REPORT

Northland Regional Council

Awanui Flood Scheme
Preliminary Design

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

REPORT

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Awanui Flood Scheme Preliminary Design

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Executive summary

In April 2013 Tonkin & Taylor (T&T) was appointed by Northland Regional Council (NRC) to develop a preliminary design for the Awanui Flood Scheme Upgrade. The objectives of the Upgrade were that it:

1. Improves the scheme to protect urban Kaitaia from river flooding to a design standard that is equivalent to a 1% Annual Exceedance Probability (AEP), with an allowance for climate change (based on peak flows) and an appropriate level of freeboard
2. Improves safety of river banks against slope failure (i.e. improves stability of river banks and associated stopbanks).

A 1% AEP design flood hydrograph for the Preliminary Design was developed following consideration of a range of hydrological studies. The hydrograph is based on a peak flow of 400 m^3/s and a temporal profile established by NIWA (2005).

A precautionary approach was taken for the design flood hydrograph. This is appropriate due to some uncertainty relating to the bifurcation of Awanui River flood flows into the Tarawhataroa at State Highway 1 upstream of Kaitaia, and the range in peak flow estimates from earlier studies.

Design flood levels were determined using a simplified version of a MIKE-FLOOD Awanui catchment model developed earlier by GHD (2012). Changes were made to the model to ensure its appropriateness as a design tool. These included revised hydrology, changes in extents, and amended cross sections.

The design philosophy adopted for the project is as follows:

i. To contain flood flows within Awanui River channel in urban Kaitaia up to a 1% AEP flood level with a 500mm of freeboard
ii. To make more frequent use of the Whangatane Spillway for conveying flood flows
iii. To prevent overtopping of the Whangatane Spillway left bank in a 1% AEP flood with an allowance for freeboard
iv. To improve stability of river banks and associated stopbanks.

A number of project risks have been identified, which will require further consideration during Detailed Design. In particular, there are data uncertainties relating to LiDAR survey data and therefore the required ground level raising for the Preliminary Design may have been underestimated. The construction cost estimate provided in the Price Schedule allows for some uncertainty relating to cut and fill volumes, but does not make allowance for changes in design approach that may be required.

In order to address existing bank stability issues, the Preliminary Design incorporates a rock revetment to increase slope stability and provide toe protection. This will reduce operational expenditure, however, it comes with a high capital expense. Alternative solutions may decrease capital expense but will increase the operational expenses. Opportunities to optimise the slope stability requirements within constrained operational and capital budgets shuld be further investigated during Detailed Design.

The cost estimate to consent, design, construct and project manage the works identified in the Preliminary Design is $18.5 million, reducing to $7.05 million if the slope stability works are not incorporated.

1 Introduction

Tonkin & Taylor (T&T) was appointed by Northland Regional Council (NRC) to develop a preliminary design for the Awanui Flood Scheme Upgrade in April 2013.

The primary objectives for the Awanui Flood Scheme Upgrade, as set out in NRC's Request for Proposal (March, 2013) are as follows:

- Improve the design standard of the flood scheme to protect urban Kaitaia from river flooding to a design standard that is equivalent to a 1% Annual Exceedance Probability (AEP) with an allowance for climate change (based on peak flows) and an appropriate level of freeboard
- Improve safety of river banks against slope failure (improve stability) of river banks and associated stopbanks.

This report represents the Preliminary Design report for the proposed upgrade of the Awanui Flood Scheme.

2 Design parameters

The design inputs parameters for the Preliminary Design have been developed from the following information, which is discussed further in this section:

i. Topographic information
ii. Design flood flow hydrograph
iii. Design flood levels
iv. Geotechnical investigation and site walkover.

2.1 Topographic information

Topographic data were available from three main sources:

i. LiDAR
ii. Cato Bolam cross section survey (2010)
iii. Cato Bolam top of stopbank survey (2010).

The Cato Bolam cross section survey (2010) was used, where available, to develop the cross sections in the open channel model. It was also used to assist with determining locations where channel widening works and/or slope stability works were required.

The LiDAR data were used to determine the existing ground topography in the floodplain and the extents of the stopbanks. This information was used to:

i. Identify required changes in ground level due to:
   - Stopbank raising
   - Spillway excavation
ii. Identify the increase in extents of the stopbanks caused by raising
iii. Determine the cut and fill volumes for stopbank raising
iv. Determine appropriate design for slope stability works.

The Cato Bolam cross section survey and top of bank survey were not sufficiently extensive to support volume calculations. For example, the survey data may indicate the top of bank level and location, but the side slopes and surrounding ground level may not be available. Therefore it was not possible to determine the volume of material needed to increase the height of the stopbank. The volume of material that was required for cut or fill volumes is an essential parameter to estimate the likely cost of the works.

The Cato Bolam (2010) top of bank survey was used to identify uncertainty in ground levels from the LiDAR data.

2.1.1 Topographic data – confidence limits

There is high confidence in survey obtained through registered surveyors (Cato Bolam, 2010). The Cato Bolam top of bank survey was therefore used to identify uncertainty in ground levels from the LiDAR data. As discussed in the previous sub-section, the LiDAR data were an essential input parameter for many of the projects objectives.

Figure 2-1 compares the ground levels from the Cato Bolam top of stopbank survey with the LiDAR levels at the same location.

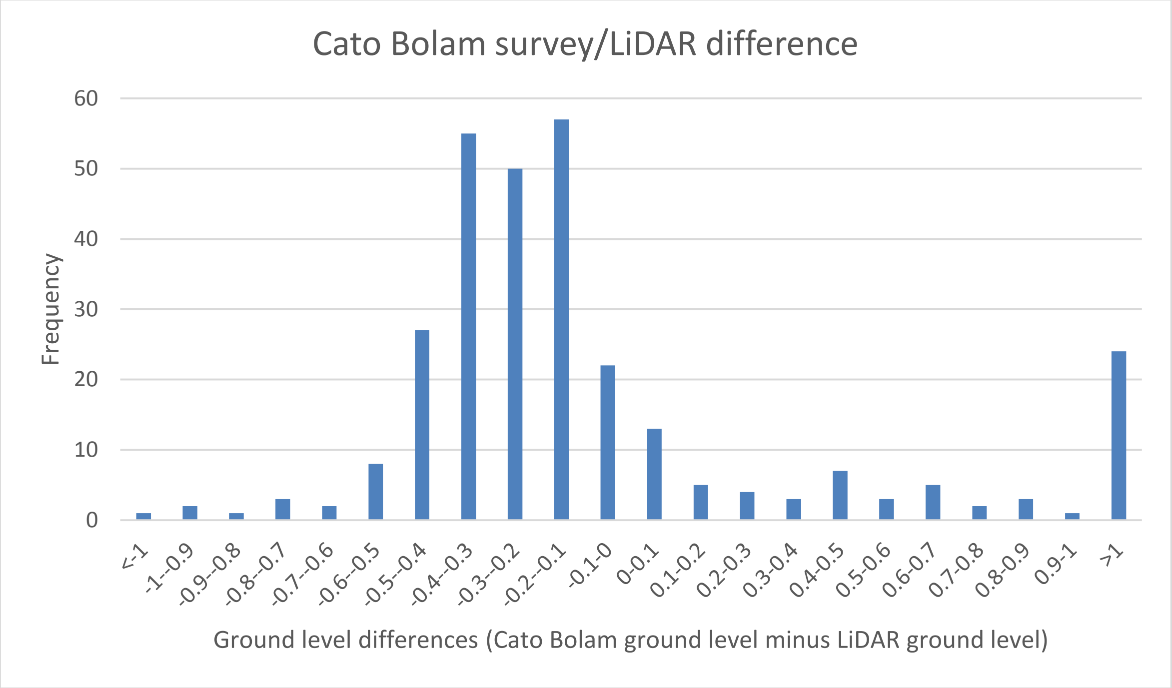

Figure 2-1 Top of bank level difference

Due to inconsistencies between surveyed levels and LiDAR levels, there is uncertainty and lower confidence in the accuracy of the LiDAR data. Allowances for this uncertainty have been made in the contingency included in the cost estimate included in this report. It is strongly recommended that a more detailed terrain survey is carried out for the Detailed Design.

The implications of the survey data uncertainty are discussed as relevant throughout this report.

2.2 Flood hydrograph

The peak 1% AEP flows in the Awanui River upstream of the overflow across State Highway 1 have been assessed using a variety of different methodologies and techniques. The various peak flows derived by different methods are presented in Table 2-1. The rationale for assessing the different flow methods is provided in Appendix A, and analysis of rain gauge data is provided in Appendix B[1].

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[1] The content of the two appendices was provided to NRC in an unpublished memo in October 2013. It was used to agree on the design parameters for the Preliminary Design of the Awanui Flood Scheme.

Table 2-1 Awanui River upstream of State Highway 1 overflow – summary of 1% AEP peak flood flows

Method	Estimated peak discharge (m^3/s)	
	Lower	Upper
Frequency analysis	380	440
Catchment model (GHD, 2013)		882
Rational method	270	312
Clark Unit Hydrograph	295	328
McKerchar & Pearson 1989	360	380
TM61	350	390
NIWA 2005		368

In accordance with the primary objectives of the Awanui Flood Scheme, the comparison of flood frequency analysis and model results is based on 1% AEP flows excluding any allowances for climate change.

Based on the hydrological analyses shown in Appendix A, the 1% AEP flood flows from the GHD catchment model were neglected because they are approximately double the peak flows that were determined using different flow estimates.

Together with input from NRC, a review of the analyses was carried out. The results of the discussions was that 400 m^3/s was adopted as the peak flow for the design of the Awanui Flood Scheme.

The NIWA (2005) design hydrograph was adopted for the temporal flow profile of the design event. The NIWA hydrograph was scaled by 8.1% to match the adopted peak flow of 400 m^3/s. Figure 2-2 presents the adopted Awanui Flood Scheme design hydrograph.

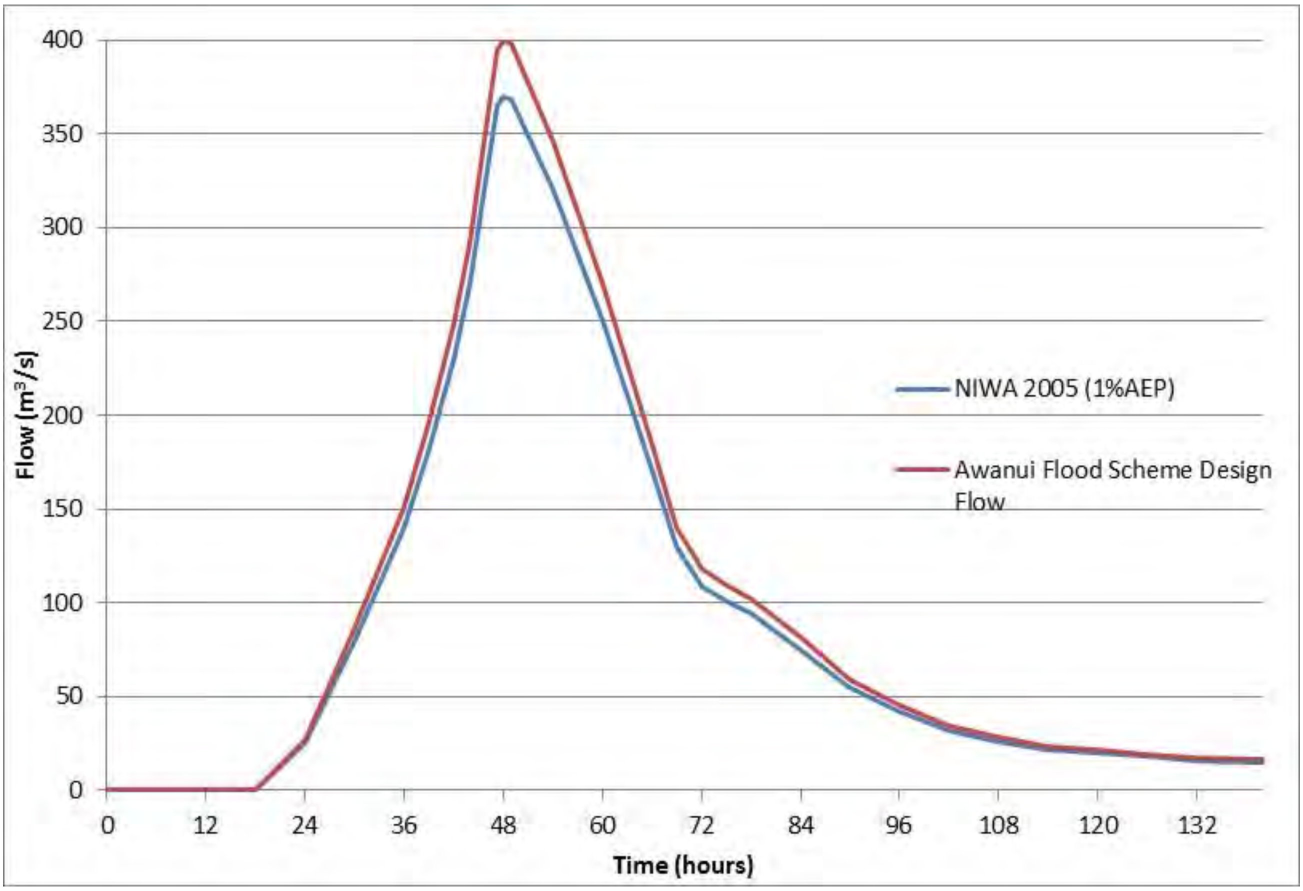

Figure 2-2 Awanui Flood Scheme – 1% AEP design hydrograph

2.2.1 Flood hydrograph – confidence limits

A precautionary approach for the design flood hydrograph has been applied for the Preliminary Design of the Awanui Flood Scheme. The adopted peak flow estimate is well founded based on application of a number of methods, and is considered to be on the upper side of the range of credible flows. By applying the NIWA hydrograph to the peak flow estimate, it is considered that there is also a conservative estimate of flood volume given that significant historical flood events have been typically shorter in duration.

The overflow of flood flows from the Awanui River across State Highway 1 and into the Tarawhataroa stream are included in the model. However there is a general acceptance that the model results (GHD catchment model and T&T revised model) do not compare well with observed flood flows. It is uncertain whether the inaccuracies relate to the rating curves in the Tarawahatroa, observed levels or the model results. The T&T revised model under-predicts diverted flood flows to the Tarawhataroa in comparison with observations, therefore the flood flows passing downstream in the Awanui may be conservatively overestimated.

2.3 Flood levels

The flood levels were modelled using a model developed from the existing MIKE-FLOOD Awanui catchment model (GHD, 2012).

The design objective was to determine peak 1% AEP flood levels from the State Highway 1 overflow to Waikuriki Bridge and down the Whangatane Spillway. The design concept was to contain all flood flows within the stopbanks along the Scheme.

The following changes were made to the GHD Awanui catchment model to ensure that the model was an appropriate design tool for the Awanui Flood Scheme Upgrade design:

1. The catchment hydrology was replaced using the design hydrograph identified in Section 2.1.
2. The model extent was modified:
    a. The 2D model extent were significantly reduced to represent only the area around the overflow to the Tarawhataroa. The 2D extent is shown in Figure 2-2.
    b. The 1D model extent was reduced to represent the Awanui River from approximately 1 km upstream of the Tarawatatora overflow to Waikuriki Bridge which is the State Highway 1 Bridge downstream from the bifurcation to the Whangatane Spillway. The rating curve at Waikuriki Bridge was used as the downstream model boundary[2]. The Whangatane Spillway was represented all the way to the coast.
3. The open channel section of the model was represented using only the 1D model to the top of stopbanks. This required modification of the cross sections based on surveyed data from Cato Bolam (2010).

    It was appropriate to use only the 1D model to represent the open channels since a design objective was to contain flood flows within the channel stopbanks. Therefore the 2D model extents were not required to represent the area of interest. It is important to note that the model may not be suitable for assessing areas outside of this project's area of interest, or for other reasons beyond the purposes for which it was created.
4. Additional cross sections in the Whangatane Spillway based on LiDAR survey data.

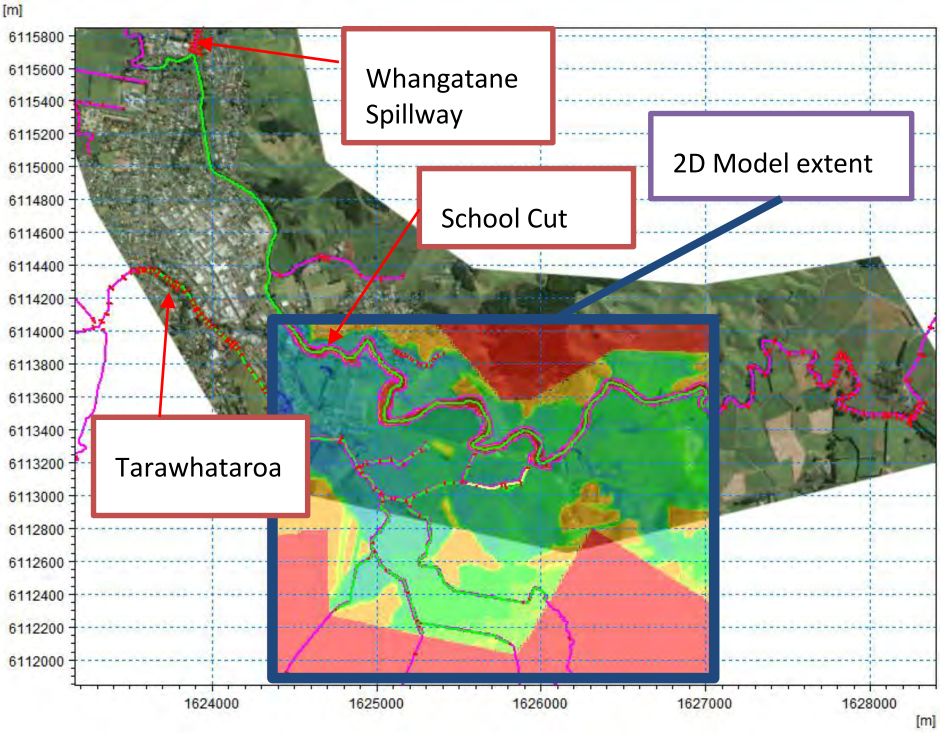

Figure 2-3 2D model extent for design tool

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[2] The rating curve was established in 1990 based on gaugings taken between 1959 and 1990 for flows up to 110 m^3/s. The confidence limits in the rating curve appears to be ±10% at higher flows (or ±10 m^3/s in absolute terms). This is based on a comparison between individual flow gauge records and the fitted rating curve.

The model was used to determine peak 1% AEP flood levels in the Awanui River and to determine appropriate stopbank levels.

2.3.1 Flood level – confidence limits

Confidence in the flood levels are based on the confidence limits in the flood hydrology (see section 2.1) and the flood hydraulics. The flood hydraulics are largely controlled by the model schemetisation, topographic survey information and model parameters.

The model schematisation is appropriate for a design objective that keeps 1% AEP flood flows within stopbanks. The model schematisation may need to be changed for scenarios that allow for overtopping of stopbanks.

The 1D elements of the model were represented using channel cross sections that were typically generated from Cato Bolam survey data extending from the river invert level to the top of bank (or top of stopbank where appropriate). In some areas only the stopbank survey information was available (i.e. no channel cross section) and the channel sections were determined from interpolation between upstream and downstream cross sections.

In contrast with the general rule that cross sections were used to represent the channel cross section, LiDAR data was used in the Whangatane Spillway to supplement the cross section data, despite the concerns regarding the quality of the LiDAR data (refer Section 2.1).

In order to allay concerns relating to the use of LiDAR generated cross sections in the Whangatane Spillway upstream from Donald Road Bridge, a sensitivity assessment was carried out to ensure that the Preliminary Design was appropriate in the range for the range of invert elevations.

Since the public meetings conducted by NRC, some changes have been incorporated in the design, but not modelled. Thus the flood levels shown on the Preliminary Design Drawings may reduce in the following areas:

1. Between Whangatane Spillway and Donald Road Bridge. The channel invert level in this area has been reduced and widened from what was originally included in the model. This will increase the available cross sectional area and therefore the changes will not increase flood levels and may lead to a small reduction for more frequent flood events. We do not expect to see a noticeable change in flood level for the 1% AEP design storm since the flows are tailwater level controlled and the hydraulic gradient is likely to remain similar to what is represented in the model.
2. Area adjacent to A&P Showgrounds. The hydraulic model includes stopbanks along the true right bank adjacent to the A&P Showgrounds which have been removed from the Preliminary Design. The stopbanks were removed from the Preliminary Design following NRC and public feedback that the floodplain on the true right bank did not need protecting. We do not expect to see a noticeable change in flood level for the 1% AEP design storm since the flows are tailwater level controlled and the hydraulic gradient is likely to remain similar to what is represented in the model

However these scenarios were not reassessed with the model because the water levels may not reduce or only reduce by a small amount for the 1% AEP design storm. However we are confident that the water levels will not increase.

Overall we consider that the MIKE-FLOOD model results are appropriate as a basis for Preliminary Design purposes.

2.4 Site visit and geotechnical investigations

T&T geotechnical staff visited the Awanui Flood Scheme area on two occasions as part of the Preliminary Design investigations. An initial site visit was in July 2013, and the second visit was after the initial Preliminary Design concept was developed, in May 2014.

The first visit identified borehole locations for investigation, and carried out a general inspection of channels and stopbanks with NRC staff (Neville Wilson and Ron Fenwick). The observations for four different reaches of the Scheme are provided in Appendix C.

The overall conclusion was that there are variable conditions along the length of the Awanui Scheme. In the urban areas of Kaitaia, there are space constraints with limited access for maintenance works, and which will restrict access and space for upgrading of existing stopbanks.

Also in the urban areas, there are widespread bank stability issues readily observed through localised bank slumping and landslips. It was noted that the local soils profile consists generally of sedimentary clays over softer marine deposits. This has implications if excavating through the top layer and for stability of the exposed slope. Past maintenance works have probably exposed this layer and led to some of the existing bank stability issues.

The second site visit (May 2014) was carried out for the purposes of checking and amending as necessary the initial Preliminary Design concept. Feedback from the site visit was incorporated into the final Preliminary Design and cost estimate prepared for NRC.

Thirty boreholes were investigated by hand auger to provide data for the geotechnical design. The locations of the boreholes and the logs are included in Appendix C.

3 Design

The Preliminary Design has been developed to meet the primary objectives of the Awanui Flood Scheme Upgrade. The design is shown on the Preliminary Design Drawings that are issued with this report.

The design philosophy for the project, discussed further in this section, is as follows:

v. To contain flood flows within Awanui River channel in urban Kaitaia to a 1% AEP flood level with a 500mm of freeboard

vi. To make more frequent use of the Whangatane Spillway for conveying flood flows

vii. To prevent overtopping of the Whangatane Spillway left bank in a 1% AEP flood with an allowance for freeboard

viii. To improve stability of river banks and associated stopbanks.

Areas outside of urban Kaitaia are also discussed below.

3.1 Urban Kaitaia flood protection

The Scheme Upgrade has been designed to contain 1% AEP flood flows through urban Kaitaia within the river channel, by increasing channel capacity in three ways:

1. Channel widening
2. Adding spillways within the flood channel
3. Raising stopbanks.

There is only limited opportunity to increase the channel width of the river in the urban area because the widened channel would encroach on neighbouring private properties. However, there are some areas (identified on the Preliminary Design Drawings) where channel widening is feasible and has been adopted as part of the design, although this has typically been carried out as a measure to improve bank stability rather than for increased channel capacity (refer Section 3.4). The increase in channel width in these areas may reduce flood levels for more frequent events[3], although model results indicate that increased channel width does not have a significant impact on reducing 1% AEP flood levels.

There are six new spillways within the flood channel proposed for the Preliminary Design, which were identified in the Haigh Workman Concept Design report for the Awanui Flood Scheme (2012). The spillways increase the flood channel capacity of the Awanui River by providing additional cross section area and reducing hydraulic head losses by straightening the channel. This has the impact of increasing conveyance and reducing velocity around the channel bends adjacent to State Highway 1. Note that the slope stability issues associated with the bends adjacent to State Highway 1 are beyond the scope of this work. Options to stabilise the river adjacent banks adjacent to State Highway 1 could be considered as part of the Detailed Design.

Raising existing stopbanks and constructing additional stopbanks through urban Kaitaia also increases the channel capacity of the Awanui River. It is proposed to raise the stopbanks to provide 500 mm freeboard above the 1% AEP design flood levels.

The typical cross section for stopbank raising and the extent of works are shown on the Preliminary Design Drawings. Where the stopbank can be raised using earthfill alone, the typical cross section incorporates a 3 m wide crest and 2:1 (horizontal : vertical) side slopes. There are

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[3] Reducing flood levels for more frequent events than a 1% AEP is not a project objective, but is included as a secondary benefit.

areas where the increase in stopbank height and extents will require works on private property, as shown on the drawings. There are a number of areas where the increase in stopbank extents was considered unsatisfactory due to the impact on private land. A mass block wall approach has been adopted in these areas to reduce the land required, and a typical section is included in the drawings. Alternative typical sections for mass block or key stone wall options are shown in the drawings and can be considered further during Detailed Design.

The topographic data uncertainties discussed earlier in this report present a project risk for areas where the required ground level increases for the design may have been underestimated, so that a change in stopbank raising approach may be required. For example, if stopbank raising needs to change from earthfill to mass block wall then there will be additional design and construction costs. The cost estimate contingency includes for changes in cut and fill volumes, but does not make allowance for changes in design approach.

There is an active landslip located on the true right bank at the sharp left bend located near to Rongopai Place (Awanui River chainage 9570 m) which will require specific consideration during Detailed Design. Bank stabilisation works in this area have been excluded from the Preliminary Design in agreement with NRC.

Specific features of the Preliminary Design to note:

1. It has been agreed, following NRC and public feedback that the reserve area adjacent to the A&P Showgrounds on the true right bank can be allowed to flood and therefore does not need flood protection.
2. Three stopbank alignment options were presented to NRC around Remembrance Park. The options either provide flood protection to the park without providing flood storage for the wider community; or provide no flood protection to the park but increase the flood storage benefits to the wider community. An option that allows Remembrance Park to flood was selected as the preferred option. The frequency of flooding has not been evaluated, but would be expected to be similar to the current scenario.
3. Model results indicate that there are no bridges in the Awanui River that overtop during the 1% AEP design storm[4]. However, the freeboard allowance that has been allowed for elsewhere in the design (i.e. stopbanks) has not been applied to bridge soffit and access roads. Bridge access road levels may be lower than the adjacent stopbanks. The risks and potential mitigation options associated with this should be investigated further during Detailed Design.
4. Where ground levels/stopbanks are to be increased in elevation, care should be taken during Detailed Design to ensure that stormwater drainage can still pass to the Awanui River. This may require flap gates to be incorporated on existing outfalls.[5]

By increasing the conveyance capacity of the Awanui River, we expect the channel capacity to increase to approximately 375 m^3/s, downstream of School Cut Creek.[6] The 375 m^3/s is the modelled peak flows in the Awanui River downstream of the State Highway 1 overflow (noting that this is likely to be conservative, based on comments made in Section 2.2.1).

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[4] Does not include Donald Road Bridge in the Whangatane Spillway.

[5] The stormwater drainage information provided by Far North District Council was not suitable for design purposes. Further information will be required for Detailed Design.

[6] The model was not developed to assess the existing channel capacity, although our estimate would be that the capacity of the existing channel is likely to be in the order of 300-330 m^3/s.

3.2 Whangatane Spillway flood flows

The invert level of the Whangatane Spillway overflow channel controls the bifurcation of river flows between the Lower Awanui River and the Whangatane Spillway channels.

Currently the channel invert level has an approximate elevation of 10.9 m. Anecdotal information suggests that there may be a hard wooden “weir” structure submerged beneath the vegetation, however, no evidence of this was observed during the site visits. A photograph of the area is shown in Figure 3-1.

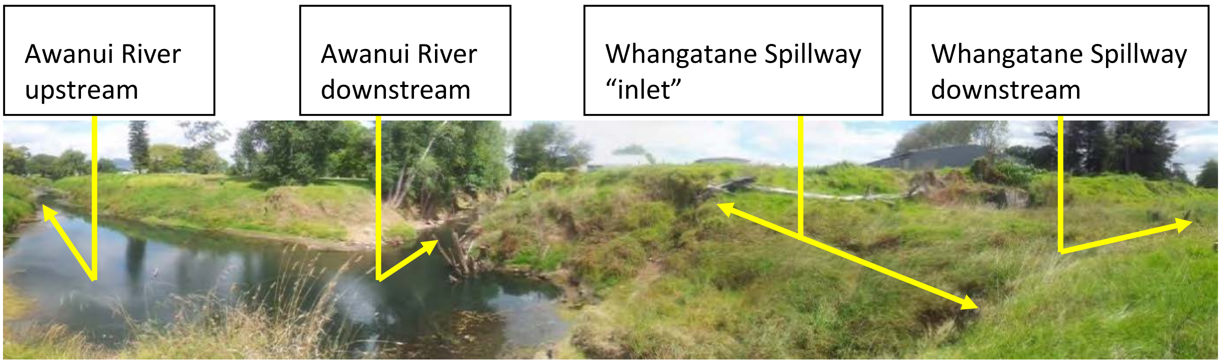

Figure 3-1 Photograph of Whangatane Spillway overflow channel and Awanui River

The concept to lower the Whangatane Spillway to pass flood flows earlier in the event was developed for the following reasons:

1. The Whangatane Spillway is more “efficient” at passing flood flows away from the urban centre than the Lower Awanui River channel (i.e. it has greater channel capacity).
2. To make more frequent use of the Whangatane Spillway
3. To reduce flood flows and flood extents in the Lower Awanui River
4. To pass increased flood volume down the Whangatane Spillway.

It is noted that lowering the level of the Whangatane Spillway inlet may cause an increase in flood risk down the Whangatane Spillway channel.

NRC has indicated a preference for flood flows to start flowing to the Whangatane Spillway when flows in the Awanui exceed approximately 20 m^3/s. Although the specific frequency of flows exceeding 20 m^3/s has not been assessed as part of this study, we note that the lowest annual maximum flow recorded at School Cut flow gauge since 1958 was 54 m^3/s (in 1983). Therefore, it can be expected that river flows would exceed 20 m^3/s several times every year.

To direct flows into the Whangatane Spillway when river flows exceed 20 m^3/s, a modified inlet weir is proposed at 10.25 m RL (Unahi datum). This level is based on a flow versus elevation relationship in the Awanui River immediately upstream of the bifurcation determined from the hydraulic model results.

The Preliminary Design for the Whangatane Spillway inlet is shown in the Preliminary Design Drawings and incorporates the following features:

- An inlet weir set at 10.25 m RL
- Gabion basket slope protection for
  - The upstream face
  - The side slopes

  - Inlet weir crest
- Lowering the Whangatane Spillway channel invert between the inlet weir and Donald Road, to approximately 9 m RL on the downstream end of the weir structure, and to approximately 8 m near the Donald Road Bridge
- Erosion protection for the slope from the inlet weir to the new channel invert level.

We note that NRC has had some poor experiences with gabion basket protection, and therefore alternative options such as mass block walls, concrete and rock should be considered in Detailed Design.

Lowering the channel on the downstream side of the inlet weir will help to reduce flood levels in the Whangatane Spillway during more frequent events, by reducing downstream water levels. However, the hydraulic grade line will not change significantly during 1% AEP flood flows, therefore 1% AEP flood levels will be similar to the existing situation.

Current (i.e. existing) peak flows passing into the Whangatane Spillway during a 1% AEP design storm event would be approximately 226 m^3/s. As a result of lowering the spillway inlet and increasing the upstream channel conveyance, bifurcation flows are likely to increase to approximately 256 m^3/s. Approximately 10 m^3/s (of the 30 m^3/s increase) is due to increased channel conveyance upstream in the Awanui River and 20 m^3/s is due to lowering the channel inlet.

3.3 Overtopping of the Whangatane Spillway left bank

Increasing 1% AEP flood flows in the Whangatane Spillway results in greater flood risk to properties located within the existing flood extents when the Whangatane Spillway stopbanks overtop. In particular, there are a large number of buildings identified in the floodplain adjacent to the true left bank of the Whangatane Spillway.

The Preliminary Design includes stopbank measures to protect buildings and property on the true left bank from the increased flood flows passing along the Whangatane Spillway.

In agreement with NRC, options to provide similar protection for buildings and property on the right bank were not developed further at this stage because the benefits of protection were considered likely to be small in comparison with the estimated costs. Measures to manage the additional flood risk, particularly to a small number of buildings located adjacent to the true right bank, should be considered further as part of the Detailed Design.

The Preliminary Design Drawings indicate the extent of stopbank raising required to provide 1% AEP level protection with 500 mm freeboard. The stopbank assessment considers the area from the Whangatane Spillway inlet weir to a location approximately 8 km downstream, beyond which the flood risk to buildings is considered low.

Previously stated concerns regarding the quality of the LiDAR data is likely to impact the extent of works and volume of earthworks required.

3.4 Stability of river banks and associated stopbanks.

The site visits and associated geotechnical investigations identified that there are widespread bank stability issues readily observed through localised bank slumping and landslips.

Two general options to improve slope stability were considered as part of development of the Preliminary Design:

1. Reducing the gradient of the bank slopes
2. Structural methods to increase the shear strength of the slope.

The Preliminary Design Drawings indicate areas where there can be some reduction in the gradient of the bank slope which will increase stability and reduce the probability of slope failure. However, the geological investigations and site walkover suggest that in places the banks will remain relatively unstable after the gradient is reduced due to the geological profile of the area (sedimentary clays over softer marine deposits).

In order to have confidence in a design solution that stabilises the banks and provides protection for the toe of the bank, passive structural methods (e.g. rock revetment, gabion baskets or mass blocks) would be required along the entire length of the Awanui River, but are not required along the Whangatane Spillway channel. The Preliminary Design incorporates a rock revetment approach, although gabion baskets or mass blocks could be considered as alternatives within the Detailed Design.

The rock revetment preliminary design has primarily been developed to provide a slope stability solution that reduces operational expenditure. However, it will come with a high capital expense. Alternative solutions (e.g. through soft engineering measures) may decrease capital expense but will increase the required operational expenses due to more frequent bank stability related issues. Opportunities to balance the slope stability requirements with operational costs in an ecologically sensitive way should be investigated further during Detailed Design.

The median rock size for a rock revetment determined for the Preliminary Design is approximately 800 mm, to resist peak flow velocities in the channel up to 4.5 m/s and a Froude number of 0.5. This should be confirmed as part of Detailed Design. We also note that the rock revetment presently proposed does not extend up to the 1% AEP flood level. To provide protection to the 1% AEP flood level would significantly increase the cost of the works further.

The active slip identified earlier in the report (near Rongopai Place) will require some detailed consideration during Detailed Design. This may involve more complex solutions than the passive solutions identified above.

4 Price Schedule

Table 4-1 summarises the cost estimate for the Awanui Flood Scheme Upgrade based on the elements shown on the Preliminary Design Drawings. Due to the high cost of bank stabilisation works, two estimates have been prepared, including and excluding bank stabilisation works. A detailed breakdown of the estimate is provided in Appendix D.

A contingency has been included in each of the construction cost estimate line items (as shown in detailed breakdown in Appendix D). The contingency amount includes for the uncertainty in cut and fill volumes due to the survey data uncertainty. However, as previously noted, changes in stopbank raising approach as a result of topographic uncertainty are not represented in the contingency, for example where stopbank raising changes from additional earthfill to a mass block wall.

Table 4-1 Price schedule summary

	Cost Estimate	
Spillways 1 – 5	**$870,500**	
Stopbank 1: 0 m – 750 m Farm to Panakareo Street	**$365,500**	
Stopbank 2: 0 m – 745 m Church Road to Church Road drain	**$285,850**	
Stopbank 3: 0 m – 830 m Allen Bell Drive to Spillway	**$249,800**	
Stopbank 4/1: 0 m – 940 m Sports Ground to Church Road	**$155,700**	
Stopbank 4/2: 940 m – 2000 m Church Road to Allen Bell Drive	**$451,500**	
Stopbank 4/3: 2000 m – 2877 m Allen Bell Drive to Mathews Park	**$513,400**	
Whangatane Spillway Weir	**$911,700**	
Stopbank 5/1: 0 m – 5290 m Weir to Quarry Road	**$572,500**	
Stopbank 5/2: 5290 m – 6940 m Quarry Road to SH10	**$70,250**	
Stopbank 5/3: 6940 m – 7950 m SH10 to end	**$356,000**	
Stream bank protection works	**N/A**	**$8,593,750**
Construction Cost Estimate	**$4,802,700**	**$13,395,950**
Detailed design (7% of works)	$336,154	$937,716
Consultation and consenting (10% of works)	$480,220	$1,339,595
Project management, construction supervision, contract administration (7% of works)	$336,154	$937,716
Planting/landscaping for aesthetic purposes (5%)	$240,110	$669,797
Whangatane Spillway - two stock crossing bridges*	$400,000	$400,000
Sub-total (excluding Construction Cost Estimate)	$1,792,638	$4,284,825
25% contingency	$448,159	$1,071,206
Total Estimate	**$7,042,997**	**$18,751,982**

*Item added at request of NRC. Prices previously supplied to NRC were $150k per bridge, which was considered low (by NRC).

The following items are not included in the Price Schedule:

a. Additional survey
b. Land and property acquisition
c. Road alignment modifications
d. Slope stability improvements and landslip remediation in the Awanui River around Rongopai Place
e. Bank stability measures adjacent to State Highway 1 upstream of the Kaitaia urban area.

5 Issues for Detailed Design

This Preliminary Design Report has highlighted a number of issues to be considered for Detailed Design. The following points summarise recommendations made elsewhere in the report:

i. Detailed survey is recommended for the Detailed Design to properly determine the extents of stopbanks and volumes. Survey of existing stormwater infrastructure may also be necessary.

ii. Options to stabilise the river banks adjacent to State Highway 1 could be considered as part of the Detailed Design scope of works.

iii. A mass block wall approach has been adopted in some areas to reduce the land required to raise flood protection levels. Alternative typical sections for mass block or key stone wall options are shown in the drawings and can be considered further during detailed design.

iv. The risks associated with having lower road levels than the adjacent stopbanks should be considered further.

v. The ability of stormwater to drain to the Awanui River will require further consideration at Detailed Design, for example using flap gates on drainage outfalls passing through stopbanks.

vi. NRC has indicated that it has had poor experience using gabion baskets and may wish to change the design of the Whangatane Spillway inlet protection works to a mass block approach during Detailed Design.

vii. The additional flood risk to buildings and property located on the true right bank of the Whangatane Spillway needs to be considered further during Detailed Design. It is noted that these areas already flood, but the increase in flood risk may require mitigation.

viii. Alternative options to the rock revetment approach for addressing the slope stability issues in the Awanui should be considered at Detailed Design. The alternative options may consider reducing the capital expenditure but accepting a lower level of service which will result in longer term operational costs than the approach currently proposed.

6 Applicability

This report has been prepared for the benefit of Northland Regional Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
………………………………………………………	………………………………………………………
Jon Rix	Project Director
Water Resources Engineer	Tim Fisher

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Appendix A: Design flows

A Design Flows

The 1% AEP peak flow and temporal flow pattern are critical design aspects for the Awanui Flood Scheme. It was agreed early on in the project that the 1% AEP flows upstream of the State Highway 1 overflow to the Tarawhataroa Stream is the appropriate location for the design flows so that the overflow can be considered as part of the project.

This chapter presents the results from a number of previous hydrological and hydraulic studies, and some additional deterministic studies carried out by T&T for the purposes of this study. Many of the approaches provide use an approach that convert peak flows recorded at School Cut to flows upstream of the Tarawhataroa overflow. Therefore this section has been organised in the following way:

1. Annual peak flows at School Cut
2. Diversion relationship between Awanui River and Tarawhataroa Stream
    a. Previous studies
    b. Catchment model
3. Flood frequency analysis
4. Additional studies carried out by T&T
5. Discussion of results and selection of 1% AEP design hydrograph.

A.1 Annual peak flows at School Cut

The annual maxima from 1958 to 2012 are provided in Figure A-1. The different colour lines reflect different sources of information and the difference between the highest and lowest estimate is highlighted. The adopted peak flow is shown in red on the graph.

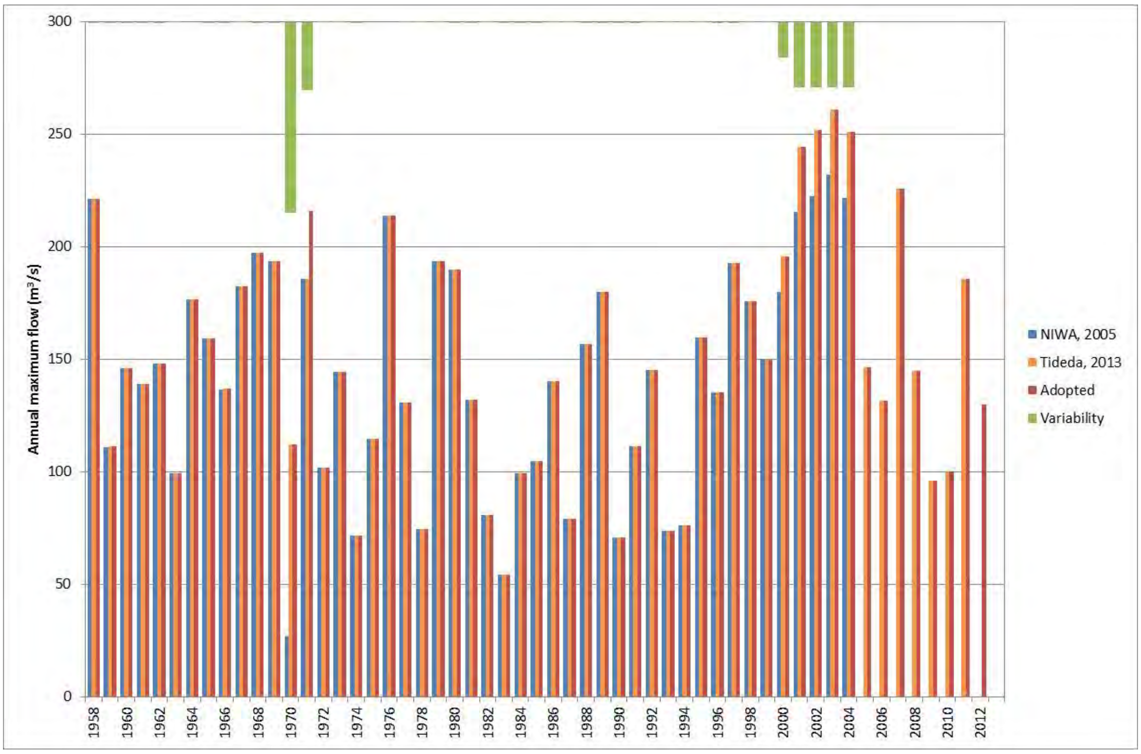


Figure A-1 Annual maximum flows at School Cut

We note the following adjustments:

1. The differences between the annual maximum from 2000 to 2005 reflect an observed difference between maximum values recorded in the NIWA (2005) report and the annual maxima derived from a hydrometric database file (Tideda) provided to T&T as part of the study. We understand that the annual maximum flows included in the NIWA report applied an earlier rating curve from November 1999 to annual maxima up to 2005. It is understood from NIWA that School Cut gaugings in 2006 and 2007 led to a revision of the rating in 2007 which was applied retrospectively to all site data (Tideda) from June 2000. For the purposes of this report, we have assumed that the Tideda database provided to T&T is correct, however there is some evidence to indicate that the rating shift established in 2007 should not have been retrospectively applied at June 2000, but at a later time after 2003. It is also noted that significant channel works, including vegetation clearance, were carried out by NRC in the vicinity of the School Cut site in early 2007.

v. The maximum flow recorded for 2007 (226 m^3/s) was based on surveyed debris level of 10 July 2007 flood because the flow gauge failed during that storm event. The July 2007 event occurred subsequent to the shift in site rating that was supported by gaugings in 2006 and 2007. There is therefore reasonable confidence in the figure of 226 m^3/s adopted for 2007 in this report.

vi. We note that only 12 days of records were available for 1970 according to the Tideda data. NRC (personal correspondence) has provided an annual maximum flow for 1970 of 112 m^3/s, the origins of which are in the NCC (1986) report, Table 6.2. It is not known why the NCC (1986) annual maxima for 1970 is different from the Tideda data.

vii. The 1971 flow of 216 m3/s was modified to reflect a flow at School Cut recorded in the NCC (1986) report (Table 6.1). The NIWA Tideda database records the peak 1971 flow as 186 m^3/s, which is approximately 30 m^3/s less than the modified flow (NCC, 1986). The reason for the modification is a gauging of 207 m^3/s for School Cut made on 24 February 1971, which is close to the value given in the NCC report. We note other differences between flows that were modified in 1986 and the current record, however they are generally considered insignificant for flood frequency analysis purposes.

A.2 Diversion relationship between Awanui River and Tarawhataroa Stream

The diversion relationship for flows passing along the Awanui River and the flows passing over SH1 into the Tarawhatatora provides the basis for modifying the annual peak flows recorded at School Cut. Once the School Cut annual peak flows are revised, a flood frequency analysis of the revised peak flows can be carried out.

A.2.1 Previous studies

Historically, there have been three approaches to assessing Tarawhataroa overflows

1. Deterministic, based on School Cut flows:
   a) *Overflow = 0.202 x (SCF – 170)*$^{1.41}$ *(NIWA, 2005; Macky, 1996)*
   b) *Overflow = 0.7 x (SCF-170)*$^{1.33}$ *(NRC, 2013)*

2. Modelling

   A catchment model was used by NCC (1986) to determine Tarawhataroa overflows based on known flows at School Cut, and cross sectional area calculation of the SH1 overflow. The derived rating for the overflow is given in NCC (1986) figure 4.2.

3. Independent assessment

   The deterministic methods presented above were derived following analysis of a large number of storm events. In particular, NRC (2013) revised the overflow estimates from the Awanui into the Tarawhataroa for 11 events.

The results of the different assessment are shown in Figure A-2.

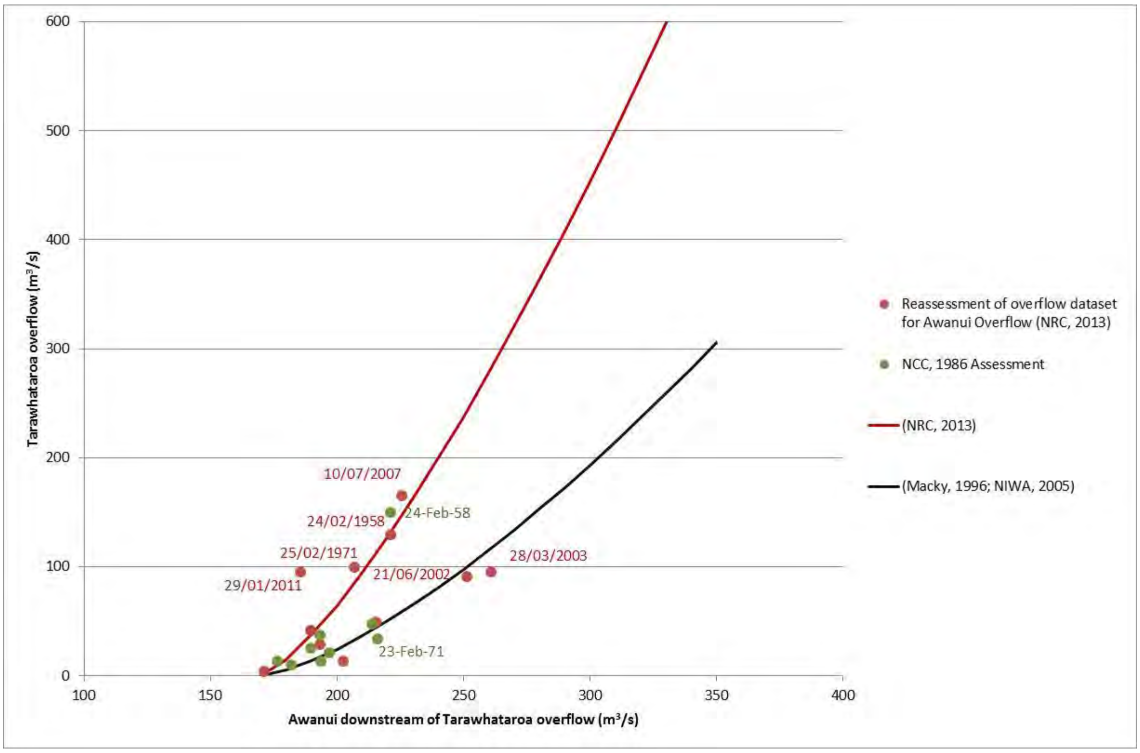


Figure A-2 *Flow diversion relationship for Tarawhataroa overflow and Awanui River downstream of overflow*

A.2.2 Catchment model

T&T carried out a review of the Awanui catchment model (GHD, 2013) results for Northland Regional Council as part of this study. The model results were assessed to provide peak flows upstream of the SH1 overflow and to provide a method of assessing the overflow characteristics of SH1, so that if one flow was known (e.g. School Cut), the other two flows could be approximated (e.g. Tarawhataroa Stream and Awanui River upstream of the SH1 overflow). This approach allows the hydraulic model representation of the catchment model to be used to estimate diversion flows for a range of flows not necessarily predicted by the model (e.g. if an alternative hydrological approach to the catchment model was preferred).

A.2.2.1 Peak flow estimate

Figure A-3 provides the results of the 100 year ARI ED flows upstream of the overflow to the Tarawhataroa. The hydrograph comprises the inflow hydrograph, represented by the

Mike 11 model and the out of channel flows in the Mike 21 floodplain. The combination of the two provides the overall 100 year ARI ED hydrograph.

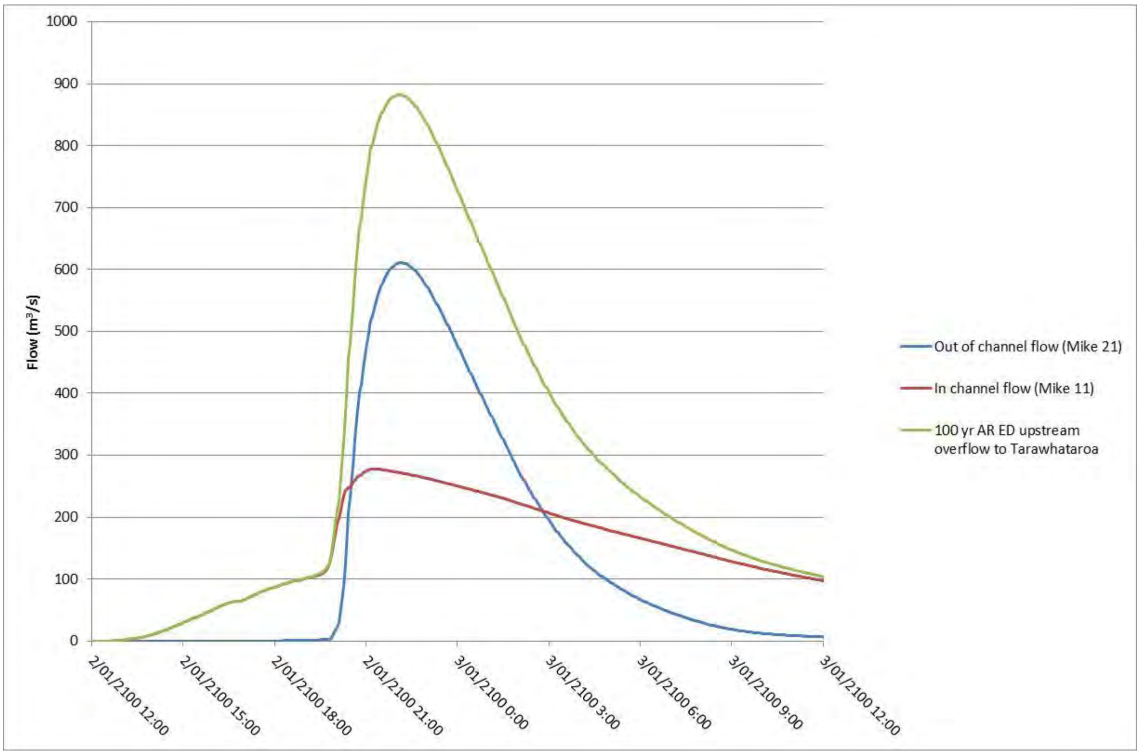


Figure A3 *100 year ARI Existing Development hydrograph upstream of the overflow to the Tarawhataroa*

The results indicate that the peak flows from the Catchment Model (GHD, 2013) are approximately 882 m^3/s.

A.2.2.2 Flow diversion characteristics

A results hydrograph was extracted from three locations in the catchment model:

1. Upstream of the SH1 overflow in the Awanui River
2. Tarawhataroa Stream (downstream of the SH1 overflow)
3. Downstream of the SH1 overflow in the Awanui River.

In order to calculate only the overflow component of the flows in the Tarawhataroa River, the Tarawhataroa catchment flows were excluded, as shown in Figure A-4.

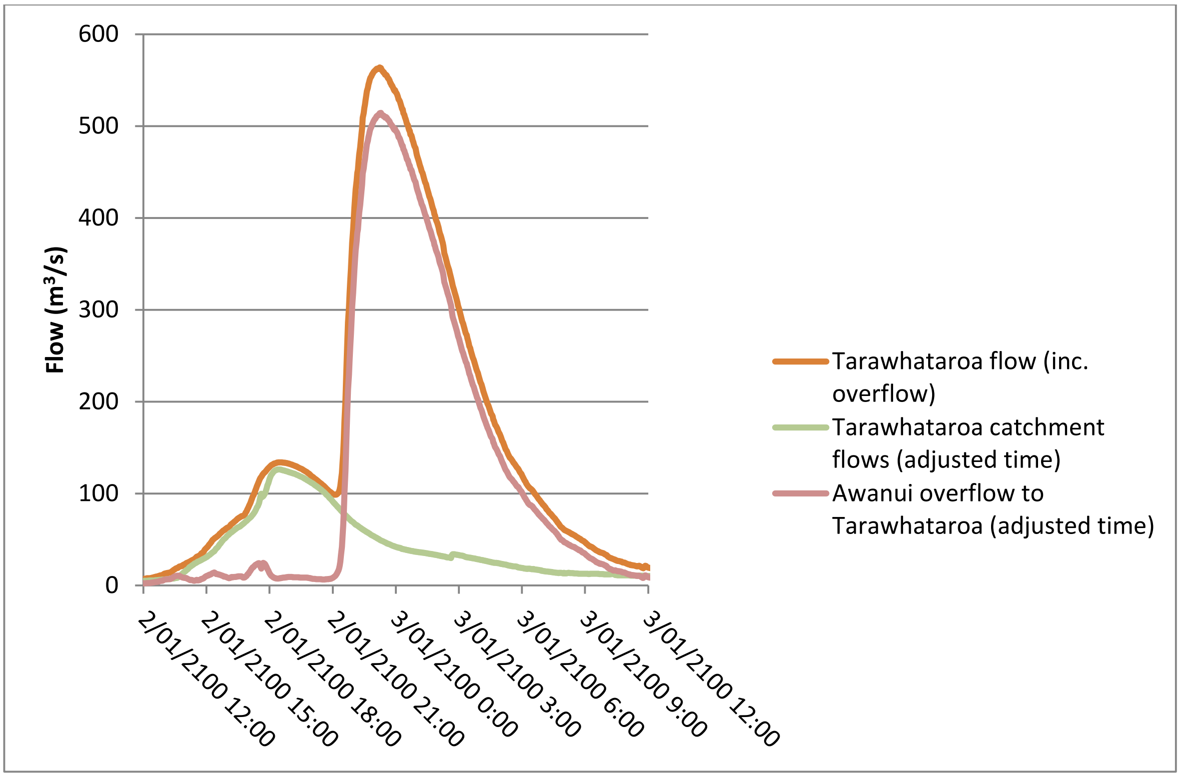


Figure A-4 Tarawhataroa flows

A relationship between the three hydrographs was then calculated so that if one flow was known, the other two flows could be approximated. An important assumption is that the peak flow in the Tarawhataroa and Awanui River at School Cut both occurred at the same time, which was a reasonable assumption because the distances downstream of the SH1 were similar in both the Awanui River and Tarawhataroa Stream.

The relationship between Awanui Catchment flows upstream of the Tarawhataroa overflow, School Cut flow and the overflow into the Tarawhataroa can be seen in Figure A-5.

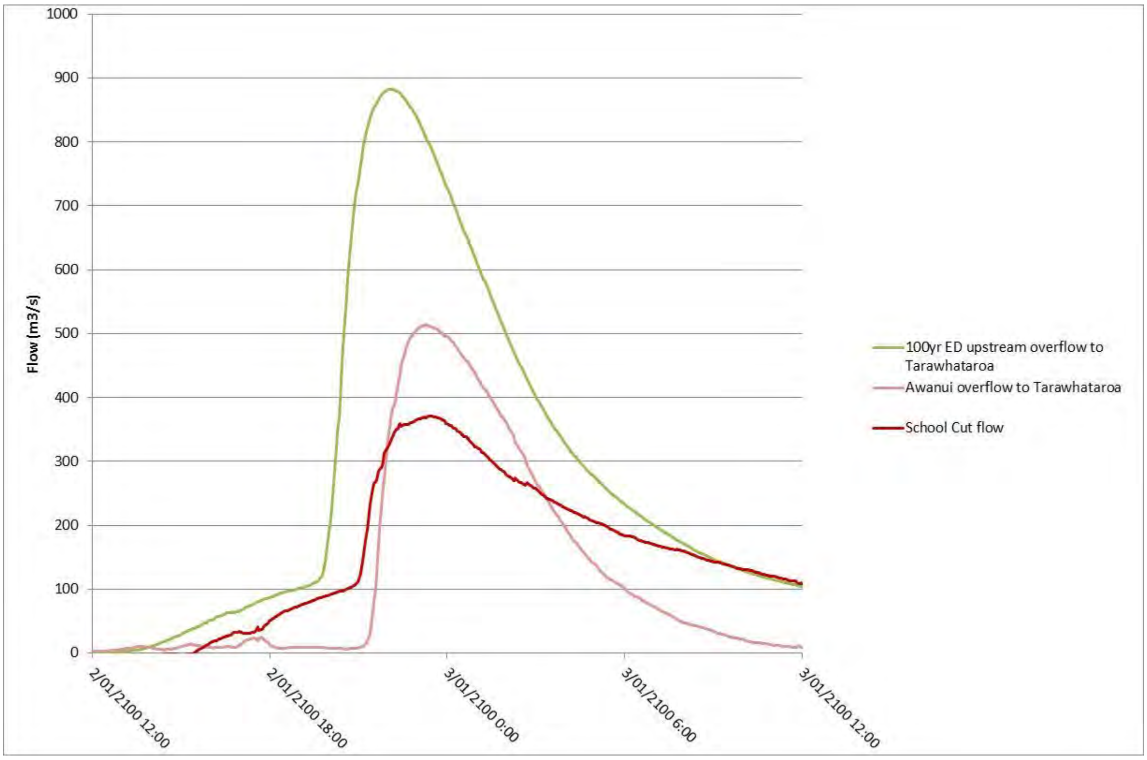


Figure A-5 *Relationship of School Cut flows to upstream flows and the overflow to the Tarawhataroa – 100 year ARI ED*

Figure A-6 provides a representation of the relationship between Awanui flows at School Cut and the overflows from the Awanui to the Tarawhataroa as determined by the catchment model (GHD, 2013). The figure reproduces the results of the historical studies.

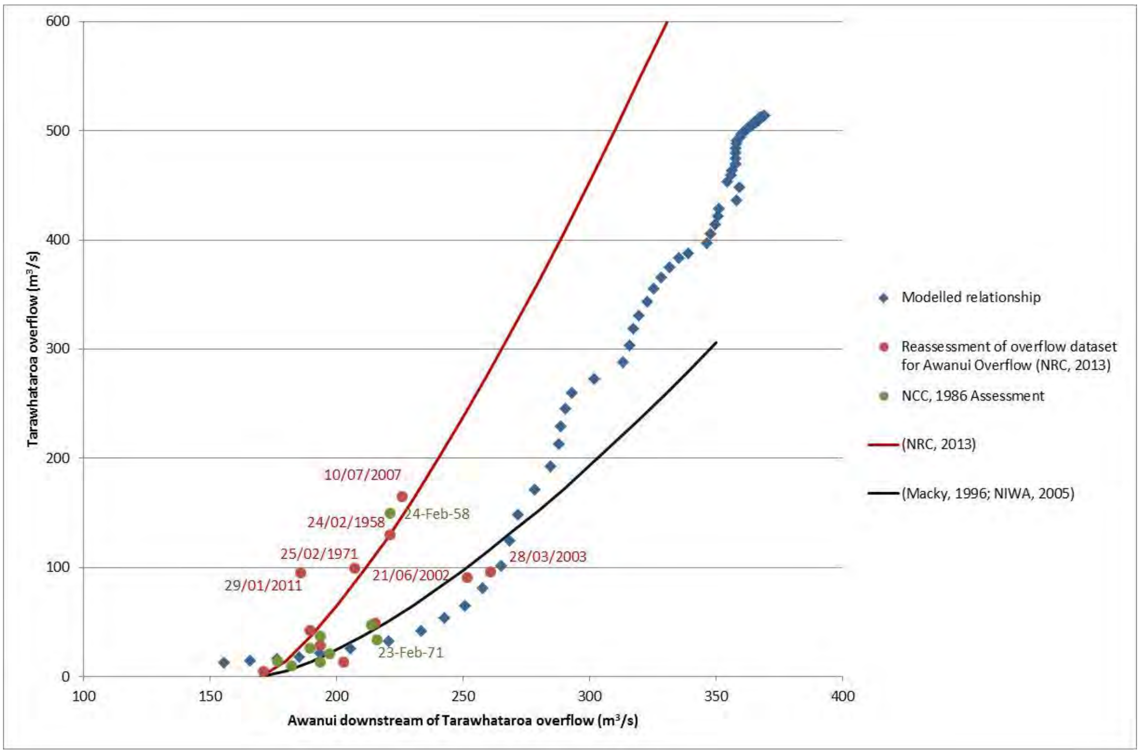


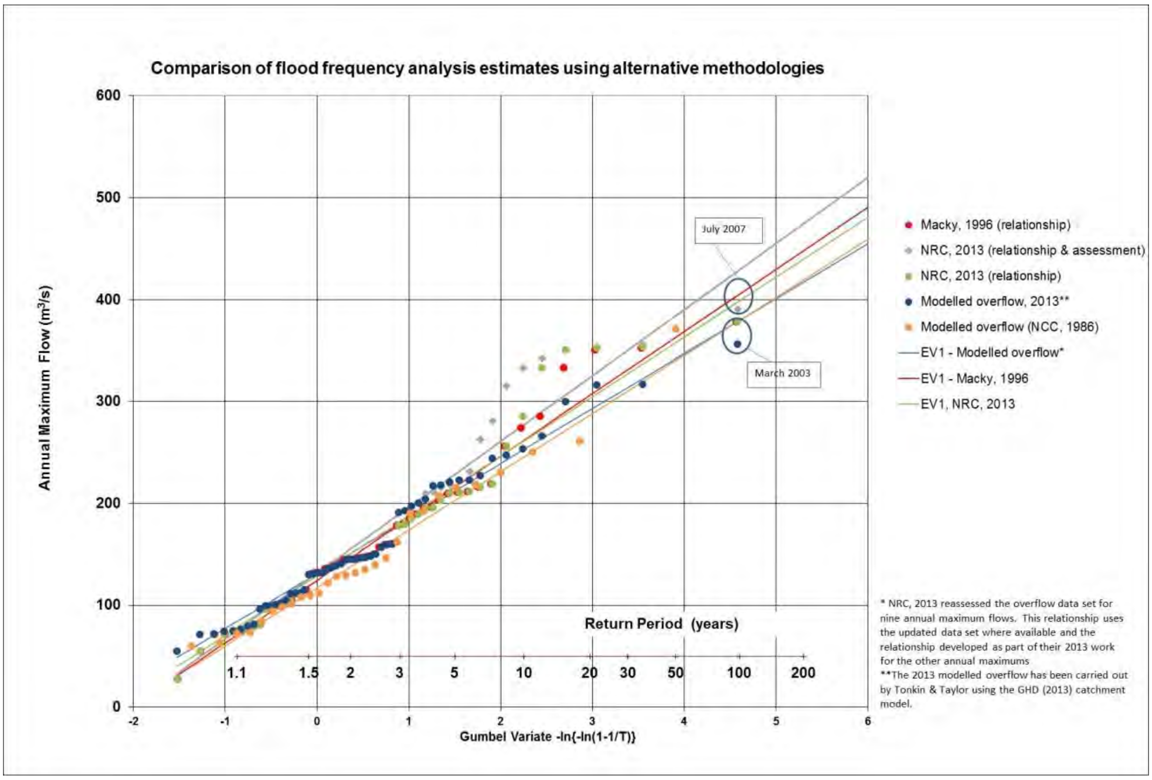
Figure A-6 *Estimates of overflows diversion relationship between Awanui River and Tarawhataroa*

A.3 Flood frequency analysis

In order to carry out a flood frequency analysis for the Awanui River upstream of the SH1 overflow catchment flows, the annual maximum School Cut flows (shown in Figure A-5) have been modified using all the diversion relationships identified in Section A.2.2.2.

A flood frequency analysis for each of the diversion assessment methodologies has been carried out using a range of distributions (Ev1, Log Normal and GEV). The results are available in Appendix B.

A comparison of the different results has been made in Figure A-7 using the EV1 distribution. The EV1 distribution provides the best fit for the different overflow assessment methods, and therefore provides the most representative distribution for comparative purposes.



* NRC, 2013 reassessed the overflow data set for nine annual maximum flows. This relationship uses the updated data set where available and the relationship developed as part of their 2013 work for the other annual maximums

**The 2013 modelled overflow has been carried out by Tonkin & Taylor using the GHD (2013) catchment model.

Figure A-7 Comparison of flood frequency analysis using alternative methodologies – EV1 distribution

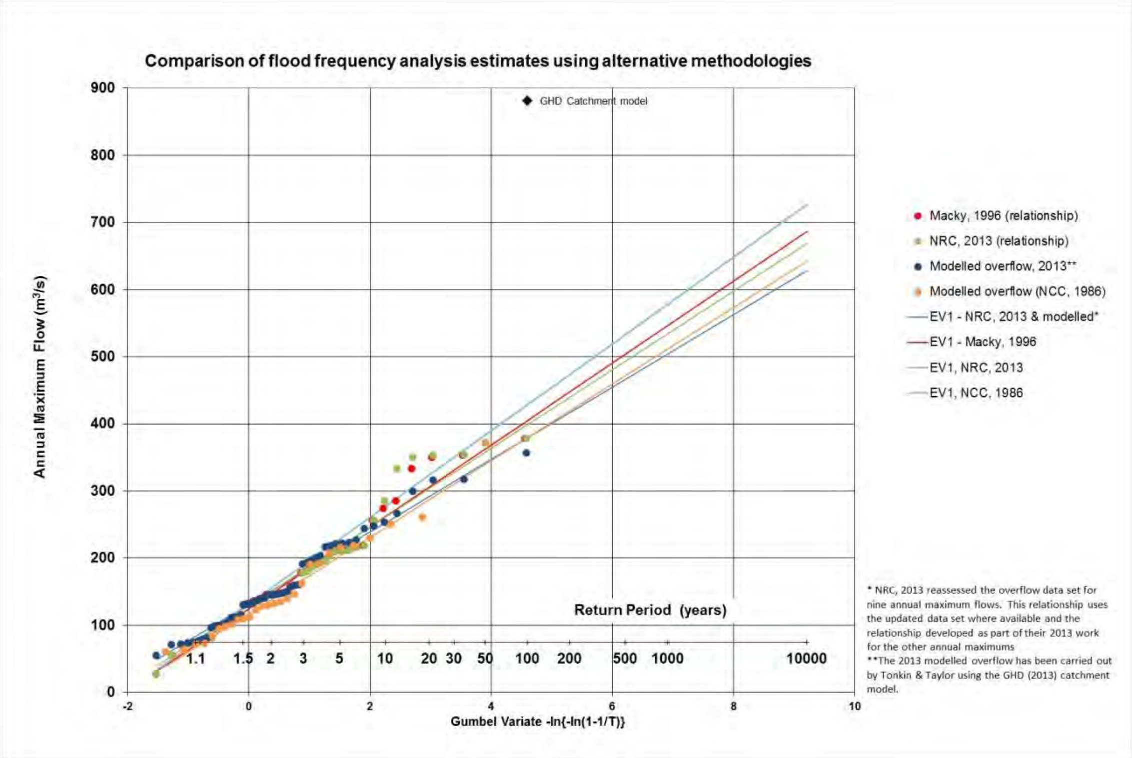
Table A-1 provides a summary of the range in 1% AEP flows for different methods. Generally the EV1 distribution provides a 1% AEP estimate at the lower end of the range for different distributions, however based on the analysis of the different distributions we recommend that the EV1 distribution is appropriate.

Table A-1 Flood frequency analysis results

Method	Estimated peak discharge (m^3/s)		
	EV1	Log normal	GEV
Modelled relationship	391	391	397
NRC, 2013 v1	440	462	487
NRC, 2013 v2	367	429	442
NCC, 1986	379	390	414
Macky, 1996 & NIWA, 2005	403	420	424

The results shown in Figure A-7 indicate that the 100 year ARI catchment flow upstream of the Tarawhataroa overflow is likely to be between 380 m^3/s and 440 m^3/s.

The results of the flood frequency analysis have been compared with the 100 year ARI flows predicted from the catchment model (GHD, 2013). The catchment model peak flows upstream of the Tarawhataroa overflow are approximately 882 m^3/s. This is shown in comparison to the flood frequency analysis results in Figure A-8.



* NRC, 2013 reassessed the overflow data set for nine annual maximum flows. This relationship uses the updated data set where available and the relationship developed as part of their 2013 work for the other annual maximums

**The 2013 modelled overflow has been carried out by Tonkin & Taylor using the GHD (2013) catchment model.

Figure A-8 Comparison of flood frequency analysis results with the catchment model (GHD, 2013) prediction of 100 year ARI flow

A.4 Additional studies carried out by T&T

A range of alternative hydrological approaches were assessed by T&T to provide additional 1% AEP estimates. The additional approaches included deterministic and regional hydrology approaches.

The Rational method and Clark Unit Hydrograph with SCS loss function were used to estimate the flood peak and hydrograph for a 1% AEP storm in the catchment. The quality of results obtained using these methods depend on selection of appropriate rainfall, loss parameters and, in the case of the Clark Unit hydrograph, the storage coefficient.

A.4.1 Time of concentration

The time of concentration (Tc) for the catchment is required for deterministic flood analysis. This was calculated using the SCS formula that includes the Curve Number for the loss function in the calculation of Tc.

The CN for the catchment was estimated at 70, based on vegetation and soil type and Tc was calculated as 9 hours using the SCS formula:

$$Tc = 0.14\, C\, L^{0.66} \left(\frac{CN}{200 - CN}\right)^{-0.55} S^{-0.30}$$

Where

Tc	*Time of concentration (hours)*	
C	*Channelization factor (1)*	*1*
L	*Length of longest water course (km)*	*29.5 km*
CN	*SCS curve number*	*70*
S	*Equal area channel slope (m/m)*	*0.005*

A.4.2 Catchment rainfall

Catchment rainfall was estimated as 82% of the HIRDS V3 storm rainfall depths for the approximate centroid of the catchment because analysis of recorded data and HIRDS data showed that the HIRDS database over estimates rainfall in the region. More information on the analyses is provided in Appendix B.

An areal reduction factor of 0.94, which is in accordance with the areal reduction factors proposed for the new Auckland Council guideline (GD02) was applied to the storm rainfall to take account of the size of the catchment. The rainfall data used in the analyses are summarised in Table A-2.

Table A-2 Storm rainfall for the Awanui Catchment

Storm duration (hours)	**1**	**2**	**3**	**6**	**9**	**12**	**24**
HIRDS rainfall (mm)	65.7	88.2	-	140.5	-	188.6	253.1
0.82 HIRDS (mm)	53.9	72.3	85.0	115.2	140.0	154.7	207.5
Areal reduction (0.94) (mm)	50.6	68.0	79.9	108.3	131.6	145.4	195.1
Average intensity (mm/h)	50.6	34.0	26.6	18.1	14.5	12.1	8.1

NOTE: Rainfall depths for 3 hours and 9.1 hours are interpolated.

A.4.3 Rational method

It is generally accepted that the Rational method should only be used for small catchments with the recommended upper bound ranging from 15 km^2 to 50 km^2, depending on the authority. However, experience in some countries such as South Africa (DWAF 2004), has shown that good results can be obtained for much larger catchments.

The Rational method flood peak is calculated using the formula:

$$Q = 0.278\ C\ I\ A$$

Where

Q	*Hydrograph peak discharge (m³/s)*
C	*Runoff coefficient*
I	*Average rainfall intensity for AEP and Tc (mm/hour)*
A	*Catchment area (km²)*
0.278	*Factor to convert units to (m³/s)*

The runoff coefficient is estimated on the basis of the catchment characteristics such as average slope, land use and soil type. For the Awanui Catchment the runoff coefficient was estimated following the component method, included in Appendix B, as between 0.30 and 0.35. Following the guidelines of the New Zealand Institute of Engineers stormwater design publication a runoff coefficient of 0.31 was estimated for the catchment. Accordingly the lower and upper bounds of 0.30 and 0.35 are considered reasonable runoff coefficients for the catchment.

In the Rational method the flood peak discharge is estimated using average rainfall intensity over the time of concentration for the catchment. For a time of concentration of 9.1 hours the average rainfall intensity for a 1% AEP storm is 14.5 mm/h and the 1% AEP flood peak for the catchment is estimated between 270 m^3/s and 312 m^3/s for runoff coefficients of 0.30 and 0.35 respectively.

A.4.4 Unit hydrograph method

The Clark unit hydrograph with SCS loss function, as implemented in HEC-HMS was used to estimate 1% AEP flood hydrographs for the Awanui Catchment. Storm rainfall, as listed in **Error! Reference source not found.**, were used in the analysis.

The primary parameters input to the hydrograph calculation are the time of concentration (Tc) and a storage coefficient (R). The storage coefficient is best determined by calibration, which requires streamflow data at the gauge and catchment rainfall for historic storm events. Streamflow and rainfall data also need to be at sufficient resolution to define the hydrograph. Rainfall data for the catchment are only available at daily time step, which are not suitable for estimating the storage coefficient by calibration. Experience has shown that the storage coefficient is usually between Tc and 2.5 times Tc, but can be significantly longer in some catchments. An initial value for the storage coefficient was estimated using a formula from the Arizona manual on road drainage:

$$R = 1.176\, Tc^{1.11}\, L^{0.8}\, A^{-0.57}$$

Where

S	*Storage coefficient (hours)*
Tc	*Time of concentration (hours)*
L	*Length of catchment (km)*
A	*Catchment area (km²)*
1.176	*Factor to convert units*

Applying this formula the storage coefficient for a time of concentration of 9 hours is estimated at 9.5 hours (i.e. 1.05 times Tc) resulting in a 1% AEP hydrograph peak for the catchment of 328 m^3/s. Increasing the storage coefficient reduces the hydrograph peak discharge. Increasing the storage coefficient to 11.5 hours (i.e. 1.25 times Tc) reduces the hydrograph peak to 295 m^3/s.

Based on the above results the 1% AEP hydrograph peak discharge at School Cut is estimated between 295 m^3/s and 328 m^3/s.

A.4.5 Regional methods

The flood peak for the 222 km^2 Awanui Catchment was estimated in accordance with the publication “Flood frequency in New Zealand”, McKerchar and Pearson, 1989 and “Methods for estimating design peak discharge”, TM61.

A.4.5.1 McKerchar and Pearson method

McKerchar and Pearson method developed maps for the whole country that can be used to estimate the mean annual flood (MAF) and the 1% AEP flood peak for a catchment. The MAF at School Cut was estimated from their map showing contours of $MAF/A^{0.8}$ (Figure 3.4 in their publication) at 157 m^3/s. This compares well with the MAF estimated by frequency analysis of the observed flow record of between 150 m^3/s and 160 m^3/s depending on the adjustments made to the dataset to compensate for spills at the SH1 overflow to the Tarawhataroa. Figure 4.8 in their publication presents contours of the ratio between 1% AEP flood peak and MAF. The factor for the School Cut catchment is 2.4, giving a 1% AEP flood peak of 377 m^3/s. Using the range of MAF determined from the frequency analysis results the 1% AEP flood peak is between 360 m^3/s and 380 m^3/s.

A.4.5.2 TM61 method

The TM61 method relates the peak discharge to AEP rainfall, the shape of the catchment and catchment area using the following formula:

$$Qp = 0.0139\ C\ R\ S\ A^{0.75}$$

The input parameters and their descriptions are summarised in Table A-3 together with the estimated peak discharge at School Cut.

Table A-3 ATM61 parameters for School Cut in the Awanui catchment

Parameter	Description	Value	
		Lower estimate	Upper estimate
C	Catchment physiography coefficient	900	900
Rainfall	1% AEP rainfall depth (mm)	136	136
R	1% AEP rainfall / standard rainfall	0.54	0.54
S	Shape factor	0.90	1.00
A	Catchment area (km^2)	222	222
Qp	Peak discharge for 1% AEP storm rainfall	350	390

Appendix B: Rainfall and flow data

B.1 Rainfall and flow data

Rainfall and streamflow data were obtained from NRC and NIWA databases to compare storm rainfall depths at selected locations, to estimate the 1% AEP flood discharge at School Cut and to evaluate the AEP of observed storm rainfall for selected events.

B.1.2 Rainfall data

Rainfall data were obtained from NRC and the NIWA CliFlo database. The rainfall data selected from the Hilltop database provided by NRC are summarised in Table B-1.

Table B-1 Rainfall data selected from data provided by NRC in a Hilltop database

Name	Location		Period of record		Years of record	Resolution
	Latitude	Longitude	Start	End		
Takahue at Te Rore	-35.178	173.372	11/12/2003	01/09/2012	9	5 minute
Te Rore at Wallace	-35.178	173.372	01/09/1966	01/01/2006	40	Daily
Te Puhi at Mangakawakawa Trig	-35.143	173.464	31/10/2002	15/08/2012	10	15 minute

The records for the stations Takahue at Te Rore and Te Puhi at Mangakawakawa were selected because their data is recorded at 5-minute and 15-minute intervals respectively, which enables 24-hour rainfall depths to be determined that are not bound by the standard day used to record daily data and also permits calculation of rainfall depths for durations less than one day. The Te Rore at Wallace record was selected even though it is a daily record because the record spans 40 years.

Annual maxima for storm durations of 6-hours, 12-hours and 24-hours and daily were extracted from the Hilltop database for input to frequency analysis.

Hourly and daily rainfall data were also obtained from the NIWA CliFlo database for rainfall stations listed in Table B-2 and VCSN sites listed in Table B-3. The VCSN sites have daily rainfall from 1960 to 2012.

Table B-2 Rainfall data selected from NIWA CliFlo database

Agent No	Name	Location		Period of record		Years of record	Resolution
		Latitude	Longitude	Start	End		
1037	Kaitaia	-35.114	173.259	01/01/1900	31/12/2012	113	Daily
1041	Kaitaia Observatory	-35.134	173.263	01/05/1985	29/07/2013	28	Hourly
17067	Kaitaia Ews	-35.135	173.262	18/12/1998	29/07/2013	15	Hourly
1024	Kaitaia Aero	-35.067	173.287	01/12/1948	30/04/1985	37	Daily
18183	Kaitaia Aero Ews	-35.067	173.287	16/07/2000	29/07/2013	13	Hourly
1018	Waiharara	-34.950	173.195	01/06/1956	30/06/2013	57	Daily

Table B-3 Rainfall data selected from NIWA VCSN database

Agent No	Location		Period of record		Years of record	Resolution
	Latitude	Longitude	Start	End		
20383	-35.075	173.325	1960	2012	53	Daily
20543	-35.075	173.225	1960	2012	53	Daily
20661	-35.125	173.275	1960	2012	53	Daily

Hourly and daily rainfall time series were downloaded from the CliFlo database. The hourly data were accumulated into 6-hour, 12-hour and 24-hour rainfall depths using the method of running totals. The annual maxima for each duration were extracted for input to the frequency analysis. Daily rainfall depths were extracted from the CliFlo database and annual maxima extracted for input to the frequency analysis.

Storm rainfall data were obtained from the NIWA HIRDS V3 site for the location of each of the rainfall station and VCSN sites.

B.1.3 Streamflow data

Annual peak discharges in the Awanui River at School Cut, from 1958 to 2012, adjusted according to the method used in the Information Review (refer Figure 2.1, T&T, 2013 Draft). These data were input to frequency analyses and the results compared to peak discharges determined using other methods.

B.2 Storm rainfall analysis

B.2.1 HIRDS V3 database

The HIRDS V3 database provides storm rainfall depths for storm durations from 10-minutes to 72-hours and for AEP from 63% to 1% for the whole of New Zealand. According to the *HIRDS V3: High Intensity Rainfall Design System – The method underpinning the development of regional frequency analysis of extreme rainfalls in New Zealand*, (Thompson, 2010) data used in the analysis are from the following sources:

- NIWA Climate database (data to end 2008)
- Water Resources Archive (data to end 2005)
- Regional Council Archives (data to end 2005).

The records for sites were combined where the sites are within 500 m of each other with the maximum values used for periods of overlapping data. This reduced the number of sites from 3,213 to 2,697. Regional frequency analyses were carried out using annual maxima for years with at least ten months of record and a record length of at least six years.

Experience in other studies has shown that storm rainfall depths obtained for a site from the HIRDS V3 database can differ significantly from single station analysis results using observed data for the same location and that the differences are not consistent across the country. The comparison between HIRDS V3 data and observed data for selected stations in the Awanui Catchment is discussed in the following section.

B.2.2 Comparison of HIRDS V3 to single station analysis storm rainfall depths

Comparisons between HIRDS V3 data and the results from single station frequency analysis of observed data were carried out to assess the differences to determine whether HIRDS data should be adjusted to be more representative of rainfall on the Awanui River catchment.

Frequency analyses were carried out using the data from the rainfall stations listed in Section B1 and the results were compared to the corresponding HIRDS V3 data. The frequency analysis results for the General Extreme Value (GEV), Extreme Value Type 1 (EV1), Normal and Log Normal distributions were tabulated together with the HIRDS V3 and factored HIRDS data. Factors were selected so that the 1% AEP HIRDS storm rainfall depth (i.e. the AEP of interest in this study) corresponded with the frequency analysis results.

The analysis results show significant variability in the relationship between HIRDS data at the rainfall station sites and the storm depths determined from frequency analysis as shown in the range of factors to adjust the HIRDS 1% AEP storm depths to conform to the observed data results for 6-hour, 12-hour and 24-hour storms summarised in Table B-4.

Table B-4 Factors to adjust HIRDS storm data to storm depths determined by frequency analysis for the stations with sub-daily data

Station name Years of record	Storm duration (hours)	Ratio of 1% AEP at site depths to HIRDS depths
Takahue at Te Rore 9 years	6	0.90
	12	0.95
	24	0.90
Te Puhi at Mangakawakawa 10 years	6	0.85
	12	0.85
	24	0.85
Kaitaia Aero Ews 13 years	6	1.05
	12	1.10
	24	1.00
Kaitaia Observatory 27 years	6	1.05
	12	1.00
	24	0.85
Kaitaia Ews 14 years	6	0.90
	12	0.88
	24	0.85

The summary shows that generally the HIRDS storm depths are approximately 10% higher than determined from the station data. The exception is the results for the longest dataset that show good agreement for the 6-hour and 12-hour storm durations (factors of 1.05 and 1.00 respectively) but a factor of 0.85 for the 24-hour storm depth, indicating that the 24-hour storm depths may be overestimated in the HIRDS database. However, this factor cannot be adopted without the support of additional analysis results. Accordingly analyses were also carried out using daily rainfall data.

Daily rainfall records are available for rainfall stations and virtual climate stations in and around the Awanui Catchment. These data are only collected once a day, usually at 9 am and does not necessarily capture the 24-hour maxima, which can occur over two consecutive days. NIWA has determined appropriate factors that can be applied to fixed duration data to estimate 24-hour, 48-hour and 72-hour rainfall of 1.14, 1.07 and 1.04 respectively, which were used in analyses for the HIRDS V3 database (Thompson 2010). Experience gained in other studies with adjustment factors for converting daily data to 24-hour, 48-hour and 72-hour annual maxima confirms that these factors are suitable.

Frequency analyses were carried out using observed daily rainfall from six sites and three VCSN sites to determine the relationship between the 1% AEP daily rainfall depths and the HIRDS V3 depths. The ratio between the 1% AEP depths and the HIRDS V3 1% AEP depths are summarised in Table B-5 together with the number of years in each record. These ratios account for both differences in HIRDS data and at site data as well as the conversion from 24-hour depths to daily depths.

Table B-5 Ratios of at site 1% AEP daily storm depths to HIRDS 24-hour storm depths

Station name	Years of record	Ratio of 1% AEP at site daily depths to HIRDS 24-hour depths
Kaitaia	113	0.73
Kaitaia Ews	15	0.80
Kaitaia Aero	37	0.65
Kaitaia Aero Ews	13	0.87
Kaitaia Observatory	28	0.78
Waiharara	57	0.68
VCSN 20383	53	0.70
VCSN 20543	53	0.71
VCSN 20661	53	0.72

Average ratios for adjusting the HIRDS V3 24-hour storm depths to daily storm depths were calculated by weighting the ratios from the stations by the length of record. The weighted average using all the data is 0.719 and 0.724 and 0.710 for the rainfall station data and VCSN sites respectively. These ratios were factored by 1.14 (the factor for converting daily storm depths to 24-hour depths) giving a factor of 0.82, which compares well with the factor of 0.85 determined by analysis of the short datasets for stations with hourly rainfall data.

The results from Table B-5 indicate that the HIRDS V3 database may overestimate storm rainfall in the Awanui Catchment for all storm durations. On the basis of the longer records and location of rainfall stations used in the daily analysis it is recommended that a factor of 0.82 is applied to HIRDS V3 data.

B3 Assessment of historic storm rainfall

Significant storms in the region occurred in March 2003, July 2004 and January 2011. The rainfall recorded by the gauges at Te Rore, Kaitaia Ews, Kaitaia Aero Ews and Mangakawakawa during these events was accumulated to determine the 6 hour, 12-hour and 24-hour storm rainfall during these months. These rainfall depths together with the AEP estimated from the HIRDS V3 database and from analysis of the observed data at the gauges are summarised in Table B-6.

The summary results show the AEP estimated from the HIRDS database and from the at station analysis are generally similar for more frequent events even though the difference is significant at 1% AEP as shown in Section 3.2.

The AEP of these events varies with storm duration and location, which is as expected. The AEP of these storms varies from 5% to over 30%, which is much higher than the AEP of the largest flood recorded at School Cut that approached 1% AEP. This difference may be partly due to higher rainfall over the catchment than recorded at the rainfall station that are clustered around Kaitaia, but also demonstrates the low correlation between AEP of rainfall and runoff.

Table B-6 Summary of storm rainfall depths together with AEP from HIRDS and at station analysis

Station	Storm Date	Storm duration (hours)								
		6			12			24		
		Depth (mm)	AEP (%)		Depth (mm)	AEP (%)		Depth (mm)	AEP (%)	
			HIRDS	Gauge		HIRDS	Gauge		HIRDS	Gauge
Te Rore	Mar-03	-	-	-	-	-	-	-	-	-
	Jul-07	68.5	25%	20%	88.5	25%	25%	115.5	25%	20%
	Jan-11	83.5	10%	9%	109.0	10%	10%	116.0	25%	20%
Kaitaia Ews	Mar-03	72.3	20%	25%	89.2	20%	33%	157.3	6%	6%
	Jul-07	77.5	14%	20%	90.8	20%	33%	121.4	20%	25%
	Jan-11	89.0	6%	5%	117.3	6%	8%	125.0	20%	20%
Kaitaia Aero Ews	Mar-03	70.8	20%	25%	88.2	29%	33%	167.2	7%	10%
	Jul-07	44.4	67%	67%	67.4	67%	67%	96.0	67%	67%
	Jan-11	87.4	10%	13%	118.0	10%	14%	126.6	20%	10%
Mangakawakawa	Mar-03	70.5	33%	33%	96.0	33%	33%	106.5	67%	56%
	Jul-07	84.0	20%	20%	139.5	9%	5%	178.0	13%	7%
	Jan-11	83.5	20%	20%	127.0	13%	11%	139.0	33%	33%

The analysis results show that the AEP of these historic storms did not exceed 5%.

Appendix C: Site visit and geotechnical investigations

C1 Site visit notes

Here are the notes from the site visit to Kaitaia 16 July 2013. The purpose of the visit was twofold:

- To confirm BH locations
- To undertake general inspection of channels and stopbanks with NRC staff.

The inspection walkover was carried out in the company of Neville Wilson and Ron Fenwick from Northland Regional Council.

I have set out the observations for four different reaches of the river:

- Awanui
- Whangatane Spillway
- Tarawhataroa
- Waihoe Channel/Control Gate.

C1.1 Borehole Locations

Borehole locations were marked up based on observed bank conditions, and also ease of access for the drilling rigs. Overall we were seeking to get data from representative site across the whole scheme. These were discussed with Joe Camuso and Toby Kay from NRC, and agreed for these investigations. Data from these are included elsewhere.

Boreholes were drilled and logged by Geotechnics from 22 to 24 July 2013. A map of locations and the borehole logs are attached to these notes, together with site notes from the drilling team.

C1.2.1 Awanui

A much modified river as a result on many years of works in efforts to increase the hydraulic capacity to convey flood flows.

The stream banks are mostly modified and appear to be over steepened. The more recently modified banks being mainly grass covered and the older, perhaps original stream banks being vegetated with trees, some quite large.

Areas, mostly to the west of the river (town site), have added stopbanks of varying size and quality at the top of the bank. Some of the stopbanks are situated directly on top of the channel bank, whilst others are set further back.

There is a substantial base flow in the channel bed. This base flow appears to scour the toe of the channel banks and as a result general slumping of the banks is occurring.

There are more specific areas where more significant bed/toe scouring has occurred and resulted in minor land slips occurring in the bank.

Bends in the channel at the outside of meanders are also suffering from scouring with the resulting bank damage.

Most of the bed/toe scouring is treated with the placement of rock spalls.

In several locations a bench has been constructed mid-way down the banks, presumably seeking to buttress the slopes, but generally it appears that this has not been effective to reduce bank slumping and minor landslips.

The stopbanks appear to be constructed from local material (and probably sourced from stream bank excavation).

Access to the stopbanks is restricted/difficult in a number of places where they have been constructed directly against urban property boundaries.

The section of stream both up and down stream of the SH No 1 bridge is in poor condition and likely represents the original stream condition with little channel stabilisation work carried out over the years. Banks are near vertical in places, have significant erosion and slumping and are covered with significant amounts and sized vegetation. This gives poor hydraulic entry and exit conditions from this bridge reach.

The channel returns more to more stable natural stream below SH No 1 and through general farm land. Only a small section of this was inspected.

Overall the banks appear to be over steepened with a result of the general slumping and minor landslips.

There was no sign of any larger global instability as a result of the stream banks slope other than the known issues at the School Cut/Bells Hill reach east of the channel.

NRC staff advises that in most places the bed of the channel is close to a transition from clayey silts to soft grey weak silts and that is often where the bank failure starts. Extreme care is required when channel cleaning is being undertaken and does not provide good foundation conditions for walls, etc. The Geotechnical investigation will establish depths and strengths to the different soil layers.

C1.2.2 Whangatane Spillway

An open and wide man-made channel at the top end, at the distributary confluence with the Awanui River man channel.

Channel invert is significantly higher than that of the Awanui main channel, and the reach at the top end is dry under normal flow conditions.

Bank slopes are flat and grass covered, most of the channel is farmed.

There are small stopbanks on the western side which are mostly located on the adjoining farm land and farmed.

No slumping or land slips were observed.

The section of stopbank at the rear of the tri-board mill is very close to the rear of the building and work areas. However, this can be accessed from the channel side.

The lower sections of the stopbank forms part of farm land and has general deterioration from cattle access and isolated farm access points for plant and tractors etc.

I understand channel bank slopes do steepen up towards the outfall end.

Overall in good condition, with a conservative channel profiles and good hydraulic conditions and expected to be mostly easy to modify stopbank levels.

C1.2.3 Tarawhataroa

Very similar to the Awanui, being a much modified stream.

Stream banks and stopbanks are mainly grass.

Sections of the true right bank stream/stopbank close to SH No1 has recently been repaired with a tied back retaining structure. There are other isolated areas of bank damage on this stretch of the stream.

Major instability was observed on the slope up past the police station and adjoining residential flats. Recent stream work has been undertaken in this area and NRC staff advised that the work may have extended into the softer weak grey silts.

Apart from the above no other significant bank damage was observed.

Access to undertake any works in the lower reaches through the urban area is significantly restricted.

Urban services (sewer??) do cross the stream in places.

C1.2.4 Waihoe Channel/Control Gate

No much to observe here.

Area is likely swamp/ peat area.

Channel banks upstream of the gate appear to be in reasonable condition and stable.

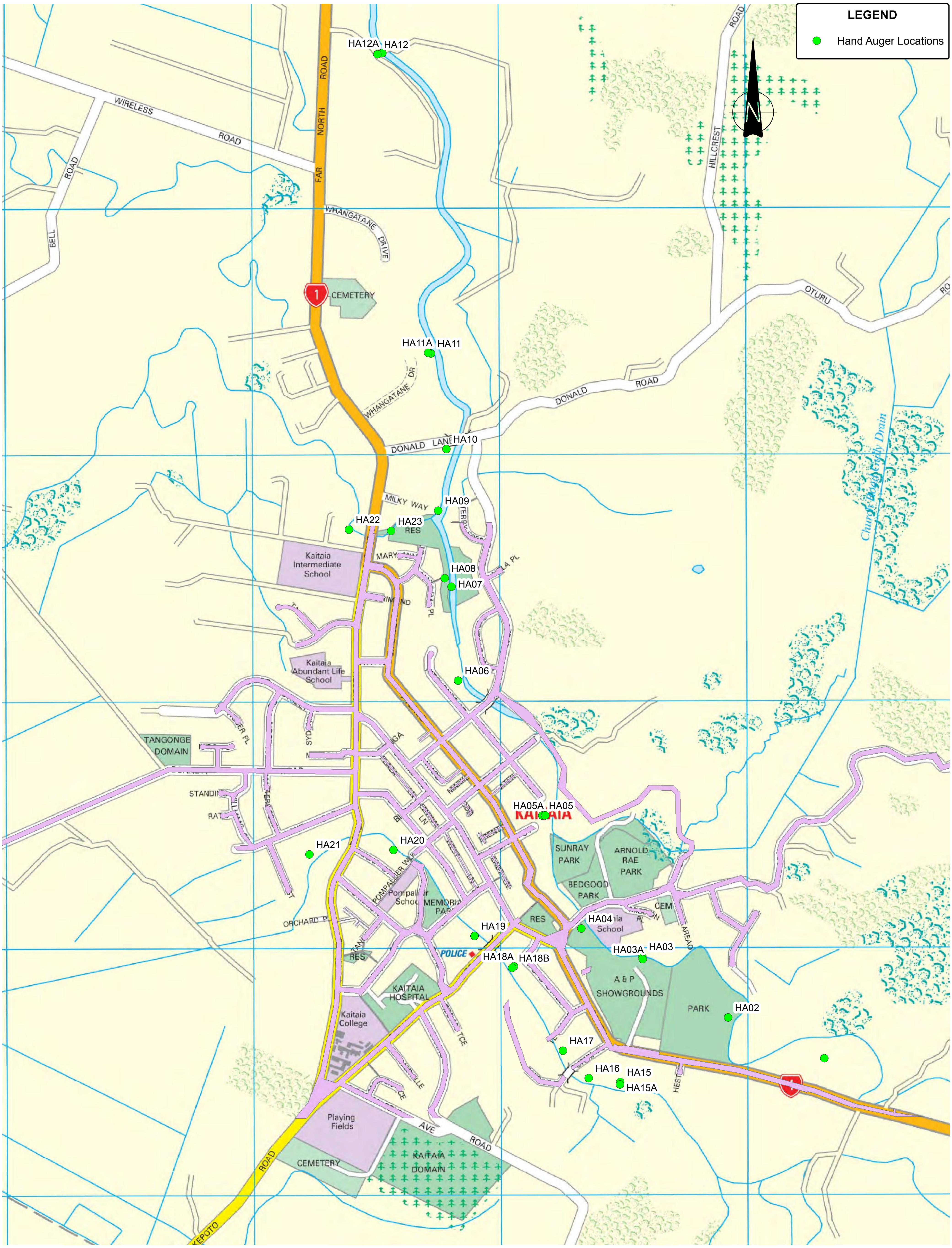
C1.3 Conclusions

Overall there are variable conditions throughout the sections of the Awanui Scheme. In the urban areas of Kaitaia there are space constraints which have probably limited scope for maintenance works in the past, and which will restrict access and space for upgrading of existing stopbanks.

Also in the urban areas, there are widespread bank stability issues readily observed through localised bank slumping and landslips. I noted that the general profile of the soils consists of sedimentary clays over softer marine deposits, and this has implications for excavating through the top layer and stability of the exposed slope. Past maintenance works have probably exposed this layer and led to some of the bank stability issues.

C2 Borehole locations

Path: P:\29154\29154.1000\WorkingMaterial\GIS\29154.Awanui.Overview.mxd Date: 9/04/2014 Time: 5:14:27 p.m.



Notes: Topo maps sourced from Terralink International
(Copyright 2002-2005-Terralink International Limited
and its licensors.

A3 SCALE 1:14,000

0 0.5 1 (km)

Tonkin & Taylor
Environmental and Engineering Consultants
105 Carlton Gore Road, Auckland
www.tonkin.co.nz

DRAWN	SSKK	Apr.14
CHECKED		
APPROVED		

ARCFILE
29154.Awanui.Overview.mxd
SCALE (AT A3 SIZE)
1:14,000
PROJECT No.
29154.100

NORTHLAND REGIONAL COUNCIL
AWANUI FLOOD SCHEME UPGRADE
GEOTECHNICAL INVESTIGATIONS
Hand Auger Locations

FIGURE No. Figure 1

Rev. 0

C3 Borehole log

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA01
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
R.L.:
DATUM:

DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 22/7/13
HOLE FINISHED: 22/7/13
DRILLED BY: Conrad/rbe
LOGGED BY: rbe
CHECKED:

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L (m)	DEPTH (m)	ENGINEERING DESCRIPTION GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
TOPSOIL		Hole dry on completion									ML	W	St				SILT, minor clay, low plasticity, wet, dark brown (topsoil)
						● 67/21kPa											
ALLLUVIUM											MC						clayey SILT, medium plasticity, wet, brown
						● 84/32kPa											
						● 101/44kPa							VSt				
									1								-brown mottled light grey
						● 116/53kPa					CL						silty CLAY, medium plasticity, wet, light grey mottled yellowish brown
						● 116/58kPa											
						● 124/63kPa											-abundant inclusions of rusty brown silt
									2		MC		H				clayey SILT, medium to low plasticity, wet, brown,with abundant inclusions of rusty brown silt
						● 207/82kPa											
						● >214kPa											
											ML		VSt				SILT, low plasticity, wet, brown, minor inclusions of clayey silt, grey
						● 185/82kPa											
											ML						SILT, minor clay, low plasticity, wet, brown
						● 149/64kPa			3								
						● 125/43kPa					MC						clayey SILT, low plasticity, wet, brown and grey
						● 110/37kPa											
													St				
						● 88/34kPa											
									4				VSt				
						● 108/34kPa											
																	END OF BOREHOLE 4.3m (target depth)
									5								
									6								
									7								

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA02
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood	LOCATION: Kaitaia	JOB No: 29154.100
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 22/7/13
	DRILL METHOD: HA	HOLE FINISHED: 22/7/13
R.L.:		DRILLED BY: Conrad/rbe
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
ALLUVIUM			MS	W	sandy SILT, non plastic, wet, brown
		58/14kPa 50/14kPa 73/21kPa	ML		SILT, minor fine sand, non plastic, wet, brown
		64/17kPa 99/24kPa 87/18kPa 98/17kPa 98/27kPa	MS		fine sandy SILT, non plastic, wet, brown -wet to saturated -dark grey
			SW		fine to medium SAND, loose, saturated, dark grey
	Water in/ level on completion	113/21kPa	SM		silty fine to medium SAND, saturated, dark grey
			SW	Sat	fine to medium SAND, loose, saturated, dark grey, becoming medium to coarse grained from 3.5m
		46/18kPa	MS		sandy SILT, low plasticity, saturated, dark grey
		44/20kPa	ML		SILT, trace fine sand, medium plasticity, wet, dark grey
		47/35kPa 93/34kPa	MC		clayey SILT, medium plasticity, wet, dark grey 4.3-4.35m: sandy SILT, non plastic, saturated, dark grey
		98/35kPa 70/32kPa	MCS	W	clayey SILT, sandy, medium plasticity, wet, grey
		59/43kPa	MC		clayey SILT, medium plasticity, wet, grey
					END OF BOREHOLE 5.6m (target depth)

T+T DATATEMPLATE.GDT RBE

Log Scale 1:32.5

BORELOG 616128.GPJ 30-Jul-2013

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA03
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
R.L.:
DATUM:

DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 22/7/13
HOLE FINISHED: 22/7/13
DRILLED BY: Conrad/rbe
LOGGED BY: rbe
CHECKED:

GEOLOGICAL										ENGINEERING DESCRIPTION							
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
ALLUVIUM											MS	W	F				sandy SILT, non plastic to friable, wet, brown; occasional layers of sand
						● 34/09kPa											
													S				
						● 24/11kPa											
						● 24/12kPa											
									1				F				
						● 37/24kPa					SM						fine to medium SAND, loose, wet, brown
						● 73/18kPa					MS		St				fine to medium sandy SILT, non plastic, wet, brown (=silty fine to medium SAND)
						● 78/20kPa											
									2								
						● 82/40kPa											
											SM	W/Sat					fine to medium SAND, loose, wet, brown
		Water in															
											SG						fine gravelly medium to coarse SAND, loose, wet, brown
						● 59/15kPa			3								
											MCS	Sat	St				clayey SILT, sandy, non plastic, saturated, dark bluish grey
		Water level on completion															
						● 53/24kPa											
						● 76/21kPa											
						● 59/21kPa											
									4								
											MS						fine sandy SILT, some clay, low plasticity, saturated, grey
						● 64/23kPa					SW						silty fine SAND, loose, saturated, grey
											SM						silty fine to coarse SAND, loose, saturated, grey
									5		GW						sandy fine GRAVEL, silty, loose, saturated, grey
											SW						fine to medium SAND, loose, grey
																	END OF BOREHOLE 5.2m (target depth)
									6								
									7								

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BOREHOLE LOG

BOREHOLE No:HA03A
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood | LOCATION: Kaitaia | JOB No: 29154.100

CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 25/7/13
HOLE FINISHED: 25/7/13
DRILL METHOD: HA
R.L.:
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL										ENGINEERING DESCRIPTION							
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
FILL AND ALLUVIUM		Hole dry on completion									MS	W	F				sandy SILT, non plastic, wet, dark brown
						● 37/12kPa											
						● 90/21kPa							St				
						● 119/29kPa			1				VSt				
						● 119/34kPa					ML						SILT, non plastic, wet, dark brown
						● 55/15kPa							St				
						● 81/24kPa			2								
						● 96/32kPa											
													VSt				-minor clay, low to no plasticity
						● 125/49kPa											
						● 120/43kPa			3								
																	END OF BOREHOLE 3.2m (target depth)
									4								
									5								
									6								
									7								

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA04
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 22/7/13
HOLE FINISHED: 22/7/13
DRILL METHOD: HA
R.L.:
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL
ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
ALLUVIUM											MC	W	VSt				clayey SILT, medium plasticity, wet, yellowish brown
											ML						SILT, some clay, low plasticity, wet, brown
						● 131/44kPa											
																	-dark brown and blackish brown
						● 131/37kPa											
									1		MC						clayey SILT, and SILT, low to medium plasticity, wet, light grey and rusty brown
						● 125/40kPa											
						● 151/55kPa											-medium plasticity, wet, light grey mottled yellowish orange brown
						● 116/55kPa											
									2								
						● 119/67kPa											
						● 140/53kPa											
																	-abundant inclusions of rusty silt
						● 171/64kPa					MC						clayey SILT, medium plasticity, wet, brown
						● 148/64kPa			3								
						● 149/56kPa											
						● 180/66kPa											
						● 98/32kPa					CL						silty CLAY, medium plasticity, wet, light brown
									4								
						● 104/34kPa					MC						clayey SILT, medium plasticity, wet, brown
						● >214kPa							St				
		Trace of water on completion				● >214kPa					ML						SILT, some clay, low to no plasticity, moist to wet, brown
									5								
						● 212/72kPa					MC						clayey SILT, low plasticity, wet, grey mottled brown
													VSt				
						● 197/61kPa											
																	END OF BOREHOLE 5.5m (target depth)
									6								
									7								

T+T DATATEMPLATE.GDT RBE

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA05
Hole Location: Refer to site maps

SHEET 1 OF 1

PROJECT: Awanui-Flood	LOCATION: Kaitaia	JOB No: 29154.100
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 22/7/13
		HOLE FINISHED: 22/7/13
R.L.:	DRILL METHOD: HA	DRILLED BY: Conrad/rbe
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED:

GEOLOGICAL										ENGINEERING DESCRIPTION							
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
FILL/ ALLUVIUM											ML	W	St				SILT, non plastic, wet, brown
						88/17kPa											
													H				
						>214kPa											
													VSt				
						180/44kPa			1								
						128/18kPa											
																	-low plasticity, brown with grey inclusions
						>211kPa							H				
						>211kPa											-low plasticity, brown
ALLUVIUM									2				VSt				
						162/72kPa											
						110/43kPa											-minor clay, trace fine sand, low to medium plasticity,
						111/49kPa											
						93/40kPa			3								
						122/52kPa											
																	-increasing sand
						98/32kPa					MS		St				sandy SILT, minor clay, low plasticity, wet to saturated, brown
						96/34kPa											
									4		MCS						clayey SILT, sandy, medium plasticity, wet, brown
													VSt				
		Hole dry on completion				124/37kPa					MSC						sandy SILT, clayey, low plasticity, wet, brown
											MS		St				fine to medium sandy SILT, low plasticity, wet, dark brown
						88/34kPa											
									5								
						73/47kPa											
																	END OF BOREHOLE 5.2m (target depth)
									6								
									7								

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA05A
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100
CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 22/7/13
HOLE FINISHED: 22/7/13
R.L.:
DRILL METHOD: HA
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	ENGINEERING DESCRIPTION SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
ALLUVIUM	W/L on compl.			MS	W	F	sandy SILT, non plastic, wet, brown
		31/08kPa					
	Water in	14/06kPa	1	MCS	Sat	S	clayey SILT, sandy, medium plasticity, saturated, brown
		58/09kPa				St	
		56/11kPa					
		37/09kPa					
			2			F	
		49/11kPa		MC			clayey SILT, medium plasticity, saturated, greyish brown
		46/15kPa					
		46/12kPa					
		52/14kPa	3	MCS			clayey SILT, sandy, medium plasticity, wet, grey
		47/21kPa					
		55/23kPa				St	
		78/27kPa	4				-dark grey
		64/27kPa		MS		F	fine to coarse sandy SILT, clayey, minor fine gravel, saturated, dark grey
		38/32kPa					
			5	SG			gravelly coarse SAND, loose, saturated, dark grey. Gravel is fine, angular
							END OF BOREHOLE 5.2m (target depth)
			6				
			7				

Other columns: FLUID LOSS, CORE RECOVERY (%), METHOD, CASING, SAMPLES, R.L (m), GRAPHIC LOG, SHEAR STRENGTH (kPa) 10 25 50 100 200, COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250, DEFECT SPACING (mm) 50 250 1000 2000

T+T DATATEMPLATE.GDT RBE

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA06
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood	LOCATION: Kaitaia	JOB No: 29154.100
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 22/7/13
R.L.:	DRILL METHOD: HA	HOLE FINISHED: 22/7/13 DRILLED BY: Conrad/rbe
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED:

GEOLOGICAL — ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour.
FILL/ ALLUVIUM		88/17kPa	ML	W	St	SILT, minor clay, non plastic, wet, brown
		70/23kPa 84/27kPa 81/37kPa	MC			clayey SILT, low to medium plasticity, wetl light greyish white -brown
		131/34kPa	MC		VSt	clayey SILT, medium plasticity, wet, grey and brown, fragment of rusty metal
ALLUVIUM			ML			SILT, non plastic, wet, brown
	Water in/ level on completion	142/31kPa 95/29kPa	MSC		St	sandy SILT, clayey, non plastic, wet, brown
		93/49kPa	MCS			clayey SILT, sandy, medium plasticity, wet, brown
		168/34kPa 110/47kPa	MC		VSt	clayey SILT, medium plasticity, wet, brown
		84/29kPa	MCS	Sat	St	clayey SILT, sandy, medium plasticity, saturated, brown
			MS			sandy SILT, minor clay, low plasticity, saturated, brown
		59/31kPa 64/37kPa 69/27kPa	MCS			clayey SILT, sandy, medium plasticity, saturated, grey
			SM			silty fine to medium SAND, loose, saturated, dark grey -inclusions of decomposed wood at 4.9m -light brown with organic fragments
			SM			silty fine to medium SAND, sautrated, dark grey
						END OF BOREHOLE 6.2m (target depth)

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA07
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100
CO-ORDINATES:
R.L.:
DATUM:
DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:
HOLE STARTED: 23/7/13
HOLE FINISHED: 23/7/13
DRILLED BY: Conrad/rbe
LOGGED BY: rbe
CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
ALLUVIUM			0	ML	W	S/F	sandy SILT, non plastic, wet, dark brown
		● 26/12kPa ● 18/12kPa ● 67/17kPa ● 26/18kPa	1				-minor clay
		● 53/15kPa ● 55/17kPa	2	MCS		St	clayey SILT, sandy, low plasticity, wet, brown
		● 55/23kPa ● 52/32kPa ● 69/40kPa	3				fine sandy SILT, non plastic, wet, brown
	Water in and level on completion ▼		4	SM			fine to medium silty SAND, loose, wet, brown
					Sat		-saturated
		● 53/27kPa		MS		St	fine sandy SILT, saturated, dark grey
		● 27/17kPa	5			F	-occasional pieces of wood
				SM			fine to medium SAND, saturated, grey
				SG			fine gravelly coarse SAND, saturated, grey
			6				**END OF BOREHOLE 5.8m (poor recovery, target depth)**
			7				

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA08
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
R.L.:
DATUM:

DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 23/7/13
HOLE FINISHED: 23/7/13
DRILLED BY: Conrad/rbe
LOGGED BY: rbe
CHECKED:

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	ENGINEERING DESCRIPTION SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
ALLUVIUM		● 87/23kPa		ML	W	St	SILT, minor sand, non plastic, wet, brown
		● 119/24kPa		ML		VSt	SILT, minor clay, low to no plasticity, wet, brown
		● 140/52kPa	1				
						St	
		● 61/24kPa					
		● 67/27kPa		MC	W/Sat		clayey SILT, trace fine sand, wet to saturated, brown
		● 61/21kPa	2				-low to medium plasticity
		● 64/27kPa					
		● 79/21kPa					
		● 85/29kPa	3	MCS	W		clayey SILT, sandy, low plasticity, wet, brown
		● 73/35kPa					
		● 67/29kPa					
		● 59/23kPa	4				
		● 55/29kPa					
				MC	Sat		clayey SILT, medium plasticity, wet to saturated, brown
		● 61/29kPa		MS			sandy SILT, non plastic, saturated, brown
						F	
	Water level on completion ▼	● 44/18kPa	5				
				SM			silty fine to medium SAND, saturated, brownish grey
							-dark grey
			6				
			7				END OF BOREHOLE 6.2m (target depth)

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA09
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood	LOCATION: Kaitaia	JOB No: 29154.100
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 23/7/13
R.L.:	DRILL METHOD: HA	HOLE FINISHED: 23/7/13 DRILLED BY: Conrad/rbe
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED:

GEOLOGICAL — GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

ENGINEERING DESCRIPTION — SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

Columns: FLUID LOSS, WATER, CORE RECOVERY (%), METHOD, CASING, TESTS, SAMPLES, R.L. (m), DEPTH (m), GRAPHIC LOG, CLASSIFICATION SYMBOL, MOISTURE / WEATHERING CONDITION, STRENGTH/DENSITY CLASSIFICATION, SHEAR STRENGTH (kPa) 10 25 50 100 200, COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 200, DEFECT SPACING (mm) 20 200 1000 2000

GEOLOGICAL UNIT	WATER	TESTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
ALLUVIUM	W/L on compl.		ML	W	F	SILT, non plastic, wet, dark brown
		● 31/06kPa	CL			silty CLAY, medium plasticity, wet, light brown
		● 52/06kPa	OL		St	organic SILT, peaty, black, with wood
		● 61/03kPa	OL	Sat		organic SILT, low plasticity, saturated, greyish brown
		● 52/14kPa ● 32/15kPa	MCS		F	clayey SILT, sandy, medium plasticity, wet, light grey
			SW			coarse SAND, loose to well packed, saturated, brown and rusty brown; silty from 2.5m
		● 31/12kPa ● 76/43kPa	SM			silty fine to medium SAND, clayey, low plasticity, saturated, light grey
			MSC			sandy SILT, clayey, saturated, greenish grey
		● 122/52kPa ● 76/38kPa	MS			silty fine to medium SAND, saturated, light grey
			SG	W	VSt St	fine gravelly SILT, some sand, low plasticity, wet, light grey

DEPTH (m): 1, 2, 3, 4, 5, 6, 7

END OF BOREHOLE 6m (target depth)

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA10
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood	LOCATION: Kaitaia	JOB No: 29154.100
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 23/7/13
		HOLE FINISHED: 23/7/13
R.L.:	DRILL METHOD: HA	DRILLED BY: Conrad/rbe
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION. | FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASING | TESTS | SAMPLES | R.L (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATION SYMBOL | MOISTURE CONDITION / WEATHERING | STRENGTH/DENSITY CLASSIFICATION | SHEAR STRENGTH (kPa) 10 25 50 100 200 | COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250 | DEFECT SPACING (mm) 50 250 1000 2000

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.
ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

FILL AND ALLUVIUM

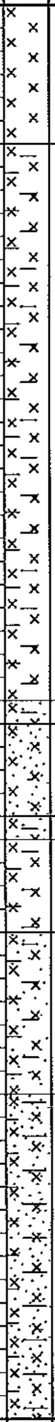
ALLUVIUM

Water in

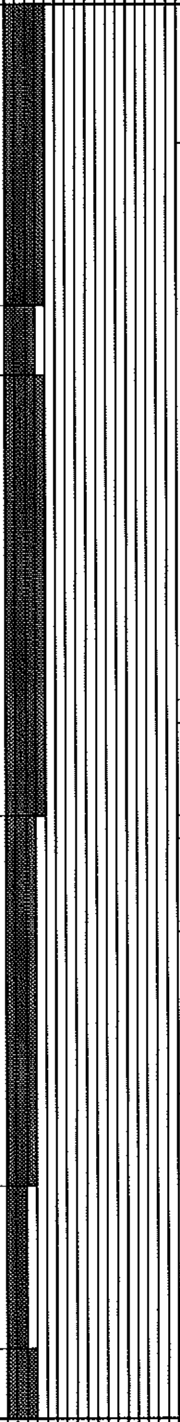
W/L on compl.

Tests:
- ● 159/58kPa
- ● 172/72kPa
- ● 136/52kPa
- ● 156/69kPa
- ● 90/41kPa
- ● 136/58kPa
- ● 151/52kPa
- ● 153/52kPa
- ● 153/43kPa
- ● 127/41kPa
- ● 76/17kPa
- ● 88/29kPa
- ● 88/23kPa
- ● 75/21kPa
- ● 52/14kPa
- ● 40/21kPa
- ● 53/29kPa

Depth (m): 1, 2, 3, 4, 5, 6, 7



CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY	SOIL DESCRIPTION
ML	W	VSt	SILT, non plastic, wet, brown -inclusions of clayey SILT, wet, brown and grey
MC			clayey SILT, medium plasticity, wet, grey and brown -low plasticity
		St	-mottled yellowish brown and rusty brown
		VSt	-low to no plasticity, wet, brown mottled grey, with inclusions of rusty silt
MC			clayey SILT, sandy, low plasticity, wet, brown
MS	W/Sat		sandy SILT, some clay, non plastic, wet to saturated, brown
MCS		St	clayey SILT, sandy, medium plasticity, saturated, brown
MC	Sat		clayey SILT, medium plasticity, saturated, greyish brown
MCS			clayey SILT, sandy, medium plasticity, saturated, greyish brown
MSC			sandy SILT, clayey, low plasticity, saturated, brownish grey
		F	
		St	



END OF BOREHOLE 6.1m (target depth)

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA11
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood	LOCATION: Kaitaia	JOB No: 29154.100
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 23/7/13
	DRILL METHOD: HA	HOLE FINISHED: 23/7/13
R.L.:		DRILLED BY: Conrad/rbe
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED:

GEOLOGICAL — GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

ENGINEERING DESCRIPTION — SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

GEOLOGICAL UNIT	WATER	TESTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
FILL	Slight inflow		MC	W	St	clayey SILT, low plasticity, wet, brown and yellowish brown, with inclusions of silt
ALLUVIUM		52/09kPa	MC			clayey SILT, low plasticity, wet, light brown mottled orange brown
		95kPa	ML			SILT, non plastic, wet to saturated, brown
		98/15kPa 162/31kPa 142/63kPa	MC		VSt	clayey SILT, low plasticity, wet, brown mottled light grey
			ML			SILT, some clay, low plasticity, wet, brown
		81/17kPa	MSC	Sat	St	sandy SILT, clayey, low plasticity, saturated, brown, occasional grey clayey bands
		92/14kPa	MC			clayey SILT, medium plasticity, wet, brown, with grey clayey bands
		98/18kPa 85/24kPa	MS			sandy SILT, non plastic, saturated, brown and grey -brownish grey -grey
		101/34kPa	MC	W		clayey SILT, medium plasticity, wet, grey
		56/23kPa	MCS			clayey SILT, sandy, medium plasticity, wet, grey
		156/23kPa 201/63kPa	MS	Sat	VSt St	sandy SILT, non plastic, saturated, grey
		81/20kPa	MS			sandy SILT, minor clay, low plasticity, saturated, grey
			MS			sandy SILT, non plastic, saturated, grey
			MS		F	sandy SILT, minor clay, saturated, grey
	Hole dry on completion	32/17kPa	MC			clayey SILT, medium plasticity, saturated, grey

END OF BOREHOLE 5.2m (target depth)

T+T DATATEMPLATE.GDT RBE

Log Scale 1:32.5

BORELOG 616128.GPJ 30-Jul-2013

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA11A
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
R.L.:
DATUM:

DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 25/7/13
HOLE FINISHED: 25/7/13
DRILLED BY: Conrad/rbe
LOGGED BY: rbe
CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
FILL		Hole dry on completion				● 104/34kPa ● 105/34kPa ● 95/40kPa			1		MC	W	VSt				clayey SILT, low plasticity, wet, light brown and yellowish brown -yellowish brown and light greyish white -inclusions of silt, dark brown
						● 52/15kPa ● 110/37kPa			2		MC		St VSt				clayey SILT, medium plasticity, wet, light brown and yellowish brown
ALLUVIUM						● 125/58kPa ● 151/70kPa ● 134/67kPa ● 113/46kPa			3		MC						clayey SILT, medium plasticity, wet, light brown mottled orange brown -low plasticity, minor light grey mottles
									4 5 6 7								**END OF BOREHOLE 3.1m (target depth)**

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA12
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100
CO-ORDINATES:
R.L.:
DATUM:
DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:
HOLE STARTED: 23/7/13
HOLE FINISHED: 23/7/13
DRILLED BY: Conrad/rbe
LOGGED BY: rbe
CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
FILL					W	VSt	GRAVEL, angular, medium to coarse, grey
		● 139/46kPa		MC			clayey SILT, low plasticity, wet, yellowish brown, light grey and brown
		● 99/38kPa				St	-inclusion of silt
		● 90/37kPa	1				-yellowish brown mottled light grey
		● 85/31kPa		ML			SILT, minor clay, trace sand, low plasticity, wet, brown and light grey
ALLUVIUM		● 85/31kPa		MC		VSt	clayey SILT, low plasticity, wet, grey and brown with rusty inclusions
		● 157/53kPa	2	ML			SILT, some clay, low plasticity, wet, rusty brown with grey mottles
		● 197/72kPa		MC			clayey SILT, and SILT, low plasticity, wet, light grey mottled rusty brown
		● 165/73kPa ● 156/64kPa	3	ML			SILT, non plastic, wet, rusty brown, with inclusions of clayey silt, grey
		● 151/69kPa		MC			clayey SILT, low plasticity, wet, brown and grey
		● 78/34kPa		MC		St	clayey SILT, medium plasticity, wet, light grey and brown
	Water in ▶	● 69/31kPa ● 82/38kPa	4	CL			CLAY, medium plasticity, wet, bluish grey
			5 6 7				**END OF BOREHOLE 4.2m (target depth and lithology)**

SHEAR STRENGTH (kPa): 10 25 50 100 200
COMPRESSIVE STRENGTH (MPa): 1 5 20 50 100 250
DEFECT SPACING (mm): 50 250 1000 2000

ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA12A
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100
CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 23/7/13
HOLE FINISHED: 23/7/13
DRILL METHOD: HA
R.L.:
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE / WEATHERING CONDITION	STRENGTH/DENSITY CLASSIFICATION	ENGINEERING DESCRIPTION SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
ALLUVIUM		W/L on compl.				● 70/17kPa ● 168/63kPa				ML	W	St	SILT, non plastic, wet, brown -minor fine gravel
						● 75/26kPa				MC			clayey SILT, medium plasticity, wet, light brownish grey
		Water in				● 70/31kPa ● 53/14kPa			1	CL			CLAY, medium plasticity, wet, light brown mottled rusty brown, yellowish orange from 1.1m -light grey and orange brown -light brown
						● 50/09kPa ● 41/17kPa			2	MC	Sat	F	clayey SILT, medium plasticity, saturated, brown
ESTUARINE SEDIMENT?						● 24/11kPa ● 21/11kPa ● 15/09kPa ● 29/12kPa ● 20/12kPa ● 21/12kPa ● 27/11kPa ● 21/12kPa ● 20/09kPa			3 4 5	MC		S	clayey SILT, medium to high plasticity, saturated, grey. Vane sinking under own weight -trace sand from 4.2m
									6 7				**END OF BOREHOLE 5.5m (target depth)**

SHEAR STRENGTH (kPa): 10 25 50 100 200
COMPRESSIVE STRENGTH (MPa): 1 5 20 50 100 250
DEFECT SPACING (mm): 50 250 1000 2000

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA13
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood	LOCATION: Kaitaia	JOB No: 29154.100
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 24/7/13
		HOLE FINISHED: 24/7/13
R.L.:	DRILL METHOD: HA	DRILLED BY: Conrad/rbe
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED:

GEOLOGICAL — ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
FILL						● 82/24kPa ● 75/21kPa				ML	W	St				SILT, some clay, low plasticity, wet, brown; with inclusions of clayey SILT, low plasticity, wet, yellowish brown and light grey
BURIED TOPSOIL						● 171/55kPa				ML		VSt				SILT, non plastic, wet, dark brown
ALLUVIUM		Water in / level on completion				● 201/64kPa ● 172/61kPa ● 145/55kPa ● 122/50kPa ● 136/61kPa ● 133/44kPa ● 104/44kPa ● 110/55kPa ● 139/50kPa ● 120/43kPa			1 2 3 4	MC						clayey SILT, medium plasticity, wet, yellowish brown mottled light grey --low plasticity, light greyish brown mottled rusty brown, with abundant rusty inclusions -brown, with grey clayey seams -low to medium plasticity -greyish brown
ESTUARINE SEDIMENT?						● 40/21kPa ● 24/08kPa ● 34/15kPa ● 27/06kPa			5	MC	Sat	F				clayey SILT, low plasticity, saturated, grey. Vane sinking under own weight
									6 7							**END OF BOREHOLE 5.2m (target depth)** Vane pushed readily to 6m

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA14
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 24/7/13
HOLE FINISHED: 24/7/13
DRILL METHOD: HA
R.L.:
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	ENGINEERING DESCRIPTION SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
FILL						63/14kPa				MC	W	St	clayey SILT, medium plasticity, wet, yellowish brown and light greyish white, with inclusions of silt, brown
						84/27kPa				MC			clayey SILT, medium plasticity, wet, light brown
						96/27kPa 85/24kPa			1	MC			clayey SILT, medium plasticity, wet, yellowish brown and brown -inclusions of topsoil -low plasticity, light brown
BURIED TOPSOIL						116/17kPa 40/15kPa 88/18kPa			2	ML			SILT, some organics, non plastic, wet, dark brown
ALLUVIUM						119/53kPa			3	MC			clayey SILT, medium plasticity, wet, greyish brown, with rusty mottles -light grey with rusty brown mottles
										ML			SILT, non plastic to friable, wet, dark greyish brown
						99/55kPa 59/17kPa				CL			silty CLAY, medium plasticity, wet, light greyish white mottled rusty brown and black
ESTUARINE SEDIMENT						52/23kPa 56/43kPa			4	MC			clayey SILT, medium plasticity, wet, blackish brown, with rootlets -blackish grey with rootlets -blackish dark grey, with vertical 5mm dia. roots
		W/L on completion				52/23kPa 32/20kPa			5	MCS		F	clayey SILT, sandy, medium plasticity, wet, dark grey
						32/14kPa				MS			sandy SILT, low plasticity, saturated, grey
									6 7				**END OF BOREHOLE 5.6m (target depth)** Vane pushed easily to 6m

Other column headings: GRAPHIC LOG; SHEAR STRENGTH (kPa); COMPRESSIVE STRENGTH (MPa); DEFECT SPACING (mm)

T+T DATATEMPLATE.GDT RBE

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA15
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 25/7/13
HOLE FINISHED: 25/7/13
DRILL METHOD: HA
DRILLED BY: Conrad/rbe
R.L.:
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
FILL		Hole dry on completion								ML	W	VSt	SILT, minor fine sand, non plastic, wet, dark brown
						● 165/43kPa ● 160/52kPa ● 149/24kPa				MS			fine to medium sandy SILT, non plastic, wet, yellowish brown
									1	SW			fine to medium SAND, minor silt, friable, wet, yellow and light grey
						● 64/21kPa				MS		St	fine to medium sandy SILT, non plastic, wet, yellowish brown
						● 134/82kPa			2	MCS		VSt	clayey SILT, sandy, low plasticity, wet, yellowish brown
										MC			clayey SILT, medium plasticity, wet, yellowish brown and light grey
										MS			sandy SILT, minor clay, non plastic, wet, yellowish brown, minor grey inclusions
						● 183/52kPa				ML			SILT, non plastic, moist to wet, grey (crushed siltstone?)
										ML			SILT, minor clay, minor sand, non plastic, wet, yellowish brown
										MC		St	clayey SILT, low plasticity, wet, yellowish brown and grey
						● 67/32kPa			3	MS		VSt	sandy SILT, minor clay, low to no plasticity, wet, grey
ALLUVIUM						● 207/107kPa ● 122/70kPa				MC			clayey SILT, medium plasticity, wet, brown mottled light grey

END OF BOREHOLE 3.5m (target lithology)

Log Scale 1:32.5

T+T DATATEMPLATE.GDT RBE

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA15A
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
R.L.:
DATUM:

DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 25/7/13
HOLE FINISHED: 25/7/13
DRILLED BY: Conrad/rbe
LOGGED BY: rbe
CHECKED:

GEOLOGICAL: GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

ENGINEERING DESCRIPTION: SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

Column headings: FLUID LOSS; WATER; CORE RECOVERY (%); METHOD; CASING; TESTS; SAMPLES; R.L. (m); DEPTH (m); GRAPHIC LOG; CLASSIFICATION SYMBOL; MOISTURE CONDITION / WEATHERING; STRENGTH/DENSITY CLASSIFICATION; SHEAR STRENGTH (kPa) 10 25 50 100 200; COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250; DEFECT SPACING (mm) 60 250 1000 2000

GEOLOGICAL	WATER	TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
FILL				MC	W	VSt	clayey SILT, low plasticity, wet, brown mottled light grey
ALLUVIUM		● 131/23kPa ● 156/37kPa		ML			SILT, non plastic, wet, dark brown
		● 140/46kPa		ML			SILT, minor clay, low plasticity, wet, light brown
	Void/ water inflow	● 125/53kPa ● 140/32kPa	1	MC			clayey SILT, low plasticity, wet, light brown mottled light grey -some black oxide inclusions
				ML		St	SILT, some clay, low plasticity, wet, brown
		● 52/03kPa	2	MC			clayey SILT, low plasticity, wet, brown mottled light grey
		● 46/14kPa		CH			silty CLAY, high plasticity, wet, dark brown and light grey
		● 168/61kPa ● 67/17kPa		MC		VSt St	clayey SILT, low plasticity, wet, dark brown and light grey
		● 108/31kPa	3	CH		VSt	CLAY, medium plasticity, wet, grey, with inclusions of dark brown silt
				CH	Sat		CLAY, high plasticity, saturated, dark grey
		● 113/43kPa ● 79/23kPa ● 56/17kPa	4	CH	W	St	silty CLAY, medium plasticity, wet, dark grey and greenish grey
	W/L on completion	● 73/17kPa ● 44/17kPa ● 46/21kPa	5	CH	W	F	CLAY, high plasticity, wet, dark grey
		● 43/14kPa ● 44/14kPa	6	CH			silty CLAY, trace fine sand, medium to high plasticity, wet, dark grey
							END OF BOREHOLE 6m (target depth)
			7				

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA16
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100
CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 25/7/13
HOLE FINISHED: 25/7/13
DRILL METHOD: HA
R.L.:
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

Geological unit	Water	Tests	Classification symbol	Moisture condition	Strength/density classification	Soil description
FILL		142/27kPa	ML	W	VSt	SILT, non plastic, wet, dark brown
		56/08kPa 67/09kPa 78/24kPa	MS		St	sandy SILT, non plastic, wet, yellowish brown
		67/24kPa 66/15kPa 84/32kPa	MC			clayey SILT, low to no plasticity, wet, yellowish brown and brown
ALLUVIUM			ML			SILT, minor clay, low plasticity, wet, brown
		85/41kPa	MC			clayey SILT, low plasticity, wet, brown with grey inclusions
		>214kPa			H	-greyish brown with grey mottles
		162/98kPa 143/70kPa 88/49kPa 120/47kPa			VSt	-light grey mottled brown
			CL			silty CLAY, medium plasticity, wet, light grey mottled brown
	Hole dry on completion	140/56kPa 159/69kPa 105/38kPa 116/40kPa	MC			clayey SILT, medium to low plasticity, wet, light brown mottled light grey

END OF BOREHOLE 5.2m (target depth)

T+T DATATEMPLATE.GDT RBE

Log Scale 1:32.5

BORELOG 616128.GPJ 30-Jul-2013

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA17
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood	LOCATION: Kaitaia	JOB No: 29154.100
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 25/7/13
		HOLE FINISHED: 25/7/13
R.L.:	DRILL METHOD: HA	DRILLED BY: Conrad/rbe
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION (Soil type, minor components, plasticity or particle size, colour.) ROCK DESCRIPTION (Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.)
FILL						● 142/41kPa				ML	W	VSt	SILT, non plastic, wet, dark brown -minor fine gravel, inclusions of clayey silt, yellowish brown and light grey
						● 78/29kPa ● 154/64kPa ● 166/52kPa ● 119/49kPa ● 63/15kPa			1 2	ML		St VSt St	SILT, minor clay, low to no plasticity, wet, brown, with yellowish brown and light grey clayey inclusions
ALLUVIUM						● 134/75kPa ● 101/38kPa ● 102/55kPa			3	MC		VSt	clayey SILT, low plasticity, wet, brown and light grey -brown and grey -medium plasticity, wet, grey; grey mottled brown from 3.2m
						● 43/26kPa				CH		F	CLAY, high plasticity, wet, dark grey
		Water in				● 29/15kPa				MS	Sat		sandy SILT, low plasticity, saturated, dark grey. Sand is fine to medium grained
						● 70/18kPa			4	MCS			clayey SILT, sandy, saturated, dark grey
										MC	W		clayey SILT, medium plasticity, wet, dark grey
		W/L on compl.				● 49/26kPa				CH			silty CLAY, medium plasticity, wet, grey
						● 69/29kPa ● 79/38kPa ● 58/32kPa			5	CH		St	CLAY, medium plasticity, wet, brown mottled light grey
									6 7				**END OF BOREHOLE 5.2m (target depth)**

SHEAR STRENGTH (kPa) | COMPRESSIVE STRENGTH (MPa) | DEFECT SPACING (mm)

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA18A
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood	LOCATION: Kaitaia	JOB No: 29154.100
CO-ORDINATES:	DRILL TYPE: 50mm hand auger	HOLE STARTED: 25/7/13
	DRILL METHOD: HA	HOLE FINISHED: 25/7/13
R.L.:		DRILLED BY: Conrad/rbe
DATUM:	DRILL FLUID:	LOGGED BY: rbe CHECKED:

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	ENGINEERING DESCRIPTION SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
FILL						● 64/17kPa				ML	W	St	SILT, some clay, low plasticity, wet, brown, with inclusions of clayey silt, medium plasticity, wet, yellowish brown
						● 182/52kPa						VSt	
						● 186/58kPa			1				
						● 166/47kPa							
						● 174/46kPa				MC			clayey SILT, medium plasticity, wet, brown, with light grey seams, and inclusions of dark brown silt
ALLUVIUM						● 116/37kPa				ML			SILT, minor clay, non plastic, wet, brown, with occasional grey inclusions
						● 191/61kPa			2				
		Hole dry on completion				● 53/24kPa						St	-low plasticity, wet, grey mottled brown
						● 59/32kPa				ML			SILT, minor clay, medium plasticity, wet, grey, minor organic inclusions
						● 53/15kPa			3				
													END OF BOREHOLE 3.1m (target depth)
									4				
									5				
									6				
									7				

SHEAR STRENGTH (kPa): 10 25 50 100 200
COMPRESSIVE STRENGTH (MPa): 1 5 20 50 100 200
DEFECT SPACING (mm): 20 250 1000 2000

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA18B
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100
CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 25/7/13
HOLE FINISHED: 25/7/13
R.L.:
DRILL METHOD: HA
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL										ENGINEERING DESCRIPTION						
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa)	COMPRESSIVE STRENGTH (MPa)	DEFECT SPACING (mm)	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
FILL						● 40/15kPa					ML	W	F				SILT, non plastic, wet, brown, with minor inclusions of clayey SILT, low plasticity, wet, yellowish brown
ALLUVIUM						● 133/44kPa ● 85/35kPa			1		ML		VSt St				SILT, minor clay, non plastic, wet, dark grey -some grey mottles
		Water in				● 93/35kPa ● 63/24kPa					MC	W/Sat					clayey SILT, medium plasticity, wet, brown and grey -wet to saturated, dark grey mottled brown; dark grey from 1.5m -buried log: moved 0.5m and recommenced
		W/L on completion				● 37/21kPa ● 41/17kPa ● 40/17kPa			2		MC	Sat	F				clayey SILT, medium plasticity, saturated, dark grey
						● 47/15kPa ● 56/24kPa			3		CH		St				silty CLAY, high plasticity, saturated, dark grey
						● 73/11kPa					MC						clayey SILT, sandy, saturated, grey. Sand is angular, medium to coarse grained -fragments of decomposed wood
						● 61/14kPa					CH						CLAY, medium plasticity, saturated, dark grey
									4		MC						clayey SILT, medium plasticity, saturated, dark grey, minor organic fragments
						● 43/17kPa ● 52/24kPa ● 35/21kPa ● 44/18kPa			5		CH	W	F				CLAY, high plasticity, wet, dark grey
									6 7								**END OF BOREHOLE 5.2m (target depth)**

T+T DATATEMPLATE.GDT RBE

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA19
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100
CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 25/7/13
HOLE FINISHED: 25/7/13
DRILL METHOD: HA
R.L.:
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
ALLUVIUM		102/26kPa 117/32kPa 76/27kPa		ML	W	VSt St	SILT, some clay, non plastic, wet, brown -inclusions of clayey SILT, yellowish brown
		79/24kPa	1	CL			silty CLAY, medium plasticity, wet, yellowish brown and brown
	Water in/ level on completion	82/24kPa 90/34kPa 104/32kPa	2	MC			clayey SILT, medium plasticity, wet, light greyish white mottled brown
				CL			silty CLAY, medium plasticity, wet, light brownish grey
		08kPa 41/06kPa	3	MC	Sat	VS S	SILT, non plastic, saturated, dark brown, with organic fragments and inclusions of decomposed wood
		21/08kPa 29/12kPa		CH			silty CLAY, high plasticity, saturated, grey
		24/12kPa		MC			clayey SILT, low to medium plasticity, saturated, brown, with organic fragments (paleosol?)
		17/09kPa	4	CH			CLAY, high plasticity, saturated, grey, with minor organic fragments
MARINE OR ALLUVIUM		24/06kPa		MC			clayey SILT, trace fine sand, medium to high plasticity, saturated, grey
		14kPa	5	MS			sandy SILT, non plastic, saturated, dark grey
		21/05kPa		MC			clayey SILT, trace sand, high plasticity, saturated, grey. Vane sinks under own weight
				MCS			clayey SILT, sandy, low plasticity, saturated, grey
		47/14kPa 24/08kPa		MSC			sandy SILT, clayey, low plasticity, saturated, dark grey
		31/12kPa	6 7	MC		F	clayey SILT, sandy, low plasticity, saturated, dark grey **END OF BOREHOLE 6.3m (target depth)**

Log Scale 1:32.5

T+T DATATEMPLATE.GDT RBE

BORELOG 616128.GPJ 30-Jul-2013

TONKIN & TAYLOR LTD

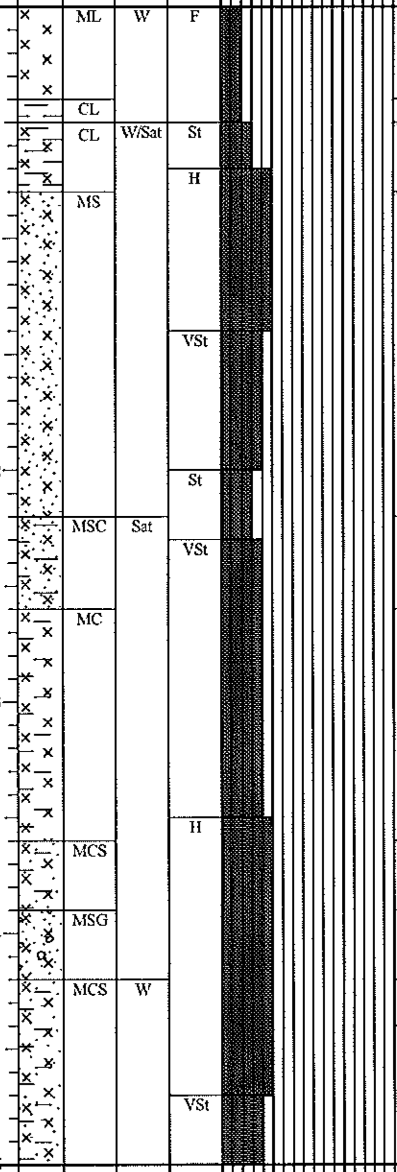
BOREHOLE LOG

BOREHOLE No:HA20
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100
CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 24/7/13
HOLE FINISHED: 24/7/13
R.L.:
DRILL METHOD: HA
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL | ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
TOPSOIL						40/14kPa				ML	W	F	SILT, non plastic, wet, brown
WEATHERED OLDER ALLUVIUM										CL			CLAY, medium plasticity, wet, yellowish brown mottled light greyish white
						82kPa				CL	W/Sat	St H	silty CLAY, minor gravel, medium plasticity, wet to saturated, light greyish white
		Water in/ level on completion				>214kPa UTP 174/29kPa 133/21kPa			1 2	MS		VSt St	sandy SILT, non plastic, wet to saturated, yellowish brown. Sand is fine to medium grained
						55/15kPa				MSC	Sat	VSt	sandy SILT, clayey, low plasticity, saturated, yellowish brown; brown with fine gravel from 2.3m
						146/31kPa 134/31kPa 197/15kPa			3	MC			clayey SILT, trace fine sand, abundant weathered fine gravel -occasional hard less weathered gravel
						UTP				MCS		H	clayey SILT, sandy, abundant weathered fine gravel, low plasticity, wet, yellowish brown. Sand is fine to coarse grained
						UTP			4	MSG			sandy SILT gravelly, non plastic, wet, yellowish brown
						>214/69kPa				MCS	W		clayey SILT, sandy, abundant fine gravel, non plastic, wet, yellowish brown and orange brown, difficult to auger. Sand is fine to coarse grained
						183/31kPa			5			VSt	clayey SILT, sandy, light grey mottled rusty brown, with inclusions of hard fine gravel; grey with purplish mottles from 4.7m
									6 7				**END OF BOREHOLE 5m (target depth)**



TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA21
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 24/7/13
HOLE FINISHED: 24/7/13
R.L.:
DRILL METHOD: HA
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL

ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
FILL		55/11kPa	ML	W	St	SILT, non plastic, wet, brown, with inclusions of yellowish brown clay from 0.3m
ALLUVIUM		55/08kPa 76/21kPa	ML		VSt	SILT, non plastic, wet, brown
		113/43kPa	ML			SILT, minor sand and clay, low plasticity, wet, brown
			MC			clayey SILT, low plasticity, wet, brown
		133/61kPa 128/58kPa 133/69kPa	CL			silty CLAY, medium plasticity, wet, light yellowish brown mottled light grey
		116/59kPa 146/58kPa 125/44kPa	MC			clayey SILT, medium to low plasticity, wet, light greyish white mottled yellowish brown -low plasticity, orange brown
	Water level on completion	88/31kPa 72/27kPa	CL	Sat	St	silty CLAY, trace sand, medium plasticity, wet, light greyish white mottled yellowish brown -saturated
		79/27kPa	MCS			clayey SILT, sandy, medium plasticity, saturated, greyish brown
		85/43kPa 47/31kPa 40/21kPa	CL		F	silty CLAY, medium plasticity, saturated, grey with rusty mottles
		59/17kPa	MSC		St	sandy SILT, clayey, low plasticity, saturated, brownish grey
		63/17kPa	MC			clayey SILT, low plasticity, saturated, yellowish brown
			MS			sandy SILT, non plastic, saturated, brown
		43/15kPa	MCS			clayey SILT, sandy, low plasticity, saturated, brown; light grey from 5.9m
		182/56kPa	MS		VSt	fine to medium sandy SILT, non plastic, wet, grey
						END OF BOREHOLE 6.2m (target depth)

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA22
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100
CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 23/7/13
HOLE FINISHED: 23/7/13
R.L.:
DRILL METHOD: HA
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	ENGINEERING DESCRIPTION SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
ALLUVIUM		● 53/11kPa ● 72/14kPa ● 63/17kPa	ML	W	St	SILT, minor clay, low plasticity, wet, dark brown -fragments of shell
		● 47/14kPa ● 49/12kPa	MS		F	sandy SILT, non plastic, wet, dark brown
	Water in/ level on completion	● 46/14kPa ● 63/15kPa ● 73/23kPa ● 56/17kPa	ML		St	SILT, some clay, minor fine sand, wet, brown
		● 37/18kPa ● 38/21kPa ● 37/14kPa ● 47/38kPa	MS	Sat	F	sandy SILT, non plastic, saturated, grey
			SW			fine to coarse SAND, loose, saturated, grey
						END OF BOREHOLE 5.2m (target depth)

Log Scale 1:32.5

T+T DATATEMPLATE.GDT RBE

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA23
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
R.L.:
DATUM:

DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 23/7/13
HOLE FINISHED: 23/7/13
DRILLED BY: Conrad/rbe
LOGGED BY: rbe
CHECKED:

GEOLOGICAL

ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

SOIL DESCRIPTION

Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION

Substance: Rock type, particle size, colour, minor components.

Defects: Type, inclination, thickness, roughness, filling.

SHEAR STRENGTH (kPa): 10 25 50 100 200

COMPRESSIVE STRENGTH (MPa): 1 5 20 50 100 250

DEFECT SPACING (mm): 50 250 1000 2000

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
FILL						63/15kPa				MC	W	St	clayey SILT, low plasticity, wet, yellowish brown, with inclusions of silt, brown
ALLUVIUM						55/09kPa 31/12kPa			1	ML		F	SILT, non plastic, wet, brown
										MS		St	fine sandy SILT, non plastic, wet, brown
										SM			silty fine SAND, non plastic, wet, brown
						70/21kPa				MC		VSt	clayey SILT, medium plasticity, wet, light grey mottled yellowish brown; with abundant inclusions of silt, orange brown
										ML			SILT, non plastic, wet, orange brown
						131/55kPa 143/53kPa 114/40kPa 136/43kPa 108/32kPa			2 3	MC			clayey SILT, low plasticity, wet, light grey mottled rusty brown; then rusty brown with occasional clayey bands
										ML			SILT, some clay, low plasticity, wet to saturated, brown
										MC			clayey SILT, low to medium plasticity, wet to saturated, brown and light grey
						200/59kPa				ML			SILT, some clay, low plasticity, wet, orange brown
										MC		St	clayey SILT, medium plasticity, wet, orange brown mottled light grey
		Water in				58/15kPa 52/18kPa			4	CL	W/Sat	VSt	silty CLAY, medium plasticity, wet to saturated, brown
						127/21kPa				MC			clayey SILT, low plasticity, saturated, brown
										MS	W	F	sandy SILT, non plastic, wet, orange brown
						49/18kPa				MC			clayey SILT, medium plasticity, wet, dark grey
										MS			sandy SILT, non plastic, wet, dark grey
		W/L on completion				43/12kPa 70/29kPa 72/23kPa 66/26kPa			5 6	ML		St	SILT, some clay, minor sand, medium plasticity, wet, grey; occasional layers of sandy silt
									7				**END OF BOREHOLE 6.2m (target depth)**

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA24
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
R.L.:
DATUM:

DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:

HOLE STARTED: 24/7/13
HOLE FINISHED: 24/7/13
DRILLED BY: Conrad/rbe
LOGGED BY: rbe
CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
ALLUVIUM										ML	W	St	SILT, non plastic, wet, brown
						● 92/15kPa							
						● 64/14kPa							
						● 63/14kPa			1				
						● 64/17kPa							
						● 88/21kPa							-minor clay, low to no plasticity
												VSt	
						● 128/40kPa			2				
						● 122/44kPa							
						● 151/82kPa				MC			clayey SILT, low plasticity, wet, light brown
						● 159/67kPa							-low to medium plasticity, brown and light grey
						● 165/58kPa			3				-low plasticity
						● 108/21kPa							
						● 143/52kPa			4				
						● 140/58kPa							-low plasticity, wet, light grey and brown
						● 124/52kPa						St	
						● 79/41kPa				CL			CLAY, medium plasticity, wet, light grey
									5				
						● 63/32kPa							
						● 47/21kPa							
						● 81/37kPa							
						● 105/50kPa				MC			clayey SILT, medium plasticity, wet, light grey
									6				**END OF BOREHOLE 6m (target depth)**
									7				

Log Scale 1:32.5

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA25
Hole Location: Refer to site maps
SHEET 1 OF 1

PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

CO-ORDINATES:
DRILL TYPE: 50mm hand auger
HOLE STARTED: 24/7/13
HOLE FINISHED: 24/7/13
R.L.:
DRILL METHOD: HA
DRILLED BY: Conrad/rbe
DATUM:
DRILL FLUID:
LOGGED BY: rbe
CHECKED:

GEOLOGICAL
ENGINEERING DESCRIPTION

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.

Geological unit	Water	Tests	Classification symbol	Moisture condition / Weathering	Strength/density classification	Soil description
FILL		93/17kPa	MC	W	St	clayey SILT, medium plasticity, wet, yellowish brown and light greyish white, with inclusions of silt, brown
BURIED TOPSOIL		108/18kPa	ML			SILT, non plastic, wet, brown
ALLUVIUM		63/09kPa 93/23kPa 59/15kPa 73/18kPa				-minor clay; brown with rusty mottles
		82/29kPa 53/18kPa	MC			clayey SILT, medium plasticity, wet, brown -dark grey
		53/17kPa	CL			silty CLAY, medium plasticity, wet, bluish grey
		56/24kPa	CH			CLAY, medium to high plasticity, wet, light grey
			CL			silty CLAY, medium plasticity, wet, brown, with organic fragments
		56/24kPa	MC			clayey SILT, organic, medium plasticiy, wet, brown, with abundant organic fragments and decomposed wood
		52/17kPa	CL			silty CLAY, medium plasticity, wet, brown
	Hole dry on completion	41/21kPa 50/23kPa 31/15kPa	CH		F	CLAY, medium to high plasticity, wet, brown, with organic fragments -trace fine sand
						END OF BOREHOLE 5.3m (target depth)

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No:HA26
Hole Location: Refer to site maps
SHEET 1 OF 1

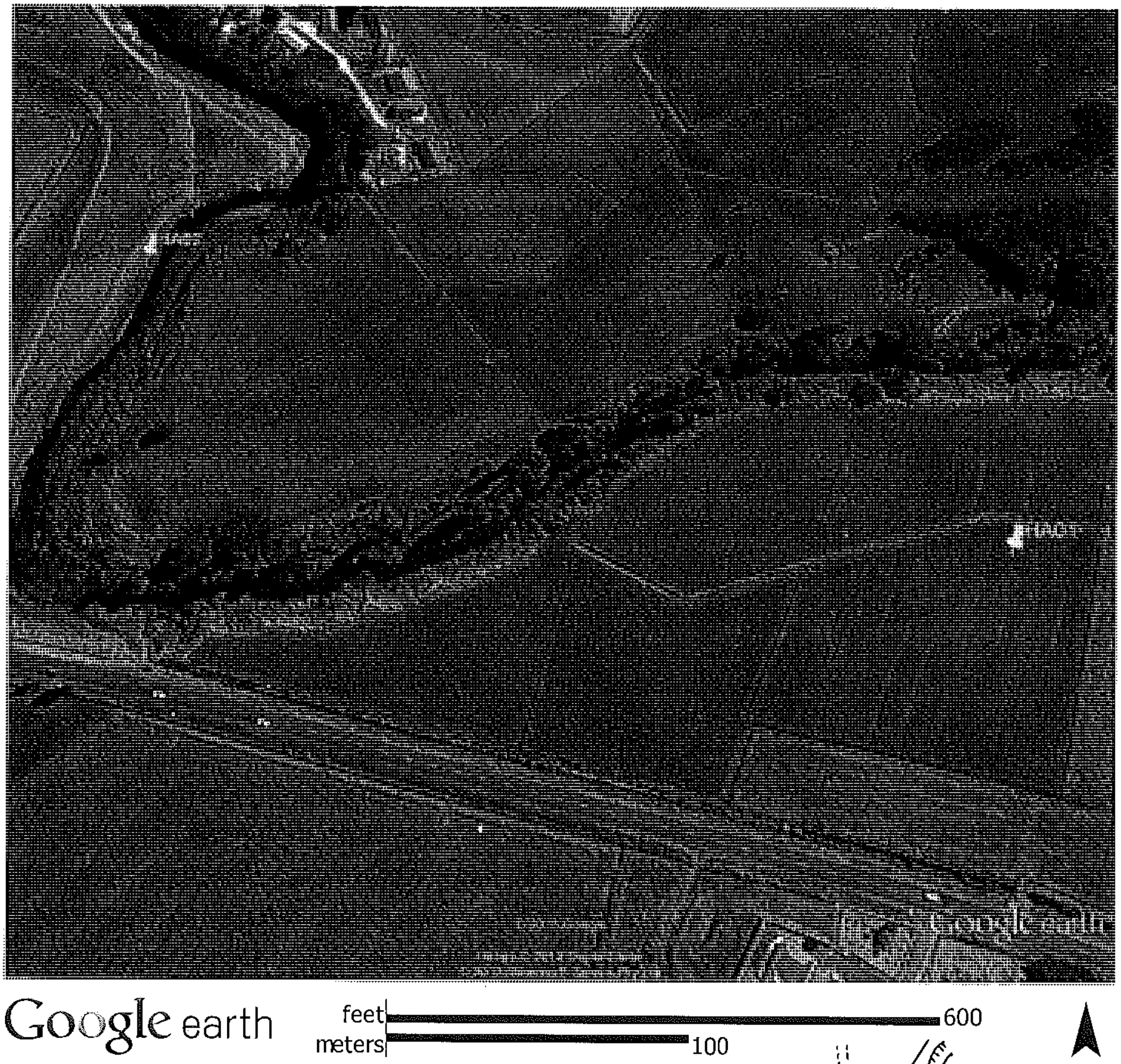
PROJECT: Awanui-Flood
LOCATION: Kaitaia
JOB No: 29154.100

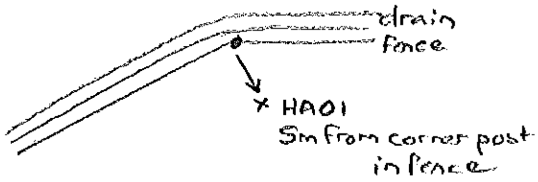
CO-ORDINATES:
R.L.:
DATUM:

DRILL TYPE: 50mm hand auger
DRILL METHOD: HA
DRILL FLUID:

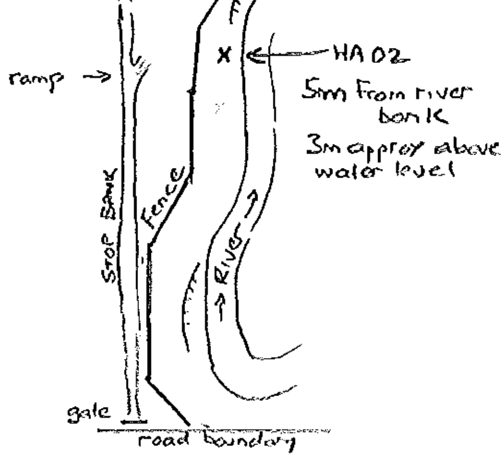
HOLE STARTED: 24/7/13
HOLE FINISHED: 24/7/13
DRILLED BY: Conrad/rbe
LOGGED BY: rbe
CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	WATER	TESTS	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
FILL			MS	W	VSt	sandy SILT, non plastic, saturated, brown
		● 119/21kPa ● 84/09kPa ● 128/20kPa ● 114/11kPa ● 87/20kPa	ML			SILT, non plastic, wet, brown, with minor inclusions of clayey SILT, light grey
			OL	M/W		organic SILT, friable, moist, blackish brown
SWAMP DEPOSITS			ML			SILT, non plastic, moist to wet, brown
		● 128/17kPa ● 76/34kPa	OL		St	organic SILT, friable, moist to wet, blackish brown, with inclusions of light brown silt
		● 104/21kPa ● 52/11kPa	Pt	W	F	PEAT, friable, wet, amorphous with some fibrous organics, wet -minor decomposed wood
	Water level on completion	● 32/18kPa ● 32/14kPa ● 23/06kPa	OL	Sat		peaty SILT, low plasticity, saturated, dark brown
			MC	W		clayey SILT, organic, low plasticity, wet, dark brown
ALLUVIUM	▼	● 35/18kPa ● 35/17kPa ● 46/26kPa ● 49/29kPa ● 44/27kPa	CH			CLAY, high plasticity, saturated, light greenish grey; bluish grey from 5.5m
						END OF BOREHOLE 5.6m (target depth)

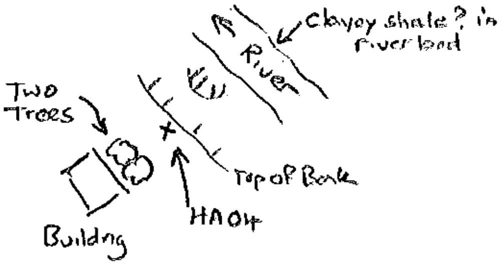




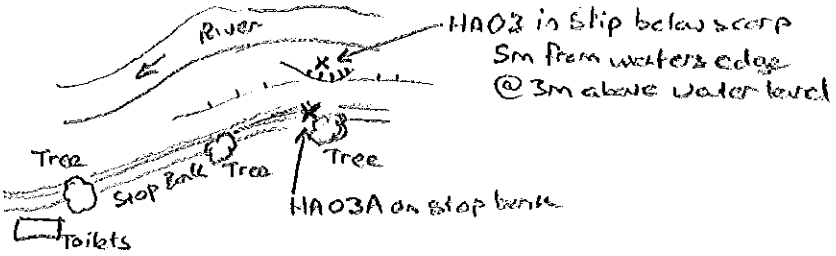
Sketchlocation
HA01



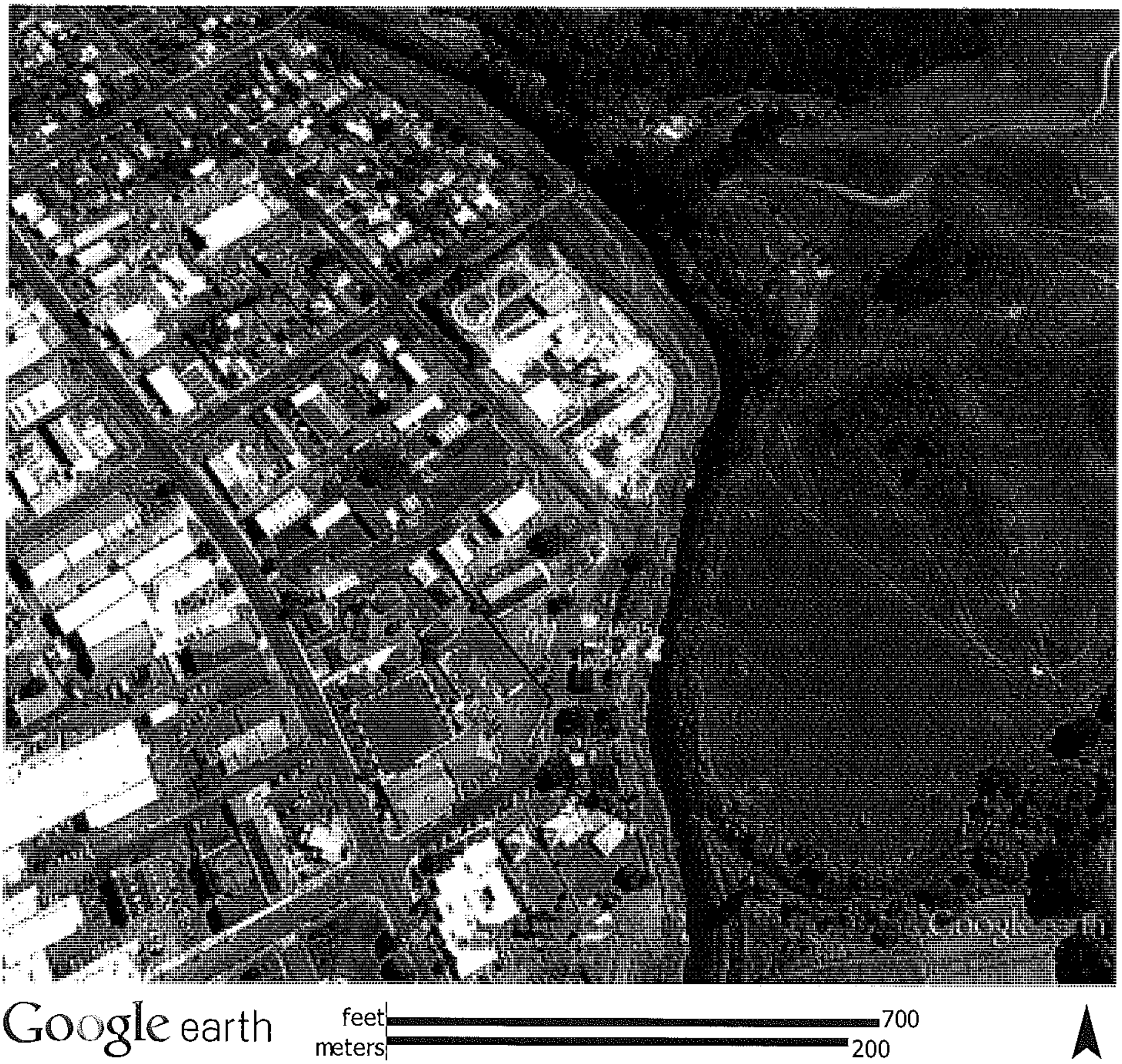
Sketch Location
HA02

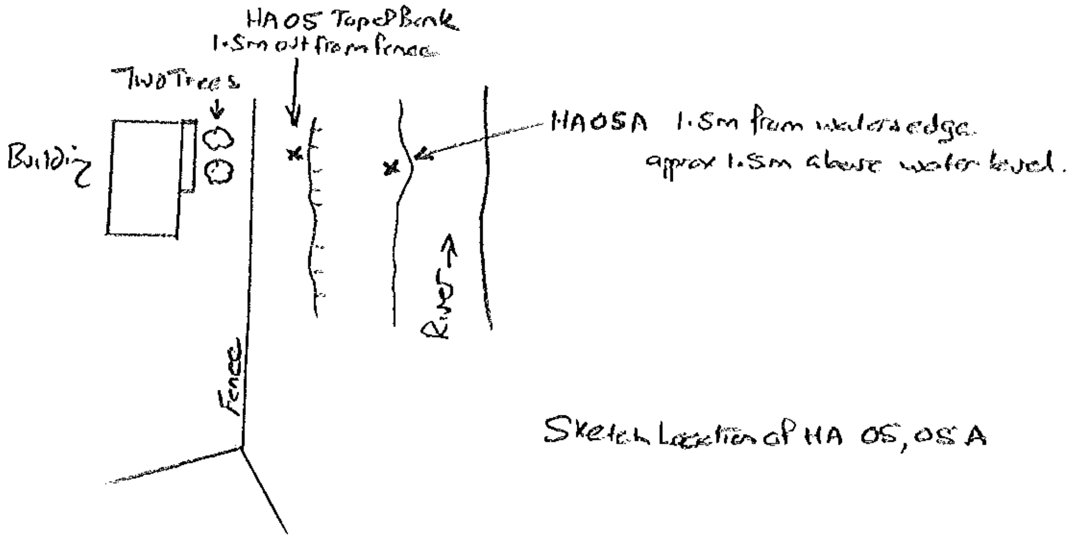


Sketch location HA04

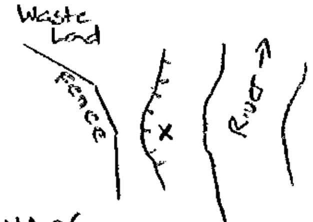


Sketch location HA03, HA03A

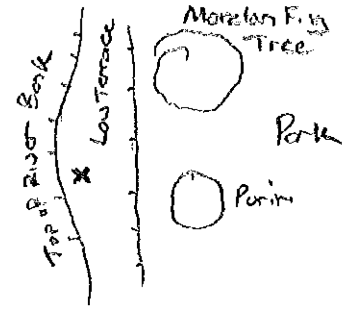




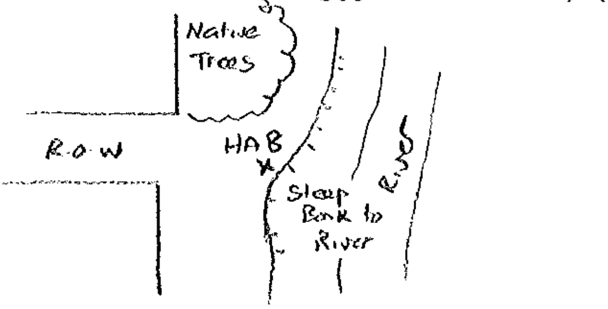
Sketch Location of HA 05, 05 A



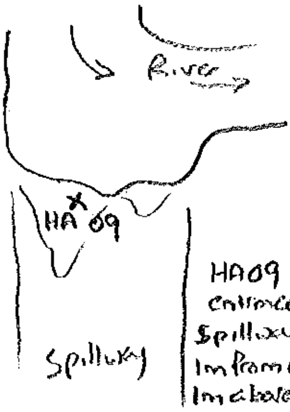
HA 06
Below Head Scarp in Slip,
approx 4m above river level.



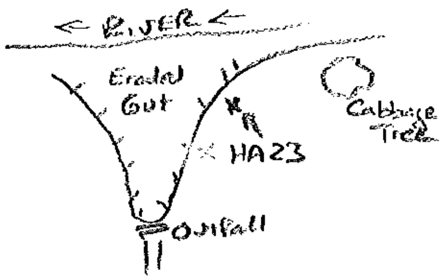
HA07. Near top of bank



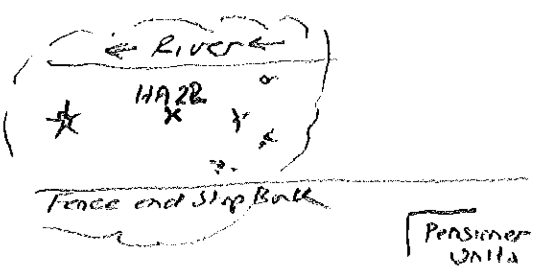
Location of HA 08. Top of flat bank.



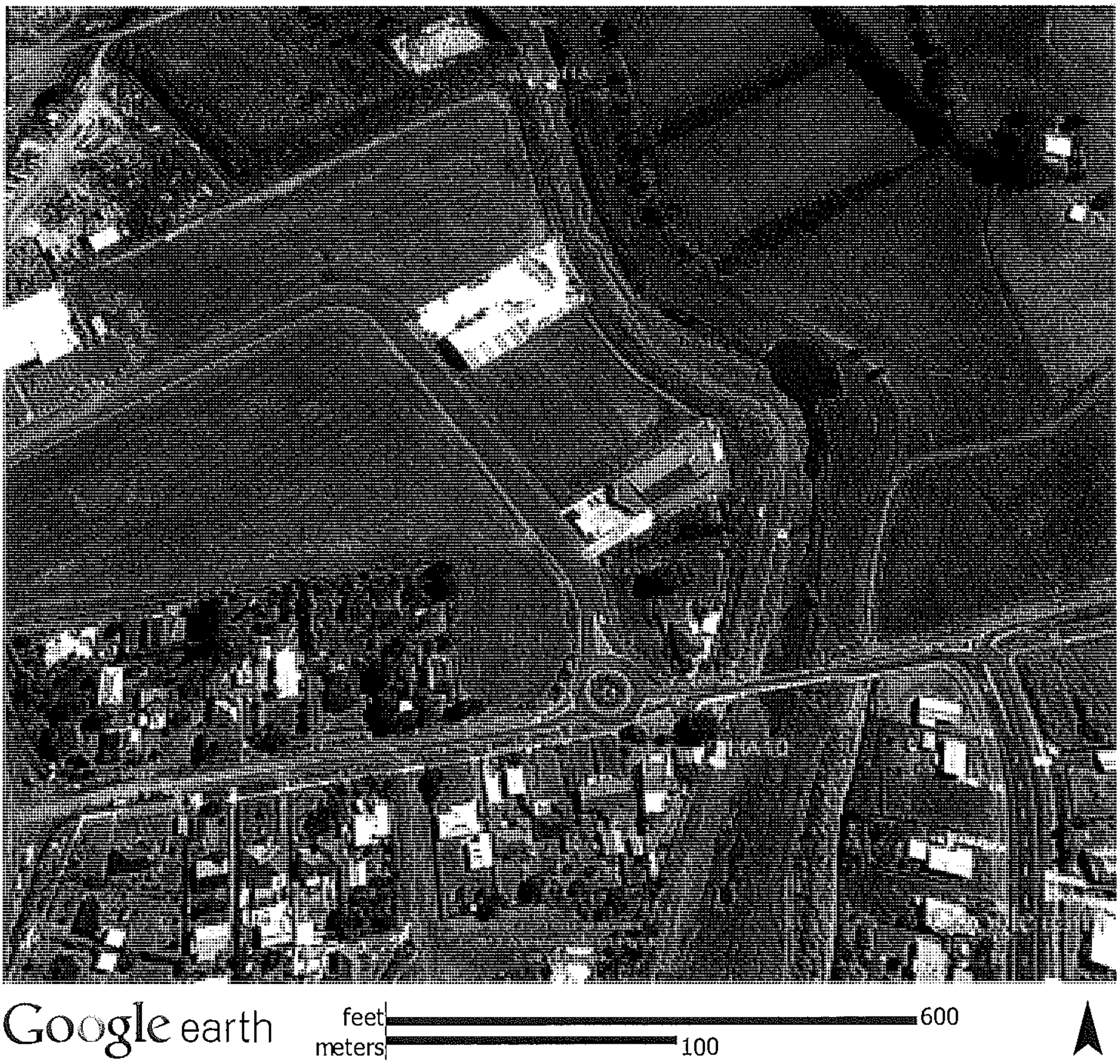
HA09
entrance to
Spillway
1m from water
1m above W/L

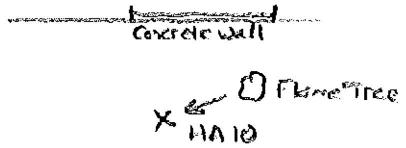


HA23 At edge of bank



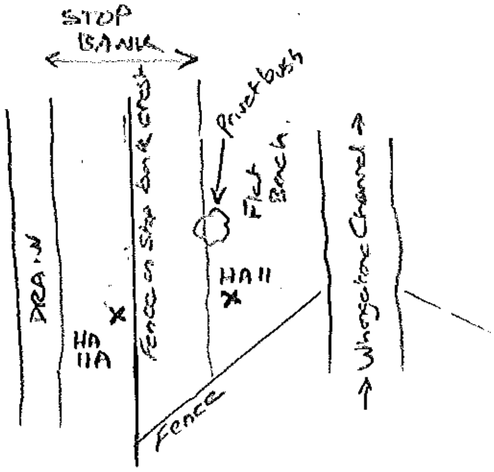
HA22 in centre of clump of Flame trees
3m from river edge.
2.5m approx above water level.





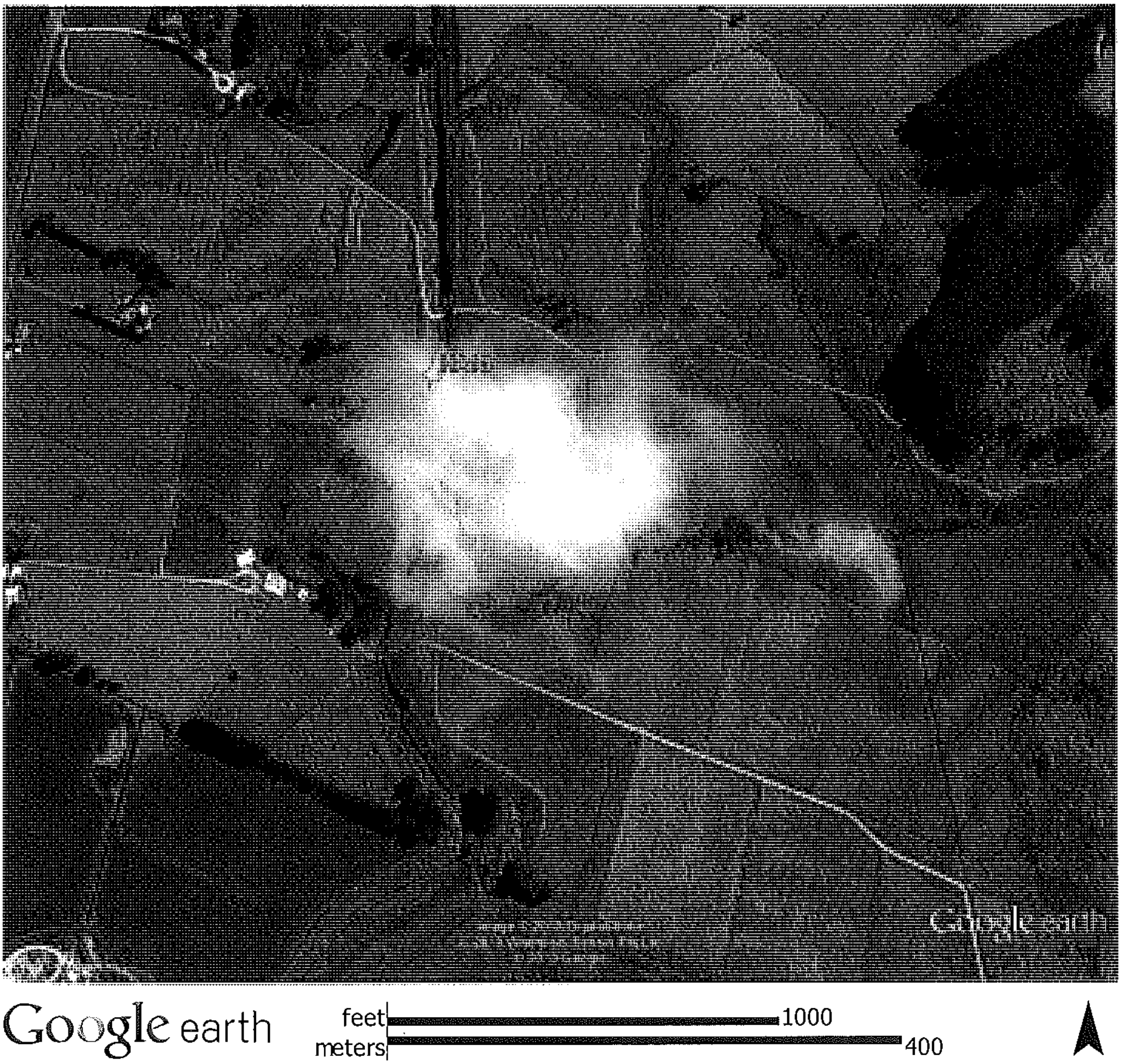
HA10
Sketch location

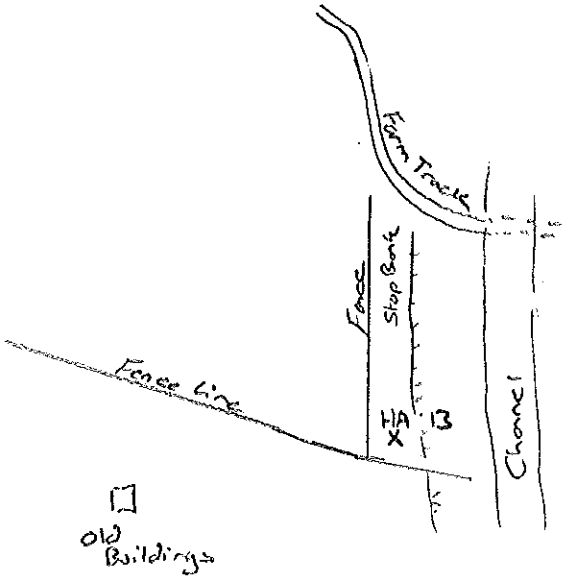
On sloping bank
HA10 3m from Flame Tree.



HA11, 11A
Sketch location

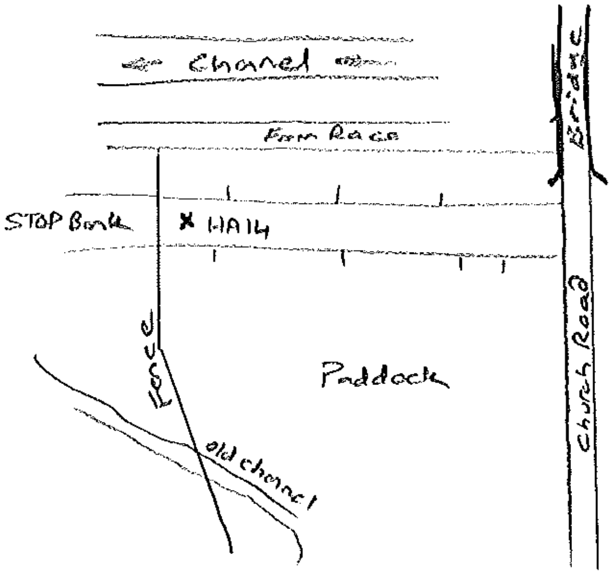
Location of HA 12, 12A   NOTE 12 A is nearer to stream
12 = on crest of steep bank west of 12A



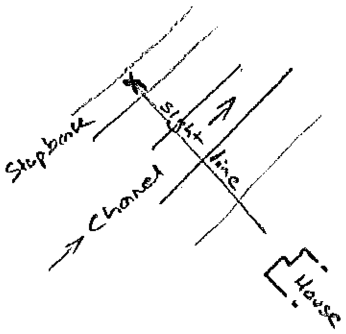


Sketch location, HA 13

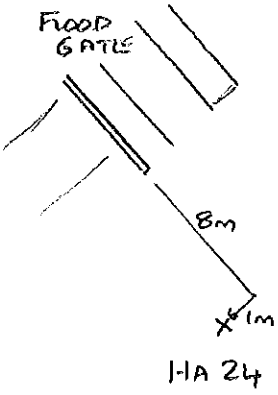
HA 14



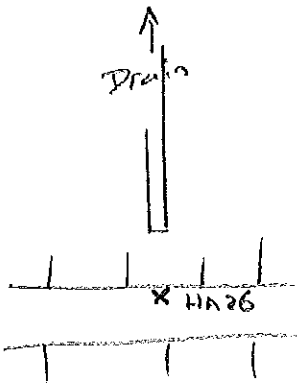
Location Sketch
HA 14



HA25
Crest of StepBank
opposite centre of
house.

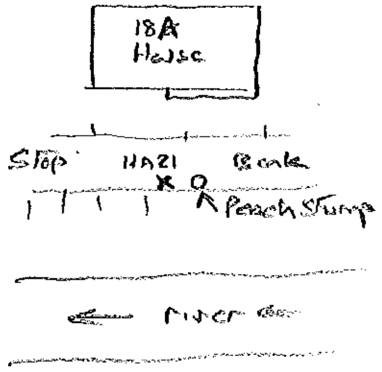


HA24 sketch location
8m from end of southern
footbridge rail
and 1m offset
to SW.

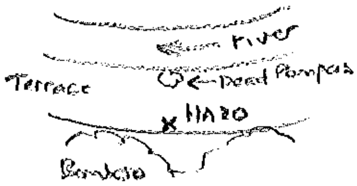


HA26 Sketch location
Edge of Embankment
directly opposite end
of drain

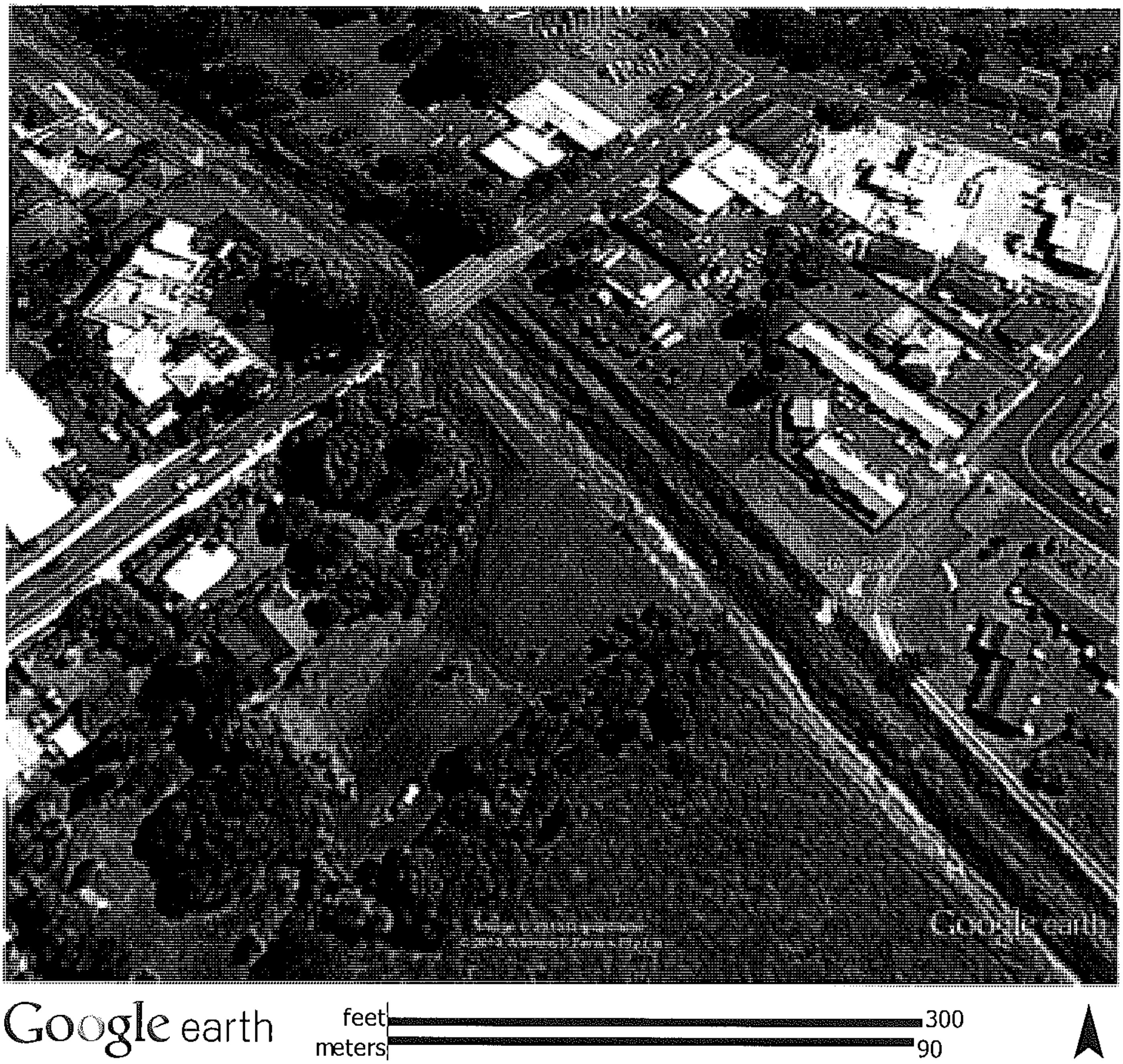
HA 21
Rear of 18A Lake Rd
1m west of Peach Tree Stump
Top edge of Slip Bank.

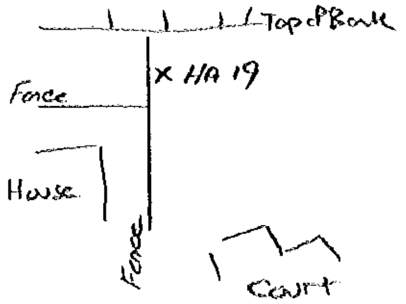


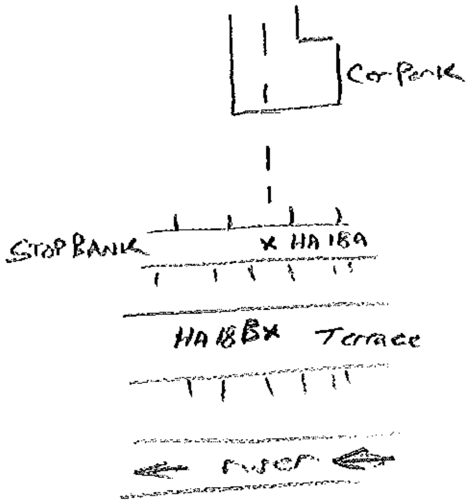
HA 20



Location Sketch HA20
5m back from river bank
at rear of terrace
at centre of bend in stream



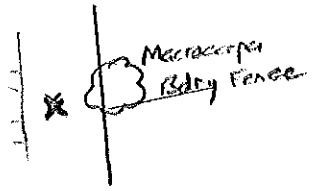




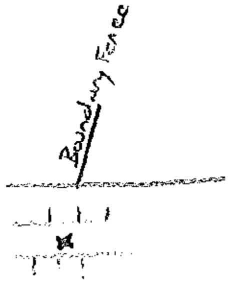
HA 19
By boundary fence extension that obstructs access to public stop bank.

HA 18A top of stop bank opp. centre of road

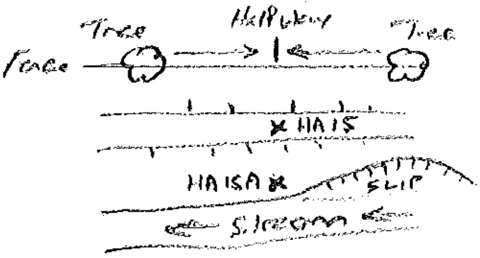
HA 18b on terrace directly below.



HA 17
Crest of Slip Bank
opp. bdy fence
by Macrocarpa



HA16
Crest of Slip bank
opp. bdry fence



HA15 Crest of Slip Bank
at point halfway
between trees.

HA15A edge of terrace
below 15,
4m approx above stm.
level.

Appendix D: Price Schedule breakdown

Items not included in the Price Schedule

- Additional survey
- Land and property acquisition
- Road shape modifications where roads are low at bridges
- Specific design Stopbank 1

Spillways 1 - 5

Item	Description	Unit	Rate	Quantity	Amount
1.0	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances.	LS	$30,000	1	$30,000
2.0	Environmental control	LS	$15,000	1	$15,000
3.0	Modify existing services (lift MH's and extent SW outfalls)	LS	$5,000	1	$5,000
4.0	Earthworks				$0
4.1	Remove vegetation to waste from works footprint	LS	$3,000	1	$3,000
4.2	Strip top soil and stock pile for reuse	m2	$1	60000	$60,000
4.3	Excavate to waste, dispose off site to form new spill ways.	m3	$10	42000	$420,000
4.4	Uplift topsoil from stockpile and re spread min 100mm depth on stopbank.	m3	$5	31000	$155,000
4.5	Grass all new surfaces, hydro seed/hay mulch.	m2	$1	60000	$60,000
5.0	Remove existing fences in work zone before works and reinstate after completion of works.	m	$25	500	$12,500
6.0	Contingency	LS	$110,000	1	$110,000
	Total				$870,500

Stopbank 1: 0 m – 1190 m Farm to Church Road

Item	Description	Unit	Rate	Quantity	Amount
1	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances.	LS	$30,000	1	$30,000
2	Environmental control	LS	$15,000	1	$15,000
3	Modify existing services (lift MH's and extent SW outfalls)	LS	$15,000	1	$15,000
4	Supply and construct mass block walls (to form inner or outer stopbank edge)				$0
4.1	1.0m high	m2	$180	0	$0

4.2	2.0m high	m2	$300	100	$30,000
5	Earthworks				$0
5.1	Remove vegetation to waste from works footprint	LS	$10,000	1	$10,000
5.2	Strip top soil and stock pile for reuse	m2	$1	5000	$5,000
5.3	Supply hard fill, bench, key into existing ground place compact, test and trim to shape stopbank.	m3	$15	5000	$75,000
5.4	Uplift topsoil from stockpile and re spread min 100mm depth on stopbank.	m2	$5	5000	$25,000
5.5	Grass all new surfaces, hydro seed/hay mulch.	m2	$1	5000	$5,000
6	Remove existing fences in work zone before works and reinstate after completion of works.	m	$50	500	$25,000
7	Stream works				$0
7.1	Supply and construct rock grade control structures	LS			$0
7.2	Supply and place rock rip rap stream bed/toe protection where instructed.	m3			$0
8	Contingency	LS	$130,000	1	$130,000
	Total				$365,000

Stopbank 2: 0 m – 630 m Church Road to Church Road drain

Item	Description	Unit	Rate	Quantity	Amount
1.0	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances.	LS	$30,000	1	$30,000
2.0	Environmental control	LS	$15,000	1	$15,000
3.0	Modify existing services (lift MH's and extent SW outfalls)	LS	$15,000	1	$15,000
4.0	Supply and construct mass block walls (to form inner or outer stopbank edge)				$0
4.1	1.0m high	m2	$180	0	$0
4.2	2.0m high	m2	$300	62	$18,600
5.0	Earthworks				$0
5.1	Remove vegetation to waste from works footprint	LS	$5,000	1	$5,000
5.2	Strip top soil and stock pile for reuse	m2	$1	6000	$6,000
5.3	Cut to fill of existing stopbank along edge of stream, bench, key into existing ground, compact, test and trim to shape new stopbank.	m3	$8	1500	$12,000

5.4	Supply hard fill, bench, key into existing ground place compact, test and trim to shape stopbank.	m3	$15	1550	$23,250
5.5	Uplift topsoil from stockpile and re spread min 100mm depth on stopbank.	m2	$5	6000	$30,000
5.6	Grass all new surfaces, hydro seed/hay mulch.	m2	$1	6000	$6,000
6.0	Remove existing fences in work zone before works and reinstate after completion of works.				$0
7.0	Stream works				$0
7.1	Supply and construct rock grade control structures	LS			$0
7.2	Supply and place rock rip rap stream bed/toe protection where instructed.	m3			$0
8.0	Supply and construct new sealed access way with kerb and channel - (allow 300mm depth pavement)	m2	$300	200	$60,000
9.0	Contingency	LS	$65,000	1	$65,000
	Total				$285,850

Stopbank 3: 0 m – 830 m Allen Bell Drive to Spillway

Item	Description	Unit	Rate	Quantity	Amount
1.0	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances.	LS	$30,000	1	$30,000
2.0	Environmental control	LS	$15,000	1	$15,000
3.0	Modify existing services (lift MH's and extent SW outfalls)	LS	$20,000	1	$20,000
4.0	Supply and construct mass block walls (to form inner or outer stopbank edge)				$0
4.1	1.0m high	m2	$180	60	$10,800
4.2	2.0m high	m2			$0
5.0	Earthworks				$0
5.1	Remove vegetation to waste from works footprint	LS	$5,000	1	$5,000
5.2	Strip top soil and stock pile for reuse	m2	$1	8500	$8,500
5.3	Cut to fill from stream bank, bench, key into existing ground, compact, test and trim to shape new stopbank.	m3	$10	2850	$28,500
5.4	Excavate to waste from channel bank.	m3	$10	1100	$11,000
5.5	Uplift topsoil from stockpile and re spread min 100mm depth on stopbank.	m2	$5	8500	$42,500

5.6	Grass all new surfaces, hydro seed/hay mulch.	m2	$1	8500	$8,500
6.0	Remove existing fences in work zone before works and reinstate after completion of works.	m	$50	100	$5,000
7.0	Stream works				$0
7.1	Supply and construct rock grade control structures	LS			$0
7.2	Supply and place rock rip rap stream bed/toe protection where instructed.	m3			$0
8.0	Contingency	LS	$65,000	1	$65,000
	Total				$249,800

Stopbank 4/1: 0 m – 940 m Sports Ground to Church Road

Item	Description	Unit	Rate	Quantity	Amount
1	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances.	LS	$30,000	1	$30,000
2	Environmental control	LS	$15,000	1	$15,000
3	Modify existing services (lift MH's and extent SW outfalls)	LS	$15,000	1	$15,000
4	Supply and construct mass block walls (to form inner or outer stopbank edge)				$0
4.1	1.0m high	m2			$0
4.2	2.0m high	m2			$0
5	Earthworks				$0
5.1	Remove vegetation to waste from works footprint	LS	$5,000	1	$5,000
5.2	Strip top soil and stock pile for reuse	m2	$1	3600	$3,600
5.3	Supply hard fill, bench, key into existing ground place compact, test and trim to shape stopbank.	m3	$15	1300	$19,500
5.4	Uplift topsoil from stockpile and re spread min 100mm depth on stopbank.	m2	$5	3600	$18,000
5.5	Grass all new surfaces, hydro seed/hay mulch.	m2	$1	3600	$3,600
6	Remove existing fences in work zone before works and reinstate after completion of works.	m	$20	50	$1,000
7	Stream works				$0
7.1	Supply and construct rock grade control structures	LS			$0
7.2	Supply and place rock rip rap stream bed/toe protection where instructed.	m3			$0

8	Contingency	LS	$45,000	1	$45,000
	Total				**$155,700**

Stopbank 4/2: 940 m – 2000 m Church Road to Allen Bell Drive

Item	Description	Unit	Rate	Quantity	Amount
1.0	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances.	LS	$30,000	1	$30,000
2.0	Environmental control	LS	$15,000	1	$15,000
3.0	Modify existing services (lift MH's and extent SW outfalls)	LS	$25,000	1	$25,000
4.0	Supply and construct mass block walls (to form inner or outer stopbank edge)				$0
4.1	1.0m high	m2	$180	100	$18,000
4.2	2.0m high	m2			$0
5.0	Earthworks				$0
5.1	Remove vegetation to waste from works footprint	LS	$5,000	1	$5,000
5.2	Strip top soil and stock pile for reuse	m2	$1	6000	$6,000
5.3	Cut to fill from stream banks, bench, key into existing ground, compact, test and trim to shape new stopbank.	m3	$10	4150	$41,500
5.4	Excavate to waste channel bank.	m3	$10	15500	$155,000
5.5	Uplift topsoil from stockpile and re spread min 100mm depth on stopbank.	m2	$5	6000	$30,000
5.6	Grass all new surfaces, hydro seed/hay mulch.	m2	$1	6000	$6,000
6.0	Remove existing fences in work zone before works and reinstate after completion of works.	m	$50	200	$10,000
7.0	Stream works				$0
7.1	Supply and construct rock grade control structures	LS			$0
7.2	Supply and place rock rip rap stream bed/toe protection where instructed.	m3			$0
8.0	Contingency	LS	$110,000	1	$110,000
	Total				**$451,500**

Stopbank 4/3: 2000 m – 2877 m Allen Bell Drive to Mathews Park

Item	Description	Unit	Rate	Quantity	Amount
1	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances.	LS	$40,000	1	$40,000
2	Environmental control	LS	$15,000	1	$15,000
3	Modify existing services (lift MH's and extent SW outfalls)	LS	$25,000	1	$25,000
4	Supply and construct mass block walls (to form inner or outer stopbank edge)				$0
4.1	1.0m high	m2	$180	30	$5,400
4.2	2.0m high	m2	$300	320	$96,000
5	Earthworks				$0
5.1	Remove vegetation to waste from works footprint	LS	$5,000	1	$5,000
5.2	Strip top soil and stock pile for reuse	m2	$1	5500	$5,500
5.3	Cut to fill from stream banks, bench, key into existing ground, compact, test and trim to shape new stopbank.	m3	$10	5350	$53,500
5.5	Excavate to waste channel bank.	m3	$10	9000	$90,000
5.4	Uplift topsoil from stockpile and re spread min 100mm depth on stopbank.	m2	$5	5500	$27,500
5.6	Grass all new surfaces, hydro seed/hay mulch.	m2	$1	5500	$5,500
6	Remove existing fences in work zone before works and reinstate after completion of works.	m	$50	200	$10,000
7	Stream works				$0
7.1	Supply and construct rock grade control structures	LS			$0
7.2	Supply and place rock rip rap stream bed/toe protection where instructed.	m3			$0
8	Contingency	LS	$135,000	1	$135,000
	Total				**$513,400**

Whangatane Spillway Weir

Item	Description	Unit	Rate	Quantity	Amount
1.0	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances.	LS	$20,000	1	$20,000
2.0	Environmental control	LS	$15,000	1	$15,000

3.0	Modify existing services (lift MH's and extent SW outfalls)	LS	$5,000	1	$5,000
4.0	Earthworks				$0
4.1	Remove vegetation to waste from works footprint	LS	$3,000	1	$3,000
4.2	Strip top soil from works footprint and stock pile for reuse	m2	$1	16000	$16,000
4.3	Cut to waste spill way invert 0-300m to new invert level	m3	$12	31000	$372,000
4.4	Uplift topsoil from stockpile and re spread min 100mm depth.	m2	$5	16000	$80,000
4.5	Grass all new surfaces, hydro seed/hay mulch.	m2	$1	16000	$16,000
5.0	Weir				$0
5.1	Excavate supply all materials and labour to construct gabion baskets on approved geotextile to form weir crest.	m3	$250	570	$142,500
5.2	Excavate supply all materials and labour to construct gabion baskets on approved geotextile to form weir abutments.	m3	$230	390	$89,700
5.3	Excavate supply all materials and labour to construct reno mattress on approved geotextile to form weir crest.	m2	$70	250	$17,500
6.0	Contingency	LS	$135,000	1	$135,000
	Total				$911,700

Stopbank 5/1: 0 m – 5290 m Weir to Quarry Road

Item	Description	Unit	Rate	Quantity	Amount
1.0	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances.	LS	$20,000	1	$20,000
2.0	Environmental control	LS	$15,000	1	$15,000
3.0	Modify existing services (lift MH's and extent SW outfalls)	LS	$5,000	1	$5,000
4.0	Earthworks				$0
4.1	Remove vegetation to waste from works footprint	LS	$10,000	1	$10,000
4.2	Strip top soil from works footprint and stock pile for reuse	m2	$1	25000	$25,000
4.3	Cut to fill from adjoining land, bench, key into existing banks, compact, test and trim to shape new stopbank.	m3	$15	18000	$270,000

4.4	Uplift topsoil from stockpile and re spread min 100mm depth on stopbank.	m2	$5	25000	$125,000
4.5	Grass all new surfaces, hydro seed/hay mulch.	m2	$1	25000	$25,000
4.6	Reinstate borrow area	LS	$5,000	1	$5,000
5.0	Fencing				$0
5.1	Remove before works and reinstate after works fences in the work zone.	m	$25	300	$7,500
6.0	Contingency	LS	$65,000	1	$65,000
	Total				**$572,500**

Stopbank 5/2: 5290 m – 6940 m Quarry Road to SH10

Item	Description	Unit	Rate	Quantity	Amount
1.0	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances.	LS	$20,000	1	$20,000
2.0	Environmental control	LS	$5,000	1	$5,000
3.0	Modify existing services (lift MH's and extent SW outfalls)	LS	$2,000	1	$2,000
4.0	Earthworks				$0
4.1	Remove vegetation to waste from works footprint	LS	$2,000	1	$2,000
4.2	Strip top soil from works footprint and stock pile for reuse	m2	$1	500	$500
4.3	Cut to fill from adjoining land, bench, key into existing banks, compact, test and trim to shape new stopbank.	m3	$15	700	$10,500
4.4	Uplift topsoil from stockpile and re spread min 100mm depth on stopbank.	m2	$5	500	$2,500
4.5	Grass all new surfaces, hydro seed/hay mulch.	m2	$1	500	$500
4.6	Reinstate borrow area	LS	$1,000	1	$1,000
5.0	Fencing				
5.1	Remove before works and reinstate after works fences in the work zone.	m	$25	50	$1,250
6.0	Contingency	LS	$25,000	1	$25,000
	Total				**$70,250**

Stopbank 5/3: 6940 m – 7950 m SH10 to end

Item	Description	Unit	Rate	Quantity	Amount
1.0	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances.	LS	$20,000	1	$20,000
2.0	Environmental control	LS	$15,000	1	$15,000
3.0	Modify existing services (lift MH's and extent SW outfalls)	LS	$5,000	1	$5,000
4.0	Earthworks				$0
4.1	Remove vegetation to waste from works footprint	LS	$7,000	1	$7,000
4.2	Strip top soil from works footprint and stock pile for reuse	m2	$1	6000	$6,000
4.3	Cut to fill from adjoining land, bench, key into existing banks, compact, test and trim to shape new stopbank.	m3	$15	12800	$192,000
4.4	Uplift topsoil from stockpile and re spread min 100mm depth on stopbank.	m2	$5	6000	$30,000
4.5	Grass all new surfaces, hydro seed/hay mulch.	m2	$1	6000	$6,000
4.6	Reinstate borrow area	LS	$5,000	1	$5,000
5.0	Fencing				$0
5.1	Remove before works and reinstate after works fences in the work zone.	m	$25	200	$5,000
6.0	Contingency	LS	$65,000	1	$65,000
	Total				**$356,000**

Stream bank protection works

Item	Description	Unit	Rate	Quantity	Amount
1.0	Establishment on site, set out, supervision, clean up on completion, location and protection of existing services permits, As Built plans, consent compliance and insurances. (5%)	LS	$100,000	1	$312,500
2.0	Environmental controls (5%)	LS	$15,000	1	$312,500
3.0	Earthworks	m	$100	6250	$625,000
3.1	Bank toe protection & bank stabilisation works (including excavation of material, laying of fileter fabric, supply and placement of rock to design levels) - HIGH priority areas	m	$900	550	$495,000
3.2	Bank toe protection & bank stabilisation works (including excavation of material, laying of fileter	m	$900	600	$540,000

	fabric, supply and placement of rock to design levels) - MEDIUM priority areas				
3.3	Bank toe protection & bank stabilisation works (including excavation of material, laying of fileter fabric, supply and placement of rock to design levels) - LOWER priority areas	m	$900	5100	$4,590,000
4.0	Contingency (25%)	LS	$1,718,750	1	$1,718,750
	Total				**$8,593,750**

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