Wellington Water

Pinehaven Stream Improvements

Erosion and Sediment Control Plan – Main Works

September 2019

greater WELLINGTON REGIONAL COUNCIL Te Pane Matua Taiao

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Pinehaven Stream Improvements

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Document history and status

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A	17/07/2019	Issued for comment	Elizabeth Garner (Jacobs) Michelle Flawn (Downer)	Jerry Spinks (Jacobs) Tim Haylock (Downer)	Ian Garside
1	12/08/2019	Updated to reflect WWL and KS comments	Elizabeth Garner (Jacobs) Michelle Flawn (Downer)	Andrew Steel (Jacobs) Helen Anderson (Jacobs) Tim Haylock (Downer)	Ian Garside
2	13/09/19	GWRC Consultation, alternative methodology	Jerry Spinks	Andrew Steele	Ian Garside

Contents

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to provide guidance on erosion and sediment controls for the Pinehaven Stream Improvements works in accordance with the scope of services set out in the contract between Jacobs and Wellington Water. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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1. Introduction

This Erosion and Sedimentation Control Plan (ESCP) document has been prepared to provide detail on the construction methodology and the associated controls, mitigation, and monitoring of erosion and sediment for the Pinehaven Stream Improvements project.

This ESCP will be referenced in the Assessment of Environmental Effects (AEE) for the Resource Consent applications to Greater Wellington Regional Council (GWRC) and Upper Hutt City Council (UHCC), respectively.

The primary control for effective erosion and sediment management for this project is to seek to avoid causing or increasing erosion and the subsequent generation of sediment as a result of constructing the proposed improvements. To achieve this, the ECI Team (formed of Jacobs and Downers) have developed two construction methodologies, as set out below.

- **Methodology 1 – sheet pile protection**

  This methodology will require predominantly machinery movements within the stream bed and whilst the stream continues to flow.

- **Methodology 2 – piped diversion.**

  This methodology will allow the majority of the machinery movements to be undertaken outside of the stream bed, and any movements within the stream bed will be undertaken in ‘dry conditions’.

The methodologies were developed in response to consultation with GWRC. The consultation comprised two meetings held in August and September.

Secondary controls include mitigation of impacts, limiting the area and duration of disturbance activities (where erosion and sediment are generated from), and monitoring the sediment generating areas / activities, where achieving the primary control is not possible. This ESCP provides detail on the proposed construction methodology, monitoring and mitigation for achieving the primary and secondary controls for this project.

Erosion Sediment Control (ESC) measures will be developed in accordance with the following:

- GWRC, Erosion and Sediment Control Guidelines for the Wellington Region (September 2002, reprinted 2006);
- GWRC, Guidelines for preparing an erosion and sediment control plan (2017).

This ESCP has been prepared to support the consenting process, and it is anticipated that the ESCP will remain a live document, where it will be updated periodically as the project proceeds through the procurement and construction phases which are outlined in Section 2.5. As part of this process, Jacobs and Downers will continue to seek feedback from GWRC’s environmental and planning teams, as the document evolves.

A separate consent will be obtained for the two road crossings (in the form of two culverts), at Pinehaven Road and Sunbrae Drive, and an entirely separate ESCP will be prepared for the road crossings.

2. Pinehaven Stream Improvements Project Description

2.1 Project Background

The Pinehaven Stream Improvements Project has resulted from the Pinehaven Flood Management Plan. The objectives of the project have been defined by the Project Steering Group comprised of representatives from Upper Hutt City Council, Greater Wellington Regional Council and Wellington Water Limited. These objectives were confirmed by Wellington Water Limited.

The objectives of the Pinehaven Stream Improvements Project are as follows:

- To reduce the risk of injury or harm from fast or deep flowing water in Pinehaven Stream and its tributaries;
- To provide improved capacity and effective and efficiently functioning stormwater infrastructure in the stream and its tributaries to a 4% AEP flood event level, which will also contribute to the management of flood risk to habitable floor levels up to the predicted peak 1% AEP flood level.
- To integrate overland flow paths into the wider stormwater network; and
- To enable efficient and effective construction and ongoing maintenance of all structures and stream improvements.

2.2 Statutory Requirements

2.2.1 Resource Consent Conditions Relevant to Erosion and Sediment Control

This section of the ESCP will be updated prior to works commencing to include the relevant consent conditions for erosion and sediment control matters, once the consent conditions have been received.

2.3 Environmental Setting

The project area is located in Pinehaven, near the community of Silverstream in Upper Hutt. The Pinehaven Stream Improvements project (Project) includes improvements to approximately 1 km of stream reach in order to improve the flood capacity of the stream to convey the 25-year flood event.

The Pinehaven Stream catchment is approximately 4.5 km² and is located on the eastern side of the Hutt Valley. The catchment is located south west of the Upper Hutt central business district and is bordered by the catchments of the Mangaroa River to the south, Stokes Valley stream to the west and Trentham to the east.

The Pinehaven Stream is an urbanised stream with a clearly defined channel and many access bridges, structures, culverts, service crossings and other potential obstructions to flooding flows along its length. Some sections of Pinehaven Stream are piped, however other than culverts at two existing road crossings (at Pinehaven Road and Sunbrae Drive), the section of stream within the Project reach is all open channel.

The catchment is comprised of numerous narrow, steep sided valleys which converge and drain northwards out onto the Hutt River floodplain. The land use within the catchment varies between the upper and lower catchment. The upper catchment and the steep sides of the numerous valleys are predominately covered in pine forest, with some residential land use adjacent to stream tributaries. As the lower catchment opens onto the Hutt River floodplain the major land use in the catchment becomes residential. Amongst the residential properties within the Pinehaven stream catchment there are two schools, a church and some community buildings. The location of the Pinehaven catchment is illustrated in Figure 1. The extent of the stream subject to improvement ('the site') is also shown indicatively.

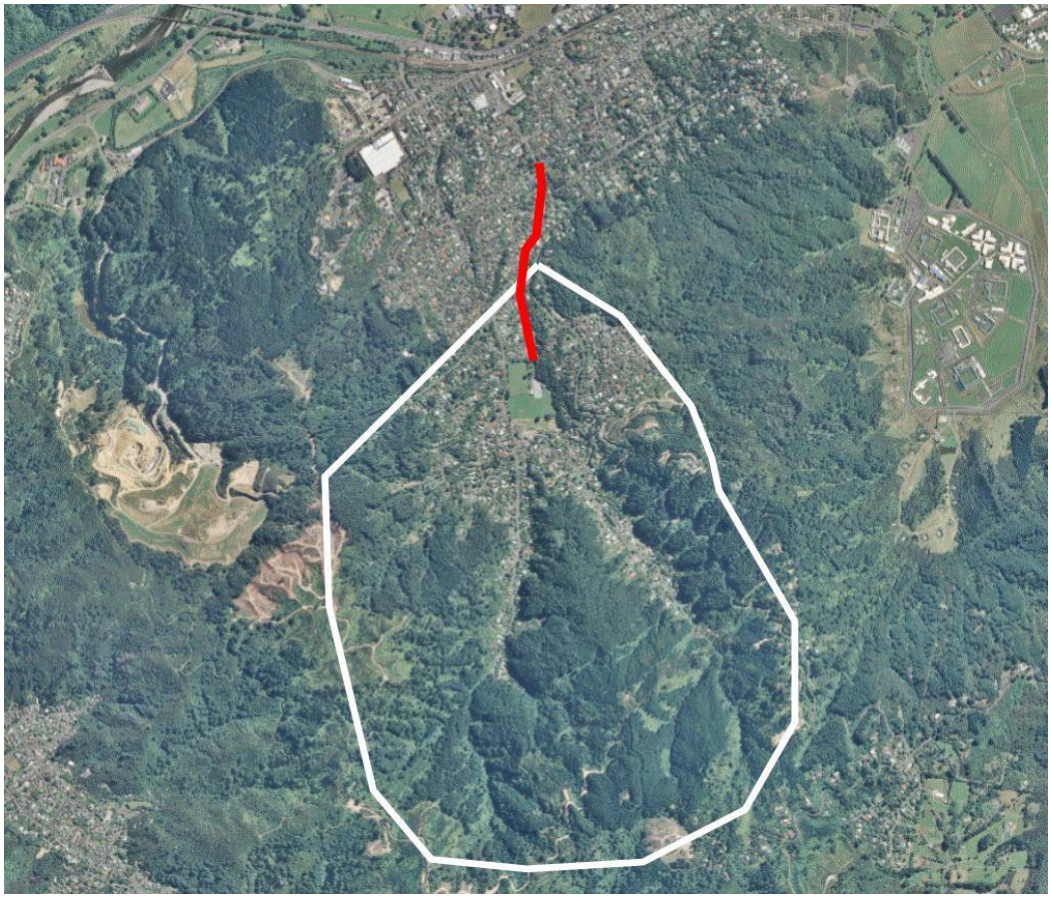

Figure 1: Pinehaven catchment (shown white polyline) and extent of stream upgrade (shown in red line).

The upper Pinehaven catchment is drained by major tributaries adjacent to Pinehaven Road, Elmslie Road and Jocelyn Crescent. In these tributaries the stream passes through private residential properties, the majority of which have access bridges across the Pinehaven Stream, before draining into the pipe network through Pinehaven Reserve.

The western catchment is drained by narrow tributaries that drain under Jocelyn Crescent and down Wyndham Road. The tributary draining under Jocelyn Crescent is similar to those in Pinehaven Road and Elmslie Road, similar in the context that they are open channels. Whereas much of the branch from Wyndham Road is contained in a piped stormwater network.

A tributary in the vicinity of Fendalton Crescent drains the eastern catchment while the western catchment drains to a piped stormwater network. These tributaries enter the main stream channel near the intersection of Pinehaven Road and Blue Mountain Road.

The lower reach of the Pinehaven Stream (the Project area of the Pinehaven Stream Improvements Project) begins in Pinehaven Reserve where the stream exits the piped stormwater network and flows northwards towards Hulls Creek. With the convergence of the upper catchment tributaries, the stream in this area is larger and wider, with higher flooding potential. The stream passes beneath Pinehaven Road and Sunbrae Drive (via existing culverts) as it flows north towards Whitemans Road. Below Whitemans Road the stream is piped with a bypass pipe that only operates when flow is sufficient to overtop a bypass weir. The low flow channel enters the pipe network before entering the pipe network that drains under Whitemans Road and discharges to an outlet into Hulls Creek.

2.4 Ground Conditions

Two tranches of ground investigations have been undertaken within the project area. The investigations were undertaken in in 2015 and 2019. The investigation locations targeted the land immediately adjacent to the stream bed. The findings from the investigations are documented within the following reports:

- Jacobs, Geotechnical and Factual Report, 16 October 2015
- Jacobs, Geotechnical Factual Report, 6 March 2019.

A full copy of both reports is provided in Appendix C.

The material extracted from the boreholes was logged by a Jacobs Geotechnical Engineer in accordance with NZGS guidelines for the classification of soils and rocks. The subsurface conditions appeared to be consistent across the site with alluvial gravel layers encountered at depths of between 1 m and 2.5 m. Overlaying the alluvial gravels was typically soft to stiff silts and clays with some sand and gravel mixtures. These materials are considered to also be alluvial deposits with some un-controlled engineered fill being found in several of the auger holes, however most of this is fairly shallow and has likely been placed for landscaping purposes.

The ground conditions encountered within the boreholes are generally representative of conditions across the site, with the exception of the near surface soil profile below the stream bed, where boreholes were not undertaken.

2.5 Project Stages

To reduce the overall environmental impact of works, and to ensure the extent of site clearance remains at a minimum, the physical works will be broken up into seven stages across three reaches. The extent of the stages was determined by Downer (the contractor) on the basis of a number of factors, including significant existing interfaces (such as the culvert crossings), safe and efficient movement of the plant and machinery, and the ability to control the site during adverse weather conditions.

Only one stage will be active at any time. By breaking the project up, the site-specific environmental management plans can be written for each one and there is reduced earthworking occurring at any one time which is more manageable when compared to not having separate stages. The indicative staging plans are supplied in Appendix B.

Note that this is not a sequential methodology as the starting of one site does not rely on the completeness of another, but is programmed generally in a downstream sequence, Starting at Stage 7 by Pinehaven Park and ending at Stage 1 at Whitemans Rd . These stages can be summarised as follows:

- **Stage 1 (Reach 1):** Will be from the northern extent on Pinehaven Road to the existing pedestrian / vehicle bridge to the Reformed Church of Silverstream. Access will be via the existing ramp immediately adjacent to the overflow structure. The stream will be bunded and flows directed down the alternative route.

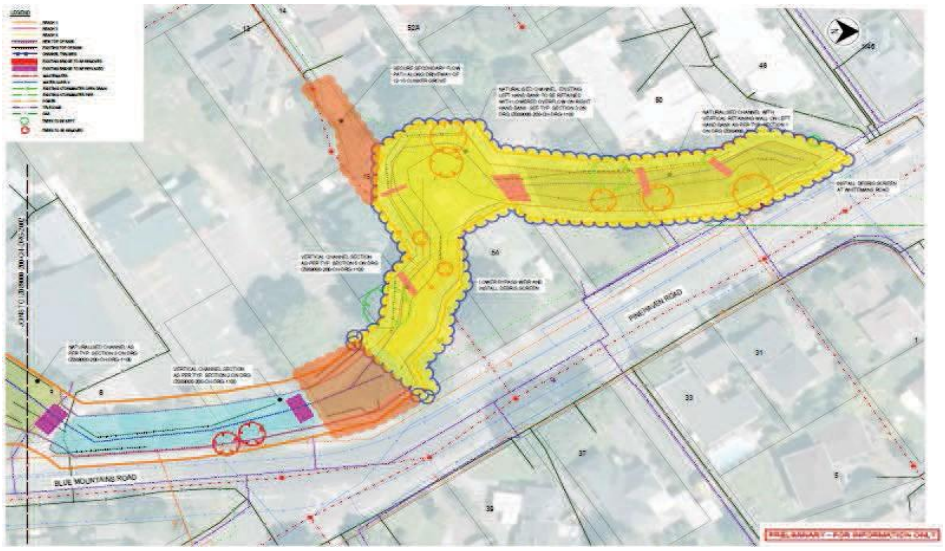

Figure 2: Stage 1 Works Adjacent to Pinehaven Road.

- **Stage 2 (Reach 1):** Will be from the southern extent of Willow Park to the Reformed Church of Silverstream. Access will be via temporary access adjacent to the overflow structure and also from Willow Park.

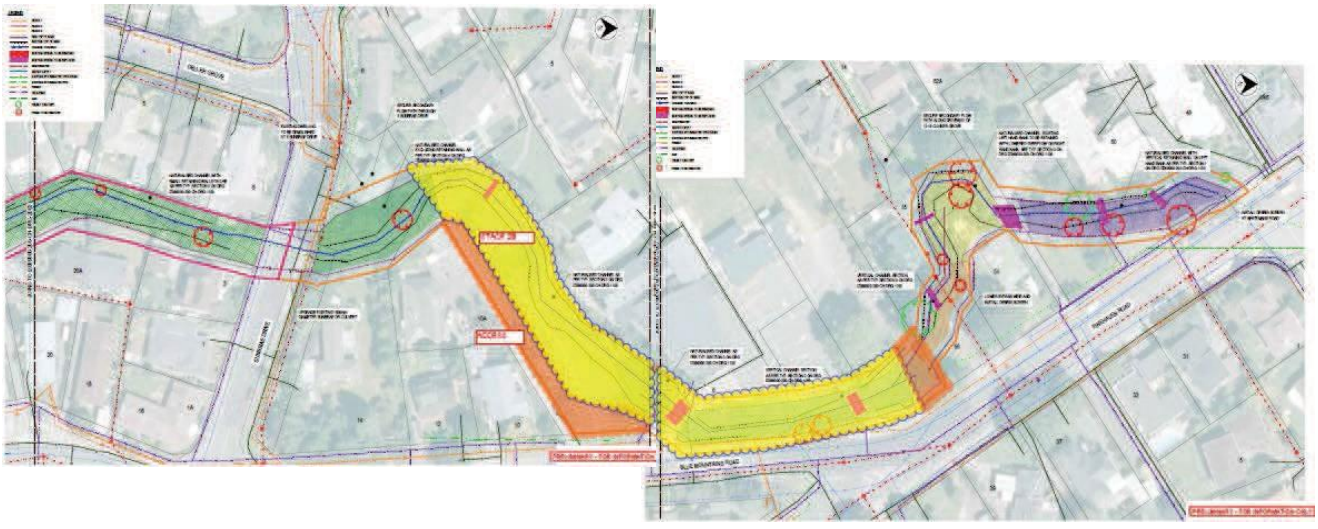

Figure 3: Stage 2 Works adjacent to Blue Mountains Road.

- **Stage 3 (Reach 1):** Will be from the southern extent of Willow Park to the existing culvert under Sunbrae Drive. Access will be via temporary access adjacent to the road and through the property of 4 Sunbrae Drive.

Figure 4: Stage 3 Works adjacent to Sunbrae Drive

- **Stage 4 (Reach 2):** Will be from the existing culvert under Sunbrae Drive to 28 Blue Mountains Road, which is owned by GWRC. Access will be via temporary access adjacent to Sunbrae Drive and 28 Blue Mountains Road. For site clearance activities, the shared driveway to 20A and 20B Blue Mountains Road will be used.

Figure 5: Stage 4 Works near Blue Mountains Road.

- **Stage 5 (Reach 2):** Will be from 28 Blue Mountains Road to the existing box culvert under Pinehaven Road. Access will be via temporary access at 28 Blue Mountains Road, and 32 Blue Mountains Road. Residents from properties 30, 32, 34, 36 and 38 Blue Mountains Road will access their properties while the bridges are being constructed via a temporary access road from 40 Blue Mountains Road.

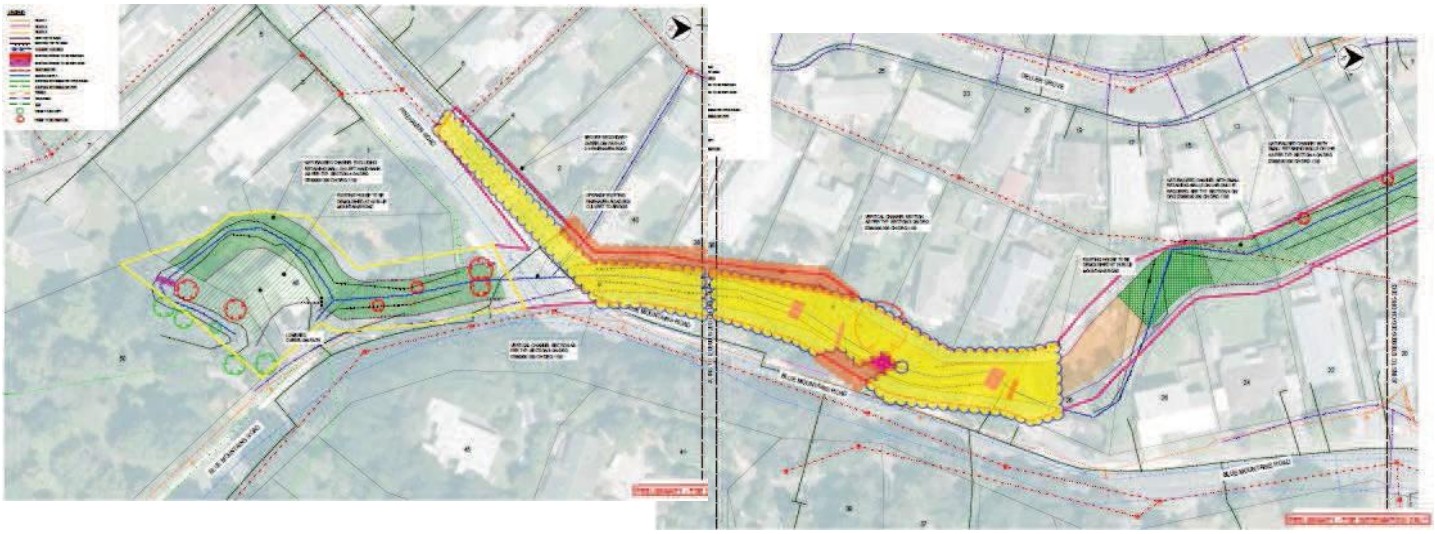

Figure 6: Stage 5 Works Alongside Blue Mountains Road, and Pinehaven Road.

- **Stage 6 (Reach 3):** Will be from the existing box culvert under Pinehaven Road to the southern extent at 50 Blue Mountains Road. Construction access will be via temporary access to the west of the stream from Pinehaven Road and 48 Blue Mountains Road.

Figure 7: Stage 6 Works near 48 Blue Mountains Road

- **Stage 7 (Reach 3):** Will be from 8 to 11 Birch Grove. Access will be via temporary access at the existing culvert between 10 and 12 Birch Grove. Access to Pinehaven Reserve will be restricted to the summer period only.

Figure 8: Stage 7 Works near Birch Grove.

In addition to this broader staging, progressive stabilisation of completed areas will be ongoing, in order to limit the potential from erosion and dust generation. This stabilisation process is outlined in Section 5 below.

Each stage of works will be guided by a Site-specific Environmental Management Plan (SEMP) that will detail the erosion and sediment control measures specific to that area of work. Further information on these plans can be found in subsequent sections of this ESCP.

3. Principles for Minimising Sediment Discharges

3.1 Erosion and Sediment Control Principles

To minimise the above adverse environmental effects the discharge of sediment from the site will be minimised by following the Principles of Erosion and Sediment Control;

1. Minimise Disturbance
2. Stage Construction
3. Protect Steep Slopes
4. Protect Watercourses
5. Stabilise Exposed Areas Rapidly
6. Install Perimeter Controls
7. Employ Detention Devices
8. Make Sure the Plan Evolves
9. Inspect

3.1.1 *Minimise Disturbance*

The extents of the site are defined by the design.

During construction exposed areas will be limited as much as practical by implementing the following principles:

- Limit earthworks extent and vegetation clearance as much as practicable.
- Stabilise exposed surfaces as soon as practicable and where they will be undisturbed for longer periods. Stabilisation can include metal, paving, polymer, hydroseed, mulch and permanent planting.
- Minimise the area of surfaces covered with fine materials.
- Identify any ‘no-go’ areas for vehicles and machinery

Workers on the site will be advised during the initial site induction of the importance of not causing disturbance outside these areas. This message will be reinforced at toolbox meetings.

3.1.2 *Stage Construction*

The required construction programme (see section 2.5) dictates that there will be a degree of staged earthworks within and alongside the Pinehaven Stream.

In addition to this broader staging, progressive stabilisation of completed areas will be an ongoing process to limit the potential from erosion and sediment generation.

3.1.3 *Protect Steep Slopes*

The overall terrain within this project is relatively flat, however, there are a number of locations along the Pinehaven Stream where stream banks are relatively steep, and avoidance of work in these areas is not practical. Notwithstanding this, the design of the works has limited, to a practical degree, the creation of steep slopes in order to reduce the flood hazard risk for the wider area.

3.1.4 *Protect Watercourses*

Pinehaven Stream is the key watercourse within the works area. Sediment laden flows will be diverted away from the Stream by sediment laden diversion bunds. The works within the watercourses will only be undertaken once suitable control measures have been implemented.

As a guiding principle streamworks are to be undertaken ‘offline’ in dry conditions achieved through the structural water diversion controls.

The SEMPs will include specific details of any streamworks including the control measures to be utilised during construction.

3.1.5 *Stabilise Exposed Areas Rapidly*

As above to minimise the generation of sediment and achieve the construction methodology progressive stabilisation will be required.

The principle measure of progressive stabilisation will be to programme and plan the works so that at the completion of works the final stabilisation, pavement or landscaping can be implemented.

Erosion control will be a priority in all circumstances by preventing sediment generation through a range of structural (physical measures) and non-structural (methodologies and construction sequencing) means. Progressive stabilisation using temporary and permanent measures will be a fundamental part of erosion control across the project. (Specific erosion control measures are described below in Section 4.)

Due to the above challenges of implementing successful temporary stabilisation measures, a key component of the erosion and sediment control methodology is to ensure that permanent stabilisation is achieved as rapidly as practical. This in turn requires robust sediment control devices to be implemented which will remain in place until the required stabilisation has been achieved.

3.1.6 *Install Perimeter Controls*

Perimeter controls to divert upslope/upstream flows from works areas will be either temporary drains or bunds. The same principle will be used on flatter sites to retain or direct sediment-laden flows to sediment retention devices. Silt fences will be used in localised areas.

3.1.7 *Employ Detention Devices*

A number of detention devices will be required on site.

Due to the nature of the Project works, the main detention devices used are likely to be the Sediment Filtration Tank and Decanting Topsoil Bunds. Silt Fences and Filter Socks will be utilised for smaller catchment areas. Further details on these devices can be found in subsequent sections of this ESCP.

During construction activity, where it is considered to be the only option that Erosion and Sediment Control (ESC) devices are required, the placement of ESCs will be undertaken with consideration of minimising catchment areas and ensuring easy access for regular maintenance.

Site-specific Environmental Management Plans (SEMP's) for each stage will allow for future innovation, flexibility and practicality of approach to ESC and in doing this will ensure that the project continues to adapt appropriately to changing conditions. Changing site conditions will require forward planning and the ability to recognise the need for a change to ESC based on works progression.

3.1.8 *Make Sure the Plan Evolves*

The pre-construction, daily and weekly inspections will provide an opportunity to plan for future changes in the site areas that will require modifications to the installed Erosion and Sediment Controls. As part of this process, Jacobs and Downers will continue to seek feedback from GWRC's environmental and planning teams, as the document evolves.

3.1.9 *Assess and Adjust*

The daily inspections will highlight any maintenance issues arising and will also be an opportunity for the effectiveness of the controls to be assessed. These inspections will also allow modifications of the minor controls such as contour drains to be adjusted to suit the changing site.

4. Erosion Control and Sediment Control Methods

The key environmental risks from this project include the following:

- dust, erosion and soil nuisance;
- sediment loss into local waterways and the UHCC water supply;
- soil and water contamination resulting from spills of hazardous materials;
- proliferation of weed and plant pests and impacts on local ecology and wildlife.

Methods adopted to avoid or minimise these risks are summarised below.

4.1 Site Management

All control measures to protect sediment entering the watercourse are to be established before works commence. This includes establishing silt fencing and protection of the headwalls. The works on the bridge abutments include their own stabilised access ways, working areas, and silt fences. The pathways alongside the stream will be stabilised as they are constructed, with silt fences installed as necessary, as secondary protection.

Two Site-specific Environmental Management Plans (SEMP's) plans have been developed for selected sites that have significant or unusual constraints, being Plans IZ089000-300-CH-SKT-2204 (Willow Park) and 2205 (28 Blue Mountains Road) (Appendix A). Plan reference IZ089000-300-CH-SKT-2203 (Appendix A) has been developed to show representative ESC measures that will be employed for the bulk of the stream works. Additional SEMP's will be written by the Contractor and submitted to GWRC for each stage of works, eventually covering the entire site. The additional SEMPs plans will be developed during mobilisation and construction of the works.

Construction of the pedestrian bridge abutments and piers will only occur in the stream dry bed i.e. above normal operating water levels.

4.1.1 Vegetation Clearance

Areas of vegetation, such as trees and bush, contribute to the amenity values in both rural and urban areas, as well as landscape quality and provision of habitats for indigenous fauna. In addition, vegetation fulfils an important function in maintaining and enhancing the quality of the environment by preventing non-point source erosion and retaining soils in place.

Care shall be taken around the trees that are to be retained. There shall be no machinery working within the dripline of any tree unless authorised, in writing, to do so by the Client's Site Representative.

When undertaking work, all appropriate measures will be taken to avoid the unnecessary removal of vegetation. Every effort shall be made to minimise damage to trees, and early consultation with regional council or qualified arborists will be carried out if tree damage or removal is likely to occur.

This section is to be updated prior to construction once a specialist arborist subconsultant has been engaged.

4.1.2 Topsoil Management

Within each works stage (as outlined in Section 2.5), progressive stripping of topsoil will be undertaken to reduce the extent of exposed earth at any one time and to minimise the risk of sediment run off. Stripping will comprise the removing of surface cover and creating an erodible surface. Following stripping, placement of fill will be undertaken.

The topsoil will be compacted and will be stabilised with grass on completion. Temporary clean and dirty water diversion bunds will be placed around the topsoil stockpiles to direct runoff to the appropriate point of discharge.

4.1.3 Temporary Stockpiles

Material which will be reused, as well as imported material, will be stockpiled within the Reformed Church sports field. The stockpiles themselves will be placed out of known overland flow paths.

It is recommended that any stockpiles set up across the site shall be fully bunded and stabilised. Before any known rainfall events, all spoil shall be covered by geotextiles in accordance with GWRC's Erosion and Sediment Control Guidelines to reduce the risk of sediment generation.

4.1.4 Stream Works

Due to the size of the stream and the constrained nature of the immediate environment, the site has very limited access. The width of the stream means that construction equipment selection is key to the constructability of the scheme. The component pieces of physical works are able to be carried out by small machinery to minimise the removal of vegetation.

Movements along the stream length will be optimised such that backloading of construction equipment is achieved. Excavated material would be removed and temporarily stockpiled prior to removal off site, imported materials would be loaded back into the wheeled dumpers and then installed in the permanent works. It is quite likely that at any time there may be two to three excavation locations and two retaining operations at any given time. The aim is to complete entire sections of retaining within each Project Stage before moving up/down the immediate location.

4.1.5 Vehicle Tracking Control Within the Stream

A maximum speed limit of no more than 5km/hr for all vehicles/machinery in the stream is to be imposed to minimise the potential for sediment generation and any unnecessary damage to the stream bed and banks.

Vehicles/machinery are to only use specified stream entry and exit points along the project site to reduce unnecessary damage to the stream bed and banks. Works are to be carefully planned prior to vehicles entering the stream to ensure that all trips along the stream bed are kept to a minimum.

No refuelling of vehicles/machinery to be undertaken in the stream.

4.1.6 Demolition

This project involves the demolition of two houses directly adjacent to Pinehaven Stream, located at 28 Blue Mountains Road and 48 Blue Mountains Road. These demolition works have the potential to generate dust, construction noise and vibration, soil contamination and sediment run off. These risks, and their associated controls, will be addressed in the Site Specific Construction Management Plan for that section of works. Erosion sediment control measures to be implemented during demolition are expected to include silt fences and/or earth bunds.

4.2 Physical Controls

There are a number of physical controls that have been developed, these can be summarised as follows:

- The two principal site wide controls, 'sheet pile protection' and 'piped diversion';
- Specific controls for the Willow Park excavation;

- More generic and localised controls which will be employed across the entire site; such as filter socks, silt fences and stormwater inlet protection.

Further details are provided in Sections 4.2.1 to 4.2.7 below.

4.2.1 Methodology 1 – Sheet Pile Protection

The construction methodology is to perform the works from within the stream and select bespoke small construction machinery that has a low ground pressure and will use the stream channel as the movement route. The benefit of this is reduced vegetation clearance on the banks and avoiding entering private property.

When a poor or heavy rain weather event forecast is received the construction equipment will be removed from the stream such that there are no obstructions in the stream channel for the rain event flows. A dry construction zone will be created by installing temporary sheetpiles such that in a weather event any exposed cut surfaces will not discharge to the “clean” stream flood water, and water would instead be collected behind the sheetpiles. The sheetpiles would be vibrated/driven into the streambed to separate the two zones so that excavation of the stream bank can be carried out over the sheetpiles and the sediment loaded/unloaded into small wheeled dumpers, thus not enter the live stream corridor.

Dirty water that gathers behind the sheetpiles will be treated by a silt filter before being released back into the stream. Once the permanent works have been constructed behind this separation wall the temporary sheetpiles will be removed as works progress up/down the stream alignment.

Following tree/vegetation clearance the temporary sheetpiles will be installed where there are excavation activities to be performed. Where retaining structures are proposed a team would be deployed following the excavation activity.

Temporary Sheet Piling Alongside Sediment Filters

Temporary sheet piling will be deployed to section off the desired works area within the stream, which could be approximately 10m long in places. The metal sheets will be machine driven into the streambed and remain in position until the required section of works are complete. Any ground water or pooled water from sheet pile installation will be removed from the work site via a pump and run through the sediment treatment filter, detailed below, before being discharged back into the stream. Flocculant is not required as the soil is not a full clay.

If the sheet piles cannot be driven into position due to an obstruction in the ground, a sand bag wall will be installed to divert the stream away from the obstruction, allowing for the excavator to excavate into the stream bed and remove the object and then the sheet piles will be driven into position.

If the obstruction cannot be removed, then the sandbags will remain and divert the stream for isolated areas.

Figure 9 below illustrates the general arrangement of the sheet piles and sediment filter.

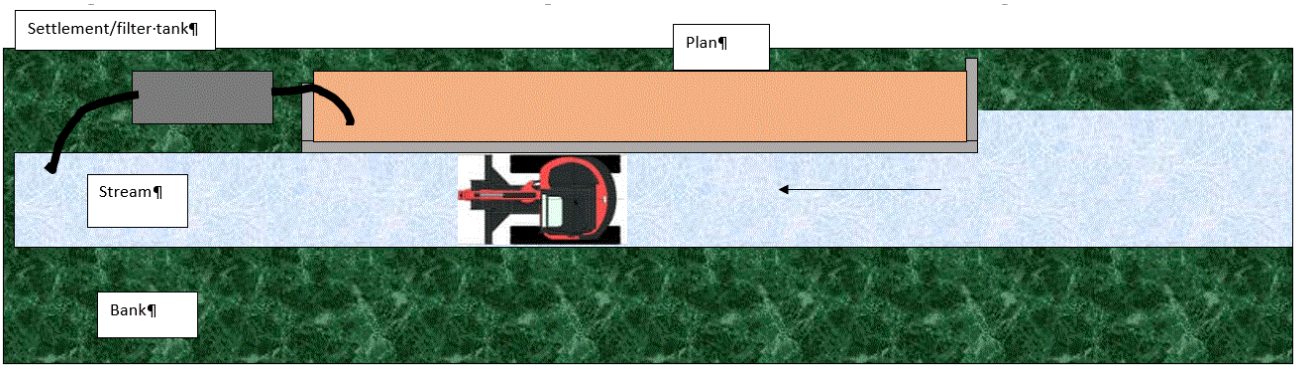

Figure 9: Sediment Filter and Sheet Piling, General Arrangement

Temporary Sheet Piling in Naturalised Channels

Figure 10 below illustrates the positioning of the plant within the stream bed, and sheet pile wall acting as a sediment control measure. The wall separates the excavation area from the live stream and to prevent sediment discharge.

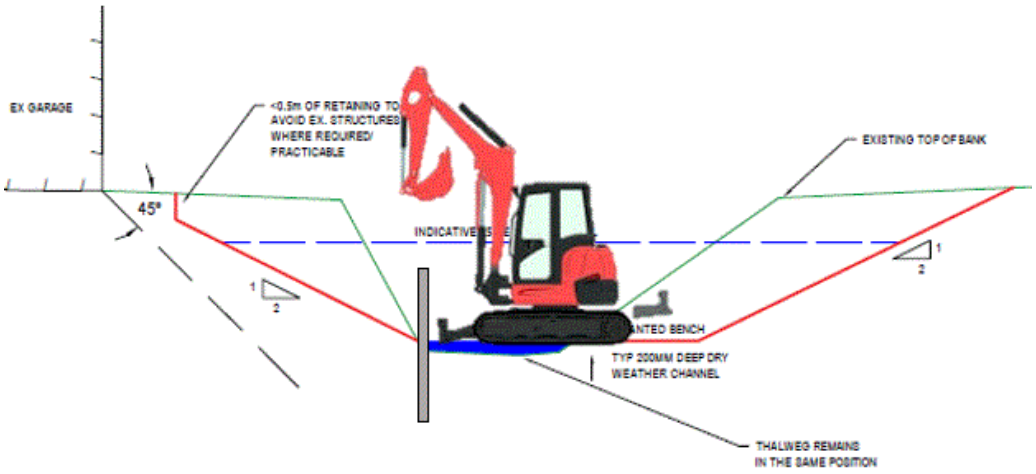

Figure 10: General Arrangement of Plant and Equipment

Temporary Sheet Piling for Construction of Vertical Retaining Walls

Figure 11 below illustrates the positioning of the plant within the stream bed, and the proposed single row or double rows of sheet piles. For clarity, the sediment filter treatment tank is not shown.

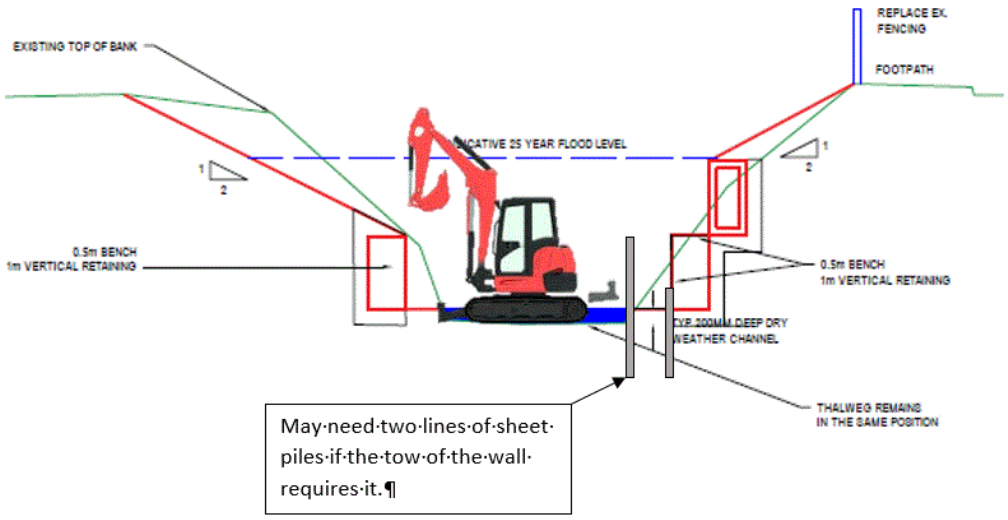

Figure 11: General Arrangement of Plant and Equipment

4.2.2 Methodology 2 – Piped Diversion

The 'piped diversion' methodology has been developed in recognition of the importance of reducing disturbance to the stream bed which may have the effect of increasing the turbidity of the water. The methodology will require significantly more land to stage the works, and will be more intrusive to selected landowners, when compared to the 'sheet pile protection methodology. These significant secondary factors will be addressed in the AEE as part of the consenting process, they are not specifically addressed in this ESCP.

The typical construction stages are set out below:

1) Install ramp down to stream;
2) Install pipe and inlet/outlet dams (the dams are anticipated to comprise sand bags or driven steel sheets);
3) Install sump pump near down steam dam and treat water through sediment curtain;
4) Excavate right bank and install wall from the bank;
5) Relocate pipe to the right side, by movement in the 'dry' stream bed;
6) Install ramp over pipe;
7) Excavate left bank from 'dry' stream bed and install wall;
8) Track out and remove ramp.

The staging and components will differ slightly where the section of stream widening comprises a trapezoidal channel, although the principal stages will still apply.

Some specific components of the diversion are set out below:

- Pipe comprises 630mm OD, Euroflow culvert pipe (or similar);
- Designed for 0.5 cumecs flow, which corresponds approximately to the 95% rainfall gauge readings;
- Steel plates or sheet piles installed to form inlet and outlet dams. Sand bags may also be employed. Earthfill dams are not an acceptable solution.

Figure 12 below illustrates the general arrangement of the pipe, excavator and retaining walls either side.

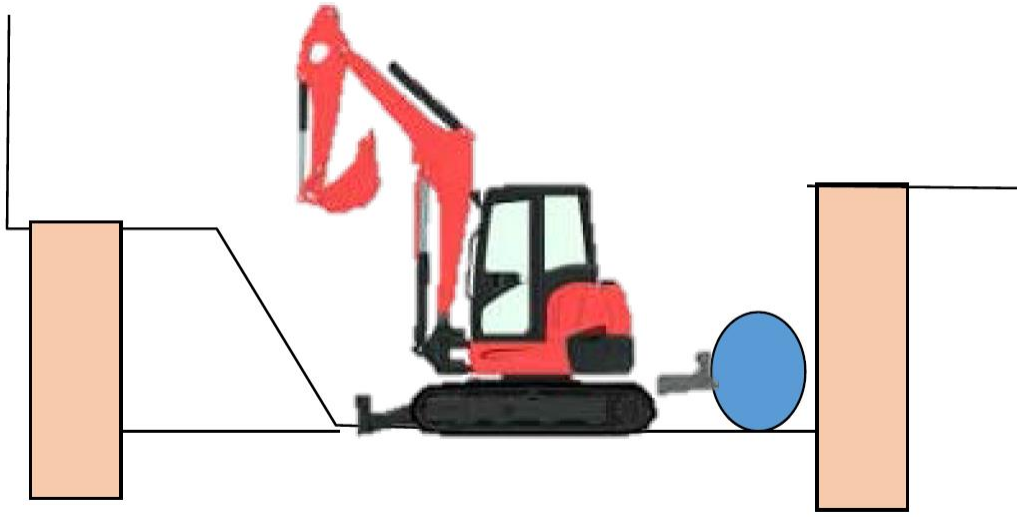

Figure 12 – Piped Diversion, general arrangement.

Further details are provided in Appendix D, 'Downers Outline Construction Methodology'.

4.2.3 Willow Park - Earth Bund and Diversion Channels

An earth bund and runoff diversion channel will be utilised during stage 1 of the on-site works at Willow Park. The bund will be located above the vegetated berms on the True Right Bank of the stream (refer Appendix A Plan IZ089000-300-CH-SKT-2204 for further details) and follow along the natural contour of the site. A dirty water diversion channel will be created below this bund, for the purpose of diverting any potential overland flow towards the decanting topsoil bunds and silt fencing.

All areas of the earth bund that are not already vegetated will be covered in geotextile cloth to minimise the risk of erosion.

The earth bund and diversion channel will be constructed as per section 4.1 of the Erosion and Sediment Control Guidelines for the Wellington Region (2002) which states:

- Design the runoff diversion channel to carry the flow from the 5% AEP period storm (plus freeboard);
- Restrict grades to no more than 2% unless armoured;
- Construct with a trapezoidal cross-sectional shape with internal side slopes no steeper than 3:1 and external slopes no steeper than 2:1. Construct runoff diversion bunds with side slopes no steeper than 3:1.
- Survey all gradients on the site;
- Ensure earth embankments used to construct runoff diversion channels/bunds are adequately compacted;
- Flow velocities greater than 1m/s will cause the runoff diversion channel/bund to erode. Incorporate stabilisation measures (such as geotextile, vegetative stabilisation or rock check dams) to minimise erosion;
- Incorporate a stable erosion-proof outfall in order to reduce water velocities and prevent scour at the outlet.

4.2.4 Willow Park - Decanting Topsoil Bunds

Two decanting topsoil bunds will be utilised at Willow Park during stage 1 of the on-site works. These bunds will be located next to the two silt fences on the lowest points of the site (refer to the staging plans (Appendix B) and Appendix A: Plan IZ089000-300-CH-SKT-2204 for further details). The purpose of these DTBs will be to detain the sediment laden runoff conveyed via the earth bund and run off diversion channel.

The DTB will be constructed as per Section 5.7 of the Erosion and Sediment Control Guidelines for the Wellington Region (2002) which states:

- Topsoil bunds should at least 4m wide by 1.5m high minimum.
- For adequate compaction track roll every 200mm lift of topsoil.
- Topsoil is more erodible than cohesive mineral soils therefore additional measures will be required to make sure there is a stabilised emergency spillway. The spillway should be well compacted, have no voids and have two layers of geotextile (UV stable impermeable weave over a soft permeable mat) pinned at 0.5m centres.
- Topsoil bunds require a decanting device, constructed of perforated ‘novacoil’ connected to a non-perforated pipe that passes through the topsoil bund. This should either discharge to a gutter or directly to a stormwater inlet. Ensure the section of pipe within the impoundment area is supported by means of a rigid upstand (waratah) allowing decanting to occur.
- Make sure the top opening of the perforated pipe is 200mm lower than the stabilised spillway.
- The freeboard above the spillway invert is at least 400mm.
- Construct the topsoil bund such that the maximum contributing catchment does not exceed 0.3 ha.

4.2.5 Silt Fencing

Silt fences will ensure all any sediment picked up by sheet flow (overland flow of water) across the work site is captured and kept out of the stream. The silt fences will be constructed and maintained in accordance with GWRC’s Erosion and Sediment Control Guidelines.

4.2.6 Filter Socks

While the excavator and small dumper trucks are working in the stream there is the potential for sediment generation to occur. Due to the low flows expected during the works, it is proposed to utilise an appropriately sized filter sock downstream from the works to be implemented as shown in Figure 13 below to act as a ‘check point’ that would also serve to intercept and filter out low levels of sedimentation within the stream. The sock would be continually monitored for effectiveness and changed if showing signs of damage/deterioration or being outflanked.

Figure 13: Example Photo of Filter Socks

The proposed use of the filter sock is considered a secondary control measure only, with the focus being on containing and treating any potential sedimentation from the works with the use of temporary sheet piling and sediment filter tanks.

4.2.7 Stormwater Inlet Protection

Stormwater inlet protection will be utilised to intercept and filter sediment-laden runoff before it enters into the stormwater network and nearby receiving environments.

All stormwater drains located near worksites, particularly vehicle access points, will be bunded off with a filter sock and a geotextile fabric and aggregate applied over the stormwater grate. Regular monitoring of these controls will be undertaken, and controls will be replaced as needed. They will be inspected after rain events.

These controls are not to be considered as primary sediment control measures.

5. Site Stabilisation

5.1 Tracking and Top Soiling

The placement of top soil over disturbed areas is an effective way of starting the stabilisation of surfaces and assists with soil moisture retention and breaking up overland flow. The thickness of topsoil will be approximately 200mm.

At the top of fill faces a bund will be constructed to prevent any overland flow over the fill face. Additional controls such as geotextile fabric may be used over exposed surfaces in instances where a heavy rainfall event is forecast.

Top soiling will be undertaken on a progressive basis when areas are completed to the final design profile.

5.2 Short Term Stabilisation

It is expected there will be a requirement to stabilise slopes in the short term, as the works proceed the next works location, and before the permanent riparian plantings and vegetation have established. . To achieve this, coconut matting (Bio-cor, dute-mesh, or similar) will be placed and secured with steel pegs. Figure 14 below illustrates the treatment.

Figure 14 – Short term stabilisation, illustration only.

5.3 Revegetation for Stabilisation

Revegetation for stabilisation will typically be achieved by hydro-seeding.

The seed mix for hydroseeding and the application rate is shown in Table 5.2. This may be revised at a later stage depending on availability of seed types.

Table 5.2: Grass Seed and Fertiliser Application Rates

Item	Mix	Application (kg/ha)
Seed types	Perennial rye grass	80
	Brown top	30
	White Clover mix	20
	Subterranean	10
	Clover	10
	Dogs tail	
Fertiliser Application	D>A>P (Di Ammonium Phosphate) or similar	240

The seed mix shall be free of noxious weeds. Each seed line shall contain less than 2% 'other crops and weeds seeds' and shall have a germination rate of 80% or more.

Hydro-seeding will be applied at a minimum rate of 2000kg/ha.

The acceptability of re-vegetation shall be a successful vegetative cover of at least 80% one month after completion of either drilling or hydro-seeding. Areas requiring additional coverage shall be re-sown until a vegetative cover of at least 80% is obtained.

Other erosion and sediment control devices treating the hydro-seeded area will not be removed until the grass has achieved an 80% strike rate, as at this point it will be considered stabilised ground.

The project includes the installation of permanent vegetation along the stream banks. Planting plans are being developed by the project landscape architect. The permanent vegetation will be installed in a progressive manner. The permanent vegetation will take several weeks or months to establish, but once in place will supplement the stabilisation provide by the hydro-seeding.

5.4 Mulching

As part of the tree removal process branches will be mulched. This mulch may be used on areas of exposed earth in preparation for planting of trees and shrubs. If used, mulch will be placed in a layer between 100mm and 200mm thick and either track rolled or compacted in place by an excavator bucket. Where required, the placement of mulch on front faces will be undertaken on a progressive basis.

5.5 Coconut Matting

Where embankments slopes are too steep for the placement of top soil or mulch, a coconut matting (i.e. BioCoir or similar) may be used to protect the embankment face from wind and water erosion and assist vegetation growth.

5.6 Additional Stabilisation Methods

Stabilisation is not limited to the methods set out above. Additional methods and technologies may be investigated and utilised during the course of earthworks, to improve the effectiveness of stabilisation. Should a new method be proposed, certification from GWRC prior to implementing will be sought.

6. Maintenance, Monitoring and Reporting

6.1 Maintenance and Monitoring of Erosion and Sediment Control Structures

Monitoring of device performance and maintaining the devices is important to ensure sediment is controlled within the site and prevented from entering the receiving environment.

Maintenance of erosion and sediment control devices is carried out in response to:

- Daily inspections during earthworking;
- 'Trigger' rainfall events as defined in Section 6.3;
- Receiving heavy rain warnings from MetService.

The maintenance actions are outlined in Table 6.1 in response to trigger rainfall events, and triggers that would be noted in the daily inspections. If the devices are found not to be operating correctly the appropriate response identified in Table 6.1 will be implemented.

Table 6.1: Maintenance actions for Erosion and Sediment Control Structures

Sediment Control Structure	Trigger	Maintenance Action
Sediment Filter	Outflow is cloudy	Stop work and clean out / replace filter materials
	Filter device not containing water (i.e. leaking)	Stop work and inspect filter device. Remediate / replace as required
	Rainfall event	Inspect for efficiency. Check for and remove any accumulated sediment. Clean out / replace filter materials as required
Decanting Topsoil Bund	Rainfall event	Check level of accumulated sediment and remove sediment if there is a risk of bund overtopping in subsequent rain events
	Evidence of scour	Armour discharge points
Inlet Protection – filter socks and aggregate / geotextile	Rainfall event	Inspect for efficiency
	Clogging of geotextile, as evident by flow backing up and appearing cloudy	Replace geotextile and aggregate
Silt fences	Fence flapping in wind	Reattach fabric to guide wire and increase number of fabric locks. If required install additional waratahs
	Build up of sediment greater than 150mm in depth resulting in straining structure	Collect sediment to be taken to appropriate disposal location
	Large rocks distorting fence alignment	Remove rocks

Sediment Control Structure	Trigger	Maintenance Action
	Bottom of silt fence not properly anchored	Dig fence into ground and use pegs to keep in position
	Under cutting of fence by concentrated flow	Identify options to avoid concentrated flow or replace with grit trap
	Silt fence broken off top wire	Install additional clips on top wire. In very windy locations a netting fence may be required to keep the silt fence in place
Temporary bund and drains	Sediment deposits in the stream	Sediment deposits to be removed prior to forecasted rain
	Excessive scour of drain base or edge of bund	Line base with rock armour where excessive scour is observed
	Frequent over-topping of drain	Enlarge the drain
Mulch strips	Sediment build up behind mulch strip, preventing effective treatment	Remove sediment build up and replace mulch strip

6.2 Site Management – Adapting to Change

The attached drawings in Appendix B indicate approximate extent of works which have informed the ESC design (refer also to Section 4) and show the overall philosophy of managing the site as three separate reaches. The drawings in Appendix A indicate the main structural controls proposed, however alterations will have to be employed given the rapidly changing site conditions (i.e. height of earthworks, extents of working areas).

Alterations to the control measures will be implemented through weekly site visits by suitably qualified and experienced person (ESC Supervisor) to identify changing site conditions. ESC planning meetings will be held fortnightly while earthworks are occurring, and the Earthworks Supervisor and the ESC Supervisor shall together prepare micro phasing sketches (typically hand drawn) as works proceed. These sketches will contain a reasonable level of detail for a small area of immediate works. As a minimum, these sketches will be prepared fortnightly, or at a reduced frequency as agreed with GWRC.

Proposed changes that may potentially affect the ESC design will be discussed at these meetings, and changes to the ESCP (if any) will be agreed with GWRC prior to implementing. These changes could include construction methodology, devices used, location of the devices, and phasing.

The micro phasing sketches will be provided to GWRC within 5 working days of the sketch being implemented.

6.3 Rainfall Trigger Events

The following rainfall events will trigger an inspection to check the condition and continued effectiveness of the erosion and sediment control measures:

- 20 mm in a 24 hour period; or
- A rainfall event with an intensity equal to or greater than 6 mm/hr.

The rain events will be measured at the GWRC Pinehaven Stream at Pinehaven reservoir and the site rain gauge located in the main construction yard.

A trigger event recorded by the GWRC Pinehaven gauge would prompt a check against the site gauge to see if a trigger rain event had occurred at this site. Additionally, should heavy rainfall occur onsite, this would prompt a check against the site gauge and Pinehaven gauge.

Water quality monitoring will be undertaken once 6 mm/hr or 20 mm/24hr is measured:

- At the site gauge during working hours (i.e. Monday to Friday 7am to 6pm); or
- At the Pinehaven gauge during non-working hours (i.e. Monday to Friday 6pm to 7am, Saturday and Sunday, or public holidays).

6.4 Water Quality Sampling

6.4.1 General Approach

Following a rainfall trigger event , water quality samples will be collected from the following locations for the purpose of water quality monitoring and to provide an initial of assessment of effects to the receiving environments from the site

- Sample Location 1 – Willow Park
- Sample Location 2 – Sunbrae Road Crossing, downstream;
- Sample Location 3 – Pinehaven Road Crossing, downstream;
- Sample Location 4 – Gard Street Outlet.

Sample locations will be identified on the associated SEMPs. Samples will also be collected at decanting topsoil bunds and surface ponding areas if the flow appears discoloured.

The contractor will be responsible for collecting water quality samples as soon as practicable (subject to safety considerations) after the noted exceedance of 6mm/hour or 20mm/24hours. Samples collected will be tested for pH, turbidity and TSS using regularly calibrated field meter equipment on-site.

Prior to construction, a start-up briefing will be undertaken by a suitably qualified practitioner and will demonstrate appropriate water quality sampling techniques to the contractor (if required).

These monitoring requirements are summarized in Table 6.2 below.

Table 6.2: Monitoring Requirements for Water Quality Parameters

Phase	Frequency (1,2)	Sites
Normal operation of earthworks being undertaken and while portions of the site are not stabilised.	As soon as practical following 6mm/hr or 20mm/24 hour rainfall being triggered.	All operating DEBs. Water quality sampling points will be annotated on the ESCP plans
	If the appearance of the water in the clean water diversion drains appears suspicious (i.e. too discoloured), and the ponds and/or drains are discharging.	Clean water drains where the suspicious appearance of water is identified.

Phase	Frequency (1,2)	Sites
Winter period Site stabilised (3) no earthworks being undertaken.	As soon as practical following a 6mm/1 hour or 20mm/24 hour rainfall level being triggered.	All operating DEBs. Water quality sampling points will be annotated on the ESCP plans.

(1) Frequency may be altered with approval of Manager, Environmental Regulation, GWRC based upon previous monitoring data.
(2) Monitoring will only occur if health and safety requirements can be complied with.
(3) For the site to be classed as stabilised, it must be to the Manager, Environmental Regulation, GWRC's satisfaction.

6.4.2 Duration

The above monitoring requirements will commence once bulk earthworks have commenced and finish when GWRC have confirmed the site is stabilised and the sediment and erosion control devices have been decommissioned.

6.4.3 Parameters

The following parameters will be monitored in the field with regularly calibrated field meter equipment: pH, total suspended solids (TSS) and turbidity.

6.4.4 Reporting

Following a rainfall trigger, the following shall be submitted to GWRC within 2 working days of the samples being collected:

- Time of rainfall trigger noted and nature of rainfall exceedance (i.e. 6mm/hr or 20mm/24hr);
- Time samples were collected;
- pH, total suspended solids (TSS) and turbidity results for each sample.

If the sample was taken outside of the agreed response timeframes (no samples will be taken during stat holidays) an explanation of why this was the case shall be included.

Samples results shall be emailed to *notifications@gw.govt.nz.*

6.5 Extreme Rainfall Events

Rain events greater than a 1 in 20 year ARI (greater than 60min duration rainfall event) will be defined as an 'extreme event'. Under these circumstances, treatment efficiencies are expected to be significantly reduced.

6.6 Water Quality Management

All practical steps shall be taken to minimise any sediment discharge to watercourses in connection with the works that may cause the production of conspicuous suspended material or conspicuous change in colour or clarity in the receiving waters (after reasonable mixing).

As provisional guidelines to trigger stormwater management investigation and response, we propose a water quality trigger of a total change in suspended sediment from upstream to downstream monitoring not exceeding a 30 percent increase of the baseline concentration (g/m3), following a trigger rain event (as set out in Section 6.3 above).

Secondary measures may be implemented as an initial reactionary response to a measured exceedance of the sediment quality trigger. The purpose of such secondary measures are to provide assistance to the primary treatment measure, or temporary treatment (until remedial actions are implemented) if failure of the upstream primary controls is identified.

6.7 Water Quality Assessment

Water quality from the monitoring locations (defined in Section 6.4. above) will be assessed against a total change from upstream to downstream monitoring not exceeding a 30 percent increase of the baseline concentration (g/m^3), at the downstream sample compared to upstream samples. Trigger levels and interventions will be developed in close coordination with our Aquatic Ecologist (EOS Ecology).

Exceedance of this trigger will initiate a stormwater management investigation, comprising of:

- Identifying where the exceedance is being generated;
- Identifying if the exceedance can be attributed to an isolated source using the monitoring data (i.e. a DEB, diversion channel);
- If the exceedance can be isolated, what remedial response/actions are required (i.e. increasing frequency of maintenance, investigating potential upstream sources);

If the exceedance cannot be isolated:

- Further discussions with the contractor and/or additional site audits may be required to determine the contributing source (if any); and
- Assessing the appropriateness of existing ESC measures within the catchment for an identified contributing source (if any).

6.8 Contingency

Construction is scheduled to commence in early to mid-2020 and will be staged as described above over approximately two years. The programme will be finalised once a Contractor has been appointed. High intensity and prolonged rainfall events are uncommon during summer months but will need to be taken into account during the winter months. The Contractor is responsible for monitoring weather forecasts, inspecting all erosion and sediment control measures and undertaking any remedial works required prior to forecasted rain events.

Construction work will be avoided during heavy rainfall events (those with forecasted heavy rain warnings by MetService). Erosion and sediment control measures will be checked by the Contractor and upgraded or modified where necessary.

7. Procedures for Reviewing and Changing the ESCP

For design and construction planning purposes, site appropriate measures are indicatively shown on the ESCP and SEMP's, attached in Appendix A. The ESC methods implemented for any given part of the works will be modified and improved in response to detailed design and site conditions as works proceed, and specific ESC measures will be implemented as required.

Specific ESC will be discussed at site meetings and daily checks will be undertaken by the contractor based on weather conditions. Details of implemented measures will be discussed at monthly audits and updates provided to GWRC by means of certification forms and site plans.

8. Site Responsibilities

A summary of the site roles and responsibilities is set out below in Table 8.1.

Table 8.1: Site roles and responsibility

Company	Role	Responsibility
Tim Haylock Downer	Project Manager	Overall responsibility to ensure resource consent conditions and E&SCP requirements met. Inspection of E&SC activities. Receive trigger text alerts from the GWRC Pinehaven Rainfall gauge.
To be confirmed Downer	Construction Manager & ESC Supervisor	Confirming site works being undertaken in accordance with engineering design and the ESCP. Regular site inspections to employ active site management techniques. Regular communication with GWRC through sketches showing micro-phasing plans. Receive trigger text alerts from the GWRC Pinehaven Rainfall gauge. Reporting of trigger rainfall events and water quality monitoring.
To be confirmed Downer	Construction Supervisor	Installation and maintenance of sediment control measures. Daily inspections of structures. Measures in advance of heavy rainfall. Receive trigger text alerts from the GWRC Pinehaven Rainfall gauge.
To be confirmed Jacobs	Construction Site Support	Construction monitoring, including regular auditing of Downers ESCP plan.
Eric Skowron Jacobs	Project Manager	Coordination of Jacobs site support.

9. Construction Timeline

The physical works are anticipated to start in early to mid-2020, and will be staged as described above over approximately two years. A more detailed programme of works and the associated ESCP will be provided following the consent submission.

Appendix A. Erosion and Sediment Control Plans – General and Site Specific examples

LEGEND

EXISTING

- TOP OF BANK
- CHANNEL THALWEG
- STORMWATER PIPE
- WASTEWATER
- WATER SUPPLY
- POWER
- TELECOMS
- GAS

DESIGN

- NEW TOP OF BANK - TRAPEZOIDAL CHANNEL
- NEW TOP OF BANK - VERTICAL WALL CHANNEL
- EXISTING BRIDGE TO BE RETAINED
- EXISTING BRIDGE TO BE REMOVED
- EXISTING BRIDGE TO BE REPLACED
- TEMPORARY BRIDGE
- TREES TO BE KEPT
- TREES TO BE REMOVED
- SILT FENCE
- BUND WALL
- FLOATING SEDIMENT BOOM
- AREA 1
- AREA 2
- AREA 3
- ACCESS RAMP
- TEMPORARY SHEET PILES

8

4

STABILISED ACCESS RAMP
GAP65 CLEAN MATERIAL
150mm THICK 10M LONG x
4M WIDE AS PER GWRC
ESCP GUIDELINES (2002)

FILTER SOCK CHECK DAM
DOWNSTREAM OF WORK

SHEET PILES TO
SEGREGATE STREAM
FROM EXCAVATED SLOPE

SEDIMENT FILTER

10M (APPROX.)

RETURN SHEET PILES TO
STOP STREAM ENTERING
EXCAVATION SITE ZONE

EXCAVATOR IN STREAM
TO INSTALL SHEET PILES
AND RETAINING WALL

SECOND SITE ALONG
STREAM

SEDIMENT FILTER

BLUE MOUNTAINS ROAD

SEQUENCE

1. INSTALL ACCESS RAMP INTO STREAM, BUND THE TOP OF RAMP AT LOW POINT.
2. INSTALL SHEET PILES FROM STREAM WITH EXCAVATORS.
3. EXCAVATE AND INSTALL WALL.
4. REMOVE SHEET PILES AND REPEAT.

SKETCH - FOR INFORMATION ONLY

REV	DATE	DRAWN	REV'D	APP'D	REVISION	DRAWING NUMBER	REFERENCE DRAWING TITLE
A	01/07/19	SK	JS	JS	SKETCH - FOR INFORMATION ONLY		

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CLIENT: WELLINGTON WATER
PROJECT: PINEHAVEN STREAM IMPROVEMENTS

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
SK	JS		
DESIGNED	DESIGN REVIEW	DATE	DATE
JS	JS		

TITLE
MAIN WORKS
EROSION AND SEDIMENT CONROL PLAN

SCALE: 1:100 @ A3
DRAWING No: IZ089000-300-CH-SKT-2203
REV: A

LEGEND

EXISTING

- TOP OF BANK
- CHANNEL THALWEG
- STORMWATER PIPE
- WASTEWATER
- WATER SUPPLY
- POWER
- TELECOMS
- GAS

DESIGN

- NEW TOP OF BANK - TRAPEZOIDAL CHANNEL
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- TEMPORARY BRIDGE
- TREES TO BE KEPT
- TREES TO BE REMOVED
- SILT FENCE
- BUND WALL
- FLOATING SEDIMENT BOOM
- AREA 1
- AREA 2
- AREA 3
- ACCESS RAMP
- TEMPORARY SHEET PILES

10A

AREA 2 (BUND WALL)

SILT FENCES TO ALLOW REMOVAL OF AREA 2

RUN OFF THROUGH SILT FENCES

SILT FENCE

SILT FENCES TO ALLOW REMOVAL OF AREA 2

AREA 1

A-1

AREA 2 (BUND WALL)

RUN OFF THROUGH SILT FENCES

SILT FENCE

ACCESS ROAD

AREA 1 IS NEW TOP OF BANK

10

EXISTING FORMATION

BUND WALL SIZED FOR 5% AEP

SILT FENCES TO ALLOW REMOVAL OF AREA 2

DETAIL A

AREA 1

AREA 2

SECTION A-A
SCALE NTS

SILT FENCES INSTALLED AND WEIGHTED DOWN

DETAIL A
SCALE NTS

ALL BUNDS WILL BE COVERED IN GEOTEXTILE CLOTH TO ENSURE THEY DO NOT ERODE (OR HYDROSEED, IF CONSTANTLY RAINING CLOTH WOULD WORK BETTER). BUNDS WILL BE CONSTRUCTED AS PER THE EROSION AND SEDIMENT CONTROL GUIDELINES FOR THE WELLINGTON REGION (2002) WITH A TRAPEZOIDAL CROSS SECTIONAL SHAPE WITH INTERNAL SIDE SLOPES NO STEEPER THAN 3:1 AND EXTERNAL SLOPES NO STEEPER THAN 2:1. SIZED FOR THE 5% AEP STORM PLUS FREEBOARD.

THE BUNDS WILL BE REMOVED DURING STAGE 2 OF THE WORKS AS THIS INVOLVES DISTURBING THE STREAM BED AND BANKS. SILT FENCING WILL BE INSTALLED ALONG THE LENGTH OF THE WORK SITE. THE SILT FENCE WILL NOT BE TOED IN BUT WEIGHTED DOWN.

SEQUENCE

1. INSTALL SILT FENCING AT STREAM LEVEL FOR AREA 1
2. EXCAVATE AREA 1 LEAVING AREA 2 AS A BUND WALL MAKING RUN OFF PASS THROUGH SILT FENCING.
3. GRASS AREA 1
4. INSTALL SILT FENCE ALONG STREAM FOR EXCAVATION OF AREA 2.
5. EXCAVATE AREA 2 AND GRASS.

SKETCH - FOR INFORMATION ONLY

REV	DATE	DRAWN	REV'D	APP'D	REVISION	DRAWING NUMBER	REFERENCE DRAWING TITLE
A	01/07/19	SK	JS	JS	SKETCH - FOR INFORMATION ONLY		

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CLIENT: WELLINGTON WATER			
PROJECT: PINEHAVEN STREAM IMPROVEMENTS			
DRAWN: SK	DRAWING CHECK: JS	REVIEWED: DATE	APPROVED: DATE
DESIGNED: JS	DESIGN REVIEW: JS		

TITLE: MAIN WORKS, WILLOW PARK
EROSION AND SEDIMENT CONTROL PLAN

SCALE	DRAWING No	REV
1:100 @ A3	IZ089000-300-CH-SKT-2204	A

LEGEND

EXISTING

- TOP OF BANK
- CHANNEL THALWEG
- STORMWATER PIPE
- WASTEWATER
- WATER SUPPLY
- POWER
- TELECOMS
- GAS

DESIGN

- NEW TOP OF BANK - TRAPEZOIDAL CHANNEL
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- TEMPORARY BRIDGE
- TREES TO BE KEPT
- TREES TO BE REMOVED
- SILT FENCE
- BUND WALL
- FLOATING SEDIMENT BOOM
- AREA 1
- AREA 2
- AREA 3
- ACCESS RAMP
- TEMPORARY SHEET PILES

32

30

28

26

INDICATIVE SHARED ACCESS DRIVE

EXISTING HOUSE TO BE DEMOLISHED AT 28 BLUE MOUNTAINS ROAD

EXCAVATOR

SMALL TRUCK

AREA 2

AREA 1

AREA 3

INSTALL SILT FENCE TO EXCAVATE AREA 2

SEDIMENT FILTER

TEMPORARY BRIDGE ACCESS TO EXCAVATE AREA 1 KEEPING THE STREAM IN ITS ORIGINAL POSITION

EXISTING STREAM

SILT FENCING

BLUE MOUNTAINS ROAD

ACCESS ROAD

SEQUENCE

1. INSTALL SILT FENCING AND TEMP BRIDGE.
2. EXCAVATE AREA 1.
3. INSTALL SILT FENCE AND EXCAVATE AREA 2.
4. GRASS AREA 1 & 2
5. REMOVE TEMPORARY BRIDGE.
6. EXCAVATE AREA 3 ALLOWING STREAM DIVERSION (CONTROLLED OPENING).
7. BLOCK OFF OLD STREAM AND BACK FILL.

SKETCH - FOR INFORMATION ONLY

REV	DATE	DRAWN	REV'D	APP'D	REVISION
A	01/07/19	SK	JS	JS	SKETCH - FOR INFORMATION ONLY

DRAWING NUMBER | REFERENCE DRAWING TITLE

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CLIENT: WELLINGTON WATER
PROJECT: PINEHAVEN STREAM IMPROVEMENTS

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
SK	JS	DATE	DATE
DESIGNED	DESIGN REVIEW		
JS	JS		

TITLE: MAIN WORKS 28 BLUE MOUNTAINS ROAD EROSION AND SEDIMENT CONTROL PLAN

SCALE: 1:100 @ A3
DRAWING No: IZ089000-300-CH-SKT-2205
REV: A

Appendix B. Indicative Staging Plans from Downer

LEGEND

- REACH 1
- REACH 2
- REACH 3
- NEW TOP OF BANK
- EXISTING TOP OF BANK
- CHANNEL THALWEG
- EXISTING BRIDGE TO BE REMOVED
- EXISTING BRIDGE TO BE REPLACED
- WASTEWATER
- WATER SUPPLY
- EXISTING STORMWATER OPEN DRAIN
- EXISTING STORMWATER PIPE
- POWER
- TELECOMS
- GAS
- TREES TO BE KEPT
- TREES TO BE REMOVED

SECURE SECONDARY FLOW PATH ALONG DRIVEWAY OF 12-15 CLINKER GROVE

NATURALISED CHANNEL. EXISTING LEFT HAND BANK TO BE RETAINED WITH LOWERED OVERFLOW ON RIGHT HAND BANK. SEE TYP. SECTION 3 ON DRG IZ089000-200-CH-DRG-1100

NATURALISED CHANNEL WITH VERTICAL RETAINING WALL ON LEFT HAND BANK AS PER TYP. SECTION 1 ON DRG IZ089000-200-CH-DRG-1100

INSTALL DEBRIS SCREEN AT WHITEMANS ROAD

VERTICAL CHANNEL SECTION AS PER TYP. SECTION 5 ON DRG IZ089000-200-CH-DRG-1100

LOWER BYPASS WEIR AND INSTALL DEBRIS SCREEN

NATURALISED CHANNEL AS PER TYP. SECTION 3 ON DRG IZ089000-200-CH-DRG-1100

VERTICAL CHANNEL SECTION AS PER TYP. SECTION 2 ON DRG IZ089000-200-CH-DRG-1100

JOINS TO IZ089000-200-CH-DRG-2002

PINEHAVEN ROAD

BLUE MOUNTAINS ROAD

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SCALE 1:250 | DRAWING No IZ089000-200-CH-DRG-2001 | REV 1

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NAME: FORSYTH, JAMES

LEGEND

- REACH 1
- REACH 2
- REACH 3
- NEW TOP OF BANK
- EXISTING TOP OF BANK
- CHANNEL THALWEG
- EXISTING BRIDGE TO BE REMOVED
- EXISTING BRIDGE TO BE REPLACED
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- EXISTING STORMWATER PIPE
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SECURE SECONDARY FLOW PATH ALONG DRIVEWAY OF 12-15 CLINKER GROVE

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NATURALISED CHANNEL WITH VERTICAL RETAINING WALL ON LEFT HAND BANK AS PER TYP. SECTION 1 ON DRG IZ089000-200-CH-DRG-1100

INSTALL DEBRIS SCREEN AT WHITEMANS ROAD

VERTICAL CHANNEL SECTION AS PER TYP. SECTION 5 ON DRG IZ089000-200-CH-DRG-1100

LOWER BYPASS WEIR AND INSTALL DEBRIS SCREEN

NATURALISED CHANNEL AS PER TYP. SECTION 3 ON DRG IZ089000-200-CH-DRG-1100

VERTICAL CHANNEL SECTION AS PER TYP. SECTION 2 ON DRG IZ089000-200-CH-DRG-1100

JOINS TO IZ089000-200-CH-DRG-2002

PINEHAVEN ROAD

BLUE MOUNTAINS ROAD

13 14 52A 48 50 1/46 15 54 56 8 31 33 37 39 1 5

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LEGEND

- REACH 1
- REACH 2
- REACH 3
- NEW TOP OF BANK
- EXISTING TOP OF BANK
- CHANNEL THALWEG
- EXISTING BRIDGE TO BE REMOVED
- EXISTING BRIDGE TO BE REPLACED
- WASTEWATER
- WATER SUPPLY
- EXISTING STORMWATER OPEN DRAIN
- EXISTING STORMWATER PIPE
- POWER
- TELECOMS
- GAS
- TREES TO BE KEPT
- TREES TO BE REMOVED

DELLER GROVE

SUNBRAE DRIVE

EXISTING DWELLING TO BE DEMOLISHED AT 4 SUNBRAE DRIVE

SECURE SECONDARY FLOW PATH THROUGH 4 SUNBRAE DRIVE

NATURALISED CHANNEL EXCLUDING RETAINING WALL AS PER TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

NATURALISED CHANNEL WITH SMALL RETAINING WALLS ON LHB AS PER TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

NATURALISED CHANNEL AS PER TYP. SECTION 3 ON DRG IZ089000-200-CH-DRG-1100

UPGRADE EXISTING 1800mm DIAMETER SUNBRAE DR CULVERT

STAGE 2B

ACCESS

JOINS TO IZ089000-200-CH-DRG-2003

JOINS TO IZ089000-200-CH-DRG-2001

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TITLE: GENERAL ARRANGEMENT SHEET 2

SCALE: 1:250
DRAWING No: IZ089000-200-CH-DRG-2002
REV: 1

LEGEND

- REACH 1
- REACH 2
- REACH 3
- NEW TOP OF BANK
- EXISTING TOP OF BANK
- CHANNEL THALWEG
- EXISTING BRIDGE TO BE REMOVED
- EXISTING BRIDGE TO BE REPLACED
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- EXISTING STORMWATER PIPE
- POWER
- TELECOMS
- GAS
- TREES TO BE KEPT
- TREES TO BE REMOVED

DELLER GROVE

SUNBRAE DRIVE

EXISTING DWELLING TO BE DEMOLISHED AT 4 SUNBRAE DRIVE

SECURE SECONDARY FLOW PATH THROUGH 4 SUNBRAE DRIVE

NATURALISED CHANNEL EXCLUDING RETAINING WALL AS PER TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

NATURALISED CHANNEL WITH SMALL RETAINING WALLS ON LHB AS PER TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

NATURALISED CHANNEL AS PER TYP. SECTION 3 ON DRG IZ089000-200-CH-DRG-1100

UPGRADE EXISTING 1800mm DIAMETER SUNBRAE DR CULVERT

JOINS TO IZ089000-200-CH-DRG-2003

JOINS TO IZ089000-200-CH-DRG-2001

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LEGEND

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- REACH 3
- NEW TOP OF BANK
- EXISTING TOP OF BANK
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- EXISTING BRIDGE TO BE REMOVED
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- EXISTING STORMWATER OPEN DRAIN
- EXISTING STORMWATER PIPE
- POWER
- TELECOMS
- GAS
- TREES TO BE KEPT
- TREES TO BE REMOVED

DELLER GROVE

EXISTING DWELLING TO BE DEMOLISHED AT 4 SUNBRAE DRIVE

SECURE SECONDARY FLOW PATH THROUGH 4 SUNBRAE DRIVE

NATURALISED CHANNEL EXCLUDING RETAINING WALL AS PER TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

NATURALISED CHANNEL WITH SMALL RETAINING WALLS ON LHB AS PER TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

JOINS TO IZ089000-200-CH-DRG-2003

JOINS TO IZ089000-200-CH-DRG-2001

NATURALISED CHANNEL AS PER TYP. SECTION 3 ON DRG IZ089000-200-CH-DRG-1100

UPGRADE EXISTING 1800mm DIAMETER SUNBRAE DR CULVERT

SUNBRAE DRIVE

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SCALE: 1:250

DRAWING No: IZ089000-200-CH-DRG-2002

REV: 1

LEGEND

- REACH 1
- REACH 2
- REACH 3
- NEW TOP OF BANK
- EXISTING TOP OF BANK
- CHANNEL THALWEG
- EXISTING BRIDGE TO BE REMOVED
- EXISTING BRIDGE TO BE REPLACED
- WASTEWATER
- WATER SUPPLY
- EXISTING STORMWATER OPEN DRAIN
- EXISTING STORMWATER PIPE
- POWER
- TELECOMS
- GAS
- TREES TO BE KEPT
- TREES TO BE REMOVED

DELLER GROVE

BLUE MOUNTAINS ROAD

BLUE MOUNTAINS ROAD

VERTICAL CHANNEL SECTION AS PER TYP. SECTION 5 ON DRG IZ089000-200-CH-DRG-1100

NATURALISED CHANNEL WITH SMALL RETAINING WALLS ON LHB ONLY IF REQUIRED. SEE TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

NATURALISED CHANNEL WITH SMALL RETAINING WALLS ON LHB AS PER TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

EXISTING HOUSE TO BE DEMOLISHED AT 28 BLUE MOUNTAINS ROAD

JOINS TO IZ089000-200-CH-DRG-2004

JOINS TO IZ089000-200-CH-DRG-2002

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TITLE: GENERAL ARRANGEMENT SHEET 3

SCALE: 1:250

DRAWING No: IZ089000-200-CH-DRG-2003

REV: 1

LEGEND

- REACH 1
- REACH 2
- REACH 3
- NEW TOP OF BANK
- EXISTING TOP OF BANK
- CHANNEL THALWEG
- EXISTING BRIDGE TO BE REMOVED
- EXISTING BRIDGE TO BE REPLACED
- WASTEWATER
- WATER SUPPLY
- EXISTING STORMWATER OPEN DRAIN
- EXISTING STORMWATER PIPE
- POWER
- TELECOMS
- GAS
- TREES TO BE KEPT
- TREES TO BE REMOVED

DELLER GROVE

BLUE MOUNTAINS ROAD

BLUE MOUNTAINS ROAD

VERTICAL CHANNEL SECTION AS PER TYP. SECTION 5 ON DRG IZ089000-200-CH-DRG-1100

NATURALISED CHANNEL WITH SMALL RETAINING WALLS ON LHB ONLY IF REQUIRED. SEE TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

NATURALISED CHANNEL WITH SMALL RETAINING WALLS ON LHB AS PER TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

EXISTING HOUSE TO BE DEMOLISHED AT 28 BLUE MOUNTAINS ROAD

JOINS TO IZ089000-200-CH-DRG-2004

JOINS TO IZ089000-200-CH-DRG-2002

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LEGEND

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- REACH 3
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- EXISTING TOP OF BANK
- CHANNEL THALWEG
- EXISTING BRIDGE TO BE REMOVED
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- EXISTING STORMWATER PIPE
- POWER
- TELECOMS
- GAS
- TREES TO BE KEPT
- TREES TO BE REMOVED

PINEHAVEN ROAD

NATURALISED CHANNEL EXCLUDING RETAINING WALL ON LEFT HAND BANK AS PER TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

EXISTING HOUSE TO BE DEMOLISHED AT 48 BLUE MOUNTAINS ROAD

SECURE SECONDARY OVERFLOW PATH AT 2-4 PINEHAVEN ROAD

UPGRADE EXISTING PINEHAVEN ROAD BOX CULVERT TO BRIDGE

JOINS TO IZ089000-200-CH-DRG-2003

LOWERED OVERFLOW PATH

VERTICAL CHANNEL SECTION AS PER TYP. SECTION 5 ON DRG IZ089000-200-CH-DRG-1100

BLUE MOUNTAINS ROAD

BLUE MOUNTAINS ROAD

1 2 3 4 5 6 7 8 27 40 38 48 50 45 41

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FS/KB	DF		

TITLE: GENERAL ARRANGEMENT SHEET 4

SCALE 1:250 | DRAWING No IZ089000-200-CH-DRG-2004 | REV 1

LEGEND

- REACH 1
- REACH 2
- REACH 3
- NEW TOP OF BANK
- EXISTING TOP OF BANK
- CHANNEL THALWEG
- EXISTING BRIDGE TO BE REMOVED
- EXISTING BRIDGE TO BE REPLACED
- WASTEWATER
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- POWER
- TELECOMS
- GAS
- TREES TO BE KEPT
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PINEHAVEN ROAD

NATURALISED CHANNEL EXCLUDING RETAINING WALL ON LEFT HAND BANK AS PER TYP. SECTION 4 ON DRG IZ089000-200-CH-DRG-1100

EXISTING HOUSE TO BE DEMOLISHED AT 48 BLUE MOUNTAINS ROAD

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UPGRADE EXISTING PINEHAVEN ROAD BOX CULVERT TO BRIDGE

JOINS TO IZ089000-200-CH-DRG-2003

OWERED VERFLOW PATH

BLUE MOUNTAINS ROAD

VERTICAL CHANNEL SECTION AS PER TYP. SECTION 5 ON DRG IZ089000-200-CH-DRG-1100

BLUE MOUNTAINS ROAD

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DRAWING No: IZ089000-200-CH-DRG-2004
REV: 1

LEGEND

- REACH 1
- REACH 2
- REACH 3
- NEW TOP OF BANK
- EXISTING TOP OF BANK
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- EXISTING STORMWATER PIPE
- POWER
- TELECOMS
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- TREES TO BE KEPT
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PINEHAVEN RESERVE

BIRCH GROVE

VERTICAL CHANNEL AS PER TYP. SECTION 5 ON DRG IZ089000-200-CH-DRG-1100

SECURE OVERLAND FLOW PATH ALONG DRIVEWAY OF 12 BIRCH GROVE

REMOVE EXISTING CULVERT AND REPLACE WITH BRIDGE

RELOCATE GARAGE

3 4 5 5A 6 7 8 9 10 10A 10B 10C 11 12

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TITLE: GENERAL ARRANGEMENT SHEET 5

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Appendix C. Geotechnical Investigations

Pinehaven Stream – Flood Protection Works

Wellington Water

Geotechnical Factual and Interpretive Report

IZ018100-GEO-ESG-RP-0001 | 1

16 October 2015

Pinehaven Stream - Flood Protection Works

Project no:	IZ018100.003
Document title:	Geotechnical Factual and Interpretive Report
Document No.:	IZ018100-GEO-ESG-RP-0001
Revision:	1
Date:	16 October 2015
Client name:	Wellington Water
Project manager:	Karla Beamsley
Author:	Steven Wilson/James Cordingley/Jack Leeves
File name:	I:\AENVW\Projects\IZ018100 - Pinehaven Survey & Geotech\Technical (controlled)\Geotechnical\03. Report\IZ018100-GEO-ESG-RP-0001_rev0.docx

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Document history and status

Revision	Date	Description	By	Review	Approved
A	03/07/2015	Issued for Internal Technical Review	S.Wilson	C.Watts	
B	12/08/2015	Issued for Internal Technical Review	S. Wilson/ J. Cordingley	C. Watts	
C	14/10/2015	Issued for Internal Technical Review	S. Wilson/ J. Cordingley/ J. Leeves	C. Watts	KJB
1	16/10/15	Issued to Client	K Beamsley		

Contents

1. Introduction

1.1 General

Wellington Water (WW) are undertaking a program which involves the reshaping of around 500m of Pinehaven Stream through predominately private property in order to upgrade the existing stream channel's capacity from less than a 5 year storm capacity to a 25 year storm capacity to quell frequent flooding in the area. Major works to be undertaken as part of this project include replacing the existing culvert located along Sunbrae Dr, with a widened bridge and widening of the existing stream bank with new slopes and retaining walls.

As such, Jacobs New Zealand Limited (Jacobs) was commissioned by WW to undertake a geotechnical investigation (GI) for the new bridge abutments at Sunbrae Drive and around the proposed retaining walls within the project extents, as well as a general overview of the site. This report provides the factual information obtained from the GI and geotechnical recommendations for the bridge upgrade, retaining wall design and stream channel slope stability.

1.2 Scope

The scope of the project was as follows:

- **Stage One**
  - A site walkover conducted over the upper catchment of the Pinehaven Stream to scope sites identified for upstream development works.
  - Nine (9) hand augered boreholes assigned along the Pinehaven stream development site.
- **Stage Two**
  - Two (2) machine cored boreholes located adjacent to the road bridge on Sunbrae Drive.
  - Preparation of a Geotechnical Factual and Interpretative Report.

2. Site Description

The site is located in Pinehaven, Upper Hutt, roughly 30km north east of Wellington's CBD (refer Figure 2.1). Pinehaven stream incorporates a catchment area of roughly 4.5 square kilometres and follows the approximate course shown in Figure 2.1, passing under Sunbrae Drive and Pinehaven Road.

Figure 2.1: Site Location

The existing culvert at Sunbrae Drive consists of a singular concrete arch which spans roughly 2 m whilst the stream embankment is retained by gabion baskets and timber cantilevered walls on either side. The stream banks currently consist of natural banks and retaining walls.

Geotechnical investigations (two machine bored boreholes) were undertaken in the vicinity of the proposed culvert upgrade at Sunbrae Drive (see Figure 2.2). The borehole locations are shown in Appendix A.

Figure 2.2: Borehole investigation Location

The nine hand augers were carried out along the entire length of the stream ideally within 5 – 10 m of the channel edge. The locations largely consisted of flat grassy areas adjacent to the stream in either Council easements or on residential properties. A summary of the hand auger locations can be found in Appendix A.

3. Existing Information

3.1 Regional Geology

The regional geology surrounding the project site was obtained from the Institute of Geological and Nuclear Sciences 1:250,000 for map 10, Wellington (established 2000). Anticipated subsurface conditions comprise of Quaternary Alluvial deposits underlain by the Torlesse Supergroup formation. For further geological detail, refer to the geological units listed in Table 3.1.

Table 3.1: Potential Geological Units

Geological Period	Description	Characteristics
Holocene Quarternary	Alluvial Deposits	Q1a - Well sorted floodplain gravels Q2a - Poorly to moderately sorted gravel with minor sand or silt underlying aggradational and degradational terraces
Early – Late Triassic	Torlesse Supergroup – Esk Head Belt	Esk Head Belt: Te - Deformed sandstone (Greywacke) and/or mudstone dominate sequence. Rakaia Terrane: Tt – Grey sandstone-mudstone sequences and poorly bedded sandstone

4. Geotechnical Investigation

4.1 Hand Auger boreholes

4.1.1 General

The stage one geotechnical investigation comprised of nine hand augers (HA1 - HA9) with a target depth of either 3 m or refusal below the ground level at the locations identified in Appendix A. The locations of the hand augers were chosen based on getting an even spread of ground information along the area of proposed works in particular around the locations where the concept design showed the solution of vertical walls on the stream channel.

The hand augers were carried out on the 22nd to 23rd of September 2015 by an experienced Jacobs' Geotechnical Engineer. The eastings and northings of the hand auger locations were determined using the Greater Wellington Regional Councils GIS viewer. A summary of the hand auger locations, depths and elevations can be found in Table 4.5 below.

Table 4.5: Hand auger locations, terminations depths and elevation

Hand Auger No.	Termination Depth (mbgl)	Easting (m)	Northing (m)	Elevation (m EGM96)
HA1	1.6	1769035	5441788	68
HA2	1.5	1769045	5441860	60
HA3	1.3	1769000	5442022	58
HA4	1.2	1769023	5442127	59
HA5	1.8	1769037	5442178	58
HA6	1.6	1769001	5442299	58
HA7	2.2	1769053	5442451	56
HA8	1.4	1769003	5442410	56
HA9	2.0	1769035	5442528	55

Prior to hand augering, an underground service locating exercise was undertaken by Underground Service Locators Ltd to ensure that no services were in the vicinity of the proposed hand augering locations. The locator marked the ground with spray paint to designate safe areas for drilling and undertook a site walkover with the Jacobs Engineer to assess the possibility of any other potential hazards during augering.

4.1.2 Hand Auger Methodology

Hand augers were carried out using a 50 mm diameter blade with in-situ shear vane tests carried out at every half metre interval. The target depth of the hand augers was 3 m however due to the site being underlain by medium dense gravels it was unlikely that any of the auger holes would reach that depth.

A dynamic cone penetration (DCP) test was carried out at the base of each hole to assess the density of the gravels.

4.1.3 Subsurface Conditions

The material extracted from the auger hole was logged by a Jacobs Geotechnical Engineer in accordance with NZGS guidelines for the classification of soils and rocks. The subsurface conditions appeared to be consistent across the site with the alluvial gravel layers being encountered at depths of between 1 m and 2.5 m. Overlaying the alluvial gravels was typically soft to stiff silts and clays with some sand and gravel mixtures. These materials are considered to also be alluvial deposits with some un-controlled engineered fill being found in several of the auger holes, however most of this is fairly shallow and has likely been placed for landscaping

purposes. A summary of the subsurface ground conditions identified by the hand auger holes is presented in Table 4.6.

Table 4.6: Summary of subsurface ground conditions from the hand auger investigation

Layer	Origin	Typical Material Characteristics	Depth Range (mbgl)	
			Top of Layer	Bottom of layer
1	Topsoil	Soft silts and clays with low to high plasticity and some roots	0	0.1 - 0.5
2	Fill[2]	Stiff silty clays with high plasticity	0.2 - 0.5	0.3 - 0.9
3	Alluvium	Silts and clays with low to high plasticity	0.1 - 0.9	1.0 - 2.0
4		Fine to medium gravels with some clays, silts and sands	1.0 - 2.0	1.2 - 2.2[1]

Note :

1. Due to the type of material it was not possible to auger through to the base of this layer. Therefore the 'bottom' of this layer reported in this table is in fact were the hand auger refused.
2. The fill material was only encountered in auger holes HA3, HA5 and HA6.

4.1.4 Ground Water

The ground water level was encountered in hand augers HA7 and HA8 at a depth of approximately 0.3 mbgl. The water level encountered was most likely a perched water table, as a result of the high rainfall before and during the site investigation.

4.2 Boreholes

4.2.1 General

The geotechnical investigation comprised two (2) boreholes, BH01 and BH02, drilled to depths of 20 m and 17.35 m below the existing ground level respectively at proposed bridge abutment locations (refer Appendix A).

Boreholes were carried out on 10-13 June 2015 by Webster Drilling and Exploration Ltd. (Webster) under the supervision of a Geotechnical Engineer from Jacobs. At the close of the investigation, borehole locations and relative levels were picked up using a hand held GPS. A summary of borehole locations, termination depths and elevations is provided in Table 4.1.

Table 4.1: Borehole termination depths, locations and elevations

Borehole No.	Termination Depth (mbgl)[1]	Easting (m)[2]	Northing (m)[2]	Elevation (m EGM96)[3]
BH01	20.0	1769012	5442367	56
BH02	17.35	1769004	5442359	56

Notes:

1. Metres below ground level
2. Coordinate system NZTM
3. EGM96 is Earth Gravitational Model 1996. This is the vertical datum system used by Google Earth Pro.

Underground service plans were obtained for the site prior to commencing underground excavation works and additionally a service locator was commissioned by Webster to clearly mark out the present underground services. Upon marking out services, a jet vacuum excavator was used to clear the first 1.5 mbgl safely in case any services were missed in the location process.

4.2.2 Borehole Methodology

Subsurface soil profiles were bored via a trailer mounted rig using a Robit Air Hammer casing advancement technique whilst subsurface rock was cored via a tractor mounted rig using wire line triple tube HQ core barrels.

Standard Penetration Tests were undertaken in both boreholes at 1.5 m intervals using a split spoon sampler to full depth. Hand held shear vane tests were carried out at the end of the split spoon where cohesive material was collected. Cohesive material logged as stiff to very stiff were not tested due to the extensive effort required to shear the sample.

4.2.3 Subsurface Conditions

A Jacobs Geotechnical Engineer logged the subsurface conditions encountered in accordance with New Zealand Geotechnical Guidelines (NZGS). Geological conditions across the proposed site appear to be relatively consistent and have been summarised in Table 4.2.

Note - full detailed borehole logs and photographs are presented in Appendix B.

Table 4.2: Subsurface Profile

LAYER	ORIGIN	MATERIAL DESCRIPTION	DEPTH RANGE (mbgl)	
			BH01:NORTH	BH02:SOUTH
1	Topsoil	Silty CLAY; Soft to firm, low to medium plasticity, extra sensitive - sensitive.	0.0 – 0.5	0.0 – 0.3
2	Alluvium	Silty CLAY; Soft to firm, low to medium plasticity, extra sensitive - sensitive.	0.5 – 3.0	0.3 – 1.75
		Clayey/Sandy GRAVEL; Medium dense	3.0 – 9.0	1.75 – 9.0
		Clayey SAND; Dense – Very dense	9.0 – 11.0	9.0 – 10.0
3	Residual Soil	Sandy CLAY; Very stiff	11.0 – 12.0	10.0 – 11.9
4	CW Rock	Completely weathered (CW) GREYWACKE; extremely weak.	12.0 – 13.0	11.9 – 13.7
5	HW Rock	Highly weathered (HW) GREYWACKE; very weak to weak	13.0 – 14.2	13.7 – 15.9
6	MW – SW Rock	Moderately weathered to slightly weathered (MW-SW) GREYWACKE; moderately strong to strong.	14.2 – 17.3	15.9 – 16.8
7	HW – MW Rock	Highly weathered (HW) GREYWACKE; very weak.	17.3 – 20.0	16.8 – 17.35

4.2.4 Groundwater

Jacobs Geotechnical Engineer recorded groundwater observations for both boreholes and the summaries are as outlined in Table 4.3 and Table 4.4.

Table 4.3: BH01 - groundwater observations

Date	Time	Water Depth (mbgl)	Water Level (m NZVD)	Comments
10/06/2015	11:00	4.0	39.0	Inferred during drilling.
11/06/2015	08:00	4.5	38.5	Downhole dipper reading (prior to drilling).
11/06/2015	16:00	2.0	41.0	Adjacent river level.

Table 4.4:BH02 - groundwater observations

Date	Time	Water Depth (mbgl)	Water Level (m NZVD)	Comments
11/06/2015	10:30	2.7	40.3	Inferred during drilling.
12/06/2015	08:00	4.4	38.6	Downhole dipper reading (prior to drilling).
12/06/2015	16:00	1.4	41.6	Adjacent river level.

5. Testing

5.1 *In-situ* Testing

5.1.1 Standard Penetration Tests (SPTs)

As mentioned in Section 4.2, standard penetration tests were undertaken at 1.5m intervals to determine the density/consistency of the subsurface materials. The results of the SPTs indicate that the material strength generally increases with depth as demonstrated in Figure 5.1.

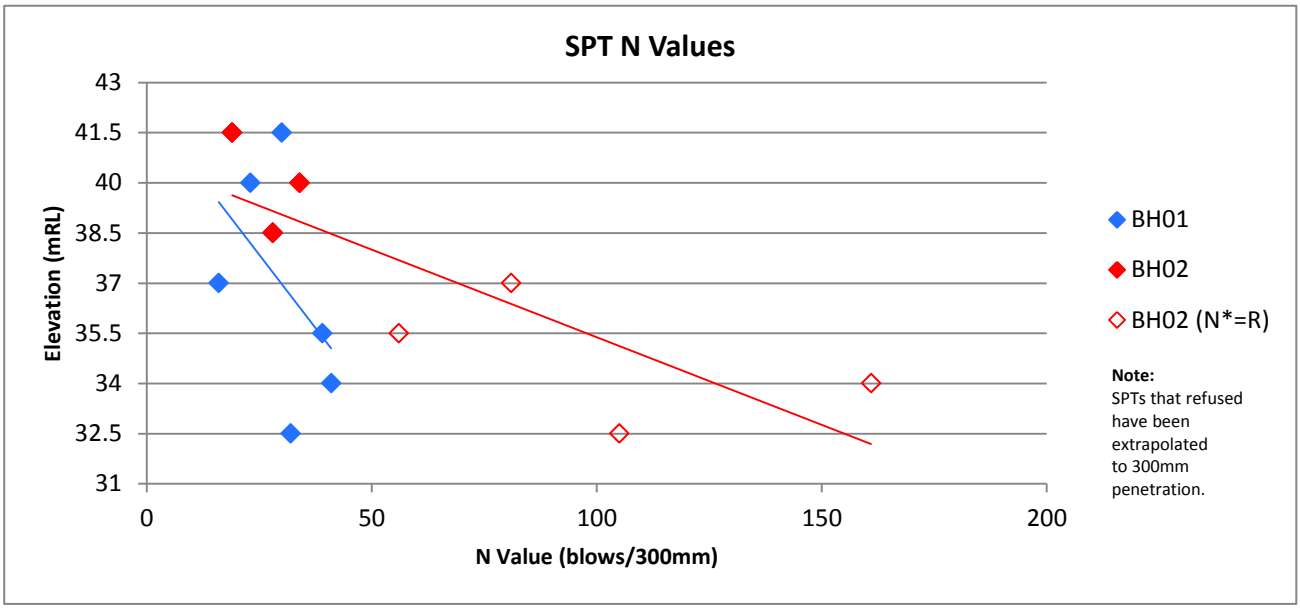


Figure 5-1: SPT Results

5.1.2 Handheld Shear Vanes

Handheld shear vane testing is limited to only very soft to firm cohesive material and given that the subsurface material on site was predominantly not of this nature, only one test was undertaken in each borehole. Both tests were undertaken on the soft to firm Silty Clay topsoil at a depth of 0.2mbgl. The results found peak undrained shear strengths of 61kPa for both boreholes and residual shear strength values of 10kPa in BH01 and 7kPa in BH02. As such, the material was logged as sensitive and extra sensitive for BH01 and BH02 respectively.

Shear vane tests were also carried out every 0.5 m in the hand auger holes. A summary of the results of this in-situ testing can be found in Table 5.1 below.

Table 5.1: Summary of in-situ shear vane results

Layer	Peak					Residual				
	Min	Max	Average	25th Percentile	# Tests	Min	Max	25th percentile	Average	# Tests
Fill	82	99	91	86	2	33	49	37	41	2
Cohesive alluvial material	33	197	94	51	17	16	58	16	32	17

5.2 Laboratory Testing

No laboratory testing has been scheduled for any samples taken during the Geotechnical Investigation at Sunbrae Drive.

6. Geotechnical Design Parameters

Table 6.1 summarises the geotechnical design parameters that have been adopted for onsite subsurface materials in accordance with the “Handbook of Geotechnical Investigation and Design Tables” (Look. B, 2007).

Table 6.1 : Geotechnical Design Parameters

Layer	Material Type	Density/ Consistency & Strength	Unit Weight[2] (kN/m^3)	Cohesion (kPa)	Friction Angle (°)	Undrained Shear Strength (kPa)	Allowable Bearing Capacity (kPa)	Earth Pressure Coefficient		
								K_a	K_o	K_p
2	Silty CLAY	Firm	17	3	28	50	80	0.36	0.53	2.8
	Clayey GRAVEL	Medium Dense	20	0	36	-	225	0.3	0.4	3.7
	Clayey SAND	Dense	21	0	40	-	300			
3	Sandy CLAY	Very Stiff	19	5	30	150	200			
4	CW Greywacke[1]	Very Dense/ Extremely Weak	22	0	45	-	800			
5	HW Greywacke	Very Weak to Weak	23	-	-	-	1000			
6	MW – SW Greywacke	Moderately Strong to Strong	25	-	-	-	2000			
7	HW – MW Greywacke	Weak to Moderately Strong	24	-	-	-	1250			

Note :

1. CW Greywacke behaves like a very dense Gravelly SAND and as such design parameters pertaining to this soil have been adopted.
2. Groundwater has been assumed to saturate all layers provided in Table 6.1 and as such the saturated unit weight has been adopted.

7. Geotechnical Considerations

7.1 Seismic Hazard

7.1.1 Subsoil Class

In accordance with NZS1170.5:2004 the site has been assessed as Class C, Shallow soil site.

7.1.2 Shaking

Reference to Greater Wellington combined earthquake hazard map for Upper Hutt, shows that the proposed bridge development on Sunbrae Drive, Upper Hutt is located within the medium hazard risk zone (refer Appendix C). The site is located within close proximity of five (5) active faults, with the primary fault of concern being the major Wellington fault located 2km North West of site. Based on the Institute of Geological and Nuclear Science active fault database, the nearest active faults have been summarised and are shown in Table 7.1.

Table 7.1 : Nearest Active Faults

Fault Name	Distance and Direction from Site	Recurrence Interval (years)
Wellington Fault	2km North West	Less than 2000
Akatarawa Fault	3km North West	5000-10000
Whitemans Valley Fault	3km South	10000-20000
Moonshine Fault	7km North West	Unknown
Crosscreek Fault	13km South East	2000-3500

From NZS1170.5 the hazard factor for Upper Hutt, Wellington is 0.42.

7.1.3 Liquefaction Risk

Greater Wellington Combined Earthquake Hazard Map for Upper Hutt shows the site as having 'No Potential' or 'Low' for Liquefaction (refer Appendix F). This is likely due to the general absence of silts and loose sands found below the water table which occurs approximately at 1.4mbgl. However, due to the regular flooding within the region, it is anticipated that the water table could fluctuate seasonally which could cause some liquefaction potential within the top silty clay layers. As such, a liquefaction risk of 'low potential' is likely to be more appropriate.

Subsurface layers underlying the silty clay are not believed to be susceptible to liquefaction due to the medium dense - dense and very stiff nature of the respective soils.

7.1.4 Lateral Spread Risk

Laterally spreading is considered possible due to the presence of free face boundaries from Pinehaven Stream located directly on site. However, primarily the site is considered to have a low potential of laterally spreading due to the low potential of soil liquefaction on site.

7.2 Impact on existing infrastructure and residential areas

The proposed widening of Pinehaven Stream is to be undertaken in a residential area, in the vicinity of existing houses, garages/other structures, bridges and roads. This widening may have detrimental impacts on these existing structures. It is understood that properties at 4 Sunbrae Drive and 48 Blue Mountains Drive are to be purchased to allow for realignment of the stream at these locations. As a result, the impacts on these properties weren't assessed.

An assessment of any potential impacts of the proposed works on existing infrastructure and properties was made by determining the approximate distance from structures/property boundaries to the existing stream banks/walls using the supplied survey drawings (20080_TP00-TP series) and site observations. From a geotechnical perspective, the following issues need to be considered as a result of the stream widening:

7.2.1 Reach 1

- Proposed vertical walls constructed in the along 8A Blue Mountains Road (in the vicinity of the church) have the potential to impact on the existing road pavement. The existing walls/banks are approximately 1-2 m from the edge of the footpath.

- The existing stream banks are close structures at 54 Whitemans Road (1-2m from house), 15 Clinker Grove (2-3 m from house), 1 Tapestry Grove (3-4 m from garage) and 10A Blue Mountains Road (2-3 m from garage/shed). If any works on the existing slope are planned at these locations, the stability of the above structures may be undermined. It is recommended that any potential impacts of the widening at this site be investigated further during the next design phase when the required stream widths are confirmed.

7.2.2 Reach 2

- Stream widening along the Deller Grove portion of the site between Sunbrae Drive and 30 Blue Mountains Road may present an issue. The existing banks are within 1 m of some existing structures and property boundaries (for example, at 3 Sunbrae Drive, 5 Deller Grove, 13 Deller Grove, 15 Deller Grove, 26 Blue Mountains Road). Further detailed investigation into the potential impacts of the stream widening on the structural/foundation stability in this reach is recommended during detailed design to confirm the stream widths and therefore the impacts.

7.2.3 Reach 3

- In the vicinity of 48 Blue Mountains Road, the existing stream banks are 3-4 m from the footpath edge, hence any widening may impact on the footpath/road pavement.

For the above areas of concern, further investigation should be undertaken during the design stage to assess the full extent of any impacts. It should be noted that the above impacts were identified via a desk study and walkover survey using survey drawings of the existing stream alignment and concept drawings of the proposed upgrade.

8. Recommendations

The following recommendations are based on the ground conditions encountered during the geotechnical investigations on Sunbrae Drive and along the Pinehaven stream.

8.1 Bridge Foundations

The choice of foundation type/s for the proposed bridge structure is likely to be governed by a number of factors including the structure loads, geotechnical conditions, constructability and cost.

However, we believe the primary foundation option will be piling into MW-SW Greywacke which was encountered at depths of 14.2m and 15.9m in BH01 and BH02 respectively.

It is anticipated that the most appropriate foundation types under the current site conditions are:

- Pre-stressed Concrete (PSC) driven piles; and
- Cast in Place (CIP) piles socketed into rock.

The following issues need to be considered before and during construction:

PSC Driven Piles

- Rapid construction progress could be achieved when compared to other foundation options.
- It is recommended that the head and toe of the PSC piles should be appropriately reinforced to cater for hard driving conditions.
- To account for possible variation in the estimated pile refusal levels, the incorporation of extended bond bars should be considered.
- Provision of estimating pile capacity by dynamic method (e.g. CAPWAP) on the installed PSC piles is recommended.

CIP Bored Piles

- Due to the potential ground water inflow, there is a high likelihood of wall collapse into the excavated holes during bored pile construction.
- To assist in managing borehole stability and possible ground water inflow into the excavated sockets, temporary steel liners may be required during construction.
- Driving liners into extremely or highly weathered rock may encounter penetration problems and progressive excavation and driving of liners may be required.
- Water ingress from the socket wall (through rock fractures) is possible, therefore, concreting under water is likely at the site. This can be performed using the tremie technique.
- Prior to pouring of concrete into sockets, the contractor must ensure base cleanliness and that the design intent foundation material is reached.
- Variation in pile founding levels may occur during construction due to variation in rock strength and degree of weathering.
- The piling plants and equipment need to be assessed to satisfy the anticipated geological conditions.

8.2 Stream Channel Retaining Walls

As part of the flood protection works, vertical retaining walls are to be constructed along sections of Pinehaven Stream. Based on the survey drawings (20080_TP00-TP series) and site observations, the maximum current bank height is approximately 2.5m. For the purposes of this report, it is assumed that the retaining walls will not exceed that height. It is recommended that the retaining walls be designed using the geotechnical design

parameters adopted in Section 6. Other design considerations will include constructability, cost, geotechnical and hydrologic conditions, geometric constraints and any loading conditions at the top of the walls.

8.2.1 Wall Types

Three wall types considered for this site are gravity, embedded and soil reinforced walls:

The geotechnical borehole investigations at Sunbrae Drive and hand augers along the stream show soft to firm silty clay is present down to depths of 1.0 to 3.0m. This material has an allowable estimated bearing capacity of 80 kPa (Look. B, 2007) which is considered unsuitable for a gravity wall foundation. The use of a gravity wall may therefore necessitate the deepening of foundations at a number of wall locations to reach a suitable bearing layer. If water and surcharge loadings are assumed to be acting on the wall, a free cantilever embedded retaining wall would require an embedment depth of 2.5 times the wall height (Look. B, 2007). This results in an embedment depth of 6.25m for a 2.5m high wall.

As a result of these constraints, we recommend the use of a soil reinforced retaining wall for this design. A soil reinforced retaining wall will have a lower bearing pressure and embedment depth compared to a gravity wall and embedded wall respectively. Soil reinforced walls also allow for different facing options such as masonry or vegetated biomats.

8.2.2 Possible Issues

A number of issues pertaining to retaining wall design and construction will need to be considered and addressed during the design and construction phases:

- Construction of retaining walls in proximity to the stream. Construction methodology should be developed during the design phase to allow for potential flooding and temporary dewatering or diversion.
- During normal stream operation or during a flood event there is the potential for a build-up of water pressure behind the retaining walls. During design, consideration should be given to reducing this potential by ensuring adequate drainage is installed.
- Potential for damage to the walls during a flood event from increased water flows and debris.
- Geometric constraints such as distances to property boundaries, existing or planned structures and the gradient of the ground above the wall.
- Surcharge loads at the top of the walls from any existing or planned bridges, footpaths, other structures, sloping ground and driveways.

8.3 Stream Channel Slope Stability

Stream banks along sections of Pinehaven Stream are proposed to be widened to increase the stream capacity as part of the flood protection works. In these sections, it is intended that new stream banks will be cut further back at a specified angle to replicate a natural stream bank. As such, consideration must be given to the stability of these new slopes. For the purposes of this report, an initial slope stability analysis was undertaken using the ground conditions encountered in BH1 and BH2 at Sunbrae Drive and the hand augers carried out along the stream banks.

Based on the results of this analysis, the maximum angle recommended for the stream channel slopes is 27° or 1 V:2 H which results in a factor of safety of 1.5 or greater for static conditions. Based on observations of the stream banks in some sections of the site, it appears that this angle may be conservative. However, it is recommended that a further detailed slope stability analysis be undertaken during the next project stage if the slope angle is to be increased beyond the angle specified. This initial recommendation is based on a maximum slope height of 2.5m (maximum current bank height as per the survey drawings).

Jacobs has taken unit specific soil parameters and applied them across the entire project area. There is some potential for soft spots of material along the stream banks which should be taken into consideration during detailed design and construction.

Issues to consider during the design and construction phases of the stream channel include:

- Earthworks in the vicinity of a watercourse – it is recommended that the impacts of flooding on construction and temporary works are considered.
- Inundation, saturation and drainage of the slope during a flood event.
- Geometric constraints such as distances to property boundaries, existing or planned structures which may result in a steeper angle required.
- Surcharge loads at the top of the slope from any existing or planned bridges, footpaths, other structures and driveways.
- Potential for damage and erosion of the slope during a flood event. It is recommended that erosion protection measures (i.e. vegetation) are considered during the design phase.
- Dewatering or diversion during construction.

9. Conclusion

The Geotechnical Investigation undertaken provided the subsurface information which enabled the ground model shown in Table 9.1 to be summarised.

Table 9.1: Ground Model based on Borehole logs

LAYER	ORIGIN	MATERIAL DESCRIPTION	DEPTH RANGE (mbgl)	
			BH01:NORTH	BH02:SOUTH
1	Topsoil	Silty CLAY; Soft to firm, low to medium plasticity, extra sensitive - sensitive.	0.0 – 0.5	0.0 – 0.3
2	Alluvium	Silty CLAY; Soft to firm, low to medium plasticity, extra sensitive - sensitive.	0.5 – 3.0	0.3 – 1.75
		Clayey/Sandy GRAVEL; Medium dense	3.0 – 9.0	1.75 – 9.0
		Clayey SAND; Dense – Very dense	9.0 – 11.0	9.0 – 10.0
3	Residual Soil	Sandy CLAY; Very stiff	11.0 – 12.0	10.0 – 11.9
4	CW Rock	Completely weathered (CW) GREYWACKE; extremely weak.	12.0 – 13.0	11.9 – 13.7
5	HW Rock	Highly weathered (HW) GREYWACKE; very weak to weak	13.0 – 14.2	13.7 – 15.9
6	MW – SW Rock	Moderately weathered to slightly weathered (MW-SW) GREYWACKE; moderately strong to strong.	14.2 – 17.3	15.9 – 16.8
7	HW – MW Rock	Highly weathered (HW) GREYWACKE; very weak.	17.3 – 20.0	16.8 – 17.35

Table 2.2 Ground model based on Hand Auger Logs

Layer	Origin	Typical Material Characteristics	Depth Range (mbgl)	
			Top of Layer	Bottom of layer
1	Topsoil	Soft silts and clays with low to high plasticity and some roots	0	0.1 - 0.5
2	Fill	Stiff silty clays with high plasticity	0.2 - 0.5	0.3 - 0.9
3	Alluvium	Silts and clays with low to high plasticity	0.1 - 0.9	1.0 - 2.0
4		Fine to medium gravels with some clays, silts and sands	1.0 - 2.0	1.2 - 2.2[1]

The primary bridge foundation option will be piling into MW -SW Greywacke encountered at depths of 14.2m and 15.9m in BH01 and BH02 respectively. Under the current site conditions, the following foundation types are considered most appropriate:

- Pre-stressed Concrete (PSC) driven piles; and
- Cast in Place (CIP) piles socketed into rock.

Based on the encountered conditions, a soil reinforced retaining wall is considered to be the most appropriate option for the stream retaining wall designs. An initial slope angle of 27° or a 1 V:2 H slope is recommended for the sloped stream sections until further slope stability analysis are undertaken.

A number of areas have been highlighted where the stream widening may impact on existing infrastructure and residential areas. Possible impacts of the widening on these areas and any other areas should be investigated further during the next design phase.

Furthermore, the following assessments were compiled as part of this investigation and subsequent report:

- Seismicity– The site has been classified as medium hazard risk zone (refer Appendix F). The primary fault of concern is the major Wellington fault located 2km North West of site.

- Liquefaction– The site has been classified as having ‘No Potential’ or ‘Low’ for Liquefaction (refer Appendix F). However, due to the regular flooding within the region, it is anticipated that the water table could fluctuate seasonally which could cause some liquefaction potential within the top silty clay layers. As such, a liquefaction risk of ‘low potential’ is likely to be more appropriate.

- Lateral Spreading - Laterally spreading is considered possible due to the presence of free face boundaries from Pinehaven Stream located directly on site. However, generally the site will be considered having a low potential of laterally spreading due to the low liquefaction potential.

10. References

Reference was made to the following documents during the assessment:

- Begg, J.G.; Johnston, M.R. (compilers) 2000: Geology of the Wellington area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences. Institute of Geological & Nuclear Sciences 1:250,000 geological map 10. 64 p. + 1 folded map

- Greater Wellington Regional Council (1996). Sheet 3 Hutt Valley (1st ed.) Combined Earthquake Hazard Map 1:30000, Pub. No. WRC/RP-T-96/14 Greater Wellington Regional Council, Wellington, New Zealand.

- Look.B, (2007), “Handbook of Geotechnical Investigation and Design Tables”

11. Limitations

The sole purpose of this report and the associated services performed by Jacobs is to investigate and assess the ground conditions for the flood protection works at Pinehaven in accordance with the scope of services set out in the contract between Jacobs and the Client (Wellington Water). That scope of services, as described in this report, was developed with the Client.

Undertaking an assessment or study of on-site conditions may reduce the potential for exposure to the presence of inadequate bearing ground. All reports and conclusions that deal with sub-surface conditions are based on interpretation and judgement and as a result have uncertainty attached to them. You should be aware that this report contains interpretations and conclusions which are uncertain, due to the nature of the investigations. No study can completely eliminate risk, and even a rigorous assessment and/or sampling programme may not detect all problem areas within a site.

This report is based on assumptions that the site conditions as revealed through sampling are indicative of conditions throughout the site. The findings are the result of standard assessment techniques used in accordance with normal practices and standards, and (to the best of our knowledge) they represent a reasonable interpretation of the current conditions on the site.

However all sampling techniques, by definition, cannot determine the conditions between the sample points and so the report cannot be taken to be a full representation of the sub-surface conditions. It is an indication of the likely sub surface conditions.

Conditions as encountered when site work commences may be different from those Jacobs infers based on its sampling techniques as the ground conditions could vary over relatively short distances. It is important that Jacobs are retained to review the site conditions during site works to confirm and update any assumptions made during the preparation of this report.

The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report.

In preparing this report, Jacobs has relied upon, and presumed accurate, certain information (or absence thereof) provided by the Client and other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

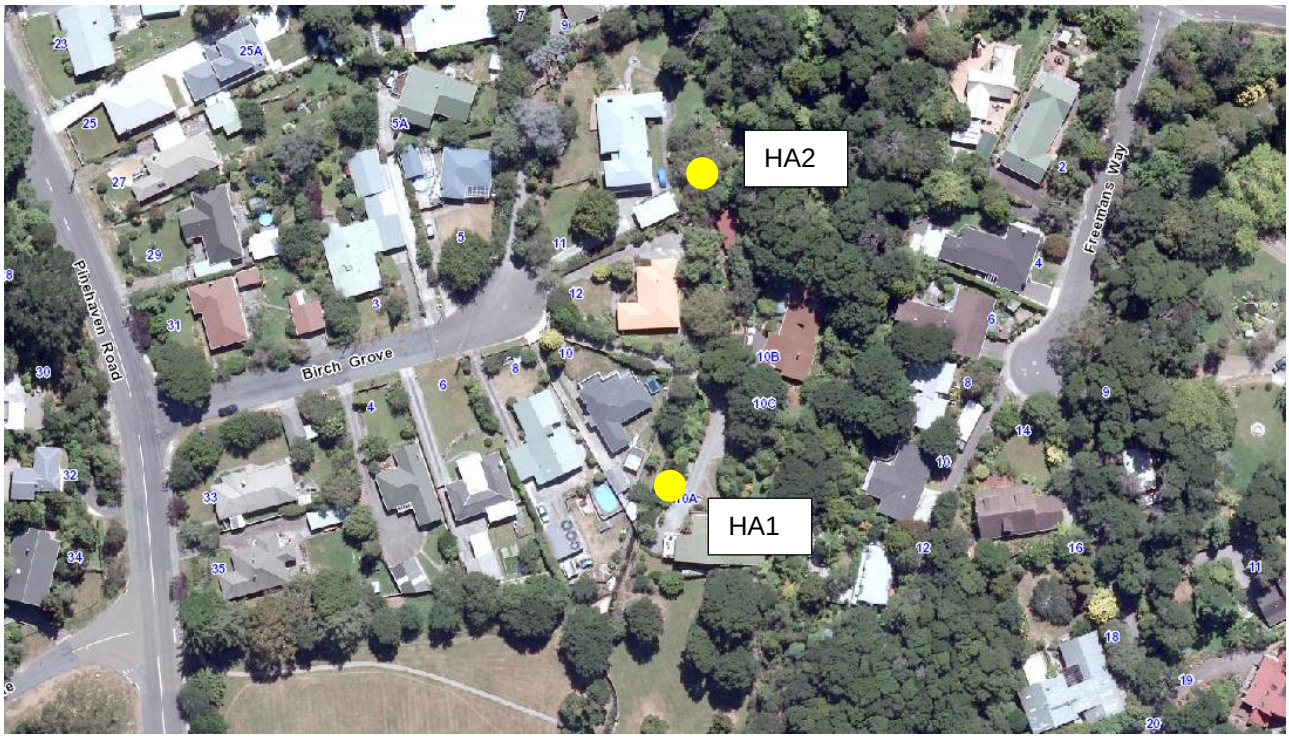
Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose of the project and by reference to applicable standards, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report.

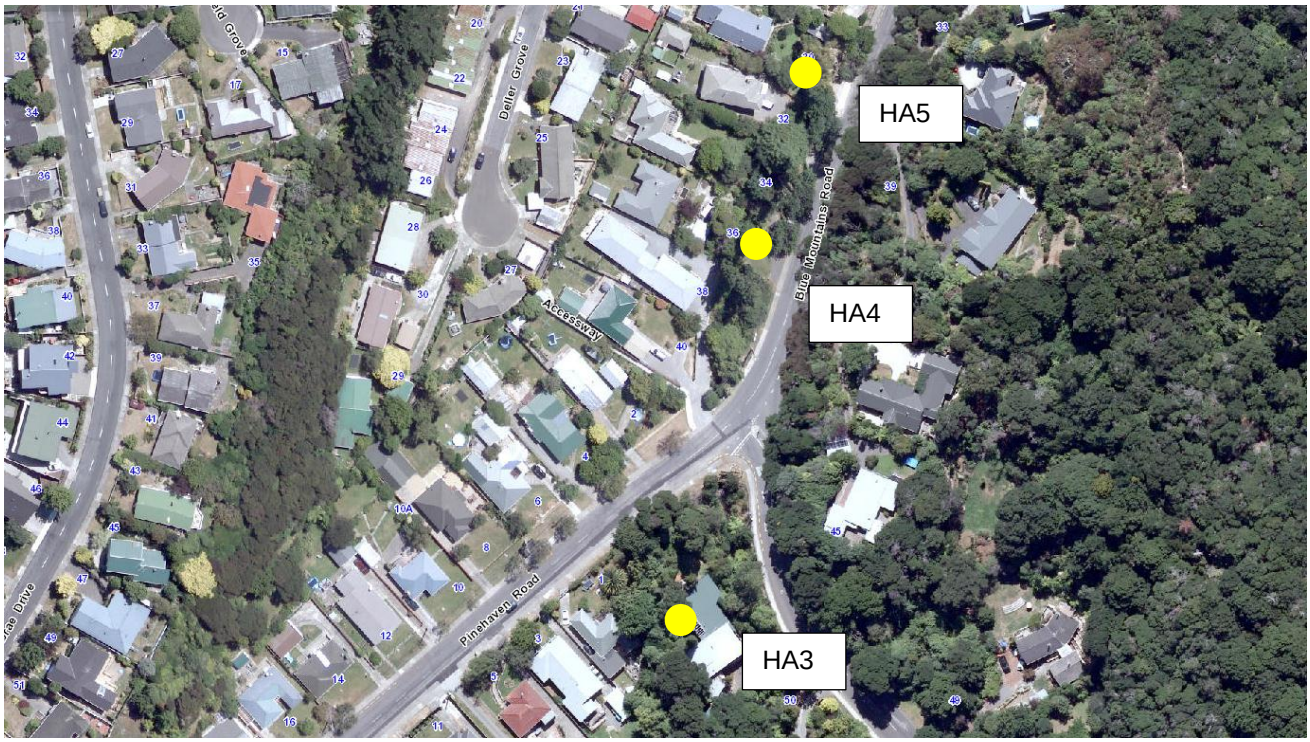
This report does not address environmental or geo-environmental issues including the presence of any contaminants or hazardous materials at the site unless Jacobs was specifically and expressly retained to do so.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in accordance with the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

Appendix A. Borehole and Hand Auger Location Plan

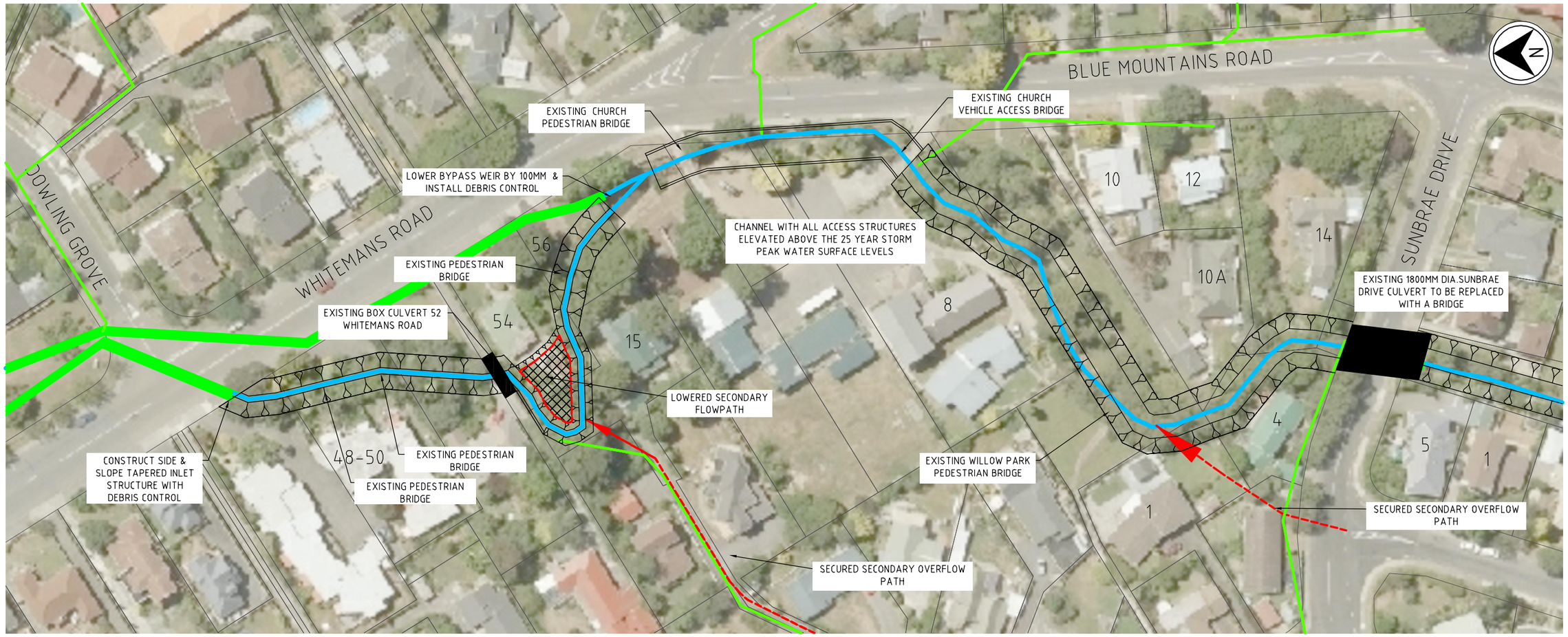



HA5
HA4
HA3
Dellor Grove
Blue Mountains Road
Accessway
Pinehaven Road


HA6
Blue Mountains Road


HA9
HA7
HA8
Whitemans Road
Mountains Road
Clinker Grove
Tapestry Grove
No 1 Line

Appendix B. Concept Plans



REACH 1 - OPTION 1.1

SCALE 1:1000 @ A1

NOTES

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

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No	DATE	DESIGN REVIEW	REVD P.MGR	APPD P.DIR	AMENDMENT
A	10/5/13	CP	MH	CM	

REF.	DRAWING NUMBER	REFERENCE DRAWING TITLE

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NEW ZEALAND
Tel: +64 4 473-4265
Fax: +64 4 473 3369
Web: www.skmconsulting.com

CLIENT: GWRC AND UHCC

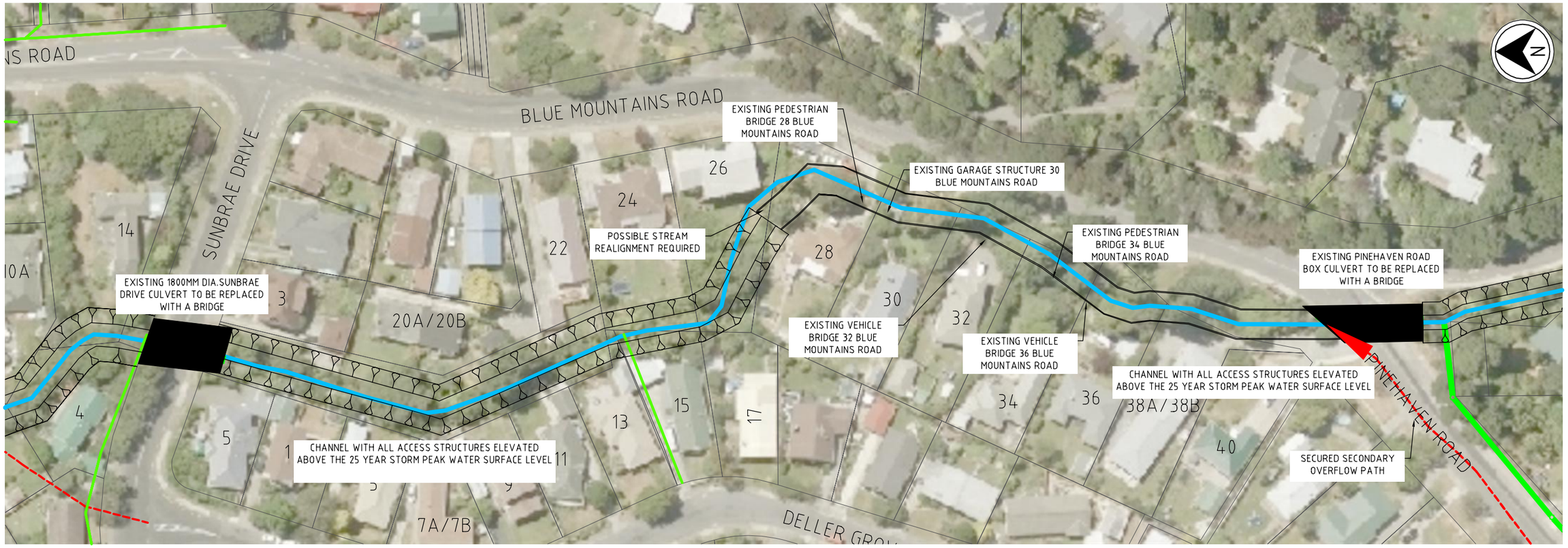
PROJECT: PINEHAVEN FMP INVESTIGATIONS - PHASE 3

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

TITLE: PINEHAVEN STREAM
REACH 1
PREFERRED OPTION

SCALE	PROJECT No	DRAWING No	AMDT
AS SHOWN	AE03975	REACH1-001	A

A1



REACH 2 - OPTION 2.1

SCALE 1:1000 @ A1

NOTES

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

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No	DATE	DESIGN REVIEW	REVD P.MGR	APPD P.DIR	AMENDMENT
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REF.	DRAWING NUMBER	REFERENCE DRAWING TITLE
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CLIENT: GWRC AND UHCC

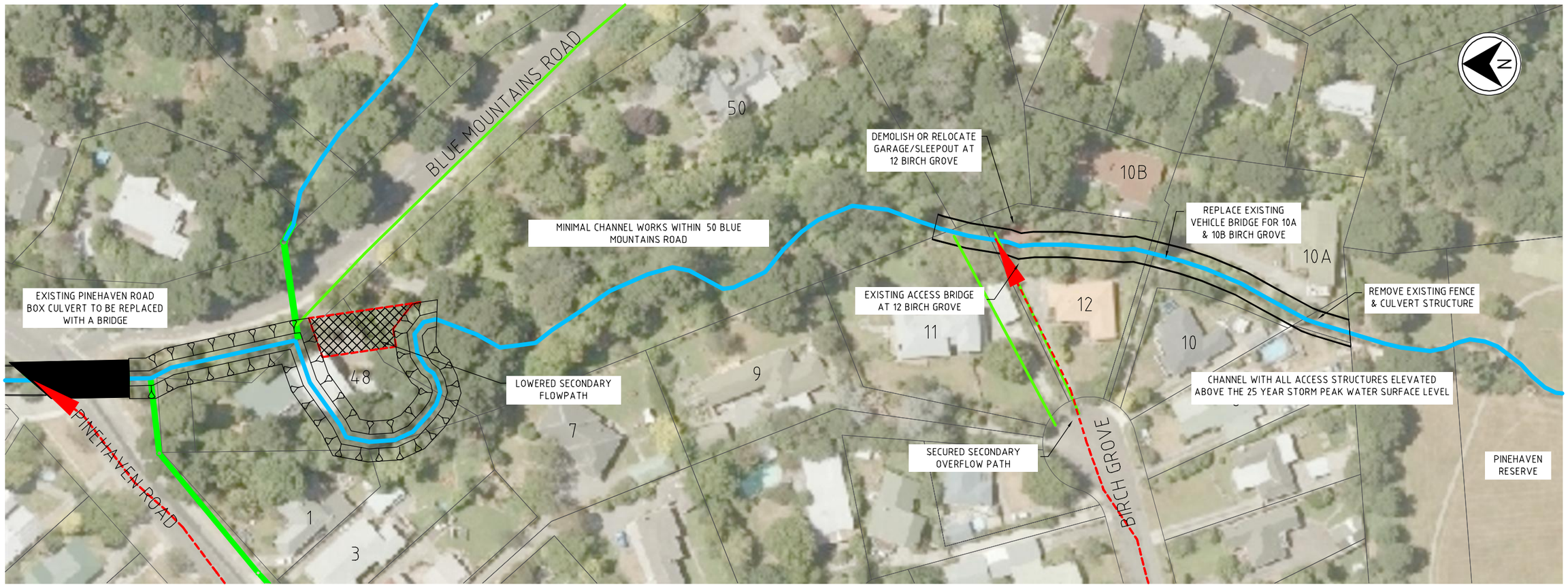
PROJECT: PINEHAVEN FMP INVESTIGATIONS - PHASE 3

DRAWN	DRAFTING CHECK	REVIEWED PROJECT MANAGER	APPROVED PROJECT DIRECTOR
JPA			
DESIGNED	DESIGN REVIEW		

TITLE: PINEHAVEN STREAM
REACH 2
PREFERRED OPTION

SCALE	PROJECT No	DRAWING No	AMDT
AS SHOWN	AE03975	REACH2-C002	A

A1



REACH 3 - HYBRID OPTION

SCALE 1:1000 @ A1

NOTES

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

ISSUED FOR INFORMATION ONLY

No	DATE	DESIGN REVIEW	REVD P.MGR	APPD P.DIR	AMENDMENT
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A	10/5/13	CP	MH	CM	

REF.	DRAWING NUMBER	REFERENCE DRAWING TITLE
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CLIENT: GWRC AND UHCC

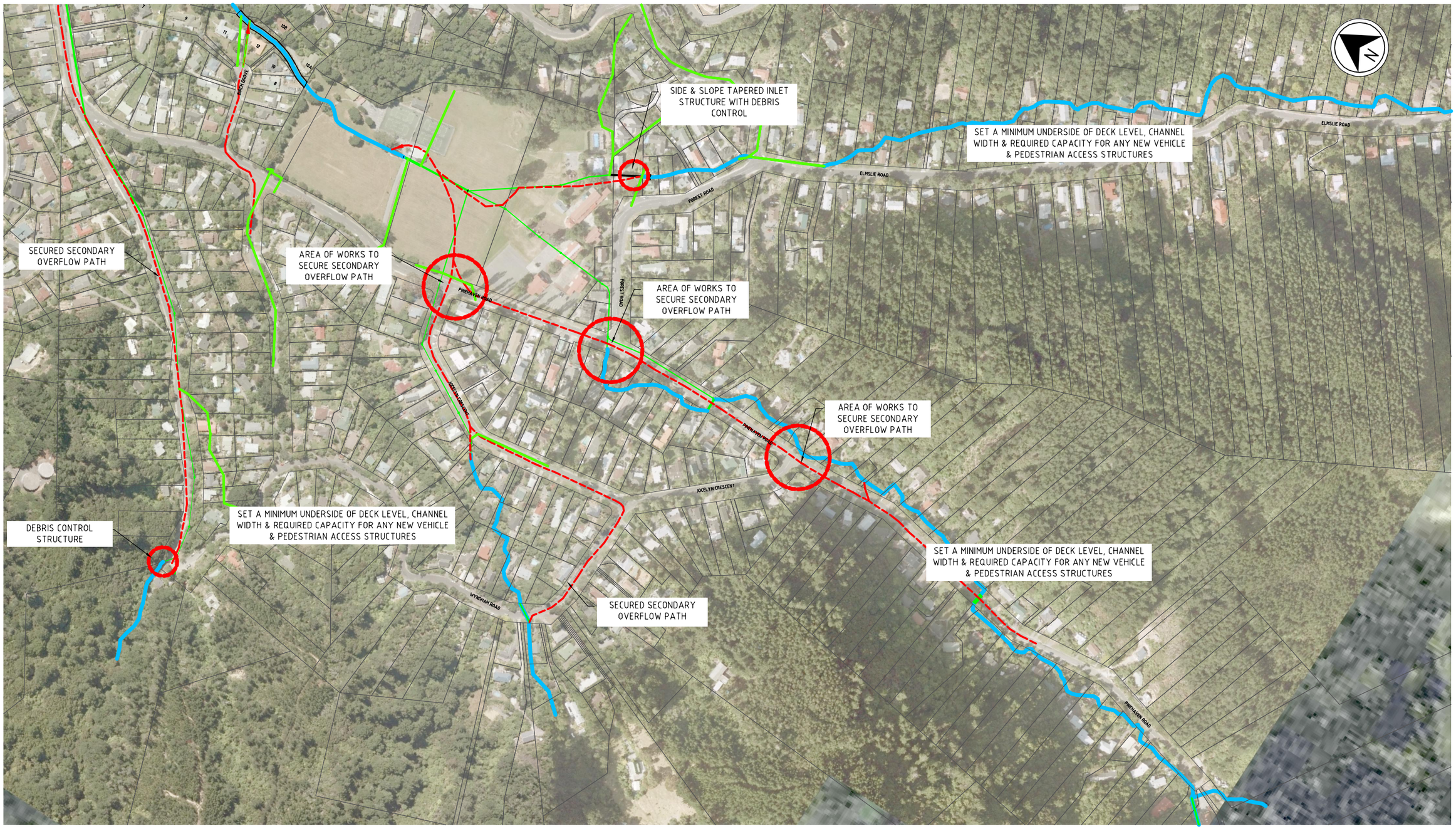
PROJECT: PINEHAVEN FMP INVESTIGATION - PHASE 3

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

TITLE: PINEHAVEN STREAM
REACH 3
PREFERRED OPTION

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

A1



UPPER CATCHMENT - OPTION 4.1

SCALE 1:2000 @ A1

NOTES

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

ISSUED FOR INFORMATION ONLY

No	DATE	DESIGN REVIEW	REVD P.MGR	APPD P.DIR	AMENDMENT
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REF.	DRAWING NUMBER	REFERENCE DRAWING TITLE
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Fax: +64 4 473 3369
Web: www.skmconsulting.com

CLIENT: UHCC AND GWRC

PROJECT: PINEHAVEN FMP INVESTIGATIONS - PHASE 3

DRAWN	DRAFTING CHECK	REVIEWED PROJECT MANAGER	APPROVED PROJECT DIRECTOR
DESIGNED	DESIGN REVIEW		

TITLE: PINEHAVEN STREAM UPPER CATCHMENT PREFERRED OPTION

SCALE	PROJECT No	DRAWING No	AMDT
AS SHOWN	AE03975	UC - C001	A

A1

Appendix C. Borehole Logs and Photographs

Preliminary Log of Investigation

JACOBS

Project: **Pinehaven Stream - Sunbrae Drive Culvert Replacement**

Borehole

Location: **Sunbrae Drive** Project No: **IZ018100-GEO**

Hole ID: **BH01**

Client: **Wellington Water**

Date: **10/06/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Details / Casing Diameter (mm))	TCR (%) (SCR (%))	RQD	In-Situ Testing	Sampling	Geology Legend	GroundWater	Description of Strata	Comments	Backfill / Installation
42.5	0.5	VAC EX		N/A	I_{vp}61/I_{vr}10				Silty CLAY with trace gravel, sand and rootlets; brown. Soft to firm, dry, low to medium plasticity, sensitive; gravel, fine to coarse, angular to sub-angular; sand, fine to coarse. **(Topsoil)**		
42.0	1.0								Silty CLAY with trace gravel and sand; brown. Soft to firm, moist, low to medium plasticity, sensitive; gravel, fine to coarse, angular to sub-angular; sand, fine to coarse. **(Alluvium)**		
41.5	1.5	SPT	91	N/A	SPT_c=4,11,19 N=30	SPTLS			1.50m: Brownish orange. Very soft lens to 1.7m.		
41.0	2.0							3 ▽			
40.5	2.5								2.50m: Gravel content increasing with depth.		
40.0	3.0	SPT	100	N/A	SPT_c=10,10,13 N=23	SPTLS			Clayey fine to medium GRAVEL with some sand; grey. Medium dense, moist, well graded, angular to subangular, maxiumum particle size of 20mm; clay, low plasticity; sand, coarse. **(Alluvium)**		
39.5	3.5										
39.0	4.0							1 ▽			

Started: 10/06/2015

Finished: 13/06/2015

Driller: Webster

Plant: Tractor Mounted

Logged: SW

Checked: ME

Groundwater Observations

No.	Struck (m)	Date	Observations	Standing (m)
1	4	10/06/2015	3. *Inferred during drilling* 24hr 11/06/2015	Directly adjacent river water level.
			1. 4m 10/06/2015	Inferred during drilling.
			2. 4.5m 11/06/2015	Downhole dipper reading prior to re-commencement of drilling.

Remarks

Co-ordinates:

5442367.00mN

1769012.00mE

Elevation: 43.00mRL

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Preliminary Log of Investigation

JACOBS

Project: **Pinehaven Stream - Sunbrae Drive Culvert Replacement**	**Borehole**
Location: **Sunbrae Drive** Project No: **IZ018100-GEO**	Hole ID: **BH01**
Client: **Wellington Water**	Date: **10/06/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Details / Casing Diameter (mm))	TCR (%) (SCR (%))	RQD	In-Situ Testing	Sampling	Geology Legend	GroundWater	Description of Strata	Comments	Backfill / Installation
38.5	4.5	SPT	100	N/A	SPT_s=5,11,17 N=28	SPTLS		2 ▽	4.50m to 4.60m: Very soft clay lense. 4.60m: Wet.		
38.0	5.0										
37.5	5.5										
37.0	6.0	SPT	100	N/A	SPT_s=7,7,9 N=16	SPTLS			6.00m to 6.20m: Stiff silty clay lense.		
36.5	6.5										
36.0	7.0										
35.5	7.5	SPT	100	N/A	SPT_s=6,14,25 N=39	SPTLS			7.50m: Becomes dense.		
35.0	8.0										

Started: 10/06/2015
Finished: 13/06/2015
Driller: Webster
Plant: Tractor Mounted
Logged: SW
Checked: ME

Groundwater Observations

No.	Struck (m)	Date	Observations	Standing (m)
1	4	10/06/2015	3. *Inferred during drilling*	2.6m 11/06/2015 Directly adjacent river water level.
			1.	4m 10/06/2015 Inferred during drilling.
			2.	4.5m 11/06/2015 Downhole dipper reading prior to re-commencement of drilling.

Remarks

Co-ordinates:
5442367.00mN
1769012.00mE
Elevation: 43.00mRL

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Preliminary Log of Investigation

JACOBS

Project: **Pinehaven Stream - Sunbrae Drive Culvert Replacement**	**Borehole**
Location: **Sunbrae Drive** Project No: **IZ018100-GEO**	Hole ID: **BH01**
Client: **Wellington Water**	Date: **10/06/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Details / Casing Diameter (mm))	TCR (%) (SCR (%))	RQD	In-Situ Testing	Sampling	Geology Legend	GroundWater	Description of Strata	Comments	Backfill / Installation
34.5	8.5										
34.0	9.0	SPT	56	N/A	SPT_c=14,17,24 N=41	SPTLS			Clayey fine to coarse SAND with some gravel; dark grey. Dense, moist, well graded; gravel, fine to coarse, angular. **(Alluvium)**		
33.5	9.5										
33.0	10.0										
32.5	10.5	SPT	100	N/A	SPT_c=11,17,15 N=32	SPTLS			10.50m: Dark blueish grey, medium dense, sub-angular to sub-rounded.		
32.0	11.0								Sandy CLAY; blueish grey. Very stiff, moist, high plasticity; sand, fine to medium. **(Residual Soil)**		
31.5	11.5										
31.0	12.0				SPT_c=10,15,17 N=32						

Started: 10/06/2015
Finished: 13/06/2015
Driller: Webster
Plant: Tractor Mounted
Logged: SW
Checked: ME

Groundwater Observations

No.	Struck (m)	Date	Observations	Standing (m)
1	4	10/06/2015	3. *Inferred during drilling* 24hr 11/06/2015	Directly adjacent river water level.
			1. 4m 10/06/2015	Inferred during drilling.
			2. 4.5m 11/06/2015	Downhole dipper reading prior to re-commencement of drilling.

Remarks

Co-ordinates:
5442367.00mN
1769012.00mE
Elevation: 43.00mRL

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

JACOBS

Borehole Log of Investigation

Project: **Pinehaven Stream - Sunbrae Drive Culvert Replacement**

Borehole

Location: **Sunbrae Drive** Project No: **IZ018100-GEO**

Hole ID: **BH01**

Client: **Wellington Water**

Date: **10/06/2015**

R.L. (m)	Depth (m)	Drilling Method	TCR (%)	SCR	RQD	Fracture Index	Drilling Flush Return (%)	Geology Legend	GroundWater	Description of Strata	Geological Unit	Weathering Grade	Relative Strength	Defect Description	Backfill
		SPT	67							Completely weathered, light blueish grey, massive GREYWACKE; extremely weak. Highly jointed, very closely spaced. Iron stained. **(Torlesse Supergroup)**				*12.30m to 12.50m: Crushed zone.*	
30.5	12.5	HQ3	100	67	0						Tt				
		HQ3	100	0	0									*12.70m: Joint, (Dip 80°) smooth, planar, narrow, surface staining of iron.*	
30.0	13.0	HQ3	100	75	17					Highly weathered, dark grey, massive GREYWACKE; Very weak. Highly jointed, very closely spaced. **(Torlesse Supergroup)**				*12.90m: Joint, (Dip 5°) rough, undulating, narrow, soil infilling of clayey gravel.* *12.95m: Joint, (Dip 90°) rough, planar, very narrow, clean.* *13.10m: Joint, (Dip 5°) rough, undulating, moderately narrow, soil infilling of gravel.* *13.20m: Joint, (Dip 15°) rough, stepped, narrow, clean.*	
29.5	13.5										Tt				
		HQ3	100	42	0					*13.90m: Iron staining present.*				*13.70m: Joint, (Dip 70°) smooth, planar, narrow, clean.*	
29.0	14.0	HQ3	100	75	21					Moderately to slightly weathered, dark grey, indistinctly banded GREYWACKE; Moderately strong to strong. Moderately jointed, closely spaced. **(Torlesse Supergroup)**				*14.50m to 14.70m: Joint, (Dip 10-30°) smooth, planar, narrow, clean.*	
28.5	14.5													*14.75m: Joint, (Dip 90°) smooth, stepped, very narrow to narrow, clean.* *14.78m: Joint, (Dip 0°) smooth, planar, very narrow to narrow, clean.* *15.00m: Joint, (Dip 70°) rough, planar, moderately narrow, mineral coating of iron.*	
28.0	15.0	HQ3	100	80	22						Tt			*15.35m: Joint, (Dip 0°) smooth, undulating, moderately narrow, clean.* *15.40m to 15.60m: Joint, (Dip 40°) smooth, planar, narrow, clean.*	
27.5	15.5														
27.0	16.0														

Started: 10/06/2015
Finished: 13/06/2015
Driller: Webster
Plant: Tractor Mounted
Logged: SW
Checked: ME

Groundwater Observations

No. Depth (m) Date Comments

Comments

Co-ordinates
5442367 N
1769012 E

Elevation: 43 masl
Inclination:

JACOBS

Borehole Log of Investigation

Project: **Pinehaven Stream - Sunbrae Drive Culvert Replacement**

Borehole

Location: **Sunbrae Drive** Project No: **IZ018100-GEO**

Hole ID: **BH01**

Client: **Wellington Water**

Date: **10/06/2015**

R.L. (m)	Depth (m)	Drilling Method	TCR (%)	SCR	RQD	Description of Strata	Geological Unit	Weathering Grade	Relative Strength	Defect Description	Backfill
26.5	16.5	HQ3	100	55	0	Highly weathered, grey to dark grey, massive GREYWACKE; Very weak. Moderately jointed, very closely spaced. **(Torlesse Supergroup)**	Tt			*16.70m: Joint, (Dip 20°) smooth, planar, narrow, clean.* *16.85m: Joint, (Dip 50°) smooth, planar, narrow, mineral coating of iron.* *17.00m: Joint, (Dip 70°) smooth, planar, narrow, clean.* *17.10m: Joint, (Dip 80°) rough, planar, moderately narrow, clean.* *17.20m to 19.00m: Joint, (Dip 15-25°) rough, planar, narrow, clean.* *17.50m to 17.55m: Crushed zone.* *17.70m to 18.60m: Joint, (Dip 10-50°) rough, planar, very narrow to narrow, clean.*	
26.0	17.0										
25.5	17.5										
25.0	18.0	HQ3	100	36	0		Tt			*18.70m: Joint, (Dip 0°) smooth, planar, moderately narrow, clean.* *18.75m: Joint, (Dip 80°) smooth, planar, moderately narrow, clean.* *18.90m to 19.10m: Crushed zone.* *19.30m to 19.40m: Crushed zone.* *19.40m to 20.00m: Joint, (Dip 5-30°) smooth, planar, narrow, clean.*	
24.5	18.5										
24.0	19.0	HQ3	100	20	0						
23.5	19.5	HQ3	100	25	0						
23.0	20.0					BH01 terminated at 20.00m Target Depth					

Started: 10/06/2015
Finished: 13/06/2015
Driller: Webster
Plant: Tractor Mounted
Logged: SW
Checked: ME

Groundwater Observations

No.	Depth (m)	Date	Comments

Comments

Co-ordinates
5442367 N
1769012 E

Elevation: 43 masl

Inclination:

Project Name:	Pinehaven Stream – Sunbrae Drive Culvert Replacement
Project No.	IZ018100-GEO
Client:	Wellington Water
Borehole ID	BH01
No. of boxes:	4

Grey scale

Colour scale

Depth (m)	**Box**	1 of 4	**Start depth (m)**	12.30	**End depth (m)**	14.80

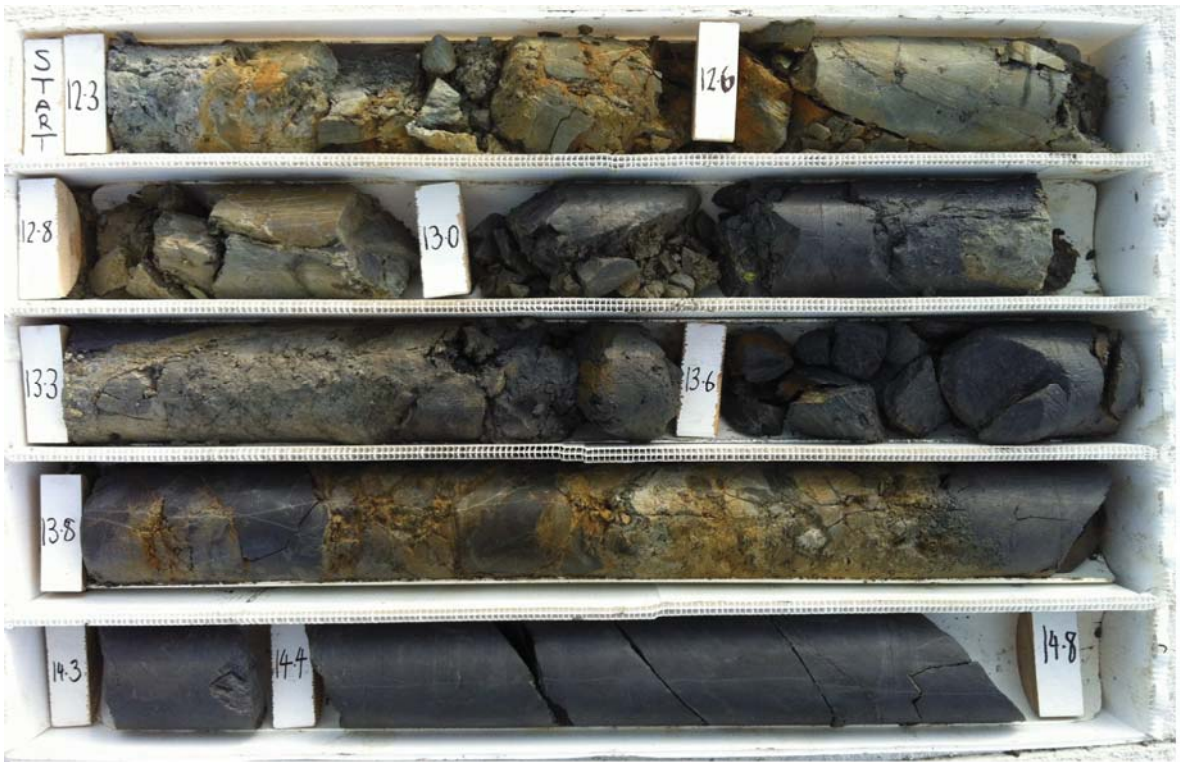
12.30

12.80

13.30

13.80

14.30



Depth (m)	**Box**	2 of 4	**Start depth (m)**	14.80	**End depth (m)**	17.00

14.80

15.10

15.60

16.10

16.60

Depth (m)	Box	3 of 4	Start depth (m)	17.00	End depth (m)	19.4 m
17.00 17.50 18.00 18.50 19.40						

Depth (m)	Box	4 of 4	Start depth (m)	19.40	End depth (m)	20.00
19.40 20.00						

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Preliminary Log of Investigation

Project: **Pinehaven Stream - Sunbrae Drive Culvert Replacement**

Borehole

Location: **Sunbrae Drive** Project No: **IZ018100-GEO**

Hole ID: **BH02**

Client: **Wellington Water**

Date: **11/06/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Details / Casing Diameter (mm))	TCR (%) (SCR (%))	RQD	In-Situ Testing	Sampling	Geology Legend	GroundWater	Description of Strata	Comments	Backfill / Installation
42.5	0.5	VAC EX		N/A	$I_{a}61/I_{w}7$				Silty CLAY with trace gravel, sand and rootlets; brown. Soft to firm, dry, low to medium plasticity, extra sensitive; gravel, fine to coarse, angular to sub-angular; sand, fine to coarse. **(Topsoil)**		
42.0	1.0								Silty CLAY with trace gravel and sand; brown. Soft to firm, dry, low to medium plasticity, extra sensitive; gravel, fine to coarse, angular to sub-angular; sand, fine to coarse. **(Alluvium)**		
41.5	1.5	SPT	67	N/A	SPT_{s}=1,9,10 N=19	SPTLS		3 ▽	1.00m: Light grey.		
41.0	2.0								Clayey fine to coarse GRAVEL; dark reddish brown. Medium dense, moist, well graded, angular to sub-angular; clay, low plasticity. **(Alluvium)**		
40.5	2.5							1 ▽	2.50m: Sand content increasing with depth.		
40.0	3.0	SPT	78	N/A	SPT_{s}=12,17,17 N=34	SPTLS			2.70m: Wet.		
39.5	3.5								Sandy fine to coarse GRAVEL; dark grey. Medium dense to dense, wet, well graded, angular to sub-angular; sand, medium to coarse. **(Alluvium)**		
39.0	4.0										

Started: 11/06/2015

Finished: 13/06/2015

Driller: Webster

Plant: Tractor Mounted

Logged: SW

Checked: ME

Groundwater Observations

No.	Struck (m)	Date	Observations	Standing (m)
1	2.7	12/06/2015	3. 1.4m 11/06/2015	Directly adjacent river water level.
			1. 2.7m 12/06/2015	Inferred during drilling.
			2. 4.4m 12/06/2015	Downhole dipper reading prior to re-commencement of drilling.

Inferred during drilling

Remarks

Co-ordinates:
5442359.00mN
1769004.00mE
Elevation: 43.00mRL

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Preliminary Log of Investigation

JACOBS

Project: **Pinehaven Stream - Sunbrae Drive Culvert Replacement**

Borehole

Location: **Sunbrae Drive** Project No: **IZ018100-GEO**

Hole ID: **BH02**

Client: **Wellington Water**

Date: **11/06/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Details / Casing Diameter (mm))	TCR (%) (SCR (%))	RQD	In-Situ Testing	Sampling	Geology Legend	GroundWater	Description of Strata	Comments	Backfill / Installation
38.5	4.5	SPT	78	N/A	SPT_s=14,14,14 N=28	SPTLS		2 ▽	4.50m: Light brown, sub-angular to sub-rounded, with some clay, low plastic.		
38.0	5.0										
37.5	5.5										
37.0	6.0	SPT	67	N/A	SPT_s=19,25,30 N=55/230	SPTLS			6.00m: Becomes very dense.		
36.5	6.5										
36.0	7.0										
35.5	7.5	SPT	67	N/A	SPT_s=18,25,26 N=51/275	SPTLS			Clayey fine to coarse GRAVEL with some sand; dark grey. Very dense, moist, well graded, sub-angular; clay, low plasticity; sand, medium to coarse. **(Alluvium)**		
35.0	8.0										

Started: 11/06/2015

Finished: 13/06/2015

Driller: Webster

Plant: Tractor Mounted

Logged: SW

Checked: ME

Groundwater Observations

No.	Struck (m)	Date	Observations		Standing (m)
1	2.7	12/06/2015	3.	1.4m	11/06/2015 Directly adjacent river water level.
			1.	2.7m	12/06/2015 Inferred during drilling.
			2.	4.4m	12/06/2015 Downhole dipper reading prior to re-commencement of drilling.

Inferred during drilling

Remarks

Co-ordinates:
5442359.00mN
1769004.00mE
Elevation: 43.00mRL

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

JACOBS

Preliminary Log of Investigation

Project: **Pinehaven Stream - Sunbrae Drive Culvert Replacement**

Borehole

Location: **Sunbrae Drive** Project No: **IZ018100-GEO**

Hole ID: **BH02**

Client: **Wellington Water**

Date: **11/06/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Details / Casing Diameter (mm))	TCR (%) (SCR (%))	RQD	In-Situ Testing	Sampling	Geology Legend	GroundWater	Description of Strata	Comments	Backfill / Installation
34.5	8.5								8.50m: Gravels becoming fine grained and sand content increasing with depth.		
34.0	9.0	SPT	44	N/A	SPT_s=19,43 N=43/80	SPTLS			Clayey medium to coarse SAND with some gravel and silt; dark grey. Very dense, moist, well graded; clay, low plasticity; gravel, medium to coarse, sub-angular. **(Alluvium)**		
33.5	9.5										
33.0	10.0								Sandy CLAY with some silt; blueish grey. Very stiff, moist, high plasticity; sand, fine to medium. **(Residual Soil)**		
32.5	10.5	SPT	0	N/A	SPT_s=30 N=30/85						
32.0	11.0										
31.5	11.5										
31.0	12.0					C					

Started: 11/06/2015

Finished: 13/06/2015

Driller: Webster

Plant: Tractor Mounted

Logged: SW

Checked: ME

Groundwater Observations

No.	Struck (m)	Date	Observations	Standing (m)
1	2.7	12/06/2015	3. 1.4m 11/06/2015	Directly adjacent river water level.
			1. 2.7m 12/06/2015	Inferred during drilling.
			2. 4.4m 12/06/2015	Downhole dipper reading prior to re-commencement of drilling.

Inferred during drilling

Remarks

Co-ordinates:
5442359.00mN
1769004.00mE
Elevation: 43.00mRL

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

JACOBS

Borehole Log of Investigation

Project: **Pinehaven Stream - Sunbrae Drive Culvert Replacement**

Borehole

Location: **Sunbrae Drive** Project No: **IZ018100-GEO**

Hole ID: **BH02**

Client: **Wellington Water**

Date: **10/06/2015**

R.L. (m)	Depth (m)	Drilling Method	TCR (%)	SCR	RQD	Fracture Index	Drilling Flush Return (%)	Geology Legend	GroundWater	Description of Strata	Geological Unit	Weathering Grade	Relative Strength	Defect Description	Backfill
		HQ3	100	0	0					Completely weathered, grey to dark grey, massive GREYWACKE; extremely weak. Extremely jointed. **(Torlesse Supergroup)**				*12.00m to 12.10m: Crushed zone.*	
														12.20m to 12.30m: Crushed zone.	
30.5	12.5	HQ3	100	0	0									*12.60m: Joint, (Dip 20°) rough, undulating, moderately wide to wide, soil infilling of fine to medium gravel.*	
											Tt			*12.70m to 12.80m: Crushed zone.*	
30.0	13.0	HQ3	100	0	0									*13.20m: Joint, (Dip 5°) rough, planar, moderately narrow, soil infilling of fine gravel.*	
29.5	13.5													*13.30m to 13.40m: Crushed zone.*	
		HQ3	100	10	0					Highly weathered, pale grey, distinictly banded GREYWACKE; Very weak to weak. Bands 2-10mm thick and dipping 70-80°. Highly jointed, very closely spaced. **(Torlesse Supergroup)**				*13.70m to 13.90m: Joint, (Dip 10-15°) rough, undulating, narrow, clean.*	
29.0	14.0													*14.20m to 14.30m: Crushed zone.*	
28.5	14.5	HQ3	100	5	0						Tt			*14.60m to 14.80m: Joint, (Dip 0-20°) rough, undulating, narrow, clean.*	
28.0	15.0													*14.95m to 15.05m: Crushed zone.*	
		HQ3	100	45	30					*15.00m to 15.40m: Moderately weathered.*				*15.13m: Joint, (Dip 45°) smooth, planar, narrow, clean.*	
27.5	15.5													*15.40m to 15.70m: Crushed zone.*	
27.0	16.0									Slightly weathered, grey to dark grey,	Tt				

Started: 11/06/2015
Finished: 13/06/2015
Driller: Webster
Plant: Tractor Mounted
Logged: SW
Checked: ME

Groundwater Observations

No. Depth (m) Date Comments

Comments

Co-ordinates
5442359 N
1769004 E

Elevation: 43 masl
Inclination:

JACOBS

Borehole Log of Investigation

Project: **Pinehaven Stream - Sunbrae Drive Culvert Replacement**

Borehole

Location: **Sunbrae Drive** Project No: **IZ018100-GEO**

Hole ID: **BH02**

Client: **Wellington Water**

Date: **10/06/2015**

R.L. (m)	Depth (m)	Shift Details / Drilling Method / Casing Diameter (mm)	TCR (%) 25 50 75	SCR	RQD	Fracture Index	Drilling Flush Return (%) 25 50 75	Geology Legend	GroundWater	Description of Strata	Geological Unit	Weathering Grade UW SW MW HW CW RW	Relative Strength EW VW W MS S	Defect Description	Backfill
26.5	16.5	HQ3	**100**	80	60					distinctly banded GREYWACKE; moderately strong to strong. Bands 2 -10mm thick and dipping 70-80°. Moderately jointed, closely spaced. **(Torlesse Supergroup)**	Tt			*16.07m: Joint, (Dip 80°) smooth, planar, narrow, clean.* *16.20m: Joint, (Dip 40°) smooth, planar, narrow, clean.* *16.28m: Joint, (Dip 40°) smooth, planar, moderately narrow, clean.* *16.42m: Joint, (Dip 60°) smooth, planar, moderately narrow, clean.* *16.56m: Joint, (Dip 80°) smooth, planar, narrow, clean.* *16.60m: Joint, (Dip 60°) smooth, planar, narrow, clean.* *16.70m: Joint, (Dip 20°) rough, planar, narrow, soil infilling of fine to medium gravel.* *17.15m to 17.35m: Crushed zone.*	
26.0	17.0	HQ3	**100**	10	0					Highly weathered, grey to dark grey, massive GREYWACKE; very weak. Highly jointed, very closely spaced. **(Torlesse Supergroup)**	Tt				
										BH02 terminated at 17.35m. Target Depth					

Started: 11/06/2015
Finished: 13/06/2015
Driller: Webster
Plant: Tractor Mounted
Logged: SW
Checked: ME

Groundwater Observations

No. Depth (m) Date Comments

Comments

Co-ordinates
5442359 N
1769004 E

Elevation: 43 masl
Inclination:

Project Name:	Pinehaven Stream – Sunbrae Drive Culvert Replacement
Project No.	IZ018100-GEO
Client:	Wellington Water
Borehole ID	BH02
No. of boxes:	3

Grey scale

Colour scale

Depth (m)	**Box**	1 of 3	**Start depth (m)**	11.90	**End depth (m)**	14.30

11.90

12.40

12.80

13.30

13.80

Depth (m)	**Box**	2 of 3	**Start depth (m)**	14.30	**End depth (m)**	16.90

14.30

14.80

15.30

15.90

16.40

Depth (m)	Box	3 of 3	Start depth (m)	16.90	End depth (m)	17.35
16.90						

Appendix D. Hand Auger logs

JACOBS

Preliminary Log of Investigation

Project: **Pinehaven Stream - Flood Protection Works**

Location: **Pinehaven** Project No: **IZ018100**

Hole ID: **HA1**

Client: **Wellington Water**

Date: **22/09/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Details / Casing Diameter (mm))	In-Situ Testing	Sampling	DCP (Blows per Drive) 5 10 15 20	Geology Legend	GroundWater	Description of Strata	Geological Unit	Backfill / Installation
68.0	1.0	HA	$I_{vp}41/I_{vr}16$					Silty CLAY; dark brown. Very Soft, wet, low to high plasticity, some roots. **(Topsoil)**		
								CLAY with some silt; light brown and orange mottles. Firm, moist, low to high plasticity **(Alluvium)**		
								Clayey fine to medium GRAVEL; orange. Sub-angular **(Alluvium)**		
			$I_{vp}49/I_{vr}16$					Silty CLAY; dark brown. Firm, moist, high plasticity **(Alluvium)**		
								Clayey fine to medium GRAVEL; grey. Sub-angular **(Alluvium)**		
								HA1 terminated at 1.60m. Unable to advance as too difficult to auger		

Started: 22/09/2015
Finished: 22/09/2015
Driller:
Plant: Hand Auger
Logged: J Leeves
Checked: TM

Depth Related Remarks
From *Remarks*

Groundwater Observations
No. *Struck (m)* *Date* *Observations* *Standing (m)*

Co-ordinates:
5441788.00mN
1769035.00mE
Elevation: 69.00mRL
Inclination: -90°

Remarks
Shear Vane values corrected, Vane ID: DR4473
CV = 1.645
Co-ordinates obtained from Wellington Council GIS viewer
No ground water table encountered
DCP is blows per 100mm.

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

JACOBS

Preliminary Log of Investigation

Project: **Pinehaven Stream - Flood Protection Works**

Location: **Pinehaven** Project No: **IZ018100**

Hole ID: **HA2**

Client: **Wellington Water**

Date: **22/09/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Detail/s; Casing Diameter (mm))	In-Situ Testing	Sampling	DCP (Blows per Drive) (5 10 15 20)	Geology Legend	GroundWater	Description of Strata	Geological Unit	Backfill / Installation
59.0	1.0	HA	$I_{vp}72/I_{vr}16$ $I_{vp}33/I_{vr}16$					Silty CLAY; dark brown. Soft, wet, low to high plasticity, some roots **(Topsoil)** Silty CLAY with some gravel; light brown with reddish orange gravels. Stiff, wet, high plasticity, gravel is medium and angular **(Alluvium)** 1m: Becomes firm Clayey fine to medium GRAVEL; dark grey. Wet, angular **(Alluvium)** HA2 terminated at 1.50m. Unable to advance as too difficult to auger		

Started: 22/09/2015
Finished: 22/09/2015
Driller:
Plant: Hand Auger
Logged: J Leeves
Checked: TM

Depth Related Remarks

From	Remarks

Groundwater Observations

No.	Struck (m)	Date	Observations	Standing (m)

Co-ordinates:
5441860.00mN
1769045.00mE
Elevation: 60.00mRL
Inclination: -90°

Remarks
Shear Vane values corrected, Vane ID: DR4473
CV = 1.645
Co-ordinates obtained from Wellington Council GIS viewer
No ground water table encountered
DCP is blows per 100mm.

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

JACOBS

Preliminary Log of Investigation

Project: **Pinehaven Stream - Flood Protection Works**

Location: **Pinehaven** Project No: **IZ018100**

Hole ID: **HA3**

Client: **Wellington Water**

Date: **22/09/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Details / Casing Diameter (mm))	In-Situ Testing	Sampling	DCP (Blows per Drive) 5 10 15 20	Geology Legend	GroundWater	Description of Strata	Geological Unit	Backfill / Installation
57.0	1.0	HA	$I_{vp}99/I_{vr}49$					Clayey SILT; very dark brown. Soft, moist, low plasticity, some roots **(Topsoil)**		
								Clayey SILT with oraganic fragments; very dark brown. Soft, moist, low plasticity, oraganic material is undecomposed root and branch materials, very difficult to auger through **(Fill)**		
								Clayey SILT; light brown and grey bands. Firm to stiff, moist, high plasticity **(Alluvium)**		
			$I_{vp}165/I_{vr}49$					1m: Becomes very stiff		
								Fine to medium GRAVEL with some clay, silt and medium to coarse sand; grey. Angular **(Alluvium)**		
								HA3 terminated at 1.30m. Unable to advance as too difficult to auger		

Started: 22/09/2015
Finished: 22/09/2015
Driller:
Plant: Hand Auger
Logged: J Leeves
Checked: TM

Depth Related Remarks
From *Remarks*

Groundwater Observations
No. *Struck (m)* *Date* *Observations* *Standing (m)*

Co-ordinates:
5442022.00mN
1769000.00mE
Elevation: 58.00mRL
Inclination: -90°

Remarks
Shear Vane values corrected, Vane ID: DR4473
CV = 1.645
Co-ordinates obtained from Wellington Council GIS viewer
No ground water table encountered
DCP is blows per 100mm.

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

JACOBS

Preliminary Log of Investigation

Project: **Pinehaven Stream - Flood Protection Works**

Location: **Pinehaven** Project No: **IZ018100**

Hole ID: **HA4**

Client: **Wellington Water**

Date: **23/09/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Detail/s; Casing Diameter (mm))	In-Situ Testing	Sampling	DCP (Blows per Drive) (5 10 15 20)	Geology Legend	GroundWater	Description of Strata	Geological Unit	Backfill / Installation
58.0	1.0	HA	$I_{vp}58/I_{vr}25$					Silty CLAY, light brown. Soft, moist, low to high plasticity, some roots **(Topsoil)** CLAY with some silt; light brown. Soft to firm, moist, high plasticity, occasional root **(Alluvium)** 0.5m: Becomes firm Fine to medium GRAVEL with some clay and silt; grey. Sub-angular **(Alluvium)** HA4 terminated at 1.20m. Unable to advance as too difficult to auger		

Started: 23/09/2015
Finished: 23/09/2015
Driller:
Plant: Hand Auger
Logged: J Leeves
Checked: TM

Depth Related Remarks
From Remarks

Groundwater Observations
No. Struck (m) Date Observations Standing (m)

Co-ordinates:
5442127.00mN
1769023.00mE
Elevation: 59.00mRL
Inclination: -90°

Remarks
Shear Vane values corrected, Vane ID: DR4473
CV = 1.645
Co-ordinates obtained from Wellington Council GIS viewer
No ground water table encountered
DCP is blows per 100mm.

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

JACOBS

Preliminary Log of Investigation

Project: **Pinehaven Stream - Flood Protection Works**

Location: **Pinehaven** Project No: **IZ018100**

Hole ID: **HA5**

Client: **Wellington Water**

Date: **23/09/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Details / Casing Diameter (mm))	In-Situ Testing	Sampling	DCP (Blows per Drive) 5 10 15 20	Geology Legend	GroundWater	Description of Strata	Geological Unit	Backfill / Installation
57.0	1.0	HA	$I_{vp}82/I_{vr}33$					Sandy SILT; dark brown. Soft, moist, low plasticity, some roots, sand is fine **(Topsoil)**		
								Silty CLAY, brown. Stiff, wet, low to high plasticity **(Fill)**		
								Clayey medium GRAVEL, dark grey and orange. Sub-angular **(Fill)**		
			$I_{vp}66/I_{vr}16$					CLAY with some silt and gravel; Stiff, wet, high plasticity **(Alluvium)**		
			$I_{vp}230+$					Silty medium GRAVEL; grey. Most to wet, low plasticity, sub-angular **(Alluvium)**		
								HA5 terminated at 1.80m. Unable to advance as too difficult to auger		

Started: 23/09/2015
Finished: 23/09/2015
Driller:
Plant: Hand Auger
Logged: J Leeves
Checked: TM

Depth Related Remarks
From *Remarks*

Groundwater Observations
No. *Struck (m)* *Date* *Observations* *Standing (m)*

Co-ordinates:
5442178.00mN
1769037.00mE
Elevation: 58.00mRL
Inclination: -90°

Remarks
Shear Vane values corrected, Vane ID: DR4473
CV = 1.645
Co-ordinates obtained from Wellington Council GIS viewer
No ground water table encountered
DCP is blows per 100mm.

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

JACOBS

Preliminary Log of Investigation

Project: **Pinehaven Stream - Flood Protection Works**

Location: **Pinehaven** Project No: **IZ018100**

Hole ID: **HA6**

Client: **Wellington Water**

Date: **23/09/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Details / Casing Diameter (mm))	In-Situ Testing	Sampling	DCP (Blows per Drive) 5 10 15 20	Geology Legend	GroundWater	Description of Strata	Geological Unit	Backfill / Installation
57.0	1.0	HA	$I_{vp}132/I_{vr}41$ $I_{vp}197/I_{vr}33$ $I_{vp}230+$					Silty CLAY; brown. Soft, saturated, low to high plasticity, some roots **(Topsoil)** Clayey medium to coarse GRAVEL; dark grey. Sub-angular, medium to coarse **(Fill)** CLAY; orange, brown and grey bands. Very stiff, high plasticity **(Alluvium)** Fine to medium GRAVEL with some clay; orange and grey bands. Fine to medium **(Alluvium)** HA6 terminated at 1.60m. Unable to advance as too difficult to auger		

Started: 23/09/2015
Finished: 23/09/2015
Driller:
Plant: Hand Auger
Logged: J Leeves
Checked: TM

Depth Related Remarks
From *Remarks*

Groundwater Observations
No. *Struck (m)* *Date* *Observations* *Standing (m)*

Co-ordinates:
5442299.00mN
1769001.00mE
Elevation: 58.00mRL
Inclination: -90°

Remarks
Shear Vane values corrected, Vane ID: DR4473
CV = 1.645
Co-ordinates obtained from Wellington Council GIS viewer
No ground water table encountered
DCP is blows per 100mm.

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

JACOBS

Preliminary Log of Investigation

Project: **Pinehaven Stream - Flood Protection Works**

Location: **Pinehaven** Project No: **IZ018100**

Hole ID: **HA7**

Client: **Wellington Water**

Date: **23/09/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Detail/s, Casing Diameter (mm))	In-Situ Testing	Sampling	DCP (Blows per Drive) 5 10 15 20	Geology Legend	GroundWater	Description of Strata	Geological Unit	Backfill / Installation
							1	Silty CLAY; dark brown. Soft to firm, wet, low to high plasticity, some roots **(Topsoil)**		
			I_{vp}123/I_{vr}49					Silty CLAY; brown. Very stiff, saturated, high plasticity **(Alluvium)**		
55.0	1.0	HA	I_{vp}115/I_{vr}33					Clayey SILT; grey and orange bands. Soft, saturated (Note: auger pushed through much of this layer, low material recovery) **(Alluvium)** 1 - 1.1m: Very Stiff Layer		
			I_{vp}99/I_{vr}33					1.5 - 1.6m: Very Stiff Layer		
54.0	2.0							Fine GRAVEL; dark grey. Sub-rounded **(Alluvium)**		
								HA7 terminated at 2.20m. Unable to advance as too difficult to auger		

Started: 23/09/2015

Finished: 23/09/2015

Driller:

Plant: Hand Auger

Logged: J Leeves

Checked: TM

Depth Related Remarks

From	Remarks

Groundwater Observations

No.	Struck (m)	Date	Observations	Standing (m)
1.	0.3m	23/05/2015	Likely a perched water table due to rain.	

Remarks

Shear Vane values corrected, Vane ID: DR4473
CV = 1.645
Co-ordinates obtained from Wellington Council GIS viewer
DCP is blows per 100mm.

Co-ordinates:
5442451.00mN
1769053.00mE
Elevation: 56.00mRL
Inclination: -90°

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

JACOBS

Preliminary Log of Investigation

Project: **Pinehaven Stream - Flood Protection Works**

Location: **Pinehaven** Project No: **IZ018100**

Hole ID: **HA8**

Client: **Wellington Water**

Date: **23/09/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Detail/s; Casing Diameter (mm))	In-Situ Testing	Sampling	DCP (Blows per Drive) (5 10 15 20)	Geology Legend	GroundWater	Description of Strata	Geological Unit	Backfill / Installation
55.0	1.0	HA	$I_{vp}99/I_{vr}33$				1	Silty CLAY; dark brown. Soft, moist, some roots **(Topsoil)**		
								Clayey SILT; light brown. Soft to firm, saturated, low plasticity **(Alluvium)**		
			$I_{vp}66/I_{vr}41$					Fine to medium GRAVEL; grey. Sub-angular **(Alluvium)**		
								HA8 terminated at 1.40m. Unable to advance as too difficult to auger		

Started: 23/09/2015

Finished: 23/09/2015

Driller:

Plant: Hand Auger

Logged: J Leeves

Checked: TM

Depth Related Remarks

From	Remarks

Groundwater Observations

No.	Struck (m)	Date	Observations	Standing (m)
1.	0.3m	23/05/2015	Likely a perched water table due to rain.	

Remarks

Shear Vane values corrected, Vane ID: DR4473
CV = 1.645
Co-ordinates obtained from Wellington Council GIS viewer
DCP is blows per 100mm.

Co-ordinates:
5442410.00mN
1769003.00mE
Elevation: 56.00mRL
Inclination: -90°

JACOBS

Preliminary Log of Investigation

Project: **Pinehaven Stream - Flood Protection Works**

Location: **Pinehaven** Project No: **IZ018100**

Hole ID: **HA9**

Client: **Wellington Water**

Date: **22/09/2015**

R.L. (m)	Depth (m)	Drilling Method (Shift Detail/s, Casing Diameter (mm))	In-Situ Testing	Sampling	DCP (Blows per Drive) 5 10 15 20	Geology Legend	GroundWater	Description of Strata	Geological Unit	Backfill / Installation
54.0	1.0	HA	$I_{vp}148/I_{vr}49$					Clayey SILT; dark brown. Soft, moist, low plasticity, some roots and plant material **(Topsoil)**		
								Silty CLAY with minor gravel; brown, grey and orange bands. Firm, moist, high plasticity, gravel is medium and angular. **(Alluvium)**		
			$I_{vp}49/I_{vr}16$					Clayey SILT; light brown with some orange and grey mottles. Soft to firm, moist, low to high plasticity **(Alluvium)**		
			$I_{vp}82/I_{vr}58$							
53.0	2.0							Sandy fine GRAVEL; dark and light grey. Moist, sub-angular, sand is medium to coarse **(Alluvium)**		
								HA9 terminated at 2.00m. Unable to advance as too difficult to auger		

Started: 22/09/2015
Finished: 22/09/2015
Driller:
Plant: Hand Auger
Logged: J Leeves
Checked: TM

Depth Related Remarks

From	Remarks

Groundwater Observations

No.	Struck (m)	Date	Observations	Standing (m)

Co-ordinates:
5442528.00mN
1769035.00mE
Elevation: 55.00mRL
Inclination: -90°

Remarks
Shear Vane values corrected, Vane ID: DR4473
CV = 1.645
Co-ordinates obtained from Wellington Council GIS viewer
No ground water table encountered
DCP is blows per 100mm.

See key sheet for an explanation of symbols and abbreviations. Material descriptions as per NZGS Guidelines - December 2005.

Appendix E. Site Photographs

ID	Description	Photograph
1	Site location of HA1 looking towards the stream from the driveway.	
2	Close up of HA1 material.	
3	Looking downstream from the HA1 site.	

4	HA2 location.	
5	Close up of HA2 material.	
6	HA3 location.	

7	Close up of HA3 material.	
8	HA4 location.	

9	Close up of HA4 material.	
10	HA5 Location.	
11	Close up of HA5 material.	

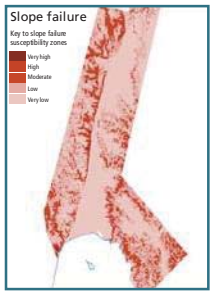
12	HA6 Location.	
13	Close up of HA6 material.	
14	HA7 location.	

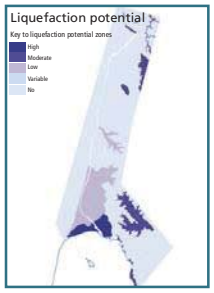
15	HA8 Location	
16	Close up of HA8 material	
17	HA9 Location.	

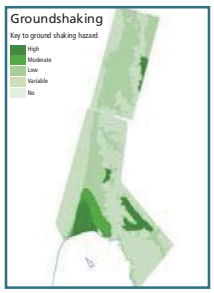
18	Close up of HA9 material.	

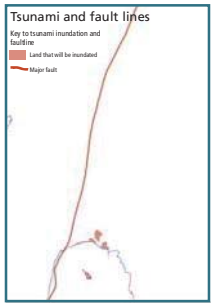
Appendix F. Upper Hutt Hazard Risk Map

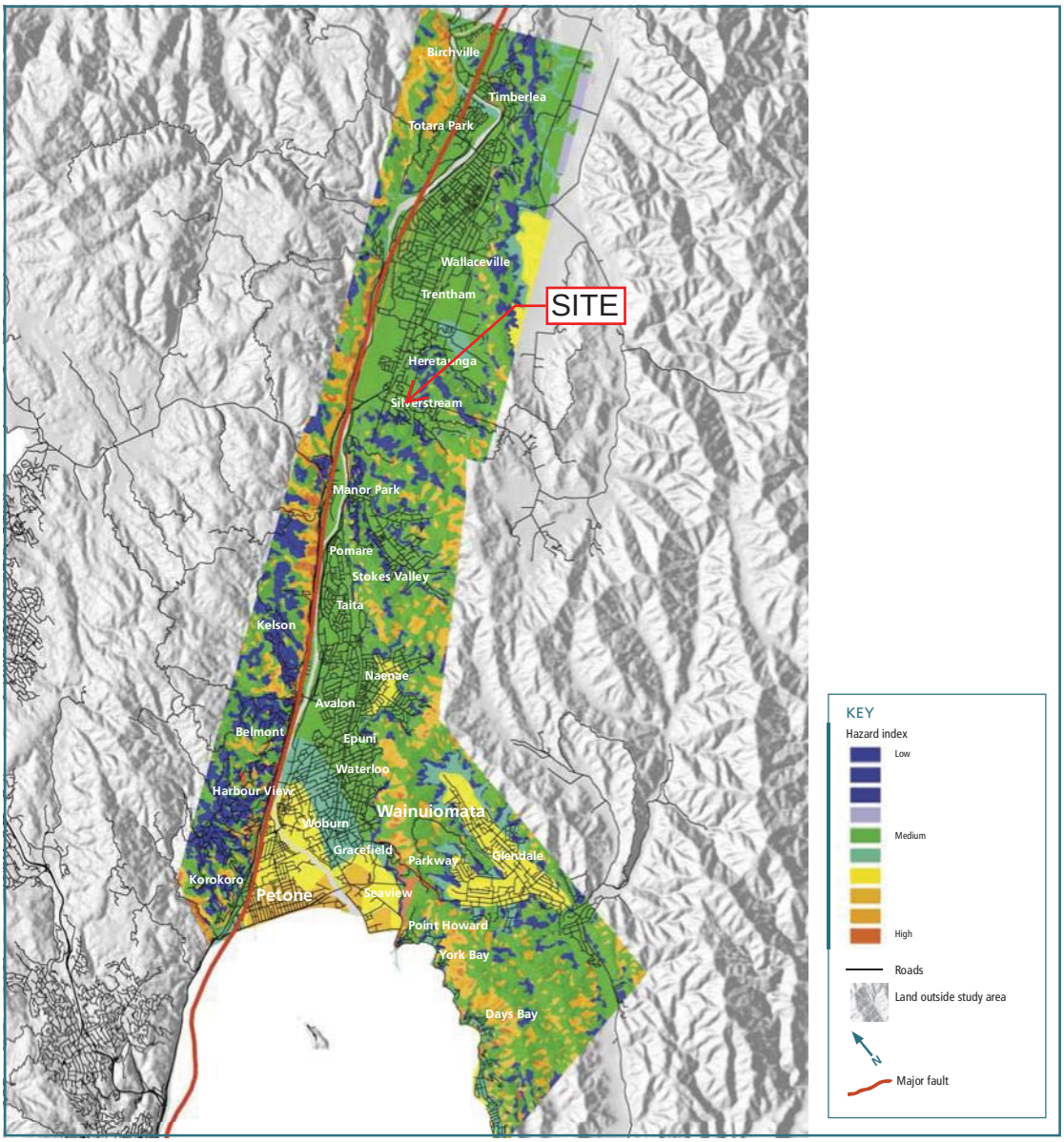
Combined earthquake hazard map
Hutt Valley











Earthquake hazard mitigation measures

Hazard	Effect on ground	Effect on facilities	Mitigation options: existing facilities	Mitigation options: planned facilities
Fault movement	Ground disturbances vertically and horizontally over a zone depends on depth to rock below surface. Cracks in land surface.	Upheaval, tearing apart, movement of foundations, severe damage to structures which cross the fault.	1. Verify. 2. Assess impact. 3. Options: a) strengthen to survive b) move facilities from fault zone c) limit damage by providing weak links or isolation	1. Verify. 2. Assess impact. 3. Options: a) construct facilities elsewhere b) incorporate special strengthening c) provide weak links or special isolation to limit damage
Ground shaking	Violent horizontal and vertical motions for up to one minute duration.	Cracking, fracture, collapse of buildings. Breaks in underground services. Deformation of surface infrastructure.	1. Verify. 2. Assess impact. 3. Options: a) strengthen or base isolate b) secure/improve vulnerable parts c) limit damage by providing weak links or isolation.	1. Verify. 2. Assess impact. 3. Options: a) comply with current codes for design and construction b) incorporate strength and resilience c) secure vulnerable parts and contents
Liquefaction	Shaking causes some soils to behave like liquid, causing loss of support to structures above. Such soils may be up to 10m below ground surface. Lateral movement of large soil masses, especially adjacent to rivers. Variable subsidence of ground surface.	Sinking and tilting of structures supported on liquefied material. Severe damage to underground services. Flotation of empty underground tanks and chambers.	1. Verify. 2. Assess impact. 3. Options: a) install piles b) install gravel drains c) drain liquefiable layers d) prepare for quick reinstatement	1. Verify. 2. Assess impact. 3. Options: a) compact ground at site b) install piles and gravel drains c) drain liquefiable layers
Slope failure	A significant soil masses moves bodily down the slope, from few hundred millimetres to many metres. Landslides occur at many different locations.	Ranges from deformation of foundations and structural failures to total destruction of site and all buildings and infrastructure above and below ground.	1. Verify. 2. Assess impact. 3 Options: a) stabilise slope – retaining walls b) stabilise slope – ground anchors c) improve drainage, reduce erosion	1. Verify. 2. Assess impact. 3. Options: a) find a better site b) stabilise slope retaining walls c) stabilise slope – ground anchors d) improve drainage, reduce erosion
Tsunami	Land flooded. Scouring action erodes soil dramatically	Flooding of basements. Undermining/destruction of surface infrastructure. Exposure/ damage to underground services. Undermining of foundations. Bodily movement of some structures, equipment, vehicles etc.	1. Verify. 2. Assess impact. 3. Options: a) construct protective sea walls b) shift critical facilities to higher level	1. Verify. 2. Assess impact. 3. Options: a) find a better site b) construct protective sea walls c) design special foundations / dikes d) put critical facilities at high level

Background statement

In recognition of the earthquake hazard in the Region, the Greater Wellington Regional Council has carried out studies on ground surface rupture from active faulting, ground shaking, liquefaction potential and associated ground damage, slope failure and tsunami inundation (Wellington Harbour). Single factor hazard maps have been produced by Greater Wellington for each of these earthquake hazards.

This map sheet is part of a series of four map sheets showing the combined earthquake hazard for the main urban areas in the western part of the Wellington Region. The map series is one of Greater Wellington's natural hazard education and awareness initiatives.

The combined earthquake hazard map is a generalised map of earthquake hazard reflecting possible effects on a typical range of facilities (buildings, roads, services, etc). The methodology has involved broad assessments of many factors which determine the effects of earthquakes.

This map series was prepared for Greater Wellington by Ian R Brown Associates Ltd in association with Kingston Morrison Ltd and Victoria University of Wellington.

Warning

The hazard assessment methodologies developed for each of the earthquake hazard components and the methodology used to combine and present the hazard information impose certain qualifications and limitations on the use of the information. Details on the qualifications and limitations, and assessment methodologies of the component earthquake hazard studies are available from Greater Wellington. The methodology used to combine the various earthquake hazards are described in the Greater Wellington Report on Mapping Methodology and Risk Mitigation Measures WRC/RP-T-96/22.

The information provided on these maps cannot be substituted for a site specific investigation. The site specific potential for and consequent damage from active faulting, amplified ground shaking, liquefaction, slope failure, and tsunami inundation should be assessed by qualified and experienced practitioners.

Bibliographic reference

Greater Wellington Regional Council (1996). Sheet 3 Hutt Valley (1st ed.) Combined Earthquake Hazard Map 1:30000, Pub. No. WRC/RP-T-96/14 Greater Wellington Regional Council, Wellington, New Zealand.

Notes on earthquake hazard mitigation measures

1. Check that the broad indication of hazard from the maps is correct for a particular site. (In many case, this could prove cost-effective towards mitigation.)
2. Obtain professional advice on implications and available countermeasures.
3. Mitigation options shown are in brief general terms. Professional advice will be needed to account for particular circumstances at the site.

Single component hazard maps

These combine to produce the Combined Earthquake Hazard Maps. Maps of the single components (ground shaking, liquefaction and earthquake induced slope failure) are available from the Hazard Analyst at Greater Wellington.

greater WELLINGTON
THE REGIONAL COUNCIL
Emergency Management

Pinehaven Stream Improvements

Wellington Water Limited

Geotechnical Factual Report

IZ089000-A.CS.GT.507-CG-RPT-0001 | 0

March 06, 2019

Pinehaven Stream Improvements

Project No:	IZ089000
Document Title:	Geotechnical Factual Report
Document No.:	IZ089000-A.CS.GT.507-CG-RPT-0001
Revision:	0
Date:	March 06, 2019
Client Name:	Wellington Water Limited
Client No:	Client Reference
Project Manager:	Eric Skowron
Author:	Logan Allan
File Name:	\\Jacobs.com\ANZ\IE\Projects\02_New Zealand\IZ089000\01 Design (Live)\10 Geotechnical\03 Supplementary Ground Investigation\\ IZ089000 Pinehaven Stream Improvements - Geotechnical Factual Report - review 01

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Document history and status

Revision	Date	Description	By	Review	Approved
00	06/03/2019	Issued for Client Comment	L. Allan	J. Spinks	I. Garside

Contents

Important note about your report

This document has been prepared by Jacobs Engineering Ltd (Jacobs) in accordance with the identified scope and for the benefit of Wellington Water Limited (WW). No liability is accepted by either of these entities (or their employees or sub-consultants) with respect to the use of this document by any other person. This disclaimer shall apply notwithstanding that this document may be made available to other persons for an application for permission or approval or to fulfil a legal requirement.

The findings contained in this report are the result of standard assessment techniques used in accordance with normal practices and standards, and (to the best of our knowledge) provide a reasonable representation of the current conditions at the locations tested. However, all sampling techniques, by definition, cannot determine the conditions between the sample points and so the report and data can only provide an indication of, and cannot be taken to be a full representation of, the sub-surface conditions. For the reasons outlined above, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

1. Introduction

1.1 Purpose of report

Wellington Water Limited (WW) are undertaking a program which involves the reshaping of around 500m of Pinehaven Stream through predominately private property. Jacobs Engineering Ltd (Jacobs) has been commissioned by WW to provide flood modelling, engineering and planning services; in support of the projects various stages of design, consenting and construction.

The upgrade is designed to increase the existing stream channel's capacity from less than a 5 year storm capacity to a 25 year storm capacity to quell frequent flooding in the area. Major works to be undertaken as part of this project include upgrading the existing culverts located along Sunbrae Dr and Pinehaven Road, replacement of private vehicle bridges and widening of the existing stream bank with new slopes and retaining walls.

1.2 Project Scope

Jacobs New Zealand Limited ('Jacobs') has been commissioned by WW to undertake additional geotechnical field investigations as part of the Pinehaven Stream Improvement program. The full scope of services and associated terms and conditions are provided in the Agreement for Engagement dated 18 April 2017. The scope of work is given in the Project Variation Request Form dated 10 October 2018.

The objectives set out below informed the scope of investigations:

- inform the detailed design and building consents;
- inform the contractors programme and cost estimates;
- allow the contractor to evaluate the construction methodology and design the temporary works.

1.3 Previous Ground Investigation

Jacobs previously completed a geotechnical factual and interpretive (Jacobs, 2015) report that provided a geotechnical investigation for the new bridge abutments at Sunbrae Drive as well as a general overview of the soil conditions at the site.

2. Site Location

The site is located along the Pinehaven Stream in Pinehaven, Upper Hutt, running from the Pinehaven Reserve to 48 Whitemans Road. The site runs approximately north south along an 800m section of the Pinehaven Stream, as shown in . The ground investigation location plans are shown in Appendix A.

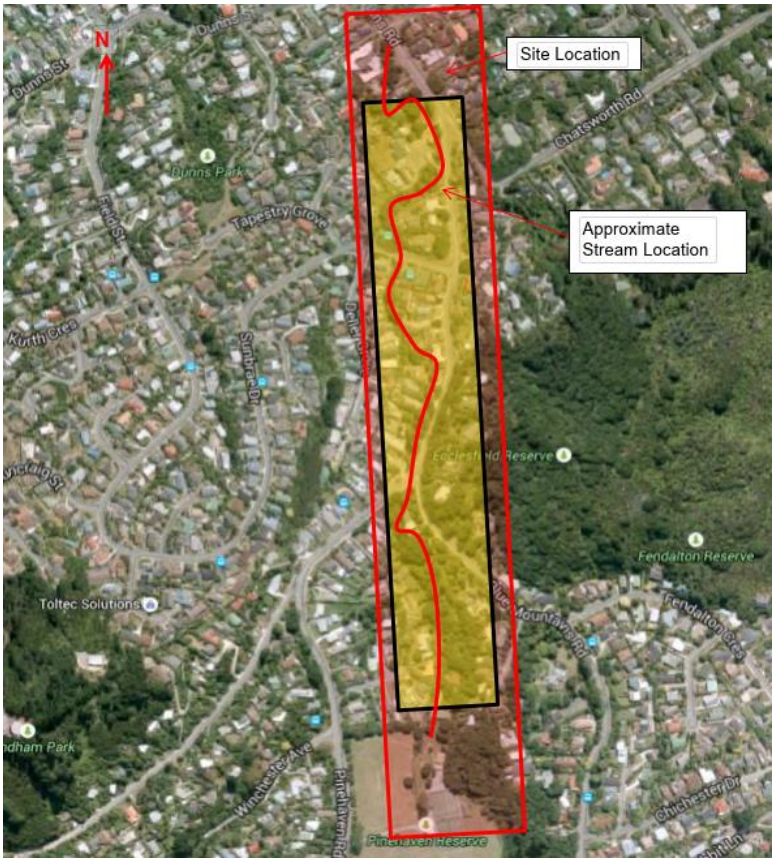


Figure 1 - Site Location

3. Geotechnical Investigations

Geotechnical investigations for this project include 6no. machine drilled boreholes (BH), 3no. test pits (TP) and 4no. hand augers (HA). The intent for these is summarised in below.

3.1 Machine Boreholes

The machine boreholes were drilled by Griffiths Drilling Limited using track mounted rotary core drilling equipment. Each borehole site was pre-drilled to clear underground services using jet vacuum with the exception of BH08 which was drilled from surface. Core samples were retrieved using HQ triple tube coring methods with standard penetration tests (SPTs). Where rock was encountered SPTs were not carried out. The boreholes were logged, sampled and photographed on site by a Jacobs Engineering Geologist in accordance with the New Zealand Geotechnical Society Guidelines (NZGS, 2005). A summary of the borehole investigations is provided in Table 1 below.

Table 1 - Summary of Machine Boreholes

BH no.	Depth bgl (m)	Jet vacuum depth bgl (m)	Ground Water bgl (m)	Insitu testing	Reason for Termination
BH03	9.45	1.5	2.85	6x SPTs from 1.5m to 9.0m taken every 1.5m.	Target
BH04	7.60	1.5	1.5	5x SPTs from 1.5m to 7.5m taken every 1.5m.	Target
BH05	15.00	1.5	2.85	6x SPTs from 1.5m to 9.0m taken every 1.5m.	Target
BH06	15.00	1.5	2.5	6x SPTs from 1.5m to 9.0m taken every 1.5m.	Target
BH07	8.90	1.0	2.5	6x SPTs from 1.0m to 8.5m taken every 1.5m.	Target
BH08	3.45	0.0	2.9	3x SPTs from 1.0m to 3.0m every 1.0m.	Target

1) BH01, BH02 were undertaken as part of the previous ground investigation (Jacobs, 2015).

The ground investigation location plans are presented in Appendix A and the borehole logs and core photos are presented in Appendix B.

3.2 Test Pits

The test pits were carried out by Griffiths Drilling Limited using a 1.7 tonne excavator. Dynamic Cone Penetrometer (DCP) testing (also referred to as a Scala test) was undertaken at each test pit. Logging was carried out on site by a Jacobs Engineering Geologist in accordance with the New Zealand Geotechnical Society Guidelines (NZGS, 2005). A summary of the test pit investigations is provided in Table 2.

Table 2 - Summary of Test Pits

TP no.	Depth bgl (m)	Ground Water bgl (m)	Insitu testing	Reason for Termination
TP01	2.3	1.8	DCP from surface	Target
TP03	1.4	1.2	DCP from surface	Collapse on all walls
TP05	2.3	Not encountered	DCP from surface	Target

Note:

1) Due to the investigation site being located on a concrete driveway, TP02 was replace with a BH08, a shallow machine borehole.

2) Due to access restrictions TP04 was replaced with HA13.

The ground investigation location plans are presented in Appendix A and the test pit logs and photos are presented in Appendix C.

3.3 Hand Auger Holes

The hand augers were undertaken by a Jacobs Engineering Geologist. DCP testing (also referred to as a Scala test) was carried out at each hand auger location. Logging was carried out on site by a Jacobs Engineering Geologist in accordance with the New Zealand Geotechnical Society Guidelines (NZGS, 2005). A summary of the hand auger investigations is given in Table 3.

Table 3 - Summary of Hand Augers

HA no.	Depth bgl (m)	Ground Water bgl (m)	Insitu testing	Reason for Termination
HA10	1.6	Not encountered	DCP from surface	Refusal
HA11	1.2	Not encountered	DCP from surface	Refusal
HA12	1.35	Not encountered	DCP from surface	Refusal
HA13	1.6	1.45	DCP from surface	Refusal

Note:

1) HA01 to HA08 were undertaken as part of the previous ground investigation (Jacobs, 2015).

The ground investigation location plans are presented in Appendix A and the hand auger logs and are presented in Appendix D.

4. References

Jacobs, 2015. *Geotechnical Factual and Interpretive Report,* Wellington: .

NZGS, 2005. *Field Description of Soil and Rock - Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes,* Wellington: New Zealand Geotechnical Society (NZGS).

Appendix A. Ground Investigation Location Plans

Legend

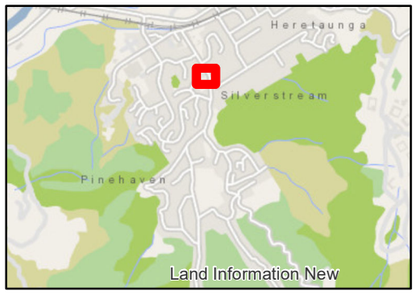
Pinehaven_GI_Locations

Point

- BH
- HA
- Previous GI
- TP

Notable Trees

Wellington_Parcels



N

0 5 10 20 Meters

Ground Investigation Location Plan

FIGURE 1

CLIENT
Wellington Water

PROJECT
Pinehaven Stream Improvements

SCALE
1:500 @ A3

PROJECT CODE
IZ089000

PROJECT MANAGER
ES

DRAWN
LA

PROJECT DIRECTOR
X

DATE
5/03/2019

FIGURE NO
1

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Parnell, Auckland
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Legend

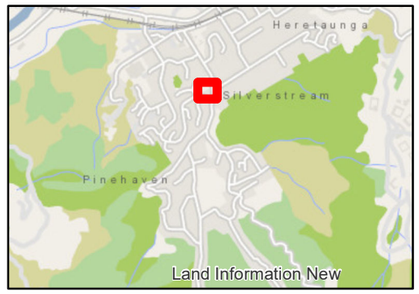
Pinehaven_GI_Locations

Point

- BH
- HA
- Previous GI
- TP

Notable Trees

Wellington_Parcels



N

0 5 10 20 Meters

Ground Investigation Location Plan

FIGURE 2

CLIENT
Wellington Water

PROJECT
Pinehaven Stream Improvements

SCALE	PROJECT CODE
1:500 @ A3	IZ089000
PROJECT MANAGER	DRAWN
ES	LA
PROJECT DIRECTOR	DATE
X	5/03/2019
FIGURE NO	REVISION
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Legend

Pinehaven_GI_Locations

Point

- BH
- HA
- Previous GI
- TP

Notable Trees

Wellington_Parcels

N

0 5 10 20 Meters

Ground Investigation Location Plan

FIGURE 3

CLIENT
Wellington Water

PROJECT
Pinehaven Stream Improvements

SCALE	PROJECT CODE
1:500 @ A3	IZ089000
PROJECT MANAGER	DRAWN
ES	LA
PROJECT DIRECTOR	DATE
X	5/03/2019
FIGURE NO	REVISION
3	Rev 1

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Legend

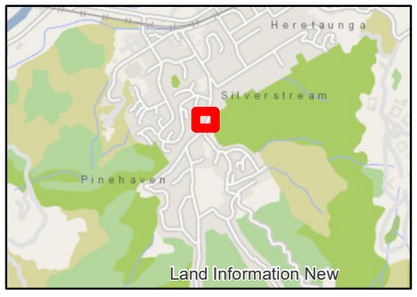
Pinehaven_GI_Locations

Point

- BH
- HA
- Previous GI
- TP

Notable Trees

Wellington_Parcels



N

0 5 10 20 Meters

Ground Investigation Location Plan

FIGURE 4

CLIENT
Wellington Water

PROJECT
Pinehaven Stream Improvements

SCALE 1:500 @ A3	PROJECT CODE IZ089000
PROJECT MANAGER ES	DRAWN LA
PROJECT DIRECTOR X	DATE 5/03/2019
FIGURE NO 4	REVISION Rev 1

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Legend

Pinehaven_GI_Locations

Point

- BH
- HA
- Previous GI
- TP

Notable Trees

Wellington_Parcels

N

0 5 10 20 Meters

Ground Investigation Location Plan

FIGURE 5

CLIENT
Wellington Water

PROJECT
Pinehaven Stream Improvements

SCALE	PROJECT CODE
1:500 @ A3	IZ089000
PROJECT MANAGER	DRAWN
ES	LA
PROJECT DIRECTOR	DATE
X	5/03/2019
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5	Rev 1

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Fax +64 9 928 5501

1769000

5A
5
3
11
12
10
8
6
4
10B
10C
6
8
10
12
Birch Grove

HA02
HA13
BH07
HA01
10A
TP05

1769000

Legend

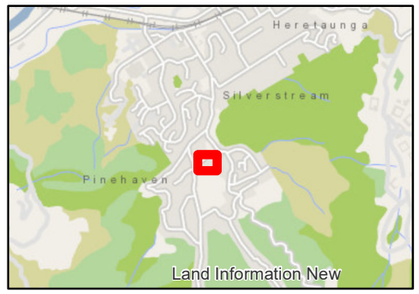
Pinehaven_GI_Locations

Point

- BH
- HA
- Previous GI
- TP

Notable Trees

Wellington_Parcels



N

0 5 10 20 Meters

Ground Investigation Location Plan

FIGURE 6

CLIENT
Wellington Water

PROJECT
Pinehaven Stream Improvements

SCALE
1:500 @ A3

PROJECT CODE
IZ089000

PROJECT MANAGER
ES

DRAWN
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PROJECT DIRECTOR
X

DATE
5/03/2019

FIGURE NO
6

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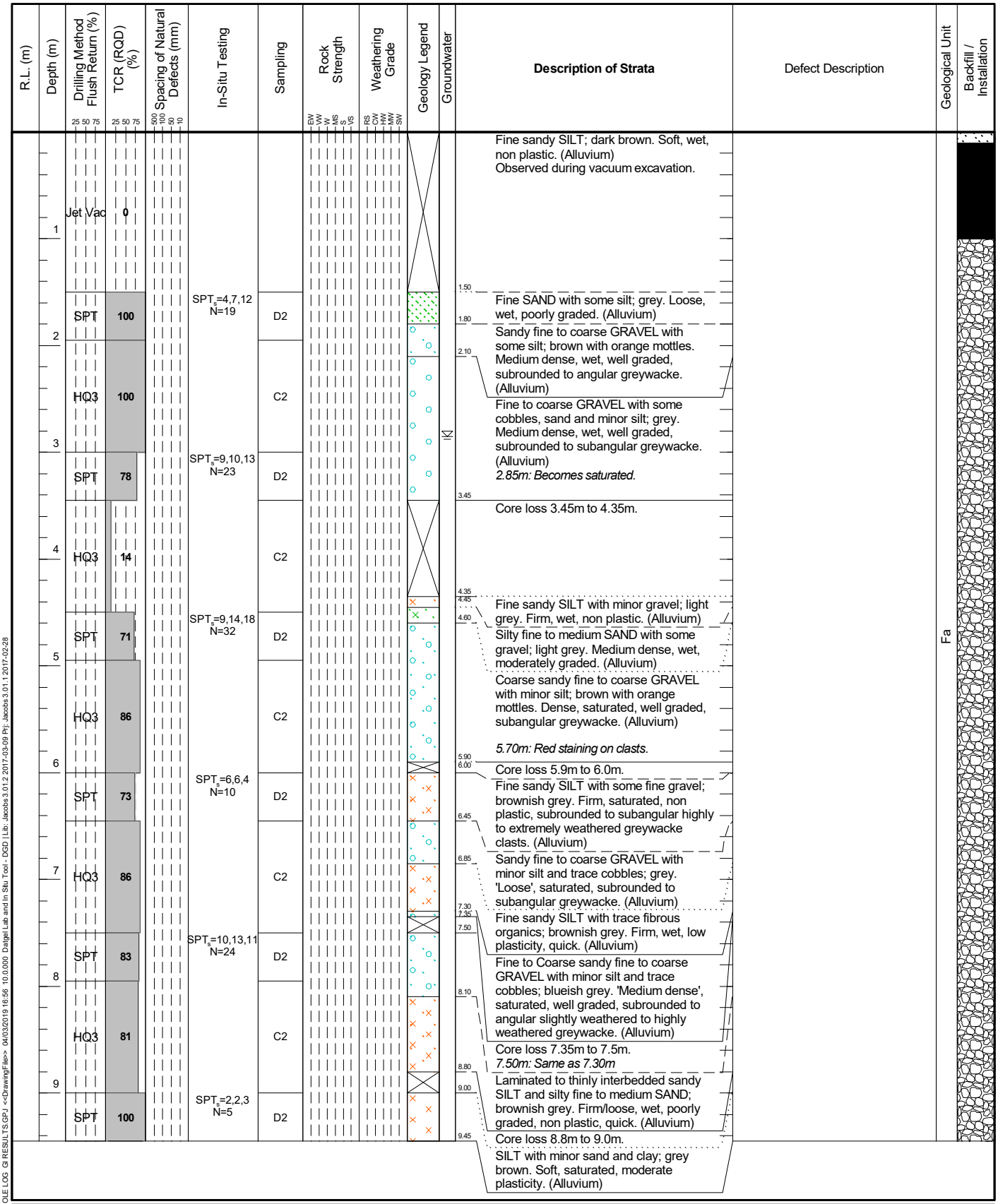
Appendix B. Borehole Logs and Photos

Borehole log

Project:	Pinehaven Stream Improvements	**Hole ID:**	BH03
Client:	Wellington Water	**Project No:**	IZ08900
Location:	Pinehaven, Upper Hutt	**Page:**	1 of 1



Driller:	Griffiths Drilling Ltd	**Easting:**	1769010.6	**Elevation:**	49.00	**Started:**	09/01/2019
Plant:	Track	**Northing:**	5442581.9	**Datum:**	MSL	**Finished:**	10/01/2019
Logged by:	LA	**Grid:**	NZTM2000	**Inclination:**	90	**Standard:**	NZS 4402:1986
Checked by:	LW	**Accuracy:**	MAP1	**Orientation:**		**Status:**	Final

Remarks:

Water Level
2.85m - 10/01/2019 am, dipped approximately 12 hours after drilling.
Sampling
C2 - Core Sample
D2 - SPT Sample
Hole location determined by MAP1.

BH03, Box 1, 1.5 to 6 m

BH03, Box 2, 6 m to 9.45 m

Pinehaven Stream improvements	
Wellington Water Limited	
Geotechnical Investigation	BH03
9/01/2019	

JACOBS®

IZ089000

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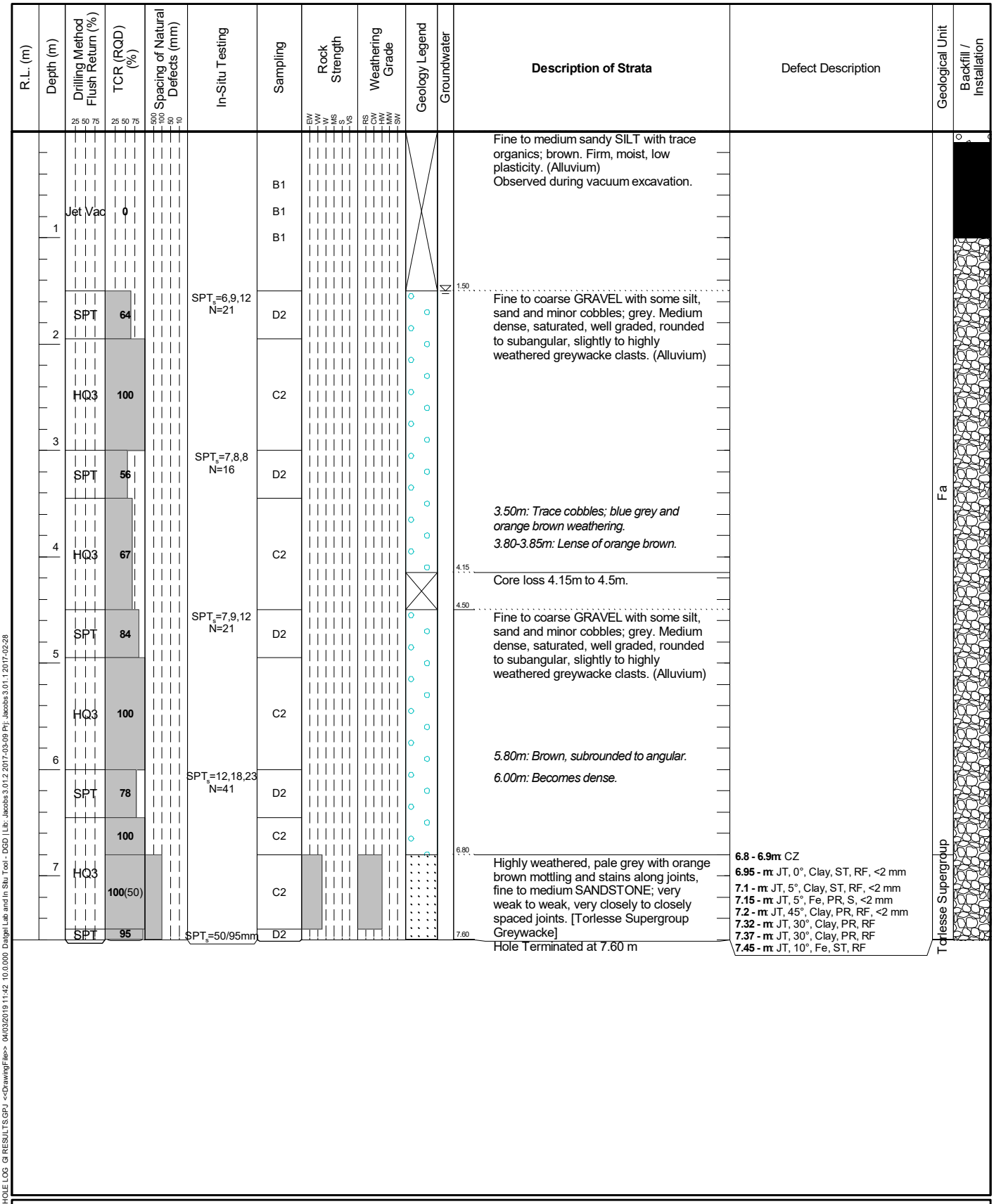
Borehole log

Project:	Pinehaven Stream Improvements	**Hole ID:**	BH04
Client:	Wellington Water	**Project No:**	IZ08900
Location:	Pinehaven, Upper Hutt	**Page:**	1 of 1



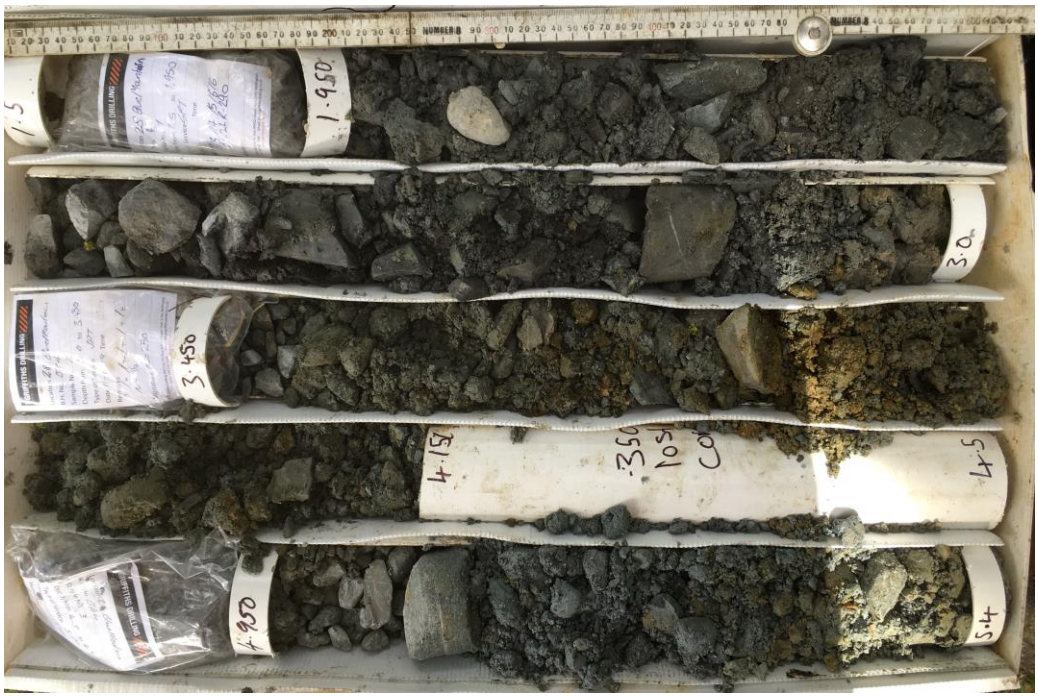
Driller:	Griffiths Drilling Ltd	**Easting:**	1769054.4	**Elevation:**	52.00	**Started:**	10/01/2019
Plant:	Track	**Northing:**	5442204.8	**Datum:**	MSL	**Finished:**	11/01/2019
Logged by:	LA	**Grid:**	NZTM2000	**Inclination:**	90	**Standard:**	NZS 4402:1986
Checked by:	LW	**Accuracy:**	MAP1	**Orientation:**		**Status:**	Final

Remarks:

Water Level
1.5m - 11/01/2019 am, dipped approximately 12 hours after drilling.

Sample
B1 - Bulk disturbed sample
C2 - Core sample
D2 - SPT sample

Hole location determined by MAP1.



BH04, Box 1, 1.5 to 5.4 m

BH04, Box 2, 5.4 m to 7.6 m

Borehole log

Project:	Pinehaven Stream Improvements	**Hole ID:**	BH05
Client:	Wellington Water	**Project No:**	IZ08900
Location:	Pinehaven, Upper Hutt	**Page:**	1 of 2

R.L. (m)	Depth (m)	Drilling Method Flush Return (%)	TCR (RQD) (%)	Spacing of Natural Defects (mm)	In-Situ Testing	Sampling	Rock Strength	Weathering Grade	Geology Legend	Groundwater	Description of Strata	Defect Description	Geological Unit	Backfill / Installation
		25 50 75	25 50 75	500 100 50 10			EW VW W MS S VS	RS CW HW MW SW						
58	1	Jet Vac	0								Brown Topsoil. (Drillers Log) Observed during vacuum excavation.			
											0.50 Silty fine to coarse GRAVEL; brown. (Drillers Log) Observed during vacuum excavation.			
											1.50 Fine sandy SILT with minor fibrous organics; brownish grey with orange mottles around organics. Soft, wet, low plasticity. (Alluvium)			
59	2	SPT	77		SPT_s=2,3,4 N=7	C2								
		HQ3	100			C2					2.40 *2.35m: Woody organics.* Fine to coarse GRAVEL with some sand, silt and cobbles; grey. Medium dense, saturated, well graded, subrounded to angular greywacke clasts. (Alluvium)			
60	3	SPT	60		SPT_s=7,12,12 N=24	D2								
61	4	HQ3	71			C2					4.20 *4.10-4.15m: Lense of coarse SAND; brownish grey.*			
											4.50 Core loss 4.2m to 4.5m. Fine sandy SILT; blueish grey. Soft, saturated, low plasticity, quick.			
62	5	SPT	100		SPT_s=2,2,1 N=3	D2					4.95 Core loss 4.95m to 5.15m.			
		HQ3	81			C2					5.15 Silty fine to coarse GRAVEL with some sand and cobbles; grey. Medium dense, saturated, well graded, subangular, slightly weather to highly weathered greywacke clasts. (Alluvium) *5.50-5.60m: Lense of fine to medium gravelly SILT with some sand; greyish brown. Soft, saturated, low plasticity, moderate sensitivity.*		Fa	
63	6	SPT	58		SPT_s=8,14,13 N=27	D2								
64	7	HQ3	52			C2					6.70 Highly weathered, blue grey with orange brown weathering, medium SANDSTONE; very weak to weak. [Torlesse Supergroup Greywacke] (Recovered as Gravelly COBBLES.)			
											7.00 Core loss 7.0m to 7.5m.			
65	8	SPT	95(0)		SPT_s=32,32,18 /78mm N=50 /228mm	D2					7.50 Highly weathered, blue grey with orange mottles, medium SANDSTONE; extremely weak to very weak. [TORLESSE SUPERGROUP Greywacke].	**8.1 - m**: JT, 65°, Clay, ST, RF		
		HQ3	90(20)			C2					8.10 Sandy fine to coarse GRAVEL some silt; brown. Very dense, well graded, angular. Highly weathered SANDSTONE [TORLESSE SUPERGROUP Greywacke].	**8.5 - 8.7m**: JT, 16 - 30°, Fe, PR, RF **8.7 - m**: JT, 30°, Clay, UN, RF		
66	9	SPT	0(0)		SPT_s=50/70mm	D2					8.50 Moderately weathered, brown, medium SANDSTONE; very weak to weak [TORLESSE SUPERGROUP Greywacke].	**8.9 - m**: JT, 28°, Fe, PR, RF **9.15 - m**: JT, 0°, Fe, UN, RF **9.37 - m**: JT, 5°, Fe, PR, RF	Torlesse Supergroup	
						C2					8.90 Core loss 8.9m to 9.0m	**9.57 - m**: JT, 30°, Fe, PR, RF		
67	10	HQ3	100(83)								9.00 Moderately weathered, brown, medium SANDSTONE; very weak to weak [TORLESSE SUPERGROUP			

Driller:	Griffiths Drilling Ltd	**Easting:**	1769006.5	**Elevation:**	57.00	**Started:**	16/01/2019
Plant:	Track	**Northing:**	5442059.5	**Datum:**	MSL	**Finished:**	17/01/2019
Logged by:	LA	**Grid:**	NZTM2000	**Inclination:**	90	**Standard:**	NZS 4402:1986
Checked by:	LW	**Accuracy:**	MAP1	**Orientation:**		**Status:**	Final

Remarks:

Water Level
2.85m - 17/01/2019 am, dipped approximately 12 hours after drilling.
Sample
C2 - Core sample
D2 - SPT sample
Hole location determined by MAP1.

Borehole log

Project:	Pinehaven Stream Improvements	**Hole ID:**	BH05
Client:	Wellington Water	**Project No:**	IZ08900
Location:	Pinehaven, Upper Hutt	**Page:**	2 of 2

R.L. (m)	Depth (m)	Drilling Method / Flush Return (%)	TCR (RQD) (%)	Spacing of Natural Defects (mm)	In-Situ Testing	Sampling	Rock Strength	Weathering Grade	Geology Legend	Groundwater	Description of Strata	Defect Description	Geological Unit	Backfill / Installation
											Greywacke].	**10.05 - m**: JT, 30°, Fe, PR, RF **10.15 - m**: JT, 80°, Fe, UN, RF **10.2 - m**: JT, 40°, Fe, ST, RF **10.35 - 10.6m**: JT, 16 - 30°, Fe, ST, RF		
	11					C2					10.90 *10.80-10.90m: Moderately weathered.*	**10.75 - m**: JT, 30°, Fe, UN, S **10.8 - m**: JT, 25°, Clay, ST, RF **10.8 - 10.9m**: JT, 0 - 90°, Fe, UN, RF		
		HQ3	**100**(61)			C2					Moderately to slightly weathered, blue grey with brown staining, medium SANDSTONE; weak [TORLESSE SUPERGROUP greywacke].	**11.15 - m**: JT, 20°, Fe, UN, RF		
											11.35	**11.35 - m**: VN, 15°, Qz, PR, RF		
	12										Moderately weathered, brown, medium SANDSTONE; very weak to weak [TORLESSE SUPERGROUP greywacke]. *11.40-11.50m: Highly weathered, very weak.*	**11.53 - m**: JT, 35°, Fe, ST, RF **11.61 - m**: VN, 50°, Qz, PR, RF **11.75 - m**: JT, 30°, Clay, UN, RF **11.85 - m**: JT, 25°, Fe, PR, RF **12.05 - m**: JT, 25°, clean, UN, RF	Torlesse Supergroup	
		HQ3	**100**(55)			C2						**12.4 - m**: JT, 35°, Clay, PR, RF **12.53 - m**: JT, 25°, Clay, UN, RF **12.55 - m**: JT, 65°, Clay, UN, S **12.8 - m**: JT, 30°, Fe, PR, RF **12.82 - m**: JT, 80°, Clay, UN, RF **13 - m**: JT, 55°, Fe, UN, RF **13.05 - m**: JT, 85°, Clay, UN, RF		
	13											**13.6 - m**: JT, 75°, Clay, UN, S **13.77 - m**: JT, 0°, Fe, ST, RF **13.85 - m**: JT, 20°, Fe, PR, RF **13.93 - m**: VN, 5°, Qz, PR, RF **13.97 - m**: JT, 20°, Fe, PR, S		
	14	HQ3	**100**(18)			C2					14.30 Moderately weathered, brown, medium SANDSTONE; very weak [TORLESSE SUPERGROUP greywacke].	**14.1 - m**: VN, 10°, Qz, PR, RF **14.16 - m**: VN, 10°, Qz, PR, RF **14.2 - m**: JT, 80°, Fe, UN, S **14.6 - m**: JT, 40°, Fe, UN, RF		
	15										15.00 Hole Terminated at 15.00 m			

Driller:	Griffiths Drilling Ltd	**Easting:**	1769006.5	**Elevation:**	57.00	**Started:**	16/01/2019
Plant:	Track	**Northing:**	5442059.5	**Datum:**	MSL	**Finished:**	17/01/2019
Logged by:	LA	**Grid:**	NZTM2000	**Inclination:**	90	**Standard:**	NZS 4402:1986
Checked by:	LW	**Accuracy:**	MAP1	**Orientation:**		**Status:**	Final

Remarks:

Water Level
2.85m - 17/01/2019 am, dipped approximately 12 hours after drilling.
Sample
C2 - Core sample
D2 - SPT sample
Hole location determined by MAP1.

BH05, Box 1, 1.5 to 5.6 m

BH05, Box 2, 5.6 m to 9.57 m

Pinehaven Stream improvements	
Wellington Water Limited	
Geotechnical Investigation	BH05
16/01/2019	

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BH05, Box 3, 9.57 m to 12.4 m

BH05, Box 4, 12.4 m to 15.0 m

Pinehaven Stream improvements	
Wellington Water Limited	
Geotechnical Investigation	BH05
16/01/2019	

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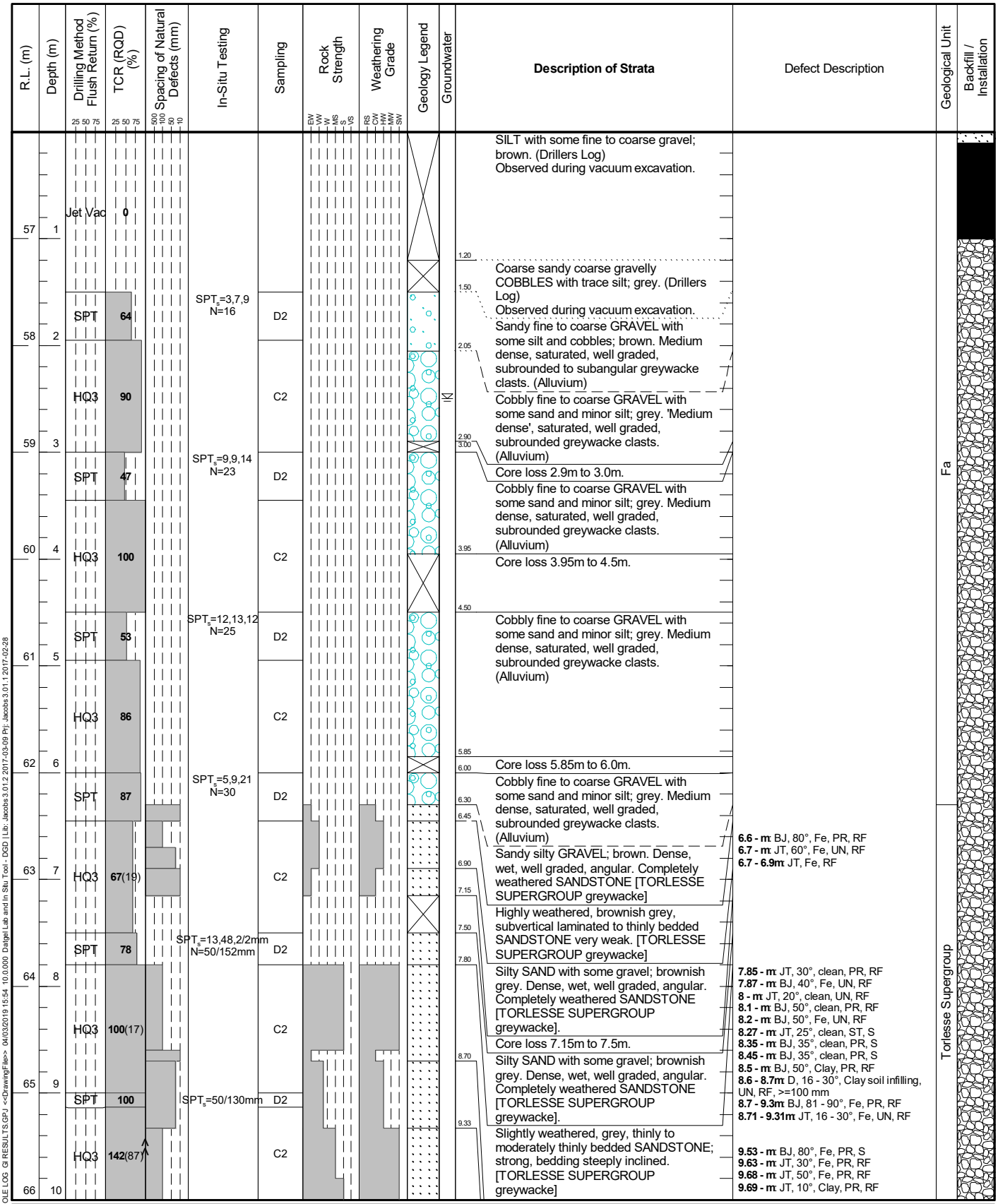
Borehole log

Project:	Pinehaven Stream Improvements	**Hole ID:**	BH06
Client:	Wellington Water	**Project No:**	IZ08900
Location:	Pinehaven, Upper Hutt	**Page:**	1 of 2



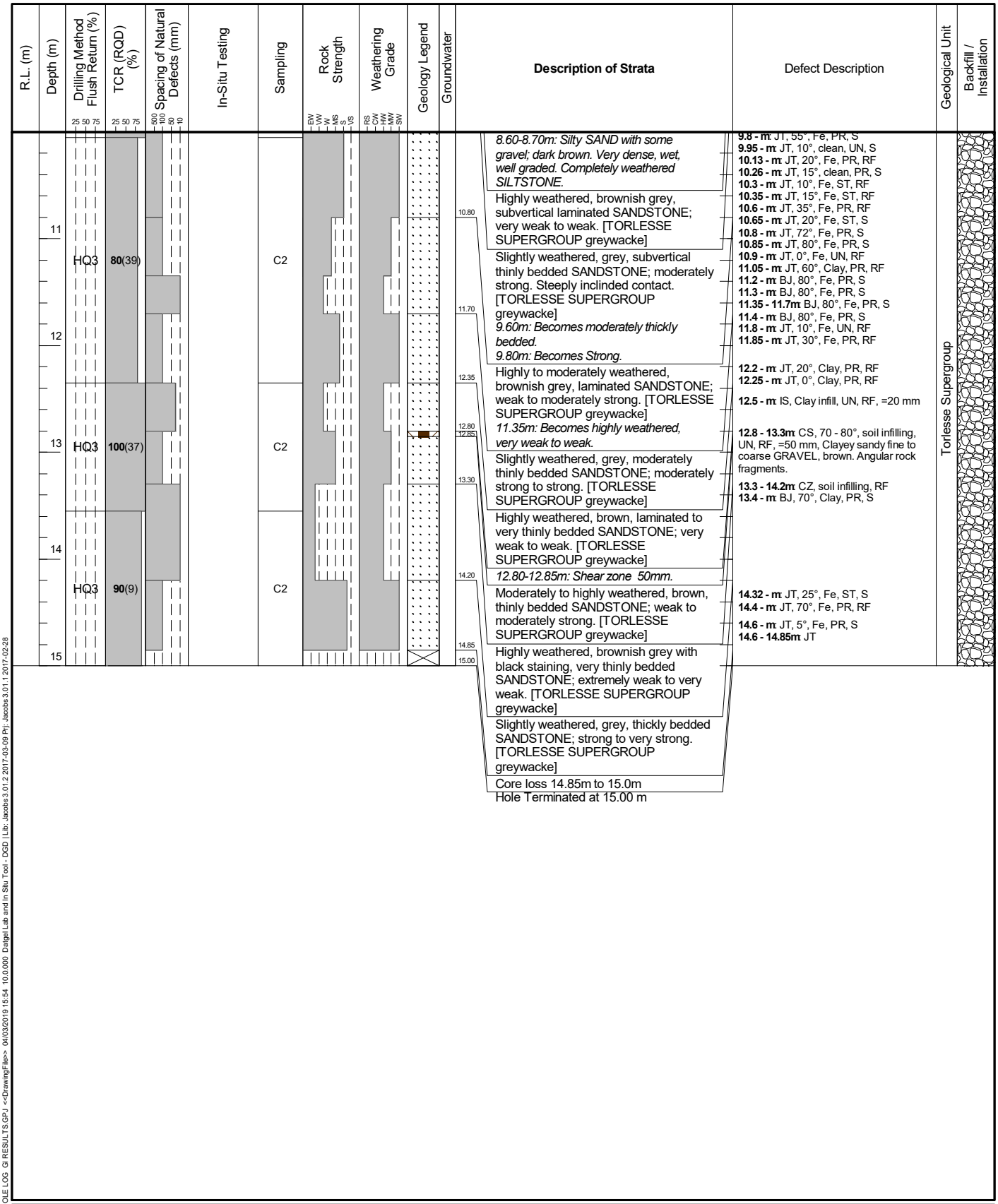
Driller:	Griffiths Drilling Ltd	**Easting:**	1769003.5	**Elevation:**	56.00	**Started:**	17/01/2019
Plant:	Track	**Northing:**	5442079.2	**Datum:**	MSL	**Finished:**	19/01/2019
Logged by:	LA	**Grid:**	NZTM2000	**Inclination:**	90	**Standard:**	NZS 4402:1986
Checked by:	LW	**Accuracy:**	MAP1	**Orientation:**		**Status:**	Final

Remarks:

Water Level
2.50m - 19/01/2019 am, dipped approximately 12 hours after drilling.
Sample
C2 - Core sample
D2 - SPT sample
Hole location determined by MAP1.

Borehole log

Project:	Pinehaven Stream Improvements	**Hole ID:**	BH06
Client:	Wellington Water	**Project No:**	IZ08900
Location:	Pinehaven, Upper Hutt	**Page:**	2 of 2



Driller:	Griffiths Drilling Ltd	**Easting:**	1769003.5	**Elevation:**	56.00	**Started:**	17/01/2019
Plant:	Track	**Northing:**	5442079.2	**Datum:**	MSL	**Finished:**	19/01/2019
Logged by:	LA	**Grid:**	NZTM2000	**Inclination:**	90	**Standard:**	NZS 4402:1986
Checked by:	LW	**Accuracy:**	MAP1	**Orientation:**		**Status:**	Final

Remarks:

Water Level
2.50m - 19/01/2019 am, dipped approximately 12 hours after drilling.
Sample
C2 - Core sample
D2 - SPT sample
Hole location determined by MAP1.

BH06, Box 1, 1.5 to 6.0 m

BH06, Box 2, 6.0 m to 9.63 m

Pinehaven Stream improvements	
Wellington Water Limited	
Geotechnical Investigation	BH06
17/01/2019	

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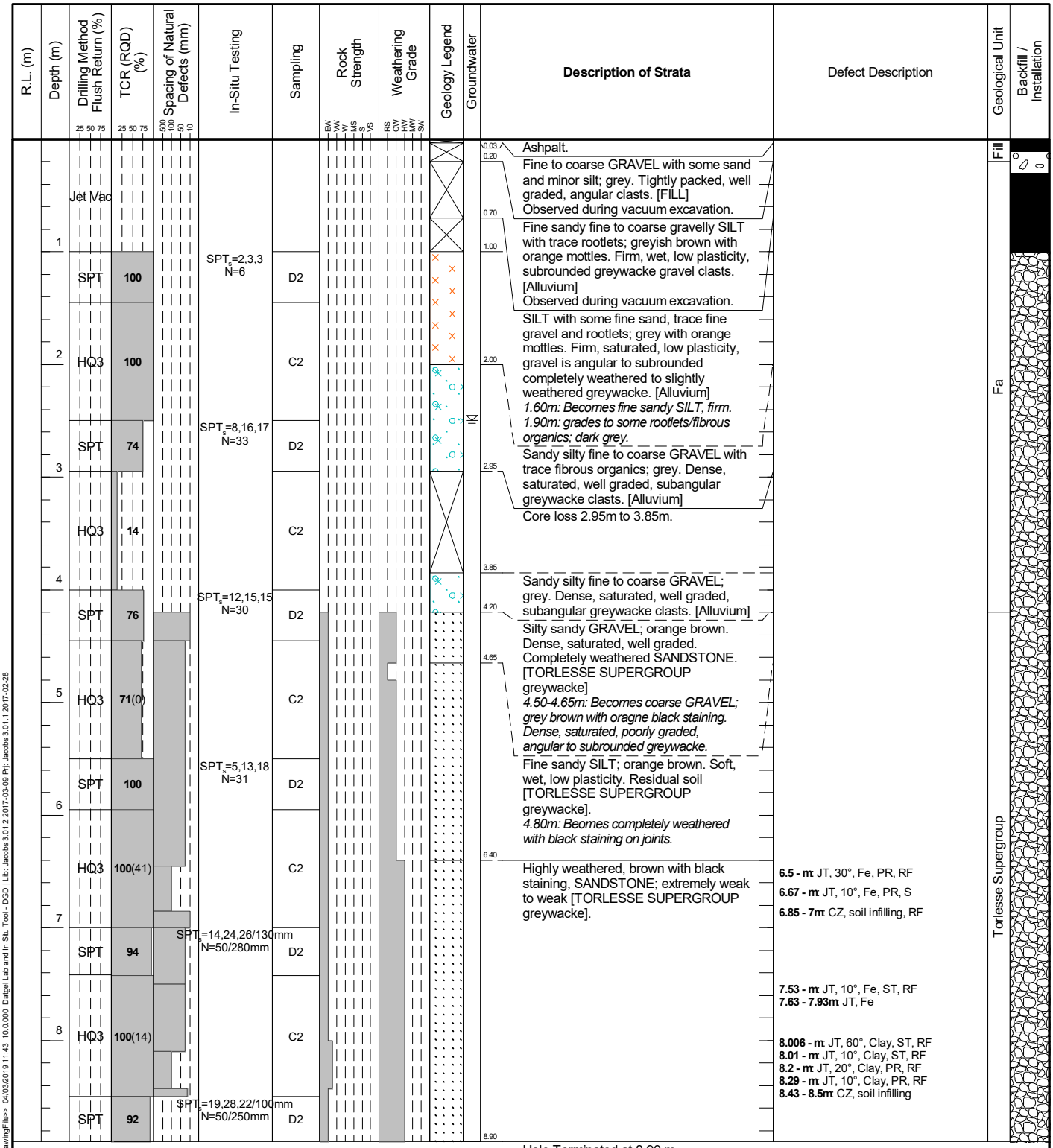
BH06, Box 3, 9.63 m to 12.65 m

BH06 Box 4, 12.65 m to 15.0 m

Borehole log

Project:	Pinehaven Stream Improvements	**Hole ID:**	BH07
Client:	Wellington Water	**Project No:**	IZ08900
Location:	Pinehaven, Upper Hutt	**Page:**	1 of 1



Driller:	Griffiths Drilling Ltd	**Easting:**	1769044.1	**Elevation:**	60.00	**Started:**	14/01/2019
Plant:	Track	**Northing:**	5441810.4	**Datum:**	MSL	**Finished:**	15/01/2019
Logged by:	LA	**Grid:**	NZTM2000	**Inclination:**	90	**Standard:**	NZS 4402:1986
Checked by:	LW	**Accuracy:**	MAP1	**Orientation:**		**Status:**	Final

Remarks:

Water Level
2.50m - 15/01/2019 am, dipped approximately 12 hours after drilling.
Sample
C2 - Core sample
D2 - SPT sample
Hole location determined by MAP1.

BH07, Box 1, 1.0 to 5.95 m

BH07, Box 2, 5.95 m to 8.9 m

Pinehaven Stream improvements	
Wellington Water Limited	
Geotechnical Investigation	BH07
14/01/2019	

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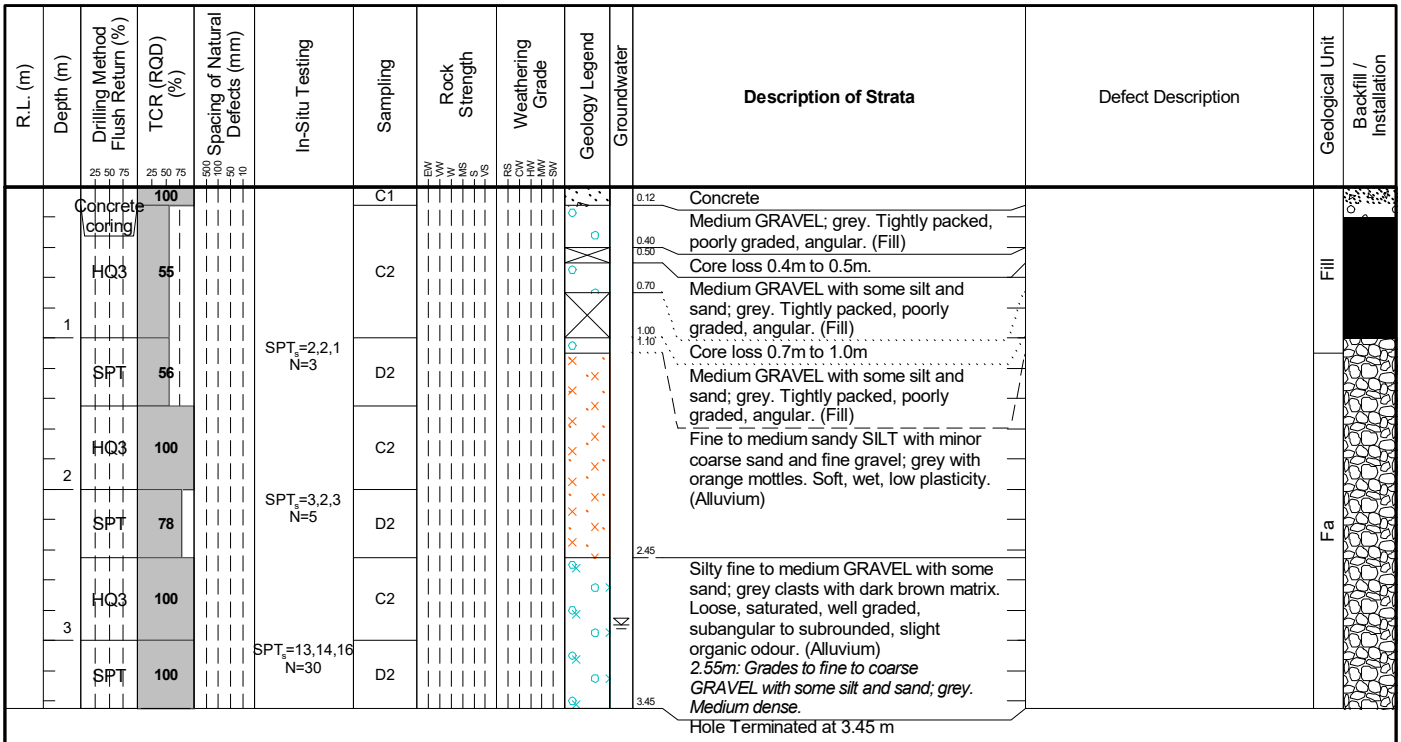
Borehole log

Project:	Pinehaven Stream Improvements	**Hole ID:**	BH08
Client:	Wellington Water	**Project No:**	IZ08900
Location:	Pinehaven, Upper Hutt	**Page:**	1 of 1



Driller:	Griffiths Drilling Ltd	**Easting:**	1769050.6	**Elevation:**	51.00	**Started:**	15/01/2019
Plant:	Track	**Northing:**	5442484.0	**Datum:**	MSL	**Finished:**	15/01/2019
Logged by:	LA	**Grid:**	NZTM2000	**Inclination:**	90	**Standard:**	NZS 4402:1986
Checked by:	LW	**Accuracy:**	MAP1	**Orientation:**		**Status:**	Final

Remarks:

Water Level
2.90m - 15/01/2019 am, dipped approximately 12 hours after drilling.
Sample
C2 - Core sample
D2 - SPT sample
Hole location determined by MAP1.

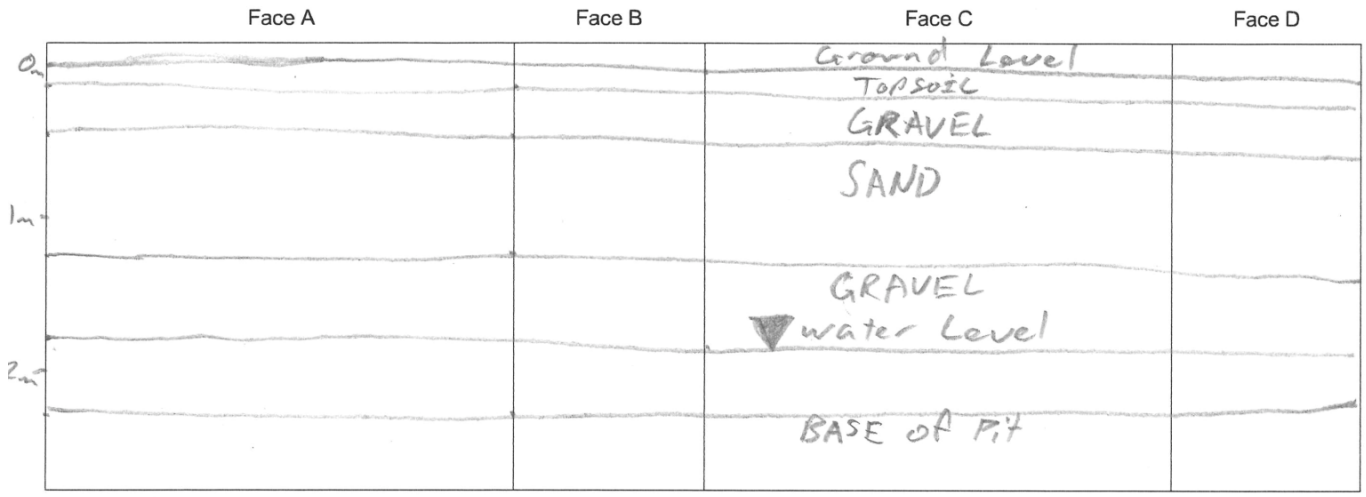
BH08, Box 1, 0.0 to 3.45 m

Appendix C. Test Pit Logs and Photos

Inspection Pit

Project:	Pinehaven Stream Improvements	**Hole ID:**	TP01
Client:	Wellington Water	**Project No:**	IZ08900
Location:	Pinehaven, Upper Hutt	**Page:**	1 of 1

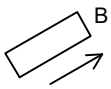
Face Sketch (including stratum boundaries and face(s) sketched).



R.L. (m)	Depth (m)	In-Situ Testing	Sampling	DCP (Blows per 100 mm Penetration) 5 10 15 20	Geology Legend	Groundwater	Description of Strata	Geological Unit
							0.15 Silty fine SAND with some gravel, rootlets and bark; blackish brown. Loose, moist, moderately graded, angular clasts. (Topsoil)	
							0.45 Sandy fine to coarse GRAVEL with some silt and minor cobbles; brown. Medium dense, dry, well graded, subangular to subrounded greywacke clasts. (Alluvium)	
53	1						Silty fine SAND; light brown and grey with orange mottles. Medium Dense, dry, poorly graded. (Alluvium) *0.55m: @0.55m becomes moist.* *0.70m: @0.70m becomes wet.*	
							1.25 Coarse sandy fine to coarse GRAVEL with some cobbles, rootlets and minor silt; grey. Dense to very dense, wet, well graded, subrounded to subangular greywacke slightly weathered to fresh. (Alluvium) *1.50m: @1.50m layer of red weathering 0.01m thick.* *1.60m: @1.6m becomes saturated.*	Fa
52	2					▽	*1.80m: @1.80m water seeping into hole.*	
							2.30 Hole Terminated at 2.30 m Machine Limit	

Contractor:	Griffiths Drilling Ltd	**Easting:**	5442528.0	**Elevation:**	54.00	**Started:**	22/01/2018
Plant:	1.7t Excavator	**Northing:**	1769044.0	**Datum:**	MSL	**Finished:**	22/01/2018
Logged by:	LA	**Grid:**	NZTM2000	**Stability:**	Flooding	**Standard:**	NZS
Checked by:	LW	**Accuracy:**	MAP1	**Shoring:**	None	**Status:**	Final

Length: 2
Width: 0.5
Orientation: 60° (As arrow)



Excavation Remarks:

Geological Unit
Fa - Alluvium
Water flooding hole @ 1.8m
Hole location determined by MAP1.

TP01 Location

TP01 Face A

Title	TP01 Site Photo	Project	Pinehaven Stream Improvement	Client	Wellington Water
Scale	Not to scale	Rev	Revision 0		

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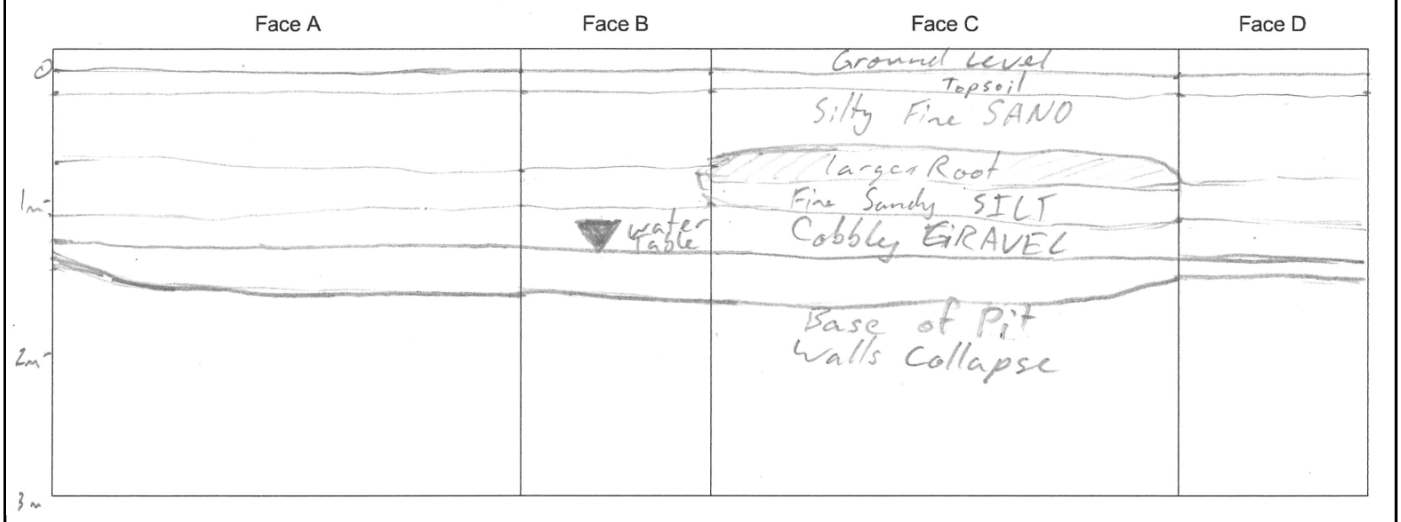
Inspection Pit

Project:	Pinehaven Stream Improvements	**Hole ID:**	TP03
Client:	Wellington Water	**Project No:**	IZ08900
Location:	Pinehaven, Upper Hutt	**Page:**	1 of 1

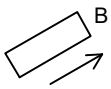
Face Sketch (including stratum boundaries and face(s) sketched).



R.L. (m)	Depth (m)	In-Situ Testing	Sampling	DCP (Blows per 100 mm Penetration)	Geology Legend	Groundwater	Description of Strata	Geological Unit
				5 10 15 20				
						0.15	Silty fine SAND with some rootlets; light brown. Medium dense, dry, poorly graded. (Topsoil)	
							Silty fine SAND with minor rootlets; light brown. Medium dense, dry, poorly graded. (Alluvium)	
							0.50m: @0.50m becomes moist.	
						0.60	Fine sandy SILT with trace rootlets; grey with orange mottles. Firm, wet, non plastic. (Alluvium)	Fa
54	1					1.05		
						1.40	Cobbly fine to coarse GRAVEL with some silt, sand, trace boulders and minor rootlets and woody organics; grey. Dense, saturated, well graded, well graded subrounded to subangular greywacke. (Alluvium)	
							1.20m: @1.20m water seeping into test pit.	
							1.40m: @1.40m Hole terminated due to collapse on all walls.	
							1.41m: @1.40 becomes very dense.	
							Hole Terminated at 1.50 m	
							Collapse	

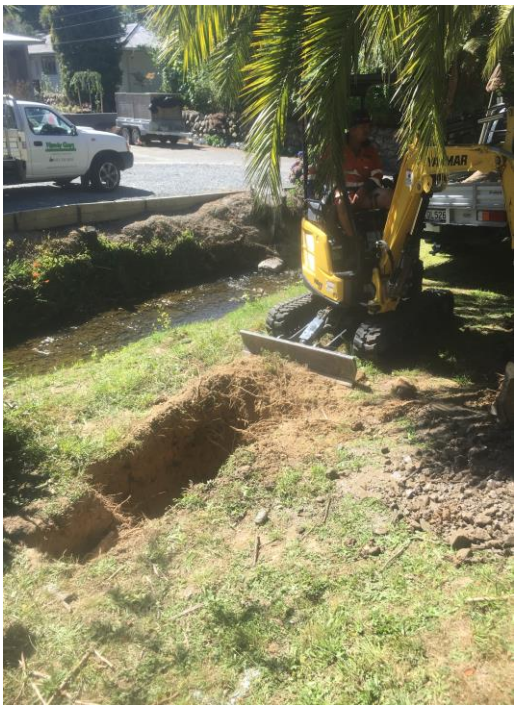
Contractor:	Griffiths Drilling Ltd	**Easting:**	5442123.0	**Elevation:**	55.00	**Started:**	22/01/2018
Plant:	1.7t Excavator	**Northing:**	1769023.0	**Datum:**	MSL	**Finished:**	22/01/2018
Logged by:	LA	**Grid:**	NZTM2000	**Stability:**	Unstable	**Standard:**	NZS
Checked by:	LW	**Accuracy:**	MAP1	**Shoring:**	None	**Status:**	Final

Length: 2
Width: 0.5
Orientation: 20° (As arrow)



Excavation Remarks:

Geological Unit
Fa - Alluvium
Hole collapse @ 1.4m
Hole location determined by MAP1.



TP03 Location

TP03 Face A

Title	TP03 Site Photo	Project	Pinehaven Stream Improvement	Client	Wellington Water
Scale	Not to scale	Rev	Revision 0		

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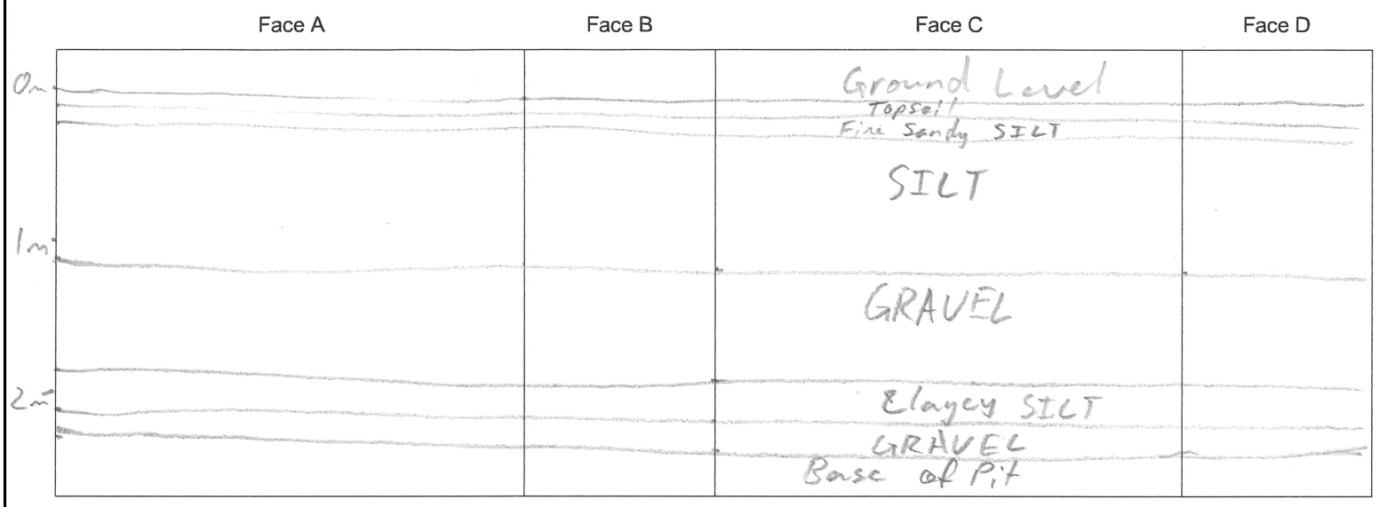
Inspection Pit

Project:	Pinehaven Stream Improvements	**Hole ID:**	TP05
Client:	Wellington Water	**Project No:**	IZ08900
Location:	Pinehaven, Upper Hutt	**Page:**	1 of 1

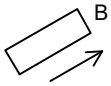
Face Sketch (including stratum boundaries and face(s) sketched).



R.L. (m)	Depth (m)	In-Situ Testing	Sampling	DCP (Blows per 100 mm Penetration) 5 10 15 20	Geology Legend	Groundwater	Description of Strata	Geological Unit
						0.10	Fine sandy SILT with minor rootlets; brown. Firm, dry, low plasticity. (Topsoil)	
						0.20	Fine sandy SILT with some fine to coarse gravel and trace rootlets; light brown. Firm, dry, non plastic. (Alluvium)	
							SILT with some clay and fine sand; grey with orange and brown mottles. Firm, dry, moderate plasticity. (Alluvium)	
							0.75m: @0.75m becomes moist.	
59	1					1.10		
							Fine to coarse GRAVEL with some clay, silt, sand and cobbles; grey. Dense, wet, well graded, angular to subrounded, slightly weathered greywacke with some highly weathered clasts. (Alluvium)	Fa
							1.55m: @1.55 becomes saturated.	
							1.75m: @1.75 becomes clayey.	
						1.85		
58	2					2.10	Clayey SILT with some fibrous/woody organics and minor fine sand; dark brown. Soft, wet, moderately to high plasticity, slight organic odour. (Swamp Deposits)	
						2.30	Fine to coarse GRAVEL with some clay, silt, sand and minor cobbles; blue grey. Very dense, saturated, well graded, subrounded to subangular, slightly weathered greywacke. (Alluvium)	
							Hole Terminated at 2.30 m Machine Limit	

Contractor:	Griffiths Drilling Ltd	**Easting:**	5441745.0	**Elevation:**	60.00	**Started:**	22/01/2018
Plant:	1.7t Excavator	**Northing:**	1769016.0	**Datum:**	MSL	**Finished:**	22/01/2018
Logged by:	LA	**Grid:**	NZTM2000	**Stability:**	Stable	**Standard:**	NZS
Checked by:	LW	**Accuracy:**	MAP1	**Shoring:**	None	**Status:**	Final

Length: 2
Width: 0.5
Orientation: 75° (As arrow)



Excavation Remarks:
Water Not Encountered

Geological Unit
Fa - Alluvium
Hole location determined by MAP1.

TP05 Location

TP05 Face A

Title	TP05	Project	Pinehaven Stream Improvement	Client	Wellington Water
Scale	Not to scale	Rev	Revision 0		

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Appendix D. Hand Auger Logs

Note: Hand auger photos not taken.

Job Number IZ08900
HAND AUGER LOG
HA10

PROJECT	: Pinehaven Stream Improvements	GROUND LEVEL (RL)	: 60.00 m MSL	SHEET	: 1 OF 1
SITE	: Pinehaven, Upper Hutt	EASTING	: 5441975.0 m	SCALE	: 1:25
START DATE	: 23/01/2019	NORTHING	: 1769039.0 m	DEPTH	: 2.50 m
END DATE	: 23/01/2019	COORD. SYS.	: NZTM2000		

DEPTH (m)	WATER LEVELS	GRAPHIC LOG	MOISTURE	USCS	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	DCP TEST (NZS 4402:1986 Test 6.5.2) Blows per 100 mm	SHEAR VANE TEST τ (kPa)	SHEAR VANE TEST τ_r (kPa)	SAMPLES	RL(m MSL)
0					SILT with some fine sand and trace rootlets; brown. Soft, wet, non plastic. (Topsoil)						60.0
					Clayey SILT with minor fine sand and trace organics; grey with orange mottles. Soft, wet, high plasticity. (Alluvium)						
0.5					SILT with some clay, fine sand and minor trace organics; grey with brown mottles. Firm, wet, low to moderate plasticity. (Alluvium)						60.5
			W								
1.0					@1.20m becomes orange brown.	FA					61.0
					Clayey SILT with minor fine sand; pale grey. Soft, wet, moderate to high plasticity. (Alluvium)						
1.5					@1.60m hand auger terminated refusal.						61.5
2.0											62.0
2.5					Scala Penetrometer Hole Terminated at 2.50 m Water Not Encountered Geological Unit Fa - Alluvium		33				62.5
3.0											63.0
3.5											63.5
4.0											64.0
4.5											64.5

LOGGED BY: LA CHECKED BY: LW CHECKED DATE: 04/03/2019

Job Number IZ08900
HAND AUGER LOG
HA11

PROJECT	: Pinehaven Stream Improvements	GROUND LEVEL (RL)	: 58.00 m MSL	SHEET	: 1 OF 1
SITE	: Pinehaven, Upper Hutt	EASTING	: 5442007.0 m	SCALE	: 1:25
START DATE	: 23/01/2019	NORTHING	: 1769017.0 m	DEPTH	: 1.40 m
END DATE	: 23/01/2019	COORD. SYS.	: NZTM2000		

DEPTH (m)	WATER LEVELS	GRAPHIC LOG	MOISTURE	USCS	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	DCP TEST (NZS 4402:1986 Test 6.5.2) Blows per 100 mm	SHEAR VANE TEST τ (kPa)	SHEAR VANE TEST τ_r (kPa)	SAMPLES	RL(m MSL)
0			M		Silt with some fine to coarse sand and minor rootlets; dark brown. Soft, moist, non plastic. (Topsoil)	FA	0 5 10 15 20 25				58.0
					Clayey SILT with some fine sand; light brown with orange mottles. Soft, wet, high plasticity. (Alluvium)						
0.5			W		Fine sandy SILT with minor fine gravel and clay; greyish brown with orange and black mottling. Soft, wet, low plasticity. (Alluvium)						58.5
					@0.70m light grey with orange brown mottling.						
1.0					Sandy fine gravelly SILT; pale grey. Firm, wet, non plastic, auger crunching. (Alluvium)						59.0
					@.1.20m hand auger terminated refusal.						
1.5					Scala Penetrometer Hole Terminated at 1.40 m Water Not Encountered @1.20m likely coarser grained than recovered by the hand auger. Geological Unit Fa - Alluvium						59.5
2.0											60.0
2.5											60.5
3.0											61.0
3.5											61.5
4.0											62.0
4.5											62.5

LOGGED BY: LA CHECKED BY: LW CHECKED DATE: 04/03/2019

Job Number IZ08900
HAND AUGER LOG
HA12

PROJECT	: Pinehaven Stream Improvements	GROUND LEVEL (RL)	: 54.00 m MSL	SHEET	: 1 OF 1
SITE	: Pinehaven, Upper Hutt	EASTING	: 5442243.0 m	SCALE	: 1:25
START DATE	: 23/01/2019	NORTHING	: 1769021.0 m	DEPTH	: 1.60 m
END DATE	: 23/01/2019	COORD. SYS.	: NZTM2000		

DEPTH (m)	WATER LEVELS	GRAPHIC LOG	MOISTURE	USCS	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	DCP TEST (NZS 4402:1986 Test 6.5.2) Blows per 100 mm	SHEAR VANE TEST τ (kPa)	SHEAR VANE TEST τ_r (kPa)	SAMPLES	RL(m MSL)
0					Fine sandy SILT with some rootlets; brown. Soft, wet, non plastic. (Topsoil)						54.0
					Fine sandy SILT; light brown grey with orange mottles. Soft, wet, non plastic. (Alluvium)						
0.5			W								54.5
					Fine to coarse SAND with minor fine gravel; grey with orange mottles. Medium dense, wet, moderately graded. (Alluvium)	FA					
1.0					Silty fine gravelly fine to coarse SAND; blue grey. Loose to medium dense, wet, well graded, angular to subrounded greywacke clasts. (Alluvium)						55.0
					Coarse sandy SILT with some fine to medium gravel; brown. Firm, wet, non plastic. (Alluvium)						
			S		Silty sandy fine to medium GRAVEL; brownish grey. Dense to very dense, saturated, well graded, subangular to subrounded greywacke clasts. (Alluvium)						
1.5											55.5
					@1.35 hand auger terminated refusal. Scala Penetrometer Hole Terminated at 1.60 m Water Not Encountered Geological Unit Fa - Alluvium						
2.0											56.0
2.5											56.5
3.0											57.0
3.5											57.5
4.0											58.0
4.5											58.5

LOGGED BY: LA CHECKED BY: LW CHECKED DATE: 04/03/2019

Job Number IZ08900
HAND AUGER LOG
HA13

PROJECT	: Pinehaven Stream Improvements	GROUND LEVEL (RL)	: 60.00 m MSL	SHEET	: 1 OF 1
SITE	: Pinehaven, Upper Hutt	EASTING	: 5441822.0 m	SCALE	: 1:25
START DATE	: 29/01/2019	NORTHING	: 1769041.0 m	DEPTH	: 1.60 m
END DATE	: 29/01/2019	COORD. SYS.	: NZTM2000		

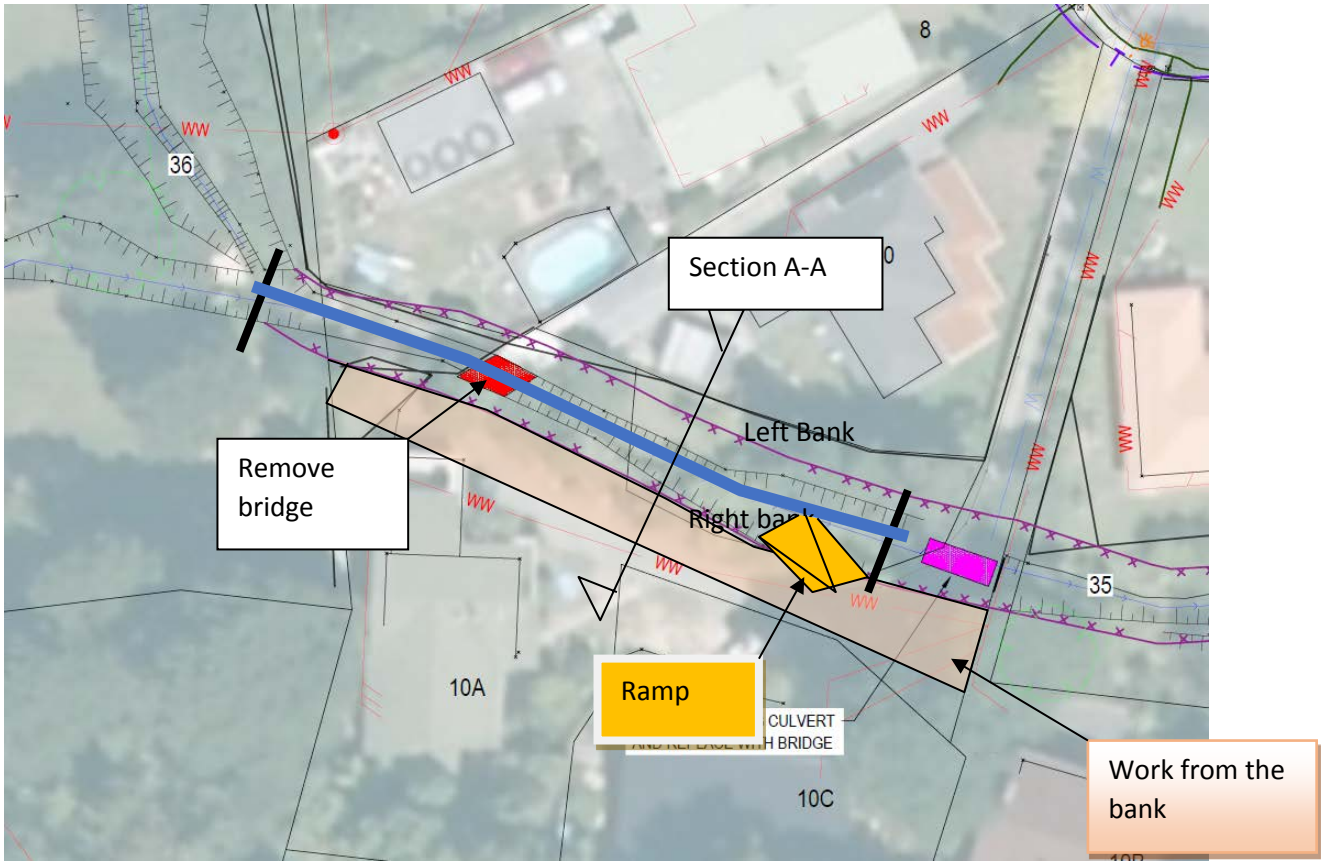
DEPTH (m)	WATER LEVELS	GRAPHIC LOG	MOISTURE	USCS	SOIL / ROCK DESCRIPTION	GEOLOGICAL UNIT	DCP TEST (NZS 4402:1986 Test 6.5.2) Blows per 100 mm	SHEAR VANE TEST τ (kPa)	SHEAR VANE TEST τ_r (kPa)	SAMPLES	RL(m MSL)
0			D		Silty fine SAND with some medium gravel; light brown. Medium dense, dry, poorly graded, angular gravel. (Topsoil)						60.0
					SILT with some clay and fine sand; grey brown with orange mottles. Soft, moist, moderate plasticity. (Alluvium)						
					@0.40m trace rounded medium gravel.						
0.5			M		@0.5m minor clay, low plasticity.						60.5
1.0					@1.15m crunching noises.	FA					61.0
			W		Fine sandy SILT with some fine gravel; grey. Firm, wet, non plastic, angular clasts. (Alluvium)						
1.5	29/01/19		S		Silty sandy fine GRAVEL; grey. Dense to very dense, saturated, well graded, subangular greywacke clasts. (Alluvium)						61.5
					Hole Terminated at 1.60 m Refusal						
					Geological Unit Fa - Alluvium						
2.0											62.0
2.5											62.5
3.0											63.0
3.5											63.5
4.0											64.0
4.5											64.5

LOGGED BY: LA CHECKED BY: LW CHECKED DATE: 04/03/2019

Appendix D. Downers Outline Construction Methodology

Assuming pipe will be approx 450-650mm dia Civil Boss or similar

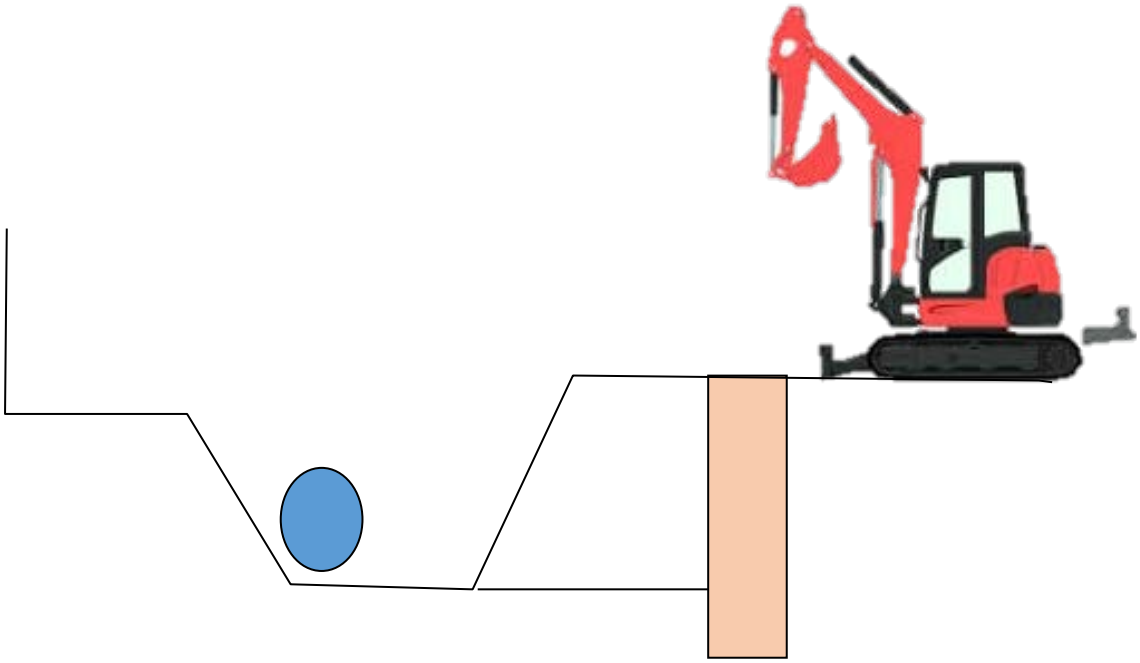
Section 1 10A -10C Birch



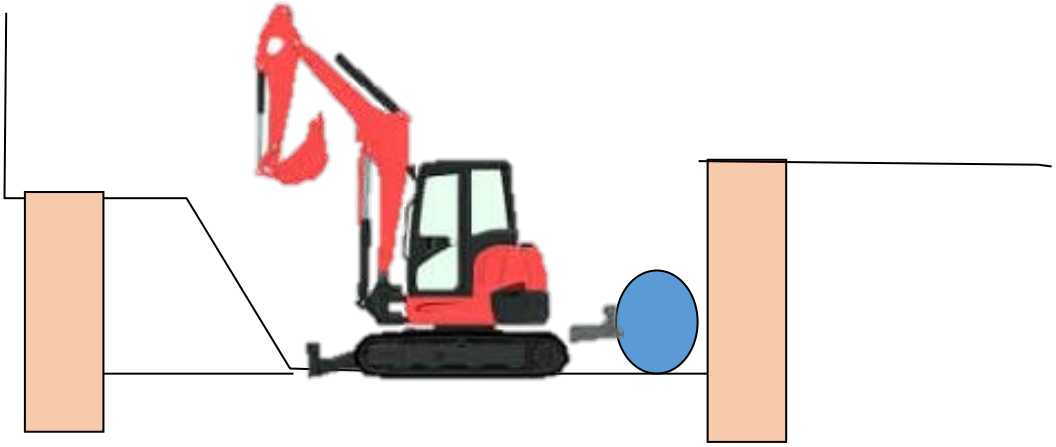
Sequence of section 1

1. Remove Bridge and install ramp into stream
2. Install pipe and Dam, working from in the stream, the sediment will most probalbly be greater than 150g/m3 but for short term (activity duration only)
3. Install Sump pump near down steam dam and treat water through sediment curtain

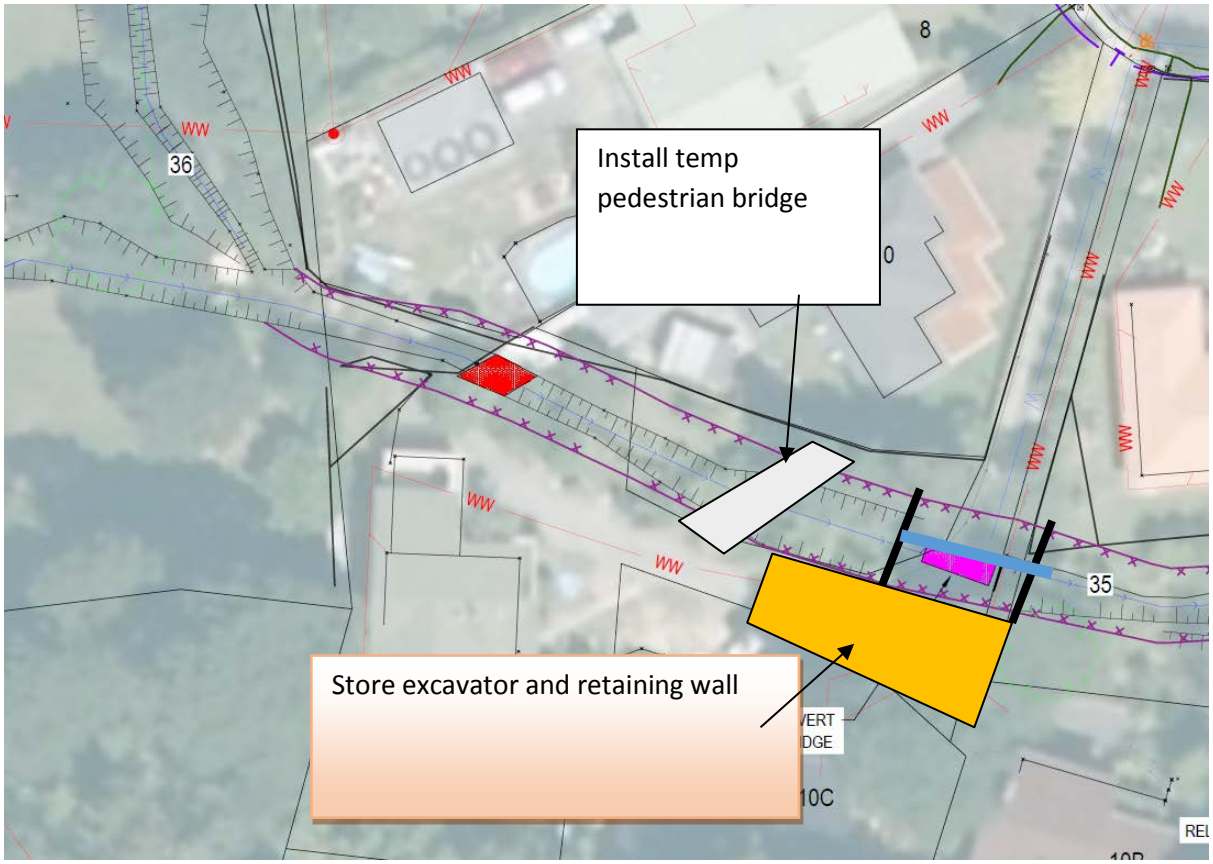
What size pipe is required? What flow will the pipe allow? What happens in a weather event and dams are still in place? Is this a option for all year round?



4. Excavate right bank and install retaining wall from the bank (not enough room in the dry stream)

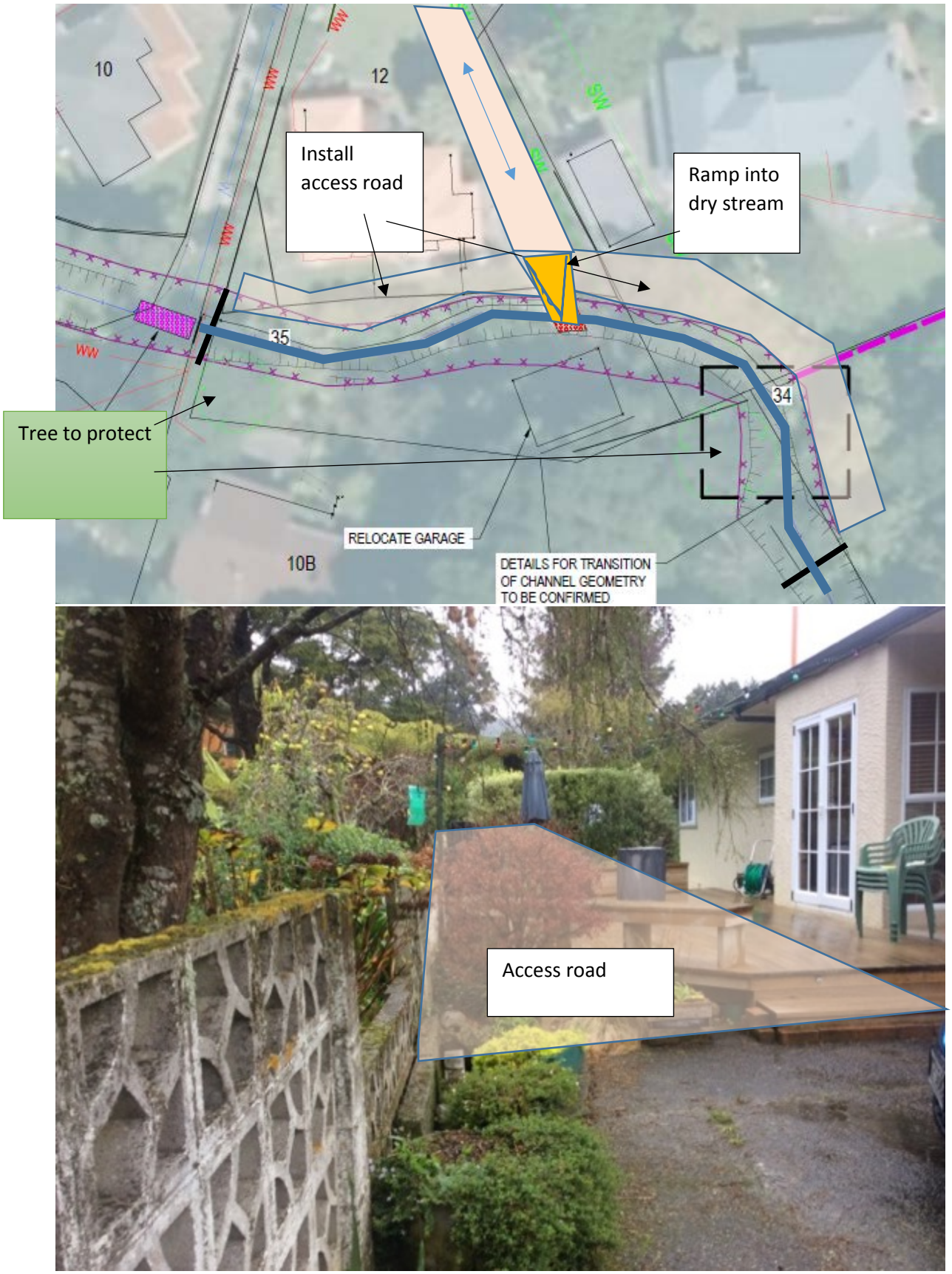


1. Relocate pipe to the right side, by working in the stream, the sediment will most probalbly be greater than 150g/m3 but for short term (activity duration only)
2. Install ramp over pipe (Size dependent)
3. Excavate left bank from dry stream bed and install wall
4. Remove Ramp
5. Complete wall on Right side



6. Store machine and materials on residence side
7. Install dam down stream of existing bridge and over pump while bridge is being demolished
8. Install Pipe so that the pump is not working 24hrs (stakeholdes)
9. Construct retainig walls from both sides of the stream
10. Install new bridge
11. Remove stock pile of materials and machinery

Section 2 – Major stakehooder interaction!!!! 12,11 Birch to 2A Freeman



What is the dam made from? Can this section be constructed at the same time and section 1?

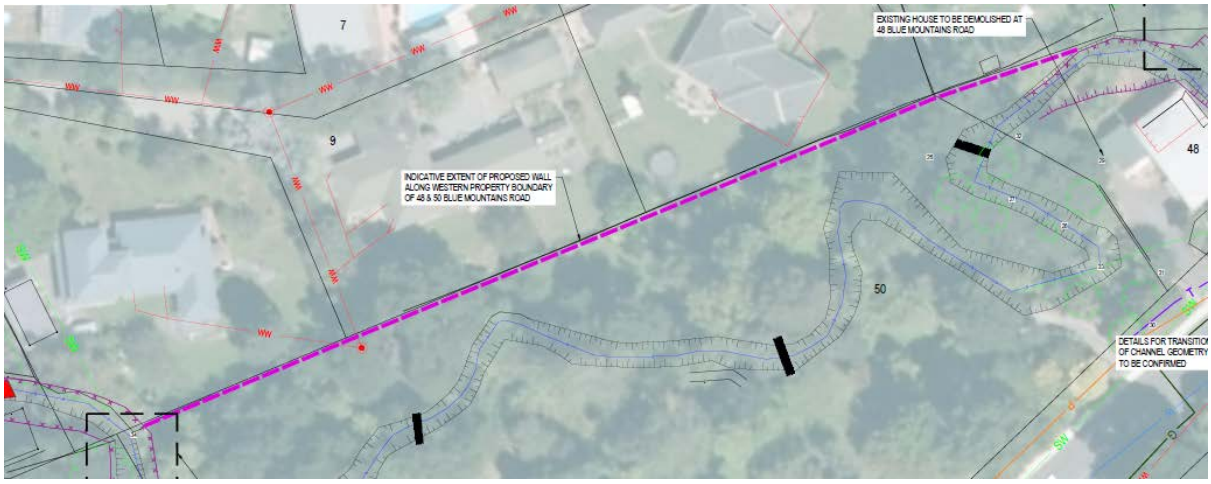
Major stakeholder interaction!!! Need to discuss more!!!

1. Install access road by removing decking and back garden from 12 &11 Birch
2. Remove garage/shed/office
3. Remove bridge
4. Install dam and pipe (pipe on right side of stream) , the sediment will most probalbly be greater than 150g/m3 but for short term (activity duration only)
5. Install ramp into dry stream
6. Excavate and install Left retaining wall up to access ramp
7. Relocate pipe to Left side, install ramp over pipe

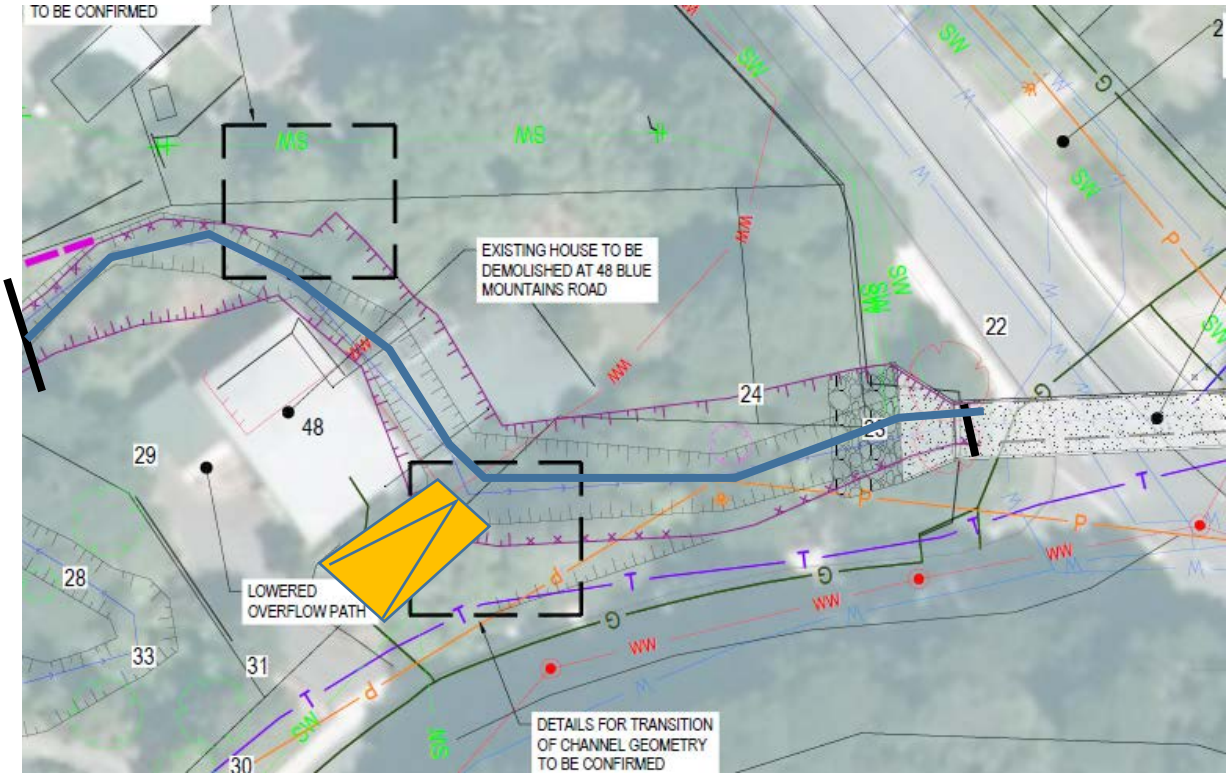
8. Excavate and install right side from the dry stream all the way to 2A freeman property
9. Move pipe to the right side
10. Complete left side from the ramp to 2A freeman and remove the ramp (working from the bank/Garden)
11. Remove pipe and dam, the sediment will most probalbly be greater than 150g/m3 but for short term (activity duration only)
12. Install new pedestrian bridge
13. Install new office/ shed
14. Reinstate gardens

Section 3

50 Blue mountain retaining wall – off line to stream

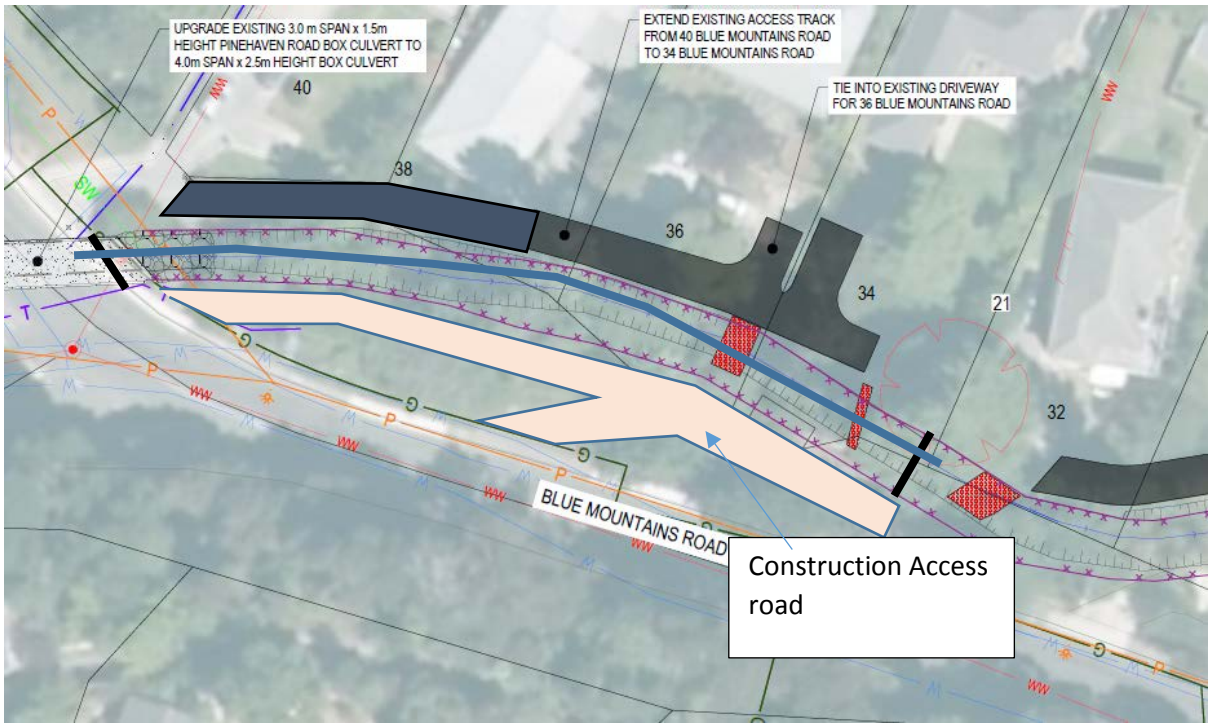


Section 4 **48 Blue Mountain**



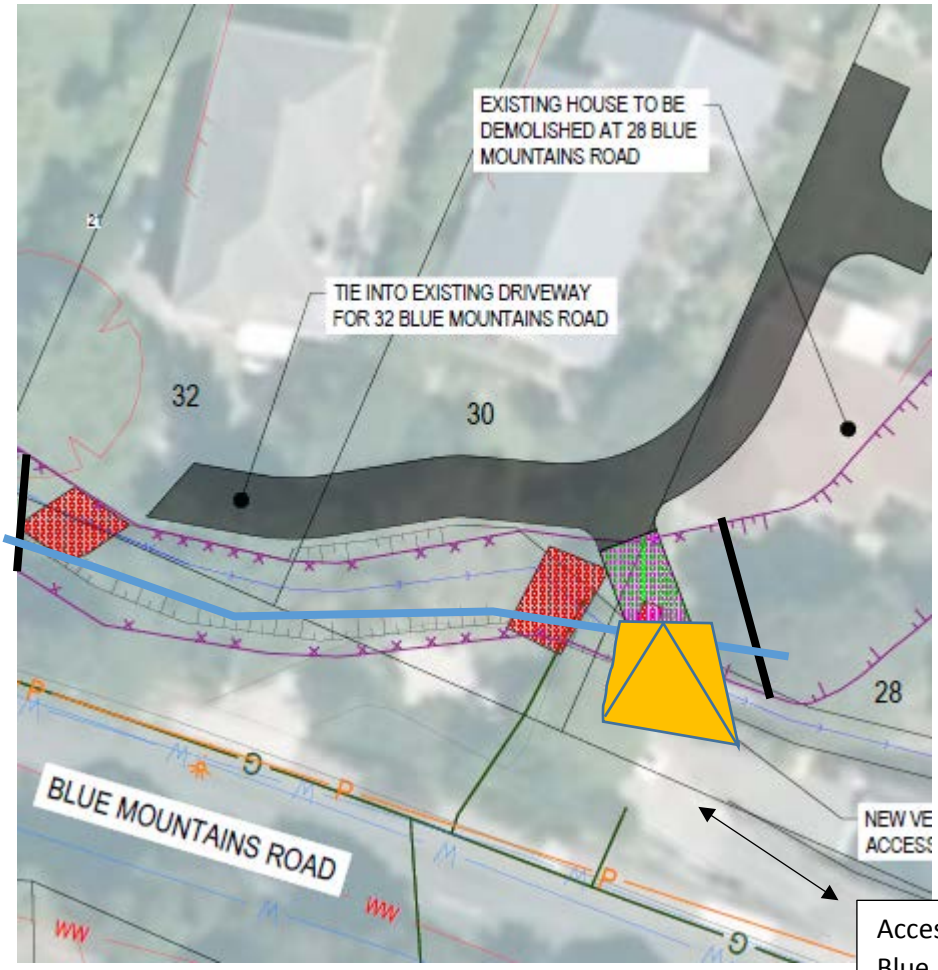
1. Install ramp into stream
2. Install dam and pipe on Left side, Excavator to enter stream to install dam, bank Hight approx 2.5m-3m, most probalbly the sedimnet will be greater than 150g/m3 but for short term (activity duration only)
3. Remove House
4. Working from the dry stream bed excavate and install new retaining wall and batter
5. Relocate pipe to Right side and install ramp over pipe
6. Construct left side wall /Bank

Section 5 40 -34 Blue Mountain



1. Install private road access
2. Install construction access road along right bank
3. Install Dam and pipe, the sediment will most probalbly be greater than 150g/m3 but for short term (activity duration only)
4. Remove bridges
5. Excavate and install Right retaining wall
6. Move pipe to the right side
7. Excavate and install Left retaining wall from Private access lane (no vehicle access for the residence, only pedestrian)

Section 6 32 -28 Blue Mountain

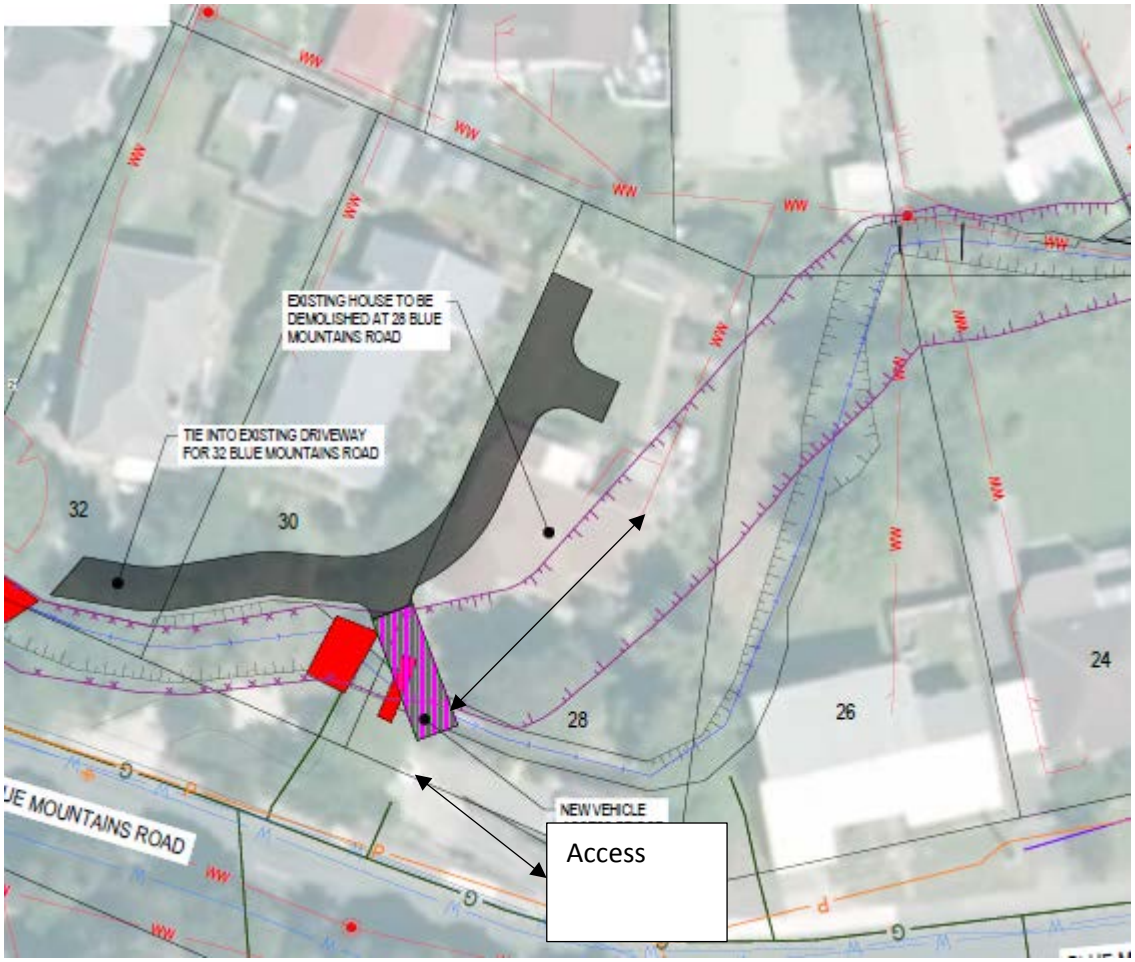


Access from 28 Blue Mountain

1. Install Temp bridge at 28 Blue mountain and install new private lane
2. Install dam and pipe on Left side into new diverted stream location (section 7 already constructed off line) the sediment will most probalbly be greater than 150g/m3 but for short term (activity duration only) Is there enogh room for pipe and excavator? Take site measurement

3. Remove stakeholders bridges
4. Install temp pedestrian bridge or can they gain pedestrian access from 34 Blue mountain?
5. Install access ramp over pipe
6. Construct Right Retaining wall
7. Move pipe to the Right side and construct the Left
8. Remove pipe and dam

Section 7 **28 Blue Mountain**



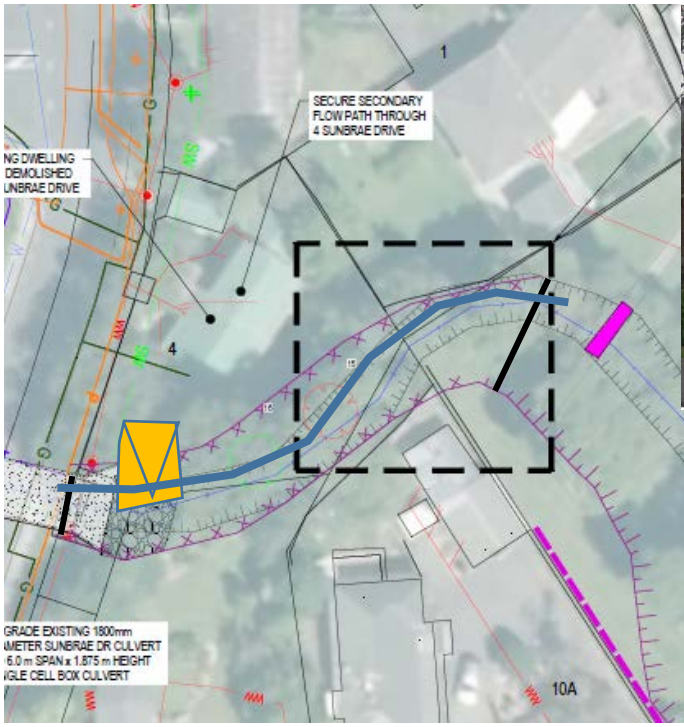
Constructed off line to the stream

Connection and diverting the stream will elevate the sediment levels, but for short term only

Section 8 26 Blue mountain to Sunbrae Culvert

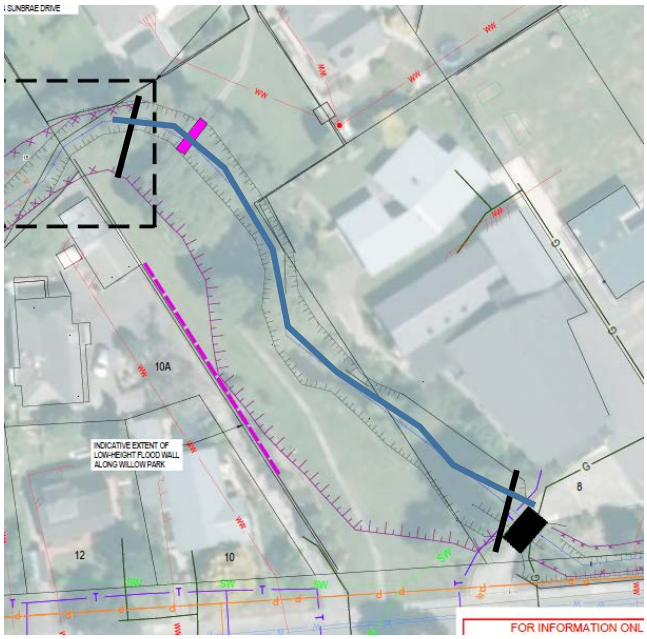
1. Sewers to be diverted before these section starts
2. Install dam and pipe work on the right side of the stream, the sediment will most probalbly be greater than 150g/m3 but for short term (activity duration only)
3. Install ramp over pipe
4. Excavate and install new Left Batter Bank
5. Relocate pipe to the Left side of the river
6. Excavate and install Right side of batter bank
7. Remove Dam and pipe , the sediment will most probalbly be greater than 150g/m3 but for short term (activity duration only)

Section 9 4 Sunbrae to 1 Tapestry



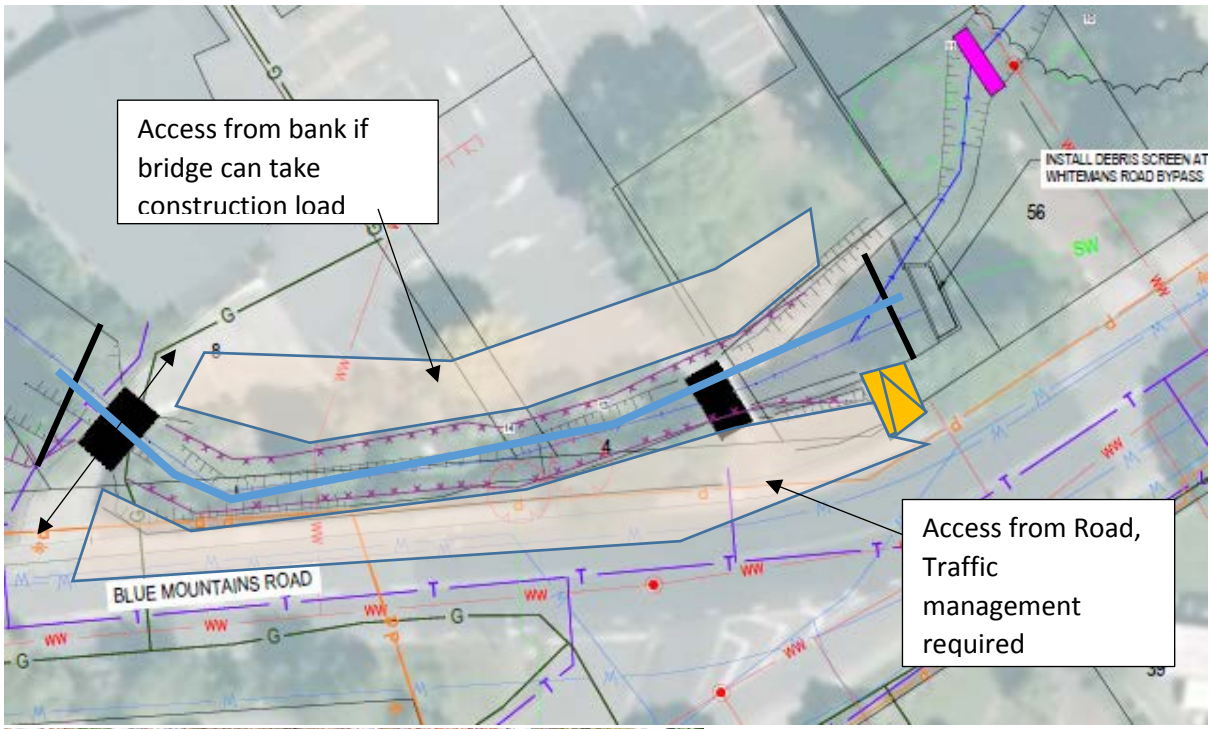
1. House to be removed before this section starts
2. Install dam and pipe, the sediment will most probalbly be greater than 150g/m3 but for short term (activity duration only)
3. Excavate and construct retaining walls on the right side from the dry stream bed
4. Relocate pipe to the right
5. Excavate and install retaing wall on the left from the dry stream bed

Section 10 Willow Park



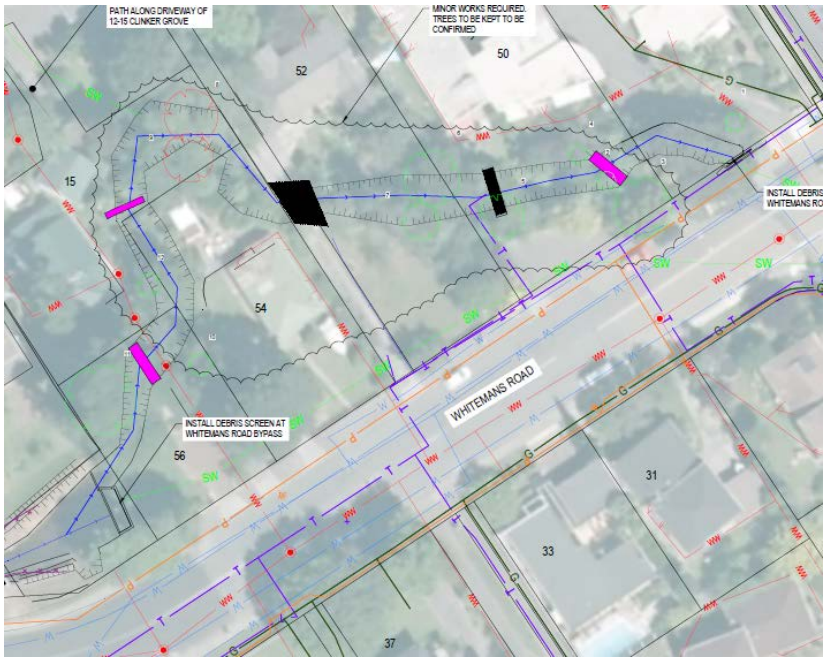
1. Dam and Install pipe
2. Excavate Willow park to new formation
3. Remove dam and pipe

Section 11 Reformed Church



1. Install Bund and pipe
2. Construct both sides form top of bank with larger plant
3. If existing bridge cannot take the construction load, then work will be completed from in the dry stream bed

Section 12 56-48 Whitemans



This section of stream will not be upgraded, but the existing bridges are to be replaced.

There is not enough room to install a pipe and track down the stream

The excavator would be required to be in the live stream on 4no visits. Track in to remove 2no bridges and then replace them.

Due to the short time frame it is proposed to work in the live stream, the sediment will most probalbly be greater than 150g/m3 but for short term (activity duration only)