Environment Waikato Technical Report 2004/13

Thames Coast Project

Summary of Technical Investigation

Revision 1

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1 Introduction

This report is a summary of the technical information that has been compiled as part of the first stage of the Thames Coast Project. It covers the catchment hydrology, river hydraulics and proposed works programmes for the following five communities:

- Tararu
- Te Puru
- Waiomu (including Pohue)
- Tapu
- Coromandel Town

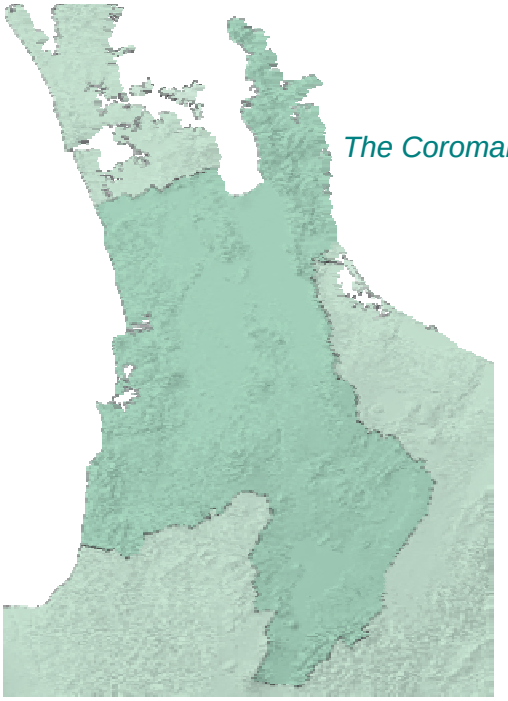
This report is a revision of Environment Waikato Technical Report 2003/10, which was published in August 2003. This revision has been prepared to assist with the procurement of Resource Consents to authorise the works proposed under the Thames Coast Project. It also reflects the feedback that Environment Waikato has received from the local community regarding the practical and economic feasibility of the proposed works.

Figure 1.1: Streambank erosion on Te Puru Creek Road following the 'weather bomb'

2 Background

The Thames Coast is the name given to the west coast of the Coromandel Peninsula. It extends from Thames in the south to Coromandel Town in the north. It is typified by relatively small, steep and well forested catchments that drain to the Firth of Thames, forming coastal alluvial fans.

Figure 2.1: The Waikato Region and the Coromandel Peninsula



During the past century, a number of coastal communities have been established on the flat land that is typical of these coastal alluvial fans. These communities, which consist of permanent homes, holiday homes, camping grounds and businesses, have progressively encroached onto the floodplains of a number of waterways. As a result, flood events on the Thames Coast seldom occur without some damage to people and property.

Figure 2.2: A typical example of urban development on a coastal alluvial fan (Te Puru)

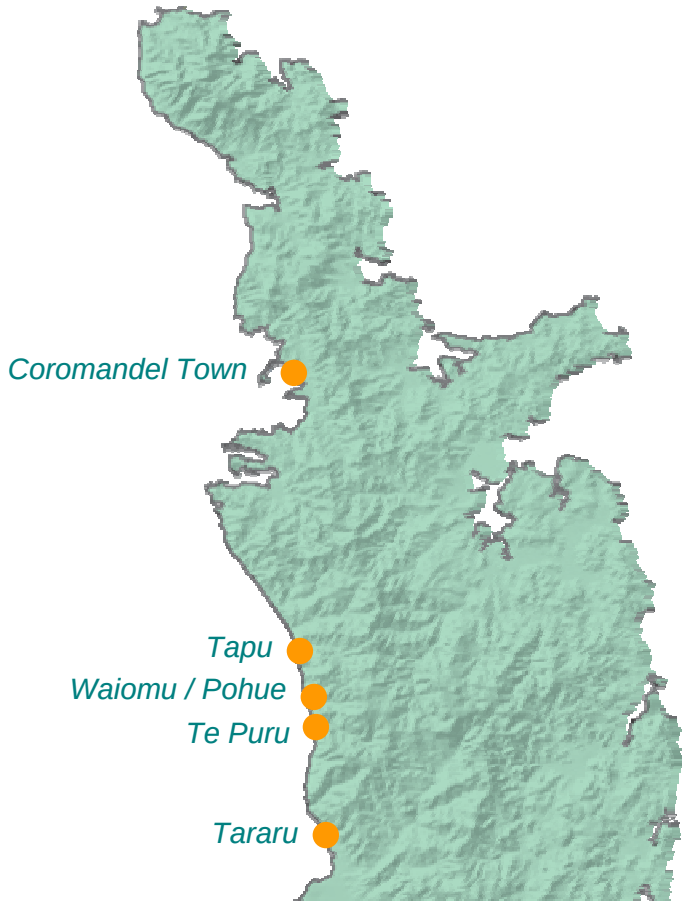
The significance of the Thames Coast flood hazard was demonstrated during the storm event that occurred on June 21, 2002 (generally referred to as the 'weather bomb'). This event brought torrential rainfall to the Coromandel Peninsula (with intensities of up to 125 mm in 25 minutes) and caused widespread damage across the Thames-Coromandel and South Waikato Districts (refer to Environment Waikato Technical Report 2002/10 (Munro, 2002)).

Following the 'weather bomb', Environment Waikato and the Thames Coromandel District Council initiated a project to quantify the Thames Coast river flood hazard and identify works to mitigate it's impact on people and property. This project is called the Thames Coast Project.

The first stage of the Thames Coast Project covered the following five communities that were identified as being worst effected by both the weather bomb and historical flood events:

- Tararu (affected by the Tararu Stream)
- Te Puru (affected by the Te Puru Stream)
- Waiomu/Pohue (affected by the Waiomu and Pohue Streams)
- Tapu (affected by the Tapu River)
- Coromandel Town (affected by the Whangarahi and Karaka Streams)

Figure 2.3: The five communities included in the initial stage of the Thames Coast Project



An initial report was prepared covering the river flooding issues that impact each of these communities and the options that were available to mitigate the impact of river flooding on people and property (refer to Environment Waikato Technical Report 2003/10). The findings of this report were presented to community meetings during

August 2003. The feedback received from these meetings indicated that additional work was required to refine the proposed mitigation options, particularly with respect to their affordability. As a result working parties were established in each community.

The objective of each working party was to recommend a proposal to address catchment and flooding issues in their respective community by meeting regularly with Environment Waikato to discuss the various community issues and disseminating meeting outcomes back into the community for feedback.

This community consultation process has resulted in a number of works being confirmed as being affordable by these communities. Environment Waikato is therefore now in the position to begin progressing these works through the design, construction and commissioning phases. This report has been prepared to assist with the procurement of Resource Consents to authorise the range of works proposed under the Thames Coast Project.

Figure 2.4: The Tararu Stream in flood during 2002.

3 Historical Research

River flooding has been a feature of the Thames Coast environment for a number of decades. This is demonstrated by the many active alluvial fans that are emerging from the valleys and extending out into the Firth of Thames.

The nature of urban development along the Thames Coast has meant that there is a long history of people and property being effected by river flooding, along with an equally long history of attempts to mitigate this impact.

3.1 Method

Before commencing the Thames Coast Project, the many reports that have been produced covering river flooding on the Thames Coast were reviewed with respect to:

1. Any historical flood flow and rainfall records.

2. The nature of technical investigations that been previously undertaken to understand river flooding on the Thames Coast.

3. Mitigation options that have been previously considered and/or implemented and/or abandoned.

3.2 Results

1. Historical flood flow and rainfall records

Table 3.2.1: 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)

2. Previously completed technical investigations

Table 3.2.2: Summary of Technical Reports covering Flood Mitigation and Management on the Thames Coast

Community	Previously Completed Technical Investigations
Tararu	Channel Improvements - HCB Report 130 (Nov 1982) Channel Improvements - HCB Report 179 (May 1985) Flood Hazard Mgmt - EW Report 1995/4 (Aug 1995)
Te Puru	Channel Improvements - HCB Report 117 (Jan 1982) Channel Improvements - HCB Report 194 (Nov 1985) Flood Hazard Mgmt - EW Report 1993/1 (Feb 1993)
Waiomu	No technical investigations previously completed
Tapu	No technical investigations previously completed
Coromandel Town	Flood Hazard Mgmt – Draft EW Report (Apr 2002)

3. Mitigation works previously completed

Table 3.2.3: Summary of Flood Mitigation and Management Works completed on the Thames Coast

Community	Previously Completed Works
Tararu	Channel improvement works were completed during the 1980's by the HCB as part of the Waihou Valley Scheme. These works included widening the channel and installing erosion protection works (concrete fabriform and rock rip rap). These works are currently maintained by EW as part of the Waihou Valley Scheme.
Te Puru	Channel improvement works were completed during the 1980's by the HCB (on behalf of the TCDC). These works included widening the channel and installing erosion protection works (rock rip rap). Since these works were completed there has been ongoing problems with the effectiveness of erosion control adjacent to Te Puru Creek Road. These works are currently maintained by TCDC, however EW will take over this responsibility from 1 July 2004.
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).
Tapu	No flood hazard mitigation works have been previously completed within the Tapu community other than periodic clearing of the channel. The high ground between the Tapu River and the Tapu-Coroglen Road is not a formal embankment, rather a consequence of the periodic clearing of the channel.
Coromandel Town	No significant flood hazard mitigation works have been previously completed within Coromandel Town other than periodic clearing of the channel.

4 Catchment Hydrology

An essential aspect of the Thames Coast Project was understanding how the various catchments responded to rainfall in terms of peak flood flows. Although a number of catchments have been previously assessed, these assessments were completed at least 20 years ago and it was therefore necessary to re-evaluate each catchment using the additional rainfall data that had been collected over the past 20 years as well as observations from the flood events that have collected.

4.1 Method

A hydrological analysis was completed for each catchment using the following steps:

1. Key hydrological parameters were derived for each catchment (i.e. area, slope and time of concentration) using 1:50,000 scale topographic maps and techniques prescribed by the MWD Culvert Manual.

2. Depth-duration rainfall data was produced for each catchment using the High Intensity Rainfall Design System (HIRDS) Version 2.0.

3. The runoff coefficient for each catchment was derived using the method prescribed by the Ministry of Works and Development Culvert Manual, which takes into account rainfall intensity, catchment relief, surface retention, infiltration and ground cover.

4. Rainfall depths were translated into peak stream flows at the bottom of each catchment using the Rational Method rainfall-runoff model.

   Note: This relatively simplistic model was used because the catchments of interest are small (i.e. less than 25 km^2) and have a relatively uniform ground cover (i.e. forest).

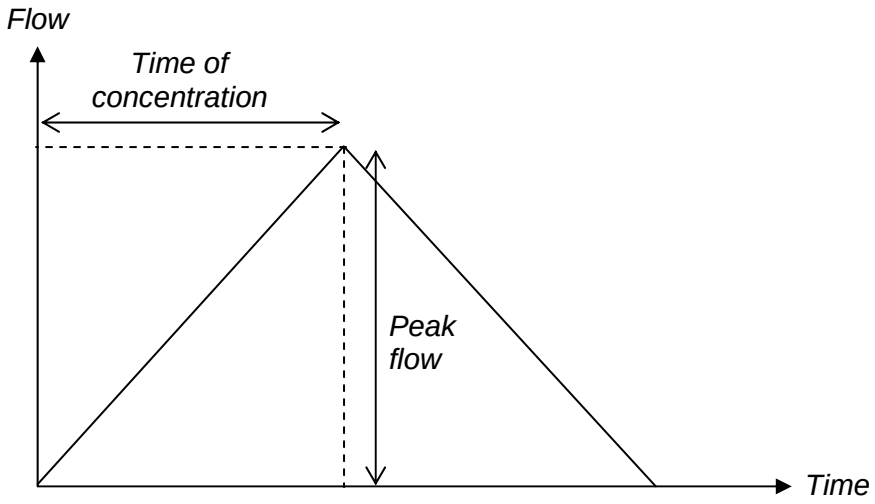
5. The results of the rainfall-runoff model were validated using the following observed data:

   a) Rainfall intensities and peak stream flows observed during the June 2002 Weather Bomb.

   b) A flood frequency analysis of the data collected by the Environment Waikato water level recorder on the lower Kauaeranga River (with a coefficient of 0.8 to allow for the translation of data to the smaller catchments that are included in this stage of the Thames Coast Project).

6. Peak stream flow estimates were translated into flood hydrographs based on the following generic diagram:

Figure 4.1.1: Generic flood hydrograph produced for each catchment



4.2 Results

1. Key hydrological parameters

Table 4.2.1: Summary of key hydrological parameters

Catchment	Area (km^2)	Slope (m/m)	ToC (hours)
Tararu Stream	15.6	0.06	1.00
Te Puru Stream	22.9	0.04	1.25
Waiomu Stream	10.4	0.06	0.75
Pohue Stream	3.4	0.09	0.50
Tapu River	26.7	0.03	1.50
Whangarahi Stream	17.5	0.04	0.75

Catchment maps are presented in Appendix 1 of this report.

2. Rainfall intensity data for critical duration event (mm/hour)

Table 4.2.2: Summary of rainfall intensities

Catchment	2Y	10Y	20Y	50Y	100Y
Tararu Stream	29	41	48	60	72
Te Puru Stream	26	37	43	54	66
Waiomu Stream	29	41	48	61	73
Pohue Stream	34	50	58	74	100
Tapu River	21	30	36	45	55
Whangarahi Stream	29	41	48	60	73

3. Derivation of runoff coefficient

Table 4.2.3: Summary of runoff coefficient sub-coefficients

Catchment Characteristic	Description	Coefficient
Rainfall Intensity	25 to 50 mm/hour	0.15
Relief	Hilly	0.05
Surface Retention	Negligible	0.25
Infiltration	Slow	0.20
Cover	Forest	0.05

The overall runoff coefficient for the catchments covered by the Thames Coast Project is therefore 0.7.

4. Peak stream flows (m^3/s)

Table 4.2.4: Summary of peak flood flows

Catchment	2Y	10Y	20Y	50Y	100Y
Tararu Stream	88	124	146	182	218
Te Puru Stream	121	168	197	245	300
Waiomu Stream	59	83	97	124	148
Pohue Stream	23	34	39	50	67
Tapu River	110	159	186	235	283
Whangarahi Stream	99	140	162	203	248

5. Validation of rainfall runoff model (weather bomb observations)

a) Peak rainfall intensity and stream flow observations from the weather bomb

Table 4.2.5: Summary of peak rainfall intensities observed during the June 2002 weather bomb

Area	Peak Rainfall Intensity (mm/hour)
Te Aroha	97
Wharepoa	60
Tapu	83
Coromandel Town	100 +

Table 4.2.6: Summary of peak flood flows observed during the June 2002 weather bomb

Catchment	Peak Stream Flow (m^3/s)
Tararu Stream	220
Te Puru Stream	345
Waiomu Stream	145
Tapu River	275

A comparison of the peak rainfall intensities and stream flows that were observed during the weather bomb show that the rainfall-runoff methodology used for the Thames Coast Project is producing reasonable but also conservative design peak flood flow estimations.

b) Flood frequency analysis of data from the EW Kauaeranga River recorder

Table 4.2.7: Summary of design flood flows and flood flows derived from the Kauaeranga River level recorder

Catchment	100Y Design	100Y Translated	% Difference
Kauaeranga River	1189	N/A	N/A
Tararu Stream	218	234	7
Te Puru Stream	300	318	6
Waiomu Stream	148	169	14
Pohue Stream	67	69	3
Tapu River	283	359	27
Whangarahi Stream	248	256	3

A comparison of the design peak flood flows derived using the Rational Method against those derived by translating the results from the flood frequency analysis of the data from the EW Kauaeranga River recorder shows that the rainfall-runoff methodology used for the Thames Coast Project is producing reasonable design peak flood flow estimations.

5 River Channel Hydraulics (1D)

One-dimensional routing of the design flood hydrographs through the five communities was completed using MIKE 11 hydrodynamic models. These models extended from the upper extend of each community through to the Firth of Thames.

The one-dimensional hydraulic models allowed for the simulation of in-channel flood flows and also some out-of-channel flood flows. It should however be noted that in most cases significant out-of-channel flood flows proved difficult to simulate using the one-dimensional hydraulic models because of the complex and variable nature of the flow across each floodplain. A more robust assessment of out-of-channel flood flows was completed using MIKE 21, which is used to create two-dimensional hydraulic models (refer to the following section).

5.1 Method

A one-dimensional hydraulic model was constructed for each stream channel (excluding Pohue Stream) using the following steps:

1. Channel cross section data was obtained from either existing surveys or from surveys that were commissioned as part of the Thames Coast Project. Roughness values were also attached to each channel based on the bed/bank material and the channel geometry.

2. Upstream boundary conditions were based on the design flood hydrographs produced by the hydrological analysis of each catchment. In most cases the entire flood hydrograph was applied to the top of each hydraulic model because of the minimal catchment area within each community. However, the hydraulic model representing the Whangarahi Stream and Karaka Stream within Coromandel Town required the overall flood hydrograph to be divided amongst a number of significant sub-catchments with the Coromandel Town urban area. This division was based on the relative area of each sub-catchment.

3. Downstream boundary conditions were based on the high tide level in the Firth of Thames. Although MIKE 11 does allow for a fluctuating downstream boundary (i.e. the rise and fall of the tide), the short duration of the simulations meant that this complexity was not necessary.

4. A limited calibration of the one-dimensional hydraulic models was completed using available flood level observations. It should be noted however that due to the lack of observations from in-channel flood events, the extent of calibration that could be completed was relatively limited. However, as these hydraulic models cover short reaches of channel and have a simple hydrology, this limited level of calibration was considered satisfactory for the development of flood protection concepts subject to the inclusion of an appropriate freeboard.

5. The outputs from the one-dimension hydraulic models were used to construct long section plots of each stream channel to assist with estimating the existing channel performance and also the scale of works required for any proposed flood protection works.

6. The outputs from the one-dimensional model were used to assess the existing performance of each channel.

7. The outputs from the one-dimensional model were used to assessment the causes of flooding within each community.

5.2 Results

1. Cross Section Data

Table 5.2.1: Summary of cross section information used to construct one-dimensional hydraulic models

Catchment	Survey Date	Survey Purpose
Tararu Stream	Jan 2004	Channel maintenance (EW)[2]
Te Puru Stream	Sep 2003	Channel maintenance (TCDC)[3]
Waiomu Stream	Nov 2002	Thames Coast Project[1]
Tapu River	Jan 2003	Thames Coast Project[2]
Whangarahi Stream	Sep 2001	Coromandel Flood Hazard Plan[2]

[1] Environment Waikato (Russell Lamb)

[2] Civil Engineering Services (Murray Preston)

[3] Frank Millington Surveyors (Mike Millington)

2. Upstream Boundary Conditions

Design flood hydrographs are presented in the following Microsoft Excel Spreadsheets:

Table 5.2.2: Summary of spreadsheets containing design flood hydrograph information

Catchment	Spreadsheet Document Number
Tararu Stream	909543
Te Puru Stream	910171
Waiomu Stream	910539
Tapu River	912252
Whangarahi Stream	

3. Downstream Boundary Conditions

The downstream boundary condition for each hydraulic model was assumed equal to a high spring tide in the Firth of Thames.

4. Calibration

Table 5.2.3: Summary of one-dimensional hydraulic model calibration

Catchment	Calibration Comments
Tararu Stream	In-channel flow calibrated using hydraulic design calculations contained in HCB Report 130. Out-of-channel flow uncalibrated. Will require two-dimensional hydraulic model to represent out-of-channel flow.
Te Puru Stream	In-channel flow calibrated using hydraulic design calculations contained in HCB Report 117/194. Out-of-channel flow uncalibrated. Will require two-dimensional hydraulic model to represent out-of-channel flow.
Waiomu Stream	In-channel flow uncalibrated (no data available). Out-of-channel flow uncalibrated. Will require two-dimensional hydraulic model to represent out-of-channel flow.
Tapu River	In-channel flow uncalibrated (no data available). Out-of-channel flow uncalibrated. Will require two-dimensional hydraulic model to represent out-of-channel flow.
Whangarahi Stream	In-channel flow uncalibrated (no data available). Out-of-channel flow uncalibrated. Will require two-dimensional hydraulic model to represent out-of-channel flow.

5. Channel Long-sections

Long-sections for each channel are presented in the following documents.

Table 5.2.4: Summary of spreadsheets containing long section information

Catchment	Spreadsheet Document Number
Tararu Stream	912061
Te Puru Stream	910292
Waiomu Stream	912047
Tapu River	910515
Whangarahi Stream	

These long-sections include 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)

6. Existing channel performance

Table 5.2.5: Comments on the existing performance of each channel

Waterway	Existing Performance	
Tararu Stream	Upstream of SH25 Bridge:	5 year event
	Downstream of SH25 Bridge:	2 year event
Te Puru Stream	Upstream of SH25 Bridge:	10 year event
	Downstream of SH25 Bridge:	5 year event
Waiomu Stream	Upstream of Dehar's Bend:	100 year event
	Dehar's Bend:	< 2 year event
	Downstream of Dehar's Bend:	< 2 year event
Pohue Stream	Upstream of culvert:	20 year event
	Downstream of culvert:	Not assessed
Tapu River	Upstream of Russek's Ford:	2 year event
	Downstream of Russek's Ford:	5 year event
	Downstream of SH25 Bridge:	< 2 year event
Whangarahi Stream		
Karaka Stream		

7. The nature and cause of flooding in each community

A map of each community outlining the nature and cause of flooding is presented in Appendix 3 of this report.

6 Floodplain Hydraulics (2D)

Two-dimensional routing of the design flood hydrographs through the five communities was completed using MIKE 21 hydrodynamic models. These models extended from the upper extend of each community through to the Firth of Thames and extend laterally to cover the extent of flooding observed during the June 2002 weather bomb.

The two-dimensional hydraulic models allowed for the simulation of out-of-channel flood flows because they allow for the complexity and variability of overland flow. It should however be noted that in most cases in-channel flood flows proved difficult to simulate using the two-dimensional hydraulic models because of the limitations of the digital terrain models that were created during the two-dimensional modelling process. A more robust assessment of in-channel flood flows was completed using MIKE 11, which is used to create one-dimensional hydraulic models (refer to the previous section).

6.1 Method

A two-dimensional hydraulic model was constructed for each community (excluding Pohue and Coromandel Town) using the following steps:

1. A digital elevation model (DEM) of each community was obtained from Terralink International. The origin of the data used for each DEM was the aerial photography taken as part of the Urban WRAPS project commissioned by the Thames Coromandel District Council. This data was enhanced by Terralink International to ensure that the key features of each floodplain were adequately defined (e.g. stream channels and bridge approaches). The accuracy of absolute accuracy of each DEM is around 0.3 m to 0.4 m, with a slightly better relative accuracy. This accuracy was considered acceptable for the simulation of two-dimensional floodplain hydraulics and flood hazard mapping.

2. Upstream boundary conditions were based on the design flood hydrographs produced by the hydrological analysis of each catchment. The entire flood hydrograph was applied to the top of each hydraulic model because of the minimal catchment area within each community.

3. Downstream boundary conditions were based on the high tide level in the Firth of Thames. Although MIKE 21 does allow for a fluctuating downstream boundary (i.e. the rise and fall of the tide), the short duration of the simulations meant that this complexity was not necessary.

4. A calibration of the two-dimensional hydraulic models was completed using available flood level observations and flood extent boundaries surveyed following the June 2002 weather bomb.

6.2 Results

Maps showing the two-dimensional depth and velocity distributions for each community are presented in Appendix 2 of this report.

7 Draft Flood Hazard Assessment

The Thames Coast Project required that the flood hazard that effects each community be mapped and used as a tool for the planning of future urban development. Flood hazard mapping allows for the identification of areas that should not be developed, areas that should be subject to other development restrictions (e.g. floor levels) and areas that should not be subject to any development restrictions.

This draft flood hazard mapping exercise is a revision of the exercise that was completed in conjunction with the initial presentation of the Thames Coast Project to the local communities in August 2003.

7.1 Method

Flood hazard maps for each community (excluding Coromandel Town) were produced using the following steps:

1. The flood event to be used in assessing the extent of the flood hazard that effects each community was selected as the 100 year (1% AEP) flood event.

2. The flood hazard classification was developed using the logic that an area subject to high flood hazard must be subject to both excessive flooding depths and excessive water velocity. The flood hazard classification would then progressively reduce from high hazard through to no hazard using the following criteria:

High flood hazard:	Areas likely to be subject to flooding depths greater than 1.0 m and water velocities greater than 1.0 m/s.
Medium flood hazard:	Areas likely to be subject to flooding depths greater than 0.5 m and water velocities less than 1.0 m/s.
Low flood hazard:	Areas likely to be subject to flooding depths less than 0.5 m and water velocities less than 1.0 m/s.
No flood hazard:	Areas likely to be subject to no flooding

3. The flood hazard classification was applied to each community using a combination of the following inputs:

   - Flood depth and velocity outputs from each MIKE 21 hydrodynamic model.

   - Observations of flooding extent and depth taken following the June 2002 weather bomb (generally accepted as a 100 year flood event).

   - Previous flood hazard mapping exercises completed for Tararu during 1995 (as part of the Thames Flood Hazard Management Plan), Te Puru during 1993 (as part of the Te Puru Flood Hazard Management Plan) and Coromandel Town during 2002 (as part of the Draft Coromandel Flood Hazard Management Plan).

7.2 Results

The application of the flood hazard classifications to the data obtained from MIKE 21 initially overestimated each flood hazard based on observations from the June 2002 weather bomb. It was therefore decided to increase the depth classifications by 0.3 m, which is the absolute accuracy of the digital elevation model used for the MIKE 21 modelling. This increase gave flood hazard maps that more accurately reflected the

flood hazard observed during the June 2002 weather bomb. To confirm, the adjusted flood hazard classifications were as follows:

High flood hazard:	Areas likely to be subject to flooding depths greater than 1.3 m and water velocities greater than 1.0 m/s.
Medium flood hazard:	Areas likely to be subject to flooding depths greater than 0.8 m and water velocities less than 1.0 m/s.
Low flood hazard:	Areas likely to be subject to flooding depths between 0.3 m and 0.8 m and water velocities less than 1.0 m/s.
No flood hazard:	Areas likely to be subject to no flooding (flooding depth is less than 0.3 m).

A draft flood hazard map for each community is presented in Appendix 4 of this report.

8 Proposed Work Programmes (Phase A)

Each community included thus far in the Thames Coast Project is keen to implement works to reduce the risk to people and property. These works can range from base-level maintenance of the existing channel through to improving the channel stability with erosion control works through to improving the channel capacity by constructing embankments and floodwalls. Environment Waikato has been discussing the scope of these works with each community and is now in the position to begin planning the detailed design, authorisation, construction and commissioning of some works.

8.1 Type of Works Proposed

There is a variety of works proposed by the Thames Coast Project that range from minor channel maintenance through to significant flood protection.

1. Base-level Channel Maintenance

   This involves the design, authorisation and implementation of an annual programme of works to maintain each stream channel to a pre-determined base-level geometry. This work includes:

   - Establishment of a cross section survey programme that is designed to monitor sections of the channel that are known to be subject to the accumulation and/or scour of bed material.

   - The establishment of a base-level geometry at each of the cross sections.

   - Annual follow-up cross sectional surveys to monitor the change in the channel geometry and identify when physical works are required.

   - Physical works required to maintain the channel to the base-level geometry.

   - Physical works required to remove debris from the channel (e.g. timber).

2. Channel Improvement Works

   This involves the design, authorisation and implementation of works within an existing channel that will improve either the capacity or the stability. This work includes

   - Removal of channel obstructions that have been identified by either the community or by Environment Waikato (e.g. overgrown vegetation or a narrow section of channel).

   - ‘Soft’ engineering solutions to improve the stability of the channel (e.g. retirement fencing and riparian planting).

   - ‘Hard’ engineering solutions to improve the stability of the channel (e.g. rock rip rap, concrete fabriform and steel sheetpiles).

3. Flood Protection Works

This involves the design, authorisation and implementation of works outside of an existing channel that improve the capacity of the channel and floodway and divert floodwaters away from properties. This work may involve either stopbanks or floodwalls.

Figure 8.1.1: Typical stopbank

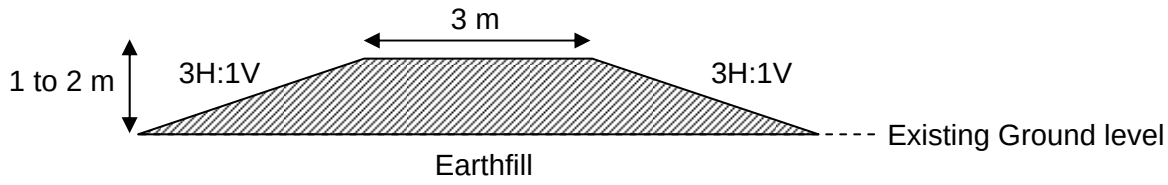
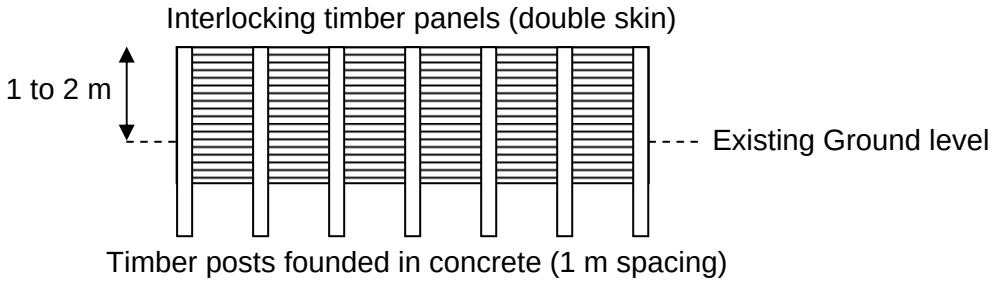


Figure 8.1.2: Typical timber floodwall



8.2 Tararu

1. Base-level Channel Maintenance

This involves the authorisation of the long-term annual works programme required to maintain the Tararu Stream channel to the design parameters specified by HCB Report 130.

The specific activities associated with this annual work programme are:

- Removal of accumulated gravel, sand and debris from the Tararu Stream between the SH25 bridge and the Victoria Street ford (i.e. 400 m length of channel).

- Removal of accumulated gravel, sand, silt and debris from under the SH25 bridge across the Tararu Stream.

- Removal of accumulated sand, silt and debris from the Tararu Stream between the SH25 bridge and Firth of Thames (i.e. 240 m length of channel).

- Disposal of excavated gravel, sand and silt on the local foreshore below the high tide level.

The proposed status of these activities with respect to the Resource Management Act (1991) are summarised in the following table. Also included in this table is the key to the diagram below that shows the physical extent of the proposed activities.

Table 8.2.1.1: Summary of activities associated with the base-level maintenance of the Tararu Stream

Activity Description	Map Key	Planning Document*	Activity Status	Applicable Rule(s)
Removal of accumulated gravel, sand and debris.		PWRP	Restricted Discretionary	4.3.7.3
Maintenance of the SH25 bridge.		PWRP	Permitted[+]	4.3.6.1[+]
Removal of accumulated sand, silt and debris.		WRCP	Permitted	16.6.2 16.6.7
Disposal of excavated gravel, sand and silt.		WRCP	Discretionary	16.6.12

* PWRP Proposed Waikato Regional Plan (Appeals Version February 2002)
WRCP Waikato Regional Coastal Plan

[+] Applicable rule and activity status subject to Environment Court appeals.

Diagram 8.2.1.1: Map of proposed base-level maintenance works in the Tararu Stream

2. Flood Protection Works

This involves the design, authorisation and implementation of new flood protection works that are designed to improve the capacity of the Tararu Stream to contain the 20 year flood event.

The specific activities associated with these works are:

- Construction of 1-2 metre high timber floodwalls along both sides of the Tararu Stream (refer to diagram for proposed extent).

- Construction of a 1-2 metre high stopbank/spillway adjacent to the southern approach to the SH25 bridge across the Tararu Stream (refer to diagram for proposed extent).

- Construction of a section of Tararu Creek Road raised by 1-2 metres to act as a stopbank/spillway adjacent to the northern approach to the SH25 bridge across the Tararu Stream (refer to diagram for proposed extent).

The proposed status of these activities with respect to the Resource Management Act (1991) is summarised in the following table. Also included in this table is the key to the diagram below that shows the physical extent of the proposed activities.

Table 8.2.1.2: Summary of activities associated with the base-level maintenance of the Tararu Stream

Activity Description	Map Key	Planning Document*	Activity Status	Applicable Rule(s)
Construction of timber floodwalls.		PWRP	Discretionary	3.6.4.13
Construction of stopbank.		PWRP	Discretionary	3.6.4.13
Raise section of Tararu Creek Rd.		PWRP	Discretionary	3.6.4.13

* PWRP Proposed Waikato Regional Plan (Appeals Version February 2002)
WRCP Waikato Regional Coastal Plan

+ Applicable rule and activity status subject to Environment Court appeals.

Diagram 8.2.1.2: Map of proposed flood protection works around the Tararu Stream

8.3 Te Puru

1. Base-level Channel Maintenance

This involves the implementation of the annual works programme required to maintain the Te Puru Stream channel to the design parameters specified by HCB Report 117 and 194.

The specific activities associated with this annual work programme are:

- Removal of accumulated gravel, sand and debris from a 600 m section of the Te Puru Stream (refer to diagram for proposed extent).

- Removal of accumulated gravel, sand and debris from under the SH25 bridge across the Te Puru Stream.

- Removal of accumulated sand, silt and debris from a 170 m section of the Te Puru Stream (refer to diagram for proposed extent).

- Disposal of excavated gravel, sand and silt on the local foreshore below the high tide level.

The proposed status of these activities with respect to the Resource Management Act (1991) is summarised in the following table. Also included in this table is the key to the diagram below that shows the physical extent of the proposed activities.

Table 8.3.1.1: Summary of activities associated with the base-level maintenance of the Te Puru Stream

Activity Description	Map Key	Planning Document*	Activity Status	Applicable Rule(s)
Removal of accumulated gravel, sand and debris.		PWRP	Restricted Discretionary++	4.3.7.3
Maintenance of the SH25 bridge.		PWRP	Permitted+	4.3.6.1+
Removal of accumulated sand, silt and debris.		WRCP	Permitted	16.6.2 16.6.7
Disposal of excavated gravel, sand and silt.		WRCP	Discretionary+++	16.6.12

* PWRP Proposed Waikato Regional Plan (Appeals Version February 2002)
WRCP Waikato Regional Coastal Plan

+ Applicable rule and activity status subject to Environment Court appeals.

++ Authorised by Resource Consent 109835 (expires 28 February 2009)

+++ Authorised by Resource Consent 101217 (expires 31 July 2008)

Diagram 8.3.1.1: Map of proposed base-level maintenance works in the Te Puru Stream

8.4 Waiomu

1. Base-level Channel Maintenance

This involves the design, authorisation and implementation of an annual works programme required to maintain the Waiomu Stream channel.

The specific activities associated with this annual work programme are:

- 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.

The proposed status of these activities with respect to the Resource Management Act (1991) is summarised in the following table. Also included in this table is the key to the diagram below that shows the physical extent of the proposed activities.

Table 8.4.1.1: Summary of activities associated with the base-level maintenance of the Waiomu Stream

Activity Description	Map Key	Planning Document*	Activity Status	Applicable Rule(s)
Removal of accumulated gravel, sand and debris.		PWRP	Restricted Discretionary	4.3.7.3
Removal of overgrown riparian vegetation		PWRP	Permitted	4.3.9.2
Maintenance of the SH25 bridge.		PWRP	Permitted+	4.3.6.1+
Removal of accumulated sand, silt and debris.		WRCP	Permitted	16.6.2 16.6.7
Disposal of excavated gravel, sand and silt.		WRCP	Discretionary	16.6.12

* PWRP Proposed Waikato Regional Plan (Appeals Version February 2002)
WRCP Waikato Regional Coastal Plan

+ Applicable rule and activity status subject to Environment Court appeals.

Diagram 8.4.1.1: Map of proposed base-level maintenance works in the Waiomu Stream

8.5 Pohue

1. Base-level Channel Maintenance

This involves the design, authorisation and implementation of an annual works programme required to maintain the Pohue Stream channel.

The specific activities associated with this annual work programme are:

- Removal of accumulated gravel, sand and debris from a 560 m section of the Pohue Stream (refer to diagram for proposed extent).

- Removal of accumulated gravel, sand, silt and debris from under the SH25 bridge across the Pohue Stream.

- Removal of accumulated sand, silt and debris from the Pohue Stream between the SH25 bridge and Firth of Thames (i.e. 40 m length of channel).

- Disposal of excavated gravel, sand and silt on the local foreshore below the high tide level.

The proposed status of these activities with respect to the Resource Management Act (1991) is summarised in the following table. Also included in this table is the key to the diagram below that shows the physical extent of the proposed activities.

Table 8.5.1.1: Summary of activities associated with the base-level maintenance of the Pohue Stream

Activity Description	Map Key	Planning Document*	Activity Status	Applicable Rule(s)
Removal of accumulated gravel, sand and debris.		PWRP	Restricted Discretionary	4.3.7.3
Removal of overgrown riparian vegetation		PWRP	Permitted	4.3.9.2
Maintenance of the SH25 bridge.		PWRP	Permitted+	4.3.6.1+
Removal of accumulated sand, silt and debris.		WRCP	Permitted	16.6.2 16.6.7
Disposal of excavated gravel, sand and silt.		WRCP	Discretionary	16.6.12

* PWRP Proposed Waikato Regional Plan (Appeals Version February 2002)
WRCP Waikato Regional Coastal Plan

+ Applicable rule and activity status subject to Environment Court appeals.

Diagram 8.5.1.1: Map of proposed base-level maintenance works in the Pohue Stream

8.6 Tapu

1. Base-level Channel Maintenance

This involves the design, authorisation and implementation of an annual works programme required to maintain the Tapu River channel.

The specific activities associated with this annual work programme are:

- Removal of accumulated gravel, sand and debris from the Tapu River upstream of the SH25 bridge (i.e. 580 m length of channel).

- Removal of accumulated gravel, sand, silt and debris from under the SH25 bridge across the Tapu River.

- Removal of accumulated sand, silt and debris from the Tapu River between the SH25 bridge and Firth of Thames (i.e. 220 m length of channel).

- Disposal of excavated gravel, sand and silt on the local foreshore below the high tide level.

The proposed status of these activities with respect to the Resource Management Act (1991) is summarised in the following table. Also included in this table is the key to the diagram below that shows the physical extent of the proposed activities.

Table 8.6.1.1: Summary of activities associated with the base-level maintenance of the Tapu River

Activity Description	Map Key	Planning Document*	Activity Status	Applicable Rule(s)
Removal of accumulated gravel, sand and debris.		PWRP	Restricted Discretionary	4.3.7.3
Removal of overgrown riparian vegetation		PWRP	Permitted	4.3.9.2
Maintenance of the SH25 bridge.		PWRP	Permitted+	4.3.6.1+
Removal of accumulated sand, silt and debris.		WRCP	Permitted	16.6.2 16.6.7
Disposal of excavated gravel, sand and silt.		WRCP	Discretionary	16.6.12

* PWRP Proposed Waikato Regional Plan (Appeals Version February 2002)
WRCP Waikato Regional Coastal Plan

+ Applicable rule and activity status subject to Environment Court appeals.

Diagram 8.6.1.1: Map of proposed base-level maintenance works in the Tapu River

8.7 Coromandel Town

1. Base-level Channel Maintenance

This involves the design, authorisation and implementation of an annual works programme required to maintain the Whangarahi Stream and Karaka Stream channel.

The specific activities associated with this annual work programme are:

- Removal of accumulated gravel, sand and debris from a 3730 m section of the Whangarahi Stream (refer to diagram for proposed extent).

- Removal of accumulated gravel, sand and debris from a 1500 m section of the Karaka Stream (refer to diagram for proposed extent).

- Removal of accumulated gravel, sand and debris from under the Albert Street bridge across the Whangarahi Stream and under the Kapanga Road bridge across the Karaka Stream.

- Removal of accumulated sand, silt and debris from the 430 m long tidal section of the Whangarahi Stream (refer to diagram for proposed extent).

- Removal of accumulated sand, silt and debris from under the Wharf Road bridge across the Whangarahi Stream.

The proposed status of these activities with respect to the Resource Management Act (1991) is summarised in the following table. Also included in this table is the key to the diagram below that shows the physical extent of the proposed activities.

Table 8.7.1.1: Summary of activities associated with the base-level maintenance of the Whangarahi Stream and Karaka Stream

Activity Description	Map Key	Planning Document*	Activity Status	Applicable Rule(s)
Removal of accumulated gravel, sand and debris.	—	PWRP	Restricted Discretionary	4.3.7.3
Removal of overgrown riparian vegetation	—	PWRP	Permitted	4.3.9.2
Maintenance of the Kapanga Road and Albert Street bridges.	●	PWRP	Permitted^{+}	4.3.6.1^{+}
Removal of accumulated sand, silt and debris.	—	WRCP	Permitted^{++}	16.6.2 16.6.7
Maintenance of the Wharf Road bridge.	●	WRCP	Permitted	16.4.20

* PWRP Proposed Waikato Regional Plan (Appeals Version February 2002)
WRCP Waikato Regional Coastal Plan

$^{+}$ Applicable rule and activity status subject to Environment Court appeals.

$^{++}$ Within Coastal Marine Area only.

Diagram 8.7.1.1: Map of proposed base-level maintenance works in the Whangarahi Stream and Karaka Stream

2. Channel Improvement Works

This involves the design, authorisation and implementation of works to improve the Whangarahi Stream and Karaka Stream channels.

The specific activities associated with these works are:

- Removal of channel restrictions identified by either Environment Waikato or the community (including the removal of riparian vegetation that is encroaching into the stream channel).

- Construction of erosion protection works consisting of rock rip rap (refer to diagram for proposed extent of works).

- Construction of works to improve the management of flood flows from the 'Golf Course' catchment (i.e. channel widening and an improved waterway crossing for the Coromandel Town Wastewater Treatment Plant).

- Fencing and riparian planting along the Karaka Stream between the Kapanga Road bridge and SH25 (i.e. 1000 m channel length).

The proposed status of these activities with respect to the Resource Management Act (1991) are summarised in the following table. Also included in this table is the key to the diagram below that shows the physical extent of the proposed activities.

Table 8.7.1.2: Summary of activities associated with the base-level maintenance of the Whangarahi Stream and Karaka Stream

Activity Description	Map Key	Planning Document*	Activity Status	Applicable Rule(s)
Removal of channel restrictions.	N/A	PWRP	Discretionary	4.3.4.4
Removal of overgrown riparian vegetation.	N/A	PWRP	Permitted	4.3.9.2
Construction of erosion protection works.		PWRP	Permitted+	4.2.15.1+
Improvement of management of runoff from 'golfcourse' catchment		PWRP	Discretionary	4.3.4.4
Fencing of Karaka Stream.		N/A	N/A	N/A
Planting of Karaka Stream.		PWRP	Permitted	4.3.8.1

* PWRP Proposed Waikato Regional Plan (Appeals Version February 2002)
WRCP Waikato Regional Coastal Plan

\+ Applicable rule and activity status subject to Environment Court appeals.

Diagram 8.7.1.2: Map of proposed erosion protection works on the Whangarahi and Karaka Stream

Diagram 8.7.1.3: Map of proposed fencing and planting along the Karaka Stream

3. Flood Protection Works

This involves the design, authorisation and implementation of works to improve the capacity of the Whangarahi Stream channel in the vicinity of the Elizabeth Park Retirement Village through the construction of a stopbank. The design standard for this stopbank is the 100 year flood event.

The specific activities associated with these works are:

- Construction of a 1-2 m high stopbank around the Elizabeth Park Retirement Village (refer to diagram for extent).

The proposed status of these activities with respect to the Resource Management Act (1991) are summarised in the following table. Also included in this table is the key to the diagram below that shows the physical extent of the proposed activities.

Table 8.7.1.3: Summary of activities associated with the base-level maintenance of the Whangarahi Stream and Karaka Stream

Activity Description	Map Key	Planning Document*	Activity Status	Applicable Rule(s)
Construction of stopbank around the Elizabeth Park Retirement Village		PWRP	Discretionary	3.6.4.13

* PWRP Proposed Waikato Regional Plan (Appeals Version February 2002)
WRCP Waikato Regional Coastal Plan

+ Applicable rule and activity status subject to Environment Court appeals.

Diagram 8.7.1.4: Map of proposed flood protection works around the Elizabeth Park Retirement Village

8.8 Summary

The following table is a summary of the five year works programme proposed under the Thames Coast Project.

Table 8.8.1: Summary of 'Phase A' work programme for each community

Community	Work Type*	Phase A
Tararu	BCM	
	CI	
	FP	
Te Puru	BCM	
	CI	
	FP	
Waiomu	BCM	
	CI	
	FP	
Pohue	BCM	
	CI	
	FP	
Tapu	BCM	
	CI	
	FP	
Coromandel Town	BCM	
	CI	
	FP	

*Work Type Key BCM: Base-level channel maintenance (annual programme)

CI: Channel improvement works

FP: Flood protection works

9 Climate Change

It is now generally accepted that global warming, caused by human-created emissions of greenhouse gases, will affect the climate, leading to a rise in temperatures and sea levels and changes in weather patterns. However, there is acknowledged uncertainty about the extent of those changes, and changes in the frequency or scale of meteorological hazards such as flood, storm, storm-surge, drought and coastal erosion. While the general direction of future changes is relatively well established, different climate models show different degrees of change, indicating the likely range that a precautionary planning approach should consider.

It is generally accepted that under climate change, New Zealand's risk of heavy rainfall will increase. However, specific model projections for changes in flooding are currently extremely variable. Environment Waikato is working with the Insurance Australia Group (who in turn is working with NIWA) in the interests of reducing this uncertainty.

Adequate planning steps need to weigh the projected range in flood risk against the additional protection costs associated with the plausible future scenario (or scenarios). We therefore need to adopt a conservative approach in our flood assessments for the Thames Coast to allow for any future management requirements or policy changes that relate to climate change. This includes allowance for engineering works to be upgraded where necessary.

10 Environmental Management

The works proposed by this investigation have the potential to enhance the existing Thames Coast environment through the stabilisation of catchments, the protection of riparian vegetation and the stabilisation of stream channels. There is however also the potential for short-term adverse effects on the environment during the construction and ongoing maintenance of works. These adverse impacts may include:

- Disturbance of the beds and banks of streams.

- Discharge of sediment to streams and the coastal environment (Firth of Thames).

- Interruption of stream habitats.

Environment Waikato will address these impacts through the process of obtaining Resource Consents and by the implementation of good environmental practices such as:

- Sediment control.

- Management of machinery within and near waterways.

- Stream bank planting.

- Habitat enhancement.

Environment Waikato will also actively seek and implement opportunities to enhance the Thames Coast environment in a manner that is consistent with Environment Waikato policies.

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12 Appendices

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Appendix 1: Catchment Maps

Appendix 2: Floodplain Depth and Velocity Maps (utilising MIKE 21)

Appendix 3: Summary of Flooding Mechanisms

Appendix 4: Flood Hazard Maps (utilising MIKE21)