GRAHAMS CREEK – FLOOD MITIGATION – WHEN ENGINEERING AND ENVIRONMENT COMBINE

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ABSTRACT

Flood mitigation from a pure engineering perspective can often be viewed as simple, in that solutions for flooding problem revolve around improving conveyance of waterways to carry flood volumes from A to B at a defined level. However, when you factor in the economic, social, cultural, ecological, environmental aspects a *wicked problem*[1] emerges. Flood mitigation projects can falter when faced with a wicked problem, conflicting knowledge – technical expert vs community, ability to pay, ownership of the issue, or even the short term nature of our memories – *'oh the flood wasn't that bad'*, can make finding an agreed solution that delivers, near impossible to find consensus.

Grahams Creek on the Coromandel Peninsulas east coast was one such area. A short sharp catchment that goes from no flood to full flood in 3 hours is further complicated by tidal influence and an undersized causeway bridge.

Decades of discussion, multiple options and conflicting views had left the community and agencies frustrated. In 2014 a Waikato Regional Council lead working party was established with community, stakeholder, political and landowner representation. This group along with key engineering and ecological oversight co-designed a new scheme. Construction of this long awaited flood mitigation scheme has commenced.

So what changed? Challenges became opportunities – Lack of funding, led to partnerships with others, ecological sensitivities led to innovation in design and construction. Collectively leading to regional firsts including; a powerless automatic floodgate and spillway designed to function similarly to coastal wetland (includes saltmarsh translocation).

This paper shares the journey from the engineering, ecological and engagement perspective from design to construction.

KEYWORDS

Community, Is the community residing by the Graham Creek in Tairua Township on the east coast of the Coromandel Peninsula.

Flood mitigation, Protection of people and property from flooding by applying appropriate measures for the affected area. In most cases measures involve

[1] A wicked problem is a social or cultural problem that is difficult or impossible to solve for as many as four reasons: incomplete or contradictory knowledge, the number of people and opinions involved, the large economic burden, and the interconnected nature of these problems with other problems.

construction of engineered structures that contain flood flows within specified floodways and/or reducing flood levels to the extent that their effects are tolerable.

Floodgate; Is a culvert structure through a stopbank/levee with a flap gate installed at its inlet or outlet which is closed to prevent water from entering a flood protected area. Floodgates are closed either by themselves under hydraulic pressure, manually, or by powered mechanisms.

Floodway; is the land area associated with a waterway over which flood flows occur when the waterway floods.

Peninsula Project, A funding policy adopted by Waikato Regional Council to provide catchment management, flood protection and river management across the Coromandel Peninsula.

Saltmarsh, Native grasses, rushes and other species uniquely found within the freshwater interface with tidal zone.

PRESENTERS PROFILE

Ghassan Basheer – Principle Technical Advisor – Waikato Regional Council

BSc. CE, MSc. Urban & Regional Planning, University of Baghdad 1978

Over 40 years of experience in a wide range of civil and hydraulic engineering design, construction and management fields. The technical management, project management with specific focus on rivers and flood schemes.

Emily O'Donnell – Harbor and Catchment Management Advisor – Waikato Regional Council

BSc Geo. Otago University 2004

15- Years of experience, Soil conservation, Community engagement and facilitation, Non statutory planning – Sea Change and harbour and catchment management, Coastal vegetation management, Programme, Zone and team Management, Project Management.

1 INTRODUCTION

The Waikato Regional Council (Council), specifically the Integrated Catchment Management (ICM) Directorate is responsible for the overall management of the region's rivers and their catchments, including the effects of flooding and erosion. Well-managed streams and rivers benefit our region's environment and economy.

Under the Soil Conservation and River Control Act 1941 the Council has a statutory responsibility to "*minimise and prevent damage within the region by floods and erosion*". ICM is tasked with fulfilling these responsibilities on behalf of the Council to the standard accepted by the community within the Long Term Plan and undertakes the following activities in this respect:

a. Construction, maintenance and management of flood protection schemes to minimise the potential impacts of flooding;

b. Management of natural processes that affect rivers and streams such as blockages, erosion, flooding and alteration of watercourses;

c. Catchment works and soil conservation works to reduce the effects of accelerated erosion; and

d. Provision of information and advice to communities.

For the Coromandel Zone, fulfilment of these responsibilities is achieved through implementation of the "Peninsula Project" an integrated catchment approach to managing rivers, soil, biodiversity and flood risk. A key area of work is the development of whole of catchment plans such as the development and implementation of the Tairua Harbour Catchment Management Plan that aim to achieve a long term reduction in adverse erosion, flooding and water quality effects through a wide range of comprehensive and integrated catchment management initiatives.

However, these river management responsibilities also frequently dictate the need for direct intervention methods requiring ICM to undertake physical works and implementation of structures within and around the bed of rivers and streams throughout the region, particularly in locations where historic human development and landuses have occurred within proximity to these systems. Implementation of these works needs to consider land use, hazard management and environmental requirements within the catchment.

This paper provides an overview of the Grahams Creek flood mitigation project and highlights the innovative approach in development, design and implementation of the project.

2 GRAHAMS CREEK

2.1 GRAHAMS CREEK CATCHMENT

Grahams Creek flows into the northern end of the Tairua Harbour and has a catchment area of 945 hectare. The upper catchment is steep and erosion prone, vegetated in a mix of wilding pine and regenerating native. The middle section of the catchment is predominantly lower gradient valley flats of fairly poor soil fertility. They are under dry stock grazing management with the stream remnant wetlands and forest fragments unprotected from stock access and poorly vegetated.

The Grahams Creek channel passes under SH25 via a bridge crossing just north of Tairua township and follows a straightened channel running parallel to Ocean Beach Road, passing through a series of residential properties which span the stream channel, prior to entering its wider estuarine reaches just upstream of the Manaia Road Causeway. The catchment exits the estuarine reaches via a short 16m span bridge through the Manaia Road Causeway into Paku Bay within the northern margins of Tairua Harbour.

The location and extent of the Grahams Creek catchment and stream channel alignment is outlined in Figure 1 below.

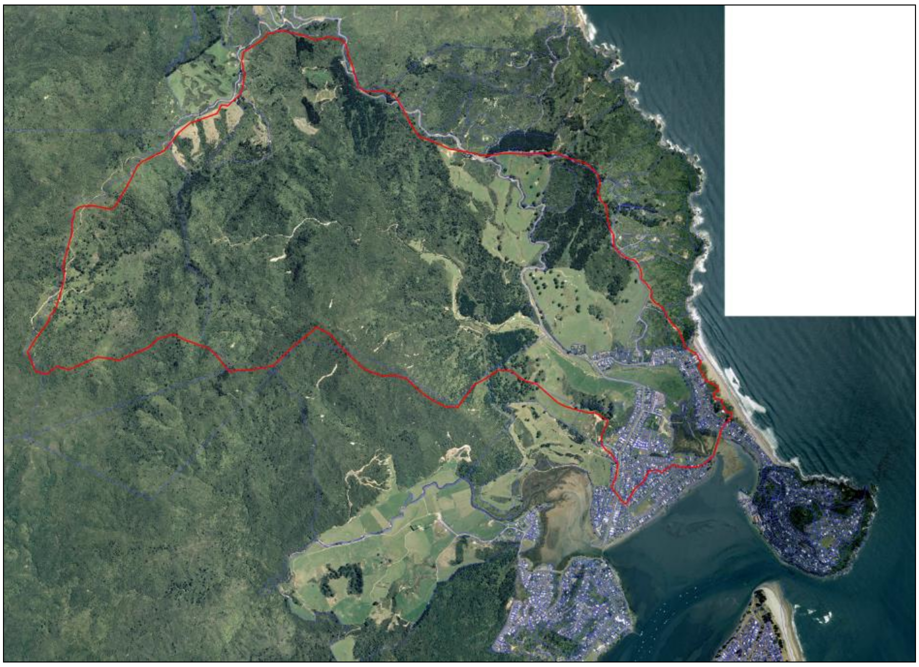

Figure 1: Graham Stream catchment

Grahams Creek has been subject to a number of catchment pressures which have exacerbated adverse flooding effects upon riparian properties within the lower catchment area below SH25 including:

a. Catchment erosion within the steep upper catchment areas including inputs from numerous slips and slumps and the effects of historical activities such as logging and mining;

b. Hill slope and stream bank erosion within the lower catchment due to riparian vegetation clearance, stock trampling and channel modification (straightening/structures) effects;

c. Historic infilling of the flood plain and uncontrolled drainage bunds within the lower reaches;

d. Encroachment of buildings and infrastructure on main channel and flood plain;

e. Construction of the Manaia Road Causeway with a restricted outlet causing a constriction to flows and significant sediment deposition (from the above areas of erosion) within the lower estuarine reaches;

f. Invasive weed colonisation and resulting accumulation of sediment.

As a result, the Grahams Creek Community, especially the residential property on Ocean Beach Road was subject to flooding several times a year.

2.2 GRAHAMS CREEK HYDROLOGY

As part of the Coromandel Peninsula, the average annual rainfall depth on Grahams Creek Catchment is 1900 mm. The normal flows vary during the seasons and is approximately 1-2 m^3/s on average.

Flood hydrology assessment was undertaken by WRC hydrologists and peer reviewed by Barnett & McMurray Consultants in 2014. Discharges for the various model scenarios are based on their hydrological review for average recurrence intervals (ARI) of 2, 5, 10, 20, 50 and 100 years are shown in (**Error! Reference source not found.**) below.

Climate change discharge assumed an average increase in temperature of 3ºC, and 8% increase in rainfall for each one degree increase in temperature.

%AEP (Average recurrence interval)	Discharge (m^3/s)
50%AEP (2 year)	46.5
20%AEP (5 year)	70
10%AEP (10 year)	86
5%AEP (20 year)	102
2%AEP (50 year)	122
1%AEP (100 year)	137
1%AEP CC*(100 year CC*)	170*

Table 1: Estimated peak flood flows for Grahams Stream.

*Climate change discharge based on simplified approach assuming a 24% increase in rainfall depth gives a similar increase in peak discharge.

Application of steady high intensity rainfall HIRDS (version 3) for different durations over the whole catchment showed that the time to peak downstream of SH25 Bridge was around 90 minutes. The following Figure 2 provides the hydrographs for different rainfall events established for the stream and applied in hydraulic modelling.

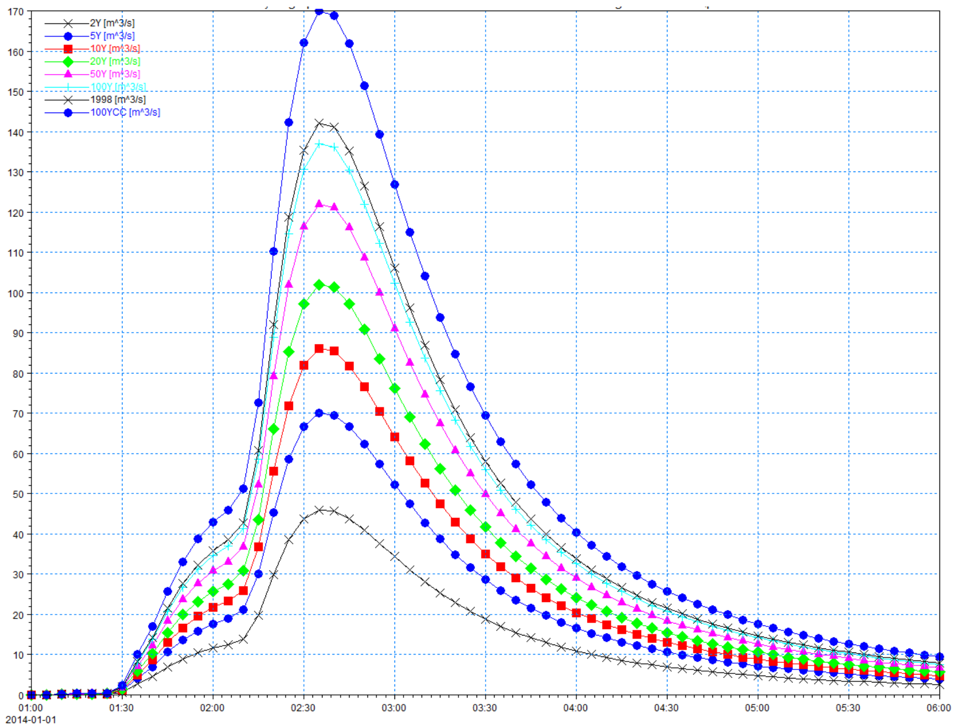

Figure 2: hydrographs for the various events applied to the hydraulic model

2.3 UNDERSTANDING FLOODS BY MODELLING

Designing flood mitigation measure requires a good understanding of the flooding mechanism and the elements that influence flood height, extent (lateral spread) and duration. Hence the need to understand the stream channel and overland flow physical set up and characteristics, the tidal influence in terms of height and extent and flood flow volume.

2.3.1 STREAM AND FLOODWAY TOPGRAPHY

It was obvious from our inspections of the stream and floodplain that significant obstacles to flows existed in the form of bunds formed from drain cleaning, sedimentation, fences, debris, vegetation and structures. Land and channel surveys were undertaken to establish an accurate representation of the channel and floodplain.

Channel and floodplain cross sections survey and LiDAR survey were carried to establish the topographical physical parameters within which flood flows pass. The results are represented in Figure 3 below.

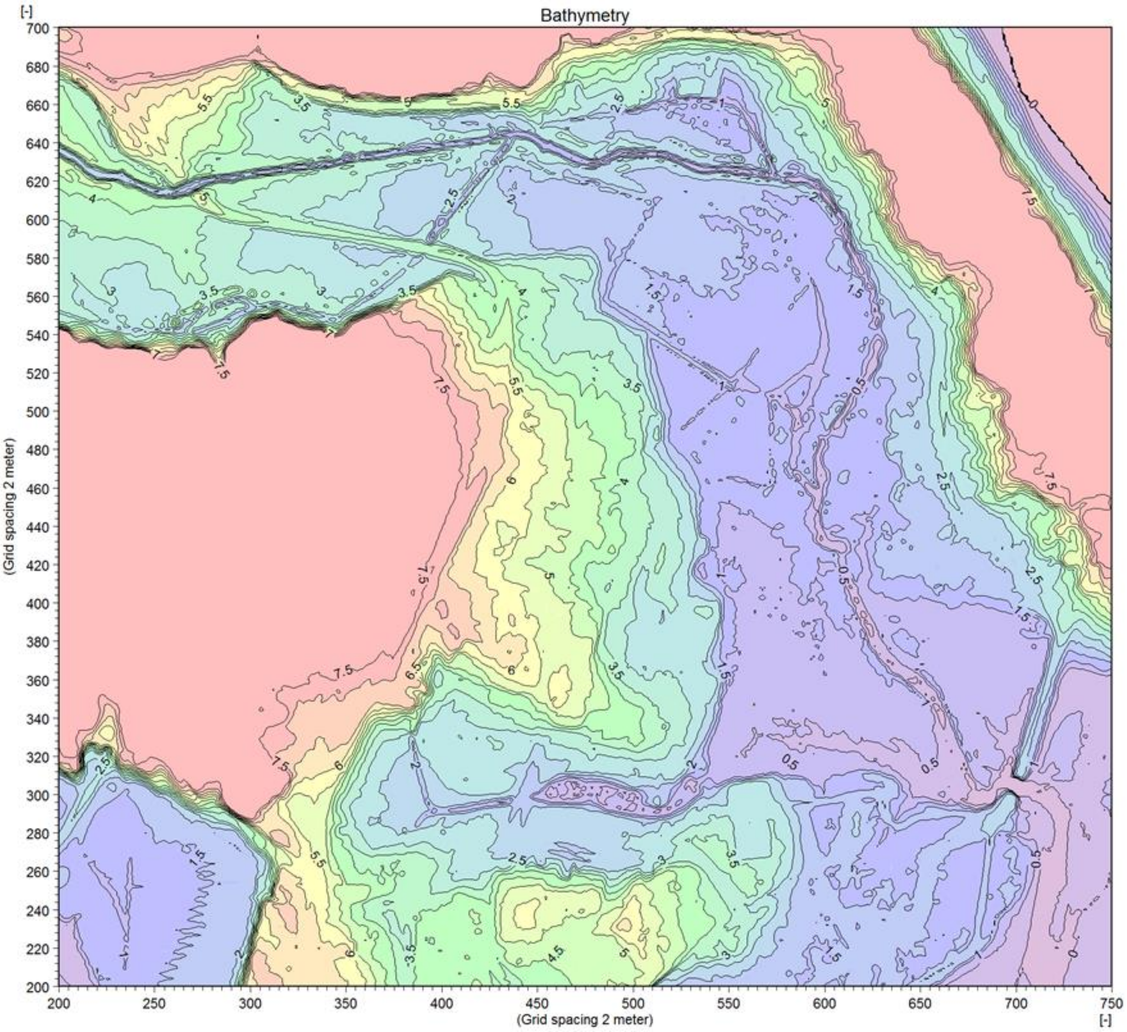

Figure 3: Existing topography of Grahams Creek area (relative to Moturiki Vertical datum)

2.3.2 TIDAL INFLUENCE

In order to ensure that the correct tide levels were used with the correct bathymetry datum, a review of reference datum used for all previous reports and surveys was undertaken, and differences documented. A design high tide level for the model was established and confirmed as an appropriate downstream boundary.

It was necessary to show the community what tidal flooding could mean with no stream flooding. This was important for the community to make an informed decisions on the level of protection they ask us to design the works for. The following two figures were results of modelling the tidal extent of current design high tide as opposed to future design high tide with sea level rise of 0.8 m. The community decision was to have the flood mitigation scheme designed for current flooding, however versatile to allow for future extensions and upgrades as a future stage to prevent future flooding of properties.

Figure 4: Tidal inundation during design high tide

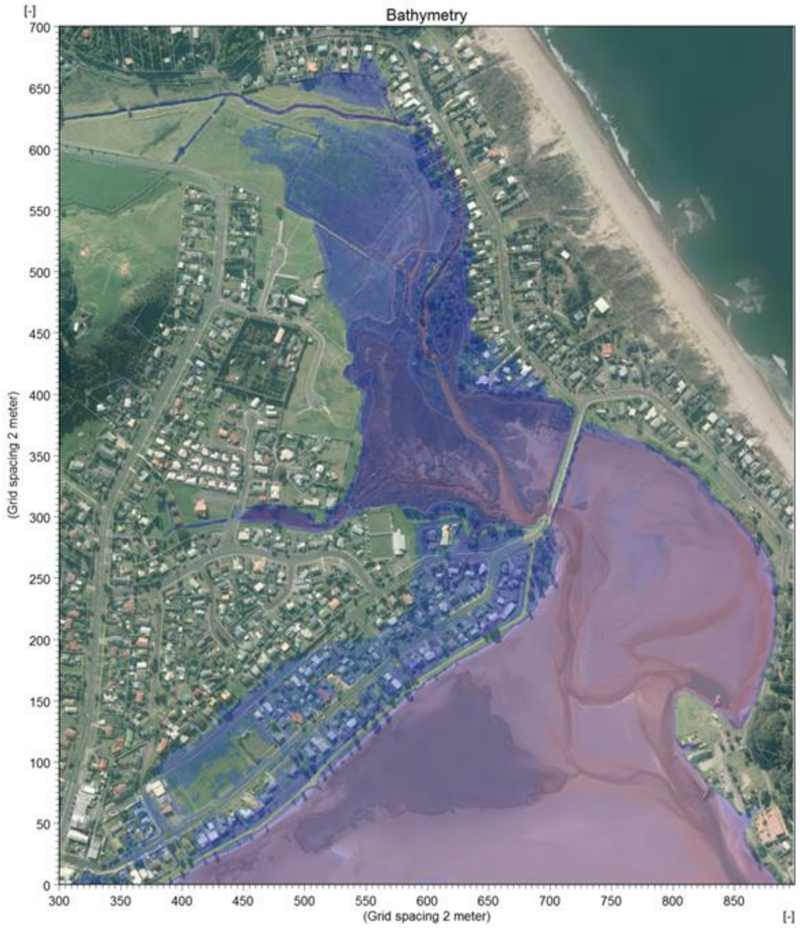

Figure 5: Tidal inundation during design + 0.8m sea level rise

2.3.3 HYDRAULIC MODELLING

A MIKE 21 hydraulic model was constructed from combining the stream channel cross sections with the LiDAR bathymetry. The model was calibrated against actual flood information and surveys undertaken during and after the 1998 flood which was considered to be slightly above the 100 year return period event.

The model was used to simulate the extent of flooding for the different flood events using the hydrographs applied some 650 m upstream of SH 25 Bridge and a design high tide of RL 1.8 m being the downstream boundary condition.

The following figures show the extent of flooding during a 50 year and 100 year events within the community.

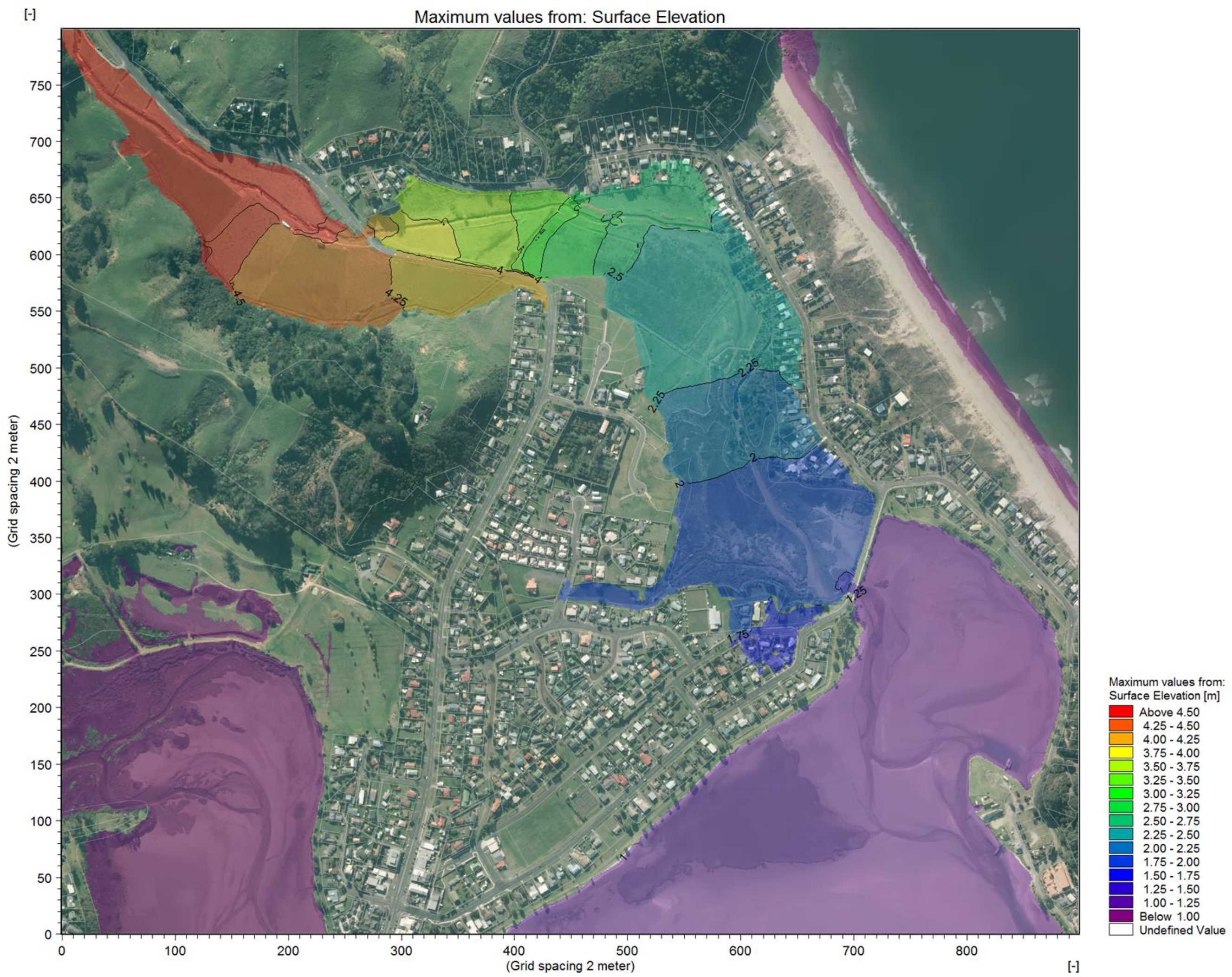

Figure 6: Grahams Creek Pre-Scheme current climate 2%AEP (50 year ARI) flood extent.

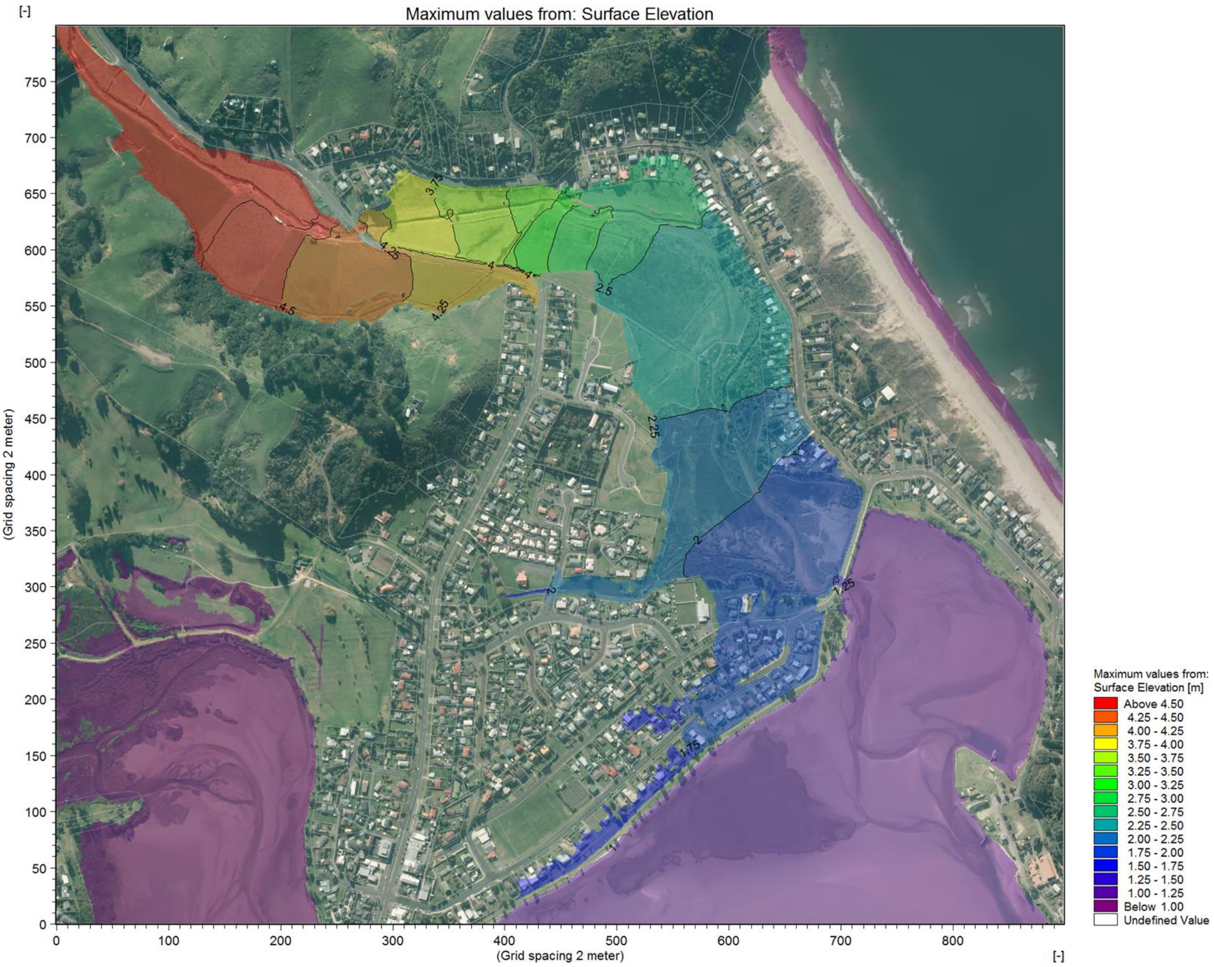

Figure 7: Grahams Creek Pre-Scheme current climate 1%AEP (100 year ARI) flood extent.

The most important lesson from modelling was learnt by observing the flow in a time stepped manner to see when overland flow occurs and how it moved across the floodplain. Through the process it was clear that:

a. Overland flow started at flows just exceeding 6 m^3/s and the majority of the stream breached its banks at 12 m^3/s. Hence, enlarging the stream capacity was vital for a successful scheme.

b. The overland flow was building up in level upstream then slowly flowing downstream as a sheet across the floodplain. This confirmed our understanding of the effect of obstruction in the stream and floodway. This highlighted the need to re-contour the upstream floodplain to ensure overland flow capacity matches the inflow at SH 25 Bridge.

c. The Manaia Causeway Bridge over the stream was not fully utilised, when the stream was already flooding properties upstream of the estuary. After the flood levels have built up upstream, the full sheet flow reaches the under sized Manaia Causeway Bridge and backs up extending the flood duration. Accordingly, there was a need to open up/widen the stream channel through the estuary and enlarge the bridge capacity.

3 THE COMMUNITY

3.1 COMMUNITY AGREEMENT CHALLENGE

As indicated in the introduction, the flooding issues were the subject of community debate and disagreement for nearly 30 years, and attempts by WRC and TCDC during the period 2005 – 2013 to getting community agreement to address flooding were not successful. The key issues that the community had included the following:

a. The floodplains are all owned by one landowner and was utilised as a dry stock farm. The system of drains and existence of historic bunds along the drains were causing increased flood levels and duration.

b. The floodplain landowner did not see benefit from giving away land for flood protection as it would remain floodable and can't be developed.

c. The landowners who have the Grahams stream running through their backyards did not want to lose the amenity value of the stream and refused to divert the stream away from their land and construct a stopbank between the stream and their properties.

d. The Tairua community as well as Iwi, Department of Conservation were opposed to works within the estuary due to the effects on native species and habitat.

e. Parts of community thought that the Manaia Causeway Bridge was the main cause of flooding and if it was enlarged, a flood scheme was not required.

f. Parts of the community were affected by the floods less than others and felt that a flood scheme will increase their rates with no measurable benefit.

The above issues were exacerbated by the community unwillingness to pay made it nearly impossible to reach agreement on a solution that all parties will support.

3.2 COMMUNITY PROCESS

To address the community agreement challenge, WRC and TCDC teamed up to establish a community working party charged with the responsibility of reaching agreement on a flood mitigation solution. The working party was formed of members representing the different views along with TCDC and WRC politicians and staff acting as advisory members to ensure agreements can be implemented under the provisions and responsibilities of both Councils. In addition to Councils representation, representatives from the Department of Conservation and Iwi were invited to attend, inform and advise the working party as necessary of potential effects of works on their interests and expected mitigation to obtain consents.

Terms of reference for the working party members covered both Councils' requirements and expectations of the working party. These included objectives, principles, guidance on methods of conducting and documenting the business and a time frame to meet Councils' long term plans timeframes to ensure provisions and budgets are allocated for implementation of the agreed solution. The working party was supported by administrative staff to coordinate meetings, document discussions, recommendations and resolutions.

This new approach gave the community ownership and leadership role. It allowed members to help develop and agree a design solution that meets their expectations. The benefits to both Councils were:

a. Building strong and trusting Council- Community relationship.

b. Significant savings in staff time on community consultation and mediation.

c. Significantly reduce the number of options for flood mitigation measures once the community agrees on principles.

d. Setting a timeframe within which the community had to reach agreement to ensure decisions feed into the Long Term and Annual Plans of both Councils.

e. Ensuring community support during implementation as significant work would occur on their land, or could affect their livelihood.

f. Ensuring support for the final product.

g. Reducing the cost of flood response and adverse publicity after each flood, noting that some properties experienced flooding several times a year.

3.3 COMMUNITY AGREEMENTS

It was important for the working party that the hydraulic model used by WRC was a robust representation of the actual flooding that the community has experienced. Accordingly, the party was initially furnished with the modelling work undertaken by WRC staff. The description of how the flood occurs in a stepped manner was confirmed by the landowners to be a reasonable representation of what they have experienced during a flood. This provided the working party with adequate level of confidence in the model and encouraged them to be involved in the design.

A scenario for an additional bridge through the Manaia Road Causeway clearly showed that the bridge enlargement on its own with no flood scheme upstream, was not going to mitigate the flood problems. The additional bridge was only helpful in reducing the duration of flooding at the tail of the event.

The working party carried 16 formal meetings other than many one on one meetings between themselves and other landowners. During these meetings views and proposals were discussed and modelled to assess their effectiveness, until all scheme elements were designed. The results formed the basis for the community agreement, and included the following:

a. The flood mitigation scheme must include an extension to the existing Manaia Causeway Bridge as well as other measures. The Bridge must be two lanes with cycleway and pedestrian footpath.

b. The flood mitigation works must be designed to mitigate current flooding with the long term mitigation in mind, so that future extensions and upgrades can be undertaken without removing the built structures, or at minimum costs.

c. The total cost of the flood mitigation works (excluding the bridge) should not exceed $600,000. This cost was considered as an upper limit that the community can afford to pay.

d. The stream running through the backyards of several properties must be retained for normal stream flow and amenity values.

e. The floodplain landowner accepted to offer parts of his land for the flood mitigation works with an easement for access and maintenance if part of the land was allowed to be developed, and the floodway was re-contoured.

f. The environmental values of the lower floodway wetland be retained and enhanced.

g. Due to cost limitations, the left bank properties along Ocean Beach road will receive flood mitigation up to a 50 year event level as an interim measure, while the right bank properties can receive flood mitigation for 100 year event with (0.5 m) freeboard. Such agreement is unusual in that a higher stopbank on one side will divert floods to the other side.

h. The working party will continue its support for the project during its design and implementation.

i. The project must keep the working party informed of progress on weekly basis so that they can explain to the community why work is being carried in a certain way, and if any issues exist requiring a different solution.

4 SCHEME DESIGN

4.1 CONCEPT DEVELOPMENT

The concept design was developed over a period of 6 months through discussions, modelling of proposed scenarios and assessment of effects of such scenarios. The design team included ecologists, hydrologists and civil engineers to ensure all aspects of concepts are covered.

The problem was to convey the volume of the design flood event through the floodplains to Paku Bay without flooding the built areas at no long term environmental cost. The following describes the design concept elements:

A. Stream channel enlargement

The stream channel between SH25 Bridge and No. 51 Ocean Beach Road was approximately 300m long and included low land adjacent to the road on the left bank. The scheme included enlargement of the channel and infilling the low land to divert flows toward the floodway along the right bank.

B. Stream diversion channel

Downstream of the enlarged section above, the stream was diverted into a new channel extending approximately 300m to a point where this diversion returned to meet the original channel. Before its confluence with the original channel, the diversion channel was to be throttled by an appropriately sized culvert, to ensure normal low flows and bed load movement continued to feed the stream. The old channel was to be completely backfilled after relocating the fish and removing some of the bed material and gravels to line the new diversion channel bed.

C. Spillway and floodway

Immediately upstream of the culvert and floodgate and at the end of the diversion channel, a spillway was constructed to allow overflow over the stream diversion bank. The spillway section had a flatter downstream slope and was strengthened to protect the surface from erosion during overflow.

D. Drain enlargement

Along the right bank of the floodway, a new drain to accommodate flows from the upstream floodplain (above SH25) was constructed. Pre-scheme, this drain was running across the floodplain to feed into the main stream. The drain banks were acting as bunds across the floodway. The new drain has a larger capacity and meets the main stream at the downstream wetland. In effect, isolating the drainage flow reduced the overall flow within the stream under flood conditions. It also improved the water quality within its upper section.

E. Floodway development

The floodway included three separate but connected areas including:

a. Upstream floodway section: this section included the farmland and stream upstream of the SH25 Bridge. This area was not developed as part of the scheme design. However, it formed part of the total flood storage.

b. Downstream floodway section: this section extended between SH25 Bridge and the estuarine wetland downstream and included the area of farmland and stream between the properties along both sides of the stream. The design included re-contouring of this section to act as an efficient flood conveyance area. The design provided for the flows within the stream to overtop the stream right banks and convey the volume of water at low level further downstream into the estuary. A 400m long, 32m wide floodway channel was formed downstream of the diversion channel spillway to convey flood flows.

c. Estuary floodway section: this section extended between the farmland and the Manaia Road Bridge/Causeway. It incorporated saltmarsh plants and wetland species, with overgrown congested stream channel and silted areas. The design included opening up/widening the stream channel and removal of vegetation and silt build up to improve its conveyance efficiency.

F. Stopbanks

a. Along the right bank, a short and shallow stopbank was needed to protect the residential properties. The rest of the area is above the 100 year event design flood level with adequate freeboard.

b. Along the left bank, a stopbank is needed to start upstream of No. 51 Ocean Beach Road and ran along the stream diversion channel, crossed over the flood-gated culvert and continued along the downstream floodway section. The stopbank terminated at the upstream end of the Estuary floodway section. This stopbank was designed to meet community wishes to retain the existing stream channel through the backyards of residential properties for amenity values. Therefore, the stream channel and adjacent properties are exposed to tidal flooding and backwater effect under flood conditions from the downstream end of the stopbank. However, due to the difference in hydraulic profile along both sides of the stopbank, the floodway side will experience higher flood levels than the residential side.

G. As indicated in A above, the strip of land between Ocean Beach Road and the stream channel left bank, is low lying and offered the project a close dump site for unwanted spoils generated from excavation. It also offered an opportunity for development by the floodplain landowner. This opportunity formed the basis for landowner agreement to access his property, construct the scheme with an easement on all works and assets for maintenance.

H. As proposed in B above, A concrete culvert (1350mm diameter) was designed to be placed on the diversion channel to allow normal flows of up to $6m^3/s$ to feed the stream. The culvert was large enough to allow bed material movement as well to ensure the stream natural processes continued. A floodgate was to be placed on the upstream side to block any additional flows from entering the culvert thereby diverting flows to spill over the diversion channel bank. The operation of the floodgate was a challenge for the project, as the working party required the floodgate to operate automatically with no electric power.

I. The existing Manaia Road Bridge structure had a span of 16m with a flow capacity of approximately $40m^3/s$, which is equivalent to the annual flow event. Larger flows back up and raise flood levels upstream. The design waterway capacity of the bridge required an extension of the bridge, by adding another 16m span, adjacent to the existing bridge. This was a key requirement for the flood protection scheme. TCDC, as the asset owner, designed and constructed the bridge extension as required.

J. The widening of the stream within the estuary causes significant loss of saltmarsh species and habitat. The areas lost were to be compensated for within the floodplain by creating similar hydrological environments to regenerate and establish within a five year period.

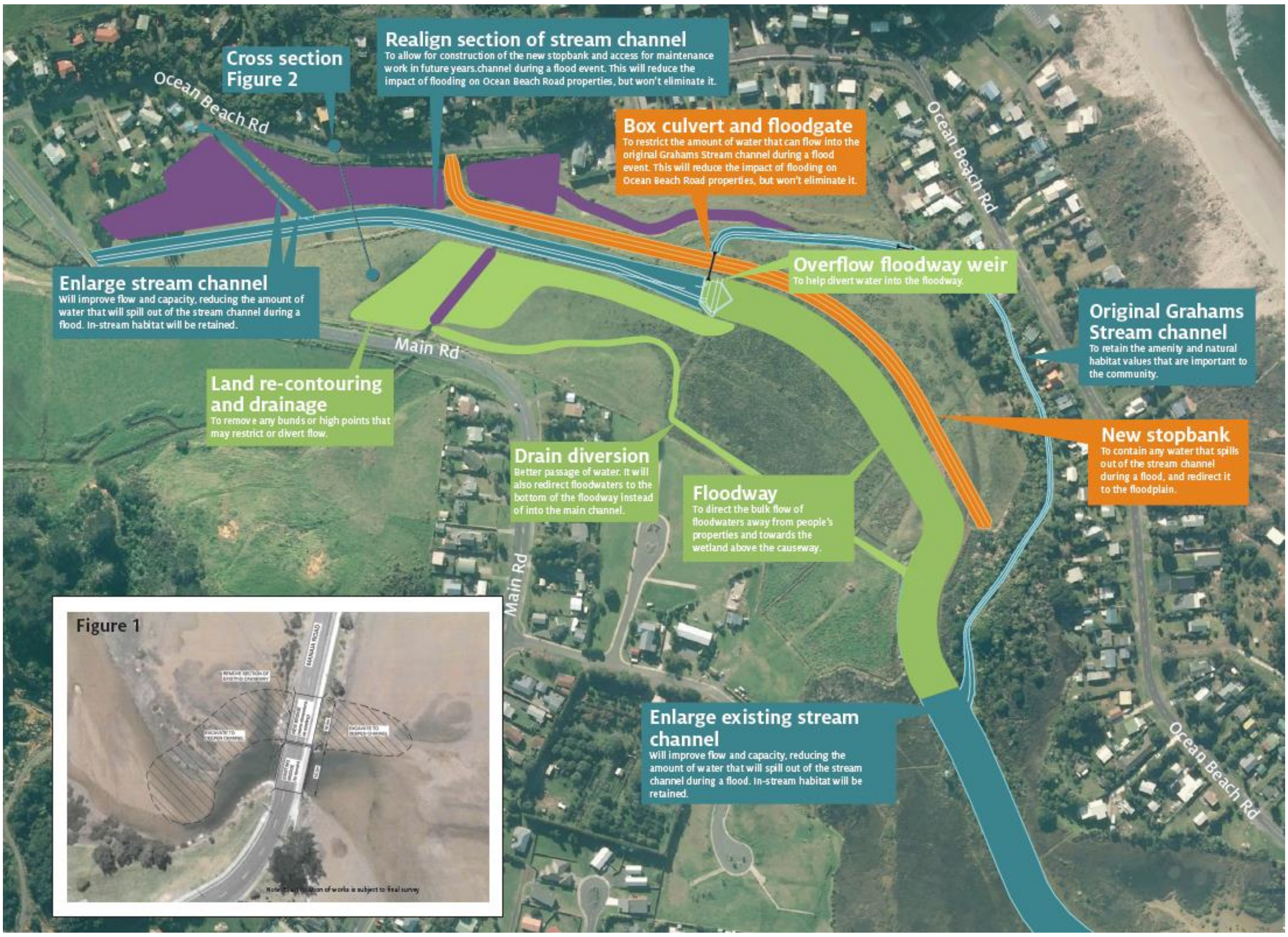

Figure 8: Schematic of flood alleviation components including stopbanks, increased channel capacity, floodway, floodgate, and redirected drain

The above points explaining the design concept, were modelled for a range of events to finally confirm the design concept shown in Figure 7 above.

The hydraulic model and results was peer reviewed by Barnett & McMurray Ltd.

The estimated cost of the works providing 50 year and 100 year protection for Ocean Beach Road were a $0.6 million and $1.0 million respectively. The community agreed to the 50 year protection. The working party signed off on the final design concept.

It should be mentioned that a member of the working party created a physical model to scale of the proposed scheme once the design drawings were complete. He was provided with all the design shape files and digital terrain data, which he fed into a CNC machine to print the model in 3D on a Styrofoam. This was very useful in explaining to the community how the scheme works.

An agreement with the floodplain landowner was reached and signed prior to starting the works.

4.2 ECOLOGICAL EFFECTS MITIGATION

Council employed Wildlands Consultants to investigate and assess the ecological values of the site, how these will be affected or be potentially affected by the proposed works, and what mitigation measures can be undertaken to ensure the net product presents an enhancement to pre-works conditions.

Following investigations and several meetings with Council staff, landowners and T&T design engineers, Wildlands prepared and issued a report titled "Ecological Effects of Proposed Flood Control works at Grahams Creek, Tairua". This report provided the following:

4.2.1 ECOLOGICAL SIGNIFICANCE

a. Estuarine habitats

Estuarine reaches of Grahams Creek, despite being subject to modification by grazing, localised drainage, and causeway construction, still support extensive areas of high value saltmarsh and mangrove habitats. Saline wetlands, including oioi-sea rush rushland, mangrove scrub and shrubland, oioi-marsh ribbonwood rushland, are relatively unmodified and can be regarded as comprising representative ecological units within Tairua Ecological District. Estuarine habitats at Grahams Creek, within the context of Tairua Harbour, can be regarded as being locally significant. Grahams Creek contains ecological sequences from saline to brackish water habitats, and supports a moderate diversity of indigenous fauna, including banded rail and little black shag.

Other habitat types of Grahams Creek, including karo-Sydney golden wattle shrubland, and oioi-harakeke rushland, whilst more modified by weed invasion, increase the extent of habitats available for both indigenous fauna and plants, and provide important riparian protection and buffering.

b. Terrestrial habitats

The lower floodplain of Grahams Creek, between State Highway 25 and the estuary, has been highly modified by historic forest clearance, and in more recent times, by grazing and drainage. Most of the floodplain is now dominated by kikuyu or tall fescue, with the indigenous rush, *Juncus edgariae*, persisting in areas with permanently moist to wet soils. Small areas of freshwater wetland remain on the northern edge of the floodplain and, despite modification by grazing, are still dominated by indigenous species. Except for the freshwater habitats of drains and the stream, which provide habitat for indigenous freshwater fish including inanga, and areas of freshwater wetland, the grazed floodplain is of low ecological value.

c. Freshwater habitats

The main channel of Grahams Creek, despite flowing through a highly modified environment, provides high quality habitat for a range of indigenous freshwater fish species, including up to five species listed as "At Risk-Declining". The macroinvertebrate community, which includes pollution-sensitive mayfly species, is indicative of high water quality.

The assessment results were mapped and are shown in Figure 8 below.

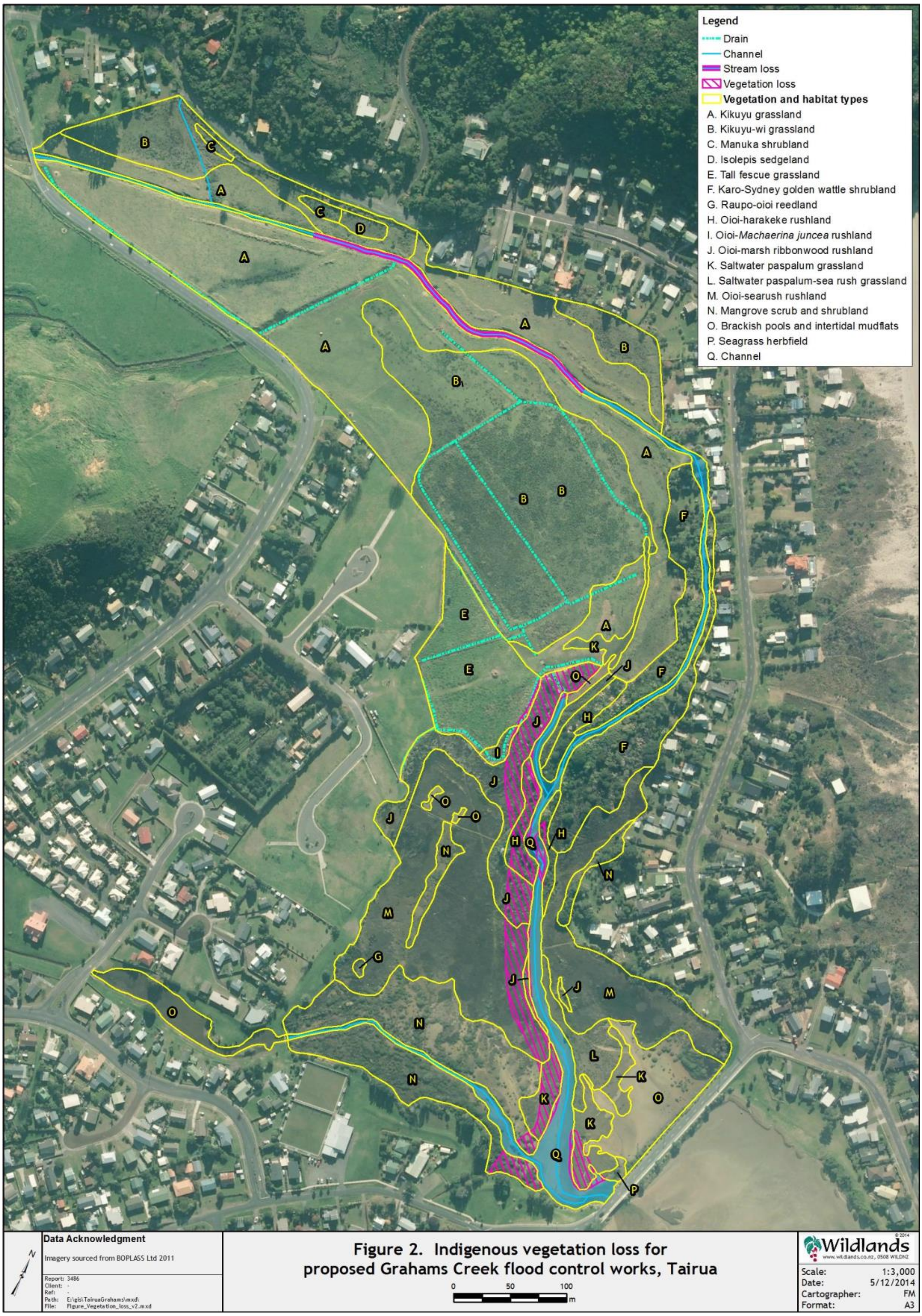

Figure 9: Indigenous vegetation loss resulting from Grahams Creek proposed flood control works

4.2.2 MODIFICATIONS TO PROPOSED DESIGN

Discussion between WRC and Wildlands has resulted in the design modifications that ensure flooding issues are addressed, whilst minimising adverse impacts on the ecology of Grahams Creek, as set out below.

a. Aquatic Habitat Values in the Diverted Section of Grahams Creek

A significant potential adverse ecological effect of the proposed works is the loss of approximately 250 m of Grahams Creek. Habitat loss will be addressed by ensuring that the new channel can develop similar habitat features to the section to be filled, e.g. runs, riffles, and pools with a variety of substrates including sands, gravels, and cobbles. These features could be constructed at the time the new channel is made.

Alternatively, the channel could be left to naturalise of its own accord post-construction, and if these features do not develop naturally over the first year, physical intervention could then be undertaken to diversify and improve the habitats present.

b. Retention of Existing Channel Between SH25 and the Stopbank

Flood capacity downstream of SH25 bridge will be significantly increased by lowering the floodplain on either side of the channel whilst retaining the existing stream bed. The adjacent banks, which are 2-3 m in height, will be lowered so that the stream has banks only c.1 m tall, and this would enable greater flood capacity before floodwaters inundate the existing floodplain. By increasing flood capacity in this manner, the existing stream bed, with riffles and runs, undercut banks, natural substrates, and fauna habitat values, can be left unmodified.

c. Retention and Restoration of a Freshwater Wetland on the Floodplain

Where the floodplain to the north of Grahams Creek is to be filled, this fill will only extend to within 10 m of either side of the stream shown in Figure 1. The riparian margins will be restored using indigenous plantings.

d. Retention of Fish Passage Pathways

If not appropriately designed, the proposed weir will prevent all migratory fish species moving between marine habitats and freshwater streams of the upper catchment. Given that all freshwater fish species confirmed as being present have part of their life cycle in the sea, impeding fish passage could result in the loss of all indigenous fish from the catchment upstream of the weir. A culvert will be placed so that low flows pass through the stopbank into the existing stream to the east. The invert of the culvert will be placed so it is submerged at all times, thus allowing unimpeded fish passage. Flow through the culvert will only be blocked briefly during floods, when all water will pass over the weir to flow down the floodway.

e. Widening of the Estuarine Reaches of Grahams Creek

Where Grahams Creek flows through saltmarsh and mangrove habitats in its lower reaches, the banks have retained their original form and hydrology. These tidal banks support a range of indigenous wetland vegetation types, and are likely to be important spawning grounds for inanga. Flood capacity will be increased by lowering the height of the floodplain on the western bank. This will reduce ecological impacts by leaving the existing channel and the eastern bank undisturbed. No ongoing maintenance work is proposed for where the floodplain is lowered, and this area is expected to regenerate with estuarine vegetation.

Figure 10: Shallow intertidal pools occur within the saltmarsh. 9 September 2014.

4.3 ENGINEERING AND ENVIRONMENTAL DESIGN

Council employed Tonkin and Taylor Consultants Ltd to carry the detailed investigations and design, taking into consideration the assessment of environmental effects and recommended mitigation measures proposed by Wildlands.

Geotechnical investigations, hydraulic and structural design of the stopbanks, stream channel and drain diversion, spillways and culvert were completed by T&T consultants. The key design modifications are summarized in the following table:

Ecological effect	Design modification
Loss of aquatic Habitat Values in the Diverted Section of Grahams Creek	- Relocate all fish in the abandoned diverted section. - Remove bed material and place in the bed of new diversion channel.
Retention of Existing Channel	- Channel enlargement is achieved by cutting a

Between SH25 and the Stopbank	bench in the right bank approximately 1-m above the bed level. Habitat in the wetted section are not affected and potentially increased with additional bench width.
Retention and Restoration of a Freshwater Wetland on the Floodplain.	- This relates to the strip of land area along Ocean Beach Road designated for fill. To offset the loss of wetland, a strip approximately 10 m along the stream and tributary drain were designated for planting with recommended native species.
Retention of Fish Passage Pathways	- Fish passage through the stream was achieved by designing a floodgate that remains open during normal flows and closes only during flood events. During floods fish can still move over the spillway and return back into the stream.
Widening of the Estuarine Reaches of Grahams Creek	- Avoid damage caused by plant moving on saltmarsh. - Use of appropriate plant for the site. - Excavate the floodway upstream of the estuary 300 mm – 500mm below design levels to create similar tidal environment to that of the estuary. - Translocate saltmarsh plant complete with roots and bedding material to new location within the floodway. - Designate additional area for within the floodway for regeneration of wetland and saltmarsh plants.

Table 2: Engineering design modifications to offset and enhance ecological values

It should be noted that in addition to the above design elements, significant environmental controls were implement during construction including erosion and sediment control, fish relocation, grassing and planting.

5 INNOVATIVE SOLUTIONS

As indicated earlier in this paper, the challenges posed by the site physical and hydrological characteristics, as well as those posed the community requirements, were used as opportunities to think outside the square. These have resulted innovative solution that the community and Councils are proud of. These are detailed below.

5.1 COMMUNITY OWNERSHIP APPROACH

Community buy in into a flood mitigation solution was complicated by the number of views and opinions the community had around causes of floods, severity and who should pay for the works. People were entrenched in their own interpretations and have not agreed to any proposal presented to them over a 30 year period.

Having undertaken a significant amount of ground work over the years, WRC and TCDC agreed to give the flooding problems and solutions back to community. The community were given ownership of the problem and leadership to find and agree solutions, with full advisory support of both Councils. This approach was based on a joint position of Councils that it will offer a unique opportunity for the community to resolve this issue, within Councils' planning cycle. The community understood that not reaching agreement on a solution, will result both Councils not allocating provisions in their plans to address the issue.

This approach involved high level and interaction of the WRC project manager and support technical and administrative staff during the design and implementation phases of the project.

For the community, the approach served building a cooperative and collaborative environment where members of the community felt ownership and responsibility for the success of the project. The success was demonstrated in a number of ways including the following:

a. The consents for the project were granted without notification, despite the environmental sensitivity of the site.

b. The works encroached on people's properties and the Manaia Causeway was closed for several weeks with only one minor complaint received over a fifteen months implementation period.

c. Members of the community provided support and helped mediation to resolve issues raised by other members.

d. Despite the stream experiencing several floods during construction no issues were raised by the community, as they were kept informed on weekly basis of what work was underway and how issues were resolved. There was also community support in responding to floods.

e. The local schools and community were involved in planting 14,000 plants at the end of the project.

5.2 FLOOD CONTROL BY HYDRAULIC SEPARATION

Retaining the stream within the backyards of properties for amenity values was a challenge to conventional flood protection design, which normally involves building a stopbank/barrier between the stream and the property, and/or diverting the stream away from properties.

The hydraulic design utilized the general topography of the natural stream and created a lower level wide floodway extending from the diversion channel to the Causeway Bridge with a stopbank separating these two channels to a point at the upper estuary boundary. The hydraulic separation created by the system meant that flood pass at higher level within the floodway, while the retained natural stream only received minor back water flow.

The levels of the natural stream hydraulic profile for the 50 year flood event was lower than the building platform of houses built in the floodplain with varying freeboard. The hydraulic separation provided the level of flood mitigation which the community was comfortable with while ensuring the stream was retained.

5.3 SELF REGULATING FLOODGATE

The community wanted the proposed floodgate placed at the upstream end of the culvert to be operated without relying on people going on site to close the gate when floods occur. They also wanted the gate to operate with remote sensing and electrically operated system due to potential power cuts during storm events.

WRC teamed with Wintec – Hamilton and supported a mechanical engineering student (Juan Martinez) project to design a self-regulating floodgate. The gate operation mechanism was to rely on stream water levels so that it is opened when the stream level within the diversion channel is at the spillway level, and closes completely when the level is 10 cm above the spillway. Mentoring and technical support to the student was provided by WRC and T&T engineers (Ghassan Basheer and Bryn Quilter) as well as by Wintec.

Different mechanisms were considered and most promising system was selected to create a prototype which was tested and proved successful. At this point drawings for the proposed gate were prepared by T&T and further developed with manufacturing engineering firm Kopu Engineering. The mechanism utilizes a standard of the shelf buoy and counter weights revolving around a shaft with levers and pivots which the flap gate is fixed to. The floodgate was installed and has been reliably operating without any issues recorded. A debris screen at the culvert inlet deflects large debris from entering the inlet and affecting the mechanism.

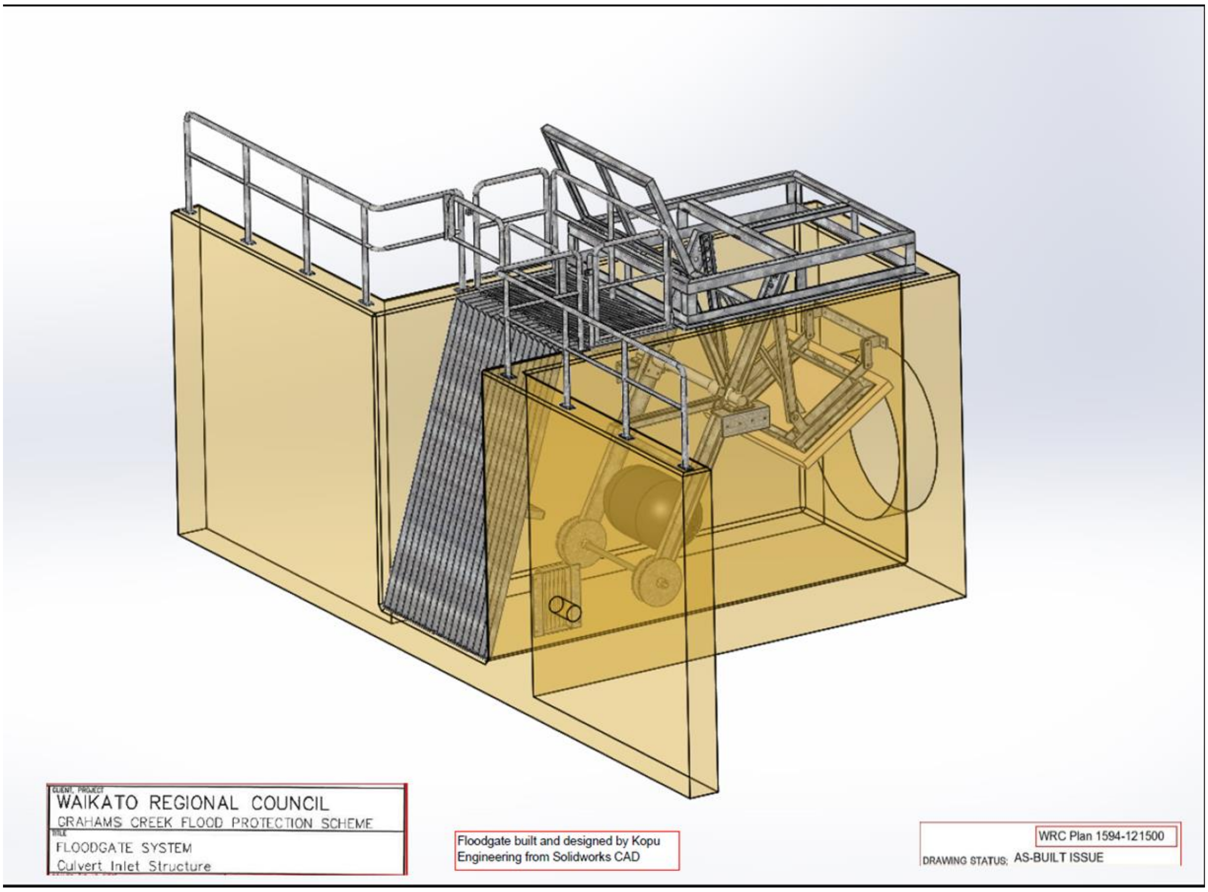

Figure 11: Self- regulating floodgate at Grahams Creek

5.4 SALTMARSH TRANSLOCATION

Translocation of the saltmarsh was another challenge that required close working relationship with the construction contractor. Following discussion of the requirements for a successful translocation, the contractor proposed a methodology for implementation.

The new location within the floodway was excavated 300 mm lower than design bed to accommodate the saltmarsh plants and soils. The operation involved using rubber track pads for the excavator and tracked truck to transport the saltmarsh to the new prepared location within the floodway. The saltmarsh translocation was a careful and slow process covering 4000 m^2 – 300 mm thick layer removed along with plants and relocated in the floodway. This operation was successful in that the saltmarsh plant recovered within the first year and continue to establish.

The site is being assessed independently and reported on to WRC regulatory arm for compliance with consent conditions. In 2018, T&T were employed to assess the site against consent conditions. In their monitoring report, they stated the following in the summary section:

“A site visit was undertaken by T+T staff on 10 July 2018. Site observations from the site visit suggested that restoration plantings and the salt marsh translocation area are continuing to establish well. These observations are similar to previous site visits detailed in Kessels(2017).”

Figure 12: Saltmarsh plants regeration within the floodway 2019

6 LESSONS

The key lessons learnt throughout this project are outlined below:

6.1 COMMUNITY ENGAGEMENT APPROACH IS FIRST STEP FOR SUCCESS

Engaging with communities requires deployment of several communication techniques, peoples skills and approaches to gain their trust, support and buy in. The best outcomes are achieved when the community is enabled to take ownership of the issues facing them and find satisfactory short and long term solutions.

The process requires careful guidance and dedication of Council and staff, however the results are rewarding.

6.2 FOR BETTER UNDERSTANDING RUN THE HYDRAULIC MODEL IN A STEPPED MANNER

Hydraulic models are very powerful tools, especially when the data used in building the model is highly accurate and representative of actual physical parameters. In most cases, practitioners look at the model results such as flow profiles, specific cross sections or extent of water spread.

Significant knowledge and understanding was gained from running the model in a stepped manner. We understood what obstruction and floodplain could not handle the flood volume, thereby increasing flood levels. This helped the design team tailor the solutions across the whole floodplain.

6.3 CHALLENGES ARE OPPORTUNITIES WHEN ACCEPTED

Challenges can be very stressful and accepting these involves taking risks. However, these are also opportunities to innovate and excel by thinking outside our comfort zones.

On this project this was experienced several times, resulting some new approaches and innovative solutions that the project team and community are proud of. These included designing a self-regulating floodgate, providing flood mitigation while retaining the stream within the residential built area, and translocation of saltmarsh.

7 CONCLUSIONS

a. Grahams Creek flood mitigation was a subject of several investigations, reports and community discussions and complaints for over 30 years. The community was divided on the causes and solutions of the floods.

b. A new approach in community engagement involving establishment of working party of community representatives and politicians, supported by Council staff in an advisory role resulted in community ownership of the problem and agreement of an acceptable solution.

c. The project was presented with several challenges which were turned into opportunities to explore new methods and designs.

d. Collaboration of hydraulic modelling practitioners, civil and environmental engineering consultants, ecologists, construction contractors and project management staff, made it possible to deliver the project successfully.

E. The project was completed in 2016 and has been successfully providing flood protection for the community. Several floods including these resulting from the cyclonic events of March and April 2017 have passed with flooding of properties within the community.

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Figures

Tables

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