Attachment B

Piha Flooding: Detailed Options Analysis

Background

1. Extreme rainfall events in Piha on 3 February and 28 April 2018 caused significant flooding.
2. On both occasions high water depths and velocities resulted in emergency evacuations and flooding of residential properties on Glenesk, Seaview and Beach Valley Roads. Access along Glenesk Road was also cut-off by flooding.

The flood safety risk in Glenesk Valley is high for a small number of people

3. After these events Auckland Council undertook flood modelling. It also carried out floor level surveys and inspections of affected properties to confirm the level of flood risk.
4. Tonkin and Taylor was commissioned to produce an independent assessment of the Piha area to further understand the flood risk and its causes. They note that the stormwater catchment for Piha is large, covering approximately 1100 hectares, across steep terrain. This catchment generates large flows and high water velocities.
5. The time for the flood waters to peak in Piha is within 40 to 50 minutes of rainstorm events. This constitutes 'flash flooding.' The speed by which flooding occurs accentuates the risk to people.
6. Tonkin and Taylor concluded that risk of drowning or injury from these frequent events is likely to arise from people undertaking risky activities. These include driving and wading through floodwaters.
7. Tonkin and Taylor also found that the majority of private bridge structures are not consented. During large flood events they would be unsafe for use and structurally unstable. One bridge was deemed dangerous.
8. These analyses conclude that the flood safety risk is high at some locations during extreme rainfall events.[1]

Flooding is a natural hazard that occurs frequently across Auckland

9. According to current estimates, 10 percent of all buildings in Auckland lie within areas that will flood during a 100-year rainstorm. Approximately 15,000 buildings are predicted to flood such an event.
10. Extreme rainfall is variable across the region. This means that we can expect localised flooding somewhere in Auckland once every three to five years from a 100-year event.
11. Piha differs from other parts of the region in terms of the flood safety risk and the frequency of flooding.

'Local solutions to local problems' is the accepted approach to flooding

12. According to the Ministry for the Environment the generally accepted approach to managing natural hazards in New Zealand, including flooding, is 'local solutions to local problems.'
13. Roles and responsibilities are clearly defined for local and central government as well as individuals and landowners.
14. Auckland Council acts in dual capacities as a regional council and territorial authority.
15. The council operates under a legislative framework for flood risk management that enables rather than requires specific levels of flood protection be achieved.

[1] For example, rainfall events which occur once every five to 10 years on average.

16. Regional councils maintain records of river flows, lake levels, rainfall and past floods. They model water flows, so they can warn of future flooding. They manage rivers and catchments and control land-use activities through the Resource Management Act 1991. Regional councils issue flood warnings and provide emergency management.

17. Territorial authorities collect information on flooding. They are responsible for controlling buildings and the effects of land use to reduce flood risk. The key tools are set out in the Building Act 2004 and Resource Management Act 1991 (see Appendix 1).

18. For Auckland Council some of the key tools include:

    - rules in the Unitary Plan based on hazard maps that manage where and what activity is allowed
    - minimum floor levels under the Building Act 2004 and Resource Management Act 1991
    - advice to warn people about flood hazards through Land Information and Project Information Memoranda
    - community emergency readiness and response planning and information.

19. The council also has a legislative role under the Building Act 2004 to assess and respond after a flooding event if a property and building is insanitary or dangerous.

20. Central government works through legislation and other policy-settings to enable local government. The police and the fire service help manage local events.

21. Central government also provides assistance following a large flood event to communities and councils to assist recovery. For example, the Earthquake Commission may provide natural disaster insurance to residential property owners in certain situations.

22. Individuals and landowners need to understand their level of flood risk and make decisions about the safety of themselves, their families and their property.

Council does not provide stormwater infrastructure in rural areas such as Piha

23. Piha is zoned as Rural – Waitakere Ranges Zone or Residential – Rural and Coastal Settlement Zone under the Unitary Plan.

24. Council provides formal storm water management and systems in urban areas of Auckland. This infrastructure does not extend to rural areas.

Problem definition

25. This problem definition set out a simple statement of the current flooding problem and who it affects.

> **Problem definition**
>
> Piha stream is subject to flash flooding. The high frequency of events, fast catchment response time (40-50 minutes) and locations of buildings, bridges and roads in the floodplain means that there is a high flood safety risk in certain areas.
>
> Glenesk Road is likely to flood on an annual basis. Overtopping of some access bridges can be expected every other year. Flooding of approximately 10 buildings is likely in a five-year event, increasing to approximately 21 buildings in a 100-year event.

There are four groups of people that may have a flood safety risk:

- residents with habitable floors within the floodplain
- residents whose access is restricted by flooding in Glenesk Road
- members of the wider Piha community
- visitors to Piha.

The risk profile of these groups of people varies based on their vulnerability, behaviour during the flood and the physical characteristics of the flood at their location.

The level of risk is likely greater at night when people may be asleep or unprepared to evacuate their homes at short notice. Darkness may make it more difficult for people to safely evacuate.

There are increased risks for children, elderly people and people with disabilities.

26. The problem statement focuses on flood safety risk to people; however, it is important to note that there are other impacts:

    - property damage, both structural and to contents
    - the cost of evacuation and providing for the welfare needs of those affected by flooding
    - disruption to users of roading infrastructure, which further impacts on economic activity.

27. Several options outlined in this document may help minimise these impacts.

Private property options

28. This report primarily focuses on options that mitigate flood safety risk collectively to residents, the wider Piha community and visitors.

29. The scope of the options does not impinge on private property rights or on the private responsibilities and choices of individual property owners. For this reason the purchase of properties, an option raised by parts of the community, is not presented in this report.

30. Private property owners may wish to consider options to reduce the impact flooding has on their property.

31. These can include building or property improvements that are not legally required under the Building Act 2004 or the Resource Management Act 1991.

32. Raising the floor level of buildings out of the 100-year floodplains is one example. This was outlined in the Tonkin and Taylor report (see Appendix 2).

33. The only exception is council's role under the Building Act 2004 relating to insanitary and dangerous buildings as a result of flooding. The Tonkin and Taylor report sets out their assessment of affected properties (see Appendix 3).

34. This information provides the individual property owners and council regulatory staff with information about future decision about whether to issue dangerous or insanitary notices. The notices can require the property owner to undertake building works at their own cost, to that ensure the properties comply with the Building Code.

35. The council will make every effort to balance its statutory responsibilities with the rights of property owners.

A range of collective options

36. A range of options respond to the problem definition and help mitigate flooding risk to the Piha community. They include existing and new initiatives focussed on collective approaches to:

    - help keep people away from floods
    - enhance our readiness and response to floods
    - physical works to keep floods away from people.

37. A long list of possible options has been developed to enable discussion between the council, landowners and the Piha community (see Table 1 below).

38. A number of the options can and may need to be combined. Implementing most of the options will be difficult. They will come at a cost to either individuals, the community or the region. The trade-offs are financial, social and environmental.

39. Four of the options entail major flood protection and control works in accordance with the Local Government Act 2002.[2] [3]

Table 1: Long list of options

Current situation to keep people away from flooding	• **Option 1: Local responses to minimise the impact of storm events (status quo)**
Enhancing readiness and response to flooding	• **Option 2: Increase flood warning time** • **Option 3: Enhance ways of warning people** • **Option 4: Raise Glenesk Road**
Physical protection works to help keep flooding away from people	• **Option 5: Build a dam(s) to contain flood water** • **Option 6: Build a tunnel to divert flood water** • **Option 7: Widen the stream to increase water flows** • **Option 8: Clear/dredge the stream from Seaview Road Bridge to the sea to increase water flows**

40. Options 5 and 7 have sub-options.

41. Dams could be built to retain floodwaters from either the Glenesk and Piha streams under option 5. A single large dam could cover both tributaries.

42. Stream widening under option 7 has been modelled for a two-year and a 10-year storm event.

43. There is an interdependency between options 7 and 8. The value of clearing the stream depends on widening the stream.

44. Several options could be implemented. Only the large infrastructure projects (options 5, 6 and 7) are considered mutually exclusive.

45. All of these options and their likely impact are discussed in detail below.

[2] These are defined as physical structures that are owned by local authorities and are designed to protect urban and rural areas from flooding from rivers and includes ancillary works such as channel realignment or gravel removal.
[3] There are non-financial performance measures and reporting requirements for major flood protection and control schemes under the Act.

46. Staff considered an option to increase the planting of native flora across the catchment to increase its capacity to absorb rainwater. Evidence shows that plants native to Aotearoa New Zealand retain more water than exotics.

47. This option was dismissed because the Waitākere Ranges is the catchment for Glenesk Valley. This area is already heavily planted with native vegetation. Any additional planting would have a minimal impact on flooding in Piha.

Assessment criteria

48. Staff developed assessment criteria to enable the comparison of all options. These criteria are unweighted and allow for objective assessment.

> **The extent to which each option:**
>
> **1) provides an effective response to the flood safety risk**
>
> **2) is able to be implemented in the short to medium-term**
>
> **3) helps preserve and protect the natural environment**
>
> **4) supports a resilient Piha community**
>
> **5) is cost effective for council, landowners and the Piha community given their roles and responsibilities in response to flooding.**

49. All options are compared against the status quo in order to understand any additional benefits or impacts.

50. The first criterion focuses on the impact an option will have on reducing the flood safety risk.

51. The second criterion considers the likelihood of successfully implementing the option - *can it be implemented within three years?* The three-year delivery timeframe is proposed because of the frequency of flooding. Implementation in the short-term will reduce the flood safety risk and maximise the impact of the option.

52. The third criterion considers the impact on the natural environment. It recognises the national, regional, and local significance of the Waitākere Ranges Heritage Area and legislative framework to promote and protect it.

53. The fourth criterion considers the social consequences of an option – *what will be the lasting impact on social fabric of the Piha community?* Staff consider the likelihood of a positive outcome.

54. The fifth criterion focuses on the cost of the option. This analysis identifies costs and benefits and seeks to ensure that they reflect the roles and responsibilities of all stakeholders. Each of these stakeholders will need to make their own assessments as to whether the benefits outweigh the costs and make decisions accordingly.

55. The assessment considers the impact of all the criteria and notes further discussion with all affected parties will be vital.

Keep people away from flooding

Option 1: Local responses to minimise the impact of storm events (status quo)

56. Council has discharged its statutory responsibilities and has implemented a number of discretionary local projects to minimise the impact of flooding in response to the 2018 storm events.

Regulatory

57. Council has included flood notations on Land Information Memoranda for properties in Glenesk Valley since 2000. These memoranda, which provide a summary of the information that council holds on a property, note the potential risk of flooding and in some cases reported instances of flooding.

58. Table 2 below outlines the notations and the timeframes in which they were made.

Table 2: Flood risk notations

Flood notation	Number of properties	Date
Potential risk of flooding / overland flow paths	12 properties in Glenesk Road Piha Mill Camp	2000
Potential risk of flooding / overland flow paths	1 property in Beach Valley Road 1 property in Glenesk Road 1 property in Seaview Road Piha Art Gallery, Campground and Fire Station	2001
Reported incidence(s) of flooding / stormwater issues	2 properties in Glenesk Road	2009
Potential risk of flooding / overland flow paths	6 properties in Glenesk Road 3 properties in Seaview Road	2013

59. This information informs landowners, and prospective landowners, of the level of flooding risk. It allows them to make decisions relating to their property and to have evacuation plans in place.

60. Auckland Council is also considering further regulatory action. It has a non-discretionary role to regulate buildings under the Building Act 2004 to ensure that "people who use a building can do so safely and without endangering their health."

61. Regulatory responses are delegated to staff who are required to act based on the best available information at their disposal.

62. The Tonkin and Taylor report will inform any regulatory decision-making.

Data collection and modelling water flows

63. In its capacity as a Unitary Authority, council commissioned Tonkin and Taylor to undertake an independent assessment of the Piha area to understand flooding risk and its causes.

64. Since 2018, council has enhanced monitoring systems for rainfall and flood events in Piha:

- a vertical pointing rain radar and tipping bucket rain gauge upstream at the Rangers hut (installed)
- a vertical pointing rain radar downstream (to be installed)
- stream gauges at Seaview Road Bridge and Piha Mill Camp Bridge (installed)

- flow and level gauge in the stream adjacent to Glenesk Road (to be installed, subject to landowner approval).

65. Improved local rainfall records and information can be included in the hazard register and inform Land Information Memoranda.

Emergency management

66. Auckland Transport has installed flood risk and depth signage at Piha. These signs inform residents, the wider community and visitors of the potential for flash flooding.

67. Auckland Emergency Management is facilitating resilience planning for the wider Piha area. This includes evacuation planning and coordination with emergency response agencies.

Stormwater

68. Council has been undertaking regular inspections to manage flood risk. This includes removing debris from Piha Stream prior to storm events.

69. Installation of closed-circuit television cameras is planned to further assist with the identification of debris between inspections as well as to help monitor flood levels.

70. These are discretionary activities, which council would not normally undertake in rural areas.

Asset management

71. Auckland Transport carries out regular, and pre-storm, maintenance of all culverts and post event repairs of roading assets.

Financial implications

72. The total costs of the above local projects is $0.20 million. These costs are being met within baselines.

Risks

73. There are no delivery risks associated with the local projects.

Option assessment: Local projects (status quo)

Effectiveness	Achievability	Environmental	Social	Cost
✓	✓✓✓	✓	✓✓	✓✓✓

Effectiveness of the response

74. The suite of current actions decrease the risk to life and injury for all four ‘at risk’ groups.

75. This risk would decrease further if council issues notices under the Building Act 2004. The impact of this action is discussed below.

76. The decrease in flood safety risk is expected to be the result of improved flood profile information, monitoring, warning alerts, maintenance systems, community preparedness and a better understanding of the level of risk.

77. Council provision of information will partially reduce risk by alerting owners and prospective owners to the likelihood of flooding and possible flood levels. People can then plan ahead and make decisions for themselves, their families as well as their property.

78. Improved warning signage and guidance on what to do (and not to do) in a flooding event will partially reduce risk. Educating members of the community and visitors to avoid known dangerous behaviours such as driving or wading in fast flowing waters will help mitigate the risk to life and/or of injury.

79. Stream gauging will only partly mitigate the risk. Short warning times will remain. At least two-hours' notice of potentially high flood risk is ideal for safe evacuation.

80. Removing debris from waterways when flooding is forecast, if required, will help to reduce the severity and impacts of an event.

81. Emergency warnings will not reach the whole community given that the text message system is voluntary. Children and elderly people may represent a higher percentage of those that do not receive these warnings.

82. Emergency management planning for communities in the wider Piha area will empower residents and businesses to be better prepared and to put appropriate plans in place. These could include specific strategies for children, elderly and people with disabilities.

83. This option will not reduce the volume or velocity of flood waters in an extreme rainfall event.

Ability to be implemented

84. All the actions have been or are being implemented.

Preserves the natural environment

85. There are no expected additional adverse environmental outcomes under this option. This option may have slight environmental benefits by helping to keep the river free from debris.

Supports a resilient Piha community

86. This option supports a resilient Piha community by increasing local knowledge and understanding of flood risk. It empowers the community to develop a collective response.

87. Residents will have a clear understanding of the level of risk that they and the wider community is potentially exposed to. This enables them to make informed decisions.

88. Some community concerns may not be assuaged. The flood safety risk may be too high for some residents. The impact of future flooding may also be unacceptable to residents and their insurers.

Cost of the option

89. The costs of the above local projects are being met within existing baselines. They are being implemented in accordance with council's statutory functions and its flood management responsibilities. Accordingly, they deliver broad public benefits.

90. There are no additional costs to landowners or the Piha community.

Enhancing readiness and response to flooding

Option 2: Increase the flood warning time

91. Council could seek to develop and install an enhanced warning system as part of its emergency management function. This would be a discretionary activity with public benefits.

92. The current warning-time is approximately 50 minutes. The objective would be to increase this to two-hours, if possible. Increasing the reach of any warnings to all four 'at-risk' groups would be another objective.

93. The proposed option entails developing a predictive warning system, which draws upon specialist weather forecast modelling and stream monitoring, rather than relying on rainfall alone.

94. This system would depend on technical inputs from the MetService and National Institute of Water and Atmospheric Research. Their modelling would be supported by data collected from the vertical pointing radar, rain gauges and water velocity sensors implemented under the status quo.

95. Initial assessments of this option indicate that the proposed system could generate false warnings. These could be up to 50 per cent of all warnings. This could undermine the value of the system. People may decide not to evacuate in an emergency if they have previously responded to prior false warnings. This may make it unsuitable as a public warning system.

96. The proposed system, despite the potential for false warnings, would still assist emergency services. It would increase preparedness and enable them to prioritise high risk properties for evacuation. For this reason it warrants further investigation.

Financial Implications

97. The estimated cost of the predictive warning system is $0.30 million. This includes a capital cost of $0.25 million and annual operational costs $0.05 million.

Risk

98. There is a medium delivery risk associated with the implementation of this option. The predictive warning system may not be effective.

Option assessment: Increased warning time

Effectiveness	Achievability	Environmental	Social	Cost
✓	✓✓	No impact	✓✓	✓✓

Effectiveness of the response

99. This option will lead to a slight reduction in the flood safety risk. The decrease is expected to be the result of improved preparedness of emergency services. There would also be an increased likelihood of reaching all affected people, for example, elderly and visitors.

100. To be fully effective the system would need to increase the warning time and the accuracy of the warning. This does not appear feasible.

Ability to be implemented

101. This option could be implemented within the short-term.

102. Trials of the predictive warning system will be required to improve reliability before it could become operational.

Preserves the natural environment

103. There are no adverse environmental outcomes under this option.

Supports a resilient Piha community

104. This option does little to support a resilient Piha community. The flood safety risk may be too high for some residents, who may choose to leave Piha.

105. The impact of future flooding may also be unacceptable to their insurers.

Cost of the option

106. The estimated cost of the predictive warning system is $0.30 million. This includes a capital cost of $0.25 million and annual operational costs $0.050 million.

Option 3: Enhance ways of warning people

107. Council could seek to improve communications technology to increase the reach of any warning system. Currently council relies on a text-based service, which people subscribe to at no cost.

108. This would be a discretionary activity as part of council's emergency management function with a mix of public and private benefits.

109. The proposed option entails expanding the text-based service. This would be in response to limitations with existing landline and cell phone coverage in Piha. This is due to gaps in coverage caused by the Waitākere Ranges and rural service levels.

110. Preliminary assessments have been made of ways to enhance telecommunications in Piha. Implementation could entail using a telecommunications booster to increase signal strength.

111. It may be possible to locate this technology in Piha, for example at the fire station, and to use it to relay signals to the existing cell phone tower.

112. If feasible, this service would provide enhanced reception across Piha. This would increase coverage and provide more reliable options to alert residents of flooding.

113. An additional cell phone tower is another way of increasing coverage.

114. Improved communications would have wider benefits for residents and visitors.

115. The introduction of a recorded voice warning is another feature of this option. This will help visitors and new residents, who may be unaware of the danger, understand the flash flooding risk. It could be much more effective than a siren.

Financial Implications

116. The estimated cost of the booster technology is $0.30 million. The cost of a new cell phone tower is $1.50 million.

Risk

117. There is a low delivery risk that landowner approval will not be granted for the location of the booster technology at the fire station.

Option assessment: Enhanced warning system

Effectiveness	Achievability	Environmental	Social	Cost
✓	✓✓✓	No impact	✓✓✓	✓✓

Effectiveness of the response

118. This option will lead to a small reduction in the flood safety risk. Improved communications may enable people to get to safety earlier. There would also be an increased likelihood of reaching all affected people, for example, elderly and visitors.

119. To be fully effective an increase in warning time is also needed. This does not appear feasible.

120. There would be a significant residual safety risk that people wade through rapid and deep water or seek to evacuate in cars.

Ability to be implemented

121. This option could be implemented within the short-term.

122. Trials of the telecommunications booster will be required to improve reliability before it can become operational.

Preserves the natural environment

123. There are no adverse environmental outcomes under this option.

Supports a resilient Piha community

124. This option supports a resilient Piha community by improving communications with local residents. It would enhance current community resilience and emergency plans.

125. The flood safety risk may be too high for some residents, who may choose to leave Piha.

126. The impact of future flooding may also be unacceptable to their insurers.

Cost of the option

127. There are costs associated with the enhancement to telecommunications. The public benefits of this investment would be limited to storm events. This should be reflected in where costs lie.

128. Improved communications would have wider benefits for the fire service as well as private benefits for residents and visitors. These stakeholders would be able to use the improved cell phone coverage and increased reliability in their day-to-day activities.

129. Trialling of the booster should allow telecommunications companies to identify the properties and areas that will benefit from any service improvement.

Option 4: Raise Glenesk Road

130. Auckland Transport could undertake transport engineering works to raise the height of Glenesk Road.

131. This would be a discretionary activity with primarily public benefits. It would allow the road to be used by emergency services and by Piha residents to evacuate during an extreme rainfall event.

132. The proposed option is to raise approximately 560 meters of Glenesk Road by approximately one metre. This would make the road usable up to a 10-year storm event.

133. Replacement of 20 metres of culverts and an existing bridge would be required.

134. This option would require the upgrade of approximately 30 driveways.

135. It is also proposed that new vehicle bays are built to prevent vehicles floating away in a flood event.

Financial implications

136. The estimated capital costs to raise Glenesk road is $1.2 million. This expenditure is unbudgeted.

Risks

137. This option would create a low financial risk to Auckland Transport. It may put other planned capital expenditure at risk.

138. There are high delivery risks associated with the implementation of this option. It relies on landowners investing in new accessways and vehicle bays.

Option assessment: Raising Glenesk Road

Effectiveness	Achievability	Environmental	Social	Cost
✓	✓✓	X	✓✓	X

Effectiveness of the response

139. This option would lead to a small decrease to the risk to life to three 'at risk' groups. This option may marginally increase the flooding risk.

140. Raising the road will reduce the risk of flooding preventing emergency services access.

141. Those who have restricted access in a flood event will see the most benefits. It will provide for safer evacuation for houses on the uphill side of the road.

142. Raising the road along with the construction of new bridges and safe vehicle bays may assist with the evacuation of houses within the floodplain. It may also accentuate flooding.

143. Reinforcing bridge structures reduces the risk of bridge damage or collapse.

144. Building safe vehicle bays reduces the risk that vehicles could float away in a flood event.

Ability to be implemented

145. Implementation of this option is dependent on landowners undertaking private works.

Preserves the natural environment

146. This option will have a low environment impact. It entails the replacement, and raising, of existing structures.

Supports a resilient Piha community

147. This option is expected to have a moderate positive impact on the Piha community.

148. Private works to improve accessways and parking bays are likely to viewed as unnecessary and costly. Landowners may not have the financial resources to undertake these works. This would add to existing stress levels.

149. This option would minimise disruption to users of roading infrastructure.

Costs of this option

150. Raising the road would provide public benefits. It would improve access for emergency services. It would also facilitate the evacuation of Piha residents.

Physical protection works to help keep flooding away from people

Option 5: Build a dam(s) to contain flood water

151. Council could consider major engineering works to construct a storage dam or dams to retain floodwaters and reduce peak flows during extreme rainfall events.

152. This would be a discretionary activity with primarily private benefits.

153. Council does not currently have any flood protection and control works of comparable size and scale. If approved, this option this would represent a significant policy shift.

154. Tonkin and Taylor set out four main dam sub-options. The key aspects of each proposal is outlined in Table 4 below.

155. Dams could be built to retain floodwaters from either the Glenesk and Piha streams. Both dams could be constructed. A single large dam could also cover both tributaries.

Table 4: Dam options

Description	Details	Dam Dimensions
Single dam - Piha tributary	Stores water from a 100-year storm event from Piha Stream The resulting flow from Glenesk Stream would be 54m³/s	27 metres high 147 metres long
Single dam - Glenesk tributary	Stores water from a 100-year storm event from Glenesk Stream The resulting flow from Piha Stream would be 54m³/s	30 metres high 205 metres long
Two dams - Piha and Glenesk tributaries	Each dam stores water from a 100-year storm event. Any compensatory release would be 20 m³/s	Refer above
Single dam - tributary confluence (Piha Mill Camp)	Stores water from a 100-year storm event. Any compensatory release would be 20 m³/s	21 metres high 180 metres long

156. This information is indicative only. The size, scope, location and functionality of any proposed dam would require detailed investigation if this option was considered feasible.

157. Any of these sub-options would be considered 'large dams' under the Building Act 2004.[4] They would require building and resource consents under the Resource Management Act 1991.

158. Each sub-option would likely be classified as 'high potential impact' category dams under the Building Act 2004. This means that they would need to meet the highest design and construction specifications. For example, the dam or dams would have to be able to withstand any seismic or volcanic event. They would also have to pass the probable maximum flood.

Financial Implications

159. The estimated capital costs for this option are:

- Single dam at Piha tributary: $17-22 million
- Single dam at Glenesk tributary: $22-28 million
- Two dams at Piha and Glenesk tributaries: $49 million

[4] A large dam means a dam that retains three or more metres depth and holds 20,000 or more cubic metres volume of water.

- Single dam at tributary confluence: $ 12-18 million.

160. There would also be significant annual operational expenditure required. High potential impact category dams require considerable operational support, maintenance and rigorous dam safety management.

161. Both the capital and operational expenditure is unbudgeted.

162. Development of infrastructure of this scale would typically be debt-funded by council and the costs recovered by way of a targeted rate payable by the Piha community.

163. The council's debt ceiling may mean that there is insufficient funding available to deliver this infrastructure in the long-term. This is due to existing commitments to growth-related projects.

Risks

164. This option would create a high financial risk to council. It would put other capital expenditure at risk.

165. There are high delivery risks associated with this implementation of this option. It is dependent on the willingness of the Piha community for a targeted rate.

Option assessment: Build a dam(s)

Effectiveness	Achievability	Environmental	Social	Cost
✓✓✓	XXX	XXX	✓✓	XXX

Effectiveness of the response

166. A well-located and constructed dam or dams to retain floodwaters could effectively eliminate the flood safety risk as well as other impacts from flooding.

167. All Piha residents and visitors would be safe under this option.

Ability to be implemented

168. The engineering feasibility of large dams is highly dependent on geology. The volcanic origins of the Waitākere Ranges may make it unsuitable for construction. Material availability might be another problem.

169. There is a high delivery risk in that the proposed construction plans may not gain consent under the Resource Management Act 1991.

170. Piha is also covered by the Waitākere Ranges Heritage Area Act 2008, which sets out additional environmental protections.

171. The combination of these factors will likely result in a lengthy timeframe for completion.

Preserves the natural environment

172. All of the dam sub-options would have a significant environmental impact.

173. Extensive clearance of native bush would be required for both the construction area and for access ways.

174. The dam or dams would have a significant negative visual amenity impact.

Supports a resilient Piha community

175. This option is likely to increase the confidence of residents during an extreme rainfall event. Residents could stay in their properties and would not need to worry about flood safety risks.

176. The community will be more confident in making informed decisions on future developments in the area.

177. Construction of a dam and its environmental impacts could be viewed negatively by some members of the community.

178. Rain water retained by the dam would need to be kept low in preparation for any storm event. There would not be any benefit to the community from increased drinking water supply. The ability to generate hydroelectricity would also be limited.

Cost of this option

179. The costs of this option are high and likely to outweigh the benefits of flood risk mitigation.

180. These costs would largely be borne by landowners in Piha. This is because flood protection and control schemes deliver private benefits to the properties they protect.

181. Council is a landowner in the area. It could derive some benefit from a flood protection and control scheme. However, council would need to weigh the costs versus benefits and may conclude that the removal of assets is more cost effective.

182. There would be some public benefits from reducing the flood safety risk. The costs of this option would need to be weighed against other options.

Option 6: Build a tunnel to divert flood water

183. Council could consider major engineering works to construct a flood flow diversion tunnel for Piha stream.

184. This option would be a discretionary activity with primarily private benefits.

185. If approved, the construction of a major flood protection and control scheme would represent a significant policy shift.

186. Tonkin and Taylor considered a flood flow diversion tunnel from Piha stream to Whekatahi Creek. It would entail boring a 1.4-kilometre long tunnel with a diameter of four to five meters.

187. This tunnel would divert floodwaters from Piha Stream in a 10-year storm event and above. However, it would increase flows and likely flood risk in areas around Whekatahi Creek.

Financial Implications

188. The estimated minimum capital cost is $45 million. The actual cost would be dependent on geology.

189. Annual operational expenditure would also be required.

190. Both the capital and operational expenditure is unbudgeted.

191. Council may not have the capacity to debt-fund construction even if there is support from the Piha community for a targeted rate to meet all capital and operational costs.

Risks

192. This option would create a high financial risk to council. It would put other capital expenditure at risk.

193. There are high delivery risks associated with the implementation of this option. It is also dependent on the willingness of the Piha community for a targeted rate.

Option assessment: Build a tunnel to divert flood water

Effectiveness	Achievability	Environmental	Social	Cost
✓✓✓	XXX	XXX	✓✓	XXX

Effectiveness of the response

194. This option would divert flood waters in an extreme rainfall event. It would significantly decrease the flood safety risk to all Piha residents and visitors.

195. There would be an increased risk to people living near, or visiting, Whekatahi Creek.

Ability to be implemented

196. This option may be impractical to implement. Consenting will be extremely difficult. The physical works may be impossible due to volcanic rock.

Preserves the natural environment

197. This option would have a significant environmental impact. It would entail boring through the Waitākere Rages. Clearance of native bush would be also required.

Supports a resilient Piha community

198. Piha residents could stay in their properties and concerns about flood safety risks would be reduced.

199. The environmental impacts could be viewed negatively by the community.

Cost of this option

200. The costs of this option are high and likely to outweigh the benefits of flood risk mitigation.

201. These costs would largely be borne by landowners.

202. While there would be some public benefits from reducing the flood safety risk, the costs of this option may be preclusive.

Option 7: Widen the stream to increase water flows

203. Council could consider engineering works to widen and lower Piha Stream. This would allow floodwaters to quickly drain into the Tasman Sea.

204. This would be a discretionary activity with primarily public benefits.

205. Tonkin and Taylor considered two design models. They cover two and 10-year storm events.

206. Implementation requires the relocation and replacement of a number of built structures, including all public and private bridges, as outlined in Table 5 below.

207. Construction within the streambed and floodplain as well as sensitive receiving environments is complex. There is a risk that this option may not be effective.

Table 5: Stream widening options

Storm event	Implementation requirements
Two-year storm event	• Widen the top width of the channel from 18 to 21 metres upstream of Seaview Road bridge and downstream to 28 metres • Replacement of three vehicles bridges and nine pedestrian bridges • Relocation/replacement of two sheds (18 and 30-32 Glenesk Road) • Relocation/replacement of one tree house and one water tank (50 Glenesk Road).
10-year storm event	• Widen the top width of the channel from 24 to 36 metres upstream of Seaview Road bridge and downstream to 50 metres • Replacement of three vehicles bridges and nine pedestrian bridges • Reconstruction of the Piha Mill Camp driveway • Construction of 600 metres of retaining wall • Relocation/replacement of five sheds (18, 30-32 and 50 Glenesk Road) • Relocation/replacement of one tree house and one water tank (Glenesk Road) • Relocation/replacement of nine cabins, one tennis court, one building and one water tank at the camp ground.

Financial implications

208. The estimated capital cost to widen the stream to cope with a two-year storm event is between $22 and 25 million. The cost range increases to $31-36 million for a 10-year storm event. Some annual operational expenditure may be required.

209. Both the capital and operational expenditure is unbudgeted.

210. Council may not have the capacity to debt-fund construction even if there is support from the Piha community for a targeted rate to meet all capital and operational costs.

Risks

211. This option would create a high financial risk to council. It would put other capital expenditure at risk.

212. There are high delivery risks associated with this implementation of this option. It is also dependent on the willingness of the Piha community for a targeted rate.

Option assessment: Widen the stream

Effectiveness	Achievability	Environmental	Social	Cost
✓✓	XX	XX	✓✓	XXX

Effectiveness of the response

213. Stream widening and lowering the channel would provide a moderate decrease to the flood safety risk for all four ‘at risk’ groups.

214. This option would result in floodwaters being discharged more effectively and lower stream levels in an extreme rainfall event.

215. Increasing stream depth will alter water flows and increase water velocities in an extreme rainfall event. This increases the risk if someone, most likely a child, was to fall into the stream.

216. This option does not eliminate the risk for extreme rainfall events. There is a residual risk of extreme rainfall events that could exceed the capacity of the stream.

Ability to be implemented

217. Construction within the streambed and floodplain and sensitive receiving environments is complex. There is a risk that the desired outcome will not be achieved.

218. Implementation of this option requires removal of some existing structures. Landowners would need to agree to these works.

219. Consenting the works is likely to present some challenges, but these could be overcome if there is support from the community.

Preserves the natural environment

220. Both options would have a moderate environmental impact. This could be mitigated by planting.

221. Increasing water velocities could increase erosion downstream.

Supports a resilient Piha community

222. Residents could stay in their properties and concerns about flood safety risks would be reduced.

223. The environmental impacts could be viewed negatively by the community.

Cost of this option

224. The costs of this option are high. There would be public benefits from reducing the flood safety risk.

Option 8: Clear/dredge the stream from Seaview Road Bridge to the sea to increase water flows

225. Council could consider engineering works to increase the stream velocities of Piha Stream from Seaview Road Bridge through the lagoon area to the Tasman Sea.

226. This would be a discretionary activity with primarily public benefits.

227. This option would entail forming a larger and deeper stream channel through a combination of excavation and dredging. It would also involve removal of the sandbar and sediment build-up in the lagoon.

228. The works would cover approximately 800 metres. Tonkin and Taylor estimate that 12,000 metres^3 of soil, sediment and sand would need to be removed.

229. This option would require ongoing excavation and dredging to be effective. This could be required on an annual or more frequent basis.

230. Further modelling and study of sediment levels over time will be required if this option is supported.

Financial implications

231. The estimated initial costs of this option are $3.5-4.5 million. There would also be annual costs from ongoing excavation and dredging. These costs are unbudgeted.

Risks

232. There are low delivery risks associated with obtaining consents for the works. This could be overcome if there is support from the community.

Option assessment: Clear/dredge the stream

Effectiveness	Achievability	Environmental	Social	Cost
Slight change	X	X	✓✓	X

Effectiveness of the response

233. This option would lead to a small change in the flood safety risk, primarily for visitors to Piha.

234. Modelling by Tonkin and Taylor indicates that this option would help reduce stream flood levels between Seaview Bridge and the coastal marine area by 0.5 to 0.85 metres in a 10-year rainfall event.

235. It would have no discernible impact on flooding at the Piha Domain Campgrounds.

236. Tonkin and Taylor also notes that sandbar clearance would have a negligible effect to water levels upstream of Seaview Bridge.

237. This option will not reduce the volume and velocity of flood waters in an extreme rainfall event.

Ability to be implemented

238. Dredging has been previously undertaken in the Piha area.

239. This option would require ongoing maintenance. There is a risk that the desired outcome will not be achieved or maintained due to tidal, wave, wind and fluvial processes.

Preserves the natural environment

240. This option will have a low long-term impact on the environment.

241. Increasing water velocities could increase erosion in the coastal marine area.

Supports a resilient Piha community

242. If implemented in conjunction with option 7, Piha residents could stay in their properties and concerns about flood safety risks would be reduced.

243. This option would also help to flush contaminated water from the lagoon. Poor water quality from run-off and septic tanks is a long-standing community concern.

Costs of this option

244. The main public benefits would be from improvements in water quality. This is not the primary objective.

Appendix 1: Legislative framework

Act	Power to require residents to leave their home temporarily during a flood?	Power to require residents to leave their homes permanently due to the risk of a flood event?	Can the Council compulsorily acquire the land due to the significant flood risk?	Compensation required?
Building Act 2004	Yes, if Council is satisfied that the building is an 'insanitary building' in accordance with section 122(1)(a)(i) and section 124(2)(d) of the BA	Yes, if Council is satisfied that the building is an 'insanitary building'; section 122(1)(a)(i) and section 124(2)(a) and (b) allow the Council to put up a hoarding and attach a notice to warn people not to approach the building.	No, Council cannot compulsorily acquire land or buildings. The Council can force buildings which are 'insanitary buildings' to be made sanitary, which can include being partly or completely demolished or moved under sections 124(2)(c) and 126. The Council could also take action to fix insanitary conditions if 'immediately' required under section 129 of the BA.	No, unless the Council is sued in tort.
Resource Management Act 1991	Yes, under section 330(2) of the RMA the Council can enter onto any place (without prior notice) and can take action, or direct the occupier to take the action immediately necessary to mitigate any actual or likely adverse effect of an emergency, if the Council forms the reasonable opinion that an adverse effect on the environment requires immediate preventative or remedial measures or any sudden event causing or likely to cause loss of life, injury or serious damage to property will occur to a natural or physical resource within its jurisdiction.	Potentially, by issuing an abatement notice or seeking an enforcement order from the Environment Court under sections 17(3), 322(1)(a)(ii), 314(1)(a)(ii) or 314(1)(da) of the RMA. The most useful power is likely to be section 314(1)(da). In our view the use of these powers are not likely to be appropriate to require the permanent removal of residents due to the risk of flooding.	No.	Yes, if the Council takes emergency action under section 330(2) of the RMA it will be liable to compensate any people harmed by the actions or the occupiers of the land injuriously affected under section 331 of the RMA. Otherwise no, unless the Council is sued in tort.

Public Works Act 1981	No.	No.	Yes, although the Council would not be requiring the land due to the significant flood risk, but rather on the basis that it is required for a 'local work'. In order to use the land acquisition process in the PWA, the Council would need to positively use the land for the purpose of a local work (directly or indirectly).	Yes, in accordance with the Part 5 of the PWA.
Civil Defence Emergency Management Act 2002	Yes, under section 86, while a state of emergency is in force, a constable or Group Controller may direct the evacuation of any premises or place if, in their opinion, it is necessary for the preservation of human life. Section 90 also allows a constable or Group Controller to requisition land while a state of emergency is in force if it is necessary for the preservation of human life. Once that person was in control of the land, they could require any residents to leave the property.	No. These e	No, the land can only be requisitioned if it is necessary for the preservation of human life, and will only remain under the control of a constable or Group Controller while a state of emergency is in force.	Yes, if land is requisitioned under section 90, the Council will be liable to pay compensation to any person having an interest in that property in accordance with section 107.
Local Government Acts 1974, 2002 and Auckland Council 2009	No.	No.	Yes, in accordance with the PWA process. Note that the Council does have functions in relation to land drainage and storm water.	Yes, as per the PWA.

Appendix 2: Private property options

Site Address	Building Type	Flood Refuge within property (From 31/01/2019 T+T structural assessment report)	Surveyed Floor Level (m) (From survey results provided by Auckland Council)	TT Hydrology Flood Risk (From T+T flood risk assessment)			Required floor level	Subfloor Space (From 31/01/2019 T+T structural assessment report)	Structural Integrity note (From 31/01/2019 T+T structural assessment report)	Action
				2 year ARI level	10 year ARI level	100 year ARI level				
Art Gallery 21 Seaview Rd	Not habitable	No	4.57	4.52	5.11	5.68	10 year flood level trigger Required Floor Level: 6.18mRL	None. Slab on grade foundation.	Gallery building positively connected to concrete slab. Sheds are marginal for fixity in ground. Some damage may occur in flood	No action
6-8 Glenesk Rd House	Habitable	Yes – upstairs on second level.	6.78	6.41	7.13	8.13	10 year flood level trigger Required Floor Level: 8.63mRL	Driven piles embedded supposedly 1.2m into natural ground.	Robust cantilevered piles embedded at reasonable depth. May incur some damage to structure in flood event.	No action
10-12 Glenesk Rd Lower house (north side of stream) – unknown address	Habitable	Yes – refuge in the attic space within upper level.	7.3	-	7.28	7.89	10 year flood level trigger Required Floor Level: 8.39RL	Low subfloor space (<300mm).	Appears to be robust.	No action
14 Glenesk Rd House	Habitable	No	7.35	7.18	7.62	8.26	10 year flood level trigger Required Floor Level: 8.76mRL	Well braced piles with reported minimum pile embedment of 450mm. Central area supported by masonry block foundation wall.	Good – likely to withstand flood event pressures, well braced foundation.	Raise – 1.41m

Site Address	Building Type	Flood Refuge within property (From 31/01/2019 T+T structural assessment report)	Surveyed Floor Level (m) (From survey results provided by Auckland Council)	TT Hydrology Flood Risk (From T+T flood risk assessment)			Required floor level	Subfloor Space (From 31/01/2019 T+T structural assessment report)	Structural Integrity note (From 31/01/2019 T+T structural assessment report)	Action
				2 year ARI level	10 year ARI level	100 year ARI level				
								Southern side of house on concrete footings.		
18 Glenesk Rd (viewed from stream bank only)	Habitable	N.A.	Floor level above 100year ARI from site inspection	7.07	7.80	8.56	No trigger	N.A.	Bank alongside stream, supporting dwelling and deck above, has eroded and poses a potential ground slip hazard and risk of undermining structure.	No action
20 Glenesk Rd Dwelling	Habitable	No	7.21	6.97	7.77	8.48	10 yr trigger Required FFL – 8.98	Braced piles, 300mm embedment.	House uninhabited. Water damage was visible to bottom of internal linings of dwelling.	Raise – 1.77m and upgrade or replace pedestrian bridge
20 Glenesk Rd Garage	Not habitable	No	6.97	7.00	7.64	8.35	10 yr trigger Required FFL – 8.85	Braced timber piles – reported embedment of 450mm.		No action
24 Glenesk Rd House	Habitable	Yes – on second level.	7.14	7.03	7.78	8.47	10 yr trigger Required FFL – 8.97	Low subfloor space ~300mm.	Some concern regarding stability of original foundations and potential undermining of the house piles from river scour. Deck and unconsented bridge were connected behind property. Flood damage to bridge may	No action

Site Address	Building Type	Flood Refuge within property (From 31/01/2019 T+T structural assessment report)	Surveyed Floor Level (m) (From survey results provided by Auckland Council)	TT Hydrology Flood Risk (From T+T flood risk assessment)			Required floor level	Subfloor Space (From 31/01/2019 T+T structural assessment report)	Structural Integrity note (From 31/01/2019 T+T structural assessment report)	Action
				2 year ARI level	10 year ARI level	100 year ARI level				
									destabilise deck which is attached to house.	
26 Glenesk Rd House	Habitable	Yes – on second level	7.76	7.18	7.92	8.57	10 yr trigger Required FFL – 9.07	Original – N.A. Extension – appears to be on internal piles	Robust original concrete structure but some damage likely to extension under extreme flood.	No action
26 Glenesk Rd Sleep-out [on north side of stream]	Habitable	Yes on upper floor/attic	Not available – assumed level of 7.4	7.22	7.89	8.54	10 yr trigger Required FFL – 9.04	Low subfloor space.		No action
45-47 Glenesk Rd	Habitable	Yes – on second and third levels.	7.23	6.91	7.71	8.39	10 yr trigger Required FFL – 9.89	Low subfloor space below dwelling.	Good – dwelling is suitably rigid.	No action
50 Glenesk Rd House 1	Habitable	Yes – on upper level.	9.19	8.87	9.01	9.38	No trigger	N.A.	Building appears well founded on piles and slab at grade and unlikely to be destabilised	No action
50 Glenesk Rd House 2	Habitable	No	9.18	8.49	8.80	9.23	No trigger	Low subfloor space. Piles on perimeter are embedded. Internal piles rest on concrete blocks.	May incur some scour damage to piles.	No action

Site Address	Building Type	Flood Refuge within property (From 31/01/2019 T+T structural assessment report)	Surveyed Floor Level (m) (From survey results provided by Auckland Council)	TT Hydrology Flood Risk (From T+T flood risk assessment)			Required floor level	Subfloor Space (From 31/01/2019 T+T structural assessment report)	Structural Integrity note (From 31/01/2019 T+T structural assessment report)	Action
				2 year ARI level	10 year ARI level	100 year ARI level				
50 Glenesk Rd House 3 (Storage)	Habitable	No	8.92	8.46	8.77	9.19	No trigger	Piles are embedded.	Some structural damage likely to occur from caravan movement in flood event.	No action
50 Glenesk Rd House 4	Habitable	No	8.7 (No survey – assumed FL)	8.53	9.89	9.23	10 yr trigger Required FFL – 9.73	Piles are embedded into ground.		Raise by 0.63m
50 Glenesk Rd Several Caravans	Habitable – not a permanent structure	No	N.A.	N.A.	N.A.	N.A.	No trigger	N.A.	Several caravans noted onsite – all are at risk of being destabilised in a flood event.	No action
52 Glenesk Rd	Habitable	No	8.8 (No survey – assumed FL)	8.93	9.10	9.39	2 yr trigger Required FFL – 9.89	N.A.	Structure vulnerable to flood/wash out. Poor construction.	Raise by 1.09m
91 Glenesk Rd	Habitable	No – for unit at rear Yes – upper storey for addition at front of dwelling	9.67	8.54	8.92	9.32	No trigger	Low subfloor space below dwelling (max height ~600mm).	Good. Dwelling appears rigid.	No action
41 Glenesk Rd	Habitable	Yes – upper storey	7.22	-	7.62	8.24	10 yr trigger Required FFL – 8.74	Building was outside of structural assessment scope	Building was outside of structural assessment scope, structural integrity of upper storey should be assessed to confirm safe refuge.	No action

Site Address	Building Type	Flood Refuge within property (From 31/01/2019 T+T structural assessment report)	Surveyed Floor Level (m) (From survey results provided by Auckland Council)	TT Hydrology Flood Risk (From T+T flood risk assessment)			Required floor level	Subfloor Space (From 31/01/2019 T+T structural assessment report)	Structural Integrity note (From 31/01/2019 T+T structural assessment report)	Action
				2 year ARI level	10 year ARI level	100 year ARI level				
64 Glenesk Rd	Habitable	Yes – upper storey	10.95	-	11.08	11.49	10 yr trigger Required FFL – 11.99	Building was outside of structural assessment scope	Building was outside of structural assessment scope, structural integrity of upper storey should be assessed to confirm safe refuge.	No action

Appendix 3: Insanitary and dangerous buildings

Buildings	Dangerous buildings criteria			Insanitary buildings criteria			Recommendations
	Building is dangerous already	Building is likely to be dangerous in a 2 year ARI flood event	People are likely to be injured or killed during evacuation in a 2 year ARI flood event	Building is in a state of disrepair already	Building is likely to be flooded above floor level in a 2 year ARI flood event	People are likely to be injured or killed during evacuation in a 2 year ARI flood event	
14 Glenesk Road dwelling	NA	NA	NA	Water through house during 28 April flood. Photographic evidence.	NA	NA	An internal inspection of the dwelling is necessary to assess the insanitary condition. If found insanitary, then an insanitary building notice may be used to require repair to the buildings. However, this may not be necessary, as the building is not in use due to the flood risk uncertainty and current consideration of flood management.
18 Glenesk Road dwelling	NA	T+T structural assessment has identified that the stream bank has eroded and subject to ground slip and is potentially undermining the deck and dwelling. Therefore the deck and house are likely to dangerous in flood events. Refer appendix D.	NA	NA	NA	NA	We consider the subject building is likely to be dangerous in the event of a flood. We recommend an engineering assessment of the foundations and that these are to be made secure as identified by that assessment.
18 Glenesk Road bridge	T+T structural assessment has identified that the timber footbridge with concrete piers	NA	NA	NA	NA	NA	We consider the subject bridge is likely to be dangerous in the event of a flood. We recommend an engineering assessment of the bridge and that it be made good as identified by that assessment.

Buildings	Dangerous buildings criteria			Insanitary buildings criteria			Recommendations
	Building is dangerous already	Building is likely to be dangerous in a 2 year ARI flood event	People are likely to be injured or killed during evacuation in a 2 year ARI flood event	Building is in a state of disrepair already	Building is likely to be flooded above floor level in a 2 year ARI flood event	People are likely to be injured or killed during evacuation in a 2 year ARI flood event	
	is unsafe and structurally unsound and should not be used. Refer appendix D.						
20 Glenesk Road dwelling	NA	NA	NA	Water through house during 28 April flood. Refer T+T structural assessment (Appendix D).	NA	NA	An internal inspection of the dwelling is necessary to assess the insanitary condition. If found insanitary, then an insanitary building notice may be used to require repair to the buildings. However, this may not be necessary, as the building is not in use due to the flood risk uncertainty and current consideration of flood management.
24 Glenesk Road dwelling		T+T structural assessment has identified concerns regarding the stability of the foundations and potential undermining of the house piles from river scour. Also flood damage to bridge may destabilise deck which is attached to the house. Therefore the deck and house are likely to be dangerous in		Water through house during 3 February flood.			We consider the subject bridge is likely to be dangerous in the event of a flood. We recommend an engineering assessment of the foundations and that these are to be made secure as identified by that assessment. An internal inspection of the dwelling is necessary to assess the insanitary condition. If found insanitary, then an insanitary building notice may be used to require repair to the buildings. However, this may not be necessary, as the building is not in use due to the flood risk uncertainty and current consideration of flood management.

Buildings	Dangerous buildings criteria			Insanitary buildings criteria			Recommendations
	Building is dangerous already	Building is likely to be dangerous in a 2 year ARI flood event	People are likely to be injured or killed during evacuation in a 2 year ARI flood event	Building is in a state of disrepair already	Building is likely to be flooded above floor level in a 2 year ARI flood event	People are likely to be injured or killed during evacuation in a 2 year ARI flood event	
		flood events. Refer appendix D.					
52 Glenesk Road dwelling	NA	NA, DV~0.5m^2/s	NA, DV~0.5m^2/s	NA	Flood predictions show that the building floor level is below the 2 year ARI flood level. Refer to Figure A13.	NA, DV~0.5m^2/s	The building may be considered as insanitary on the basis of being in the 2 year ARI floodplain. However, the current consideration of flood management may influence decisions about this building.