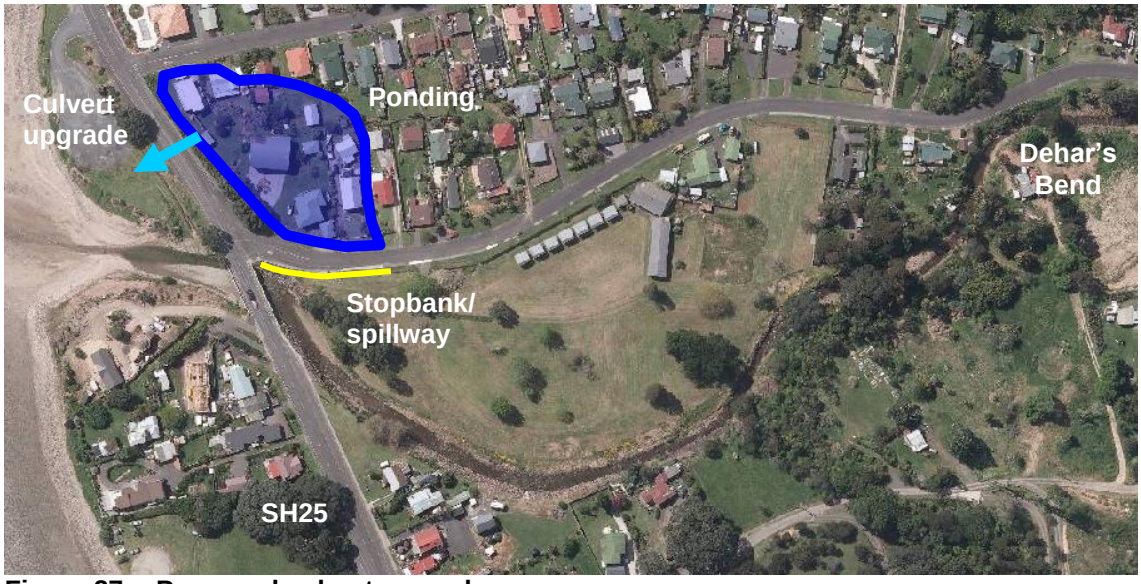


Figure 27 Proposed culvert upgrade

The existing small culvert under SH25 is designed to provide for local drainage only hence the SH25 embankment acts as a dam behind which flood waters pond, refer to details of the existing local drainage system in Appendix 5. To reduce the ponding duration and levels another culvert is proposed under SH25. A 1.5 metre diameter culvert is estimated to reduce the ponding period to approximately four hours and flood levels by approximately 250 mm on average.

If the SH25 culvert is not upgraded then the residential area to the north of Waiomu Valley Road is susceptible to a level of ponding for a relatively significant duration. This area is in the high flood hazard category. If the full scheme is in place, the increased culvert capacity would help to address residual risk into the future, that is, it would drain the ponding area in greater than design events, etc.

NZTA was originally going to undertake the design and implementation of the culvert upgrade under the SH25 as it is the SH25 embankment that is acting as a dam. However due to design complications NZTA were not able to proceed with the project, and requested that Waikato Regional Council undertake the design and then hand it over to NZTA for construction. This is an outstanding item that Waikato Regional Council needs to progress.

6.3 SH25 Bridge upgrade

The existing SH25 Bridge capacity was assessed by Waikato Regional Council and peer reviewed by Auckland University and Opus Consultants (Opus Consultants, October 2004, WRC DM#3126273). The clear water capacity with no change in cross sections was assessed as approximately 160 m^3/s. As the floods are characterised by floating debris and significant bed material movement, it is assumed that 20% of the bridge waterway area would be blocked in a 1% AEP event, hence reducing the bridge capacity to approximately 128 m^3/s. This is equivalent to the 2% AEP event (assessed at 130m^3/s) for the Waiomu Stream.

If in the future NZTA decides to upgrade the SH25 Bridge, it is proposed that the stopbank/spillway upstream of the SH25 Bridge would be raised to provide full protection up to the 1% AEP standard (1% AEP flood level plus 500mm freeboard) for the properties north of Waiomu Valley Road (refer to Appendix 1 for design levels). Works would also be needed to protect properties downstream of the SH25 on the left bank. Figure 28 below illustrates the predicted inundation area downstream of SH25 for the future 1% AEP event with the bridge and scheme upgraded with no works downstream of the bridge.

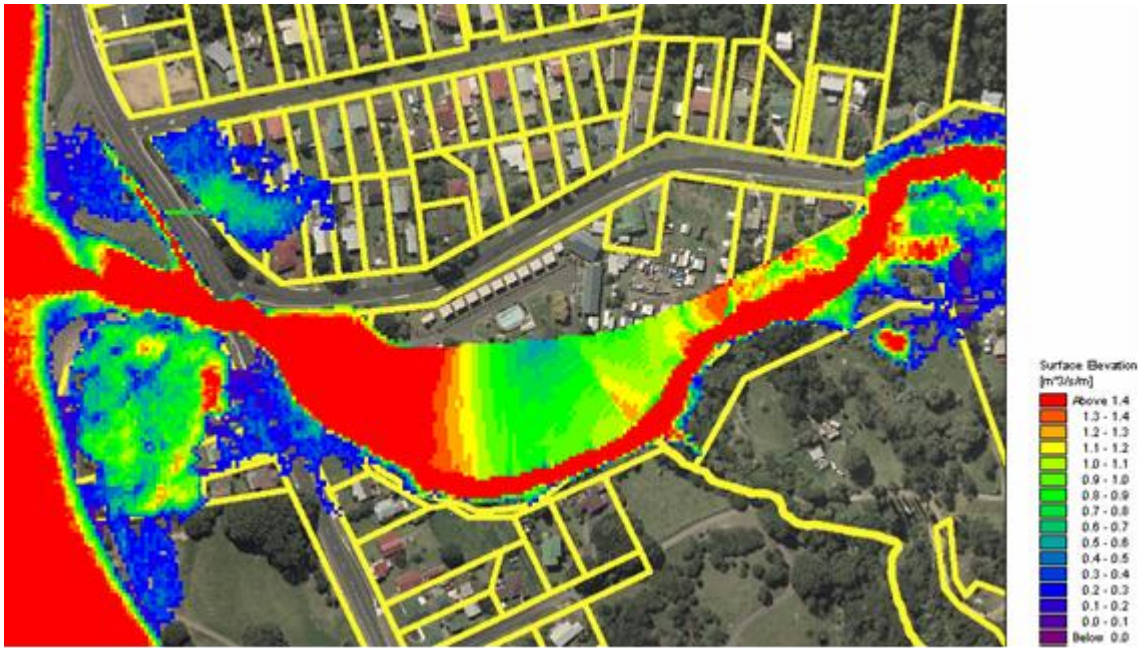


Figure 28 Predicted flood depth with SH25 Bridge upgraded and completed scheme upstream of SH25 (future 1% AEP event)

Figure 28 demonstrates that the residential area on the left bank downstream of the SH25 would be vulnerable to flooding from the Waiomu Stream and from spill over the SH25 carriageway. This residential area is predicted to flood to a depth of 0.8 – 1.5m in the future 1% AEP event. The estimated peak discharge spilling over the SH25 is predicted to be 6.5 m^3/s. The area downstream of SH25 is predicted to flood from water coming out of bank on the left bank downstream of SH25, before the area is affected by flooding spilling over SH25. Note that this area is subject to an existing flood hazard from Waiomu Stream as illustrated on the flood hazard maps in Section 9.2.

6.4 Sale of remaining council owned land

6.4.1 Background

A portion of the former holiday park (12 Waiomu Valley Road, Lot 1, CT SA17A/1173) has been raised and sold (March 2012). This 0.4629ha parcel of land is shown on Figure 29 below.

There is a remaining portion of land (0.2714ha) that council still owns (18A Waiomu Valley Road, Lot 2, CT SA882/86) that does not comprise part of the floodway and hence is surplus to Waikato Regional Council's requirements and can be sold. This parcel of land is also shown on Figure 29 below.

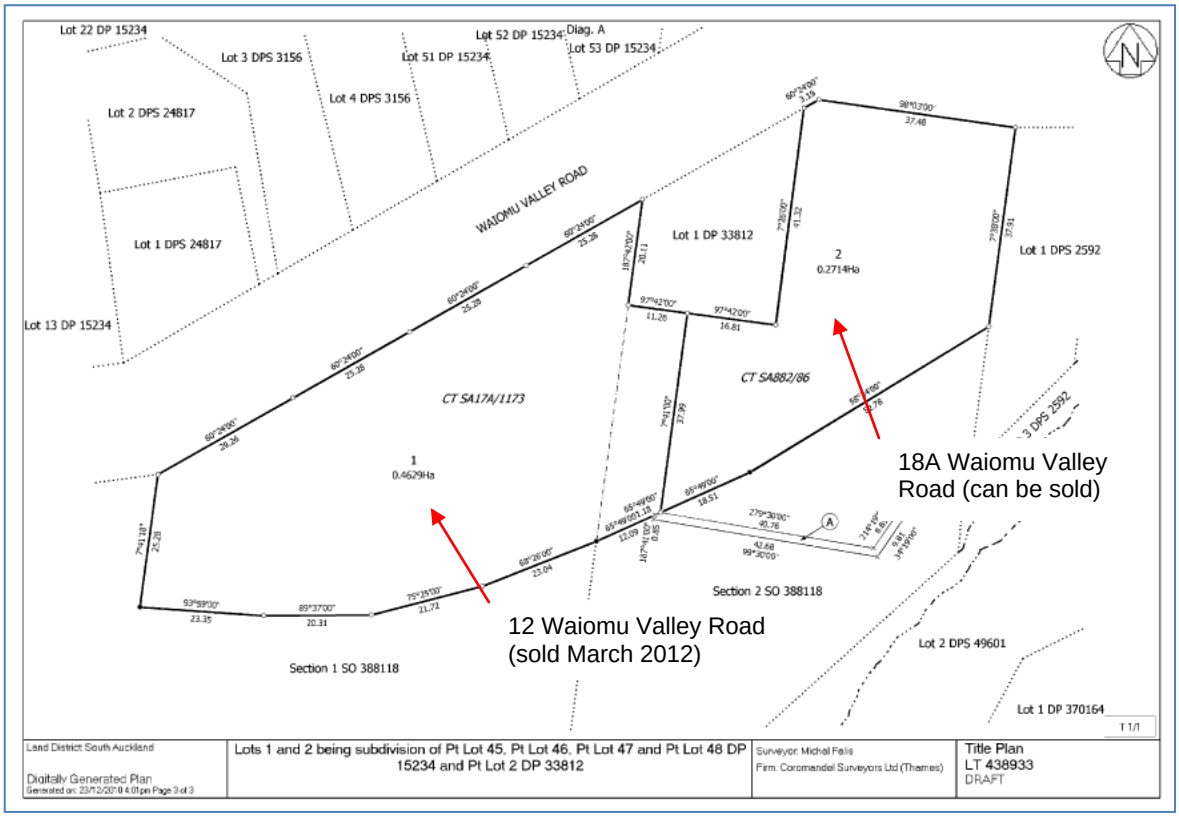


Figure 29 Land for disposal

The original intent was to raise 18A Waiomu Valley Road at the same time as 12 Waiomu Valley Road and to sell all the raised land that was surplus to council requirements at the same time. However since the adjacent land owners were not comfortable with the total fill proposal, Waikato Regional Council left 18A Waiomu Valley Road at existing ground levels.

If 18A Waiomu Valley Road was to be sold it is essential that the potential purchaser/s understand the flood hazard that exists at the property from Waiomu Stream and the limitations on activities that can be undertaken at the site.

6.4.2 Flood protection assets at 18A Waiomu Valley Road

The property at 18A Waiomu Valley Road is cut in half by an earth bund/flood wall, the indicative location of which is illustrated in Figure 15.

This earth bund/flood wall is a flood protection asset that was constructed by Waikato Regional Council to protect existing buildings located at 12 and 18 Waiomu Valley Road. This earth bund cannot be altered without the consent of River & Catchment Services, Waikato Regional Council.

If at some time in the future the total flood protection scheme is able to be constructed at Waiomu, the properties 18, 18A, 20 and 22 Waiomu Valley Road would all be raised above the future 1% AEP flood level, and the bund would be included in this fill.

If the potential land owner of 18A Waiomu Valley Road wanted to raise the property prior to the adjacent properties being raised, they would need a consent, and they would need to provide for local drainage draining from Waiomu Valley Road to the Waiomu Stream floodway.

6.4.3 Flood hazard at 18A Waiomu Valley Road

Figure 30 below shows an excerpt from the flood hazard map for Waiomu, on this map the property at 18A Waiomu Valley Road is outlined in blue. This figure demonstrates that a portion of the site is subject to flood hazard ranging from low to high flood hazard closest to the floodway boundary.

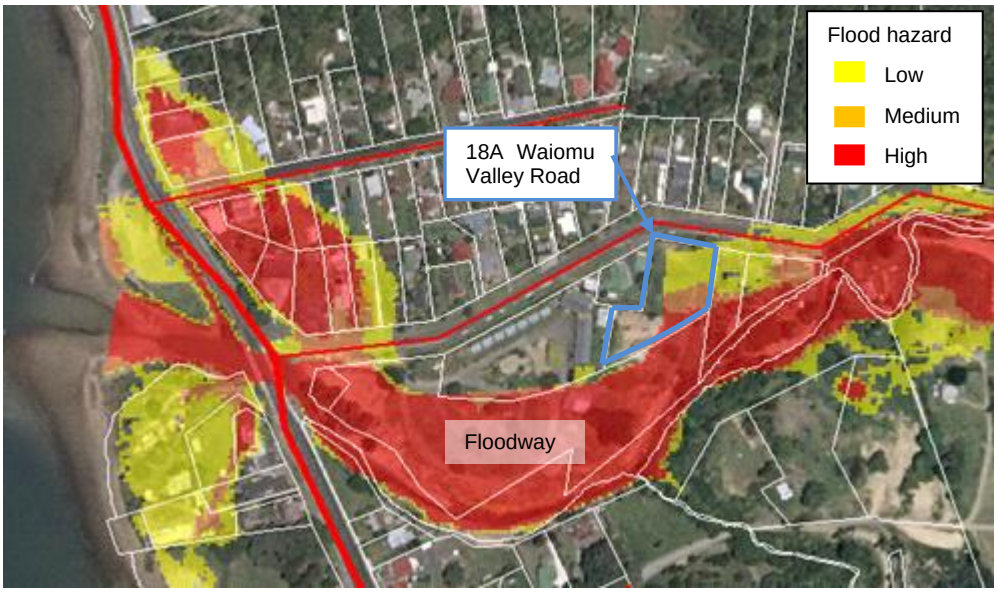


Figure 30 Flood hazard at 18A Waiomu Valley Road

This flood hazard status means that certain activities are not suitable to be undertaken at this site. River & Catchment Services, Waikato Regional Council can be contacted for advice about what can and cannot be undertaken at the property. For details on the rules about land use activities that can be undertaken at this site refer to the Thames Coromandel District Plan or contact Thames Coromandel District Council. Refer to Section 11 for details of the planning controls relevant to this property.

7 Agreed levels of service

The Coromandel Zone Management Plan (River and Catchment Services et al, 2011) outlines the agreed levels of service for the Coromandel. The agreed levels of service provided for the Coromandel Zone were initially developed when the Peninsula Project was established in 2004. The current service levels were confirmed through an extensive consultation process initially undertaken in 2003/04, and subsequently updated by the LTP processes in 2006 and 2009.

In the Coromandel Zone Management Plan the Thames Coast, including the Waiomu catchment, is identified as a high priority area for flood protection schemes and for upper catchment protection through animal pest control (feral goats and possums). Additional works could focus on hill side erosion and stabilising erosion prone pastoral lands. The Thames Coast has a direct relationship to the Firth of Thames.

The current scheme works provide the Waiomu community with flood protection against Waiomu Stream floods up to a 2% AEP (50 year ARI) event. This level of service is provided through a combination of floodway improvements, channel stabilisation, stopbanks and a spillway. The key to ensuring the performance of this scheme is to maintain the channel and floodway conveyance capacity, hence the high focus on river management works within the maintenance programme.

The flood protection scheme at Waiomu is identified as needing to be maintained and managed to ensure the level of service for flood protection assets is maintained. The level of service provided by the scheme at Waiomu is detailed in this design report and in the Appendices A-F. The general location of the flood protection assets is shown in Figure 31 below.

Figure 31 Flood defences in the Waiomu community

Routine river management is identified for high priority catchments to reduce the risks of localised flooding through removal of willow congestion and blockages and to provide long term environmental benefits through improved water quality, keeping stock out of stream and fencing and planting of stream banks to reduce stream bank erosion.

8 Operation and maintenance

The main channel of the Waiomu Stream is monitored and periodically maintained by the Waikato Regional Council to remove accumulated sediment and debris (refer to Figure 32). This work maintains the capacity of the Waiomu Stream and reduces the risk to adjacent land that would otherwise be inundated more frequently, and also helps to maintain the performance of the flood protection scheme.

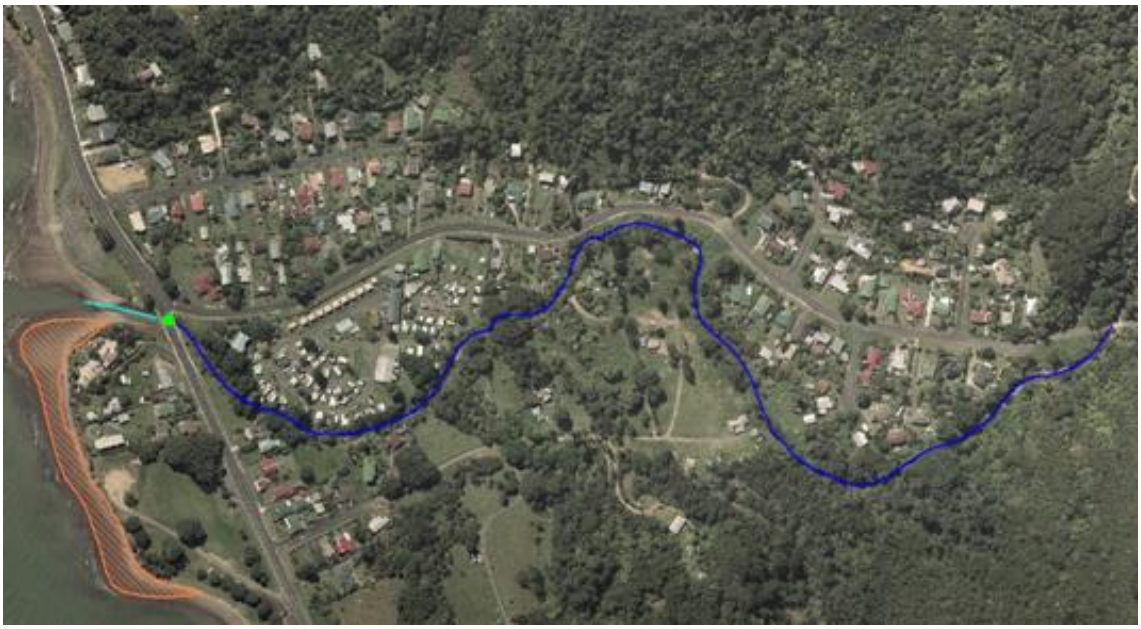


Figure 32 Extent of channel maintenance

The annual maintenance programme includes the removal of accumulating gravel and sediment in Waiomu Stream, based on current cross sectional areas. These works are carried after annual inspection and monitoring of changes in the streams. The specific activities associated with this annual work programme include:

- The stream is walked over at least once a year to undertake a condition survey.
- Removal of accumulated gravel, sand and debris from the Waiomu Stream between the SH25 Bridge and the Waiomu Valley Road ford (i.e. 1080 m length of channel).
- Removal of accumulated gravel, sand, silt and debris from under the SH25 Bridge across the Waiomu Stream.
- Removal of accumulated sand, silt and debris from the Waiomu Stream between the SH25 Bridge and Firth of Thames (i.e. 60 m length of channel).
- Disposal of excavated gravel, sand and silt on the local foreshore below the high tide level.
- Vegetation management/spraying is completed annually along the entire extent of maintenance illustrated in the figure above.
- After rain events, access is gained to the relevant sections of the stream to clear the channel and restack rocks along the bank. In particular the upstream section of stream at Dehar's Bend.

Constructed flood defences at Waiomu (predominantly flood wall with some sections constructed earth stopbank) are inspected annually for:

- Visible damage to the sections of flood wall.
- Visible damage to the batter slope and crest of the sections of clay stopbank.
- Any associated stream channel erosion and scour and potential undermining of flood protection assets.

Any necessary repair work is undertaken as required.

Stopbank crest level surveys are undertaken on a 10 yearly cycle and topped up where necessary.

This maintenance programme is consistent with other stopbanks managed by Waikato Regional Council in the Waikato region (eg. Lower Waikato Waipa Control Scheme).

9 Flood hazard assessment

9.1 River flood hazard classification

A river flood hazard classification describes the significance of river flooding with regard to the likely impact on people and property. The classification that forms part of this assessment has been developed using the following considerations:

- Floodwaters have the potential to cause a person to become unstable and unable to manoeuvre. International research suggests that there is a danger of being knocked over when the product of the flood depth and flood speed exceeds 0.5, with a significantly greater risk to life when the same product exceeds 1.0.

- Floodwaters have the potential to impede a person's ability to rescue themselves or others. When the flood depth exceeds 1.0 m (i.e. waist depth), a person's ability to navigate through flood waters (both on foot and using a vehicle) is restricted, therefore impeding the rescue of themselves and others.

- Floodwaters have the potential to damage buildings, both superficially and structurally. International research suggests that structural damage is likely when the flood speed exceeds 2 m/s. It is also likely that structurally weak points such as doors and windows will be damaged when the flood speed exceeds 1 m/s.

These considerations have been translated into a river flood hazard classification by first defining four distinct levels of river flood hazard based on the likely impact on people and property. These levels are outlined in Table 9.

Table 9 Description of river flood hazard categories

Category	Impact on people	Damage to property
Low	The combined depth and speed of floodwaters are unlikely to impede the manoeuvrability or stability of the average person.	Damage to property is likely to be non-structural and mainly due to inundation and deposition of sediment.
Medium	The combined depth and speed of floodwaters are likely to start to impede the manoeuvrability or stability of the average person.	Damage to property is unlikely to be structural provided that weak points such as windows and doors are retained above flood level.
High	The combined depth and speed of floodwaters are likely to significantly impede the manoeuvrability or stability of the average person.	Damage to property is likely to be widespread and structural, including instances where buildings have been raised above the 'flood level'.
Defended	This flood hazard category identifies land that is within an identified river flood hazard area but has been subsequently included in a flood protection scheme that is managed and maintained by the Waikato Regional Council.	

The three levels of river flood hazard (low, medium and high) have then been quantified through the creation of a matrix that assigns a river flood hazard level based on the predicted depth and speed of flooding (refer to Figure 33).

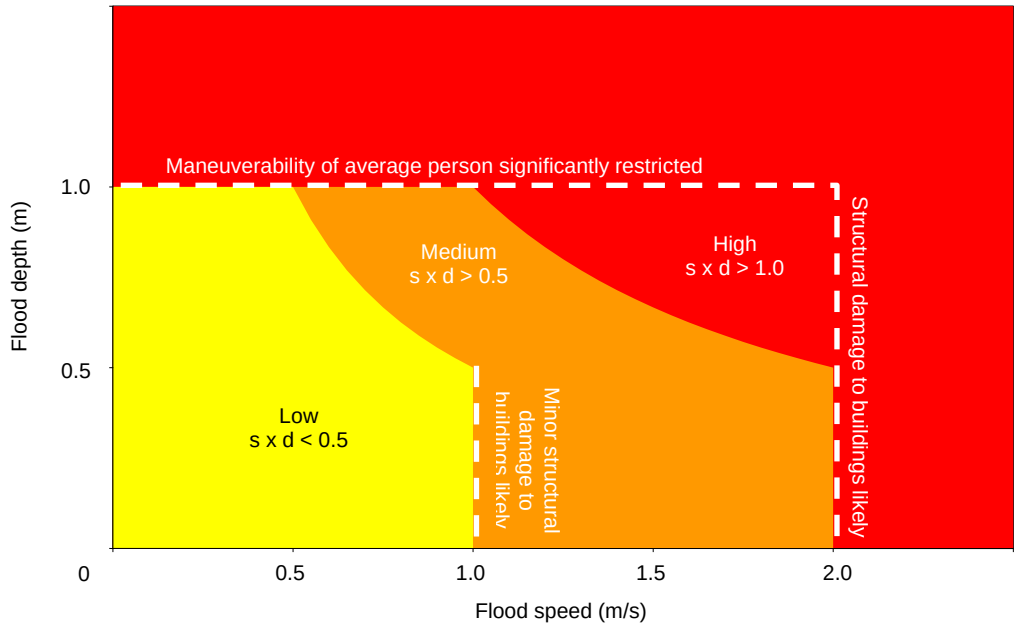


Figure 33 River flood hazard classification matrix

The following two scenarios also result in a 'high' flood hazard classification:

- Land that is surrounded by flooding that is classified as a 'high' flood hazard.
- Instances where floodwaters are directed by flood defences, including formal spillways.

The fourth level of flood hazard (i.e. defended) is intended to represent instances where a property is located within the natural floodplain but benefits from flood defences (e.g. floodwalls and stopbanks).

9.2 River flood hazard map

The river flooding information has been used to produce a river flood hazard map for the Waiomu community due to the Waiomu Stream. Two figures are provided below, Figure 34 shows the flood hazard map for Waiomu pre-scheme and Figure 35 shows the flood hazard post-completed works.

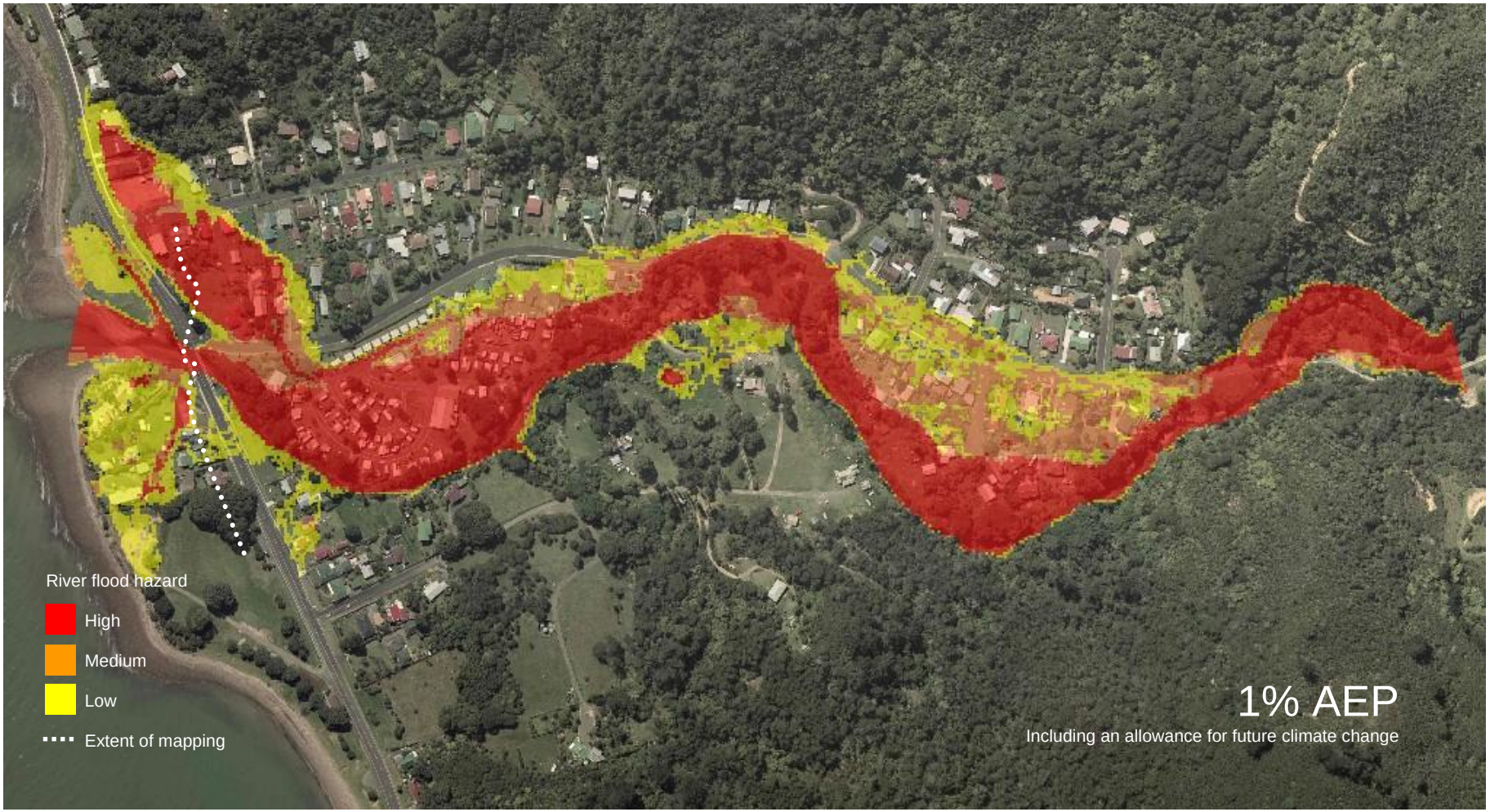


Figure 34 River flood hazard (with no flood protection works in place)

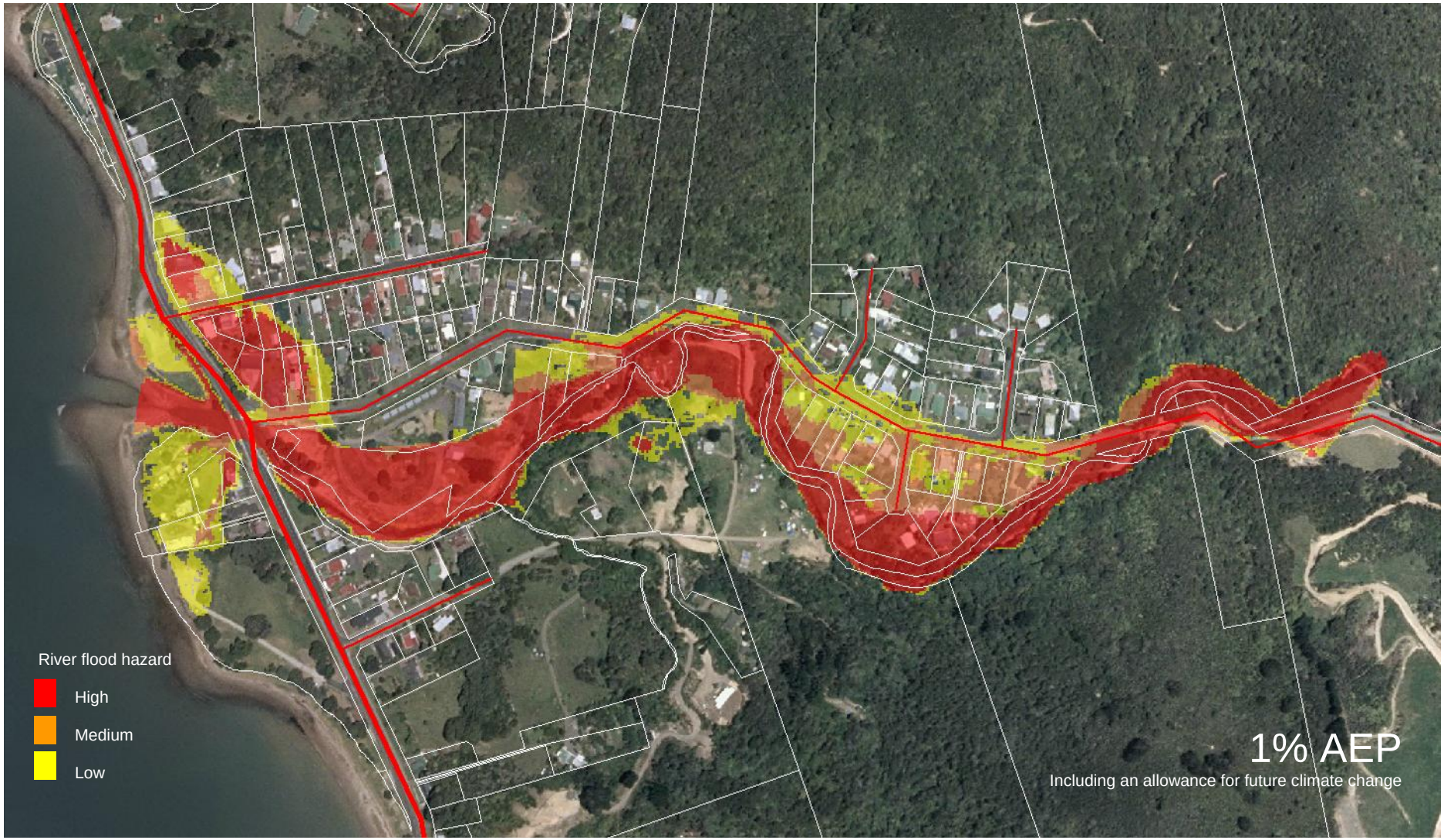


Figure 35 River flood hazard map with completed works in place

10 Residual flood risk

'Residual flood risk' is a term used to describe a river flood risk that exists due to the potential for 'greater than design' flood events to occur. The concept of residual flood risk is relatively new, but provides a more complete assessment of risk when compared with traditional approaches that rarely look beyond 'design conditions'.

The residual flood risks that affect the Waiomu community are described as follows:

- Flood protection schemes are generally designed to provide protection for up to the future 1% AEP event. Due to the capacity restrictions of the SH25 Bridge at Waiomu, only an interim scheme was developed that generally provided protection to the community from the 2% AEP event. Due to community feedback and financial limitations the interim scheme was only partially completed.

- The river flood model used to design the flood protection scheme is based on a 'design flood event'. There is however the potential for larger flood events to occur, resulting in wider, higher and faster flood waters.

- The river flood model used to design the flood protection scheme is based on detailed ground level information, but excludes obstructions such as buildings and walls. These obstructions may result in wider, higher and faster flood waters.

- The river flood model used to design the flood protection scheme incorporates the impacts of sediment and debris. However, there may be instances where sediment and debris causes localised changes to the flood extent, depth and speed. This includes debris flow events that will produce significantly different flooding characteristics.

- This river flood model used to design the flood protection scheme is only relevant to flooding caused by the Waiomu Stream. However, there is also the potential for flooding to occur in other waterways and due to the overwhelming (or lack) of local land drainage infrastructure.

- The river flood model is based on the existing condition of the Waiomu Stream catchment. Any significant change to this condition will affect the river flood hazard that affects the Waiomu community. For example, land use changes, deforestation and the intensification of development. Where significant changes do occur, this river flood model and associated flood protection scheme should be reviewed.

11 Planning controls

11.1 General

The proposed engineering works if completed in entirety, combined with river and catchment management activities, would protect most residential properties in the lower reaches of the Waiomu Stream against a 1% AEP event. Due to the incomplete nature of the works at Waiomu, parts of the community are still at risk from events above the 2% AEP event, and some parts of the community in the lower reaches remain unprotected. There remains residual flood risk to the community as outlined in Section 10.

Based on the flood hazard status of land in the community, TCDC has various planning controls in place via the Thames Coromandel District Plan, that restrict what land use activities can be undertaken. The planning controls include measures such as:

- No development or re-development allowed in the floodway, and in residual high risk areas.
- Minimum floor level restrictions and construction requirements (e.g. flood proofing) for areas not protected by the works.
- For other protected areas within the present flood hazard areas, limited floor level restrictions would have to apply.

Refer to the Thames Coromandel District Plan and Thames Coromandel District staff for details.

11.2 No. 12 Waiomu Valley Road

To ensure the safety of 12 Waiomu Valley Road against flooding in the long term the following planning controls have been applied to future development of the site:

- 12 Waiomu Valley Road has been raised above the future 1% AEP flood level. The property cannot be lowered.
- A bund has been constructed from the floodway boundary of 12 Waiomu Valley Road through 18A Waiomu Valley Road in a north east direction to Waiomu Valley Road. This bund cannot be lowered.
- The building platform levels should be set 300mm above the assessed future (allowing for climate change) 1% AEP flood levels. On average the proposed building platform levels will vary from RL7.2 metres (LiDAR datum) at the upstream end of 12 Waiomu Valley Road to RL6.3 metres (LiDAR datum) at the western edge of 12 Waiomu Valley Road. The long section provided in Appendix 6 provides the minimum building platform levels for 12 Waiomu Valley Road.
- The building floor levels should be set at a minimum height of 500mm above the building platform levels, or 800mm above the future 1% AEP flood level. This would be dealt with via the normal building consent process, however it should be noted that 800mm freeboard is atypical for TCDC. The figure in Appendix 6 provides the minimum floor levels for 12 Waiomu Valley Road.

- A minimum 6 metre set back along the floodway boundary should be left unfilled. This will provide a buffer zone between the floodway and any building platforms. The batter slope for the filled land forms this 6 metre buffer zone.

- All new buildings shall be set back at least 10 metres from the edge of the Waiomu stream floodway boundary, i.e. the set back is 10 metres from the toe of the filled area.

- The existing buildings with less than 800mm freeboard above the future 1% AEP flood level can be used until 2030. After this date the buildings will need to be removed or raised to the appropriate floor level.

- When the existing buildings are removed /refurbished, the adjacent land would need to be raised to the future 1% AEP flood level to tie in with the adjacent infilled portion of 12 Waiomu Valley Road. If this area was raised and the eastern portion of 18A Waiomu Valley Road had been filled, adequate provisions would need to be made to ensure drainage for 18 Waiomu Valley Road was maintained.

11.3 No. 18A Waiomu Valley Road

18A Waiomu Valley Road has not been raised above the future 1% AEP flood level. A bund/flood wall has been constructed through the centre of 18A Waiomu Valley Road to protect existing buildings at 12 and 18 Waiomu Valley Road from flooding. Due to the flood hazard status of this site there are some planning controls that need to be observed to ensure the safety of the property against flooding in the long term, as outlined below:

- The existing earth bund/flood wall cannot be altered, without consent from River & Catchment Services, Waikato Regional Council.

- Advice can be sought from Waikato Regional Council about suitable activities to undertake at the property.

- TCDC can be contacted for details on the rules about land use activities that can be undertaken at the property.

- The property cannot be raised without a resource consent. Advice should be sought from River & Catchment Services, Waikato Regional Council about any fill proposal.

- Any fill proposal would need to consider potential flood effects on adjacent properties (18 Waiomu Valley Road and 20 Waiomu Valley Road) from stream flooding and local drainage.

If the property is ever raised, the following planning controls would apply to any future development proposals:

- The building platform levels should be set 300mm above the assessed future 1% AEP flood levels (allowing for future climate change predictions). The long section provided in Appendix 6 provides the minimum building platform levels for 18A Waiomu Valley Road.

- The building floor levels should be set at a minimum height of 500mm above the building platform levels, or 800mm above the future 1% AEP flood level, refer to Appendix 6.

- A minimum six metre set back along the floodway boundary should be left unfilled. This will provide a buffer zone between the floodway and any building platforms.

- All new buildings shall be set back at least 10 metres from the edge of the Waiomu Stream floodway boundary.

12 Scheme review

The Coromandel Zone Management Plan outlines agreed levels of service for the flood protection schemes on the Coromandel, including commentary on scheme reviews. It is stated that river and flood protection schemes will provide the standard of flood protection agreed with the community, and that this will be achieved by:

- Maintaining stopbanks to the design heights, achieving performance grade 3 or better.
- Responding to flood events by alerting communities prior to events, continuously monitoring river systems, undertaking emergency remedial works and reviewing system performance and maintenance requirements following flood events.
- Undertaking ongoing visual inspections of flood protection structures, reporting formally on an annual basis and following up on maintenance and repair requirements following flood events.
- Reporting annually to the subcommittee and Catchment Services Committee on flood protection performance measures.
- Undertaking flood protection works within consent conditions.
- Making the likelihood and consequences of greater-than-design flood events clear to communities and providing advice for communities on managing these risks (residual flood risks).
- Conducting all flood protection work in accordance with Council health and safety policies.

The following procedures will measure whether performance targets are achieved:

- Annual performance and condition inspections.
- Yearly performance measures reports to subcommittee and Catchment Services Committee.
- Assessing ongoing changes to catchments, and undertaking design flood level reviews once every 5 years as required.
- Annual health & safety audits.

The river flood model and hence the design of the flood mitigation scheme is based on the existing condition of the Waiomu Stream catchment. Any significant change to this condition, for example land use intensification or deforestation, will affect the assumptions of the river flood model and hence compromise the basis of the scheme design. Where significant changes do occur, the river flood model and associated flood mitigation scheme should be reviewed.

Due to funding constraints the full flood mitigation scheme was not constructed. If feedback from the community indicates that the community wants to increase their level of protection and are able to fund the works, then the scheme would be reviewed and completed if practicable.

13 References

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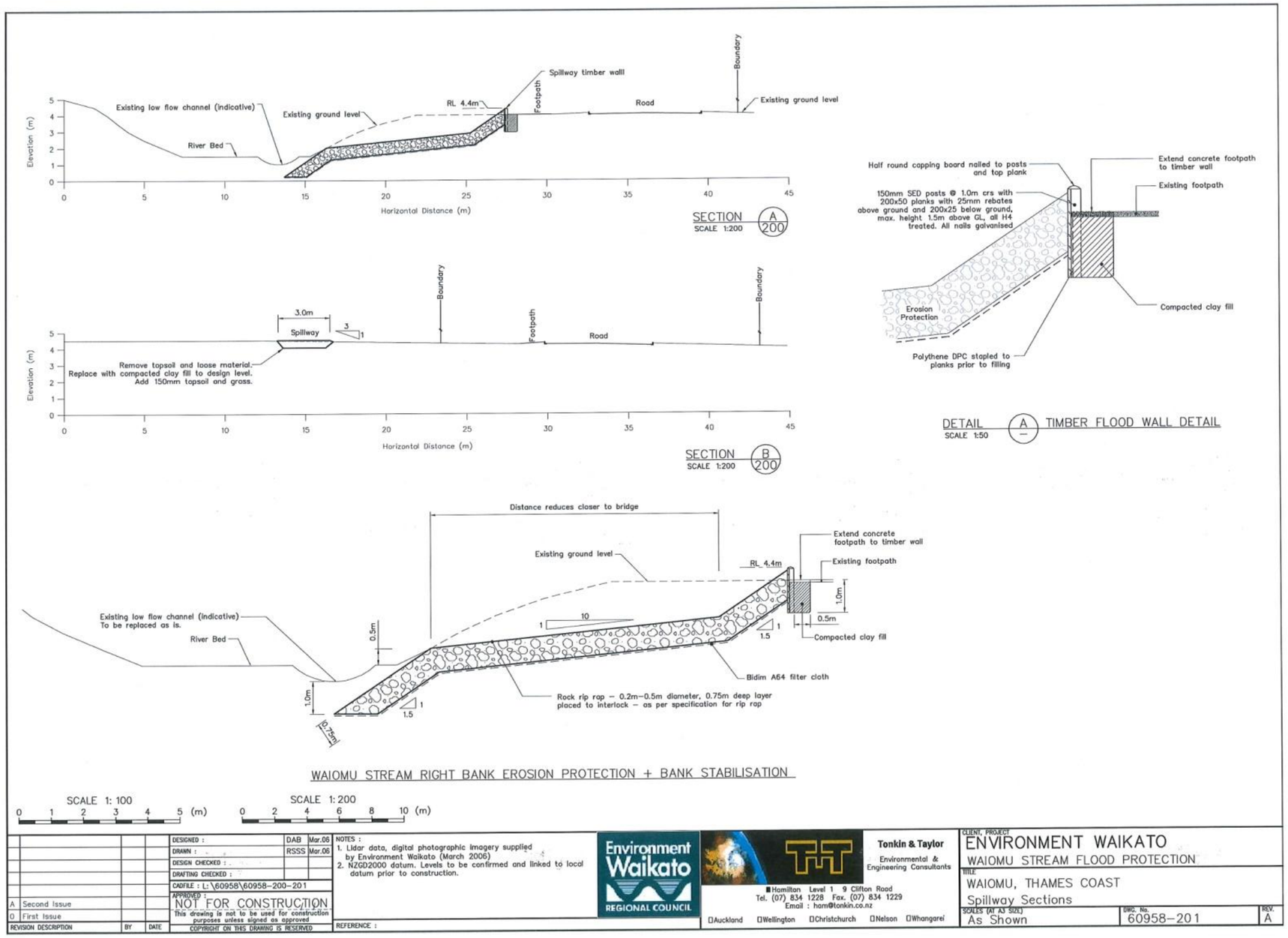
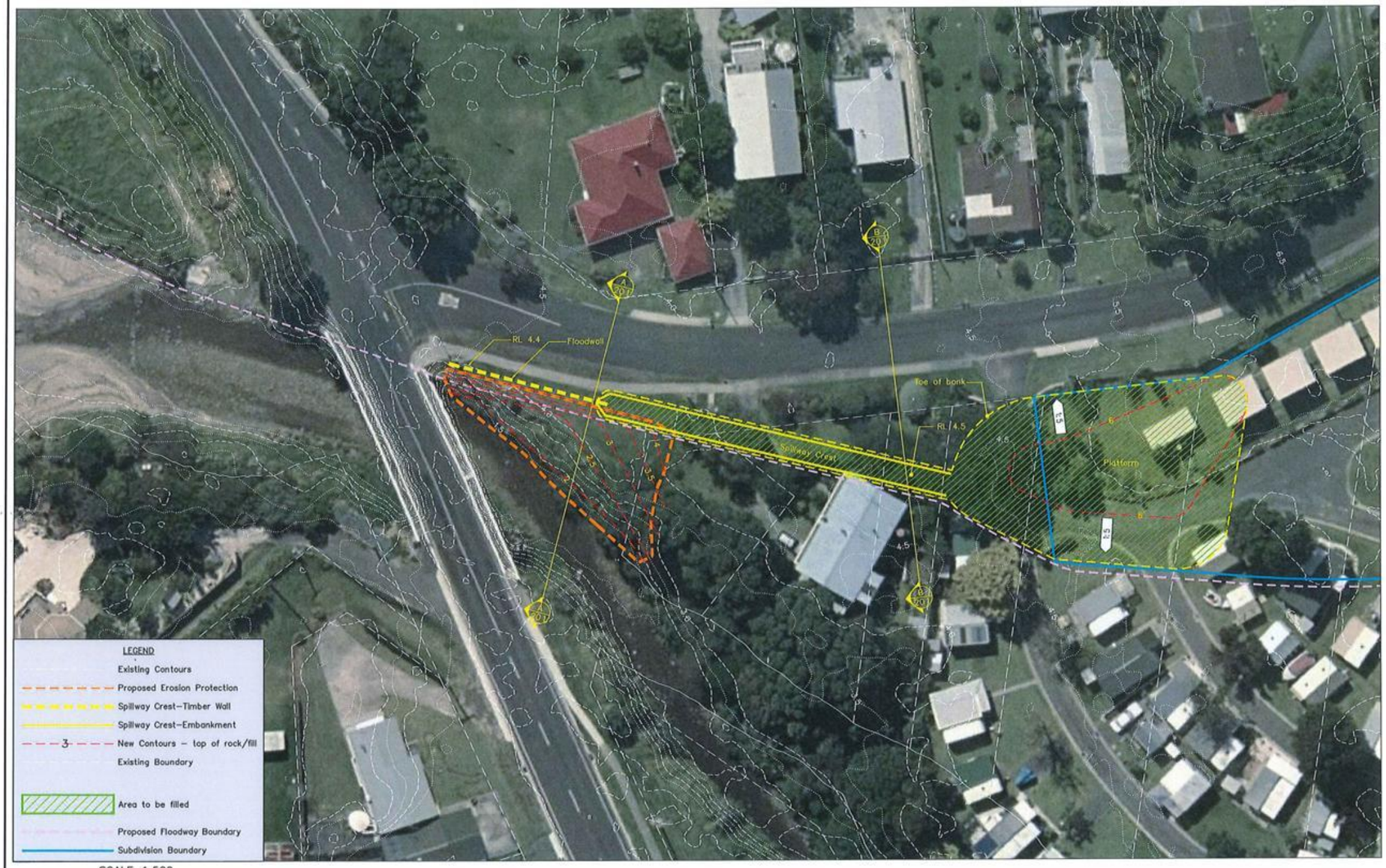
Appendix 1 Spillway design





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2. NZGD2000 datum. Levels to be confirmed and linked to local datum prior to construction.

REFERENCE :

Environment Waikato REGIONAL COUNCIL

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Environmental & Engineering Consultants
Hamilton Level 1 9 Clifton Road
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Email : ham@tonkin.co.nz
Auckland Wellington Christchurch Nelson Whangarei

CLIENT, PROJECT
ENVIRONMENT WAIKATO
WAIOMU STREAM FLOOD PROTECTION
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Spillway Layout Plan
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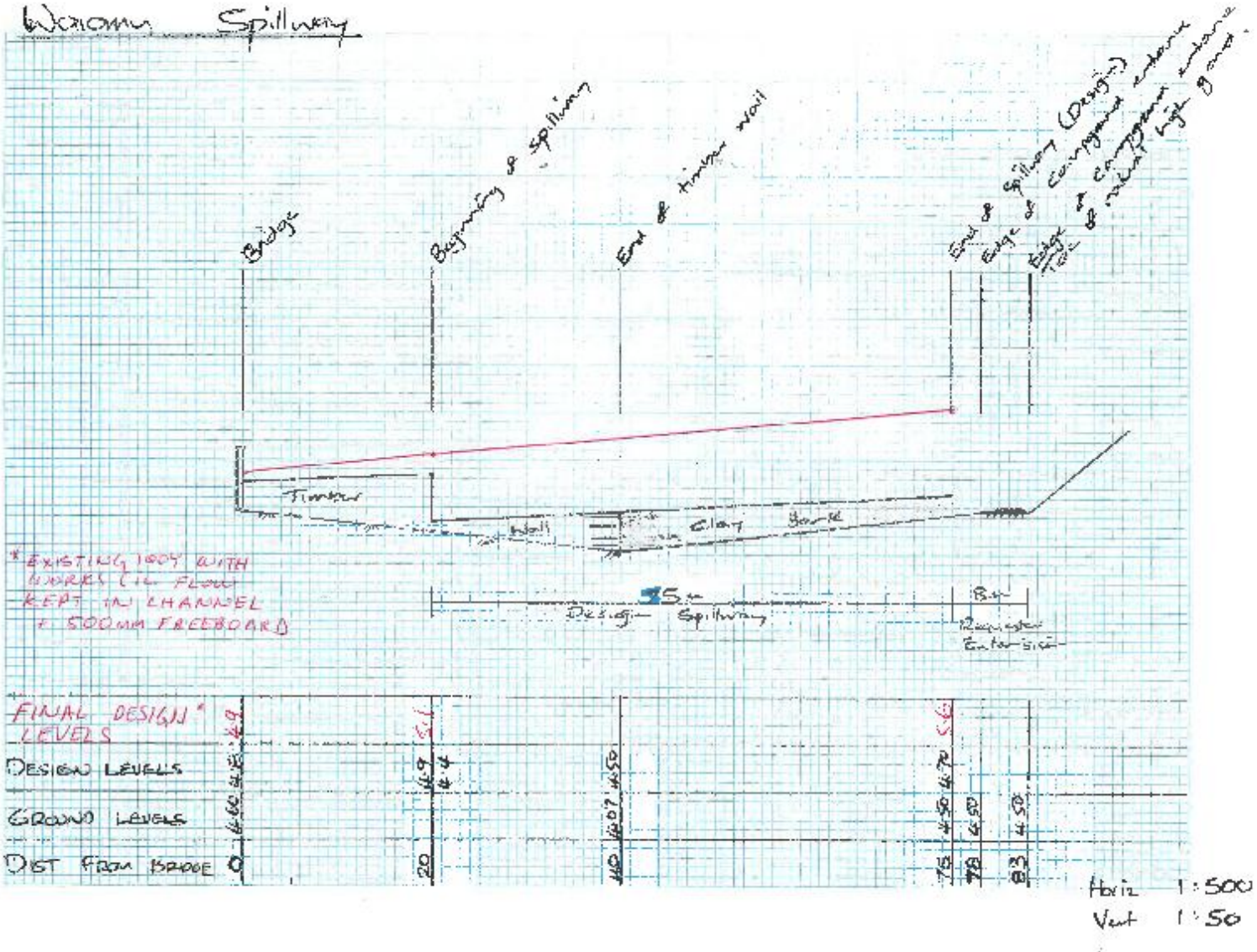

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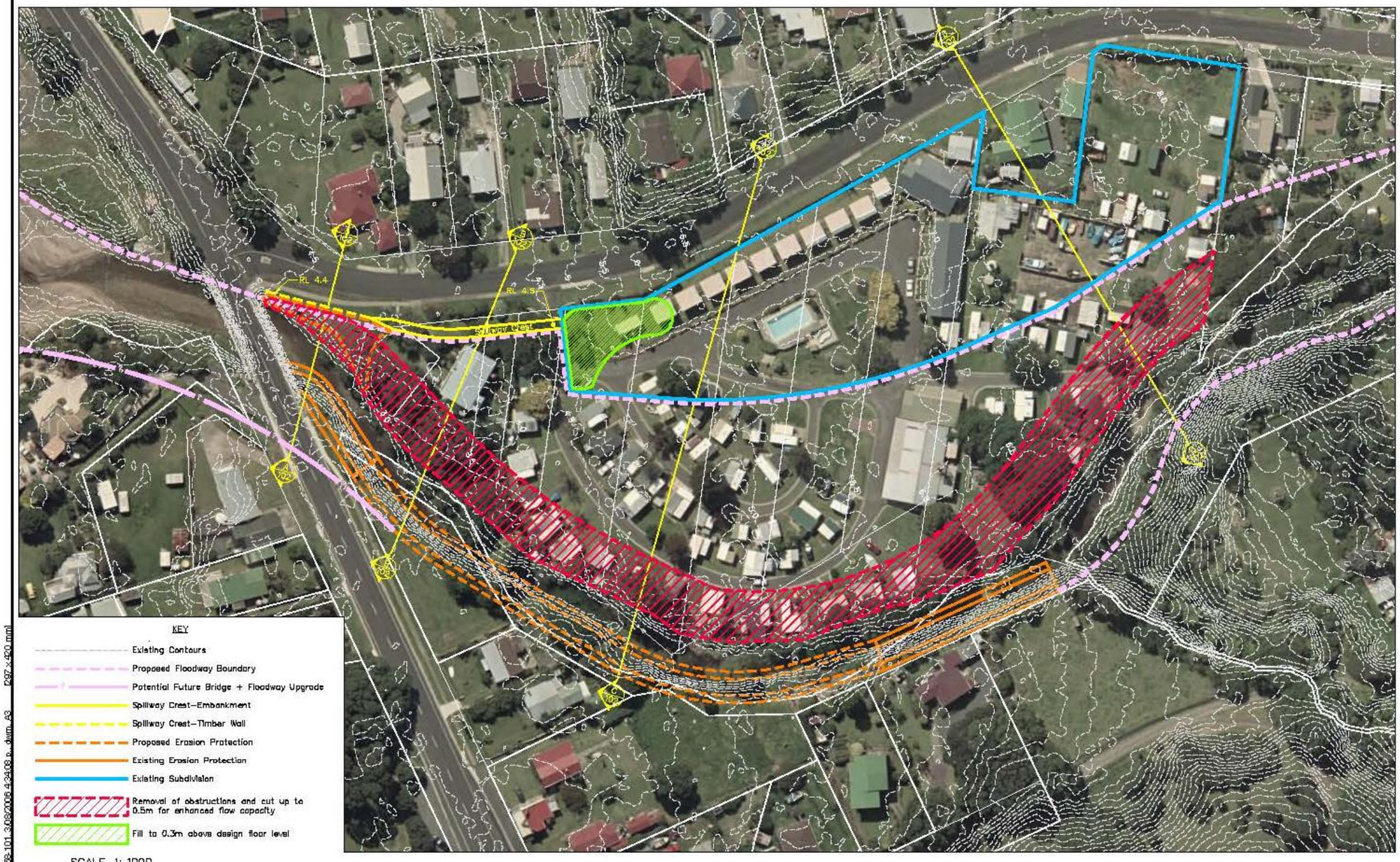
Appendix 2 Fill levels along floodway boundary



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CLIENT, PROJECT
ENVIRONMENT WAIKATO
WAIOMU STREAM FLOOD PROTECTION

TITLE
WAIOMU, THAMES COAST
Conceptual Floodway Layout Plan

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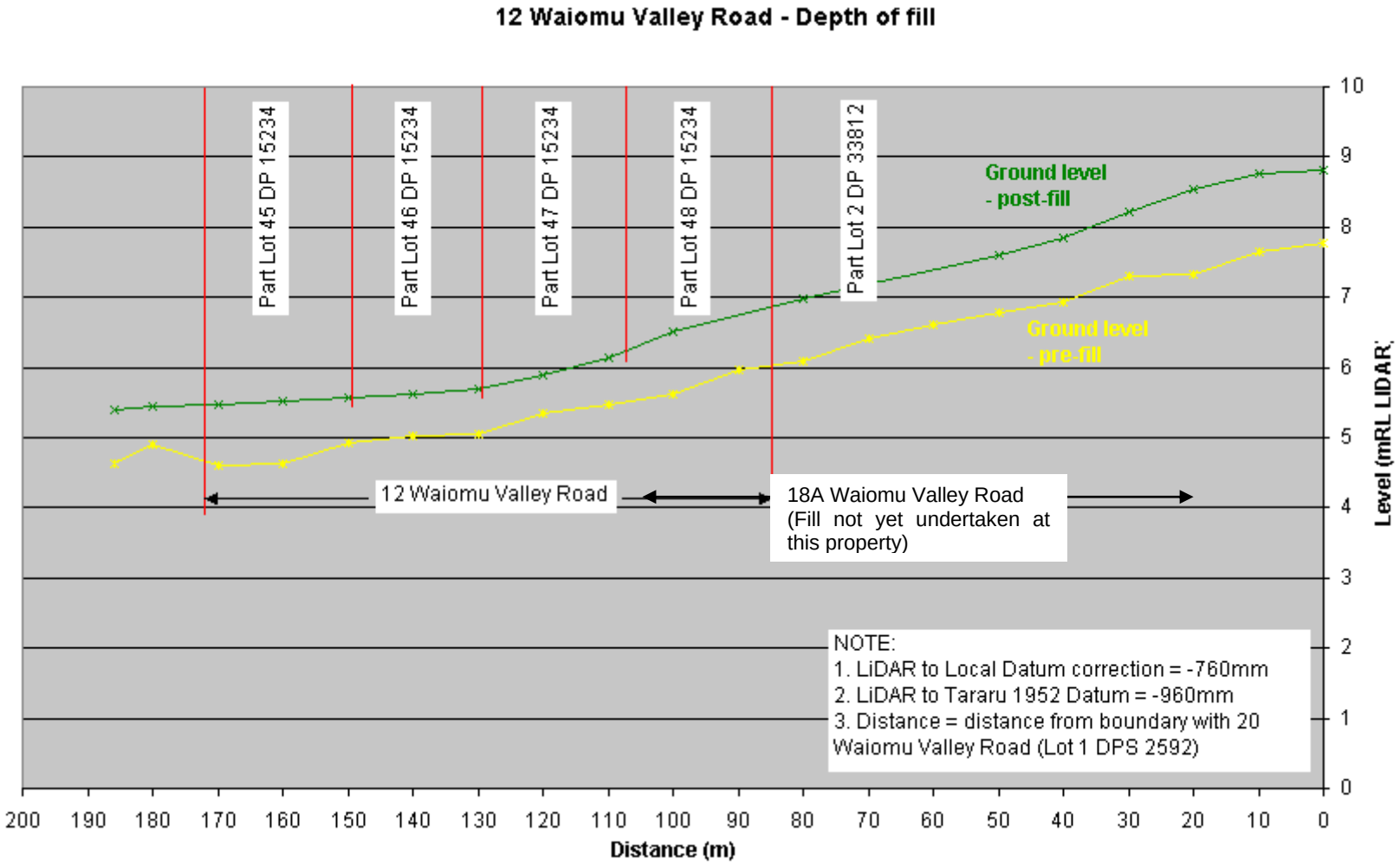

12 Waiomu Valley Road - Depth of fill
Part Lot 45 DP 15234
Part Lot 46 DP 15234
Part Lot 47 DP 15234
Part Lot 48 DP 15234
Part Lot 2 DP 33812
Ground level - post-fill
Ground level - pre-fill
12 Waiomu Valley Road
18A Waiomu Valley Road (Fill not yet undertaken at this property)
NOTE:
1. LiDAR to Local Datum correction = -760mm
2. LiDAR to Tararu 1952 Datum = -960mm
3. Distance = distance from boundary with 20 Waiomu Valley Road (Lot 1 DPS 2592)
Distance (m)
Level (mRL LIDAR)

Schedule of levels

Chainage[1]	Future 1% AEP flood level (m LIDAR datum)
0	8.81
10	8.76
20	8.54
30	8.22
40	7.84
50	7.59
60	
70	
80	6.98
90	
100	6.50
110	6.15
120	5.89
130	5.70
140	5.62
150	5.56
160	5.51
170	5.48
180	5.44
186	5.40

Note:

1 Distance along floodway boundary shown on T&T DWG No 60958-100 measured from boundary intersection with 20 Waiomu Valley Road

Appendix 3 Bund design details

FIELD REPORT / CALC PAD

Environment Waikato
REGIONAL COUNCIL

NAME	
ADDRESS	

DATE	REPORT BY	FILE REFERENCE
27/1/11		

Project: WAIOMU
Description: BUND DESIGN

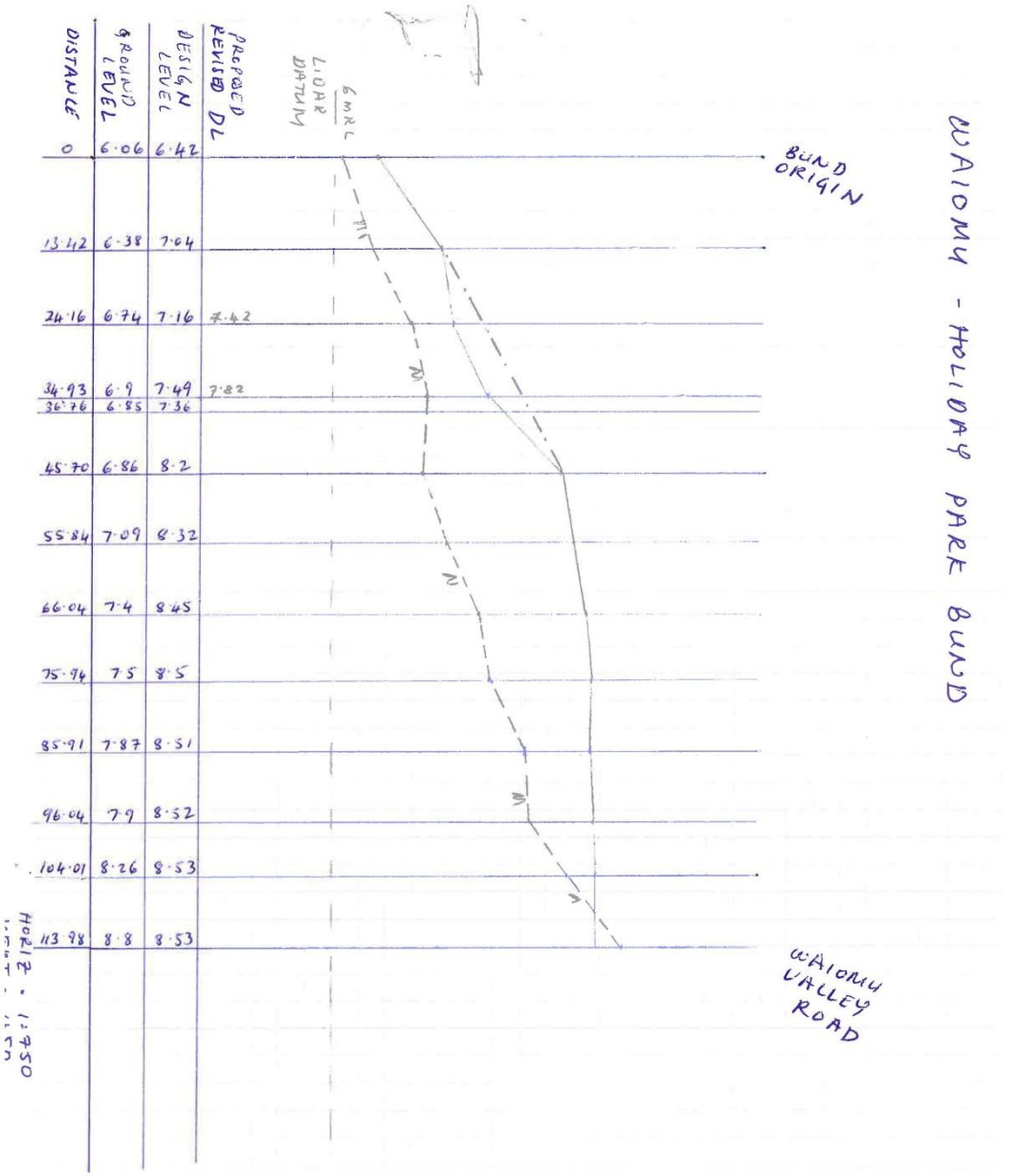
HAMILTON OFFICE
3 Cook Street, Hamilton
P.O. Box 4010, Hamilton East
Telephone: 0-7-859 0999
Facsimile: 0-7-859 0998

PAEROA OFFICE
13 Opaiito Road, Paeroa
Telephone: 0-7-862 8376
Facsimile: 0-7-862 6094

TAUPO OFFICE
Cnr Paora Hapi & Tibraupenga Sts
PO Box 501 Taupo
Telephone: 0-7-378 6539
Facsimile: 0-7-378 9049

WHITIANGA OFFICE
33-35 Albert Street
PO Box 192, Whitianga
Telephone: 0-7-866 0172
Facsimile: 0-7-866 0173

Computed	MW 27/1/2011
Checked	20
Revised	20
Checked	20
Office	
Job No	
File	
Sheet No.	



FIELD REPORT / CALC PAD

Environment Waikato REGIONAL COUNCIL

NAME		
ADDRESS		
DATE	REPORT BY	FILE REFERENCE

HAMILTON OFFICE
3 Cook Street, Hamilton
P.O. Box 4010, Hamilton East
Telephone: 0-7-859 0999
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PO Box 501 Taupo
Telephone: 0-7-378 6539
Facsimile: 0-7-378 9049
WHITIANGA OFFICE
33-35 Albert Street
PO Box 192, Whitianga
Telephone: 0-7-866 0172
Facsimile: 0-7-866 0173

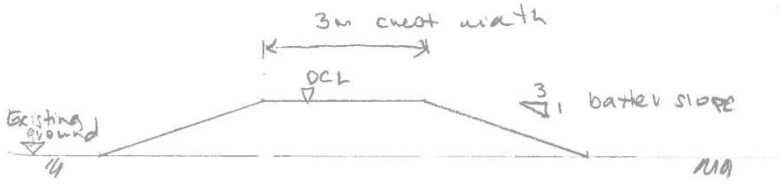
Computed	MAW 26/7/2011
Checked	20
Revised	20
Checked	20
Office	
Job No	
File	
Sheet No.	

Project: WAIOMU FLOOD PROTECTION

Description: BUND DESIGN (DRAFT FOR CONSULTATION)

STANDARD BUND SECTION

Vert - 1:100
Hor - 1:100



NOTE:

1. Bund to be topsoiled and grassed
2. Bund heights, refer to longsection

POLLUTION CONTROL * LAND USE PERMITS * PEST CONTROL * LAND/PASSENGER TRANSPORT * WATER USE PERMITS * SOIL CONSERVATION * REGIONAL WASTE MANAGEMENT
NOXIOUS WEED CONTROL * REGIONAL CIVIL DEFENCE * FLOOD CONTROL * COASTAL PERMITS * LAND DRAINAGE * MARITIME PLANNING * ENVIRONMENTAL PLANNING * ROAD SAFETY

REGIONAL COUNCIL

DATE	REPORT BY	FILE REFERENCE
27/1/11		

Project: WAIOMU

Description: BUND DESIGN

Facsimile: 0-7-862 6094
TAUPO OFFICE
Cnr Paora Hapa & Titiraupenga Sts
PO Box 501 Taupo
Telephone: 0-7-378 0629
Facsimile: 0-7-378 0049
WHITIANGA OFFICE
33-35 Albert Street
PO Box 158, Whitianga
Telephone: 0-7-866 0172
Facsimile: 0-7-866 0173

Checked 2

Office

Job No

File

Sheet No.

DISTANCE	GROUND LEVEL	DESIGN LEVEL	PROPOSED REVISED DL
0	6·06	6·42	
13·42	6·38	7·04	
24·16	6·74	7·16	7·42
34·93	6·9	7·49	7·82
36·96	6·85	7·36	
45·70	6·86	8·2	
55·84	7·09	8·32	
66·04	7·4	8·45	
75·94	7·5	8·5	
85·91	7·87	8·51	
96·64	7·9	8·52	
104·01	8·26	8·53	
113·98	8·8	8·53	

6mRL LIDAR DATUM

BUND ORIGIN

WAIOMU VALLEY ROAD

WAIOMU - HOLIDAY PARK BUND

HORIZ. 1:950
VERT. 1:50

Appendix 4 Erosion protection design details

T&T job no: 60958
14 June 2006

Environment Waikato
Private Bag 4010
HAMILTON EAST

Attention: Ghassan Basheer

Dear Ghassan

Waiomu Stream Erosion Protection Works
Design Report

Further to our joint site visit, and subsequent discussions, this letter provides a brief report on the design of the erosion protection works for the left bank of the Waiomu Stream for the 190 m immediately upstream of the State Highway 25 bridge.

Background

Erosion of the left bank of the Waiomu Stream has been an issue for several years. Left bank erosion protection works (rock rip-rap) are in place 7 Valder Place (see photo 1) Over the past year, progressive erosion of the left bank outside the house at 624 Thames Coast Road (SH25) has resulted in undermining an auxiliary building (see photo 2) . This has been the subject of an Earthquake Commission (EQC) investigation and report (Tonkin & Taylor ref 23290, 24 February 2006) There has also been erosion of the left bank at the SH25 Bridge abutment and immediately upstream. This has recently been repaired by Transit contractors. (see photos 3 and 4)

The campground on the right bank immediately upstream of the bridge was built on a flood plain and has suffered flooding on a number of occasions. The campground has built a low stopbank around the stream bank to reduce the risk of flooding. This stopbank may be constraining the stream during floods resulting in greater erosion potential on the left bank. We understand that it is Environment Waikato's intention to remove this stopbank and reinstate the flood plane to improve the hydraulic capacity of this section of stream including the approach to the bridge.

Tonkin & Taylor Ltd was commissioned in February 2006 to design erosion protection works for the left bank. The brief included erosion protection outside the house at 624 Thames Coast Road as a first priority (taking into account EQC investigation and remedial works).

The designed works are also required to tie in with Transit work at the bridge abutment, and the existing protection works at the upstream end of the reach being considered. Photographs are included in Annex 1.

Data Provided by Environment Waikato

Environment Waikato staff provided:

- Digital aerial ortho photographs.
- Contour data derived from LIDAR survey. We understand that the datum of the contour data is as used for the LIDAR survey and has not been adjusted.
- Result files from the Mike 21 model including a water velocity plot, water level plots for the 100 year 45 minute flood in the existing channel, water levels for the 100 year 45 minute flood with a preliminary floodway design for the right bank, and water levels for the same flood with a secondary floodway design.
- Level data for preliminary floodway design on right bank.

Copies of the EW output files as supplied are included in Annex 2.

Design Assumptions

The design criteria and assumptions used are:

- Design flood is 100 year 45 minute flood (assessed as critical duration storm by EW).
- Assumed depth of design flood as per EW Mike 21 plot with secondary floodway on right bank. This indicates a flood level of 5.5m at 624 Thames Coast Road.
- Water velocity on the right bank indicates 2-3 m/s with peak velocities in the centre of the stream of 4 m/s. 3 m/s has been adopted for rock size calculation.
- Using the MWD Culvert Manual Figure 9, and a side slope of 1.5H:1V, the equivalent spherical rock size is 0.3m. This gives a mean size of 0.35m, and a suggested range of 0.2 m to 0.5 m.
- The right bank floodway design level opposite 624 Thames Coast Road is approximately 4.3m. Floods higher than this level will spread out across the flood plain. This is likely to reduce the erosion potential on the left bank. It was therefore decided after discussion with yourself, to extend the left bank rock protection to a slightly above the level of the right bank floodway rather than to the top of the bank.
- Rock protection will be constructed from good quality rock and will include sub-excavating the toe, and shaping the bank to limit the side slope, and will be constructed according to technical specifications for rip rap.

Description of Design

The proposed erosion protection works consist of 0.2 to 0.5 m diameter rock rip rap constructed along the left bank extending 2m across the stream bed, and 2m vertically up the bank at a side slop of 1.5 horizontal to 1 vertical. Above the level of the rock, the bank slope will reduce to about 2 H to 1 V. This slope will be topsoiled and planted with erosion resistant small plants (grass or small shrubs).

It will be necessary to remove at least two trees on the left bank before completing this work as the stream has already undermined their roots. The bank will need some re-shaping in places to give a smooth transition.

Drawing 60958-01 shows the extent of the existing and proposed rock protection works.
Drawing 60958-02 shows a design cross section at 624 Thames Coast Road.
Drawings are attached in Annex 3.

A technical specification for supply and placement of rip rap is attached in Annex 4.

Future Work

Note that there may also need to be some erosion protection of the right bank immediately upstream of the bridge where the river turns left to flow through the bridge. We understand that this will be designed and constructed together with the right bank floodway and spillway. The right bank erosion protection is indicated on Drawing 01 but is subject to further detailed design and confirmation.

Applicability

This report has been prepared for the benefit of Environment Waikato with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Closure

We trust this report and design drawings meet your requirements. We look forward to being of assistance with the next phase of the project.

Yours sincerely
TONKIN & TAYLOR LTD

David Bouma
SENIOR CIVIL AND ENVIRONMENTAL ENGINEER

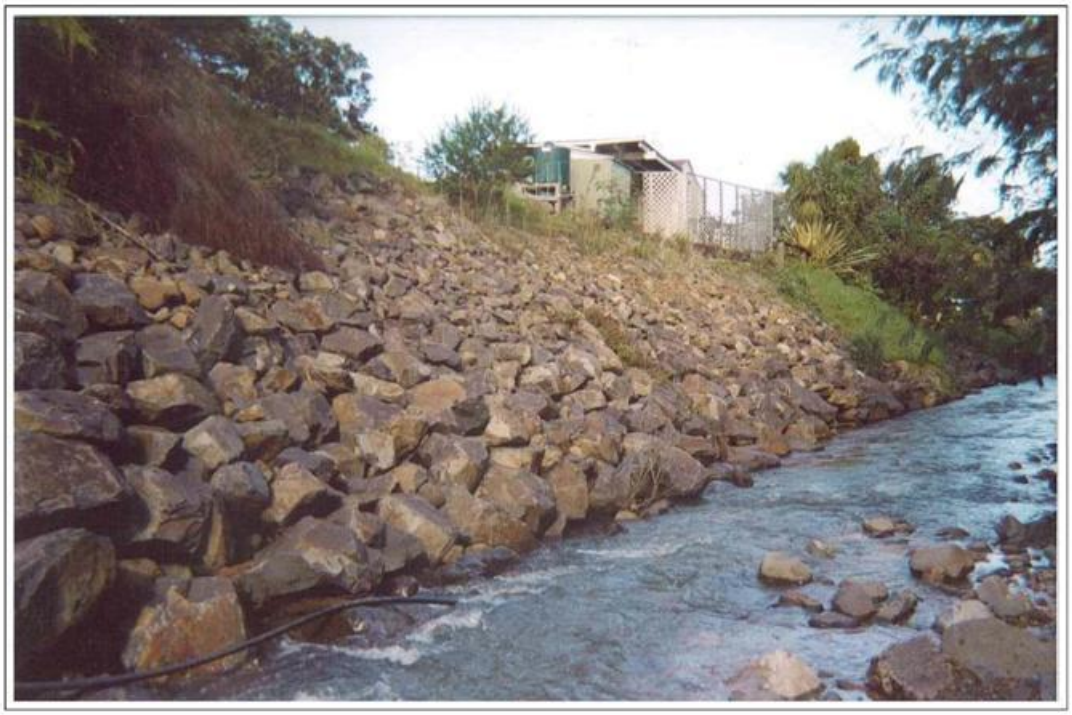
Attachments:

Annex 1. Photographs
Annex 2. EW Mike 21 data
Annex 3. Design Drawings
Annex 4. Technical Specification for Rip rap

17-Nov-15
j:\60958\060517dab design report.doc

Annex 1 Photographs

Waiomu Stream Erosion - 2006



1 Erosion protection outside 7 Valder Place

2 Erosion outside 624 Thames Coast Rd

Tonkin & Taylor Ltd Page 1 of 2

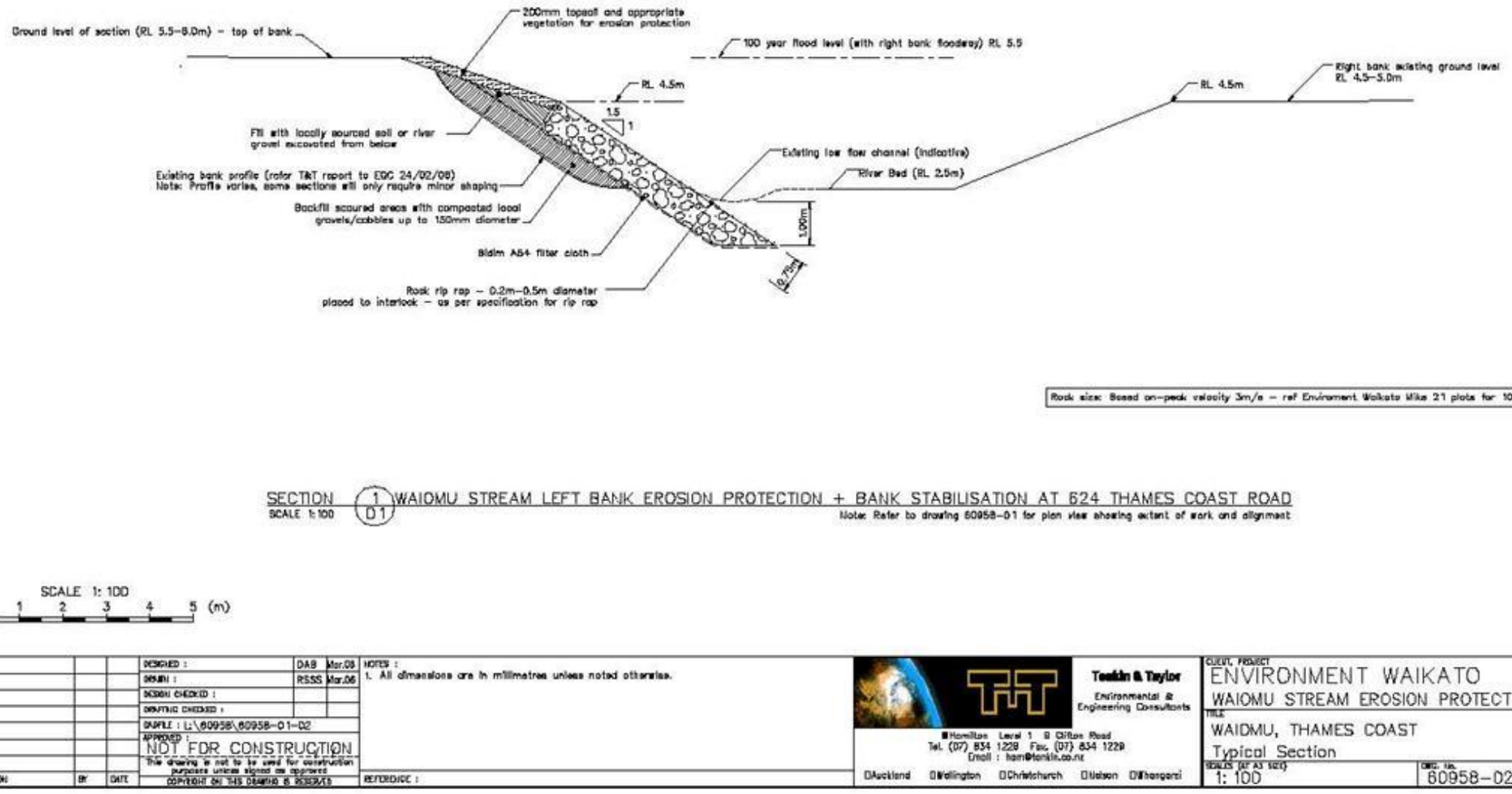
3. Erosion of left bank at SH 25 bridge

4 Recent erosion protection works placed by Transit

Annex 2 Hydraulic Modelling Data from Environment Waikato

Not included

Annex 3 Design Drawings

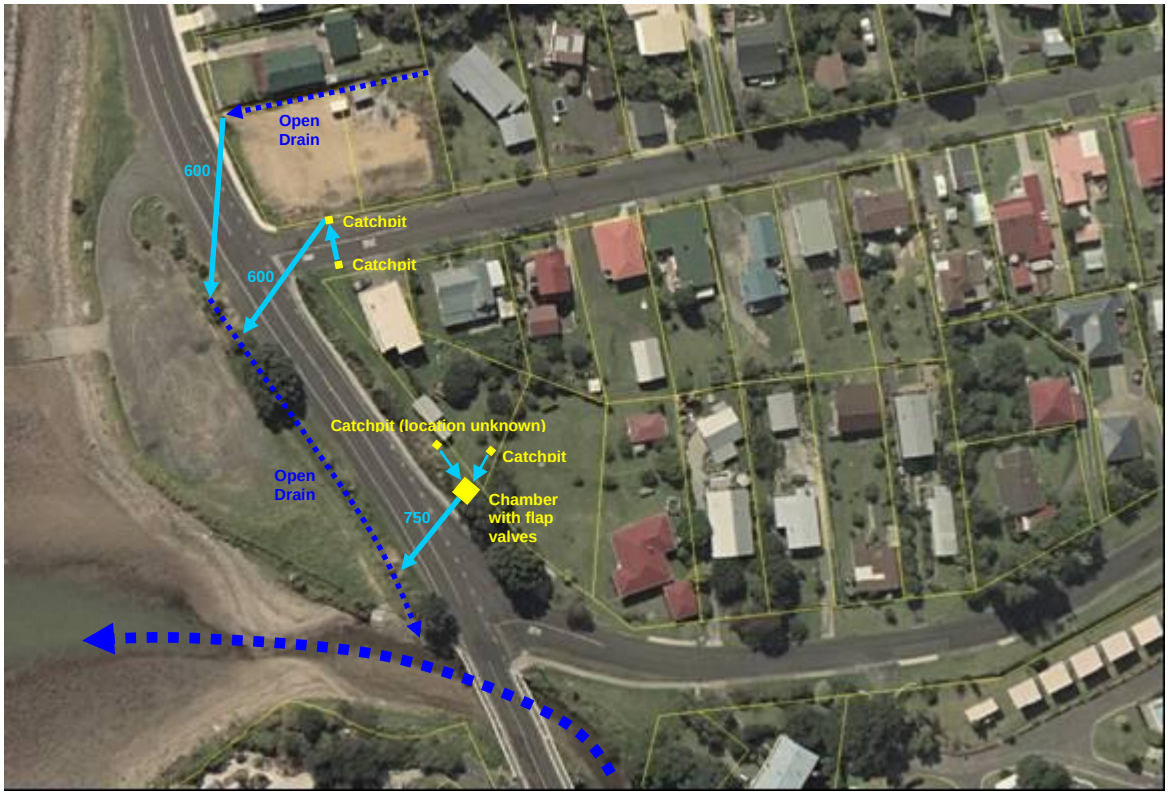


Annex 4 Technical Specification

Not included, refer WRC DM# 1098874

Appendix 5 Trotter Avenue existing drainage

Following a visual inspection, the existing drainage infrastructure in the vicinity of Trotter Avenue was identified as shown in the following diagram.

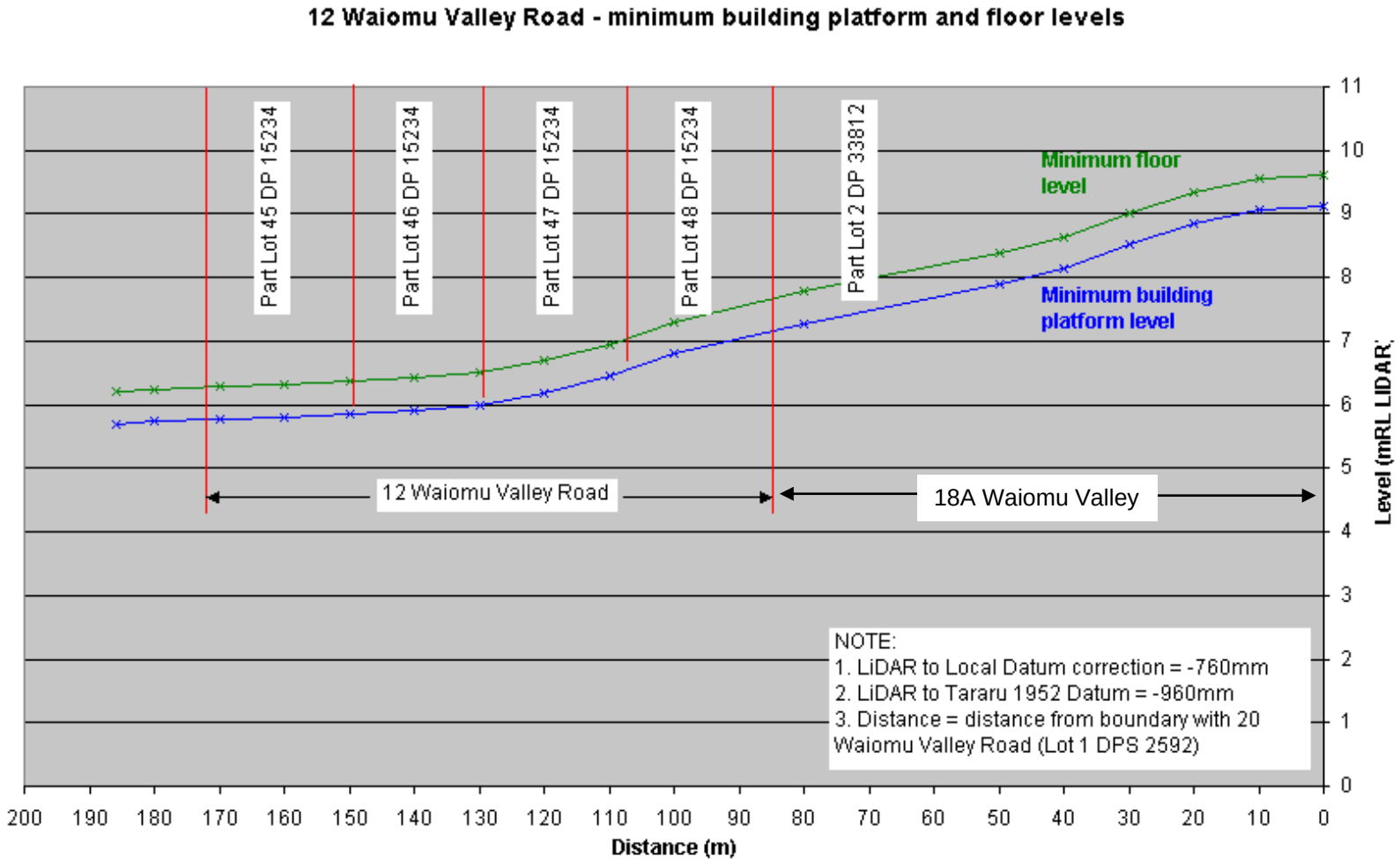


The above existing drainage infrastructure consists of the following culverts under SH25:

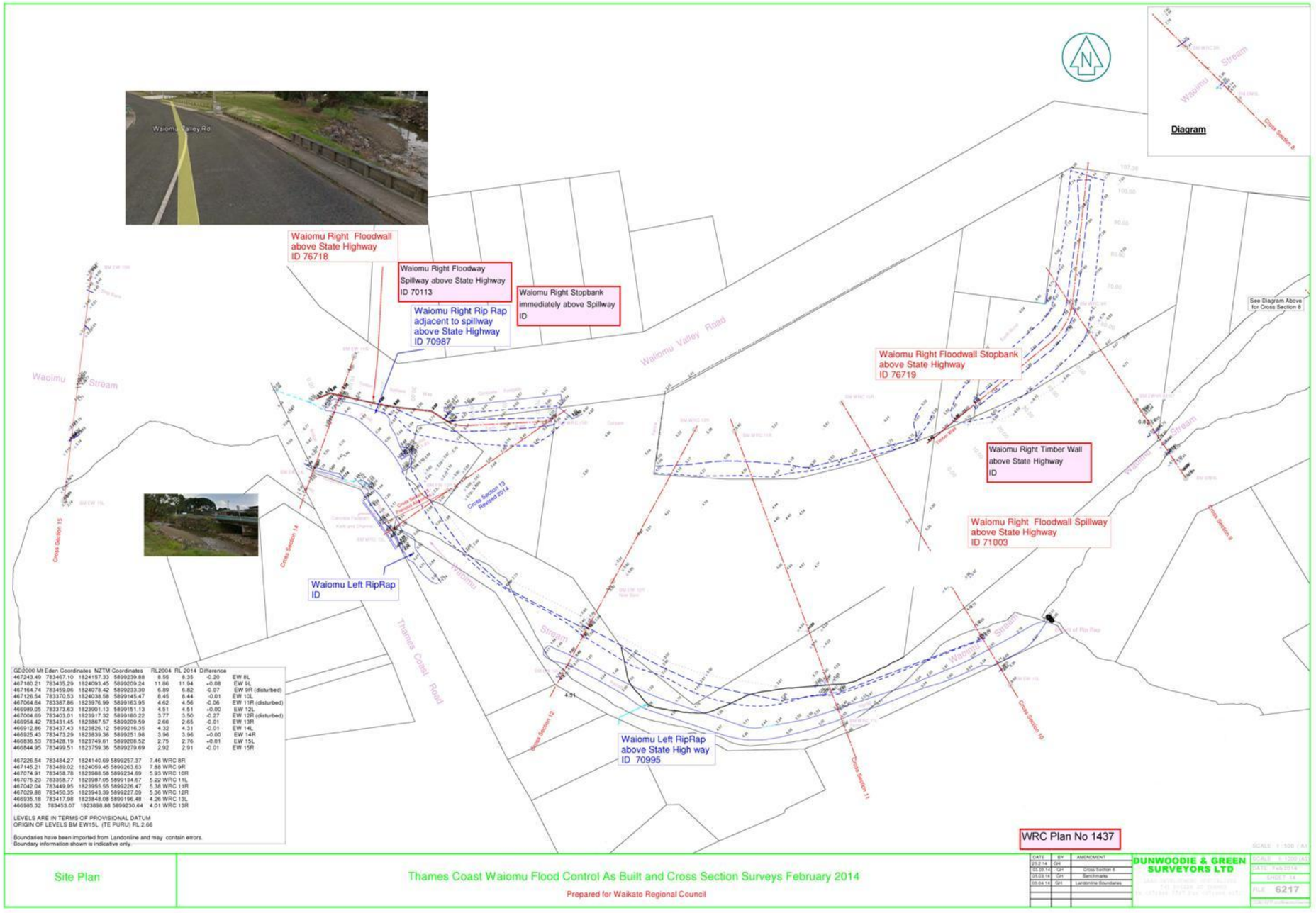
1. 600 mm culvert taking runoff from a small open drain.
2. 600 mm culvert taking runoff from two catchpits on Trotters Ave.
3. 750 mm culvert taking runoff from two catchpits on adjacent private property. This includes a chamber that houses a flap valve for each catchpit to stop backflow during high tides (refer to photo).

All three culverts drain to an existing open drain running parallel to SH25 that was overgrown at the time of the inspection.

Appendix 6 Building platform levels



Appendix 7 As-built survey



GD2000 Mt Eden Coordinates	NZTM Coordinates		RL2004	RL 2014	Difference	
467243.49	783467.10	1824157.33 5899239.88	8.55	8.35	-0.20	EW 8L
467180.21	783435.29	1824093.45 5899209.24	11.86	11.94	+0.08	EW 9L
467164.74	783459.06	1824078.42 5899233.30	6.89	6.82	-0.07	EW 9R (disturbed)
467126.54	783370.53	1824038.58 5899145.47	8.45	8.44	-0.01	EW 10L
467064.64	783387.86	1823976.99 5899163.95	4.62	4.56	-0.06	EW 11R (disturbed)
466989.05	783373.63	1823901.13 5899151.13	4.51	4.51	+0.00	EW 12L
467004.69	783403.01	1823917.32 5899180.22	3.77	3.50	-0.27	EW 12R (disturbed)
466954.42	783431.45	1823867.57 5899209.59	2.66	2.65	-0.01	EW 13R
466912.86	783437.43	1823826.12 5899216.35	4.32	4.31	-0.01	EW 14L
466925.43	783473.29	1823839.36 5899251.98	3.96	3.96	+0.00	EW 14R
466836.53	783428.19	1823749.61 5899208.52	2.75	2.76	+0.01	EW 15L
466844.95	783499.51	1823759.36 5899279.69	2.92	2.91	-0.01	EW 15R
467226.54	783484.27	1824140.69 5899257.37	7.46	WRC 8R		
467145.21	783489.02	1824059.45 5899263.63	7.88	WRC 9R		
467074.91	783458.78	1823988.58 5899234.69	5.93	WRC 10R		
467075.23	783358.77	1823987.05 5899134.67	5.22	WRC 11L		
467042.04	783449.95	1823955.55 5899226.47	5.38	WRC 11R		
467029.88	783450.35	1823943.39 5899227.09	5.36	WRC 12R		
466935.18	783417.98	1823848.08 5899196.48	4.26	WRC 13L		
466985.32	783453.07	1823898.88 5899230.64	4.01	WRC 13R		

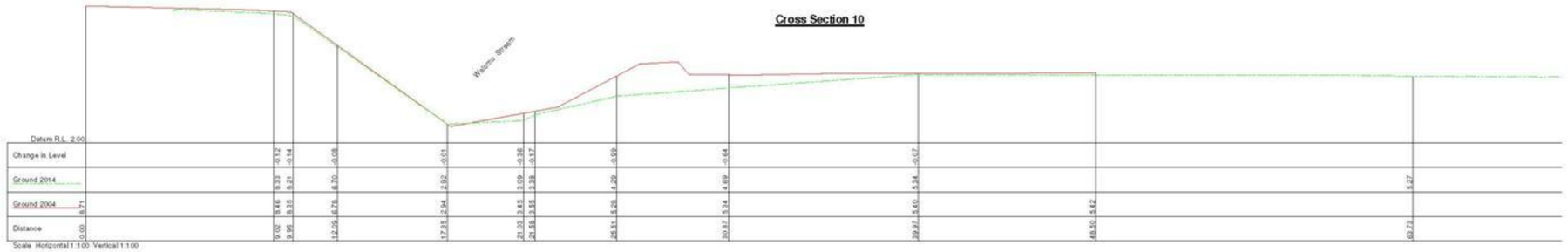
LEVELS ARE IN TERMS OF PROVISIONAL DATUM
ORIGIN OF LEVELS BM EW15L (TE PURU) RL 2.66

Boundaries have been imported from Landonline and may contain errors.
Boundary information shown is indicative only.

DATE	BY	AMENDMENT
29.2.14	GH	
03.03.14	GH	Cross Section 8
05.03.14	GH	Benchmarks
03.04.14	GH	Landonline Boundaries

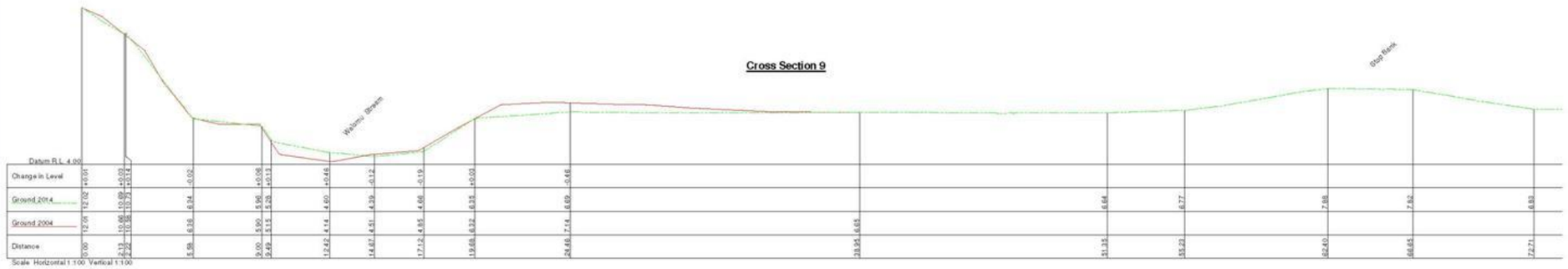
SCALE 1:1000 (A1)
DATE Feb 2014
SHEET 1/4
FILE 6217

Cross Section 10

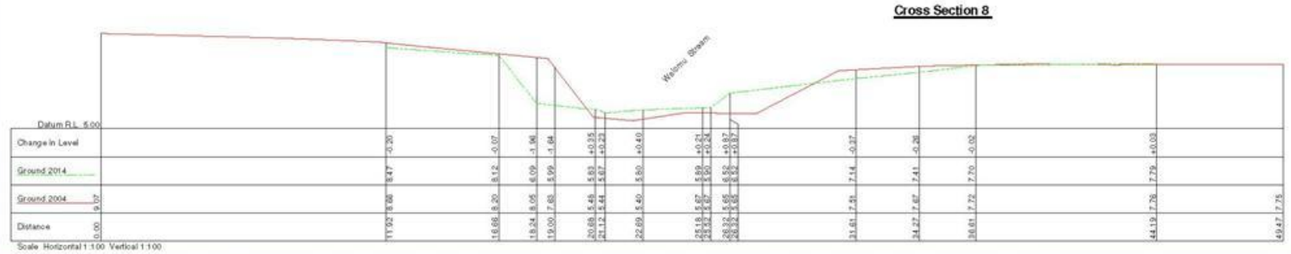


Cross Section 10 continued

Cross Section 9



Cross Section 8



LEVELS ARE IN TERMS OF PROVISIONAL DATUM
ORIGIN OF LEVELS BM EW15L (TE PURU) RL 2.66

WRC Plan No 1437

River Cross Sections

Thames Coast Waiomu Flood Control As Built and Cross Section Surveys February 2014

Prepared for Waikato Regional Council

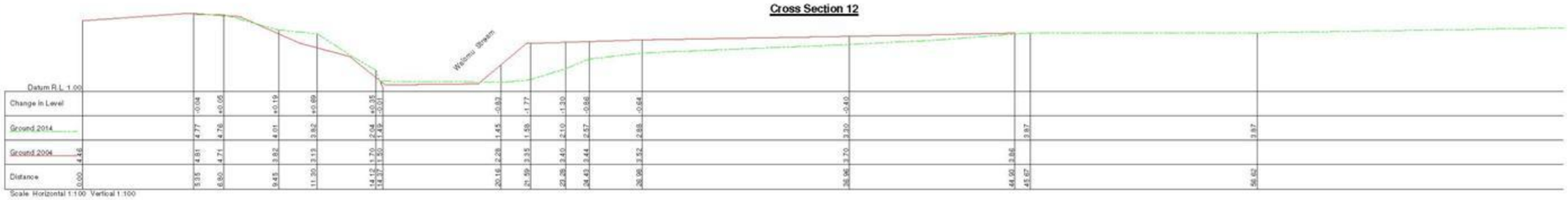
DATE	BY	AMENDMENT
25.2.14	GH	
05.04.14	GH	CROSS SECTION 8

DUNWOODIE & GREEN SURVEYORS LTD

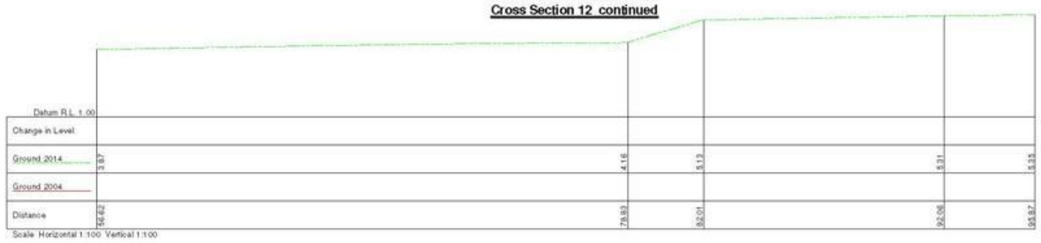
LAND DEVELOPMENT SPECIALISTS
542 POLLEN ST THAMES
Ph 07 868 7567 Fax 07 868 8232

SCALE 1:100 (A1)
SCALE 1:200 (A3)
DATE Feb 2014
SHEET 1/8
FILE 6217

Cross Section 12

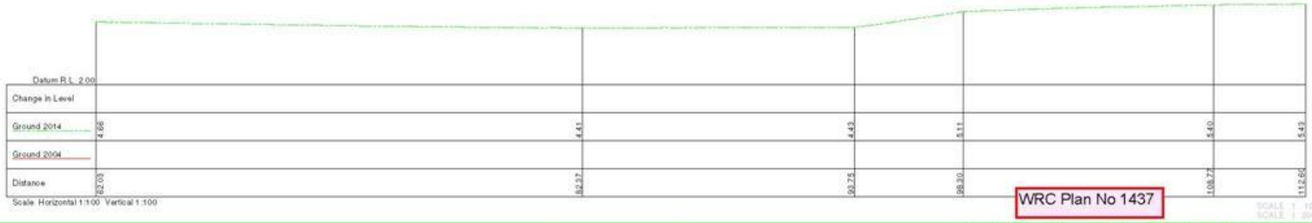


Cross Section 12 continued



Cross Section 11

Cross Section 11 continued



LEVELS ARE IN TERMS OF PROVISIONAL DATUM
ORIGIN OF LEVELS BM EW16L (TE PURU) RL 2.66

WRC Plan No 1437

River Cross Sections

Thames Coast Waiomu Flood Control As Built and Cross Section Surveys February 2014

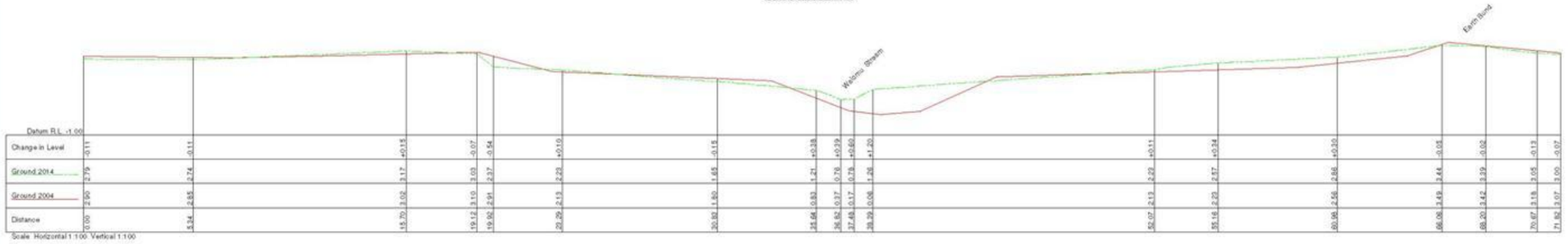
Prepared for Waikato Regional Council

DATE	BY	AMENDMENT
26.2.14	GH	

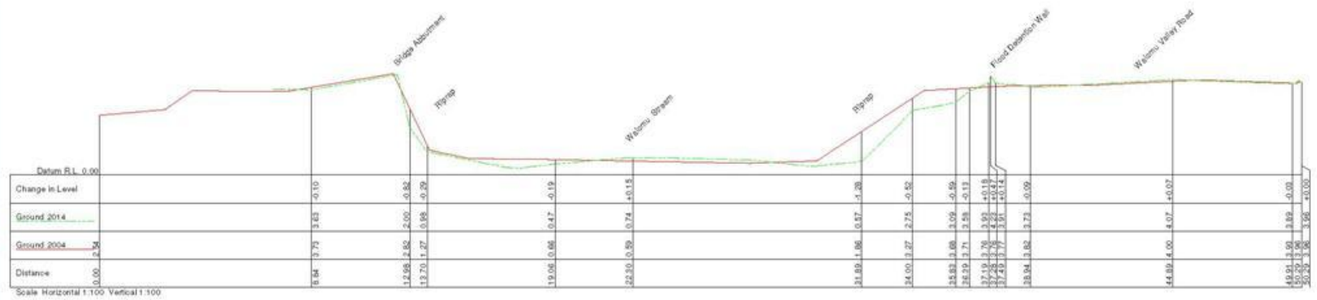
DUNWOODIE & GREEN SURVEYORS LTD

FILE 6217

Cross Section 15

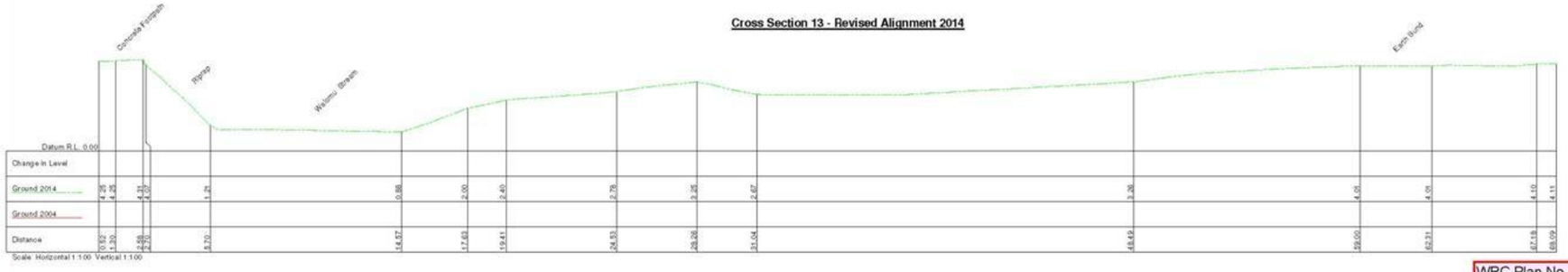


Cross Section 14



LEVELS ARE IN TERMS OF PROVISIONAL DATUM
ORIGIN OF LEVELS BM EW1 SL (TE PURU) RL 2.66

Cross Section 13 - Revised Alignment 2014



WRC Plan No 1437

River Cross Sections

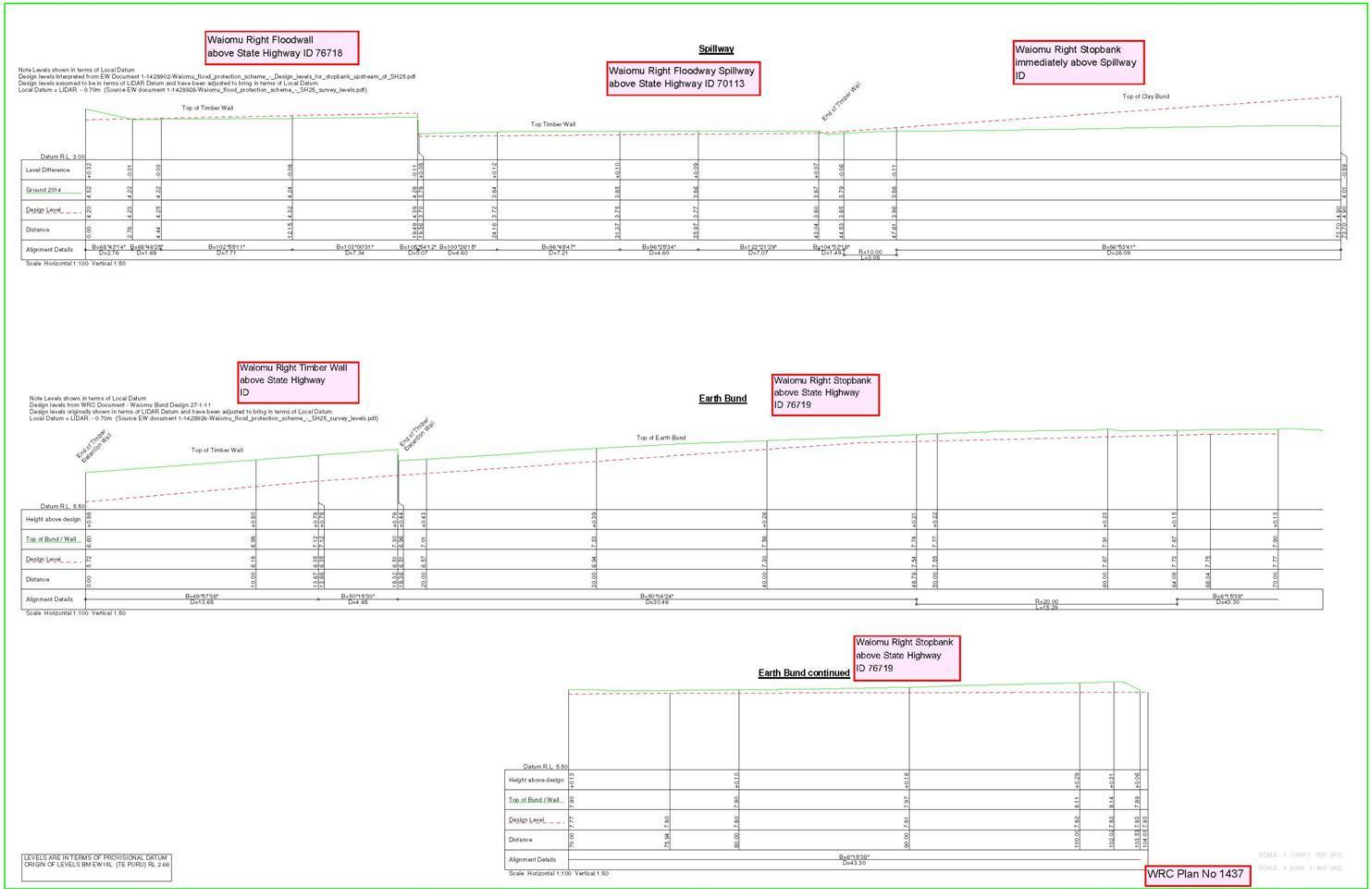
Thames Coast Waiomu Flood Control As Built and Cross Section Surveys

Prepared for Waikato Regional Council

DATE	BY	AMENDMENT
28.2.14	GH	

DUNWOODIE & GREEN SURVEYORS LTD
LAND DEVELOPMENT SPECIALISTS
141 PULLAR ST THAMES
PH. 0714848 7587 FAX 0714848 6230

SCALE 1:100 (A1)
DATE FEB 2014
SHEET 1 OF 1
FILE 6217



Spillway and Bund Long. Sections

Thames Coast Waiomu Flood Control As Built and Cross Section Surveys

Prepared for Waikato Regional Council

DUNWOODIE & GREEN SURVEYORS LTD

6217