Pinehaven Stream

Floodplain Management Plan

Volume 1

UPPER HUTT CITY
UPPER HUTT CITY COUNCIL

greater WELLINGTON
THE REGIONAL COUNCIL

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1. Executive Summary

The Pinehaven Catchment, located in the eastern hills of Upper Hutt, is home to the Pinehaven Stream and the communities of Pinehaven and Silverstream. These communities have experienced a number of floods. The most significant flood in living memory was a flood event in 1976, and floods have occurred many times since.

Upper Hutt City Council (UHCC) and Greater Wellington Regional Council (GWRC) work together on the management of flood risk in the Pinehaven Catchment. These organisations have formed a Council Project Group which has, over a number of years worked with the community and technical specialists to identify the cause and extent of flooding in the Catchment and to understand key flooding issues.

Building on this work, the Council Project Group has developed this Pinehaven Floodplain Management Plan (the FMP). The FMP establishes goals and objectives for management of flood issues in the catchment that draw on the policies of UHCC and GWRC and feedback from the Catchment communities. The goals and objectives were developed to achieve an overall vision of:

A prosperous, and safe community that proactively manages the risk of flooding in the Pinehaven catchment.

The draft FMP was circulated to the public for comment in 2014. Since then, in response to submissions the flood risk hazard modelling and mapping has been independently audited. The audit findings confirmed the assessment is appropriate however there were ways the flood hazard has been identified can be more clearly communicated to the public. This updated FMP now includes the revised maps. The revised FMP was then consulted on in 2015. This final version of the document takes account of the feedback provided through consultation and documents the Council's understanding of flood risk in the Pinehaven catchment.

The FMP proposes a suite of methods for the management of flooding in the catchment. Together these methods provide a comprehensive and long-term approach for flood management in Pinehaven and Silverstream. The primary methods are a package of structural works, a Plan Change and non-structural on-going stream management activities.

The structural works are designed to provide capacity in the stream for a 4%AEP/1 in 25 year return period flood event and to protect floor levels of homes to a 1%AEP/ 1 in 100 year return period flood event. The works will be focused on key flooding areas around Blue Mountains Rd, Sunbrae Dr, Whitemans Rd, Pinehaven Rd, Birch Gr, Pinehaven Reserve, and Chichester Dr.

The Pinehaven Plan Change will include the flood hazard maps in the Upper Hutt District Plan. The Plan Change will manage development in the area to manage the residual flood risk above what the structural works provide (i.e. anything above the 25 year return period interval flood). This addresses how the planning framework can better address flood issues in the Pinehaven Catchment.

A range of other non-structural methods are also proposed to guide the long-term management of the catchment and will be led by UHCC and in some cases private land owners and community groups. These non-structural methods include:

- Working with the communities to address restrictions to flood flows that are located on private properties (e.g. driveway stream crossings);
- Procedures for preparing for and responding to flood events in the catchment; and
- Maintaining the stream to support its flood carrying capacity and the quality of the stream.

This FMP is intended to be a long term plan and living statement of approach to flood management in the Pinehaven Catchment. It will be reviewed and developed during its lifetime to ensure that it remains fit-for-purpose.

2. Introduction

The Pinehaven Catchment is home to the communities of Silverstream and Pinehaven. The Pinehaven Stream flows from the hills into Pinehaven and on through Silverstream before reaching Hulls Creek and the Hutt River.

The Stream has long been an important part of the Pinehaven and Silverstream Communities. The beauty of the stream and wooded valley attracted people to the area which became a holiday retreat before evolving into the permanent settlements of Silverstream and Pinehaven.

As the two communities have developed, the stream has been viewed as an asset, an obstacle and a threat:

- The stream was an obstacle for developing land. For example, this meant that bridges and other structures were built so that land near the stream could be developed;
- The stream has also been seen as an asset; adding to the beauty and experience of living in Pinehaven and Silverstream;
- Over time as the catchment has been developed around the stream, this development has limited the available room for the stream to naturally flood;
- The communities experienced significant flooding in 1976. Particularly after these floods the stream has also been seen as a threat to properties and people.

Flooding has occurred many times since 1976 including significant events in February 2004, January 2005 and July 2009 when flooding of properties alongside the stream occurred. As a result, the community and councils are well aware of the flood risk in the catchment and accept that measures need to be put in place to manage this risk.

Figure 1: Pine trees typically seen in the catchment

2.1 The Pinehaven Floodplain Management Plan

The Pinehaven Stream is jointly managed by GWRC and UHCC. UHCC manages the catchment and its upper tributaries until they combine in Pinehaven Reserve. GWRC then manages the stream channel from the reserve until it meets Hulls Creek.

GWRC and UHCC are equal partners in the recent flood management investigations that have been undertaken in Pinehaven Stream catchment (for more information on these investigations see Appendix A. These investigations, along with community consultation (focused on identifying the flood hazards and how they should be managed) have led to the development of the Pinehaven Floodplain Management Plan (the FMP).

The FMP represents a long term approach to floodplain management within the Catchment:

- Section 3 provides a background of flood issues in the Catchment;
- Section 4 sets out the goals, visions and objectives of the plan;
- Section 5 summarises elements of the environment that were considered when developing the plan;
- Section 6 presents the methods proposed for managing flooding in the Catchment;
- Section 7 considers how these methods may be implemented; and
- Section 8 sets out processes for monitoring and reviewing the plan.

UHCC will lead the implementation of the floodplain management plan, and will take over future management and responsibility for the stream.

2.2 Why should I read further?

A major flood could have significant impacts on the community of the Pinehaven Catchment through damaging assets and temporarily affecting access to properties. If you live, have assets or an interest in this area it is important that you read this plan. It contains information about the stream and its tributaries, the risk of flooding, and what has been done to manage the risk so far. It also sets out what the Councils are intending to do and what you can do to minimise your risk in the event of a flood. In addition this FMP outlines potential environmental values in the catchment and how through work in the stream corridor you can help contribute to improving the stream environment.

The plan sets out the outcomes the community wants to see achieved in the catchment. If you were involved in any of the community meetings, you may want to know how your contribution influenced this document. If you have not been involved to date, you may want to know what outcomes were chosen and why.

2.3 Who is responsible for making this Plan happen?

There are three principal groups responsible for implementing the plan. The roles of each of these groups are outlined below:

2.3.1 Pinehaven and Silverstream communities

The communities have had a significant role in determining what appears in the plan. Community members also play a crucial role maintaining private structures within the catchment (many of the structures that can impact flooding are on private property). The community also plays a very important role in:

- Education
- Preparedness
- Funding
- Monitoring and review
- Enhancement of the environment

2.3.2 Local Authorities Roles

UHCC has a role in:

- Controlling land uses through the district plan
- Upgrading and maintaining channels
- Funding outcomes through local UHCC rates
- Emergency management
- Building and maintaining the storm-water pipe networks
- Future management of the stream

GWRC has a role in:

- Regional Plan controls
- Funding through special purpose and regional rates
- Stream management (will transfer to UHCC)
- Flood mitigation
- Flood warning
- Emergency management
- Maintenance of ecosystems and indigenous biodiversity

Other agencies listed in Appendix C are also involved in emergency management activities. These are broadly grouped as health, welfare, relief, law and order and utilities (e.g. gas and electrical supplies).

Figure 2: The Silverstream Shops, 1976 Flood

3. Background

3.1 Pinehaven Catchment

Pinehaven Stream drains a catchment of approximately 4.5km² (450 hectares) on the eastern side of the Hutt Valley. The catchment runs from the Pinehaven Hills down to Hulls Creek. It includes the suburbs of Pinehaven and part of Silverstream and is bordered by the catchments of the Mangaroa River to the south, Stokes Valley stream to the west and Trentham to the east.

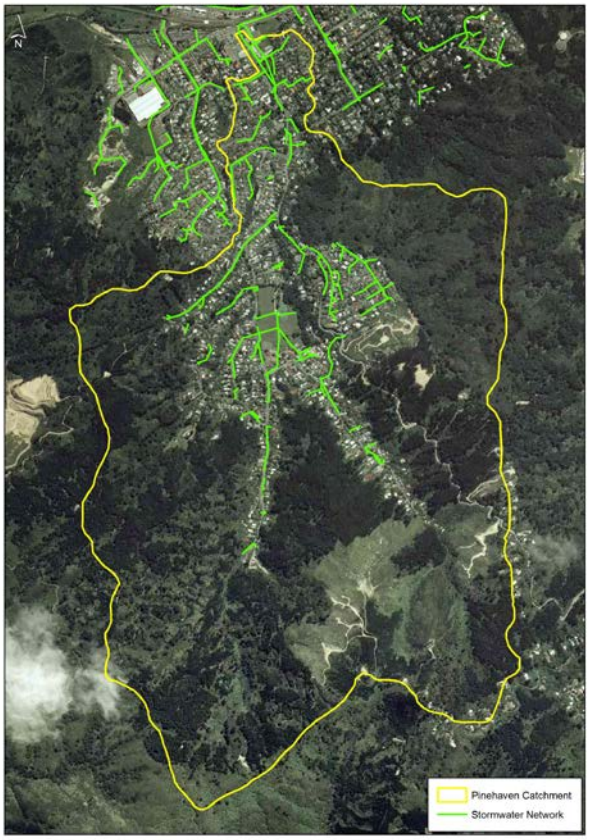


Figure 3: Pinehaven Catchment (Include all catchment)

The upper catchment is comprised of steep-sided, pine-clad valleys from which Pinehaven gets its name. Thin ribbons of housing follow the tributaries of the stream up into these valleys.

In the lower catchment, the valleys meet and drain northwards through the residential areas of Pinehaven and Silverstream. As Pinehaven stream passes through these suburbs it becomes an 'urban stream' with sections of the stream containing bridges, culverts and constructed channels. The stream passes under Silverstream Village in two large pipes and runs into Hulls Creek near Silverstream Railway Station before flowing out onto the Hutt River floodplain.

The Pinehaven Stream is jointly managed by GWRC and UHCC.

GWRC and UHCC have been equal partners in developing this plan which has been strongly informed by the community. This is extremely important as ultimately this plan is for the community and many of the actions in the plan will be implemented by them.

3.2 Why Undertake Floodplain Management Planning?

Floodplain management planning is a process or philosophy that emphasises the need to keep people away from floodwaters. At the same time, it better prepares them for coping with a flood when it occurs.

The process aims to ensure that any future development of the floodplain takes flood risk into account.

Generally this process aims to:

- Minimise risks to life, health and safety
- Reduce the severity of flood damage
- Promote the sustainable use of flood-prone land
- Control future development to avoid flood risk.

The FMP has been developed taking into account the following best practice principles:

- Take a long-term risk management perspective, including climate change, residual risk and having a 'no regrets' precautionary approach to risk and uncertainty;
- Allow for natural processes, such as erosion, debris accumulation, and changes in the stream bed to occur where practical;
- Incorporate 'green' infrastructure, such as riparian planting into flood protection planning and design where possible;
- Incorporate elements of natural stream habitats, such as stream shading, diversity of in-stream (pool, run, and riffle) habitats, and use of appropriate native plants where possible;
- Ensure that existing fish passage is maintained and enhance opportunities for fish passage;
- Use non-structural flood protection methods where possible;
- Integrate flood risk management with sustainable land management and catchment management policies and decisions that affect the magnitude of flooding and/or the consequences of flooding;
- Consider the consequences of flooding, including the resilience and vulnerability of communities and infrastructure as well as the risk to life and property;
- Ensure individuals and communities take primary responsibility for their safety and livelihoods;
- Take a partnership approach with, and between, central government, local authorities, communities and Māori;

- Recognise that local, regional and national perspectives are different and may require different inputs with different goals and outcomes;
- Investment in flood plain management needs to be made at the appropriate level of government that maximises the outcomes sought in flood risk and catchment management, and that this is based on the robust evaluation of options, costs and benefits over time and across the community;
- Floodplain management option selection needs to involve communities as part of decision-making about levels of acceptable risk and mitigation measures for those communities;
- Take an adaptive management approach that is responsive to change over time and that optimises sustainable structural, non-structural and emergency management solutions.[1]

The FMP was also developed to support the implementation of relevant legislation and associated national, regional and local policies and plans. These are outlined in Appendix A.

The success of this FMP relies on collaboration between:

- GWRC
- UHCC
- Iwi
- NGO's
- Community groups and schools
- Private land owners.

This is because the vision set out in the FMP requires the support of not just the council but the community and private individuals to bring it to life. The next section describes how we have engaged with the community to inform the development of the FMP.

Figure 4:1976 Flood

[1] These have been informed by guidance from MfE

3.3 Defining the Problem

Pinehaven stream has a history of flooding. The most severe flooding event in living memory occurred in December 1976 when a severe storm, thought to be in excess of a 1%AEP rainfall event and occurred over much of the Wellington region. This event caused widespread damage throughout the Pinehaven catchment with many homes and businesses flooded.

The 1976 flood is thought to have been aggravated by the debris left behind when large tracts of pine around the valley were felled. This may again need to be considered as an issue given Upper Hutt's Growth Strategy notes potential development in the catchment on Guilford Timber Company's land.

Since 1976, flooding has occurred numerous times in the catchment including significant events in 2004, 2005 and 2009 when streets and properties alongside the stream were flooded.

What is AEP?

Annual Exceedance Probability (AEP) describes the size of a flood event by the likelihood of it occurring in any given year. A 1%AEP flood has a 1% probability of occurring in any year. It is sometimes referred to as a one-hundred-year flood or 1-in-100 year return period flood.

3.3.1 What Causes Flooding?

In the Pinehaven Catchment, flooding is mainly caused by a combination of three factors; rain, urban development, and forestry.

Urban development in the catchment further limits the flows that the stream can accommodate. For example, flooding is aggravated during high rainfall by bridges and culverts which constrain the stream.

Furthermore, the upper reaches of the catchment are dominated by plantation forestry. These plantations go through a 20-30 year cycle of growth followed by harvesting. Forestry debris has, in the past, created restrictions and blockages in the stream. These blockages can significantly increase the extents of flooding.

3.3.2 How was the flood identified?

Flood modelling has been undertaken to identify the cause and map the extent of the flood risk in the catchment. This flood mapping shows that a number of properties in Pinehaven are at risk of flooding.

3.3.3 Independent Audit of Flood Model

Flood modelling has shown that much of the Pinehaven Stream channel can accommodate less than a 20%AEP/ 1 in 5 year return period flood event.

After identifying this flood hazard, the flood modelling completed by Sinclair Knight Merz (now Jacobs) in 2011-2 was also reviewed through an independent audit by Beca Carter Ferner Ltd in 2015 in addition to the peer reviews undertaken by Jacobs and GWRC (refer to Appendix D). This audit confirmed the findings of the flooding model and maps are fit for purpose. Additional recommendations were also provided outlining it would be useful for the following map layers to be included in addition to the 1 in 100 year return period flood maps and maps showing Flood Sensitive Areas:

- *1 in 10 year flood extent* incorporating climate change to 2090
- *1 in 100 year flood hazard* map showing the flood extent and food risk within the extent from low to high based on an assessment of flood depth and flow velocity.

These maps have now been included in Volume 2 maps.

A full set of flood maps are provided in Volume 2 maps. Table 1 shows the approximate number of dwelling floor levels that are at risk of flooding in different sized flood events (from 10%AEP to 1%AEP).

Table 1: Buildings at risk of flooding[2]

	Depth Above Floor Level (mm)	Number of floor levels at risk to each flood level category			
		10% AEP	5% AEP	2% AEP	1% AEP
Level 1	-100-0	12	11	16	13
Level 2	0-50	2	3	5	12
Level 3	50-500	4	7	7	8
Level 4	500-2000	0	0	0	0
Total		19	21	28	33

[2] Note, when the blockage scenario is included the numbers identified above approximately doubles the number of floor levels at risk across each AEP category.

Birch Grove

The properties surrounding Birch Grove have a history of flooding. In 2009, during what was thought to be between a 10-20%AEP / 1 in 5 and 1 in 10 year storm event, floodwaters entered a number of garages, sleep outs and sheds.

Much of the flooding in Birch Grove results from the nature of Pinehaven Stream as it passes the street. The stream is narrow and is constrained by several bridges and fences. In a flood event, overflow from the stream passes through low-lying properties before reconnecting with the stream near Pinehaven Road. The overflow path creates a hazard for properties in the area and could cause ponding up to 0.5-1m deep in a 1%AEP storm.

In addition to overflow from the stream, observations by residents also indicate that in heavy rainfall water also flows down Winchester Ave, crosses Pinehaven Rd and contributes to the flooding in Birch Grove.

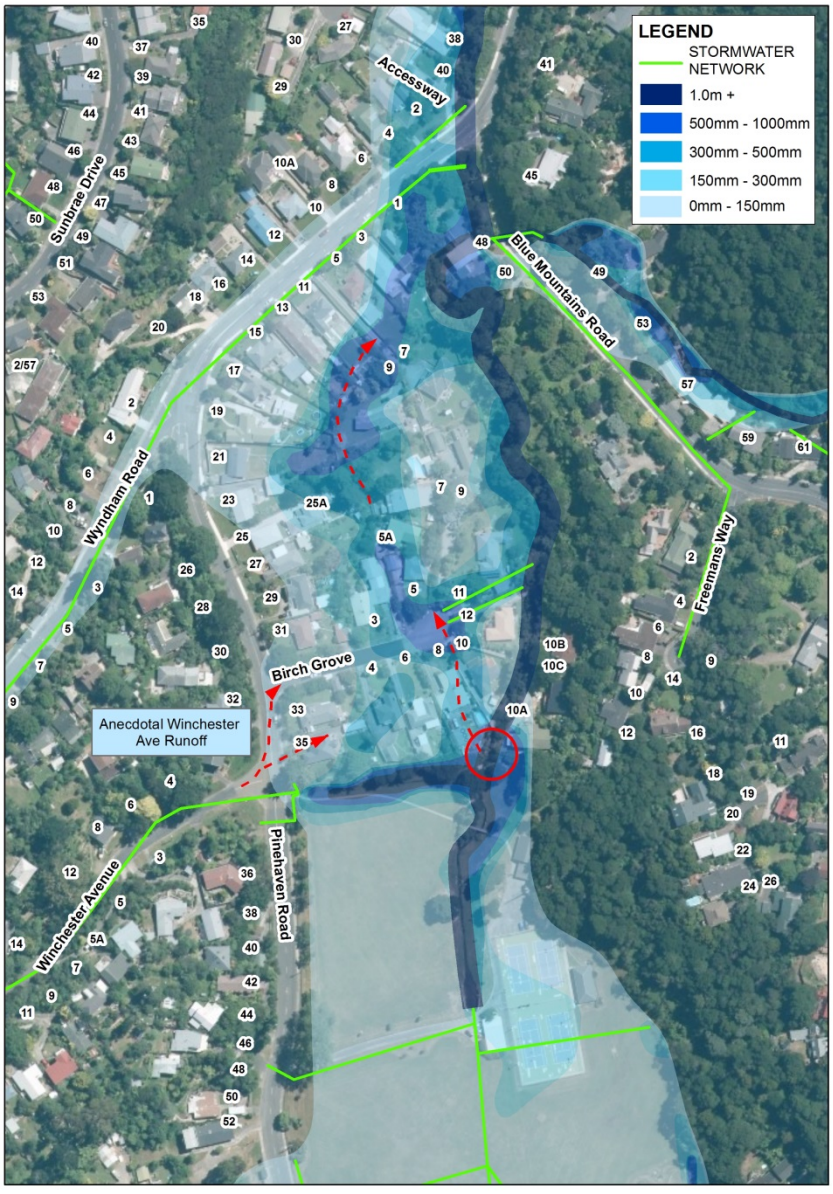


Figure 5 – Modelled flood depths at Birch Grove

Blue Mountains Rd

The properties along Pinehaven Stream, between 2 Pinehaven Road and 28 Blue Mountains Road are a known flood prone area. In this location Blue Mountains Road is on the true right bank of the stream and is significantly higher than the true left bank of the stream. So, any overflows are directed through these low lying properties on the true left bank. This situation is aggravated by a number of bridges over the stream and by the Sunbrae culvert located downstream.

In some flood events, waters could exceed the floor levels of these properties. In 2009, flood waters came within 30mm of the floor level of one house.

Figure 6 – Modelled flood depths at Blue Mountains Road

Sunbrae Drive

Pinehaven Stream currently passes under Sunbrae Drive in a culvert. This culvert limits the capacity of the stream and contributes to flooding in the area.

In 2009, the stream overtopped the culvert resulting in flooding of the road and a number of surrounding properties. When the culvert overtops, the water flows west along Sunbrae Drive and ponds in the low point at the intersection of Sunbrae Drive and Deller Grove.

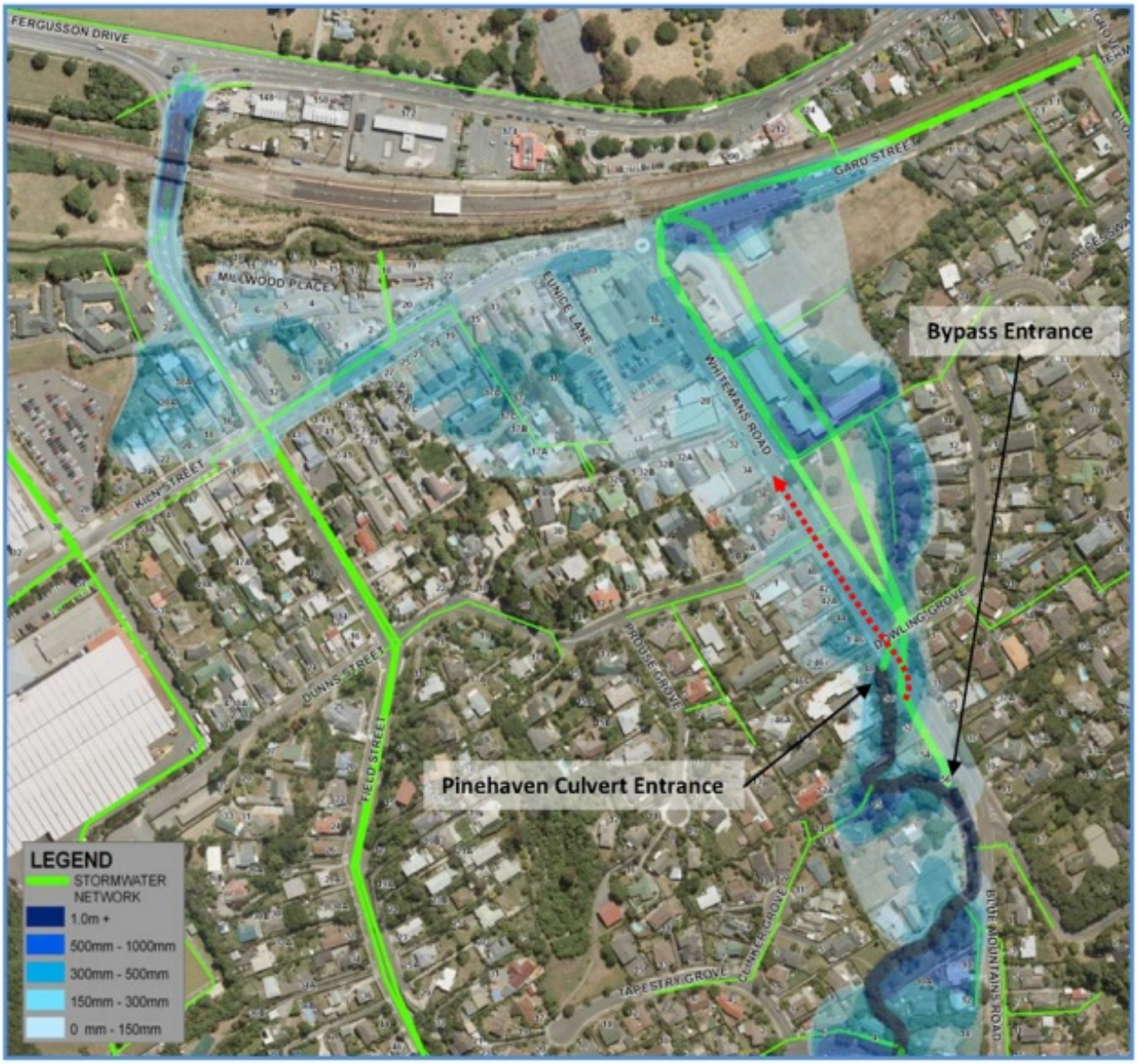
Figure 7 – Modelled flood depth at Sunbrae Drive

Whiteman's Road

Pinehaven stream is piped from near 48 Whiteman's Road into Hulls Creek near the Silverstream Railway Station. Parallel to the piped stream is the Whiteman's Road bypass whose inlet is located near 54 Whitemans Rd.

This bypass was constructed to help prevent a reoccurrence of severe flooding experienced in December 1976 and provides flood protection to the area in a 2%AEP/1-in-50 year return period storm event. With all the vegetation, sheds and fences that line the banks of the stream, there is a risk that the bypass will block during a storm, the resulting flooding could reach properties on either side of Whitemans Road, including Silverstream School and Silverstream Village. As the flooding is over a wide area it would mostly be shallow and is unlikely to exceed floor levels of houses in many locations. However, some lower lying residential and the commercial properties in Silverstream Village could be at risk of flood damage.

Figure 8 - Blockage forming at bypass intake



3.4 Consultation undertaken during the FMP Process

The Pinehaven and Silverstream communities have been included in the development of flood risk management for the Pinehaven stream catchment since completion of the draft flood modelling in 2009. The community engagement has predominantly involved public open days and meetings with the flood and proposed stream work affected property owners. In addition, information and resources have been made available to the community through both printed and web based material.

Letter Drop

At the start of this project, an initial letter drop was undertaken. This included information on the local flooding history and the sharing of experience was invited from the residents in the Pinehaven catchment. Pinehaven has numerous long term residents who have valuable knowledge of past flooding events, including the flooding in 1976. Council staff and Jacobs (formerly SKM) met and discussed flooding history with a number of residents, whose local knowledge proved to be invaluable in verification of the modelling work and in understanding the catchment.

Drop-in Session

A community 'drop in' session was held in Pinehaven on 12th September 2009 where residents had the opportunity to comment on draft flood hazard maps prepared from initial modelling results for the 10 and 100 year storms. Over 150 residents took the opportunity to comment and a large amount of detailed information relating to the catchment was collected. Where applicable, this information was used to enhance the hydraulic model and assist in the mapping of the flood hazard. The overall consensus of the residents was that, the predicted flooding extents matched what they had personally observed and experienced. This endorsement adds further confidence to the outcomes of the investigations.

Open Day

An open day and evening was held on 18th July 2012 to discuss and develop combinations of options with the community. The open day was visited by 60 residents and the general attitude was supportive of the need to undertake direct action to increase the management of the risk.

The open day highlighted high level community values of the stream, including discussion of; impacts of the project on ecological values of the stream; the cost of the project; cost and fear of damages; development and planning controls; and timeframes for implementation.

Property Owner Consultation

Individual meetings with property owners impacted by potential structural options have been on-going since these were identified in 2012. These relationships will be maintained between the property owners, GWRC and UHCC throughout implementation of the floodplain management plan.

Figure 9: Photo from the community consultation drop-in held on 12th September 2009

These meetings discussed the direct impacts on the particular property owners and identified the values which were important to those owners. These discussions aimed to identify the social, environmental, cultural and economic values held by property owners. The meetings covered broad topics including; spiritual attachment to the area, visual appeal, recreational opportunities, ecological health, flood risk, security, access, affordability, connectedness, community, resilience and emergency management.

2014 Consultation and Submissions

The draft FMP was notified to the community in October 2014, which gave the community an opportunity to make submissions. 32 submissions were received, predominantly from private property owners within the catchment. The primary concern raised by the community was if the flood modelling and map extents were accurate. As part of this, many submitters requested an independent audit be undertaken. In direct response to the submitters concerns, an independent audit was undertaken. This review concluded that the modelling was accurate and fit for purpose.

Other issues raised by two submitters included making sure trees and native bird populations in Pinehaven were recognised and managed through the design of structural improvements. The first stage of the ecological survey for future works has now been undertaken and will inform future design activity.

2015-2016 Consultation and Submissions

A revised draft FMP was released for consultation in September 2015. The purpose of this consultation was to not only outline how the independent review of the flood modelling had been undertaken and influenced the design of the updated FMP, but to undertake further engagement on the Plan Change request to the Upper Hutt District Plan and to understand any further views on the proposed structural works.

Open days were held alongside other related activities that were being consulted on by UHCC. Over the two open days 40 people[3] attended who noted they were there to understand the FMP.

Attendees represented a broad area of the catchment, drawing residents and owners from the lower, middle and upper catchment, and included both those who were subject to potentially significant flooding, and those who were outside the identified flood prone area.

Submissions on the FMP were sought, both through the open days and via GWRC and UHCC websites and facilities (such as the Pinehaven Library). The submissions received were considered and updates were made to the FMP, including the clarification of 'stormwater neutrality' (provided in section 6.3.1.2).

The updated FMP was considered by the Hutt Valley Flood Management Subcommittee (HVFMS) at a hearing in April 2016. Submitters were also given the opportunity to present at the hearing. Following the hearing, the HVFMS endorsed the FMP, on the condition that additional information was provided to explain how the flood risk was represented on the flood maps. As a result, a series of maps showing the flood modelling process were created in discussion with a focus group that was selected to represent the Pinehaven and Silverstream communities – these are attached in Volume 2 - maps.

The final version of the FMP, was also endorsed by GWRCs Environment Committee.

Iwi Consultation

The council project group have met with representatives from Te Atiawa No Runga I Te Rangi (represented by the Port Nicholson Block Settlement Trust) to discuss the cultural significance of the Pinehaven Stream catchment. Discussions were also held with Rangitane o Wairarapa, however, these discussions have now been superseded by confirmation in the Proposed Natural Resources Plan that the Rangitane o Wairarapa Rohe is east of the ridgeline of the Rimutakas. In addition a cultural likelihood of discovery database held by GWRC was checked. The outcomes of this were that the Pinehaven catchment had significance as a waterway, but was not known to be an area of historic cultural significance or current cultural significance to Māori.

3.5 Community Principles for the FMP

The Pinehaven community is aware of their current levels of flood risk exposure, which is seen as unacceptable. They are consequently supportive of structural works being completed. There has also been support for the council project team recommendation of a target service level of a 1-in-25 year return period flood channel capacity with secured secondary 1-in-100 year return period overflow paths and a 1-in-100 year level of protection for habitable floor levels.

At each stage of refining the flood risk management options, the community feedback has been used to directly influence the evolving flood risk management option combination. Key principles drawn from community consultation include:

- Minimise impact to private property from any proposed widening works;
- The implementation of the preferred option combination should be funded through general rates rather than targeted rates;
- The character of the stream following restoration work should match or enhance the existing character;
- Significant trees are to be retained;
- Protection of habitable floor levels to the 1-in-100 year flood event;
- Property purchase and removal should be considered as a viable option;
- Flood walls and stop banks should be avoided to reduce the risk of cutting off overland flow paths and limiting access to the stream;
- Access to and on private property is to be retained where possible.

  Options will include consideration of the opportunities to improve native habitat.

Want to know more about the FMP?

The FMP sets out the methods for achieving its goals in section 4 below.
Collaboration, funding and timing requirements for how these methods will be implemented are discussed further in section 6

[3] Who signed the register

4. Outcomes of the FMP

4.1 FMP Vision, Goals and Objectives

The vision for this FMP is to provide:

A prosperous and safe community, that proactively manages the risk of flooding in the Pinehaven catchment.

A full description on how this can be achieved is demonstrated through the concept design illustrations in Section 4.2. These concepts can only be realised through collaboration with all interested parties identified in this plan. An example illustration of how these goals and objectives can be achieved is shown in 4.1.2.

4.1.1 We want to achieve this through the following goals (what do we want to do)

- Reduce the risk to life or injury or harm from fast or deep flowing water;
- Manage the appropriate use and development of land in a way that is compatible with the objectives of reducing flood risk;
- Inform and empower communities to take appropriate action to reduce the flood risks to themselves and their neighbours;
- Contribute to the economic wellbeing and resilience of the region through flood risk management;

Figure 9: Birch Grove Overland Flow Path

- Recognise the relationship of tangata whenua with waterbodies and cultural values they attribute to streams in the catchment;
- Protect and where possible enhance the ecological values of the stream by using designs that manage the consequences of flooding as much as practicable within a natural state;
- Maintain recreational opportunities along the stream corridor that contribute to the community wellbeing; and
- Encourage best practice in flood risk management.

4.1.2 Flood Protection Objectives (what can we achieve)

1. Reduce the risk of injury or harm from fast or deep flowing water

- Design and maintain flood protection assets so they perform to the UHCC target level of service for streams;
- Identify, inform and protect the potential secondary overland flowpaths of flood waters;
- Upgrade the capacity of the stream channel to improve its ability to convey floods;
- Advise people of the flood risk through the planning and emergency management mechanisms outlined in this FMP;
- Locate new development away from the flood hazard areas;
- Help the community and the emergency services to plan effective responses to flooding.

2. Ensure use and development of land is compatible with the objectives of reducing flood risk:

- Communicate and provide advice on flood risk, so that appropriate decisions are made about land use;
- Protection of secondary overflow paths;
- Control future development and land use in the catchment. As a minimum, new development should demonstrate hydraulic neutrality in comparison with existing background peak flow rates;
- Control future forestry operations in the catchment so that forestry debris do not limit the flood-carrying capacity of streams.

3. Inform and empower communities to take appropriate action about flood risk through:

- The provision of publicly accessible flood hazard information and advice;
- The provision of standard stream channel and crossing design capacities for private upgrade works;
- Provide recommended building levels to reduce the flood risk to residential dwellings.

Figure 10: Typical concept cross section for private bridge crossing

4. Contribute to the economic wellbeing and resilience of the region through flood risk management

- Agree levels of service with the community and confirm responsibilities and extent of stream channel maintenance;
- Maintain channels and flood mitigation assets;
- Inform land owners about flood risk management through identification of appropriate building floor levels and how to maintain or improve driveway and structure crossings of the Pinehaven Stream;
- Consider the potential impacts of climate change in the design of flood management infrastructure.

5. Recognise the relationship of tangata whenua with water bodies and the cultural values they attribute to streams in the catchment

- Continue to engage with tangata whenua to understand their interest in future upgrades of the flood protection assets within the Pinehaven Catchment;
- Enhance the environmental quality of streams in the catchment;
- Avoid or minimise the damage to the existing ecosystems;
- Restore habitat that is damaged or destroyed during the construction process;
- Remove barriers to fish passage where this will not have negative impacts on native fish populations;
- Maintain and where possible enhance the surrounding environment when undertaking flood protection works. For example, by identifying opportunities to enhance the ecosystems of the catchment when undertaking flood protection works;
- Raise public awareness of the important ecological and recreational function that streams provide in the catchment, and the community's responsibility in flood protection through:
  - Providing education programmes on the values of natural ecosystems in providing hazard protection (through erosion control and through retention/ uptake of surface water;
  - The functioning of stream ecosystems and the species that live there;
  - Guidance on appropriate riparian planting (for community groups).
- Foster a sense of community responsibility for flood protection and the river environment through facilitating/engaging community groups in restoration activities.

6. Recognise and provide for recreation use within stream corridors in the catchment, where this is appropriate

- Develop design responses that create opportunities for improved recreation use or community accessibility to facilities in the area;
- Maintain existing recreation opportunities as part of the implementation of any structural upgrade works within current recreation reserve space;
- Look for opportunities for additional community stream access;
- Maximise co-benefits of flood detention/green space;
- Maintain community resilience.

4.2 Design Concepts

This section outlines the design concepts that communicates the vision for the project. These images are intended to convey the general concepts and opportunities which may be possible as part of the Floodplain Management Plan implemented by the project team, the community or individuals. The images below are intended to facilitate discussion around opportunities for improvements to different areas of Pinehaven in the future and they demonstrate how elements of this link to FMP principles. As they are visionary design concepts they may change over time as they are implemented in order to meet the intent of the design principles developed.

EXISTING VIEW

fmp objective:5

INCREASED VISIBILITY OF THE STREAM

with planting and recontouring to collect runoff from the road, the visibility of the stream could be improved, creation of waterfalls, features which only work during rain events

fmp objectives:5 and 6

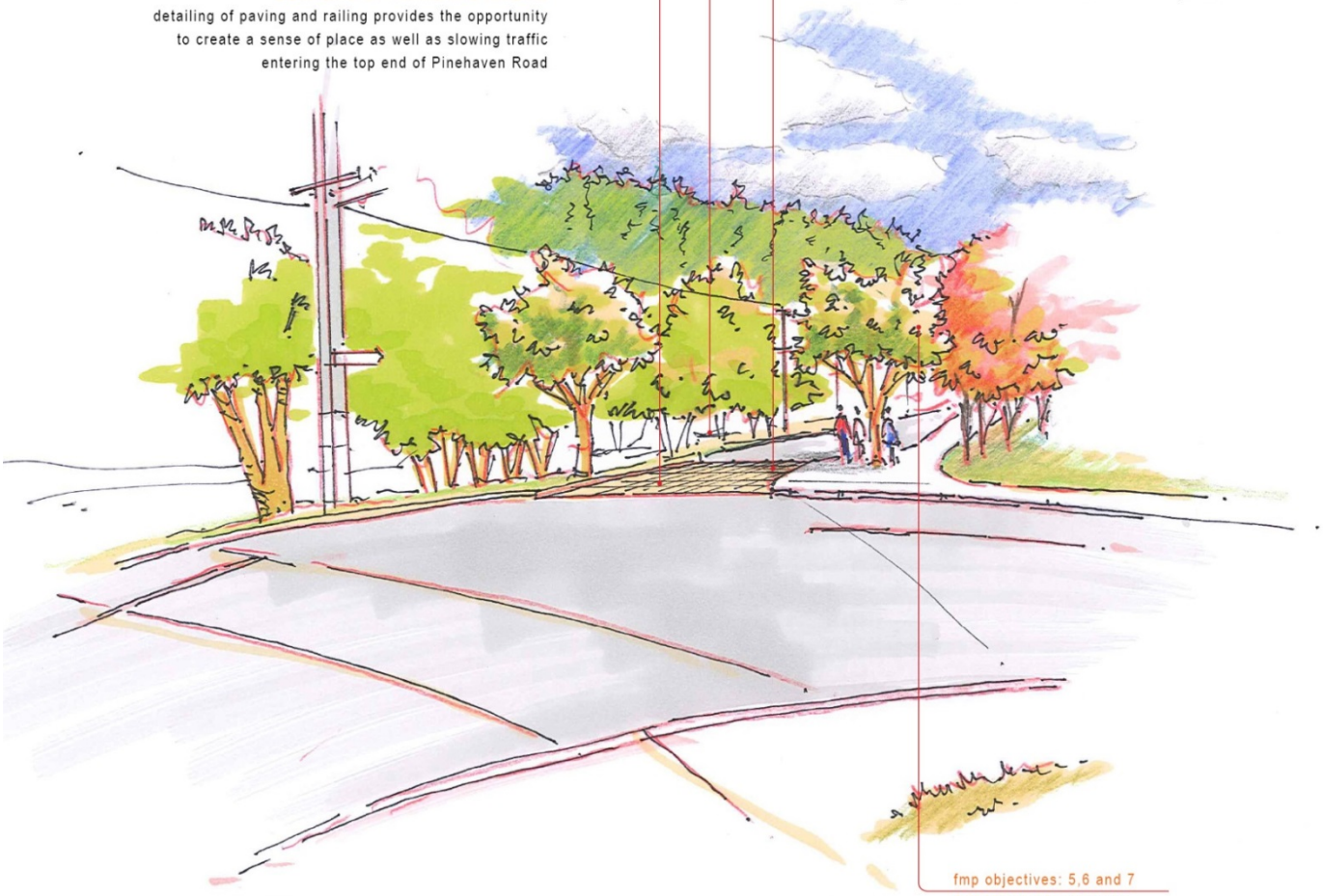
DETAILING OF PAVING AND RAILING

detailing of paving and railing provides the opportunity to create a sense of place as well as slowing traffic entering the top end of Pinehaven Road

fmp objectives:2, 4 and 6

NARROWING OF STREET

the raised paved platform is designed to direct stormwater running down Pinehaven Road at the intersection of Jocelyn Cres into the stream. The platform will also act to slow traffic entering this section of the road while maintaining the bus route to continue down Jocelyn Cres.



fmp objectives: 5,6 and 7

RIPARIAN AND STREET PLANTING

planting of native low-maintenance species along the street edge to reduce lawn mowing maintenance and increases bank stability

DESIGN INSPIRATION

POSSIBLE ENHANCEMENTS

INTERSECTION OF JOCELYN AND PINEHAVEN, PINEHAVEN

EXISTING VIEW

fmp objectives: 1,2 and 6

WIDENING OF CHANNEL

increasing the width of the channel to allow for greater capacity as well as the creation of pools and riffles

fmp objectives: 5,6 and 7

RIPARIAN PLANTING

planting of native low-maintenance groundcover species along both sides of the stream banks to improve amenity and ecological values such as improved inga breeding habitat

fmp objectives: 1,2 and 7

RE-USE OF STONE MATERIAL

the existing stone from the lowered walls can be reused to line the stream channel and provide a more natural edge than concrete. Can also be used in the stream to create pools and turbulance

fmp objectives: 1,2 and 7

CHANNEL EDGE / SLOPE SOFTENING/ ACCESSBILITY TO WATER

provide a 'soft', more natural slope on at least one side of the stream to allow easy access to the water and reduce safety issues from people falling into a high sided channel

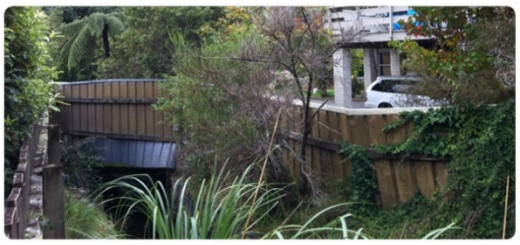
DESIGN INSPIRATION

Photos show (from left to right):

1. Shallow slopes
2. Riparian planting
3. Material reuse

POSSIBLE ENHANCEMENTS

PINEHAVEN RESERVE, PINEHAVEN



EXISTING VIEW

fmp objectives: 1,2 and 3

ADJOINING FENCING

encourage open style fences which allow water to pass through as well as views into the stream. Removal of fences across the stream which could cause blockages

fmp objectives: 5,6 and 7

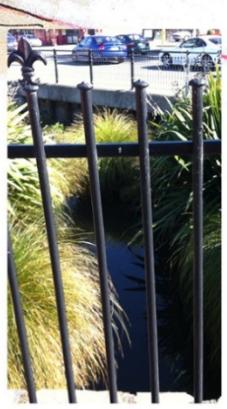
RIPARIAN PLANTING

planting of native low-maintenance groundcover species which enjoy wet roots and planting against fences to soften their visual impact

fmp objectives: 1,2 and 6

WIDENING OF CHANNEL

increasing the width of the channel to allow for larger flows as well as the creation of pools and riffles



DESIGN INSPIRATION

Photos show (from left to right):

1. Natural stream bed
2. Decorative railing
3. Transparent fencing

POSSIBLE ENHANCEMENTS

10A BIRCH GROVE, PINEHAVEN

EXISTING VIEW

fmp objective:1
REMOVAL OF CULVERT RESTRICTION
bridges have the dual benefit of increased capacity and a naturalised stream bed

fmp objective:5
RECOGNISE AND PROVIDE FOR RECREATION USE
open style fencing will provide views into the stream corridor as well as maintaining overland flow paths

fmp objectives: 5 and 6
DETAILING OF HANDRAILS
detailing of handrails provides the opportunity to reflect the local and cultural history of the stream and provide a point of difference from other areas

fmp objectives:2, 4 and 6
COST EFFECTIVE DESIGN
narrowing the carriageway reduces construction costs while maximising 'daylighting' of the stream

fmp objectives: 5,6 and 7
RIPARIAN PLANTING
planting of native low-maintenance species along the stream edges reduces lawn mowing maintenance and increases the amenity of the corridor

DESIGN INSPIRATION

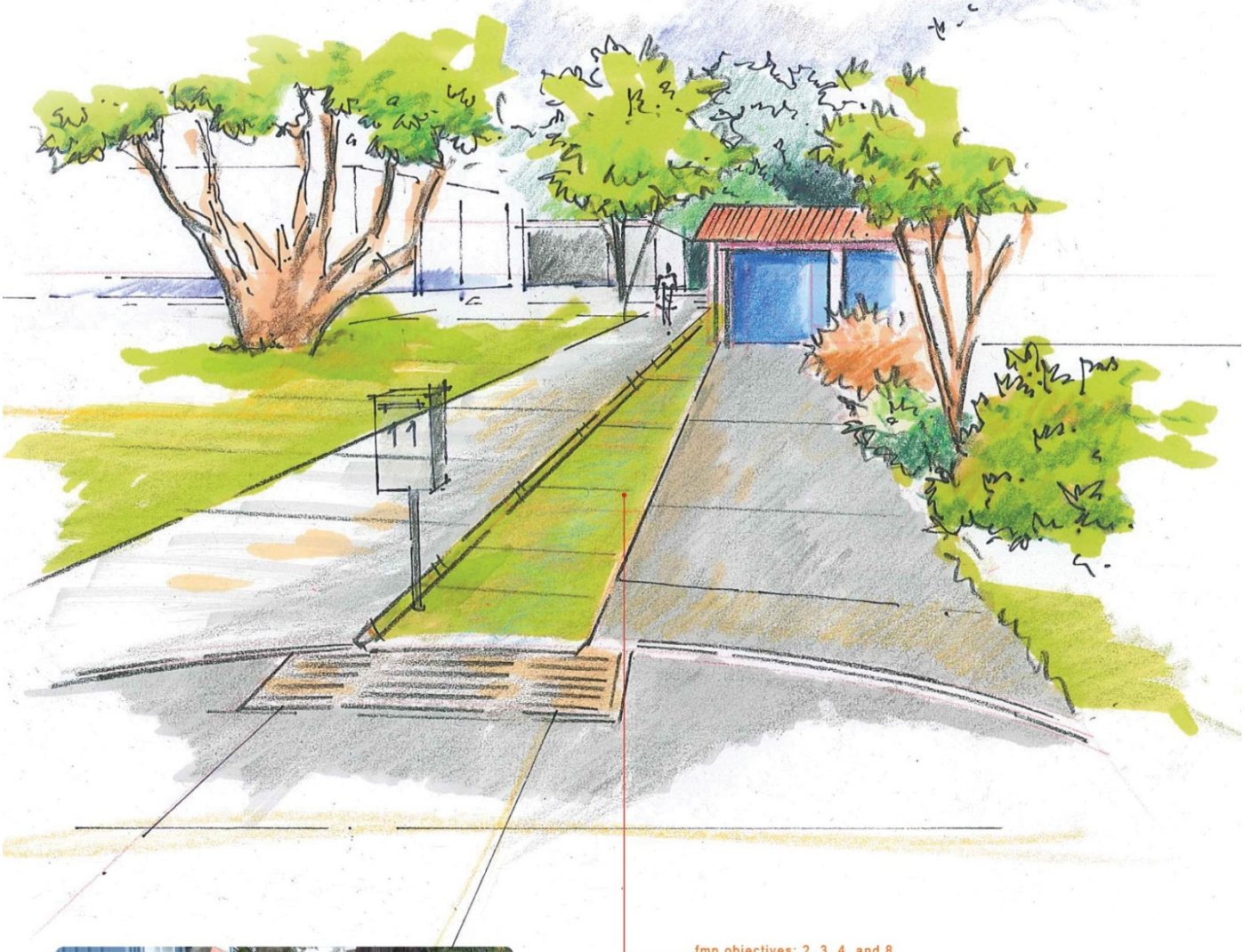
Photos show (from left to right):

1. Paved threshold treatment
2. Transparent fencing
3. Decorative panel design
4. Decorative hand railing

POSSIBLE ENHANCEMENTS

SUNBRAE DRIVE BRIDGE, PINEHAVEN

EXISTING VIEW



fmp objectives: 2, 3, 4, and 8

SECURING OVERLAND FLOWPATHS

the creation of a shallow channel connecting to the stream to provide an exit point for flooding waters from the end of Birch Grove

DESIGN INSPIRATION

the above photos shows an overland flow path between two residential dwellings in Talbot Park, Auckland

POSSIBLE ENHANCEMENTS

BIRCH GROVE OVERLAND FLOW PATH, PINEHAVEN

EXISTING VIEW

fmp objectives: 1,2 and 6
WIDENING OF CHANNEL
increasing the width of the channel to allow for larger flows as well as the creation of pools and riffles

fmp objectives: 5,6 and 7
RIPARIAN PLANTING
planting of native low-maintenance groundcover species which enjoy wet roots and planting against fences to soften their visual impact

fmp objectives: 1,2 and 3
ADJOINING FENCING
the existing fence is pulled back to the start of the garage and the removed portion replaced with an open style fence that is 300mm clear of the ground surface

fmp objectives: 1,2 and 7
CHANNEL EDGE / SLOPE SOFTENING/ ACCESSBILITY TO WATER
provide a 'soft', more natural slope on at least one side of the stream to allow easy access to the water and reduce safety issues from people falling into a high sided channel

POSSIBLE ENHANCEMENTS

WILLOW PARK (TOP END), PINEHAVEN

EXISTING VIEW

fmp objectives: 5 and 7

DETAILING

detailing of signage and furniture should reflect the local and cultural history of the catchment, recognising the importance of creating a unique environment

fmp objectives: 1, 3, 5 and 7

SIGNAGE AND INFORMATION BOARDS

provide information regarding the hydrological and ecological importance of the stream. Previous flood height markers could be installed as a point of interest.

fmp objectives: 5, 6, and 7

RIPARIAN PLANTING

planting of native low-maintenance groundcover species which enjoy wet roots on the edges of the stream to improve ecologial benefits as well as amenity

fmp objectives: 1, 2, and 7

WIDENING OF CHANNEL AND SOFTENING EMBANKMENT

the existing bank is recontoured to provide a wider channel with a shallow slope to increase capacity as well as increase the visibility of the water fromthe path/deck

fmp objectives: 1,2 and 7

BOARDWALK

the boardwalk allows for the recontouring of the ground below (to increase capacity) while maintaining safe all weather access during large rain events

fmp objectives: 1,2, and 7

IMPROVED ACCESSIBILITY TO WATER

creation of a deck and seating area over the widened stream. steps down to the water's edge with the creation of a small beach-like space

DESIGN INSPIRATION

POSSIBLE ENHANCEMENTS

WILLOW PARK (ENTRANCE), PINEHAVEN

EXISTING VIEW

fmp objective:5

RECOGNISE AND PROVIDE FOR RECREATION USE

open style fencing will provide views into the stream corridor as well as maintaining overland flow paths

fmp objectives: 5 and 6

DETAILING OF HANDRAILS / FENCING

detailing of handrails provides the opportunity to reflect the local and cultural history of the stream and provide a point of difference from other areas

fmp objectives: 1, 2, and 7

WIDENING OF CHANNEL AND SOFTENING EMBANKMENT

the existing bank is recontoured to provide a wider channel with a shallow slope to increase capacity as well as increase the visibility of the water from the surrounding street

NATURAL STREAM BED

fmp objectives: 5, 6, and 7

RIPARIAN PLANTING

planting of native low-maintenance groundcover species which enjoy wet roots on the edges of the stream to improve ecologial benefits as well as amenity

TYPICAL CROSS SECTION OF VERTICAL SIDED CHANNEL

5. Considerations

5.1 Introduction

The community have communicated values for consideration when developing the floodplain management methods that are set out in Section 7. A summary of the issues and opportunities in the Pinehaven Catchment is set out in this Section under the following headings:

- Physical Environment;
- Human Environment;
- Māori;
- Ecology;
- Recreation, Landscape and Cultural Values;
- Planning and Land Use.

5.2 Physical Environment

The west-facing Pinehaven Catchment drains an area of approximately 4.5km² before running into Hulls Creek and the Hutt River.

The physical characteristics of the catchment are very different in the upper and lower catchments.

The Upper Catchment

The upper catchment is comprised of steep-sided valleys dominated by pine plantation, the area also includes some residential development in the valleys down to Pinehaven Reserve. The land use is important when considering flooding as the vegetation generates a lot of debris, particularly during logging, and this can increase the risk of blockage. The trees were last felled shortly before the 1976 storm, adding to the intensity of flooding and causing blockages in the stream channel.

The upper Pinehaven Catchment is drained by major tributaries adjacent to Pinehaven Road and Elmslie Road. In these tributaries the stream passes through private residential properties, the majority of which have access across the stream from bridges and culverts which constrain the channel and are susceptible to blockage. The channel is narrow and constrained with vegetation lining the majority of the banks. The tributary in Pinehaven Road crosses the street a number of times before entering a piped network in Pinehaven Reserve.

The Lower Catchment

At Pinehaven Reserve the steep sided valleys of the upper catchment start to open out onto a floodplain that is largely residential. The land uses in this area are described in greater detail in Section 5.5.

The lower Pinehaven Stream becomes an 'urban stream'. In this area, many sections of the stream have been heavily modified, both as a result of the development of the area and to manage flood issues. Modifications include constructed channel sections, piped stream sections and bridges.

The lower reaches of the Pinehaven Stream are made up of alluvial gravels that are more susceptible to erosion and scour. Erosion risk is greater during high flows where the stream is running fast. Typically the areas at greatest risk are on poorly vegetated banks, at culvert outlets and on the outside bends in the stream.

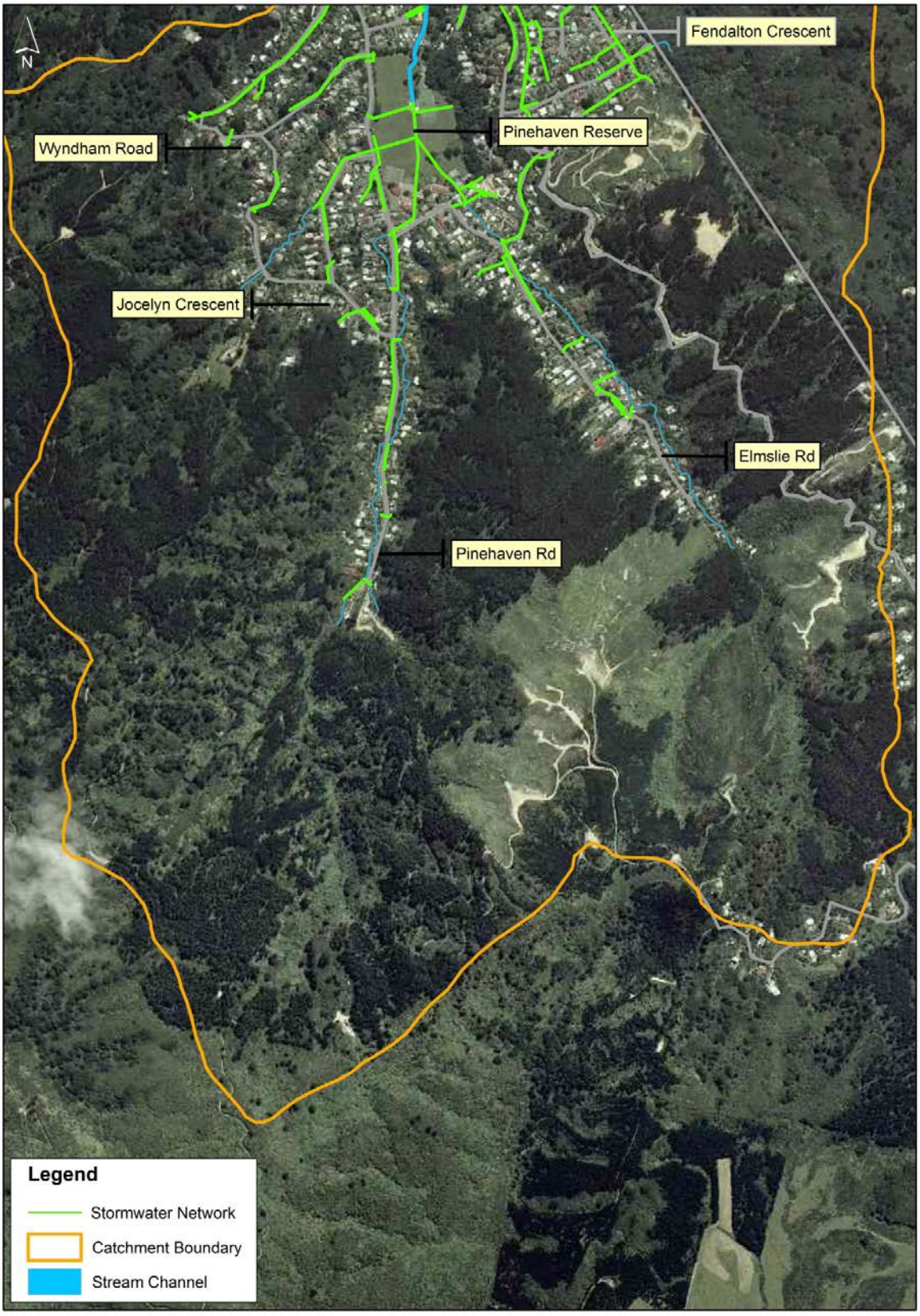


Figure10 : Pinehaven Upper Catchment

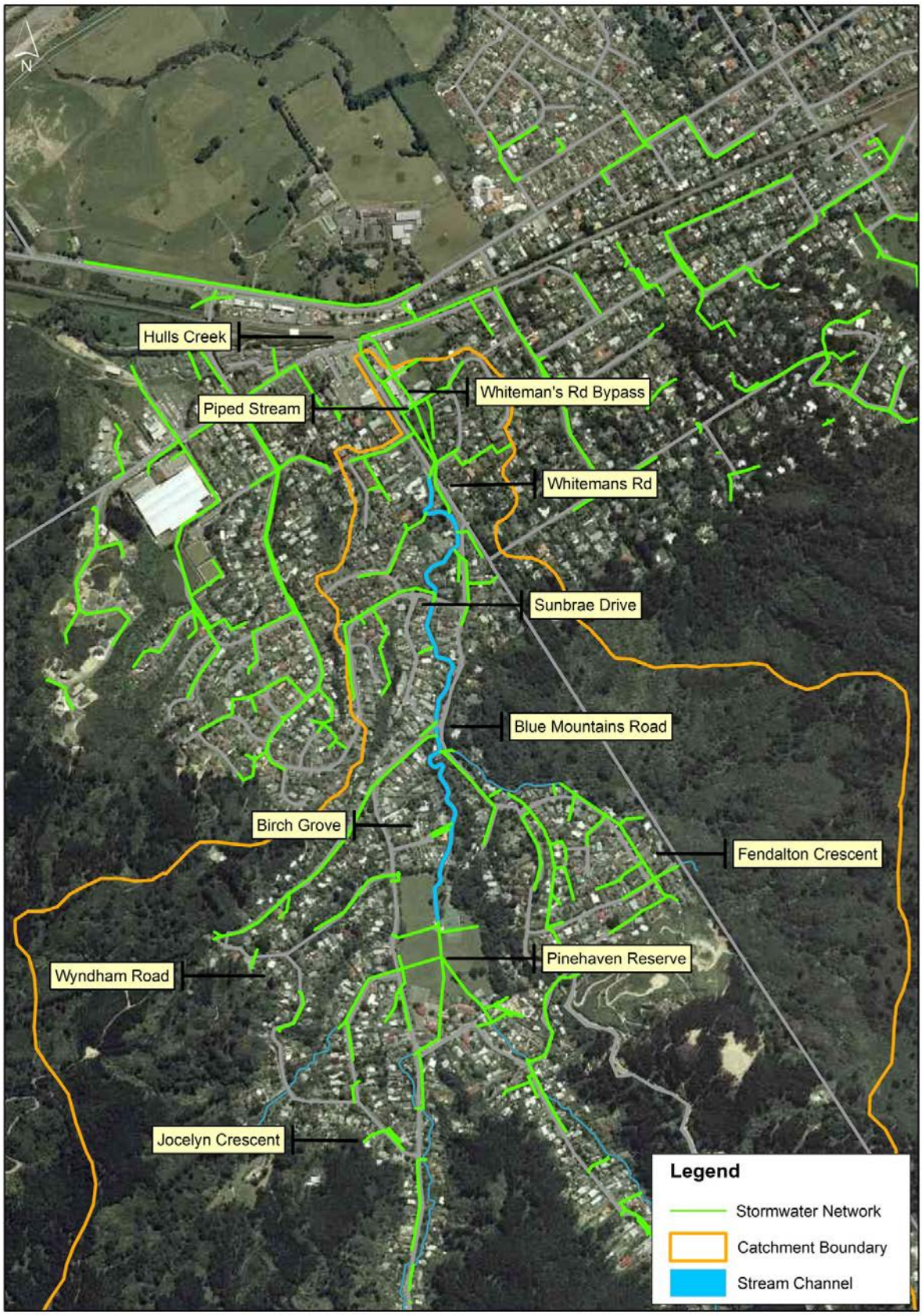


Figure11: Lower catchment

5.3 Human Environment

Character and Community Facilities

Pinehaven is a suburb of Upper Hutt, situated in the Eastern Hills of the Hutt Valley, instantly recognisable in character due to the extensive pine plantings that circle the valley and scattered throughout the residential properties in the area. A notable stand of trees also marks the entrance to Pinehaven at the intersection of Pinehaven and Blue Mountains Roads.

Pinehaven, like many of Upper Hutt's suburbs, began as a popular spot to holiday away from Wellington, before evolving into the permanent settlement it is today. One of the reasons the suburb was so popular was due to the undeveloped rural nature of the area. Visitors felt they could "get away from the city".

Pinehaven is built around the Pinehaven Reserve, which forms a focal point for the community and is also the location of the Pinehaven School, Pinehaven Community Hall, Pinehaven Scout Hall and Pinehaven Tennis Club. In addition to this reserve there are a number of other areas of reserve, park or bush on the valley sides such as Willow Park and Witako Scenic Reserve.

Part of Silverstream is located on the floodplain at the bottom of the Pinehaven Catchment near where the Pinehaven Stream flows into Hulls creek. The centre of Silverstream is defined by a shopping arcade which boasts a supermarket, cafés, restaurants, and a number of small businesses. Silverstream is serviced by its own railway station, Silverstream School and several churches.

The Silverstream community was the birthplace of the New Zealand impressionist movement, with the former Pumpkin Cottage as a focal point for artists in the late 19th and early 20th centuries. The site of Pumpkin Cottage is now used as a reserve.

As the Pinehaven floodplain management plan continues to be developed it is important to consider the impacts on and opportunities available to work with community recreation and amenity projects.

The People

At the time of the 2013 census, the population based in the Pinehaven Catchment numbered approximately 4,100. The community is well established and stable - indicated by above average percentages of privately owned homes, families with children, and longer than average residency in the same house. As a result, the community is very aware of flood issues; many having experienced several floods including, for some, the 1976 flood.

As discussed in Section 3.4, the Pinehaven and Silverstream communities are aware of their current levels of flood risk exposure and see it as unacceptable. Consequently, there has been strong support and engagement for the flood management work undertaken to date.

Figure12: Existing environment upper catchment

5.4 Cultural Values

Māori values associated to a particular river, place, or community, are most commonly generated through the occupation of an area, and the cultural requirement to behave in a manner consistent with kaupapa Māori (foundation of cultural normalities).

Iwi in general seek two outcomes from involvement in management of natural resources. Mana Whakahaere, which can be defined as recognition of their mana over natural resources through their role as kaitiaki (guardians) and Mana Kaitiaki which can be defined as improved environmental outcomes which are consistent with their obligations as kaitiaki.

The Pinehaven catchment is not known to have been occupied by Māori and the Proposed Regional Plan does not identify any mana whenua sites of significance in the catchment. However the Pinehaven stream is a significant tributary to Te Awa Kairangi (the Hutt River) and sits on the edge of a flood plain. These conditions would have been ideal for establishment and support of settlement, providing transport links, food source, and building materials. In addition the valley provides many sites which would have traditionally acted as good vantage points to provide security and warning of threat.

However the principles of Kaitiaki (guardianship) and Ki uta ki tai (mountains to the sea) remain an important concept and are reflected in a total catchment management approach. These values have been significantly degraded in the Pinehaven stream. This is due to the intensive modification of land throughout the catchment which has confined the floodway to a narrow steep sided channel restricting the streams ability to find its own natural path through the surrounding environment including confining it to concrete pipes between 52 Whitemans Valley Road and its confluence with Hulls Creek.

These channel modifications have reduced habitat values and restricted fish passage and therefore reduced the potential for it to hold value of Mahinga Kai (areas of value for traditional food and natural resources). While there is a desire to 'daylight' piped streams this is an unlikely prospect in the near future of the Pinehaven Stream. However this should remain a long term aspirational goal for the stream.

Te Atiawa

Issues relevant to Te Atiawa and impacts of the development of a floodplain management plan have been discussed with Teri Puketapu as representative of Te Atiawa. No specific sites of cultural significance have been identified as a result of these discussions, or from research of the cultural sites database available to the council project team.

Rangitāne

It was highlighted during discussions with a representative of Te Atiawa that sites of historic or cultural significance to Rangitāne (ancient settlers of the Upper Hutt Valley area) are also potentially present in the Pinehaven catchment. No documented sites of historic or cultural significance to Rangitāne have to date been identified in the project area.

Common to all capital works projects, accidental discovery protocols will be recommended for use during any physical works to ensure any sites of cultural significance are identified if exposed.

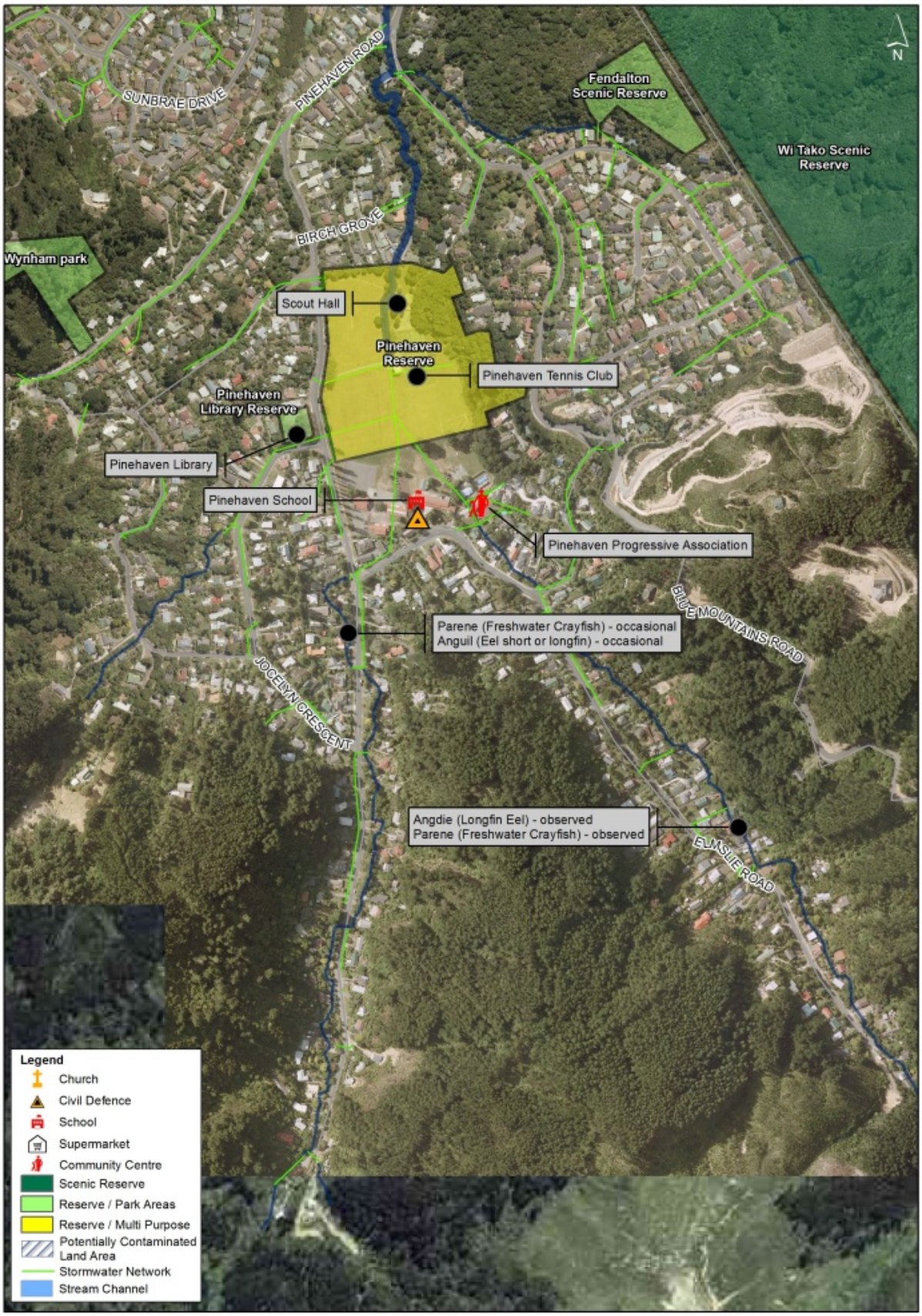


Figure13: Existing environment lower catchment

5.5 Natural Environment

The Pinehaven catchment lies within the Eastern hills of the Hutt Valley. It comprises of a variety of land forms and land use types, and is home to a number of differing habitats. The community of Pinehaven is proud of the natural character of the area, and it is one of the key features identified by residents as a reason that they choose to live in the area.

5.5.1 Aquatic Ecology

Pinehaven Stream and its tributaries are a habitat for a number of fish and insect species. Freshwater surveys in 2015 found shortfin eels, longfin eel, freshwater crayfish, and common bully. In addition giant kokopu also have been found in the past. A range of aquatic insect species were also found in the surveys including mayflies, stoneflies and caddisflies. A wide range of species, including those that are sensitive to pollution, is considered to reflect a stream with favourable water quality.

Figure 15: Freshwater crayfish found in the recent steam survey

Native fish prefer slow moving water, pools and riffles to migrate through the stream whilst insects require open flight paths to fly upstream to lay eggs. The long culverted sections of the stream are likely to be an impediment to migratory species and may be reducing the diversity of species living in this area.

5.5.2 Riparian Margins

The riparian margin in much of Pinehaven Stream is modified and generally no wider than 10m in most of the lower catchment. Tree species present in the riparian margin are generally mature and help shade the stream.

The lower part of the Pinehaven stream between bypass culverts and the junction between Bluemountains Road and Pinehaven Road is formed from a combination of engineered, but natural banks and lined sections of the stream. Those areas which are lined vary from vertical concrete sides, to gabions, wooden retaining walls and stepped retaining walls. The current banks contain a number of mature tree species which provide shading to the stream apart from the area immediately adjacent to the bypass culvert.

The stream character changes from the junction of Bluemountains Road and Pinehaven Road. This section of the stream contains a greater number of mature native species and has retained a more natural stream channel form with increased shading until it reaches Pinehaven Reserve where the stream has some concrete retaining.

Pinehaven reserve has limited riparian planting and almost no shaded stream sections before the stream is piped.

The upper catchment of the stream has retained a more natural character. However in this area the stream runs through private property, and in some instances erosion protection works and bridging structures have been built without consideration of impacts on preserving the natural channel of the stream. However, in general the quantity of stream shading is high.

5.5.3 5.5.3 Terrestrial Ecology

Vegetation in the Pinehaven Catchment differs between the upper and lower catchment. The upper catchment is dominated by pine forest, however, this includes both a native understory as well a number of exotic weed species. The Pinehaven Hills are also home to Witako Scenic Reserve - a diverse mix of mature lowland podocarp and beech forest. Monitoring has shown that the reserve supports a high diversity of native bird species: visits by rifleman, kakariki, tomtit, ruru and whitehead are common.

The lower catchment is more modified and vegetation is more limited. Within the flood hazard zones there are several parks including Willow Park and Pinehaven Reserve. Vegetation in the lower catchment is a mix of natives and exotic plant species. Among the native species, stands of black beech are notable. Exotic species such as willows are also common around the stream. Although the lower catchment is highly modified it continues to provide an ecological link between the upper catchment and the Hutt River.

5.5.4 Avian habitat

The range of tree species in the catchment provides a food source for a wide variety of bird species. Native species recently observed include tui, silvereye, kereru (New Zealand Pigeon), and grey warbler. Exotic species observed included blackbird and starlings as well as eastern rosella and chaffinch.

Figure 16: Tui observed during avian survey

5.5.5 Land Use

The range of land uses in the Pinehaven Catchment is shown in the Upper Hutt District Plan.

The upper catchment, with its extensive pine plantations is largely zoned as 'rural hill' or 'open space', with small areas of 'residential hill' and 'rural lifestyle'.

In the lower catchment, a mix of more urban land uses are found including 'residential', 'residential conservation', 'business commercial' and 'business industrial'. Dotted among this are a number of small areas designated as parks, community buildings, or schools.

5.6 Identified flood risk

Flood hazard zone maps have been developed based on the 1%AEP/ 1 in 100 year return period flood event. These maps also include an erosion hazard setback. The flood hazard zone maps are shown in Volume 2 maps.

The flood hazard maps allow the community to see where the higher risk areas are in the catchment. This can help improve the community's preparedness for flood, as they know which areas to avoid.

The land uses appropriate to each flood hazard category will vary. For example, buildings and services that may be required in an emergency, e.g. hospitals, schools, community halls, and police and fire stations (vital services), should not be sited on flood-prone land. Other developments and land uses may be compatible with particular flood hazards.

6. Methods

We propose a combination of methods to manage flooding in the Pinehaven Catchment. The methods fall into three categories:

- Structural. These methods are physical works designed to manage flood risk associated with the stream channel. The methods relate predominantly to increasing the capacity of the stream, reducing blockages and managing flows on the floodplain. No above ground level structural works are proposed.
- Non-structural. These methods relate to planning controls for development in the catchment, community awareness and preparedness, and emergency procedures. Non-structural methods can have high benefits for relatively low implementation costs.
- River management. This method covers the day-to-day maintenance of the stream to avoid blockages, maintain capacity and minimise erosion.

Each of these methods are described in more detail in sections 6.2 - 6.4. A detailed breakdown of structural methods implementation, costs and alternate opportunities to be considered at time of consent application is included in Volume 2 maps.

6.1 Implementation

Each of the method categories described above lend themselves to a different implementation strategy.

Structural methods require significant investment and already funding has been planned for works to be carried out between 2016 and 2022. The order and timing of works will depend on the degree of risk and the potential for improvement, but in general will start from the bottom of the catchment and progress in an upstream direction.

Non-structural methods represent up-front planning for long-term outcomes. This work will be incorporated into the relevant Regional or District Plans and emergency plans. The non-structural methods include planning controls for activities within the flood prone area as well as the purchase and removal of three properties.

River management is an on-going process. The maintenance activities proposed in this plan will become part of the regular Council activities in the Pinehaven Catchment as well as being undertaken by the community.

6.2 Structural Methods

Physical works to manage flood risk form an important part of the Pinehaven FMP. The works in the catchment have been designed to provide capacity in the channel for a 4%AEP/1-in-25 year return period flood event and protection of building floor levels to a 1%AEP/1-in-100 year return period flood event. A summary of the structural options is shown in Volume 2 maps.

These works will be designed with reference to the FMP outcomes detailed in section 4.1 of this document. However implementation of the works in many instances is carried out on private property and reinstatement which may affect environmental outcomes will be influenced by the preference of the property owner. This in general will relate to planting of non-eco-sourced natives within private property during reinstatement works.

The proposed structural works are separated into four sections (reaches) of the Pinehaven Stream:

6.2.1 Reach 1: Sunbrae Drive to Whitemans Road

Reach 1 extends from the culvert that passes under Sunbrae Drive to the bypass located near the corner of Blue Mountains and Whitemans Roads. Key features of the physical works in this reach include:

- Widening the stream through 8 Blue Mountains Road (The Reformed Church) to 8.2m with constructed sides, and a natural channel bed;

Figure 17: Typical cross section of constricted vertical walls

- For the remainder of this reach stream widening (from 8.7m to 12.7m) is planned by using a naturalised channel with low maintenance native planting that can assist in stabilising soil along the stream banks;
- Construction of a new bridge at Sunbrae Drive to increase the capacity of the channel;
- Replacement of existing primary access private bridge crossings with improved capacity bridges;
- Removal of some existing secondary or ancillary access unconsented bridge crossings;
- Upgrade of piped stream & bypass inlet structures, including debris protection;
- The purchase of 4 Sunbrae Drive and removal of structures from this property;

- Creation of designated secondary overflow path through 4 Sunbrae Drive;
- Create overflow paths through a lowered driveway and easement servicing 13, 14 and 15 Clinker Grove and from Deller Grove through 6 Sunbrae Drive and 1 Tapestry Grove.
- Increasing channel capacity through 54 Whitemans Road and creation of a lowered secondary flow path through the rear of this section (which includes part of the sections of 15 Clinker Grove/56 Whitemans Road).

6.2.2 Reach 2: Pinehaven Road to Sunbrae Drive

Reach 2 covers the stream between Sunbrae Drive and Pinehaven Road. Key features of the structural works in this reach include:

- Purchase of 28 Bluemountains Road, and removal of the structures on this property;
- Creating a widened channel (approx. 6.8m) with constructed sides and a natural bed from Pinehaven Road to 26 Blue Mountains Road;
- For the remainder of this reach, stream widening to approximately 11.3m is planned but using a naturalised channel with planting along the stream banks for the remainder of the reach;
- Construction of a new bridge where the stream passes under Pinehaven Road (near the intersection with Blue Mountains Road) to increase the capacity of the channel.
- Replacement of existing primary access private bridge crossings with improved capacity structures;
- Removal of existing secondary unconsented bridge crossings;
- Upgrade the inlet structures at the intake to the pipe network under Wyndham Rd to reduce the risk of blockages;
- Create a swale to capture overflows at 2 and 4 Pinehaven Road.

Figure18: Typical cross section of replacement bridge

6.2.3 Reach 3: Pinehaven Reserve to Pinehaven Road

Reach 3 covers the area from Pinehaven Reserve to Pinehaven Road and contains the flood risk area of Birch Grove. Key features of the physical works in this reach include:

- Purchase of 48 Blue Mountains Road;
- Upgrade to the stream capacity at 48 Blue Mountains Road including providing greater channel capacity and creating a secondary overland flow path across the driveway (see Volume 2 maps);
- Minimal works in 50 Blue Mountains Road to protect banks from erosion and scour;
- Increasing channel capacity through Birch Grove properties to a width of 5.8m with constructed side vertical walls and a natural bed;
- Create an overflow path by lowering the driveway at 12 Birch Grove in conjunction with upgrading the storm-water network;
- No structural works in Pinehaven Reserve have been identified, but there are opportunities to support community initiatives to enhance the area around the stream as it passes through the reserve which aim to improve amenity and ecological biodiversity in this area (see section 4.2, Pinehaven Reserve Design Concept).

6.2.4 Upper Catchment

Beyond the three defined reaches, a number of physical works are proposed in the upper catchment, these include:

- Upgrade the inlet structures at Chichester Drive to reduce the risk of blockages;
- Upgrade intake to culvert at Pinehaven Community Hall;
- Modifying road kerbs, road grading, crossings and driveways as well as easements to secure overflow paths at the intersection of Jocelyn Crescent and Pinehaven

Road (both Northern and Southern) and Forest Road and Pinehaven Road (see Volume 2 maps);
- Provide advice and direction to owners on new and existing structures over the stream to ensure channel capacity requirements are met (see typical bridge detail in Section 4.2, typical bridge cross section).

6.3 Non-Structural Methods

The proposed structural works will increase the stream's capacity to manage flood events up to a 25 year return period. To support this it is proposed to implement non-structural methods that recognise flood events up to the 100 year return period. This aligns with current best practice and the direction of the Greater Wellington Regional Policy Statement.

Methods include planning controls within the District Plan for existing and future land use and subdivision activities, with controls requiring stormwater neutrality, protection of infrastructure, and management of earthworks and forestry impacts, particularly in the upper catchment.

Future work may also be done to build community preparedness by planning for emergencies and building public awareness of the risks and how they can be managed.

6.3.1 Planning and Development Controls

Through the planning framework we have the opportunity to manage the effect that activities have on flood risk in the Pinehaven Catchment and vice versa. Planning controls are important for managing future development and the existing controls could be strengthened with the aim to manage or reduce flood risk in the long-term.

6.3.1.1 The current planning framework

The planning controls specific to flooding in the Pinehaven Catchment exist within a broader planning framework. This planning framework is described in more detail in Appendix A, and can be summarised as follows:

- Legislation (primarily the Resource Management Act (RMA) and the Building Act);
- Plans under the RMA including:
  - The Wellington Regional Policy Statement;
  - The Wellington Regional Plans;
  - The Upper Hutt District Plan.
- Council work understanding and monitoring hazards.

Regional Policy Statement for the Wellington Region (2013)

The operative Regional Policy Statement for the Wellington Region, 2013 (RPS) identifies both major river flooding, and localised flooding and inundation from streams and stormwater overflow, as region-wide issues. It also identifies how climate change will affect flood hazards in the medium to long term, particularly the increased frequency and magnitude of natural hazard events. The RPS provisions look to avoid potential flood hazards rather than trying to only mitigate these hazards and to provide for resilience.

In general, the RPS seeks to manage flood risk in the region through:

- District Plan implementation: controlling subdivision and land use in areas subject to hazards;
- Information on flooding hazards and climate change effects, including identifying areas subject to high risk from hazards and information about natural features to protect property from natural hazards;
- Protecting residential floor levels to a 1-in-100 year return period flood level;
- Resource consent and Notice of Requirement decision making;
- Changing, varying or replacing plans.

The District Plan needs to take into account these provisions and future development applications for resource consent or notice of requirement will need to ensure they are consistent with these policies.

The Upper Hutt District Plan (2004)

The Upper Hutt District Plan, 2004 (the District Plan), is a key tool for managing flood risk in the Pinehaven Catchment. The District Plan includes some provisions that indirectly assist in reducing flood risk in the Pinehaven Catchment. These include:

- Provisions that provide for larger areas of land to absorb floodwaters and could mean less run-off. (i.e. bigger lot sizes and more permeable surfaces);
- Provisions that provide for open space that creates a buffer around the Pinehaven stream.

As the District Plan provisions for managing flood risk largely relate to the Hutt River, a number of gaps in flood risk management for Pinehaven have been identified. They are:

- Land zoned residential close to Pinehaven Stream is not subject to any flood hazard controls in terms of controls that would reduce the risk to property and people (such as building height, setbacks, or controlling stream crossings);
- The Hutt River FMP principles do not apply beyond the Hutt River catchment and the plan does not address how natural hazards are to be managed outside of the catchment;
- There is basic recognition of flood hazard issues with regard to subdivision. However, there is no reference to Council's ability to decline subdivision consents based on

potential flood and erosion damage to land (s106 of the RMA);

- While the District Plan acknowledges that upstream activities (such as the Pinehaven catchment) may increase the likelihood of major flood effects, it focuses the flood hazard provisions on the Hutt River catchment, excluding controls that could prevent flood hazards within adjoining catchments;
- The top of the Pinehaven catchment is established with pine forest. In the past harvesting operations have resulted in post-harvest debris entering the catchment and restricting or blocking the stream corridor and exacerbating flooding in the lower catchment. The activity of 'Forestry' within the UHCC Plan is identified as a Permitted Activity within rural zones. The current rules do not provide sufficient protection, however, the Ministry for Primary Industries are currently seeking feedback about developing a National Environmental Standard for forestry practices which would guide the UHCC District Plan.

6.3.1.2 What are the solutions?

The key solution required to provide planning support to manage flood risk in the catchment is to introduce a comprehensive framework of objectives, policies and supporting rules to the District Plan. The aim of which is to manage Flood Hazards in the Pinehaven catchment via a Council led Plan Change Request. This will be informed by the flood hazard investigations that have already taken place (see Volume 2 maps).

This Plan Change will be made up of the following proposed policy and rule measures:

- Objectives and Policies added which are consistent with the Pinehaven FMP within the UHCC District Plan;
- Identification of land use activities in the Pinehaven catchment that have potential to directly influence flood risk, such as building new structures within the primary and secondary stream corridor;
- Development of policies that directly reflect the flood risk issues so we are not relying on the indirect benefit of some polices. For example, there are existing indirect methods such as residential large lot (minimum lot size) and Open Space zones that reduce risk and provide a buffer for flood risk areas;
- Providing rules that restrict development in hydraulically sensitive areas which are the Pinehaven Stream corridor, the erosion set back line and secondary overflow paths. Remaining flood risk areas within the 1:100 year flood level will also be managed to protect habitable floor levels. These rules will be relevant to all land use activities, including residential and commercial;
- Rules (relevant to all land use activities) that keep development out of the stream channel setback area to prevent the impact of new buildings or extensions adversely affecting flood flows;
- Rules to control bridge crossings and perpendicular fencing to the stream channel to avoid restriction and blockages;
- Planning controls over earthworks to prevent runoff and sediment build up in the stream;
- Add flood risk into the controls on subdivision to support that Council's may decline subdivision consent based on potential flood and erosion damage to land (under s106 of the RMA);
- Add stormwater neutrality to subdivision requirements to ensure additional stormwater runoff does not exacerbate the existing issue;
- Add rules to manage the appropriate placement and management of utilities in relationship to flood hazard zones;

- Finally in terms of forestry controls in the upper catchment these will not be addressed through a proposed Plan Change. This is because a National Environmental Standard for Plantation Forestry is being developed by central government which will address matters which would have been addressed through a future Plan Change.

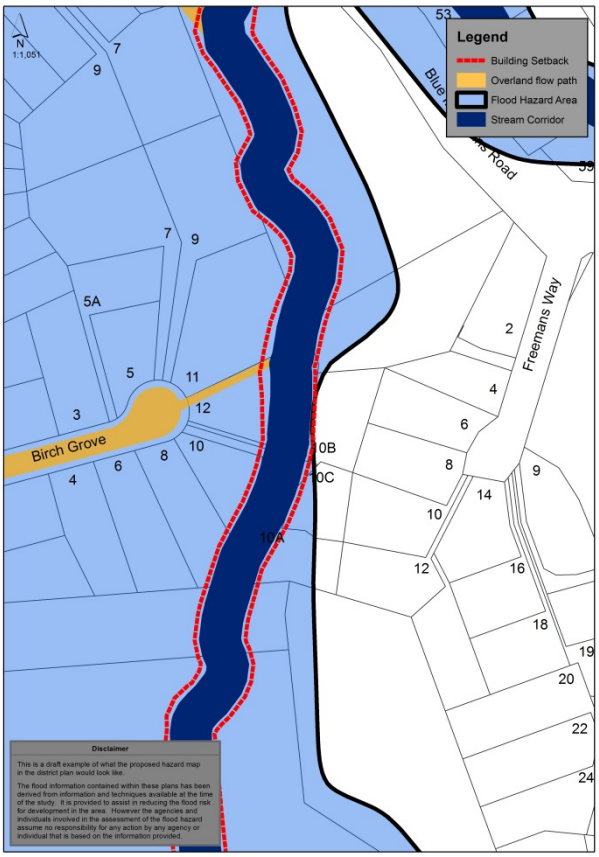


Figure 19: Example image showing a potential building set back line.

Section 32 Report

A key element of the Plan Change process is the preparation of the Section 32 report, which assesses the extent to which the proposal is the most appropriate way to achieve sustainable management. This includes considering why regulation (through the use of planning rules) is the best method, as it does result in restrictions on landowner rights.

This FMP will provide the basis of the s32 report in terms of clearly identifying the issue (or problem), and will inform the objectives and policies and methods (generally rules), that we propose in the Plan Change.

The FMP informs a number of issues:

- The existing built development and structures within the stream corridor and on the surrounding flood prone areas that are at risk from flooding;
- Inappropriate land use activities and structures/ buildings in flood prone areas can negatively affect the function of the stream and the way that it floods;
- Private landowners within the stream corridor can conflict with the management objectives;
- New development or further intensification adjacent to the stream or on flood prone areas may increase the risk of flooding to the surrounding environment;
- Development and use of the stream corridor and floodplain may have an adverse effect on flood mitigation structures;
- Deforestation in the upper catchment can have a significant adverse effect upon flows particularly following pine forest harvesting increasing sediment discharge and debris blocking channels.

Planning controls in the form of rules will be a most effective form of controlling and managing the risk. Some District Plans approach this by identifying any development within flood hazard areas as requiring a resource consent, as such the key change that many land owners in Pinehaven might notice will be the requirement to obtain a resource consent for activities (such as extensions or building a deck) where they are currently permitted activities (because the current rule framework does not distinguish between development in flood prone areas and those outside). Often the activity status will be discretionary (or restricted discretionary) and require assessment of the effect the proposed activity will have on the flood risk area.

The planning controls that are being developed in Pinehaven are also being written at the same time as an updated Mangaroa Plan Change Request is being developed. As a result consistency in approach to managing flood risk where this is appropriate in the catchments will be able to be achieved. PC15 is currently being updated and replaced by a new Plan Change for Mangaroa (identified as Plan Change 44). This change is to address updated flood modelling, and make the Plan Change specific to Mangaroa rather than the wider Hutt River.

Potential rules that will need to be considered

The following rule concepts could be included within the Plan Change to address the identified issues;

- Limit extensions to existing dwellings in the identified floodplain (e.g. limited to within the existing footprint or no greater than 20m^2 to the existing dwelling footprint);
- Require minimum finished floor levels or building platforms for new buildings;
- Set minimum setback distances from stream corridors and identified overland flow paths;
- Restrict site coverage of buildings or structures in hydraulically sensitive areas;
- Require hydraulic neutrality for infill or comprehensive subdivisions;
- Introduce matters of discretion for subdivision applications based on flood hazard issues, requiring a suitably qualified and experienced engineer to consider the implication of the activity on the flood matters. This would support the consent process with sufficient information for

the Council to determine s106 matters which address the susceptibility to inundation;

- Restrict structures within properties or along the boundary of properties that could impede flood capacity or flow paths;
- Require minimum design standards for structures such as driveways crossing over identified stream channels;
- Restrict new buildings or structures within flood prone areas; this might be addressed though identified matters of discretion based around the degree of risk the site has from flooding, the effect the proposal might have on the ponding capacity of the site, the impact on flooding of adjacent properties and the function of any identified flow paths.

Timeframes

Developing and implementing the Plan Change described above is likely to be a relatively low cost/high benefit option. The Plan Change is currently being drafted and will be informed by the community feedback on the FMP. The Plan Change will be drafted and circulated to the community for comment. It will then be finalised for lodgement and go through the statutory process (including public notification and hearing).

What is Stormwater Neutrality and how can it be implemented?

Development can increase stormwater flows. Stormwater neutrality is defined as managing peak flows within a development, so that it does not increase the risk of flooding elsewhere in the catchment. Achieving stormwater neutrality in a development can mitigate the effect of the development on flooding, and may reduce the risk of flooding. Measures that are commonly used to achieve stormwater neutrality include:

- Storage ponds and wetlands
- Permeable surfaces

In addition to the impacts of stormwater neutrality on flows, stormwater neutrality measures can improve water quality by reducing contaminant loads, controlling the temperature of stormwater and supporting biodiversity by maintaining and improving baseflows downstream.

Stormwater neutrality is required by numerous local authorities in NZ and internationally. For example, Kapiti Coast District Council requires all new developments to be hydraulically neutral and Auckland Council's Proposed Unitary Plan requires new developments above 1000m^2 to have controls in place to meet permitted activity standards."

6.3.1.3 Other Planning Methods

Managed retreat

Managed retreat is an approach based around removing vulnerable assets from the floodplain to reduce the flood risk and is an important option to consider.

Within the Pinehaven catchment managed retreat would have some complicating factors including:

- High velocities of flood flows on private property would still present a significant risk to life even if the dwellings are raised above the floodplain;
- The steep catchment means that retirement of property does not present the opportunity for creation of significant storage and therefore is likely to have only property specific benefits.

However, in some cases where flood risk, particularly risk to life, is high and the structural methods to protect assets is constrained, partial or full private property purchase has been considered under the Public Works Act 1981. Previous work has identified three properties for purchase and removal. This process is underway. Other approaches to managed retreat might include rezoning land (for example removing residential zoning and rezoning as public open space to provide buffers for the higher risk areas).

6.3.1.4 Stream Corridor property management

There are multiple options to achieve the maintenance works required to protect the Pinehaven stream channel and banks and its capacity for natural flood events. Legal access is required by Council to achieve this maintenance, otherwise alternative methods are required to put the onus on the property owner. Through enabling the Council to have access to land, the stream corridor can be maintained and managed over time in a consistent manner. Otherwise the management and maintenance of protection structures is left with the individual landowners resulting in an ad hoc approach.

Pinehaven Stream Corridor

Achieving property management of the Pinehaven Stream Corridor can be achieved when converting land ownership from private to public ownership where future construction and maintenance of flood protection works is required. This would secure access and legal protection of the corridor and the identified risk area and any structures within it. A change in ownership can be achieved via the RMA through the subdivision provisions where land is vested in the Council or provided as a reserve contribution. Land can also be purchased by the Crown or Council either by agreement or through the Public Works Act.

A further step in protecting the ability for Council to undertake necessary works is the provision for a designation over the stream channel and associated banks to allow for maintenance and protection works.

Council can also create minimum design standards and/or a private bridge crossing guide for private access ways over the identified streams. This method will need to be enforced by the Upper Hutt building consents team for building consent applications, as well as the Greater Wellington and Upper Hutt resource consents teams for applications on structures over waterways.

Secondary stream corridor – overland flow paths

Options that do not alter the land ownership, but provide legal protection and certainty include granting easements over land for access over private property include registering consent notices or covenants on the title which require hazard setbacks or restrictions within the identified area. This is being considered for secondary stream corridors such as overland flow paths.

Easements are a preferred method as they safeguard access to the stream corridor for management, without having to purchase land. Design requirements are another preferred option of stream corridor management as it allows for property to remain private, while ensuring structures over the stream corridor are appropriate and do not obstruct the stream corridor.

Another option, that doesn't utilise rights over property is to develop Council policy that ensures property owners are responsible for maintenance of a water body where it runs through their property. A policy like this exists for the Heretaunga Drain (Upper Hutt City Council Policy Manual) and could be developed for the Pinehaven Stream. For example, in this policy Council expects individual property owners to be responsible for the maintenance of the part of the Heretaunga drain that runs through their property, including, but not limited to:

1. "Provision of support to the banks or structures on or near the banks of the drain;

2. Removal and maintenance of trees and other foliage on or near the banks of the drain;

3. Reinstatement of damage to the banks or structures on or near the banks of the drain which arises from erosion caused by the natural action of the flow of water in the drain.

Council Procedures

There are also other methods that the Council can use to manage the risks. These include the building consent process and the post-subdivision certification process where development approvals are issued by the Councils engineers. At this point Council can consider a number of factors including whether development meets minimum standards for service. If necessary, these minimum standards could be amended in response to flood issues. This could include controls and guidelines for new bridges, culverts or in-stream structures.

6.3.2 Private Property Obstructions: Education and Design Advice

Along the length of the stream, but particularly in the upper catchment, on roads such as Pinehaven Road, there are many private driveways and pedestrian crossings over the stream. Many of these are restrictions to high flows and increase the potential for blockages.

In most cases the flood waters that overwhelm these crossings quickly return to the waterway. However, some also increase the flood risk for neighbouring properties.

We propose to manage these issues, in the first instance, by encouraging owners to upgrade problem structures. This will include education to raise public awareness around the impact of structures. Also, we will provide advice to owners on how structures can be upgraded in a way that lowers flood risk.

If necessary, it is possible for local government to use enforcement options under the RMA.

Abatement Notices

Enforcement is another tool available to the Council and could be used to address unlawful existing structures (such as driveways) over streams when they begin to cause adverse environmental effects. Generally, this approach would be a last resort, but it would allow the Council to focus on structures that have an adverse effect during floods. Council will consider if these structures were built without meeting the requirements of the Regional Plans (which cover whether the structure affects the ability of the river to convey flood flows). Those that did not comply could be served an Abatement Notice under sections 322(1)(a)(i) and 322(1)(b) of the RMA.

6.3.3 Civil Defence Emergency Management (CDEM)

The aim of CDEM is to minimise loss of life and property damage by preparing communities for potential flood hazards and developing responses for when they occur. CDEM is an essential part of the Pinehaven FMP, particularly for extreme flood events above the capacity of the structural methods.

The national CDEM framework is coordinated at local, group (regional), and national levels depending on the extremity of the emergency.

- The local level is operated by UHCC;
- The group level is operated by the Wellington Region CDEM Group, which manages the Pinehaven catchment;
- The national level is operated by the Ministry of Civil Defence Emergency Management on behalf of the central government;
- The following sections describe how to respond to potential flood hazards in the catchment.

Emergency Management Programmes and Procedures

When a flood emergency happens, how well a community copes depends entirely on how well prepared it is, and this includes emergency services, public agencies, utility services, businesses and ordinary residents.

Emergency management under the Pinehaven Floodplain Management Plan covers flooding caused by the Pinehaven Stream. The potential hazard caused by a flood can be determined by taking the following factors into account:

- Depth and velocity of floodwaters;
- Difficulty and danger of evacuating people and their property;
- Residual risk from flooding;
- Potential for damage to property and social disruption.

Emergency management targets households at risk from flooding, but also aims to build an environment of self-help and mutual support within the wider community so that people are better able to manage their own emergency response.

Emergency management is provided by Wellington's Civil Defence Emergency Management Group (CDEM) made up of the UHCC, and the GWRC, along with other Wellington Councils, emergency services, lifeline service providers and government departments with the assistance of many volunteers and voluntary organisations. A description of flood emergency management response and recovery procedures is provided in Appendix C.

The procedures and programmes for dealing with flooding emergencies are based on the four Rs:

- Reduction of risk;
- Readiness;
- Response;
- Recovery.

Resilient communities are ready for emergencies and have the knowledge, skills, resources and relationships to respond to and recover from an emergency event.

Reduction of Risk

Reduction is the process of identifying and analysing long-term risk to human life and property from hazards, taking steps to eliminate if practicable, or reducing the magnitude of their impact and likelihood of their occurring.

Much of this Floodplain Management Plan relates to reducing risk in the Pinehaven Catchment. This is done through identifying and understanding the flood hazard (section 3.2 and Volume 2 maps), and undertaking structural, planning and maintenance measures (sections 6.2-6.4 and Volume 2 maps) to reduce and manage this risk.

This FMP also links to other risk reduction and management measures in the region, including:

- The risk reduction work of Councils under a range of legislation (RMA, the Local Government Act, the Building Act, the Civil Defence and Emergency Management Act);
- Other non-statutory instruments generated by the above statutory documents (eg. guidelines, Structure Plans, Asset Management Plans);
- Identification of lifeline assets through the Wellington Lifelines Group (WeLG);
- Business continuity management plans of organisations operating in Wellington;
- CDEM work to support on-going research about the region's hazards and risks and educates the community about hazards and risks.

Readiness

Resilient communities are better able to respond to, and recover from, an emergency situation. All members of the Wellington Region CDEM Group have responsibilities to enhance community resilience and assist where possible. The CDEM Group have highlighted the importance of encouraging communities to take ownership and empowering communities to be able to provide for themselves in an emergency.

As discussed above, it is important for the Pinehaven community to be aware of the flood hazards in their area and understand how they can personally respond to the risk of these hazards occurring.

Response

The UHCC is responsible for ensuring that it has appropriate plans in place to ensure they are able to deliver their core services in an emergency. These plans need to be integrated with the CDEM response to ensure both components (Local Authority and CDEM responsibilities) can run seamlessly in an emergency.

The Response Team for Upper Hutt is the Upper Hutt Community Rescue. The team is responsible for ensuring they are trained to national standards, and have the procedures and capability to respond to incidents in a support role.

Appendix C gives details on existing response procedures in place at local, regional, and national levels. In general, response to a flood in the Pinehaven Catchment is outlined below:

Flood Warning

GWRC monitors the rainfall depths in the Region and are therefore responsible for a flood warning. A summary of the

flood warning procedures to be followed in a flood are shown in Appendix C.

The monitoring and gauging sites will be upgraded through the implementation of the floodplain management plan.

How should we prepare for responding to flood hazards in Pinehaven at a community level?

To understand how Council and community groups need to respond to emergencies has been outlined in Appendix C. In terms of the local community, the following discussion outlines how you should prepare and respond to responding to a flood if you are situated in a flood zone which is at greatest risk should a flood occur. However with careful planning and preparation, that risk can be mitigated to ensure fast and effective response and recovery during and after a flood event.

Prior to a flood occurring you can undertake the following actions:

- Store emergency water;
- Have an emergency survival kit;
- Have a household emergency plan;
- Learn how to remove the water from your hot water cylinder and other alternative water sources;
- Keep your valuables and some food and clothing above what you judge to be the high-water mark;
- Store weedkillers, insecticides and other chemicals above your estimated high-water mark.

In addition to the above considerations, if your property has flood water levels are in excess of 0.3m in the Pinehaven catchment, it will be unsafe to drive a vehicle through the water no matter what velocity the flood water is. As a result do not try to evacuate by vehicle via any roads in the flood zones if the water level is in excess of 0.3m.

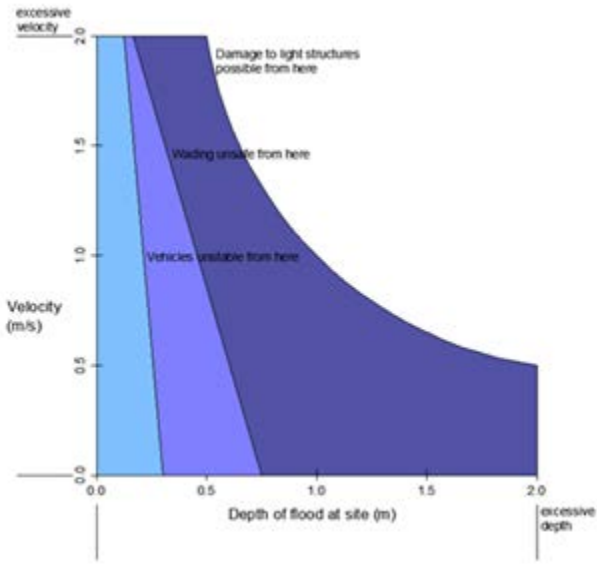


Figure 20: The risks of flood waters depth and velocity relationship

Figure 20 shows the depths and velocities of flood waters that can cause varying degrees of threat to life and property (New South Wales Government 1986).

The figure also shows that it is unsafe to wade in flood water when the water is deeper than 0.2m and flowing faster than 2.0m/s, or if the water level is deeper, it is unsafe to wade at slower speeds. As a precaution, do not try to evacuate by foot via areas in the flood zones if the water level is deeper than 0.5m, it is best to remain at home/where you are.

If it is safe to leave your home, head to high land and avoid those areas the will be flooded as shown in the maps in Volume 2.

During a flood

During a flood please undertake the following actions. Listen to your radio for information. Follow civil defence advice and instructions

- If you need mobility aids, insist on bringing your aid if you are evacuated. Moving to safety is fine, but you won't want to be helpless when you get there;
- Disconnect electrical appliances and move valuables, clothing, food, medicines and chemicals above the likely reach of the floodwater;
- Take your emergency survival kit with you if you have to leave your home. Turn electricity and gas off at the mains only if you smell gas. Remember to wait for professional advice before reconnecting the gas supply;
- Take your pets with you if possible;
- Do not go into floodwaters alone;
- Do not go sightseeing through flooded areas;
- Do not drink floodwater - it could be contaminated.

After a flood

- Listen to your radio for advice and information;
- Report injuries or fires to the emergency services (dial 111);
- Wet electrical connections can cause fire;
- Do not turn on essential services until checked by the relevant authority;
- If your property is damaged, take notes and/or photos for the loss adjustor;
- Do not throw anything out until you contact your insurance company;
- Be aware that mud and debris will be contaminated
- Always wear protective clothing when cleaning up after flood waters;
- Do not go sightseeing and stay out of damaged buildings;
- Do not eat produce from a garden which has been flooded.

Recovery

Recovery is the process of bringing about the immediate, medium and long-term rehabilitation of a community after an emergency.

Recovery involves minimising the escalation of the consequences of an emergency, rehabilitation of the emotional, social, physical and economic wellbeing of communities, taking opportunities to meet future community needs, and reducing future exposure to hazards and risks.

If necessary, recovery activities will be managed by CDEM alongside any central government personnel. Recovery starts immediately (during the response phase) as key decisions during the response phase are likely to directly influence and shape recovery. Activities will address social, built, natural and economic needs of the community and also opportunities to reduce vulnerability to future hazard events. As recovery is about rehabilitation of a community, it will be crucial for the CDEM to work closely with the community in this stage of emergency management.

GWRC will assist UHCC in the improvement of disaster recovery procedures. See Appendix C for details of existing recovery procedures.

Outcomes for Emergency Management Measures

The focus of the emergency management measures in this Plan is to increase the service or coverage provided by the councils for all people at risk from the direct or indirect effects of flooding. This doesn't mean that current emergency management measures are insufficient. It means we want to enhance the current systems to take advantage of new opportunities and innovations. As well as Council-led initiatives, the Plan also seeks to improve people's ability to help themselves.

6.4 Stream Management

Stream blockages have historically played an important role in flooding in the Pinehaven Catchment. In 1976 blockages caused by slash from recently felled pine trees contributed to the flood damages and risk to life.

Targeted maintenance is proposed to reduce the flood risks in Pinehaven. This will include providing maintenance information which clearly define property owner responsibilities and engaging with the neighbours of the streams, as well as Council maintenance programmes particularly targeting blockage prone areas and blockage prevention structures.

One of the management outcomes of the stream will also be to ensure there is clear channel capacity. This is in order for there to be enough space for maintenance crews to make a quick judgement call about whether to carry out any channel clearing works. Refer to Volume 2 maps for details on the size of channel expected.

Figure20: Debris from overtopping of a culvert in flood

Guidance on the types of plantings or upgrades that should be encouraged along the stream banks will also need to be developed. This will enable private property owners to manage the stream in their properties in a way that is consistent with the flood protection and amenity objectives of the FMP.

7. Implementation and Funding

7.1 Introduction

This section sets out the process for bringing to life the floodplain management objectives and methods described in this FMP.

There will be a variety of flood mitigation methods implemented as part of the FMP. They will be carried out by a number of different authorities and individuals. Most costs will be incurred through methods implemented by the Council and these will be funded by the Council through rates of various types.

The community will contribute through monitoring the implementation, engaging in voluntary activities such as planting and restoration work, granting access through private property to carry out the flood protection upgrades and accepting the changes in stream character on both public and private land required to achieve the flood improvement benefits.

Iwi will contribute to the implementation through their working partnership with GWRC, and provide expert assistance in establishment of discovery protocols and advise in any case of discovery during implementation which may have cultural significance.

7.2 Community Flood Protection Responsibilities

Principles

Landowners have responsibility for the stream within their private property boundaries. Further details can be found in GWRC publication 'Watercourses and You'

Implementation

In the upper catchment landowners will be expected to comply with the rules included in UHCC district plan. This includes; improving the flood carrying capacity of private access structures which cross the stream. A minimum capacity dimension and conceptual sketch to assist with visualisation of an ideal structure is included in Figure 10 to assist with this. Controls on forestry and other land clearance activities; building floor levels and subdivision and other land use activities will be managed through the proposed district plan for this catchment.

In the middle and lower catchment structural upgrade works are planned to improve the flood carrying capacity of the stream. Much of this work occurs on private property and provides direct benefit to those properties. The implementation of the physical upgrade components of the floodplain management plan relies on the council project team and individual landowners agreeing an acceptable channel alignment and reinstatement works through affected private property.

On-going Management

Future management of the stream will reside with UHCC.

Property owners will remain responsible for clearing blockages within private property boundaries and maintaining the flood carrying capacity of the stream. This includes ensuring that any stream bank or riparian planting does not impede flood flows or block the stream. Additional planting and restoration advice is available from the Biodiversity team at GWRC.

7.3 Councils' Flood Protection Policies/Responsibilities

Policies

GWRC and UHCC each set out their intentions for flood management in the Pinehaven catchment in their Long Term Plans (2015-2025).

GWRC's activities are focussed on understanding flood risk, maintaining flood protection and control works, and improving flood security. GWRC's long-term approach to flood protection is to promote a safe and prosperous community through appropriate flood protection measures while maintaining a natural river environment.

UHCC also highlight floodplain management as an on-going programme for improving system performance and minimising the risks caused by natural disasters.

Both GWRC and UHCC note the Pinehaven FMP as a key mechanism for achieving their flood management goals in the catchment. This approach is intended to minimise loss of life, support economic development, inform and empower the community, enhance ecological quality and provide for recreational opportunities.

Implementation

A number of parties will work together to implement the FMP. These include:

- GWRC is responsible for the majority of structural in channel works. UHCC will implement many of the non-structural measures including implementing land use controls and, in the long-term, taking over management of the Pinehaven stream;
- UHCC will undertake the bridge upgrades on public roads;
- The Floodplain Management Committee. The Committee's role is focused on ensuring the action plan (see Section 7.4) is developed and implemented. The Committee also acts as a contact point for issues regarding the implementation of the FMP;
- Landholders in the hazard areas will be required to upgrade private stream crossing structures where they become a hazard or generate adverse effects on neighbouring properties;

- Community groups will have the opportunity to contribute to the plan through enhancements to areas of the Pinehaven stream and floodplain. In particular community groups can also have the opportunity to undertake planting and environmental education projects to implement the vision of this FMP. This can be achieved through GWRC providing guidance and designs regarding the types of enhancements that will support ecology and amenity, and community groups may bring these visions to life through activities such as stream planting.

In order to address these flood risk issues, the following table outlines potential timeframes for addressing flood risk and lead agencies responsible for delivery.

On-going Management

It is intended that UHCC will take over long term management of the stream and management of the FMP. It is recommended that this includes two annual stream maintenance inspections are carried out by a maintenance team who will check the condition of assets, check for blockages or potential blockages, and assess the flood carrying capacity and condition of the stream and channel. Any required work will be identified and the responsible party contacted to address the issue. It is recommended that additional inspections will be carried out during and after flood events which exceed an annual flood level 100%AEP/1-in-1 year return period flood event.

Flood Pegging

Following a flood event of 5%AEP/1-in-20 year return period or greater it is recommended that a team of council officers are sent to the catchment to record locations of flood damage and mark flood extents to assist with future calibration of the flood model See Appendix G.

7.4 What the Council will Fund

Both GWRC and UHCC have identified funding within their long term plans over the next decade for developing and implementing the Pinehaven FMP. This is recorded in each of the Councils' Long Term Plans for 2015-2025 as:

- GWRC to provide $5.1 million over ten years between 2015 [4].;
- UHCC to provide $5.8 million over the ten years between 2015-24[5]..

The details of funding allocation will be confirmed as the project progresses. The Council's project team will report to the Hutt Valley Floodplain Management Subcommittee. The committee will develop an annual action plan detailing elements of the FMP that will be funded and implemented in each financial year.

When each stage of funding is confirmed the following implementation schedule will be able to be undertaken as outlined in the table below.

[4] GWRC Long Term Plan 2015-25, section 3, p80 sourced, http://www.gw.govt.nz/assets/Plans--Publications/LTP-2015-25/Accessible-versions/2-Long-Term-Plan-2015-18-Section-3.pdf
[5] UHCC Long Tern Plan 2015-25, p141, sourced http://www.upperhuttcity.com/wp-content/uploads/2015/07/Long-Term-Plan-2015-2025.pdf

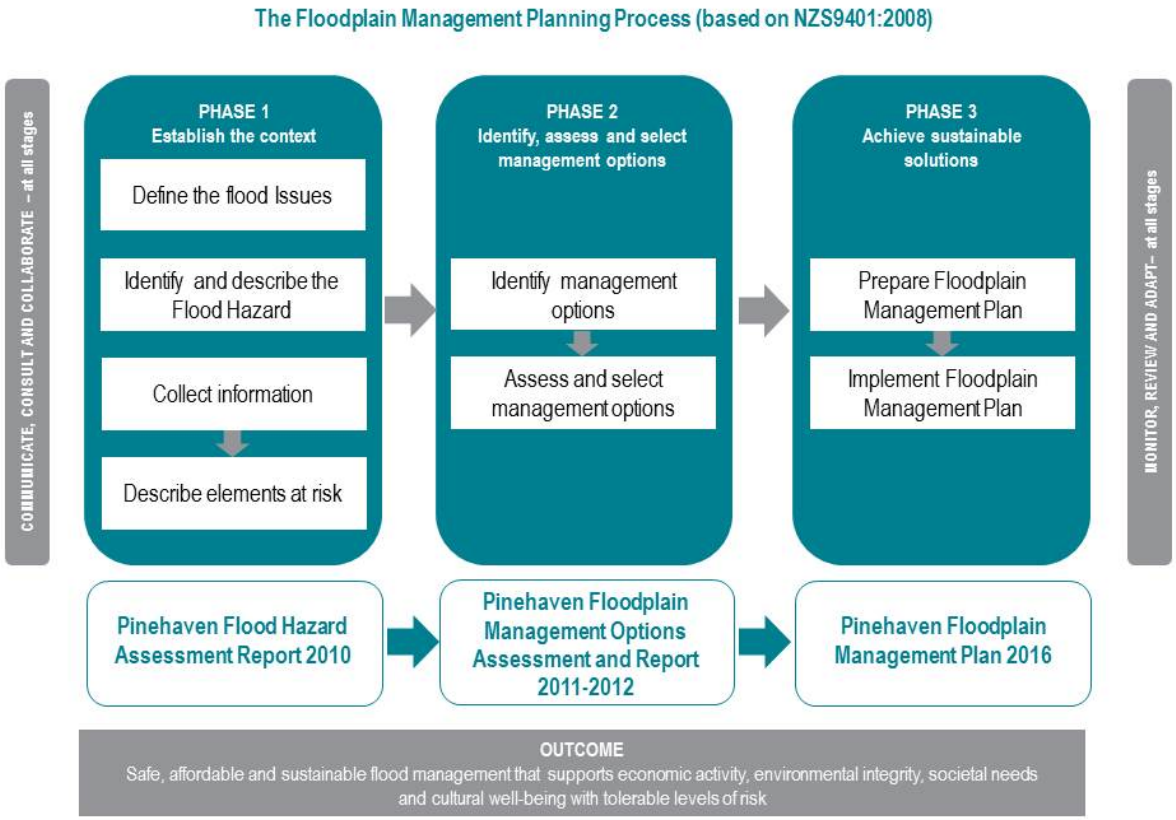
Pinehaven Stream Floodplain Management Plan – Implementation Schedule							
Activity	15/16	16/17	17/18	18/19	19/20	20/21	21/22
Structural works consenting strategy 201/16, approvals sought 2016/2017							
Structural works							
Developing Plan Change to the UHDP							
Provision of design advice (private crossings and ecological plantings)							
Upgrades to private crossings							
Council-led and community-implemented enhancements to the stream and floodplain							

8. Monitoring and Review

This FMP is a living document and should be reviewed regularly to ensure the FMP is fit for purpose and is being used effectively. The following review timeframes will be undertaken with the following scope and reporting associated with each review:

Review scope	Review period	Reporting
• Monitoring implementation of actions • Operational programme summary • Annual action plan	Once a year for 3 years until the main structural works and Plan Change are complete	As part of the annual Council reporting, a single report will be prepared for use outlining: • What we said we would do • What we actually did • Why the difference • What's proposed for next year • Summary of implementation status
• Processes for implementing the plan • Effectiveness of the measures implemented • Progress on implementing all management measures • Review of catchment hydrology, including determining the flood extent and river hydraulics • Reviewing flood events and damages • Capital and operational expenditure • Prioritising and costing all outstanding works.	Every 10 years	Providing a full report on effectiveness and management measures and anticipated outcomes which can be used by both UHCCand GWRC
• Extent of flood hazard, including maps • Performance of flood protection works • Flood damages and disruption • Effectiveness of land use control methods • Advice to landowners,	In response to specific flood events, or where a major change is proposed in future land use trends outside of those considered in the FMP	A report would be provided outlining advice on how to respond following the event or land use change to landowners, territorial authorities and other interested parties.

Appendix A Phases of Floodplain Management Planning



Appendix B Legislative Framework

The following sets out the planning framework within which flooding in the Pinehaven Catchment will be managed.

Resource Management Act

In New Zealand, the Resource Management Act 1991 (RMA) is the primary statute for natural hazard management policy, planning and decision making.

Roles of Local Government

Under s.30 of the RMA, regional councils are responsible for (among other things) the control of the use of land and rivers. This includes responsibilities for the avoidance or mitigation of natural hazards, through regional plans and rules (s63-68). Regional councils are responsible for preparing the Regional Policy Statement (RPS) which can amend regional/district plans to *give effect* in regard to how regionally significant resource management issues are to be addressed. This provides direction to what matters must be incorporated into regional and district plans.

The RPS is an important mechanism that influences how regional and district plans address the effects of flood risk, and can be used to further clarify which local authority is responsible for controlling the use of land for the avoidance or mitigation of these effects. Including a regional policy approach to flood hazard in the RPS can assist in ensuring an integrated approach between local and territorial authorities.

District Councils, such as Upper Hutt City Council, provide objectives, policies and rules in their District Plan. These objectives, policies and rules often originate and are justified for through the RPS in some circumstances. Rules can include tools such as setbacks, identifying zones, building levels, adaptation ability to raise heights, financial contributions and limitations on land use activities.

District and Regional Plan rules can be used to control various aspects of new development in flood prone areas. Rules can address the design, construction, location, configuration and density of developments. While regional plans such as the Regional Coastal Plan, the Regional Soil Plan, the Regional Freshwater Plan and the Regional Plan for Discharges to Land obviously have a large role to play with regards to flood hazard measures, the focus in this section has been on district plan provisions in order to focus on the brief at hand.

Subdivision Controls

Section 106 of the RMA grants consent authorities the ability to refuse subdivision consents in particular circumstances:

(1) A consent authority may refuse to grant a subdivision consent, or may grant a subdivision consent subject to conditions, if it considers that—

(a) the land in respect of which a consent is sought, or any structure on the land, is or is likely to be subject to material damage by erosion, falling debris, subsidence, slippage, or inundation from any source; or

(b) any subsequent use that is likely to be made of the land is likely to accelerate, worsen, or result in material damage to the land, other land, or structure by erosion, falling debris, subsidence, slippage, or inundation from any source; or

(c) sufficient provision has not been made for legal and physical access to each allotment to be created by the subdivision.

(2) Conditions under subsection (1) must be—

(a) for the purposes of avoiding, remedying, or mitigating the effects referred to in subsection (1); and

(b) of a type that could be imposed under section 108.

Enforcement Provisions

Section 322 of the Resource Management Act 1991 (RMA) allows enforcement officers to issue abatement notices to either require a person to cease an activity or to undertake an activity to ensure compliance with the RMA, any regulations, resource consents, or a plan.

(1) An abatement notice may be served on any person by an enforcement officer—

(a) requiring that person to cease, or prohibiting that person from commencing, anything done or to be done by or on behalf of that person that, in the opinion of the enforcement officer,—

(i) contravenes or is likely to contravene this Act, any regulations, a rule in a plan, or a resource consent; or

(ii) is or is likely to be noxious, dangerous, offensive, or objectionable to such an extent that it has or is likely to have an adverse effect on the environment:

(b) requiring that person to do something that, in the opinion of the enforcement officer, is necessary to ensure compliance by or on behalf of that person with this Act, any regulations, a rule in a plan or a proposed plan, or a resource consent, and also necessary to avoid, remedy, or mitigate any actual or likely adverse effect on the environment—

(i) caused by or on behalf of the person; or

(ii) relating to any land of which the person is the owner or occupier

Enforcement orders (section 314 of the RMA) are a similar mechanism to abatement notices, but require a successful application to the Environment Court, in contract to abatement notices, which can be served by council enforcement officers. Enforcement orders provide more options for councils, including the ability (with consent of the court) to undertake the work on the respondent's behalf and recover these costs.

Building Act 2004

In addition to the RMA, a variety of other statutes are relevant to flood management. The Building Act 2004 provides a performance-based building control system that applies to the construction, alteration, demolition and maintenance of most structures. The controls within the Building Act assist in ensuring development is compatible with the prevailing flood hazard and that the overall level of flood damage will not be significantly increased. Types of controls available through the Building Act are, for example, setting of floor levels and filling of sites.

Land Drainage Act 1908

The Land Drainage Act 1908 includes a range of powers for local authorities and private land owners in relation to stormwater management. Section 62(1) of the Land Drainage Act 1908 allows local authorities to order the removal of obstructions if they are 'calculated to impede the free flow of water' in a watercourse and the obstruction is 'likely to cause damage to any property'. If the owner/occupier does not undertake the work within the specified timeframe, the local authority has the ability to undertake the work and charge the owner/occupier the cost incurred.

Other Legislation

A number of other acts also impact upon the management of natural hazards in New Zealand, including:

- Local Government Acts 1974 and 2002
- Local Government Official Information and Meetings Act 1987
- Environment Act 1986
- Conservation Act 1987
- Soil Conservation and Rivers Control Act 1941
- Forest and Rural Fires Act 1977

The Civil Defence Emergency Management Act 2002 (CDEMA) provides the primary legal framework for emergency management policy, planning and decision making.

The Upper Hutt District Plan

The UHCC are responsible for delivering a District Plan that is consistent with the relevant GWRC policies and Plans and managing the resource consent process for land use and subdivision.

The UHCC directly influences flood risk through the District Plan rule framework, which provides for land use and subdivision. Despite this, the Report highlights that there are very few policies and rules included in the UHCC District Plan that address flood and erosion hazards. Where provisions have been included, they are primarily informed by the Hutt River Floodplain Management Plan (2001) and thus are restricted to flood impacts associated with the Hutt River, which excludes the Pinehaven catchment.

Through the FMP stage I report, this highlighted that the UHCC addresses flood risk via;

- District Plan – restriction of activities and structure within the river berms of Hutt River
- Restricting buildings in a 1% flood area of the Hutt River

- Flood hazards identified on Maps
- Hazard register referred to in Building Consent process and LIM, PIM and Resource Consent process.
- Information requirement for Resource Consent applications including plans of all structures within the application site
- When UHCC is concerned they can request to commission of report under s92.

The only direct method used to manage flood risk is a rule elevating the erection of buildings and structures within the 1AEP% area to a Discretionary Activity status and requiring an analysis of the impact. While the objectives, policies and rules of Section 14 (Natural Hazards) relate to Pinehaven in a general sense, only activities taking place within the 1% area is subject to the rules and analysis. In this case, Pinehaven is not identified within the 1% area.

While the District Plan lacks direct policies and rules addressing flood risk for Pinehaven, there are indirect measures that assist in reducing flood risk to private property. These include:

- Larger lot sizes in the Residential Conservation Zone, which comprise a large area of Pinehaven, meaning the surface area to absorb flood waters is greater than that of the standard pattern of residential land use. This potentially means less run-off from areas and thus (indirectly) reducing the intensity of development affected by flood risk.
- The open space zones provide a positive hazard management method by providing buffers along the Pinehaven Stream setting private property back from the identified hazard risk.

However, these zones focus on providing active and passive open space for the community and thus are not comprehensive addressing hazard management.

How is flood risk being managed elsewhere in Upper Hutt?

The UHCC notified Proposed Plan Change 15 – Hutt River and Mangaroa River in 2012. Plan Change 15 included issues related to flood risk management in Pinehaven. The Proposed Plan Change rules were crafted to seek a risk based approach to identify suitable provisions and aims to bring the Plan in line with GWRC's Hutt River Floodplain Management Plan.

Plan Change 15 has been on hold since 2013 and will be formally withdrawn. A new Plan Change is now being developed and will be brought back to Council. The reason for this change is to include updated flood modelling, which has removed the Hutt River Model and responded to comments made through the independent review of the previous Plan Change. While the mapping extents will be altered based on updated modelling, the provisions of the proposed Plan Change 44 will be largely consistent with the former proposed PC 15.

The former Proposed PC 15 proposed to identify and manage activities within a 'Flood Hazard Area' which will be shown on the Planning Maps. This area was to be further divided into the following four 'sub-areas' to be depicted on a new set of Hazard Maps: 'River Corridor', 'Overflow Path', 'Ponding Area' and 'Erosion Hazard Line'. Changes are proposed to objectives, policies, rules, definitions and maps.

The plan maps would show the identified areas (such as ponding or overflow) as an overlay. Activities proposed within the overlay will be subject to permitted activity conditions (e.g. minimum requirements) or specific information requirements as a matter of discretion where a resource consent is required.

The level of influence PC 15 / PC 44 has on the Pinehaven Catchment is limited. However, it has guided future planning controls in the catchment.

Appendix C Emergency Management

Civil Defence Emergency Management

The national Civil Defence Emergency Management (CDEM) framework consists of three tiers; National, Group (Regional) and Local.

- The National Level is operated by the Ministry of Civil Defence Emergency Management on behalf of the central government.
- New Zealand is divided into 16 CDEM Groups. Each Group is an association of a region's local councils, the local authorities and representatives from emergency services, lifeline authorities and government departments.
- The local level is operated by the territorial and/or city authorities.

Each level of emergency management has different responsibilities and procedures as shown below.

Local civil defence and emergency management

Everyday business	National Level	Regional Level	Local Level
Administer the Civil Defence Emergency Management Act	●		
Provide CDEM advice to the Minister and Cabinet	●		
Develop national CDEM policy, guidelines and plans	●		
Promote and raise public preparedness and hazard awareness	●	●	●
Identify, assess, reduce and manage hazards and risks		●	
Develop Civil Defence Emergency Management Group Plans		●	
Plan response to localised emergencies			●
Foster resilience by co-ordinating the 4Rs of CDEM	At a national perspective	At a regional perspective	Within the community
During response to an emergency			●
Deliver emergency response activities to the local community			●
Manage central government during emergencies of national significance	●		
Co-ordinate resources between local areas with the Group		●	
Provide support to regional response authorities	●		
Provide support to local response authorities and agencies		●	

Response Procedures

Greater Wellington Regional Council and Upper Hutt City Councils are responsible for managing emergency events in their area, where civil defence measures are required.

A flood can become a civil defence emergency if:

- Evacuations are required
- Roads need to be closed
- The emergency services (Police, Fire Service) do not have enough resources to do the tasks that are required, or
- Emergency housing and welfare are needed.

To respond effectively to an emergency, the councils work with the emergency services, essential services providers (for example, water suppliers, electricity suppliers), volunteer organisations and people with specialist information (such as the MetService, or the Regional Council Flood Protection Group).

Response Team

The Response Team for Upper Hutt is the Upper Hutt Community Rescue (also known as NZRT-9). The team was formed in 1995 out of a community initiated response to provide Upper Hutt with a viable and effective civil defence team. The team is administered by an elected committee and runs as a non-profit organisation.

Upper Hutt Community Rescue is committed to:

- Providing a service to the Upper Hutt community and the Wellington region
- Supporting community activities where first aid and rescue may be required
- Having all members trained to a common standard using recognised programs and methods
- Continuous expanding the teams skill and knowledge base to enable compatibility with existing emergency services
- Open communication between UHCR and existing emergency services.

Local Emergency Operations Centres

The city council will manage emergency events from specialised Emergency Operations Centres (EOC). The role of these centres is to gather information, organise the appropriate response, and disseminate information about the emergency back to the affected communities.

Representatives from the essential response organisations such as the Police, Fire Service, utility companies and medical services may be present at the emergency operations centres to offer expert advice and updates on the situation. If it is a declared civil defence emergency, the response representatives will direct their organisations according to priorities set by the local civil defence organisation.

The Upper Hutt City Council emergency operations centre is located on the ground floor, Council Buildings, 840 Fergusson Drive, Upper Hutt.

An EOC may be partially or fully activated as the circumstances of a developing incident dictate.

The following may result in a Local EOC being activated:

- An alert or warning has been received that requires action within a localised area;
- Local emergency agency notifies emergency management staff of a developing incident;
- Local emergency agency requests EOC to coordinate response to an incident;
- Local emergency agency requests the use of CDEM facilities;
- CDEM personnel determine that CDEM input is required.

Role of local Emergency Operations Centres

Under the direction of the Local Controller, the local EOC will coordinate the local CDEM response by:

- Operating according to CIMS structure;

- Monitoring events and escalate response as required;
- Ensuring local emergency response agencies are involved in the local response, and emergency services liaison officers available in the EOC;
- Ensuring communications are in place with key local response agencies;
- Arranging for community welfare and support facilities and services;
- Receiving, assessing and disseminating information for local emergency response agencies;
- Providing information to the media about the event and the local response;
- Reporting to the ECC (if required);
- Community response coordination and volunteer management.

Civil Defence Centres

In a major event, it is your community that would open a civil defence centre. Go to a civil defence centre if you need help or information, or if you are able to offer assistance. The civil defence centres within the Pinehaven Catchment are:

- Pinehaven Civil Defence Centre
- Pinehaven School, Forest Road
- The Silverstream Civil Defence Centre is also located nearby, at:
- Silverstream School, Whitemans Road.

Recovery

If necessary, the council will appoint a Local Disaster Recovery Managers. Local Recovery Managers are responsible for the coordination of recovery activities within their local area. These managers will work alongside any central government recovery personnel.

Actions to enhance recovery start in the early part of the emergency response and continue until essential services are restored to a minimum operating standard. Civil defence powers (such as the councils' abilities to evacuate and requisition equipment) are not maintained during the recovery period.

An expenditure management system will be set up during the response phase. This must be closed off at the transition from response to recovery and the details submitted to the Group Recovery Manager and Wellington Region CDEM Group.

Territorial Authorities finance systems and staff will be used for all local recovery financial transactions.

Regional Emergency Management

Everyday business	National Level	Regional Level	Local Level
Administer the Civil Defence Emergency Management Act	●		
Provide CDEM advice to the Minister and Cabinet	●		
Develop national CDEM policy, guidelines and plans	●		
Promote and raise public preparedness and hazard awareness	●	●	●
Identify, assess, reduce and manage hazards and risks		●	
Develop Civil Defence Emergency Management Group Plans		●	
Plan response to localised emergencies			●
Foster resilience by co-ordinating the 4Rs of CDEM	At a national perspective	At a regional perspective	Within the community

During response to an emergency			●
Deliver emergency response activities to the local community			●
Manage central government during emergencies of national significance	●		
Co-ordinate resources between local areas with the Group		●	
Provide support to regional response authorities	●		
Provide support to local response authorities and agencies		●	

General Responsibilities

The Civil Defence Emergency Management Act 2002 (CDEM Act) requires every regional council and every territorial authority to establish a Civil Defence Emergency Management Group (CDEMG). The Upper Hutt City Council is part of the Wellington Region CDEMG.

Section 48 of the CDEM Act requires every CDEM Group to prepare and approve a CDEM Group Plan. The original Wellington Region CDEM Group Plan (Group Plan) was approved by the CDEM Group in 2005. The 2nd Generation CDEM Group Plan is currently in draft and public consultation stage.

The Wellington CDEMG is be made up from all territorial local authorities in the Wellington region, the Regional Council, and Marlborough District Council. The CDEMG would also receive input from the Police, Fire Service, lifelines organisations and other emergency responders.

Response Procedures

Wellington Region Emergency Management Office

The new Wellington Region Emergency Management Office (WREMO) was launched on 2 July 2012 to manage Civil Defence Emergency Management services in support of the nine City, District, and Regional Councils of the Wellington region. A shared approach to emergency management will enable our communities to be better prepared and will provide an ability to share resources to best effect.

WREMO's responsibilities include:

- Monitoring, evaluation and reviewing activities against the CDEM Group Plan;
- Carrying out its responsibilities specified in the CDEM Group Plan;
- Coordinating the involvement of local authorities and other agencies in CDEM Group activities;
- Assisting local authorities CDEM obligations are met;
- Coordinating the provision of professional advice to the CDEM Group Joint Committee;
- Directing and participates in CDEM Group work programme activities;
- Establishing liaison links with CDEM agencies, other agencies, volunteers and the community;
- Developing emergency management plans, guidelines, systems and Standard Operating Procedures as required.

WREMO is "home-based" in the earthquake-resistant Emergency Management building in Turnbull Street, Thorndon, and another purpose built facility in Laings Road, Hutt City. The WREMO staff continue to work throughout the region, operating from Emergency Management Offices at Porirua, Kapiti, and Masterton.

Role of the Group Emergency Coordination Centre

Under the direction of the Group Controller, the ECC will coordinate the regional CDEM response by:

- Operating under CIMS structure;
- Coordinating and/or supporting activated Local EOCs;
- Receiving, assessing and disseminating information for emergency response agencies;
- Where possible, providing logistical support when requested by a Local EOC;
- Ensuring major emergency response agencies are involved in the Group response, and major support agencies have liaison officers available;
- Ensuring communications are in place with key regional response agencies;
- Receiving, assessing and disseminating information about lifeline utility services through a Lifelines Co-ordination Centre within the ECC;
- Providing information to the media about the event and the Group response;
- Reporting to Central Government (if required).

Recovery

Priorities for regional recovery are the safety of people, social restoration, economic restoration and physical restoration. The Regional Council may appoint a Recovery Manager to guide the recovery process if necessary. The Group Recovery Manager is responsible for coordinating the recovery activities for the CDEM Group area. The Group Recovery Manager role will commence during the response and cease upon completion of the exit strategy.

During recovery, the Greater Wellington Regional Council finance system and staff will be used for managing all Group recovery financial transactions.

National emergency management

Everyday business	National Level	Regional Level	Local Level
Administer the Civil Defence Emergency Management Act	●		
Provide CDEM advice to the Minister and Cabinet	●		
Develop national CDEM policy, guidelines and plans	●		
Promote and raise public preparedness and hazard awareness	●	●	●
Identify, assess, reduce and manage hazards and risks		●	
Develop Civil Defence Emergency Management Group Plans		●	
Plan response to localised emergencies			●
Foster resilience by co-ordinating the 4Rs of CDEM	At a national perspective	At a regional perspective	Within the community
During response to an emergency			●
Deliver emergency response activities to the local community			●
Manage central government during emergencies of national significance	●		
Co-ordinate resources between local areas with the Group		●	
Provide support to regional response authorities	●		
Provide support to local response authorities and agencies		●	

Response Procedures

The Ministry of Civil Defence & Emergency Management (MCDEM) may become involved in emergency response when more than one region is involved, international co-ordination is required or national or central government resources (such as the NZ Defence Force) are required.

The National Crisis Management Centre

The National Crisis Management Centre (NCMC) facilitates the Central Government crisis management arrangements and offers inter-agency and scalable operability to deal with any type of event or crisis. The NCMC is managed and maintained in a continued state of readiness by the Readiness Unit of the MCDEM.

A large emergency in Wellington is likely to be heavily supported by the NCMC

The NCMC is situated below ground in the Beehive (Parliament buildings) sub-basement, contained within the outer perimeter of the building. Its design is aimed at maximum self-sustainability in the event of a major Wellington earthquake or other local disasters and service failures.

When activated for a CDEM event, the NCMC is staffed by MCDEM Wellington personnel and liaison officers from other relevant government and support agencies (depending on the level of activation and the demands dictated by the event). From the NCMC, the Ministry:

- Monitor and assess CDEM events and local and regional CDEM emergencies.
- Collect, analyse and disseminate information on events/emergencies.
- Action requests for operational and logistical support from local level CDEM response.
- Accommodate, inform and guide meetings of Central Government structures on response requirements.
- During a national emergency, manage and control the entire response to the event.

The Department of Internal Affairs administers funding for emergency expenditure related to accommodating, transporting, feeding and clothing emergency evacuees. Other emergency expenditure may be eligible for subsidy if expenditure is greater than the threshold of 0.01 per cent of net equalised rateable value.

Recovery

The Ministry of Civil Defence & Emergency Management may appoint a disaster recovery co-ordinator to work with affected communities and institute necessary programmes of disaster recovery. The Ministry also assesses proposals for recovery funding, making recommendations to central government.

Depending on the scale of recovery required, financial arrangements for relief funds, donated goods and services, monetary donations and financial assistance from central government and Councils could be available.

Flood Detection

Flood Detection starts with the detection of heavy rainfall capable of leading to an increase in river levels. Several methods are available to predict if and how river levels may react to a heavy rainfall event, such as manual estimations, computer modelling, and past experience. GWRC currently uses telemetered river level recorders and telemetered rainfall information to provide the necessary data to predict river levels and hence a flood. GWRC is in the process of implementing a real time flood forecasting model. Once this model has been validated it will provide more accurate computer-generated estimates.

Flood Warning Time

The warning time is how long a person subject to a flood has to react. The warning is determined by a combination of flood detection and recognition, plus the time taken to issue warnings and take action. The warning time in Pinehaven is generally short, it can be as short as half an hour.

Examples of Support Organisations

Support Organisation	Function
WREMO	Information and resource management including reconnaissance and needs assessment, logistics supply, volunteer management and support, and incoming external personnel management and support Registration of evacuees Welfare co-ordination Emergency clothing
NZ Police	Law and order, evacuations, normal Police role
NZ Fire Service	Fire fighting, rescue
Hutt Valley District Health Board	Medical treatment and medical provisions
Regional Public Health	Public Health
Salvation Army	Emergency food
Civil Defence centres	Collection point for information and people needing assistance
Initially WREMO until Housing NZ are able to take over and coordinate temporary housing	Emergency shelter
Ministry of Social Development (via Work and Income)	Financial support

Appendix D Independent Audit of Flood Model

www.beca.com

Report

Pinehaven Stream - Flood Mapping Audit

Prepared for Greater Wellington Regional Council

Prepared by Beca Ltd (Beca)

13 July 2015

Revision History

Revision Nº	Prepared By	Description	Date
1	**Michael Law**	Final	13 July 2015
2			
3			
4			
5			

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Michael Law**		13July 2015
Reviewed by	**Graham Levy**		13 July 2015
Approved by	**Graham Levy**		13 July 2015
on behalf of	Beca Ltd		

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Executive Summary

Flood hazard maps have been developed for the Pinehaven Stream catchment in the Hutt Valley. The maps are based on the outputs of hydrological and hydraulic modelling carried out from 2008 to 2010, and are being used to inform control of development and flood alleviation options for the catchment.

The scope of the audit described in this report is neatly summarised as follows:

"The audit builds upon previously completed investigations and peer review work and elevates this to an additional level of scrutiny and analysis. These previous investigations and peer reviews found both the hydrology and hydraulic model fit for purpose, however some of the community still had concerns that the scope of the reviews done to date was not extensive enough, and therefore an additional more comprehensive audit has been requested by the Hutt Valley Floodplain Management subcommittee, (the governing body for the development of the floodplain management plan). This audit is to contain a review of the hydrology, hydraulic model and the application of freeboard."[1]

The terms of reference (ToR) for the audit and appointment of the auditor have been subject to community scrutiny. This audit report contains a review of the hydrological and hydraulic modelling, the application of freeboard, and the presentation and interpretation of the flood hazard maps. Meetings have been held with the modellers and with two community groups; Save Our Hills and Pinehaven Progressive Association. The concerns raised, and case studies provided, by the Save Our Hills group are addressed in the audit.

As requested in the RFP ToR, guidance is also provided in the report on how to:

- Set storm water neutrality provisions within district plan.
- Define the impact of intensification of development on the runoff characteristics of the Pinehaven hills.

A review of the hydrological and hydraulic modelling has been carried out as part of this audit, and is described in the ToR as an audit of:

- The type of software and modelling package used for the hydrology and hydraulic model
- The modelling method used and its appropriateness for both hydrology and the hydraulic model
- The use of freeboard and method by which it was applied
- Representation of the flood hazard through the way in which maps are displayed and information provided.

The review found that the hydrological and hydraulic modelling is fit for purpose. The methods and level of detail reflected the catchment information and modelling methods available in 2008-2010.

While there have been advances in modelling methods and available information since 2009 updating and upgrading the models is not recommended by this audit, and doing so would be unlikely to significantly alter the flood extents and depths for the design flood events and scenarios modelled.

The way that the flood extent and hazard maps are presented in published information obscures the components that have been used to derive the extents. Describing the 'flood extent plus freeboard' maps as Flood Hazard Maps does not adequately describe the complexity of information included in the

[1] Paragraph 6 of the ***Request for Proposal - Pinehaven Stream Flood Mapping Audit.*** *WGN_DOCS-#1437397-v3-ToR_Pinehaven_Stream_FMP_Audit.doc*

Maps. These issues lead to confusion and misunderstanding within the community regarding the interpretation and use of the maps. As such, the presentation of flood information in published map form could be modified which may provide greater transparency and understanding.

This may be achieved by distinguishing modelled levels from wider flood sensitive areas, taking freeboard and sensitivity to factors such as debris blockage into account. Currently, this information is available to an individual by request from GWRC; however these additional details are not included in published maps.

Given that the maps are to be used for planning purposes, the inclusion of an allowance for climate change to a suitable horizon is appropriate, as is the inclusion of freeboard. 2090 is suggested as it is one of the time horizons reported in MfE's 2008 guidance. Similarly, the choice of ARI for the map could be altered to reflect local consenting requirements.

The modelling underlying the flood maps is now 6-7 years old. Flood maps are periodically updated in line with council long term plans, or in response to significant new data becoming available after a major storm event, or when major changes occur within the catchment. The community should be made aware of this, and understand that mapped flood extents may be refined in future as a result of programmed revision to flood modelling and mapping.

The issue of including stormwater (or hydrological) neutrality into local planning guidelines is complicated. While general principles regarding matching or lowering peak flows at the outlets from developments are widely adopted, the hydrological effect of potential developments should be considered on a case by case basis, as in some cases downstream flood risk may be reduced if runoff from the development is discharged early to the receiving water course before floodwater from upstream arrives. However, this is unlikely to be the case for the Pinehaven catchment, where runoff attenuation is likely to provide the most benefit to reducing downstream flood risk.

With regard to assessing the hydrological effect of potential future development on the Pinehaven Hills, peak flows in the affected sub-catchments could increase by about 18% (if not attenuated) and flood volumes may increase by about 6%. Further down the catchment the relative percentage increases in peak flow and flood volume will be smaller, as the cumulative catchment area is increased by the inclusion of catchments that have not been subject to future development. Further work will be completed to develop suitable controls for future development within the Pinehaven catchment to support a plan change by UHCC.

Confirming the main conclusion of the audit; **the hydrological and hydraulic modelling underlying GWRC's flood extent and hazard maps is fit for purpose, but the way that flood information is presented in map form could be modified, which may increase the understanding and acceptance of the maps by the community.**

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Appendices

Appendix A – Terms of Reference

Appendix B – Large Figures

1 Introduction and scope

Flood hazard maps have been developed for the Pinehaven Stream catchment in the Hutt Valley. The maps are based on the outputs of hydrological and hydraulic modelling carried out from 2008 to 2010, and are being used to inform control of development and flood alleviation options for the catchment through local and regional planning guidelines.

The scope of this audit is neatly summarised as follows:

"The audit builds upon previously completed investigations and peer review work and elevates this to an additional level of scrutiny and analysis. These previous investigations and peer reviews found both the hydrology and hydraulic model fit for purpose, however some of the community still had concerns that the scope of the reviews done to date was not extensive enough, and therefore an additional more comprehensive audit has been requested by the Hutt Valley Floodplain Management subcommittee, (the governing body for the development of the floodplain management plan). This audit is to contain a review of the hydrology, hydraulic model and the application of freeboard."[2]

The terms of reference (ToR) for the audit and appointment of the auditor has been subject to community scrutiny. The ToR are listed in Section 7 of the Request For Proposal (RFP), which also provided the prospective auditor with the opportunity to include issues not specifically identified in the RFP. The ToR are provided in Appendix A.

This audit report contains a review of the hydrological and hydraulic modelling, the application of freeboard, and the presentation and interpretation of the flood hazard maps. Meetings have been held with the modellers and with two community groups; Save Our Hills and Pinehaven Progressive Association. The concerns raised, and case studies provided, by the Save Our Hills group are addressed in the audit.

As requested in the RFP ToR, guidance is also provided on how to:

- Set storm water neutrality provisions within the district plan, as laid out in Section 7.4.1 of the RFP.
- Define the impact of intensification of development on the runoff characteristics of the Pinehaven Hills, as laid out in Section 7.4.2 of the RFP.

The RFP requested that the audit be delivered as a single volume Audit Report (this report), containing:

- *"Executive summary including comment about whether the flood maps produced and the process by which these were derived makes them fit for purpose.*
- *A completed checklist with a series of YES/NO questions that answer the key question on a topic by topic basis as to whether that particular aspect of the process used to develop the flood maps is fit for purpose.*
- *A summary explanation of any issue which is deemed as being not fit for purpose and what remedial work would be required to make this fit for purpose and deliver a positive audit result.*
- *Results of the additional investigation requesting guidance on how to set storm water neutrality provisions, and how to define the impact of intensification of development."* (Section 9, RFP)

[2] Section 6 of the ***Request for Proposal - Pinehaven Stream Flood Mapping Audit.*** *WGN_DOCS-#1437397-v3-ToR_Pinehaven_Stream_FMP_Audit.doc*

2 Background information

The following reports were reviewed, along with other information, as part of the audit.

- ***Report on storm of 20 December, 1976***, Wellington Regional Water Board.
- ***Pinehaven Stream Flood Hydrology***, MWH for Greater Wellington Regional Council. 2008, plus 2009 update.
- ***Pinehaven Stream Flood Hazard Assessment: Volumes 1 (modelling report) and 2 (flood and hazard maps)***, SKM (now Jacobs) for Greater Wellington Regional Council and Upper Hutt City Council. 25 May 2010.
- ***Pinehaven Stream Floodplain Management Plan***, Greater Wellington Regional Council. 13 October 2014.
- ***Review comments on Pinehaven hydrology report***, Greater Wellington Regional Council memo. 24 October 2014.
- ***Terms of Reference for Audit Pinehaven Stream Flood Maps***, Save Our Hills presentation to GWRC Hutt Valley Floodplain Management subcommittee. 24 February 2015.

It is assumed that the reader of this audit report has a general knowledge of the Pinehaven catchment. However, if needed, a good description of the Pinehaven catchment, Pinehaven Stream, and Flood History is provided in Section 2 of the Volume 1 of SKM's *Pinehaven Stream Flood Hazard Assessment*.

The 1976 flood is used as the reference storm event for the Pinehaven catchment. It resulted in significant flooding within the catchment and had an average recurrence interval (ARI) of about 100 years. As such, it is the event against which modelled flood extents are compared. A contributing factor to the impact of the flood was surges in flow caused by the breaking of debris dams in the upper catchment. Following the 1976 flood, a bypass culvert was constructed in the lower part of the catchment to increase conveyance of floodwater to Hulls Creek.

Unfortunately, stream flows and water levels were not recorded in the catchment prior to MWH's hydrological modelling in 2008, which meant that the derived flow hydrographs in their report were derived from general hydrological methods rather by calibration against observed events. Temporary flow and water level measurement was installed for a period during 2008 and 2009, during which a small flood event was recorded on 23 July 2009. This event was used to calibrate the hydrological modelling in the 2009 update to the report, but it is noted that the July 2009 event had an ARI of about 10 years; significantly lower than the 1976 event.

GWRC reviewed MWH's hydrology and did not find any major issues, although they acknowledged the absence of data against which to calibrate the modelling.

MWH's derived flow hydrographs were used in the coupled 1D/2D hydraulic modelling of the Pinehaven catchment by SKM (now Jacobs) in 2009. The hydraulic modelling was reviewed by DHI (suppliers of the MIKE FLOOD software used) at the time, and found to have been built within DHI's model build guidelines. 5-year to 100-year ARI scenarios were modelled. Community consultation was carried out to provide feedback and comments on the draft outputs of the modelling. Scenarios incorporating combinations of climate change, culvert blockage, and increased land development were modelled to assess the sensitivity of the model results and inform the choice of a suitable allowance for 'freeboard' above modelled flood levels.

The key outputs from SKM's modelling were three sets of maps, as presented in Volume 2 of the *Pinehaven Stream Flood Hazard Assessment.* The maps are:

- Base scenario Q10[3] flood inundation
- Q100 design scenario including partial blockages, freeboard and predicted impacts of climate change
- Flood hazard zone and erosion set back line.

The flood maps are reproduced in GWRC's *Pinehaven Stream Floodplain Management Plan*, in which options for flood alleviation and mitigation are described, and put in their consenting and legal context.

3 Meetings

As part of this audit, the auditor (Mike Law) carried out the following meetings and visits:

- 1 April 2015 — Briefing by Alistair Allan (GWRC's Project manager), and site visit to the Pinehaven catchment.
- 15 April 2015 — Meetings with:
  - Stephen Pattinson and Darryl Longstaffe, representing the Save Our Hills group
  - David Brown and Chris Coslett, representing the Pinehaven Progressive Association
  - Kristin Stokes (MWH).
- 7 May 2015 — Meetings with:
  - Ben Fountain (SKM [now Jacobs])
  - Mike Harkness (GWRC), author of the 2008 MWH hydrology report
  - Alistair Allan (GWRC).

4 Model Review and Checklist

As noted in Section 2, the hydrological modelling has been reviewed by GWRC and the hydraulic modelling reviewed by DHI. Both reviews found the modelling to be acceptable. An additional review of the hydrological and hydraulic modelling has been carried out as part of this audit as required by the terms of reference, and is described below.

The general scope for the model review is described in the terms of reference as an audit of:

- The type of software and modelling package used for the hydrology and hydraulic model
- The modelling method used and its appropriateness for both hydrology and the hydraulic model
- The use of freeboard and the method by which it was applied
- Representation of the flood hazard through the way in which maps are displayed and information provided.

Elements of the modelling have been reviewed (Sections 4.1 and 4.2) and rated using a 0-3 scoring system (described in Table 4.1), which flags up issues that will affect model use. This provides more definition than the simpler Yes/No categorisation specified in the terms of reference.

[3] Q10 = 10-year ARI

Table 4.1 – Model review rating scheme

Description	Audit rating	Fit for use
No issue: The element or parameter being reviewed is modelled acceptably	0	Yes
Minor issue: There is an issue, but it is unlikely to significantly affect model results	1	
Major issue: Failure to resolve the issue compromises the model and should be rectified, but may be resolved by explanation or acceptance of model limitations.	2	?
Fatal flaw: Failure to resolve this issue severely compromises the model, and should be rectified before the model is accepted.	3	No

4.1 Hydrological modelling

The hydrological modelling was carried out by MWH in 2008. The modelling was updated in 2009 following calibration against a small flood event that had been recorded by temporary flow monitoring equipment.

Table 4.1 – Hydrological modelling

Item	Comment	Audit rating	Fit for Use
Software	The hydrological modelling was undertaken using Hydstra software. Hydstra is a standard software package that incorporates a catchment runoff model, and is appropriate for this level of analysis.	0	Yes
Rainfall data	There are rain gauges in (or close to) the lower lying parts of the Pinehaven Stream catchment, and one gauge that is representative of the hills of the upper catchment. The modelling of extreme rainfall depths and profiles is well described in the MWH report and is considered appropriate. As rainfall records lengthen over time and more severe storm events are included in the record, it is worth undertaking occasional reviews of the design rainfall depths and profiles as this will increase the reliability of the modelling in predicting more extreme storms.	1	Yes
Critical storm duration	The critical storm duration for the Pinehaven Stream catchment is 2-3 hours. The critical duration will be less for smaller sub-catchments than for the whole Pinehaven Stream catchment. The temporal pattern used by MWH was based on analysis of 17 Wellington storms. The resulting storm approximated to a triangular profile, with peak rainfall occurring about 70% through the storm. Use of a nested storm profile might improve peak flow calculation for the upper catchments, but is unlikely to have a significant effect on flood extents.	1	Yes
Catchment definition	Catchment and sub-catchment definition is acceptable. The number of sub-catchments was adjusted to meet the hydraulic modelling network	0	Yes
Hydrological method and calibration	Regional flood frequency methods were used to estimate peak flows. These were then used to check the results of rainfall-runoff modelling. Initial and (constant) Continuing losses were used to calculate the effective rainfall, and coefficients used to route flows through the catchment.	0	Yes
Measured flood flows and calibration	The modelled flows were calibrated against the relatively small flood events of 31 July 2008 (Mean Annual Flood) and 23 July 2009 (10-year ARI). Ideally, the model should be calibrated against a larger flood event. In the absence of recorded water level and flow data for the catchment, calibration against the hydrological response of a monitored catchment with similar hydrological characteristics would increase confidence in the modelled flow hydrographs.	1	Yes

Item	Comment	Audit rating	Fit for Use
Calculated flows	The calculated peak flows have been cross-referenced against regional methods for estimating peak flows, and similar results found. It is six years since the hydrological modelling was carried out, and consideration should be given to reviewing the hydrology as a longer period of rainfall data becomes available, as predictions for the effects of climate change evolve, and as the understanding of the hydrological response of the Pinehaven Stream (and similar catchments) improve.	**1**	**Yes**
Climate change	Climate change was not included in the MWH hydrological modelling, but was recommended to be included in further work. Note comments regarding climate change in the review of the hydraulic modelling, below.	**1**	**Yes**

The conclusion of the review of the hydrological modelling is that the derived peak flows and hydrographs are fit for use in the subsequent hydraulic modelling in 2009/2010.

It is six years since the hydrological modelling was undertaken. Flood maps are periodically updated in line with council long term plans, or in response to significant new data becoming available. At such time, the hydrology should be updated to account for longer rainfall records and more storm events. More robust hydrology could be provided by calibration against recorded flow data, especially for a large flood event. In the absence of recorded data, calibration against the hydrological response of a similar catchment should be considered when the hydrology is reviewed. Updating the hydrology is unlikely to make significant changes to the flood maps at the catchment scale, although there may be refinements at the property level.

4.2 Hydraulic modelling

Hydraulic modelling of the Pinehaven Stream catchment was carried out in 2009/2010 by SKM[4], utilising the outputs of MWH's hydrological modelling.

DHI carried out a review of the model in 2009, and confirmed that the build was in line with DHI's own guidelines and training. The DHI model review concentrated on model build parameters, such as Timestep, Flood & Drying Depths, and Hydrodynamic factors. While these have been considered for this audit, more emphasis has been placed on inputs to the model, model extents, and whether the model provides an appropriate representation of flood depths and extents in the Pinehaven catchment.

Table 4.1 – Hydraulic modelling

Item	Comment	Audit rating	Fit for Use
Software	The hydraulic modelling was carried out using DHI's MIKE FLOOD software package to build a coupled 1D/2D model. The stream channels and culverted bypass were modelled in 1D using MIKE 11 and the floodplain in 2D using MIKE 21. DHI's MIKE software is widely used worldwide and is suitable for modelling Pinehaven Stream.	**0**	**Yes**

[4] SKM merged with Jacobs in late 2013, and now operate under the Jacobs name, but for the purposes of this report the name SKM will be retained.

Item	Comment	Audit rating	Fit for Use
Model Extent	The upstream limits of the model are the points where tributary streams enter the built environment. Upstream of these points the streams flow through dense and steep bush and forestry. The downstream boundary of the model is the outfall to Hulls Creek. The model extents are appropriate.	**0**	**Yes**
Floodplain cross-sections and/or 2D extent	Gridded LiDAR data was used to construct the 2D model bathymetry. The LIDAR data was collected on 4 June 2009, and so was current at the time of model build. The use of LiDAR data is generally appropriate. LiDAR is widely used when constructing flood models, but can be less reliable in dense vegetation and for small channels, where topographical survey is required. The 2D model bathymetry had a grid spacing of 5 m. While this gives reasonable definition in generally flat areas, it is relatively coarse for defining flood extents in steeper terrain and detailed overland flow paths where smaller obstructions (such as road curbs) may have a significant effect. Ideally a smaller grid size would be used, but a smaller grid would have significantly increased the time taken to run the model when it was built in 2009. As such, a 5 m grid spacing would have been appropriate at that time, and is still commonly used due to run time constraints. However, DHI's MIKE software now has the ability to use a flexible mesh approach to model bathymetry, which coupled with advances in computing power since 2009 could be used in future to improve the definition of flood extents and overland flow paths.	**1**	**Yes**
Cross-sections	Cross-sections of the stream channel were surveyed for the modelling by Landlink Ltd in June 2009. An appropriate number of cross-section were surveyed around larger structures (such as road crossings), but there are longer than ideal distances between surveyed sections where the streams flow through or behind private properties. Access can be an issue in these circumstances, so the gaps are understandable. They are unlikely to have a significant effect on modelled flood outlines, but do represent a less than optimal situation, especially in channels where cross-sections change over short distances and where there are multiple obstructions, culverts and bridges (see comment below). This may affect flood outlines at the individual property scale.	**1**	**Yes**
Flood plain obstructions	Roughness factors (Manning's 'M') are applied to the 2D model bathymetry surface to represent how easily water can flow across the surface. Smoother surfaces such as roads have a higher M value (lower roughness) than dense bush. The M values used in the MIKE 21 model are appropriate. A Manning's 'M' value of 10 has been used to represent the developed parts of the catchment. This indicates a rough surface, which would be expected with buildings, fences and vegetation providing barriers to flow. It does not appear as though individual buildings and structures on the floodplain have been blocked out or given very high roughness values. This may be due to the use of the fairly coarse 5 m grid for the 2D surface and the computing processing available in 2009. If the model were being built in 2015, it could be expected that buildings would be treated differently than the land around them.	**1**	**Yes**

Item	Comment	Audit rating	Fit for Use
Stream channel roughness coefficients	Within the stream channels a default Manning's 'n' value of 0.035 was applied to represent channel roughness[5]. This is appropriate for reasonably straight and uniform natural channels such as those in the middle and lower reaches of Pinehaven Stream. In the upper reaches higher (0.200) roughness values were used, which reflects the smaller, more vegetated channels, but also the means by which culverts and bridges were accounted for in these reaches (see comment below).	0	Yes
Structures - Weirs, bridges and culverts	Road bridges, larger culverts and bypass channels have been included in the MIKE 11 1D model. Smaller bridges and crossings, especially in the upper Pinehaven Road and Elmslie Road tributaries, have not been included in the model. Rather, their effect on water levels has been represented by the use of a higher channel roughness coefficient. Reasons for not including the smaller channels in the model include difficulty gaining access to survey the crossings, and increased model complexity that can lead to model stability issues, especially in steep channels. The use of increased roughness to represent small bridges and crossings is reasonable, so long as it is realised that the definition of water levels and flood extents at the property scale will be reduced in these areas. Long culverts are modelled as closed cross-sections, rather than as culverts. Manhole losses are not included when this modelling approach is taken.	1	Yes
Boundary conditions	The upstream boundary conditions for the model are the flow hydrographs derived by MWH. The hydrographs for each of the 15 sub-catchments modelled were applied at the top of the tributaries, or as lateral inflows along the stream channels. The downstream model boundary is the water level in Hulls Creek. Water levels are not recorded, and so a constant water level was defined by SKM with due regard to anecdotal evidence of water levels in the Creek during the 1976 event and subsequent remediation works, including upstream storage in Hulls Creek that attenuates flow. Sensitivity checks were carried out on the downstream boundary. The boundary conditions are considered acceptable.	0	Yes
Design events and climate change	The MIKE FLOOD model has been run for the: ■ 5, 10, 20, 50 and 100-year ARI storm events without an allowance for climate change. ■ 23 July 2009 storm event for calibration ■ PMF (Probable maximum flood) ■ 100-year ARI storm events with an allowance (16% increase in rainfall) for climate change. In addition scenarios including full or partial blockage of culverts and/or increased development of the catchment were modelled. See below.	0	Yes

[5] Note that Manning's 'n' is the inverse of Manning's 'M'. SKM used 'M' for the floodplains and 'n' for the cross-sections.

Item	Comment	Audit rating	Fit for Use
Blockage	The probability and consequence of culverts, bridges and channels being fully or partial blocked during floods by water borne debris is a reality, especially in heavily vegetated (including forestry) catchments with lots of culverts and bridge, such as Pinehaven. Model runs were carried out that included partial or full blockage of 12 culverts in the catchment. This is a reasonable approach for assessing the sensitivity of the catchment to blockage given the uncertainty surrounding the timing, location and extent of blockage that may occur during an event.	**0**	**Yes**
Future development	The upper parts of the Pinehaven catchment are bush and forestry. Sub-division development has been mooted for these areas and it could be expected that there would be some infill development in the lower parts of the catchment. While not pre-judging the outcome of any application to develop within the catchment, it is prudent to assess the effects of possible future development when undertaking flood mapping and hazards studies. To that end, SKM ran the model with reworked hydrographs to represent the additional impervious area associated with the development of 1665 lots of 750 m^2 in the upper parts of the catchment. This is probably an over-estimate of the number of lots that could be developed, and as such represents an upper bound on the effect of development on catchment flows and flood extents. Given that the upper catchment is steep, natural runoff could be expected to be quite high and so the relative effect of development would not be great. Were development to occur, mitigation measures would almost certainly be required to attenuate flows and at least reduce peak flows to existing conditions. As noted in Section 8 below, including future development increases modelled peak flows by 18% in sub-catchment B and 13% in sub-catchment E. However, there is no post-development increase in flood volumes. This is unexpected given the increase in impermeable area. MWH were unable to provide an explanation for the lack of increase in flood volume, and so the future development runs of SKM's flood model are potentially compromised in this regard.	**2**	**No**

The conclusion of the review of the hydraulic modelling is that the model is fit for use for producing the flood extent and hazard maps for current development, but that better definition of flood depths, extents and overland flow paths could be provided if the model were to be updated to account for current computer processing power and advances in modelling software. Specifically:

- The use of a finer grid or flexible mesh to construct the 2D model bathymetry would provide better definition of flood extents and overland flow paths.
- Blocking out buildings within the 2D model bathymetry would improve definition of overland flow paths and should be considered if the models are to re-run.
- Review (and update, if necessary) future development hydrology for use in model runs assessing the impact of potential development in the catchment.

Given access issues and the high cost of survey, it is probably impractical to include additional channel cross-sections or model all of the minor bridges and culverts across the stream channel at a catchment level.

4.3 Flood hazard mapping

Figures 4.1, 4.2, and 4.3 show examples of the three sets of flood extent and hazard maps produced by SKM Jacobs as outputs from the hydraulic modelling. The three maps are:

- ***Base scenario Q10 flood inundation:*** 10-year ARI flood depth and extent.
- ***Q100 design scenario including partial blockages, freeboard and predicted impacts of climate change***: 100-year ARI flood depth and extent. This scenario does not include future development.
- ***Flood Hazard Zone and erosion set back line:*** Flood Hazard Zone extent defined by the '*Q100 design scenario including partial blockages, freeboard and predicted impacts of climate change'* extent. Erosion hazard zones and setback shown along channels.

The extent of the Flood Hazard Zone is the same as the extent of the Q100 design scenario including partial blockage, freeboard and predicted impacts of climate change. The Q100 flood depth and extent map includes an allowance for 'freeboard'. Freeboard is an additional depth added to modelled water levels, and is an allowance for:

- Uncertainty in the modelling process or parameters, such as limited survey, lack of recorded flow data, and assumptions regarding stream and floodplain roughness, and antecedent conditions.
- The residual risk of flooding from extreme events (i.e. those greater than the design event), although this is not an element included in freeboard applied to GWRC Flood Hazard Maps.
- Local wave action and obstructions.

Figure 4.1 – Base scenario Q10 flood inundation

Figure 4.2 – Q100 design scenario including partial blockages, freeboard and predicted impacts of climate change

Figure 4.3 – Flood hazard zone and erosion set back line

Application of freeboard extends the potential floodplain beyond the modelled flood extent, and is used in development control to flag that flooding is an issue to be considered at the site and to assist in the setting of levels for floors and vulnerable services. The application of freeboard is one of the issues reviewed in Table 4.4 as part of the audit of the flood and hazard maps.

Elements of the Flood maps have been reviewed and rated using a 0-3 scoring system (described in Table 4.1), which flags up issues that will affect the understanding and interpretation of the maps. As with the review of the hydrology and hydraulic modelling this provides more definition than the simpler Yes/No categorisation specified in the terms of reference.

Table 4.3 – Model review rating scheme

Description	Audit rating	Fit for use
No issue: The element or parameter being reviewed is represented acceptably	0	Yes
Minor issue: There is an issue, but it is unlikely to significantly affect use of the maps	1	
Major issue: Failure to resolve the issue compromises the maps and should be rectified, but may be resolved by explanation or acceptance of map limitations.	2	?
Fatal flaw: Failure to resolve this issue severely compromises the understanding and interpretation of the maps, and should be rectified before the maps are accepted.	3	No

Table 4.4 – Flood hazard mapping

Item	Comment	Audit rating	Fit for Use
Application of freeboard	For the Pinehaven Flood Hazard Map, freeboard is added to the modelled flood levels that already incorporate the effects of partial or total culvert blockage. This is a conservative approach (as the effects of culvert blockage can be incorporated in the freeboard), but reflects the importance given by the Council to debris and blockage in the catchment, as occurred during the reference 1976 flood.	1	Yes
Freeboard height	A freeboard of 0.3 m above the 100-year ARI flood level has been used for the majority of the Pinehaven catchment, with the exception of the reach between Pinehaven Reserve and the bypass channel at Whitemans Road where the freeboard of 0.5 m is allowed. Both of these freeboard depths are in the range used elsewhere in New Zealand, and are considered appropriate.	0	Yes
Scenarios	Two scenarios have been modelled and three maps produced. There is a significant difference between the inputs to the 'Baseline' 10-year ARI flood map and the 100-year ARI map that includes climate change, culvert blockage and freeboard. Such a change makes it impossible to assess the effects of each input that has changed. More clarity would have been provided if a Baseline 100-year ARI map had been produced, then separate maps showing the 100-year map incorporating climate change and blockage; individually and in combination. Finally, the Flood Hazard Map including freeboard would be presented. The effects of uncontrolled runoff from future development in the catchment are not incorporated in the three published flood hazard maps. This means that the issues raised above regarding future development hydrology are not an issue with regard to the published flood hazard maps.	1	Yes

Item	Comment	Audit rating	Fit for Use
Presentation of flood extent maps	The two flood maps show both flood depth and extent. There is an advantage in this in terms allowing users to assess the severity of the flooding. However, different scales are used for the depth of flooding on the Q10 and Q100 flood maps. On the Q100 map the increments of flood depth shown on the maps are 500 mm. There can be a big difference in the consequences of flooding between a flood depth of 50 mm and one of 450 mm, especially in areas where freeboard is set at 300 mm. Reducing the flood depth increments to those on the Q10 flood map would improve the usefulness of the Q100 maps. Where GIS viewers are available, it can be helpful to view flood extents for different flood events at the same time. This isn't an option with the hard copy maps. Due to the concerns raised in Table 4.2 regarding the stream cross-section spacing, modelling of small crossings, and the size of the grid for the 2D model bathymetry, the flood extents shown on the maps may not be detailed enough to define flood levels at, or across, individual properties, especially in the steeper upper reaches of the modelled area. In these areas, a degree of caution and judgement will be required in the use of the maps.	**2**	**Yes**
Presentation of flood hazard maps	As noted above, the current Flood Hazard Map extents equate to the flood extent for the 100-year ARI storm including climate change, blockage and freeboard. Using a single shading for the whole flood hazard extent does not give a full understanding of the hazard in each location. GWRC advise the public to contact the Council for more complete and detailed information and advice. Flood hazard maps often show the flood hazard calculated as a product of the flood depth and water velocity. This is useful from a hazard assessment perspective to understand potential danger to people, and can be readily calculated from the outputs of 2D hydraulic models. However, such a map would not show any hazard in the buffer zone between the modelled flood extent and the extent including freeboard. This suggests that using the term 'hazard' in the title of the maps may be inappropriate and that an alternative name should be used for these maps, as they are used to indicate areas where the risk of flooding should be taken into account. Some alternatives are noted in Section 6.1. The terminology currently used may be one of the reasons why some sections of the local community are struggling to accept the current maps. This may be especially the case where a property owner perceives that their property is not at risk of flooding, and that inclusion within the mapped flood hazard extent could adversely affect the value or development potential of the property.	**2**	**?**

While there is logic to the information contained within the current flood extent and hazard maps, it is not immediately obvious what information was used to generate them. This is demonstrated in the failure of some sections of the local community to understand and/or accept the concepts of the maps, their use and limitations.

Flood maps are limited by the quality of the information used to derive them. As has been noted above, the definition of flood depths and extents in the Pinehaven catchment is restricted by the grid spacing of the model bathymetry and the number of stream cross-sections. This means that in some areas (such as the upper reaches of Pinehaven Road and Elmslie Road) where there is a shallow overland flow path along a road that is raised above the stream channel and streamside properties, the plotted flood extent may be too wide and may be wrongly interpreted as implying deep flooding of properties if it is assumed that flood levels will be the same from one side of the flood extent to the other.

5 Community concerns

The Save Our Hills (SOH) group, which was formed in 2014, has expressed strongly held concerns about what they perceive as serious discrepancies between the published maps and calculations. These concerns were presented to the Hutt Valley Flood Management Sub-Committee (HVFMS) on 27 February 2015, and were discussed with the auditor during a meeting on 15 April 2015 at Beca's office in Wellington. SOH were represented at the meeting by Stephen Pattinson and Darryl Longstaffe.

5.1 SOH case studies and flood hazard mapping

The main concern expressed by SOH was that the flood and hazard extents shown on the published map appeared too great for the modelled flows. Cross-sections were provided for case studies at the following four locations within the catchment:

- Top of Pinehaven Road
- 27 Elmslie Road
- Dunns Street
- Pinehaven Reserve

Figures B.1 and B.2 in Appendix B show the information provided by SOH for 27 Elmslie Road. At this location, the Flood Hazard Map extent is approximately 70 m wide, stretching from edge of Elmslie Road to approximately 15 m beyond the stream channel on the true right (east) bank.

Elmslie Road runs along a relatively narrow valley containing a tributary of Pinehaven Stream. At No. 27, the edge of the road is approximately 50 m from the stream, with the property between the road and the stream. The ground cross-sections produced by SOH and contained within the 5 m gridded model bathymetry show that ground level around the house to be about 1.0 m to 1.5 m below road level, while SOH's cross-section indicate that the bed of the stream is a further 2 m lower.

SOH assumed that the water surface across the cross-section was flat, and then calculated the cross-sectional area (not including an allowance for freeboard) to be about 15 m^2. SOH assumed an average flow velocity of 1 m/s, giving a flow of 15 m^3/s. This is approximately three times the 100-year ARI flow for that part of the catchment. The opinion of SOH is that the discrepancy between the expected modelled flow and the flow that they calculated casts doubt on the validity of the Flood Hazard Map extents. This issue was discussed by the auditor with Ben Fountain of SKM/Jacobs, who was the project manager for the flood modelling and preparation of the flood and hazard maps.

One critical area of difference between SOH's understanding of flood/hazard extents relates to the water surface across the cross-section. As noted above, SOH assumed that the water surface is flat, while SKM have provided cross-sections that indicate that the water level varies across the cross-section. Figure B.3 in Appendix B shows modelled water levels for SKMs sections in the vicinity of 27 Elmslie Road. The water levels were extracted from the 2D surface model results. They indicate shallow flooding (as low as 10 mm) at the margins of the floodplain, and lower water levels in the main channel. This may be due to overland flow paths on the floodplain carrying flow that has broken out from the stream channel upstream.

We note that the varying water level surface is confirmed by the Q100 flood map (Figure 5.1), which shows that flood depth across the site is less than 500 mm. If the water surface were flat across the cross-section, flood depth of more than 500 m could be expected close to the stream channel due to the slope of the ground. With the water level surface dipping towards the stream, the active cross-section area will be lower than the 15 m^2 that was calculated by SOH, and hence the calculated flow will also be lower.

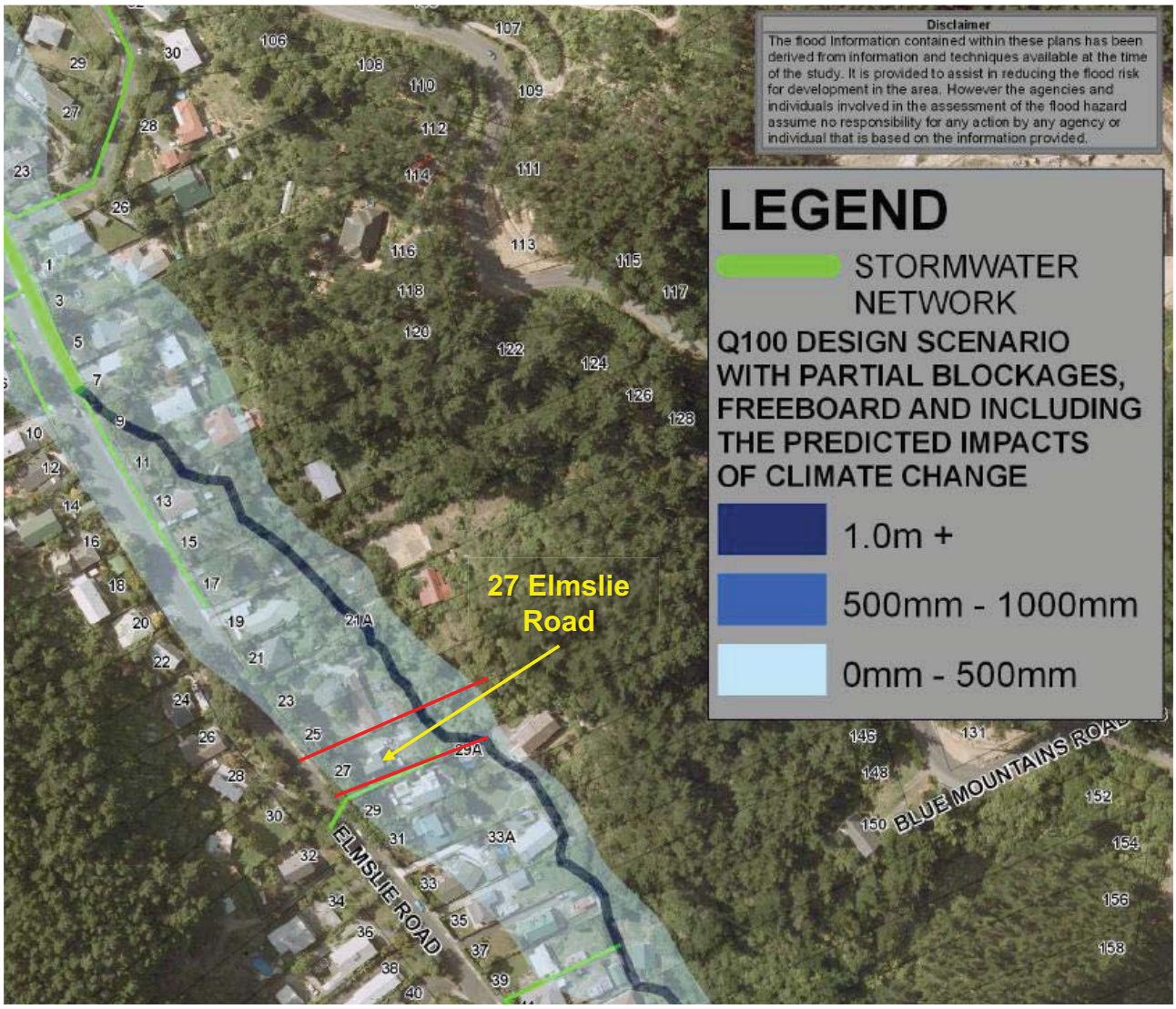


Figure 5.1 – Q100 (including culvert blockage, climate change and freeboard) flood extent at 27 Elmslie Road

Figure 5.2 represents some of the elements that could contribute to the definition of the flood extent; illustrating why:

- The flood level may be different on opposite sides of a valley when 2D modelling is used.
- Why it may be inappropriate to assume that the water surface is flat across the flood extent.

As well as inundation of the floodplain adjacent to the stream channel, the flood extent may be extended laterally by hillslope runoff towards the channel, secondary overland flow paths (such as roads), and water spilling between secondary flow paths and the stream channel.

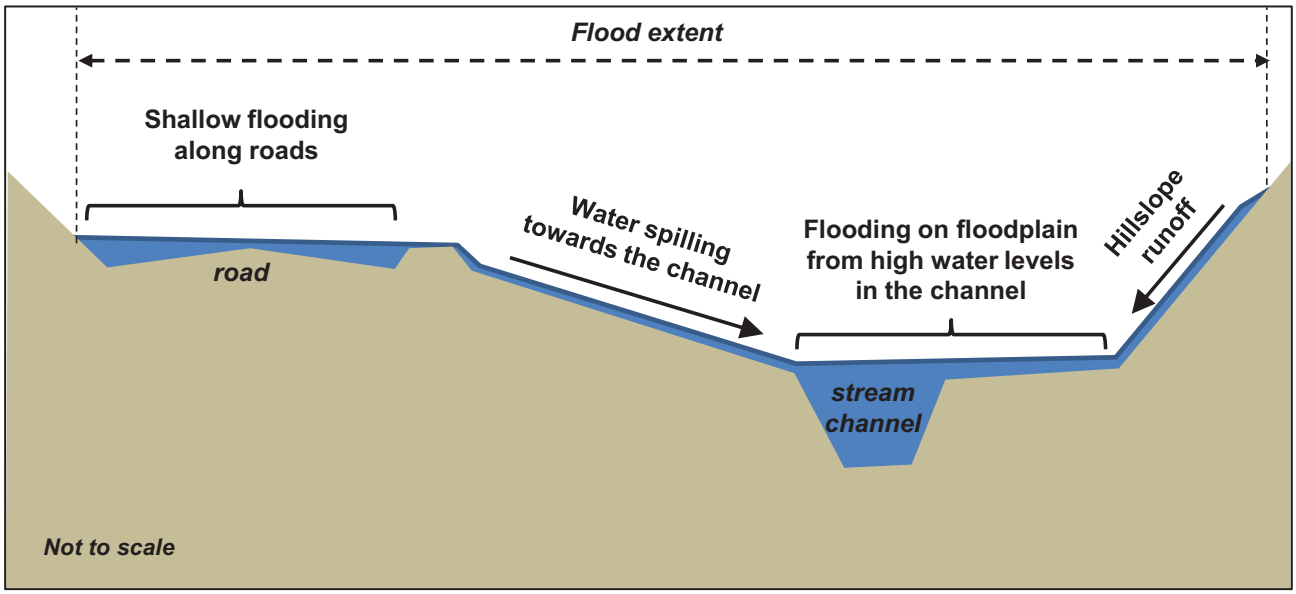


Figure 5.2 Flood extent elements

Similar situations to that at Elmslie Road occur at the other three locations identified by SOH's case studies. In general the flood hazard extents shown on the maps are accurate, in terms of representing the Q100 (incorporating blockage and climate change) flood extent plus freeboard. However, they are open to misinterpretation. Alternative approaches to providing flood extent and hazard information in maps are discussed in Section 6.

5.2 Other issues raised by SOH

While the perceived discrepancy regarding the mapped flood hazard extents is the main issue for SOH, the group members also expressed concern regarding:

- Including culvert blockage in the Q100 map used for defining the flood hazard extent.
- Future development:
  - Was it included in the published flood hazard extent map
  - The small difference between existing and future development flood extents.
- Whether the flood maps are too conservative.
- The terms of reference for the audit in relation to:
  - Stormwater neutrality
  - The impact of future development.

5.2.1 Blockage

SOH are of the opinion that blockage should not be included in baseline modelling used to define floodplain extents. At a separate meeting, representatives of Pinehaven Progressive Association indicated that they were content for blockage to be included in the published flood maps.

As noted in the review of the hydraulic modelling (Section 4.2), the probability and consequence of culverts, bridges and channels being fully or partial blocked during floods by water borne debris is a reality, but there is uncertainty surrounding the timing, location and extent of blockage that may occur during an event. Channel blockage and subsequent breaking of the debris dams caused surges of floodwater during the 1976 flood event.

As such we conclude it should be accounted for in flood hazard mapping. Model runs could be carried out to assess the sensitivity of the modelled flood depth and extents to blockage, and either an allowance for potential blockage included in freeboard, or alternatively a suitable blockage scenario used to better inform the flood extant mapping (which may differ in the flood plain as a result of blockage) but with less freeboard allowed. Separating blockage out from the baseline modelling reduces the opportunity for uncertainty regarding the flood maps.

5.2.2 Future development

The results of the future development scenario modelled by SKM are not included in the Q100 flood map that includes blockage, climate change and freeboard, and which is used for defining the flood hazard extent.

SOH noted the small differences between the existing and future development flood extents for the 100-year ARI including climate change event, as shown in Figure 19 of Volume 1 of SKM's *Pinehaven Stream Flood Hazard Assessment* report, and which is reproduced below as Figure 5.3. In the upper parts of the catchment, existing and future development flood extents are very similar, but larger differences are evident towards the bottom of the catchment.

The edges of the flood extents in the upper catchment are generally steeper than in the lower catchment. As such an increase in flood level due to increased future development runoff will not result in a large increase in the lateral extent of the floodplain. The small scale of Figure 19 in the SKM report makes it difficult to see small increases in floodplain extent.

In the lower reaches, the land is flatter and (due to the most of the flow being culverted to Hulls Creek) the relative difference in existing and future development overland flows means that much of the increased flow spreads across the wider flood plain and there is consequently a greater increase in flood extent, which is visible on SKM's Figure 19.

As described in more detail in Section 8, while SKM's modelling of future development resulted in an increase in modelled peak flows, there was not the expected increase in flood volume. SKM used hydrology provided by MWH. However, MWH have not provided an explanation as to why there is no increase in future development flood volumes. Therefore, SOH's concerns are upheld that the effects of future development on flood extent are not modelled correctly. However, because the peak flow has been increased, and because there is freeboard incorporated into the results, the flood maps are unlikely to be materially affected by this apparent anomaly.

5.2.3 Are the mapped flood and hazard extent conservative?

Based on the model review (Section 4) and consideration of SOH's case studies (Section 5.1), the published flood maps represent the modelled situation appropriately, although there are legitimate concerns over:

- Whether blockage should be included as a separate item to freeboard,
- The level of definition provided by the 5 m grid spacing for the 2D model bathymetry,
- The spacing between surveyed cross-sections, and
- The representation of minor stream crossings.

Figure 5.3 – Q100CC existing and future development flood extents

5.2.4 Audit terms of reference

When the draft terms of reference (ToR) for this audit were discussed at the HVFMS in February 2015, SOH were concerned that the ToR did not:

- *Make existing baselines for assessing stormwater neutrality explicit*
- *Investigate GWRC's assertion that 1,665 new houses on 4 hill sub-catchments will have only a "minor" impact on the catchment, nor address how future developments will be assessed for stormwater neutrality*

These items were included in the final ToR, and are considered in sections 7 and 8 of this report.

6 Presentation of flood hazard information

It is assumed that a map is the best method for displaying flood risk or hazard information for an area. That being the case, it is essential that an effective means of communicating the information is used. As has been noted above, the way that information is presented on the Pinehaven Flood Hazard Map has led to misinterpretation of the flood risk and hazard in the catchment.

Below, alternative ways of presenting flood risk/hazards maps are considered, and a recommendation made as to how flood hazards maps for Wellington Region may be presented in future.

6.1 Alternative practice for flood hazard mapping

When considering how flood risk or hazard is best represented it is worth considering how this is achieved in other jurisdictions, and draw on best practice when proposing a way forward. While one of the recommendations of this audit is that GWRC undertake a thorough review of best practice in New Zealand and overseas, three examples are provide below; Auckland Council, Christchurch City Council, and the Environment Agency in England.

In the two New Zealand cases, the difference between modelled flood extents and the extents incorporating freeboard are differentiated. In England a different approach is taken, with two flood zones being used. This is not a comprehensive review of alternative practice, but a snapshot of some alternatives.

6.1.1 Christchurch

Flood maps for Christchurch are found on the city's public GIS website[6]. The user is able to choose which map layers are displayed, and these include 50-year and 200-year flood extents and corresponding 'Control' areas. The layers are defined[7] as follows:

- **Flood extent (50 year)** – estimated water level in a rainfall event with an average return interval of 50 years or a likelihood of 1/50 (=2%) in any one year.
- **Flood extent (200 year)** – estimated water level in a rainfall event with an average return interval of 200 years or a likelihood of 1/200 (=0.5%) in any one year. This return interval is used in the City Plan Flood Management Areas (FMA) to provide extra protection to areas which are otherwise vulnerable. The

[6] http://maps.cera.govt.nz/advanced-viewer/?Viewer=Ccc-Floor-Levels

[7] http://www.ccc.govt.nz/homeliving/goaheadbuildingplannings00/buildingandplanningprojects-s02/property-s02s0305/floorlevels-s02s0305-08.aspx

viewer shows these areas within the FMA only as they are not used for setting floor levels beyond the FMA.

- **Floor Level Control Areas** – include the 50 year and 200 year flood extents plus the area encompassed by an increase in water level of 400 mm (representing the 400 mm freeboard to floor levels that Council applies in these areas).
- **Flood Management Areas**[8] - were identified in a City Plan change before the Canterbury earthquakes and are areas that are prone to flooding as a result of major tidal or rainfall events and are vulnerable to the effects of rising sea levels.

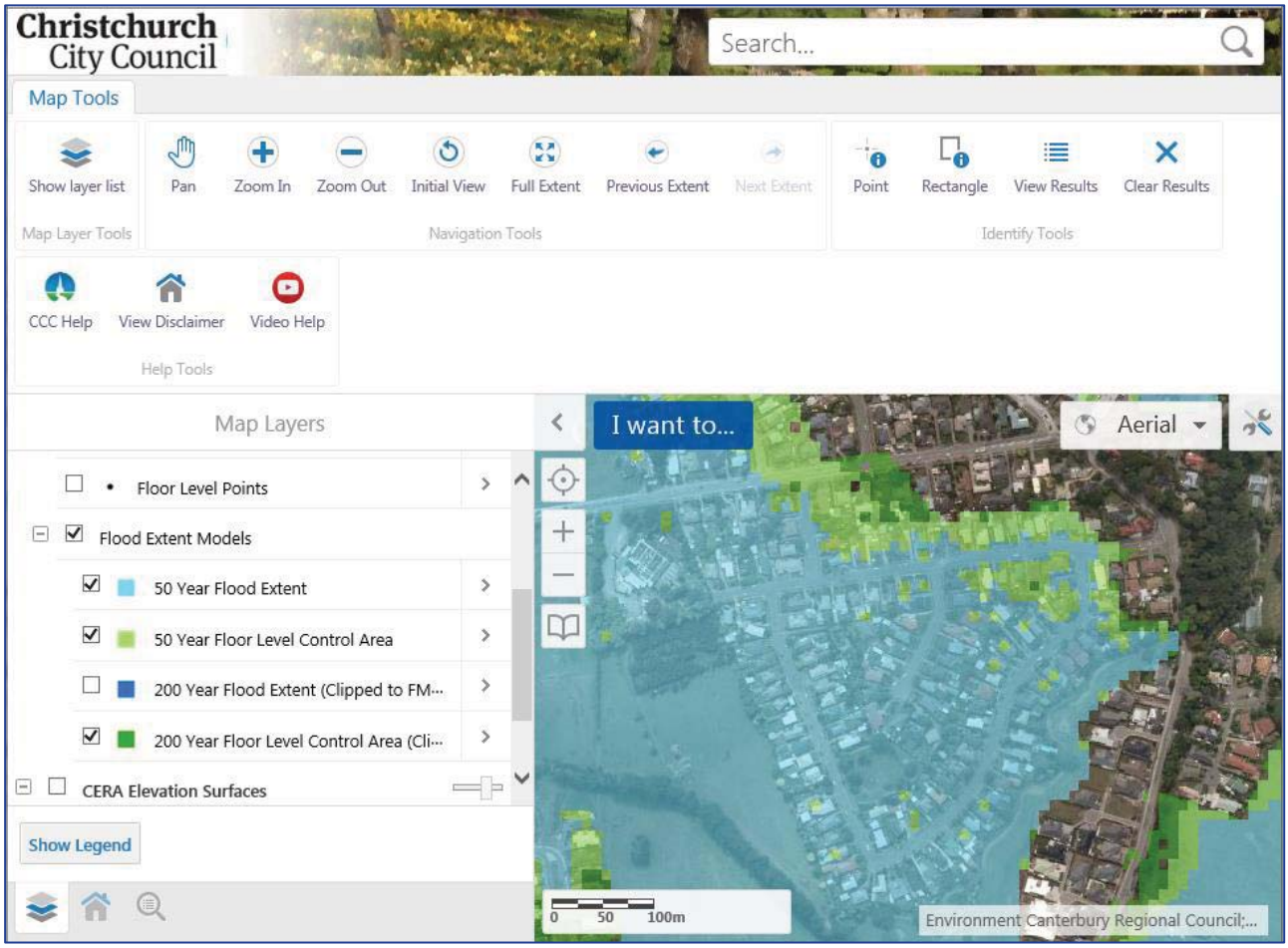


Figure 6.1 – CCC flood map

Though the ARIs of the design events and the amount of freeboard are different, Christchurch's flood control areas are the equivalent of Wellington Regions flood hazard areas. Both represent those areas beyond the design flood event extent in which measures are appropriate to mitigation against the design event and the residual flood risk associated with extreme flood events, unforeseen blockages, and other factors that could

[8] http://www.ccc.govt.nz/thecouncil/policiesreportsstrategies/districtplanning/cityplan/proposedvariations/operativevariation48.aspx

increase flood levels beyond modelled levels. However, Christchurch use best estimate of modelled flood levels then explicitly specify the freeboard to be added for setting the finished floor levels in these areas.

6.1.2 Auckland

Figure 6.2 shows an extract from Auckland Council's GIS Viewer, which includes layers for floodplains, flood prone areas, and flood sensitive areas, which are defined as:

- **Floodplains** are areas predicted to be covered by flood water as result of a rainstorm event of a scale that occurs on average once every hundred years. These areas have been produced from hydraulic modelling. The floodplain contains the most up to date information for each of the 23 Stormwater Catchments in the Auckland region. Summary data for each catchment is attributed against each floodplain.
- **Flood prone areas** are topographical depressions. The areas occur naturally, or are created by dammed gullies created by man-made features such as roads and railway embankments. The flood prone extent is the area water will pond up to in a 1% AEP extreme rainfall event assuming the outlet to the topographical depression is blocked.
- **Flood Sensitive Areas** are areas adjacent to the 100yr ARI floodplain that are within 0.5 m of the predicted 100yr ARI flood level. These mapped areas are to ensure the appropriate planning rules are considered for properties developing adjacent to the floodplain

The map also shows overland flow paths, with the line style reflecting the size of surface catchment draining to that area. The overland flow path does not necessarily indicate that flood will occur along its length, as the stormwater network will convey water.

For Auckland, the Flood Sensitive Areas are the equivalent of Wellington Region's flood hazard areas and Christchurch's flood control areas.

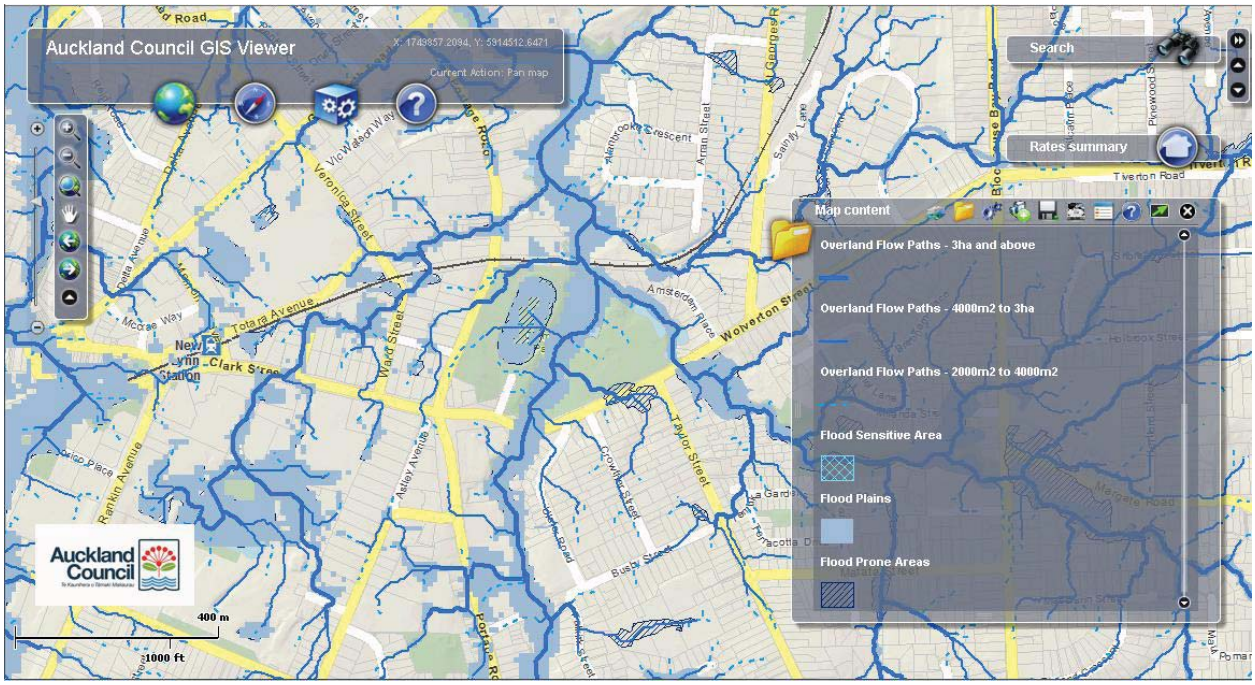


Figure 6.2 – Auckland Council GIS Viewer flood layers

6.1.3 Environment Agency in England

Rather than each council having a separate approach to defining and presenting flood risk/hazard information, the information is providing a uniform manner across England. The information is provided by the Environment Agency, and forms part of the planning process. Figure 6.3 shows the ***Flood Map for Planning***[9][10] for York in the North of England.

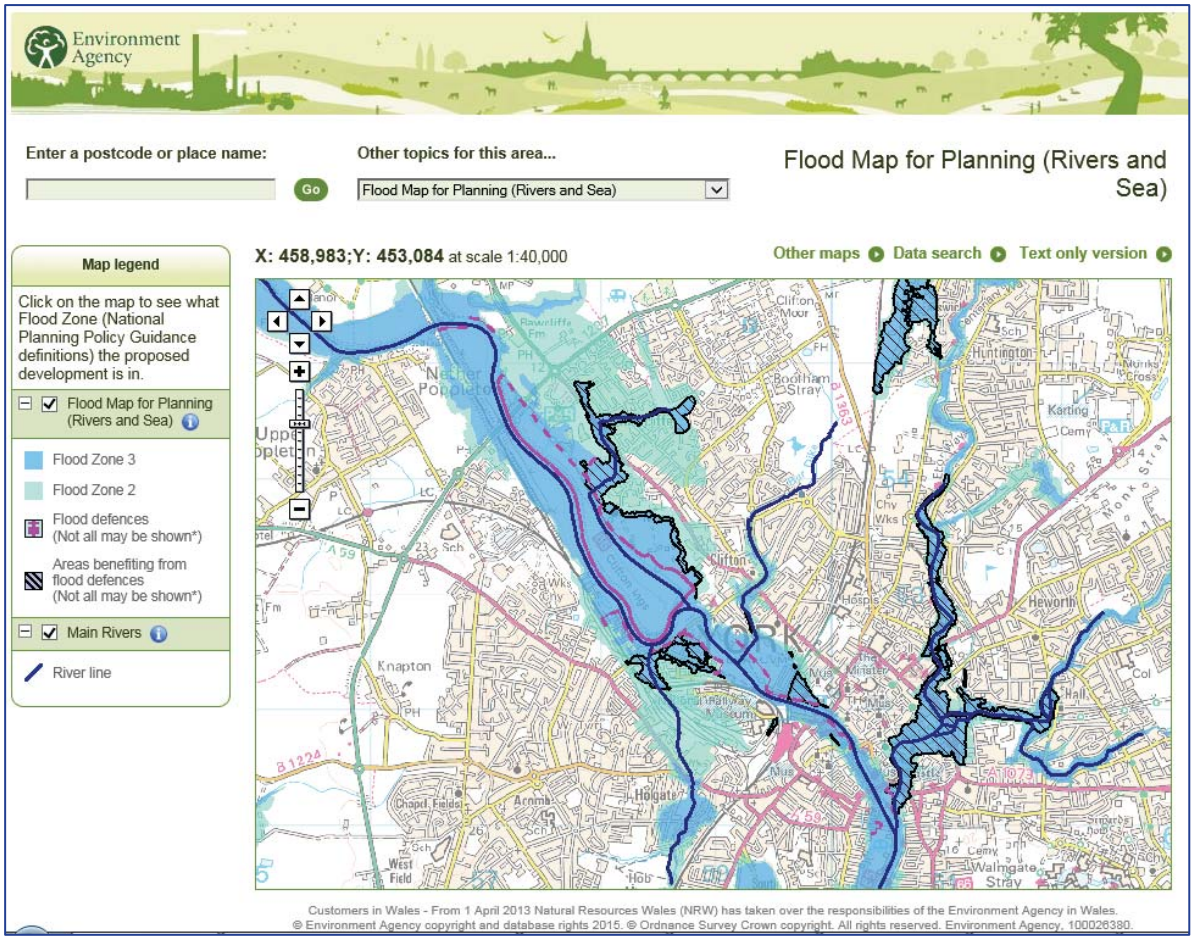


Figure 6.3 – Environment Agency Flood Map for Planning

There are two different kinds of area shown on the Flood Map for Planning:

- **Dark blue** ■ (Flood Zone 3) shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:
  - from the sea by a flood that has a 0.5 per cent (1 in 200) or greater chance of happening each year;
  - or from a river by a flood that has a 1 per cent (1 in 100) or greater chance of happening each year.

- **Light blue** □ (Flood Zone 2) shows the additional extent of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1 per cent (1 in 1000) chance of occurring each year.

[9] http://apps.environment-agency.gov.uk/wiyby/37837.aspx

[10] http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

Where there is no blue shading, this shows the area where flooding from rivers and the sea is very unlikely. There is less than a 0.1 per cent (1 in 1000) chance of flooding occurring each year. The majority of England and Wales falls within this area. For planning and development purposes, this is the Flood Zone 1.

With regard to development control, the flood zones are used in conjunction with the *Sequential Test* to steer vulnerable development away from areas of high flood risk. Where there is no option but to develop in flood zone, an *Exception Test* is applied to minimise the risk and consequences of flooding through the adoption of mitigation measures.

The flood extents do not include freeboard. Rather, an allowance is made for freeboard when setting floor levels and flood sensitive infrastructure through the development control and planning process.

6.2 Suggestions for future flood hazard mapping for Pinehaven

6.2.1 Map format

The common theme of the Christchurch and Auckland flood maps is that users can clearly differentiate between the modelled flood extents (or floodplain) and the areas included when freeboard is applied, and in which flood risk should also be considered and mitigated against. This indicates that Auckland and Christchurch recognise that users, including the local community, are able to understand the difference between modelled flood extents and the 'buffer' zones represented by the Flood Control Areas (Christchurch) and Flood Sensitive Areas (Auckland).

With the areas differentiated, users can see how the flood maps are drawn up, which will increase understanding of the maps' purpose. With this approach, Council can still define the flood sensitive margins as requiring consideration from a flooding point of view.

For example, describing the area covered by freeboard beyond the modelled flood extent as a Flood Sensitive Area may be more transparent and more appropriate than GWRC's use of all-encompassing Flood Hazard Areas. Changing the name would allow GWRC to provide true flood hazard maps, based on the combination of water depth and flow velocity at any location. These flood hazard maps can be particularly informative in areas where flood extents are large, but there is also deep or fast flowing water in defined flow paths or depressions. Figure 6.4 shows how flood hazard is defined in Hamilton, while Figure 6.5 shows an example of a flood hazard map from the UK based on similar principles.

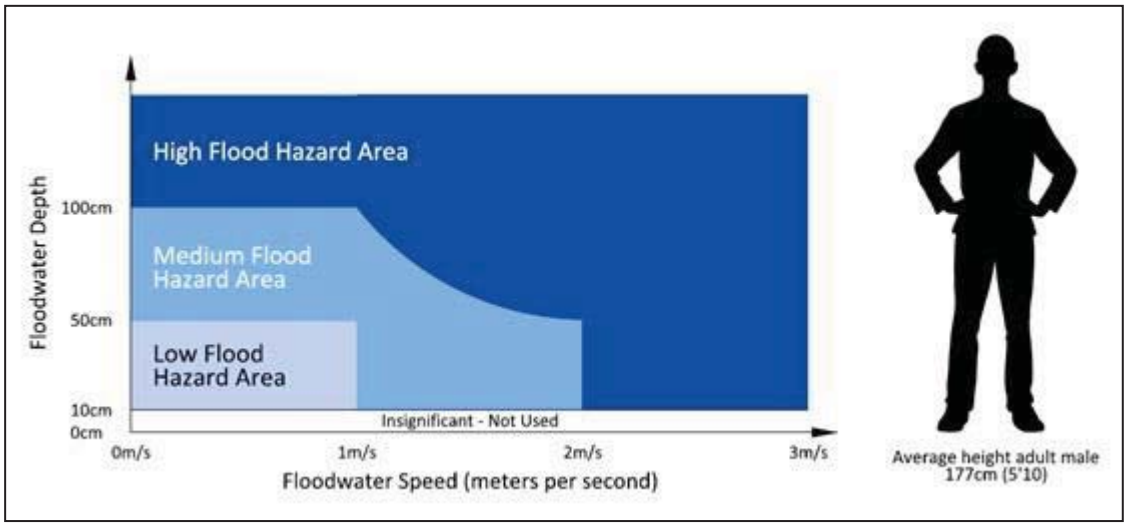


Figure 6.4 – Definition of flood hazard[11]

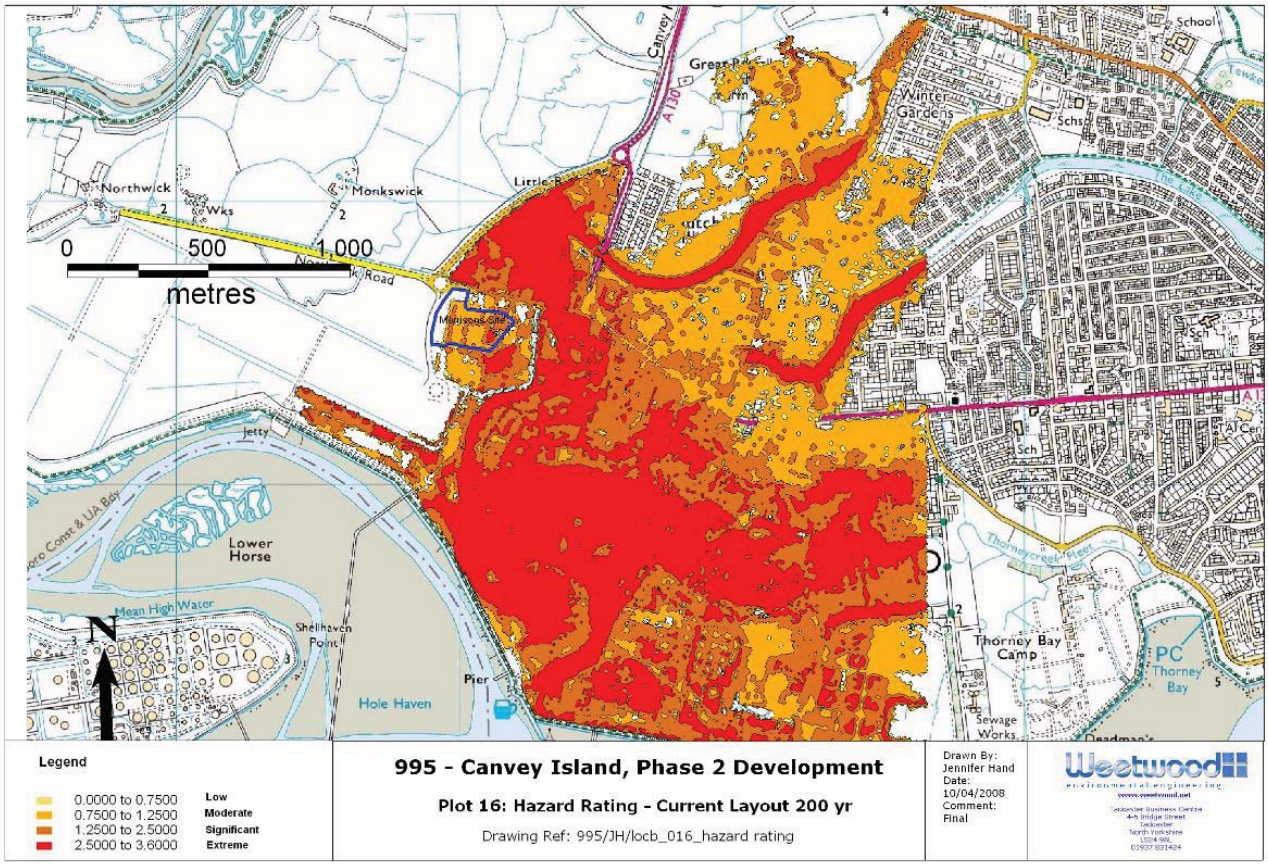


Figure 6.5 – Flood Hazard Map

It is recommended that for Pinehaven, flood maps should show the following map layers, which would provide greater clarity:

- **Flood extent (10-year ARI):** Model extent of flooding in a rainfall event with an average return interval of 10 years, and incorporating climate change to 2090, as already provided.
- **Flood extent (100-year ARI):** Model extent of flooding in a rainfall event with an average return interval of 100 years, and incorporating climate change to 2090.
- **Flood Hazard Map (100-year ARI):** Areas within the 100-year ARI flood extent are defined by flood risk ranging from Low to High, based on an assessment of flood depth and flow velocity. The information required to generate these maps can be extracted from the existing flood models.
- **Flood Sensitive Areas:** Model extent of flooding in a rainfall event with an average return interval of 100 years, and incorporating:
  - Climate change to 2090
  - The application of freeboard to the modelled flood extents. Freeboard will include the potential effect of channel/culvert blockage by debris.

It is noted that different depths of freeboard are applied across the Pinehaven catchment. This is an acceptable approach, allowing freeboard to vary with location and risk profile.

[11] http://www.hamilton.govt.nz/our-council/council-publications/districtplans/flood/Pages/Flood-FAQ.aspx

6.2.2 Accessing flood information

It should be easy for the community to find flood map information. Internet searches for “Flood Map” for Wellington, Auckland and Christchurch yield varying levels of success in finding flood maps. Some links lead to web pages stating that flood mapping has been carried out, but all too often there is no link to a map viewer. In other cases, PDF versions of maps are provided at a scale that does not allow close examination of specific addresses or location.

An internet search for “Pinehaven Flood Hazard Map” yields links to PDFs of Flood Hazard Information Sheets for the catchment, which include the maps. However, large scale copies of the flood extent and hazard maps are not readily found.

7 Storm water neutrality provisions

As part of the implementation of the floodplain management plan, Upper Hutt City Council will set storm water neutrality controls through the District Plan. The council is seeking independent guidance about how these should be established and how these should be measured.

The main purpose of hydraulic neutrality is to not increase the risk of flooding elsewhere in the catchment.

Volume One of the Proposed Kāpiti Coast District Plan defines Hydraulic Neutrality as “a nil increase in the peak stormwater runoff discharged from new subdivision, new buildings and/or new land use activities undertaken on the site.”[12]

Peak flow is just one measure of the changes in hydrological response due to development. Increases in peak flow are caused by a combination of a reduction in permeable area and quicker runoff from smoother post-development channels and overland flow paths. The decrease in permeable area is also likely to result in an increase in flood volume.

Therefore to be truly neutral, the post-development runoff should match pre-development runoff peak flows, runoff volume and timing of runoff at the outlet from the development area. In practice, this is difficult to achieve, hence the focus on limiting peak flow to no more than pre-development peak flows. Peak flows can be reduced by providing storage within the development to attenuate the flow hydrograph.

The effect of attenuation is to release storm runoff later than would have occurred without storage in the expectation that flood levels throughout the receiving catchment will be receding when the water is released and so peak flood levels are not increased. This approach works where flood volume is not the critical factor in determining flood levels and where attenuated flows do not coincide with peak flows arriving from other parts of the receiving catchment that have longer times of concentration. Further, the increase volume of runoff means that there is increased likelihood of high runoff from sub-catchments coinciding. It may be that for developments close to bottom of catchments, it is better to have little attenuation and allow discharge of peak flows early in the event so that they have passed out of the catchment before peak flows arrive from the upper parts of the catchment.

Therefore, developments need to be considered on a case by case basis, and appropriate conditions for managing hydrological neutrality applied. Initial guidelines for comment would include:

[12] http://www.kapiticoast.govt.nz/contentassets/68a0006af1314ac3b1f1570d37a2763c/chapter01-introduction-and-interpretation.pdf

- Conditions for post-development flow peaks and volumes should be applied at the outlet from the development site, as hydrological conditions elsewhere in the catchment are beyond the control of the developer.
- Generally, in urban and growth areas post-development peak flows should be no more than 80% of pre-development peak flows. Providing a 20% reduction in peak flows is used in other Council areas, such as Kāpiti Coast, and provides the opportunity for betterment or off-setting any negative effects of increased flow volumes. The exception to implementing this rule would be where it can be demonstrated through modelling that quick release of runoff from the site is beneficial to reducing flood risk elsewhere in the catchment.
- The developer should undertake an assessment of the receiving catchment to determine whether flood volumes are a significant factor in determining peak flood levels and extents. Where that is the case, modelling should be carried out to demonstrate to the Council's satisfaction that the risk of flooding is not increased elsewhere in the catchment. However, caution should be used when modelling individual developments, as this does not adequately address the cumulative effects of multiple developments where zoning or growth strategies allow such developments.

The Council should be clear as to the event or range of events for which hydrological neutrality should be achieved. While proposed stormwater management structure may attenuate post-development peak flows to 80% of pre-development peak flows in the 10-year ARI storm (for example), consideration should also be given to the effects in other ARI events. Will the developer be required to match 80% flows in those events, as well? It may not be possible to provide hydrological neutrality for all events.

8 Defining the impact on runoff of development

As part of the flood hazard study carried out by SKM, a future case scenario was modelled to determine the impact of a future development scenario for the Pinehaven Hills. In undertaking this modelling, assumptions were made about the runoff changes that would occur as a result of future development, based on:

- 1665 lots
- Average lot size of 750 m^2
- 40% increase in impermeable area across the affected sub-catchments

Figure 8.1 shows the change in flood hydrographs for existing development (*E4_Q100CC_2hr_HB.bnd11*) and future development (*E4_Q100CC_FP_2hr_HB.bnd11)* for sub-catchment B, which is in the southwest of the catchment and drains to the top of Pinehaven Road. Future development increases the peak flow by 18% (from 3.07 m^3/s to 3.64 m^3/s), and the flow recession is steeper than for the existing land use. However, the flood volume does not increase. This is unexpected, as increasing the impervious area of sub-catchment by 40% to reflect the development would be expected to reduce rainfall losses and increase runoff volume. Similar results were found for sub-catchment E, which drains to Wyndham Road.

Assuming a 100-year ARI plus climate change rainfall depth of 87.1 mm for the 3-hour storm, an Initial Loss of 5 mm, Ongoing Loss of 2 mm/hr, and 40% impermeable area for the affected post-development sub-catchments, then the effective rainfall depths would be;

- 76.7 mm (88%) for existing land use
- 80.8 mm (93%) for post-development land use

The difference between existing and post-development flood volumes would be expected to be to a similar ratio. The existing ground cover of bush and pine forest on sloping catchments generated relatively high runoff, when compared to natural vegetation on flatter ground. This is reflected in the 88% effective rainfall for the existing situation and only 5.6% increase in effective rainfall post-development.

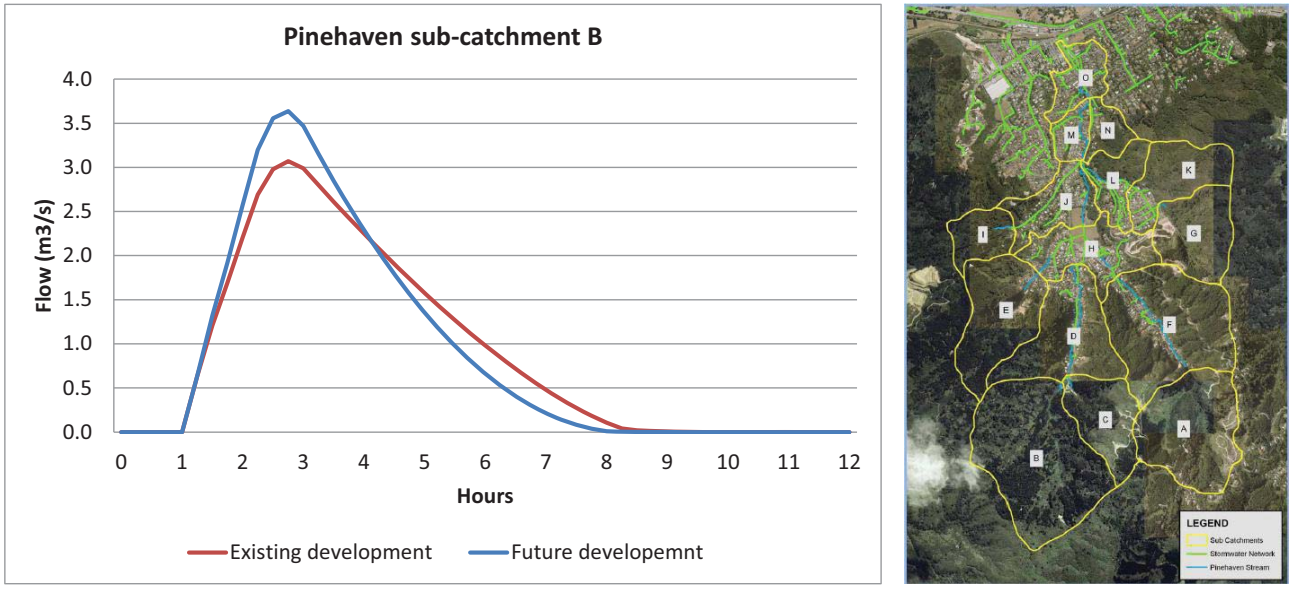


Figure 8.1 – Existing and maximum probable development hydrographs

Lower density development would have a smaller effect on peak flows and flood volumes. With reference to Section 7, it is highly unlikely that post-development runoff from developments on the Pinehaven Hills would be consented to discharge to the streams without attenuation to at least match, or reduce, peak flows.

The greatest effect on un-attenuated flood flows as a result of development on the Pinehaven Hills will be seen in the upper catchments, as this is where there is the greatest relative change in modelled impervious area. Further down the catchment, the relative change in impervious areas reduces and so the difference in modelled flows will be less.

The issue of no increase in post-development flood volume was raised with MWH, but they have not been able to provide an explanation as to why there is not an increase in flood volume. While this does not affect the validity of flood extents defined for current development, it does invalidate the post-development flood extents and reduces community confidence in the flood mapping process.

9 Conclusions and Recommendations

9.1 Conclusions

The hydrological and hydraulic modelling used to derive the flood hazard maps is fit for purpose. The methods and level of detail reflected the catchment information and modelling methods available in 2008-2010.

However, the way that the flood extent and hazard maps are presented obscures the components that have been used to derive the extents. Describing the ‘flood extent plus freeboard’ maps as Flood Hazard Maps does not adequately describe the Maps. These issues lead to confusion and misunderstanding within the community regarding the interpretation and use of the maps. As such, the presentation of flood information in map form should be modified.

9.2 Recommendations

9.2.1 Hydrological and hydraulic modelling

The modelling underlying the flood maps is 6-7 years old. The flood maps will be updated as new information becomes available or changes in the catchment occur and in conjunction with District Plan and Regional Planning Review work programmes. The community should be made aware of this, and understand that mapped flood extents may be refined as a result of revised modelling and mapping in the future.

Better definition of flood depths, extents and overland flow paths could be provided if the modelling were updated to account for current computer processing power and advances in modelling software. Specifically:

- Review hydrological modelling:
  - To account for longer rainfall records
  - Ensure that 'future development' hydrology is correctly modelled
  - With reference to flood flows for hydrologically similar catchments to validate design flood hydrographs for the ungauged Pinehaven catchment.
- The use of a finer grid or flexible mesh to construct the 2D model bathymetry would provide better definition of flood extents and overland flow paths.
- Blocking out buildings with the 2D model bathymetry would improve definition of overland flow paths and should be considered if the models are to re-run

While advances in modelling methods and available information since 2009 could be used to improve aspects of the modelling, it is unlikely that updating and upgrading the models would significantly alter the flood extents and depths for the current design flood events and scenarios modelled.

9.2.2 Presentation of flood maps

A limited review of how flood extents and risk are mapped elsewhere indicates alternative approaches that GWRC could utilise to improve the understanding and acceptance of the Pinehaven flood mapping and the modelling that underlies the maps. For example, using the same modelling results, the flood maps could show the following map layers:

- **Flood extent (10-year ARI):** Model extent of flooding in a rainfall event with an average return interval of 10 years, and incorporating climate change to 2090.
- **Flood extent (100-year ARI):** Model extent of flooding in a rainfall event with an average return interval of 100 years, and incorporating climate change to 2090.
- **Flood Hazard Map (100-year ARI):** Areas within the 100-year ARI flood extent are defined by flood risk ranging from Low to High, based on an assessment of flood depth and flow velocity.
- **Flood Sensitive Areas:** Model extent of flooding in a rainfall event with an average return interval of 100 years, and incorporating:
  - Climate change to 2090
  - The application of freeboard to the modelled flood extents. Freeboard will include the potential effect of channel/culvert blockage by debris.

Given that the maps are to be used for planning purposes, the inclusion of an allowance for climate change to a suitable horizon is appropriate, and this has been included.

However, it is recommended that GWRC undertake a review of best practice flood mapping in New Zealand and overseas so as to ensure that flood risk and hazard information is communicated clearly to the community, and is able to still be applied in a robust manner.

9.2.3 Stormwater neutrality

The issue of including stormwater (or hydrological) neutrality into local planning guidelines is complicated. Developments should be considered on a case by case basis, and appropriate conditions for managing hydrological neutrality applied. General guidelines for comment would include:

- Conditions for post-development flow peaks and volumes should be applied at the outlet from the development site.
- Post-development peak flows in urban or urbanising areas should be no more than 80% of pre-development peak flows so as to provide opportunities for betterment or off-setting any negative effects of increased flow volumes and consequent greater coincidence of subcatchment peaks.
- The developer should demonstrate to the Council's satisfaction that the risk of flooding is not increased elsewhere in the catchment.
- Caution should be used when modelling individual developments, as this does not adequately address the cumulative effects of multiple developments where zoning or growth strategies allow such developments.

Confirming the main conclusion of the audit; the hydrological and hydraulic modelling underlying GWRC's flood extent and hazard maps is fit for purpose, but the way that flood information is presented in map form could be modified, which may increase the understanding and acceptance of the maps by the community.

Appendix A – Terms of Reference

Section 7 of the ***Request for Proposal - Pinehaven Stream Flood Mapping Audit.*** *WGN_DOCS-#1437397-v3-ToR_Pinehaven_Stream_FMP_Audit.doc* Request For Proposal (RFP)

7. Terms of reference for audit

The audit will comment on the appropriateness and fitness for purpose of the following criteria. We invite additional suggestions for assessment criteria as part of the proposal.

7.1 General

The following are *general* assessment items to be included in the audit;

- The type of software and modelling package used for the hydrology and hydraulic model
- The modelling method used and its appropriateness for both hydrology and the hydraulic model
- The use of freeboard and method by which it was applied
- Representation of the flood hazard through way in which maps are displayed and information provided

7.2 Numbers

The assessment of the *numbers* used to create the flood model shall include;

- Rainfall data
- Measured flood flows
- Cross section surveys
- Lidar surveys

7.3 Assumptions

The assessment of *assumptions* used to create the flood maps include;

- Run-off coefficients
- Predicted flood flows
- Roughness coefficients of the channel
- How the buildings and structures on the floodplain are treated through use of roughness coefficients
- Treatment of bridges, culverts and pipe crossings
- Use of freeboard to define flood hazard
- How the freeboard has been applied to the model and suitability of the freeboard values used

7.4 Additional Work

In addition to the key audit tasks above, it has been agreed with the community that the following additional investigations would be carried out by the appointed auditor.

7.4.1 Guidance on how to set storm water neutrality provisions within district plan

As part of the floodplain management plan implementation, Upper Hutt City Council will set storm water neutrality controls through the District Plan. The council is seeking independent guidance about how these should be established and how these should be measured.

This independent guidance will be considered when developing the plan change that will incorporate these controls.

Key information sought is;

- How to establish a base line against which any development proposal will be measured in a District Plan context
- What are appropriate levels at which to set controls

7.4.2 Guidance on how to define the impact of intensification of development on the run off characteristics of the Pinehaven hills

As part of the flood hazard study carried out by SKM, a future case scenario was carried out to determine the impact of a worst case development scenario for the Pinehaven Hills. This made some assumptions about the run off changes that would occur as a result of this development.

We would like a comment on assumptions about the impact of intensification of development within the Pinehaven catchment and how this would affect the run-off characteristics of the current usage if it was changed from pine forest into a partly developed or intensively developed area.

Key information sought is;

- What impact a high intensity development may have on run-off from the Pinehaven hills area
- What impact a medium intensity development may have on run-off from the Pinehaven hills area
- What impact a low intensity development may have on run-off from the Pinehaven hills area

Appendix B – Large Figures

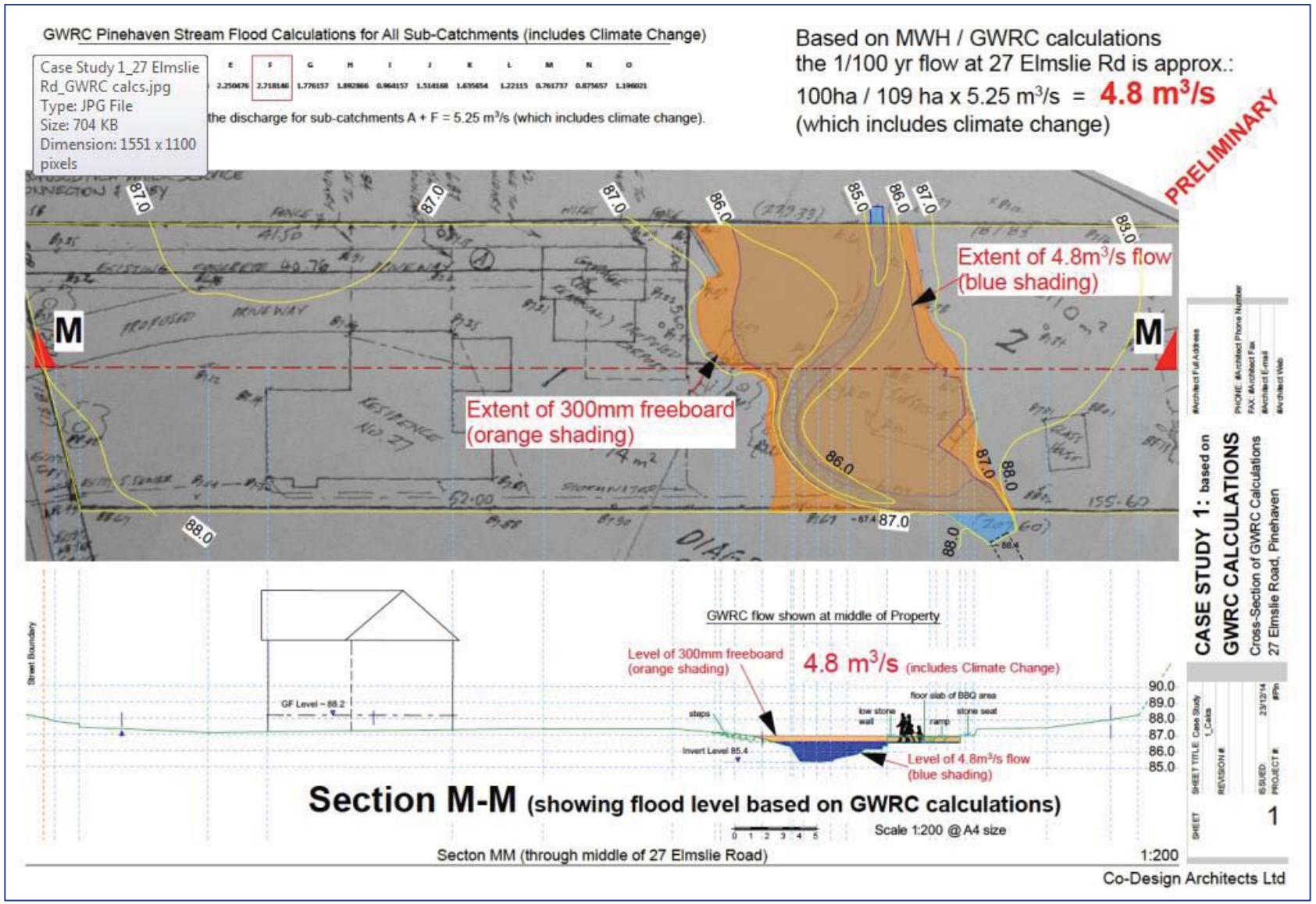


Figure B.1 – SOH slide 1 for 27 Elmslie Road

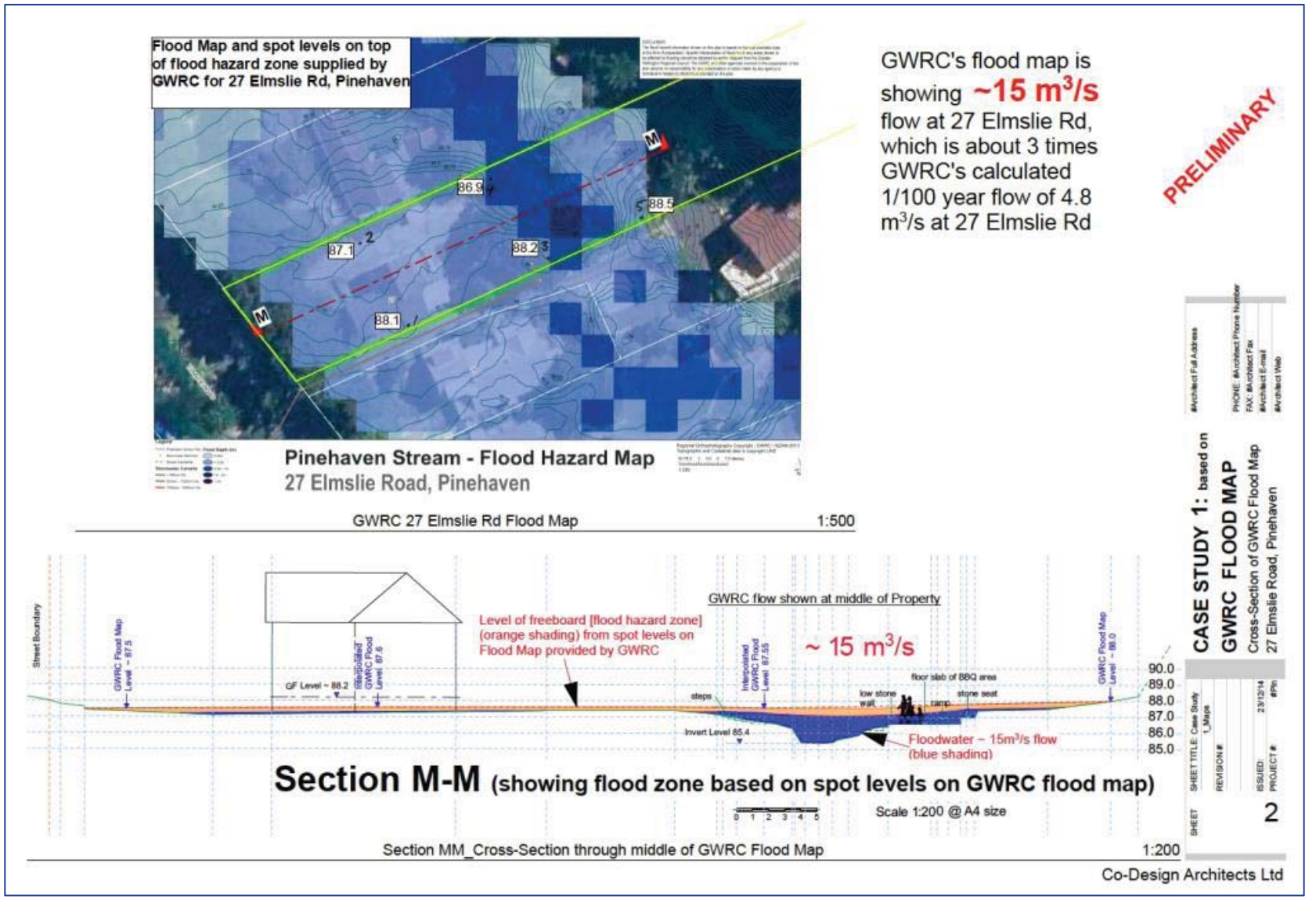


Figure B.2 – SOH slide 2 for Elmslie Road

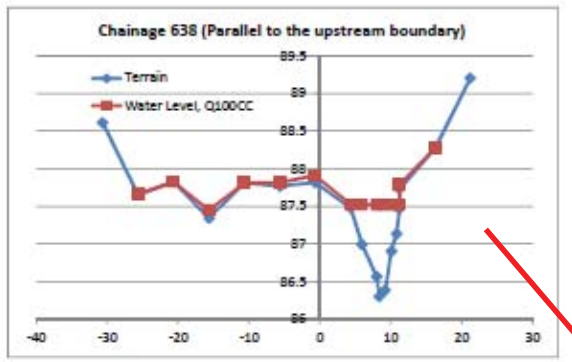
COMBINED DATA Nulls are yellow

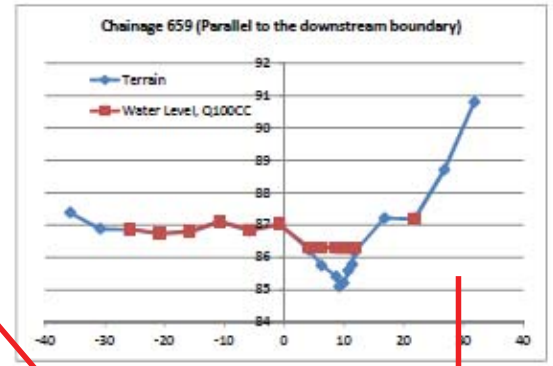
Terrain X	Chainage 638 (Parallel to the upstream boundary) Y	Water Level, Q100CC
-30.65	88.61	
-25.65	87.66	87.66
-20.65	87.83	87.83
-15.65	87.34	87.45
-10.65	87.81	87.81
-5.65	87.77	87.82
-0.65	87.82	87.91
4.35	87.48	87.53
5.96	86.99	87.53
8.00	86.57	87.53
8.42	86.30	87.53
9.23	86.39	87.53
10.07	86.90	87.53
10.82	87.13	87.53
11.23	87.47	87.53
11.23	87.73	87.79
16.23	88.26	88.27
21.23	89.20	
26.23	90.20	
31.23	91.45	
36.23	93.10	

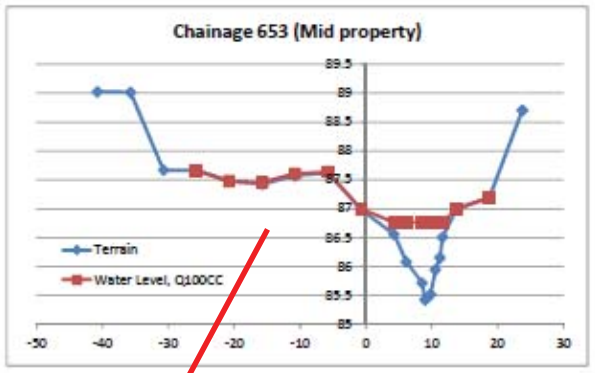
Terrain X	Chainage 659 Y	Water Level, Q100CC
-35.75	87.39	
-30.75	86.88	
-25.75	86.86	86.87
-20.75	86.73	86.74
-15.75	86.79	86.81
-10.75	87.10	87.11
-5.75	86.82	86.84
-0.75	87.02	87.03
4.25	86.22	86.30
6.24	85.76	86.30
8.76	85.41	86.30
9.28	85.11	86.30
10.00	85.20	86.30
10.77	85.60	86.30
11.45	85.79	86.30
11.81	86.16	86.30
16.81	87.21	
21.81	87.19	87.19
26.81	88.71	
31.81	90.80	

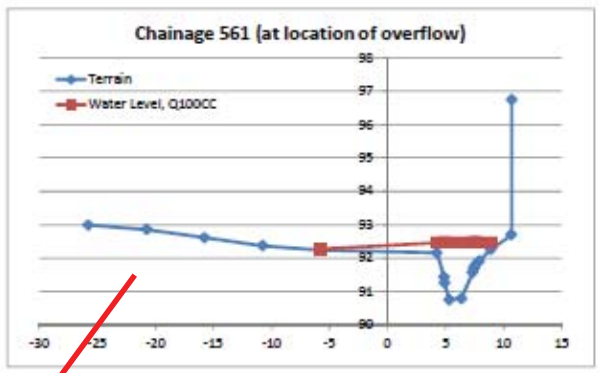
Terrain X	Chainage 653 Y	Water Level, Q100CC
-40.73	89.02	
-35.73	89.01	
-30.73	87.67	
-25.73	87.66	87.66
-20.73	87.47	87.48
-15.73	87.43	87.45
-10.73	87.57	87.61
-5.73	87.61	87.64
-0.73	86.98	86.99
4.27	86.56	86.76
6.16	86.08	86.76
8.56	85.72	86.76
9.05	85.43	86.76
9.80	85.52	86.76
10.58	85.95	86.76
11.28	86.15	86.76
11.66	86.51	86.76
13.78	87.00	87.00
18.78	87.19	87.19
23.78	88.71	

Terrain X	Chainage 561 Y	Water Level, Q100CC
-25.76	92.99	
-20.76	92.86	
-15.76	92.61	
-10.76	92.37	
-5.76	92.23	92.27
4.24	92.16	92.46
4.84	91.44	92.46
4.90	91.25	92.46
5.32	90.75	92.46
6.35	90.79	92.46
7.32	91.57	92.46
7.42	91.68	92.46
7.51	91.75	92.46
7.67	91.84	92.46
7.91	91.92	92.46
8.89	92.26	92.46
10.67	92.70	
10.70	96.75	
14.91	101.96	









Peak Flows at 27 Elmslie Road
100 Year Rainfall with the predicted impacts of climate change
In channel **3.4m3/s**
On Floodplain **1.0m3/s**

Crossection Averaged Peak Velocities at 27 Elmslie Road
100 Year Rainfall with the predicted impacts of climate change
0.9m/s

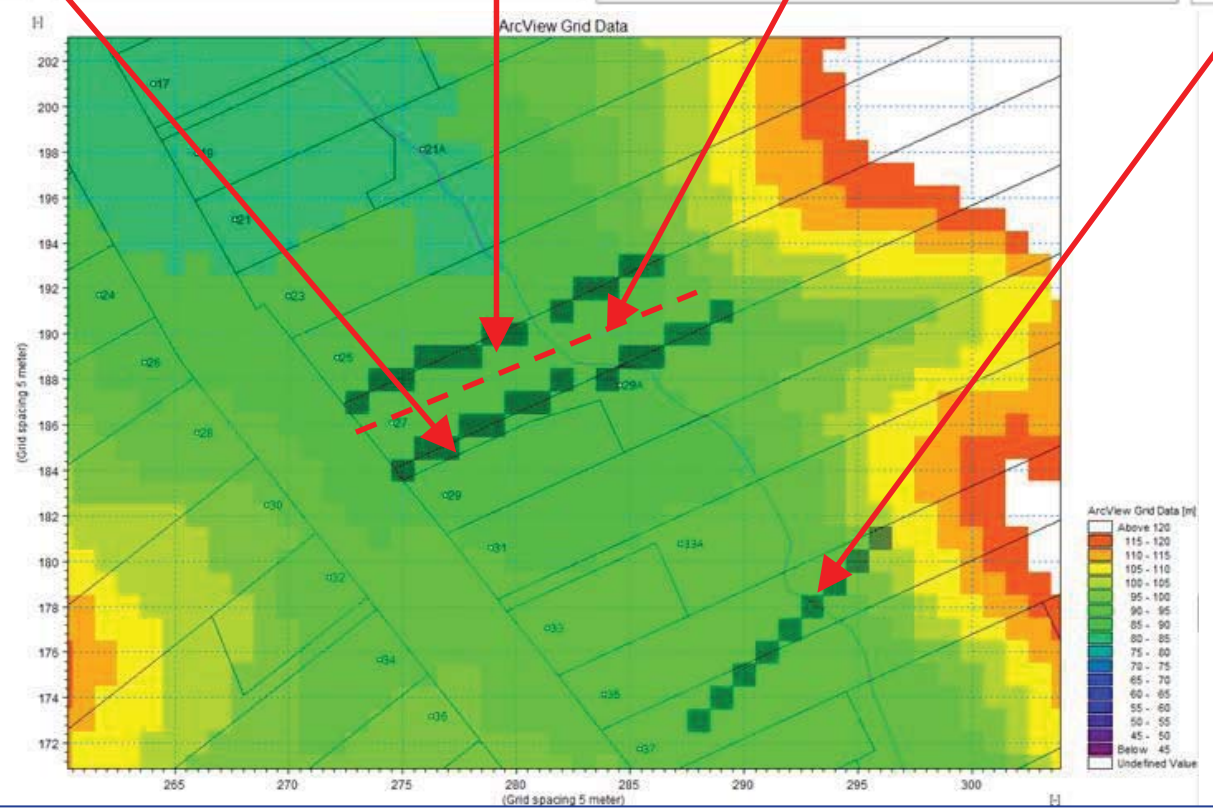


Figure B.3 – SKM Jacobs example cross-sections at 27 Elmslie Road

Appendix E Pinehaven Hydrology Summary

The information presented on the following pages is extracted from the full Pinehaven Stream Flood Hydrology report, [published on 5th September 2008, MWH]. Reference should be made to the full hydrology report when considering hydrology within the Pinehaven catchment, and the extract within this appendix should not be relied upon in isolation.

Hydrology is one component of modelling flood risk, and alone does not provide a complete picture of flood risks within a catchment. The table below shows the results of peak flow calculations made to develop the hydraulic (flood) model at a subcatchment level. The subcatchment locations are shown in the map below.

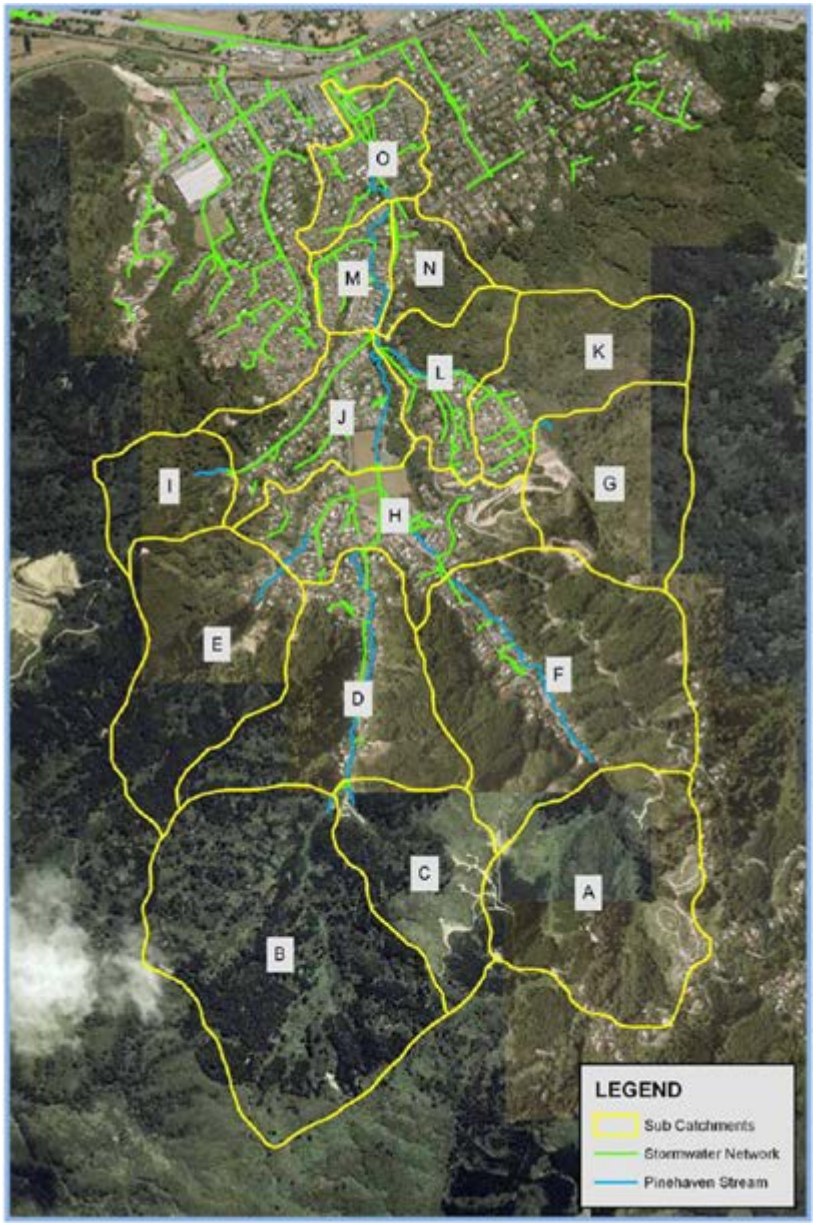
These numbers have been included in this appendix for reference purposes, and should not be used as a substitute for detailed, site specific assessments.

The information does not include the effects of climate change.

SUBCATCHMENT	PEAK FLOW (m^3/s, rounded 2dp)
A	2.54
B	3.08
C	1.61
D	2.14
E	2.26
F	2.72
G	1.78
H	1.90
I	0.97
J	1.52
K	1.64
L	1.23
M	0.77
N	0.88
O	1.20
TOTAL	26.16

1-in-100 year peak flow hydrology for the Pinehaven Stream subcatchments A-O, developed for Hydraulic Modelling of the Pinehaven Stream Floodplain. Values shown do not include the effects of climate change.

Total shows accumulated total of all flow peaks, and does not represent the flow total at the bottom of the catchment, due to time to concentration.



Appendix F Structural Methods

REACH 1 –Whitemans Road to Sunbrae Drive

OPTION	DESCRIPTION	Cost[6]
Sunbrae Drive to Whitemans Road Option 1.1	25 year channel capacity to protect residential floor level up to the predicted peak 100 year flood level. Reduced footprint channel shape. Key features: ■ Vertical sided lined section through 8 Blue Mountains Road Property (Reformed Church of Silverstream) ■ Naturalised channel with suitable riparian planting as per Option 1.0 for remainder of reach. ■ New bridge at Sunbrae Drive (25 year capacity) ■ Upgrade of piped stream & bypass inlet structures ■ Negotiation with property owners heavily impacted by works ■ Securing secondary flow paths through a lowered driveway and easement servicing 13/14/15 Clinker Gr. ■ Securing secondary flow paths from Deller Grove through 6 Sunbrae Dr and 1 Tapestry Grove ■ Purchase of 4 Sunbrae Drive	$3,340520

REACH 2 –Sunbrae Drive to Pinehaven Road

OPTION	DESCRIPTION	Cost
Pinehaven Road to Sunbrae Drive Option 2.1	25 year channel capacity to protect residential floor level up to the predicted peak 100 year flood level. Reduced footprint channel shape. Key features: ■ Vertical sided lined section from Pinehaven Rd to 26 Blue Mountains Road ■ Naturalised channel with suitable riparian planting as per Option 2.0 for remainder of reach. ■ Bridge at Pinehaven Road (25 year capacity) ■ Replacement of private crossings ■ Blockage reduction measures at inlet structures at Wyndham Rd ■ Swale to capture secondary flow paths at 2 and 4 Pinehaven Road ■ Purchase 28 Bluemountains Road	$4,839,130

[6] Concept design estimate only. Estimate completed in 2014. This is the same for all cost assumptions for each option.

REACH 3 –Pinehaven Road to Birch Grove

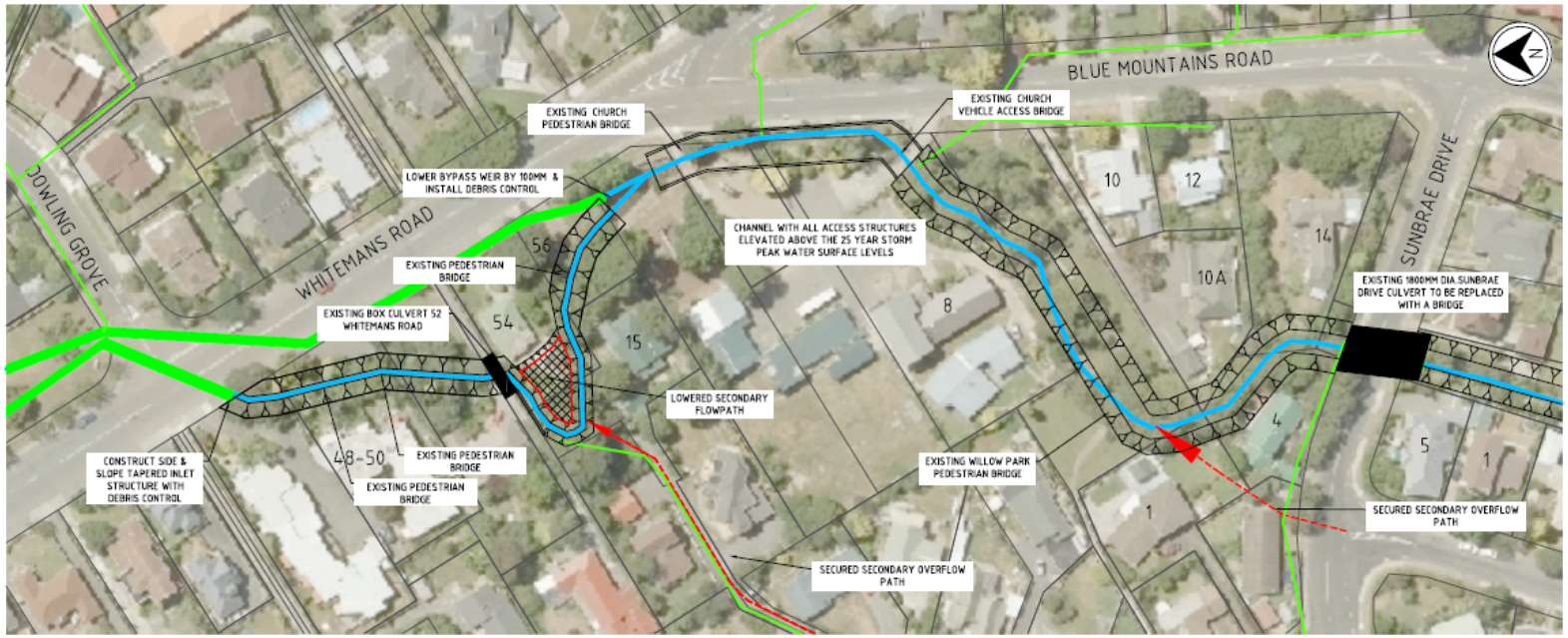
OPTION	DESCRIPTION	Cost
Pinehaven Reserve to Pinehaven Road Hybrid	Hybrid option of a concrete lined 25 year channel capacity through the space restricted areas adjacent to Birch Grove, no channel capacity upgrades in the Park or 50 Blue Mountains Road and the construction of a naturalised channel diversion through 48 Blue Mountains Road. Key features: ■ 25 year capacity vertical sided lined section through Birch Grove properties ■ Naturalised channel through 48 Blue Mountains Road ■ Minimal works in 50 Blue Mountains Road ■ No work in Pinehaven Reserve ■ Secure secondary flow path by lowering driveway in Birch Grove and upgrading storm-water in Winchester Ave ■ Purchase 48 Blue Mountains Road	$2, 342,950

UPPER CATCHMENT

OPTION	DESCRIPTION	Cost
Upper Catchment Option 4.1	Secure flow paths & blockage reduction upgrades to facilitate long term improvements in the upper catchment ■ Set a minimum underside of deck level, channel width and required capacity for any new vehicle and pedestrian access structures. ■ Blockage reduction measures at inlet structures at Chichester Drive ■ Upgrade intake to culvert at Pinehaven Community Hall ■ Modifications to road kerbs, road grading, crossings and driveways as well as easements to secure secondary overflow paths at the intersection of Jocelyn Cr and Pinehaven Rd (both Northern and Southern) and Forest Road and Pinehaven Rd. ■ Information, education and enforcement of upgrades to nuisance flooding from private structures.	$198,000

CATCHMENT WIDE OPTIONS

OPTION	DESCRIPTION	COST ESTIMATE*
Option 5.0	Increased planning controls to help prevent increases in flood risk by new development. Example planning controls: ■ Identify flood zonings ■ Zone and control important secondary flow paths ■ Hydraulic neutrality or reduction in runoff requirements for new development ■ Source control measures for new buildings such as Attenuation of peak flows in the catchment using onsite rainwater tanks ■ Enforcement of addressing nuisance flooding associated with private stream crossings	Low cost
Civil Defence	Civil Defence and Emergency Preparedness: ■ Identify and map flood hazard warning time zones, including at risk residential property and area response priority. ■ Identify critical infrastructure and lifelines ■ Identify flooding types (nuisance, hazard to services, pollution hazard, property and life) ■ Raise community awareness of civil defence centres, alerts and public warning systems. ■ Investigation options for location of additional flow gauge and rain gauging stations. ■ Incorporation in future regional flood warning system.	-



REACH 1 - OPTION 1.1
SCALE 1:1000 @ A1

NOTES
1. THE POTENTIAL UPGRADE OPTIONS CONTAINED IN THESE PLANS ARE SCOPING CONCEPTS ONLY AND HAVE BEEN DERIVED FROM INFORMATION AND TECHNIQUES AVAILABLE AT THE TIME OF THE STUDY. THE AGENCIES AND INDIVIDUALS INVOLVED IN THE ASSESSMENT OF THE UPGRADE OPTIONS SHOWN HERE, ASSUME NO RESPONSIBILITY FOR ANY ACTION BY ANY AGENCY OR INDIVIDUAL THAT IS BASED ON THE INFORMATION PROVIDED.

ISSUED FOR INFORMATION ONLY

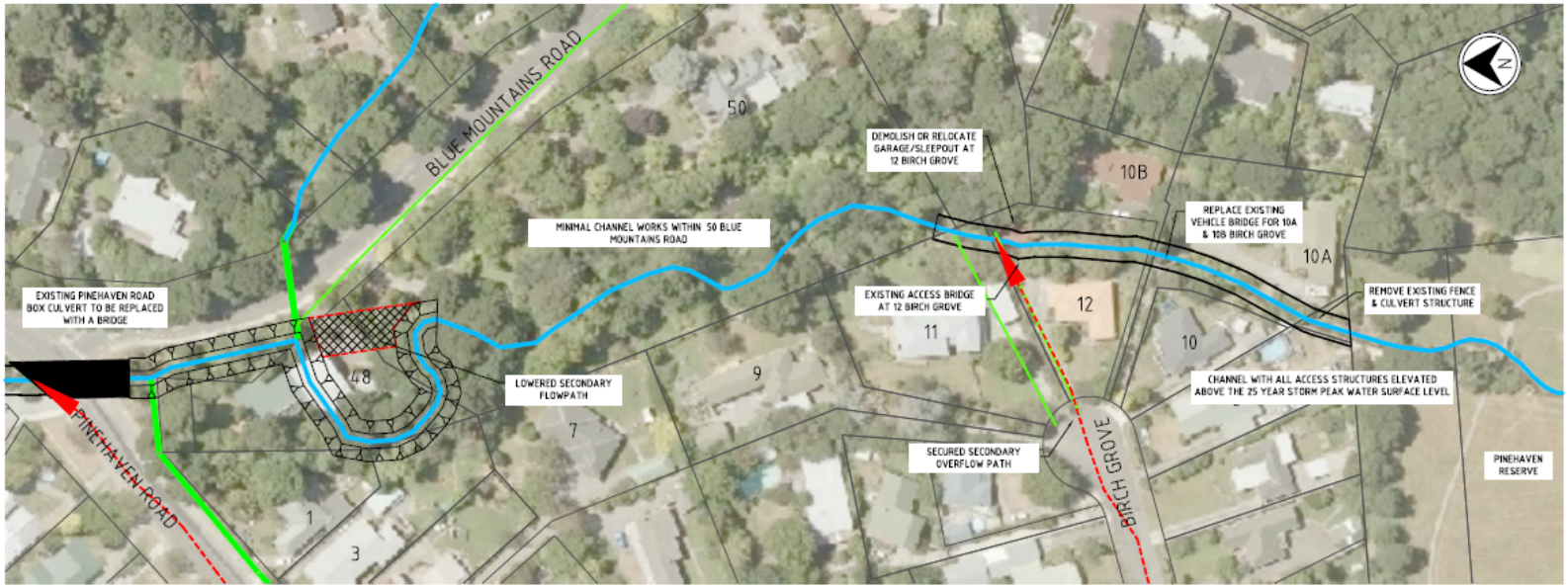
NO	DATE	DRAWN INITIALS	MH	CM	AMENDMENT
A	10/5/13	CP	MH	CM	

UPPER HUTT CITY
greater WELLINGTON THE REGIONAL COUNCIL
SKM

CLIENT: GWRC AND UHCC
PROJECT: PINEHAVEN FMP INVESTIGATIONS - PHASE 3
DRAWN: CP | DRAFTING CHECK: | DESIGNED: | DESIGN INITIAL: CP | REVIEWED PROJECT MANAGER: MH 10/5/13 | APPROVED PROJECT DIRECTOR: CM 10/5/13

TITLE: PINEHAVEN STREAM
REACH 1
PREFERRED OPTION

SCALE: AS SHOWN | PROJECT No: AE03975 | DRAWING No: REACH1-001 | PART: A



REACH 3 - HYBRID OPTION
SCALE 1:1000 @ A1

NOTES
1. THE POTENTIAL UPGRADE OPTIONS CONTAINED IN THESE PLANS ARE SCOPING CONCEPTS ONLY AND HAVE BEEN DERIVED FROM INFORMATION AND TECHNIQUES AVAILABLE AT THE TIME OF THE STUDY. THE AGENCIES AND INDIVIDUALS INVOLVED IN THE ASSESSMENT OF THE UPGRADE OPTIONS SHOWN HERE, ASSUME NO RESPONSIBILITY FOR ANY ACTION BY ANY AGENCY OR INDIVIDUAL THAT IS BASED ON THE INFORMATION PROVIDED.

ISSUED FOR INFORMATION ONLY

No	DATE	DRAWN Initials	RVWD Initials	APPD Initials	AMENDMENT
A	10/5/13	CP	MH	CM	

REF	DRAWING NUMBER	REFERENCE DRAWING TITLE

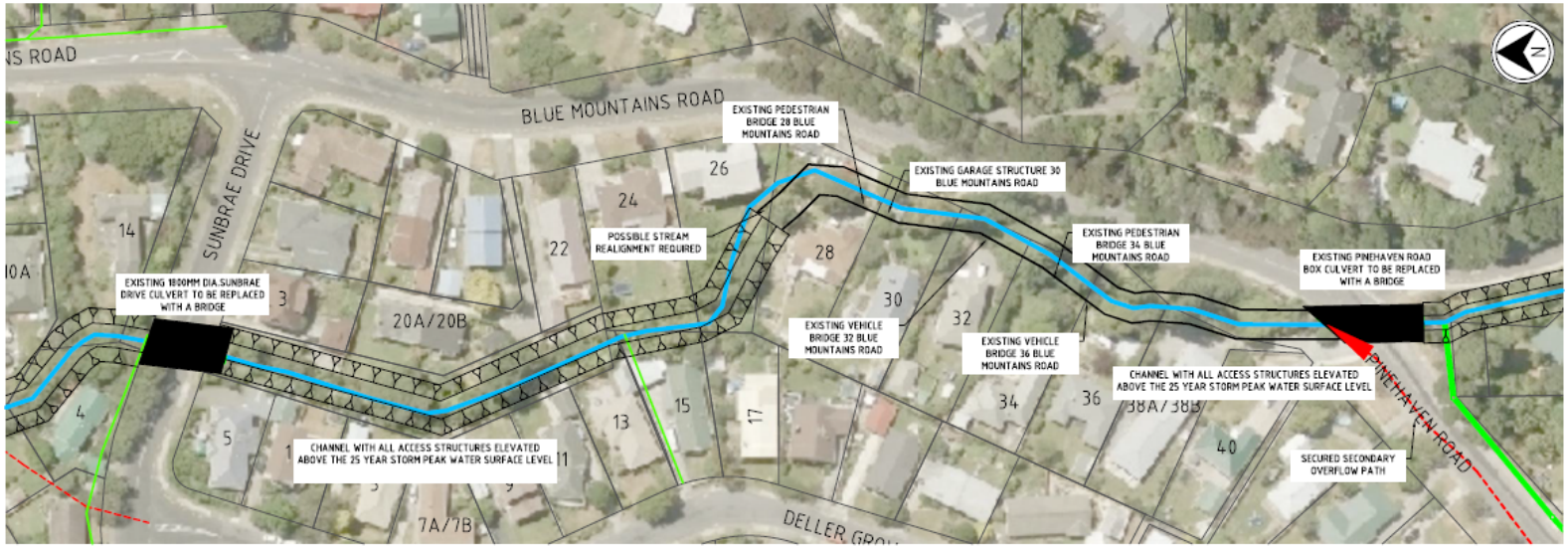
UPPER HUTT CITY | greater WELLINGTON THE REGIONAL COUNCIL | SKM

CLIENT: GWRC AND UHCC
PROJECT: PINEHAVEN FMP INVESTIGATION - PHASE 3

DRAWN	DRAFTING CHECK	DESIGNED	DESIGN REVIEW	REVIEWED PROJECT MANAGER	APPROVED PROJECT DIRECTOR
			CP	MH 10/5/13	CM 10/5/13

TITLE: PINEHAVEN STREAM
REACH 3
PREFERRED OPTION

SCALE	PROJECT No.	DRAWING No.	AMDT
AS SHOWN	AE03975	REACH3-003	A



REACH 2 - OPTION 2.1
SCALE 1:1000 @ A1

NOTES

1. THE POTENTIAL UPGRADE OPTIONS CONTAINED IN THESE PLANS ARE SCOPING CONCEPTS ONLY AND HAVE BEEN DERIVED FROM INFORMATION AND TECHNIQUES AVAILABLE AT THE TIME OF THE STUDY. THE AGENCIES AND INDIVIDUALS INVOLVED IN THE ASSESSMENT OF THE UPGRADE OPTIONS SHOWN HERE, ASSUME NO RESPONSIBILITY FOR ANY ACTION BY ANY AGENCY OR INDIVIDUAL THAT IS BASED ON THE INFORMATION PROVIDED.

ISSUED FOR INFORMATION ONLY

CLIENT	GWRC AND UHCC
PROJECT	PINEHAVEN FMP INVESTIGATIONS - PHASE 3
TITLE	PINEHAVEN STREAM REACH 2 PREFERRED OPTION
SCALE	AS SHOWN
PROJECT No.	AE03975
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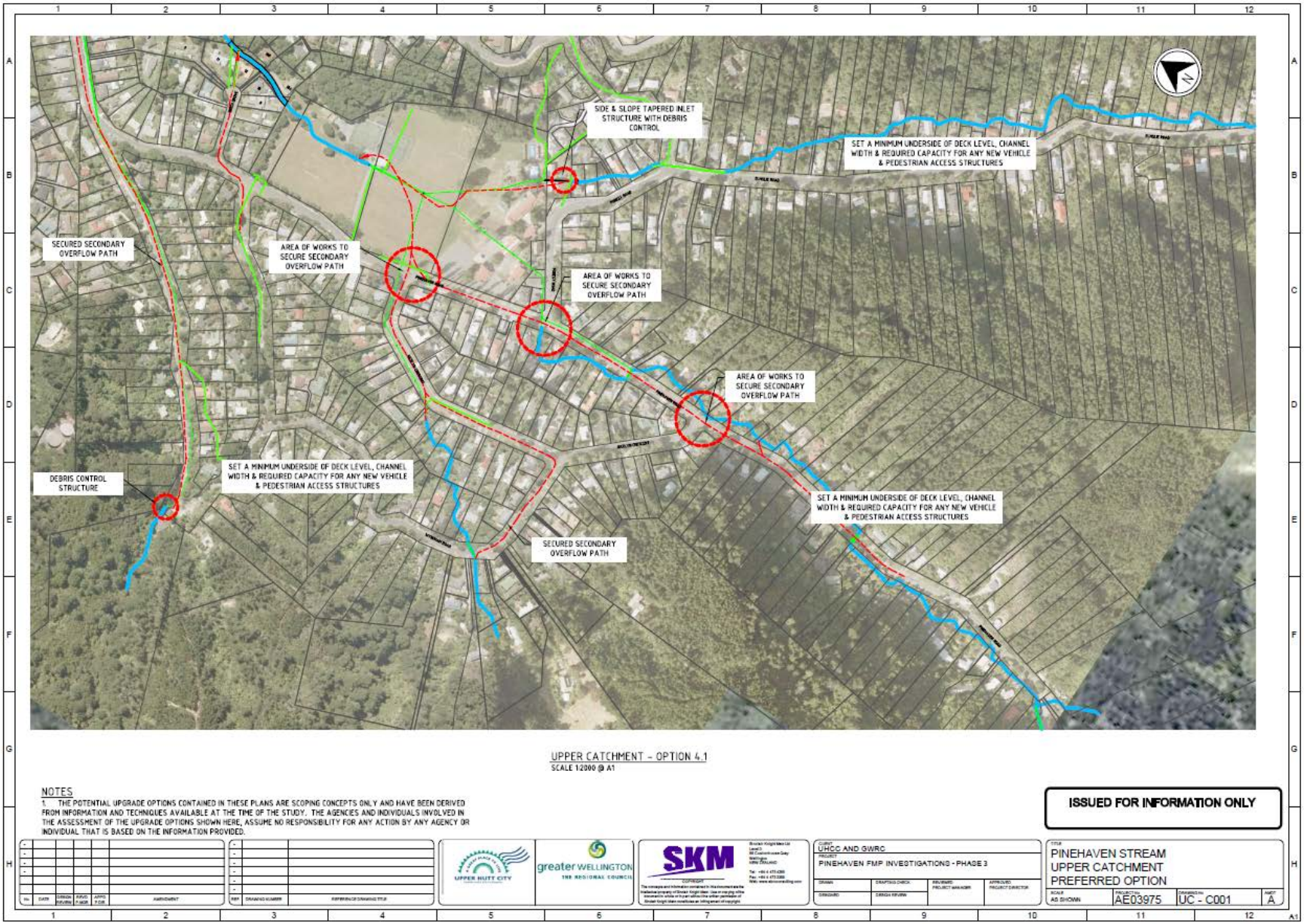
AMDT	A



UPPER CATCHMENT - OPTION 4.1
SCALE 1:2000 @ A1

NOTES
1. THE POTENTIAL UPGRADE OPTIONS CONTAINED IN THESE PLANS ARE SCOPING CONCEPTS ONLY AND HAVE BEEN DERIVED FROM INFORMATION AND TECHNIQUES AVAILABLE AT THE TIME OF THE STUDY. THE AGENCIES AND INDIVIDUALS INVOLVED IN THE ASSESSMENT OF THE UPGRADE OPTIONS SHOWN HERE, ASSUME NO RESPONSIBILITY FOR ANY ACTION BY ANY AGENCY OR INDIVIDUAL THAT IS BASED ON THE INFORMATION PROVIDED.

ISSUED FOR INFORMATION ONLY

UPPER HUTT CITY | greaterWELLINGTON THE REGIONAL COUNCIL | SKM

UHCC AND GWRC
PINEHAVEN FMP INVESTIGATIONS - PHASE 3

PINEHAVEN STREAM
UPPER CATCHMENT
PREFERRED OPTION

AS SHOWN | AE03975 | UC - C001 | A

Appendix G Flood Pegging and Survey Procedures

Introduction

There are two parts to obtaining flood levels:

- Pegging levels during or after an event
- Recording pegged levels

Preparation

The following is a checklist of what is required in the field when pegging the progress of a flood.

Vehicle

For normal departmental business only vehicles allocated to the Flood Protection Department are to be used. However, during a flood event extra vehicles may be required and this can be arranged through your supervisor or Lisa Baudinet on extension 8307, or Pat Gray on extension 8824.

Pegs

A supply of standard 50mm x 25mm and 50mm x 50mm survey pegs are available from Jeff Evans at the Mabey Road Depot, phone 567 6609.

Hammer or any peg bashing instrument

Pegs should protrude just above, or preferably flush to, the ground to minimise damage to mowers, plus giving less chance of being removed by vandals. Use a sledge hammer or preferably a peg bar which are available from Level 9, Otaki Depot or Mabey Road Depot.

Pegging Sheets

Print out of the current Aerial Mosaics as required using the 'Flood Protection Drawings / Plans Database' to mark peg locations & a writing pad to record peg information.

Supply of Pencils

Can be obtained from the stationary cabinet on Level 9 or from the main stationery cupboard on the Ground Floor.

Dazzle

Take two cans of either orange or pink dazzle. Other colours are less visual and subsequent location for surveying of flood levels could be difficult, especially if done by another person.

Food

You could be in the field for most of the day.

Wet Weather Gear

Gumboots, leggings and a coat are standard issue. There are spares available on Level 9, RCC.

Tape

30m or 50m tape.

Location aerials

Take copies of the current Aerial Mosaics available from the 'Flood Protection Drawings / Plans Database' or plan cabinets.

Watch

The time that you record a flood level is important. Record to the nearest five minute interval.

Keys for Gates

Your access along river berms will be limited without the appropriate key. Refer to the Mabey Road Depot (phone 567 6609).

Council Identification and Cards to leave with people

Council identification is important in situations in which public access may be withheld (Civil Defence situations). Having left a card with a member of the public advertises the fact that you have been around and therefore you are less likely to receive adverse publicity and, in face, could receive information regarding floods, etc.

Camera and Film

Photos can be a help in the subsequent interpretation of flood events. See the Flood Protection secretary for the Departments Digital Camera.

Slasher

It will help you get to a site as well as reduce the time required to level in pegs at a later stage. These can be borrowed from Flood Protection staff at Mabey Road. Have them sharpened before borrowing.

Flood Level Pegging

It may be that only floods with a return period more than two years be pegged. This will depend upon the river and previous investigation work done. However, if the river cross-section changes significantly, then smaller floods may require pegging. This will be decided in the office prior to staff having to go into the field.

The purpose of pegging is to pick up the flood peak level either from pegging during the flood or from debris levels after the peak has passed.

Place pegs with caution ensuring that the site is representative of the local flood level.

Some areas where debris marks are obvious after a flood have usually been identified. Check beforehand as pegging of these areas during a flood is low priority. They can still be surveyed at a later time.

For recurring flood events in a river it is preferable that the pegging be done by someone who has done the river before. Familiarity with the sites to peg and watch should hasten the pegging.

For major rivers two people pegging is advised. Each person could work one side of the river. Alternatively the pair could 'leapfrog' down reaches of the river following the peak more effectively.

Information Required

1. Debris mark or observed flood levels:

    a) If an observed flood level record time of pegging and comment on any surging and water level variations across the section, etc.

    b) If a debris mark note the type of debris mark, i.e. silt on vegetation, flattened grass, etc.

    c) Peg both upstream and downstream of bends and bridges and if possible on both sides of the river (essential for bends). Make a visual assessment of the backwater effects across the bridge and assess alignment of flow both into and out of a bridge. Note any debris build-up around either abutments or piers. With the complex hydraulics occurring at these sites a photograph can often save time and provide detailed information.

    d) Plot position of the peg on the an Aerial Mosaic map with respect to sighting points or other permanent marks, if sighting points are inappropriate. Sketch the extent of flooding on the aerial photo. Dazzle fence or trees nearby if appropriate. Attempt to place the peg on the Cross-section alignment. Tape the distance to the peg and record especially if subsequent location may be difficult.

    e) Note which position on the peg reflects water level. Preferably the ground level adjacent to the peg should be the flood level. This improves the chances of the mark being surveyed even if the peg is removed. If flood level is other than general ground level by peg record in field book (Xmm above ground).

    f) Dazzle the peg and circle it.

g) Record flood levels other than pegged sites as appropriate. This would include all staff gauges and temporary recorders for a river.

Surveying Pegged Flood Levels

After pegging flood marks the levelling in should be carried out as soon as possible. The longer this is left the more likely the pegs will be disturbed or be of annoyance to landowners if on private property.

In parks or regularly maintained areas, place pegs asap flush to the ground as the local authorities tend to get in and clean up shortly after a flood event.

The following is a check list of what is required in order to survey in previously pegged flood levels:

- Vehicle and gate keys
- Staff person
- Surveying equipment

a) Flood Protection Department has its own levelling & survey equipment held in the equipment / Photocopy room.

The following equipment is available:

- Carl Zeiss Ni21 Level
- Sokkisha Set 4 Total Station, Field book & Associated 12D Software
- Calculator

Useful in checking closing of traverse prior to moving level to new position.

- Standard flood level pegging sheets
- Slasher
- There probably will be a need to clear lines of sight in order to take readings.
- WRC identification and cards
- The public will want to know who you are and what you are doing.

3.1 Surveying procedure

- An EDM could be adopted for this.

If adopted the data is to be supplied to GWRC in spreadsheet form as in our XS surveys, example below:

Cross-section ID	Northing	Easting	RL	Code	Date
280	i. ***	ii. ***	iii. ***	iv. FLRB/ FLLB	v. 021123
	vi. (2 decimal places)	vii. (2 decimal places)	viii. (3 decimal places)		ix. 23 Nov 2002

Whereby: FLRB denotes Flood Level Right Bank

FLLB denotes Flood Level Left Bank

- Generally levelling with a standard level is sufficient.

Record the following details in the level book:

- Name of person on level
- Name of person on staff

- Date of flood being surveyed
- Date / Time of survey

Note: Copies of the pages from the level book will need to be placed on file.

- Read all levels to the nearest millimetre.
- Double check all readings taken.
- Close all traverses (even if a simple traverse).
- Repeat traverse if close is greater than 5mm unless otherwise required. The hydraulic modelling carried out on the VAX computer is usually to the nearest 10mm therefore the order of accuracy is +/- 5mm.
- If position of peg shown on marked up aerial is incorrect, tape or use level to establish position with respect to known points.
- Remove pegs only after readings are checked and finalised.
- Reduce readings in level book, photocopy and place on general file (N/70/3/2 flood marks and peggings). Also copy to relevant river file and supply copies of level book information to the Engineering Technical Officer to ensure transfer of information into GIS.

Appendix H Glossary

Adverse effect

A negative impact on the environment caused by a particular activity or set of activities.

Adverse effects can:

- be temporary or permanent
- have a low or high impact
- have a low or high chance of occurring
- be cumulative: arising over time in combination with other effects
- vary in their scale, duration, intensity or frequency.

Minimising adverse effects means taking all practical and reasonable steps to limit adverse effects. This implies allowing minor effects, but does not mean that all adverse effects must be eliminated.

A legal definition of the term 'effect' can be found in Section 3 of the Resource Management Act 1991.

Amenity values

Those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness and aesthetic coherence, and its cultural and recreational attributes. Adverse amenity effects occur when these values are impacted on in a negative way.

Annual exceedance probability (AEP)

Expressed as a percentage, it gives the chances of a flood of that size or larger occurring in any given year. It is equal to the inverse of the "return period" that is also used to describe flood probability. For instance:

- A "1% AEP flood" means a flood with a 1% or 1 in 100 chance of occurring in any given year. This is equal to a "100 year return period flood event". On average, this is expected to occur once in 100 years, based on past flood records, though in reality it could happen at any time.
- A "5% AEP flood" means a flood with a 5% or 1 in 20 chance of occurring in any given year. This is equal to a "20 year return period flood event".

Asset management plans (AMP)

Plans that assist with the physical and financial management of a Council's assets.

Catchment

The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.

Design standard

The standard of the flood management methods designed to contain a flood of a certain size (e.g. the height of river stopbanks).

Development

Erecting a building, carrying out excavations, using land for a building, or subdividing land. *Infill development* refers to developing vacant blocks of land that are generally surrounded by developed properties. *Greenfield development* refers to developing properties in previously undeveloped areas, e.g. the urban subdivision of an area previously used for rural purposes (see *non-structural measures*).

Effects

See *adverse effect* or *flood hazard effects*.

Flood

A relatively high river flow that overtops the natural or artificial banks in any part of a watercourse

Flood Sensitive Area

Model extent of flooding in a rainfall event with an Average Return Interval of 100 years incorporating:

- Climate change to 2090
- The application of freeboard to the modelled flood extents. Freeboard includes a range of factors including additional channel/culvert blockage from channel/culvert blockage by debris, changes in rainfall patterns or tailwater conditions.

Flood defences

Physical structures that keep floodwaters in the river corridor. They include stopbanks and flood walls (see *structural measures*).

Flood extent

Base model extent of flooding in a rainfall event with an Average Return Interval of 100 years, incorporating climate change to 2090

Flood hazard

The potential for damage to property or people due to flooding and associated erosion.

Flood hazard effects

The negative impacts of flooding caused by fast flowing or deep ponded flood waters. Fast flowing or ponded flood waters are dangerous for people, becoming more severe where floods affect urban areas. These effects also include damage to the flood protection system, and other structures and buildings by water and debris, or by erosion.

Floodplain

The low-lying portion of a river valley, adjacent to the *river corridor*, which is covered with water when the river overflows during floods.

Flood risk

The combination of the probability of a flood occurring multiplied by the consequence of the effects of that flood

Flood warning

The process used to warn a community of an impending flood. Warnings to the general public may be provided by methods such as local radio stations and street alarm systems (see *emergency management measures*).

Floodway

The area where most water flows during a flood occupying large areas of the *river corridor*. It is often aligned with naturally defined channels. If even partially blocked, floodways can cause a significant redistribution of flood flow, which can then adversely affect other areas.

They are also areas of swifter and often deeper flow. The floodway includes land adjacent to the riverbed, required to maintain an adequate corridor for the safe passage of flood waters to the sea.

Freeboard

An allowance used when setting floor levels, stopbank crest levels , that takes account of:

- Uncertainties in the precision of the hydraulic modelling
- Physical processes that may not have been allowed for in the design water level, eg debris build-up, wave action, changes in bed level
- Uncertainties in the prediction of physical processes (eg rainfall patterns) that affect the design water level

The inclusion of a freeboard allowance provides an upper confidence level that water levels will have a high degree of certainty of not being exceeded.

Habitat

An area with the appropriate combination of resources – such as food, water, nesting sites, shelter - and environmental conditions – such as temperature, humidity or shade – for the survival of a species.

Hazard

A hazard refers to the potential for flooding and erosion to affect floodplain. See *flood hazard effects*.

House raising

The action of raising the floor level on existing houses to reduce potential flood damage.

Infill development

See *development*.

Infrastructure

Networks, links and parts of facility systems, e.g. transport infrastructure (roads, rail, parking) or water system infrastructure (pipes, pumps and treatment works).

Lifelines

Utilities and/or organisations that provide services essential for the on-going functioning of a community during and following an emergency event. They include utility service providers including telecommunications, gas, electricity, water; and transportation network provides (for road, rail, port and airport services).

Other essential services include hospitals and medical centres, and emergency services (such as the police, ambulance and fire services).

Land

This includes land covered by water.

Mitigation

For this guideline, the act of moderating or reducing the effects of the flood hazard or flood protection works (see *flood hazard effects* and *adverse effects*).

Non-structural measures

Non-structural measures mainly deal with the residual risk of flooding. These measures keep people away from flood waters and help the community cope when flooding occurs. *Land-use measures* influence the way land is used and buildings are constructed. They include *regulatory methods* (policies and rules in district plans) and *voluntary actions* (information and advice to help people to make their own decisions). *Emergency management measures* seek to improve the community's preparedness and response to flooding. Non-structural measures are the most cost-effective flood mitigation approach.

Overflow path

Overflow paths (also known as a flow path) includes areas in the *river corridor* and on the adjacent *floodplain* where a large volume of water could flow during a major event. They are often areas of land which lead fast-flowing water away from the *river corridor* and over the *floodplain*.

The depth and speed of flood waters are such that development could sustain major damage, and there may be potential danger to life. The rise of flood water may be rapid. Evacuation of people and their possessions would be dangerous and difficult and social disruption and financial loss could be high. A blocked overflow path could potentially cause a significant redistribution of flood flows to other areas of the floodplain. Due to water depths and velocities, overflow paths are generally unsuitable for development, unless adequate flood avoidance and/or mitigation provisions are made.

Ponding area

Ponding areas are those areas where flood waters would pond either during or after a major flood event. Water speed is slow in ponds, but water levels could rise rapidly. Evacuation of people and their possessions may be difficult, especially on foot, and may need to be by boat. There could be danger to life. Social disruption may be high. Generally, ponding areas are unsuitable for development, unless adequate avoidance and mitigation provisions are made (see *flood hazard effects*).

Probable maximum flood (PMF)

The largest flood that could occur.

Residual risk

The risk of flooding that exists despite the protection provided by flood protection structures. In other words, it is the additional or 'left over' risk due to possible breaching and overtopping of structures such as stopbanks.

Riparian management

This is the management of the riparian zone, which consists of the *berms* and the *floodway*. The riparian zone is an important ecological link between the river and land-based ecosystems. Good riparian management is essential for minimising bank erosion, maintaining healthy ecosystems and ensuring good water quality.

Riverbed

Riverbed is defined in the Resource Management Act 1991: "In relation to any river, the space of land which the waters of the river cover at its fullest flow without overtopping the banks."

River corridor

Includes land immediately adjacent to the river. It is the minimum area able to contain a major flood and enable the water to pass safety to the sea. Because of its location, the river corridor represents a significant flooding and erosion hazard to people and structures, including the flood defences, sited in the corridor. The depth and speed of flood waters are such that existing development in the corridor could sustain major damage, and there is a potential danger to life. Water may rapidly rise, evacuation of people and their possessions would be extremely difficult, and social disruption and financial loss could be very high.

Risk

Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of these Guidelines, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

Service

As in *utility service*, it is a system and its network infrastructure that supply a community need.

Sustainable management

As defined by section 5 of the Resource Management Act:

Managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while:

a) *sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
b) *safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and avoiding, remedying, or mitigating*

Upper catchment

The generally hilly and mountainous areas in the headwaters of a catchment.

Zone/zoning

Areas of land classified for a certain range of land-uses; e.g. residential zoning specifically provides for residential homes as well as associated structures such as garages and storage sheds

Appendix I Bibliography

Ministry for the Environment (2008) *Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand*

Agricultural Engineering Institute (December 1992) *Hutt River Flood-plain Management Plan, Phase 1 – Hutt River Flood Control Scheme Review Report No. 9, Flood Damage Assessment* Report WRC/RI-T-92/42 prepared for Greater Wellington Regional Council

Austroads (1994) *Waterway Design: A Guide to the Hydraulic Design of Bridges, Culverts and Floodways*

Begg, J.G., Mazengarb, C. (1996) *Geology of the Wellington Area*, Scale 1:50000. Institute of Geological and Nuclear Sciences geological map 22

Greater Wellington Regional Council (January 2009) *Pinehaven Stream Flood Hazard Assessment Contract Documents #3077*

Hicks D.M. and Mason P.D. (1998) *Roughness Characteristics of New Zealand Rivers*. NIWA

MWH (2008) *Pinehaven Stream Flood Hydrology*. Report prepared for Greater Wellington Regional Council

New South Wales Government (1986), Floodplain Development Manual

Rawlinsons Media Group (2009) *Rawlinsons New Zealand Construction Handbook 2009*, Twenty Fourth Edition

Statistics New Zealand (2009) Table: *CPI – CPI All groups for New Zealand* (Quarterly – Mar/Jun/Sep/Dec). Available Online: www.stats.govt.nz/infoshare

Upper Hutt City Council (January 1983) *Report on Flood Control Measures in Whiteman's Road*

Upper Hutt City Council (2004) *Upper Hutt District Plan*

Upper Hutt City Council (2013) *Manual of Policies*

Upper Hutt City Council (September 2007) *Upper Hutt Urban Growth Strategy*

Wellington Regional Water Board, *Report on Storm of 20 December 1976*

Greater Wellington Flood Management Plan Guideline