LIFE IN THE FLOODPLAIN – FLOOD MITIGATION CONCEPT TO CONSTRUCTION

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ABSTRACT

Edgecumbe township is located between major river, canal and stop bank flood protection systems. The town is subject to severe stormwater flooding in relatively minor events. The 28 January 2011 rainfall event was considered to be significantly smaller than the 10-year stormwater design standard, however a number of properties were flooded.

Harrison Grierson was commissioned by Whakatane District Council (WDC) to investigate flooding issues in the north-western quadrant of Edgecumbe. The objective of the project was to alleviate stormwater flooding in order to reduce risk to people and property, while also reducing stormwater ingress into the wastewater system. This project was carried out in parallel with improvements to the town's wastewater system to address issues relating to stormwater infiltration into the wastewater system, which has resulted in wastewater overflows in the town.

The principal outcomes of this investigation were to:

- Identify houses at risk of flooding for a 10-year '2090' design rainfall event.
- Identify, conceptualise, and evaluate potential remedial options within WDC's available capital works budget for Edgecumbe.

The option available within Council budget was a 1.05m diameter gravity stormwater relief pipe, which would reduce water levels by up to 300mm for a 10-year '2090' rainfall event.

From the perspective of a fresh Environmental Science Graduate, this paper will discuss the conceptual design process and challenges experienced during this high profile flood mitigation project, which was successfully constructed in early 2013.

KEYWORDS

Urban runoff, Stormwater Flooding, Floodplain, Climate Change

1 INTRODUCTION

Edgecumbe township is located on the western side of the Rangitaiki River within the Bay of Plenty, New Zealand. The town is home to over two thousand residents who live in a floodplain.

This Paper outlines my perspective of living in a floodplain. Our livelihood and income relies on six hundred dairy cows situated just 5km north-east of Edgecumbe. Also located in Edgecumbe town is a large Fonterra dairy factory and Transpower which provides the main employment for locals and many other small businesses.

As with much of the Whakatane District, Edgecumbe has a high level of deprivation, many single parent families, low incomes and relatively high housing costs considering that they are located within a floodplain. The town is subject to severe stormwater flooding in relatively minor rainfall events. This is due to its low lying topography. Edgecumbe town is protected from Rangitaiki River flooding by stop-banking provided by the 'Rangitaiki River Scheme' but this scheme does not include protection from urban flooding.

The Edgecumbe earthquake in 1987 reportedly caused up to two metres of land subsidence in the area, increasing land drainage issues for the town and surrounding land. Stop banks were also damaged by the earthquake.

Low lying areas of Edgecumbe, especially within the study area, have ongoing problems with local stormwater flooding. This flooding has numerous adverse effects, including temporary road closures and property flooding. Surface flooding in Edgecumbe is considered to be a major source of inflow into the sewer system, which overloads the wastewater pump stations and oxidation ponds, causing sewer overflows within Edgecumbe and on adjacent farmland. Sewer overflows have the potential to cause serious health risk to people and environmental health risks.

Due to the frequency of flooding and the ongoing problems with wastewater infiltration, WDC commissioned Harrison Grierson to investigate the stormwater flooding issues in the north-western quadrant of Edgecumbe.

Having grown up and spent the majority of my life living on a floodplain, I have always been aware of the risks and issues that surround us during flood events. My involvement in this exciting project from concept to construction within my first year at work led me to share my experiences and perspectives within this Paper.

2 CATCHMENT DESCRIPTION

The study area is located in the north-western quadrant of Edgecumbe town, which is low lying with residential and light commercial areas covering approximately sixty hectares, including two schools and a small commercial area.

The catchment is immediately adjacent to the Rangitaiki River to the east, with the Omeheu Canal approximately 1km to the west. Edgecumbe is heavily reliant on the Omeheu canal for land drainage, and this is managed by Bay of Plenty Regional Council (BoPRC). The major features within the study area are shown in Figure 1 below. The main land drainage schemes on the Rangitaiki Plains were completed in the years before, and following, World War 1. For many years after the Plains continued to be subject to almost annual flooding from the Rangitaiki River. Finally over the period 1971 to 1980, the Bay of Plenty Catchment Commission completed the Rangitaiki-Tarawera River major scheme. The key elements of this scheme include:

- Stop banking of the main river channel from below Te Teko, past Edgecumbe, out to the river mouth at Thornton.
- Stop banking of the lower Tarawera River and river bank protection works across the whole catchment including the Galatea tributaries.
- Reids Central Floodway.

Due to its physical location between two major rivers (Rangitaiki and Tarawera Rivers) and major land drainage systems, flooding can originate from many sources, including:

- Overtopping or breach of the Rangitaiki River stopbanks.
- Overtopping or breach of the Tarawera River.
- Overtopping or breach of the BoPRC drainage canals, such as the Omeheu Canal.
- Urban stormwater falling within the immediate urban catchment area.

This investigation only considered urban stormwater arising from rainfall on the Edgecumbe township, however this Paper discusses the wider flood risk implications.

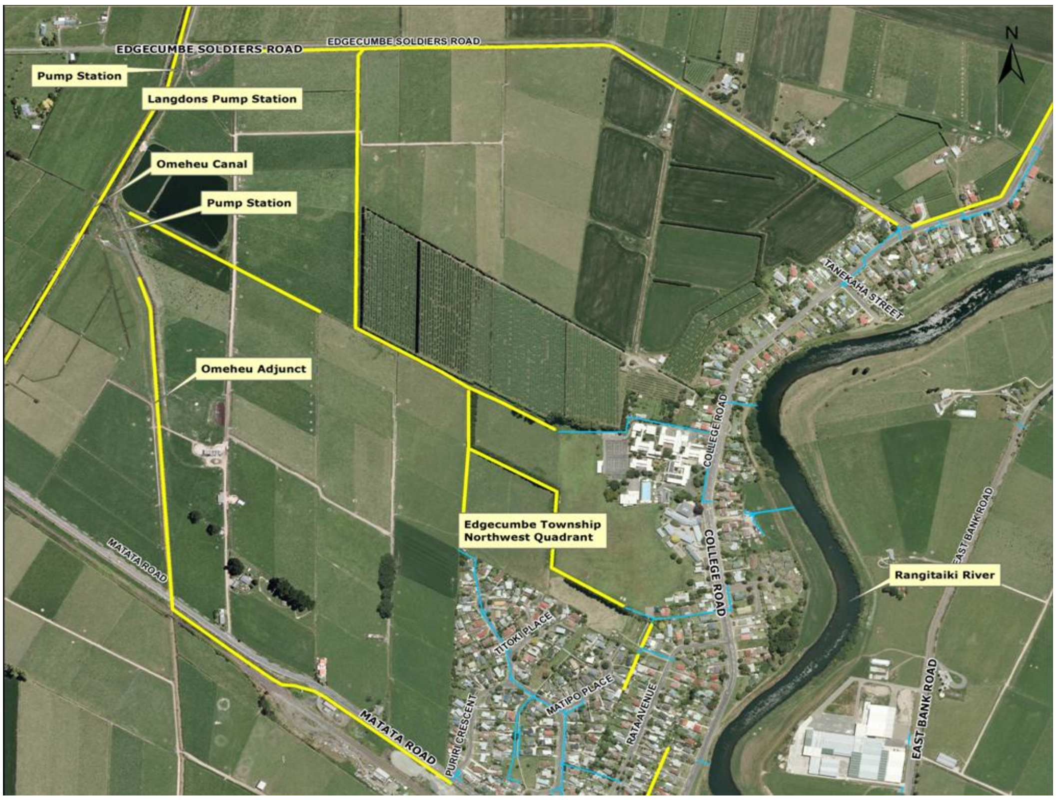

Figure 1 - Study Area Overview and Main Features

3 HISTORICAL FLOODING

A flow of 464 m3/s severely tested the rivers and drainage scheme in 1998. This flood had an extended hydrograph lasting over seven days. The flood was not large enough to spill into Reids floodway, but came within 0.5m of overtopping in the lower river downstream of Edgecumbe, highlighting a lack of channel capacity in the lower reaches. This flood caused damage to several properties, leading to some becoming uninhabitable.

Figure 2 –Flood looking towards the Fonterra dairy factory

In 2004, a second major river flood occurred and was estimated to be a 100-year flow which peaked at approximately 760 m3/s. The stop bank breached at Sullivans bend on the rising limb of the flood, shortly after the spillway to Reids floodway had commenced operation. Stopbanks at several spots within Edgecumbe were under severe stress and the Sullivans breach may well have prevented a breach within the Edgecumbe urban area by diverting water out of the main channel and immediately reducing downstream water levels.

This flood also caused significant damage to several properties due to the stormwater not being able to escape through the current drainage network leading to many homes again becoming uninhabitable.

At an early stage of the investigation we spoke to several home owners who were affected by the urban flooding and confimed our modelled flood extent was correct. This was a great experience talking with land owners and get an outside perspective of how the flood affects their daily life. Land owners also provided us with some footage and photographs of property that was flooded in the township, as presented below.

Figure 3- Children wading in urban flooding in January 2011on Matipo Place in the study area.

Figure 4 – Flooded properties on the corner of Puriri Crescent during January 2011 urban floods

With over three times more water entering the Edgecumbe wastewater system than would be expected for a town of this size, it was clear that the stormwater infiltration issues needed to be addressed and minimized. Ever since the 1987 earthquake locals have deemed the two meter subsidence to be the cause of a lot of the wastewater and stormwater issues, however, prior to the earthquake these issues were present. Due to damage and faults, there was definitely higher inflow and infiltration of water into the system through cracks and seepage. This puts an extremely high amount of pressure on the lines and oxidation ponds to hold volumes that they are not designed for, and in turn leads to overflows. Overflows increase the level of stormwater flooding, are a public health risk and also cause significant inconvenience to the community and council. WDC have strategically incorporated the stormwater upgrades to benefit the wastewater system as well, this is a very efficient way of minimising both stormwater and wastewater issues in the Edgecumbe township.

4 TECHNICAL ASPECTS

4.1 HYDRAULIC MODELLING

A full pipe model was constructed using InfoWorks Integrated Catchment Management software. This included a 2-dimensional model of the overland flow surface, and integration between the pipe and overland flow networks.

The HIRDS version 3 design rainfall statistics developed by West (2011) assumed a 16% increase in rainfall intensity to the year '2090' as derived from climate change guidelines (MfE 2008). The modelled maximum water level is generally within 150mm of the surveyed floor level at these known flooded locations. Given potential rainfall variability from the Thornton gauge, and likely error in the LiDAR data, 150mm is considered to be a good match. Assessment of habitable floor flooding was considered to be indicative to allow quantification of the effectiveness of proposed mitigation options. The model was considered to be a good tool for the assessment of mitigation option effectiveness.

4.2 MODELLED SURFACE INDUNDATION

The maximum modelled water depth for the 10-year '2090' design rainfall event is shown in figure 5. There are three main areas of inundation:

1. In the northern extent of the study area, at Tawhara Place, Titoki Place and Matipo Place.

2. Further south around the intersections of Hinau Place, Rata Avenue, and Puriri Crescent.

3. Properties on the southern side of Bridge Street.

The described flooding was well verified by speaking with locals affected by the flooding, including a local fireman who assisted in the 2011 flood recovery.

Figure 5 – Maximum Modelled Depth, Existing Pipe Network, 10-year '2090' Rainfall event, and Flooded Habitable Floors.

4.3 FLOODING OF HABITABLE FLOORS

With the current pipe network configuration, nineteen houses were modelled as being flooded from urban rainfall runoff during the 10-year ‘2090’ rainfall event on flooding. Habitable floor flooding was been identified as follows:

1. When the floor level has been surveyed, the habitable floor was deemed to flood when the modelled maximum water level over the whole parcel boundary exceeds the surveyed floor level

2. If the floor level was not surveyed, the habitable floor level is deemed to flood when the maximum modelled depth over the whole parcel boundary exceeds 0.5m. This is analysed by intersecting the 2D overland mesh results from InfoWorks ICM with the parcel boundaries, and summarising to identify the maximum modelled depth over the whole parcel.

5 PREFERRED MITIGATION OPTION

Pumping to the Rangitaiki River was considered to be the best option, however due to the low relief of the area, the potentially elevated water levels in the stop banked receiving environments, and the volumes of water involved in urban flooding.

Budget was a major constraint as the available construction budget was approximately $350,000. Therefore, measures for comprehensive flood protection from all possible flood sources, including pumped options were not considered feasible. Only runoff from the immediate urban area, utilizing gravity drainage options could be considered. Gravity options could potentially involve overland, or piped solutions. Three mitigation options are considered as below:

1. Mitigation Option 1 – Overland flow from the northern end of Matipo Place, to the open drain system. This option was discounted at an early stage due to the higher contour at the northern side of Matipo Place and Tawhara Place.

2. Mitigation Option 2 – A 1.2m diameter pipe from Puriri Crescent (between 32 and 34 Puriri Crescent), heading north-east through reserve, to the open drainage system. This option was later discounted in discussion with WDC in favour of Option 3. This is due to the lowest topography, or area of deepest ponding, being on Matipo Place, rather than Puriri Crescent.

3. Mitigation Option 3 - A 1.05m diameter stormwater relief pipe from the intersection of Puriri Crescent and Matipo Place, heading north-east to the open drainage system.

Model results indicate that the proposed 1.05m pipe is effective in decreasing flood levels by up to 300mm for the 10-year design rainfall event at the lowest point in Matipo Place.

The impact of this is to reduce the number of habitable floors assessed as flooding from around 19 to 3 subject to the limitations of the analysis. This suggests a pipe can be a very effective solution in mitigating flooding of habitable floors in the study area, provided water level conditions in the receiving environment do not significantly impede the flow in the pipe. This is likely to be the case only in significant rainfall events (in excess of the 10-year design rainfall considered here) where considerable flooding may occur in the farmland around the Omeheu Canal.

One of the main objectives for this study was to prevent ingress of stormwater into the wastewater system. As such the duration of flooding also needs to be considered. Model results indicate that the duration of flooding is also substantially reduced. Figure 3 below shows the modelled duration and depth of flooding before and after the stormwater relief pipe is modelled.

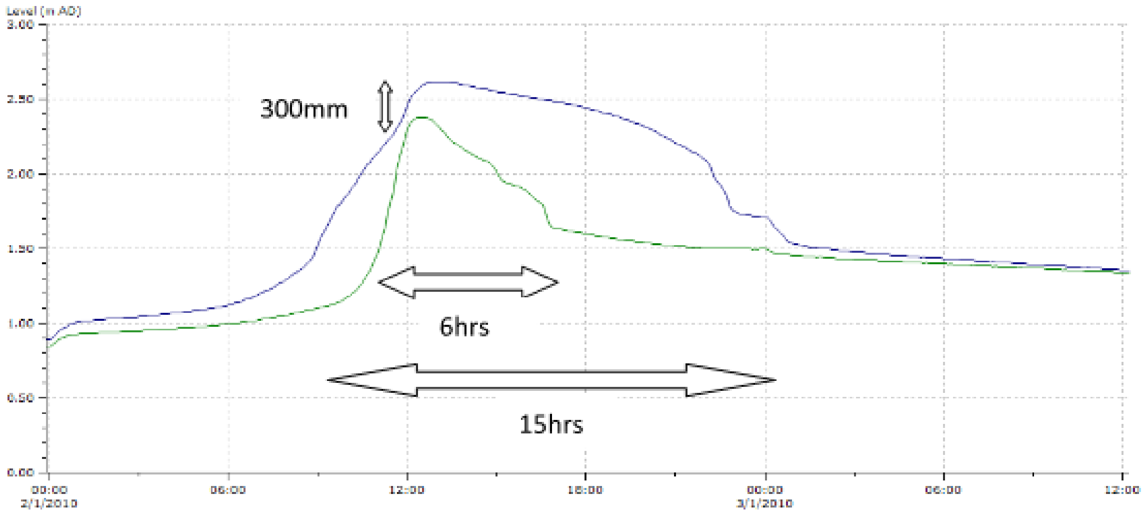

Figure 5 - Levels on Matipo Place before and after installation of Mitigation Option 3 for the 10-year design storm shows a 300mm reduction in peak level and a 9-hour reduction in flooding duration.

6 FLOOD MITIGATION ASPECTS

Key issues and concerns in Edgecumbe relating to the four-well beings include the following:

Social

- Improved protection of people's property and lives from flooding
- Doesn't make people want to leave their home towns anymore
- Livelihood
- Protects their assets
- Improves their living conditions

Environmental

- Risks associated with flash floods after heavy rainfall
- Health impacts associated with the spreading of diseases associated with the slow flow speed of water and wastewater sitting in the township.

Cultural

- Polluting the local, natural kai
- The construction of land and/or re-diversion of waterways to alleviate flooding is upsetting the Mauri or Edgecumbe

Economic

- Frequency of flood events vs. justification of this project
- Consider the cost associated with the relocation of people vs. the costs of the project
- Economy of the town

WDC and BoPRC have guidelines in place to control development within flood prone areas by the setting of minimum floor levels for new residential construction through the sub divisional consent process. All building consent applications within the Rangitaiki Plains area received by WDC are referred to BoPRC for review of floor levels.

BoPRC currently provides two minimum floor levels for areas of the Plains within the Rangitaiki flood control scheme boundary. The first is defined in terms of the Q100 flood level from local stormwater, plus freeboard. In areas within the flood spread of a major river breach, a level based on the breach level, plus 500mm of freeboard is also given. The location will determine which level is higher. For areas outside of the scheme boundary landowners are required to obtain independent professional advice to set a floor level.

Within the Edgecumbe urban area there are a number of streets which are below the flood breach level. While there is no requirement to retrospectively raise floor levels of properties, major additions or new dwellings may have floor levels set which will be high relative to existing dwellings – possibly up to 1.5 metre in some streets.

7 CONCLUSION

The objective of the project was to alleviate stormwater flooding in order to reduce risk to people and property, whilst also reducing stormwater ingress into the wastewater system of the Edgecumbe north-western quadrant.

Mitigation option 3, a 1.05m diameter stormwater relief pipe was the preferred choice as the model results indicated that this had the most significant beneficial impact on the flooding issues, reducing maximum flood levels around Matipo Place by up to 300mm and reducing the number of habitable floors flooded from approximately nineteen to three.

The stormwater relief pipe was successfully installed and commissioned in early 2013. WDC strategically carried out this project in parallel with improvements to the towns wastewater system to help reduce the issues associated to stormwater infiltration into the wastewater system. Model results indicated that the duration of flooding was also substantially reduced.

Based on the above outcomes it can be concluded that despite the challenges discussed, the set objectives of this project were achieved within budget and programme.

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