Environment Waikato Technical Report 2006/26

Waiomu Flood Protection Interim Report

Prepared by:
Ghassan Basheer

For:
Environment Waikato
PO Box 4010
HAMILTON EAST

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Murray Mulholland Date December 2008

Approved for release by:
Julie Beaufill Date December 2008

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1 Introduction

Following the severe floods generated by the "weather bomb 2002" on the Thames coast, Environment Waikato and Thames Coromandel District Council have jointly worked to address the flooding issues along the Thames Coast. 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. A critical area of risk within the Waiomu community is the Waiomu Bay Holiday Park.

The initial investigations into the flooding of the Waiomu settlement is set out in Environment Waikato Technical Report 2003/10 dated 13 August 2003, and community meetings, identified the issues causing and exacerbating flood risks and proposed solutions for these. The issues included:

- catchment stability
- lack of channel maintenance
- inappropriate development within the floodplain
- State Highway 25 and the bridge waterway capacity
- local drainage network.

In addressing these issues both councils have jointly adopted a whole catchment approach and strategically engaged with central government to ensure that the issues are addressed sustainably in the long term. The main tasks undertaken following the initial technical investigations included:

- risk assessment
- business case to central government
- community consultation.

The Peninsula Project was initiated in 2002 and formally adopted in 2004 to address river and catchment issues across the Coromandel Peninsula. This umbrella project identified the river and catchment services needs over the whole peninsula area, established a long term works programme to meet these needs and a funding system that supports implementation of these programmes and maintaining their benefits in the long term. The programme within the Waiomu catchment included the following:

- establishment of the channel maintenance programme
- establishment of a catchment management programme including soil conservation and animal pest control in conjunction with the Department of Conservation
- establishment of the flood protection and channel improvements capital works programme.

The success of the business case provided different levels of central government contributions to implement the proposed capital works programmes. However, upgrading the State Highway 25 bridge could not be included in the Transit NZ 10-year

plan. This meant that a staged approach needed to be taken in providing flood protection within the Waiomu community.

Since July 2004, detailed surveys and conceptual design reviews have been undertaken to ensure that flood risks are addressed sustainably in the long term. The results of the review provided that the initial conceptual design didn't provide adequate floodway to accommodate current and future flood flows. A significant part of the campground area needed to be retired as a floodway. Negotiations with the landowners were concluded with the purchase of the whole campground and No. 2 Waiomu Valley Road properties.

This report provides the results of the design review, the proposed flood protection and control works and future management strategy to ensure that flood risks within the Waiomu community are addressed in a sustainable manner.

2 Conceptual design review

2.1 Background

Following the initial engineering investigation, detailed surveys of the river channel, flood plains, services and legal boundaries were undertaken. The information has been used to further model the extent of flooding for different events, risk assessments and options for flood protection.

The joint (EW and TCDC) councils direction is that of promoting and supporting solutions that provide sustainable community outcomes in the long term.

Accordingly, in analysing the flood risks a number of aspects need to be investigated in detail including the following:

- current floods
- future floods (including climate change effects)
- channel stability
- river bed infilling (bed load movement and its effects)
- floating debris.

And in addressing these risks a number of measures are undertaken within the framework of a flood risk management strategy including the following:

- floodway and channel improvements
- flood protection and control works
- planning and land use controls.

2.2 Scope of hazards

The existing flood risks within the Waiomu settlement were assessed following the June 2002 flood event with flood hazard maps produced defining the different levels of risk across the area. The assessment was based on the current 100-year flood and the conceptual flood mitigation design approach didn't consider the full range of hazards in the long term.

Since then, and to ensure that council's objectives are met in terms of sustainable outcomes in the long term, further work has been undertaken to identify the range of risks associated with floods now and in the long term. In 2004 the Ministry for Environment published its guidelines for local government "Preparing for Climate Change" and amended the RMA to ensure that climate change effects are considered in planning and development. Also, following the Manawatu and Bay of Plenty regional floods, central government has been leading a number of initiatives to improve the ways flood protection works are designed and managed. The Matata debris flow event also highlighted the need to understand further the risks of such events in small steep catchments such as these on the Thames coast.

The flood risks within the Waiomu area could be briefly described as below.

- **Flooding**: The Waiomu stream has a capacity of approximately 80 m^3/s and overland flow occurs upstream of the state highway bridge through the campground and gradually rises to cover all other areas. The extent of flooding covers adjacent, developed floodplains.

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

- **Channel stability**: The Waiomu stream channel has a gravel bed and vegetated banks, is relatively deep upstream of the ford culvert and becomes wider and shallower through the Waiomu settlement. 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 50-year annual recurrence interval event.

- **Climate change effects**: Based on Ministry for the Environment guidelines, the effects of global warming are expected to be increased rainfall and higher sea levels. Effectively, this means that what is assessed as a 100-year flood flow today might be have a lower return period in the future. The 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, it is obvious that future floods and associated risks are expected to be much higher than the initial investigation report suggested which required review of the original design and development of a new concept to address these risks on a long term basis.

2.3 Original design

The originally proposed concept was based on addressing the current flood risks only through a combination of engineering works and planning controls. The works were more focussed on restricting the flood flows within the channel by way of stopbanks and channel works. These works included the following elements.

- Improving the channel capacity and stability between the upstream ford culvert and Dehar's bend.

- Raising the Waiomu Valley Road levels in breakout points.

- Stopbanking along the right bank between Dehar's bend and the State Highway 25 bridge.

- Upgrading the State Highway 25 bridge to accommodate the design flows with adequate freeboard.

The proposal was based on current 100-year flood flows of 150 m^3/s and levels derived from a one dimensional hydraulic model. The following map (Figure 1) shows the elements of the original proposal.

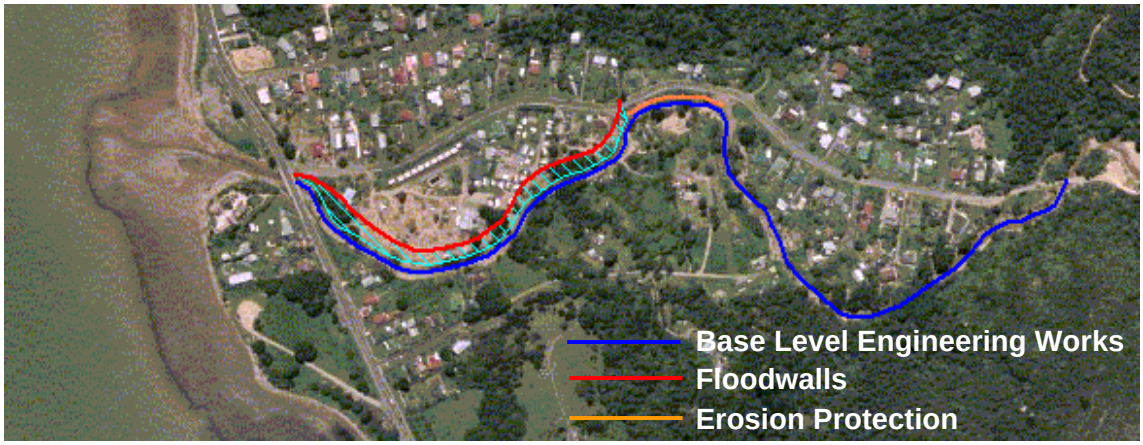

Figure 1 Original design

However, since the proposal was initially developed, and during the detailed design phase of the project, review of the design was undertaken based on detailed surveys of the Waiomu catchment and stream. The review included two-dimensional hydraulic modelling of the current and future 100-year design event based on the (LiDAR) survey. The results of the review are given below.

- The original proposed works at Dehar's bend and upstream remain appropriate in terms of channel improvements and road raising, as these are adequate to retain current flood flows within the channel and adjacent floodplains. However, the proposed works won't adequately address future floods.

- The proposed right bank stopbank was significantly restricting the floodway and diverting the flood flows on the opposite left bank properties. The impacts of restricting the floodway would be exacerbated further by future climate change effects and other channel and flood characteristics such debris and gravel deposition. Hence, the need for an adequate floodway to accommodate design flows without impacting on other properties. Detailed investigation into the topography of the floodway, flood depth and velocity was undertaken for different current and future events. The findings suggested that a substantial part of the campground and the property at 2 Waiomu Valley Road were required to be retained as a floodway and some re-contouring of the site was necessary to provide protection for the community.

- This led to recommendations to acquire and retire the campground and adjacent property at 2 Waiomu Valley Road. The technical analysis of the risks and the need for the acquisition of the properties is included in a report (Docs # 997200).

- The Waiomu bridge upgrade could not be included within Transit NZ 10-year plan, which meant that the design flows couldn't be passed safely through the bridge until the bridge is replaced/upgraded at least within the short term. Because of this, a staged approach needs to be taken in providing flood protection for the area north of Waiomu Valley Road.

These findings have lead to the development of a new concept that addresses the risks in the long term.

2.4 New design concept

The main principles of risk management include avoidance, reduction and mitigation of risks. The new concept in addressing the flood and erosion risks sustainably in the long term is based on these principles and is approached in the following manner.

a) Define the natural current and future floodway, necessary to accommodate the flows for the full continuum of flood events.

b) Provide a stable channel, floodway and adequate flood storage capacity, taking into account the damming effect of the current State Highway 25 embankment and bridge and other infrastructure limitations.

c) Retain flood flows within the confines of the channel and adjacent floodplains between the ford culvert on Waiomu Valley Road upstream of the Waiomu settlement and the State Highway 25 bridge.

d) Protect the existing development by way of a combination of measures including, road raising, upgrade of the State Highway 25 bridge and construction of stopbanks.

e) Protection of existing and future development against the residual risks by way of appropriate landuse planning controls.

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. Hence, 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 is proposed. Therefore the new concept incorporates the following elements:

- adequate floodway
- stable channel
- protection along the right bank byway of stopbanks/floodwalls/road raising
- appropriate planning controls to address the residual risks.

2.4.1 Design approach

The approach and methodology taken for designing the flood risk mitigation work include the following.

2.4.1.1 Design standards

In defining the flood protection design standard, 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 100-year flood event is an acceptable standard within urban areas.

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. These were described in section 2.1 above.

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

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

b) A stable floodway to accommodate the current and future 100-year flood flows.

c) Protection of the residential area along the right bank (north) of the stream against floods up to the current 100-year (return period) with adequate freeboard to accommodate uncertainties.

d) Appropriate planning and landuse controls to ensure that over design events would pass safely through the settlement with minimal or no damage.

2.4.1.2 Design flows

The following chart shows the Waiomu Stream current flows for different events and the predicted future flows in 2030 and 2080 based on the MfE guidelines.

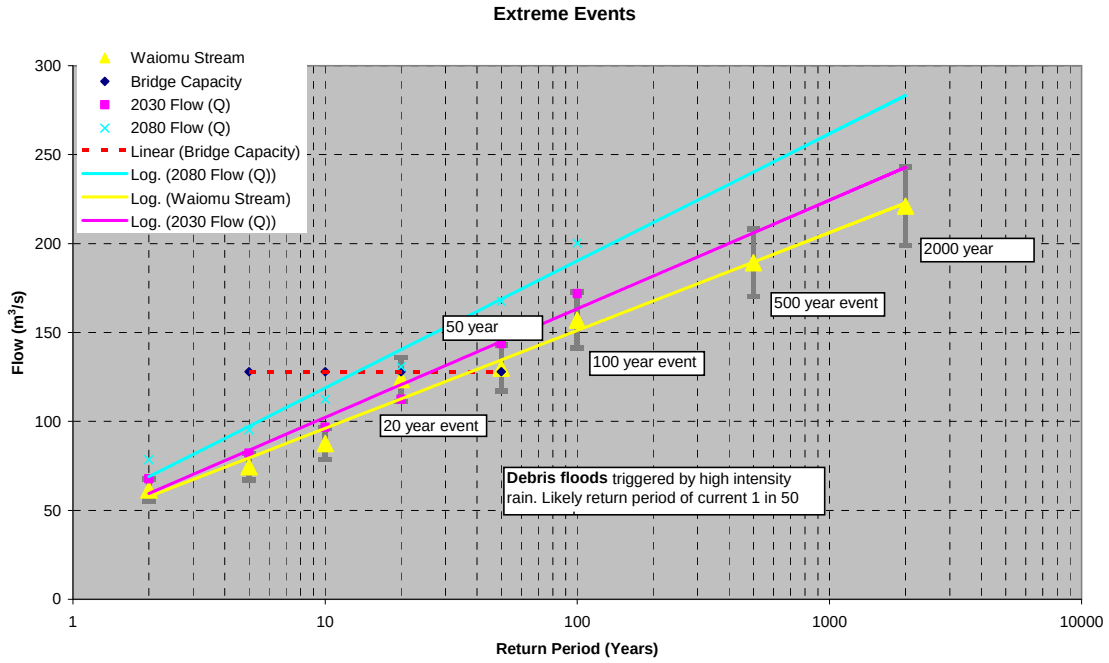

Figure 2 Existing and future flood flows

The current 100-year flood flow is assessed as 160 m^3/s, which is predicted to increase to 190 m^3/s in 2080. As indicated earlier in this report, these are exacerbated by the likely channel infilling, floating debris and site limitations such as ground levels, existing development and infrastructure. It is obvious that flood mitigation can't be feasibly

achieved against the full continuum of events through engineering works alone. Accordingly, the proposed design standards were tested through computer modelling of different scenarios including current design flows and sea levels, future design flows and sea levels, proposed works in place and debris and channel infilling effects.

2.4.1.3 Floodway design

The Waiomu Stream bank full capacity is assessed as 60 to 80m^3/s (less than the 10-year flood flow) at the campground, above which the campground starts to be inundated. The current floodplain is restricted by the campground buildings (bachs, caravans, and other restrictions) and flood levels are affected by these as well as the bridge restriction. Velocities within the stream channel are typically above 2.5 m/s while on the campground these vary and drop down to less than 0.5 m/s in some parts of the area. Similarly the floodwater depth above the campground varies between (0.0 and 2 m) depending on the natural ground levels.

The criteria for designing the floodway and defining its boundaries include 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 is achieved by raising the land along the floodway boundaries. For the Waiomu floodway it is proposed to use the material won from the floodway re-contouring to raise the remainder of the campground property. This will achieve two goals, the first of which is improving the performance of the floodway and the second preventing overland flows across the campground into the Waiomu settlement north of the Waiomu Valley Road.

An initial general concept was plotted and tested through modelling and further refined to ensure that the reformation of the floodway and associated raising of the remainder of the campground property will not adversely impact on other properties.

Figure 3 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 100-year flows within the proposed floodway will not cause an increase in flood levels above these currently experienced, and that the property could be developed for residential or commercial use.

2.4.1.4 Channel and bank stability

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 bridge. Over the last year, the channel has been cleared twice and such 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.

Bank erosion is being experienced especially in the lower channel at bends. Erosion of the left bank has been experienced in the past and is likely to continue unless adequate bank protection and/or stabilisation works are undertaken. Such works are proposed as channel improvement works which should be undertaken over time in consultation with the landowners, to ensure future channel stability.

Figure 4 Proposed erosion protection

Other reaches of the channel also require attention especially the bends upstream of the campground (Dehar's bend). This work is necessary to protect the road and a proposed banking and road raising upstream of the campground.

2.4.1.5 Right bank flood protection

Overland flows on the right bank between the ford culvert and Dehar's bend currently occur. It is proposed to retain these flows within the floodway by way of raising the Waiomu Valley Road at two locations and infilling low spots along the bank.

- Between the bend and the upstream end of the camp, a short stopbank is proposed to retain the flows within the floodway. The northern part of the campground property along the Waiomu Valley Road is relatively high and prevents current flood flows from overtopping the road.

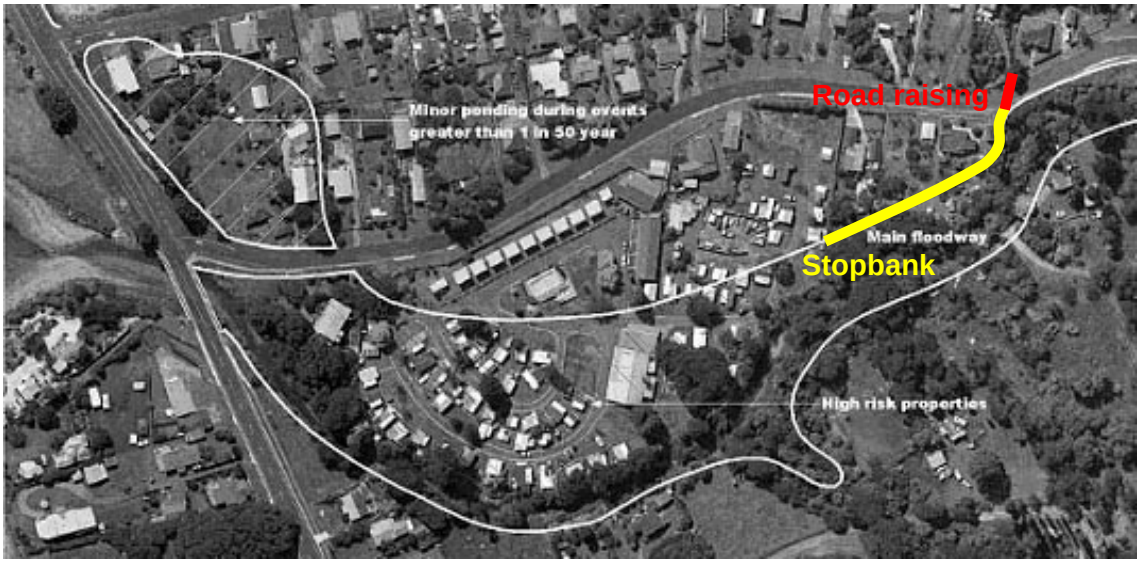

Figure 5 Proposed upstream stopbank and raised road

- Between the downstream end of the campground and the bridge, overland flow occurs in (10-20 year) events, causing flooding and ponding within the settlement north of the Waiomu Valley Road. A stopbank is proposed in this reach to protect this area up to the 100-year flow standard. However, due to the restricted bridge capacity this standard couldn't be achieved with confidence at this stage. It is therefore proposed to build the stopbank up to a 50-year design standard and raise the stopbank to the full protection following replacement or upgrade of the bridge.

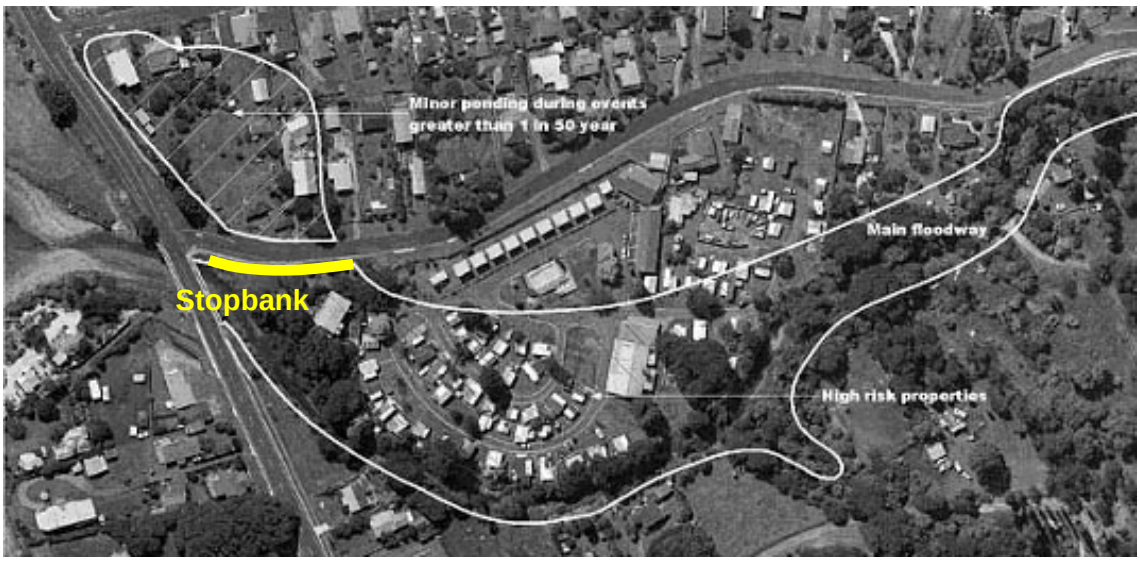

Figure 6 Proposed downstream stopbank

It should be noted that the current bridge capacity was assessed by Environment Waikato and further peer reviewed by Auckland University and Opus Consultants. 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 100-year flood. This will reduce the bridge capacity to approximately 128 m^3/s. This is equivalent to the 50-year flow (assessed at 130 m^3/s) of the Waiomu stream.

2.4.1.6 Ponding

The residential area north of Waiomu Valley Road is low lying and is bound by the State Highway 25. While the proposed embankment (between the bridge and lower end of the camp) will protect this area up to a 50-year 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 the 100-year event. The State Highway embankment acts as a dam behind

which flood waters pond, as the existing small culvert under the highway is designed for local stormwater drainage only. To reduce the ponding duration and levels another culvert is proposed under State Highway 25. A 1.5 m diameter culvert is estimated to reduce the ponding period to approximately four hours and flood levels by approximately 250 mm on average.

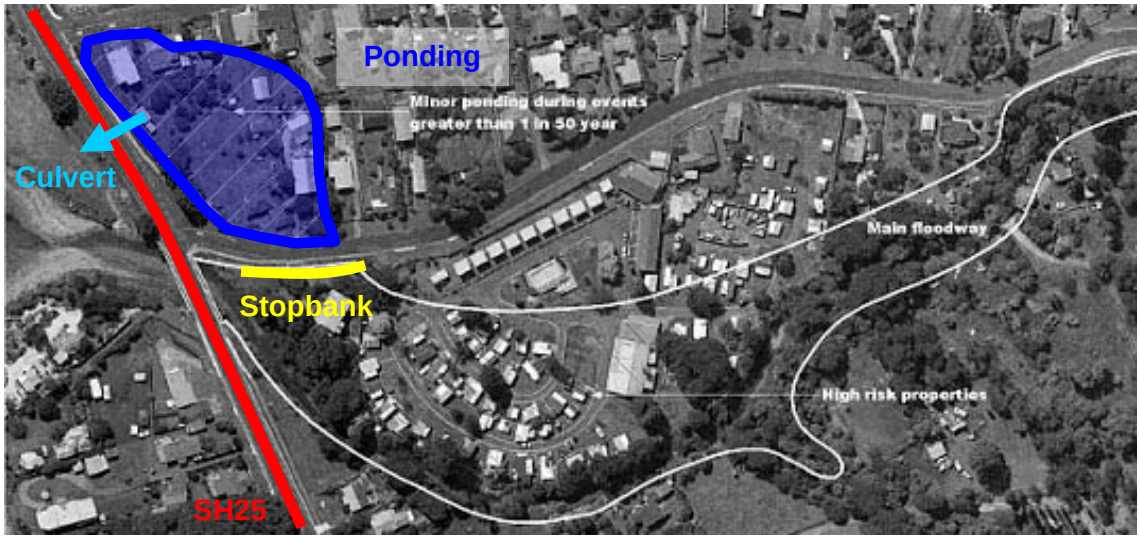

Figure 7 Proposed culvert

2.4.1.7 Future protection

Following replacement or upgrade of the bridge, it is proposed that the spillway embankment would be raised to provide full protection up to a 100-year standard for the properties north of Waiomu Valley Road. Similar works would be needed upstream of Dehar's bend.

2.4.1.8 Future planning requirements

A computer hydraulic model including an assumed future bridge that would pass the future flows, the raised stopbank and full protection was established and run for the future climate change scenario and for the channel infilling scenario. The scenarios assume flood flows of 190 m^3/s and a sea level rise of 0.5 m for the first, and a similar assumption with the channel in-filled with gravel up to the stream bank level for the second.

Based on the results of these models, the residual flood risks were identified and some planning requirements are proposed for the whole area such as building floor levels and set back distances to ensure these risks are appropriately managed into the future.

3 Design parameters

The design parameters of the different elements of the proposed works are derived from the computer hydraulic models for different scenarios of floods under a range of boundary conditions. The main assumptions for the models are given 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 State Highway 25 bridge.
- The flows are assumed to be steady and have the following discharges.

Parameter	Current (2004)	Future (2080)
50 year flood flow	130 m^3/s	
100 year flood flow	157 m^3/s	188 m^3/s
Mean high water springs*	RL 2.00 m	RL 2.50 m

*In terms of local 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.

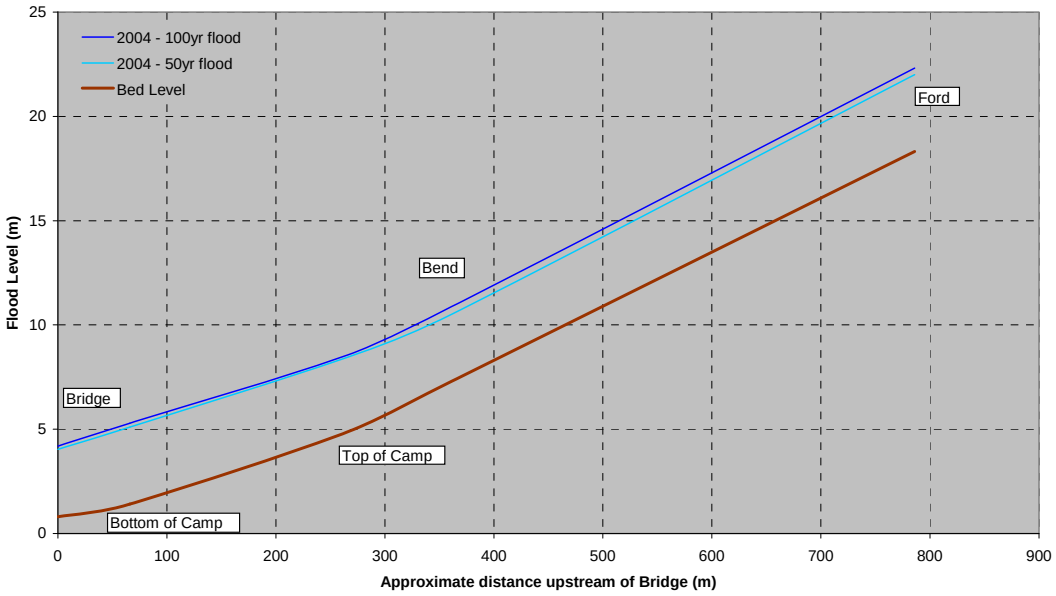

Figure 8 Existing flood levels

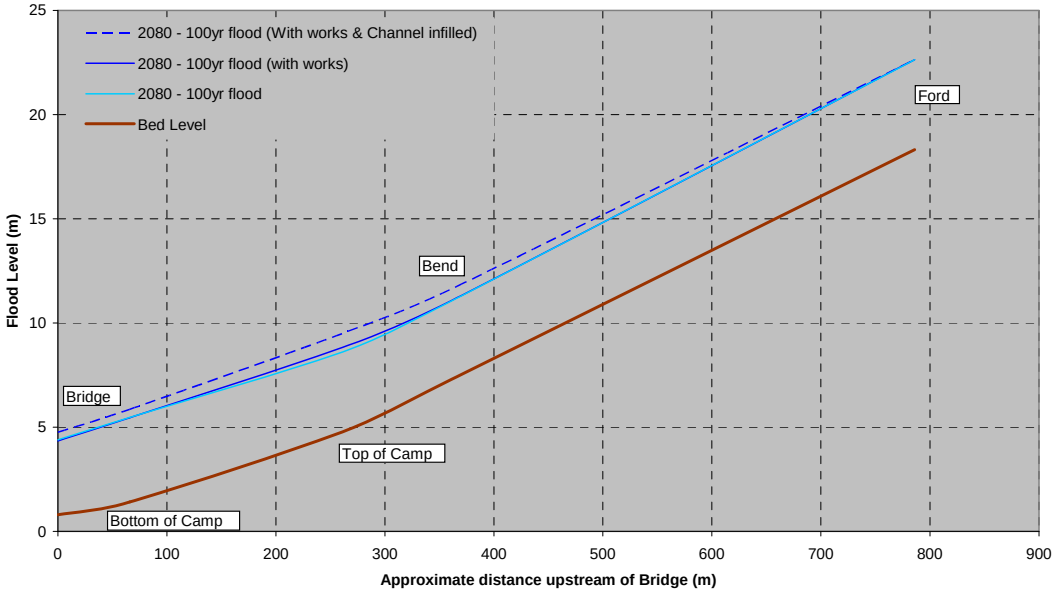

Figure 9 Future flood levels

3.1 Floodway parameters

The proposed floodway along the campground property is approximately 380 m long with varying widths (35 m to 80 m) across the site. The flood levels for the climate change scenario gradually fall from approximately 9.0 m at the upstream end of the campground to 5.3 m at the downstream end.

The current ground levels of the floodway vary between 7.5 m at the upstream end of the campground and 3.5 m at 2 Waiomu Valley Road property. It is proposed that a 10 to 20 m wide strip along the stream bank within the floodway be re-contoured and ground levels graded in both east to west (flow) direction along the stream channel and north to south (perpendicular to flow) direction sloping down towards the channel, to levels ranging from 7.5 m to 3.0 m. This includes an average cut of 0.40 m across the site, most of which will be closer to the channel.

It is also proposed to confine the floodway within the design parameters to ensure its efficiency in transporting the sediment and bed load material. This is normally achieved through stopbanking along the floodway, however within the campground it is proposed to raise the ground levels of the remainder (northern side of the designated floodway) of the property.

Figure 10 Proposed floodway works

The volume of stripped material is estimated to be approximately 2500 m^3. It is proposed to utilise this material for building the 50 year stopbank within 2 Waiomu Valley Road and raising the levels of the remainder of the property above the expected flood levels of the future 100-year flow.

3.2 Remainder of campground

It is proposed to dispose the surplus part of the campground property and subdivide it to recover part of the costs of the property purchase. However, to ensure the safety and protection of any future development of this part, further modelling and analysis has been undertaken to establish appropriate planning controls and conditions which should be tagged to the disposed property. Modelling of different current and future scenarios was undertaken. The resulting flood profiles were plotted against the natural ground levels. The results are shown in the following figures.

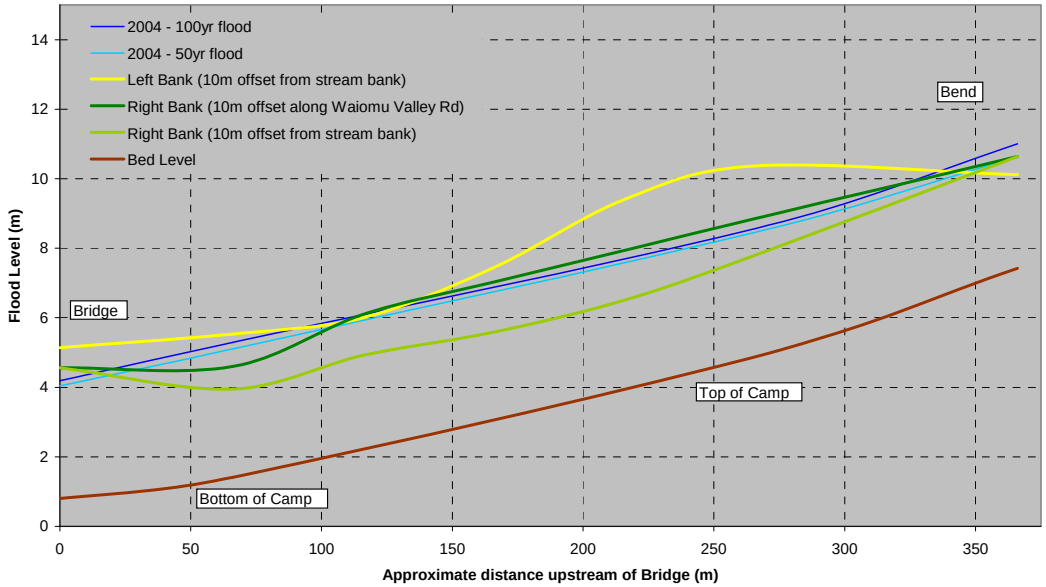

Figure 11 Ground levels and existing flood levels adjacent to campground

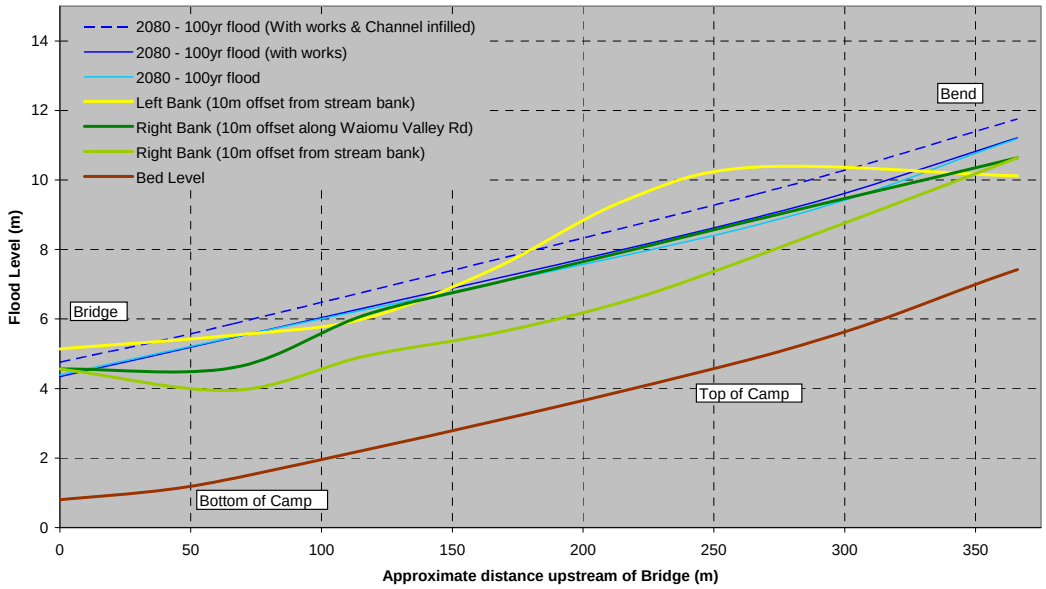

Figure 12 Ground levels and future flood levels adjacent to campground

The following is obvious from these graphs.

a) Other than two short sections upstream of the campground and the lower part closer to the bridge, the strip of the campground property along Waiomu Valley Road is higher than current and 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 low terrace where the swimming pool is located.

b) The left bank of the stream is high for most of its length opposite the campground down to the bridge.

c) Raising the remainder of the property to establish building platforms will have less than a minor effect on the floodway capacity, especially with the proposed re-contouring of the floodway.

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

To ensure the safety of the property against flooding in the long term it is proposed to apply the following landuse controls on any future development.

- The building platform levels should be set above the assessed future 100-year flood levels (considering climate change and sea level rise effects). On average the proposed platform levels will vary from 9.5 m at the upstream end to 6 m at the spillway.

- A minimum of 6 m set back along the floodway boundary should be left unfilled. This will provide a buffer zone between the floodway and any building platforms.

- The buildings floor levels should be set at a minimum height of 0.5 m above the platform levels platform.

Under the above conditions, this area will be the safest against floods within the whole Waiomu settlement. The only other residual risk that couldn't be assessed is the debris flow events. However modelling shows the area that would be most affected is upstream of Dehar's bend and especially the properties along the left bank of the stream.

3.3 Right bank stopbank

As indicated earlier short stopbanks are proposed along the right bank to prevent overflows into the main settlement across Waiomu Valley Road.

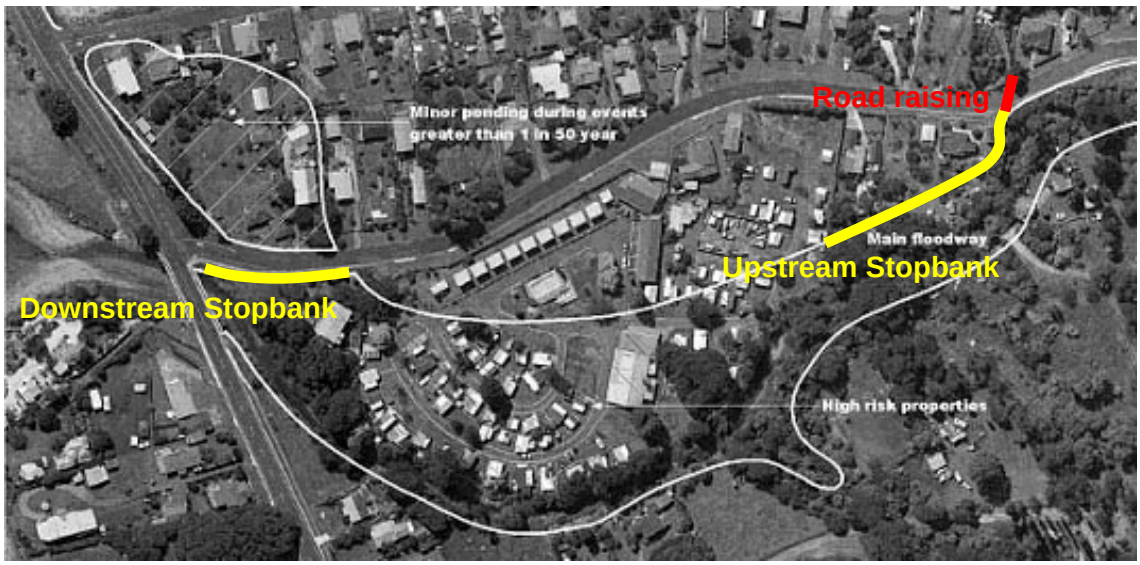

Figure 13 Location of proposed stopbanks

The upstream stopbank is approximately 70 m long extending from the upper end of the campground to the bend. This stopbank would have an average height of one m including the freeboard. The crest level of this stopbank would vary between RL 10.00 m and RL 11.20 m.

The downstream right stopbank will be approximately 60 m long, which would be built up to the 50-year event level as a first stage. The crest level of this bank would be set at approximately RL 4.5 m. Once the bridge is upgraded to carry the full design flows, this bank would be raised to full design height. The remainder of the campground property immediately upstream of this bank will be raised to full design height of RL 6.00 m.

In the interim, the lower stopbank would be overtopped in events exceeding the 50-year event which would cause some flooding and ponding within the residential area north of the Waiomu Valley Road. To reduce the effects of ponding a culvert under the

State Highway is proposed to discharge ponding water back into the stream, thereby reducing the ponding level and duration significantly.

3.4 Stream bank stabilisation

The left bank of the stream opposite the campground and downstream to the bridge is experiencing severe erosion. Re-contouring of the floodway will reduce the pressure on the left bank, however the toe of the bank is likely to be eroded, eventually undermining the bank. Following the recent erosion of left bank, Environment Waikato employed Tonkin and 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 m linking with rock protection works undertaken by Transit NZ upstream of the bridge. The works aim at stabilising the toe of the bank with the rest of the bank protected by vegetation and plant. The design drawings and specifications are available from Environment Waikato's River and Catchment Services Group.

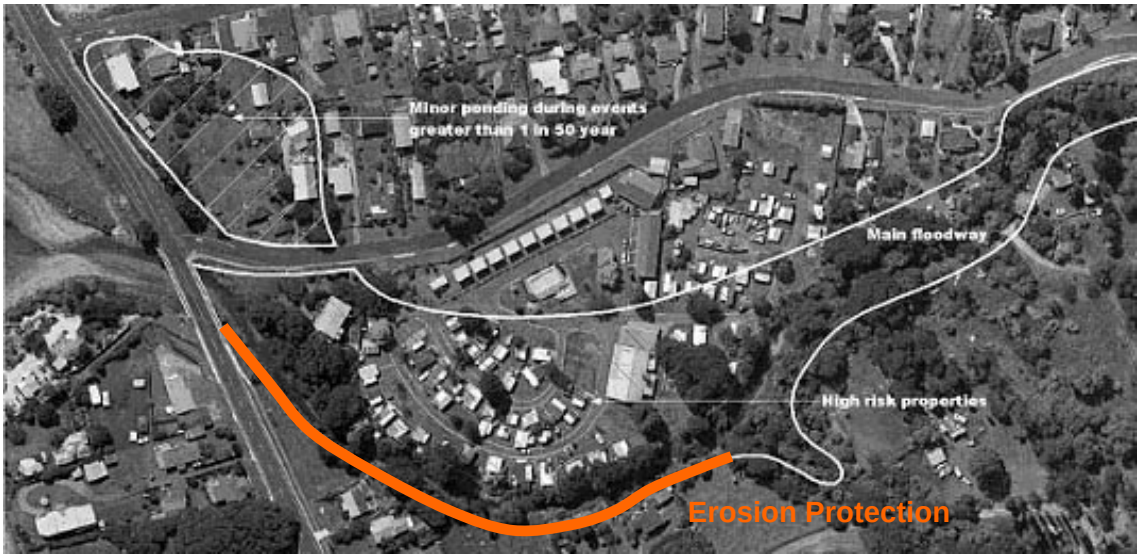

Figure 14 Proposed erosion protection

4 Implementation

The joint councils have approved the purchase of the campground and 2 Waiomu Valley Road properties. Staff have successfully negotiated the purchase with the owners and both properties will be evacuated completely by November 2006.

Implementation of the project includes three parts, the first of which is the property development part; the second is the engineering construction part; and the third is the implementation of planning controls. The construction part includes works within the two properties and the remainder of the protection works. These two parts need to be coordinated and undertaken simultaneously.

The proposed project implementation plan includes the following stages.

4.1 Stage I

4.1.1 Part A: Floodway development

a) Acquisition of the properties 2 & 6 Waiomu Valley Road.

b) Taking ownership and securing the properties.

c) Removal, disposal and/or sale of buildings (including request for proposal and contract letting).

d) Subdivision and disposal of the remainder of the campground property.

e) Reserving the floodway part of the properties.

4.1.2 Part B: Engineering works

a) Works within the purchased properties

- Re-contouring of the floodway.
- Backfilling part of the remaining property in the vicinity of the spillway.
- Construction of the spillway.

b) Remainder of works

- Construction of the rock protection works at Dehar's bend and left bank, subject to landowners and district council agreement.
- Construction of the floodwall and/or stopbank upstream of the campground, subject to landowners agreement.
- Road raising at the ford culvert, subject to district council approval.
- Construction of the culvert under State Highway 25, subject to Transit NZ approval.

4.1.3 Part C: Planning controls

Implementation of appropriate planning controls to ensure that existing and future development would be protected.

4.1.4 Timing

Part A (floodway development and associated engineering works) needs to be completed by April 2007 at the most. The remainder of the works (Parts B and C) are the subject of further consultation with the community and Transit NZ and it is proposed that these would be completed by April 2008.

4.2 Stage II

In the medium to long term, it is proposed that the following works should be undertaken:

4.2.1 Part A: Bridge upgrade

In order to pass the required design flow (i.e. the 100-year flood event), the existing State Highway bridge requires an upgrade.

4.2.2 Part B: Improvement to existing works

Following the replacement of the State Highway bridge, it is necessary to raise the spillway proposed under Stage I (part B) to provide protection up to the 100-year flood event.

5 Planning controls

Following the completion of the proposed development and protection works, there remains some residual flood risks, which would be exacerbated by the predicted climate change effects. These risks would arise from the following.

5.1 Greater than design flood events

Consideration was given for greater than design events including the likely extent of flooding and associated risks. In this regard, modelling for the 500-year event was considered. The results suggest that the proposed freeboard of 500 mm is adequate to ensure the banks and building platforms will remain above flood height. However, for greater events especially those which could block the bridge, overtopping would occur. Planning controls to ensure building floor levels are set above platform levels are proposed.

5.2 Debris flood events

Debris flood events are triggered by high rainfall intensities over saturated catchments, causing major land slips (avalanches) of silt, rock and trees. The heavy mass mixed with flood waters moves at an exponentially increased speed within steep channels. The likelihood of debris flows occurring in the Waiomu Stream is very low however possibly similar to other streams along the Thames coast.

No specific investigation into debris flow events within the Waiomu has been undertaken. However, the investigation undertaken for the Karaka Stream in Thames suggests that short steep streams with unstable catchments are more vulnerable and the impact of debris flow is greater due to the limited capacity of the stream and floodplain system to accommodate the material carried. It should be noted that the Waiomu Stream and its catchment is somewhat different to that of the Karaka Stream. The lower reach of stream channel and associated floodplains has a capacity of approximately 150,000 m^3, which can absorb the impact of such events and reduce its effects within the Waiomu settlement.

5.3 Climate change

The expected climate change effects include a 20% increase in flood flows and a 500 mm rise in sea level over the next 80 to 100 years. A computer hydraulic model simulation was undertaken for this scenario with the proposed protection works completed and bridge replaced. The results included the following:

a) Overland flows would occur at Dehar's bend.

b) The area immediately north of Waiomu Valley Road would pond due to back water through the culvert.

c) The area on the left bank upstream and downstream of State Highway 25 would experience flooding.

d) The freeboard for the building platforms and stopbank along the right bank of the stream between Dehar's bend and the bridge, which will be reduced to 200 mm to 50 mm. Accordingly, the building platforms within this reach have been raised in the final design to achieve a minimum freeboard of 300 mm above the future 100-year flood level.

   The following map shows the extent of flooding under this scenario.

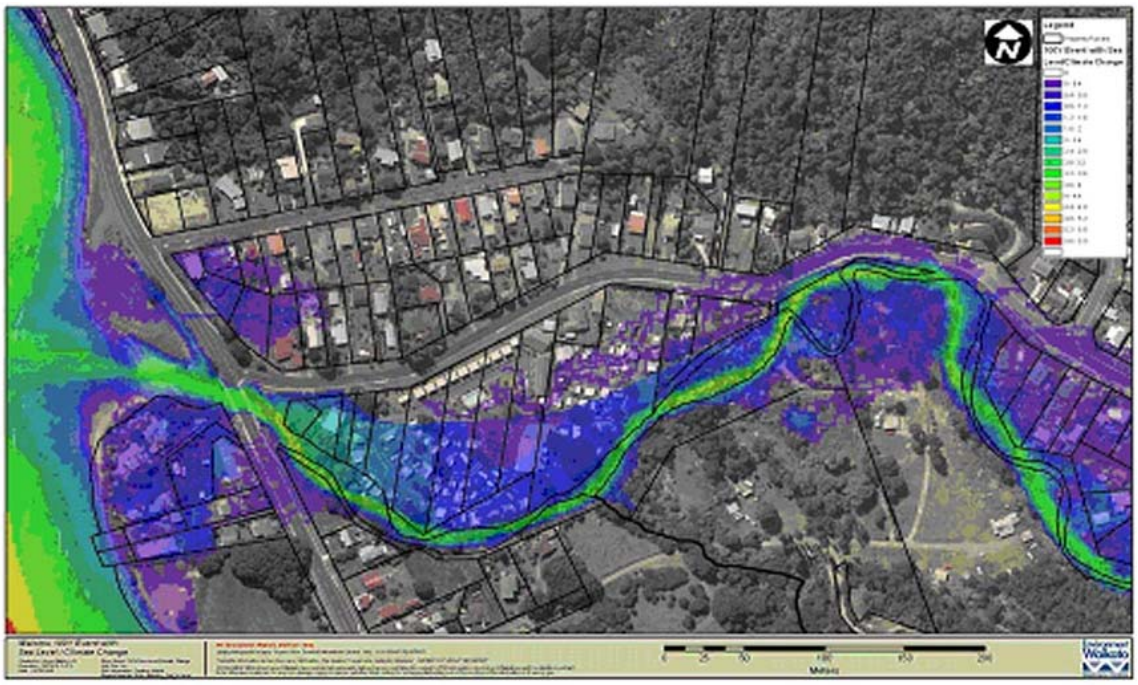

Figure 15 Future 100 year flood extent with proposed works

To ensure that such hazards are appropriately managed in the future, certain planning controls and future works are necessary. The following principles are proposed as basis for future works and planning controls.

a) The Waiomu Valley Road levels should be raised in the medium term to ensure future floods would not overtop the road and cause flooding of the settlement on the northern side of the road.

b) The design of the future bridge upgrade should be based on the future design flows and the effects of climate change. Consideration should be given to extend the bridge to the south of the current bridge. This will ensure alignment of the bridge with the natural floodway.

c) Building platform levels for all residential sections on both sides of State Highway 25 should be raised 500 mm above the predicted future 100-year flood levels.

d) All buildings should have the inhabitable floor levels built 500 mm above platform levels.

e) All new buildings shall be set back by at least 10 m from the edge of the Waiomu Stream floodway.

f) All existing buildings within the floodplains shall not be redeveloped or refurbished unless they meet the criteria in above.

g) No further development should occur within the floodplains of the Waiomu Stream and along the sea foreshores unless adequate protection measures are undertaken. Such protection measures should be consistent with, and should not compromise the integrity of, the proposed protection works above and their design standards.

The planning controls should be developed by the Thames Coromandel District Council, along with their flood hazard variation of the Thames Coromandel District Plan.