Managing flood risk from the Hutt River, Wellington, New Zealand and impacts on insurance

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Abstract:

The Hutt River catchment in the Wellington region of New Zealand covers 655 km^2, has five major tributaries and is a steep alluvial river with a flood travel time from onset of heavy rain in the ranges to the Wellington harbour of 7 hours (for ≥ 10% AEP event) The Hutt River has a history of flooding, and intensive settlement and land use have created a highly modified environment, with around 70,000 people living on the floodplain and assets worth $NZ6billion at risk from flooding. The Hutt River Floodplain Management Plan, published in 2001, was developed by the Greater Wellington Regional Council and Upper Hutt and Lower Hutt City Councils, and sets out a 40-year management plan to reduce flooding effects from the Hutt River. Improvements are being carried out to upgrade stopbanks from a 1% AEP flood standard to the 0.23% AEP (440 year return period) standard to increase resilience to severe flooding. Greater Wellington Regional Council and Hutt City Council are currently working through upgrading the Hutt River City Centre reach, which will include capacity to allow for increased flows from climate change effects and include channel improvements, stopbank upgrading and potentially, bridge replacement. Following completion of upgrade works, an asset management programme is put in place to ensure performance of completed works is maintained. In this paper implementation of the Hutt River Floodplain Management Plan is discussed, and insights are given into how an insurance company evaluates this progress, and takes it into account in providing insurance cover to protected populations/businesses.

Introduction

Greater Wellington Regional Council (GWRC) manages the flood risk from the Hutt River for flood protection purposes in partnership with the community, city councils and iwi (Maori tribes). Understanding of the flood risk and requirements for improving flood security are driven through the Hutt River Floodplain Management Plan (HRFMP), a 40-year plan to reduce the flooding effects from the Hutt River. Through the HRFMP, structural and non-structural flood protection measures are being put in place; however the Hutt Valley continues to rely heavily on stopbanks and edge protection measures which are being re-constructed and upgraded to reduce flood risks. A comprehensive asset management system is in place to maintain the flood protection and control works. Managing the residual risk of flooding in the event the stopbanks are overtopped or breached is in part covered by the insurance industry. This paper explores how the management and maintenance measures carried out in the Hutt River are taken into account in insurance assessment of the risk to insured assets on the floodplain.

The Hutt River Catchment

The Hutt River catchment covers an area of 655 km^2 in the Wellington Region of the lower North Island of New Zealand, as shown in Figure 1 (from HRFMP, 2001). The river has a 54km main river channel which flows from the Tararua Ranges to the river mouth at Petone and five major tributaries (Pakuratahi River, Mangaroa River, Akatarawa River, Whakatikei River and Waiwhetu Stream).

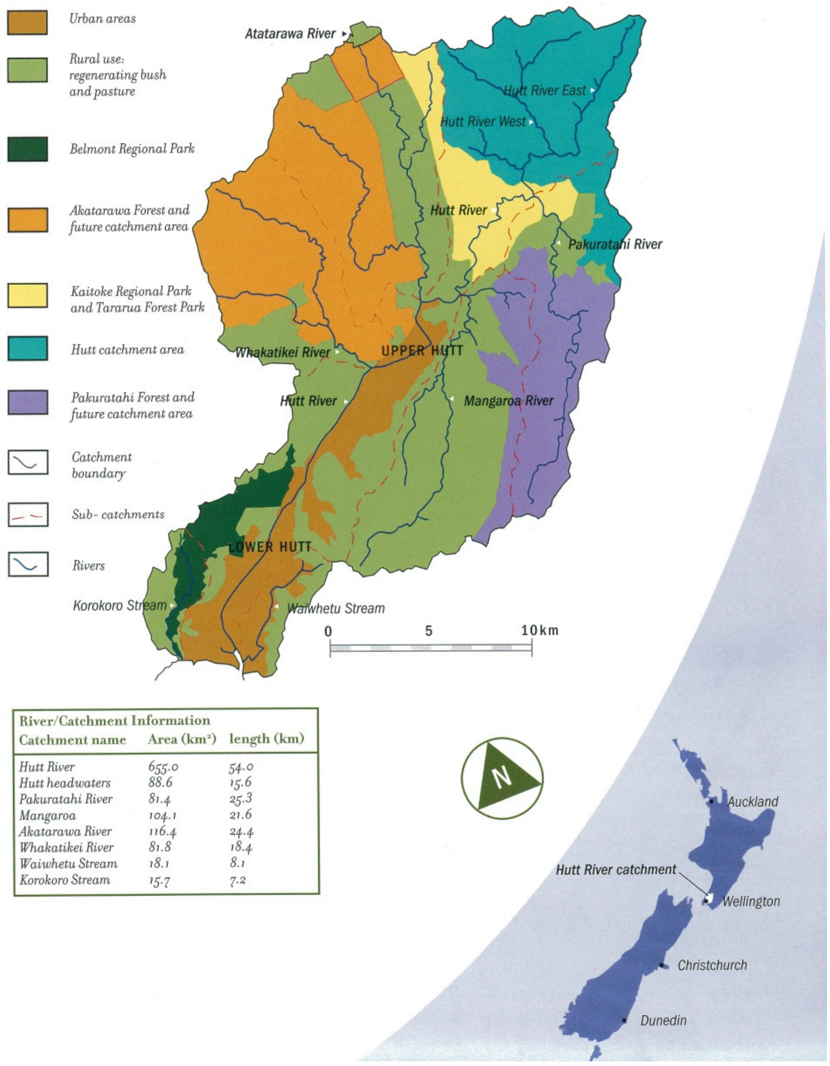

Figure 1: Hutt River catchment

The present river valley was formed through glacial erosion during the last ice age, 2 million years ago (LWTR, 1996). Sea level changes and deposition of gravels also resulted in formation of the Hutt Valley aquifer, now approximately 20m below the present valley floor. The Hutt Valley follows an active earthquake fault (the Wellington Fault) and in 1855 movement of an adjacent fault line (the Wairarapa Fault) lifted parts of the Valley by over 1.5m and drained the estuarine swamps of Petone and Waiwhetu.

The early valley was heavily forested and early Maori inhabitants had little impact on the river and its processes. However, the influx of European settlers since 1840 has substantially changed the Hutt River since the early days of settlement. Early mid-19th century surveys showed the Hutt River had large meanders and split channels and a substantial estuary at the mouth. The forested lower catchment was cleared between

1850 and 1880 and is now heavily developed with over 70,000 people living on the floodplain (HRFMP, 2001). Forest clearance resulted in rapid changes to the river system, channel realignment and flooding.

Major uplift during earthquakes in 1420 and 1855 contributed to the river becoming entrenched at the estuary and over time the channel has been progressively straightened and confined as the valley floor was developed (Williams, 2015). The development has further exacerbated the need to manage the river, remove gravel deposits and contain floodwater. Straightening and removal of meanders in the Hutt River from 1943 to 1973 are shown in Figure 2 below.

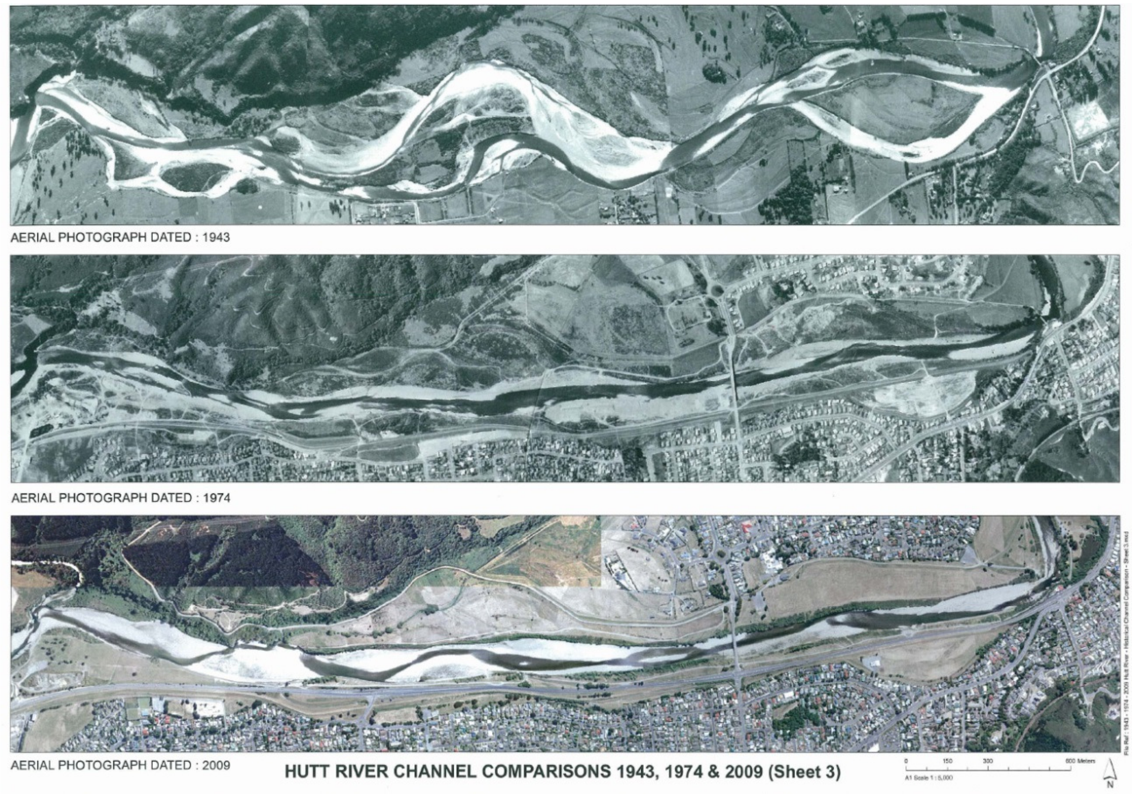

Figure 2: Hutt River Channel Comparisons 1943, 1974 & 2009

Precipitation across the Hutt River catchment varies, primarily due to orographic effects, and is relatively evenly distributed throughout the year but peaks in winter. Mean annual precipitation varies from about 1,200mm a year in low lying areas to 5,000mm a year in some headwater areas in the Tararua Ranges (Wellington Regional Council 1995). The steep alluvial catchment has a flood travel time from onset of heavy rain in the Taraua Ranges to the Wellington harbour of about 7 hours (for ≥ 10% Annual Exceedance Probability (AEP) event). Flood frequencies for the Hutt River at Taita Gorge near the Hutt City Centre are 1751 cubic meters per second (cumecs) for a 2% AEP and 1944 cumecs for a 1% AEP flood event (GWRC Flood Procedures Manual, 2015). Table 1 lists significant historical floods experienced in the Hutt River.

Table 1: Hutt River Historical Floods (Harkness, 2016)

Hutt River Historical Floods Date	Flow (cumecs)	Return Period (year) – based on The National Institute of Water and Atmospheric Research (NIWA) current (1999) flood frequency estimates)
1855	-	-
1858	2000 approx	125
1878	-	-
1893	1550 & 1700	25 & 40
1898	2000 & 1500	125 & 20
1931	1400	14
1939	1600	30
1976	-	-
1994	1196	7
1997	1251	9
1998	1305 & 1540	10 & 20
2000	1253	9
2004	1067	5
2005	1562	25

The river bed load sediment transport capacity of the main Hutt River channel is around 75,000 m^3 a year, based on repeat channel surveys and extraction records. The upper river tends to be eroding, with deposition occurring in the lower reaches and at the mouth. (Williams 2015).

The GWRC Flood Protection Department actively manages the lower 26 kilometres of the Hutt River from Upper Hutt to the river mouth at Petone (Cox & Bibby, 2015). This active management comprises structural and non-structural flood protection measures, and also involves recreational and environmental management, as the river environs are a popular community facility.

The Hutt River tributaries in the upper catchment (Pakuratahi River, Mangaroa River, Akatarawa River and Whakatikei River) are predominantly rural, mainly forest and with some farmland. Increasing pressure is coming onto the flatter floodplains of these watercourses for lifestyle blocks and smaller subdivisions. GWRC watercourse maintenance in these tributaries is restricted to minor extents of the lower reaches where maintenance comprises keeping the watercourse free from obstructions such as fallen trees. GWRC maintains the Waiwhetu Stream, and in partnership with the New Zealand Ministry for the Environment in 2010 carried out a major project to remove contaminated material from the lower reaches of the stream which also improved the flood-carrying capacity to about the 2.5% AEP (40 year return period) flood event. However, the environs of the Waiwhetu Stream are still subject to flooding in more severe local rainfall events, as shown in Figure 3.

Figure 3: Flooding from the Waiwhetu Stream 16 February 2004 (Approximately 2% AEP event)

History of Flooding and Effect on the Community and Development

Flooding of the Hutt River has been documented since early records of European settlement. Floods that reached from one side of the valley to the other occurred with alarming consequences and "during the first 60 years of settlement at least 21 floods were recorded. Histories of the river are littered with tragic tales of drownings, and of homes and livelihoods swept away. Bridges were repeatedly wiped out, stock was lost, gravel and silt were dumped onto good pasture, paddocks next to the river were eaten away overnight." (LWTR, 1996). In response, flood defences were built along the river channel, the river straightened and substantial quantities of gravel excavated to improve the flood-carrying capacity of the river.

Between 1893 and 1972 construction of the Hutt River stopbanks (also known as levees) progressed northwards to protect new housing estates. These stopbanks were constructed to contain the largest flood experienced to date, with an allowance for freeboard. Formation of the stopbanks was accompanied by other river control methods such as gravel extraction (where the gravel was mined commercially as well as used to construct the stopbanks), groyne construction and river re-shaping and diversion by methods such as cross-blading where the gravel is pushed from one side of the river channel to the other to alter the channel alignment.

Since 1972 isolated and sub-standard stopbanks have progressively been extended or rebuilt. Existing stopbanks have been maintained. Large scale gravel extraction and river straightening have steadily been changed to re-establish vegetative bank edge protection works and a healthy riparian ecology (LWTR, 1996).

The priority and standard of works was set in 2001 through HRFMP and since then, in line with the HRFMP the approach has been to upgrade and strengthen stopbanks, bank edge protection and introduce planning controls and emergency management responses.

A particularly large flood over the Hutt River floodplain today may cause injury or even death. Utilities such as electricity, water supply and telecommunications could be put out of action for days. The flood would have wide-ranging social and psychological impacts; there would be physical damage and disruption to homes, schools workplaces, community facilities (such as public halls and clubrooms), essential services (including hospitals) and emergency services. The financial cost from such a flood could exceed one billion dollars. Damages to buildings and roads could take many months to repair, crippling the day-to-day functioning of the Hutt Valley community. Recovery from a large flood is likely to be slow. The associated disruption would have an enormous impact on the regional economy, and may affect the national economy as well. Social and psychological impacts (intangible damages) are likely to cost individuals and the community at least as much again as the physical or tangible damages. (Berghan, 2009)

Floodplain Management Planning

The Floodplain Management Planning process carried out for the Hutt River enabled the GWRC Flood Protection Department to work with other key decision-makers and the community within the Hutt River catchment to identify and agree policies and options for sustainable flood risk management. It resulted in the HRFMP (published in 2001), and involved the following steps over ten years of background work:

- investigating and understanding the probability and likely extent of flooding and the economic, social, cultural and environmental values within the catchment;
- Identifying, evaluating and selecting a range of appropriate management options to reduce the probability and impact of flood risk.

These resulted in a 40-year programme to implement preferred option/s in a manner that ensures a co-ordinated affordable response by relevant agencies and/or individuals.

The HRFMP established an approach for managing the hazard for floods across the spectrum i.e. from very small return period events to the PMF (Probable Maximum Flood). Through the HRFMP the agencies and community agreed a 2300 cumec (0.23% AEP or 440 year return period) design standard for construction of structural works to be built as part of the plan. This was considered a sufficiently high standard of protection that development behind the stopbanks was able to continue unhindered, with no District Planning considerations applied to manage residual risk of flooding i.e. no-build areas, minimum floor level requirements etc. In reality however this means that the residual risk is managed through emergency management and insurance.

Considerable works have been completed since publishing the HRFMP including upgrading stopbanks and improving the security of bank edge protection. Requirements for rebuilding have included geotechnical and hydraulic analyses. The Hutt City Centre Project is the last major structural work required to provide Hutt City with the design standard of protection.

A review of the HRFMP is pending. GWRC is in the process of completing an upgrade of the hydraulic model of the complete Hutt River flood hazard, as it has been 17 years since the model was last updated. Partial models of the flood hazard have been used to evaluate the effects of works (such as the Boulcott Stopbank) carried out over this time.

Of the main Hutt River tributaries, Floodplain Management Planning for the Waiwhetu Stream has begun and some of the background studies have been carried out including flood hazard modelling and mapping. This is not yet completed. Flood hazard mapping has been carried out for the Mangaroa River and the information is currently being prepared for inclusion in the Upper Hutt City Council District Plan so that it can guide future development. There are no plans to prepare a Floodplain Management Plan for this watercourse as the risk can largely be managed through development controls.

Climate Change and GWRC Adaptive Management

Climate change is expected to impact the Hutt River catchment. This is by increasing the water holding capacity of the atmosphere, leading to greater and more intense rainfall, and increasing sea level, with consequent effects on the lower catchment as floodwater is unable to escape. These will increase the flood risk to communities on the floodplain and potentially impact the security of structural measures being implemented through the HRFMP.

The level of service of the Hutt River stopbanks is the 2300 cumec flood event, which is currently approximately 0.23% AEP flood event. Studies have been carried out by the New Zealand Climate Change Research Institute, Victoria University, Wellington looking at the change in flood frequencies for the Hutt River from a range of different emissions scenarios and climate models. These studies show that the frequency of Hutt River flooding is likely to significantly increase over the twenty-first century. A 2300 cumec flood, which is currently considered to have a return period of 440 years [0.23% AEP], could become a roughly 50 year return period [2% AEP] event under a high-emissions scenario. Even under a low-emissions scenario, a flood of this magnitude could still become a 100 year event return period [1% AEP] event. Damage-cost modelling indicates that floods above 2100 cumec begin to have direct, but relatively minor, damage costs. Above 2300 cumec, flood damages increase sharply and have significant financial impacts on the Hutt community". (Lawrence et.al, 2011).

Adaptive management provides an approach for managing flood risk through the uncertainty of climate change by not locking in options that may need to be revisited in future if the planned-for scenario is different in actuality. The Hutt River City Centre project has taken an adaptive approach and considered different options pathways to address flood risk for "what if" scenarios.

Following evaluation of 10 options investigated by a design working group, two options were consulted on with the community. These both included building the flood defences on a widened river corridor to provide and maintain the Hutt River Floodplain Management Plan recommended 0.23% AEP flood standard over a long period of time, with allowances for the predicted climate change impacts on the flood frequencies. (The Hutt City Centre on the Hutt River is shown in Figure 4.) Option A is a one-step process to complete flood defences on the wider corridor. Option B is a staged approach, where part of the flood defences will be constructed to the final profile, but part will be widened in around 20 years' time to maintain the recommended flood standard. Costs are higher for Option B as some of the initial works will need to be demolished, but initial costs are reduced. Option A has been decided as the preferred option by the community. As part of this project, Hutt City Council are endeavouring to improve the linkages between the City and the river, using the stopbank as an active edge to promote commercial development. Also, the New Zealand Transport Agency is investigating Melling intersection improvements with some options including replacement of the Melling Bridge (foreground of Figure 4), which currently has a capacity of around a 1.54% AEP (sixty-five year return period) flood event. The full benefits of the HRFMP will not be achieved until this capacity is increased.

Figure 4: Aerial view of the Hutt River and the Hutt City Centre

Structural Protection Works and Asset Management

Since 1972 over $NZ55 million has been spent upgrading and reconstructing the early flood defences and on managing the Hutt River to reduce the risk of flooding to the community. Implementing this programme of works has resulted in an increased asset base requiring management.

On the Hutt River the GWRC Flood Protection Department is responsible for managing assets with a value of $NZ66.2 million (as at 30 June 2012). This asset management needs to be carried out in compliance with the New Zealand consent regulations under the Resource Management Act 1991, and to meet legal and organisational requirements. These require ongoing monitoring and reporting.

The Department has an asset management system that identifies the services and strategies required to meet a defined level of service on a sustainable and cost-effective basis, and the expenditure and funding needed to achieve this. (Cox, 2014)

Elements of the asset management programme include the following:

- Annual monitoring and inspection of the Hutt River assets are carried out to verify that the various assets are being maintained to the required level of service, that they will perform as designed and that, where required, the assets are being improved.
- Three-yearly aerial photography of the Hutt River. This is used for maintenance and river management purposes, and to report on the ecological sustainability of the Hutt River through pool and riffle counts.
- 5-yearly cross-section surveys to monitor the bed levels and analyse gravel quantities in the river. (Current policy aims to maintain the bed levels, in particular in the lower reaches to approximate design levels, which roughly equate to the 1998 bed levels.)
- Implementation of risk mitigation measures following earthquake risk assessment.

Insurance Evaluation of Flood Risk

Understanding risk is a key factor in determining an appropriate level of financial protection.

History of flooding is a valuable indicator of the presence of hazards for a specific area but, as the world changes it is far from being the perfect guide to the future. Property developments have been gradually modifying the response of floodplains and contributing catchments to rainfall and the variability of climate conditions is notable. Such changes prevent reasonable qualitative or quantitative predictions of the effects of a flood being made, even for the next year or two based solely on history. Hence the importance of having available periodically updated hydrologic and hydraulic studies reflecting the present conditions.

Availability of flood insurance, general facts about pricing

A key aspect of an insurance company's ability to provide maximum capacity, pay the losses they intend to insure against and minimise the impact to coverage terms and conditions, is their ability to understand and manage aggregate exposures like flood, where numerous properties can be involved in the same event. In order to underwrite and price risk, an insurer needs to understand the risk and be able to quantify the severity and the probability of that loss occurring. If the likelihood and severity is high the premium will need to be high to adequately fund the insurance pool. For flooding this assessment results from identifying the potential height of flood waters and the return period of the flood at potentially exposed properties.

Some insurance companies use commercially available models that apply estimated damage against insured value in an estimated area of impact, to give a probabilistic outcome they can use to deploy capacity at an appropriate price, contemplating terms and conditions such as deductibles and limits.

The models do this by variations of the following process:

- Generate various different scenarios for the flood event that could occur, running countless variations that consider the frequency, severity and location of the flood;
- Analyse what the exposure is at the specific property, with physical information about the property fed into the model, such as building construction, occupancy, the presence of basements and below ground areas and replacement value of property;
- The damage to the building is then applied based on past historic loss data matching the physical characteristics of the location. This probabilistic approach can incorporate comprehensive data on stopbanks, and other local area flood protection measures and is able to quantify their effect and also the likelihood and impact of their failure or over-topping in the event;
- The terms and conditions of the insurance policy (limits, deductible, exclusions etc.) are then applied to give outputs such as a loss figure for the event, the Aggregate Annual Losses (AAL) and the Annual Exceedance Probability (AEP).

Stopbanks considered reliable for flood protection can be included into the model to revise the loss estimates based on the impact this has on the flood event.

Reality of engineering should be the basis for insurance cover rather than the uncertainty of actuaries.

Pricing of insurance products should reflect the quality of the risk as well as the level of financial protection for a specific asset located in a specific geographic area. The majority of insurers make efforts to understand their customers, efforts that vary widely depending on the nature of the assets to be protected. For property insurance risks relevant data typically includes the construction type of the main buildings or structures (for example age, construction materials, yard and floor elevations etc.), the type of activities conducted on the premises as well as neighbouring properties, and the presence of risk mitigation features.

Some insurance companies also use engineers to evaluate the flood hazard at flood exposed locations so that this information can be used in both the underwriting process and in the aggregate modelling to provide a more deterministic outcome to this model, deploying capacity more efficiently and pricing accordingly. While the presence of flood and other natural perils is arguably common knowledge these days, understanding the frequency and likely consequences of floods requires very detailed studies and intimate knowledge of the area. If updated hydrologic and hydraulic studies are not available, the use of historical data publically available leads to inconsistent estimations of the flood risk, based on experience obtained from flood events associated with similar types of catchments leading to disproportionate insurance premiums.

Quantification of the risk fully reflective of its quality is critical. On-site risk evaluations offer the best opportunity to refine modelled damage estimations utilising real flood damage databases, as collected post previous events.

This is particularly valuable for both the insured and the insurer particularly if the insurance company is underwriting on a location basis. The data can also be used to revise the location flood loss estimate and resultant capacity, pricing and terms and conditions.

A flood protection stopbank, if understood to be reliable for certain flood frequencies, offers the opportunity to adjust both the output of the model used to determine possible flood loss aggregation for the area and most importantly the loss estimates for a particular property located in the protected area. The terms and conditions as well as the pricing of the insurance product will therefore reflective of the quality of the risk for that particular property.

Some stopbanks are better than others – let's give them the credit they deserve

Communities adopt a certain level of protection (e.g. 1%, 0.2% or rarely 0.001 % AEP) but there is still an inherent risk of stopbank failure even when floodwater remains below the intended protection height due to poor design, insufficient maintenance or operator error. Stopbank failure or even only overtopping results usually in catastrophic damage depending on the depth of water and the wide expanse of flooding.

There is a vast investment in building and maintaining flood mitigation structures. Lower property insurance premiums is one of the positive outcomes of having a reliable stopbank system in place.

It is the responsibility of the local authorities in charge of the flood protection scheme to determine the level of protection (in consultation with the community) and for these authorities to be satisfied on ongoing basis with the scheme's physical condition. For property owners in the area to benefit from a premium fully reflecting the mitigated risk, information about the design, construction, maintenance and operation of the flood protection system should be made available to interested insurance companies:

- Stopbank extent, the protected area map (best represented by the stopbank failure flood extent map for the 1% and 0.2% AEP flood events in GIS format), and the longitudinal flood profile showing the elevation of the stopbank obtained from the latest hydraulic studies and stopbank topographical surveys are of particular importance.

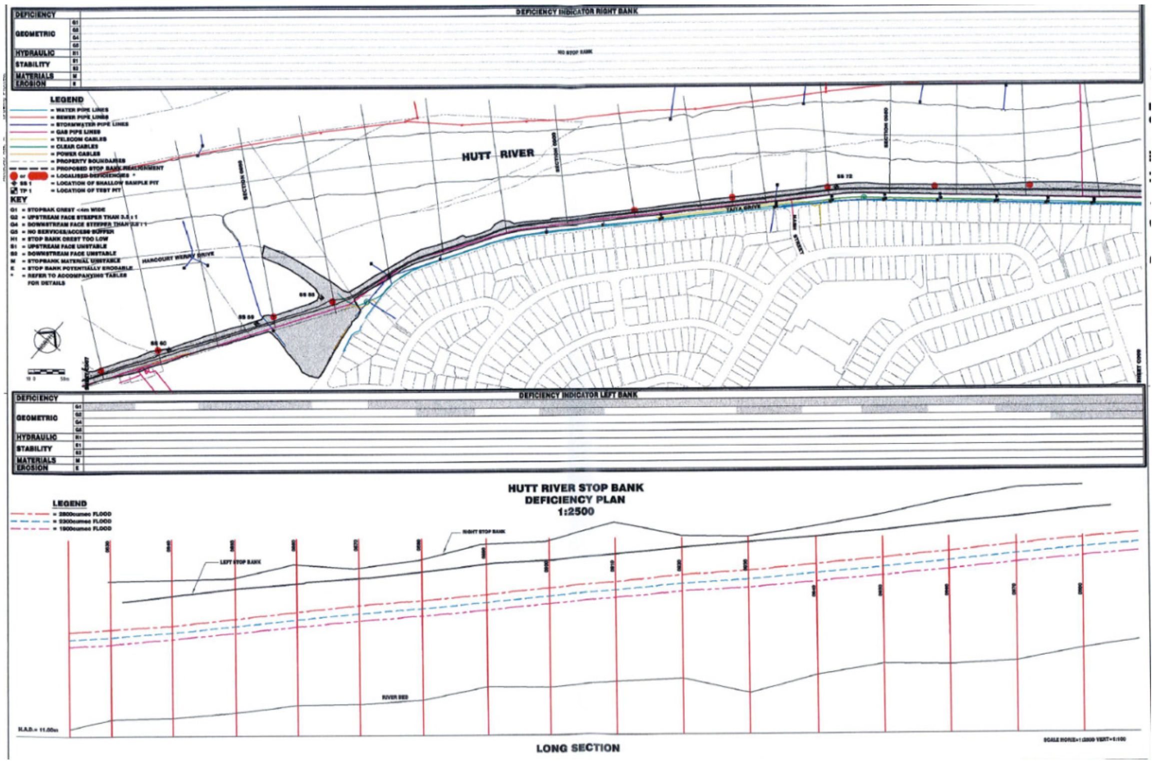

Figure 5: Longitudinal flood profile vs. stopbanks height, cross sections 820 to 980 (Beca Carter Hollings & Ferner Ltd., 1999)

The freeboard of a stopbank is intended to compensate for several factors like uncertainties and simplifications in the hydrological-hydraulic models used to predict flood flows and flood levels, wave action and localised hydraulic behaviour, as well as settlement.

Traditionally, the minimum freeboard adopted for stopbanks varies from country to country between 0.5 m and 0.9 m. However, there are stopbanks with lower (0.3 m) or no freeboard.

While lesser freeboards are undesirable, better understanding of the flood protection scheme including positive features used in the design and construction of the stopbank, together with a well-documented and implemented operational, maintenance, monitoring and asset management plan may allow in certain situations for a stopbank with a relatively low freeboard to be given a certain level of credit for underwriting purposes.

Longitudinal profiles for lower frequency flood events (for example Probable Maximum Flood (PMF) or 0.1% AEP) when compared with the stopbank profile can further support the acceptability of a relatively low freeboard.

- Peak flood levels and extent maps allow for a superior evaluation of the risk and understanding of the flood behaviour. Peak flood depth and extent maps also provide a general indication of the risk particularly valuable when yard or building finished floor levels are not readily available. The capability to obtain site specific flood levels for various frequencies is very important and generally not available interrogating shades of colour on a map, particularly if they are based on larger than 0.5 m depth intervals.

  It is not uncommon, as in the case of the Hutt River flood protection scheme, for the design flood (0.23% AEP), to fall between the numbers used by the insurance industry. Fortunately the height of the upgraded stopbanks includes at least a 0.9 m freeboard allowing for the 0.2% AEP to be also contained by the stopbanks with a slightly reduced freeboard.

- Climate change and sea level rise scenarios provide valuable information for planning purposes as well as design of flood mitigation structures. Given the uncertainties of the predictions and to prevent the need for raising the stopbank in the foreseeable future, a higher design standard and therefore a larger freeboard for today's 0.2% AEP flood, where applied, will help increase the reliability of the flood protection scheme. To take full benefit of any flood mitigation scheme it is of paramount importance that hydraulic models also provide outputs for the current climate scenarios. This will help ensure that for the forthcoming 12 months property owners obtain insurance cover for the current climate conditions and pay premiums reflecting todays level of risk.

- Construction details of the flood protection scheme are valuable in assessing its reliability. This is particularly important as in the absence of an Australian or New Zealand standard for construction of stopbanks, they are designed and constructed utilising at best relevant geotechnical standards and guidelines developed independently by some states in Australia, USA, Netherlands etc. Hence the variety of design techniques employed at the time of (re)construction. Cross sections showing the location and characteristics of the impervious core/key, if required, and drainage systems allow for a better understanding of the scheme. It is important to confirm that the materials used in (re)construction of the (stopbank) are suitable for the modelled flows, velocities and duration associated with the design flood. Best practices recommend the design to provide an adequate factor of safety against sliding, overturning etc.

- Operational plans, up-to-date and well documented, are particularly important for flood protection scheme relaying on manual intervention to close gates or increasing the freeboard height for low areas, if any, in order to place the scheme in flood fighting mode. Service crossings are well managed once identified and well documented. Maintenance and monitoring ongoing tasks well documented in the asset management plan are reflective of the interest and ability to ensure a reliable flood protection scheme.

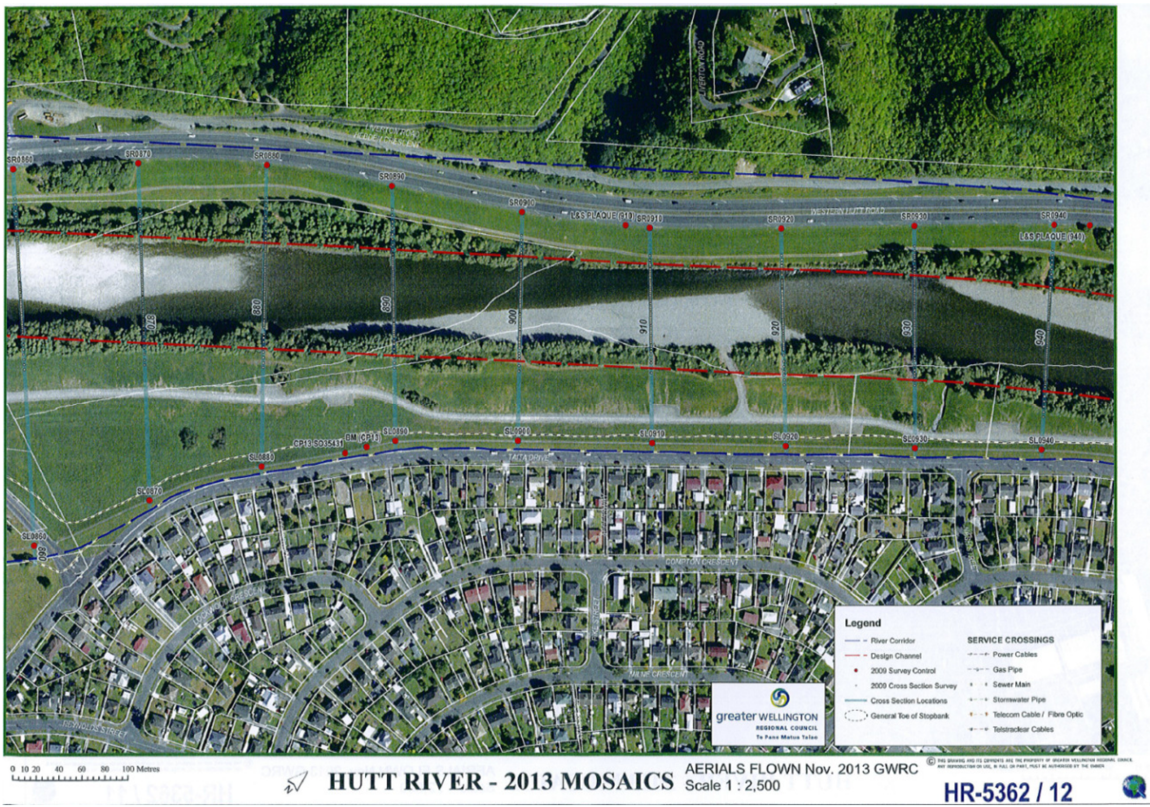

Figure 6: Stopbank elevation survey and services crossings vs. cross sections 870 to 940 (GWRC, 2013)

Open discussions with the GWRC and contractors in-charge of the periodic inspections and ongoing maintenance followed by a visual inspection of the flood protection scheme, including some of the critical components, have been of paramount importance in assessing the reliability level of the flood protection scheme. Controlled vegetation, well maintained embankments, flood walls and gates as well as pumping stations are indicative of an effective management plan.

What else could we do to reduce the flood risk and its potential costs?

Flood protection schemes are of various ages and quality, have varying budgets for maintenance over time and differing amounts of supporting documentation (design, construction, maintenance, operations). Also, they are as reliable as the weakest component for each individual stopbank section. This means appetite for risk, reflected in premiums, will vary from underwriter to underwriter depending on the aggregation of risk protected and the engineering field assessment. The easiest and most comprehensive way to reduce both the risk and the potential cost is therefore to reduce the uncertainty of elements defining them.

This is assisted by:

- Understanding the risk:
  - More accurate flood modelling, including better representation of the bridges, buildings etc. for the present conditions;
  - Better/more accurate studies of worst breach locations and potential for flood damage;
  - Better predictions for climate change impacts (changing rainfall and sea level rise).

- Communicating the risk:
    - Accurate as-built drawings;
    - Survey data;
    - Aerial photography;
    - Documented geotechnical surveys.

- Avoiding the risk:
    - Taking the precautionary approach and avoiding areas of high risk for new development.

- Improving resilience:
    - Flood proofing buildings;
    - Raising floor levels.

Further hydraulic modelling of the Hutt River and periodic surveys of the stopbank elevations will aim for outputs valuable to other stakeholders, namely insurance companies, reassuring all parties of the adequacy of the flood protection scheme to protect against the design flood but also against the 1% and 0.2% AEP floods showing the available freeboard.

Availability of relevant data in a user friendly format and open discussions help ensure correct understanding of the scheme capabilities with the aim of having reduced property insurance premiums reflecting the level of flood mitigation.

Conclusion

The historic development of the Hutt River floodplain has led to extensive development potentially vulnerable to flood hazard. GWRC manages this hazard through implementation of the HRFMP, and monitoring and maintenance of flood protection works such as stopbanks. Assessment by insurance companies of the protection works, their standards and their maintenance is important for accepting risk transfer and determining the associated premiums charged to owners of protected properties. In carrying out their assessment, insurance companies consider owner's opinion about the quality of a flood protection scheme, as well as supporting documentation. Availability of the main characteristics of the flood protection scheme and open dialog with interested parties will support council's opinion and allow an insurance company to give the same level of credit, but possibly higher or lower, based on their own appetite for risk. The insurance industry, considering that it comprises a multitude of private commercially competitive companies, will only have a consultative capability rather than that of driving decisions regarding standards of protection works. In understanding the effects of decisions about the level of flood protection and mitigation, authorities and communities should approach and utilise insurance companies operating in the geographic area to provide some support and explain the (premium) implications of certain decisions.

References

Berghan, T (2009), *KGB to Ewen Project Boulcott Hutt Stopbank Notice of Requirement, Resource Consent Application and Assessment of Environmental Effects Volume 1.* Greater Wellington Regional Council

Beca Carter Hollings & Ferner Ltd., (1999), *Hutt River Floodplain Management Plan*, Deficiency Indication Plan Sheet 8, Fraser Park – Taita Drive, Drawing 3401472/C0008.

Bibby, N. *Flood Protection Asset Management Report for 2014/15* Report 15.461 to the Hutt Valley Flood Management Subcommittee. 20 September 2015. File ENAR-8-89142

Cox, J (2014). *Hutt and Wainuiomata Rivers Asset Management Report for 2013/14.* Report 14.579 to the Hutt Valley Flood Management Subcommittee.20 November 2014. FileN/50/01/30

Floodplain Management Australia, (2015) Local Government and Insurance, Insurer Flood Data Requirements, [online] Available at: http://floods.org.au/wp-content/uploads/Insurer-flood-data-requirements-FMA-ICA-Fact-sheet-May-2015.pdf [Accessed 6 Mar. 2016].

Greater Wellington Regional Council. Flood and Erosion Hazard Information Sheet 1, [online] Available at: http://www.gw.govt.nz/assets/Our-Services/Flood-Protection/Hutt/Hutt-Haz-Maps/Hutt-River-Flood-and-Erosion-Hazard-Information-Sheet-1.pdf

Greater Wellington Regional Council, (2013), Hutt River 2013 Mosaics, aerials flown November 2013

Harkness, M. (2016). *Pers Comm*.

Lawrence, J; Tegg, S; Reisinger, A & Quade, D (2011) *Vulnerability and adaptation to increased flood risk with climate change—Hutt Valley summary* The New Zealand Climate Change Research Institute Victoria University of Wellington NZCCRI 2011 report 02.

The State of Victoria Department of Environment, Land, Water and Planning, (2015), *Levee Management Guidelines,* Impact Digital, Brunswick

Wellington Regional Council (2001a) *Hutt River Floodplain Management Plan (HRFMP)*. Report for Flood Protection Group, WRC, Wellington. pp233.