PALMERSTON NORTH CITY COUNCIL

ATTACHMENTS

PLANNING & STRATEGY COMMITTEE UNDER SEPARATE COVER

9AM, WEDNESDAY 30 JUNE 2021

COUNCIL CHAMBER, FIRST FLOOR, CIVIC ADMINISTRATION BUILDING
32 THE SQUARE, PALMERSTON NORTH

PLANNING & STRATEGY COMMITTEE MEETING

30 June 2021

UNDER SEPARATE COVER

7. Whiskey Creek Private Plan Change Request

1. Private Plan Change Request for Whiskey Creek Residential Area by Flygers Investment Group Ltd Page 5

FLYGERS INVESTMENT GROUP LIMITED

PRIVATE PLAN CHANGE REQUEST FOR WHISKEY CREEK RESIDENTIAL AREA, PALMERSTON NORTH.

20 APRIL 2021

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12. Whiskey Creek Plan Change: Stormwater Management Plan: Mitch Hydro.

REPORT INFORMATION

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Author	Paul Thomas
Review By	Kevin Judd

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PART A

REQUEST FOR A CHANGE TO THE OPERATIVE PALMERSTON NORTH DISTRICT PLAN

REQUEST TO CHANGE THE PALMERSTON NORTH DISTRICT PLAN PURSUANT TO SECTION 73(2) AND IN ACCORDANCE WITH PART 2 OF THE FIRST SCHEDULE OF THE RESOURCE MANAGEMENT ACT 1991

To: The Chief Executive
Palmerston North City Council
32 The Square
Palmerston North 4410

1. Flygers Investment Group Limited requests the plan change set out below.

2. Description of the Plan Change

The requested Plan Change involves the rezoning of approximately 12.9 hectares of land from Rural Zone to Residential Zone and an area of 10 hectares of land adjacent to that from Rural to Recreation Zone to establish the Whiskey Creek Residential Area. The remainder of 611 Rangitikei Line shall remain with its current Rural Zone.

The area is located at the northern urban edge of the City adjacent to Rangitikei Line. The land abuts existing residential land at Meadowbrook Drive.

Part of the plan change site is also currently within the District Plan Flood Prone Overlay. The development of the land will involve earthworks that will reduce the area subject to flood risk. The plan change request, therefore, also includes amendment to the Flood Prone Overlay in accordance with Plan A below. This aspect of the change shall only take effect once the earthworks has been completed. Consequently, it is proposed to seek resource consent for the earthworks ahead of completion of the plan change so that specific cross reference to this consent can be included in the Plan provisions.

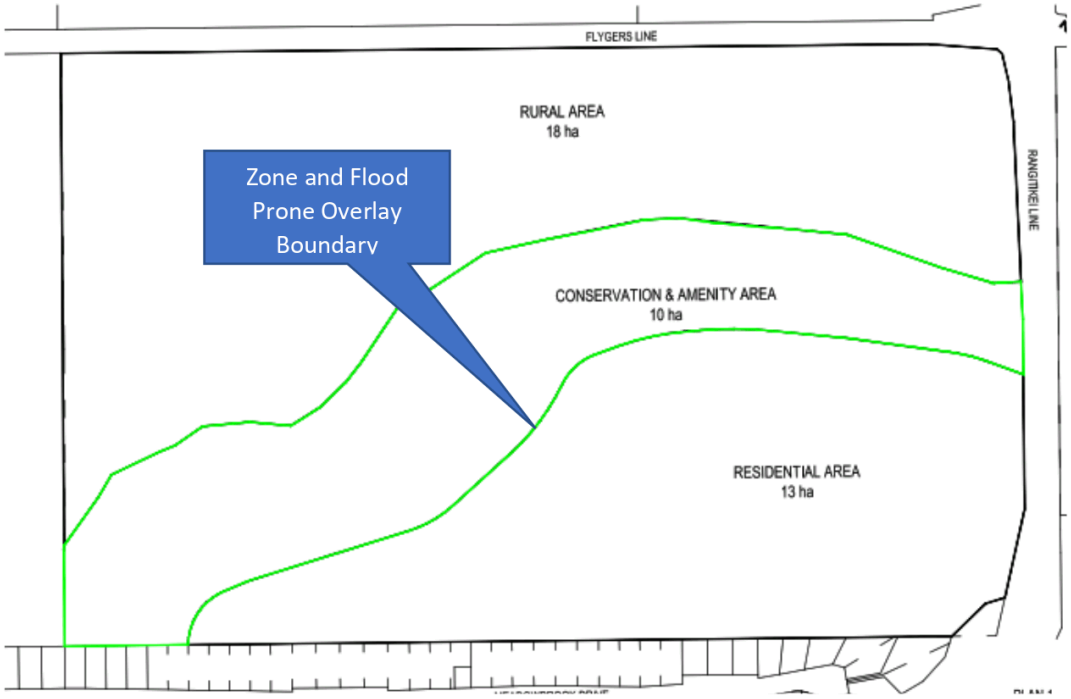
The land to which Plan Change relates consists of four properties as follows.

1. The 19.2 hectare property owned by Flygers Investment Group Limited with the address of 611 Rangitikei Line and described as Lot 2 DP 389924 in the title referenced WN493/128.

2. The adjacent 20.23 hectare property owned by Flygers Investment Group Limited with the address of 165 – 243 Flygers Line and described as Part Section 553 Town of Palmerston North referenced in title WN329/81.

3. The property of 0.86 hectares with a single large dwelling at 609 Rangitikei Line owned by Mr Bruce Robertson. The land is described as Lot 1 DP 389924.

4. 127 Benmore Avenue being Lot 14 Deposited Plan 40933 described in the title referenced WN10D/573.



Plan A

The Plan Change incorporates site specific provisions into Section 7A Greenfield Residential Areas. This section of the District Plan was repurposed to be the framework for all new Greenfield Areas as part of Plan Change C.

The Plan Change also includes the Whiskey Creek Structure Plan.

3. Proposed Changes to the Operative Palmerton North District Plan.

The specific changes to the District Plan proposed are as follows:

1. Changes to Section 4 Definitions

Add the following definition

Whiskey Creek Residential Area:

means the Greenfield Residential Area shown in the Whiskey Creek Structure Plan.

Amend Pressure Sewer Areas definition to include:

- *The Whiskey Creek Residential Area as shown on Map 7A.3.*

2. Changes to Section 7A: Greenfield Residential Areas

Add an additional bullet to 7A.1 Introduction paragraph 2.

- *The Whiskey Creek Residential Area (Map 7A.3)*

Add an additional Resource Management Issue to 7A.2

10. The effects of development on the Lower Manawatu Drainage Scheme.

Add an additional Policy Section 7A. 3 under Objective 2 being Policy 2.8:

4.8 To ensure that subdivision in the Whiskey Creek Residential Area:

- *Avoids, remedies or mitigates adverse effects on the Lower Manawatu Drainage Scheme*
- *Provides for restoration of the ephemeral tributary of Whiskey Creek as recreational reserve with quality recreational links.*
- *Provides appropriate setbacks of buildings from the natural gas pipeline that traverses part of the area and locates the pipeline within a public service corridor.*
- *Provides for vehicle access to both Benmore Avenue and Rangitikei Line.*
- *Has regard for the existing residential subdivision boundaries where it abuts Meadowbrook Drive.*

Add to 7A.4 Methods - General

- *The Whiskey Creek Structure Plan (Map 7A.3)*

(iii) Changes to Section 7A.5 Residential Zone

Add to 7A.5.2 .2 Performance Conditions for Restricted Discretionary Activity.

Part (d) Lot Size.

Sub part (i) add at the end of this clause:

, except for the Whiskey Creek Residential Area which must have an average lot size of 400m^2 – 500 m^2.

Sub part (iii) amend to read:

*No single lot shall exceed 1000m2 (except **neighbourhood centre lots** and balance lots).*

R7A.5.2.3 Assessment Criteria for Restricted Discretionary Activity

Insert (h) as follows:

(h) Subdivision design and layout within the Whiskey Creek Residential Area.

(i) *The extent to which the design and layout avoids, remedies or mitigates adverse effects on the Lower Manawatu Drainage Scheme.*

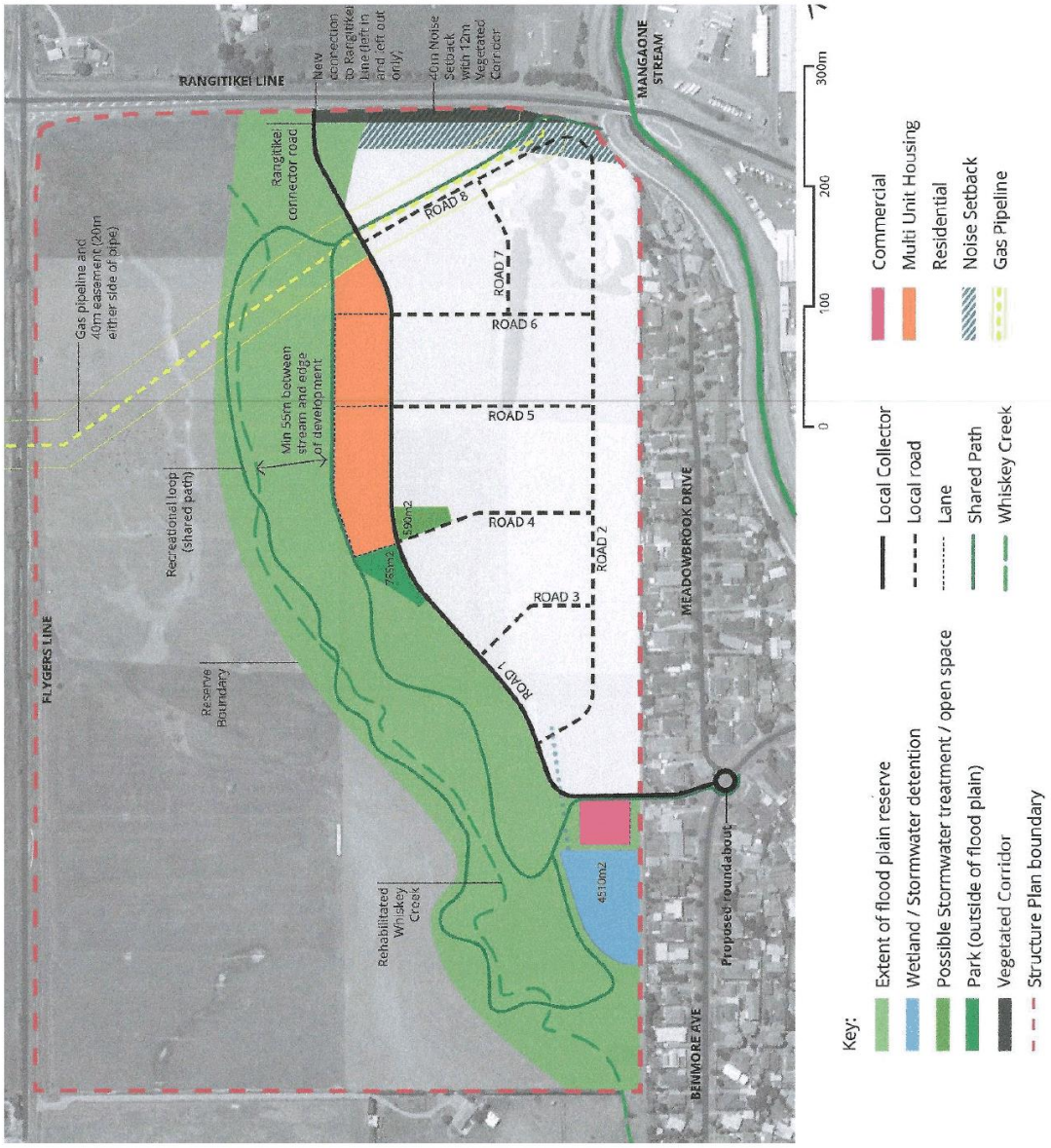
(ii) *The extent to which the design and layout provides for restoration of the ephemeral tributary of Whiskey Creek as recreational reserve with quality recreational links.*

(iii) *The extent to which the design and layout provides appropriate setbacks of buildings from the natural gas pipeline that traverses part of the area and locates the pipeline within a public service corridor.*

(iv) *The extent to which the design and layout provides for vehicle access to both Benmore Avenue and Rangitikei Line.*

(v) *The extent to which lot boundaries are consistent with the existing residential lots in Meadowbrook Drive where the lots abut those properties.*

Insert Map 7A.3.


RANGITIKEI LINE
New connection to Rangitikei Line (left in and left out only)
40m Noise Setback with 12m Vegetated Corridor
MANGAONE STREAM
Rangitikei connector road
ROAD 8
ROAD 7
ROAD 6
ROAD 5
ROAD 4
ROAD 3
ROAD 2
ROAD 1
Gas pipeline and 40m easement (20m either side of pipe)
Min 55m between stream and edge of development
Recreational loop (shared path)
Reserve Boundary
FLYGERS LINE
MEADOWBROOK DRIVE
BENMORE AVE
Proposed roundabout
Rehabilitated Whiskey Creek
450m2
190m2
75m2
0
100
200
300m
Key:
Extent of flood plain reserve
Wetland / Stormwater detention
Possible Stormwater treatment / open space
Park (outside of flood plain)
Vegetated Corridor
Structure Plan boundary
Local Collector
Local road
Lane
Shared Path
Whiskey Creek
Commercial
Multi Unit Housing
Residential
Noise Setback
Gas Pipeline

Map 7A.3.

(iv) Changes to Section 10 Residential Zone

10.3 Objectives and Policies

Insert Policy 9.7

To enable multi-unit housing development within the Whiskey Creek Residential Area in accordance with the Structure Plan (Map 7A.3).

10.6.1.5 Dwellings and Accessory Buildings in the Greenfield Residential Areas.

Performance Standards – Insert the following

(b) Maximum Building Height, Height Recession Planes and Overlooking

iii No building within the Whisky Creek Residential Area on lots that abut existing residential boundaries on Meadowbrook Drive shall exceed a maximum height of 5 m.

(c) Separation Distances

iii Any building other than an accessory building shall be located a minimum of 20 m from the Gas Pipeline located within the Whiskey Creek Residential Area and shown on Map 7A.3.

(d) Site Area and Coverage

Insert ii. (c) Dwelling units in the Whiskey Creek Residential Area shall have the following permeable areas:

25% of the net site area for each dwelling where this is between 171m^2 and 366m^2

30% of the net site area for each dwelling where this is between 367m^2 and 449m^2

35% of the net site area for each dwelling where this between 450m^2 and 561m^2

40% of the net site area for each dwelling where this between 562m^2 and 1050m^2

(e) Acoustic insultation and Setbacks for the Whakarongo Residential Area

add to heading *and Whiskey Creek Residential Area*

Amend Rule 10.6.3.3 to read: (amendment shown in bold)

Multi-unit residential development in the multi-unit housing areas identified on Maps 10.6.3.3(a)-(g) **and Map 7A.3** is a Restricted Discretionary Activity with regard to:

Amend I b) to read:

A minimum notional site area of 150m^2 applies if the development site is located within either Areas B, D, G **or the multi unit housing area shown on Map 7A.3.**

Amend ii b) to read:

Each unit must have a gross floor area greater than 60m^2, if the site is located within either Areas B, D, G **or the multi unit housing area shown on Map 7A.3.**

Amend (vi) by adding:

In the Whiskey Creek Residential Area multi unit housing area identified on Map 7A.3 the following applies:

(i) No building may exceed a height of 11 m

(ii) All parts of a building shall be contained within a 60 degree plane commencing at 3 metres above ground level inclined inwards at right angles in plan.

(iii) Front yard fences shall not exceed a height of 0.9 metres.

(v) Where a fence is erected along a property boundary directly adjoining public open space it shall not exceed 0.9 m.

Amend Rule R 10.7.3.5 Commercial Activity

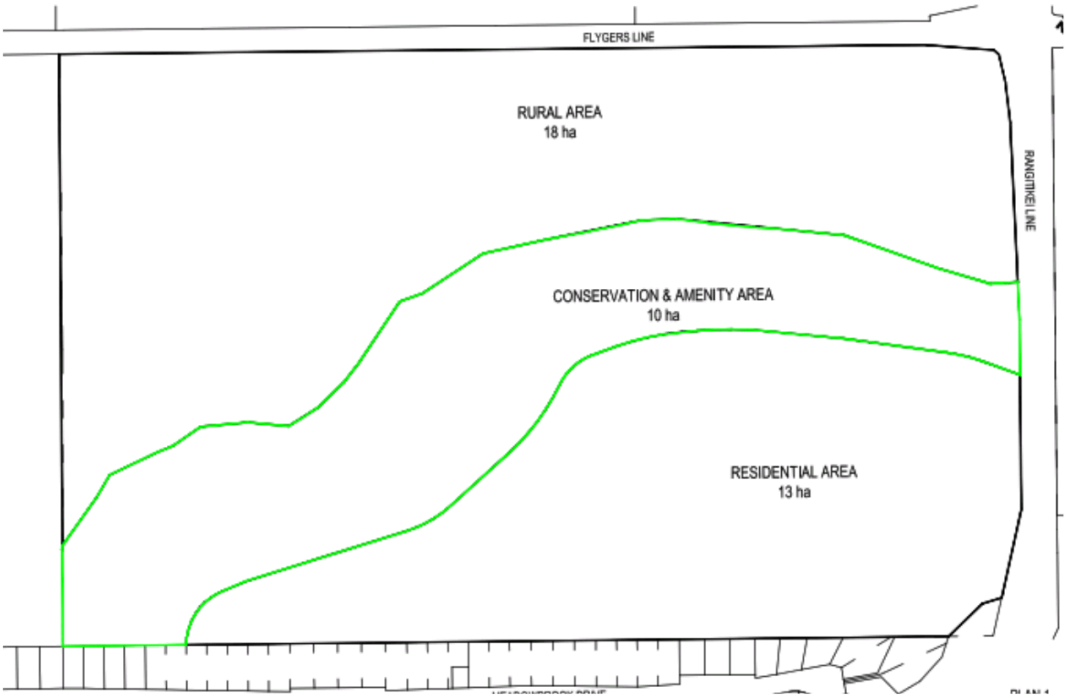
Delete from this rule the words:

and the application is included as part of the application for subdivision consent

(vi) Changes to the District Plan Maps

Amend the District Plan Maps to zone the Whiskey Creek Residential Area part Residential, part Conservation and Amenity Zone and part remaining as Rural as shown on Plan B.

Amend the Flood Prone Overlay boundary associated with the Whiskey Creek Residential Area to the boundary of the Residential Zone as shown below with the following annotation. *"The change to the Flood Prone Overlay shown here shall take effect once the earthworks authorised in Resource Consent XXXXXX have been fully implemented."*



Plan B

(vii) The Purpose Of The Plan Change Request

The purpose of the Plan Change Request is to enable residential development of the land to be zoned residential in accordance with a structure plan that addresses the key opportunities and constraints. This includes development of a reserve along the western edge of the development.

(viii) The Reasons For The Plan Change Request

The reasons for the Plan Change Request include:

- To assist in meeting future residential needs of Palmerston North in accordance with the City Development Strategy.
- The site is well located for both town centre, employment and community facilities. Earthworks are proposed to reduce the extent of flood prone area and increase the developable area whilst protecting the functioning of the Lower Manawatu Drainage Scheme.
- In conjunction with the residential development the former Whisky Creek stream bed will be redeveloped as a green corridor and will form a public reserve.

Additional information on the purpose and reasons for the Plan Change Request is provided in later sections of this report.

(ix) As required by Clause 22 of the First Schedule to the Resource management Act 1990 the attached report includes an Assessment of Environmental Effects and an evaluation report prepared in accordance with Section 32 of the Act.

Signed by the agent for the requestor



Paul Thomas:

Thomas Planning Ltd

Date: 20 April 2021

Address for service for the applicant:

Thomas Planning Limited

2A, Jacobsen Lane

Ngaio

WELLINGTON 6035

Attention: Paul Thomas

Telephone No: (04) 4795034

E Mail: paul@thomasplanning.co.nz

PART B

PLAN CHANGE REQUEST ASSESSMENT AND EVALUATION

WHISKEY CREEK RESIDENTIAL AREA

1. BACKGROUND TO THE PLAN CHANGE REQUEST

The land associated with this plan change request is located at the northern urban edge of Palmerston North. It is bounded to the northwest by Flygers Line and to the northeast by State Highway 3. To the south is the northern edge of the Cloverlea residential area.

The Mangaone Stream flows south to the east of the site and separates the Cloverlea residential area from the Bennett Street industrial area.

Whiskey Creek previously flowed through the site but was diverted to a watercourse adjacent to the western side of Flygers Line as part of the Lower Manawatu Drainage Scheme. However, there remains a length of ephemeral stream within the site. Further, a large part of the area is affected by sheet flow across State Highway 3 through the site in a 1 in 100 year AEP flood event in conjunction with the triggering of the Flygers Line Spillway located further north.

The land adjoins properties on the north west side of Meadowbrook Drive which is a cul-de-sac off Benmore Avenue. Benmore Avenue is classed as a Collector Road and links Cloverlea to Rangitikei Line via Bennett Road in the northeast and Gillespies Line to the south west.

All the land is currently zoned Rural as shown in Figure 1 which also shows the extent of the Flood Prone Overlay. The land is currently used for cropping, generally for maize.

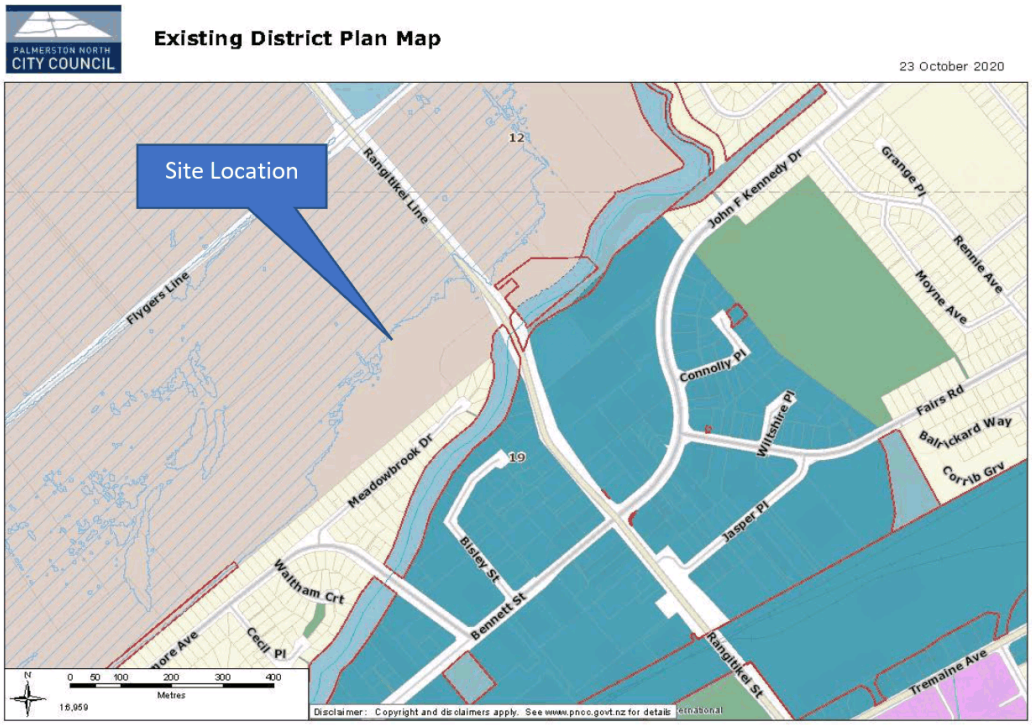


Figure 1: Existing District Plan Map

As much of the site is flood prone, consideration was given to whether the area of developable land could be increased by cut and fill earthworks from the land that is flood prone.

After initial discussions with Horizons Regional Council DHI Ltd was commissioned to model a number of different earthworks scenarios. This showed that with a specific earthworks design the operation of the flood prone ponding area can be protected without adverse effects on other land. The assessment was reviewed by both Horizons Regional Council and Palmerston North City Council before proceeding to develop this plan change.

The effect of this is that the developable area is increased from 7 hectares to nearly 13 hectares. The flood management issues are considered in more detail in Section 11 of this report and the DHI Ltd assessment is provided at Appendix 2.

The Plan Change development process from this point is detailed in Section 10.



Figure 2: The Plan Change Area Viewed From Flygers Line.

2. BRIEF DESCRIPTION OF THE PROPOSED PLAN CHANGE

The Plan Change Request is to provide objectives, policies and rules for the development of the land in the manner shown on the Proposed Structure Plan.

The land is proposed to be zoned part Residential Zone, part Conservation and Amenity Zone and part is to remain as Rural Zone as shown in Figure 3 below.

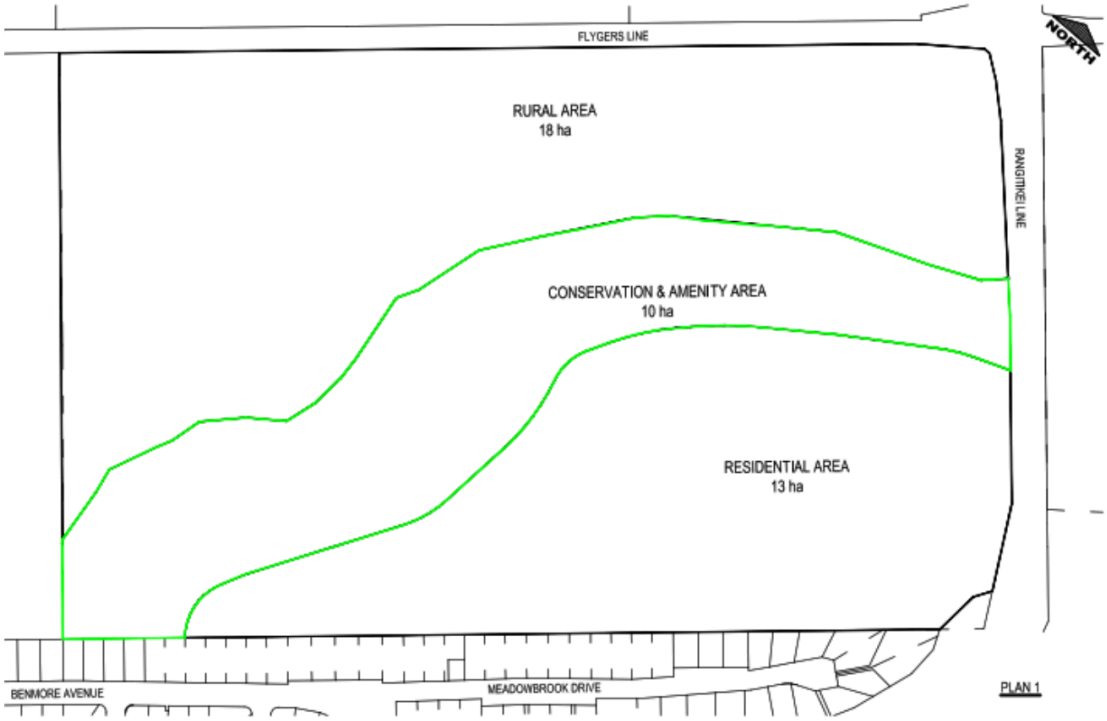


Figure 3: The Proposed Zones.

The scope of provisions to be inserted in the Plan include:

Section 7A: Greenfield Residential Zone

- An additional policy relating to site specific issues associated with development of the area.
- Assessment criteria for subdivision and development of the land which will apply to Restricted Discretionary Activities.
- An average lot size for the development.
- Inclusion of a Structure Plan.

Section 10: Residential Zone

- Policy and provisions to enable multi unit housing as shown on the Structure Plan with some amended performance standards.
- An additional performance standard for lots that abut the existing residential properties on Meadowbrook Way relating to building height.
- Additional performance standard for building setback from the gas pipeline.
- Application of existing acoustic insulation and setback rules.

In addition, it is proposed to amend the Flood Prone Overlay to match the changed flood prone area once recontouring of the land has been completed. To formalise this, it is proposed to apply for consent for this work in advance of completion of the Plan Change.

The specific details of the plan change are set out in the request in Part A and also in Section 12.

2 THE EXISTING DISTRICT PLAN PROVISIONS FOR THE LAND

The entire site is currently zoned rural in the operative Palmerston North District Plan and much of the land is affected by the Flood Prone Overlay as shown in Figure 1 above.

In this zone subdivision of land down to 20 hectares is enabled as a Controlled Activity, except for subdivision of a surplus dwelling which has a 1 hectare minimum and 2 hectares maximum.

Permitted activities in the Rural Zone include farming, horticulture, production forestry, home occupations and roads.

The land does not have a rural residential overlay. However, one dwelling is permitted on sites of 20 hectares or less and 2 dwellings on sites over 20 hectares.

Garden centres, home occupations with retailing, some nurseries and roadside stalls, dependant dwelling units and expansion of existing listed industries are all classed as Controlled Activities.

The policy framework for the zone emphasises the following:

- protection of rural land from the effects of unplanned urban expansion,
- encouraging the effective and efficient us of the resources of the rural area
- maintaining or enhancing the natural character
- enhancing the diversity of the rural community
- managing the effects of and on Palmerston North Airport
- protecting outstanding natural features and landscape and
- enabling renewable energy developments and managing the effects of them on the environment.

The existing zone is clearly inappropriate for managing the urban development of part of the site and the development and use of the reserve. Therefore, given the nature of the development proposal a change to the District Plan is both necessary and appropriate.

3 THE PLAN CHANGE REQUEST PROCESS

Part 2 of the First Schedule to the Resource Management Act sets out the requirements and process of approval of a Private Plan Change. The request is required to explain the purpose of, and reasons for, the proposed plan change. It is also required to contain an evaluation in accordance with Section 32 of the Act. The environmental effects of implementation of the plan change are required to be described in such detail as corresponds to their scale and significance.

The request is reviewed by the local authority which may request further information to better understand the plan change within 20 working days. As a result of this further information the local authority may, with the agreement of the person who made the request, modify the request.

Then within 30 working days the local authority must decide whether the request is to be adopted as its own plan change, continue as a private plan change, or is to be dealt with as if it were an application for a resource consent.

The authority may also reject the request at this point but only on grounds that it:

- Is frivolous or vexatious
- Is the same as a matter dealt with in the last 2 years
- Is not in accordance with sound resource management practice.
- Would be inconsistent with Part 5 or
- The Plan has been operative for less than 2 years.

If accepted as a private plan change, the local authority is then required to prepare the plan change in consultation with the requestor and within 4 months must notify the change for submissions.

Once accepted the procedure is the same as that for a Council plan change. Submissions are summarised and notified for further submissions and then a hearing of submissions is conducted.

The decision of the local authority is then publicly notified and submitters and the requestor have the right of appeal to the Environment Court.

4 COUNCIL STRATEGIES

There are a number of current Palmerston North City Council Strategies that have some relevance to this proposal and have been had regard to in developing the Plan Change.

Of perhaps greatest importance is the City Development Strategy 2017 which provides the overall direction of urban growth for the next 20 years. It proposes to accelerate the City's growth and prosperity and adopt sustainable development practices. It seeks to establish a clear planning framework to promote growth and urban development by providing certainty for public and private investment. This includes an adequate supply of development land with infrastructure to support growth. It also includes a specific target of 12,000 more jobs in Palmerston North by 2028.

The strategy proposes to release land at City West earlier than previously anticipated and this has been achieved in part through the Kikiwhenua Residential Area. It also proposes to work with the land owners at Napier Road and Flygers Line on small greenfield additions to the housing land supply.

This plan change request is that referred to as "Flygers Line" in the Strategy. It is, therefore, fully in line with the Council current housing land supply strategy.

The Council is currently preparing a new 10 Year Plan. This is still in draft form for consultation and not approved by Council so the relevant plan is the 10 Year 2018 – 28. The City Development Strategy is built into this 10 Year Plan along with a host of other strategies and plans.

Goal 1 is an Innovative and Growing City. The City Development Strategy is a key means of achieving this goal.

"Palmerston North is expanding, and Council wants to accelerate the city's growth and prosperity. Having a ready supply of land with infrastructure to support the city's growth will ensure Council can harness new development opportunities and increase Palmerston North's competitiveness. Council will provide infrastructure in a timely way while managing the financial risks of providing too much

infrastructure in multiple locations. Integrating land use planning and infrastructure can be a powerful economic development tool. The Government has provided strong direction about this, particularly for housing, in its National Policy Statement for Urban Development Capacity (2016)."

The Plans under this strategy are:

• ***District Plan***

The plan change request seeks to change the District Plan to provide for a residential development capable of accommodating 160 dwellings in a sustainable manner. The City View Objectives in the Operative District Plan are assessed in Section 11.

• ***Housing and Future Development Plan***

This Plan seeks to ensure that residential land supply exceeds demand by 20%. This means there is a constant supply of at least 1,800 greenfield residential sections. It also recommends zoning changes to provide additional housing choice and specifically refers to Napier Road and Flygers Line.

• ***Strategic Partners Development Plan***

The development of the Plan Change Request has recognised Rangitane o Manawatu as mana whenua and as a strategic partner of the Council.

• ***Urban Design Plan***

This plan seeks to ensure that principles of good urban design are elevated to be an *"intrinsic and effective part of everyday city making and co-creation."* Strong urban design principles underpin this plan change request and are detailed later in the report and in Appendix 3.

• ***Heritage Management Plan***

While there are few heritage issues associated with the site, the requestor has worked closely with Rangitane O Manawatu on the development of this proposal.

• ***Growth Infrastructure Plan***

This Plan seeks to ensure that Council front foots new infrastructure in advance of growth and has clear growth priorities. It stresses the importance of collaboration with landowners and developers on the provision of infrastructure capacity which should exceed demand by 20%. The servicing of the Whiskey Creek Residential Area can be achieved without major infrastructure provision.

• ***Strategic Transport Plan***

This Plan promotes a freight ring road using the Kairanga Bunnythorpe Road which is to the north of the proposal.

Goal 2 is "A creative and exciting city." The key priorities relevant to this Plan Change are:

1. *To Create a city that has great places for all people, and particularly families*
2. *To focus on building communities and places.*
3. *Increasing access to quality green space and active transport networks is seen as strategically important.*

A placemaking approach has been adopted for this plan change with expert urban design and landscape inputs to the design process. The Whiskey Creek tributary restoration and associated public reserve development is a major feature of the proposal. The location is also well served by public transport and will incorporate active transport features.

Plans under this strategy include:

• ***Placemaking Plan***

The focus of this plan is to build resilience in residential and village neighbourhoods through place based projects. These include community led streetscape projects and a laneways programme.

• ***Active Communities Plan***

The relevant actions planned in the Active Communities Plan are:

- Extend the walking and cycling network, including completing and upgrading parts of the existing network.
- Plan for and provide sport and recreation facilities in urban growth areas.
- Provide signage and wayfinding to direct people to places and spaces to recreate in.

• ***Active and Public Transport Plan***

This includes:

- Provide for the extension of public transport, cycling, and pedestrian facilities and services into residential and industrial growth areas, and the rural villages.
- Apply the principles of good urban design.
- Continue development of the shared path loop around the city and along the Manawatū River edge linking Ashhurst, Linton, Longburn, Bunnythorpe and Feilding, including the Mangaone Stream Shared Path connection to Manawatū River Shared Path (by end of 2020/2021)

• ***Biodiversity Plan***

The relevant outcomes sought in the Biodiversity Plan are:

- More native-friendly species are planted within the city, providing year-round food sources for native wildlife.
- The mauri of urban streams is enhanced, and native aquatic life is thriving.
- All streets have street trees, where practicable.

• ***Three Waters Plan***

The relevant outcomes sought in the Three Waters Plan are:

- A pressure sewer policy is developed to support wastewater bylaw reviews to mandate pressure sewer implementation in NEIZ and City West zones.
- A city-wide wastewater network hydraulic model is completed and in use to inform asset management and city development decisions.
- Evaluate options to implement controls by way of permeable surface coverage, stormwater detention, water sensitive design and minimum floor level separation to mitigate the effects of and flooding risks associated with new development.

- Urban waterways are thriving ecosystems.
- District Plan provisions enable Council to require mitigation to restrict impacts of stormwater run-off from new development, particularly infill or brown field redevelopment.
- There is a formal cultural monitoring framework for freshwater management with Rangitāne o Manawatū.
- Council understands iwi and community values around urban waterways.
- Stormwater services are resilient enough to cope with the effects of climate change.
- District plan controls better manage the effects of urban development on stormwater services.

The Plan Change Request includes adding the site to the identified Pressure Sewer Areas, and also provides for management of stormwater.

These strategies have all been had regard to in developing this proposal and in evaluating options through the Section 32 Assessment.

5 RESIDENTIAL LAND CAPACITY

Palmerston North City Council undertook a Housing and Business Capacity Assessment in 2019 as required by the then National Policy Statement on Urban Development Capacity 2016.

This assessment included consideration of this Plan Change Request coming forward.

The Capacity Assessment also links to the Housing and Future Development Plan referred to above which also identifies the need to provide zoning adjustments to provide additional housing choice at Flygers Line.

The assessment found that:

- Annual population growth is expected to be higher than the 1,000 people per year previously projected.
- There has been a significant increase in housing construction in the City, with consents for construction of new houses increasing from 161 in the year to December to 477 consents in the year to December 2018.
- Despite this, there has been strong growth in house prices.
- Demand can be accommodated in the short term if Whiskey Creek is developed, however, in the medium and long term there will be a deficit of greenfield land supply.

The assessment specifically recommended that a Future Development Strategy is prepared that identifies additional opportunities for housing to meet projected growth demands. Further, that Council review how the Ratings Policy can best support the release of residential zone for development.

6 THE PLAN CHANGE DEVELOPMENT PROCESS AND CONSULTATION

The Plan Change development process has involved extensive investigations over more than 2 years. The first phase of investigation considered whether the land area which is not exposed to flood risk could be increased whilst maintaining the efficiency of the flood ponding area associated with the Manawatu Drainage Scheme, and, in particular, the flow of flood water through the area when the Flygers Spillway is triggered. This is approximately once every ten years.

This involved specific technical investigation which was initially reported to both Horizons Regional Council and Palmerston North City Council. The next step in the process was to investigate how the area would be accessed and then embark on a range of engineering and urban design investigations to determine an overall master plan which, in turn, has directed the proposed Structure Plan.

During this stage a Cultural Impact Report was also commissioned from Rangitane o Manawatu which is attached at Appendix 4. More recently after being approached there have also been discussions with Ngati Turanga, which is a hapu of Ngati Raukawa and has interests west of the Magaone Stream.

Palmerston North City Council, First Gas Ltd and Horizons Regional Council have also been consulted on regular occasions during the process. In addition, there have been direct discussions with Waka Kotahi NZTA that is reported in the Transportation Assessment.

Horizons Regional Council provided a formal consultation response on 25th February 2021. This drew attention to the One Plan objectives and policies which are specifically considered in Section 10. It also drew attention to:

- the Accelerate25 programme which seeks to see managed urban growth and increased economic activity in the region,
- The One Plan Climate Change and Transport policies, and
- Potential regional consent requirements.

The feedback supported a left in left out connection to Rangitikei Line and a collector road that could potentially be used for public transport.

There has also been consultation with residents of the Cloverlea neighbourhood. This involved distribution of project information directly to some 600 households and two follow up drop in sessions. These were held on the evening of Friday 19th February and the following Saturday morning of 20th February in the hall at Cloverlea School. Project material was displayed and team members were available to answer questions and discuss issues. Feedback was then recorded on feedback forms and by e mail.

In total 32 addresses were represented at the drop in sessions and feedback was received from 23 parties. As would be expected there was strong representation from Meadowbrook Drive and Benmore Avenue.

Issues of concern included:

- Loss of views and sun for Meadowbrook Drive adjoining properties
- Increased traffic on Benmore Avenue
- Risk of additional flooding
- Construction effects
- Use of agricultural land
- Effects on property values

Discussions with the Meadowbrook Drive adjoining neighbours identified a strong preference for single story dwellings to reduce sun, privacy and bulk effects and for some views. It also identified a preference for lining up the side boundaries of the new lots with existing side boundaries so that only one property backs onto an existing property.

These measures have been adopted by the plan change request and include policy, standards and assessment criteria to ensure those matters are considered at both subdivision stage and dwelling construction.

A number of feedbacks also sought specific additional information. Those providing feedback have been responded to by e mail with the additional information requested and, for Meadowbrook residents, advising of the changes adopted in response to their concerns. Parties have also been advised of the intention to apply for earthworks consents ahead of the plan change approval and the expected time of submission of this Plan Change Request.

7 PRINCIPAL ISSUES AND ASSESSMENT OF ENVIRONMENTAL EFFECTS

Th following section addresses the principal issues associated with the suitability of the site for residential development, the opportunities arising, the design concept and the positive and adverse effects on the environment.

The section draws on the technical reports prepared by a range of experts which are included in the Appendices to this request.

The general order of addressing these issues is the bigger picture issue, development constraints and then management of risks of adverse effects.

7.1 IS THE LOCATION APPROPRIATE FOR THE SCALE OF DEVELOPMENT PROPOSED?

The Site is positioned at the intersection of Rangitikei Line and Flygers Line, adjacent to the city's current urban edge along Meadowbrook Drive and Benmore Avenue. Located some 3km from Te Marae O Hine / The Square, the Site is notably closer to the CBD than other designated growth areas. Benefits associated with this close proximity include the potential for greater take-up of active movement modes and increased accessibility of amenities, while consolidation of the city's urban footprint helps resolve the city's edge along Rangitikei Line.

SH3 (Rangitikei Line) provides excellent north-south connectivity into the city and out towards the future NZTA ring road that will service the planned Regional Freight Hub. Flygers Line provides an east-west link that accesses the airport and the future growth area of Kākātangiata.

Construction of 9,440 new dwellings is anticipated in Palmerston North City in the 30 years to 2048. Half of these are expected to be built on greenfield land. Three major growth locations are being pursued by Council: Whakaronga, Kākātangiata (formerly City West and Anders Road / Racecourse), and Aokautere. Council projections at Aokautere are for some 1,200 additional dwellings beyond those currently zoned, 500 dwellings at Whakaronga and over 5,000 at Kākātangiata. In this context, Whiskey Creek is relatively small (157 dwellings) but contributes to the picture of growth around the city's edge.

The wider urban structure around the site reflects the former boundary between Palmerston North City and Manawatu District with rural land to the north east affected by the Flygers Line spillway and residential and industrial areas to the south west. The Mangaone Stream is an important feature which separates the industrial and residential areas, while the State Highway 3 bridge over the Mangaone Stream forms the northern gateway to the City.

The site forms an extension to the community of Cloverlea. It is only 700 m to Cloverlea Park, which is adjacent to Cloverlea Primary School, and also Colquhoun Park to the east. Despite this a significant reserve development is proposed as part of the development based around the restoration of the tributary of Whiskey Creek which sits alongside the development area. The nearest local centre is approximately 1.3 km away at Herbert Avenue. City wide amenities are available by bus public transport.

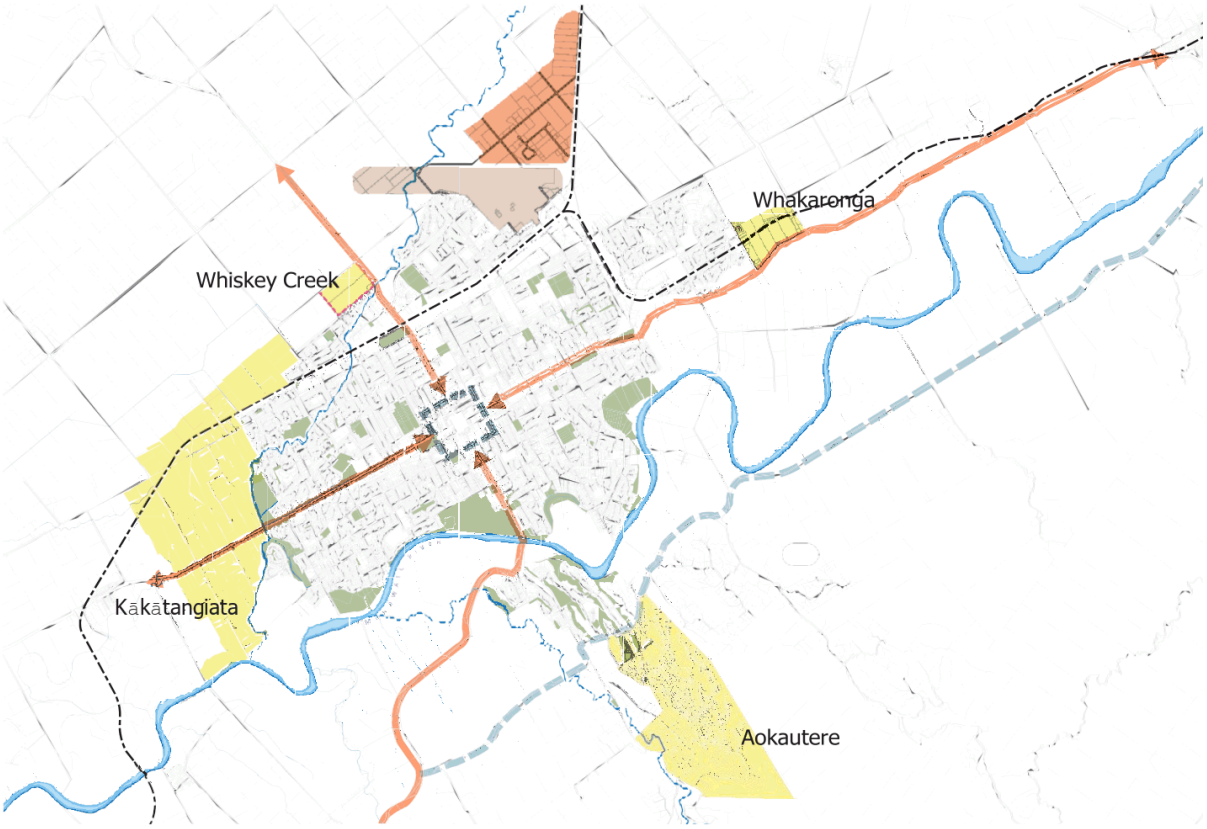


Figure 4: Future Growth Areas.

The proposed residential area therefore provides a small but valuable addition to the larger growth areas and has long been considered part of the wider greenfield residential areas strategy. It will provide choice in terms of housing and living location and provide an enhanced northern gateway to the City. With good access to services and employment it is an appropriate location for greenfield growth.

7.2 WHAT EFFECT WILL DEVELOPMENT HAVE ON FLOOD MANAGEMENT IN THE LOCALITY?

This is a critical issue because much of the site is classed as flood prone land. This occurs only when the Flygers Spillway is triggered. The spillway relieves flood pressure on the Mangaone Stream as part of the Lower Manawatu Flood Control Scheme. The spillway is located west of Milsons Line and Flygers Line and when triggered diverts floodwater to the Whiskey Creek basin. This in turn

floods land north east of Rangitikei Line. If this ponding area is exceeded water flows across State Highway 3 southwest into the area of the Plan Change site.

The Lower Manawatu Flood Control Scheme includes two other constructed spillways which all collectively feed floodwater into the Taonui Basin and then to the Manawatu River as shown in Figure 5 below.

DHI Ltd was specifically commissioned to determine whether earthworks designed to increase the area of non flood prone land in this vicinity could be undertaken without adversely affecting the operation of the Flood Control Scheme and any other land in terms of flood risk. A range of earthworks design options were modelled and tested. This report is included as Appendix 2.

DHI Ltd regularly undertake modelling for Horizons Regional Council and were therefore familiar with the Flood Scheme and its requirements. Horizons agreed to share their model with the project to undertake this work. DHI developed a "MIKE" Flood Model using digital ground elevation information from Horizons. The model covered the area from the Flygers Spillway to the intersection of Whiskey Creek with Cloverlea Road. This was subsequently reduced to the area upstream of Gillespies Line when no backwater effects down stream of Gillespies Line were identified.

The earthworks modelled involved 0.112 km^2 of earthworks with a predominance of cut of 20,000 m^3 and the reworking of drainage across the site including rerouting of the drain that runs through the middle of the property.

The initial assessment found that major infrastructure assets downstream such as roads are not affected by the earthworks. However, there is an increase of flood levels downstream of 14 cm.

Consequently, a series of low impact design options were tested. These included bunds to direct flow, a detention pond in the northern corner of the site, and a series of swales and diversion to improve flow connectivity. The modelling also took account of the Benmore Avenue stopbank upgrade being undertaken by Horizons to provide 0.5% AEP flood protection.

In total 6 options were investigated and these are detailed in the DHI Report (Appendix 2). Only Option 6 was found to manage flood risk to a less than minor extent for downstream properties. This includes a series of swales connecting to the ephemeral Whiskey Creek stream bed including one from the repositioned drain, two online ponds either side of the same stream bed. These ponds seek to divert overland flow paths to the west and this is achieved with an east – west bunds crossing both drains but with a stream opening of 2 metres. In addition, there are two retention ponds at the downstream end of the property to store peak flood volumes. The specific concept is shown in Figure 6 below and has been adopted. To provide further certainty this will be further detailed in resource consents for earthworks that will be sought ahead of the Plan Change.

With these measures adopted there will be less that minor effects on properties and infrastructure from the earthworks proposed and this has therefore been adopted as the basis for developing the overall plan change proposal.

The ponds will be incorporated into the detailed earthworks design and the design of the reserve. The pond south of the development detention pond will be considered for use as a constructed wetland for stormwater treatment.

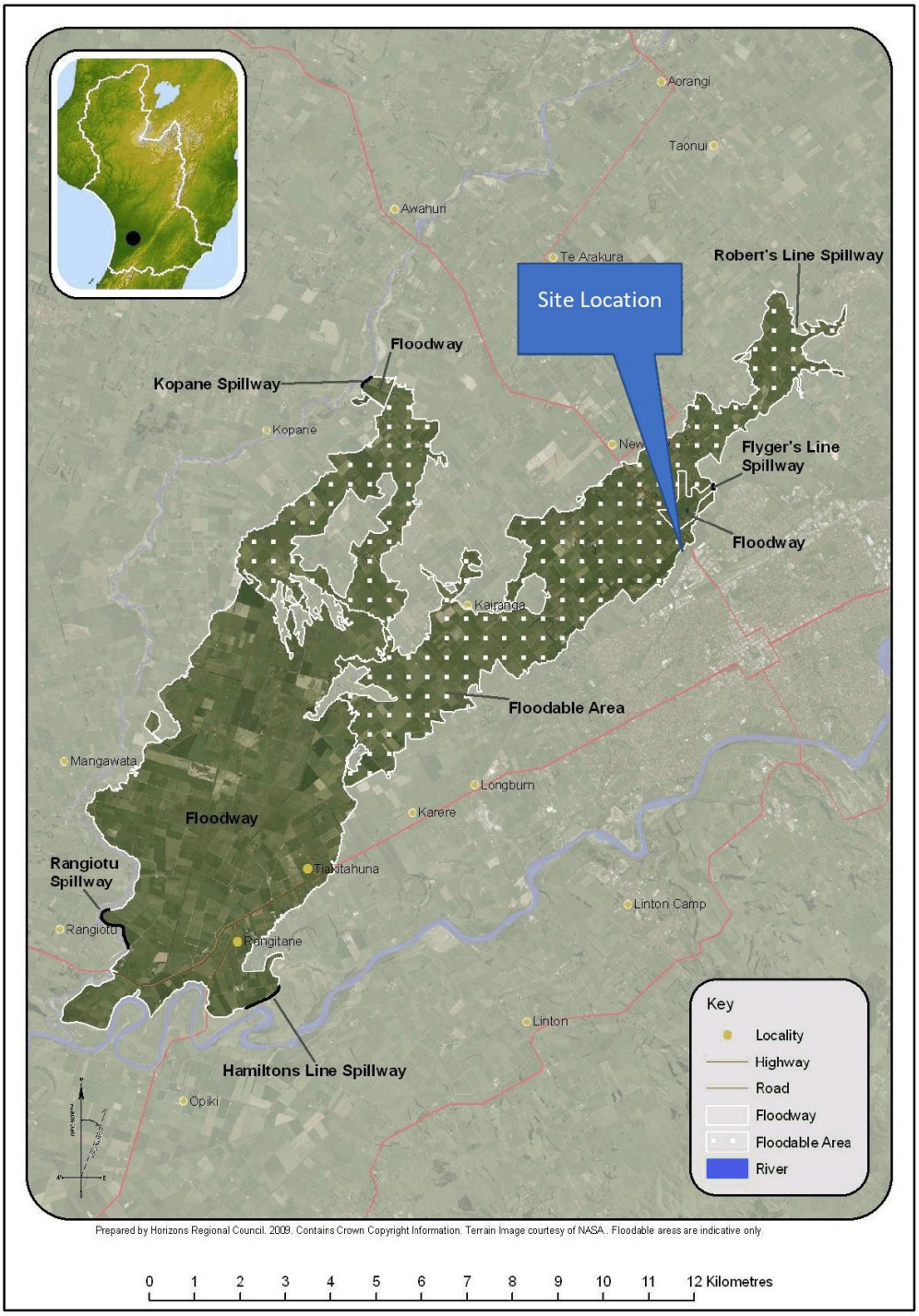


Figure 5: Taonui Basin Spillways, Floodways and Floodabble Area.

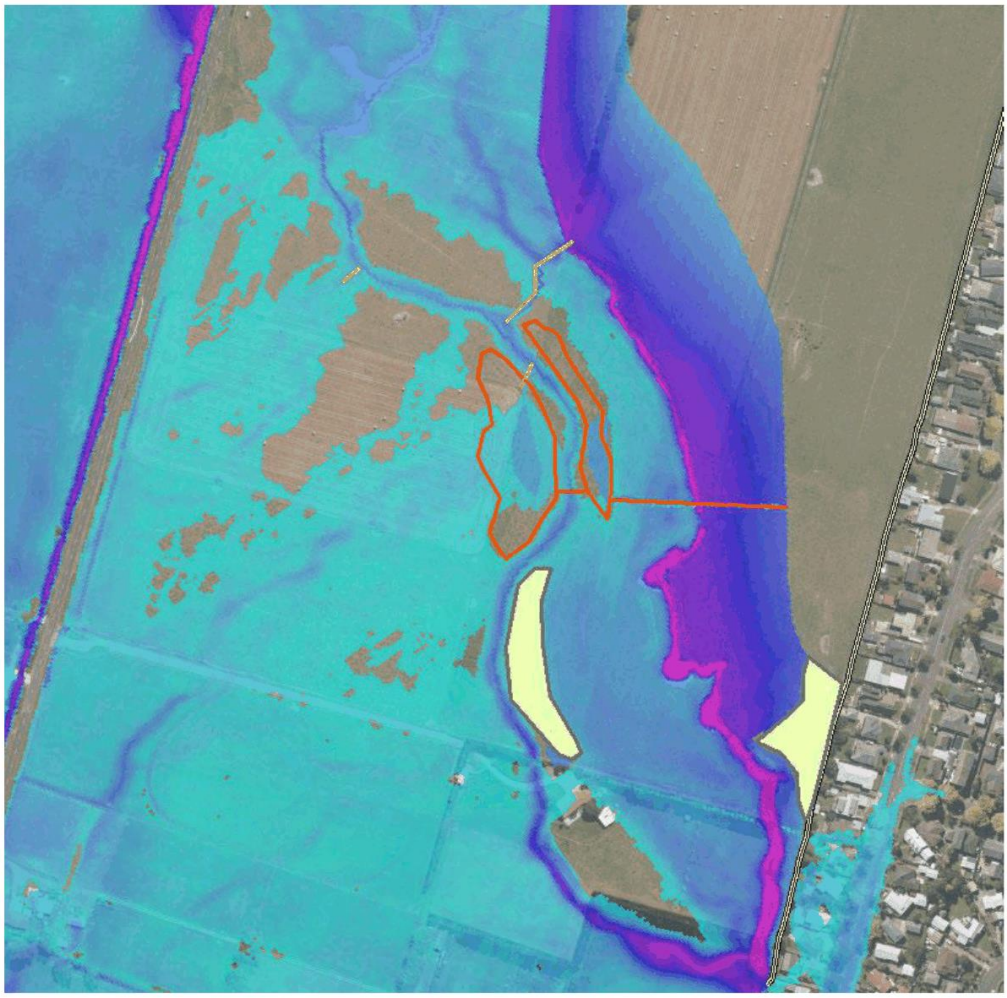


Figure 6: Proposed Flood Retention and Diversions Measures.

7.3 ARE THERE ANY CULTURAL ISSUES THAT MAKE THE AREA INAPPROPRIATE?

In order to understand any cultural issues associated with the proposal, Rangitane o Manawatu, who are mana whenua, was commissioned to undertake a cultural impact assessment. This is included at Appendix 4.

Rangitane o Manawatu deliver a maori model of environmental management through the Te Ao Turoa Environmental Centre. The Centre undertakes ecological and cultural monitoring projects, restoration of waterways through planting and plastic reduction, weed and pest control, and engagement in planning processes.

The Cultural Impact Assessment was undertaken by Siobhan Karaitiana and reviewed by Danielle Harris. The assessment used a Whanua Ora Outcomes Framework with the three key outcomes tested being:

Rangatiratanga

- Exercising rangatiratanga by collaboration in planning.
- Identifying and providing for cultural landscape values.
- Iwi awareness of assets held in common.

Healthy Lifestyles

- Participation in a sustainable economy
- Whanua physical well being
- Access to a healthy environment
- Affordable housing

Te ao Maori

- Language is visible and celebrated
- Street and place names adopt Rangitane names

The assessment found no fatal flaws from a cultural / whanau ora perspective. The assessment supports the restoration of the Whiskey Creek tributary, recreation access and housing. However, in a number of areas further information has been requested and there will be further engagement at the more detailed design stage associated with the individual resource consents.

7.4 IS THERE ANY CONTAMINATED LAND?

Riley Consultants Ltd was commissioned to undertake a Preliminary and Detailed Site Investigation to determine the suitability of the site in terms of any risk of land contaminated. This report is attached at Appendix 5.

The Preliminary Site Investigation identified the potential for market gardening to have historically occurred on the site and for isolated hydrocarbon contamination within farm sheds. In addition, it was identified that in the 1942 period an abattoir was located on the northern site boundary on Flygers Line.

As up to three HAIL activities have potentially occurred on the site a Detailed Site Investigation was undertaken in accordance with the National Environmental Standard for Contaminated Sites (NES-CS).

This included 13 hand auger boreholes in the field, 3 hand dug test pits underneath the sheds and 9 hand auger boreholes at the abattoir site. The results of laboratory testing of these samples showed the following;

- Cadmium in seven out of the 13 surface samples collected from the field
- Arsenic, cadmium chromium, copper, and zinc in the samples collected from the shed footprint
- Cadmium, chromium, copper, lead, and zinc in the samples collected from the footprint of the former abattoir

None of these exceeded the NES-CS soil contaminant standards for residential land use.

Further:

- Polycyclic aromatic hydrocarbons (PAHs) were detected but not at levels that exceed the NES-CS soil contaminant standards for residential land use.
- Neither Organochlorine pesticides nor acid herbicides were found in detectable concentrations.
- None of the Total petroleum hydrocarbons (TPH) values exceed relevant health-based assessment criteria within the MfE Petroleum Hydrocarbon Guidelines.

These findings will be had regard to in the detailed methodology for the earthworks and may require a controlled activity resource consent under the NES-CS. However, the detailed assessment has confirmed he suitability of the site for residential development in terms of land contamination risks.

7.5 ARE THE GEOTECHNICAL CONDITIONS SUITABLE FOR DEVELOPMENT?

Specific investigations have been undertaken to determine if there are any geotechnical hazards that may have an impact on residential development. Riley Consultants Ltd was commissioned to undertake a first stage of investigation and this is detailed in their report in Appendix 6.

The investigation assessed sub surface conditions to a depth of 6.5m with Cone Penetrometer Tests followed by 3 boreholes. The sub soils are firm sandy and clayey silts and sands down to 5-7m below ground level and then gravels with lenses of stiff clayey silt. Testing of these soils classed them as non-liquifiable.

Groundwater levels vary seasonally and following rainfall events and have been recorded within the range of 1m and 4m below ground level.

Despite the overall soil testing some liquefiable materials were identified in the soil profile being discrete layers of loose to medium dense sandy silt, or silty sand. The liquefaction assessment identified potential for induced settlement in the order of 20 mm to 100 mm under a ULS Ultimate limit state) event.

Lateral spread was also assessed in relation to the drainage ditches and stream bank. This raised the prospect of the need for a 50 m setback of dwellings from stream or ditch however it also noted that "negligible lateral spread is predicted in the SLS (serviceability limit state) event and the lateral spread risk is correspondingly low." (page 6 Geotechnical Assessment Rileys Ltd). However, the assessment also recommended that further investigations are undertaken to obtain a more accurate prediction of lateral spread displacements.

Consequently, once a preliminary design concept for the land development had been established, Total Ground Engineering Ltd was commissioned to carry out supplementary investigations and analysis of risk of lateral spread. This is reported in the Lateral Spreading Assessment in Appendix 7.

The further investigations associated with this assessment found groundwater ranging between 0.85m and 1.3m depth. In general, this assessment agreed with the Riley Consultants conclusions above. It identified three potential mitigation approaches as follows:

- a building exclusion line 55m from the limit of the earthworks, or
- realigning the overflow channel to be 55m from the flood protection line. Or
- construction of an 8 m wide band of ground improvement at the flood protection line which could be stone, columns, dynamic compaction or replacement of sediments with river gravels.

In finalising the proposal and structure plan option 2 has been adopted and the drainage channel positioned to achieve this. The earthworks design incorporating the within reserve flood ponds has also confirmed that there is sufficient setback from these faces.

7.6 IS THE SITE IMPORTANT FOR FOOD PRODUCTION?

The site is currently used to grow maize for feedstock. The Land use Capability is recorded as Class 2 soils. As a result, Perrin Ag Consultancy Ltd was commissioned to advise on the productivity of the soils. This report is attached as Appendix 8.

This report identifies the soils as Kairanga silt loam and Te Arakura sandy loam shallow phase which are "*poorly and imperfectly drained and have a continuing slight wetness after drainage. Water tends to lie in the winter and are susceptible to compaction and pugging, restricting winter grazing by heavy cattle. These soils tend to dry out in winter.*" (page 3 Perrin Ag)

There is also some Karapoti brown sandy loam which is a free draining soil, but the gravel and drying out in summer limits intensive or horticultural use.

The soils are classed as IIw2 and IIs1 which are at the lower end of the LUC class 2 and reflects their limitations.

The assessment confirmed that the soils are true to the mapping information and are poorly drained and unsuitable for horticulture of vegetable growing uses. They can, however, be used for arable crops and grazing.

The remaining rural zoned land is likely to continue to be cropped. To help facilitate this it is expected that the subdivision of the land will include a right of way from Road 1 through the reserve to access the rural land. Overall, the assessment concluded that the soil capability limitation did not preclude development for urban land uses.

7.7 HOW WILL DEVELOPMENT FIT WITH THE HIGH PRESSURE GAS PIPLEINE?

The Taranaki to Napier High Pressure Gas Pipeline crosses the northern part of the site between Flygers Line and Rangitikei Line. At Rangitikei Line is passes under SH 3 to the gas gate compound where there is a take off for low pressure gas reticulation of Palmerston North.

It is important that this infrastructure is adequately protected from damage during and after development of the area. The gas is a potentially explosive hazard if the pipeline is ruptured.

Discussions have been held with First Gas Ltd who own and operate the pipeline. This has included the nature and extent of earthworks proposed and appropriate protocols.

In terms of integration of the pipeline into the development the requirements of First Gas are that the pipeline is to be within in a service corridor within road reserve berm and secondly that there is a habitable building set back of 20m either side of the pipeline.

The structure plan has been designed to fully meet these requirements and shows the pipeline on the northern side of Road 8 with a requirement for a 20m set back. This has also been proposed as a building standard for this residential area in the proposed provisions.

With these measures in place the gas pipeline can be accommodated without undue risk to the safety of the pipeline and therefore safety of those living in the vicinity and the wider community.

Detailed design work on the earthworks has confirmed the depth of the pipeline and will ensure that sufficient cover is retained over the pipeline to meet First Gas requirements.

7.8 ARE THERE NOISE EFFECTS FROM RANGITIKEI LINE (SH3)?

Acousafe Ltd was commissioned to advise on whether any site specific noise performance standards or other provisions were required for the residential area. The Noise Assessment Report is included as Appendix 9.

The assessment concluded that the existing noise limits and activity rules that are generally applied across the existing Residential Zone can be applied to the Whiskey Creek Residential Area. The Residential standards are 5 decibels stricter than the existing Rural zone standards during the day and night with no change in the evening. It also concludes that the residential and rural interface is appropriately controlled.

The principal issue arising is, as indicated in the heading, is the potential for reverse sensitivity effects from vehicle noise on SH3 Rangitikei Line. The speed limit on the adjacent stretch of highway is 100 kph with the 50 kph zone located just to the south. Given the traffic flows on the highway, the NZTA recommended buffer to dwellings is 40 metres. At this distance the expected noise level will be 62 $bBL_{Aeq(24hr)}$. A modern double glazed dwelling with windows closed provides 22 dB noise reduction achieving an acceptable indoor noise level of 40 $bBL_{Aeq(24hr)}$. This zone extends out to 80 m from the State Highway.

The assessment therefore recommends that performance standards for dwelling construction be included that require a building setback of 40 metres and insulation and ventilation requirements between 40 m and 80 metres from SH 3. The proposed structure plan specifically provides for the building set back and both aspects are proposed for specific rules applying to the Whiskey Creek Residential Area. These are the same standards that have been applied for the Whakarongo Residential Area and are already in force for that area.

There is the potential for a small increase in traffic related noise levels from Road 1 for the properties at 1 Meadowbrook Drive and 125 Benmore Avenue which will be adjacent to the new road. This will be considered further during the resource consent process and, if necessary, noise mitigation measures such as insulation or fencing/bunding will be assessed and incorporated as required in consultation with the property owners.

7.9 WHAT ARE THE TRANSPORTATION RELATED EFFECTS?

A Transportation Assessment of the Proposal has been undertaken by Harriet Fraser Traffic Engineering and Transportation Planning. This is attached as Appendix 10.

The key proposals in terms of road access and road/shared path structure are:

- primary road connection to Benmore Avenue with a four-arm roundabout created with Meadowbrook Drive;
- secondary road connection to SH3 with a left in/ left out only arrangement;
- extensive shared path network within the site which connects with the existing shared path along the edge of the Mangaone Stream at one end and with the footpath network on Benmore Avenue at the other end; and
- an indicative internal road layout that provides route choice options within the subdivision.

There are three types of street within the internal road hierarchy, the collector road that connects Benmore Avenue to Rangitikei Line, the local roads that provide access to area to the south of the collector road and lanes which provide access to housing on the northern side of the collector road.

Benmore Avenue is classed as a Collector Road and currently carried about 3,300 vehicles per day. While Rangitikei Line is an Arterial Road with some 11,500 vehicles per day. Meadowbrook Drive currently has 55 houses generating a morning peak of 25 vehicles per hour. There is a bus service to the City Centre with stops on Benmore Avenue and an important recreational cycle path along the Mangaone Stream.

The Whiskey Creek Residential Area is expected to generate approximately 1570 vehicle movements per day. Within this there would be 157 movements per hour in the weekday traffic peak. The table below shows the forecast trip distribution.

	Weekday Morning Peak (7.45-8.45am) (vph)	Weekday Evening Peak (4.30-5.30pm) (vph)
Outwards		
L to Benmore Ave	89	17
R to Benmore Ave	20	20
L to Rangitikei Line	9	3
Inwards		
L from Benmore Ave	4	52
R from Benmore Ave	24	44
L from Rangitikei Line	12	22
TOTAL	158	158

Table 1: Forecast Traffic Flows

The connection to Rangitikei Line is proposed to be limited to left in left out only. This is for safety reasons and has been agreed in principle with NZTA. The expected level of use of this connection is limited to 22 vehicle movements per hour which, the Transportation Assessment finds, can be safely and efficiently accommodated. Specific design measures will be required to prevent right turns and it is also proposed that there are design measures to discourage traffic travelling through the subdivision to from the Cloverlea area to access SH3.

The Collector Road serving the development is proposed to connect to Benmore Avenue and Meadowbrook Drive by means of a roundabout. A preliminary design concept for this is shown in Figure 7 below.

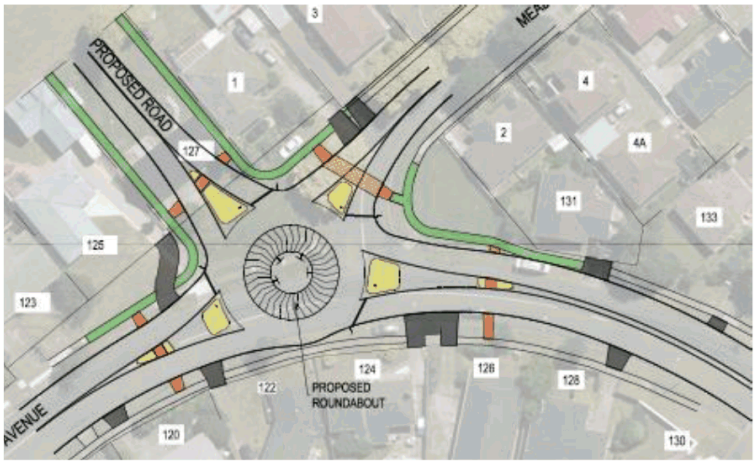


Figure 7: Proposed Roundabout Design Concept.

The Transportation Assessment concludes that, while this is a preliminary design, it can readily accommodate the additional traffic. However, detailed design will need to give particular consideration to affected residential driveways and accommodation of pedestrians and cyclists. Consultation with affected parties on this issue has commenced.

With regard to the wider local road network, an additional 72 vehicles per hour are expected to travel south west along Benmore Avenue which can easily be accommodated by this Collector Road. There is some existing congestion at the Bennett Street/ SH3/ John F Kennedy Drive intersection. An additional 3 vehicles are expected on the approach during each cycle of the traffic signals in the morning peak. The assessment finds this is unlikely to add to existing delays through the intersection.

The assessment also specifically considers the existing objectives and policies of the District Plan and concludes that the proposal is compatible with those provisions.

7.10 WHAT ARE THE EFFECTS OF THE PROPOSED EARTHWORKS?

In terms of the proposed earthworks the site can be divided into three zones. Firstly, the existing area above the flood risk level which is largely left untouched. Secondly an area of fill amounting to about 16,500 m^3 of material which is cut from the third area north of the fill. The fill area will be compacted and form part of the development site, while the cut area will form part of the proposed reserve. There will be surplus cut of about 28,000 m^3 which will be removed off site.

Importantly the detailed design features required to manage floodwater flows have been incorporated into the earthwork design as recommended by DHI Ltd and referred to in Section 7.2 above and shown on the earthworks plan in Figure 8 below.

While the area of earthworks is quite large the volumes involved are not large because the depth of cut and fill involves less than 500 mm apart from the areas where flood ponds are required. The exercise is therefore more one of recontouring than mass earthworks.

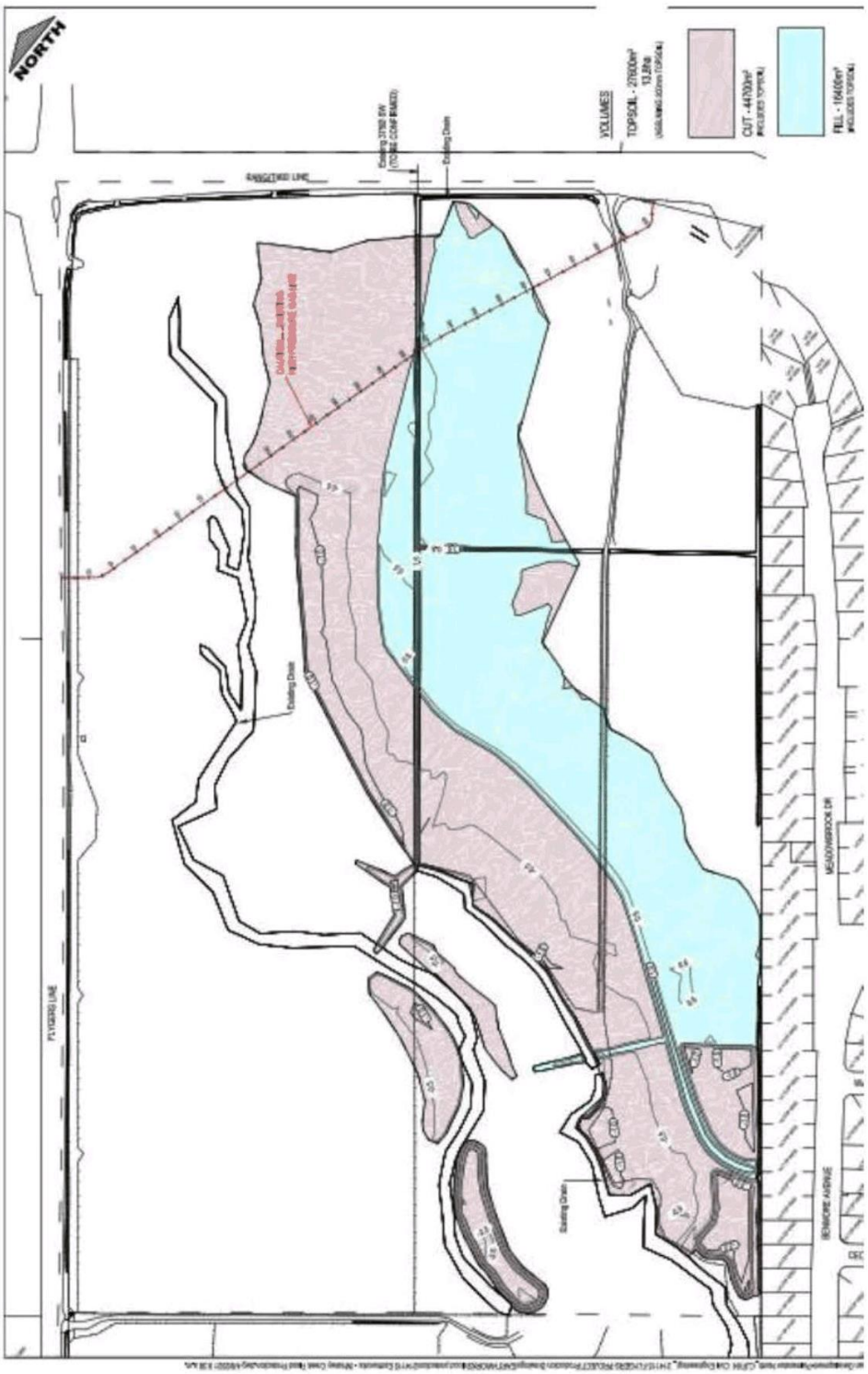


Figure 8: Proposed Earthworks.

It is not expected that the earthworks will extend for more than one summer construction season.

For most of the existing residents of Meadowbrook Drive there is a buffer of some 150 metres from the nearest earthworks. This buffer reduces to the south and there are 9 existing residential properties that will have no buffer from the fill area.

For these occupiers it will be important to manage construction effects which will be addressed through the required resource consents. This can be expected to include a Construction Management Plan which will detail management measures associated with controlling noise, dust, sediment and erosion and traffic.

7.11 WHAT ARE THE EFFECTS OF STORMWATER GENERATED BY THE DEVELOPMENT?

Currently the topography of the land means that rain either soaks to ground or flows north to the existing drain and the ephemeral Whiskey Creek.

Development for residential dwellings means that there is less ground permeability and therefore more stormwater run off. The additional run off can add to loads on the reticulated stormwater system as well as adding to flood risks. Mitch Hydro Ltd was commissioned to investigate stormwater and recommend management measures. This report is included at Appendix 12.

The area drains roughly east to west until it is intercepted by the remnant Whiskey Creek open channels draining to the south, which culminate at the floodway stop-bank adjacent to No. 91 Benmore Avenue, where the PNCC 900mm diameter stormwater main commences. This is about 110 metres south of the southern corner of the site.



Figure 9: PNCC Stormwater Connection adjacent to 91 Benmore Avenue.

The entire site is affected by localised catchment flooding, but more significantly by Mangaone Stream spillway events considered earlier in Section 7.2. The Flygers Line spillway is located some 1.4 km upstream and was constructed in 1982 to reduce flooding through Palmerston North.

During Flygers Line spillway events there are multiple flow controls across site, including the two open channels (Whiskey Creek and tributary) plus sheet flow across driveways and roads etc. The February 2004 and June 2015 flood events both flooded across the Rangitikei Line / Flygers Line intersection. The spill flows drain to the Taonui Basin and downstream to the Oroua and Manawatū Rivers.

The assessment has calculated the rainfall depths for specified storm events using the HIRDS V4 procedure. The existing permeability of the land was then assessed to calculate the existing catchment run off. The development concept was then used to calculate stormwater generation once full developed.

The Stormwater Mitigation Plan is based on a pipe layout within proposed roads leading to a flood detention pond at the southern end of the development. Secondary flow paths will be contained within the road corridors.

The pond has been sized to contain the stormwater of a 50 year ARI event and will be approximately 90 m long, 50m wide and 1.5m deep with 3:1 embankment batters. Stormwater from the development will be channelled through the pond to a 300 mm culvert outlet. The floor of the pond will be planted with native species and will be dry most of the time. However, storm events that exceed the capacity of the 300mm outlet will then be detained in the pond and released as the inflow reduces. Events greater than 50 year ARI will result in spillage from the pond via a constructed spillway discharging the surplus water to the Whiskey Creek flood area. The 300 mm outlet will discharge to the reserve and drain via an open swale for a distance of 100 m to the Whiskey Creek channel immediately upstream of the south western property boundary. The PNCC stormwater outlet shown above is a further 110 m downstream.

The outlet area of the reserve could also be used for stormwater quality treatment by way of a constructed wetland. Other treatment options include rain gardens / bioretention devices.

The proposed flood detention pond will provide hydraulic neutrality with reductions in peak discharges in all events up to the 100 year ARI event. However other options will also be considered at the subdivision resource consent stage which may include roof-water tanks and underground storage with a view to additional upstream discharge points to enhance waterflow through the reserve.

The assessment also considered how site stormwater would relate to the timing of floodwater releases from the Flygers Line spillway. It found that the Mangaone Stream catchment has a time of concentration of 30-40 hours compared with the Whiskey Creek Residential Area of 30-40 minutes. Therefore, the mitigated peak outflows from the proposed flood detention pond would be unlikely to coincide with the peak discharge from the Flygers Line spillway to the Taonui Basin. The increased runoff volume in the 1% AEP event as a result of the Plan Change is also minimal i.e. in the order of 0.2% of the total spilled volume down the Flygers Line spillway during the February 2004 (approx. 1% AEP) event.

7.12 WHAT ARE THE EFFECTS ON WATER AND WASTEWATER SERVICES?

The existing wastewater network in the area has a 150mm ø main located within Benmore Avenue. This sewer main flows to the south west and eventually discharges into the Wastewater Treatment Plant in Totara Road, some 5km away. The depth of the wastewater system adjacent the proposed roundabout, is in the order of 2 metres deep.

Two servicing options were considered to service the estimated 160 lots proposed within the residential land. These being a gravity drainage system and a pressure system.

A typical gravity system includes a 100mm ø rigid lateral pipe to each property. These laterals connect to a 150mm ø rigid main pipe within the roadway. These pipes are graded to fall towards the connection point of the existing system. If the connection point is too high a lifting pump chamber is required to discharge the sewage into the existing system.

A pressure system requires each lot to have installed a small pump chamber which is fitted with a grinder pump. Sewage is pumped into a 50mm ø flexible pipe within the street which in turn discharges into the connection point. No lifting pump is required, as the system relies on pressure.

Due to the proposed ground levels of the land in question, it was calculated that there wasn't sufficient elevation for a gravity system to drain the site without the need for a pump lifting station.

It was also considered that any gravity system could increase the peak flow effects on the down stream network, due to the users discharging sewage at peak times.

The pressure sewer system would be able to service the entire development without the need for a lifting station. The individual pump systems are able to be time coordinated so that the discharge from the site can be timed to occur outside peak flow hours, which would not cause any downstream capacity issues. Pressure sewer systems are also less susceptible to the effects of water infiltration, liquefaction and ground movement.

The Council has a general policy that pressure sewer systems should be used in Greenfield Residential Areas and the North East Industrial Zone. This policy is stated as Policy 1.1 in Section 7A of the District Plan which is to provide for installation of pressure sewer systems in Pressure Sewer Areas. The site is not currently identified as a Pressure Sewer Area, but it is proposed that the Plan Change provisions amend the definition to include the Whiskey Creek Residential Area.

Discussions have been held with Council over the proposed sewage disposal options and Council has confirmed that the pressure system is their preferred option.

In regard to water supply, the system has separate 150mm ø water mains in Benmore Avenue, directly opposite the proposed development, and at the northern end of Rangitikei Line, as shown in Figure 10 below.

It is proposed to extend the watermain at the northern end of Rangitikei Line by 150m to the eastern corner of the site. This extended watermain will be looped through the development to Benmore Avenue by a new 150mm ø main. The system will provide the required minimum service pressure of 350kPa and a minimum peak flow capacity of 25L/s for fire-fighting purposes. Discussions with Council have indicated that this will provide a compliant water supply system for the development.

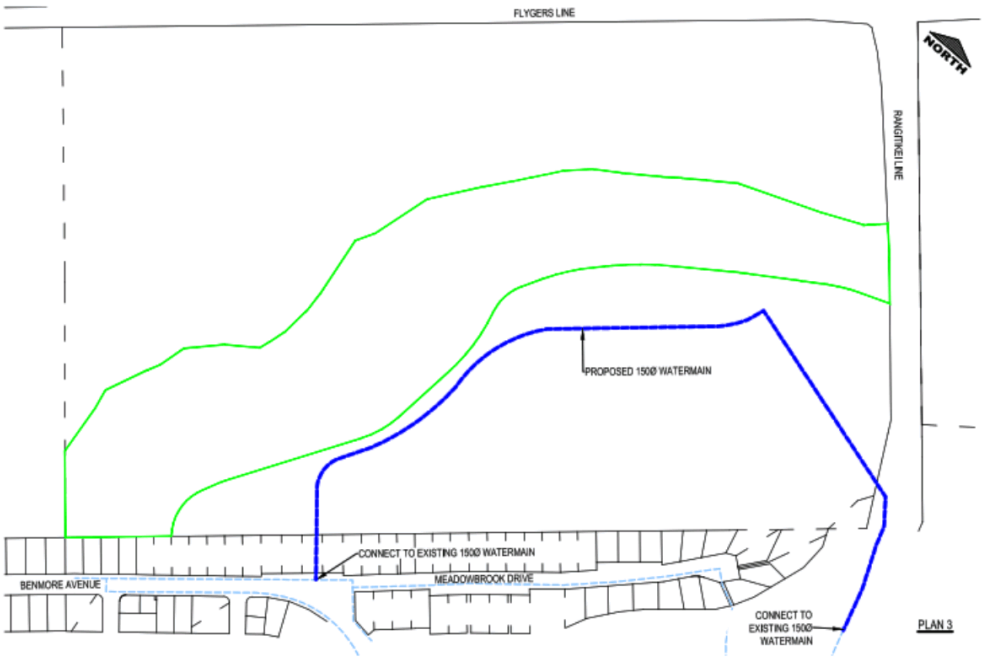


Figure 10: Proposed Watermain.

7.13 URBAN DESIGN, LANDSCAPE AND RECREATION EFFECTS

The principal issues addressed above have informed the development of a Structure Plan and Illustrative Masterplan for the development.

A detailed Urban Design Report is attached at Appendix 3. This was prepared by McIndoe Urban and Local Landscape Architecture Collective and reports on the design process for the plan change request.

The design process was based on nine Design Principles which are:

Strategic Alignment

- Whiskey Creek aligns with National Policy Statement on Urban Development.
- Development helps to implement high-level PNCC strategies and plans.
- Whiskey Creek establishes a more logical northern growth limit.

Connectivity

- Fully connected movement network.
- Recreational pathways forming circuits.
- Proximity to public transport.

Place-Based Identity

- Legible spatial structure.
- Distinctive elements with clear relationships to one another.
- Intuitively understood street hierarchy.

Absolute Urban Edge

- Sharply defined urban edge creates a new northern gateway.
- Permanent edge condition creates special character and amenity.
- Restoration of Whiskey Creek draws attention to flood plain.

Neighbourliness

- Proposed spatial structure connects to the city at macro and micro scales.
- Lot and dwelling types acknowledge existing subdivision patterns.
- Street layout creates positive front/back relationships with existing houses.

Flexibility, Diversity and Choice

- Proposed plan offers a range of densities and dwelling types.
- Development delivers various amenities within walking distance.
- Potential exists for connections to further development on the northern margin.

Mixed Use Activation

- Different densities and dwelling types increase housing capacity and choice.
- Strong local destinations encourage residents to walk and ride.
- Well-used amenities and public spaces attract further visitation.

Environmental Design

- Stormwater management is an integral part of spatial planning.
- Proposal promotes restoration and naturalisation of waterways.
- Proposal enhances biodiversity and extends green corridors.

Within these design principles the aim has been to achieve:

- A feasible development with a mix of housing density, housing type and price point.
- An identified area of multi-unit housing in a location of high amenity.
- The scale, alignment and orientation of the new development matched to existing patterns.
- An attractive, safe road connection from Benmore Avenue.
- A small convenience retail / café facility near the connection with Benmore Avenue.
- Revitalisation of Whiskey Creek.
- A sustainable and liveable neighbourhood that provides a high level of amenity.

The Illustrative Masterplan shown in Figure 11 below emerged from testing various options which are consider further in the Section 32 assessment. The design is built around six design strategies.

These are:

- External linkage to both Benmore Avenue and Rangitikei Line ensuring the development is an integral addition to the existing urban fabric.

- A clear street hierarchy with a main collector road skirting the northern edge of the development, local roads feeding to the collector road and lanes serving the multi-unit housing area.
- Recreational pathways within the Whiskey Creek Reserve connecting to the local street network and links to the Mangaone Stream corridor providing a recreational circuit.
- Small blocks creating a permeable neighbourhood minimising the need for rear lots and maximising north south alignment for sun access to properties.
- A broad reserve along Whiskey Creek providing the developments principal ecological and recreational asset.
- Lot type and density to meet market needs and good neighbour interface.

The Indicative Masterplan features a widened stream corridor to enhance ecological outcomes and address potential liquefaction. Yield and block layout have been optimised within the developable portion of the Site as dictated by the revised flood line. The Masterplan provides a through-site connection between Benmore Avenue and Rangitikei Line. Multi-unit housing occurs along a portion of the stream corridor, and a mixed use area is located near the intersection with Benmore Avenue. The stormwater detention area sits above the flood line and the gas pipe easement and SH3 noise buffer have been incorporated.

The implementation of the Master Plan will be the subject of detailed design for subdivision and development consents. It has however informed the final Proposed Structure Plan which forms part of the Plan Change provisions. The Proposed Structure Plan shown in Figure 11 below shows:

- The access and road structure arrangements.
- The extent of floodplain reserve and rehabilitation of Whiskey Creek.
- A neighbourhood park contiguous with the reserve but above flood prone level.
- The area of residential development with 40m noise set back from SH 3.
- Location of stormwater detention pond and adjacent neighbourhood centre.
- Gas pipeline location and associated building set back.
- Location of multiunit housing overlay area
- Indicative recreational loop and connections.

While the ability to achieve hydraulic neutrality has been tested and proven, the detailed design will consider other options for stormwater management with a view to additional discharge points to the reserve further north in order to enhance waterflow through the reserve into Whiskey Creek.

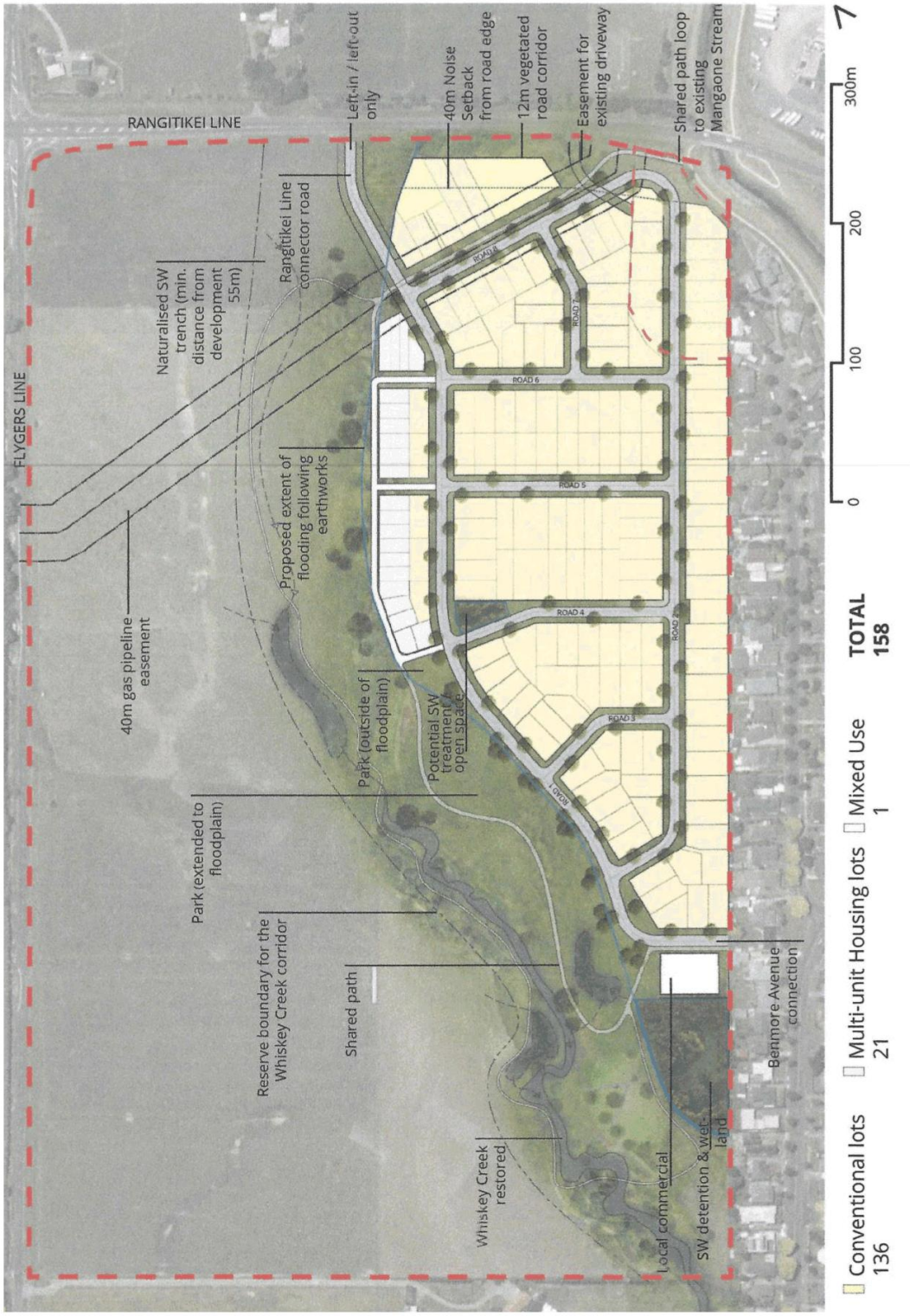


Figure 11: Illustrative Masterplan.

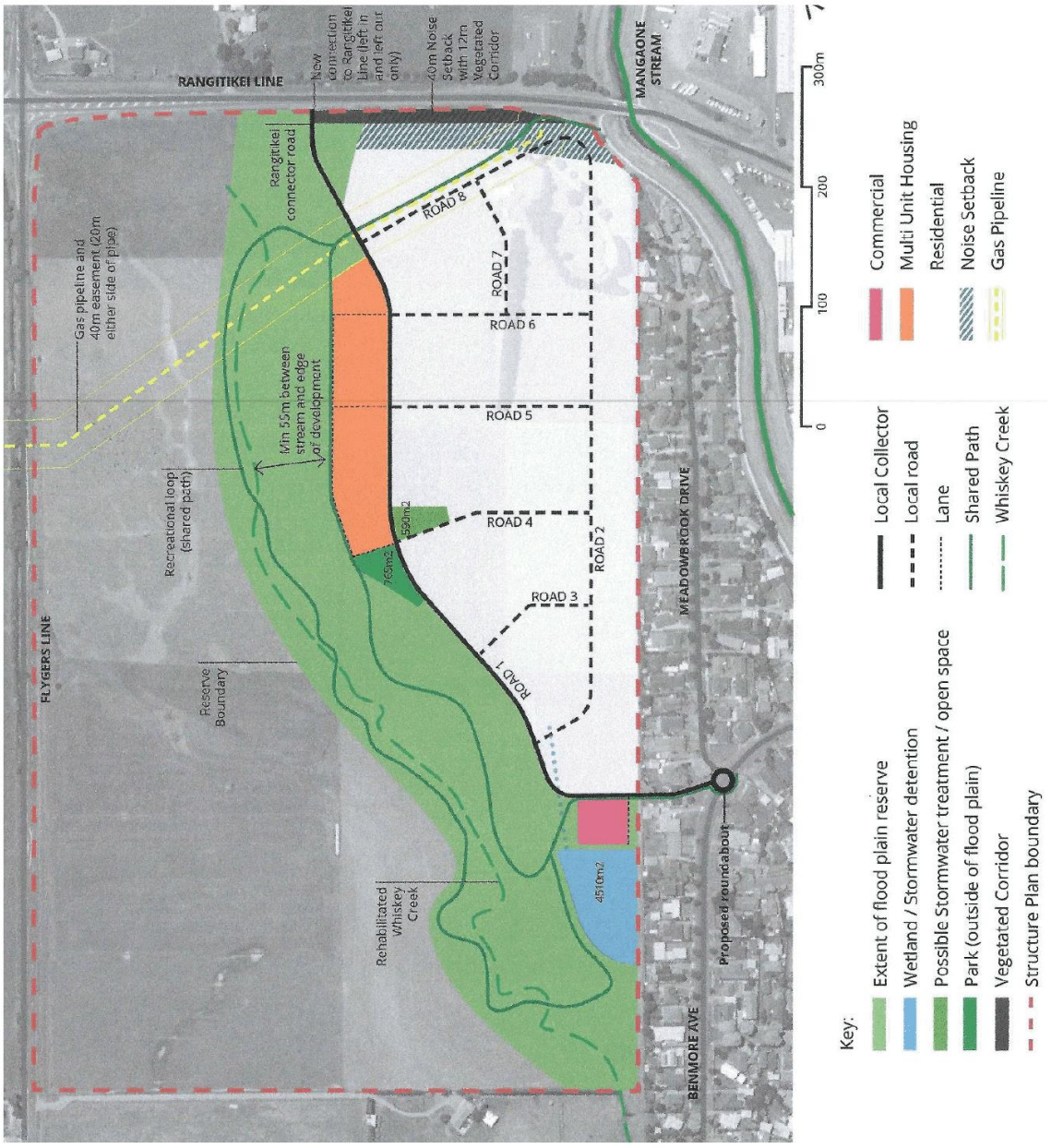


Figure 12: Proposed Structure Plan.

7.14 EFFECTS ON NEIGHBOURS

One of the key design strategies has been to have an appropriate interface with the existing established residential properties of Meadowbrook Drive and Benmore Avenue. The issues of this interface were informed by the public consultation held as part of the Plan Change design process.

The existing residential properties that border the Plan Change are predominantly, but not exclusively, single storey dwellings and a number have had the benefit of an expansive view to the

northwest across open rural land. This has generally provided a sunny but windy climate with neighbour privacy.

Understandably one of the key concerns of these owners and occupiers is the loss of that amenity associated with being at the urban rural interface.

A clear preference was expressed for aligning proposed lot boundaries with existing lot boundaries on the north west side of Meadowbrook Drive so that the development creates single, rather than multiple, neighbours for each property.

This has been adopted and provisions are proposed to maximise the extent of these aligned boundaries when subdivision consent applications are assessed.

In addition, there was also a clear preference for single level dwellings on adjoining sites to reduce the concerns regarding sun access and privacy. This has also been adopted and a height performance standard at this interface of 5 metres is proposed. This is reduced form the standard residential height standard of 9 metres.

While there will clearly still be a significant change in character of the outlook for these properties, the measures adopted will reasonably mitigate those effects.

7.15 OTHER COMMUNITY EFFECTS

Generally, it is considered that other community effects will be positive. The proposed reserve development is a substantial area of 10 hectares compared with the residential area of 13 hectares. The reserve will be accessible to the wider Cloverlea community adding to the amenity of the wider neighbourhood.

Similarly, the site for the small neighbourhood centre has been selected to have maximum accessibility to the wider community as well as exposure to the amenity of the reserve. This development may include a café with outlook to the reserve and also a small convenience shop.

The development is also expected to provide additional students for Cloverlea School which is within a reasonable walkable distance for students.

8 PROPOSED CHANGES TO THE DISTRICT PLAN

There are a number of sections within the District Plan that are relevant to this Plan Change request. They include:

- Section 7A which deals with Subdivision in Greenfield Residential Areas
- Section 10 which deals with activities and development within the Residential Zone including the multi-unit housing overlay, and commercial activities within the residential zone
- Section 22 which deals with Natural Hazards including Flood Prone Areas.
- Section 15 which deals with the Recreation Zone.

Both Sections 7A and 10 were amended through Plan Change C to provide for development of the Kikiwhenua Residential Area and appeals to these provisions have only recently been resolved.

The Plan Change Request seeks to incorporate the Whiskey Creek Residential Area into the Section 7A and Section 10 provisions with relatively few amendments.

The technical work completed for the Plan Change Request has covered a wide range of areas as detailed in Section 7 above and in Appendices.

All policies and rules in Section 7A that are generic to Greenfield Residential Areas are proposed to apply to the Whiskey Creek Residential Area. Importantly this requires at each stage of development the submission of a Comprehensive Development Plan to ensure that each stage is considered against the Structure Plan. It also includes policies relating to design principles, natural features, open space and location of neighbourhood centres.

These policies have been had regard to in the development of the Structure Plan. The key features have emerged from the design process which has been detailed in Section 7 and includes:

- A development area for approximately 157 dwellings with sections likely to average around 450 m^2 and a road structure that provides strong connections to the adjacent open space.
- The development of a 10 hectare public open space and reserve along the edge of the development based on the rehabilitation of the ephemeral Whiskey Creek tributary.
- Road connection to Benmore Avenue at the existing Meadowbrook Drive / Benmore Avenue intersection by means of a roundabout.
- Road connection to Rangitikei Line which will be restricted to left in and left out only.
- An area at the edge of the development identified for possible multi-unit medium density development for about 20 units.
- A site for a small neighbourhood centre which is also accessible to the existing residential area.
- Managed stormwater including an identified area for detention.
- Incorporation of the existing high pressure gas pipeline into proposed road reserve.
- A 40m building setback from Rangitikei Line to avoid effects from road noise.

The Structure Plan will be included in Section 7A as Map 7A.3.

To be consistent with other greenfield residential areas it is proposed that a definition of Whiskey Creek Residential Area be included in Section 4 Definitions that refers specifically to the land shown on the Structure Plan. Similarly, it is proposed that the definition of Pressure Sewer Areas also be amended to include the Whiskey Creek Residential Area.

Most of the relevant resource management issues for the Area are covered by the existing issues in section 7A.2. However, there is one exception for this greenfield area and that is the effect of development on the Lower Manawatu Drainage Scheme. It is, therefore, expressly proposed that this be added to Section 7A.2 as issue 10.

Existing Policy 2.7 relates specifically to the Kikiwhenua Residential Area and addresses the site specific issues of that greenfield residential area. It is proposed to similarly insert one additional policy that responds to the key development issues for the Whisky Creek Residential Area. These are the effects on the Lower Manawatu Drainage Scheme, restoration of Whiskey Creek, protection of the high pressure natural gas pipeline and vehicle access to the area. Also arising out of public consultation is an expressed preference that boundaries of existing residential properties align with the new lot boundaries. The final limb of the policy seeks to address this matter.

The following additional policy is, therefore, proposed.

8.8 To ensure that subdivision in the Whiskey Creek Residential Area:

- *Avoids, remedies or mitigates adverse effects on the Lower Manawatu Drainage Scheme*
- *Provides for restoration of the ephemeral tributary of Whiskey Creek as recreational reserve with quality recreational links.*
- *Provides appropriate setbacks of buildings from the natural gas pipeline that traverses part of the area and locates the pipeline within a public service corridor.*
- *Provides for vehicle access to both Benmore Avenue and Rangitikei Line.*
- *Has regard for the existing residential subdivision boundaries where it abuts Meadowbrook Drive.*

Reference to the Structure Plan is also required in Section 7A.4 – Methods.

The existing consent regime for subdivision of greenfield residential areas is based on a Restricted Discretionary resource consents with a wide range of discretionary matters.

The performance conditions to qualify as a Discretionary Activity focus on the submission of a Comprehensive Development Plan including expert reports on hydraulic and geotechnical engineering issues and an urban design statement.

In addition, Lot sizes are required to average between 500m^2 and 550m^2, with a minimum of 350 m^2 and a maximum of 1000m^2.

While additional provisions will apply to the multi-unit housing area which are addressed below, the existing average lot size is larger than is being targeted by this development. A smaller average of 400m^2 to 500m^2 is therefore proposed.

In addition, the neighbourhood centre development may involve a lot in excess of 1000m^2 and therefore this has been added to the existing balance lot exemption. As proposed, this would also apply to other greenfield residential areas. If this is not considered appropriate specific reference can be added to the neighbourhood centre shown on Map 7A.3.

The provisions also include extensive assessment criteria. Not all of these are relevant to the Whiskey Creek Residential Area but that can be addressed at the time of application assessment. There are also site-specific assessment criteria for the Whakarongo and Kikiwhenua Residential Areas. In many respects these reflect the site-specific policies which are a requirement to consider in assessing resource consent applications.

While it is not considered that additional assessment criteria are necessary for Whiskey Creek Residential Area they have been included for consistency with the approach to other Greenfield Residential Areas.

The next District Plan Section to address is Section 7 – The Residential Zone.

The provisions of this section apply to activities and built development on the land zoned Residential. Objectives 9, 10 and 11 and their respective policies apply specifically to Greenfield Residential Areas. Objective 9 has an urban design focus, Objective 10 addresses neighbourhood centres within Greenfield Residential Areas and Objective 10 relates to natural hazards.

None of the policies deal with multi-unit housing within Greenfield Residential Areas. As the proposed Structure Plan seeks to provide the option of multiunit housing within a specifically identified part of the Residential Area it is appropriate to recognise this with an additional policy.

Consequently, an additional Policy 9.7 is proposed as follows:

9.7 *To enable multi-unit housing development within the Whiskey Creek Residential Area in accordance with the Structure Plan (Map 7A.3).*

Rule 10.6.1.5 specifically deals with Performance Standards for dwellings and accessory buildings in the Greenfield Residential Areas. These include:

- Access and parking
- Building height recession planes and overlooking
- Separation distances
- Site area and coverage
- Acoustic insultation and setbacks
- On-site amenity
- Fencing
- Flood hazards

There are a number of aspects of these standards that are proposed to be amended through the Plan Change.

Two of them relate to development abutting residential properties on Meadowbrook Drive where it is appropriate that there be a reasonable building set back of 5 m which will limitation development to single storey dwellings.

The next is in relation to permeable areas within residential lots. The strategy for managing stormwater and achieving hydraulic neutrality involves a detention pond with a storage capacity of approximately 3700m^3. This is detailed later in this assessment and the Stormwater Management Plan by Mitch Hydro Ltd is included at Appendix 12. This requires there to be specific levels of permeability within each residential lot.

It is therefore appropriate to include a Performance Standard within Rule R10.6.1.5 relating specifically to Whiskey Creek Residential Area. It is noted that the standard for Kikiwhenua Residential Area is 30% of the net site area for each dwelling. In this case it is proposed to have different percentages depending on the size of the lots as follows:

- 25% of the net site area for each dwelling where this is between 171m^2 and 366m^2
- 30% of the net site area for each dwelling where this is between 367m^2 and 449m^2
- 35% of the net site area for each dwelling where this between 450m^2 and 561m^2
- 40% of the net site area for each dwelling where this between 562m^2 and 1050m^2

The next matter is in relation to acoustic insultation and setbacks from State Highway 3. Assessment of existing and future noise levels from traffic flows on State Highway in the specialist report by Acousafe Consulting and Engineering Ltd has led to the recommendation that the requirements for the Whakarongo Residential Area in relation to road noise also apply to the Whiskey Creek Residential Area.

This can be achieved by simply expanding the performance standard heading to include the Whiskey Creek Residential Area, even though the rule also includes measures for railway noise which is not relevant to Whiskey Creek.

Finally, a performance standard is proposed to be included to provide a 20 m setback for non accessory buildings from the high pressure gas pipeline as shown on the Structure Plan.

Non compliance with any of the standards triggers a restricted discretionary consent pursuant to Rule R10.6.3.2 and this includes Assessment Criteria. No changes to these provisions are proposed.

Rule R10.6.3.3 then deals with multi-unit residential development in identified multi-unit housing areas. While the focus of these areas is redevelopment within existing residential areas, the provisions have also been applied to the Hokowhitu Lagoon Residential Area.

While Council has indicated that these provisions will be reviewed in the future, they are generally fit for purpose for the multi-unit housing area within the Whiskey Creek Residential Area with some amendments. It is, therefore, proposed to amend the rule to include reference to the multi-unit residential area shown on Map 7A.3.

The provisions have different minimum site areas and gross floor areas for different groups of multi-unit housing areas. For Whiskey Creek Residential Area it is proposed that the minimum notional site area be 150 m^2 and the minimum unit size be 60 m^2. It is, therefore, proposed to amend Performance Standards i. b) and ii. b) to include specific reference to these standards also applying to the multi-unit housing area shown on Map 7A.3.

In addition, there are two standards for the multi unit residential area that are proposed to be amended. These are in line with other currently being developed Council plan changes enabling multi-unit residential development. They are an increase in the building height standard from 9 metres to 11 metres, and a change to the height recession plane from 2.8 m and 45 degrees to 3 metres and 60 degrees. These changes are to enable three level dwellings in the multi-unit residential area. It is also proposed that the front fence height of 0.9 m which applies to Greenfield Residential Area also apply to the multi-unit provisions.

Multi-unit housing that does not comply with the standards is a Discretionary Activity.

Importantly, rule R10.7.3.5 will also be applicable to the Neighbourhood Centre in terms of any commercial activity proposed as part of that area. This rule classes any commercial activity shown in a Comprehensive Development Plan in accordance with R7a.5.2.2 as a Restricted Discretionary Activity. This rule has been designed for the nature of commercial activity proposed in the Structure Plan. However, the rule confines its application to a land use consent applied for as part of the subdivision consent. It is not clear why this limitation has been applied. In most cases development of a commercial site can be expected to occur sometime after subdivision has been completed. The Plan Change Request, therefore, includes amendment to this rule to enable its application separately from the subdivision. It is appreciated that this has wider application and there may be other means of improving the effectiveness and efficiency of this rule that should be considered ahead of public notification. However, this specific amendment is proposed to clearly establish scope.

Adjoining the residential development area is a proposed reserve which involves the rehabilitation of both the permanently flowing tributary of Whiskey Creek and the upstream ephemeral section. This upper section will be realigned to maintain a setback of 55 metres from the residential

development. This is an important mitigation of risk of liquefaction lateral spread in the event of a seismic event.

This land will be zoned "Conservation and Amenity Zone". While currently the conservation values of the area are not high, rehabilitation and development of the reserve is expected to provide material conservation and amenity values incorporating a shared path loop track through the reserve and linking through the residential area to the Mangaone Stream. No buildings are anticipated within the reserve but public toilets could at some stage be provided. Cultural signage and information boards will also be included.

The remainder of the property will remain with its current Rural Zone.

The final element of the plan change request is to amend the Flood Prone Overlay. This area of flood prone land within the property will be reduced in line with the proposed earthworks for the site. The extent of this is a matter of some accuracy detail and will be authorised through resource consent approval which will provide full detail of the proposed earthworks.

As a result, it is proposed to make early application for the earthworks in parallel with the plan change request. This will allow the Plan Change to include the change to the Flood Prone Land on the Plan Map and include the specific reference to it taking effect only when the resource consent has been fully implemented.

9 NATIONAL POLICY CONTEXT

The National Policy Context is relevant to the assessment and determination of this plan change request.

Of greatest significance is the National Policy Statement on Urban Development 2020 (NPSUD) which came into effect on 20th August 2020 and replaced the National Policy Statement on Urban Development Capacity 2016.

Within this document Palmerston North City is classed as a Tier 2 local authority.

The objectives of the NPSUD include:

- Ensuring planning decisions improve housing affordability by supporting competitive and land and development markets.

- District Plans enable more people in areas of an urban environment where one or more of the following apply:
    - The area is near a centre zone or other area with employment opportunities.
    - The area is well serviced by existing or planned public transport.
    - There is high demand for housing land in the area, relative to other areas within the urban environment.

- Planning decisions relating to the urban environments take into account the principles of the Treaty of Waitangi.

- Local authority decisions are:

- Integrated with infrastructure planning and funding.
- Strategic over the medium and longer term.
- Responsive to proposals that add development supply.

Policies to achieve these objectives include:

- Planning decisions are to support well functioning urban environments.
- All local authorities are to provide sufficient development capacity to meet expected demand for housing over both the short medium and long term.
- The District Plan shall enable heights and density of urban form commensurate with the greater of:
  - The level of accessibility to active or public transport to a range of commercial activities and community services or
  - Relative demand for housing and business use on that location

Policy 8 is of particular relevance in that it requires local authorities to be responsive to plan changes that would add significantly to development capacity and contribute to well functioning urban environments, even if the development capacity is:

- Unanticipated by RMA Planning documents; or
- Out of sequence with planned land release

The National Policy Statement on Freshwater Management 2020 (NPSFM) is also potentially relevant given the relationship with Whiskey Creek and its proposed restoration. This NPSFM seeks to ensure that freshwater is managed to prioritise the health and well being of the ecosystem ahead of the needs of people.

It aims to ensure that freshwater is managed in an integrated way through a National Objectives Framework. Policies require no further loss of wetland or river extent. To achieve this, it inserts three policies into regional plans without recourse to the First Schedule process. The first relates to wetlands, the second to loss of river extent and the third to fish passage.

The definition of natural wetland includes any area of improved pasture that is dominated by exotic pasture species and is subject to temporary rainfall derived water pooling.

In this case the land involved is currently used for cropping and not pasture. There are no existing wetland areas although sheet flow of floodwater can occur as part of operation of the Flygers Line Spillway. The stormwater treatment may include the creation of new areas of managed wetland between the detention pond and Whiskey Creek and possibly other areas within the reserve. Further, the extent of stream will at least be maintained and if possible increased as part of the restoration of the stream habitat. The nature of the proposal is, therefore, fully in line with the intent and specific requirements of the NPSFM.

10 REGIONAL POLICY CONTEXT

The Regional Policy Statement and Regional Plans are contained in the compendium Horizons One Plan. As indicated above both the National Policy Statements above have implications for the

Regional Planning Context going forward. In particular, the Manawatu Wanganui Regional Council is a Tier 1 local authority in terms of the NPSUD and is required along with PNCC prepare a Future Development Strategy.

In terms of existing Regional Policy Statement policy the following objectives and policies are relevant.

Objective 3-3: The strategic integration of infrastructure^ with land^ use

Urban development occurs in a strategically planned manner which allows for the adequate and timely supply of land^ and associated infrastructure^.

Assessment: The site has long been signalled for development as part of the City Development Strategy and Housing and Future Development Plan. This plan change has taken some time to finalise because of the flood modelling challenges. However, it is intended to now complete this development as soon as possible to contribute to addressing a shortage of residential growth land in the City.

Objective 3-4: Urban growth and rural residential subdivision on versatile soils

To ensure that territorial authorities consider the benefits of retaining Class I and II1 versatile soils for use as production land when providing for urban growth and rural residential subdivision.

Assessment: The quality of the soils of the site have been carefully assessed and sit at the lower quality end of Class 2 soils. This is because of wetness limitations which make them unsuitable for horticulture and market gardening. The potential of the land is limited to arable drops such as the maize currently grown on the site.

Policy 3-4: The strategic integration of infrastructure with land use

Territorial Authorities must proactively develop and implement appropriate land use strategies to manage urban growth, and they should align their infrastructure asset management planning with those strategies, to ensure the efficient and effective provision of associated infrastructure.

Assessment: The development has limited infrastructure requirements. The development of the reserve will create a valuable asset and contribute to restoring the streams and waterways of the City. A roundabout connection to Benmore Avenue is required. The Council has considered the infrastructure requirements in its current work on the review of the Long Term Plan.

Policy 3-5: Urban growth and rural residential subdivision on versatile soils

In providing for urban growth (including implementing Policy 3-4), and controlling rural residential subdivision ("lifestyle blocks"), Territorial Authorities must pay particular attention to the benefits of the retention of Class I and II versatile soils for use as production land in their assessment of how best to achieve sustainable management.

Assessment: See above.

In relation to flood hazard the following are relevant.

Objective 9-1: Effects of natural hazard events

The adverse effects of natural hazard events on people, property, infrastructure and the wellbeing of communities are avoided or mitigated.

Assessment: The only natural hazard is one of flood risk which is part of a managed drainage scheme. The area of development will not be flood prone once earthworks are complete and the earthworks will not create adverse flood conditions for any other property.

Policy 9-2: Development in areas prone to flooding

a. *The Regional Council and Territorial Authorities must not allow the establishment of any new structure or activity, or any increase in the scale of any existing structure or activity, within a floodway mapped in Schedule J unless:*

i. *there is a functional necessity to locate the structure or activity within such an area, and*
ii. *the structure or activity is designed so that the adverse effects of a 0.5% annual exceedance probability (AEP) (1 in 200 year) flood event on it are avoided or mitigated, and*
iii. *the structure or activity is designed so that adverse effects on the environment, including the functioning of the floodway, arising from the structure or activity during a flood event are avoided or mitigated,*

in which case the structure or activity may be allowed.

b. *Outside of a floodway mapped in Schedule J the Regional Council and Territorial Authorities must not allow the establishment of any new structure or activity, or an increase in the scale of any existing structure or activity, within an area which would be inundated in a 0.5% AEP (1 in 200 year) flood event2 unless:*

i. *flood hazard avoidance is achieved or the 0.5% AEP (1 in 200 year) flood hazard is mitigated, or*
ii. *the non-habitable structure or activity is on production land, or*
iii. *there is a functional necessity to locate the structure or activity within such an area,*

in any of which cases the structure or activity may be allowed.

c. *Flood hazard avoidance must be preferred to flood hazard mitigation.*

d. *When making decisions under Policies 9-2(a) and b(i) regarding the appropriateness of proposed flood hazard mitigation measures, the Regional Council and Territorial Authorities must:*

i. *ensure that occupied structures have a finished floor or ground level, which includes reasonable freeboard, above the 0.5% AEP (1 in 200 year) flood level.*
ii. *ensure that in a 0.5% AEP (1 in 200 year) flood event the inundation of access between occupied structures and a safe area where evacuation may be carried out (preferably ground that will not be flooded) must be no greater than 0.5 m above finished ground level with a maximum water velocity of 1.0 m/s, or some other combination of water depth and velocity that can be shown to result in no greater risk to human life, infrastructure or property,*

iii. *ensure that any more than minor adverse effects on the effectiveness of existing flood hazard avoidance or mitigation measures, including works and structures within River and Drainage Schemes, natural landforms that protect against inundation, and overland stormwater flow paths, are avoided,*

iv. *ensure that adverse effects on existing structures and activities are avoided or mitigated,*

v. *have regard to the likelihood and consequences of the proposed flood hazard mitigation measures failing,*

vi. *have regard to the consequential effects of meeting the requirements of (d)(ii), including but not limited to landscape and natural character, urban design, and the displacement of floodwaters onto adjoining properties, and*

vii. *have regard to the proposed ownership of, and responsibility for maintenance of, the flood hazard mitigation measures including the appropriateness and certainty of the maintenance regime.*

e. *Within that part of the Palmerston North City Council district that is protected by the Lower Manawatū River Flood Control Scheme to a 0.2% AEP (1 in 500 year) standard, including the Mangaone Stream stopbank system, additional flood hazard avoidance or mitigation measures will generally not be required when establishing any new structure or activity or increasing the scale of any existing structure^ or activity.*

f. *Despite Policy 9-2(d)(i) and (ii), within that part of the Whanganui central city bounded by Bates Street, Ridgway Street and Victoria Avenue, flood hazard mitigation measures will not be limited to considering flood height and flow but will include such methods as resilient construction and emergency management systems.*

g. *This policy does not apply to new critical infrastructure*

Assessment: It is important to note that in Figure J2 the site is classified as a "floodable area" and not a "floodway". No habitable buildings are proposed to be within a floodable area. However, the proposed reserve will be within the floodable area and any proposed structures will need to have regard to the above policies.

The District Plan mapping of flood prone areas is currently consistent with Schedule J Figure J:2. However the earthworks will reduce the area of the site that is flood prone and the Plan Change request includes amendment to the District Plan Maps to recognise this once the earthworks have been implemented.

Policy 3-7: Energy efficiency*

a. *The Regional Council and Territorial Authorities must have particular regard to the efficient end use of energy in consent decision-making processes for large users of energy.*
b. *Territorial Authority decisions and controls on subdivision and housing, including layout of the site and layout of the lots in relation to other houses/subdivisions, must encourage energy-efficient house design and access to solar energy.*
c. *Territorial Authority decisions and controls on subdivision and land use must ensure that sustainable transport options such as public transport, walking and cycling can be integrated into land use development.*

Assessment: The Structure Plan design has had regard to the ability for house designs to maximise solar access and the location of the development is accessible to both the City Centre and local community facilities. The collector road will also be suitable for a public transport route.

11 DISTRICT CITY VIEW OBJECTIVES

The District Plan City View Objectives represent the broad outcomes that the Plan seeks to achieve. While this is a request to change the Plan, it should still have regard to the broader strategic direction of the existing overall District Plan.

Relevant objectives are considered below.

1. Planning for residential, industrial, commercial and rural-residential growth sustains a compact, orderly and connected urban form which avoids the adverse environmental effects of uncontained urban expansion into the rural zone.

Assessment: The proposal provides a strong connected edge to this part of the city and supports a compact form. The proposal is also well integrated with the existing Cloverlea neighbourhood and the structure plan provides an "orderly" development.

2. The provision of infrastructure, particularly within identified growth areas, shall be efficient, timely, environmentally sensitive and economically sustainable.

Assessment: The Plan Change Request Structure Plan signals a specific roading layout and connections and also specific proposals for stormwater infrastructure. Other services extensions are efficient and economically sustainable.

3. The integrated and efficient provision of, and access to, infrastructure, network utilities and local services is facilitated for all residents.

Assessment: The proposal supports local services and will provide a significant new reserve and neighbourhood centre for the wider local community.

5. A variety of high quality residential living environments are provided to satisfy the needs of all residents.

Assessment: The proposed design has a strong urban design basis and reserve interface providing potential for high quality living environments.

8. The distinctive rural and urban character of the City is recognised and a clear differentiation is provided regarding subdivision, development and servicing expectations within rural and urban areas.

Assessment: The proposal forms a clear edge to the City and enhances the north west gateway. It helps differentiate between urban and rural environments.

9. Subdivisions, buildings and infrastructure are designed and constructed to promote a coordinated, healthy and safe environment.

Assessment: The Structure Plan and landownership will ensure a coordinated approach to the development. The reserve develop will also support active lifestyles and quality recreation connections.

10. The visual appeal of the City is enhanced.

Assessment: The reserve development will restore a tributary of Whiskey Creek and its ephemeral connections. The development of this reserve will materially add to the visual appeal of the City at an important gateway.

11. The principles of good urban design are given effect to for all new subdivisions, urban intensification and major building developments, particularly those located within the City Centre or fronting key transportation routes.

Assessment: The development concept has been built on strong urban design principles.

15. Active engagement from tangata whenua within resource management decisions.

Assessment: The development of this Plan Change request has included active involvement of mana whenua.

17. The natural and cultural heritage features of the City are preserved and enhanced, including the margins of the Manawatu River and sites of significance to tangata whenua.

Assessment: The reserve development will make a significant contribution to restoration of the natural heritage of the City.

19. The effects of natural hazards are avoided or mitigated taking into account the effects of climate change and the significant social disruption caused by natural hazard events.

Assessment: The proposal has had specific regard to protecting the efficient functioning of floodwater diversion from the Flygers Spillway and will not result in adverse flood effects for any other properties.

21. A broad range of recreation and leisure opportunities are provided for in the City which contribute towards an enhanced quality of life.

Assessment: The proposed reserve will incorporate a shared path recreational loop linking with the Mangaone Stream walkway and will add to the recreational opportunities of the local area.

22. Appropriate noise standards are in place to protect noise sensitive activities.

Assessment: The noise effects of traffic on SH3 have been considered and appropriate standards proposed.

24. All forms of transport, including public transport, walking, cycling and private vehicles are adequately provided for to assist with sustainable energy use and a healthy lifestyle.

Assessment: The road network proposed provides for private vehicles, cycling and walking and also potentially provides for public transport.

It can reasonably be concluded from the above that the proposal has a strong fit with the relevant City View Objectives.

12 SECTION 32 ASSESSMENT

The process of development of the Plan Change Request has provided for careful evaluation of alternatives throughout the process. Inherently a process of this nature is an iterative process with expert inputs from a wide range of experts influencing the design process.

Section 32 requires that there be evaluation of the extent to which the objectives of the proposal are the most appropriate way to achieve the purpose of the Act and examine whether the proposed provisions are the most appropriate way to achieve the objectives by assessing the efficiency and effectiveness of other reasonably practicable options.

The objectives of the proposal can be described as to achieve:

- A feasible development with a mix of housing density, housing type and price point.
- A sustainable and liveable neighbourhood that provides a high level of amenity and connectivity and incorporates the revitalisation of Whiskey Creek.
- A maximised development area without adversely affecting the flood management function of the area.
- Appropriate management of environmental risks associated with liquefaction, stormwater discharges, environmental noise and existing infrastructure.

These objectives themselves have specific regard to the purpose of the Act. Evaluation of their appropriateness can be considered in the context of the District Plan zoning of the site. In this regard there are a number of alternatives including:

1. Retaining the existing rural zoning.

2. Applying the District Plan Rural Residential overlay enabling development at a density of 1 dwelling per 1 – 2 hectares where there is no flood risk.

3. Residential zoning of land not subject to flood risk.

Evaluation of these options has been undertaken at a high level using a multi criteria assessment approach. The criteria reflect the purpose of the Act in this context and the alternatives have been rated according to the following scale.

Fully supports/exceeds	
Supports in most regards	
Partial support of criteria	
Minor alignment only	
Does not support / undermines	

The assessment is set out in the table below.

Assessment Topic & Criterion	Scenario 1: Rural Zone	Scenario 2: Rural Residential	Scenario 3: Part Residential
1.0 STRATEGIC ALIGNMENT			
A1.1 Aligns with high-level PNCC strategies and plans. • Correlates well with city's economic development. • Supplies new housing in step with population growth. • Adds to range of housing options available.	• No contribution to city growth targets. • No increase in housing choice. • Area not flood prone would be land bank for future development.	• Little contribution to city growth targets. • Little increase in housing choice. • Some potential for future intensification.	• Significant contribution to city growth targets. • Contributes to housing choice.
A1.2 Promotes responsible growth. • Directs greenfield development to low-impact locations. • Produces cohesive well-integrated outcome. • Locates new housing near existing amenities.	• Under-utilised low-impact location. • Hard urban rural interface • No improvement of weak city edge.	• Under-utilised low-impact location. • Partially integrated with rural zone. • Some improvement of weak city edge.	• Moderately well utilised low-impact location. • Comprehensively planned. • Moderately well integrated with residential zone. • Stream corridor within walking distance. • Improvement of weak city edge.
A1.3 Protects high-value agricultural land. • Retains high-class soils in agricultural use. • Avoids fragmentation of productive land.	• All land in agricultural production. • All large rural lots.	• Some land in agricultural production. • Smaller rural lots.	• Some land in agricultural production. • Some large rural lots. • Co-location of new and existing housing.
A1.4 Improves water quality. • Restores mauri and mana of waterways. • Treats waterways as integrated system. • 'Naturalises' tributaries of Manawatū River.	• No restoration of mauri and mana. • No overall management. • No naturalisation of landscape/waterways.	• No systematic restoration of mauri and mana. • No overall management. • Potential for some naturalisation (lifestyle lots).	• No systematic restoration of mauri and mana. • Potential for some overall management. • Potential for some naturalisation (green space).

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A1.5 Increases biodiversity. • Improves quality of natural environment. • Restores natural ecologies (incl. streams/wetlands). • Contributes to network of biodiversity corridors.	• No improvement in natural environment. • Potential for further degradation of waterway. • Impediment to biodiversity corridors.	• Some improvement in natural environment. • Potential for further degradation of waterway. • Potential impediment to biodiversity corridors.	• Potential for some improvement (green space). • Potential for further degradation of waterway. • Potential impediment to biodiversity corridors.
2.0 FEASIBILITY			
A2.1 Meets economic feasibility criteria. • Generates acceptable development costs. • Offers adequate yield at the right price point. • Allows phased development with built-in flexibility.	• Minimal development cost. • No housing yield. • Potential for future development.	• Low development cost. • Low housing yield. • Some potential for future development.	• Moderate development cost. • Moderate housing yield. • Limited potential for phased development.
A2.2 Minimises risks from natural hazards. • Manages threat from flooding. • Manages threat from liquefaction. • Manages threat from slope failure (lateral spreading). • Builds in resilience.	• Low SW impact (very low density) • Low flood risk (very low density) • Little risk from liquefaction (very low density).	• Low SW impact (low density) • Low flood risk if structures confined to flood free land. • Low risk from liquefaction (low density). • Little built-in resilience (single access).	• Potential for low-impact SW management • Low flood risk if structures confined to flood free land. • Some risk from liquefaction (mod. density) • Built-in resilience (multiple access).
A2.3 Minimises risks associated with consenting process. • Presents strong rationale for change. • Minimises reverse sensitivities. • Benefits neighbours and other stakeholders.	• Zero risk (no DP change).	• Some risk (DP change required for rural res overlay). • Loss of agricultural production. • Low impact on remaining rural activities. • Low impact on neighbouring residential zone. • Established urban fringe development pattern.	• Some risk (DP change required). • Loss of agricultural production. • Some impact on remaining rural activities • Some impact on neighbouring residential zone. • Contiguous with existing residential area. • Some increase in recreational amenities.

3.0 IDENTITY			
A3.1 Creates a strong place-based identity. • Possesses recognisable formal/spatial components. • Organises components in clear relationships. • Offers a point of difference.	• No distinctive feature. • Retention of arbitrary rural/urban boundary.	• No distinctive feature. • Improved transition at rural/urban interface.	• Some distinctiveness / partial open space edge. • Recognition of natural rural/urban boundary. • Conspicuous rear boundaries at city gateway. .
4.0 CONNECTIVITY			
A4.1 Contributes to good city-wide network structure. • Supports multi-modal movement network. • Connects existing/new residential areas with wider city. • Extends city-wide network of greenways/off-road trails.	• No improvement of movement network. • No new through connections. • No extension to greenways or off-road trails.	• No improvement of movement network. • No new through connections. • No extension to greenways or off-road trails.	• Some improvement in network (PT viability). • New north-south connection to Flygers Line. • Moderate internal connectivity. • Expansive rural views from through-route. • Potential addition to greenways. • Off-road paths limited to short mid-block links.
5.0 GOOD NEIGHBOUR			
A5.1 Demonstrates good urban design at macro level. • Amplifies natural features and existing landscape. • Provides coherent addition to existing urban structure. • Connects and consolidates existing residential areas.	• No enhancement of existing landscape. • No increase in coherence of urban form.	• Some enhancement of existing landscape. • Clearer transition at rural/urban interface. • Contiguous with existing residential area. • Limited connection with neighbouring suburb.	• Some enhancement of landscape (flood plain). • Contiguous with existing residential area. • Some connection with neighbouring suburb.

6.0 ECOLOGY			
A6.1 Improves environmental quality. • Reinstates, restores and protects local habitats. • Creates ecological corridors (esp. along waterways). • Encourages revegetation (min. 10% indigenous cover).	• No improvement in natural environment. • Potential degradation of waterway. • Impediment to biodiversity corridors.	• Some improvement in natural environment. • Potential degradation of waterway. • Potential impediment to biodiversity corridors. • Some indigenous revegetation (private lots).	• Potential for restored habitats (green space). • Potential for degradation of waterways. • Potential impediment to biodiversity corridors. • Some indigenous vegetation (incl. street trees). • Potential connection to Mangaone Stream.

A visual summary of the assessment results is tabulated below and if all criteria are treated as being of similar relative importance then a Part residential development of the site is the most appropriate way to achieve the purpose of the Act.

Assessment Topics & Criteria	Scenario 1: Rural	Scenario 2: Rural Residential	Scenario 3: Part Residential
A1.1 Aligns with high-level PNCC strategies and plans.			
A1.2 Promotes responsible growth.			
A1.3 Protects high-value agricultural land.			
A1.4 Improves water quality.			
A1.5 Increases biodiversity.			
A2.1 Meets economic feasibility criteria.			
A2.2 Minimises risks from natural hazards.			
A2.3 Minimises risks associated with consenting process.			
A3.1 Creates a strong place-based identity.			
A4.1 Contributes to good city-wide network structure.			
A5.1 Demonstrates good urban design at macro level.			
A6.1 Improves environmental quality.			

Section 32 also requires specific evaluation of the proposed plan provisions. While there are multiple aspects to the specific changes and additions to the provisions, they are for the most part captured in some manner in the proposed Structure Plan and Indicative Masterplan. This stage of the Section 32 evaluation therefore focusses on evaluating other reasonably practicable design options for achieving the objectives. This similarly takes a Multi Criteria Assessment approach and evaluates options that were considered in the design process and resulted in the current Structure Plan.

It is also important to recognise that the provisions proposed seek as much as possible to fit the format, style and nature of the existing District Plan and particularly Section 7A Greenfield Residential Areas. This section has been through a number of plan changes and therefore associated Section 32 scrutiny and evaluation. In particular, Plan Change C sought to make this a section that can accommodate additional greenfield areas as they arise. It is, therefore, not appropriate to re-evaluate the content of Section 7C and this makes it even more appropriate to focus on alternative design options for the Structure Plan / Master Plan.

The three options evaluated are identified in Section 3.4 of the Urban Design Report in Appendix 3.

Option 1: Business As Usual.

Described as a hybrid geometry to maximise the number of standard sized lots with uniform lot orientation and road connection to Flygers Line.



Figure 13: Option 1.

The key characteristics of this option are:

• Low-moderate market risk, some variation/mix in density and dwelling type.

- Predominantly north-south lots with sub-optimal sun access.
- Good levels of open space amenity.
- Partly responsive to local landscape but discontinuous edge.
- Allows for ecological corridors.
- No local centre. Moderate external connectivity to Benmore Avenue and Flygers Line.
- Legible street pattern with clear geometry and range of street types.
- Potential for high-quality streetscape.

Option 2: Landscape – led Approach.

Described as a 'distorted grid' street structure that provides views of the stream corridor at the end of each street and establishes clear sightlines with a continuous green amenity corridor along the boundary.

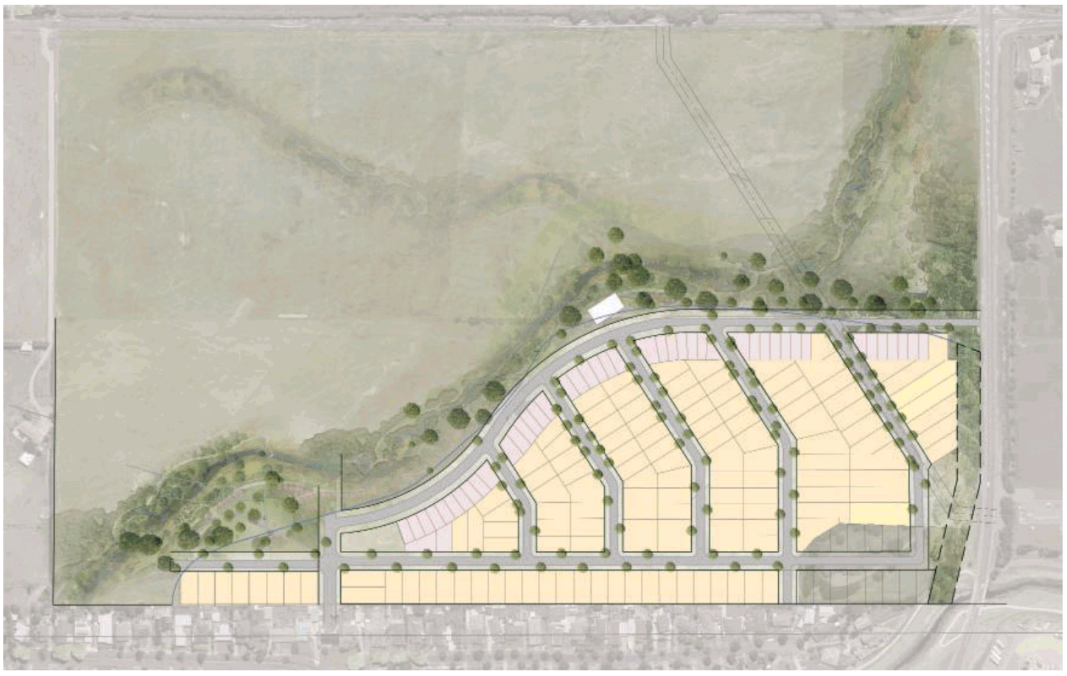

Figure 14: Option 2.

The key characteristics of this option are:

- Moderate-high housing yield, moderate market risk associated with multi-unit housing.
- Significant variation/mix in density and dwelling type and local centre provision.
- Predominantly east-west lots offering good orientation for sun.
- High levels of open space amenity.
- Responsive to local landscape.
- Naturalisation of Whiskey Creek corridor, extension of ecological corridors.
- Integrated low-impact SW management.
- Significantly improved urban edge.
- Good external connectivity to Benmore Avenue and Rangitikei Line.
- Strong support for PT/active modes.

• Extension to recreational trails, including the Mangaone Stream.
• Moderate internal connectivity but limited east-west connection.
• Legible street pattern and clear geometry.
• Potential for high-quality streetscape.

Option 3: Neighbourhood Network.

Described as a formal grid structure providing different densities, lot orientations and bringing open spaces into the developed area.

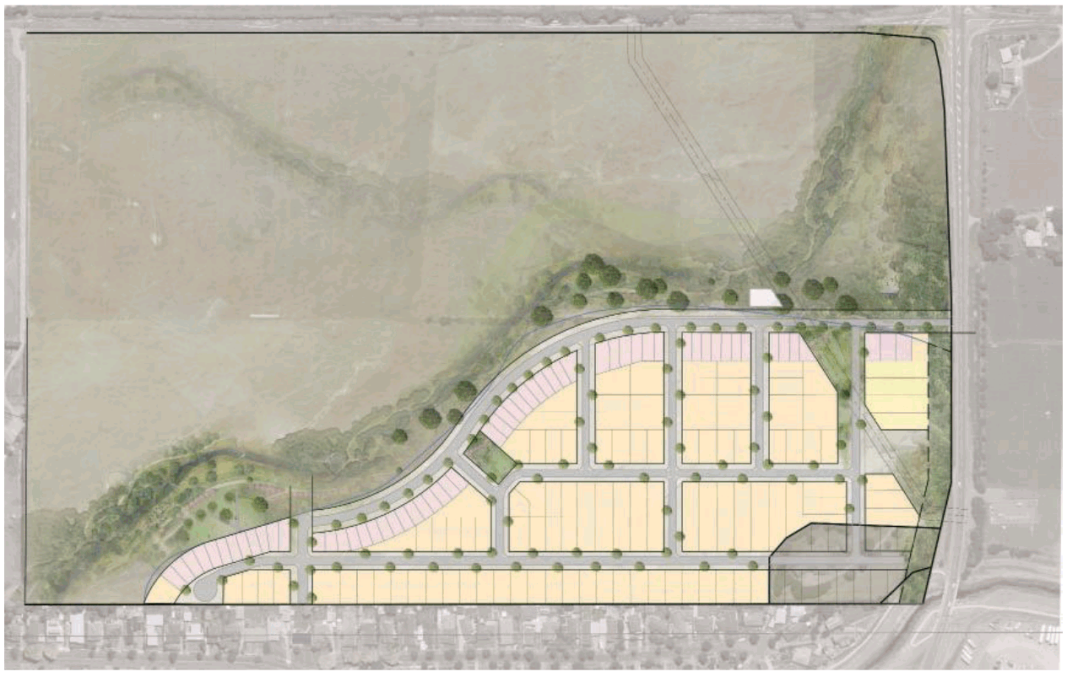

Figure 15: Option 3.

The key characteristics of this option are:

• Moderate-high housing yield, moderate-high market risk associated with multi-unit housing.
• Local centre provision.
• Significant variation/mix in density and dwelling type.
• Very high open space amenity.
• Responsive to local landscape.
• Naturalisation of Whiskey Creek corridor, extension to ecological corridors.
• Integrated low-impact SW management.
• Significantly improved urban edge.
• Good external connectivity to Benmore Avenue and Rangitikei Line.
• Strong support for PT/active modes.
• Extension to recreational trails including the Mangaone Stream.
• High internal connectivity with small blocks and no cul-de-sacs.
• Legible street pattern.
• Potential for high-quality streetscape.

The Multi Criteria Assessment of these options is set out in the table below.

Assessment Topic & Criterion	Option 1: Hybrid Geometry	Option 2: Deformed Grid	Option 3: Neighbourhood Network
1.0 STRATEGIC ALIGNMENT			
B1.1 Recognises Rangitāne as mana whenua. • Recognises value of landscape and natural systems. • Acknowledges and protects cultural sites. • Expresses Māori culture in the physical environment.	• Potential for Rangitāne stewardship of restored habitats. • Potential for interpretive material (reserves, trails). • Potential for Te Reo placenames.	• Potential for Rangitāne stewardship of restored habitats. • Potential for interpretive material (reserves, trails). • Potential for Te Reo placenames.	• Potential for Rangitāne stewardship of restored habitats. • Potential for interpretive material (parks, reserves, trails). • Potential for Te Reo placenames.
2.0 FEASIBILITY			
B2.1 Meets economic feasibility criteria. • Generates acceptable development costs. • Offers adequate yield at the right price point. • Allows phased development with built-in flexibility.	• Well-proportioned lots in compact layout. • Moderate yield; low-moderate market risk (medium density). • Part single-loaded thoroughfare (Road 1). • Potential for phased development.	• Well-proportioned lots in compact layout. • Moderate-high yield; moderate market risk (med density). • One single-loaded thoroughfare (Road 1). • Potential for phased development.	• Well-proportioned lots in compact layout. • Moderate-high yield; moderate-high market risk (med density). • One single-loaded thoroughfare (Road 1). • Potential for phased development.
B2.2 Minimises risks associated with consenting process. • Presents strong rationale for change. • Minimises reverse sensitivities. • Benefits neighbours and other stakeholders.	• Sympathetic interface with Meadowbrook Drive. • Localised impact on Benmore Ave (new street, vehicles). • Added value for Robertson block. • Creek corridor buffer to rural zone. • Significant increase in local open space amenity.	• Sympathetic interface with Meadowbrook Drive. • Localised impact on Benmore Ave (new street, vehicles). • Added value for Robertson block. • Creek corridor buffer to rural zone. • Significant increase in local open space amenity.	• Sympathetic interface with Meadowbrook Drive. • Localised impact on Benmore Ave (new street, vehicles). • Added value for Robertson block. • Creek corridor buffer to rural zone. • Significant increase in local open space amenity.



B2.3 Contributes to a sustainable utility network. • Provides integrated cost-effective wastewater system. • Encourages reduced domestic demand for water. • Encourages reduced flow of wastewater.	• Potential for low impact SW management • Some impact on demand.	• Potential for low impact SW management • Moderate impact on demand.	•Potential for low impact SW management • Moderate impact on demand.
3.0 IDENTITY			
B3.1 Creates a strong place-based identity. • Possesses recognisable formal/spatial components. • Organises components in clear relationships. • Offers a point of difference.	• Strong spatial hierarchy. varied density/lot type/streetscape. • Local centre at threshold with existing residential area. • Local centre linked to creek corridor reserve/trails. • Distinctive naturalised creek corridor.	• Spatial hierarchy but some repetition. Varied density/lot type. • Commercial facility linked to creek corridor reserve/trails. • Distinctive naturalised creek corridor.	• Strong spatial hierarchy (varied density/lot type/streetscape). • Retail facility linked to creek corridor reserve/trails. • Neighbourhood park linked to creek corridor reserve/trails. • Distinctive naturalised creek corridor.
B2.2 Responds to threshold between city/plains. • Accesses unique visual and recreational assets. • Creates gateway feature on city's northern fringe.	• Urban edge follows natural feature (flood plain). • Perimeter street and creek corridor reserve along urban edge. • Frequent direct connections to creek corridor/urban edge. • Terrace housing "sentinel" along part of urban edge.	• Urban edge follows natural feature (flood plain). • Perimeter street and creek corrido reserve along urban edge. • Frequent very direct connections to creek corridor/urban edge. • Terrace housing "sentinel" along full urban edge.	• Urban/rural boundary follows natural feature (flood plain). • Perimeter street and creek corridor reserve along urban edge. • Frequent connections to creek corridor/urban edge. • Terrace housing "sentinel" along full urban edge.

4.0 CONNECTIVITY			
B4.1 Ensures movement is safe, efficient and enjoyable. • Provides efficient routes for through movement. • Calms vehicular traffic on local streets. • Includes recreational circuits and off-road trails.	• Alternative routes to/from all locations. • One efficient through-route. • Expansive views from perimeter street (Road 1). • Quiet local streets. • Trail between Whiskey Creek and Mangaone Stream.	• Alternative routes to/from all locations. • One efficient through-route. • Expansive views from perimeter street (Road 1). • Quiet local streets. • Trail between Whiskey Creek and Mangaone Stream.	• Alternative routes to/from all locations. • One efficient through-route. • Expansive views from perimeter street (Road 1). • Quiet local streets. • Trail between Whiskey Creek and Mangaone Stream.
B4.2 Produces good local network structure. • Produces interconnected multi-modal network. • Possesses a clear internal street hierarchy. • Connects existing/new residential areas. • Extends local network of greenways/off-road trails.	• Good internal connectivity (alternative routes). • Highly legible street pattern (well-developed hierarchy). • Moderately good external connectivity (two links). • Expansive views from perimeter street. • Trail between Whiskey Creek and Mangaone Stream.	• Good internal connectivity (alternative routes). • Legible street pattern (some repetition). • Moderately good external connectivity (two links). • Expansive views from perimeter street. • Trail between Whiskey Creek and Mangaone Stream.	• Good internal connectivity (alternative routes). • Highly legible street pattern (well-developed hierarchy). • Moderately good external connectivity (two links). • Expansive views from perimeter street. • Trail between Whiskey Creek and Mangaone Stream.
B4.3 Encourages balanced mix of transport modes. • Offers transport options (alternatives to private vehicle). • Encourages shift to public transport and active modes. • Supports walking/PT with high quality public realm.	• Good support for PT, walking and cycling. • Good connections to existing trail networks. • Walkable destinations (local centre and reserves).	• Good support for PT, walking and cycling. • Good connections to existing trail networks. • Walkable destinations (retail facility and reserves).	• Good support for PT, walking and cycling. • Good connections to existing trail networks. • Walkable destinations (retail facility, park and reserves).

5.0 GOOD NEIGHBOUR			
B5.1 Demonstrates good Urban Design at local level. • Amplifies natural features and existing landscape. • Acknowledges existing built form/open space patterns. • Consolidates residential character.	• Expressed natural limit to urban growth. • Contiguous with existing built-up area. • Enhanced open space network. • Clear priority for residential development.	• Expressed natural limit to urban growth. • Contiguous with existing built-up area. • Enhanced open space network. • Clear priority for residential development.	• Expressed natural limit to urban growth. • Contiguous with existing built-up area. • Enhanced open space network. • Clear priority for residential development.
B5.2 Supports high-quality public realm. • Encourages street-facing development. • Sets the scene for high quality streetscape. • Supports CPTED principles (incl. passive surveillance).	• Predominantly street-facing development. • Active interesting frontages (few rear lots, limited garaging). • Custodial presence (legible routes, visible signs of inhabitation).	• Predominantly street-facing development. • Active interesting frontages (few rear lots, limited garaging). • Custodial presence (legible routes, visible signs of inhabitation). • Some deep lots with potential for long driveways.	• Predominantly street-facing development. • Active interesting frontages (few rear lots, limited garaging). • Custodial presence (legible routes, visible signs of inhabitation). • Some deep lots with potential for long driveways.
B5.3 Delivers services equitably and effectively. • Meets existing/projected community services demand. • Ensures services are accessible and pleasant to use. • Accommodates a wide range of users and activities.	• Open space amenity exceeds status quo . • Extended network of recreational trails and cycleways. • Green connections between new and existing reserves. • Highly accessible open spaces. • Highly accessible local centre to new and existing areas.	• Open space amenity exceeds status quo. • Extended network of recreational trails and cycleways. • Green connections between new and existing reserves. • Highly accessible open spaces. • Accessible retail facility.	• Open space amenity exceeds status quo. • Extended network of recreational trails and cycleways. • Green connections between new and existing reserves. • Highly accessible open spaces. • Accessible retail facility.

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ITEM 7 - ATTACHMENT 1

6.0 ECOLOGY			
B6.1 Incorporates sustainable SW management practices. • Manages SW responsibly on site. • Incorporates natural waterways in SW system. • Reduces sedimentation by limiting runoff/erosion. • Treats stormwater prior to discharge. • Avoids large point source discharge.	• Accommodates detention pond. • Controlled discharge to creek corridor • Potential for SW treatment • No-build area within flood plain.	• Can accommodate detention pond with some amendment. • Controlled discharge to creek corridor • Potential for SW treatment • No-build area within flood plain.	• Can accommodate detention pond with some amendment. • Controlled discharge to creek corridor • Potential for SW treatment • No-build area within flood plain.
B6.2 Raises amenity value of ecological areas. • Increases accessibility and visibility of ecological areas. • Joins Whiskey Creek and Mangaone Stream corridors. • Creates destinations and promotes recreational use.	• Highly accessible open spaces. • Naturalised creek corridor. • Green corridor between Whiskey Creek and Mangaone Stream. • Good support for walking and cycling. • Street trees on most thoroughfares. • Local centre linked to open space.	• Highly accessible open spaces. • Naturalised creek corridor. • Green corridor between Whiskey Creek and Mangaone Stream. • Good support for walking and cycling. • Street trees on most thoroughfares. • Local centre linked to open space.	• Highly accessible open spaces. • Naturalised creek corridor. • Green corridor between Whiskey Creek and Mangaone Stream. • Good support for walking and cycling. • Street trees on most thoroughfares. • Local centre linked to open space.
7.0 HOUSING CHOICE			
B7.1 Provides volume, choice and flexibility. • Helps meet existing and projected demand. • Responds flexibly to changing demographics. • Provides choice of dwelling type.	• Moderate housing yield. • Some variation in density/lot type.	• Moderately-high housing yield. • Significant variation in density/lot type (range of dwellings).	• Moderately-high housing yield. • Significant variation in density/lot type (range of dwellings).

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A visual summary of the assessment is set out below in accordance with the adopted rating scale of:

Fully supports/exceeds	
Supports in most regards	
Partial support of criteria	
Minor alignment only	
Does not support / undermines	

Assessment Topics & Criteria	Option 1: Hybrid Geometry	Option 2: Deformed Grid	Option 3: Neighbourhood Network
B1.1 Recognises Rangitāne as mana whenua.			
B2.1 Meets economic feasibility criteria.			
B2.2 Minimises risks associated with consenting process.			
B2.3 Contributes to a sustainable utility network.			
B3.1 Creates a strong place-based identity.			
B2.2 Responds to threshold between city/plains.			
B4.1 Ensures movement is safe, efficient and enjoyable.			
B4.2 Produces good local network structure.			
B4.3 Encourages balanced mix of transport modes.			
B5.1 Demonstrates good Urban Design at local level.			
B5.2 Supports high-quality public realm.			
B5.3 Delivers services equitably and effectively.			
B6.1 Incorporates sustainable SW management practices.			
B6.2 Raises amenity value of ecological areas.			

The Proposed Structure Plan and Illustrative Masterplan seeks to combine the best aspects of the three options evaluated above. In addition, it provides a mix of densities and uses. The multi-unit housing area is located on Road 1 at the Whiskey Creek Reserve edge. A mixed-use commercial neighbourhood centre is located near the link to Benmore Avenue. This promotes activation and definition of the 'absolute urban edge'. Lot configuration along the southern boundary allows a complementary relationship with the existing urban fabric.

The design provides a high level of external and internal connectivity by means of

(i) a connected spatial network,
(ii) a legible spatial structure and
(iii) a street hierarchy
(iv) external connections to Rangitikei Line and Benmore Avenue.

The street and block structure connects the Site with Whiskey Creek reserve and avoids the need for cul-de-sacs. Efficiently sized north-south blocks create east-west lots that maximise sun. The extended green corridor proposed along the revitalised Whiskey Creek corridor will include shared path and walkway system providing recreational loops and connections to the Mangaone Stream walkway. Formal and informal play spaces and observation will be incorporated into the reserve. Combined with the local street network, well-connected open spaces create characterful 'place elements' that contribute to a unique Whiskey Creek identity.

The Masterplan provides new blue and green infrastructure for the Site integrated into the overall development. The main stormwater detention area is located outside of the floodplain and allows flows back into Whiskey Creek through a wetland. This will improve water quality and revitalise the ephemeral stream bed. Options for separate discharge to the reserve will also be considered at the subdivision consent stage.

The Whiskey Creek green corridor with its ephemeral wetlands, stream bed and restored area of lowland forest could become a significant habitat node to the north of the city. It can function as a stepping stone connecting areas such as Manderson's Bush with the suburban environment.

13 RISKS AND UNCERTAINTIES

Section 32 (2)(c) requires assessment of the risk of acting or not acting if there is uncertain or insufficient information about the subject matter of the provisions.

In this case there is considered to be sufficient information and certainty to proceed and therefore this assessment is not required. Appropriate expertise has been applied in each aspect of the proposal and there has been extensive consultation with stakeholders such as NZTA, PNCC, Horizons and iwi as well as the local community.

Importantly, the proposed provisions do not permit development without further scrutiny through restricted discretionary resource consents at both the territorial authority and regional council level. This will require information to a more detailed level and certainty including appropriate management plans. This allows any remaining uncertainty to be addressed through consent conditions.

14 CONCLUSIONS

The Plan Change Request for Whiskey Creek Residential Area has been carefully investigated with recognised experts and tested in terms of Section 32.

The resulting proposal provides significant community and environmental benefits while ensuring the flood management performance and infrastructure is protected.

The development is expected to add to the residential land supply to the extent of 150 – 160 dwellings.

While there has been extensive consultation with interested and affected parties this request will now be considered by Palmerston North City Council and then notified for submissions which will be considered at a hearing before this Plan Change has effect.

In parallel with this it is proposed to advance detailed resource consents for earthworks so that this land supply can be expedited.

APPENDIX 1

CERTIFICATES OF TITLE

RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD

Search Copy

R.W. Muir
Registrar-General
of Land

Identifier **360745**

Land Registration District **Wellington**

Date Issued 15 August 2007

Prior References
WN493/128

Estate Fee Simple

Area 8623 square metres more or less

Legal Description Lot 1 Deposited Plan 389924

Registered Owners
Dobbin Investments Limited

Interests

771525 Gazette Notice declaring portion of State Highway No. 3 to be a limited access road - 30.1.1969 at 2:55 pm

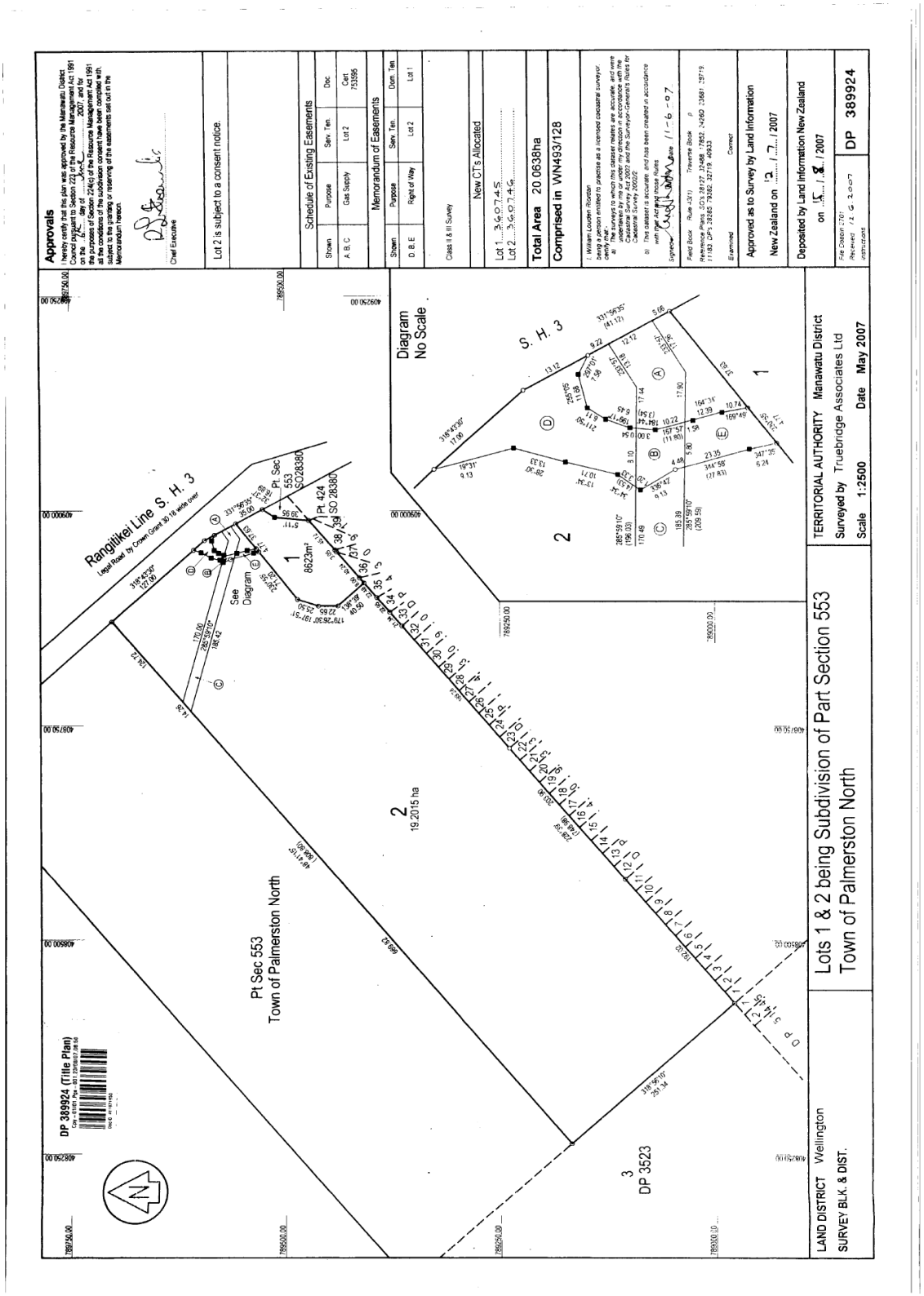
6109041.4 Mortgage to Bank of New Zealand - 9.8.2004 at 9:00 am

Appurtenant hereto is a right of way created by Easement Instrument 7503733.4 - 15.8.2007 at 9:00 am

The easements created by Easement Instrument 7503733.4 are subject to Section 243 (a) Resource Management Act 1991

10201260.5 Variation of Mortgage 6109041.4 - 19.10.2015 at 10:42 am

Identifier **360745**



RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD

Search Copy

R.W. Muir
Registrar-General
of Land

Identifier	**360746**
Land Registration District	**Wellington**
Date Issued	15 August 2007

Prior References
WN493/128

Estate	Fee Simple
Area	19.2015 hectares more or less
Legal Description	Lot 2 Deposited Plan 389924
Registered Owners	

Flygers Investment Group Limited

Interests

753595 Pipeline Easement Certificate pursuant to Section 70 of the Petroleum Act 1937 creating a gas supply easement over part marked A,B,C on DP 389924 - 6.8.1968 at 10.12 am

771525 Gazette Notice declaring portion of State Highway No. 3 to be a limited access road - 30.1.1969 at 2:55 pm

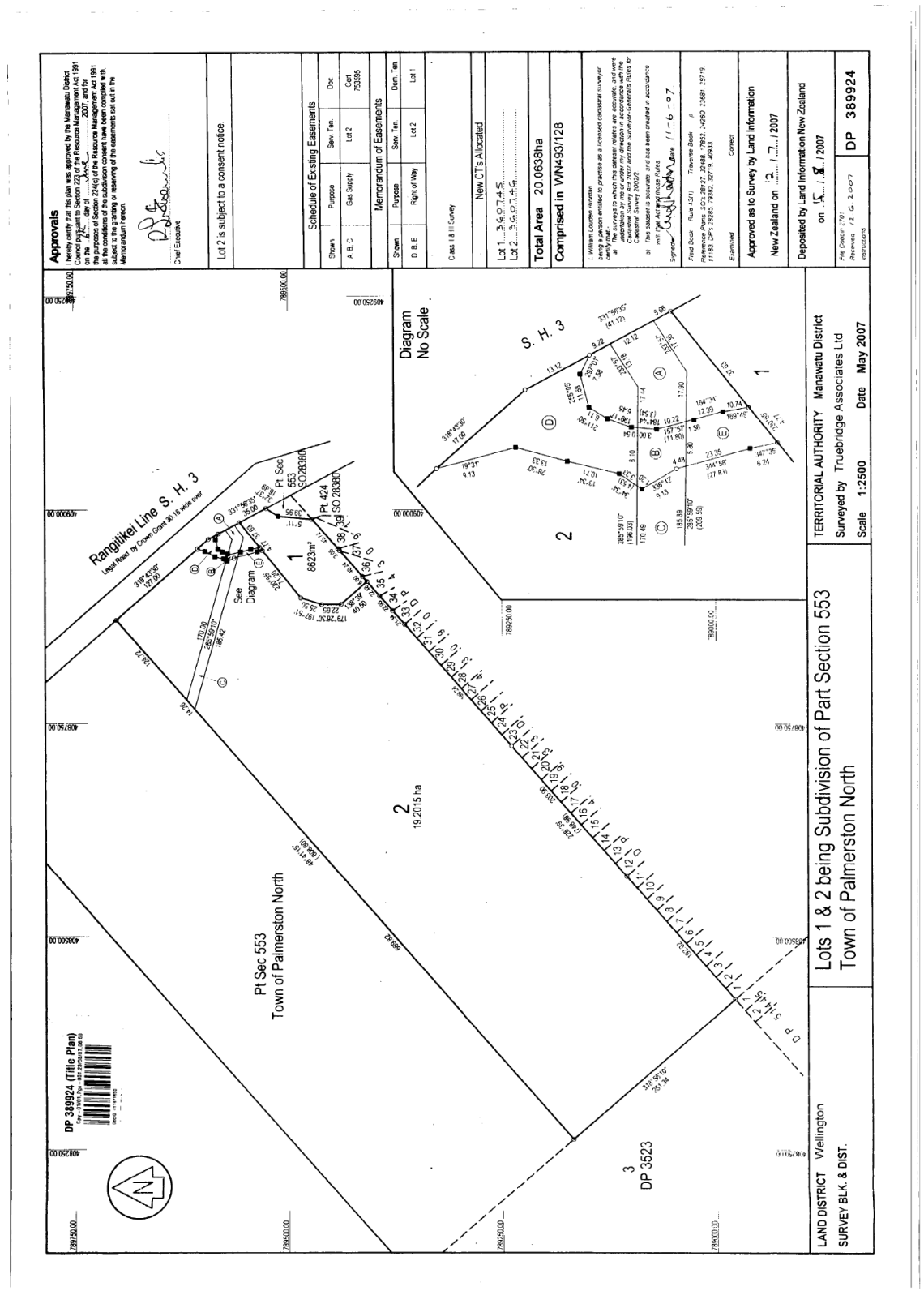
948353.1 Variation of the terms of Pipeline Easement Certificate 753595 - 16.9.1988 at 1.52 pm

7503733.2 Consent Notice pursuant to Section 221 Resource Management Act 1991 - 15.8.2007 at 9:00 am

Subject to a right of way over part marked D,B,E on DP 389924 created by Easement Instrument 7503733.4 - 15.8.2007 at 9:00 am

The easements created by Easement Instrument 7503733.4 are subject to Section 243 (a) Resource Management Act 1991

Identifier **360746**



RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD

Search Copy

R.W. Muir
Registrar-General
of Land

Identifier **WN10B/294**

Part-Cancelled

Land Registration District **Wellington**

Date Issued 21 July 1972

Prior References
WN29/81

Estate	Fee Simple
Area	20.2343 hectares more or less
Legal Description	Part Section 553 Town of Palmerston North

Registered Owners

Flygers Investment Group Limited

Interests

753595 Pipeline Certificate pursuant to Section 70 of the Petroleum Act 1937

771525 Gazette Notice declaring portion of State Highway No.3 to be a limited access road

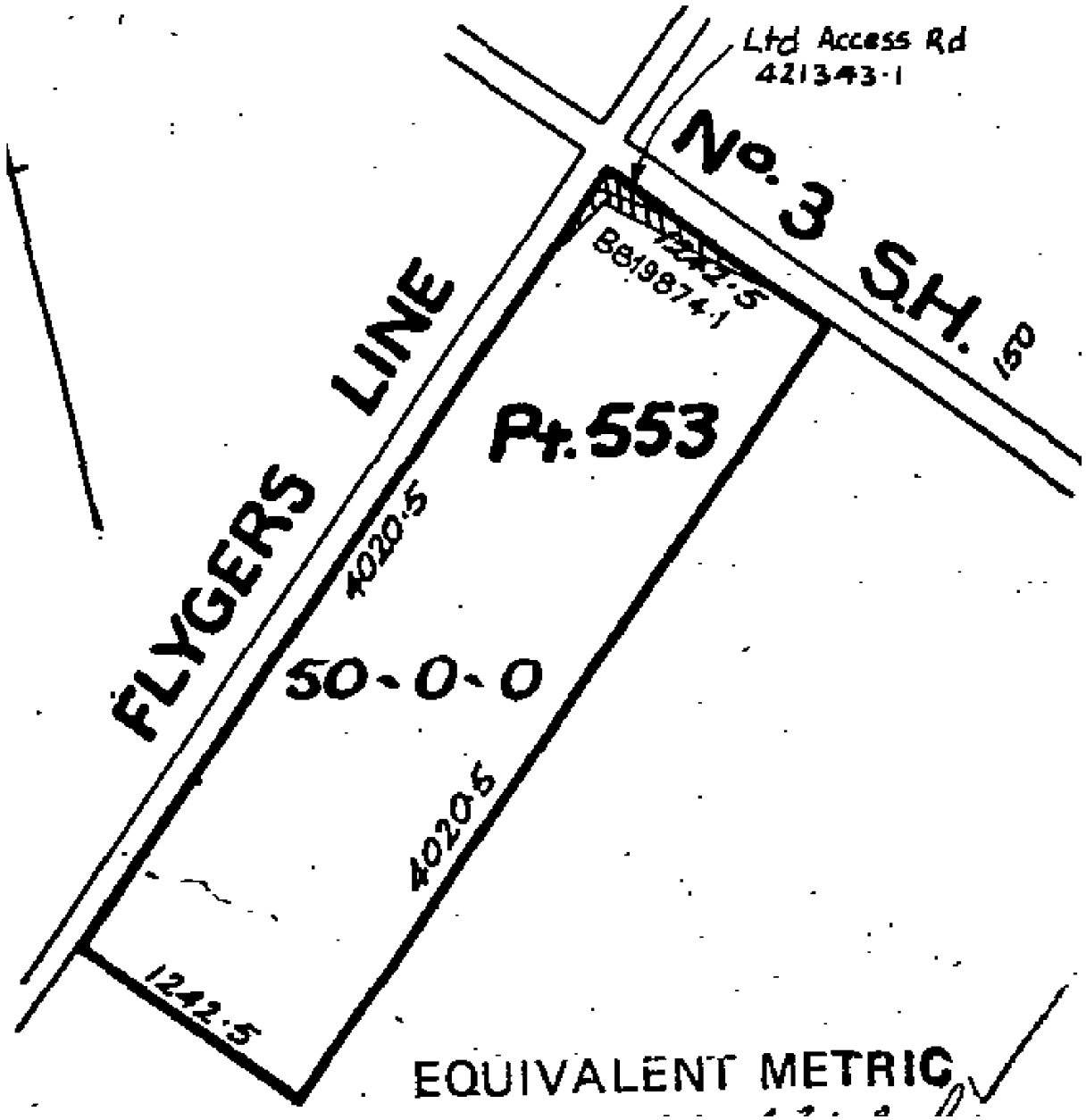
421343.1 Gazette Notice declaring part 224mm² (hatched black hereon) taken for a limited access road from and after 27th November 1980 - 22.12.1980 at 11.20 am

948354.1 Variation of the terms of Pipeline Easement Certificate 753595 - 16.9.1988 at 1.52 pm

B702612.2 Compensation Certificate pursuant to Section 19 Public Works Act 1981 - 19.1.1999 at 1.58 pm

B819874.3 Gazette Notice declaring part (1143mm², Section 5 SO 38312) is acquired for limited access road and has become road, limited access road and State Highway and vested in the Crown on 25.1.2001 - 30.1.2001 at 9.00 am

Identifier **WN10B/294**



RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD

Search Copy

R.W. Muir
Registrar-General
of Land

Identifier	**WN13A/672**
Land Registration District	**Wellington**
Date Issued	23 May 1974

Prior References
WN10D/573

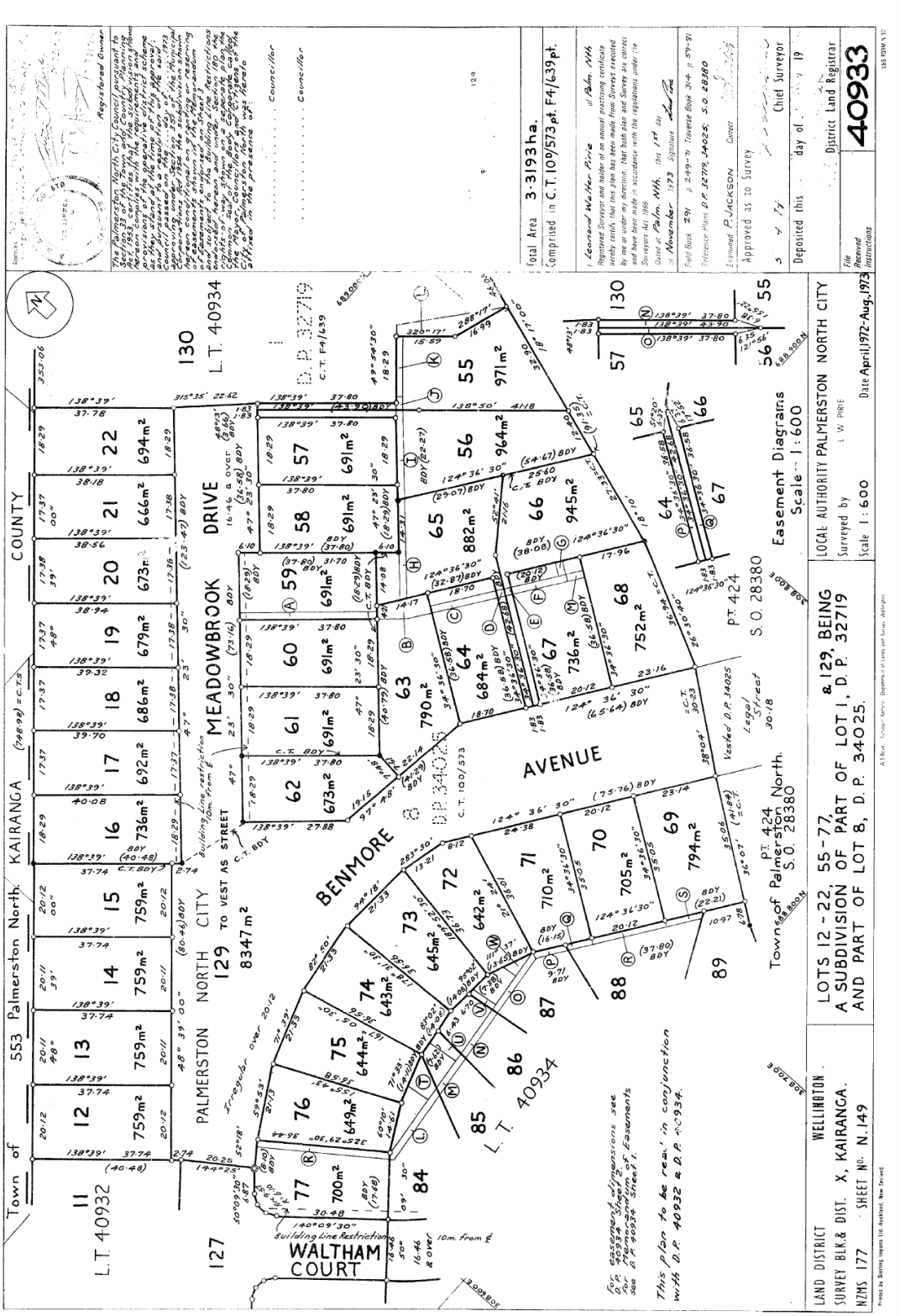
Estate	Fee Simple
Area	759 square metres more or less
Legal Description	Lot 14 Deposited Plan 40933
Registered Owners	

Flygers Investment Group Limited

Interests

11516672.3 Mortgage to Redhib Limited - 16.8.2019 at 3:17 pm

Identifier **WN13A/672**



APPENDIX 2

FLYGERS LINE HYDRAULIC MODELLING:
DHI LTD.

The expert in WATER ENVIRONMENTS

DHI

MEMO

To:	Kevin Judd
Cc:	Paul Mitchell
From:	Nuno Jeronimo
Date:	18-10-2019
Subject:	Flygers Line Hydraulic Modelling

1. Introduction

DHI has been commissioned by the Flygers Investment Group Limited to assist in the quantification of floodplain management effects associated with the earthworks for a proposed residential development adjoining Flygers Line and Rangitikei Line.

The objective of this memorandum is to provide sufficient detail for a plan change application on the recommended solutions for floodplain management as a result of the proposed development, in order to meet the requirements of Horizons Regional Council One Plan.

Hydraulic modelling for the area was previously undertaken by Philip Wallace (2005[1] and 2008[2]) and by DHI (2015[3]). The level of spatial detail of the aforementioned projects was insufficient to perform a detailed hydraulic analysis of the residential development.

2. Standards

The following District and Regional Council documents identify the design requirements for the stormwater system for the development, which is located in a designated "floodway" (Appendix A). The main documents to consider are the Palmerston North City Council (PNCC) District Plan and the Horizons Regional Council (HRC) One Plan.

Key considerations for the design from these documents are:

- **Climate Change:** The previous standard for delineating flood prone areas of a 1% AEP event was modified to 0.5% AEP to account for the likely effects of climate change.
- **Hydraulic neutrality:** hydraulic neutrality must be achieved such that any more than minor adverse impacts of a 0.5% AEP of the design are avoided or mitigated.
- **Property Floor Levels and Flood Hazard allowances:** building sites for habitable structures must have a finished floor that includes freeboard above the 0.5% AEP flood level; and an identified safe wading zone, if not flood free, no greater than 0.5m above finish ground level and with a maximum water velocity of 1 m/s or any other combination of flood hazard which does not represent risk to human life, infrastructure of property.

[1] Flygers Line Commercial Development: 2-D Hydraulic Modelling of Flood Hazard, P. Wallace, 2005.

[2] Hydraulic Modelling of Lower Manawatu Scheme – No Stopbanks Scenario, P. Wallace, 2008.

[3] Mangaone Stream and Taonui Basin – Floodplain Hazard Assessment, DHI, 2007.

- **Design Requirements:** Design elements must comply with the NZ4404:2010 Land Development and Subdivision Infrastructure Standard. The responsibility for maintenance is part of the requirements and the flood hazard mitigation measures must address the likelihood of failing.

The Lower Manawatu River Flood Control Scheme (LMS), which includes the Mangaone Stream stopbank system, provides flood protection, in a section of the PNCC district, to a 0.2% AEP (1 in 500 year) standard. The Benmore Avenue – Whiskey Creek stopbank (as part of the LMS City Reach Flood Protection Upgrade Project), was scheduled (2018) to be upgraded to the same design standard, adjoining the Flygers Line Spillway stopbank.

3. Site Description

The site is described as Part Section 553 TN OF Palmerston North, Lot 1 DP 389924 and Lot 2 DP 389924 and covers an area of 0.4 km². The site has a steep gradient (Appendix B), with levels across the site (from northeast to southwest) between RL29.0 and RL24.5m (over 800m).

The property is impacted by two major drainage systems, the Taonui Stream from the west and the Mangaone Stream spillway from the north. The two current overland flow paths (OFP) onsite run from the Whiskey Creek drain, at the intersection of Flygers Line with Rangitikei Line. One of the flow paths, a shallow drain, crosses the property and discharges at the southern limit, below an existing dwelling; during larger storm events, the aforementioned flow path merges with a second OFP, an incised drain that runs through the middle of the property and connects, at the south-eastern end, to the Benmore Avenue stormwater network (PNCC).

The site is currently covered in pasture and it is crossed by the North Island gas transmission pipeline.

Proposed Earthworks

The concept for the site's earthworks has been designed by Resonant and was provided to DHI as an AutoCAD format (.dwg), on the 11th January 2019 and the subsequent email dated 18th of March with additional detail (contours) on the surface model.

The intention of the proposed earthworks is to create suitable level platforms for the proposed buildings. The concept design includes 0.112 km² of earthworks, with a predominance of cut (- 20 000 m³) and reworking of the drainage across the site, particularly, a deviation of the upper section of the drain that runs through the middle of the property (between Part Section 553 TN OF Palmerston North and Lot 2 DP 389924). The earthworks are shown in Figure 1.

Some further refinement will be required during detailed design to ensure the proposed options for flood storage can be accommodated in an effective way so as not to restrict access to the buildings during a floodway or localised storm event.

The original conceptual earthworks design displaces 9,400 m³ of stormwater outside the property limit, with an increase in depth of up to 14cm (above the existing 40cm flood depth), adjacent to the Benmore Avenue stopbank, beyond the southern property limit.

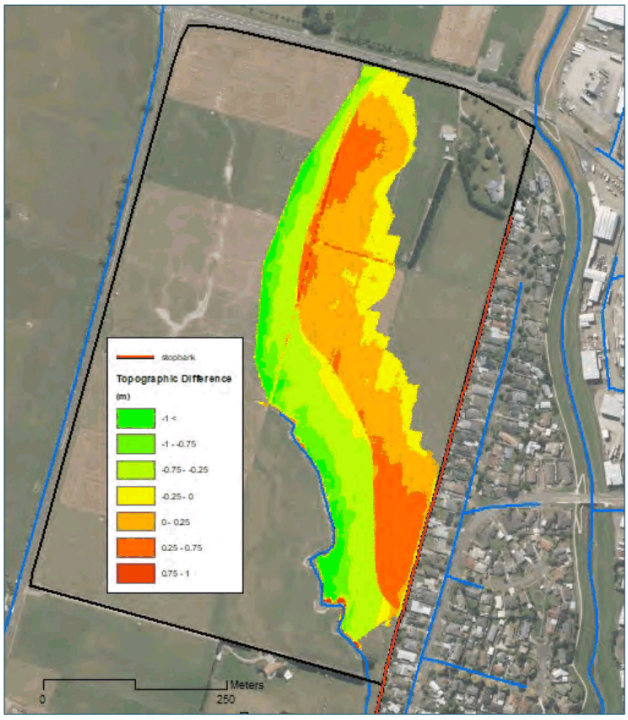


Figure 1 - Flygers Development Earthworks (original concept design)

4. Hydraulic Modelling

A MIKE FLOOD (MIKE 11 + MIKE 21) rectangular grid model of the Whiskey Creek was developed for the site, using boundary conditions from the existing Taonui hydraulic model, more specifically, flows from the 0.5% AEP Existing Development (ED) scenario.

A digital elevation model (DEM) was provided by Horizons on the 21st December 2018, the most recent information available for the study area; this 1m DEM was produced from LiDAR survey obtained in 2005, with a vertical error of ±0.5m. The DEM was combined with survey performed by Resonant on the development site to create a replica of the existing scenario. The topographical model was further refined, excluding most of the baseline survey (with a lower horizontal accuracy), and the 1m DEM was used instead onsite, enforced with the addition of stopbank survey and onsite drain/channel survey obtained by Resonant.

The topography was resampled to create a refined model of the area of interest (2m²), which defined the existing situation. The model initially extended from Milson Line/Mangaone spillway to the intersection of Whiskey Creek with Cloverlea Road (approximately); the downstream boundary was then brought closer to the site, at Rongotea Road, since there was a need to improve run times and no artificial backwater effects were created by the boundaries at the area of interest. The Mangaone Spillway is included in the 2D component of the model with the labyrinth weir raised (Appendix C).

Main culverts were added into the model, at Rangitikei Line, Flygers Line, Gillespies Line and Benmore Avenue. The information was obtained by DHI on the 25th February 2019.

Flygers baseline model follows the assumptions of the Taonui hydraulic model, but includes additional structures and a topographical resolution 12.5x higher, allowing for a better representation of linear features, which could act as blockage or preferential flow paths upstream and within the site.

5. Options Assessment

The initial assessment results show that major infrastructure assets downstream of the development site are not impacted by the development, but there is an increase of flood levels of 14cm downstream the property limit.

These initial results assumed the Flygers Line/Benmore stopbank provides the designed protection level for the 95 Benmore Avenue. Figure 2 shows an analysis comparing the stopbank levels from Horizons (1m) DEM and the surveyed info, overlayed with the Existing Development and Proposed Development levels, for the initial assessment. The graph indicates that by using the raw DEM levels (1m) or the surveyed information we should expect different flood overtopping conditions for Benmore Avenue, at the south-eastern corner of the property boundary.

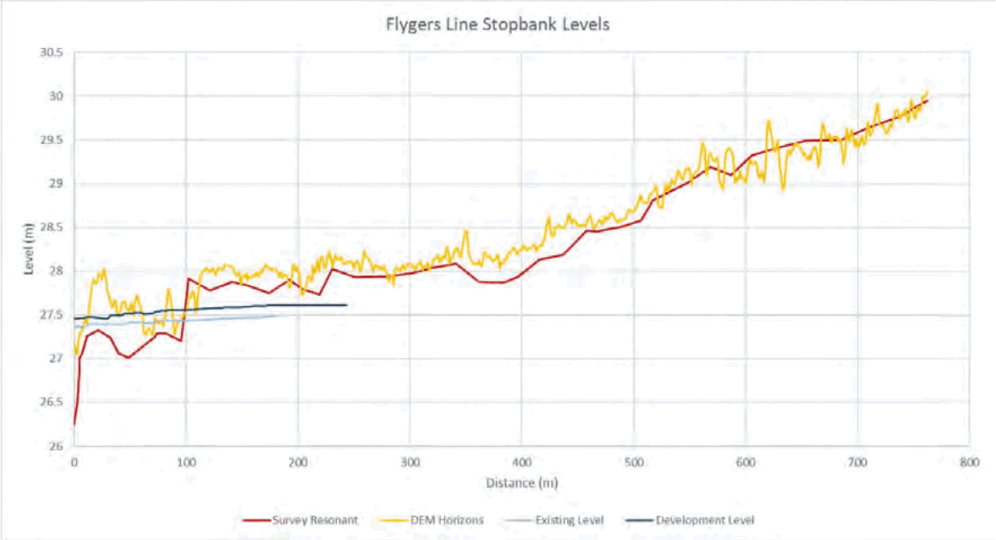


Figure 2 - Flygers Line Stopbank Levels

The initial results have highlighted the need to consider a number of Low Impact Design (LID) measures for the conveyance of Mangaone spillway floodwaters through the property site, in order to retain storage and mitigate any potential adverse impacts of the development offsite.

The options were assessed on the basis of the design principals for the site, which in summary provides for hydraulic neutrality and design requirements.

Table 1 Summary of Stormwater Options to provide attenuation for the site

Stormwater Measure	Commentary
Causeway/bund	Located at the transition between a decrease and increase in flood levels within the property, but also at the southern limit of the property. The aim was to restrict flow to pre-earthworks rates.

Stormwater Measure	Commentary
Detention Pond	A detention pond with a storage of 4600m³ adjacent to Rangitikei Line; this feature would include one outflow control of 225mm.
Swale/diversions	A series of swales were considered across the site to improve connectivity between areas of increased and decreased flood levels.
Benmore Avenue Stopbank upgrade	The stopbank elevations included in the 1m Horizons DEM are conservative and survey from Resonant has shown that it does not provide a 0.5% AEP protection to Benmore Avenue. The flood management of the Flygers site would be simplified with the stopbank upgrade.

Stormwater management from the residential development will be separately assessed, where other LID features could be considered, such as, soakpits, wetlands and permeable pavement.

Options were assessed on the basis of the design principals for the site, which in summary provides for hydraulic neutrality and design requirements.

- **Option 1 – Retention pond and island**

Based on the results of the initial assessment and the estimated volume displaced, a retention pond with a storage of 4600m³ was tested. The outflow discharge was controlled.

In addition, an island at the bottom of the property was included. This island used mostly dry land and its goal was to force flow towards the western side of the property.

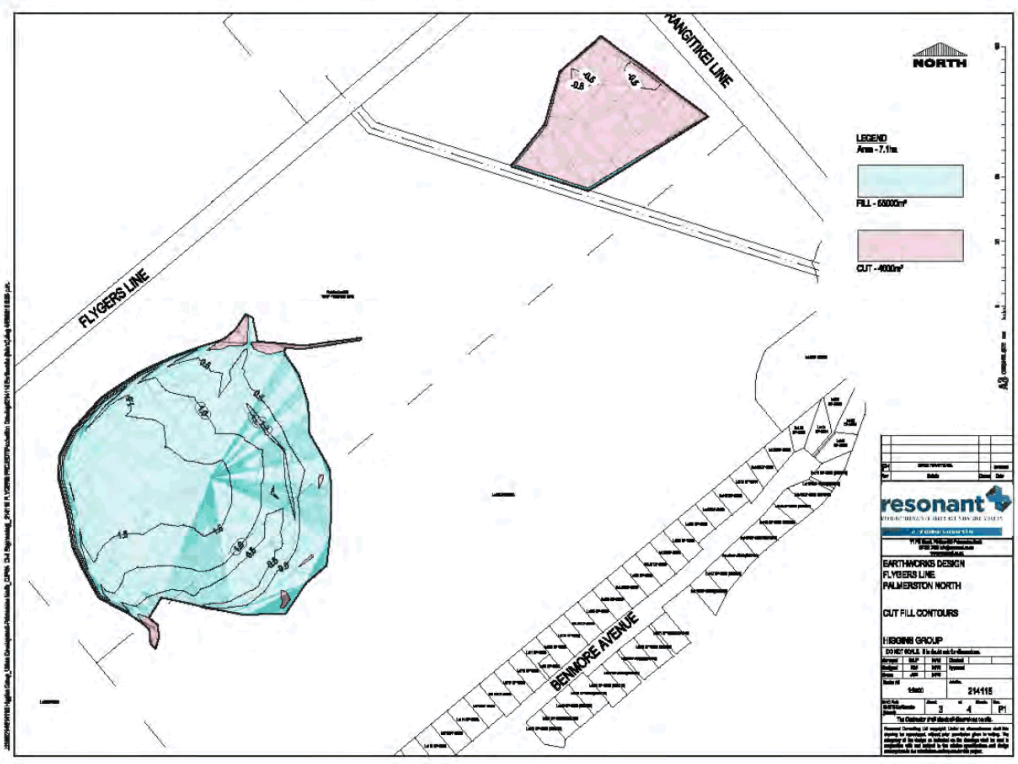


Figure 3 - Concept Design Option 1

- **Option 2 – Causeway and bund**

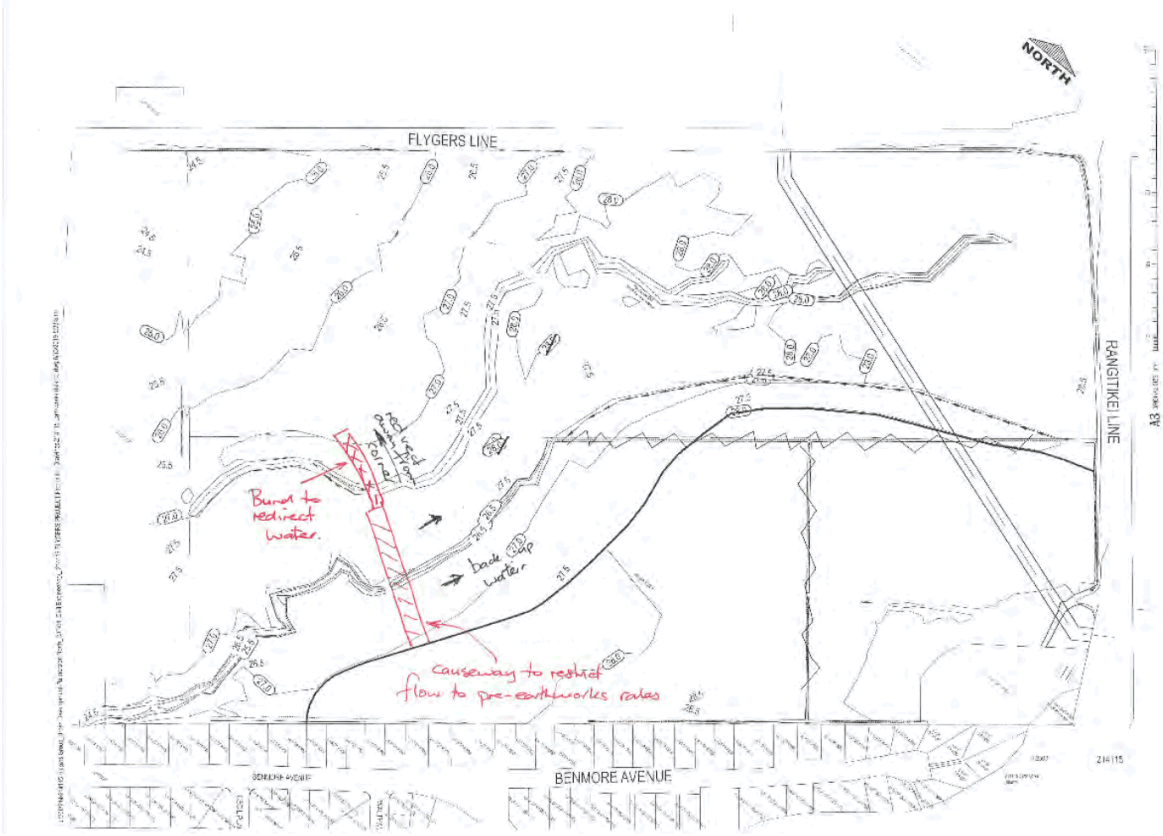


Figure 4 - Concept Design Option 3

The option two included a causeway across the main drain which would restrict flows and retain flood volumes, diverting them to Flygers Line; a bund would be placed at the western end for diversion purposes. The causeway would be placed where the effects of the original proposed earthworks started to create an increase in flood levels downstream.

- **Option 3 – Swales and bund at property limit**

Option 2 with narrowing the blockage and a bund across the property limit at RL26.5m, with two independent retention ponds (left and right bank) and a 1.35m culvert on the main drain (causeway) and improved connectivity between the main OFPs.

- **Option 4 – Online storage in dry land and increased diversion**

Option 4 would retain the main drain configuration (open), but bund the surrounding area to RL 27.5m, with one breach (2m) towards the property limit (to the east), next to the stopbank. The smaller drain, to the west, would also be bunded to 27.5m, with a single 2m breach, with the aim to throttle the flow and divert it further west.

A series of “dry” islands (hatched polygons below) would also be flattened to 27.5m, to ensure connection between the throttled area and the west.

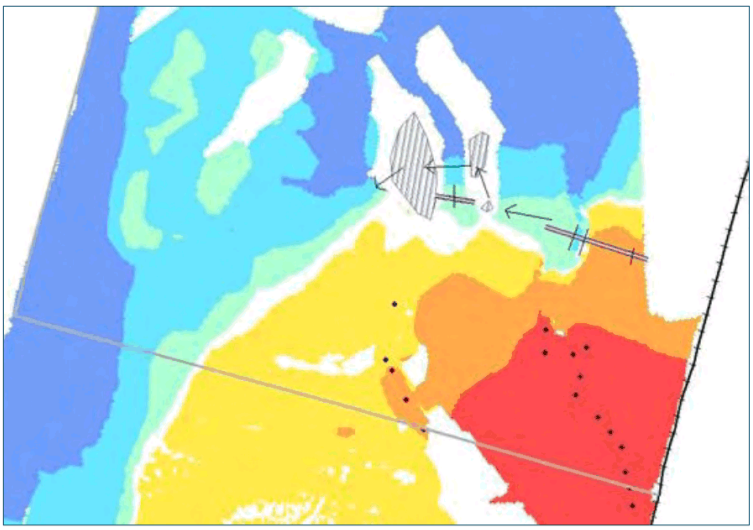


Figure 5 - Option 4 diversion mechanisms

- **Option 5 – Online and offline storage with scruffy domes**

The creation of two online ponds immediately upstream the property limit and divert flow at two locations (upstream and downstream the hollow polygons). This option would add to Option 4 by increasing the diversion towards the west, lowering the levels.

Two scruffy domes would be connected to one offline storage each to divert water once a certain threshold was reached; this scenario would work in conjunction with a bund at the property limit.

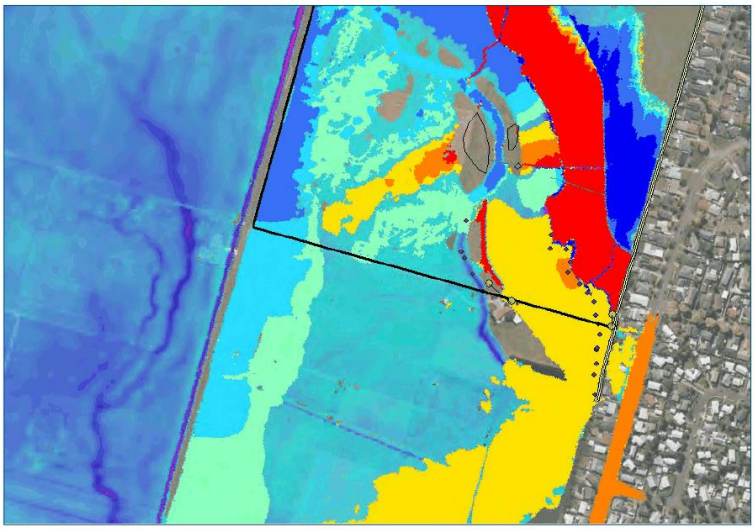


Figure 6 – Option 5 scruffy-domes (green dot)

- **Option 6 – Online and offline storages with improved diversions**

This option includes some of the features from previous options; a swale connecting the two drains (RL26.85m), and minor swales (yellow lines) connecting overland flow paths to the western side of the property via two online ponds (orange polygons). These flow paths are enforced with bunds (RL27.77m) across both drains (red line), but an opening of 2 meters. Two additional retention ponds (light green polygons) were located at the property limit to store peak flood volumes; the features are flooded from the southern end at RL27.6m (western pond) and RL27.4m (eastern pond), with an invert of RL25m.

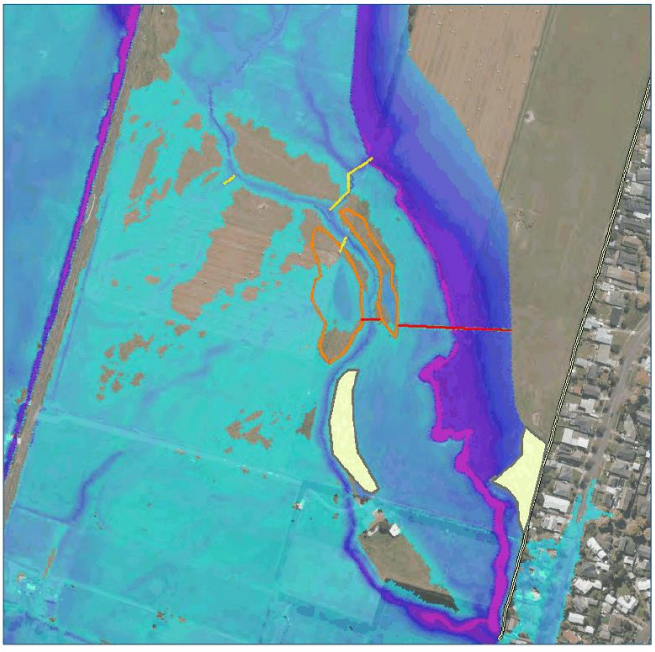


Figure 7 - Option 6 flood retention and diversion mechanisms

The following assumptions were included in all earthworks models/options:

- Land roughness is currently based on the previous Taonui model (25m coarse);
- Structures were modelled without blockages;
- The Flygers/Benmore stopbank uses surveyed levels;
- The local runoff, from the Benmore Avenue stormwater network, which drains into a Whiskey Creek OFP, was not incorporated into the model.

6. Preferred option

Option 6 is the only solution that manages the flood risk to a less than minor impact to adjacent properties. The number of measures included in this option exceed other options, but it is an example of floodplain management that focuses mainly on earthworks, rather than control structures, which are more difficult to maintain. During the detailed design phase these measures can be further refined since their individual impact was not quantified.

This preferred option allows the original design to be maintained while keeping the impact on the downstream area as minor or less than minor (±50mm change in flood level). Annex D shows the existing flood depth results, the proposed earthworks with Option 6 flood depth, level, and a difference map of flood depths between Option 6 and the existing situation.

Recommended building levels will follow existing guidelines, with an appropriate freeboard to be agreed with the HRC/PNCC.

7. References

Horizons Regional Council (2014); *Lower Manawatu Scheme & Ashhurst Stream Scheme.* Palmerston North.

Horizons Regional Council (2014); *One Plan Chapter 9 – Natural Hazards.* Palmerston North.

Palmerston North City Council (2018); *District Plan Section 22 - Natural Hazards.* Palmerston North.

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Appendix A – One Plan Schedule J: Floodways and Areas Prone to Flooding

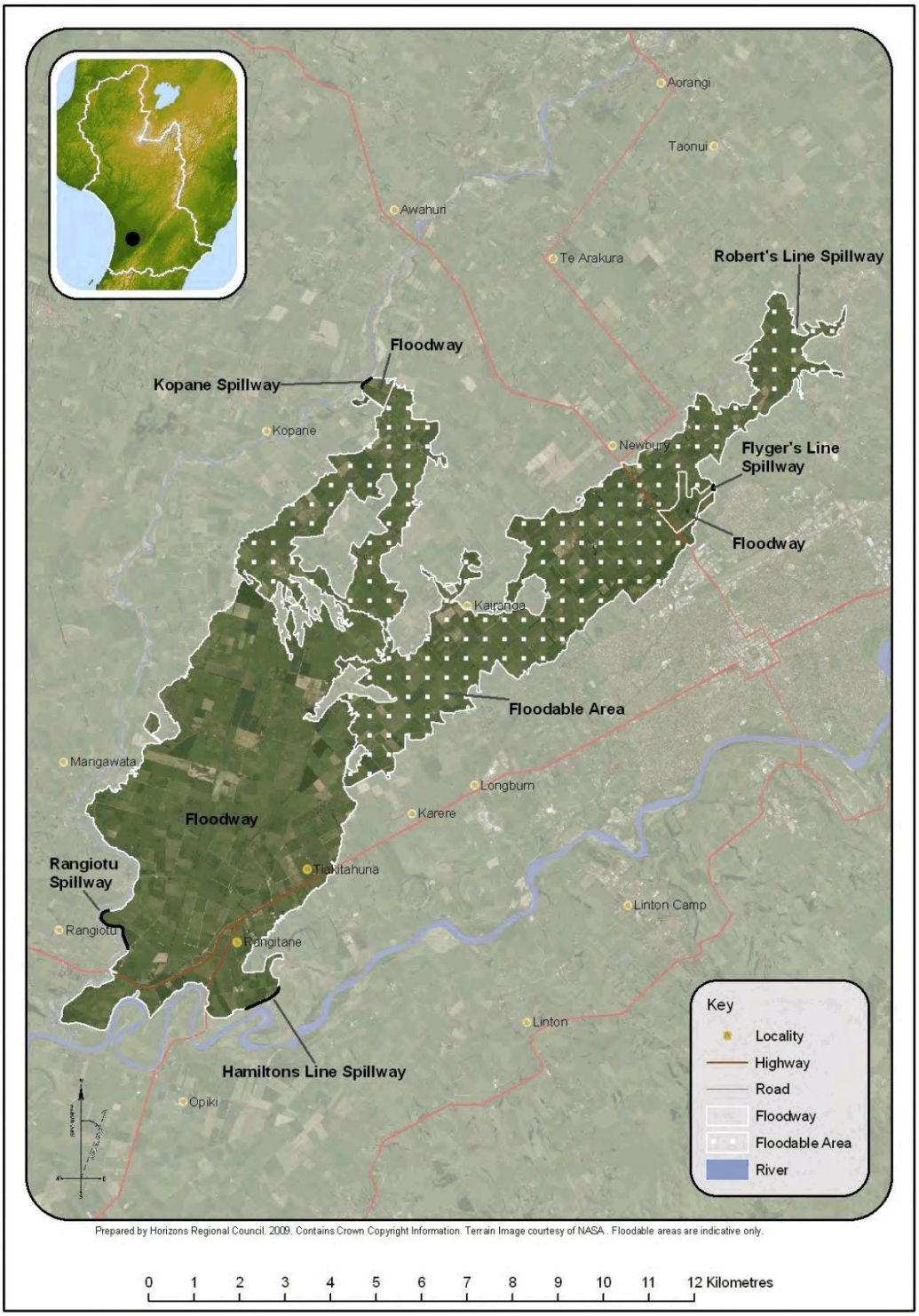

Figure J:2 Taonui Basin spillways, floodways and floodable areas

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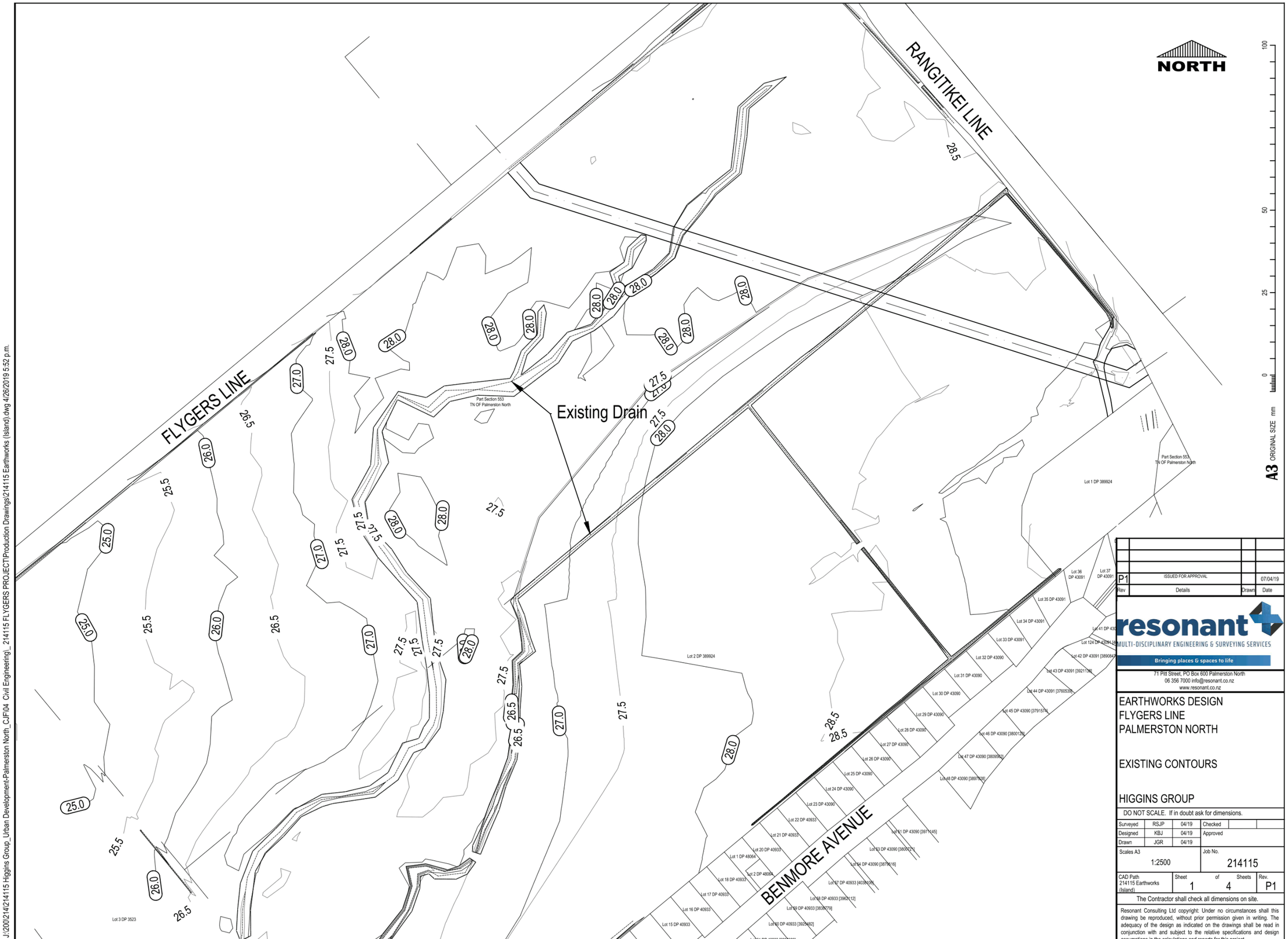
Appendix B – Existing Topography



Rev	Details	Drawn	Date
P1	ISSUED FOR APPROVAL		07/04/19

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MULTI-DISCIPLINARY ENGINEERING & SURVEYING SERVICES
Bringing places & spaces to life
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06 356 7000 info@resonant.co.nz
www.resonant.co.nz

EARTHWORKS DESIGN
FLYGERS LINE
PALMERSTON NORTH

EXISTING CONTOURS

HIGGINS GROUP

DO NOT SCALE. If in doubt ask for dimensions.

Surveyed	RSJP	04/19	Checked		
Designed	KBJ	04/19	Approved		
Drawn	JGR	04/19			

Scales A3	Job No.
1:2500	214115

CAD Path	Sheet	of	Sheets	Rev.
214115 Earthworks (Island)	1	4		P1

The Contractor shall check all dimensions on site.

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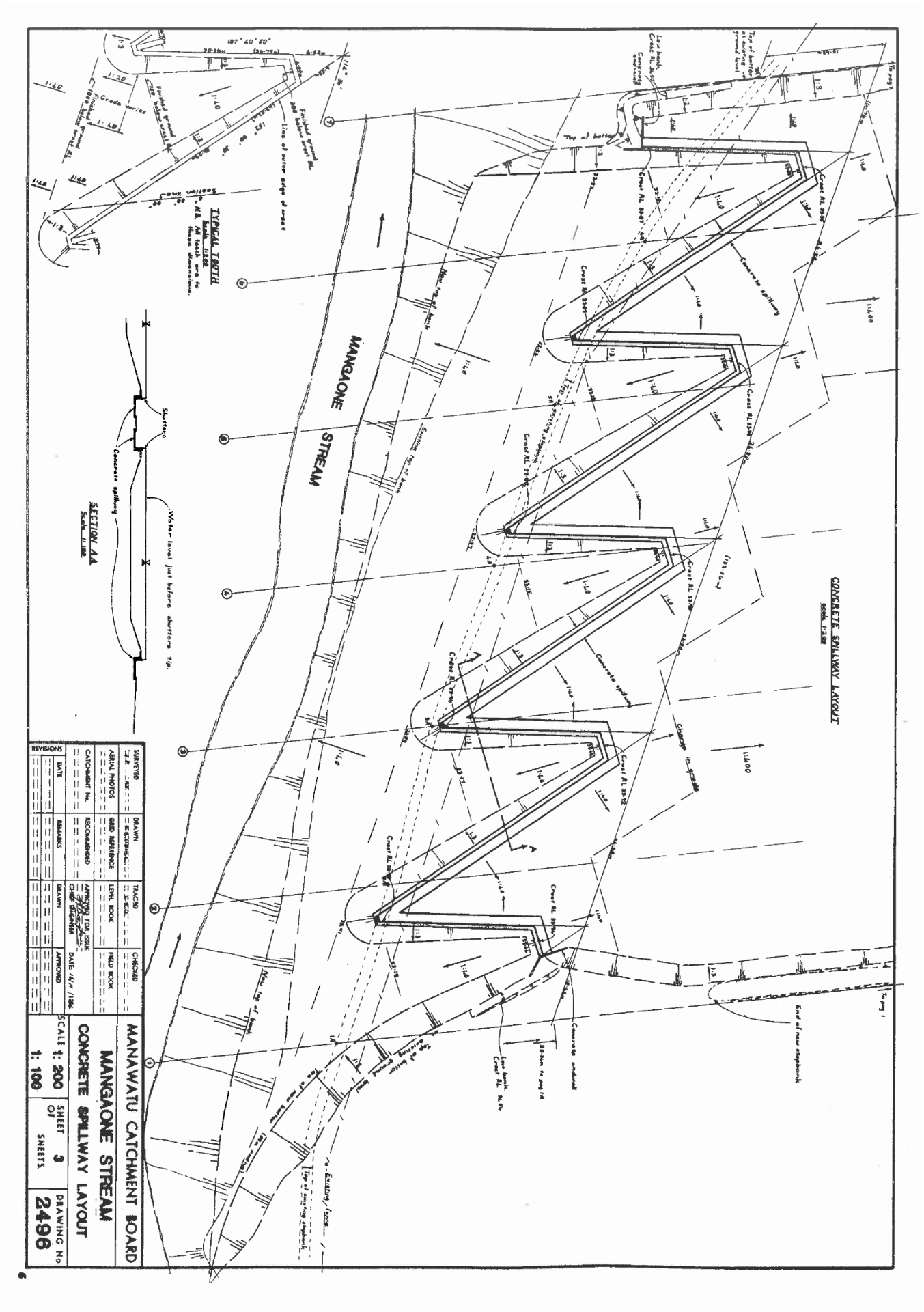
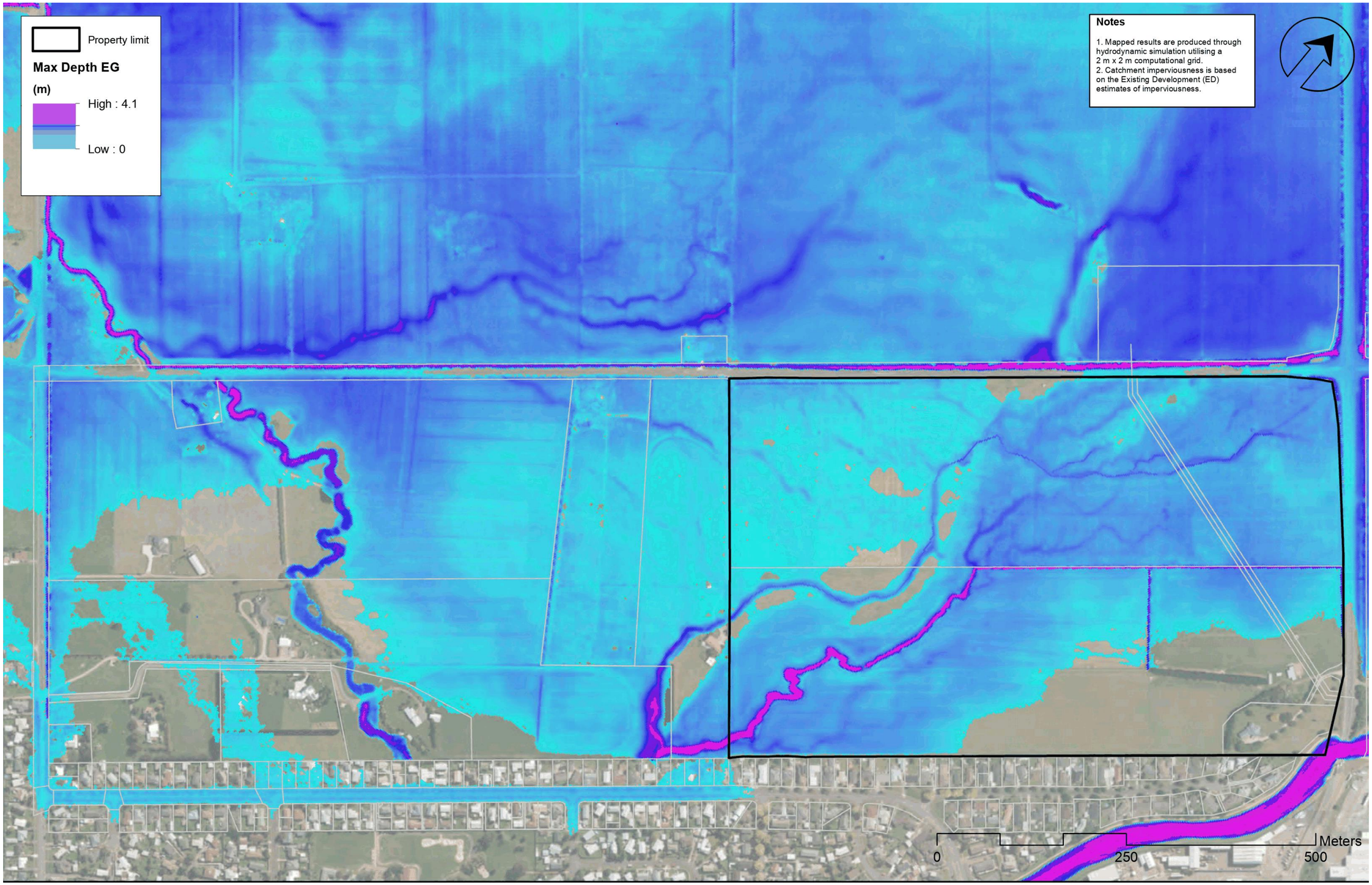
J:\200\214\214115 Higgins Group_Urban Development-Palmerston North_CJF\04 Civil Engineering_214115 FLYGERS PROJECT\Production Drawings\214115 Earthworks (Island).dwg 4/26/2019 5:52 p.m.

Appendix C – Mangaone Spillway


MANGAONE STREAM
CONCRETE SPILLWAY LAYOUT
SECTION AA
TYPICAL TOOTH
MANAWATU CATCHMENT BOARD
MANGAONE STREAM
CONCRETE SPILLWAY LAYOUT
SCALE 1: 200
1: 100
SHEET 3 OF SHEETS
DRAWING No 2496

The expert in WATER ENVIRONMENTS

Appendix D – Existing Development Flood Depth, Option 6 Flood Depth, Option 6 Flood Level and Difference Map (Developed O6-Baseline)

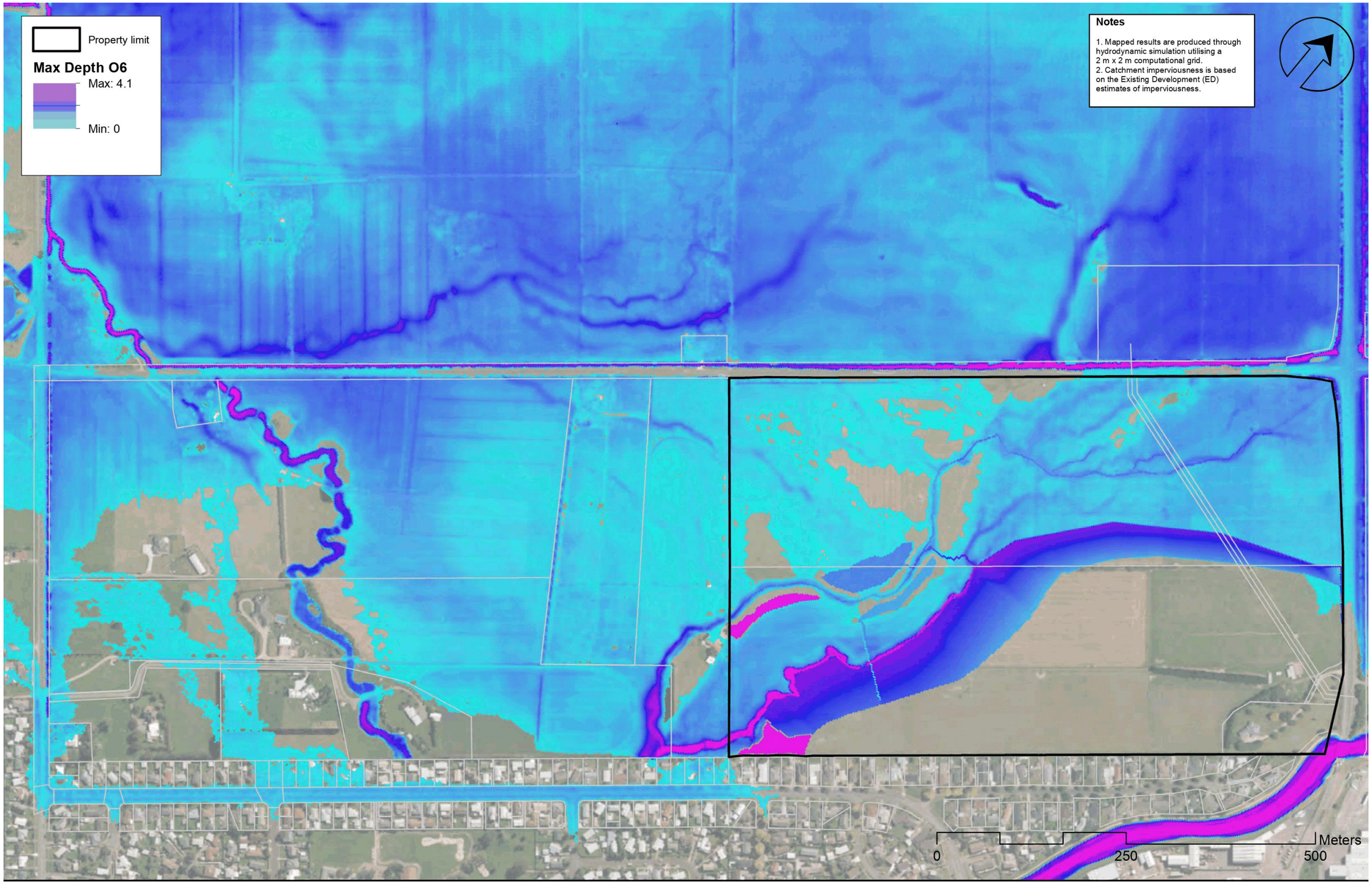


Flygers Line Development - Existing Ground

Existing, 200 year-ARI: depth

200 year-ARI rainfall/river flow; 2006 climate; ED catchment imperviousness

Project No.	44801375
Prepared by	N. Jeronimo
Date	29/10/2019
Drawing Ref.	200yrExisting-Flygers Development

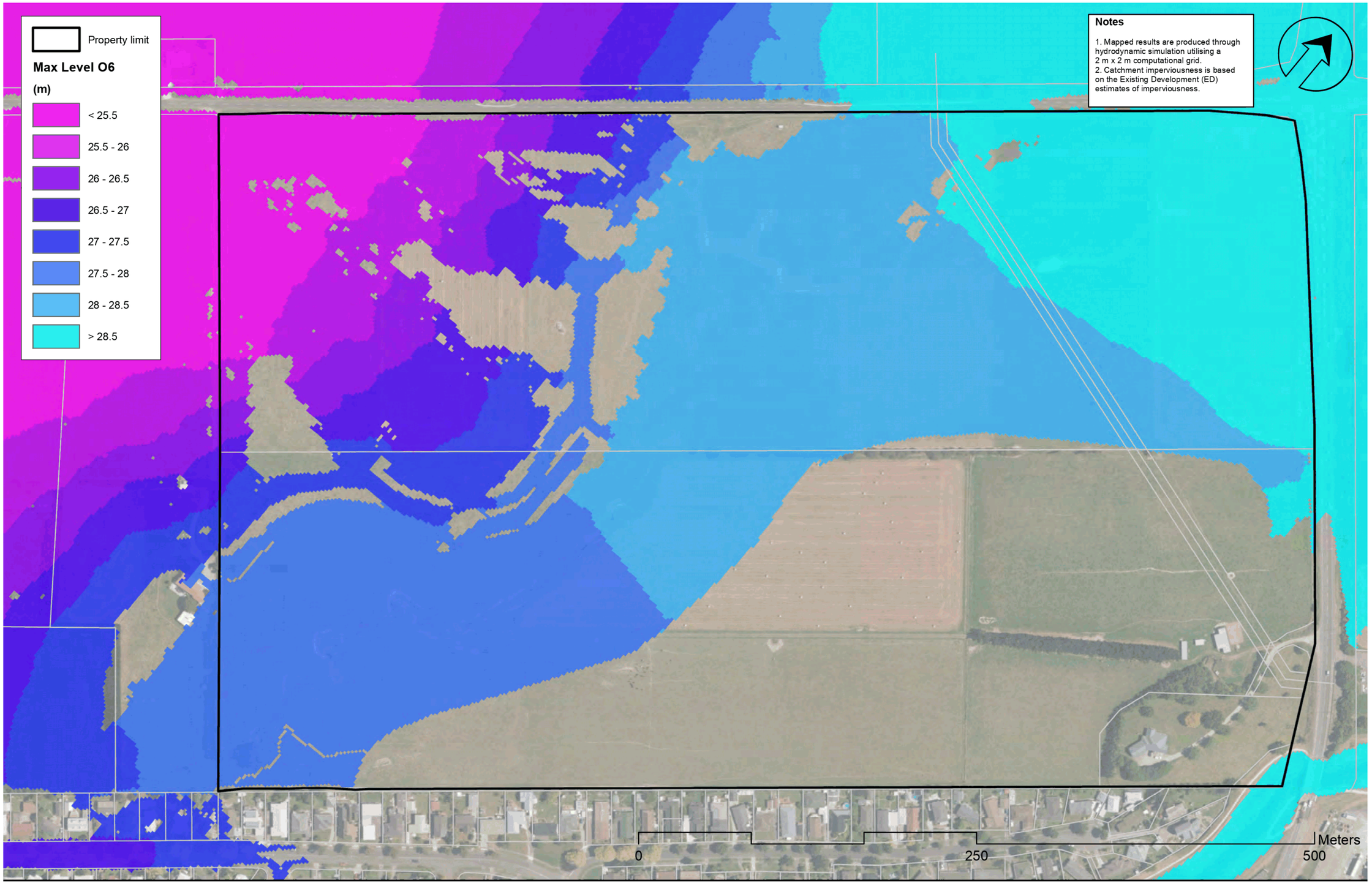


Flygers Line Development - Proposed Development - Option 6

Design, 200 year-ARI: depth

200 year-ARI rainfall/river flow; 2006 climate; ED catchment imperviousness

Project No.	44801375
Prepared by	N. Jeronimo
Date	29/10/2019
Drawing Ref.	200yrPD Depth-Flygers Development

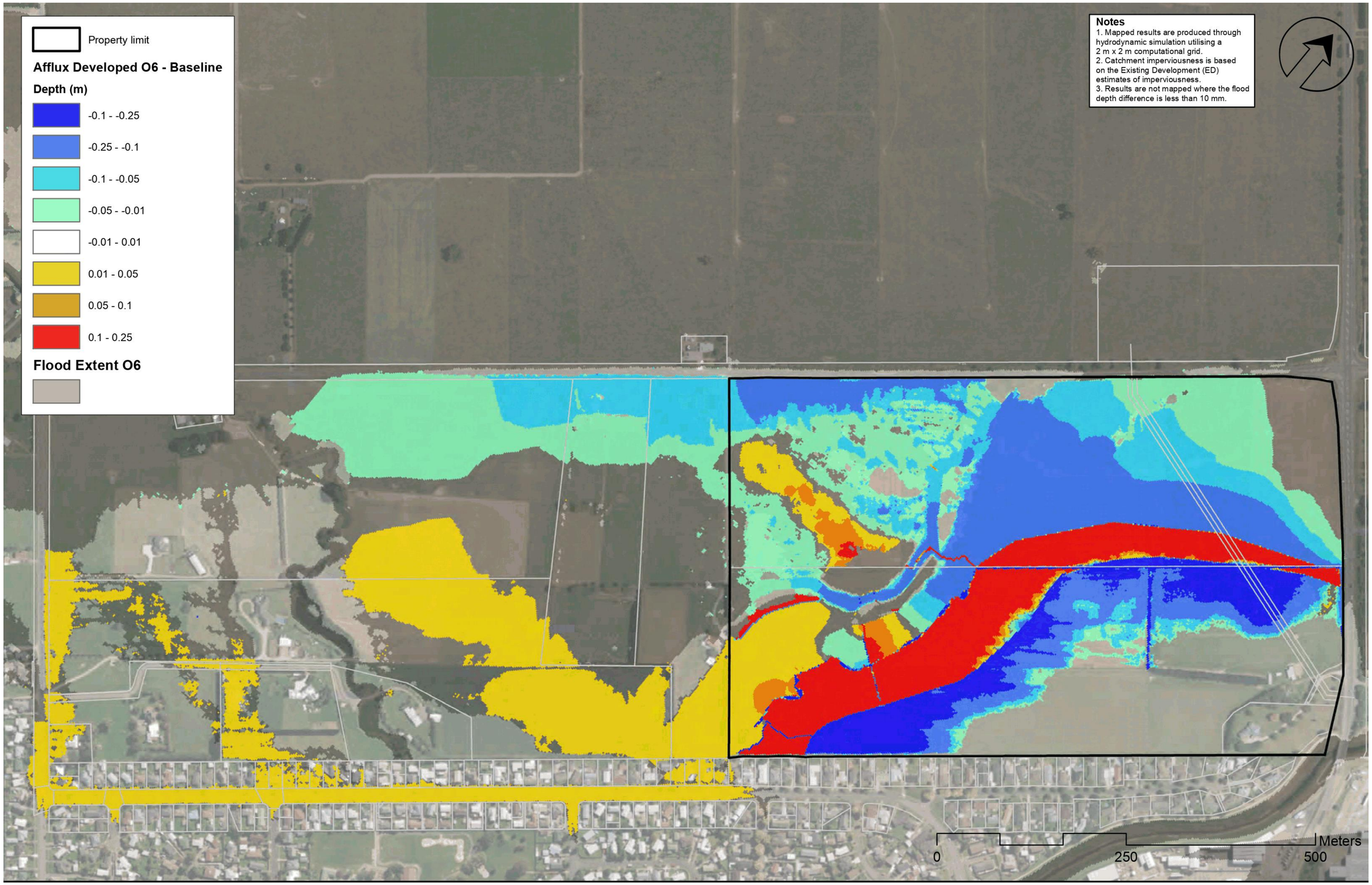


Flygers Line Development - Proposed Development - Option 6

Design, 200 year-ARI: level

200 year-ARI rainfall/river flow; 2006 climate; ED catchment imperviousness

Project No.	44801375
Prepared by	N. Jeronimo
Date	29/10/2019
Drawing Ref.	200yrProposed-Flygers Development



DHI

Flygers Line Development - Assessment of Flood Effects - Option 6

Design, 200 year-ARI: depth, Proposed Development O6

200 year-ARI rainfall/river flow; 2006 climate; ED catchment imperviousness

Project No.	44801375
Prepared by	N. Jeronimo
Date	29/10/2019
Drawing Ref.	200yrAfflux-Flygers Development

APPENDIX 3

WHISKEY CREEK URBAN DESIGN REPORT:

MCINDOE URBAN LTD AND LOCAL LTD.

WHISKEY CREEK

Urban Design and Landscape Report



local | McIndoe Urban

WHISKEY CREEK

Prepared for: **Flygers Line Investment Group**

Prepared for
Flygers Line Investment Group

Prepared by
Local Landscape Architecture Collective
McIndoe Urban

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Appendix A - Multi Criteria Assessment

1. Introduction

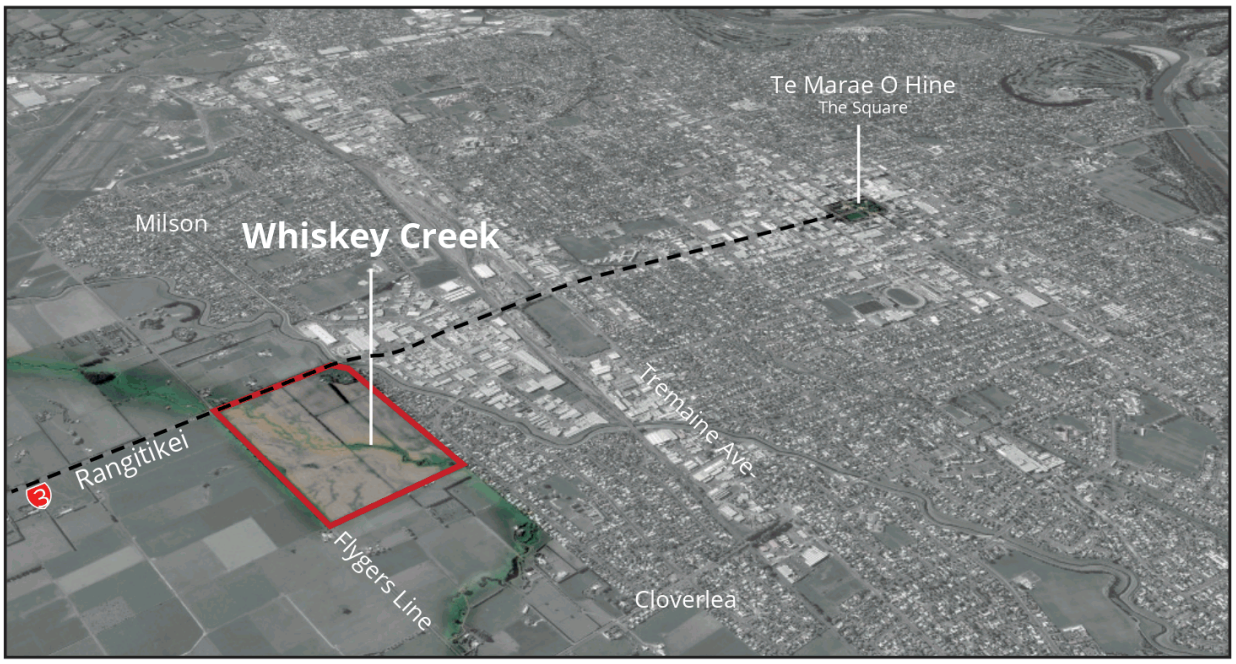


Figure 1. ***Site location***

Whiskey Creek Private Plan Change (formerly Flygers Line) is acknowledged in the council's Housing and Future Development Plan (2018/21) as a future growth area subject to "zoning adjustments". This Urban Design and Landscape Report presents a summary of the design work undertaken to support the plan change and structure plan.

The structure plan and plan change area (the Site) is currently flat farmland, located north of the Mangaone stream. The alluvial soils of the Whiskey Creek catchment are subject to regular flooding and this limits the land's capacity for housing. However, parts of the Site to the south east sit outside of the "floodway" as identified by Horizons Regional Council. This south east quadrant - adjacent to Meadowbrook Drive and Rangitikei Line - comprises the site of the proposed development.

A new urban edge to the city will be formed at the Site fulfilling important gateway functions on approach along Rangitikei Line. The presentation of new homes fronting onto a revitalised waterway with diversified ecology will establish a clear and attractive identity for the new community.

2. Context

2.1 Location

The Site is positioned at the intersection of Rangitikei Line and Flygers Line, adjacent to the city's current urban edge along Meadowbrook Drive and Benmore Avenue. Located some 3km from Te Marae O Hine / The Square, the Site is notably closer to the CBD than other designated growth areas. Benefits associated with this close proximity include the potential for greater take-up of active movement modes and increased accessibility of amenities, while consolidation of the city's urban footprint up to the northern floodplain resolves the city's edge along Rangitikei Line.

SH3 (Rangitikei Line) provides excellent north-south connectivity into the city and out towards the future NZTA ring road that will service the planned Regional Freight Hub. Flygers Line provides an east-west link that accesses the airport and the future growth area of Kākātangiata.

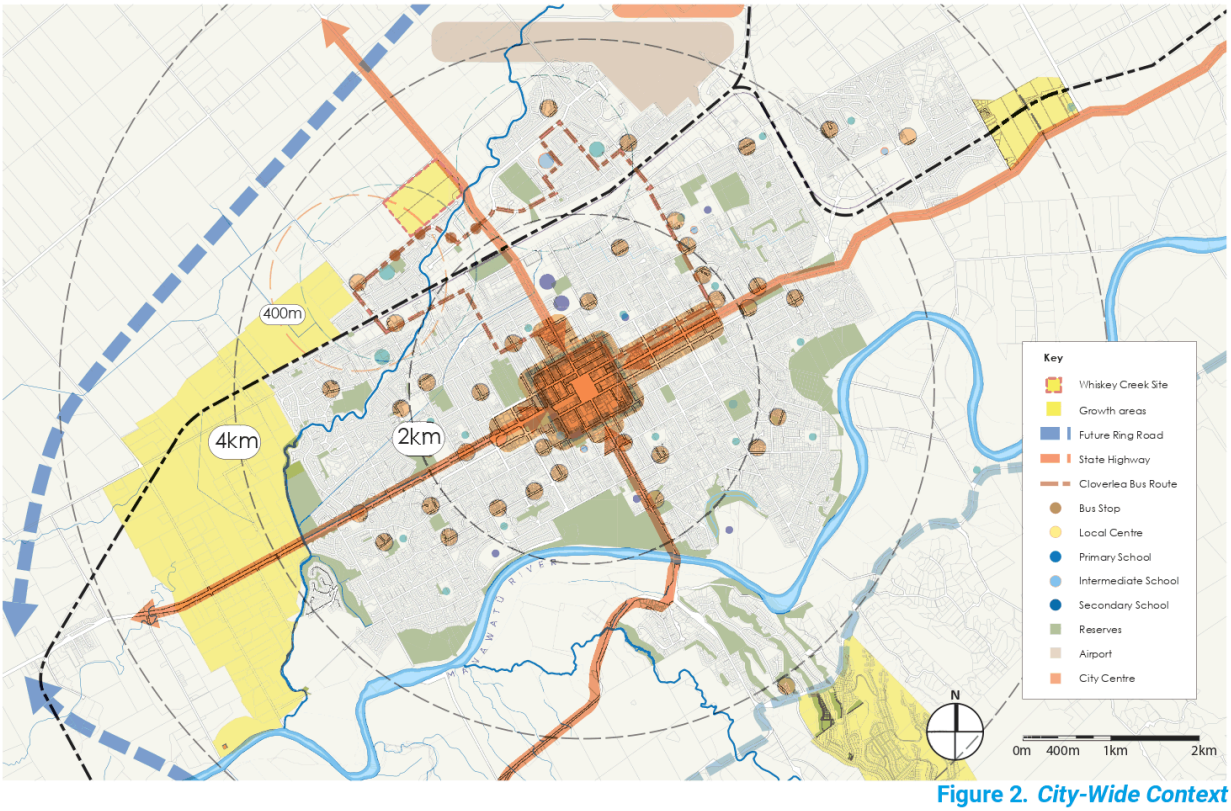


Figure 2. *City-Wide Context*

2.2 Cultural significance

The site encompasses a 40ha area of the wider Whiskey Creek floodplain, adjacent to the Mangaone Stream corridor. Figure 3 below shows there are no significant Mana Whenua sites or important structures on the Site.

Swamp forest historically covered most of the alluvial plains across the Manawatū. Dominant tree species in these forests were kahikatea (*Dacrycarpus dacrydioides*) and pukatea (*Laurelia novae-zelandiae*), with swamp maire (*Syzygium maire*). These forests were biodiversity hotspots, offering year-round resources for nearby kāinga in the form of eels, other fish and birds. Rongoā and raranga plants were found across the extensive lowland forests. Around 98% of this floodplain ecosystem was cleared and drained and the main part of the catchment's mid and lower reaches has less than 1% indigenous vegetation left. Notable trees are limited to the established urban areas and are mostly exotics.

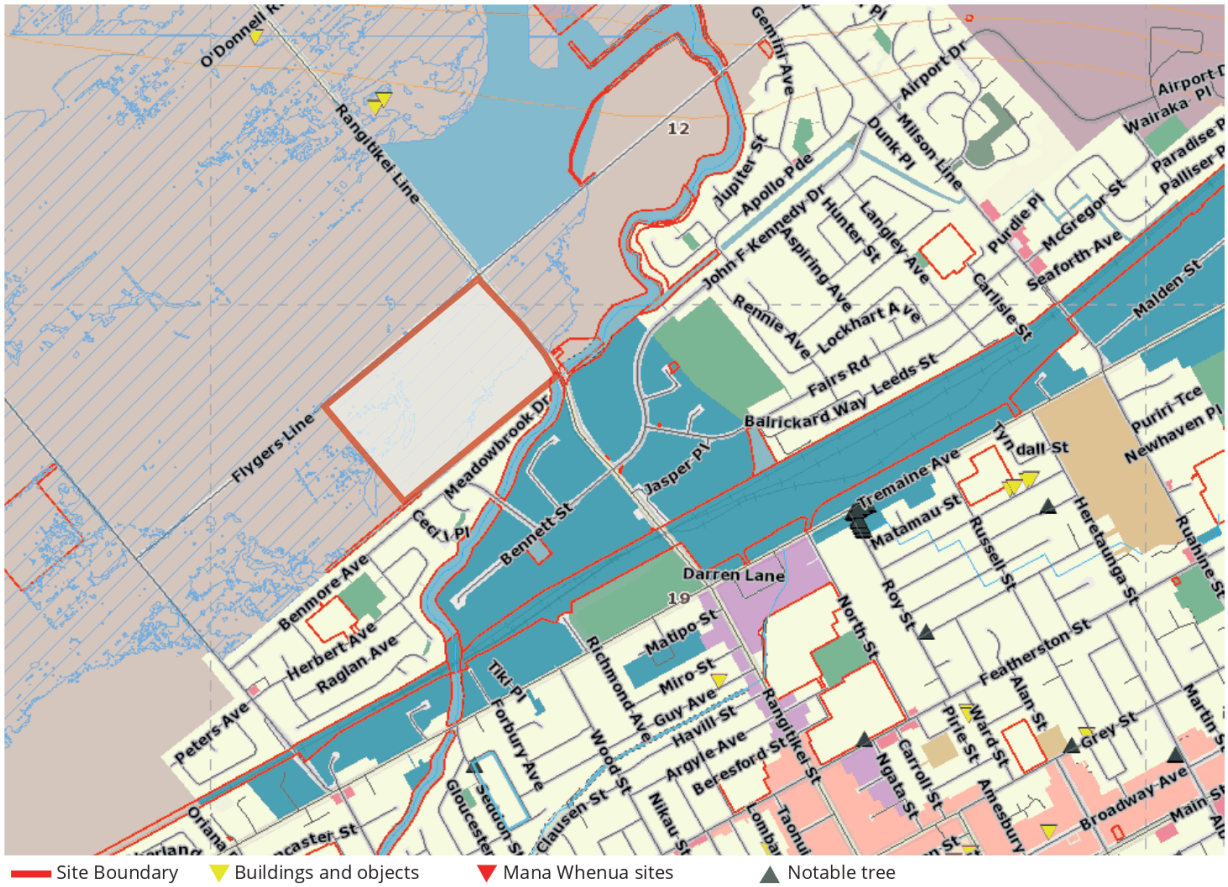


Figure 3. ***Sites of Cultural Significance (PNCC Geomaps, not to scale)***



Scorched forest farm, No. 1 Line, 1896



The Square in 1878, with the original land cover of lowland forest in the background



Kahikatea swamp forest

Figure 4. ***Historic photographs***

CULTURAL IMPACT ASSESSMENT

A Cultural Impact Assessment has been prepared by Rangitāne o Manawatū. This was undertaken using a Whānau Ora Framework. A summary of key value outcomes is presented below:

1. Rangitāne o Manawatū exercise rangatiratanga by collaborating in planning for ngā Atua Māori.
2. Rangitāne contribute to the understanding of the cultural landscape, including identifying and providing for their values and relationships with whenua, wai, taonga, and wāhi tapu.
3. Rangitāne o Manawatū are aware of their interests in assets held in common and have a clear idea of their opportunities, rights and responsibilities.
4. Whānau are able to actively participate in a sustainable economy.
5. Whānau are able to support their hinengaro, physical wellbeing, and their wairua.
6. Whānau have access to and can safely interact with wai, whenua, taonga, and wāhi tapu.
7. Whānau can afford to buy and rent houses, in safe locations that allow them to fully interact within the community.
8. Te ao Kōrero Māori/Māori language is visible and celebrated in the wider community.
9. Street and place names acknowledge Māori place names, values, significant sites and tupuna (ancestors).

2.3 Strategic Growth Context

Palmerston North's population is expanding and the Council anticipates an annual increase of 1.0% over the next ten years followed by more moderate growth of 0.6% to 0.7% per annum. The number of households will increase even faster. Predictions are that the city requires up to 500 new dwellings per year until 2043.

Council's intentions towards housing growth across the city are that for the city as a whole, construction of 9,440 new dwellings is anticipated in the 30 years to 2048. Half of these are expected to be built on greenfield land. Three major growth locations are being pursued by Council: Whakaronga, Kākātangiata (formerly City West and Anders Road / Racecourse), and Aokautere. Council projections at Aokautere are for some 1,200 additional dwellings beyond those currently zoned, 500 dwellings at Whakaronga and 5,000+ at Kākātangiata. In this context, Whiskey Creek is relatively small (157 dwellings) but contributes to the picture of growth around the city's edge.



Figure 5. ***Future Growth Areas***

2.4 Urban Structure

The wider urban structure around the Site is influenced by the nature of the predominant land uses, namely residential and industrial areas meeting farmed rural landscapes. Residential areas display a relatively fine grain street and block pattern though the north edge of Benmore Avenue and Meadowbrook Drive presents a long and unbroken suburban 'barrier' to the rural landscape, exacerbated by a back fence condition as shown on Figure 6 below. Extending a fine grain walkable block structure across the Site is important. Industrial areas separate residential neighbourhoods from Rangitikei Line and the quality of access for residents is reduced as a result. Achieving access directly off Rangitikei Line (albeit left-in, left-out) provides improved connections for the Site.

Mangaone Stream is an important feature that intersects with the south eastern corner of the Site and providing quality recreational links is an important outcome.

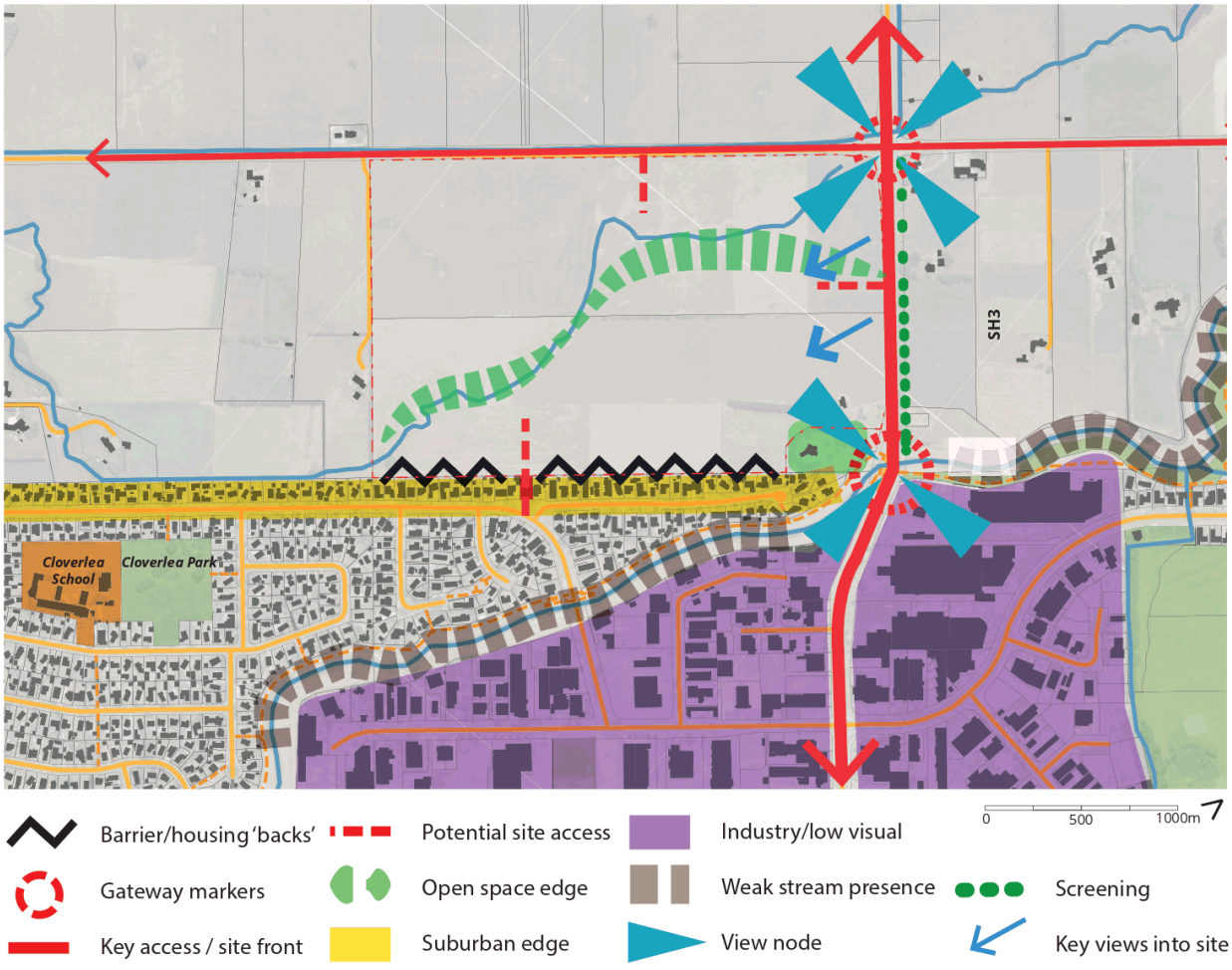


Figure 6. ***Site Context, 1:10,000 @A4***

The SH3 bridge over Mangaone Stream emphasises the northern gateway to the city and future development on the Site must enhance the visual quality of this area.

ACCESS AND MOVEMENT

The Site is provided with excellent strategic connectivity. A direct link to SH3 provides access to the proposed NZTA ring road that will service the planned Regional Freight Hub. East-west movement is provided by Flygers Line. This connects to the airport via Milson Line and Airport Drive. Western links via Benmore Ave and Flygers Line connect via Gillespies Line to Cloverlea and the planned Kākātangiata growth area.

Local site connections are provided via the proposed Road 1 that connects with Benmore Ave. This is described further in the Transport Impact Assessment. Generally, local movement is affected by the natural barrier of Mangaone Stream. This has caused numerous cul-de-sacs and a single connection over the stream via Benmore Ave. The stream corridor itself provides city-wide walking and cycling connections that are proposed to link into the Site.

Public transport is readily available with the No. 105 Cloverlea via Wood Street bus route. This runs along Benmore Avenue, passing the intersection with the proposed Road 1. Route No. 105 links the Site to The Square and to the hospital via Ruahine Street.

2.5 Green & Blue Infrastructure

Much of the ecological significance in the Manawatū relates to its rivers and waterways, as over 98% of the original land cover of lowland forests has been cleared since the 19th century. The ecology and green infrastructure of the northern gateway therefore strongly relates to the blue infrastructure. Open spaces along waterways are important to establish future green corridors, as highlighted in the City Development Strategy

FLOOD RISK

The existing edge of the residential area at Cloverlea has largely been determined by the land that is flood prone as a result of the Flygers Line Floodway and the wider Manawatū Drainage Scheme.

As previously noted, the area designated for development sits higher than the surrounding floodplain and is therefore not flood prone. Investigations show that this area can be extended by using earthworks to create a secure development platform. This can be achieved without adversely affecting the operation of the drainage scheme. Changes in ground level of less than 1m would increase the developable area while maintaining the flood ponding function. The floodway is required about once every ten years and involves water crossing Rangitikei Line from the north east. This aspect of the proposal has been carefully studied. Modeling has confirmed that - with specific design - the flood hydrology can be maintained.

WHISKEY CREEK

Whiskey Creek once played an important role as part of the Manawatū catchment. Despite being largely modified and confined to farm drains and trenches, the creek corridor preserves important habitat. Most water has been diverted into trenches along Flygers Line. As a result, this section of creek is currently an ephemeral waterway, which crosses the Site in a northeast-southwest direction. The stream bed is a significant morphological feature, mostly surrounded by intensive farmland and lined with exotic vegetation. There's potential to partially restore the creek as part of the proposed green corridor along the development edge.

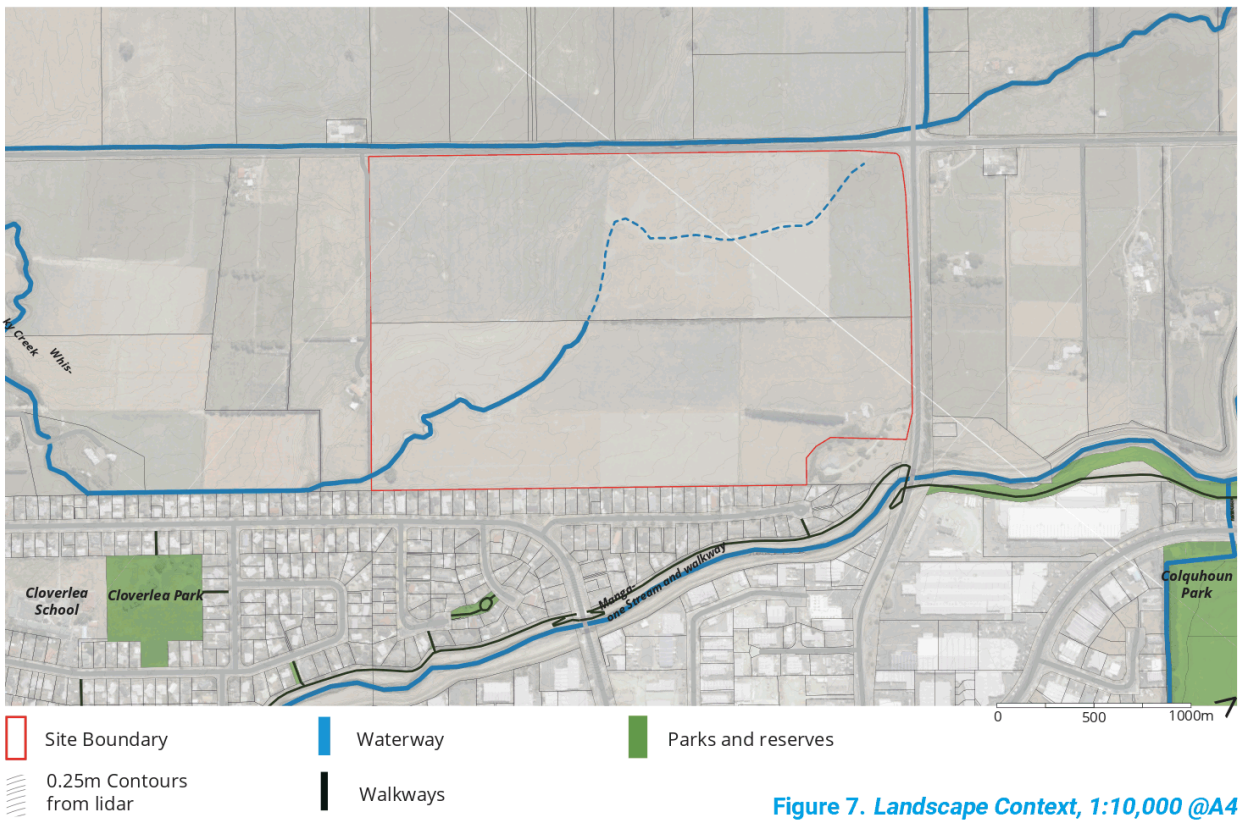


Figure 7. *Landscape Context, 1:10,000 @A4*

OPEN SPACE NETWORK

The map on the previous page shows local parks and reserves, i.e. areas zoned for recreational use in the District Plan. Cloverlea Park is easily accessible from via Benmore Avenue. It contains a playground and an area for informal ball games.

Colquhoun Park is accessible from the project site along the Mangaone Stream Corridor. This reserve is dedicated almost entirely to active recreation. It was recently upgraded for the 2020 Junior Men's Softball World Championship. The park caters for summer and winter sports including softball, tennis, basketball, rugby and football. The diverse facilities make Colquhoun Park one of the busiest in Palmerston North. A pavilion, public toilets and a play area are also located here.

Waltham park is a small neighbourhood park connecting two cul-de-sacs. It has a modest playground.

The rural land immediately north of the site is flat, intensively farmed land and offers expansive views towards the north. Mt Ruapehu is visible on clear days. 500m north along SH3, Orlando Country Golf Course forms an isolated pocket within the surrounding farmland. The Lakehouse is a well known venue with its own open space amenity.



Figure 8. ***Aerial image of Colquhoun Park***

VEGETATION AND ECOLOGY

The study area is in the oceanic climate zone (Cfb, Köppen-Geiger) characterised by around 980mm annual rainfall and high fertility alluvial soils. The original land cover of lowland kahikatea-pukatea forest has been cleared and the arable land is currently used for crop production. The once extensive wetland system related to Whiskey Creek and Mangaone Stream has disappeared, with fragments surviving in trenches and confined to a few low lying areas. The last notable natural feature of the site is the ephemeral bed of Whiskey Creek, where remnant sedge specimens are still present.

The agricultural use of the surrounding area means large shelter belts of predominantly exotic species has been established. These shelter belts typically follow property boundaries including those at the interface between rural and residential parcels. Typical species include pines (most frequently Pinus radiata), macrocarpa (Cupressus macrocarpa), Casuarina, Eucalyptus and poplar (Populus). Internal boundaries and road edges are often lined with large scale shelter belts and privacy planting. This vegetation isolates dwellings visually from the high speed traffic environment. A significant hawthorn hedge is located in the middle of the property, indicating the location of a former boundary.

Many of the residential properties to the south of the site contain a variety of exotic and native vegetation, smaller scale amenity planting is often located around dwellings and driveways. Meadowbrook Drive and Benmore Avenue have significant street trees.



Hawthorne hedge



Exotic shelter belts (poplars show)



Maize stubble after harvest



Remnant sedges along Whiskey Creek

2.6 Activities & Amenities

The Site is integrated into the city's wider street structure via Rangitikei Line and, more locally, via Benmore Avenue. These routes afford access to local and city-wide amenities that are generally found to the south of the Site.

LOCAL SERVICES & AMENITIES

Cloverlea Primary School and Cloverlea Park are located some 700m from the main access point to the Site. As a result, existing educational facilities and open space can be accessed on foot via Benmore Avenue, Bendigo Street and Rosedale Crescent. The nearest local centre is approximately 1.3km away at Herbert Ave, i.e. beyond comfortable walking distance. As a result, the proposed plan change includes new commercial activities (convenience retail) that are positioned with both existing and future residents in mind.

City-wide amenities such as high schools, the CBD and supermarkets are accessible by public transport or by the Benmore Ave connections into Rangitikei Street and the wider city street network. The Mangaone Stream walkway provides quality walking and cycling connections to the south-west. These will eventually connect with planned town and local centres within Kākātangiata.

INDUSTRIAL AND EMPLOYMENT ACTIVITIES

The area to the south of the site across Mangaone Stream is zoned for industry; part of a wider industrial area to the northeast of the city. This zone provides locally accessible employment opportunities. It also offers some specialised recreational activities (e.g. indoor karting).

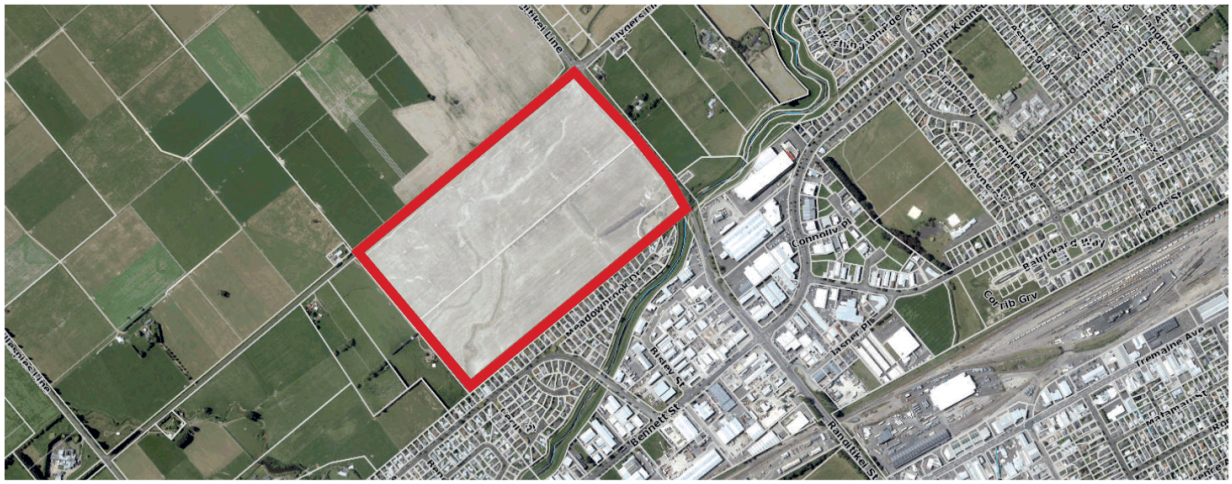


Figure 9. ***Plan Change Area (PNCC)***

MANGAONE STREAM CORRIDOR

The Mangaone Stream is a culturally significant waterway running generally northeast-southwest and emptying into the Manawatū River at Awapuni. The stream corridor is a designated Flood Protection area in the District Plan and plays an important role in the stormwater management of the city. A section of the stream is accessible from the Site, providing the proposed development with city-wide walking and cycling connections.

The stream itself is confined between stopbanks and has been stripped of its original riparian vegetation. The corridor separates industrial and residential zones along Cloverlea's southern boundary, although grassed banks provide weak visual buffering. Past stormwater management practices have lined the stream margins with exotic grasses and invasive species. However, the waterway has the potential to become an important green corridor, boosting the ecology of Cloverlea. Restored ecology and a well-developed shared path system could enhance the Mangaone's amenity value and transform the stream corridor into a visitor destination with a range of recreational activities.



The stream in flood



Degraded riparian habitat and walkway along Mangaone Stream



Channelised stream bed



Bridge over the channelised stream

2.7 Easements

The Plan Change area is currently zoned Rural in the District Plan, and a 100 km/h speed limit applies to the adjacent section of Rangitikei Line (SH3).

NOISE

Waka Kotahi/NZTA requires a 40m noise setback along the boundary with SH3. The easement can be narrowed if noise management tools such as sound walls or mounds are applied, but this could hinder visibility / access to the site. Part of the easement could potentially become an extended vegetated road reserve along Rangitikei Line. The remainder of the setback could be private land subject to building restrictions.



Figure 10. ***Rangitikei Line (SH3)***

GAS MAIN

A section of high pressure gas transmission pipeline owned by First Gas crosses the property in a north-west-southeast direction. An easement of 6m in both directions from the centreline of the gas main is required. Building restrictions apply within 20 m of the centreline.

FLOOD LINE

The boundary of the flood prone area associated with the Flygers Line Floodway is shown in the District Plan. Due to the low lying alluvial nature of the site, even a slight change in the contours displaces this flood line. The effect of these changes has been modelled and carefully studied. A revised flood line boundary is shown on the proposed Structure Plan.

LIQUEFACTION

Geotechnical assessments have established that the Site's soils are similar to other alluvial areas within the floodplain. To prevent erosion and liquefaction, a 55m easement is required between any watercourse (temporary or permanent) and the development.

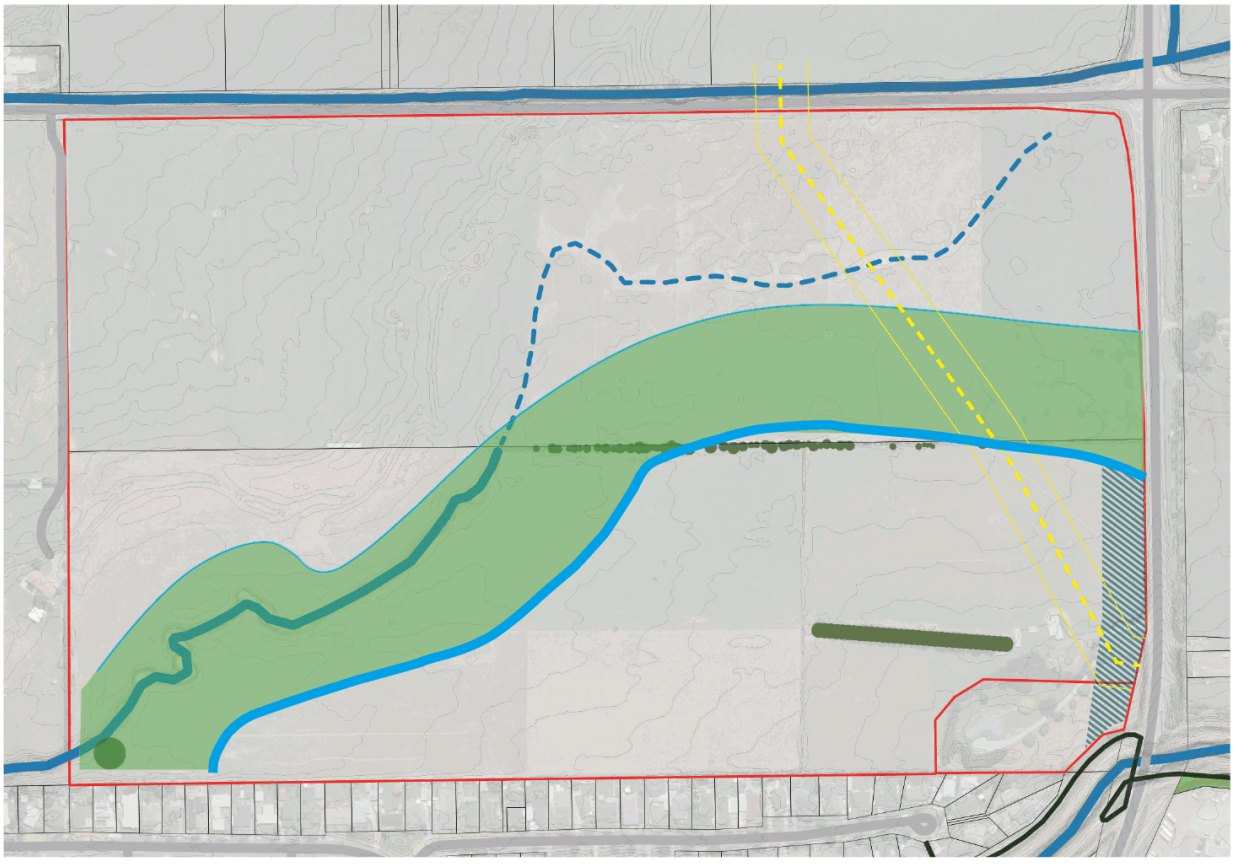


Figure 11. ***Easements***

2.8 Existing site conditions

The 40ha site is zoned 'Rural' and is currently used to grow maize. Open, arable land offers uninterrupted views to the north. To the south, the outlook is less attractive because it includes the backs of existing housing. Other than maize, vegetation is confined to shelter belts along some property boundaries and exotic, invasive species along the old Whiskey Creek streambed. An old growth hawthorn hedge in the middle of the Site indicates a former property line or a change in land use.

Currently the land is accessible only from Flygers Line, where there are two site entrances.

Aerial imagery indicates subtle changes in landform and soil types/colours. These relate to occasional sheet flows across Rangitikei Line during major flood events. The old Whiskey Creek streambed is an important morphological feature being a remnant of the original lowland native ecosystem prior to European settlement.

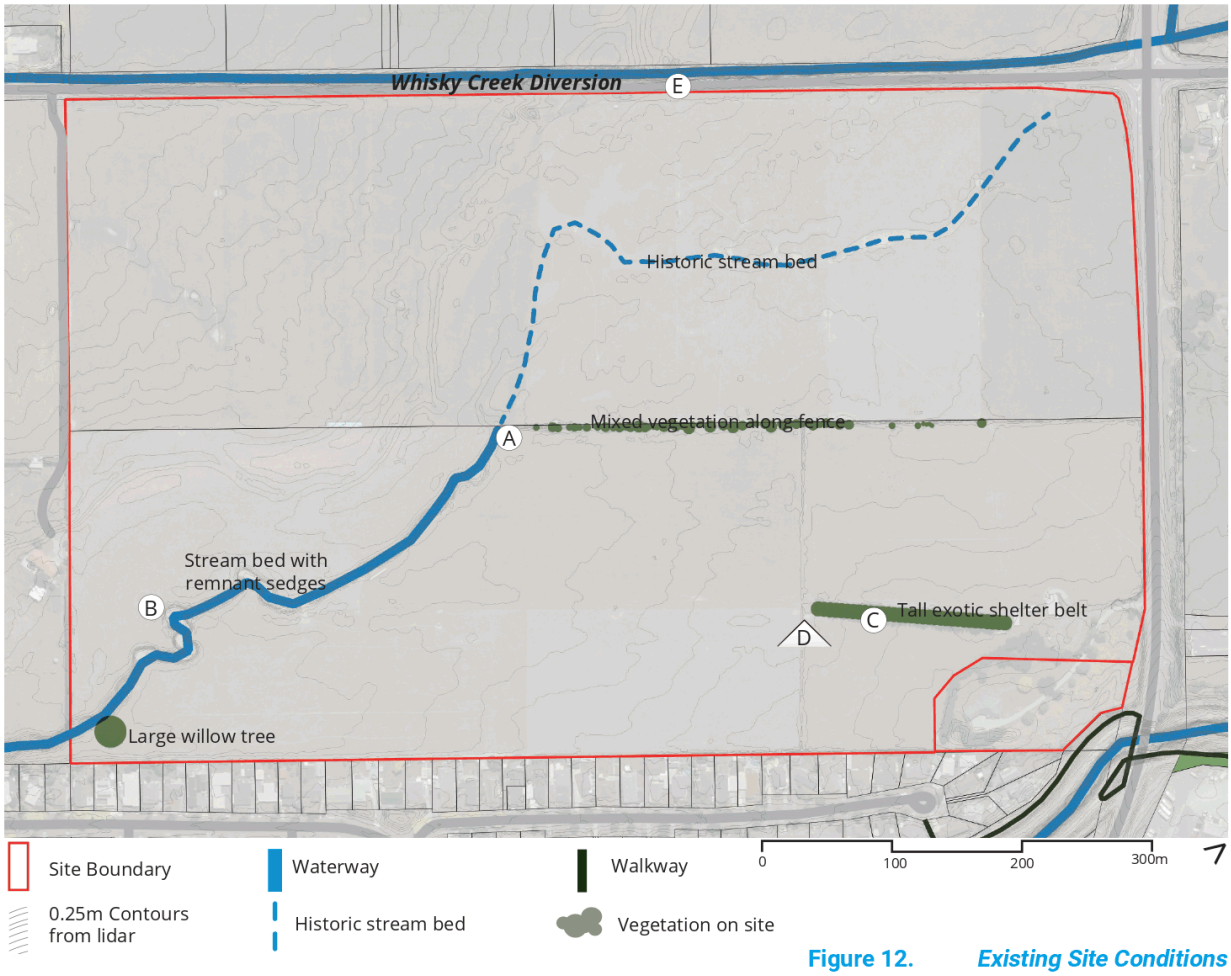


Figure 12. *Existing Site Conditions*



Whiskey Creek stream bed



Whiskey Creek stream bed



Existing residential boundary



Exotic shelter belts



Channelised Whiskey Creek diversion

Figure 13. ***Site photographs***

2.9 Site Characteristics - Summary

SUMMARY OBSERVATIONS AND IMPLICATIONS FOR DEVELOPMENT

- STRATEGIC GROWTH LOCATION: identified in the Housing and Future Development Plan 2018/21 as an area suitable for housing expansion.
- NEW CITY EDGE: The northern floodplain establishes the absolute extent of urban development. Whiskey Creek will become the new urban city limit. Quality housing fronting onto a revitalised re-vegetated stream will establish new identity.
- ACCESS & MOVEMENT: SH3 provides excellent strategic north-south connectivity while Flygers Line provides east-west links to the airport and the future growth area of Kakatangiata. Walking and cycling connections will connect the Site to Mangaone Stream, and public transport is readily available.
- URBAN STRUCTURE: A fine-grain, walkable block structure is proposed, connecting with Benmore Avenue and Rangitikei Line. The latter route offers an alternative to the current approach, which passes through an industrial area.
- LOCAL AMENITIES: Cloverlea School and Cloverlea Park offer walkable educational facilities and play spaces. New on-site commercial/retail services are necessary because the Herbert Ave shops are over 1km away.
- FLYGERS LINE FLOODWAY: The floodway activates about once every ten years and involves water crossing Rangitikei Line from the north east. Careful modeling has confirmed that with specific design existing flood hydrology can be maintained.
- FLOOD RISK: the area designated for development sits higher than the surrounding floodplain and is therefore not flood prone.
- WHISKEY CREEK: The section of creek crossing the Site in a northeast-southwest direction is currently an ephemeral waterway with most of its water diverted to trenches along Flygers Line. Revitalisation of this stream will be an important outcome for the plan change, complemented by new native planting.

- OPEN SPACE NETWORK: new recreational paths within the Whiskey Creek reserve will connect to the Mangaone Stream. Cloverlea Park and Colquhoun Park are located nearby.

- VEGETATION & ECOLOGY: The Site is used for growing maize. Exotic shelter belts exist along some property boundaries and a few native sedges remain in the streambed. It is important to reintroduce ecologically diverse planting and habitat along Whiskey Creek.

- EASEMENTS: noise restrictions along SH3, gas main easement, flood boundary and easement for liquefaction all affect the potential for housing development.

3. Planning & Design Intentions

This section presents an outline of the land owners' requirements and aspirations along with key constraints on development. Following the Brief, nine Design Principles are identified. These emerged during the Discovery and Analysis stage of the project and were used to guide development options and inform criteria for the subsequent Multi-Criteria Analysis (MCA). Subsequently, a set of Design Strategies are identified. These describe six key moves within the illustrative masterplan, which in turn generates the Structure Plan. Lastly, this chapter introduces a range of planning and design scenarios that were developed prior to the final preferred masterplan.

3.1 Development Brief

MARKET RELEVANCE AND FEASIBILITY

The proposed Masterplan and Structure Plan respond to the landowners' requirements to deliver a primarily residential development. Yield recognises that the developable area is restricted by flood plain requirements. Over most of the plan, 'conventional' suburban lots average 450sq.m in area. Medium-density lots measuring 220-330sq.m are envisaged in higher-amenity parts of the site. In these areas, the council's Multi Unit Housing Area (MUHA) overlay is anticipated to apply with modified controls that align with emerging structure plans at Roxburgh Crescent and Aokautere. To support new residential activity - recognising the relative remoteness of the location and the lack of walkable convenience retail - the project calls for a quantum of commercial activity. This is positioned to serve existing housing as well as the new development.

The landowners' requirements for the structure plan called for alignment with local housing market demand having regard for projected population growth (set out in part 2 of this report) and demographic change (smaller households, compact dwellings, housing affordability, greater choice and multi-unit developments). The brief therefore sought consistency with national and city strategies, and in particular:

- A mix of housing density offering choice of housing type and pricepoint.
- The size of urban blocks dimensioned to accommodate a range of lot sizes and dwelling types whilst achieveing efficient roading layouts.

- A variety of housing that would be attractive to a wider demographic and that allows for changes in housing market demand.
- Identified areas of multi-unit housing in locations of high amenity, supporting the plan's wider character outcomes.

GOOD NEIGHBOURS

The Site shares an extensive common boundary with adjoining suburban housing along Benmore Avenue and Meadowbrook Drive. The proposed development seeks a positive relationship between new and existing housing. Sensitive integration along the southern boundary is achieved by:

- Aligning proposed lot boundaries with those of existing lots where possible.
- Limiting height to 5m (single storey) on new lots that adjoin existing parcels.
- Achieving larger lots (500-550sqm) along the common boundary to allow for more generous yards and appropriate positioning of dwellings.
- Generally matching the scale, alignment and orientation of new development to existing patterns.
- Ensuring all flood mitigation is managed on the Site with no adverse flooding effects on neighbouring properties.
- Establishing an attractive, safe road connection from Benmore Ave into the Site.
- Providing for an appropriately located small convenience retail/cafe facility near the connection with Benmore Ave.

CREEK REVITALISATION AND FLOODING

Parts of the Site are subject to flooding, with the majority of the Plan Change area sitting within the regional council's designated "floodway" (see stormwater report by DHI). District and Regional Council documents (One Plan) identify design requirements for the development's stormwater system. These requirements limit housing to a portion of the Site, i.e. the south-east quadrant. Further earthworks are required to adjust levels across this quadrant and establish a suitable base for any new roads and buildings. Towards the flood line, the Site will be raised by up to 1m. Adjacent to existing housing, the ground will remain at current levels. An existing storm drain along the common boundary will need to be re-engineered to ensure there are no adverse flooding effects on neighbours.

Figure 14. ***Reserve Edge Condition***

Revitalisation of Whiskey Creek is to form part of the structure plan, returning the stream to a functioning waterway that is re-vegetated and ecologically diverse. This area will become an attractive reserve and an urban wetland amenity for local residents and visitors using the path network.

SUSTAINABLE NEIGHBOURHOOD

The structure plan is to set the conditions for a sustainable and liveable neighbourhood that provides a high level of amenity for residents and visitors. Important attributes of this are:

- A coherent, permeable network of streets and open spaces that create attractive walking and cycling environments.
- Good connectivity with the 'host' neighbourhood.
- Attractive and accessible public outdoor recreational areas and appropriate private on-site open spaces.
- Walkable local neighbourhood centre-type opportunities.
- Quality footpath connections to public transport.
- Managed relationships between different housing densities and between new and existing residential areas.

QUALITY PUBLIC & PRIVATE OUTCOMES

Both public and private realms are designed to provide high quality outcomes. Exchanges between private domains and streets or other public spaces are the generator of activation and visual interest. Key outcomes include:

- Ensuring lots have adequate street frontages enabling a positive relationship between dwellings and the street; promoting community engagement, legibility and confident street edges.
- Integrating stormwater management and ecological revitalisation into the design of streets and open spaces.
- Locating higher density housing in areas of high outdoor amenity where such forms can be more readily absorbed and where there is more need for overlooking and activation.

3.2 Design Principles

The structure plan identifies nine Design Principles that provide terms of reference for key elements and relationships within the Whiskey Creek development. By jointly addressing functional and aesthetic imperatives, the principles direct the project towards high-quality outcomes in the natural and built environment. They generate urban wetlands and a network of off-road recreational trails along with a network of streets and neighbourhood parks. The resulting public domain supports amenity-rich private living environments. In combination, the principles help to establish a memorable identity for the new neighbourhood.



Figure 15. ***Multi-unit housing***

1. STRATEGIC ALIGNMENT

- Whiskey Creek aligns with National Policy Statement on Urban Development (2020).
- Development helps to implement high-level PNCC strategies and plans.
- Whiskey Creek establishes a more logical northern growth limit.

Palmerston North's growth strategy concentrates greenfield residential development in Aokautere, Kākātangiata and Whakaronga. Collectively, smaller subdivisions such as Hokowhitu, Roxburgh Crescent and Whiskey Creek also make a significant contribution to housing supply. Although the number of new dwellings supplied is relatively modest, Whiskey Creek brings new housing options to an established residential area with good transport connections, schools and open space amenities.

2. CONNECTIVITY

- Fully connected movement network.
- Recreational pathways forming circuits.
- Proximity to public transport.

A hierarchy of interconnected streets creates a legible movement network. Off-road recreational pathways promote walking and cycling particularly when these routes form circuits with varying lengths and different experiences. Joining these loops to the Mangaone Stream corridor provides the development with access to a city-wide trail network. The Cloverlea bus route is within walking distance and provides a connections to The Square.

3. PLACE-BASED IDENTITY

- Legible spatial structure.
- Distinctive elements with clear relationships to one another.
- Intuitively understood street hierarchy.

The location of the site offers a significant opportunity to draw on the natural character of the area and incorporate design elements to express a unique place-based identity. An intuitive street hierarchy and legible spatial structure allow easy orientation and the establishment of prominent sightlines.

Creating distinctive 'place' elements allows differentiation between individual streets, blocks and stages of development. The natural character of the northern edge presents a unique selling point and gives Whiskey Creek the potential to become a city-wide destination. Recreation areas present an opportunity for cultural signage, information boards and mahi toi, which share Rangitāne o Manawatū values and connections with land and waterways.



Figure 16. ***Wetland park at Hobsonville Point, Auckland***

4. ABSOLUTE URBAN EDGE

- Sharply defined urban edge creates a new northern gateway.
- Permanent edge condition creates special character and amenity.
- Restoration of Whiskey Creek draws attention to flood plain.

Establishing a new neighbourhood on the edge of the city allows strong connections to be forged with adjacent natural and rural environments. The current residential boundary appears arbitrary and is marred by back fences. The proposed new urban edge is defined by the Flygers Line Floodway. Drawing from the natural history of the site, the floodplain can become a green corridor, expressing the floodplain threshold and boosting the biodiversity of the area.

5. NEIGHBOURLINESS

- Proposed spatial structure connects to the city at macro and micro scales.
- Lot and dwelling types acknowledge existing subdivision patterns.
- Street layout creates positive front/back relationships with existing houses.

Although Whiskey Creek represents a logical extension to an established residential area, the development necessarily changes the setting of houses on Benmore Avenue and Meadowbrook Drive. The proposed subdivision reduces impacts on existing residents by matching lot pattern and dwelling type to those found in neighbouring streets. The layout of streets and parcels produces a complementary back-to-back relationship between new and existing properties along the site's southern boundary.

6. FLEXIBILITY, DIVERSITY & CHOICE

- Proposed plan offers a range of densities and dwelling types.
- Development delivers various amenities within walking distance.
- Potential exists for connections to further development on the northern margin.

Changing lifestyles, demographic shifts and reduced affordability all stimulate demand for more diverse housing stock. New housing preferences create a market for smaller dwellings on compact sites especially in high-amenity locations. Whiskey Creek increases housing choices by introducing a variety of new dwellings to the edge of an established residential area. Specifically, the development accommodates a mix of fully attached, semi-detached and fully detached houses.

7. MIXED USE ACTIVATION

- Different densities and dwelling types increase housing capacity and choice
- Strong local destinations encourage residents to walk and ride.
- Well-used amenities and public spaces attract further visitation.

Mixing uses promotes the activation of streets and open spaces and increases the carrying capacity of the development. Likewise, a range of densities helps to differentiate among blocks and gives weight to the hierarchy of streets. The structure plan anticipates a mix of lot sizes and dwelling types, including a zone where commercial elements can be present. These commercial components help the activation of surrounding open spaces and play an important role in creating destinations.



Figure 17. ***Urban wetland at Barry Curtis Park, Auckland***

8. ENVIRONMENTAL DESIGN

- Stormwater management is an integral part of spatial planning.
- Proposal promotes restoration and naturalisation of waterways.
- Proposal enhances biodiversity and extends green corridors.

Innovative infrastructure solutions reduce environmental footprint and establish strong spatial and ecological connections with the surrounding landscape. These connections contribute to a distinctive place-based identity and differentiate the development from other neighbourhoods. When stormwater management is fully integrated with streetscape and public reserves, maintenance costs reduce and outcomes are more resilient than traditional piped networks.



The re-vegetation of the stream corridor has potential to provide significant ecological benefits in terms of water quality, habitat (both aquatic and terrestrial) and food source for fauna, as well as the ability to recreate a measure of the original forest cover. The site can provide a 'stepping stone' for fauna (most notably birds) moving within the suburban landscape and between significant ecological areas such as Manderson's Bush.

Stepping stones are important to the ecological health of an area, as these allow animals to find shelter and food or rest on their journey between larger forested areas. This allows populations to build resilience and - on a tangible level - increases the likelihood of people seeing native birds in their backyards.



kahikatea (*Dacrycarpus dacrydioides)*



pukatea(*Laurelia novae-zelandiae)*



harakeke (*Phormium tenax*) and raupo (*Typha orinetalis*) swamp



bellbird (*Anthornis melanura*)



tui (*Prosthemadera novaeseelandiae*)

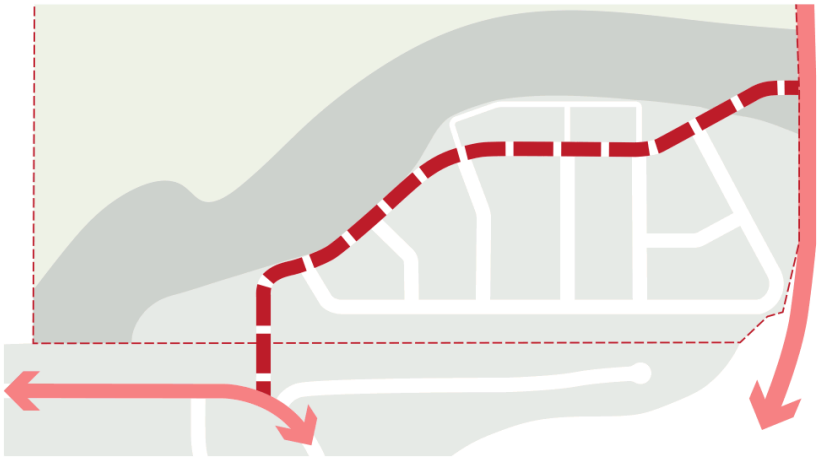


kereru *(Hemiphaga novaeseelandiae)*

3.3 Design Strategies

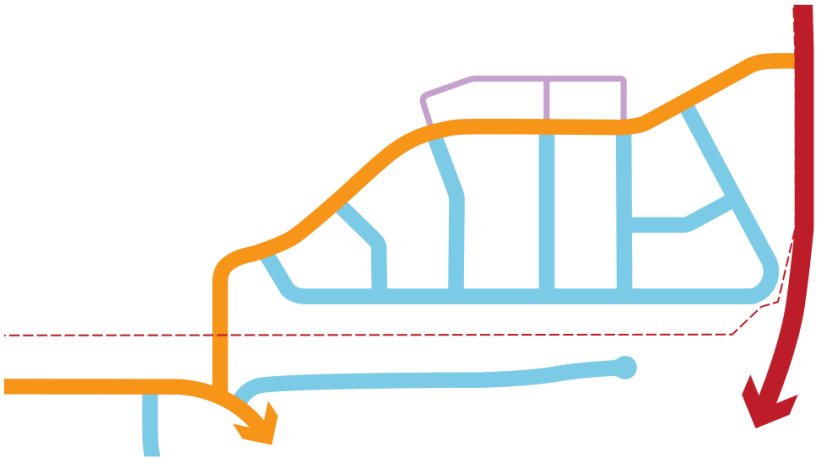
The structure plan employs six main Design Strategies. Although these are described sequentially, all the strategies are mutually supportive and combine to produce a coherent spatial structure. No strategy is more important than another. Some strategies – such as Connectivity - are applicable in some form to any urban location. These have been re-interpreted and adapted to suit the context of Whiskey Creek. Other strategies – such Absolute Urban Edge – are more particular to this development and its environs. These help to give a unique character to the new subdivision.





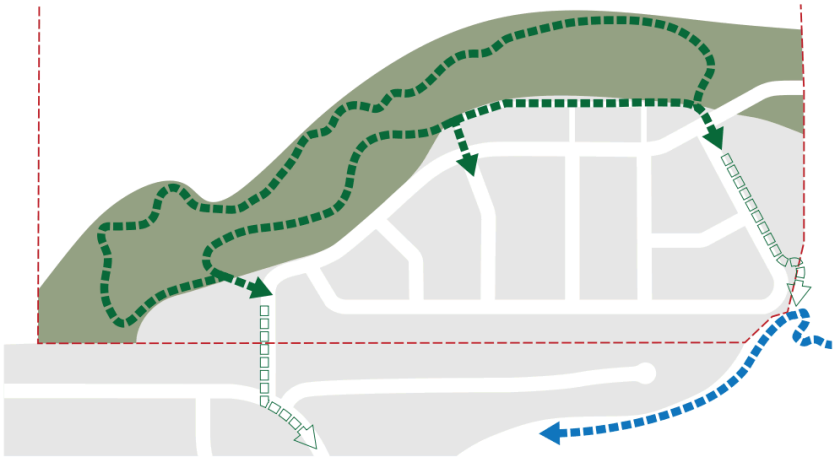
EXTERNAL LINKAGES

Whiskey Creek is accessed from Benmore Avenue and Rangitikei Line. Located at the plan's extremities, these two gateways ensure that the development is an integral addition to existing urban fabric. The Benmore Avenue link is city-facing and reinforces Whiskey Creek's status as a logical extension to established residential areas. The left-in left-out intersection with Rangitikei Line anchors the development to Palmerston North's north-south axis and connects residents with the future freight hub and other strategic initiatives on city's north-eastern fringe.



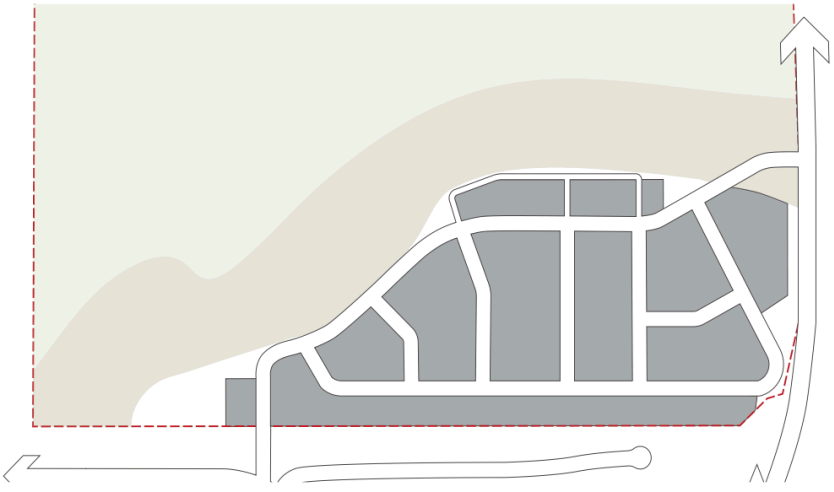
STREET HIERARCHY

A clear street hierarchy organises movement and strengthens place-based identity. As the only through-route, Road 1 (orange) serves as a primary collector and offers all residents a common experience. Its curved trajectory traces out the edge of the flood plain and orients travellers to the adjacent rural landscape. Local streets (blue) are more regular and share an angular geometry. However, each thoroughfare has a characteristic alignment or inflection. A lane (purple) brings public access and a north-facing frontage to the edge of the flood plain reserve.



OFF-ROAD TRAILS

Recreational pathways are established within the regenerating vegetation of Whiskey Creek. At intervals, these off-road trails connect to the local street network. In this way, the development provides a precedent for further trails to east and west. The Whiskey Creek subdivision bridges between the northern floodplain and the Mangaone Stream corridor. Designated residential streets join the trail systems associated with these important natural features. The resulting network introduces valuable recreational circuits to this part of the city.



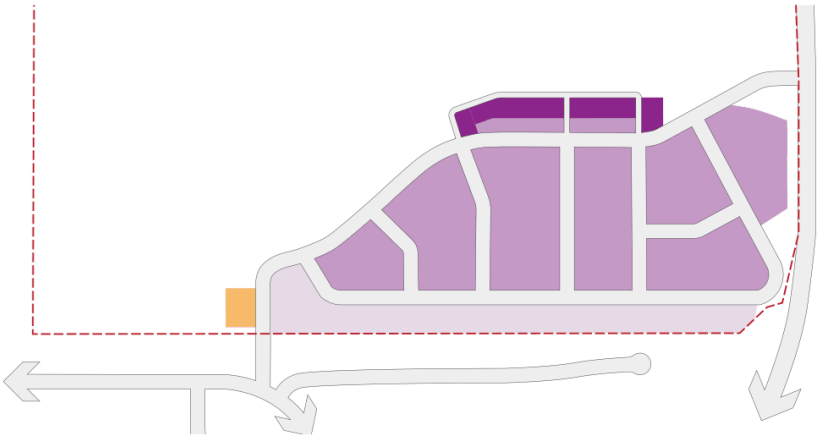
BLOCK PATTERN

Small blocks and joined up streets create a permeable neighbourhood with travel choices and built-in resilience. By adding frontage, the multiplicity of routes reduces the need for rear lots. Most streets have a north-south alignment, providing direct access to Road 1 and the flood plane reserve. Because they are oriented east-west, most residential lots enjoy good morning and afternoon sun. Southern aspects are minimised. The principal exception is Road 2, which complements the existing subdivision pattern along Benmore Avenue and Meadowbrook Drive.



OPEN SPACES

A flood plain limits further urban expansion to the north. This absolute boundary is expressed as a broad reserve along Whiskey Creek. As the development's principal ecological and recreational asset, this open space contains regenerating riparian vegetation and off-road trails. The green corridor is keyed into the local street system as a series of neighbourhood parks and stormwater detention areas. The largest of these hosts a mixed-use building at the western end of the site. A 30m setback from the eastern boundary reduces the impact of traffic on Rangitikei Line.



LOT TYPE & DENSITY

Most parcels are conventional suburban lots, which are suitable for detached dwellings of one or two storeys. Special conditions apply along the northern and southern boundaries of the plan. On the edge of the Whiskey Creek reserve, medium density development enjoys unobstructed views and direct access to recreational open space. Here, the plan anticipates two and three-storey semi-detached and fully attached dwellings. On the southern boundary, single-storey detached dwellings match the fabric of Benmore Avenue and Meadowbrook Drive.

3.4 Indicative planning and design options

Design development and site planning were undertaken at two levels. The first level considered broad land use scenarios: (i) existing rural zoning, (ii) rural residential and (iii) suburban residential. These are presented in Appendix A. The second level of design development explored different masterplan options for a 'suburban residential' scenario. These options are presented below. Both levels were subject to a Multi-Criteria Assessment, which is included within the section 32 analysis.

OPTION 1 - Business as usual

A hybrid geometry option to maximise the number of standard lots with uniform lot orientation. Connection to Flygers Line across the floodplain was investigated.



Figure 18. *Development Option 1*

Key characteristics:

- Low-moderate market risk, some variation/mix in density and dwelling type.
- Predominantly north-south lots with sub-optimal sun access.
- Good levels of open space amenity.
- Partly responsive to local landscape but discontinuous edge.
- Allows for ecological corridors.
- No local centre. Moderate external connectivity (Benmore Avenue, Flygers Line).
- Legible street pattern (clear geometry, range of street types).
- Potential for high-quality streetscape (range of street types).

OPTION 2 - Landscape-led approach

A 'distorted grid' street structure that provides views of the stream corridor at the end of each street and establishes clear sightlines. A continuous green amenity corridor along the boundary was tested.

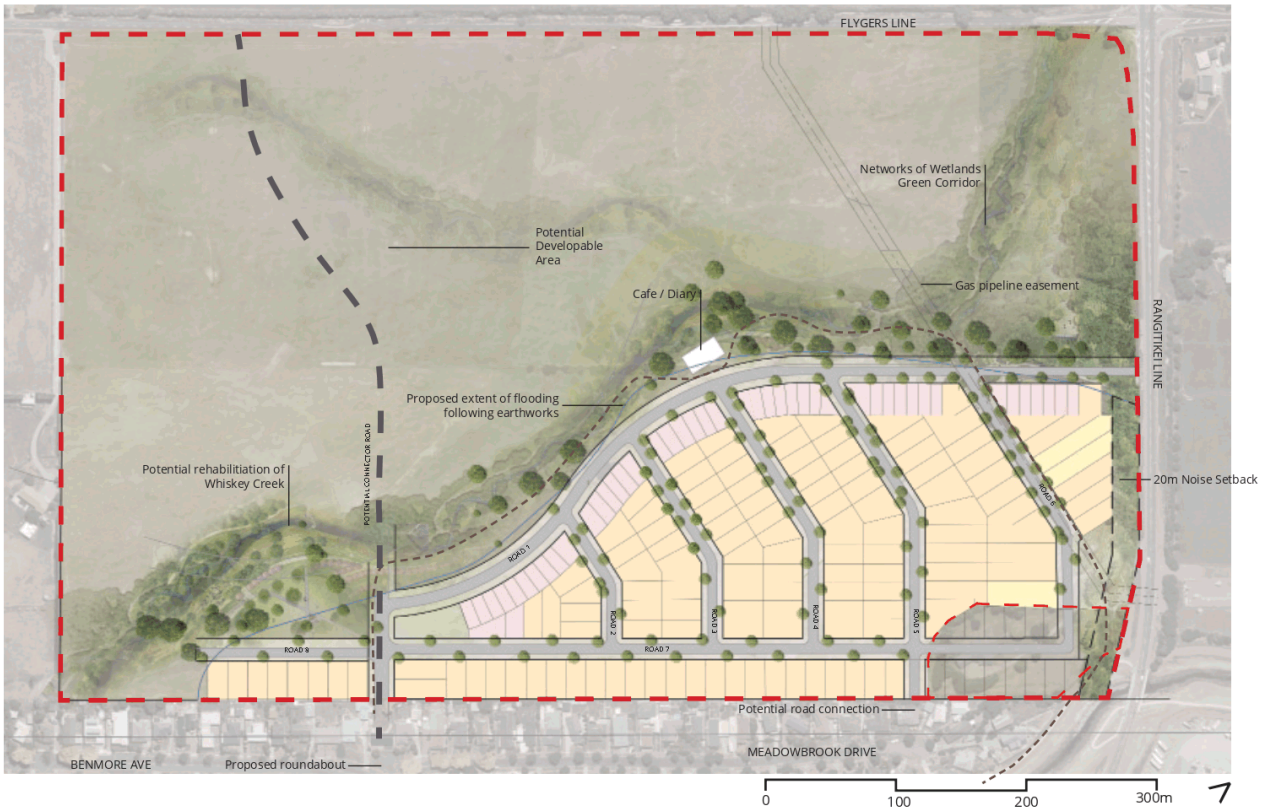


Figure 19. *Development Option 2*

Key characteristics:

- Moderate-high housing yield, moderate market risk (multi-unit housing).
- Significant variation/mix in density and dwelling type and local centre provision.
- Predominantly east-west lots offering good orientation for sun.
- High levels of open space amenity.
- Responsive to local landscape (flood plain, waterway).
- Naturalisation of Whiskey Creek corridor, extension of ecological corridors.
- Integrated low-impact SW management.
- Significantly improved urban edge.
- Good external connectivity (Benmore Avenue, Rangitikei Line).
- Strong support for PT/active modes (including walking).
- Extension to recreational trails (including Mangaone Stream).
- Moderate internal connectivity (no cul-de-sacs) but limited east-west connection.
- Legible street pattern (clear geometry).
- Potential for high-quality streetscape.

SCENARIO 3 - Neighbourhood network

A formal grid structure was tested to establish different densities, lot orientations and bring open spaces into the developed area.



Figure 20. *Development Option 3*

Key characteristics:

- Moderate-high housing yield, moderate-high market risk (multi-unit housing).
- Local centre provision.
- Significant variation/mix in density and dwelling type.
- Very high open space amenity (formal/informal).
- Responsive to local landscape (flood plain, waterway).
- Naturalisation of Whiskey Creek corridor, extension to ecological corridors.
- Integrated low-impact SW management.
- Significantly improved urban edge.
- Good external connectivity (Benmore Avenue, Rangitikei Line).
- Strong support for PT/active modes (including walking).
- Extension to recreational trails (including Mangaone Stream).
- High internal connectivity (small blocks, no cul-de-sacs).
- Legible street pattern (varied blocks, range of street types).
- Potential for high-quality streetscape (range of street types).

SUMMARY - OPTIONS DEVELOPMENT

- YIELD, DENSITY AND MARKET RISK: The amount and location of multi-unit housing is a key difference among the options. These factors play an important role in defining the absolute urban edge. However, they also pose a potential risk to developers because multi-unit housing is not common at edge locations in Palmerston North.

- LANDSCAPE CONNECTION AND AMENITY: Establishing a green corridor between the developed land and the agricultural land is a key consideration. This would provide amenity and improve ecology. All three options include this corridor. However, the extent and configuration varies slightly.

- RESPONSE TO FLOOD PLAIN: The area of developable land was a given, as the modified flood line was carefully modelled and taken into consideration for all three options. Therefore all options address Whiskey Creek and combine blue and green infrastructure along the boundary of the flood plain.

- EXTERNAL CONNECTIVITY: Connection to Benmore Avenue is common to all options along with a new proposed roundabout as the main link to the existing street network. Across the three options, connections to Rangitikei Line and Flygers Line were investigated. From multiple standpoints - roading, economic and urban design - a Rangitikei Line connection is favoured.

- INTERNAL CONNECTIVITY: Three different development patterns were investigated to combine maximum yield and an efficient internal movement network. The final preferred street network draws on the best outcomes of all three options, as seen in the illustrative masterplan overleaf.

3.5 Illustrative Masterplan

The indicative masterplan is presented in Figure 21 below. The masterplan emerged from testing various options presented in the preceding section. The plan features a widened stream corridor to enhance ecological outcomes and address potential liquefaction. Yield and block layout have been optimised within the developable portion of the Site as dictated by the revised flood line. The masterplan provides a through-site connection between Benmore Avenue and Rangitikei Line. Multi-unit housing occurs along a portion of the stream corridor, and a mixed use area is located near the intersection with Benmore Avenue.

Stormwater detention areas (in the form of wetlands) sit above the flood line. In low-flow events, these have potential contribute to the ephemeral Whiskey Creek. The gas pipe easement, SH3 noise buffer and flood boundary have been incorporated in the masterplan.

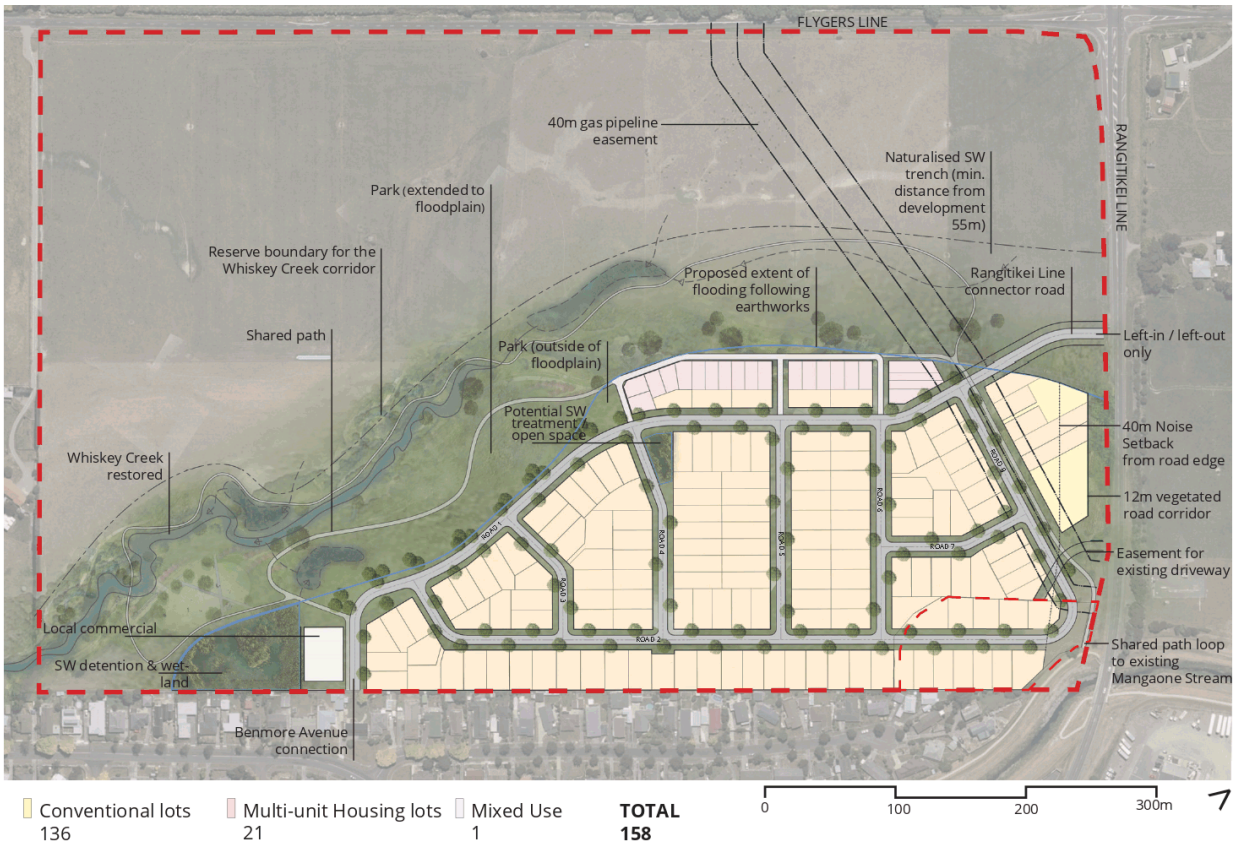


Figure 21. *Illustrative Masterplan*

Key masterplan characteristics:

CHOICE, FLEXIBILITY AND DIVERSITY: The masterplan indicates a mix of densities and uses. Multi-unit housing is located along Road 1 at the Rangitikei entrance / Whiskey Creek Reserve edge. A mixed-use area is located near the Benmore Avenue link. The mixed use area and graded densities provide choice, flexibility and diversity. They also promote activation and definition of the 'absolute urban edge'. Lot configuration along the southern boundary allows a complementary relationship with the existing urban fabric.

HIGH LEVEL OF EXTERNAL AND INTERNAL CONNECTIVITY: The masterplan combines the best aspects of the three scenarios to produce three key outcomes: (i) a connected spatial network, (ii) a legible spatial structure and (iii) a street hierarchy with external connections to Rangitikei Line and Benmore Avenue.

OPTIMISED AND PERMEABLE GRID: A street and block structure connects the Site with Whiskey Creek reserve and avoids the need for cul-de-sacs. Efficiently sized north-south blocks create east-west lots that maximise sun.

LANDSCAPE CONNECTIONS, AMENITY AND IDENTITY: An extended green corridor - at least 50m wide - is proposed along the revitalised Whiskey Creek corridor. A shared path and walkway system provides recreational loops and connections to the Mangaone Stream walkway. Formal and informal play spaces and observation areas are incorporated into the reserve. Combined with the local street network, well-connected open spaces create characterful 'place elements' that contribute to a unique Whiskey Creek identity.

ENVIRONMENTAL DESIGN: The masterplan provides new blue and green infrastructure for the Site integrated into the overall development. Stormwater detention areas are located outside of the floodplain and allow low flow back into Whiskey Creek through a set of wetlands. These improve water quality and revitalise the ephemeral stream bed. The street cross sections allow for open channels (SUDs) to be combined with traditional piped systems. The size of most private lots allows individual, on-site water storage and management to occur.

ECOLOGY AND BIODIVERSITY: The Whiskey Creek green corridor with its ephemeral wetlands, stream bed and restored area of lowland forest could become a significant habitat node to the north of the city. It can function as a stepping stone connecting areas such as Manderson's Bush with the suburban environment. The planting palette for streets and private lots will draw on the surrounding natural environment to provide a food source and shelter for returning fauna.

4. Planning Controls

4.1 Structure Plan

The structure plan is derived from the preferred planning and design outcome. It embodies the requirements of the client brief, design principles and design strategies identified earlier in this report.



Figure 22. *Structure Plan*

STRUCTURE PLAN - KEY FEATURES

- New local collector street (Road 1) linking Benmore Avenue to Rangitikei Line: 16.2m wide legal road corridor (13.6m wide adjacent to reserve).
- New local roads (Roads 2-8): 15.2m wide legal road corridor.
- New shared street lanes: 4.5m wide carriageway.
- New roundabout connection with Benmore Avenue and left-in / left-out connection with Rangitikei Line.
- Sustainable Urban Drainage (SUD) network integrated into the street and open space system.
- Variation in housing density - conventional suburban lots (ranging from 450-550sqm) and a Multi-Unit Housing Area overlay along part of the Reserve edge.
- Whiskey Creek Reserve including a revitalised waterway and planting to achieve an ecologically diverse and rich area.
- Public shared pathways throughout the area and connecting Mangaone Stream to Whiskey Creek Reserve.
- Incorporation of gas pipeline easement, SH3 setback/buffer and flood boundary.
- Area of restricted height for lots adjoining existing Meadowbrook Drive properties to achieve sensitive transition and protect amenity.

4.2 Development Standards

In general, PNCC residential zone standards apply to the Whiskey Creek Structure Plan. A Multi-Unit Housing Area (MUHA) overlay is proposed for part of the Plan. Specific development objectives require several new or modified standards to be introduced. These are summarised in tabular form at the end of this report.

STREET HIERARCHY

LOCAL COLLECTOR ROAD: Road 1 is the backbone of the development, connecting the roundabout at Benmore Avenue to a left-in /left-out intersection with Rangitikei Line. Road 1 also creates connections between residential blocks and the Whiskey Creek corridor. A carriageway width of 6.5m is proposed with varied parking / planting to help reduce speed. Additional traffic calming may include raised table crossings. On Road 1, visitor car parking is unobtrusive, and there is enhanced street planting along the reserve edge.

LOCAL ROAD: Roads 2-8 are local roads with a proposed carriageway width of 5.5m. These streets allow for integrated low-impact stormwater management features within the road reserve and enhanced street planting to promote ecological connections and walkability. The streets provide clear sightlines, including visual links to Whiskey Creek Reserve. Streetscape consists of simple, high-quality treatments.

LANE: Lanes are confined to the multi-unit housing area and form an integral part of the shared path network. Lanes are designed as shared streets along the reserve boundary and strengthen the landscape connection between the reserve and the development, performing well as part of the mobility network. The shared street carriageway is generally one-way with a width of 4.5m, permeable paving solutions are encouraged to minimise impact on the reserve.

SHARED PATHS: A shared path network provides walking and cycling connections within the development and creates external connections to Benmore Avenue and the Mangaone Stream corridor. The typical width of the shared path network is 3m with a hard surface to allow permanent use throughout the year.

SUSTAINABLE AND RESILIENT BLUE AND GREEN INFRASTRUCTURE

STORMWATER: a combination of traditional piped connections, open channels and rain gardens create a resilient, environmentally friendly network. The stormwater system is connected into detention areas which are constructed as shallow, planted areas / ephemeral wetlands. This naturalised network of wetlands and open channels has potential to deliver temporary base flows to the enhanced Whiskey

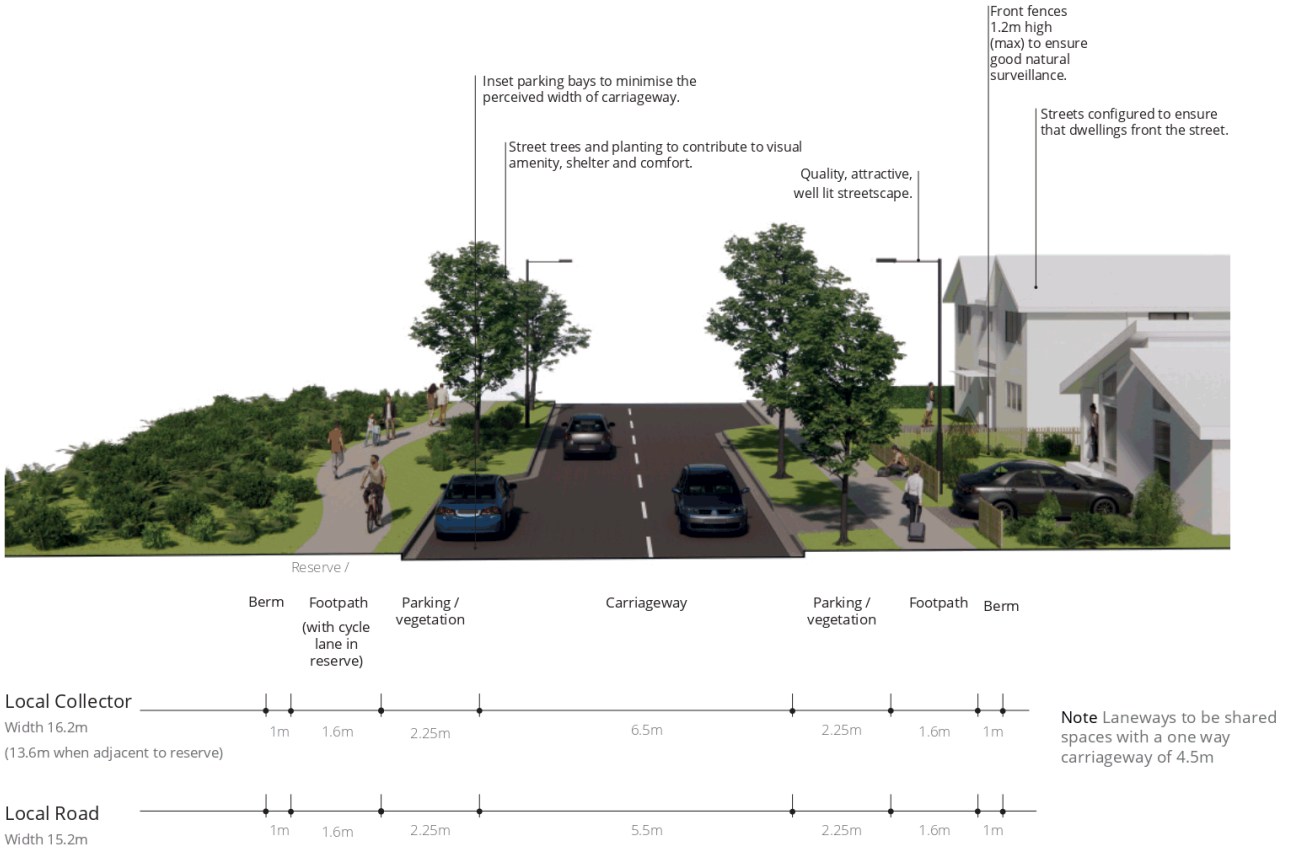


Figure 23. ***Illustrative street cross section***

Creek stream bed, which would allow an increased amount of water to be present in the system, especially after rain events. Sustainability and resilience are important factors and the network will be developed using water sensitive design.

RESERVES, ECOLOGY AND VEGETATION: Future ecology on the site is focused on the Whiskey Creek corridor. This presents an opportunity to re-establish stands of once-present lowland kahikatea swamp forest. Eco-sourced native planting in the reserves and wetland areas are important to boost biodiversity.

The planting palette is to be developed collaboratively with Council's biodiversity team and Rangitāne-o-Manawatū to provide year-round resource, food and shelter for native wildlife, most notably birds. The reserves also provide benefits for residents in the form of māra, indigenous plants and fruit trees. The installation of iwi-designed signs, bollards and other landscape elements would allow for Rangitāne storytelling, highlighting their history and relationships with the landscape and waterways. Working with mana whenua, the council needs to identify appropriate locations for show-casing mahi toi art and features like pou.

MINIMUM NET SITE AREA

The range in housing density is shown on the structure plan and on the indicative masterplan described earlier in this report.

Within conventional suburban areas, existing District Plan Performance Standards apply, i.e. a min 350sq.m lot size. The Greenfield Residential Area average lot size of 500-550 is proposed to be adjusted to 400-500sq.m. Within MUHA overlay the District Plan standard minimum net site area per dwelling of 150sqm applies although in these areas a general lot size range of 220sqm to 330sqm is anticipated.

CONVENTIONAL SUBURBAN LOTS: These lot types occupy the majority of the Plan. Measuring at least 450m2, they continue established planning and development practices and create a sympathetic relationship to existing built up areas. Additional constraints on lot alignment occur along the interface with existing Meadowbrook Drive lots where lot lines are aligned whenever possible. Careful attention to block size and street layout has resulted in only four rear lots.

MUHA LOTS: Medium Density housing occupies parts of the Plan facing Whiskey Creek Reserve. These are generally north-facing lots accessed via a shared street laneway. They accommodate the plan's smallest residential lots. With a District Plan minimum net site area per dwelling of 150sqm (and an general range of 220-330sqm), these Lots combine the benefits of more intense / low maintenance living within a semi-rural experience. This format extends housing options not just at Whiskey Creek but within Palmerston North as a whole and reflects the approach taken at Aokautere.

COMMERCIAL LOT: A single local commercial area is proposed (within the residential zone) fronting Road 1 close to Benmore Avenue. This area is suitable for subdivision into smaller commercial tenancies if required. In this location the plan anticipates ground-floor commercial accommodation with the potential for residential apartments above if market demand exists for these types of accommodation. There is no restriction on lot size.

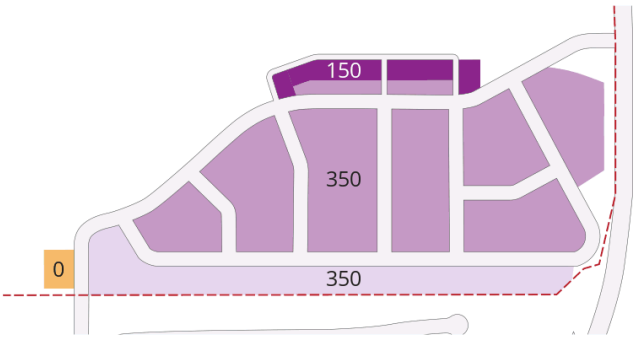
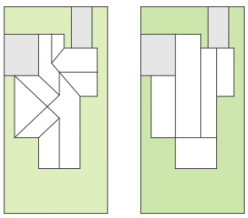
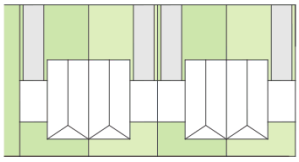


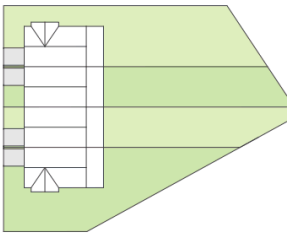
Figure 24. ***Minimum lot areas (sqm)***



Conventional suburban lots
DP min 350sq.m
Anticipated lot size range 450-550sq.m
Single or two-storey houses



Medium density lots (MUHA)
DP min 150sqm
Illustrative range 220-330sqm
Lot width 10m
Two or three-storey semi-detached



Medium density lots (MUHA)
DP min 150sq.m
Illustrative range 220-330sqm
Lot width avg 6m
Three-storey terraced (fully attached)

Figure 25. ***Illustrative lot size and development outcomes***

MAXIMUM BULDING HEIGHT

Most of the Plan area is subject to the standard 9m residential height limit. However, a proposed maximum height of 11 metres applies to MUHA overlay areas.

A 9m height limit comfortably accommodates two-storey detached houses. The proposed 11m limit enables three-storey construction that is commonly associated

with semi-detached dwellings and terraced houses on narrower lots. These dwelling types frequently contain a ground-level garage with two floors of living accommodation above. In general terms, the additional height encourages compact medium-density development and a wider range of dwelling types.

Within the proposed MUHA area, the 11m height limit encourages stronger spatial definition of the Whiskey Creek Reserve and wetlands. Also, taller development takes advantage of the exceptional visual quality of the new public reserve.

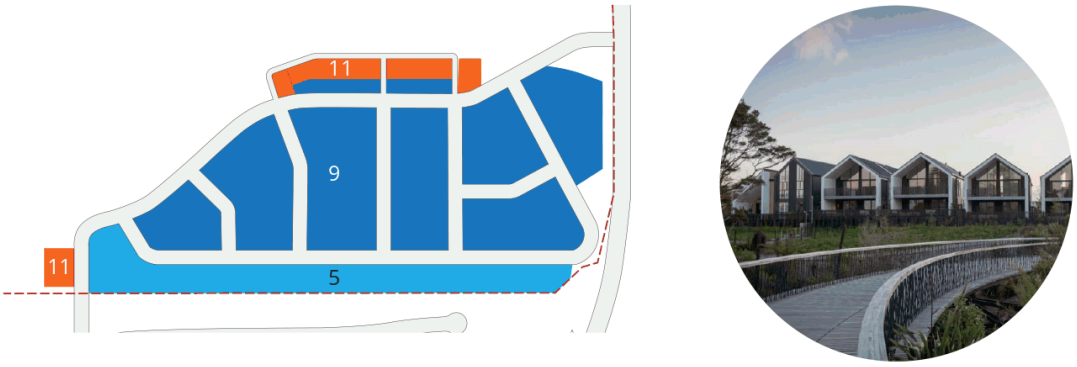


Figure 26. ***Proposed maximum building heights (m)***

BOUNDARY CONTROLS

The Whiskey Creek Structure Plan employs a wider range of boundary controls than the Operative District Plan. Within Medium Density areas (MUHA overlay) along the northern edge of the development more permissive boundary controls enable semi-detached and fully attached (terraced) dwellings within comprehensively designed developments. Existing Residential Zone boundary controls apply to the Conventional Suburban Lots that comprise the bulk of the Plan.

Narrow lots make efficient use of high-amenity locations overlooking Whiskey Creek. Semi-detached and fully attached dwellings are well-suited to such locations. To facilitate this subdivision pattern and associated housing types, height recession planes and separation distances are relaxed or omitted. Relaxing these controls is contingent upon coordinated planning and careful design.

To facilitate semi-detached dwellings, the Plan permits zero separation distance along a single shared side boundary within a coordinated development on two

or more adjoining parcels. This provision also applies to Accessory Buildings and Additional Minor Dwellings. To facilitate fully attached dwellings, the Plan permits zero separation distance along all shared side boundaries within a coordinated development on multiple adjoining parcels.

A height recession plane does not apply along a shared side boundary where the zero separation provision is activated. In effect, a pair of semi-detached dwellings – or a row of fully attached townhouses – is treated as one building.

To accommodate two and three-storey dwellings on narrow lots, the height recession plane is proposed to be steeper and more elevated. The plane commences 3m above ground and inclines upwards at an angle of 60 degrees to the horizontal. Once again, coordinated planning and careful design are required to mitigate effects on neighbouring sites. Restricted discretionary Assessment Criteria (R10.6.3.3 and R10.6.3.1) will also apply to ensure amenity effects are addressed.

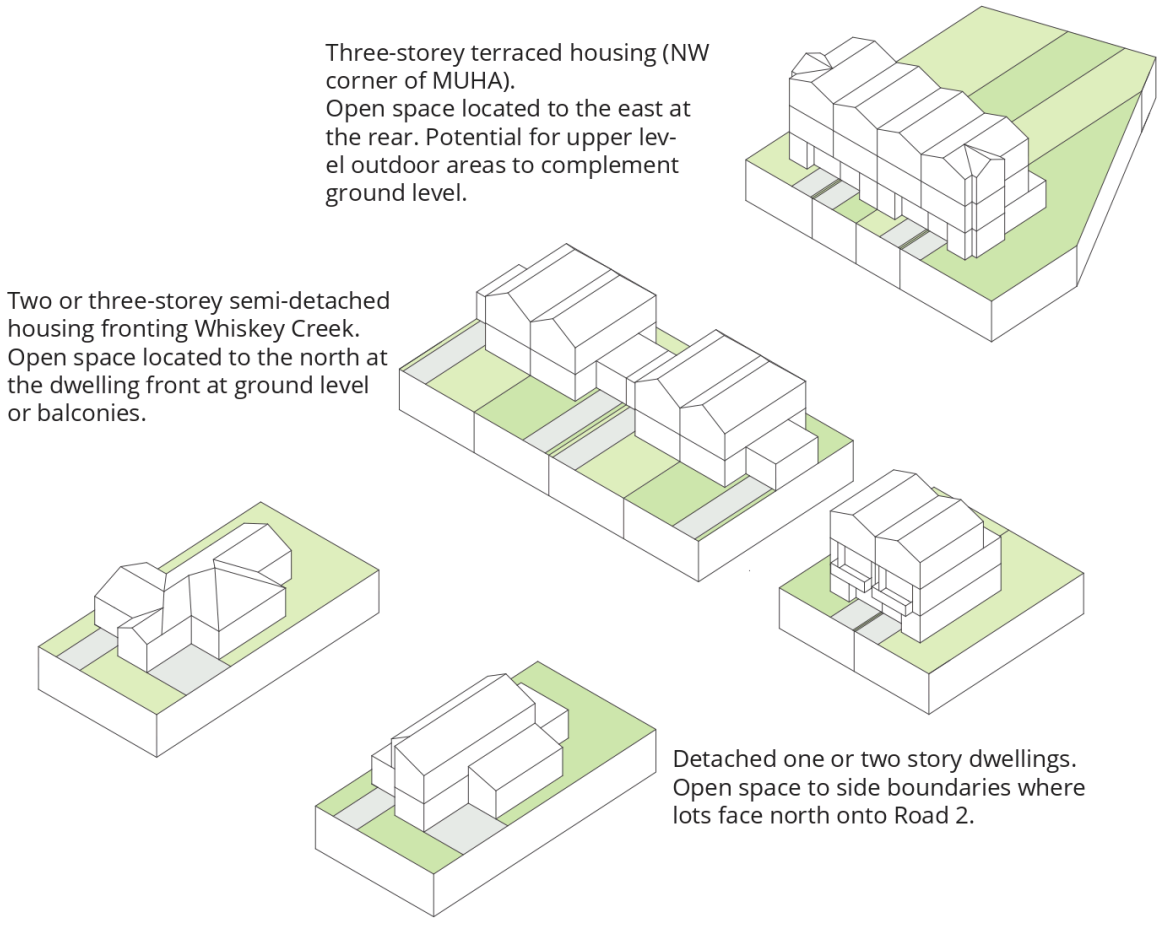
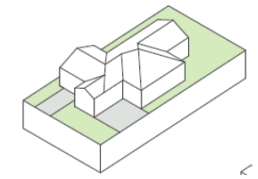
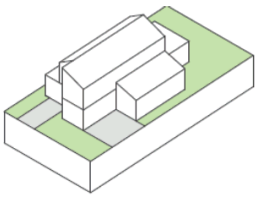
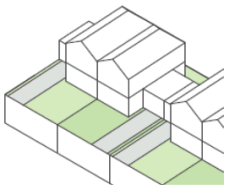
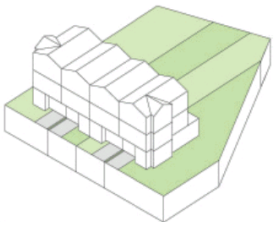


Figure 27. ***Illustrative dwellings - setback, massing, open space***

PRIVATE OUTDOOR AMENITY

Where the 11m maximum building height applies, private outdoor amenity areas may be elevated above ground level. The 11m height limit anticipates three-storey dwellings with first-floor living spaces. In this case, a well-oriented generously proportioned deck or balcony may complement ground-level garden spaces. An elevated outdoor area can deliver better views and support passive surveillance of adjacent public space.

SUMMARY OF DEVELOPMENT STANDARDS

LOT/BUILDING TYPE	Greenfield Residential replacing Conventional Suburban		
CONVENTIONAL SUBURBAN		***Existing Standards***	***Whiskey Creek Plan Change***
 	Min Lot Size (sq.m)	350	No change
	Avg Lot Size (sq.m)	500-550	400-500
	Max Coverage (%)	40 on sites < 500m² 200m² on sites 500-572 m² 35 on site >5762 m²	No change
	Min Front Setback (m²)	3 (6 for garage/carport)	No change
	Min Separation (m²)	1.5	No change
	Max Height (m)	9	No change except 5m at interface with existing Meadowbrook lots
	Recession Plane	45° at 2.8m	No change
	Min Amenity Area (m²/unit)	36	No change
	Fencing (m)	0.9	No change
	Description: Enables 1 and 2-storey detached dwellings. Dwellings match the scale and character of adjacent established residential areas. Larger lots on corner sites allow flexibility for dwelling design to address both streets and accommodate alternative access arrangements. Larger lots introduce more room for vegetation along boundaries.		
MUHA		***Existing Standards***	***Whiskey Creek Plan Change***
 	Min Lot Size (m²)	Nil or 150	150
	Min unit size (m²)	40 or 60	60
	Max Coverage (%)	40	No change
	Min Front Setback (m)	3 (6 for garage/carport)	No change
	Min Separation (m)	1.5*	1.5**
	Max Height (m)	9	11
	Recession Plane	45° at 2.8m	60° at 3m**
	Min Amenity Area (m²/unit)	30	No change ***
	Fencing (m)	0.9	No change
	Description: Enables 2 and 3-storey terraced or semi-detached townhouses. Attached typologies and narrower lots increases yield and optimises very high open space amenity locations onto the proposed reserve. Townhouse shared street design establishes clear identity and sense of place at transition to Whiskey Creek Reserve with safe recreational trail access. A 6m street setback allows for front yard open space for north-facing lots but has the negative effect of increasing visual presence of cars. A 3m setback reduces vehicle presence on shared streets and provide sense of enclosure to lanes. With reduced north-facing front yards, balconies supplement at-grade open space when main living area is elevated. Assessment required against Multi-Unit design criteria.		

* Does not apply when two dwellings are joined by their respective garages.

** Does not apply to a party wall boundary between two or more comprehensively designed dwellings.

*** Min 8sq.m balcony/decks to complement ground level opens space if living area is above ground.

5. Conclusions

The Whiskey Creek proposed Structure Plan and Plan Change has been developed over a 10 month period from May 2020 with expert input from a multi-disciplinary team. Positive engagement and feedback has been recevied from PNCC that has led to various Plan adjustments; notably decisions around stormwater, open space provision and roading. Engagement has also taken place with local residents. This resulted in amendments to the residential interface with exitsing Meadowbrook dwellings; namely a reduction of maximum height to 5m and aligning of property boundaries wherever possible.

The Site is suitable for a combination of conventional suburban housing and multi-unit medium-density housing with a range of dwelling types. A high level of amenity will be created through a revitalised Whiskey Creek. This will create an attractive northern edge to the city along with generous wetland parks and public recreational trails. A new local centre-type facility adds further amenity.

Overall, the proposed structure plan and anticipated development performs positively from and urban design and landscape perspective for the reasons summarised below:

1. Comprehensive planning produces a high-quality, walkable public realm with visual and physical connections between the development and Whiskey Creek. The local street system is complemented by a network of off-road trails, which link residential properties to city-wide corridors (Mangaone Stream).

2. Coordinated development incorporates medium-density housing (as a proposed MUHA overlay) with a range of lot sizes and dwelling types as well as conventional housing.

3. Local centre-type facilities are proposed in an appropriate location accessible to both existing and future residents as well as general public users of the planned Whiskey Creek ecological corridor.

4. Targeted development standards have been established to address the relationship with existing housing and to ensure the effects of multi-unit housing are mitigated.

5. New site-specific standards include: 400-500sqm average net site areas; the reduction of some separation distances; and the relaxation of some height recession planes. These provisions encourage narrow lots with street-facing housing and the capacity to accommodate a range of housing types. An 11m maximum building height is proposed in high-amenity MUHA-capable areas. This provision accommodates two and three-storey dwellings, which make better use of the most favourable locations.

6. A revitalised Whiskey Creek corridor includes riparian planting, the introduction of new wetland features and enhanced Whiskey Creek water flows. Througout this corridor a variety of new pedestrian and cycle paths are proposed linking with the wider street network and Mangaone Stream.

7. The proposed street network presents a street heirearchy that is consistent with Council's direction elsewhere (Aokautere and Roxburgh Crescent). High amenity, connected streets are proposed that include street tree planting and sustainable urban drainage. Streets are configured to connect visually and physically with the Whiskey Creek corridor.

8. Open spaces are provided across the development area offering public recreational opportunities including walking and play. All lots are sized and designed to allow for District Plan private open space requirements.

9. Stormwater management has been carefully considered (see separate report by DHI), and a solution provided that integrates water flows with the design of streets and open spaces. Detention ponds and reticulation are incorporated as positive wetland features in the plan.

APPENDIX 4

FLYGERS LINE PLAN CHANGE CULTURAL IMPACT ASSESSMENT

TO HOTU MANAWA O RANGITANE O MANAWATU MARAE

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Te Hotu Manawa o Rangitāne o Manawatū Marae
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Flygers Line Plan Change

Cultural Impact Assessment

Assessed by Siobhan Karaitiana

Reviewed by Danielle Harris

Introduction and Background

Rangitāne o Manawatū have been engaged by Flygers Investment Group Limited to undertake an assessment of cultural values and impacts on Rangitāne o Manawatū of the Flygers Line Plan Change. This assessment is undertaken using a Whānau Ora Framework.

Rangitāne o Manawatū whakapapa

Ancestors of Rangitāne o Manawatū arrived in New Zealand aboard the Kurahaupo waka over 30 generations ago. Whatonga, who was a captain of the waka, settled in Heretaunga and explored a large part of Aotearoa. Whatonga is the epitimous ancestor whom the people of Rangitāne o Manawatū trace their lineage. Rangitāne was the grandson of Whatonga whose descendants occupy the Manawatū and other areas of the lower North Island and the top of the South Island today.

Tini whetu ki te rangi, ko Rangitānenui ki te whenua

As numerous as the stars in the sky are the people of great Rangitāne upon the land



Mātauranga a Rangitāne

Rangitāne o Manawatū worldview is based on the holistic principle that all elements are interrelated. Every part of the environment is understood to have a common genealogy, descending from a common ancestor. The principle ancestors being Io Matua te Kore (the nothingness), Ranginui and Papatūānuku (Sky Father and Earth Mother). This genealogy places Rangitāne iwi as descendants of the environment they inhabit. It reinforces cultural identity and a deep connection to the land. This mātauranga links Rangitāne o Manawatū to the world creating an inseparable bond and a responsibility to protect the environment from misuse. Rangitāne o Manawatu have been mana whenua for hundreds of years, thus have a deep connection to life-giving land and waters of the Manawatū and an obligation to protect and restore the mauri for future generations.

Manawatū Awa

At the turn of the 19th century Rangitāne and Rangitāne whānaunga had held mana over nearly the entire drainage basin of the Manawatū River for many hundreds of years. Life centered around the river and its tributaries which came to shape the worldview of Rangitāne. Thus the naming of the Manawatū River and its creation feature prominently in Rangtāne lore.

The story of Haunui a Nanaia and naming of the Manawatū River

> *After Haunui moved to the west coast of the North Island, his wife Wairaka ran away with a man named Weku or Weka. Haunui set off in pursuit of the runaways who had gone southward along the coast. As Haunui followed them he named many of the rivers he had to cross on his journey. One morning he came to a river so cold, wide and deep that it made his breath stand still. He called it Manawa-tū, meaning still breath. Haunui overtook Weku and Wairaka at Pukerua Bay, after arriving at the summit of the Rimutaka Range he called upon his god Rongomai to return him to his home on the west coast.*

The story of Okatia and the creation of the Manawatū River

> *In the distant past lived a totara tree growing on the slopes of Puketoi Range. This totara tree became possessed by a super natural being called Okatia. Under the influence of the spirit, the tree began to move gouging a large channel north-west. Before long it came to the Ruahine-Tararua Mountain Belt, the totara tree turned westward and hammered its way through the mountain chain breaking through, exhausted the totara tree meandered across the Mananwatū plains until it reached the Foxton river mouth and made its way out to sea.*

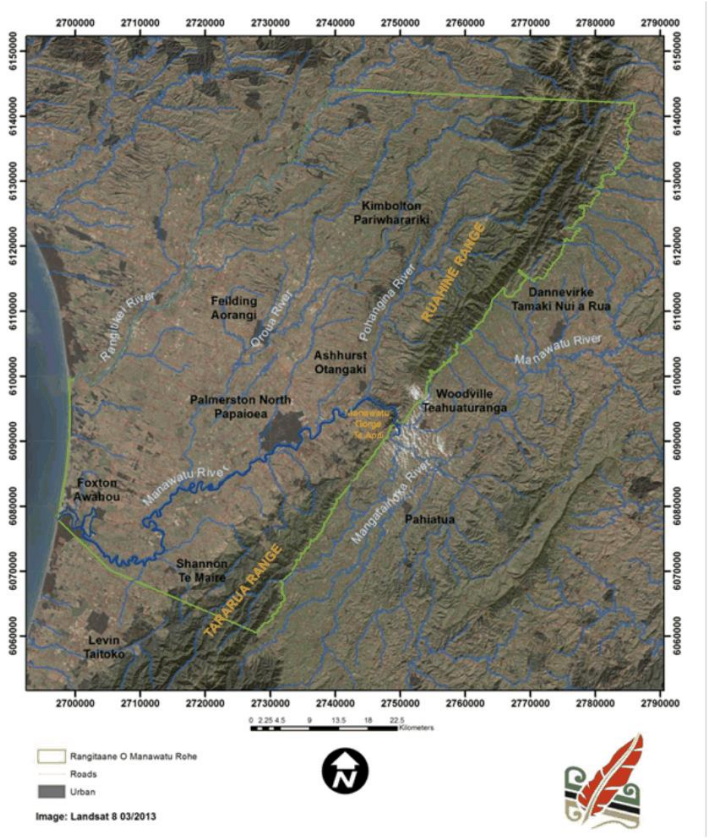

Figure 1. Rangitāne o Manawatū area of interest- post Treaty of Waitangi settlement.

Rangitāne o Manawatū Hapū

Rangitāne o Manawatū is a collective of six hapū. Leaders within hapū work closely together and each hapū has a place on the Rangitāne o Manawatū Treaty Settlement Trust. This collaboration forms the mandate for Rangitāne o Manawatū Iwi. The six hapū are as follows.

Ngāti Mairehau (Also known as Ngai Tuahuriri)

- Descend from the land on the east bank of the Manawatū River between Turitea and Tokomaru, including over the Tararua Ranges to Pahiatua.

Ngāti Te Kapuarangi

- Descend from the land surrounding the current city of Palmerston North.

Ngāti Hineaute

- Descend from the land from Te Apiti to the northern boundary of Palmerston North City.

Ngāti Rangitepaia (Also known as Ngāti Rangi)

- Descend from the land from the southern boundary of the City to the confluence of the Oroua and Manawatū Rivers.

Ngāti Rangiaranaki

- Descend from the land between Te Apiti and Palmerston North with Ngāti Hineaute.

Ngāti Tauira

- A Rangitāne – Ngāti Apa hapū that descend from the land around the Oroua River above Mangawhata extending to the Rangitikei River.

Te Ao Turoa Environmental Centre

Te Ao Turoa Environmental Centre contribute to upholding kaitiakitanga on behalf of Rangitāne o Manawatū Iwi. They work to promote the health and wellbeing of people, the environment, wāhi tapu and taonga by forming positive relationships and partnerships with local councils, governmental agencies, private developers and community. Te Ao Turoa Environmental Centre undertake ecological and cultural monitoring projects; restoration of waterways through planting, weed and pest control, and plastics in waterways reduction initiatives; they engage in planning processes including local policy review, town planning, and resource consenting. The center is closely linked to Bestcare (Whakapai Hauora) Charitable Trust, Te Hotu Manawa Marae, Rangitāne o Manawatū Settlement Trust and Tanenuiarangi Manawatū Incorporated. Te Ao Turoa Environmental Centre are delivering a Māori model of environmental management. With support from Perception Planning, the center developed a means of identifying and measuring outcomes sought by the iwi using the Whānau Ora Framework.

The Whānau Ora Framework

Structuring a Cultural Impact assessment using Whānau Ora

Whānau Ora simply translates to “family health.” The philosophy is based on a set of consistent whānau-focused outcomes, and is a framework for assessing the success of projects and directing project actions. Whānau Ora was created in response to the recognition that standard ways of delivering social and health services was not working and outcomes particularly for Māori whānau, were not improving. In 2010 Whānau Ora was launched as an innovative whānau-centred approach to supporting whānau wellbeing and development.

In 2015 a Whānau Ora Partnership Group made up of six Iwi and six Crown representatives was established. This group provided a strategic oversight of Whānau Ora and advised the Minister for Whānau Ora. The Whānau Ora Outcomes Framework, agreed by the Whānau Ora Partnership Group, is the principle measurement for indicating the success of Whānau Ora. The framework sets out seven principal outcomes that can be applied in any setting, to achieve improvements for whānau over the short, medium and long-term.

Framework Outcomes

Whānau ora allows for iterative decision-making with outcomes that support an indigenous world view. The approach moves away from focusing on crisis and deficit language, to supporting the aspirations. The seven principal outcomes are described below that were developed as part of the framework.

Whānau Ora is being met when whānau are:

- self-managing and empowered leaders
- living healthy lifestyles
- confidently participating in te ao Māori (the Māori world)
- participating fully in society
- are economically secure and successfully involved in wealth creation
- cohesive, resilient and nurturing
- responsible stewards for their natural and living environments.



Rather than trying to understand what's the matter with you, we're more interested in what matters to you. ~ Sir Mason Durie, Massey University

The Whānau Ora Outcomes Framework is used as a guide to ensure environmental management is holistic in definition and design, has a positive impact on lifestyles and ecosystems, and can be easily tracked and monitored. Three most relevant values have been extracted from the framework that the iwi feel are most relevant to the Flygers Line Plan Change. The Assessment recommends ways in which these values can be supported and impacts of the Plan Change can be mitigated.

Whānau Ora Assessment for Flygers Line Subdivision

Value: Rangatiratanga- Rangitāne are self-managing and empowered leaders

Key Value Outcomes	Giving effect to these Outcomes in Flygers Line Subdivision	Assessment
Rangitāne o Manawatū exercise rangatiratanga by collaborating in planning for ngā Atua Māori.	Resourcing Rangitāne o Manawatū to participate in the Plan Change process	This Cultural Impact Assessment has been resourced by the developer
	The developer and Rangitāne o Manawatū work together to co-design a plan for the management of the stream corridor.	Rangitāne o Manawatū have been engaged to provide comment on the proposal. The iwi are supportive of the approach to managing the ephemeral stream corridor and recreation.
Rangitāne contribute to the understanding of the cultural landscape, including identifying and providing for their values and relationships with whenua, wai, taonga, and wāhi tapu.	The developer supports restoration of biodiversity and develops recreation within appropriate landscapes of significance and wāhi tapū.	A pathway will be provided for along the stream corridor. Biodiversity restoration should use indigenous species eco-sourced from the Manawatū area.
	Cultural signage, information boards and mahi toi within recreation areas are provided to share Rangitāne o Manawatū values and relationships with the land and waterways.	Not incorporated to date. Comment is requested from the developer.
	The developer supports Rangitāne o Manawatū connection to whenua by using traditional names to bring those names back to life.	Not incorporated to date. Request the developer considers this proposal.

	Appropriate soundscape and light-scapes are a required to protect natural and cultural areas. The use of treatment wetlands and water sensitive design are included in all new developments and land intensification proposals.	Request street lights use biodiversity sensitive lighting. Proposed at a high level. Request further information to understand what this means for water quality and quantity of discharge.
Rangitāne o Manawatū are aware of their interests in assets held in common and have a clear idea of their opportunities, rights and responsibilities.	Impacts on any permanent, ephemeral and temporary streams and wetlands are reduced, mitigated and offset. Impacts on any indigenous biodiversity and vegetation is reduced, mitigated and offset. Rangitāne o Manawatū Accidental Discovery Protocol is included in earthworks consents and when new paddocks are	Stream loss will be minimum, stream will be realigned and enhanced. There is little indigenous habitat or taonga species directly impacted by this project. Request for inclusion in consent conditions.

Value: Hauoranga -Whānau are leading Healthy Lifestyles

Key Outcomes	Giving effect to these Outcomes	Assessment
Whānau are able to actively participate in a sustainable economy.	The green spaces for māra, indigenous plants, fruit trees, and solar opportunities is mapped. Te Ao Turoa Environmental Centre are supported with resourcing to enable whānau to reconnect with the whenua, wai and wahi tapū through the creation of environmental mahi.	The project should incorporate the use of fruit and nut trees in the stream enhancement area. Opportunity exists to work with Rangitāne o Manawatū to undertake planting in the site area. Developer to consider.
Whānau are able to support their hinengaro, physical wellbeing, and their wairua.	Pathways/cycleways connect natural places and communities in a safe and integrated manner.	Recreation access and pathways are provided for. Detailed design requires further consultation.
Whānau have access to and can safely interact with wai, whenua, taonga, and wāhi tapu.	Development does not cause adverse sedimentation issues within the Mangaone Stream or Wiskey Creek	A condition should be provided for to designate an appropriate monitoring program, including cultural health monitoring.

		Sediment and Erosion control will occur on site.
Whānau can afford to buy and rent houses, in safe locations that allow them to fully interact within the community.	Greenfield housing must be developed with access to new green spaces and education facilities. The developer supports the creation of affordable housing for Palmerston North community and whānau. Housing is developed in appropriate areas that are safe form natural hazards	Provided for. Detailed design should be in consultation with Rangitāne o Manawatū Section sizes are modest and appropriate for the area. Approach supported by Rangitāne o Manawatū. Rangitāne o Manawatū care oncerned about location and flooding. Further information requested.

Value: Tuakiritanga – Whānau are confidently participating in te ao Māori

Key Outcomes	Giving Effect to these Outcomes	Assessment
Te ao Kōrero Māori/Māori language is visible and celebrated in the wider community.	Ensure Te Reo translation is included in any signage.	Further information requested.
Street and place names acknowledge Māori place names, values, significant sites and tupuna (ancestors).	Work in partnership with Rangitāne to identify original place names, values, significant sites and tupuna names that could be utilised for street or place names. Use original Rangitāne place names as much as Possible. Install iwi-designed bollards and signs to represent Rangitāne story and their relationships, and history, with the landscape and waterways. Identify with mana whenua	Further information requested

	appropriate public areas to show-case mahi toi art and features like pou.	

Conclusions

Rangitāne o Manawatū have not identified any fatal flaws from a cultural/whānau ora perspective for this Plan Change. Further information requests have been made throughout the assessment. Rangitāne o Manawatū expect the developer will put forward clauses within the plan change to reflect whānau ora and cultural values discussed within this assessment and for on-going consultation requirements as the Plan Change takes shape into the future.

APPENDIX 5

PRELIMINARY AND DETAILED SITE INVESTIGATION: CONTAMINATED LAND.

RILEY CONSULTANTS LTD

RILEY CONSULTANTS

PRELIMINARY AND DETAILED SITE INVESTIGATION CONTAMINATED LAND RANGITIKEI LINE AND FLYGERS LINE PALMERSTON NORTH

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PRELIMINARY AND DETAILED SITE INVESTIGATION
CONTAMINATED LAND
RANGITIKEI LINE AND FLYGERS LINE, PALMERSTON NORTH

Report prepared for: Flygers Line Investment Group Limited

Report prepared by: Ali Anwar, Geoenvironmental Scientist

.....

Report reviewed by: Marcus Herrmann, Principal – Contaminated Land

.....

Approved for issue by: Rob Burden, Technical Director

.....

Report reference: 170672-B

Date: 22 February 2019

Copies to: Flygers Line Investment Group Limited 1 electronic copy

Riley Consultants Ltd 1 copy

Issue:	Details:	Date:
1.0	Preliminary and Detailed Site Investigation	22 February 2019

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Appendix A: Historic Aerial Photographs
Appendix B: Site Contamination Enquiry Report
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PRELIMINARY AND DETAILED SITE INVESTIGATION CONTAMINATED LAND RANGITIKEI LINE AND FLYGERS LINE, PALMERSTON NORTH

1.0 Introduction

As requested by Ms Holly Jenkins of Kevin O'Connor & Associates Ltd (KOA) on behalf of Flygers Line Investment Group Limited, Riley Consultants Ltd (RILEY) has been engaged to provide ground contamination assessment services for two lots of land on the corner of Flygers Line and Rangitikei Line in Palmerston North. This assessment has been prepared as part of an overall submission to Palmerston North City Council (PNCC) to rezone the existing rural site as residential land.

The following report outlines the findings from a desktop assessment of available historic information relating to ground contamination and an intrusive soil sampling investigation.

This report has been reviewed by suitably qualified and experienced practitioners as required by the NES-CS[1] and as described in the NES-CS Users' Guide[2]. The report meets the general requirements of a Preliminary Site Investigation (PSI) and Detailed Site Investigation (DSI), in accordance with the Ministry for the Environment's Contaminated Land Management Guideline #1 (MfE CLMG #1)[3], the MfE CLMG #5[4] and the NES-CS.

2.0 Site Description

2.1 Site Location

The site is a rectangular property made up of two lots on the corner of Flygers Line and Rangitikei Line, legally described as Pt Sec 553 Town of Palmerston North and Lot 2 DP 389924. The site covers an area measuring 39.32ha.

2.2 Proposed Development

Development details or plans are yet to be finalised, however, at this stage it is proposed to rezone the site for residential use. As such, a ground contamination due diligence assessment is required to assess any legacy ground contamination, inform (if required) ongoing site management, provide an initial contaminated land risk assessment for construction workers during future development works, and for site end users (i.e. future residents).

3.0 Geology and Hydrogeology

From a review of the 1:250,000 Geological Map, together with our experience of the surrounding area, we infer that the site is underlain by Holocene river deposits comprising gravel, sand, silt, mud, and clay with local peat. Topographical information available online indicates that the ground surface profile on the site is relatively flat with a stream running north to south through the middle of the site.

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[1] *Ministry for the Environment (2011) Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011.*
[2] *Ministry for the Environment (2012) Users' Guide: National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health.*
[3] *Ministry for the Environment – Contaminated Land Management Guideline #1: Reporting on Contaminated Sites in New Zealand (revised 2011).*
[4] *Ministry for the Environment – Contaminated Land Management Guideline #5: Site Investigation and Analysis of Soils (revised 2011).*

A recent RILEY geotechnical report for this site[5] (RILEY Ref: 170672-D) has identified that subsoil conditions typically comprise firm sandy silts from the surface through to ~4.5m below ground level (m bgl). This is underlain by 1m of soft clayey silt, whereupon very dense gravels were encountered. Machine boreholes identified the gravel layer extended from ~5.5m to 9.5m bgl, underlain by stiff clayey silt and very dense sandy gravel.

The RILEY geotechnical investigation identified the presence of groundwater at 3.5m bgl during summer (January 2019), and from 0.8m to 1.9m bgl in winter (June 2018). A groundwater level of 4m bgl was mapped in the GNS report for Palmerston North.

4.0 Preliminary Site Investigation

As part of the investigation, a PSI was undertaken to identify any potential risk of soil contamination relating to past and current activities carried out on-site. The PSI was carried out in accordance with MfE CLMG #1 and the NES-CS.

The PSI includes the following:

- A review of historic aerial photographs.
- Obtaining and reviewing PNCC property files.
- Obtaining and reviewing Horizons Regional Council (HRC) contamination reports.
- Obtaining and reviewing historic Certificates of Title.

4.1 Aerial Photograph Search

A review of available historic aerial photographs, dated 1940 to 2017 (Appendix A), is presented in Table 1:

Table 1: Review of Available Historic Aerial Photographs

Date	Description
1942	• The property appears to be a paddock with three buildings directly off Flygers Line, and a centrally located shed. • Horizontal lines appear on some parts of the property, which might be associated with crop beds. • A stream runs north to south through the middle of the site.
1949	• A building has been developed on the south-eastern corner of the property. • The centrally located shed has been removed.
1963	• The infrastructure on the south-eastern corner of the property has been extended.
1967	• One of the buildings off Flygers Line has been removed.
1979	• All the buildings off Flygers Line have now been removed.
1995	• The buildings on the south-eastern corner of the property have been removed.
2007	• The current sheds on the south-eastern corner have been developed. • Livestock appear to be grazing on the northern portion of the site. • There appears to be some pooling of water on the north-eastern quadrant of the property.
2017	• No significant changes to land use observed.

[5] *RILEY, February 2019: Geotechnical Assessment for Proposed Plan Change - Rangitikei Line and Flygers Line, Palmerston North, 170672-D.*

4.2 Palmerston North City Council Property File Search

- An application to the Manawatu District Council for a building consent was lodged on 30 September 1996, to build a calf-rearing shed on the south-eastern corner of the property. The application was approved on 16 October 1996.
- A second application to the Manawatu District Council for a building consent was lodged on 30 January 2001, to build an additional calf-rearing shed on the south-eastern corner of the property. The application was approved on 26 January 2001.

4.3 Horizons Regional Council Site Contamination Enquiry Report

The following pollution incidents were found in the HRC records:

Table 2: Pollution Incidents

Location	Date	Description
On-site	09/07/1998	Complaint about dead cow in neighbours' paddock. Cow was dead for about one week and began to smell.
Off-site	01/03/1999	Piggery smell on Benmore Avenue.
Off-site	19/05/2003	Neighbour dumping rubbish over back fence onto Mangaone Stream stop bank.
Off-site	11/04/2005	Discoloured water as a result of cattle grazing in Whiskey Creek.
Off-site	06/05/2005	Abandoned car on Flygers Line, bounded by Rangitikei Line and Gillespies Line.
On-site	15/08/2007	The owner of property on Rangitikei line burnt two truck tyres and a small amount of green waste, once asked he put fire out immediately.
Off-site	20/09/2009	Dead lamb in waterway next to walking track, 100m downstream of bridge over Mangoane stream on Rangitikei Line.
Off-site	07/01/2013	Rubbish such as; washing machine, car tyres etc. in road side drain on Flygers Line in between Rangitikei Line and Gillespies Line.
Off-site	23/04/2014	Dead deer carcass in drain on Flygers Line.
Off-site	25/06/2014	Four to seven televisions and other kinds of whiteware were dumped on Flygers Line, approximately 60m from the top of the road.

None of the pollution incidents identified above appear to pose a ground contamination risk to the site. A copy of the site contamination enquiry report is included in Appendix B.

4.4 Certificates of Title

The ownership history of Lot 2 DP 389924 (southern portion of the site) is as follows:

- The earliest ownership record dates back to 2 February 1877, when William McDouall (farmer) purchased the property. The record shows a number of mortgage transfers and leases to other farmers over the years.
- A pipeline easement certificate pursuant of Section 70 of the Petroleum Act 1937 creating a gas supply on 6 August 1968.
- Ownership of the property was transferred to Dobbin Investments Limited, then to MC2 Group Limited, and then finally to Flygers Investment Group Limited on 31 August 2007.

The ownership history of Pt Sec 553 Town of Palmerston North (northern portion of the site) is as follows:

- The earliest ownership record dates back to 7 October 1945, when William Rudd Pratt (farmer) purchased the property. The record shows a number of mortgage transfers and leases to other farmers over the years.
- Ownership of the property was transferred to Edna Daphne Pratt (widow of William Rudd Pratt) and Leonard August Morton (farmer) on 24 January 1961.
- Ownership of the property was transferred to Kairanga Knitwear Company Limited on 20 September 1972 and then transferred again to Torthorwold Farms Limited on 30 January 1973.
- Ownership transfer to Rama Ravji (retired) took place on 23 November 1987. His wife Pani Ben Ravji was then added as a tenant in common in equal shares on 10 November 1989.
- Transmission of the share of Pani Ben Ravji to Rama Ravji and Alan Desmon White as executors was carried out on 17 June 1998.
- Several other ownership transfers occurred over the year between farmers/retirees until ownership was transferred to Dobbin Investments Limited on 18 October 2004.
- Ownership was then transferred to Flygers Investment Group Limited on 31 August 2007.

The two properties appear to have continually been used as farm land to primarily rear livestock until as recently as June 2018.

4.5 Anecdotal Evidence

The former tenant was on-site on 29 June 2018. The tenant informed RILEY staff as they were leaving the site that an abattoir operated on-site and was located along the northern site boundary (buildings observed on the 1942 aerial photograph). The tenant also mentioned that the sheds may have historically been used to store minor amounts of diesel.

4.6 Hazardous Activities and Industries List Activities On-site

The desktop review indicates the potential for market gardening to have historically occurred on-site, and for isolated hydrocarbon contamination within the sheds. Potential contaminants and sources are presented below in Table 3.

Table 3: Potential Contamination Sources

Activity	Potential Contaminants	Likelihood of contamination	HAIL[6] reference
Potential market gardening.	• Heavy metals • Organochlorine pesticides (OCPs) • Acid herbicides	Likely to occur across areas subject to market gardening. The proposed development works would include ground disturbance and potential exposure of construction workers and future site end users to contaminants. This would complete a source-pathway-receptor link.	Activity A10: Persistent pesticide bulk storage or use including sport turfs, market gardens, orchards, glass houses or spray sheds.
Potential storage of diesel within sheds.	• Heavy metals • Total petroleum hydrocarbons (TPH) • Polycyclic aromatic hydrocarbons (PAHs)	Likely to occur within footprint of the sheds. The proposed development works would include ground disturbance and potential exposure of construction workers and future site end users to contaminants. This would complete a source-pathway-receptor link.	Activity I: Any other land that has been subject to the intentional or accidental release of a hazardous substance in sufficient quantity, that it could be a risk to human health or the environment.
Use of fill on unknown quality beneath the former abattoir.	• Heavy metals • PAHs • Asbestos	Likely to occur within footprint of the former abattoir. The proposed development works would include ground disturbance and potential exposure of construction workers and future site end users to contaminants. This would complete a source-pathway-receptor link.	

4.7 Preliminary Site Investigation Conclusions

As up to three HAIL activities have potentially occurred on-site, a DSI is required to clarify whether contamination is present on-site, its types and levels if present, and to identify potential risks from soil contamination to construction workers and site end users. The DSI will also clarify consenting activity status under the NES-CS of any ground disturbance associated with future site development.

5.0 Detailed Site Investigation

The intrusive site investigation was undertaken on 28 to 29 June 2018 and 17 January 2019, following the PSI. A total of 13 hand auger boreholes in the field, three hand-dug test pits underneath the sheds, and nine hand auger boreholes within the footprint of the former abattoir were advanced to visually assess the encountered material and to collect samples for analysis.

The sampling locations are shown on RILEY Dwg:170672-10 (Appendix F).

5.1 Soil Sampling Procedures

Soil sampling was undertaken in general accordance with the requirements of the NES-CS and the MfE CLMG #5.

[6] *Ministry for the Environment: Hazardous Activities and Industries List, October 2011.*

Soil samples for chemical testing were collected according to the following procedure:

- Discrete soil samples were collected from varying depths from each of the boreholes.
- The soil in each borehole was logged in accordance with the New Zealand Geotechnical Society Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes.
- Freshly gloved hands were used to collect the samples, which were placed immediately into the appropriate laboratory supplied sample containers.
- Sampling equipment was wiped down and cleaned with freshwater and Decon-90 (sulphate free detergent) between each sampling location.
- Samples were couriered in chilled containers to IANZ-certified Analytica Laboratories under chain of custody documentation.

5.2 Observations

13 hand auger boreholes (HA1 to HA5; HA7 to HA14) were drilled to a maximum depth of 1m bgl between 28 and 29 June 2016. The following observations were made:

- Topsoil was encountered to a depth of 0.2m to 0.35m bgl at all test locations.
- Alluvial sediments from the Tauranga Group were encountered across all test locations from 0.2m to 1.0m bgl (target depth). These deposits generally consisted of non to moderately plastic silts with varying concentrations of clays and non-plastic silty sands with varying concentrations of clay. Organic material was not encountered in any of the boreholes.
- Groundwater was encountered at 0.9m bgl within HA1, but not encountered in the other boreholes.
- There were no visual or olfactory signs of contamination detected at any of the test locations.

Eight surface samples and one hand auger sample were collected on 17 January 2019:

- Surficial soils within the footprint of the former abattoir comprise sandy silt with fragments of concrete and metal. No odours or staining were noted (Photograph 1).
- The remainder of the site was planted with maize (Photograph 2).
- Sheds on the south-eastern corner of the site that were historically used to rear calf but were empty at the time of inspection (Photograph 3). The sheds are of a timber construction with a corrugated iron roof. Ground surface within the footprint of the sheds comprised of a mixture or sand and hay (Photograph 4).
- There were no visual or olfactory signs of contamination detected at any of the test locations.

6.0 Laboratory Testing and Acceptance Criteria

A total of 29 soil samples were collected and couriered to IANZ-accredited Analytica Laboratories for testing. The samples were analysed as follows:

Table 4: Analytical Regime

	Borehole	Sample IDs	Sample Depth (m)	Analyses
HAIL Activity A10	HA1	HA1_0m	0	Metals, OCPs and acid herbicides
		HA1_0.25m	0.25	Metals and OCPs
	HA2	HA2_0m	0	Metals and OCPs
		HA2_0.25m	0.25	Metals and OCPs
	HA3	HA3_0m	0	Metals, OCPs and acid herbicides
		HA3_0.3m	0.3	Metals and OCPs
	HA4	HA4_0m	0	Metals and OCPs
		HA4_0.25m	0.25	Metals and OCPs
	HA5	HA4_0m	0	Metals, OCPs and acid herbicides
		HA4_0.3m	0.3	Metals and OCPs
	HA7	HA7_0m	0	Metals, OCPs and acid herbicides
		HA7_0.25m	0.25	Metals and OCPs
	HA8	HA8_0m	0	Metals and OCPs
		HA8_0.25m	0.25	Metals and OCPs
	HA9	HA9_0m	0	Metals, OCPs and acid herbicides
		HA9_0.25m	0.25	Metals and OCPs
	HA10	HA10_0m	0	Metals and OCPs
		HA10_0.3m	0.3	Metals and OCPs
	HA11	HA11_0m	0	Metals and OCPs
		HA11_0.25m	0.25	Metals and OCPs
	HA12	HA9_0m	0	Metals, OCPs and acid herbicides
		HA9_0.2m	0.2	Metals and OCPs
	HA13	HA3_0m	0	Metals and OCPs
		HA3_0.3m	0.3	Metals and OCPs
	HA14	HA14_0m	0	Metals and OCPs
		HA14_0.2m	0.2	Metals and OCPs
HAIL Activity I Former Sheds	HS1	HS1	0	Metals, TPH and PAHs
	HS2	HS2	0	Metals, TPH and PAHs
	HS3	HS3	0	Metals, TPH and PAHs
HAIL Activity I Former Abattoir	AB1	AB1	0	Metals, TPH and PAHs
	AB2	AB2	0	Metals, PAHs and Asbestos
	AB4	AB4	0	Metals, PAHs and Asbestos
	AB5 0.5m	AB5 0.5m	0.5	Metals, PAHs and Asbestos
	AB8	AB8	0	Metals, PAHs and Asbestos
	AB10	AB10	0	Metals, PAHs and Asbestos
	AB12	AB12	0	Metals, PAHs and Asbestos
	ABR1	ABR1	0	Metals, PAHs and Asbestos
	ABR2	ABR2	0	Metals, PAHs and Asbestos

The results have been evaluated against the following criteria:

- Environment Canterbury's (ECan) trace elements level 2, derived from "Background concentrations of selected trace elements in Canterbury soils", prepared for ECan by Tonkin and Taylor Ltd (July 2002).
- NES-CS soil contaminant standards for outdoor worker (unpaved) and residential (10% produce) land uses.

The ECan trace elements level 2 were selected to represent on-site trace element background concentrations for the following reasons:

- No published trace element background concentrations for the Palmerston North region are available.
- The Canterbury region has historically been subject to market gardening and is, therefore, similar to the subject site's potential land use history and trace element background concentrations.
- The two areas share similar geomorphologies, i.e. alluvial deposits.

6.1 Data Quality

A quality assurance and quality control (QA/QC) programme was implemented as part of field procedures to confirm that the soil analytical data was fit for purpose, including:

- Transportation of samples with accompanying chain of custody documentation.
- Laboratory testing by an IANZ-accredited laboratory.
- Compliance with sample holding times.

Laboratory QA/QC reports are available on request.

7.0 Results

A summary of the laboratory test results is provided in Appendix C, with full laboratory transcripts included within Appendix D.

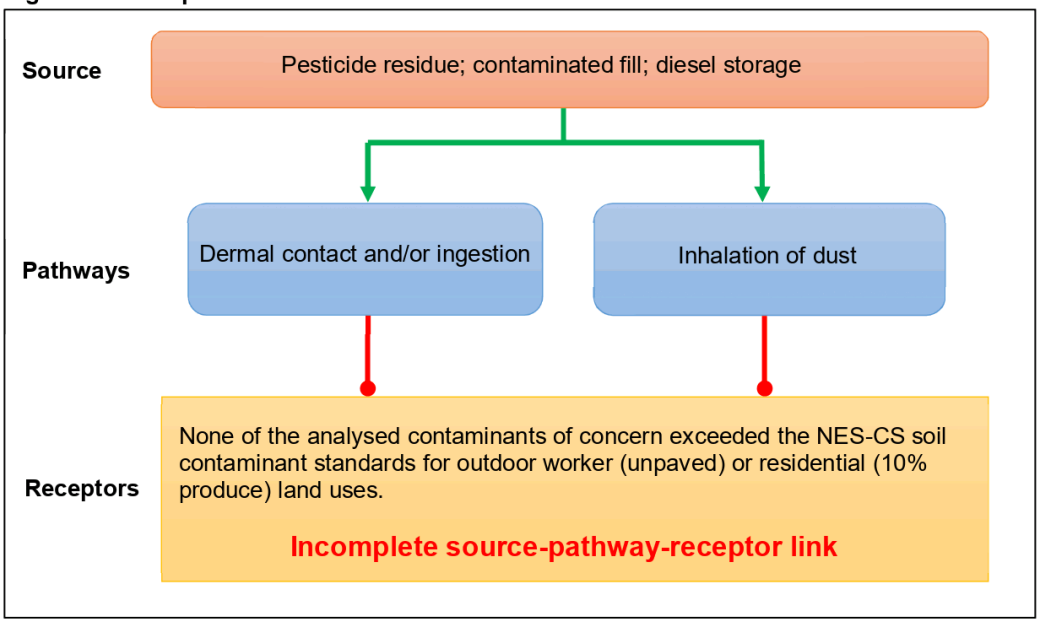
- Heavy metals:
  - Cadmium in seven out of the 13 surface samples collected from the field, exceeded the adopted background criterion.
  - Arsenic, cadmium chromium, copper, and zinc in the samples collected from the shed footprint exceeded the adopted background criteria.
  - Cadmium, chromium, copper, lead, and zinc in the samples collected from the footprint of the former abattoir exceeded the adopted background criteria.
  - None of the analysed metals exceeded the NES-CS soil contaminant standards for outdoor worker (unpaved) and residential (10% produce) land uses.
- Organochlorine pesticides:
  - None of the samples contained detectable concentrations of OCPs.
- Acid herbicides:
  - None of the samples contained detectable concentrations of acid herbicides.

- Polycyclic aromatic hydrocarbons (PAHs):
  - All of the samples analysed for PAHs contained detectable levels (0.03 to 0.67mg/kg), however, none exceeded the NES-CS soil contaminant standards for outdoor worker (unpaved) and residential (10% produce) land uses.
- Asbestos:
  - None of the analysed samples contained detectable levels of asbestos.
- Total petroleum hydrocarbons (TPH):
  - All the samples analysed for TPH contained detectable levels of light and heavy TPH fractions. However, none of the TPH values exceed relevant health-based assessment criteria within the MfE Petroleum Hydrocarbon Guidelines[7].

8.0 Conceptual Site Model

A post-investigation conceptual site model (CSM) has been developed to summarise the sources of contamination at the site, the human receptors that may be exposed to those contaminants, and the potential pathways for exposure.

Figure 1: Conceptual Site Model



9.0 Regulatory Implications

The rules relating to the control of contaminated sites and potentially contaminated sites, specific to the protection of human health, are specified in the NES-CS.

[7] *Ministry for the Environment: Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand, revised 2011.*

9.1 NES-CS

The NES-CS came into effect on 1 January 2012. The NES-CS generally considers issues relating to land use and the protection of human health. The need, or otherwise, for contamination related resource consents for the proposed development has been evaluated against this regulatory requirement.

The NES-CS applies to specific activities on land where a HAIL category has, or is more likely than not to have, occurred. Activities covered under the NES-CS include soil disturbance, soil sampling, fuel systems removal, subdivision, and land use change.

9.1.1 Applicability

The following table, as provided in the NES-CS Users' Guide (April 2012), confirms the NES-CS applies to the site.

Table 5: Preliminary Site Investigation Checklist

NES-CS Requirement	Applicable to site?
Is an activity described on the HAIL currently being undertaken on the piece of land to which this application applies?	No
Has an activity described on the HAIL ever been undertaken on the piece of land to which this application applies?	Yes
Is it more likely than not that an activity described on HAIL is being or has been undertaken on the piece of land to which this application applies?	Yes
If 'Yes' to any of the above, then the NES-CS may apply. **The five activities to which the NES-CS applies to are:**	
Is the activity you propose to undertake removing or replacing a fuel storage system or parts of it?	No
Is the activity you propose to undertake sampling soil?	No
Is the activity you propose to undertake disturbing soil?	Yes
Is the activity you propose to undertake subdividing land?	Yes
Is the activity you propose to undertake changing the use of the land?	Yes
Conclusion: The NES-CS applies.	

9.1.2 NES-CS Activity Status

An assessment against the relevant permitted activity rules of the NES-CS is provided in Table 6, for the activity of soil disturbance.

Table 6: NES-CS Permitted Activity Assessment for Soil Disturbance

NES-CS – Soil disturbance permitted activity conditions [Regulation 8(3)]	Assessment
a. Implementation of controls to minimise exposure of humans to mobilised contaminants.	CAN COMPLY Compliance based on the development and implementation of a suitable Site Management Plan (SMP).
b. The soil must be reinstated to an erosion free state within one month of completing the land disturbance.	INDETERMINATE No preliminary earthworks or design plans have been made available; therefore, the likelihood of compliance with this condition cannot be assessed at this time.
c. The volume of the disturbance of the piece of land must be no more than $25m^3$ per $500m^2$.	INDETERMINATE No preliminary earthworks or design plans have been made available; therefore, the likelihood of compliance with this condition cannot be assessed at this time.
d. Soil must not be taken away unless it is for laboratory testing or, for all other purposes combined, a maximum of $5m^3$ per $500m^2$ of soil may be taken away per year.	INDETERMINATE No preliminary earthworks or design plans have been made available; therefore, the likelihood of compliance with this condition cannot be assessed at this time.
e. Soil taken away must be disposed of at an appropriately licensed facility.	CAN COMPLY If required, soil will be removed from site and disposed of at an approved facility.
f. The duration of land disturbance must be no longer than two months.	INDETERMINATE No preliminary earthworks or design plans have been made available; therefore, the likelihood of compliance with this condition cannot be assessed at this time.
g. The integrity of a structure designed to contain contaminated soil or other contaminated materials must not be compromised.	CAN COMPLY (not applicable) There is no current indication that such a structure is required or intended to be constructed.

As indicated in Table 7, the activity status of the proposed soil disturbance for any future development of the site cannot be determined at this time, as no preliminary design or earthworks plans related to intended development of the site have been provided. Should the proposed soil disturbance and/or soil removal volumes exceed the permitted activity threshold volumes, a controlled activity consent under the NES-CS will be required.

10.0 Conclusions and Implications

The findings of the PSI and intrusive sampling investigation, as described in the previous sections, indicate:

- Surficial fill/topsoil was identified across the site. Anthropogenic materials (e.g. brick fragments, metals, and timber) were identified within the footprint of the former abattoir.
- No asbestos was detected in any of the nine soil samples taken from the abattoir footprint.

- Seven out of the 26 samples collected from the field contained cadmium at concentrations exceeding the adopted background level. All seven samples were collected from surficial soils. None of the cadmium concentrations detected exceeded the relevant heath-based NES-CS soil contaminant standards.
- All three surface samples from the shed area contained various heavy metals at concentrations exceeding the adopted background levels. Light and heavy TPH fractions were also identified in all three samples. None of the detected contaminants of concern exceeded the relevant health-based NES-CS soil contaminant standards.
- Eight out of the nine samples, collected from the footprint of the former abattoir, contained various heavy metals (primarily zinc, lead, chromium, mercury, and copper) at concentrations exceeding the adopted background levels, and all nine samples contained detectable PAHs. None of the heavy metals, nor PAH detects, exceeded the relevant health-based NES-CS soil contaminant standards.

10.1 Consenting Implications

Due to the identification of heavy metals above adopted background levels and the presence of PAHs and TPH, it is likely that future development of the site for residential purpose will require a controlled activity land use consent under the NES-CS, from PNCC. A SMP pre-works and Site Validation Report (SVR) post-works is also likely to be required under this consent.

11.0 Limitation

This report has been prepared solely for the benefit of Flygers Line Investment Group Limited as our client with respect to the brief given to us. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

Riley Consultants Ltd has performed the services for this project in accordance with the standard agreement for consulting services and current professional standards for environmental site assessment. No guarantees are either expressed or implied.

The recommendations and opinions expressed are based on data from limited test positions. The nature and continuity of subsoil conditions away from the positions are inferred, and it must be appreciated that actual conditions could vary considerably from the assumed model.

Opinions and judgements expressed herein are based on our understanding and interpretation of current regulatory standards and should not be construed as legal or planning opinions. Where opinions or judgements are to be relied on they should be independently verified with appropriate advice. There is no investigation that is thorough enough to preclude the presence of materials at the site which presently, or in the future, may be considered hazardous. Because regulatory evaluation criteria are constantly changing, concentrations of contaminants present and considered to be acceptable may, in the future, become subject to different regulatory standards, which cause them to become unacceptable and require further remediation for this site to be suitable for the existing or proposed land use activities.

APPENDIX A

Historic Aerial Photographs










FLYGERS




2007 Aerial Image
Google Earth
N


2017 Aerial Image
Google Earth
N

APPENDIX B

Site Contamination Enquiry Report

Ali Anwar

Subject: Cnr Rangitikei & Flygers Line pollution summary

From: Samuel Fuchs <Samuel.Fuchs@horizons.govt.nz>
Sent: Friday, 20 July 2018 10:52 AM
To: Ali Anwar <aanwar@riley.co.nz>
Subject: RE: Cnr Rangitikei & Flygers Line pollution summary

Hi Ali
Please find a list below of incidents in relation to this property or in close proximity to the property boundary (100 metre buffer).

Incident No: 1969 Date of incident: 09/07/1998
Notes: Complaint about dead cow in neighbours paddock. Cow been dead for about 1 week and starting to smell.
Resolved: Yes

Incident No: 3647 Date of incident: 01/03/1999
Notes: Piggery smell on Benmore Avenue
Resolved: Yes

Incident No: 10674 Date of incident: 19/05/2003
Notes: Neighbour dumping rubbish over back fence onto Mangaone Stream stopbank.
Resolved: Yes

Incident No: 13015 Date of incident: 11/04/2005
Notes: Discoloured water as a result of cattle grazing in Whiskey Creek
Resolved: Yes

Incident No: 13080 Date of incident: 06/05/2005
Notes: Abandoned car on Flygers Line - bounded by Rangitikei Line and Gillespies Line.
Resolved: Yes

Incident No: 15356 Date of incident: 15/08/2007
Notes: The owner of property on Rangitikei line burning 2 truck tyres and a small amount of green waste - once asked he put fire out immediately.
Resolved: Yes

Incident No: 16998 Date of incident: 28/09/2009
Notes: Dead lamb in waterway next to walking track, 100m downstream of bride over Mangoane stream on Rangitikei Line
Resolved: Yes

Incident No: 18869 Date of incident: 07/01/2013
Notes: Rubbish such as washing machine, car tyres etc in road side drain on Flygers Line in between Rangitikei Line and Gillespies Line.
Resolved: Yes

Incident No: 20021 Date of incident: 23/04/2014
Notes: Dead deer carcass in drain on Flygers Line
Resolved: Yes

Incident No: 20132 Date of incident: 25/06/2014
Notes: 4-7 tvs, plus other kinds of whiteware, on flygers line, 60 metres down from start, on RHS, there are some deep drains, somewhere just after where the white rails/road barriers are.
Resolved: Yes

Kind regards,

Samuel Fuchs | Consents Monitoring Officer
Horizons Regional Council | 11-15 Victoria Avenue | Palmerston North 4410
0508 800 800 | DD: 06 952 2851 | M: 021 227 7920

APPENDIX C

Site Photographs

Appendix C: Site Photographs



Photo 1: Fragments of concrete and metal within footprint of former abattoir



Photo 2: Remainder of field planted with maize



Photo 3: Sheds were empty at time of the investigation



Photo 4: Shed surface comprised of sand and hay

APPENDIX D

Results Tables

Riley Consultants Ltd
Job No. 170672

Flygers Line Investment Group Ltd
Flygers Line
Soil Analytical Results

February 2019

		Criteria: Background Concentration [1]	Criteria: NES Residential (10% produce)	Criteria: NES Outdoor Worker	HA1_0m	HA1_0.25m	HA2_0m	HA2_0.25m	HA3_0m	HA3_0.3m	HA4_0m	HA4_0.25m	HA5_0m	HA5_0.3m	HA7_0m	HA7_0.25m
Metals	Arsenic	12.58	20 [2]	70 [4]	3.44	3.9	3.98	5.82	5.6	5.84	4.18	4.61	5.57	4.69	3.07	3.65
	Cadmium	0.19	3 [2]	1,300 [4]	0.17	0.061	0.19	0.092	0.16	0.077	**0.55**	0.074	0.16	0.079	**0.23**	0.071
	Chromium	22.7	460 [2]	6,300 [4]	18.7	18.4	17.1	19.8	18.3	21.1	18.5	19.2	20.4	21.9	18.4	19.9
	Copper	20.3	10,000 [2]	10,000 [4]	10	5.91	10.4	7.67	10.1	7.52	15.5	8.29	10.4	8.6	17.4	7.81
	Lead	40.96	210 [2]	3,300 [4]	13.8	15.5	15.1	17.8	15.7	17.1	19.2	17	18.6	17.6	18.1	16
	Mercury	0.11	310 [2]	4,200 [4]	0.055	0.06	0.057	0.068	0.054	0.064	0.068	0.073	0.07	0.074	0.06	0.067
	Nickel	20.7	400 [3]	6,000 [3]	12.1	12	12	13.7	11.9	13.1	13.3	12.6	13.8	13.9	11.8	12.7
	Zinc	93.94	7,400 [3]	400,000 [3]	84.5	66.8	73.8	73.3	73.9	69.5	91.3	75.6	81.7	70.3	82.6	70.9
Organochlorine Pesticides [6]	Total DDT	-	70 [2]	1,000 [4]	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	Dieldrin	-	2.6 [2]	160 [4]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acid Herbicides	2,4,5-Trichlorophenoxyacetic acid	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	2,4,5-Trichlorophenoxypropionic acid	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	2,4-Dichlorophenoxyacetic acid	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	(2,4-Dichlorophenoxy)butanoic acid	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Acifluorfen	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Bentazone	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Bromoxynil	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Clopyralid	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Dicamba	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Dichlorprop	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Fluazifop	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Fluroxypyr	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Haloxyfop	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	MCPA	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	MCPB	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Mecoprop	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Oryzalin	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Pentachlorophenol	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Picloram	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Quizalofop	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	2,3,4,6-Tetrachlorophenol	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
	Triclopyr	-	-	-	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	<0.05	-
Total Petroleum Hydrocarbons	C7-C9	-	120 [5]	120 [5]	-	-	-	-	-	-	-	-	-	-	-	-
	C10-C14	-	740 [5]	1,500 [5]	-	-	-	-	-	-	-	-	-	-	-	-
	C15-C36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C7-C36 (Total)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycyclic Aromatic Hydrocarbons	Benzo(a)pyrene TEQ	-	10 [2]	35 [4]	-	-	-	-	-	-	-	-	-	-	-	-
Asbestos	Qualitative Asbestos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		HA8_0m	HA8_0.25m	HA9_0m	HA9_0.25m	HA10_0m	HA10_0.3m	HA11_0m	HA11_0.25m	HA12_0m	HA12_0.2m	HA13_0m	HA13_0.3m	HA14_0m	HA14_0.2m
Metals	Arsenic	2.46	2.43	6.44	2.84	3.03	2.46	2.5	3.64	3.23	3.03	3.13	3.78	2.72	3.45
	Cadmium	**0.35**	0.14	0.17	0.073	**0.22**	0.052	**0.27**	0.15	0.15	0.11	**0.27**	0.046	**0.21**	0.082
	Chromium	18.8	20.8	14.6	13.7	18.6	20	19	22.2	12.3	12.5	19.8	22.4	17.7	21.3
	Copper	10.9	7.19	7.76	5.3	11.6	7.05	11.6	7.63	6.03	4.28	13.5	8.06	11.8	6.9
	Lead	15.2	15.8	10.6	9.67	17.8	14.2	19	20.1	9.49	9.4	16.5	16.8	15.7	16.4
	Mercury	0.048	0.062	0.04	0.045	0.056	0.069	0.064	0.077	0.032	0.042	0.065	0.071	0.05	0.065
	Nickel	11.2	13.1	8.31	8.86	11.5	11.3	11.2	12.8	6.52	6.98	13.4	12.7	11.1	11.7
	Zinc	79.7	77.5	53.7	45.8	76.6	61.4	77.3	72.4	42.7	41.2	87.3	74	83	75.6
Organochlorine Pesticides [6]	Total DDT	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	Dieldrin	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acid Herbicides	2,4,5-Trichlorophenoxyacetic acid	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	2,4,5-Trichlorophenoxypropionic acid	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	2,4-Dichlorophenoxyacetic acid	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	(2,4-Dichlorophenoxy)butanoic acid	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Acifluorfen	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Bentazone	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Bromoxynil	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Clopyralid	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Dicamba	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Dichlorprop	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Fluazifop	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Fluroxypyr	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Haloxyfop	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	MCPA	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	MCPB	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Mecoprop	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Oryzalin	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Pentachlorophenol	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Picloram	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Quizalofop	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	2,3,4,6-Tetrachlorophenol	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
	Triclopyr	-	-	-	<0.05	-	-	-	-	-	<0.05	-	-	-	-
Total Petroleum Hydrocarbons	C7-C9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C10-C14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C15-C36	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C7-C36 (Total)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycyclic Aromatic Hydrocarbons	Benzo(a)pyrene TEQ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Asbestos	Qualitative Asbestos	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		HS1	HS2	HS3	AB1	AB2	AB4	AB5 0.5m	AB8	AB10	AB12	ABR1	ABR2
Metals	Arsenic	**15.5**	7.81	5.5	8.06	6.5	4.13	5.42	3.97	5.11	7.15	2.54	4.68
	Cadmium	**0.31**	**0.25**	**0.37**	**0.59**	**0.61**	**0.53**	**0.33**	0.14	0.13	**0.22**	0.13	**0.32**
	Chromium	**40.1**	20.2	14.8	**23.6**	**25.5**	15.7	18.3	14	17.3	19.4	12.3	16.8
	Copper	**53**	**24.8**	**20.7**	**50.1**	**40.9**	**25.9**	14.1	13.3	10.6	13.4	12.2	**22.3**
	Lead	20	20.5	20.6	**182**	**140**	**58.7**	24.3	26.4	27.1	**41.5**	**68.8**	**122**
	Mercury	0.038	0.057	0.054	-	-	-	-	-	-	-	-	-
	Nickel	6.49	6.96	6.46	14.1	13.9	12.4	16.3	12.3	15	15.6	7.96	11.4
	Zinc	**522**	**165**	**174**	**528**	**516**	**252**	**576**	**106**	92.4	**140**	**109**	**217**
Organochlorine Pesticides [6]	Total DDT	-	-	-	-	-	-	-	-	-	-	-	-
	Dieldrin	-	-	-	-	-	-	-	-	-	-	-	-
Acid Herbicides	2,4,5-Trichlorophenoxyacetic acid	-	-	-	-	-	-	-	-	-	-	-	-
	2,4,5-Trichlorophenoxypropionic acid	-	-	-	-	-	-	-	-	-	-	-	-
	2,4-Dichlorophenoxyacetic acid	-	-	-	-	-	-	-	-	-	-	-	-
	(2,4-Dichlorophenoxy)butanoic acid	-	-	-	-	-	-	-	-	-	-	-	-
	Acifluorfen	-	-	-	-	-	-	-	-	-	-	-	-
	Bentazone	-	-	-	-	-	-	-	-	-	-	-	-
	Bromoxynil	-	-	-	-	-	-	-	-	-	-	-	-
	Clopyralid	-	-	-	-	-	-	-	-	-	-	-	-
	Dicamba	-	-	-	-	-	-	-	-	-	-	-	-
	Dichlorprop	-	-	-	-	-	-	-	-	-	-	-	-
	Fluazifop	-	-	-	-	-	-	-	-	-	-	-	-
	Fluroxypyr	-	-	-	-	-	-	-	-	-	-	-	-
	Haloxyfop	-	-	-	-	-	-	-	-	-	-	-	-
	MCPA	-	-	-	-	-	-	-	-	-	-	-	-
	MCPB	-	-	-	-	-	-	-	-	-	-	-	-
	Mecoprop	-	-	-	-	-	-	-	-	-	-	-	-
	Oryzalin	-	-	-	-	-	-	-	-	-	-	-	-
	Pentachlorophenol	-	-	-	-	-	-	-	-	-	-	-	-
	Picloram	-	-	-	-	-	-	-	-	-	-	-	-
	Quizalofop	-	-	-	-	-	-	-	-	-	-	-	-
	2,3,4,6-Tetrachlorophenol	-	-	-	-	-	-	-	-	-	-	-	-
	Triclopyr	-	-	-	-	-	-	-	-	-	-	-	-
Total Petroleum Hydrocarbons	C7-C9	<10	<10	<10	-	-	-	-	-	-	-	-	-
	C10-C14	**16***	**24***	**223***	-	-	-	-	-	-	-	-	-
	C15-C36	**2334***	**1940***	**20469***	-	-	-	-	-	-	-	-	-
	C7-C36 (Total)	**2351***	**1965***	**20692***	-	-	-	-	-	-	-	-	-
Polycyclic Aromatic Hydrocarbons	Benzo(a)pyrene TEQ	0.27	0.64	0.45	0.07	0.07	0.29	0.03	0.03	0.03	0.03	0.67	0.51
Asbestos	Qualitative Asbestos	-	-	-	ND	ND	ND	ND	ND	ND	-	-	-

Notes

*Published background concentrations for TPH are unavailable therefore any detectable concentrations are considered a background exceedance.

1 Environment Canterbury's trace elements level 2 derived from "Background concentrations of selected trace elements in Canterbury soils" prepared by Tonkin and Taylor Ltd (July 2002).

2 MfE, 2011. NES Users' guide soil contaminant standards for residential (10% produce) landuse.

3 National Environment Protection (Assessment of Site Contamination) Measure 1999. Schedule B1: Guideline on Investigation Levels for Soil and Groundwater.

4 MfE, 2011. NES Users' guide soil contaminant standards for commercial/industrial outdoor worker (unpaved) landuse.

5 MfE, 1999. Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand (revised 2011).

6 Entire suite of OCPs were analysed - only reporting compounds with human health based guidelines.

APPENDIX E

Laboratory Transcripts

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Certificate of Analysis

Riley Consultants Ltd
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Auckland
Attention: Ali Anwar
Phone: 0274663240
Email: aanwar@riley.co.nz

Lab Reference: 18-23220
Submitted by: Gareth Jackson
Date Received: 4/07/2018
Date Completed: 11/07/2018
Order Number:
Reference: 170672

Sampling Site: Rangitikei Line

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories. Samples were in acceptable condition unless otherwise noted on this report.

Heavy Metals in Soil

	Client Sample ID		HA1_0m 0	HA1_0.25m 0.25	HA2_0m 0	HA2_0.25m 0.25	HA3_0m 0
	Date Sampled		28/06/2018	28/06/2018	28/06/2018	28/06/2018	28/06/2018
Analyte	Unit	*Reporting Limit*	18-23220-1	18-23220-2	18-23220-3	18-23220-4	18-23220-5
Arsenic	mg/kg dry wt	*0.125*	3.44	3.90	3.98	5.82	5.60
Cadmium	mg/kg dry wt	*0.005*	0.17	0.061	0.19	0.092	0.16
Chromium	mg/kg dry wt	*0.125*	18.7	18.4	17.1	19.8	18.3
Copper	mg/kg dry wt	*0.075*	10.0	5.91	10.4	7.67	10.1
Lead	mg/kg dry wt	*0.05*	13.8	15.5	15.1	17.8	15.7
Mercury	mg/kg dry wt	*0.025*	0.055	0.060	0.057	0.068	0.054
Nickel	mg/kg dry wt	*0.05*	12.1	12.0	12.0	13.7	11.9
Zinc	mg/kg dry wt	*0.05*	84.5	66.8	73.8	73.3	73.9

Heavy Metals in Soil

	Client Sample ID		HA3_0.3m 0.3	HA4_0m 0	HA4_0.25m 0.25	HA5_0m 0	HA5_0.3m 0.3
	Date Sampled		28/06/2018	28/06/2018	28/06/2018	28/06/2018	28/06/2018
Analyte	Unit	*Reporting Limit*	18-23220-6	18-23220-7	18-23220-8	18-23220-9	18-23220-10
Arsenic	mg/kg dry wt	*0.125*	5.84	4.18	4.61	5.57	4.69
Cadmium	mg/kg dry wt	*0.005*	0.077	0.55	0.074	0.16	0.079
Chromium	mg/kg dry wt	*0.125*	21.1	18.5	19.2	20.4	21.9
Copper	mg/kg dry wt	*0.075*	7.52	15.5	8.29	10.4	8.60
Lead	mg/kg dry wt	*0.05*	17.1	19.2	17.0	18.6	17.6
Mercury	mg/kg dry wt	*0.025*	0.064	0.068	0.073	0.070	0.074
Nickel	mg/kg dry wt	*0.05*	13.1	13.3	12.6	13.8	13.9
Zinc	mg/kg dry wt	*0.05*	69.5	91.3	75.6	81.7	70.3

IANZ ACCREDITED LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation, with the exception of tests marked *, which are not accredited.

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Heavy Metals in Soil

Client Sample ID			HA7_0m 0	HA7_0.25m 0.25	HA8_0m 0	HA8_0.25m 0.25	HA9_0m 0
Date Sampled			29/06/2018	29/06/2018	29/06/2018	29/06/2018	29/06/2018
Analyte	Unit	*Reporting Limit*	18-23220-11	18-23220-12	18-23220-13	18-23220-14	18-23220-15
Arsenic	mg/kg dry wt	*0.125*	3.07	3.65	2.46	2.43	6.44
Cadmium	mg/kg dry wt	*0.005*	0.23	0.071	0.35	0.14	0.17
Chromium	mg/kg dry wt	*0.125*	18.4	19.9	18.8	20.8	14.6
Copper	mg/kg dry wt	*0.075*	17.4	7.81	10.9	7.19	7.76
Lead	mg/kg dry wt	*0.05*	18.1	16.0	15.2	15.8	10.6
Mercury	mg/kg dry wt	*0.025*	0.060	0.067	0.048	0.062	0.040
Nickel	mg/kg dry wt	*0.05*	11.8	12.7	11.2	13.1	8.31
Zinc	mg/kg dry wt	*0.05*	82.6	70.9	79.7	77.5	53.7

Heavy Metals in Soil

Client Sample ID			HA9_0.25m 0.25	HA10_0m 0	HA10_0.3m 0.3	HA11_0m 0	HA11_0.25m 0.25
Date Sampled			26/06/2018	28/06/2018	29/06/2018	29/06/2018	29/06/2018
Analyte	Unit	*Reporting Limit*	18-23220-16	18-23220-17	18-23220-18	18-23220-19	18-23220-20
Arsenic	mg/kg dry wt	*0.125*	2.84	3.03	2.46	2.50	3.64
Cadmium	mg/kg dry wt	*0.005*	0.073	0.22	0.052	0.27	0.15
Chromium	mg/kg dry wt	*0.125*	13.7	18.6	20.0	19.0	22.2
Copper	mg/kg dry wt	*0.075*	5.30	11.6	7.05	11.6	7.63
Lead	mg/kg dry wt	*0.05*	9.67	17.8	14.2	19.0	20.1
Mercury	mg/kg dry wt	*0.025*	0.045	0.056	0.069	0.064	0.077
Nickel	mg/kg dry wt	*0.05*	8.86	11.5	11.3	11.2	12.8
Zinc	mg/kg dry wt	*0.05*	45.8	76.6	61.4	77.3	72.4

Heavy Metals in Soil

Client Sample ID			HA12_0m 0	HA12_0.2m 0.2	HA13_0m 0	HA13_0.3m 0.3	HA14_0m 0
Date Sampled			29/06/2018	29/06/2018	29/06/2018	29/06/2018	29/06/2018
Analyte	Unit	*Reporting Limit*	18-23220-21	18-23220-22	18-23220-23	18-23220-24	18-23220-25
Arsenic	mg/kg dry wt	*0.125*	3.23	3.03	3.13	3.78	2.72
Cadmium	mg/kg dry wt	*0.005*	0.15	0.11	0.27	0.046	0.21
Chromium	mg/kg dry wt	*0.125*	12.3	12.5	19.8	22.4	17.7
Copper	mg/kg dry wt	*0.075*	6.03	4.28	13.5	8.06	11.8
Lead	mg/kg dry wt	*0.05*	9.49	9.40	16.5	16.8	15.7
Mercury	mg/kg dry wt	*0.025*	0.032	0.042	0.065	0.071	0.050
Nickel	mg/kg dry wt	*0.05*	6.52	6.98	13.4	12.7	11.1
Zinc	mg/kg dry wt	*0.05*	42.7	41.2	87.3	74.0	83.0

Heavy Metals in Soil

Client Sample ID			HA14_0.2m 0.2	HS1 0	HS2 0	HS3 0
Date Sampled			29/06/2018	29/06/2018	29/06/2018	29/06/2018
Analyte	Unit	*Reporting Limit*	18-23220-26	18-23220-27	18-23220-28	18-23220-29
Arsenic	mg/kg dry wt	*0.125*	3.45	15.5	7.81	5.50
Cadmium	mg/kg dry wt	*0.005*	0.082	0.31	0.25	0.37
Chromium	mg/kg dry wt	*0.125*	21.3	40.1	20.2	14.8
Copper	mg/kg dry wt	*0.075*	6.90	53.0	24.8	20.7
Lead	mg/kg dry wt	*0.05*	16.4	20.0	20.5	20.6
Mercury	mg/kg dry wt	*0.025*	0.065	0.038	0.057	0.054

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Heavy Metals in Soil

			Client Sample ID	HA14_0.2m 0.2	HS1 0	HS2 0	HS3 0
			Date Sampled	29/06/2018	29/06/2018	29/06/2018	29/06/2018
Nickel	mg/kg dry wt	*0.05*		11.7	6.49	6.96	6.46
Zinc	mg/kg dry wt	*0.05*		75.6	522	165	174

Organochlorine Pesticides - Soil

		Client Sample ID	HA1_0m 0	HA1_0.25m 0.25	HA2_0m 0	HA2_0.25m 0.25	HA3_0m 0
		Date Sampled	28/06/2018	28/06/2018	28/06/2018	28/06/2018	28/06/2018
Analyte	Unit	*Reporting Limit*	18-23220-1	18-23220-2	18-23220-3	18-23220-4	18-23220-5
2,4'-DDD	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
2,4'-DDE	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
2,4'-DDT	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDD	mg/kg dry wt	*0.003*	<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDE	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDT	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Total DDT	mg/kg dry wt	*0.02*	<0.02	<0.02	<0.02	<0.02	<0.02
alpha-BHC	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Aldrin	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
beta-BHC	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
cis-Chlordane	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
cis-Nonachlor	mg/kg dry wt	*0.01*	<0.01	<0.01	<0.01	<0.01	<0.01
delta-BHC	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Dieldrin	mg/kg dry wt	*0.05*	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan I	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Endosulfan II	mg/kg dry wt	*0.01*	<0.01	<0.01	<0.01	<0.01	<0.01
Endosulfan sulphate	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Endrin	mg/kg dry wt	*0.05*	<0.05	<0.05	<0.05	<0.05	<0.05
Endrin aldehyde	mg/kg dry wt	*0.01*	<0.01	<0.01	<0.01	<0.01	<0.01
Endrin ketone	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
gamma-BHC	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor epoxide	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Hexachlorobenzene	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Methoxychlor	mg/kg dry wt	*0.01*	<0.01	<0.01	<0.01	<0.01	<0.01
trans-nonachlor	mg/kg dry wt	*0.01*	<0.01	<0.01	<0.01	<0.01	<0.01
trans-Chlordane	mg/kg dry wt	*0.01*	<0.01	<0.01	<0.01	<0.01	<0.01
Chlordane (sum)	mg/kg dry wt	*0.02*	<0.020	<0.020	<0.020	<0.020	<0.020
TCMX (Surrogate)	%	*1*	96.9	95.8	86.8	87.2	81.7

Organochlorine Pesticides - Soil

		Client Sample ID	HA3_0.3m 0.3	HA4_0m 0	HA4_0.25m 0.25	HA5_0m 0	HA5_0.3m 0.3
		Date Sampled	28/06/2018	28/06/2018	28/06/2018	28/06/2018	28/06/2018
Analyte	Unit	*Reporting Limit*	18-23220-6	18-23220-7	18-23220-8	18-23220-9	18-23220-10
2,4'-DDD	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
2,4'-DDE	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
2,4'-DDT	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDD	mg/kg dry wt	*0.003*	<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDE	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDT	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005
Total DDT	mg/kg dry wt	*0.02*	<0.02	<0.02	<0.02	<0.02	<0.02
alpha-BHC	mg/kg dry wt	*0.005*	<0.005	<0.005	<0.005	<0.005	<0.005

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Organochlorine Pesticides - Soil

			Client Sample ID	HA3_0.3m 0.3	HA4_0m 0	HA4_0.25m 0.25	HA5_0m 0	HA5_0.3m 0.3
			Date Sampled	28/06/2018	28/06/2018	28/06/2018	28/06/2018	28/06/2018
Aldrin	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
beta-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
cis-Chlordane	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
cis-Nonachlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
delta-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Dieldrin	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan I	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Endosulfan II	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Endosulfan sulphate	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Endrin	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Endrin aldehyde	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Endrin ketone	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
gamma-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor epoxide	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Hexachlorobenzene	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Methoxychlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
trans-nonachlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
trans-Chlordane	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Chlordane (sum)	mg/kg dry wt	*0.02*		<0.020	<0.020	<0.020	<0.020	<0.020
TCMX (Surrogate)	%	*1*		82.8	92.4	89.9	89.0	88.5

Organochlorine Pesticides - Soil

			Client Sample ID	HA7_0m 0	HA7_0.25m 0.25	HA8_0m 0	HA8_0.25m 0.25	HA9_0m 0
			Date Sampled	29/06/2018	29/06/2018	29/06/2018	29/06/2018	29/06/2018
Analyte	Unit	*Reporting Limit*		18-23220-11	18-23220-12	18-23220-13	18-23220-14	18-23220-15
2,4'-DDD	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
2,4'-DDE	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
2,4'-DDT	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDD	mg/kg dry wt	*0.003*		<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDE	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDT	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Total DDT	mg/kg dry wt	*0.02*		<0.02	<0.02	<0.02	<0.02	<0.02
alpha-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Aldrin	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
beta-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
cis-Chlordane	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
cis-Nonachlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
delta-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Dieldrin	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan I	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Endosulfan II	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Endosulfan sulphate	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Endrin	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Endrin aldehyde	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Endrin ketone	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
gamma-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor epoxide	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Hexachlorobenzene	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Methoxychlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
trans-nonachlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01

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Organochlorine Pesticides - Soil

			Client Sample ID	HA7_0m 0	HA7_0.25m 0.25	HA8_0m 0	HA8_0.25m 0.25	HA9_0m 0
			Date Sampled	29/06/2018	29/06/2018	29/06/2018	29/06/2018	29/06/2018
trans-Chlordane	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Chlordane (sum)	mg/kg dry wt	*0.02*		<0.020	<0.020	<0.020	<0.020	<0.020
TCMX (Surrogate)	%	*1*		91.2	87.5	87.6	91.2	95.5

Organochlorine Pesticides - Soil

			Client Sample ID	HA9_0.25m 0.25	HA10_0m 0	HA10_0.3m 0.3	HA11_0m 0	HA11_0.25m 0.25
			Date Sampled	26/06/2018	28/06/2018	29/06/2018	29/06/2018	29/06/2018
Analyte	Unit	*Reporting Limit*		18-23220-16	18-23220-17	18-23220-18	18-23220-19	18-23220-20
2,4'-DDD	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
2,4'-DDE	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
2,4'-DDT	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDD	mg/kg dry wt	*0.003*		<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDE	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDT	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Total DDT	mg/kg dry wt	*0.02*		<0.02	<0.02	<0.02	<0.02	<0.02
alpha-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Aldrin	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
beta-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
cis-Chlordane	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
cis-Nonachlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
delta-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Dieldrin	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan I	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Endosulfan II	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Endosulfan sulphate	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Endrin	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Endrin aldehyde	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Endrin ketone	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
gamma-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor epoxide	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Hexachlorobenzene	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Methoxychlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
trans-nonachlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
trans-Chlordane	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Chlordane (sum)	mg/kg dry wt	*0.02*		<0.020	<0.020	<0.020	<0.020	<0.020
TCMX (Surrogate)	%	*1*		91.8	88.7	91.6	87.5	83.5

Organochlorine Pesticides - Soil

			Client Sample ID	HA12_0m 0	HA12_0.2m 0.2	HA13_0m 0	HA13_0.3m 0.3	HA14_0m 0
			Date Sampled	29/06/2018	29/06/2018	29/06/2018	29/06/2018	29/06/2018
Analyte	Unit	*Reporting Limit*		18-23220-21	18-23220-22	18-23220-23	18-23220-24	18-23220-25
2,4'-DDD	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
2,4'-DDE	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
2,4'-DDT	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDD	mg/kg dry wt	*0.003*		<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDE	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
4,4'-DDT	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Total DDT	mg/kg dry wt	*0.02*		<0.02	<0.02	<0.02	<0.02	<0.02

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Organochlorine Pesticides - Soil

			Client Sample ID	HA12_0m 0	HA12_0.2m 0.2	HA13_0m 0	HA13_0.3m 0.3	HA14_0m 0
			Date Sampled	29/06/2018	29/06/2018	29/06/2018	29/06/2018	29/06/2018
alpha-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Aldrin	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
beta-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
cis-Chlordane	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
cis-Nonachlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
delta-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Dieldrin	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan I	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Endosulfan II	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Endosulfan sulphate	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Endrin	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Endrin aldehyde	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Endrin ketone	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
gamma-BHC	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor epoxide	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Hexachlorobenzene	mg/kg dry wt	*0.005*		<0.005	<0.005	<0.005	<0.005	<0.005
Methoxychlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
trans-nonachlor	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
trans-Chlordane	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01	<0.01
Chlordane (sum)	mg/kg dry wt	*0.02*		<0.020	<0.020	<0.020	<0.020	<0.020
TCMX (Surrogate)	%	*1*		86.4	88.7	85.4	85.3	83.2

Organochlorine Pesticides - Soil

			Client Sample ID	HA14_0.2m 0.2
			Date Sampled	29/06/2018
Analyte	Unit	*Reporting Limit*		18-23220-26
2,4'-DDD	mg/kg dry wt	*0.005*		<0.005
2,4'-DDE	mg/kg dry wt	*0.005*		<0.005
2,4'-DDT	mg/kg dry wt	*0.005*		<0.005
4,4'-DDD	mg/kg dry wt	*0.003*		<0.005
4,4'-DDE	mg/kg dry wt	*0.005*		<0.005
4,4'-DDT	mg/kg dry wt	*0.005*		<0.005
Total DDT	mg/kg dry wt	*0.02*		<0.02
alpha-BHC	mg/kg dry wt	*0.005*		<0.005
Aldrin	mg/kg dry wt	*0.005*		<0.005
beta-BHC	mg/kg dry wt	*0.005*		<0.005
cis-Chlordane	mg/kg dry wt	*0.005*		<0.005
cis-Nonachlor	mg/kg dry wt	*0.01*		<0.01
delta-BHC	mg/kg dry wt	*0.005*		<0.005
Dieldrin	mg/kg dry wt	*0.05*		<0.05
Endosulfan I	mg/kg dry wt	*0.005*		<0.005
Endosulfan II	mg/kg dry wt	*0.01*		<0.01
Endosulfan sulphate	mg/kg dry wt	*0.005*		<0.005
Endrin	mg/kg dry wt	*0.05*		<0.05
Endrin aldehyde	mg/kg dry wt	*0.01*		<0.01
Endrin ketone	mg/kg dry wt	*0.005*		<0.005
gamma-BHC	mg/kg dry wt	*0.005*		<0.005
Heptachlor	mg/kg dry wt	*0.005*		<0.005
Heptachlor epoxide	mg/kg dry wt	*0.005*		<0.005
Hexachlorobenzene	mg/kg dry wt	*0.005*		<0.005
Methoxychlor	mg/kg dry wt	*0.01*		<0.01

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Organochlorine Pesticides - Soil

			Client Sample ID	HA14_0.2m 0.2
			Date Sampled	29/06/2018
trans-nonachlor	mg/kg dry wt	*0.01*		<0.01
trans-Chlordane	mg/kg dry wt	*0.01*		<0.01
Chlordane (sum)	mg/kg dry wt	*0.02*		<0.020
TCMX (Surrogate)	%	*1*		86.9

Acid Herbicides in Soil

			Client Sample ID	HA1_0m 0	HA3_0m 0	HA5_0m 0	HA7_0m 0	HA9_0m 0
			Date Sampled	28/06/2018	28/06/2018	28/06/2018	29/06/2018	29/06/2018
Analyte	Unit	*Reporting Limit*		18-23220-1	18-23220-5	18-23220-9	18-23220-11	18-23220-15
2,4,5-Trichlorophenoxyacetic acid	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
2,4,5-Trichlorophenoxypropionic acid	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
2,4-Dichlorophenoxyacetic acid	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
(2,4-Dichlorophenoxy)butanoic acid	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Acifluorfen	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Bentazone	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Bromoxynil	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Clopyralid	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Dicamba	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Dichlorprop	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Fluazifop	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Fluroxypyr	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Haloxyfop	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
MCPA	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
MCPB	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Mecoprop	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Oryzalin	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Pentachlorophenol	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Picloram	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Quizalofop	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
2,3,4,6-Tetrachlorophenol	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
Triclopyr	mg/kg dry wt	*0.05*		<0.05	<0.05	<0.05	<0.05	<0.05
2,4,6-Tribromophenol (Surrogate)	%	*1*		103.8	100.7	96.9	95.5	98.8

Acid Herbicides in Soil

			Client Sample ID	HA12_0m 0
			Date Sampled	29/06/2018
Analyte	Unit	*Reporting Limit*		18-23220-21
2,4,5-Trichlorophenoxyacetic acid	mg/kg dry wt	*0.05*		<0.05
2,4,5-Trichlorophenoxypropionic acid	mg/kg dry wt	*0.05*		<0.05

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Acid Herbicides in Soil

			Client Sample ID	HA12_0m 0
			Date Sampled	29/06/2018
2,4-Dichlorophenoxyacetic acid	mg/kg dry wt	*0.05*	<0.05
(2,4-Dichlorophenoxy)butanoic acid	mg/kg dry wt	*0.05*	<0.05
Acifluorfen	mg/kg dry wt	*0.05*	<0.05
Bentazone	mg/kg dry wt	*0.05*	<0.05
Bromoxynil	mg/kg dry wt	*0.05*	<0.05
Clopyralid	mg/kg dry wt	*0.05*	<0.05
Dicamba	mg/kg dry wt	*0.05*	<0.05
Dichlorprop	mg/kg dry wt	*0.05*	<0.05
Fluazifop	mg/kg dry wt	*0.05*	<0.05
Fluroxypyr	mg/kg dry wt	*0.05*	<0.05
Haloxyfop	mg/kg dry wt	*0.05*	<0.05
MCPA	mg/kg dry wt	*0.05*	<0.05
MCPB	mg/kg dry wt	*0.05*	<0.05
Mecoprop	mg/kg dry wt	*0.05*	<0.05
Oryzalin	mg/kg dry wt	*0.05*	<0.05
Pentachlorophenol	mg/kg dry wt	*0.05*	<0.05
Picloram	mg/kg dry wt	*0.05*	<0.05
Quizalofop	mg/kg dry wt	*0.05*	<0.05
2,3,4,6-Tetrachlorophenol	mg/kg dry wt	*0.05*	<0.05
Triclopyr	mg/kg dry wt	*0.05*	<0.05
2,4,6-Tribromophenol (Surrogate)	%	*1*	95.7

Total Petroleum Hydrocarbons - Soil

			Client Sample ID	HS1 0	HS2 0	HS3 0
			Date Sampled	29/06/2018	29/06/2018	29/06/2018
Analyte	Unit	*Reporting Limit*		18-23220-27	18-23220-28	18-23220-29
C7-C9	mg/kg dry wt	*10*		<10	<10	<10
C10-C14	mg/kg dry wt	*15*		16	24	223
C15-C36	mg/kg dry wt	*25*		2,334	1,940	20,469
C7-C36 (Total)	mg/kg dry wt	*50*		2,351	1,965	20,692

Polycyclic Aromatic Hydrocarbons - Soil

			Client Sample ID	HS1 0	HS2 0	HS3 0
			Date Sampled	29/06/2018	29/06/2018	29/06/2018
Analyte	Unit	*Reporting Limit*		18-23220-27	18-23220-28	18-23220-29
1-Methylnaphthalene	mg/kg dry wt	*0.01*		<0.1	<0.1	<0.1
2-Methylnaphthalene	mg/kg dry wt	*0.01*		<0.1	<0.1	<0.1
Acenaphthene	mg/kg dry wt	*0.01*		<0.1	<0.1	0.17
Acenaphthylene	mg/kg dry wt	*0.01*		<0.1	<0.1	<0.1
Anthracene	mg/kg dry wt	*0.01*		<0.1	0.11	0.44
Benz[a]anthracene	mg/kg dry wt	*0.02*		<0.2	0.38	0.35
Benzo[a]pyrene	mg/kg dry wt	*0.01*		<0.1	0.42	0.24
Benzo[b]&[j]fluoranthene	mg/kg dry wt	*0.02*		<0.2	0.38	0.32
Benzo[g,h,i]perylene	mg/kg dry wt	*0.02*		<0.2	<0.2	<0.2

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Polycyclic Aromatic Hydrocarbons - Soil

			Client Sample ID	HS1 0	HS2 0	HS3 0
			Date Sampled	29/06/2018	29/06/2018	29/06/2018
Benzo[k]fluoranthene	mg/kg dry wt	*0.01*		<0.1	0.11	0.12
Chrysene	mg/kg dry wt	*0.01*		<0.1	0.27	0.31
Dibenz(a,h)anthracene	mg/kg dry wt	*0.01*		<0.1	<0.1	<0.1
Fluoranthene	mg/kg dry wt	*0.02*		<0.2	0.73	0.97
Fluorene	mg/kg dry wt	*0.01*		<0.1	<0.1	0.85
Indeno(1,2,3-cd)pyrene	mg/kg dry wt	*0.01*		0.13	0.30	0.19
Naphthalene	mg/kg dry wt	*0.01*		<0.1	<0.1	<0.1
Phenanthrene	mg/kg dry wt	*0.01*		<0.1	0.25	1.60
Pyrene	mg/kg dry wt	*0.02*		0.36	0.72	7.28
Benzo[a]pyrene TEQ (LOR)	mg/kg dry wt	*0.01*		0.27	0.64	0.45
Benzo[a]pyrene TEQ (Zero)	mg/kg dry wt	*0.01*		0.01	0.54	0.35
Anthracene-d10 (Surrogate)	%	*1*		92.1	94.9	104.6

Moisture Content

		Client Sample ID	HS1 0	HS2 0	HS3 0
		Date Sampled	29/06/2018	29/06/2018	29/06/2018
Analyte	Unit	*Reporting Limit*	18-23220-27	18-23220-28	18-23220-29
Moisture Content	%	*1*	15	8	6

Method Summary

Elements in Soil	Acid digestion followed by ICP-MS analysis. US EPA method 200.8.
OCP in Soil	Samples are extracted with hexane, pre-concetrated then analysed by GC-MSMS. In house method. (Chlordane (sum) is calculated from the main actives in technical Chlordane: Chlordane, Nonachlor and Heptachlor)
Total DDT	Sum of DDT, DDD and DDE (4,4' and 2,4 isomers)
Acid Herbicides in Soil	A portion of dried soil sample is extracted with acidified methanol and diluted with acetic acid followed by LC-MS/MS analysis.
TPH in Soil	Solvent extraction, silica cleanup, followed by GC-FID analysis. (C7-C36)
PAH in Soil	Solvent extraction, silica cleanup, followed by GC-MS analysis. **Benzo[a]pyrene TEQ (LOR)**: The most conservative TEQ estimate, where a result is reported as less than the limit of reporting (LOR) the LOR value is used to calculate the TEQ for that PAH. **Benzo[a]pyrene TEQ (Zero)**: The least conservative TEQ estimate, PAHs reported as less than the limit of reporting (LOR) are not included in the TEQ calculation. Benzo[a]pyrene toxic equivalence (TEQ) is calculated according to *'Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health'*. Ministry for the Enivronment. 2011.
Moisture	Moisture content is determined gravimetrically by drying at 103 °C.

Elizabeth Fitzgerald, B.Sc.
Inorganics Team Leader

Nathan Howse, B.Sc.
Technician

Karam Wadi, B.E. (Hons)
Technologist

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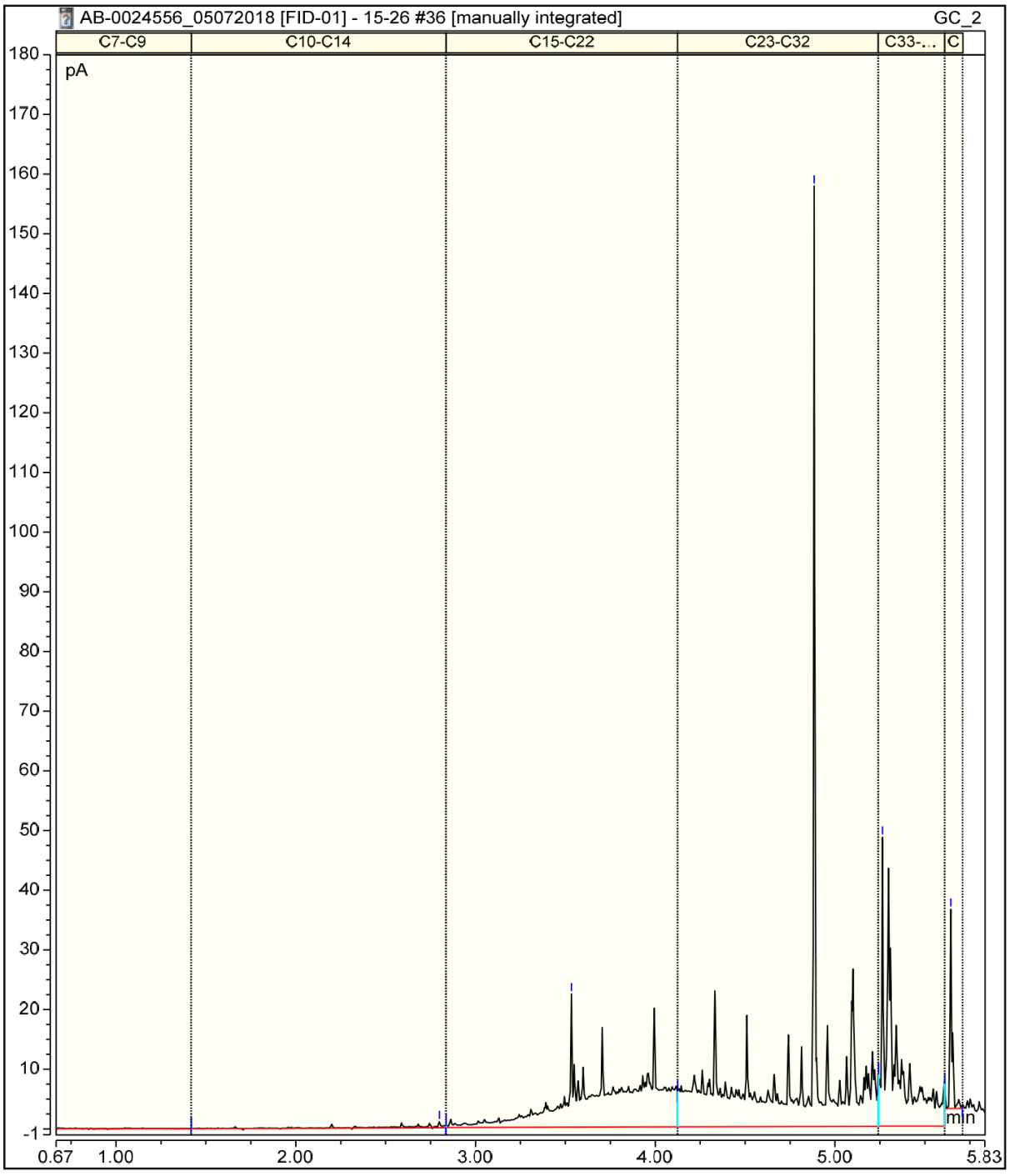
Instrument:Agilent_7890 Sequence:AB-0024556_05072018 [FID-01] - 15-26

Chromatogram

18-23220-27

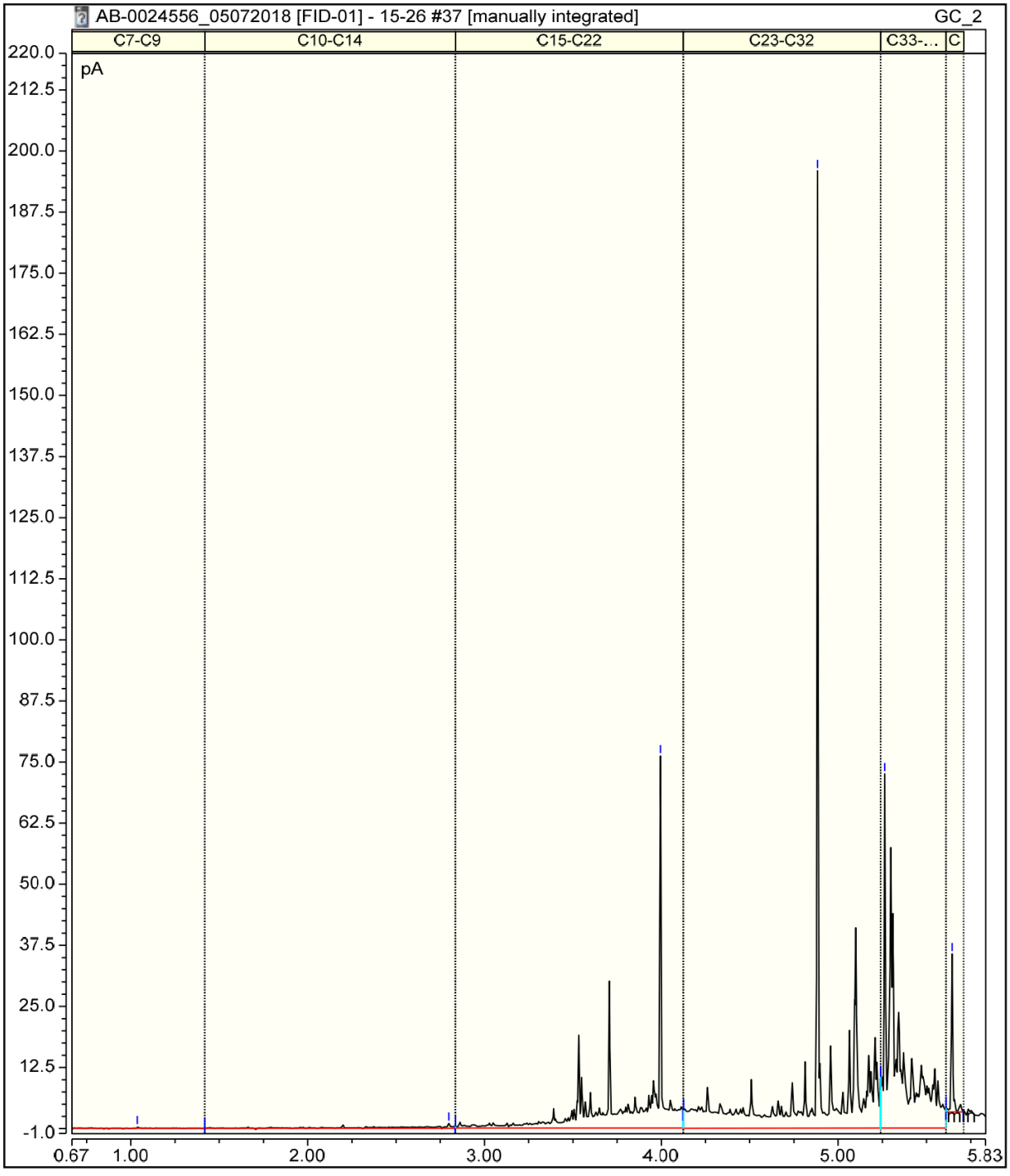


svTPH Report/Chromatogram

Chromeleon (c) Dionex
Version 7.2.5.9624

Chromatogram

18-23220-28



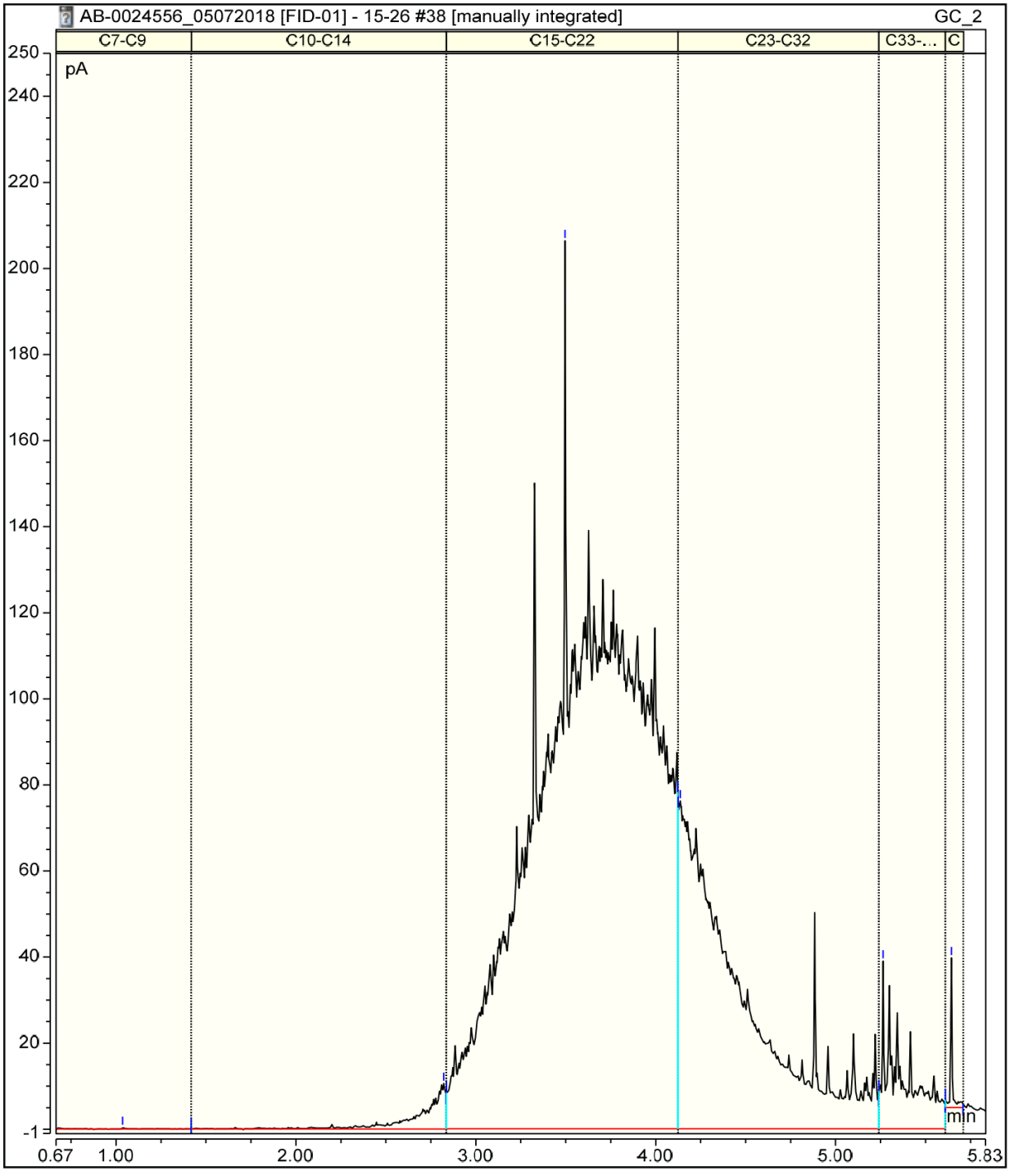
svTPH Report/Chromatogram

Chromeleon (c) Dionex
Version 7.2.5.9624

Instrument:Agilent_7890 Sequence:AB-0024556_05072018 [FID-01] - 15-26

Chromatogram

18-23220-29



svTPH Report/Chromatogram

Chromeleon (c) Dionex
Version 7.2.5.9624

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Certificate of Analysis

Riley Consultants Ltd
Level 1, 4 Fred Thomas Drive
Auckland
Attention: Ali Anwar
Phone: 09 489 7872
Email: aanwar@riley.co.nz

Lab Reference: 19-01327
Submitted by: Gareth Jackson
Date Received: 19/01/2019
Date Completed: 25/01/2019
Order Number:
Reference: 170672

Sampling Site: Flygers Line

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories. Samples were in acceptable condition unless otherwise noted on this report.

Heavy Metals in Soil

			Client Sample ID	AB1 0	AB2 0	AB4 0	AB5 0.5m 0.5	AB8 0
			Date Sampled	17/01/2019	17/01/2019	17/01/2019	17/01/2019	17/01/2019
Analyte	Unit	*Reporting Limit*		19-01327-1	19-01327-2	19-01327-4	19-01327-6	19-01327-8
Arsenic	mg/kg dry wt	*0.125*		8.06	6.50	4.13	5.42	3.97
Cadmium	mg/kg dry wt	*0.005*		0.59	0.61	0.53	0.33	0.14
Chromium	mg/kg dry wt	*0.125*		23.6	25.5	15.7	18.3	14.0
Copper	mg/kg dry wt	*0.075*		50.1	40.9	25.9	14.1	13.3
Lead	mg/kg dry wt	*0.05*		182	140	58.7	24.3	26.4
Nickel	mg/kg dry wt	*0.05*		14.1	13.9	12.4	16.3	12.3
Zinc	mg/kg dry wt	*0.05*		528	516	252	576	106

Heavy Metals in Soil

			Client Sample ID	AB10 0	AB12 0	ABR1 0	ABR2 0
			Date Sampled	17/01/2019	17/01/2019	17/01/2019	17/01/2019
Analyte	Unit	*Reporting Limit*		19-01327-10	19-01327-12	19-01327-13	19-01327-14
Arsenic	mg/kg dry wt	*0.125*		5.11	7.15	2.54	4.68
Cadmium	mg/kg dry wt	*0.005*		0.13	0.22	0.13	0.32
Chromium	mg/kg dry wt	*0.125*		17.3	19.4	12.3	16.8
Copper	mg/kg dry wt	*0.075*		10.6	13.4	12.2	22.3
Lead	mg/kg dry wt	*0.05*		27.1	41.5	68.8	122
Nickel	mg/kg dry wt	*0.05*		15.0	15.6	7.96	11.4
Zinc	mg/kg dry wt	*0.05*		92.4	140	109	217

IANZ ACCREDITED LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation, with the exception of tests marked *, which are not accredited.

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Polycyclic Aromatic Hydrocarbons - Soil

			Client Sample ID	AB1 0	AB2 0	AB4 0	AB5 0.5m 0.5	AB8 0
			Date Sampled	17/01/2019	17/01/2019	17/01/2019	17/01/2019	17/01/2019
Analyte	Unit	*Reporting Limit*		19-01327-1	19-01327-2	19-01327-4	19-01327-6	19-01327-8
1-Methylnaphthalene	mg/kg dry wt	*0.01*		<0.014	<0.012	<0.01	<0.01	<0.01
2-Methylnaphthalene	mg/kg dry wt	*0.01*		<0.014	<0.012	<0.01	<0.01	<0.01
Acenaphthene	mg/kg dry wt	*0.01*		<0.014	<0.012	<0.01	<0.01	<0.01
Acenaphthylene	mg/kg dry wt	*0.01*		<0.014	<0.012	<0.01	<0.01	<0.01
Anthracene	mg/kg dry wt	*0.01*		<0.014	<0.012	<0.01	<0.01	<0.01
Benz[a]anthracene	mg/kg dry wt	*0.02*		0.04	0.04	0.13	<0.02	<0.02
Benzo[a]pyrene	mg/kg dry wt	*0.01*		0.04	0.05	0.22	<0.01	<0.01
Benzo[b]&[j] fluoranthene	mg/kg dry wt	*0.02*		0.05	0.05	0.21	<0.02	<0.02
Benzo[g,h,i]perylene	mg/kg dry wt	*0.02*		<0.02	<0.02	0.06	<0.02	<0.02
Benzo[k]fluoranthene	mg/kg dry wt	*0.01*		0.02	0.01	0.06	<0.01	<0.01
Chrysene	mg/kg dry wt	*0.01*		0.03	0.03	0.10	<0.01	<0.01
Dibenz(a,h)anthracene	mg/kg dry wt	*0.01*		<0.014	<0.012	0.01	<0.01	<0.01
Fluoranthene	mg/kg dry wt	*0.02*		0.05	0.05	0.13	<0.02	<0.02
Fluorene	mg/kg dry wt	*0.01*		<0.014	<0.012	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	mg/kg dry wt	*0.01*		0.02	0.02	0.12	<0.01	<0.01
Naphthalene	mg/kg dry wt	*0.01*		<0.014	<0.012	<0.01	<0.01	<0.01
Phenanthrene	mg/kg dry wt	*0.01*		0.02	0.02	0.02	<0.01	<0.01
Pyrene	mg/kg dry wt	*0.02*		0.05	0.05	0.15	<0.02	<0.02
Benzo[a]pyrene TEQ (LOR)	mg/kg dry wt	*0.01*		0.07	0.07	0.29	0.03	0.03
Benzo[a]pyrene TEQ (Zero)	mg/kg dry wt	*0.01*		0.06	0.06	0.29	<0.01	<0.01
Anthracene-d10 (Surrogate)	%	*1*		100.9	105.7	114.1	113.3	106.0

Polycyclic Aromatic Hydrocarbons - Soil

			Client Sample ID	AB10 0	AB12 0	ABR1 0	ABR2 0
			Date Sampled	17/01/2019	17/01/2019	17/01/2019	17/01/2019
Analyte	Unit	*Reporting Limit*		19-01327-10	19-01327-12	19-01327-13	19-01327-14
1-Methylnaphthalene	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01
2-Methylnaphthalene	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01
Acenaphthene	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01
Acenaphthylene	mg/kg dry wt	*0.01*		<0.01	<0.01	0.04	0.03
Anthracene	mg/kg dry wt	*0.01*		<0.01	<0.01	0.02	0.02
Benz[a]anthracene	mg/kg dry wt	*0.02*		<0.02	<0.02	0.22	0.16
Benzo[a]pyrene	mg/kg dry wt	*0.01*		0.01	0.02	0.50	0.39
Benzo[b]&[j] fluoranthene	mg/kg dry wt	*0.02*		<0.02	<0.02	0.45	0.37
Benzo[g,h,i]perylene	mg/kg dry wt	*0.02*		<0.02	<0.02	0.21	0.15
Benzo[k]fluoranthene	mg/kg dry wt	*0.01*		<0.01	<0.01	0.16	0.11
Chrysene	mg/kg dry wt	*0.01*		<0.01	0.01	0.21	0.16
Dibenz(a,h)anthracene	mg/kg dry wt	*0.01*		<0.01	<0.01	0.04	0.02
Fluoranthene	mg/kg dry wt	*0.02*		<0.02	<0.02	0.20	0.16
Fluorene	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	mg/kg dry wt	*0.01*		<0.01	<0.01	0.39	0.29
Naphthalene	mg/kg dry wt	*0.01*		<0.01	<0.01	<0.01	<0.01
Phenanthrene	mg/kg dry wt	*0.01*		<0.01	<0.01	0.03	0.03
Pyrene	mg/kg dry wt	*0.02*		<0.02	<0.02	0.26	0.19
Benzo[a]pyrene TEQ (LOR)	mg/kg dry wt	*0.01*		0.03	0.03	0.67	0.51

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Polycyclic Aromatic Hydrocarbons - Soil

			Client Sample ID	AB10 0	AB12 0	ABR1 0	ABR2 0
			Date Sampled	17/01/2019	17/01/2019	17/01/2019	17/01/2019
Benzo[a]pyrene TEQ (Zero)	mg/kg dry wt	*0.01*		0.01	0.02	0.67	0.51
Anthracene-d10 (Surrogate)	%	*1*		104.5	104.9	107.8	109.0

Moisture Content

		Client Sample ID	AB1 0	AB2 0	AB4 0	AB5 0.5m 0.5	AB8 0
		Date Sampled	17/01/2019	17/01/2019	17/01/2019	17/01/2019	17/01/2019
Analyte	Unit	*Reporting Limit*	19-01327-1	19-01327-2	19-01327-4	19-01327-6	19-01327-8
Moisture Content	%	*1*	35	37	24	26	5

Moisture Content

		Client Sample ID	AB10 0	AB12 0	ABR1 0	ABR2 0
		Date Sampled	17/01/2019	17/01/2019	17/01/2019	17/01/2019
Analyte	Unit	*Reporting Limit*	19-01327-10	19-01327-12	19-01327-13	19-01327-14
Moisture Content	%	*1*	5	5	13	14

Method Summary

Elements in Soil Acid digestion followed by ICP-MS analysis. (US EPA method 200.8).

PAH in Soil Solvent extraction, silica cleanup, followed by GC-MS analysis.
Benzo[a]pyrene TEQ (LOR): The most conservative TEQ estimate, where a result is reported as less than the limit of reporting (LOR) the LOR value is used to calculate the TEQ for that PAH.
Benzo[a]pyrene TEQ (Zero): The least conservative TEQ estimate, PAHs reported as less than the limit of reporting (LOR) are not included in the TEQ calculation.
Benzo[a]pyrene toxic equivalence (TEQ) is calculated according to *'Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health'*. Ministry for the Environment. 2011.

Moisture Moisture content is determined gravimetrically by drying at 103 °C.

Elizabeth Fitzgerald, B.Sc.
Inorganics Team Leader

Nathan Howse, B.Sc.
Senior Technician

Sharelle Frank, B.Sc. (Tech)
Technologist

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PRECISE
CONSULTING & LABORATORY

Report Date: 24 Jan 2019

Certificate Number: P1901221401

Analytica Laboratories
Ruakura Research Centre, 10 Bisley Road, Private Bag 3123

Client Reference: 19-01327

Dear Analytica Laboratories,

Re: Asbestos Soil Identification Analysis – 19-01327

6 sample(s) received on 22 Jan 2019 by Georgina Jackson.

The results of fibre analysis were performed by Georgina Jackson of Precise Consulting and Laboratory Ltd on 24 Jan 2019.

The sample(s) were stated to be from 19-01327.

Sample analysis was performed using polarised light microscopy with dispersion staining in accordance with *AS4964-2004 Method for the qualitative identification of asbestos in soil samples.*

The results of the fibre analysis are presented in the appended table.

Should you require further information please contact Georgina Jackson.

Yours sincerely

Georgina Jackson

Georgina Jackson
PRECISE LABORATORY IDENTIFIER

Sample Analysis Results

Certificate Number: P1901221401
Report Date: 24 Jan 2019
Site Location: 19-01327

PRECISE CONSULTING & LABORATORY

Note 1: The reporting limit for this analysis is 0.1g/kg (0.01%) by application of polarised light microscopy, dispersion staining and trace analysis techniques.

Note 2: If mineral fibres of unknown type are detected (UMF), by PLM and dispersion staining, these may or may not be asbestos fibres. To confirm the identity of this fibre, another independent analytical technique such as XRD analysis is advised.

Note 3: The samples in this report are "As Received". The laboratory does not take responsibility for the sampling procedure or accuracy of sample location description. This document may not be reproduced except in full.

Identified by: Georgina Jackson

Approved Identifier: Georgina Jackson

Reviewed by: Georgina Jackson

Key Technical Person: Georgina Jackson

Sample ID	Client Sample ID	Sample Location/Description/Dimensions	Analysis Results
S001	AB1	- Non-Homogeneous Soil 46.0g	No Asbestos Detected Organic Fibres
S002	AB2	- Non-Homogeneous Soil 30.0g	No Asbestos Detected Organic Fibres
S003	AB4	- Non-Homogeneous Soil 53.0g	No Asbestos Detected Organic Fibres
S004	AB5 0.5m	- Non-Homogeneous Soil 60.5g	No Asbestos Detected Organic Fibres
S005	AB8	- Non-Homogeneous Soil 92.5g	No Asbestos Detected Organic Fibres
S006	AB10	- Non-Homogeneous Soil 109.5g	No Asbestos Detected Organic Fibres

Appendix 1: Soil Analysis Raw Data

Certificate Number: P1901221401
Report Date: 24 Jan 2019
Site Location: 19-01327

PRECISE
CONSULTING & LABORATORY

Sample ID	Client Sample ID	Total Sample Weight (g)	ACM Approximate Dimensions (g)*	Form	Trace Asbestos Detected**
S001	AB1	46.0	-	-	N
S002	AB2	30.0	-	-	N
S003	AB4	53.0	-	-	N
S004	AB5 0.5m	60.5	-	-	N
S005	AB8	92.5	-	-	N
S006	AB10	109.5	-	-	N

* The reporting limit for this standard is 0.1g/kg
** Trace asbestos present is indicative that freely liberated respirable fibres are present and dust control measures should be implemented or increased
*** Asbestos weights listed in this table are indicative only and are outside of IANZ accreditation and is therefore not endorsed by IANZ.

PALMERSTON NORTH CITY COUNCIL

ITEM 7 - ATTACHMENT 1

APPENDIX F

RILEY Dwg: 170672-10



1	FIRST ISSUE	WY	04.02.19	DESIGN CHECKED: GJ AA	APPROVED FOR ISSUE: R BURDEN	RILEY CONSULTANTS P.O.BOX 100 253 NORTH SHORE AUCKLAND 0745 TEL. 09-4897872 FAX. 09-4897873	TITLE: FLYGERS LINE INVESTMENT GROUP LIMITED RANGITIKEI LINE AND FLYGERS LINE, PALMERSTON NORTH DETAILED SITE INVESTIGATION - SITE PLAN
REV	DESCRIPTION	BY	DATE	DRAWN CHECKED: GJ JM	DATE: 13/02/19		CADFILE: 170672-10 SCALES (A3): 1:2500 ACENZ DRAWING No.: 170672-10 REV.: 1
				DATE DRAWN: FEB 2019			

APPENDIX 6

GEOTECHNICAL ASSESSMENT: PROPOSED PLAN CHANGE RANGITIKEI LINE AND FLYGERS LINE

RILEY CONSULTANTS LTD.



GEOTECHNICAL ASSESSMENT PROPOSED PLAN CHANGE RANGITIKEI LINE AND FLYGERS LINE PALMERSTON NORTH

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GEOTECHNICAL ASSESSMENT
PROPOSED PLAN CHANGE
RANGITIKEI LINE AND FLYGERS LINE, PALMERSTON NORTH

DRAFT

Report prepared for: Flygers Line Investment Group Limited

Report prepared by: Laura Smith, Geotechnical Engineer

.....

Report reviewed and approved for issue by: Don Tate, Director, CPEng

.....

Report reference: 170672-D

Date: 22 February 2019

Copies to: Flygers Line Investment Group Limited Electronic copy

Riley Consultants Ltd 1 copy

Issue:	Details:	Date:
0.1	Draft Geotechnical Assessment	22 February 2019

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2.0 Scope of Work 1
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4.0 Geology 2
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Appendices

Appendix A: CPT, MH, and HA Investigation Logs
Appendix B: Laboratory Test Results
Appendix C: Liquefaction Outputs
Appendix D: RILEY Dwgs: 170672-1 and -2

DRAFT

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GEOTECHNICAL ASSESSMENT
PROPOSED PLAN CHANGE
RANGITIKEI LINE AND FLYGERS LINE, PALMERSTON NORTH

1.0 Introduction

Riley Consultants Ltd (RILEY) has prepared the following report at the request of Resonant Consulting Limited (RCL) on behalf of Flygers Line Investment Group Limited. This geotechnical assessment has been prepared as part of an overall submission to Palmerston North City Council (PNCC) to rezone the existing rural site as residential land.

Our brief has not included potential flooding hazards. A ground contamination investigation has also been carried out on this site as part of the proposed plan change submission (RILEY Ref:170672-B, dated 13 February 2019).

2.0 Scope of Work

The scope of work has included the following main elements:

- Desktop review of historical aerial photographs, data available from the New Zealand Geotechnical Database (NZGD), and the GNS report for Palmerston North[1].
- Subsurface geotechnical investigations including 12 cone penetrometer tests (CPT), three machine boreholes, and three standpipe piezometers. Shallow hand auger boreholes, drilled as part of the ground contamination investigation, also give additional information.
- Laboratory testing of selected samples recovered from the machine boreholes to assist interpretation.
- Assess the extent of liquefaction susceptibility and associated risks to the proposed residential land.
- Comment on options for mitigation measures where required for future development.
- Assess any other geotechnical hazards that may have an impact on residential development.

3.0 Site Description

The site proposed for re-zoning, legally described as Lots 1 and 2 DP 389924, is located beyond the present northern urban limit of Palmerston North and is bordered by Flygers Line, Rangitikei Line, residential housing to the south-east, and rural farmland to the south-west. Aerial photography and LiDAR data show that the site is relatively flat with a stream running north to south through the middle of the site. The site is currently used as farmland and cropping.

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[1] *Assessment of liquefaction and related ground failure hazards in Palmerston North, New Zealand. GNS Science Consultancy Report 2011/108 July 2011.*

4.0 Geology

From a review of the 1:250,000 Geological Map, together with our experience of the surrounding area, we infer that the site is underlain by Holocene river deposits comprising gravel, sand, silt, mud, and clay with local peat. A review of the New Zealand Geotechnical Database (NZGD) yielded no investigations within the site itself, but a few deep wells just outside the site boundaries are shown in the GNS report.

5.0 Geotechnical Investigations

To assess the subsurface conditions, 12 CPTs were carried out on 29 June 2018 to a maximum depth of 6.5m where practical refusal was reached in all tests. A tractor rig supplied and operated by Geotech Drilling Limited (Geotech Drilling) was used to push the CPTs.

Initial analyses of the shallow CPTs indicated moderate liquefaction potential, therefore, a further three machine holes (MH1 to MH3) were drilled on 16 January 2019 to depths of 10m to 15m where the target depth was reached. Material recovered from the boreholes were logged in accordance with the NZGS Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes. In-situ standard penetrometer testing (SPT) was carried out at 1.5m intervals. Standpipe piezometers were installed in each machine hole targeting depths between 6m and 15m. A sonic rig supplied and operated by Geotech Drilling was used to drill the machine holes.

14 hand auger boreholes were drilled to a maximum depth of 1m as part of the ground contamination investigation and are summarised in the Preliminary and Detailed Site Investigation Contaminated Land report (RILEY Ref:170672-B, dated 13 February 2019).

The machine hole, CPT, and hand auger borehole locations are shown on RILEY Dwg: 170672-1, attached, and machine hole, hand auger, and CPT logs are included within Appendix A.

6.0 Laboratory Testing

Laboratory testing was undertaken by Opus Laboratory on a sample selected from MH3. Atterburg Limit tests were carried out to provide a comparison to soil type from descriptions and inferred from CPT tests. Further testing was not considered necessary because the soil types from CPT and machine hole logs were consistent.

Results of the Atterburg Limit test gives a liquid limit of 69 and a plasticity Index of 42, which plots on the Casagrande Plasticity Chart as a highly plastic, inorganic, non-dilatant clay (CH). This soil can, therefore, be classified as non-liquefiable. Laboratory test results are presented within Appendix B.

7.0 Results of Subsurface Investigation

Subsoil conditions typically comprise firm sandy and clayey silts and sands from the surface to approximately 5m below ground level (bgl) to 7m bgl, where very dense gravels were encountered and on which the CPTs terminated. The machine boreholes below this depth largely encountered gravels with lenses of stiff clayey silt and very dense sandy gravel in places.

Subsoil conditions encountered at the test locations are summarised below and detailed descriptions of the soils encountered during drilling are given on the appended logs.

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Table 1: Geological Model

Layer no.	Geological Unit	Description	Depth to top of layer (m)	Layer thickness (m)	Typical SPT 'N' value	Typical CPT tip resistance qc (MPa)
1	Topsoil	Brown, trace fine rootlets.	0	0.15 to 0.2	N/A	
2	Holocene River Deposits	Silt/sandy silt; dark grey. Firm, wet to saturated, moderately plastic.	0.15 to 0.2	4.3 to 4.35	18, 6, 3, 4	1 to 12
3	Holocene River Deposits	Silt/clayey silt; light bluish grey. Very soft, saturated, moderately plastic.	4.5	0.8 to 1.4	0, 1	0 to 2
4	Holocene River Deposits	Fine to medium gravel and fine to coarse sand; dark grey. Very dense, rounded, well graded.	5.3 to 5.9	4.1 to 6.0	50+	10 to 35, 20+, 10 to 30
5	Holocene River Deposits	Clayey silt/silt; grey. Stiff, slightly to moderately plastic.	9.4 to 11.9	1.6 to 2.1	15, 10, 15	
6	Holocene River Deposits	Silty sandy gravel; grey. Very dense, rounded.	11+ to 14	1.35+	50+	

The ground conditions encountered during the investigation are broadly consistent with published local geological maps. Groundwater was encountered between 3.0m and 4.2m bgl in the machine boreholes during January, and groundwater was measured after each CPT in June between 0.9m and 1.9m bgl. The shallow hand auger boreholes also encountered groundwater between 0.8m and 0.9m bgl.

8.0 Geotechnical Considerations

8.1 Depth to Groundwater

Groundwater was measured between 3.0m bgl and 4.2m bgl in the machine holes during January 2019 and between 0.8m and 1.9m bgl following each CPT and hand auger borehole carried out in June 2018. Groundwater levels are likely to vary seasonally and following rainfall events. A groundwater level of 4m bgl was mapped in the GNS report for Palmerston North.

8.2 Liquefaction Potential

8.2.1 Seismic Site Classification

The seismic loading induced on a structure will depend on, amongst other factors, the stiffness of the underlying soil/rock where the structure is located. Sites with low strength deep soils can amplify ground accelerations, requiring the structures built on them to resist a higher seismic coefficient. The New Zealand Structural Design code, NZS 1170.5:2004: Earthquake Actions, contains response spectra for structural design. Sites are categorised into five classes, Classes A to E. The site classes range from rock sites, Class A and B, to very soft or deep soil sites, Class E. These categories are used in structural design analysis.

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A review of the machine hole logs and CPT data indicates that depths of firm to stiff sandy silts and very dense gravels encountered in the machine holes and CPTs did not exceed the maximum depth limits for site subsoil Class C (refer Table 3.2 in NZS 1170.5:2004), however, refusal in gravels does not discount the possibility of the site being classed as subsoil Class D. Therefore, the site is conservatively identified as category **Class D (deep soil sites)** for the purposes of our liquefaction assessment.

8.2.2 Methodology

Liquefaction can occur in saturated loose to medium dense cohesionless deposits (silts and sands) in moderate to severe ground shaking. Geologically, recent materials or very weak man-made fills are the most susceptible soils. Effects on structures and subdivision infrastructure such as roads and services include; lateral spreading, settlement, loss of support, and other effects such as flotation. The steps in the liquefaction assessment are as follows:

- Review the range of soils encountered for susceptibility on a qualitative basis.
- Analytical assessment of the CPT data using GeoLogismiki v.2.1.6.7.
- The methods are based on the latest methodology from the NZGS and Ministry of Business, Innovation and Employment (MBIE) Guidelines, developed after the Canterbury earthquake sequence, with the most up to date guidance published in 2016.
- The CPT is generally regarded within the industry as the most reliable method of testing potential liquefiable materials. The ground motion parameters are based on the following:
    - 500-year return period shaking for Ultimate Limit State (ULS).
    - Class D (deep soil).
    - Magnitude 6.9 earthquake (ULS), 6.1 Servicability Limit State (SLS).
- For the purposes of the liquefaction analyses presented in this report, a depth to groundwater of 1.0m bgl has been used.

The resulting peak ground acceleration for liquefaction analysis is 0.34g for ULS, and 0.09g for SLS using the latest MBIE guidance (2016), MBIE Module 1: Method 1, New Zealand Transport Agency Bridge Manual Addendum 6A.

8.2.3 Results

A qualitative assessment of each individual CPT investigation point has been made in terms of liquefaction susceptibility. Potentially liquefiable materials were identified within the upper 6.0m of the soil profile, comprising discrete layers of loose to medium dense sandy silt, or silty sand. The dense to very dense gravels encountered below 6m depth are not likely to liquefy. Table 2 shows the assessed thickness of any potentially liquefiable zones (i.e. saturated loose to medium dense materials) at each investigation location within alluvium and the corresponding settlement (for the SLS case of 0.09g and ULS case of 0.34g). Results from the liquefaction assessment are attached in Appendix C.

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Table 2: Results of Liquefaction Assessment for ULS and SLS Event

CPT Location	CPT Depth (m)	Depth Interval of Potentially Liquefiable Soils (m)	SLS Vertical Settlement (mm)	ULS Vertical Settlement (mm)	Technical Category
1	4.8	1.0 to 1.1, 1.7 to 1.9, 2.1 to 3.4, and 3.7 to 4.5	2.5	94	TC2
2	6.1	1.0 to 2.4, 2.5 to 3.6, 3.7 to 4.3, and 4.8 to 5.7	1.5	119	TC2/3
3	5.7	1.3 to 1.5, 2.6 to 3.8, 4.2 to 4.6, and 5.5 to 5.6	2.5	80	TC2
4	4.1	1.0 to 2.2 and 2.6 to 2.9	0	39	TC2
5	5.6	1.0 to 1.2, 2.0 to 2.2, 2.6 to 3.2, 3.4 to 4.4, and 4.7 to 5.1	2.5	85	TC2
6	5.6	1.0 to 1.7, 2.0 to 2.2, 3.3 to 4.9, and 5.2 to 5.5	4	79	TC2
7	6	1.5 to 2.0, 4.2 to 4.9, and 5.2 to 6.0	2.5	71	TC2
8	5.3	3.4 to 3.7 and 4.0 to 4.4	0	24	TC2
9	5.7	2.2 to 3.7, 4.0 to 4.6, and 5.1 to 5.6	1.5	84	TC2
10	6.5	2.0 to 3.1, 4.5 to 5.2, and 5.7 to 6.5	2.5	92	TC2
11	5.7	1.0 to 1.5, 2.6 to 2.7, 3.2 to 3.3, 3.6 to 5.0, and 5.5 to 5.6	1	69	TC2
12	1.9	1.0 to 1.6 and 1.7 to 1.8	0	17	TC1

The assessed liquefied soils are within the upper Holocene River Deposits, typically described as loose to medium dense sandy silt, or silty sand. Overall, the thickness of liquefied soils for the SLS event is negligible, and several metres for the ULS event. Associated settlements are less than 15mm for the SLS event and less than 100mm (with one exception) for the ULS design seismic event. Liquefaction induced settlements in the order of 20mm to 100mm should be anticipated under the ULS event.

The liquefaction severity number (LSN) is a parameter based on investigation data, and considers the potential for liquefaction and the depth at which liquefaction occurs. This parameter has been correlated with evidence of surface ground damage in Christchurch. The LSN calculated for this site is typically between 20 and 30 (up to 45 in CPT2) and generally indicates moderate expression of liquefaction, sand boils, and minor damage to ground surface as well as minor differential settlement of structures.

The GNS Report for Palmerston North describes the low-lying materials of Holocene age, particularly saturated loose sands and silts, to be most likely to liquefy. The geological map categorises the site in the moderate to high liquefaction category for ground damage potential, however, it is noted that further subsurface information and assessment is required to determine material thicknesses and groundwater levels.

Based on the geotechnical investigation and the assessment undertaken for this site, in accordance with MBIE guidance, the site has a predicted future land performance **consistent with TC2**. We note that the MBIE guidance is for residential sites in Christchurch, however in the absence of any other available guidance, the MBIE guidelines are considered a suitable approach for this assessment.

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Liquefaction presents a hazard to urban infrastructure in addition to dwellings (i.e. roads, buried services etc). This should be taken into account in infrastructure development.

8.3 Lateral Spreading

Lateral spreading may occur if a continuous horizon of liquefied soil is present. Free-face lateral spreading conditions may occur when liquefiable layers are continuous to a stream bank. The nearest free-face is adjacent to any of the streams or drainage ditches running through or close to the site. The main stream has an estimated free-face height of 2.5m located in the south-west area of the site and drainage ditches also just beyond the northern boundary (alongside Flyers Line) and in the centre of the site running approximately east to west. For conventional residential dwellings and land to be categorised as TC2 land for residential dwellings, up to 100mm of lateral stretch under the ULS event is considered acceptable and 50mm in the SLS event.

Empirical methods used to evaluate lateral spreading displacements for this site produced highly varying results with corresponding required setback distances exceeding 100m. As a comparison, MBIE have recommended various fallback setback distances from a free-face for TC3 sites in Christchurch (minor to moderate movement of less than 300mm). These distances range from 50m for typical watercourses to 100m to 200m for the Avon and Heathcote rivers. Given that the soil conditions at this site are in the TC2 category compared to the much more severe TC3 category, significantly less deformation would be expected, but this is balanced by the TC2 deformation limit of 100mm. Based on this approach, a setback distance in the order of 50m could be justified, but dwellings would need to be designed to a higher foundation standard of TC3. We note, however, such an approach may not be desirable for a new development. The options to mitigate the hazard include the following:

1. Ground improvement, which may be costly on a large-scale (allowing for a TC2 type foundation).
2. Utilise TC2 type foundations with appropriate setback i.e. without ground improvement (the setback distance requires refinement but could be considerable).
3. Utilise TC3 type foundations with a lesser setback than Option 2.

It should be noted that negligible liquefaction is predicted in the SLS event and the lateral spreading risk is correspondingly low. Also, there is a wide variability in seasonal groundwater levels, which also influences the lateral spreading risk. We recommend that further investigations surrounding stream banks and other free-faces are carried out to gain a more accurate prediction of lateral spreading displacements for this site and further develop options to mitigate the hazard.

9.0 Other Geotechnical Constraints

Land across the site is generally flat, therefore, the risk of slope instability is considered to be negligible.

Previously infilled streams will need to be investigated further to define the extent and nature of the material used for infilling. There may be a risk of settlement due to historic filling in these areas depending on the material used for infilling. The scale of these features is small relative to the size of the site and potentially only localised to these areas. It has been noted that none of the shallow hand augers encountered any obvious fill material.

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10.0 Conclusions

From the site investigation, subsoil conditions comprise Holocene river deposits described as firm sandy and clayey silts and sands from the surface to approximately 5m bgl to 7m bgl, where very dense gravels were encountered.

An assessment of the site and subsoil conditions was carried out to determine the geotechnical risks present. These risks include liquefaction, lateral spreading, and slope instability. Since the site is generally flat, the risk of slope instability is considered to be negligible. However, the site is susceptible to liquefaction induced settlements and lateral spreading during future earthquake events.

Our liquefaction assessment predicts the upper loose river deposits to have negligible risk of liquefaction following an SLS event and 20mm to 100mm of liquefaction induced settlement under the ULS event. This corresponds to a predicted future land performance **consistent with TC2** and generally indicates moderate expression of liquefaction, sand boils, and minor damage to ground surface as well as minor differential settlement of structures. Foundations for new buildings in these areas are likely to be TC2 type foundations.

The risk of lateral spreading following an SLS event is considered to be negligible, however, under a ULS event the amount of lateral displacement varies significantly. Additional geotechnical investigations and assessments, tailored to the specific development, are recommended surrounding stream banks and other free-faces to gain a more accurate prediction of lateral spreading displacements for this site and further develop options to mitigate the hazard. In any event, we expect that with appropriate mitigation measures the site should be suitable for residential development from a geotechnical perspective, subject to the recommendations outlined in this report.

11.0 Limitation

This report has been prepared solely for the benefit of Flygers Line Investment Group Ltd as our client with respect to the brief and Palmerston North City Council in processing the plan change. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

Recommendations and opinions in this report are based on data from limited test positions. The nature and continuity of subsoil conditions away from the test positions are inferred, and it must be appreciated that actual conditions could vary considerably from the assumed model.

During excavation and construction, the site should be examined by an engineer or engineering geologist competent to judge whether the exposed subsoils are compatible with the inferred conditions on which the report has been based. It is possible that the nature of the exposed subsoils may require further investigation and the modification of the design based upon this report.

Riley Consultants Ltd would be pleased to provide this service to Flygers Line Investment Group Ltd and believes the project would benefit from such continuity. In any event, it is essential Riley Consultants Ltd is contacted if there is any variation in subsoil conditions from those described in the report as it may affect the design parameters recommended in the report.

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APPENDIX A

CPT, MH, and HA Investigation Logs

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GEOTECHNICAL AND GEOLOGICAL INFORMATION

SOIL TYPES AND SYMBOLS

- FILL
- TOPSOIL
- SILT
- SAND
- GRAVEL
- CLAY
- PEAT
- GROUNDWATER LEVEL
- 10,11,10 — SCALA PENETROMETER — LAST 3 NUMBER OF BLOWS PER 50mm INCREMENT

ROCK TYPES AND SYMBOLS

- SANDSTONE
- SILTSTONE
- MUDSTONE
- LIMESTONE
- BASALT
- TUFF
- IGNIMBRITE
- GREYWACKE

SOIL STRENGTH CLASSIFICATION

FINE GRAINED COHESIVE SOILS

TERM	FIELD IDENTIFICATION	UNDRAINED SHEAR STRENGTH (KPa)
Very Soft (Vs)	Exudes between fingers when squeezed.	<12
Soft (S)	Easily indented by fingers.	12 – 25
Firm (F)	Indented only by strong finger pressure.	25 – 50
Stiff (St)	Indented by thumb pressure.	50 – 100
Very Stiff (VSt)	Indented by thumbnail.	100 – 200
Hard (H)	Difficult to indent by thumbnail.	200+

SPT & SCALA PENETROMETER RESULTS

TERM	SPT VALUE No. of BLOWS/300mm	SCALA PENETROMETER No. of BLOWS/100mm
very dense	>50	17+
dense	30 – 50	7 – 17
medium dense	10 – 30	3 – 7
loose	4 – 10	1 – 3
very loose	0 – 4	0 – 2

ROCK STRENGTH CLASSIFICATION

TERM		FIELD IDENTIFICATION	UNCONFINED UNIAXIAL COMPRESSIVE STRENGTH (MPa)
Extremely weak	(EW)	Indented by thumbnail.	< 1
Very weak	(VW)	Crumbles under firm blows with point of geological hammer. Can be peeled with pocket knife.	1 – 5
Weak	(W)	Difficult to peel with pocket knife.	5 – 20
Moderately strong	(MS)	Cannot be scraped or peeled with pocket knife.	20 – 50
Strong	(S)	More than one blow of geological hammer to fracture.	50 – 100
Very strong	(VS)	Many blows of geological hammer to break.	100 – 250
Extremely strong	(ES)	Can only be chipped with geological hammer.	250+

MOISTURE CONDITION

Dry (D)	Looks and feels dry; powdery and friable.
Moist (M)	Feels cool; darkened in colour; no free water when remoulded.
Wet (W)	Feels cool; darkened in colour; free water forms on hands.
Saturated (S)	Free water is present on sample.

SAMPLE TYPES

- UNDISTURBED
- MACHINE AUGER DISTURBED
- D — HAND AUGER DISTURBED
- STANDARD PENETRATION TEST (solid cone)
- STANDARD PENETRATION TEST (hollow cone)

DRILLING METHOD

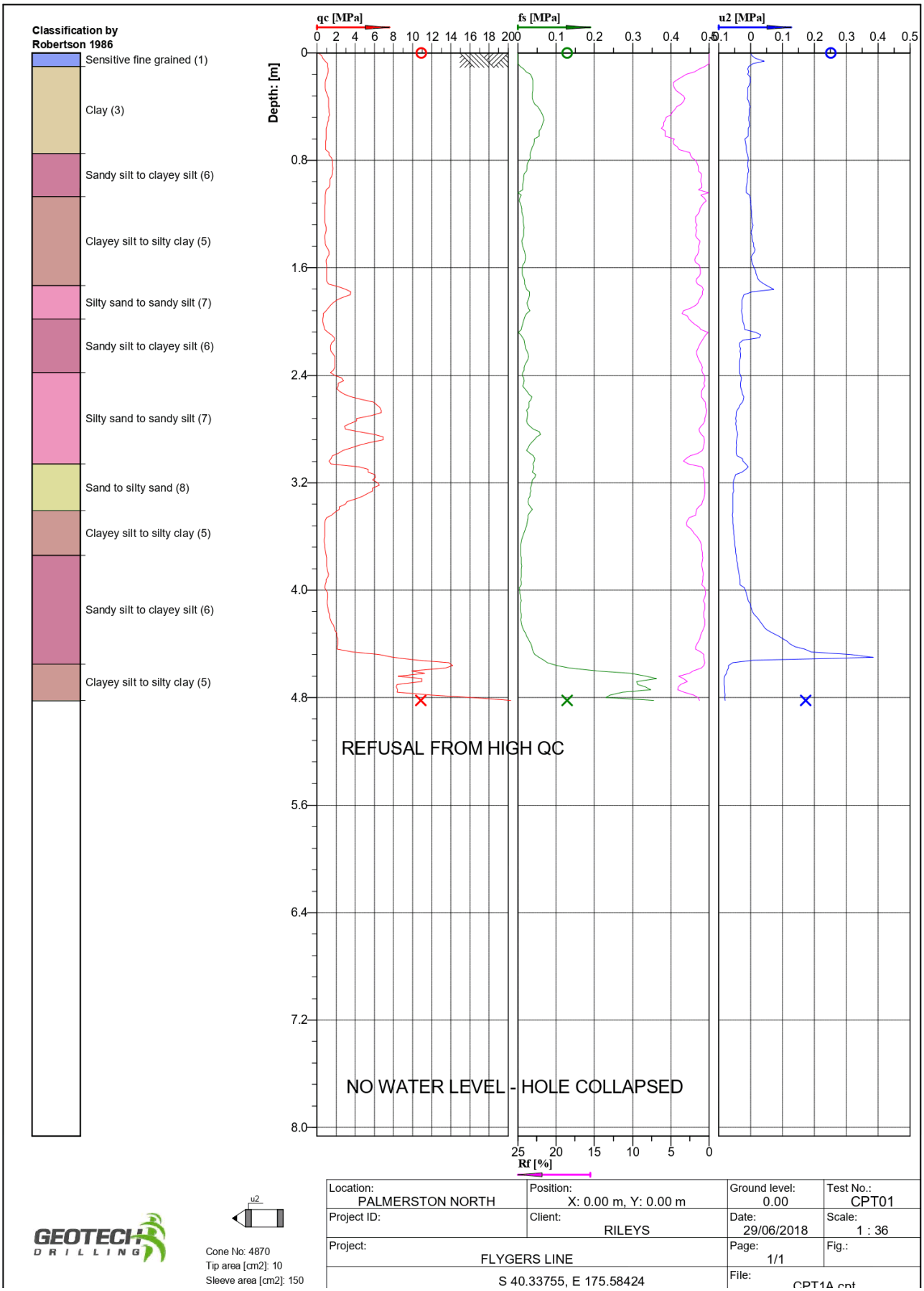
OB	OPEN BARREL
TT	TRIPLE TUBE
WB	WASH BORE
SH	UNDISTURBED SHELBY TUBE
RC	ROCK CORE
SPT	STANDARD PENETRATION TEST

FIELD TESTS

V	SHEAR VANE (corrected to BS:1377)
R	REMOULDED STRENGTH
P	POCKET PENETROMETER
CH	CLEGG HAMMER

INFORMATION BASED ON THE NZ GEOTECHNICAL SOCIETY INC. GUIDELINES FOR THE CLASSIFICATION AND DESCRIPTION OF SOIL AND ROCK FOR ENGINEERING PURPOSES

GEOLOGICALINFO.DWG REV. 3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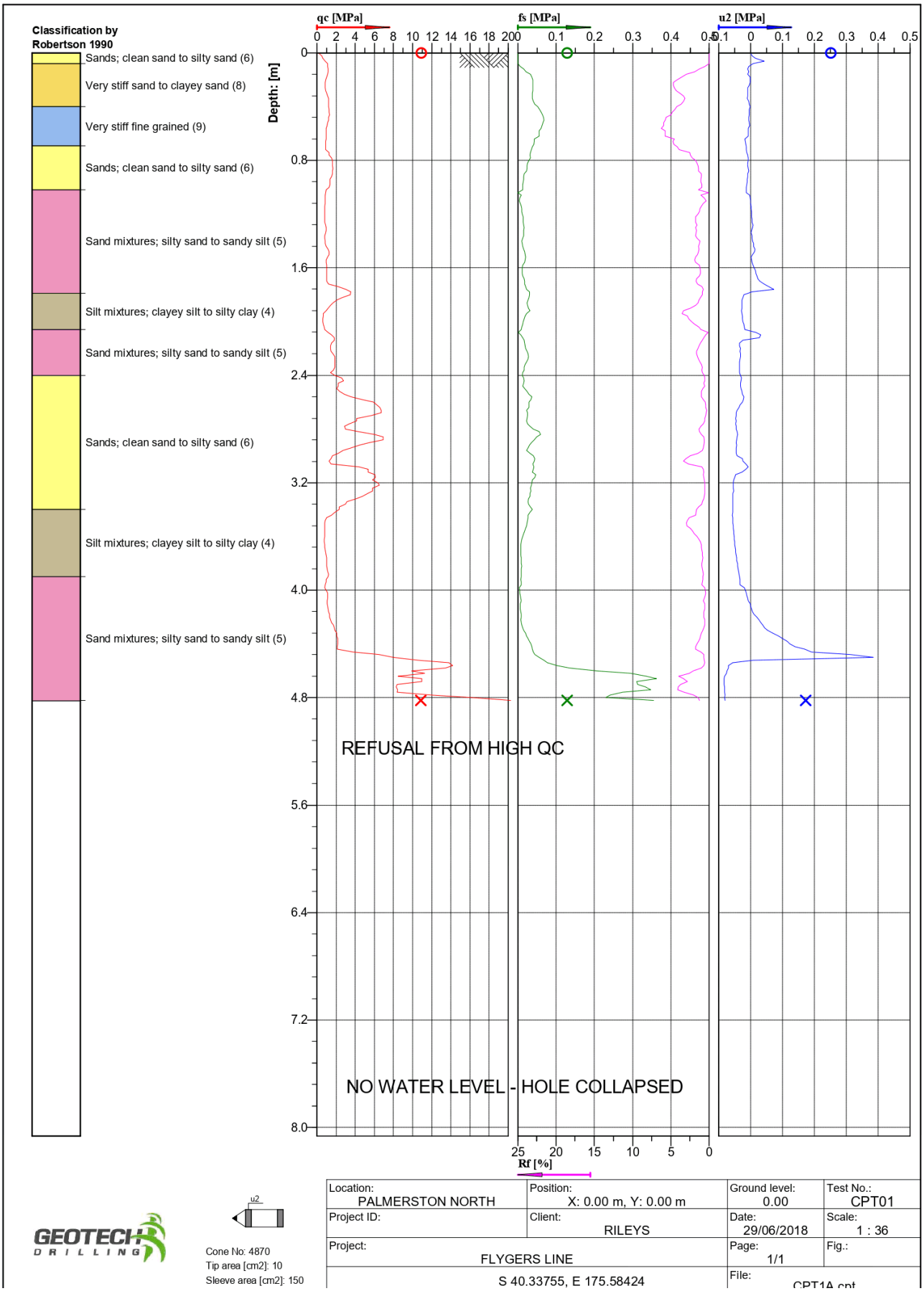
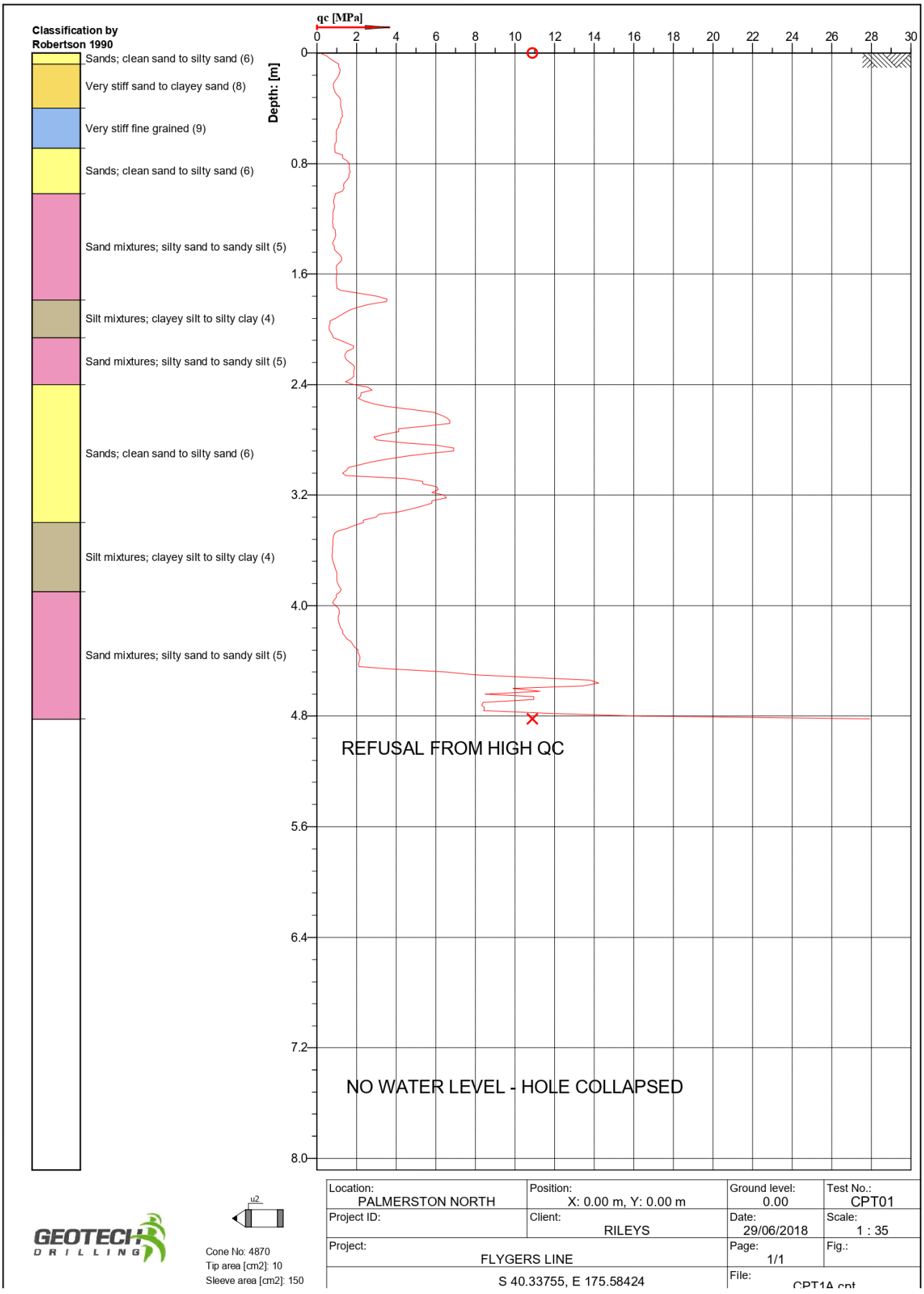
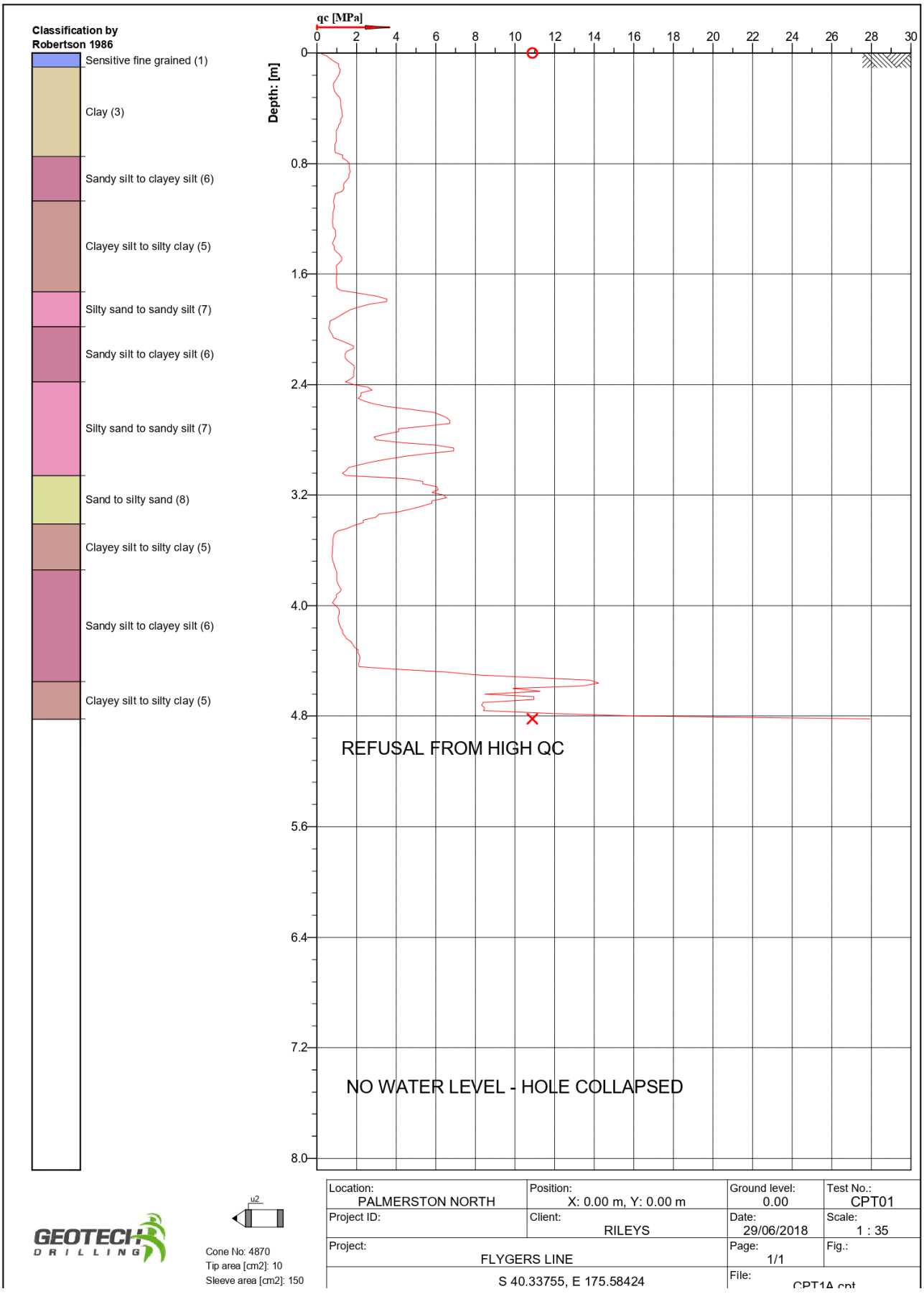
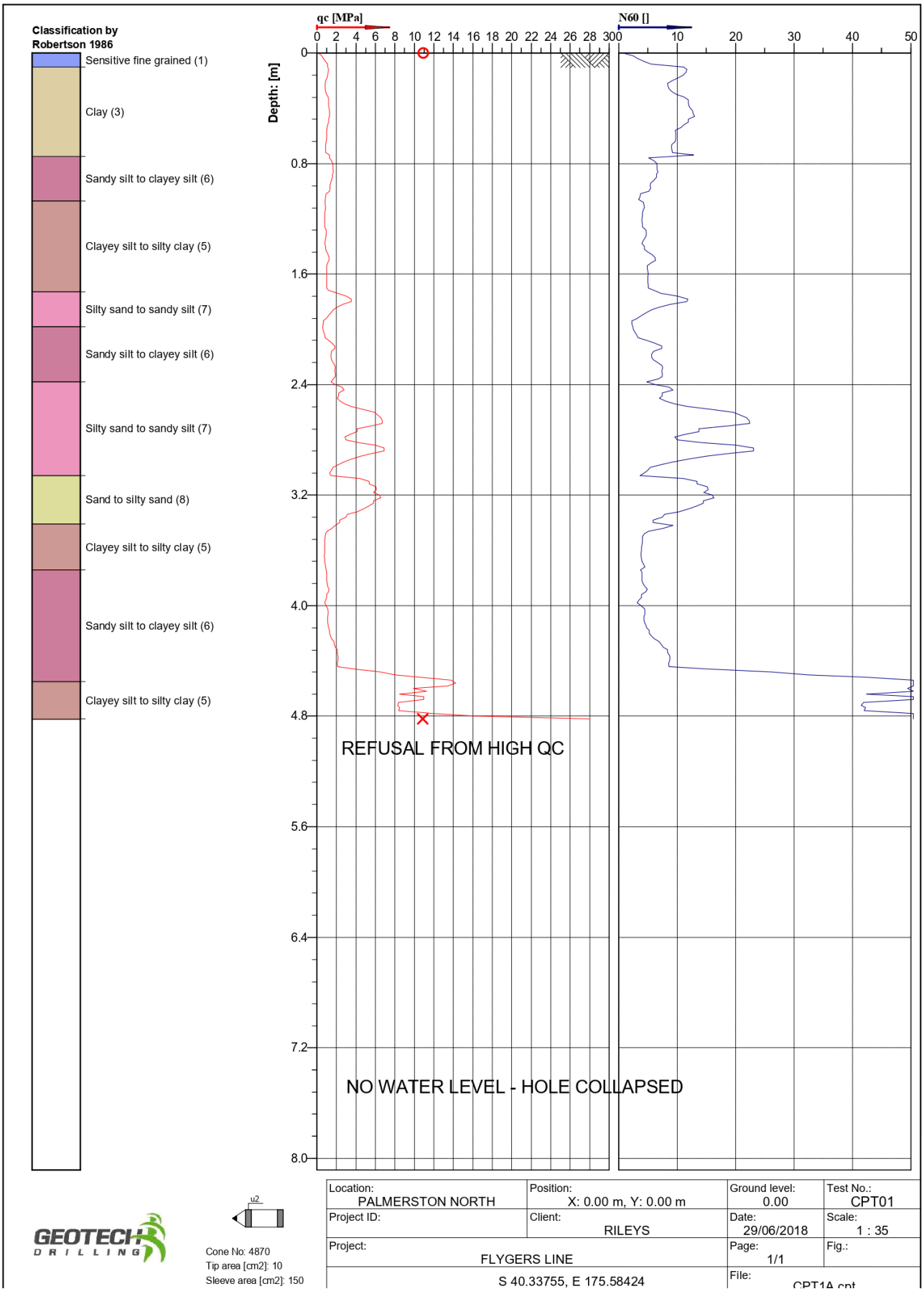
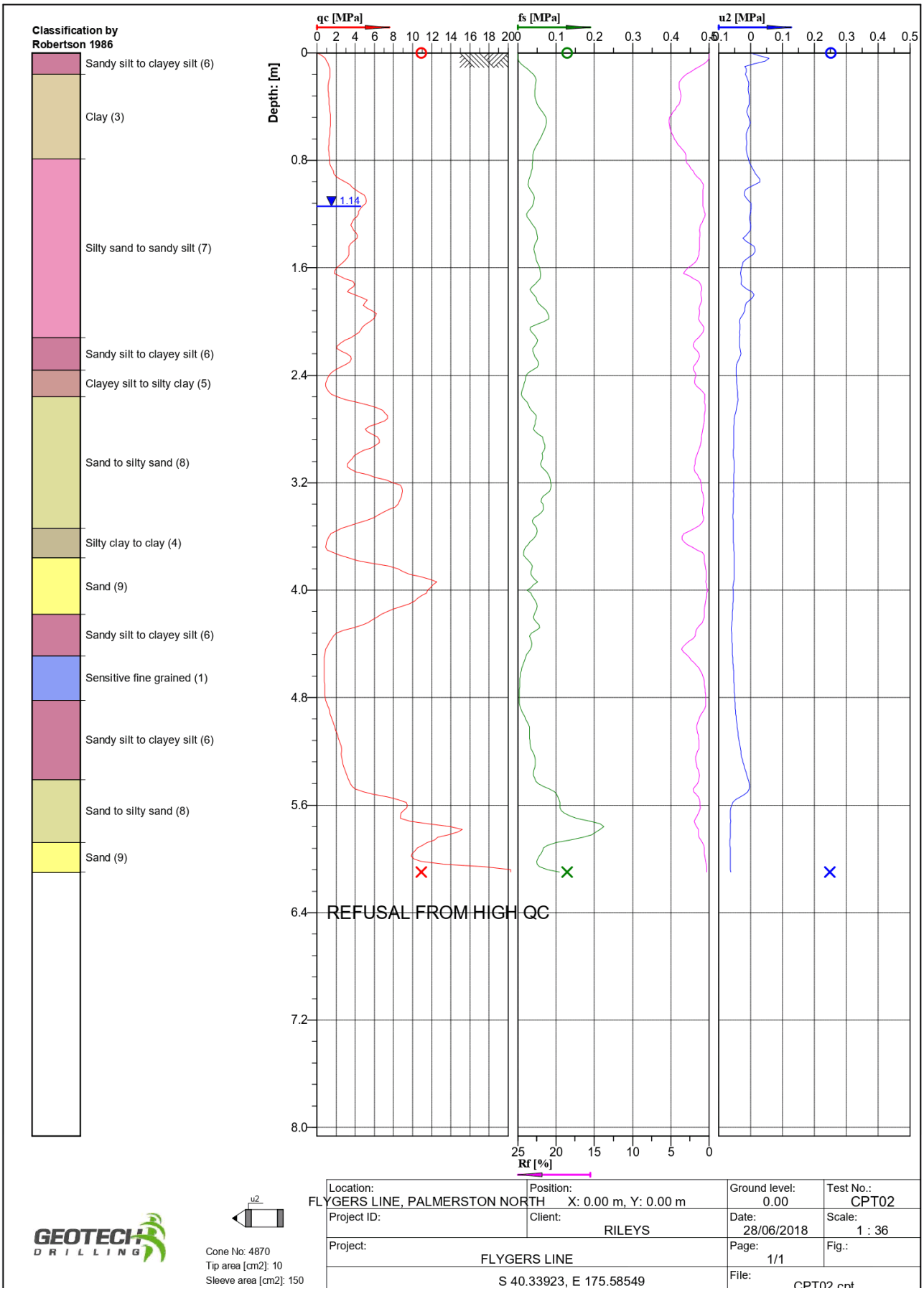
Clay (3)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Silty sand to sandy silt (7)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT01
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33755, E 175.58424
File: CPT1A.cpt


Classification by Robertson 1990
Sands; clean sand to silty sand (6)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT01
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33755, E 175.58424
File: CPT1A.cpt


Classification by Robertson 1990
Sands; clean sand to silty sand (6)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT01
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33755, E 175.58424
File: CPT1A.cpt


Classification by Robertson 1986
Sensitive fine grained (1)
Clay (3)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Silty sand to sandy silt (7)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT01
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33755, E 175.58424
File: CPT1A.cpt


Classification by Robertson 1986
Sensitive fine grained (1)
Clay (3)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Silty sand to sandy silt (7)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
N60 []
0 10 20 30 40 50
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT01
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33755, E 175.58424
File: CPT1A.cpt


Classification by Robertson 1986
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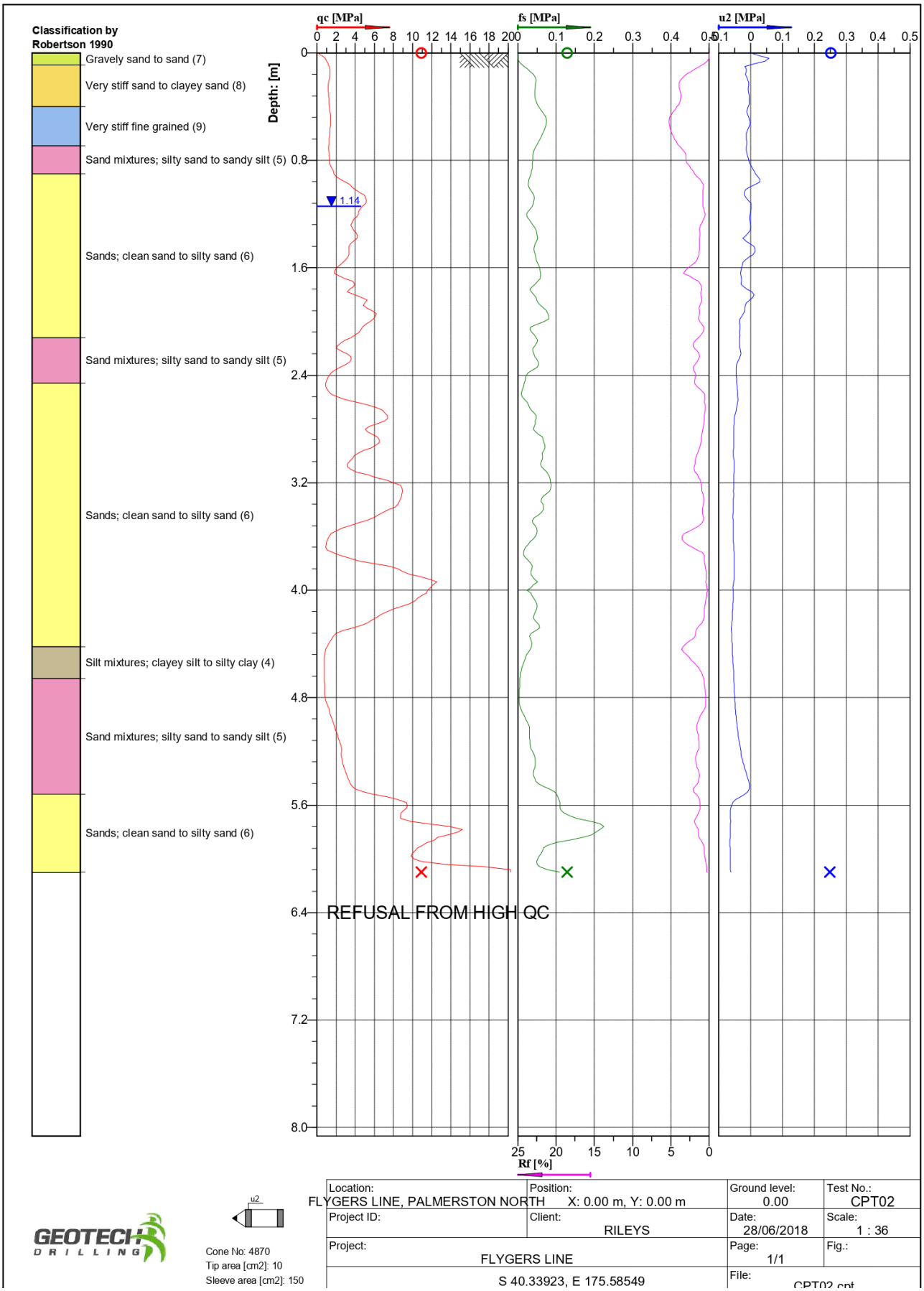
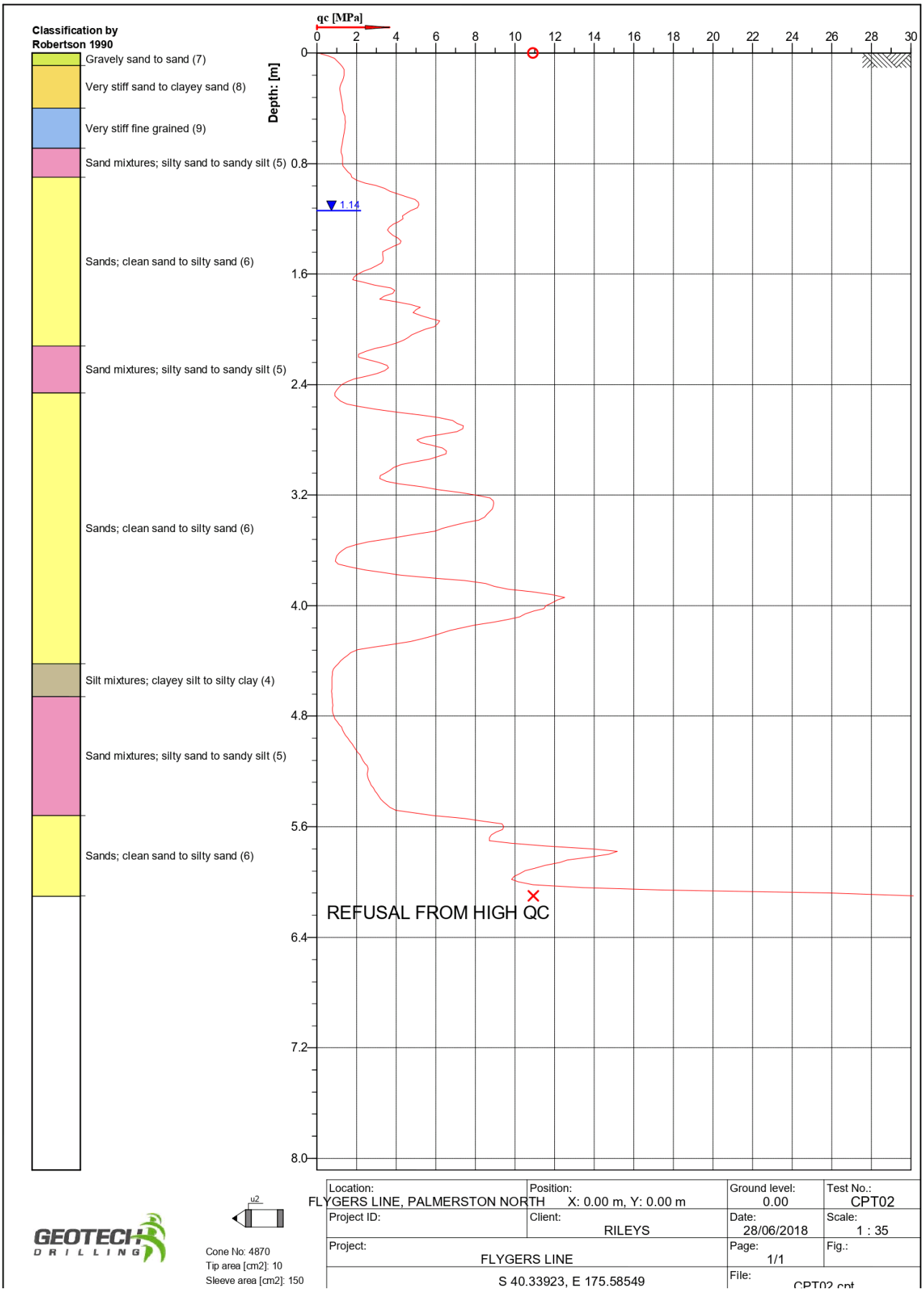
Clay (3)
Silty sand to sandy silt (7)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sand to silty sand (8)
Silty clay to clay (4)
Sand (9)
Sandy silt to clayey silt (6)
Sensitive fine grained (1)
Sandy silt to clayey silt (6)
Sand to silty sand (8)
Sand (9)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
1.14
REFUSAL FROM HIGH QC
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
GEOTECH DRILLING
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT02
Project ID:
Client: RILEYS
Date: 28/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33923, E 175.58549
File: CPT02.cpt


Classification by Robertson 1990
Gravely sand to sand (7)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
1.14
REFUSAL FROM HIGH QC
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT02
Project ID:
Client: RILEYS
Date: 28/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33923, E 175.58549
File: CPT02.cpt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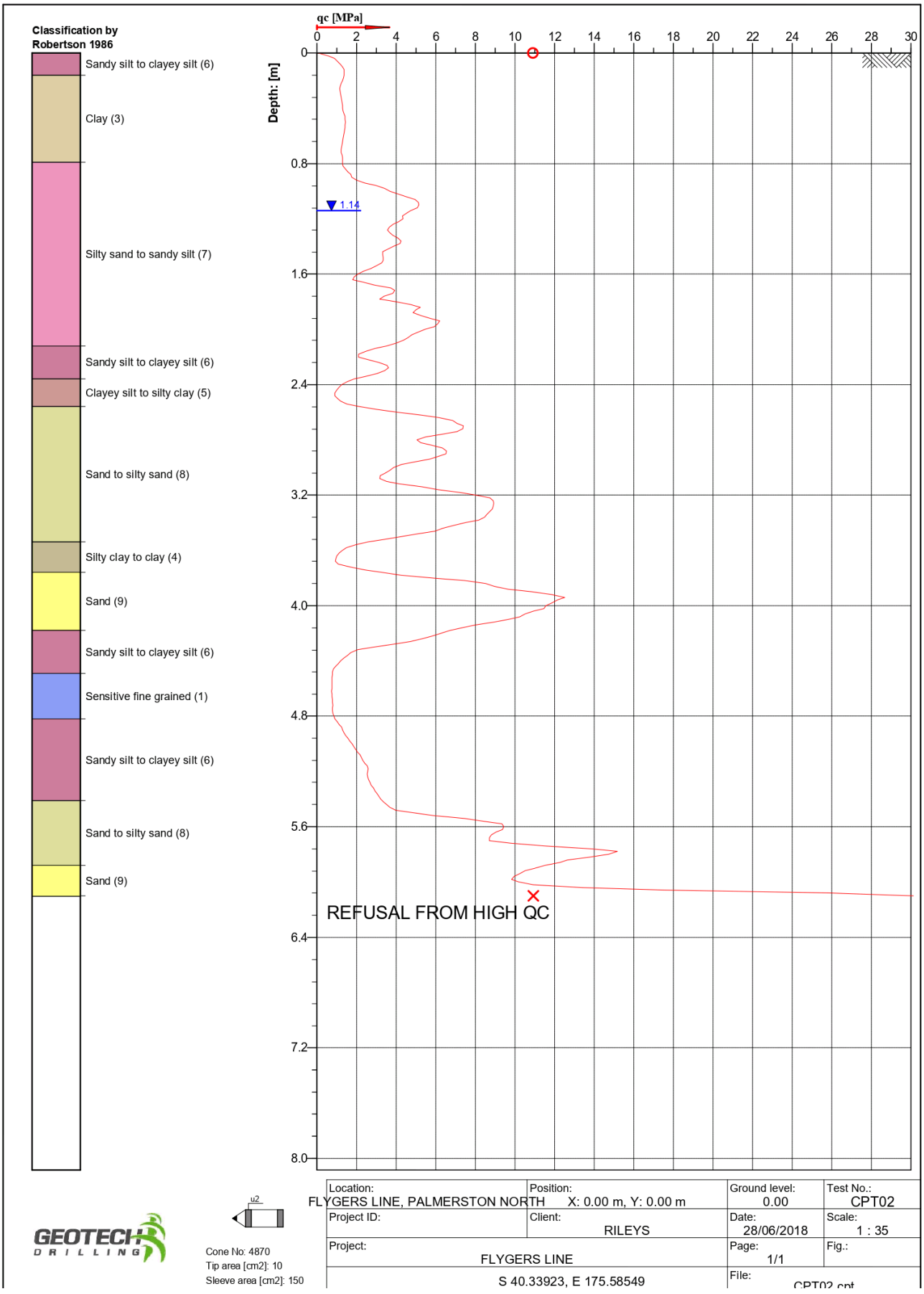
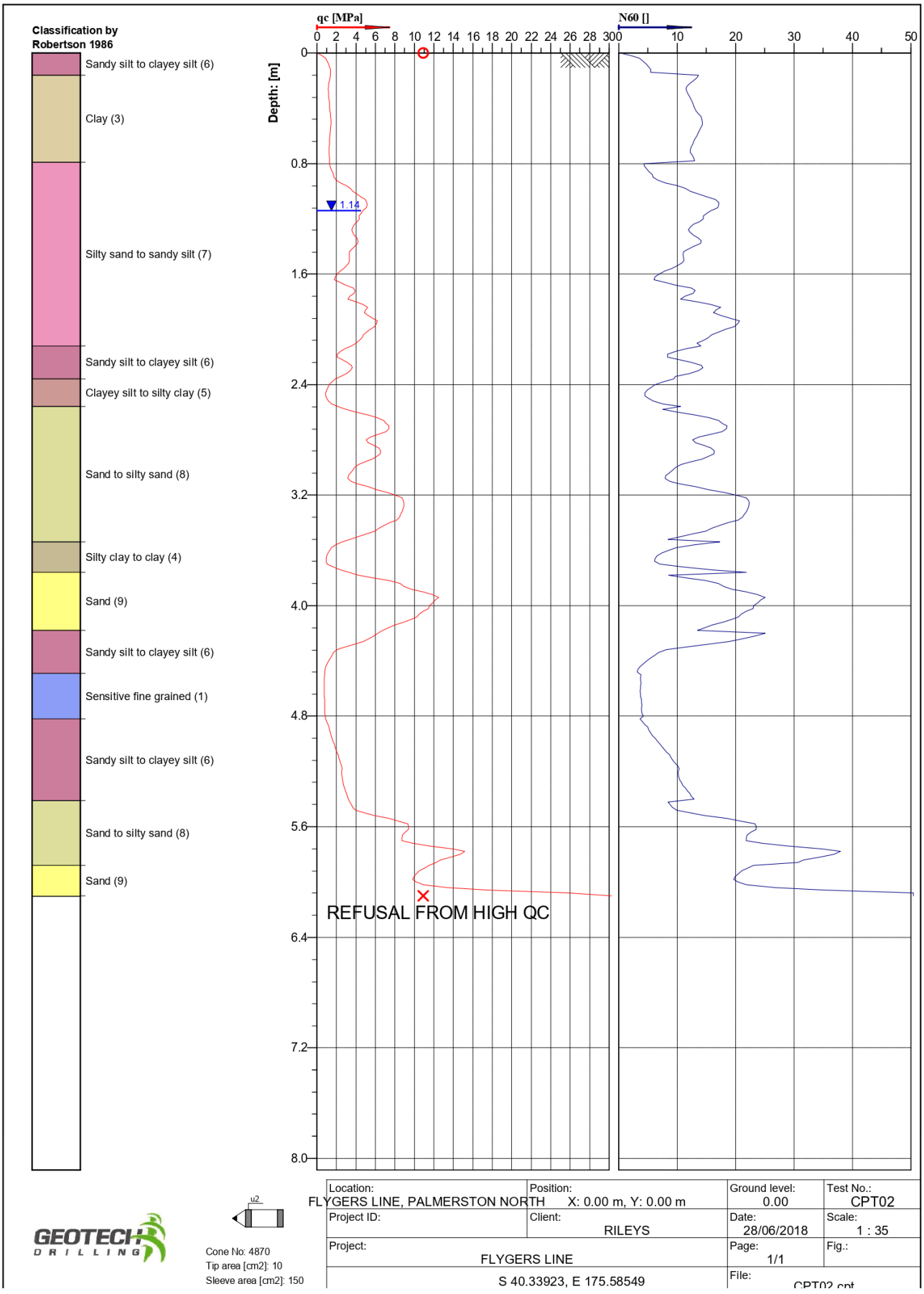
Gravely sand to sand (7)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
1.14
REFUSAL FROM HIGH QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT02
Project ID:
Client: RILEYS
Date: 28/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33923, E 175.58549
File: CPT02.cpt


Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clay (3)
Silty sand to sandy silt (7)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sand to silty sand (8)
Silty clay to clay (4)
Sand (9)
Sandy silt to clayey silt (6)
Sensitive fine grained (1)
Sandy silt to clayey silt (6)
Sand to silty sand (8)
Sand (9)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
1.14
REFUSAL FROM HIGH QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT02
Project ID:
Client: RILEYS
Date: 28/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33923, E 175.58549
File: CPT02.cpt


Classification by Robertson 1986
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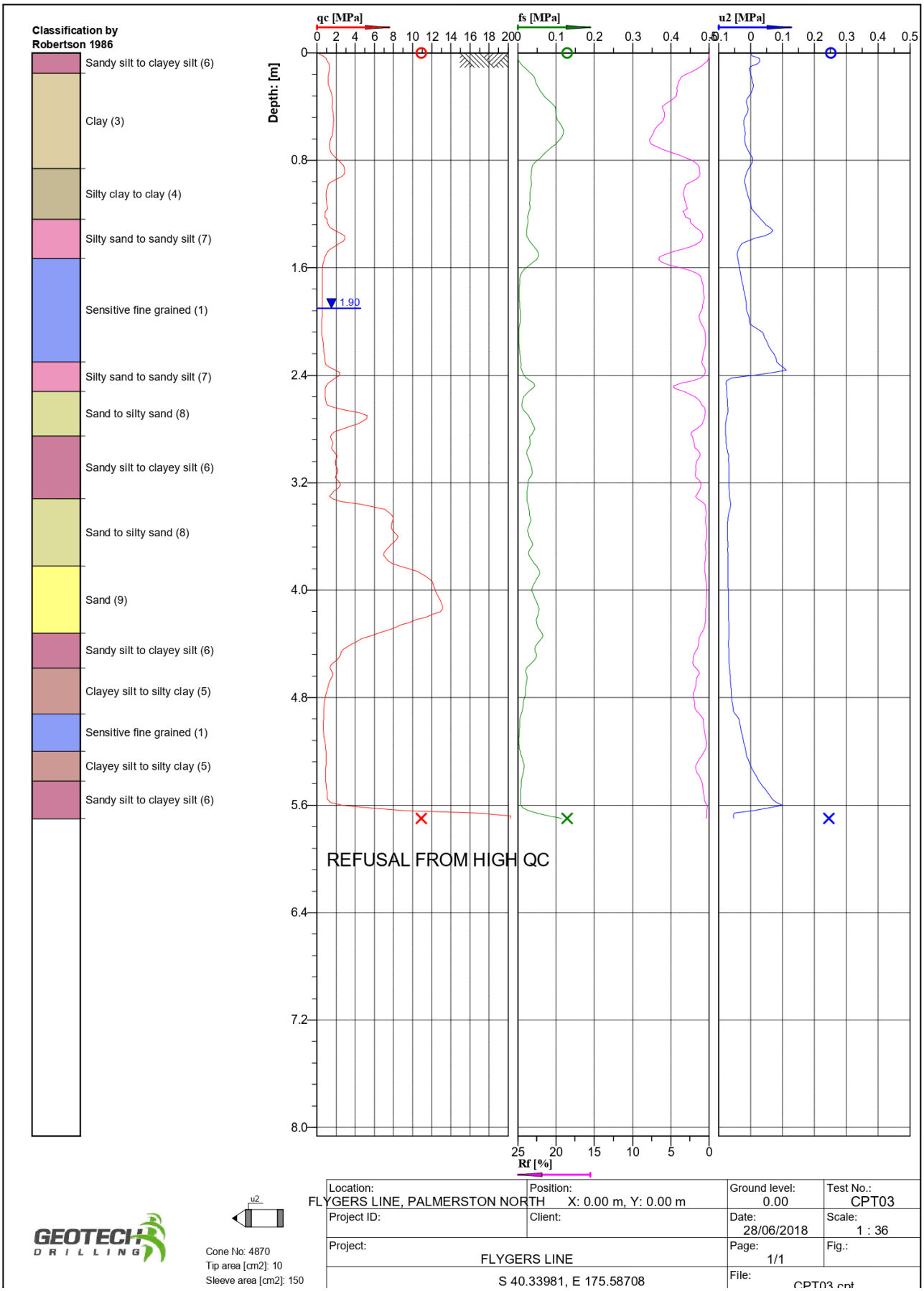
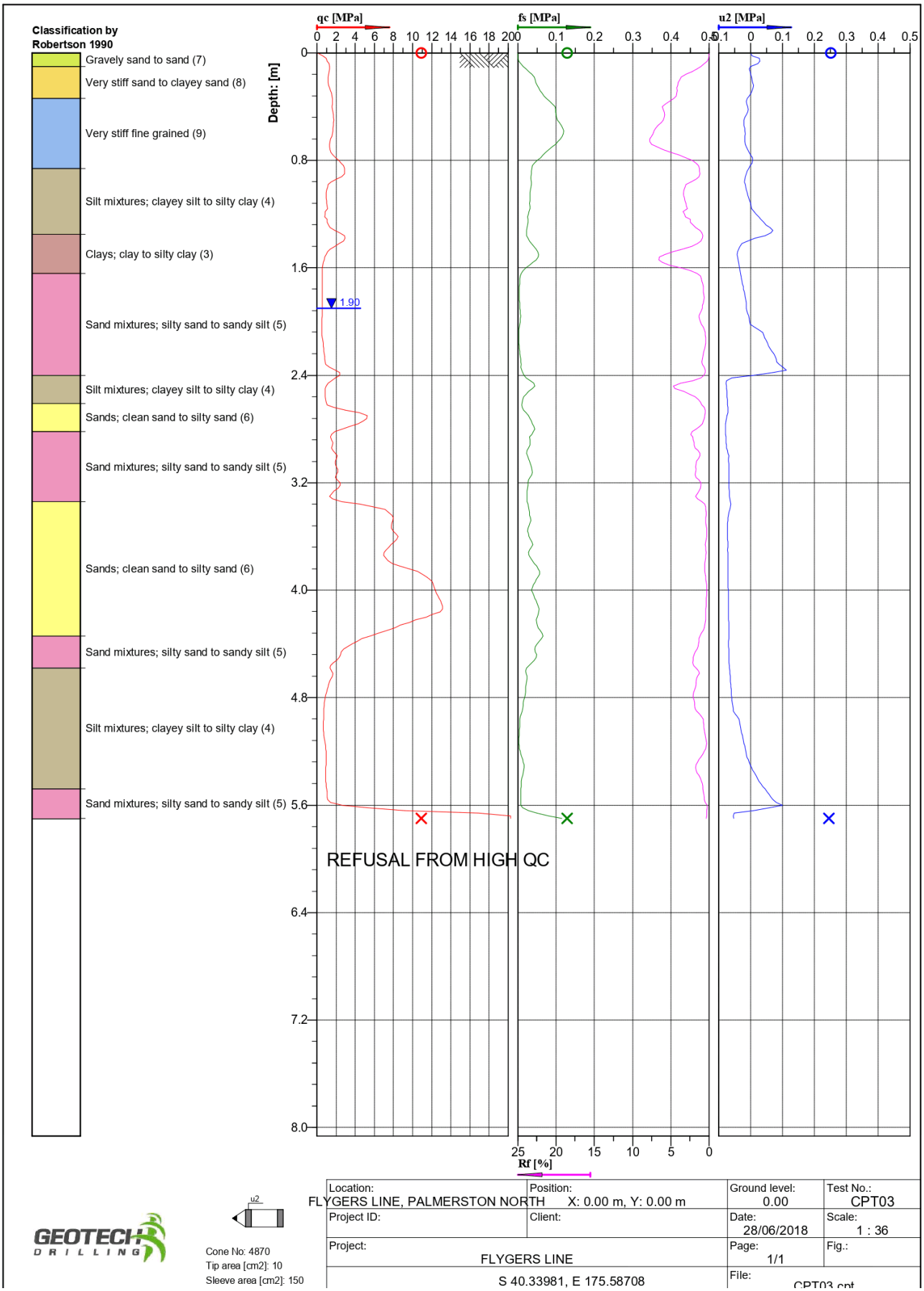
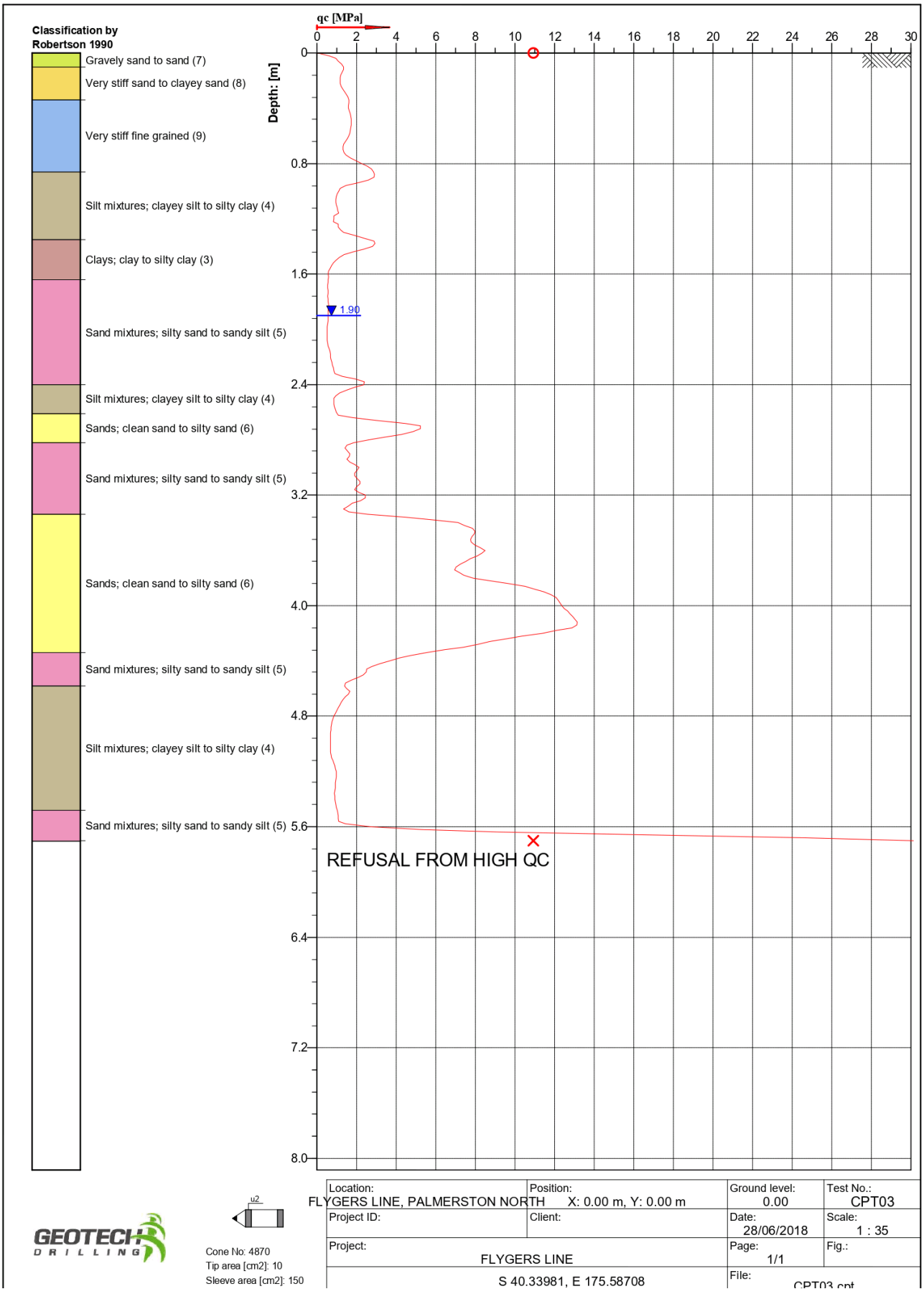
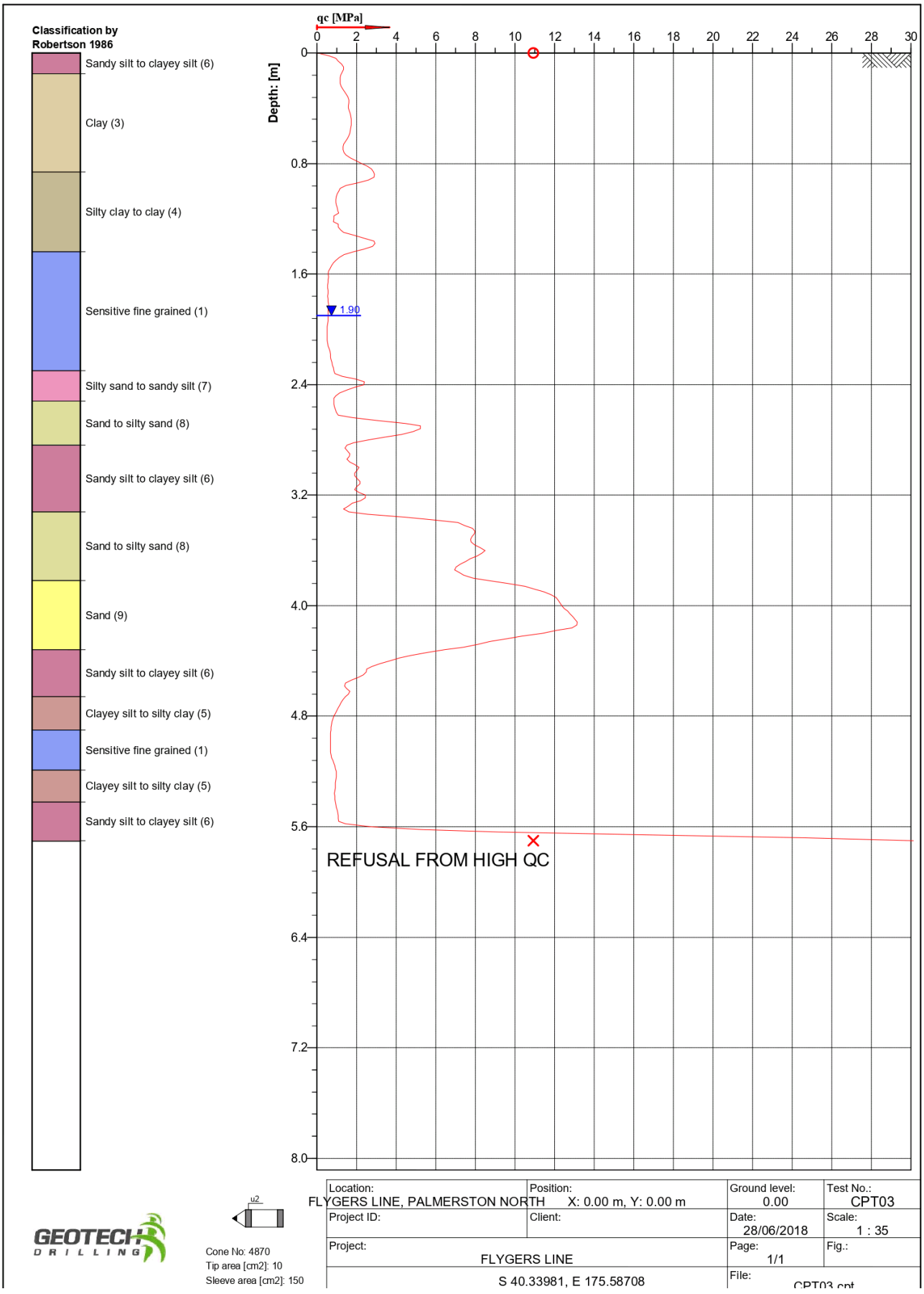
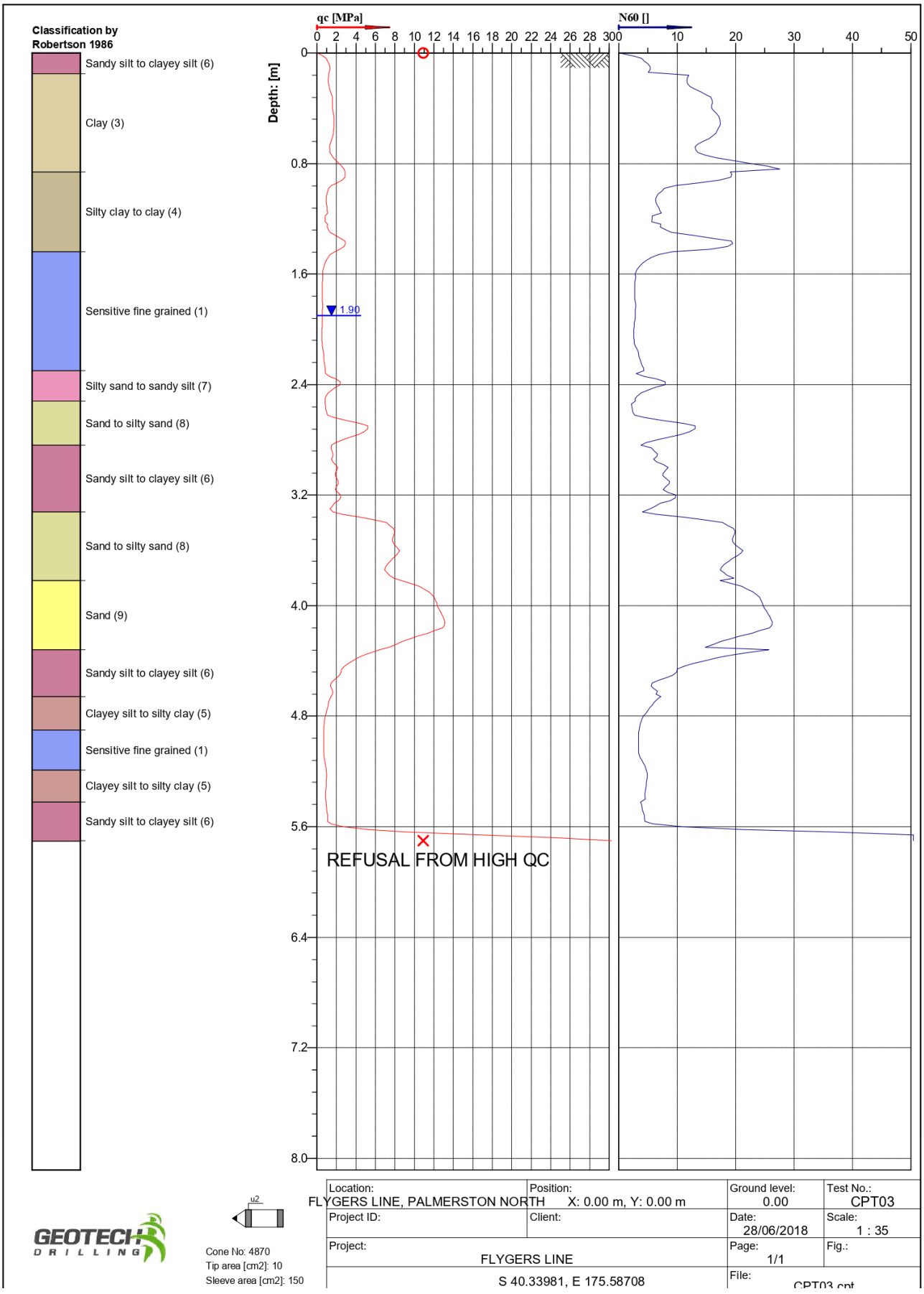
Clay (3)
Silty sand to sandy silt (7)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sand to silty sand (8)
Silty clay to clay (4)
Sand (9)
Sandy silt to clayey silt (6)
Sensitive fine grained (1)
Sandy silt to clayey silt (6)
Sand to silty sand (8)
Sand (9)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
N60 []
0 10 20 30 40 50
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
1.14
REFUSAL FROM HIGH QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT02
Project ID:
Client: RILEYS
Date: 28/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33923, E 175.58549
File: CPT02.cpt


Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clay (3)
Silty clay to clay (4)
Silty sand to sandy silt (7)
Sensitive fine grained (1)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Sandy silt to clayey silt (6)
Sand to silty sand (8)
Sand (9)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
1.90
REFUSAL FROM HIGH QC
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
GEOTECH DRILLING
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT03
Project ID:
Client:
Date: 28/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33981, E 175.58708
File: CPT03.cpt


Classification by Robertson 1990
Gravely sand to sand (7)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Silt mixtures; clayey silt to silty clay (4)
Clays; clay to silty clay (3)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Depth: [m]
qc [MPa]
fs [MPa]
u2 [MPa]
Rf [%]
1.90
REFUSAL FROM HIGH QC
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT03
Project ID:
Client:
Date: 28/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33981, E 175.58708
File: CPT03.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150


Classification by Robertson 1990
Gravely sand to sand (7)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Silt mixtures; clayey silt to silty clay (4)
Clays; clay to silty clay (3)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
1.90
REFUSAL FROM HIGH QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT03
Project ID:
Client:
Date: 28/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33981, E 175.58708
File: CPT03.cpt


Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clay (3)
Silty clay to clay (4)
Sensitive fine grained (1)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Sandy silt to clayey silt (6)
Sand to silty sand (8)
Sand (9)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
1.90
REFUSAL FROM HIGH QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
GEOTECH DRILLING
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT03
Project ID:
Client:
Date: 28/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33981, E 175.58708
File: CPT03.cpt


Classification by Robertson 1986
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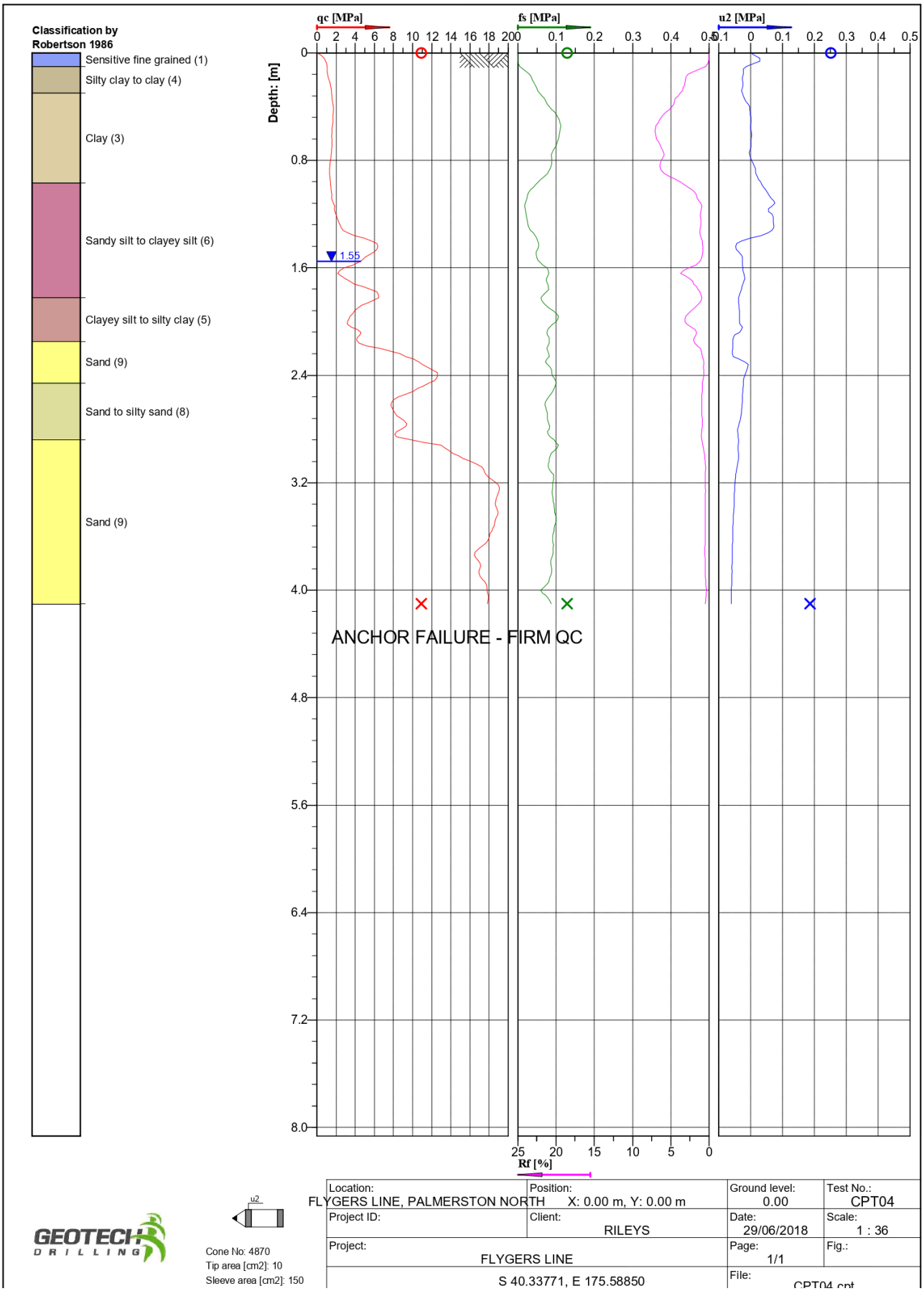
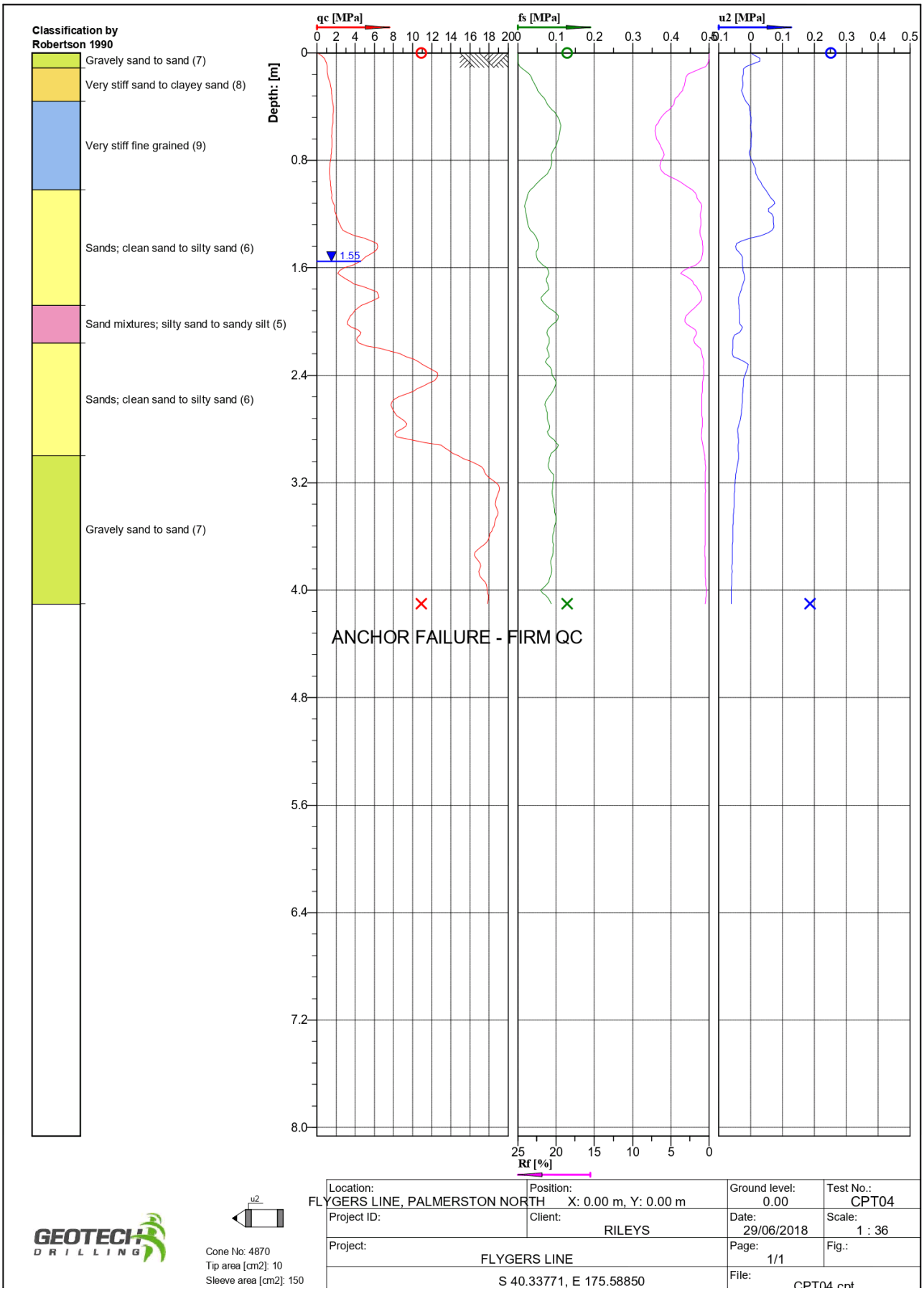
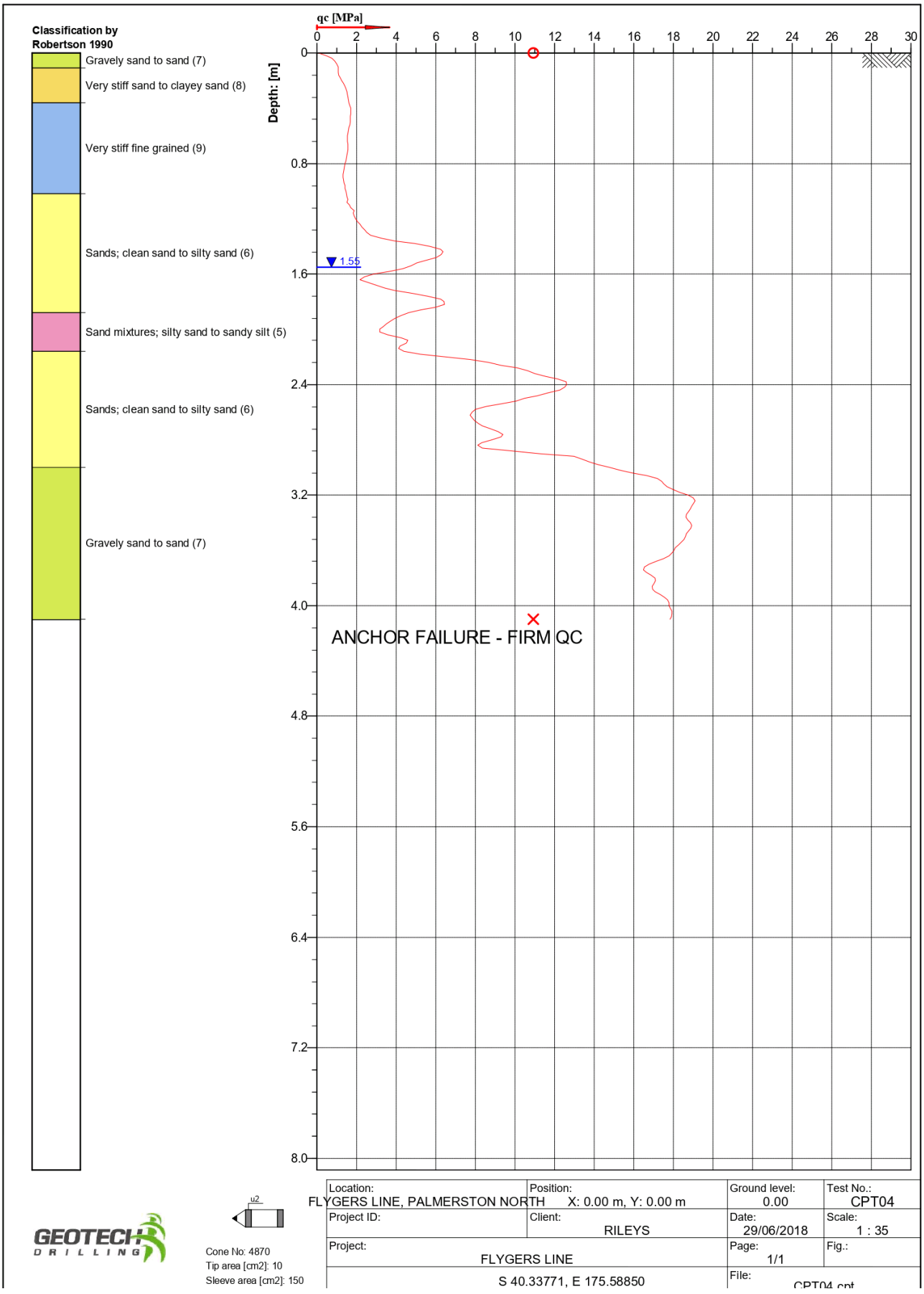
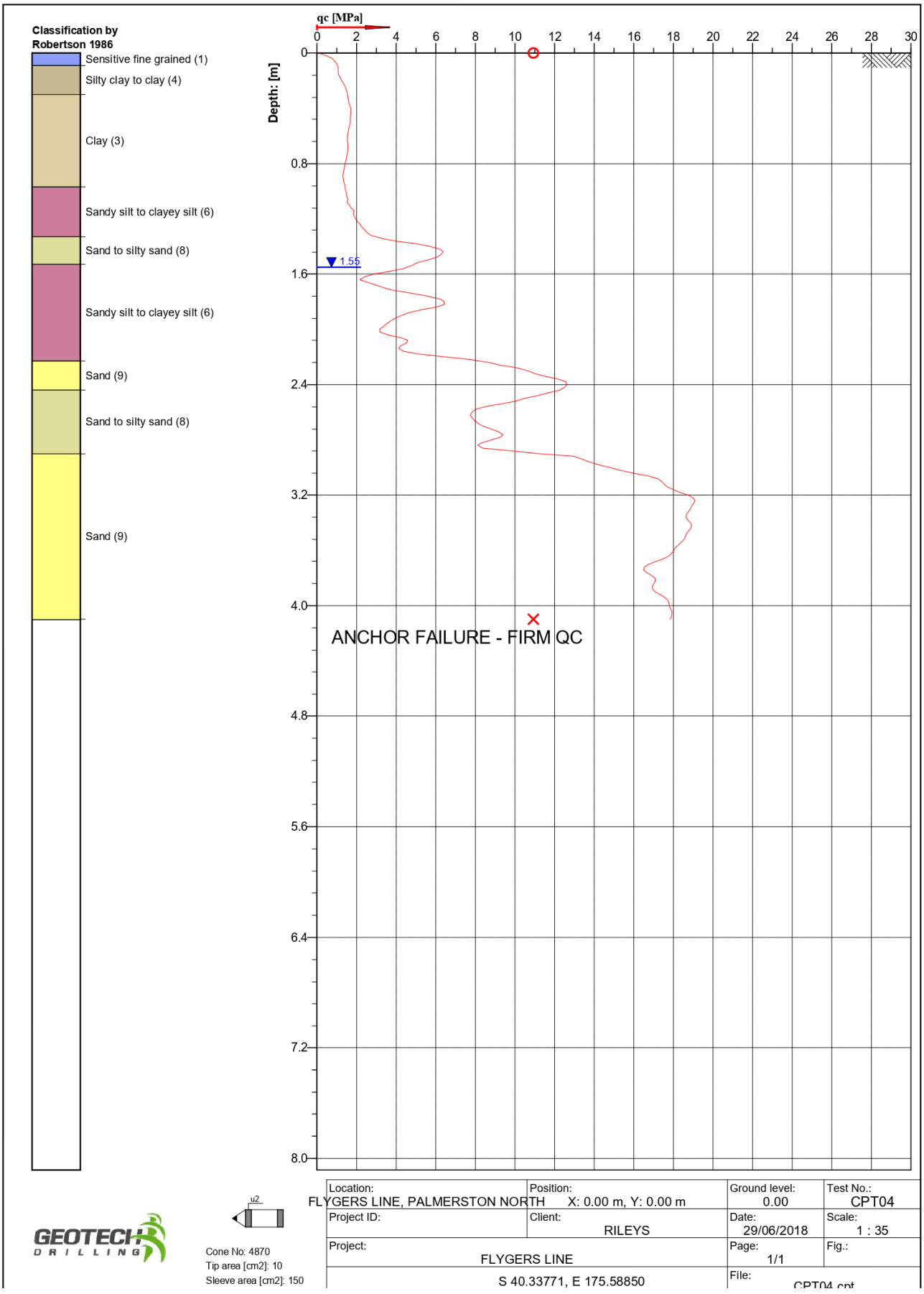
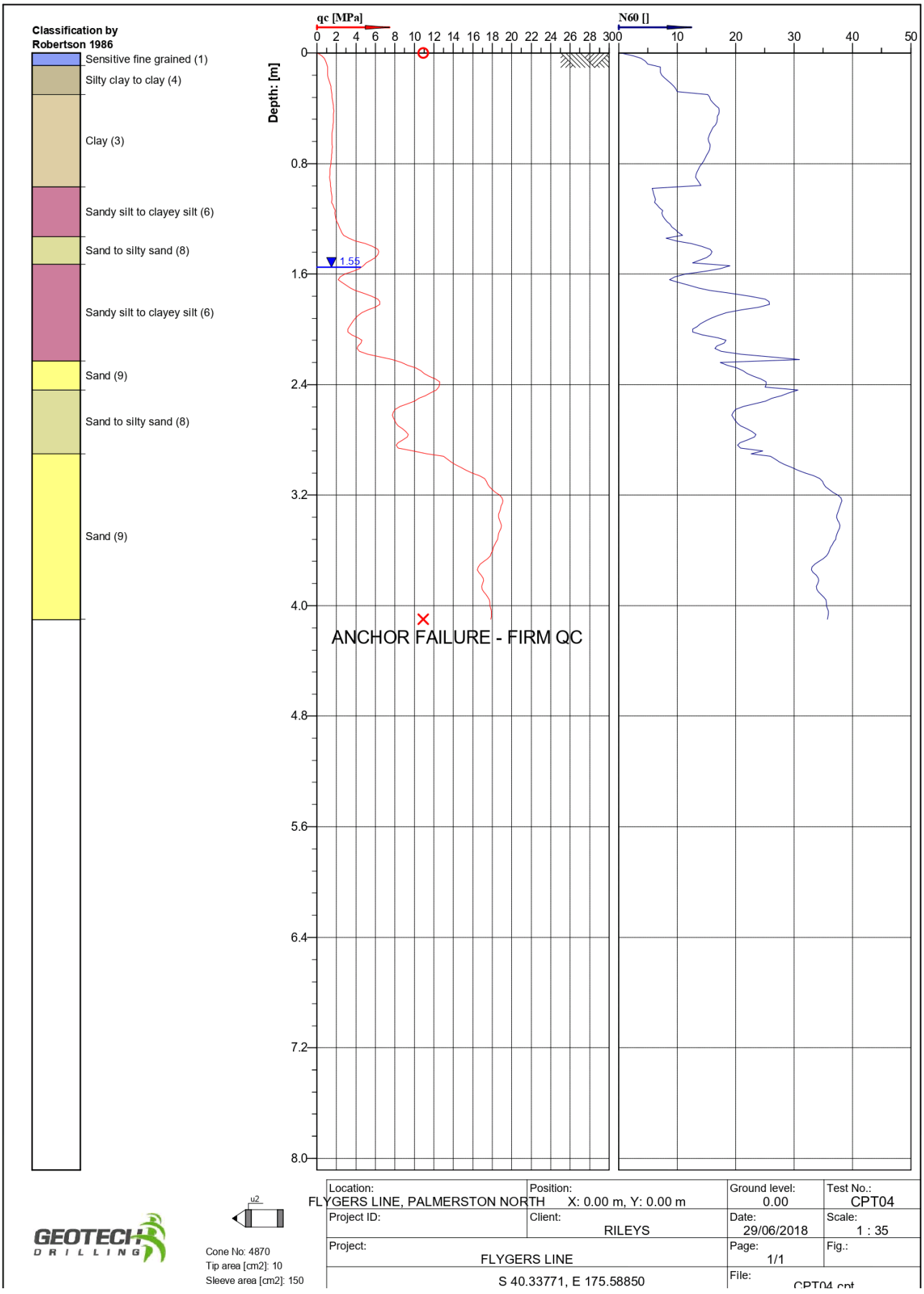
Clay (3)
Silty clay to clay (4)
Sensitive fine grained (1)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Sandy silt to clayey silt (6)
Sand to silty sand (8)
Sand (9)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
N60 []
0 10 20 30 40 50
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
1.90
REFUSAL FROM HIGH QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT03
Project ID:
Client:
Date: 28/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33981, E 175.58708
File: CPT03.cpt

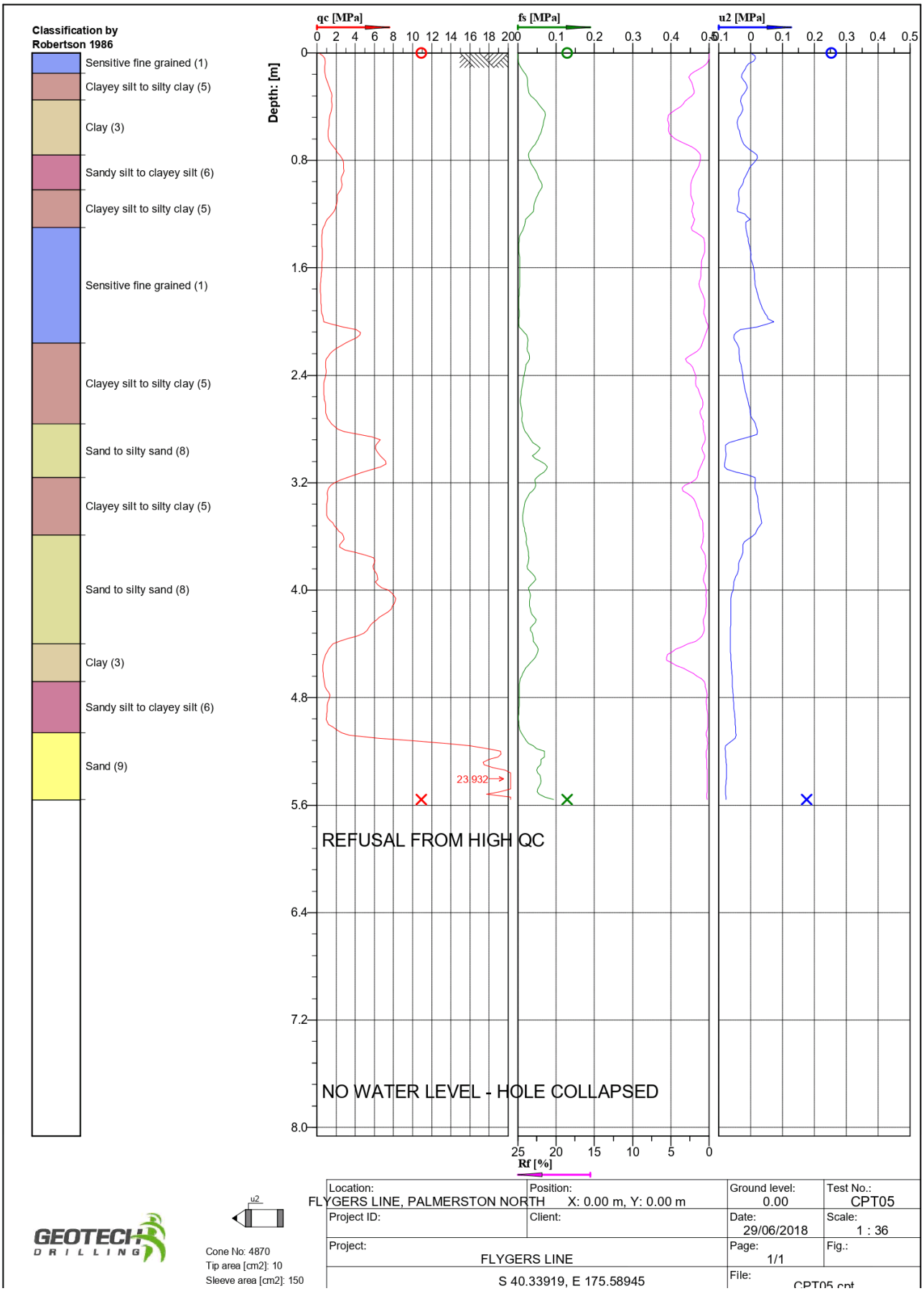

Classification by Robertson 1986
Sensitive fine grained (1)
Silty clay to clay (4)
Clay (3)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sand (9)
Sand to silty sand (8)
Sand (9)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
1.55
ANCHOR FAILURE - FIRM QC
Rf [%]
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT04
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33771, E 175.58850
File: CPT04.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

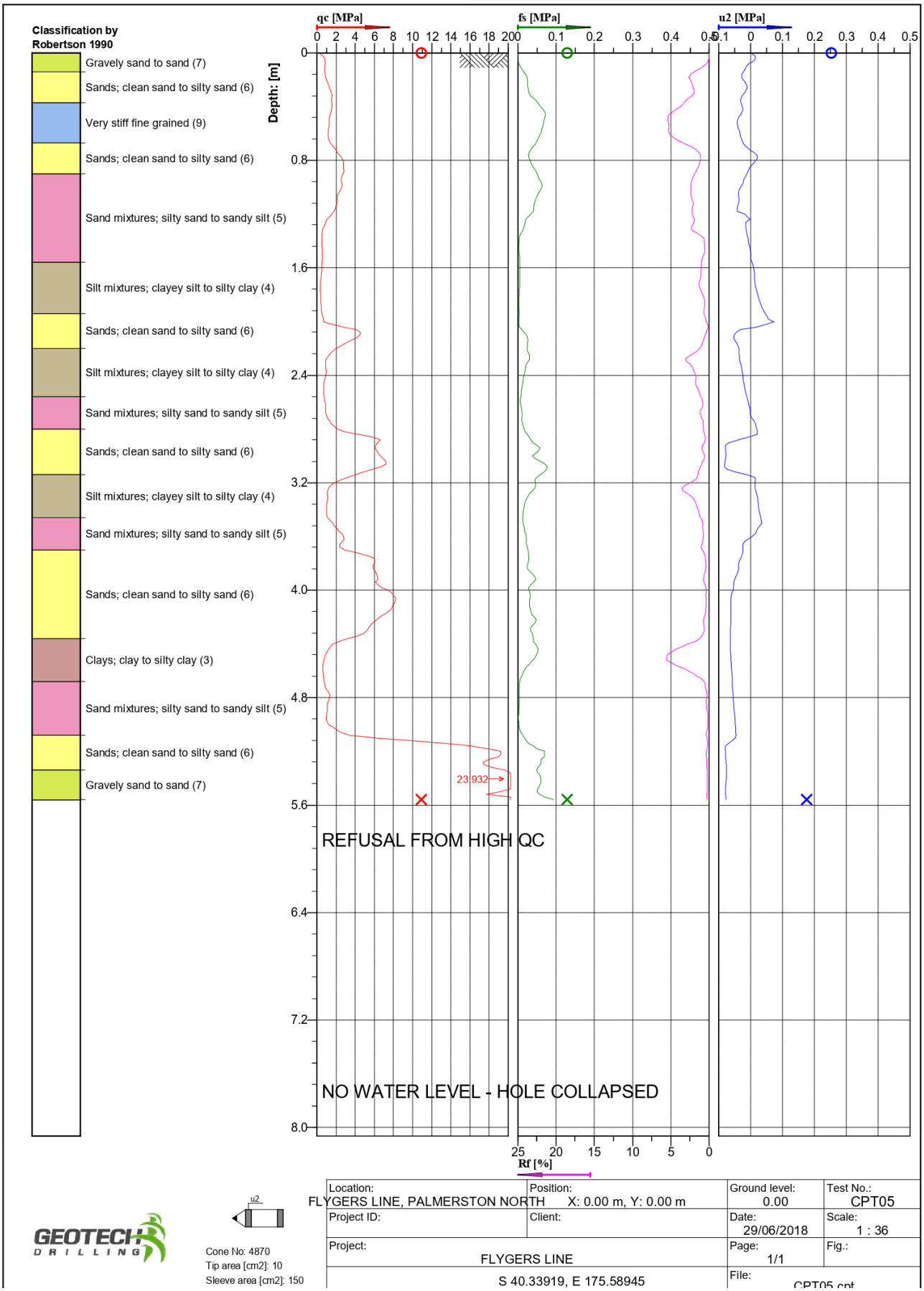

Classification by Robertson 1990
Gravely sand to sand (7)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Gravely sand to sand (7)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
1.55
ANCHOR FAILURE - FIRM QC
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT04
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33771, E 175.58850
File: CPT04.cpt

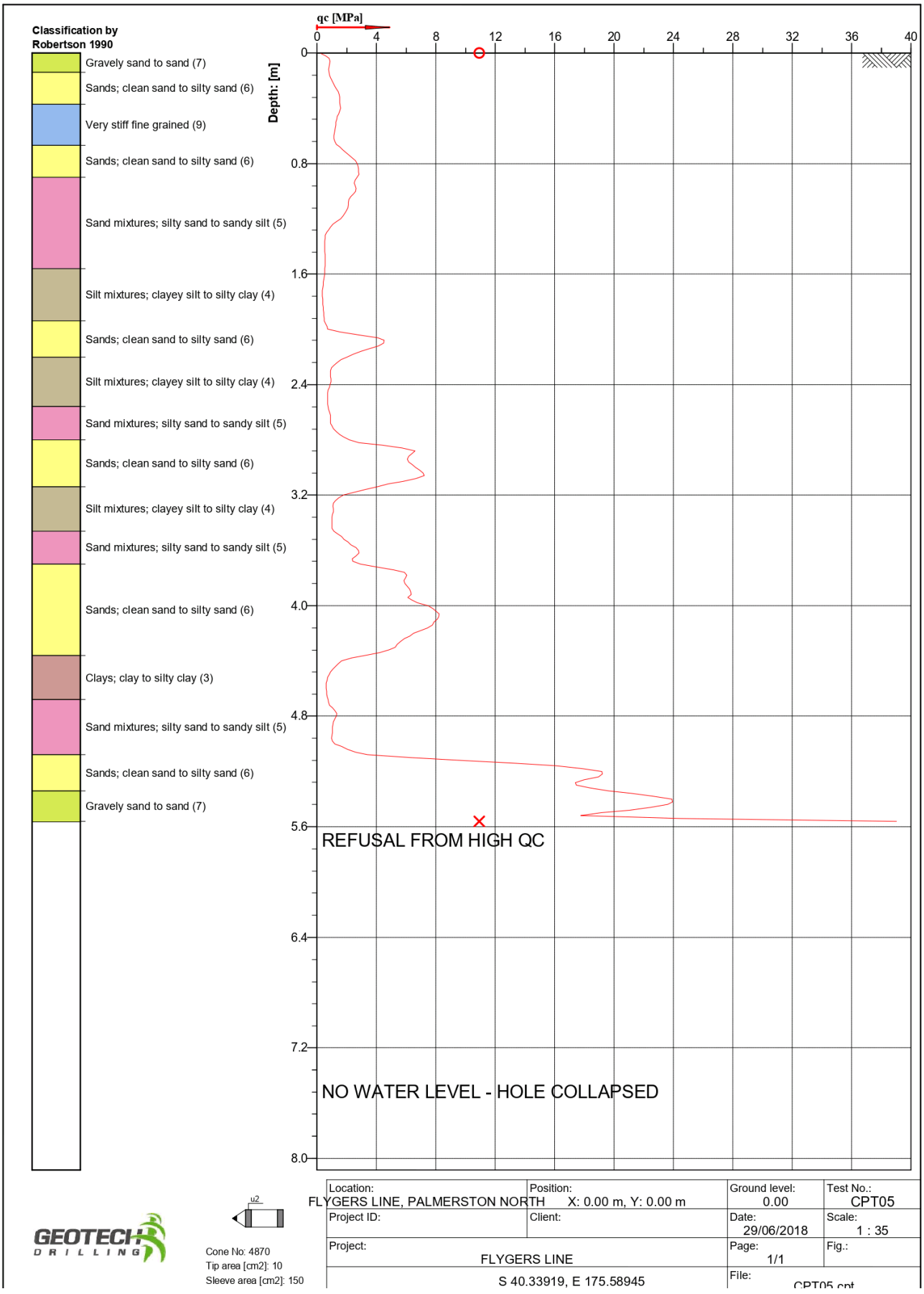

Classification by Robertson 1990
Gravely sand to sand (7)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Gravely sand to sand (7)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
1.55
ANCHOR FAILURE - FIRM QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT04
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33771, E 175.58850
File: CPT04.cpt

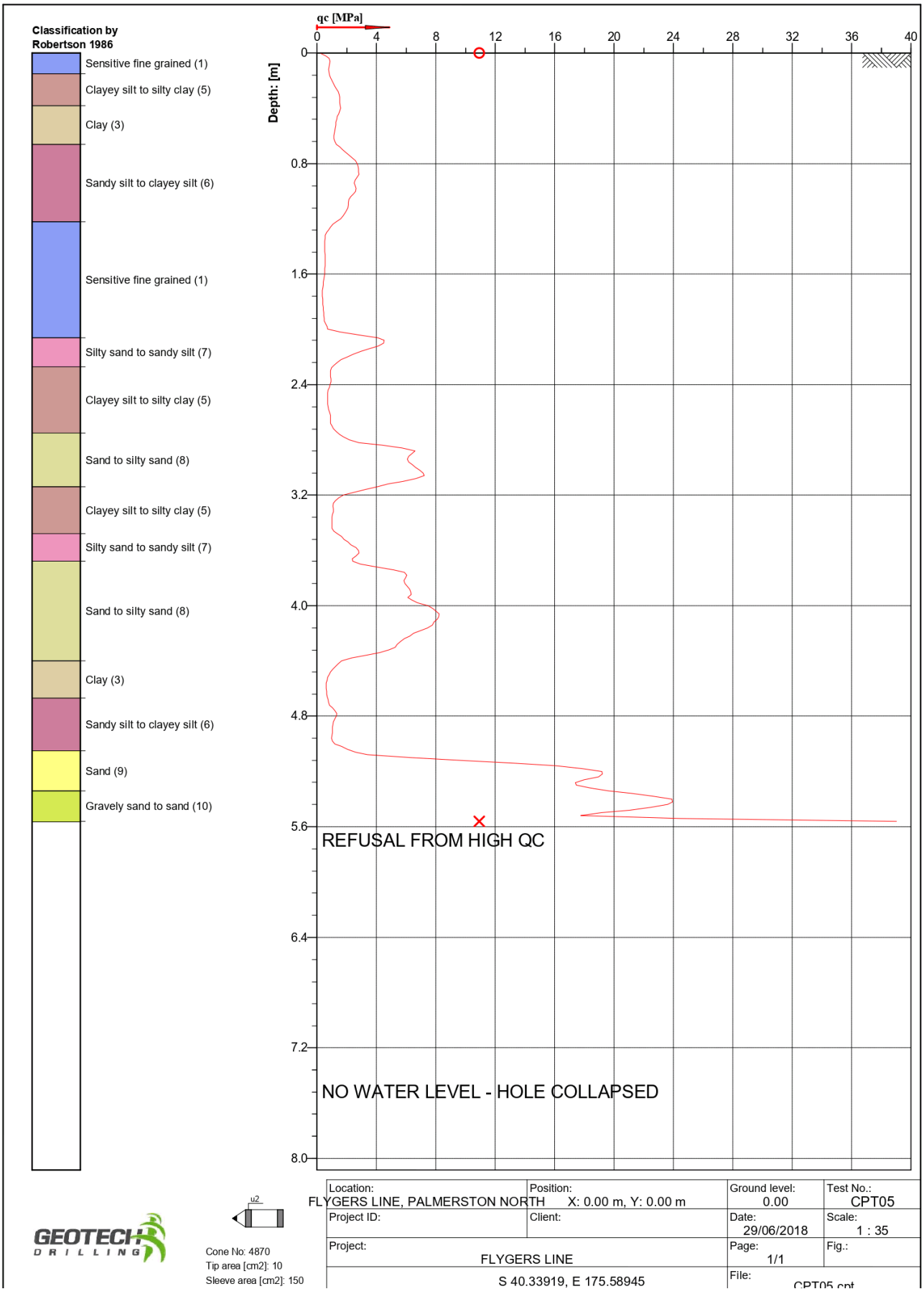

Classification by Robertson 1986
Sensitive fine grained (1)
Silty clay to clay (4)
Clay (3)
Sandy silt to clayey silt (6)
Sand to silty sand (8)
Sandy silt to clayey silt (6)
Sand (9)
Sand to silty sand (8)
Sand (9)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
1.55
ANCHOR FAILURE - FIRM QC
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT04
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33771, E 175.58850
File: CPT04.cpt

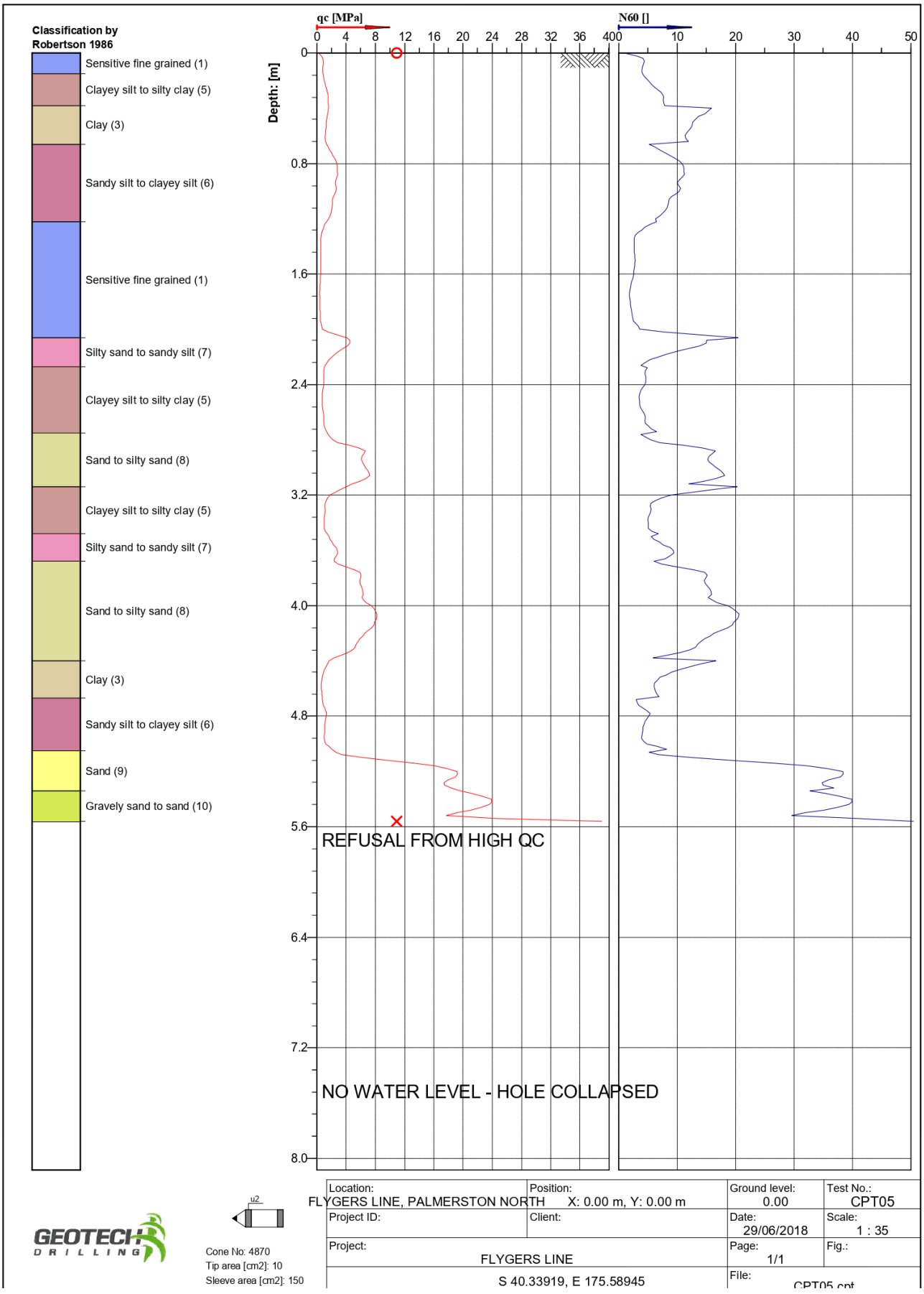

Classification by Robertson 1986
Sensitive fine grained (1)
Silty clay to clay (4)
Clay (3)
Sandy silt to clayey silt (6)
Sand to silty sand (8)
Sandy silt to clayey silt (6)
Sand (9)
Sand to silty sand (8)
Sand (9)
qc [MPa]
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 300
N60 []
10 20 30 40 50
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
1.55
ANCHOR FAILURE - FIRM QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT04
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33771, E 175.58850
File: CPT04.cpt

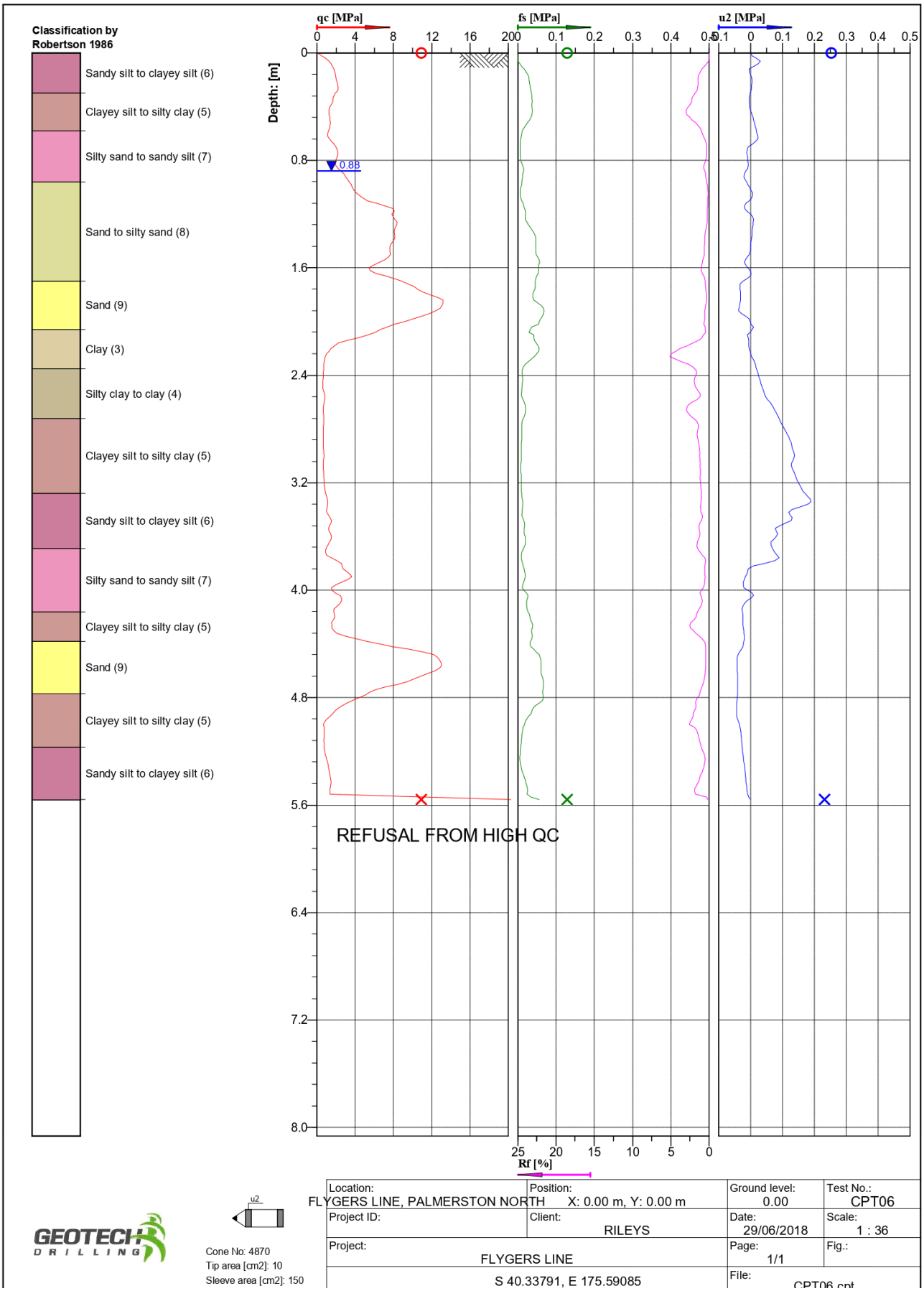

Classification by Robertson 1986
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Clay (3)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Sand to silty sand (8)
Clayey silt to silty clay (5)
Sand to silty sand (8)
Clay (3)
Sandy silt to clayey silt (6)
Sand (9)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
23.932
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
Rf [%]
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT05
Project ID:
Client:
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33919, E 175.58945
File: CPT05.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

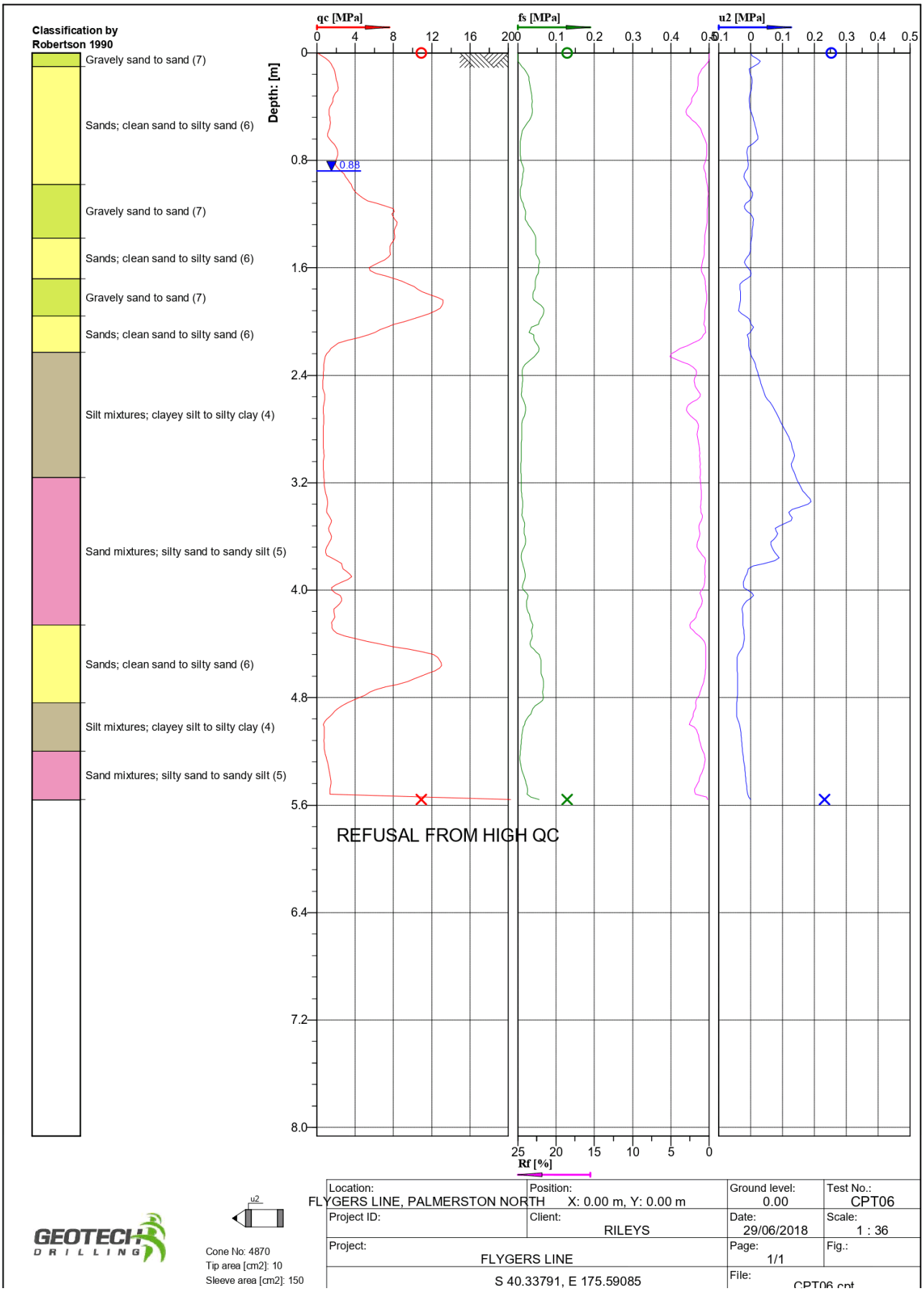

Classification by Robertson 1990
Gravely sand to sand (7)
Sands; clean sand to silty sand (6)
Very stiff fine grained (9)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Clays; clay to silty clay (3)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Gravely sand to sand (7)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
23.932
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
Rf [%]
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT05
Project ID:
Client:
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33919, E 175.58945
File: CPT05.cpt
GEOTECH DRILLING
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

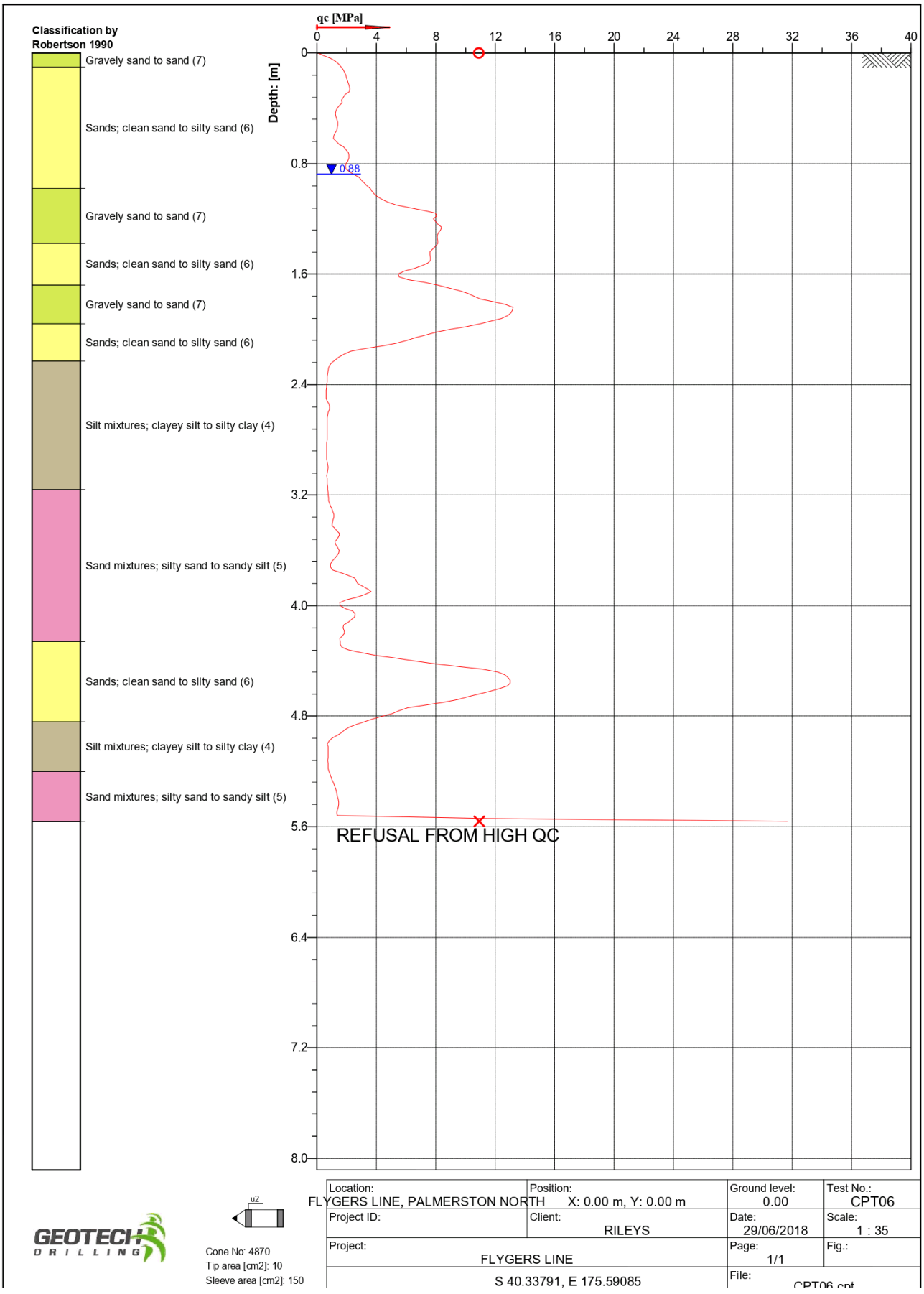

Classification by Robertson 1990
Gravely sand to sand (7)
Sands; clean sand to silty sand (6)
Very stiff fine grained (9)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Clays; clay to silty clay (3)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Gravely sand to sand (7)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT05
Project ID:
Client:
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33919, E 175.58945
File: CPT05.cpt
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

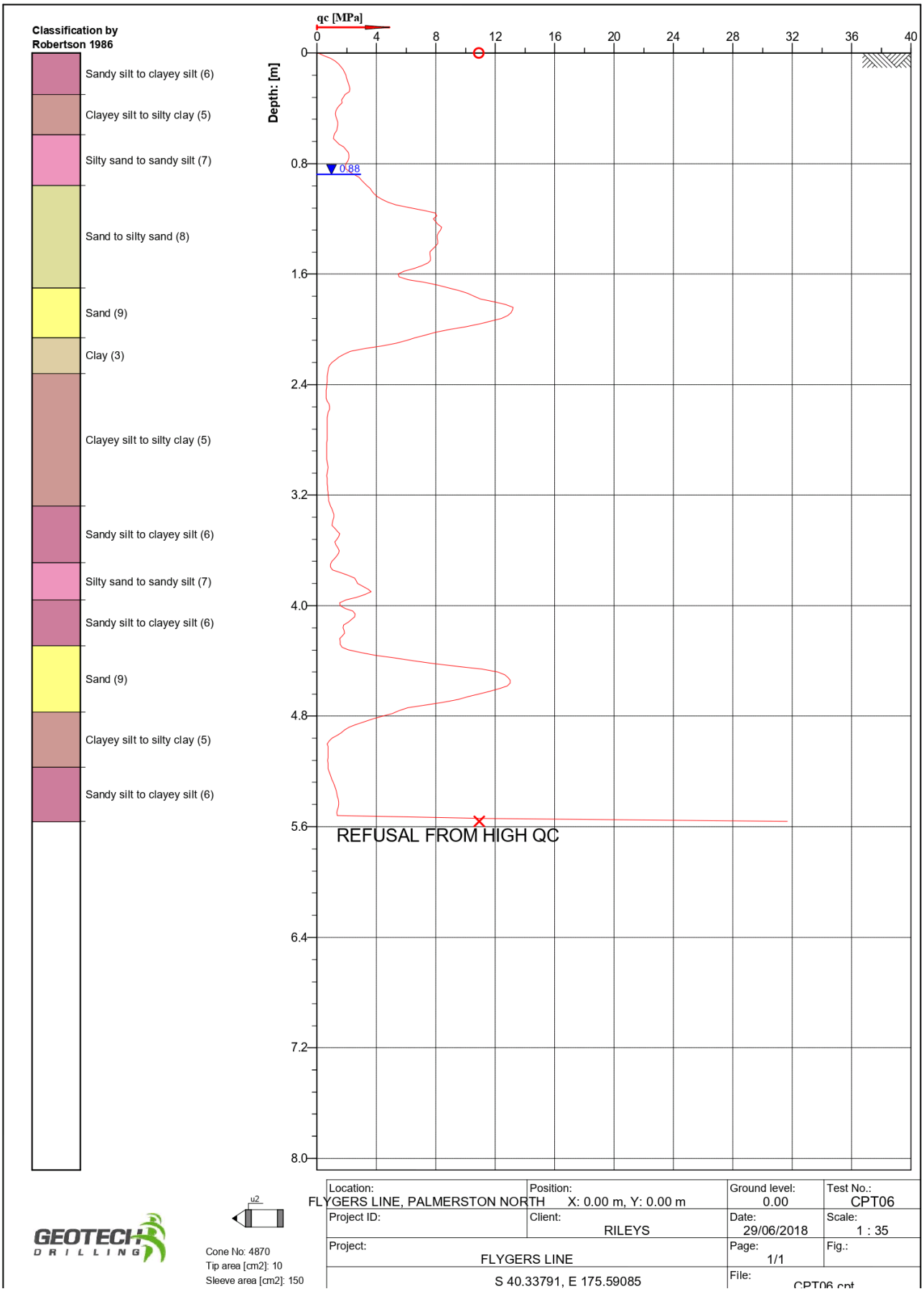

Classification by Robertson 1986
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Clay (3)
Sandy silt to clayey silt (6)
Sensitive fine grained (1)
Silty sand to sandy silt (7)
Clayey silt to silty clay (5)
Sand to silty sand (8)
Clayey silt to silty clay (5)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Clay (3)
Sandy silt to clayey silt (6)
Sand (9)
Gravely sand to sand (10)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT05
Project ID:
Client:
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33919, E 175.58945
File: CPT05.cpt

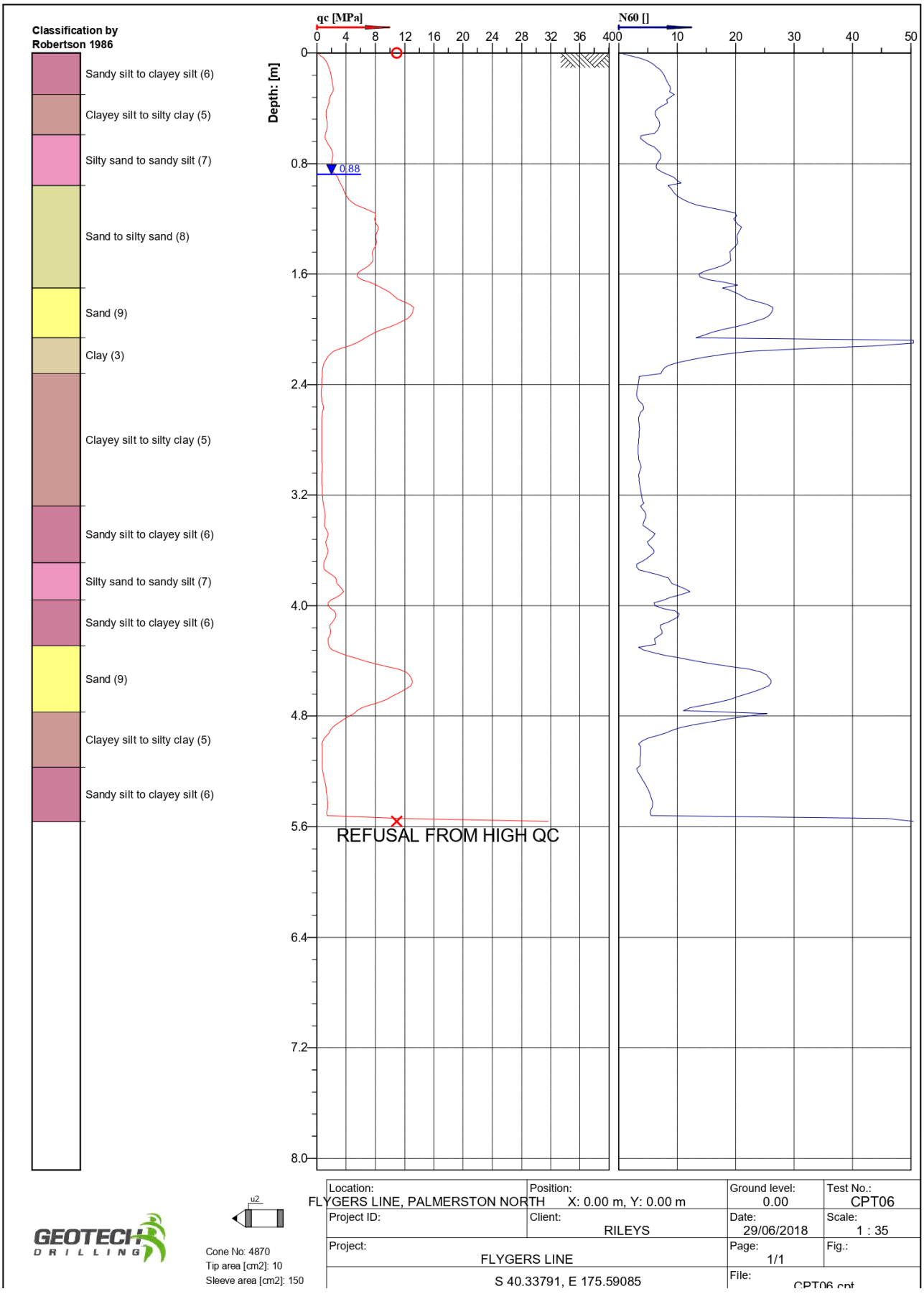

Classification by Robertson 1986
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Clay (3)
Sandy silt to clayey silt (6)
Sensitive fine grained (1)
Silty sand to sandy silt (7)
Clayey silt to silty clay (5)
Sand to silty sand (8)
Clayey silt to silty clay (5)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Clay (3)
Sandy silt to clayey silt (6)
Sand (9)
Gravely sand to sand (10)
qc [MPa]
0 4 8 12 16 20 24 28 32 36 400
N60 []
10 20 30 40 50
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT05
Project ID:
Client:
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33919, E 175.58945
File: CPT05.cpt

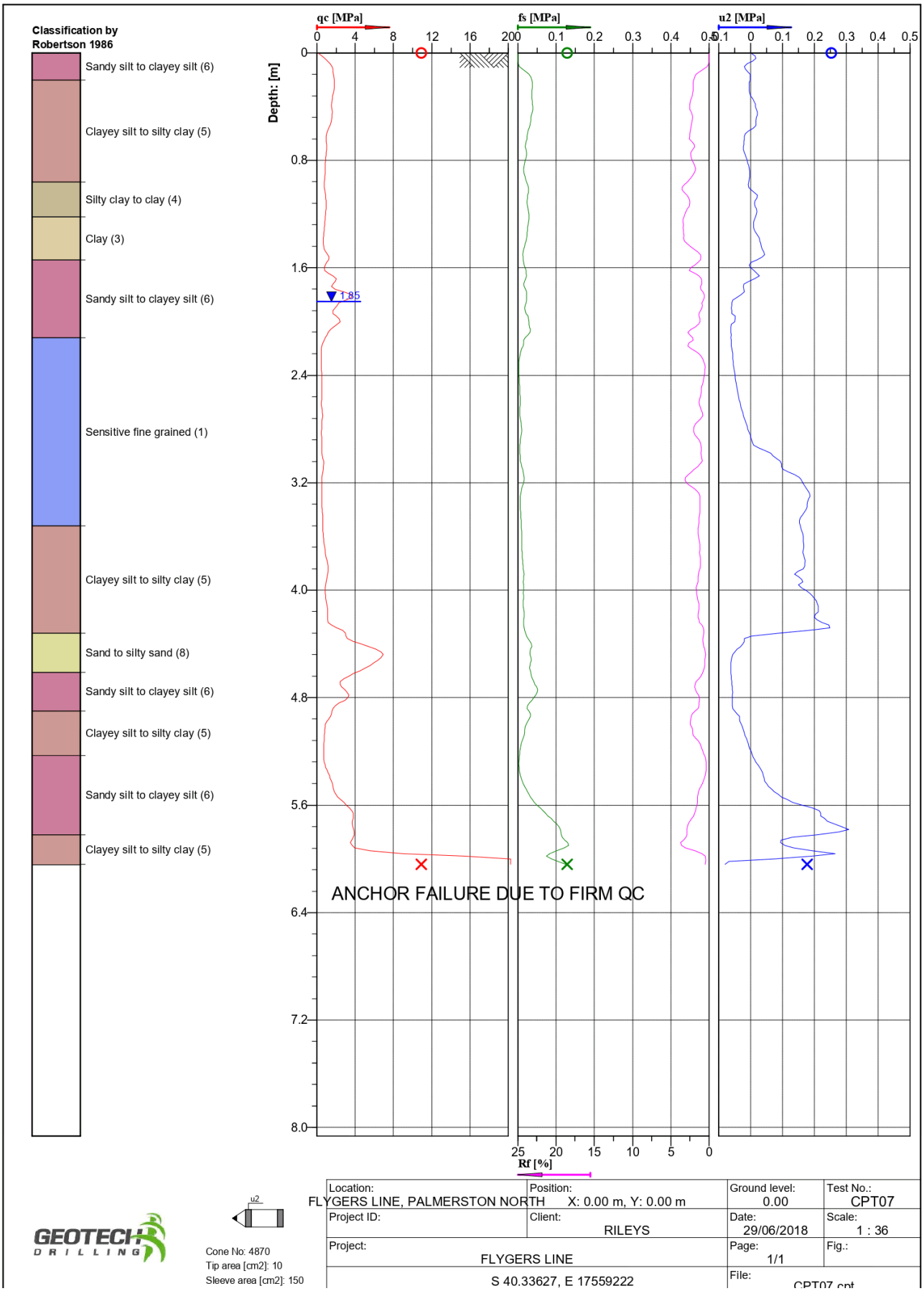

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Sand (9)
Clay (3)
Silty clay to clay (4)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Clayey silt to silty clay (5)
Sand (9)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
0.88
REFUSAL FROM HIGH QC
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT06
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33791, E 175.59085
File: CPT06.cpt

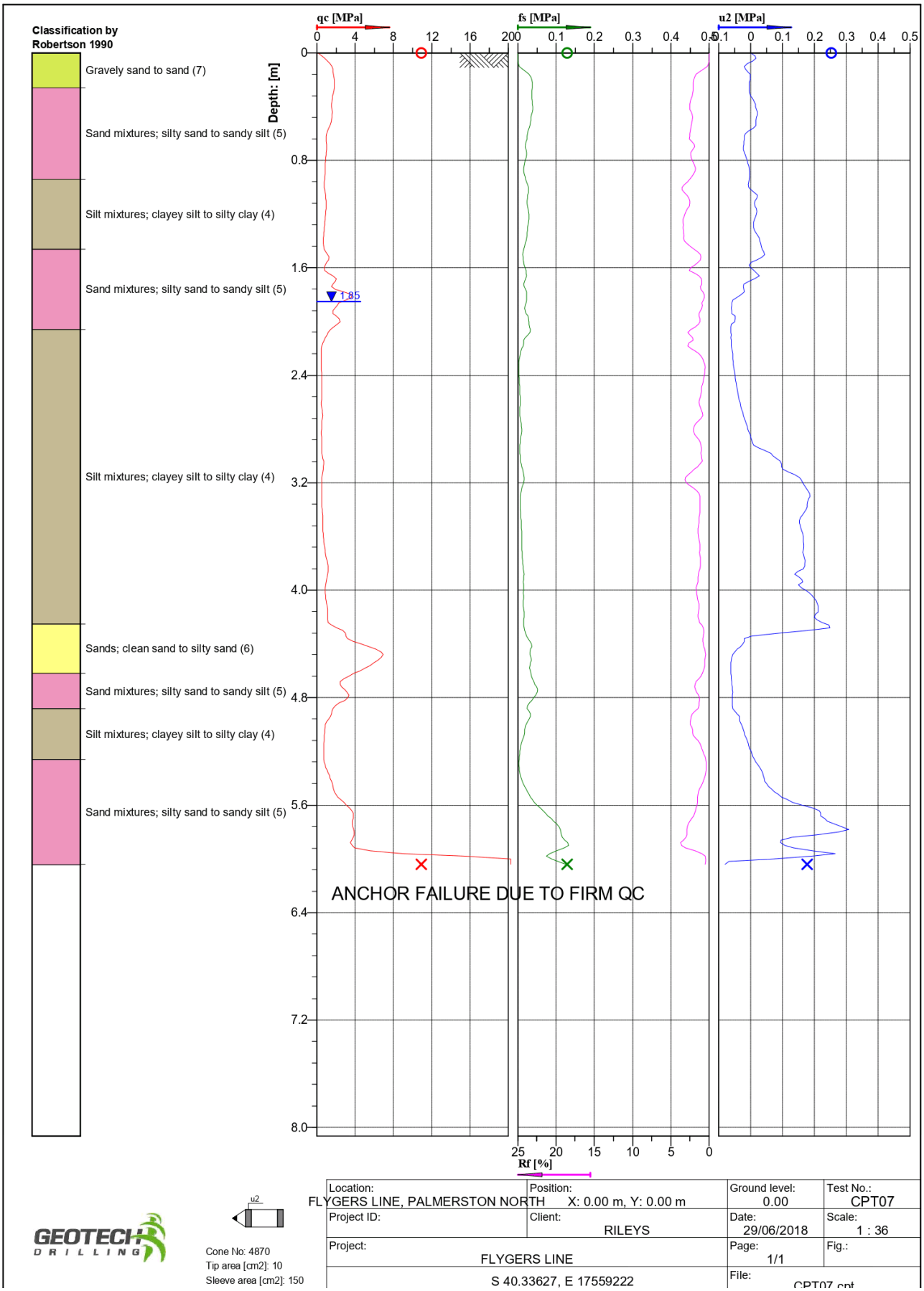

Classification by Robertson 1990
Gravely sand to sand (7)
Sands; clean sand to silty sand (6)
Gravely sand to sand (7)
Sands; clean sand to silty sand (6)
Gravely sand to sand (7)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
0.88
REFUSAL FROM HIGH QC
Rf [%]
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT06
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33791, E 175.59085
File: CPT06.cpt

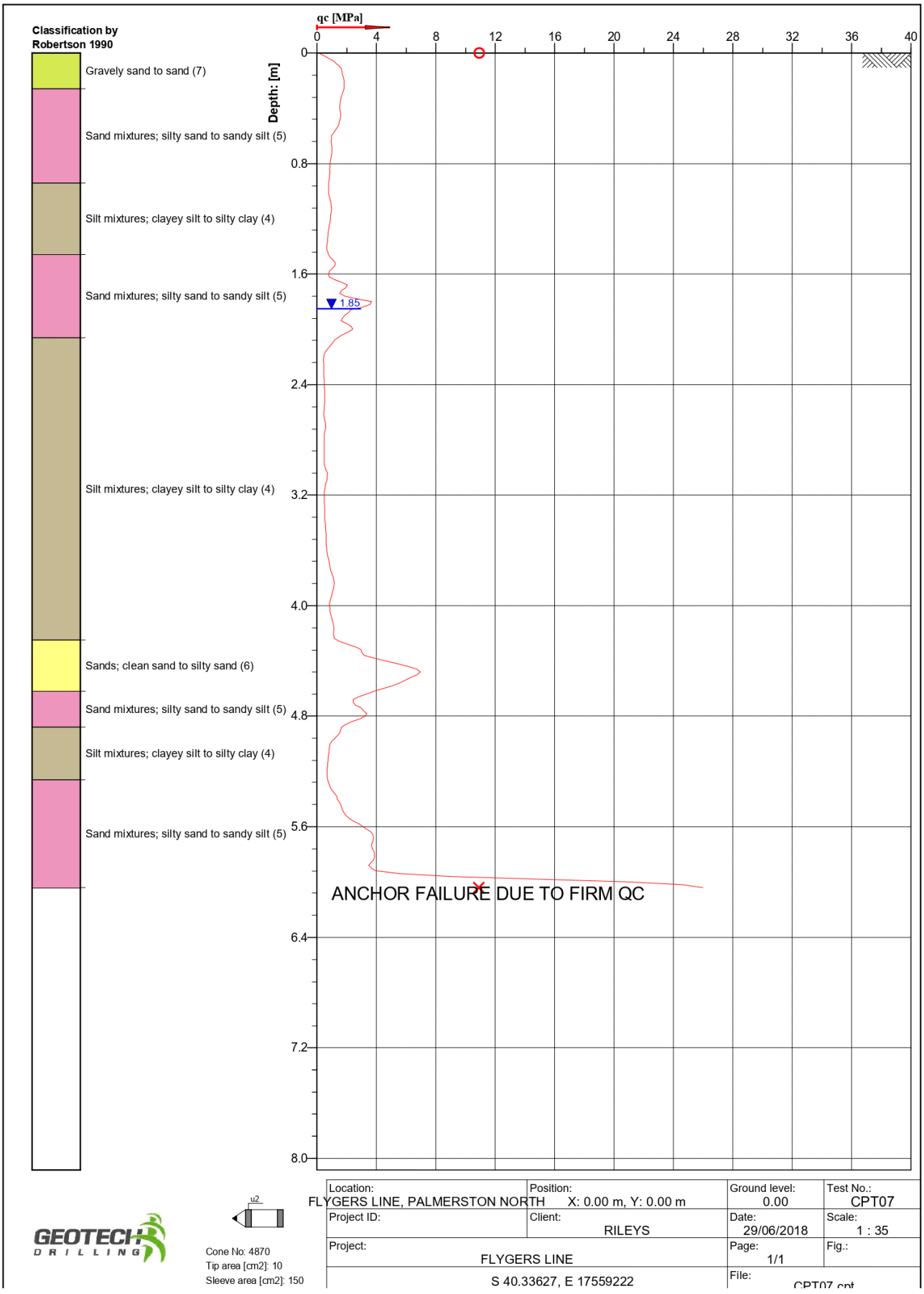

Classification by Robertson 1990
Gravely sand to sand (7)
Sands; clean sand to silty sand (6)
Gravely sand to sand (7)
Sands; clean sand to silty sand (6)
Gravely sand to sand (7)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
0.88
REFUSAL FROM HIGH QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT06
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33791, E 175.59085
File: CPT06.cpt

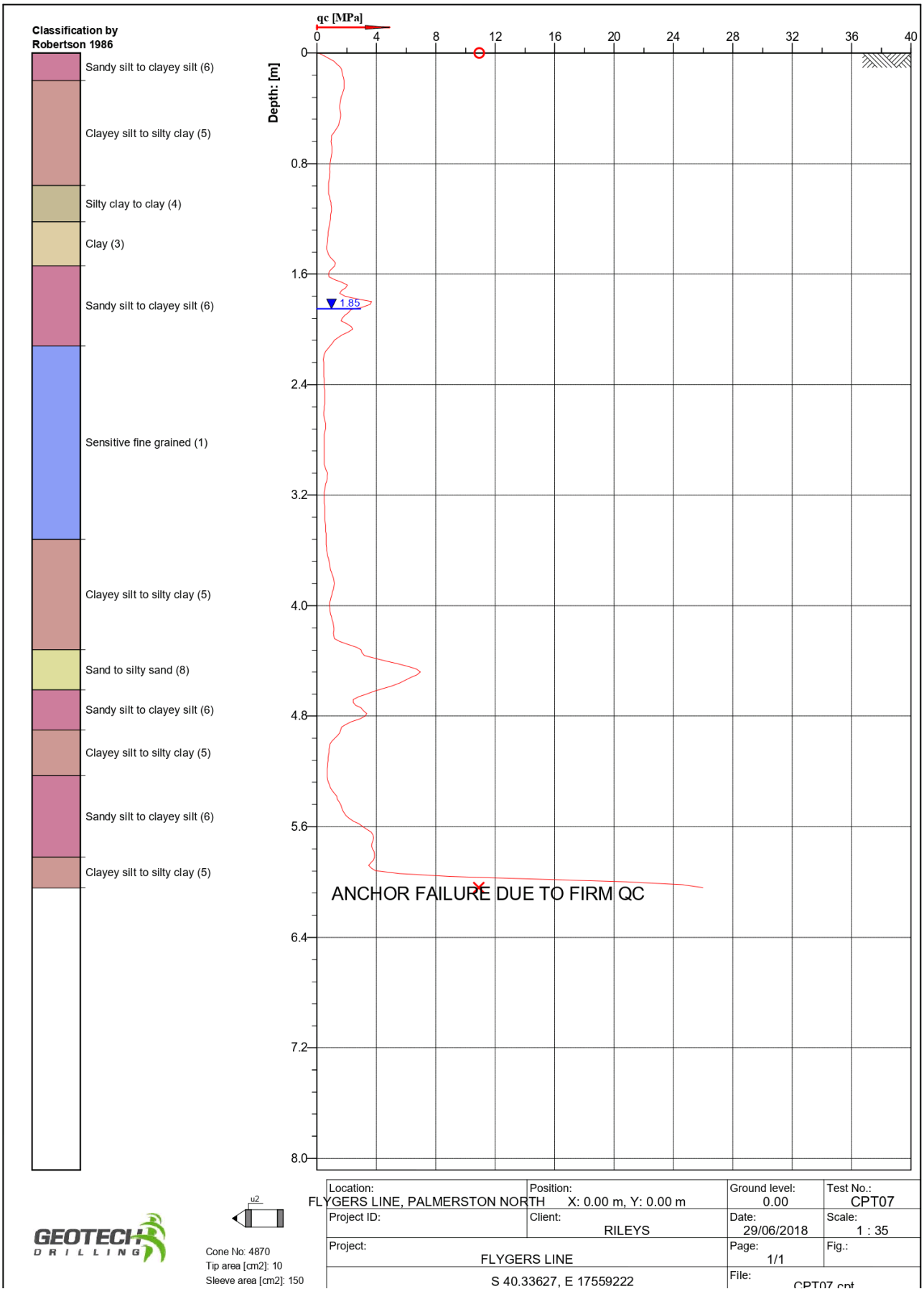

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Sand (9)
Clay (3)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Sandy silt to clayey silt (6)
Sand (9)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
0.88
REFUSAL FROM HIGH QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT06
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33791, E 175.59085
File: CPT06.cpt

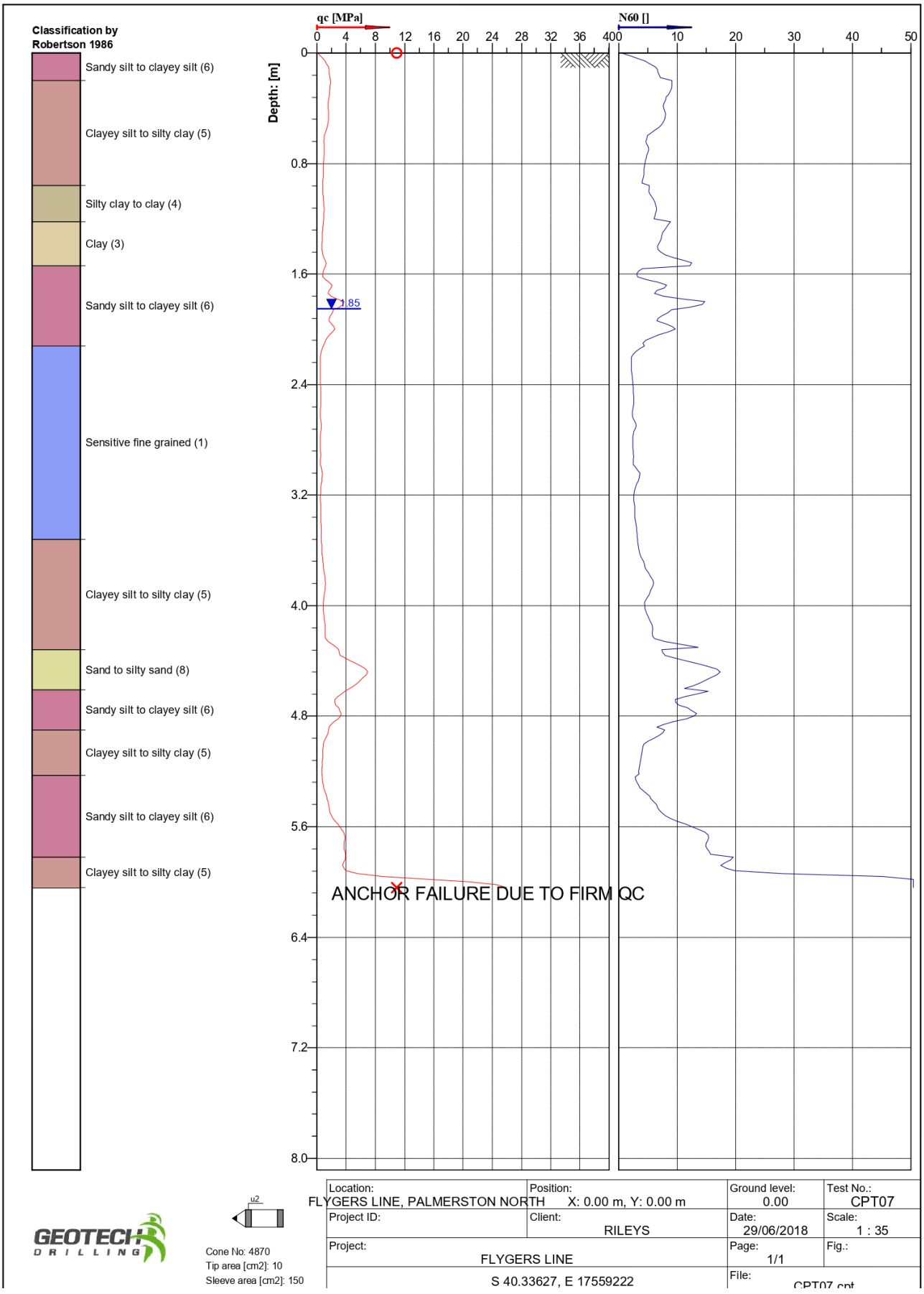

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Sand (9)
Clay (3)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Sandy silt to clayey silt (6)
Sand (9)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
0 4 8 12 16 20 24 28 32 36 40
N60 []
10 20 30 40 50
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
0.88
REFUSAL FROM HIGH QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
GEOTECH DRILLING
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT06
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33791, E 175.59085
File: CPT06.cpt

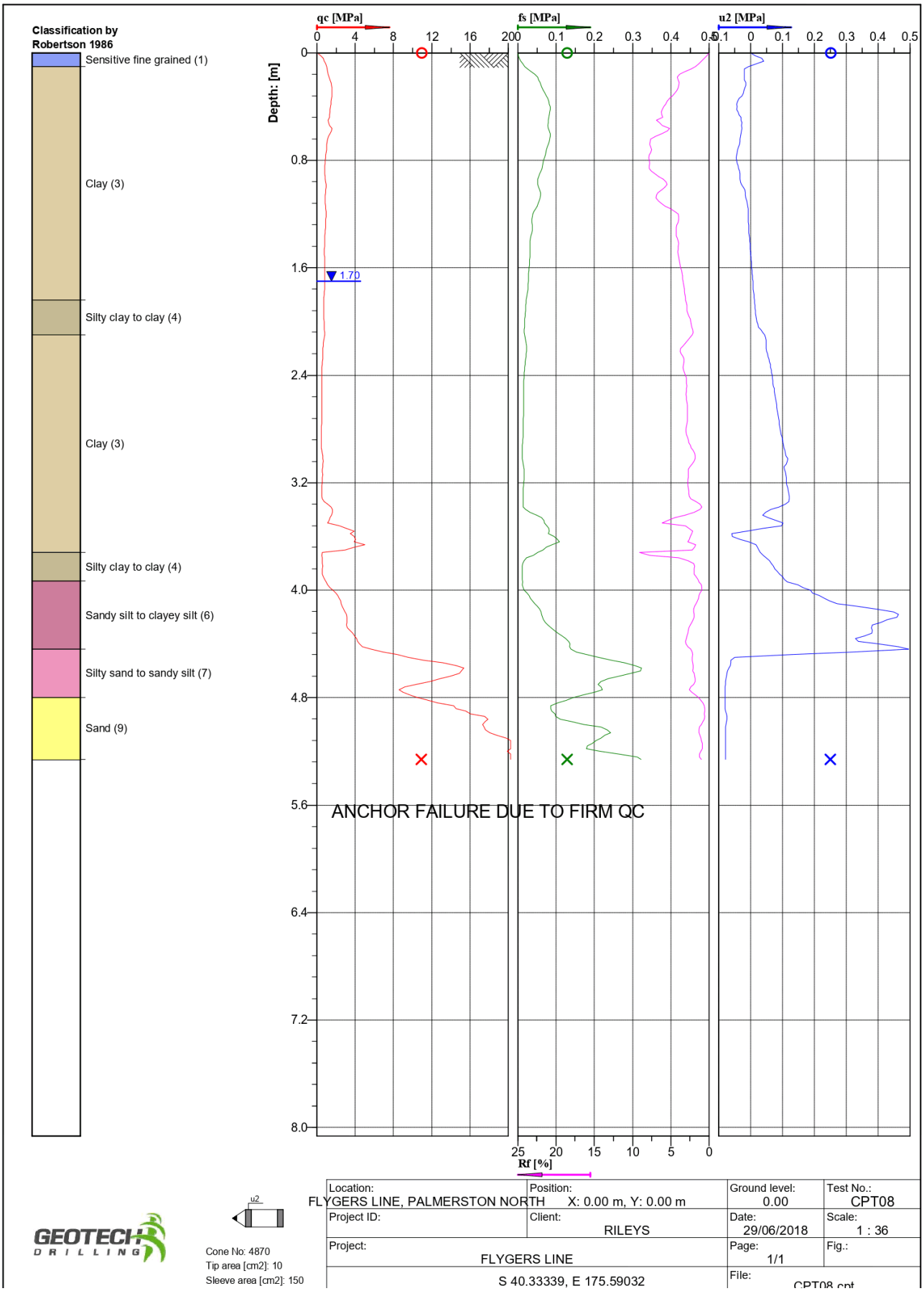

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Silty clay to clay (4)
Clay (3)
Sandy silt to clayey silt (6)
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Sand to silty sand (8)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
1.85
ANCHOR FAILURE DUE TO FIRM QC
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
GEOTECH DRILLING
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT07
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33627, E 17559222
File: CPT07.cpt

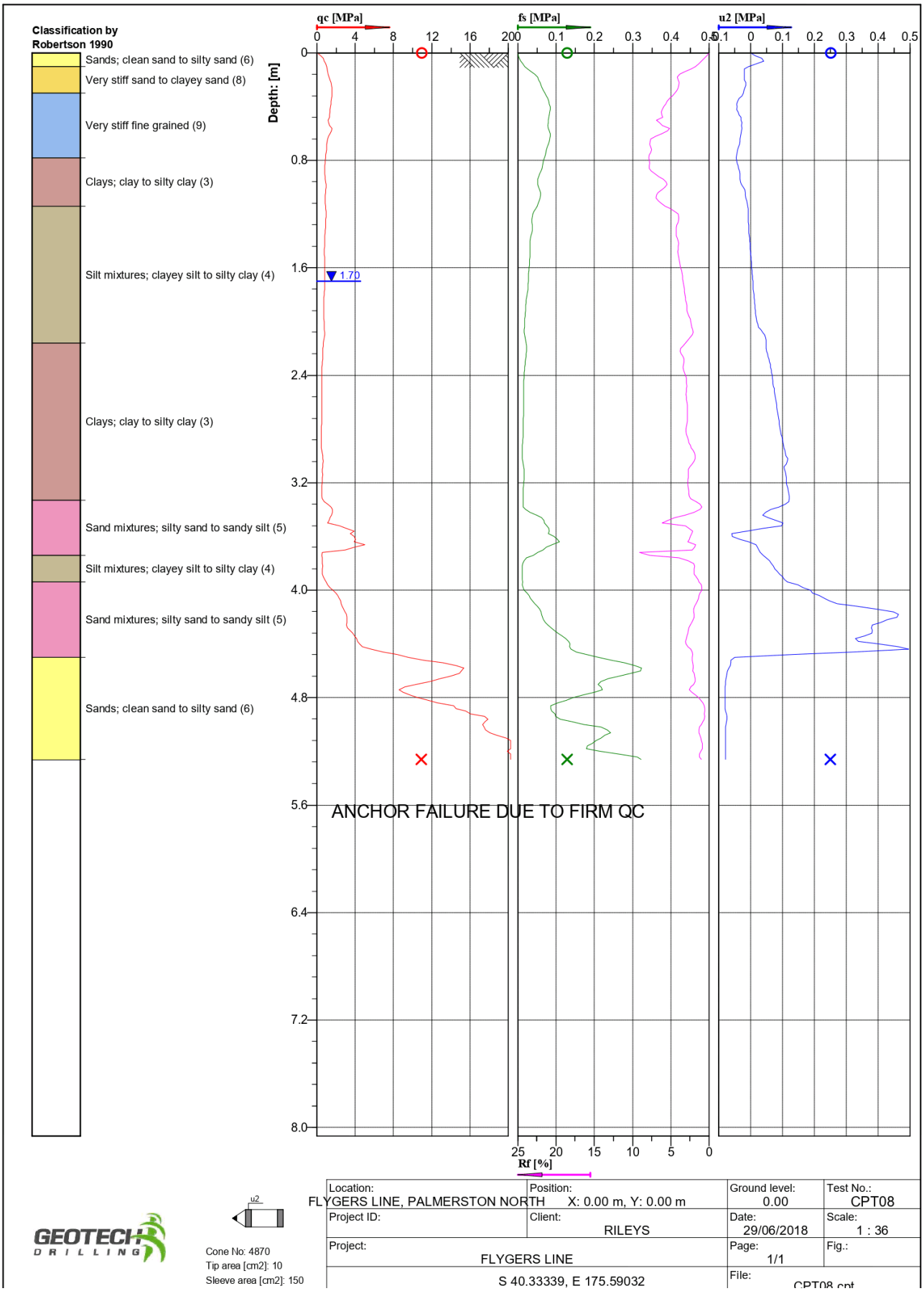

Classification by Robertson 1990
Gravely sand to sand (7)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Depth: [m]
qc [MPa]
fs [MPa]
u2 [MPa]
Rf [%]
1.85
ANCHOR FAILURE DUE TO FIRM QC
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT07
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33627, E 17559222
File: CPT07.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

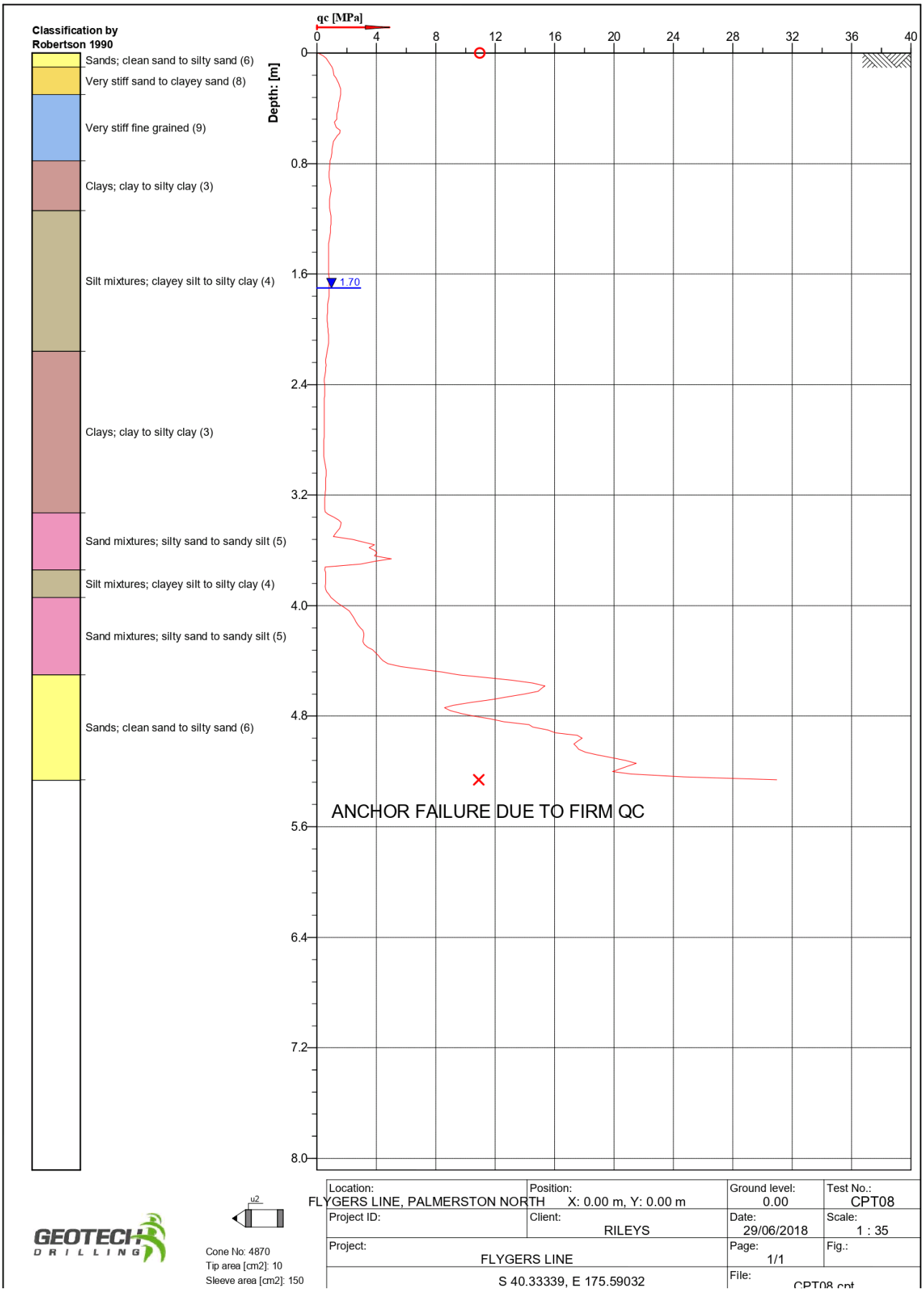

Classification by Robertson 1990
Gravely sand to sand (7)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
1.85
ANCHOR FAILURE DUE TO FIRM QC
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT07
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33627, E 17559222
File: CPT07.cpt

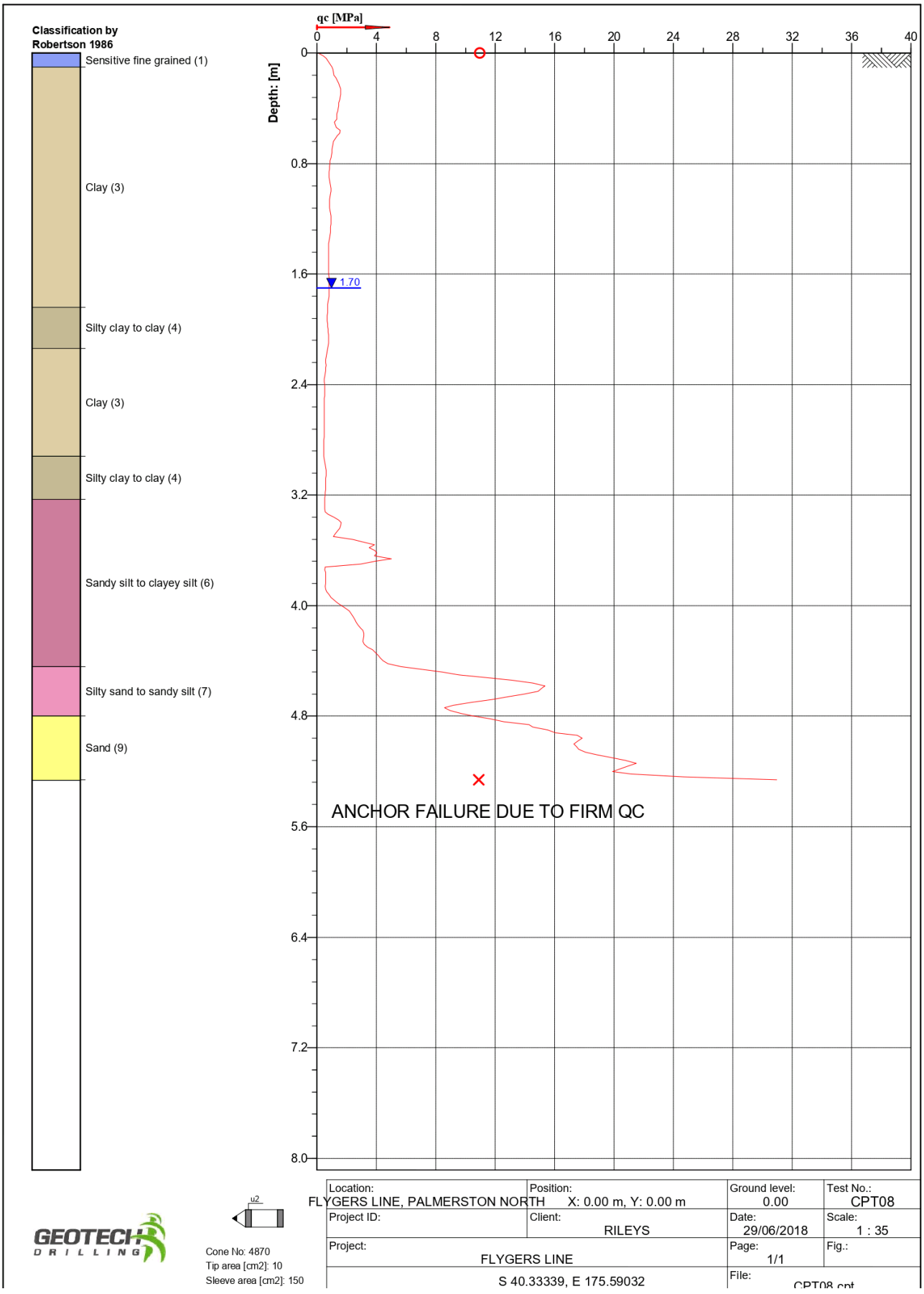

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Silty clay to clay (4)
Clay (3)
Sandy silt to clayey silt (6)
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Sand to silty sand (8)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
1.85
ANCHOR FAILURE DUE TO FIRM QC
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT07
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33627, E 17559222
File: CPT07.cpt

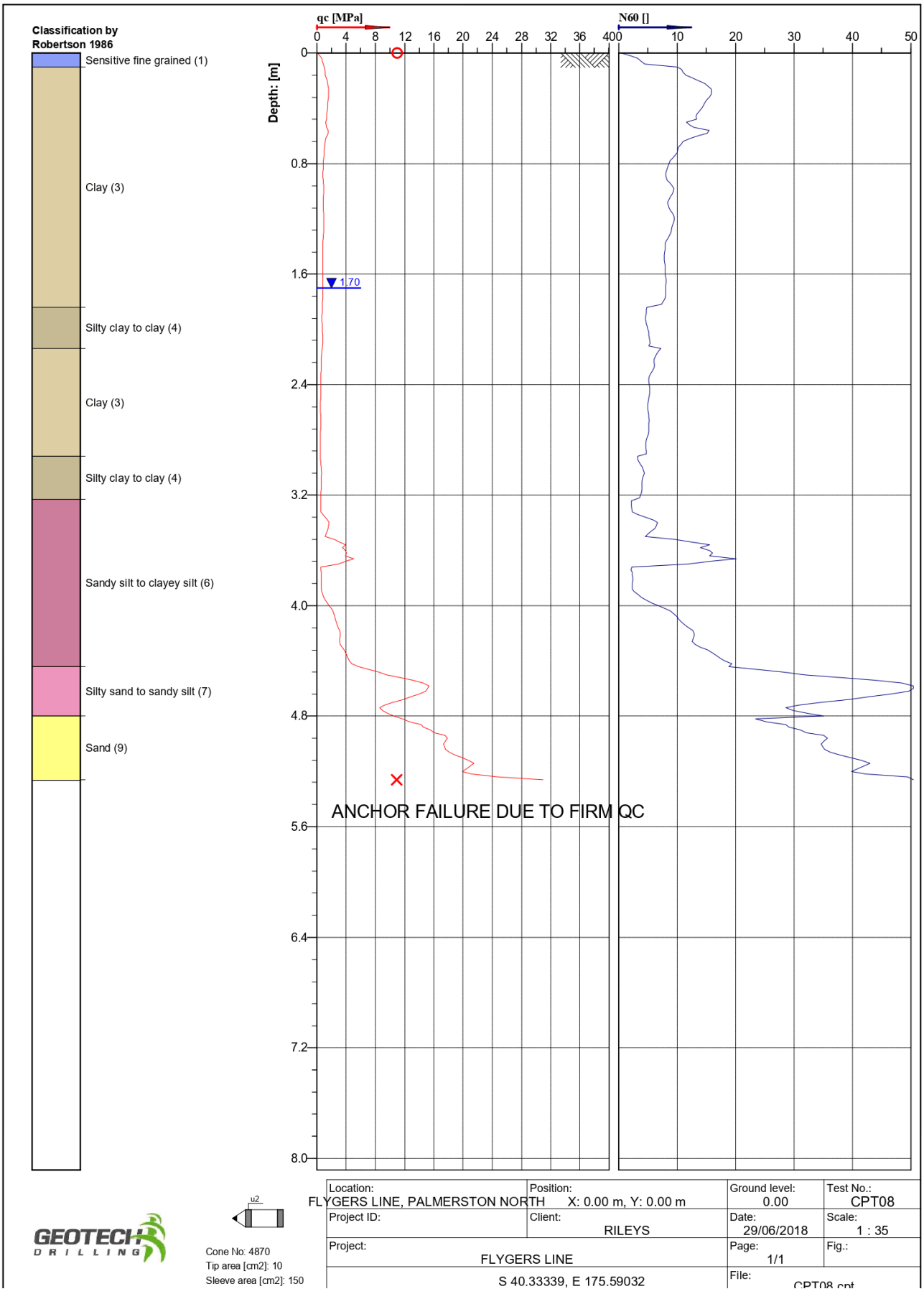

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Silty clay to clay (4)
Clay (3)
Sandy silt to clayey silt (6)
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Sand to silty sand (8)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
qc [MPa]
0 4 8 12 16 20 24 28 32 36 400
N60 []
10 20 30 40 50
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
1.85
ANCHOR FAILURE DUE TO FIRM QC
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT07
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33627, E 17559222
File: CPT07.cpt

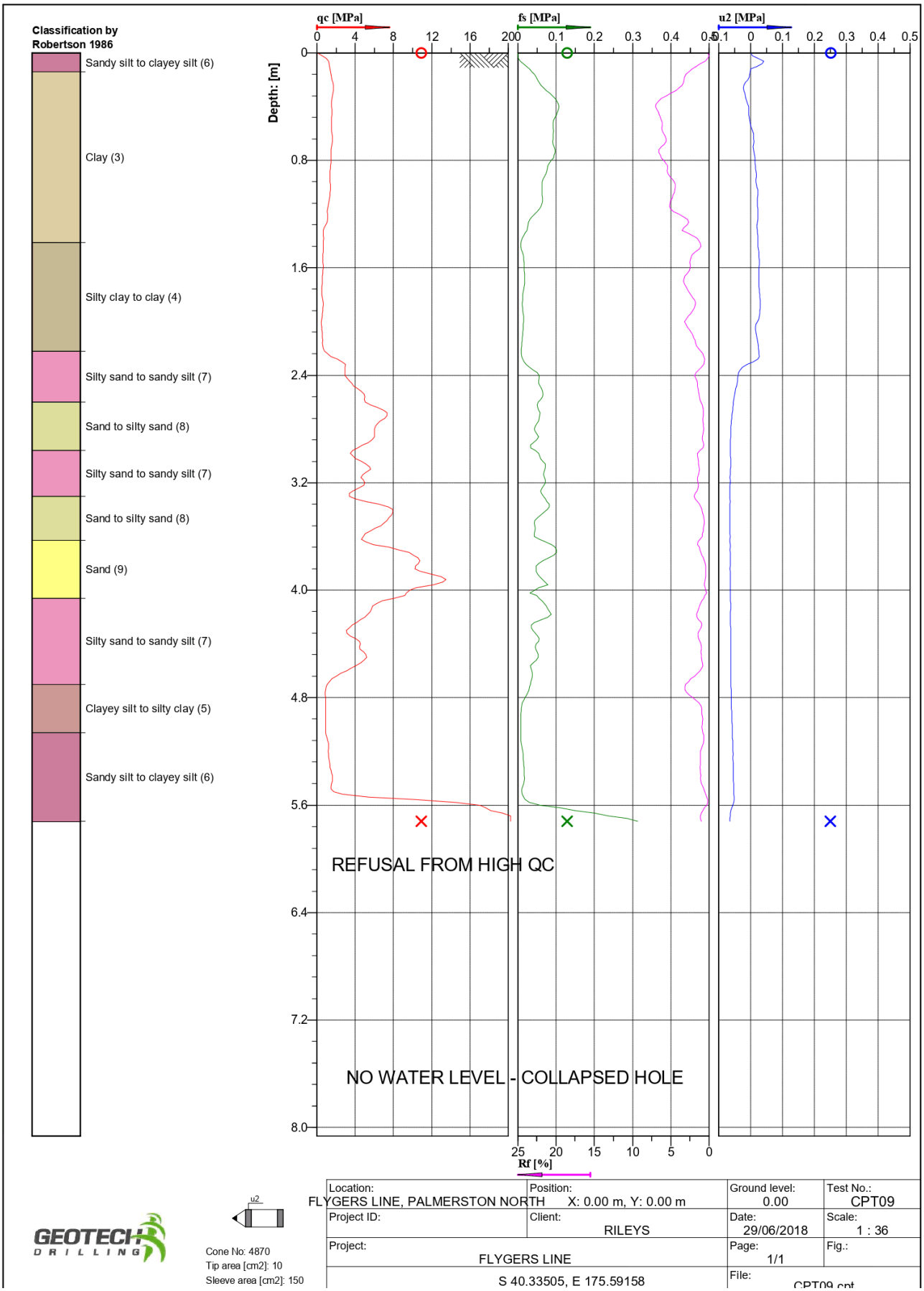

Classification by Robertson 1986
Sensitive fine grained (1)
Clay (3)
Silty clay to clay (4)
Clay (3)
Silty clay to clay (4)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Sand (9)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
1.70
ANCHOR FAILURE DUE TO FIRM QC
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT08
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33339, E 175.59032
File: CPT08.cpt

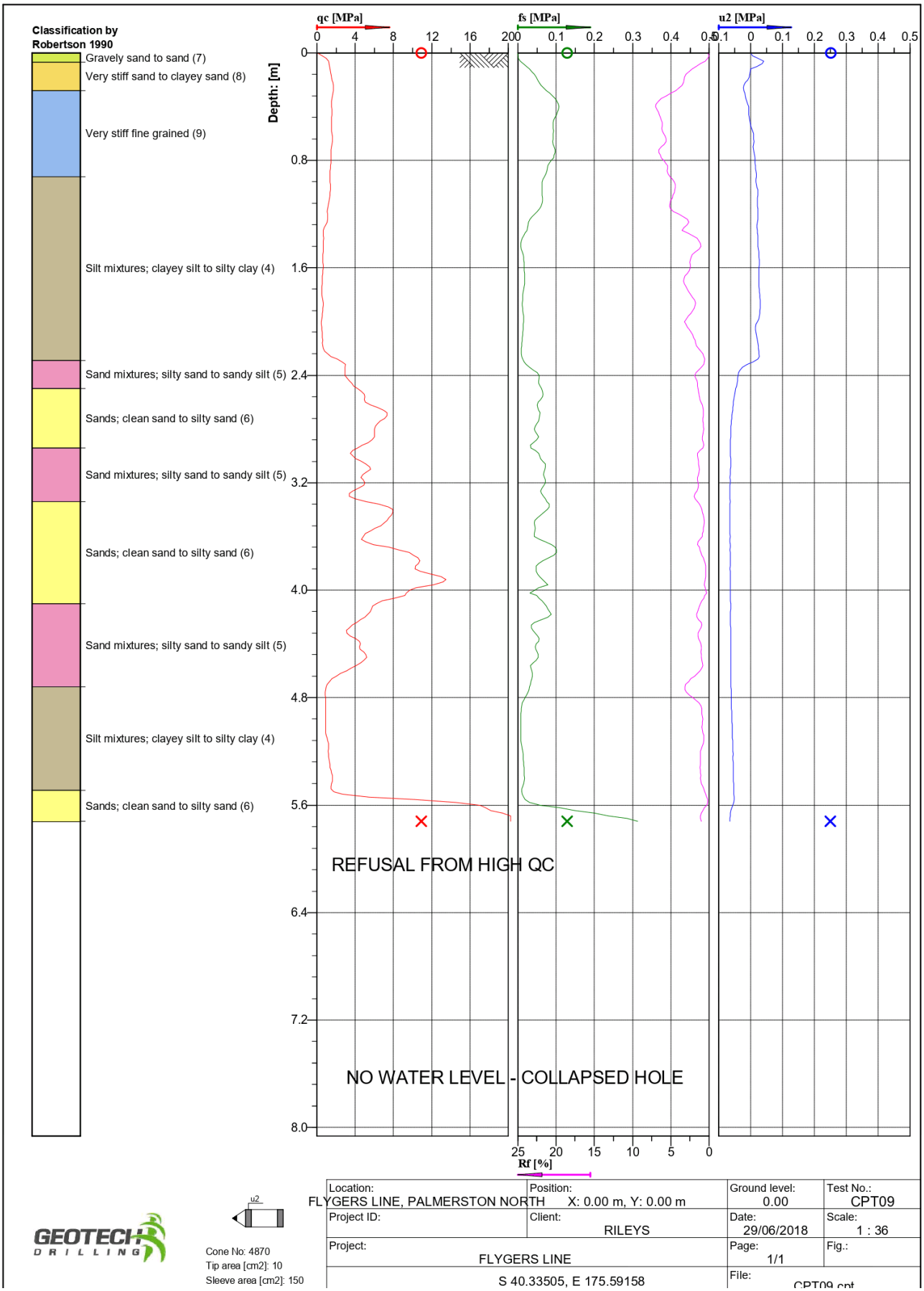

Classification by Robertson 1990
Sands; clean sand to silty sand (6)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Clays; clay to silty clay (3)
Silt mixtures; clayey silt to silty clay (4)
Clays; clay to silty clay (3)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
1.70
ANCHOR FAILURE DUE TO FIRM QC
Rf [%]
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT08
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33339, E 175.59032
File: CPT08.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

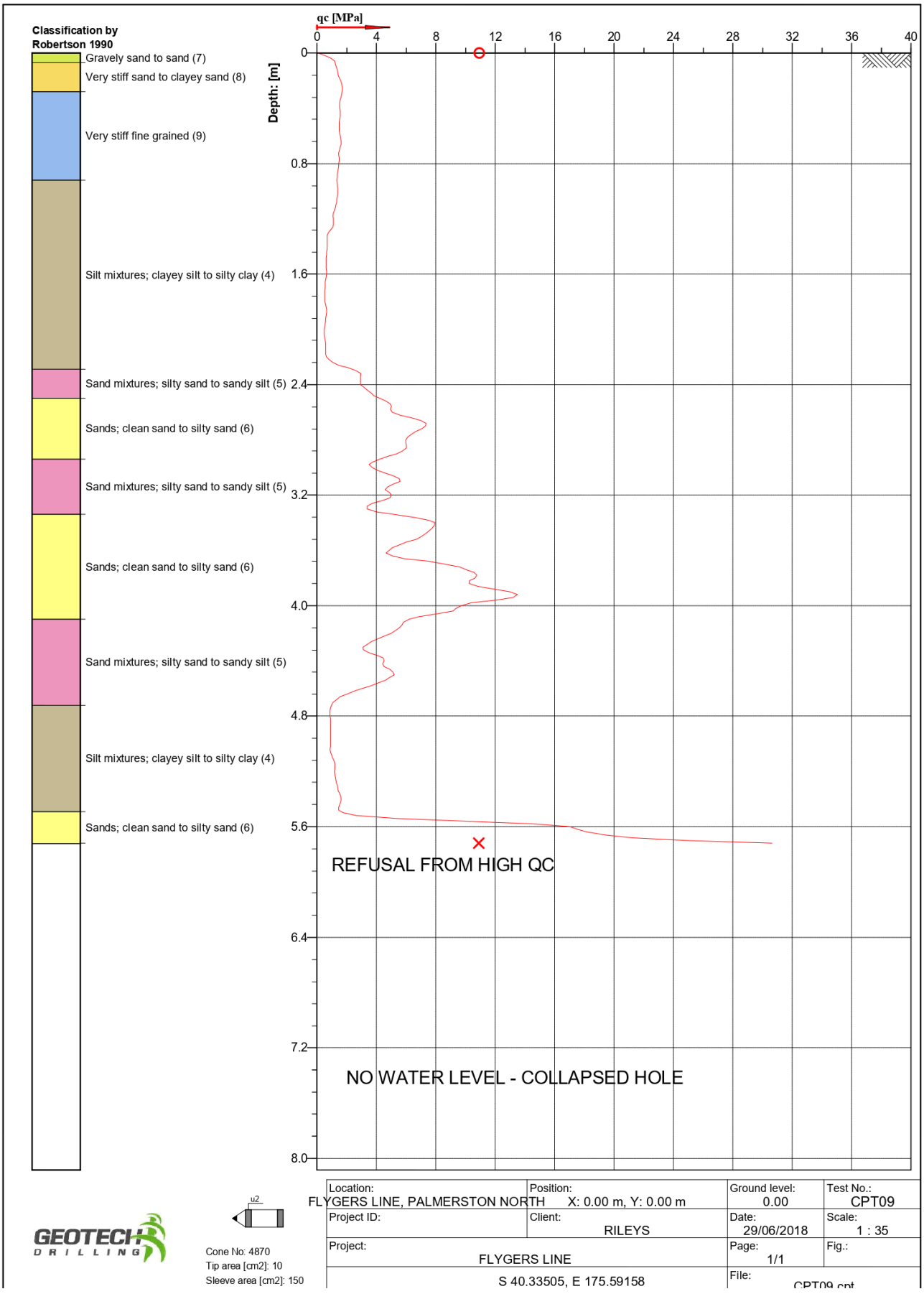

Classification by Robertson 1990
Sands; clean sand to silty sand (6)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Clays; clay to silty clay (3)
Silt mixtures; clayey silt to silty clay (4)
Clays; clay to silty clay (3)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
1.70
ANCHOR FAILURE DUE TO FIRM QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT08
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33339, E 175.59032
File: CPT08.cpt

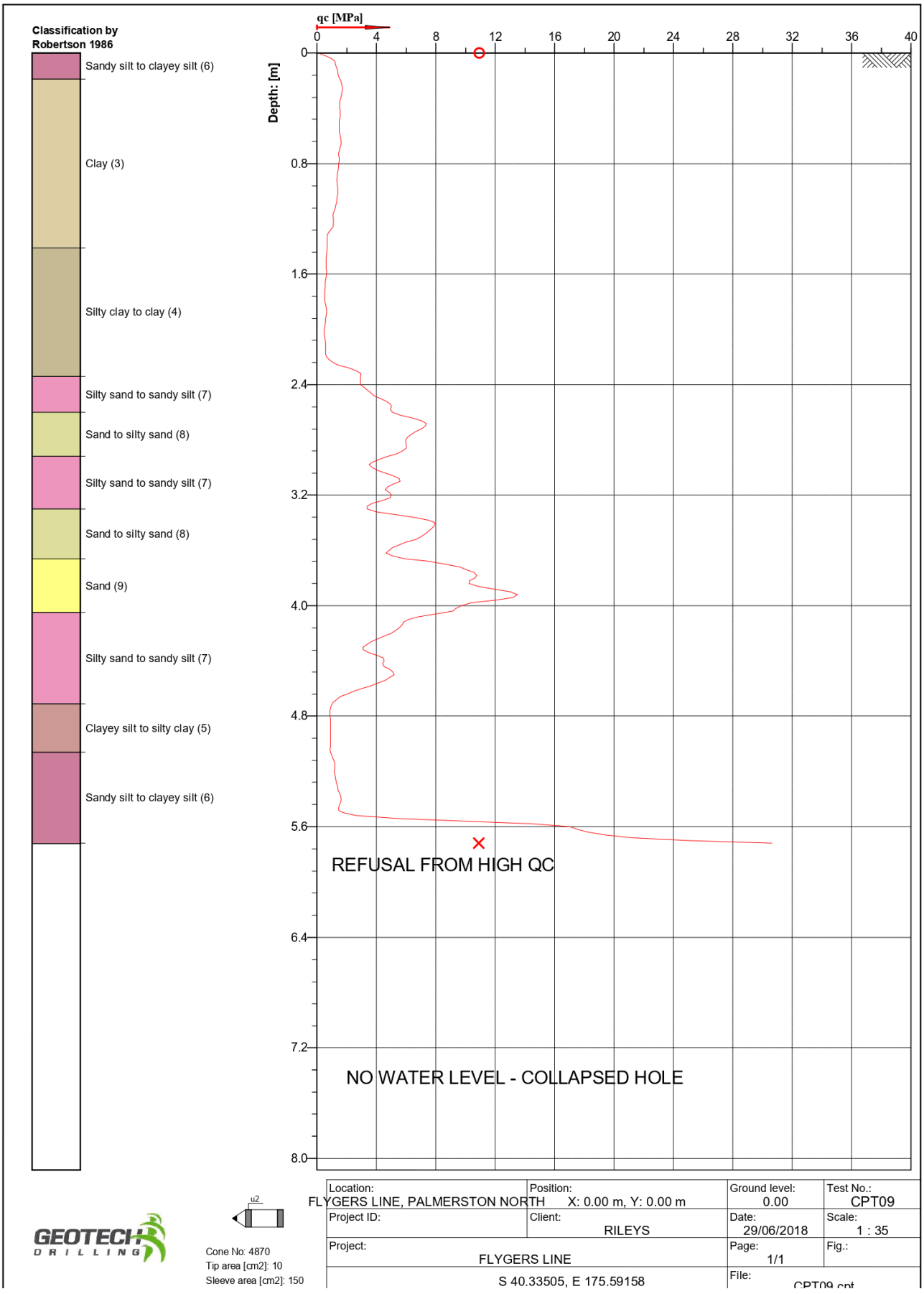

Classification by Robertson 1986
Sensitive fine grained (1)
Clay (3)
Silty clay to clay (4)
Clay (3)
Silty clay to clay (4)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Sand (9)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
1.70
ANCHOR FAILURE DUE TO FIRM QC
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT08
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33339, E 175.59032
File: CPT08.cpt

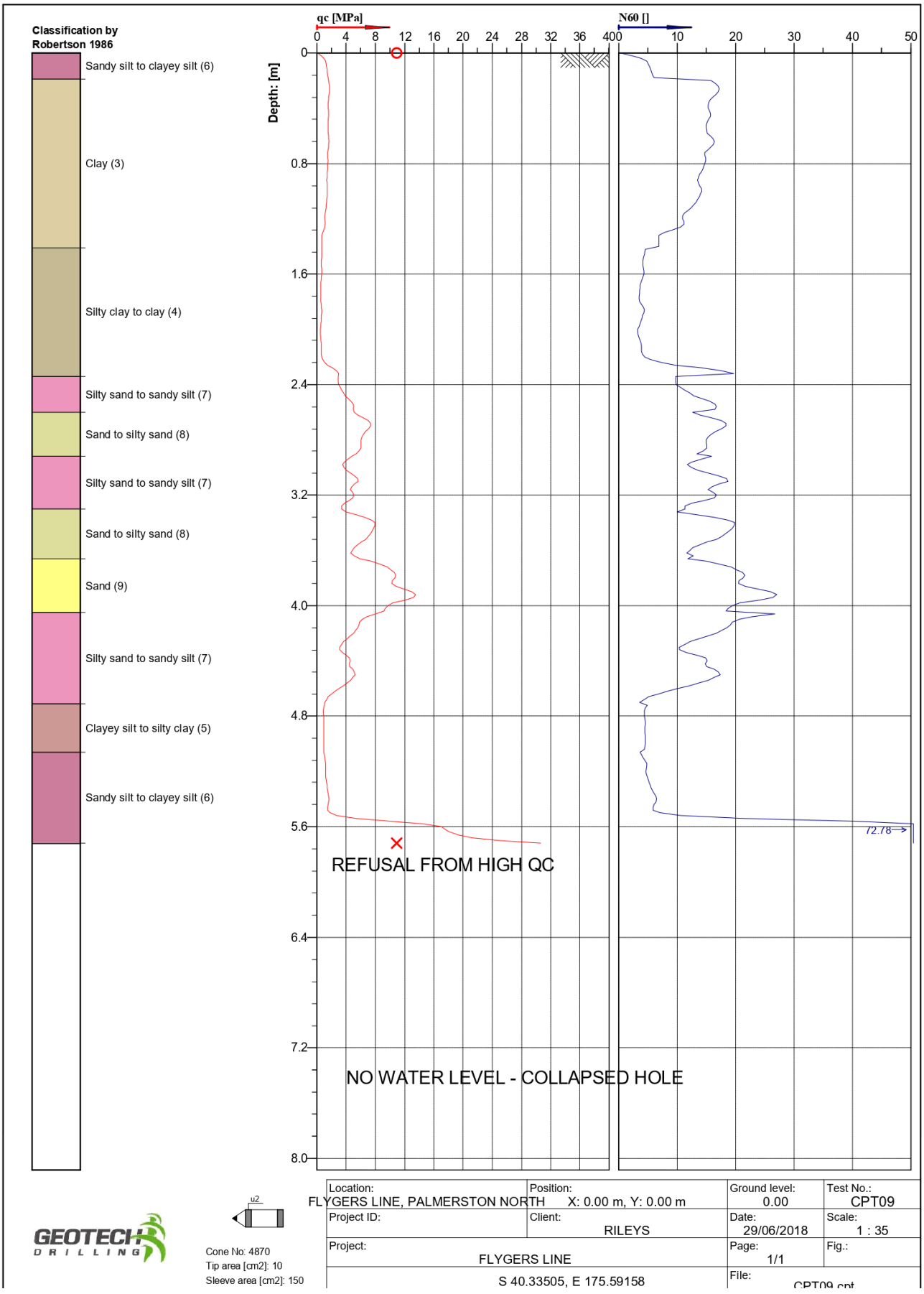

Classification by Robertson 1986
Sensitive fine grained (1)
Clay (3)
Silty clay to clay (4)
Clay (3)
Silty clay to clay (4)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Sand (9)
qc [MPa]
N60 []
Depth: [m]
1.70
ANCHOR FAILURE DUE TO FIRM QC
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT08
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33339, E 175.59032
File: CPT08.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

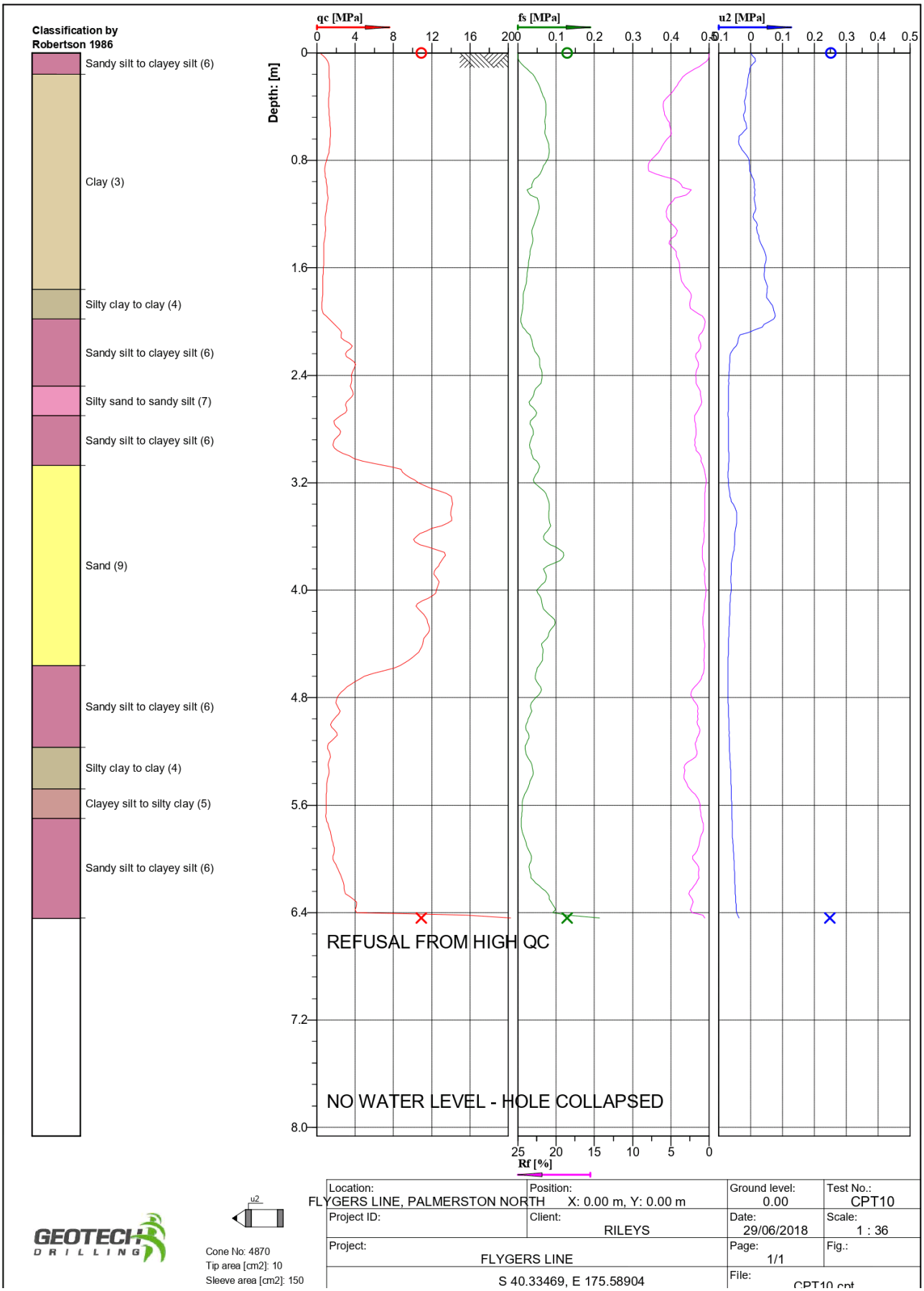

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clay (3)
Silty clay to clay (4)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Sand (9)
Silty sand to sandy silt (7)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
REFUSAL FROM HIGH QC
NO WATER LEVEL - COLLAPSED HOLE
Rf [%]
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT09
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33505, E 175.59158
File: CPT09.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

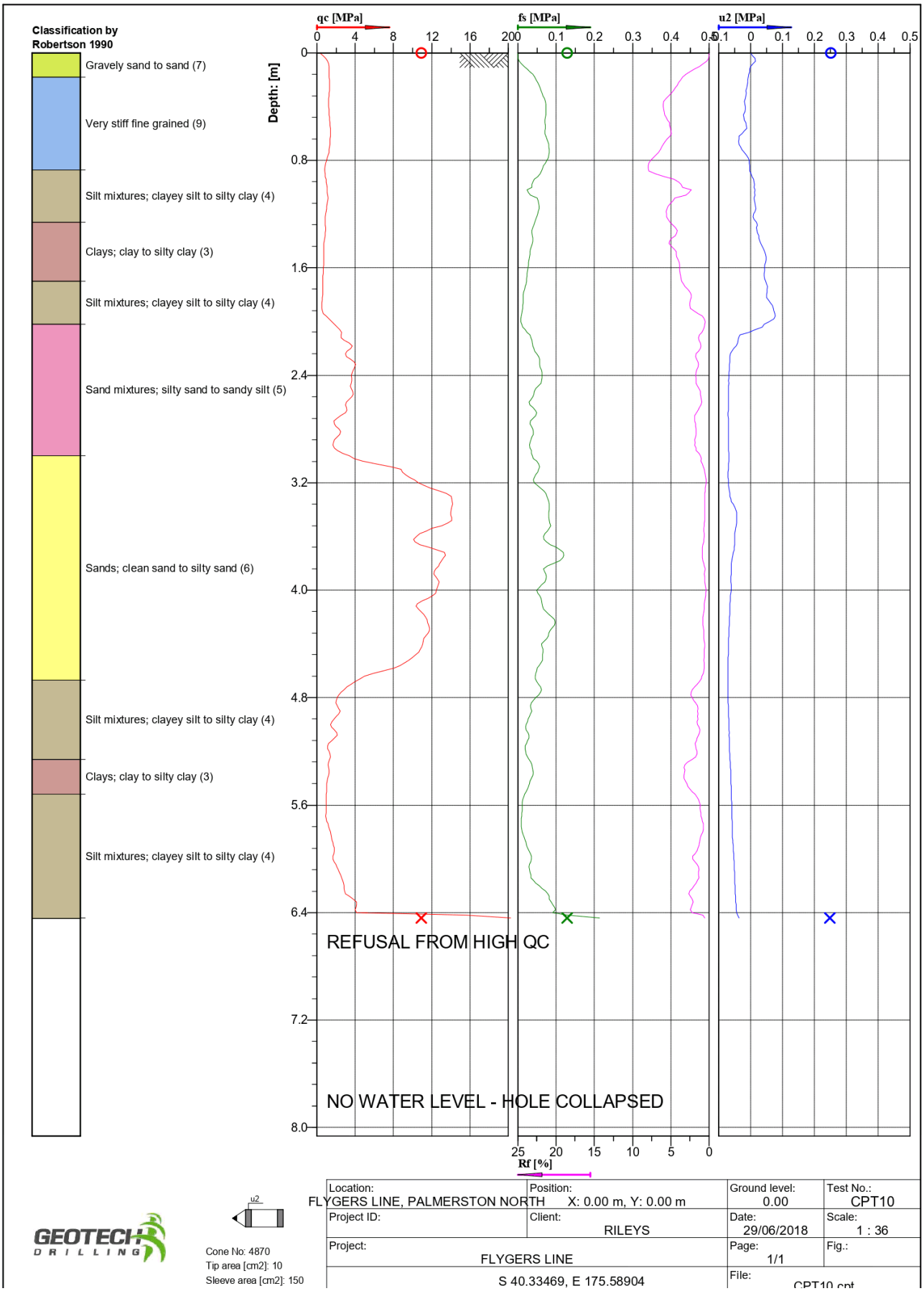

Classification by Robertson 1990
Gravely sand to sand (7)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
Rf [%]
REFUSAL FROM HIGH QC
NO WATER LEVEL - COLLAPSED HOLE
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT09
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33505, E 175.59158
File: CPT09.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

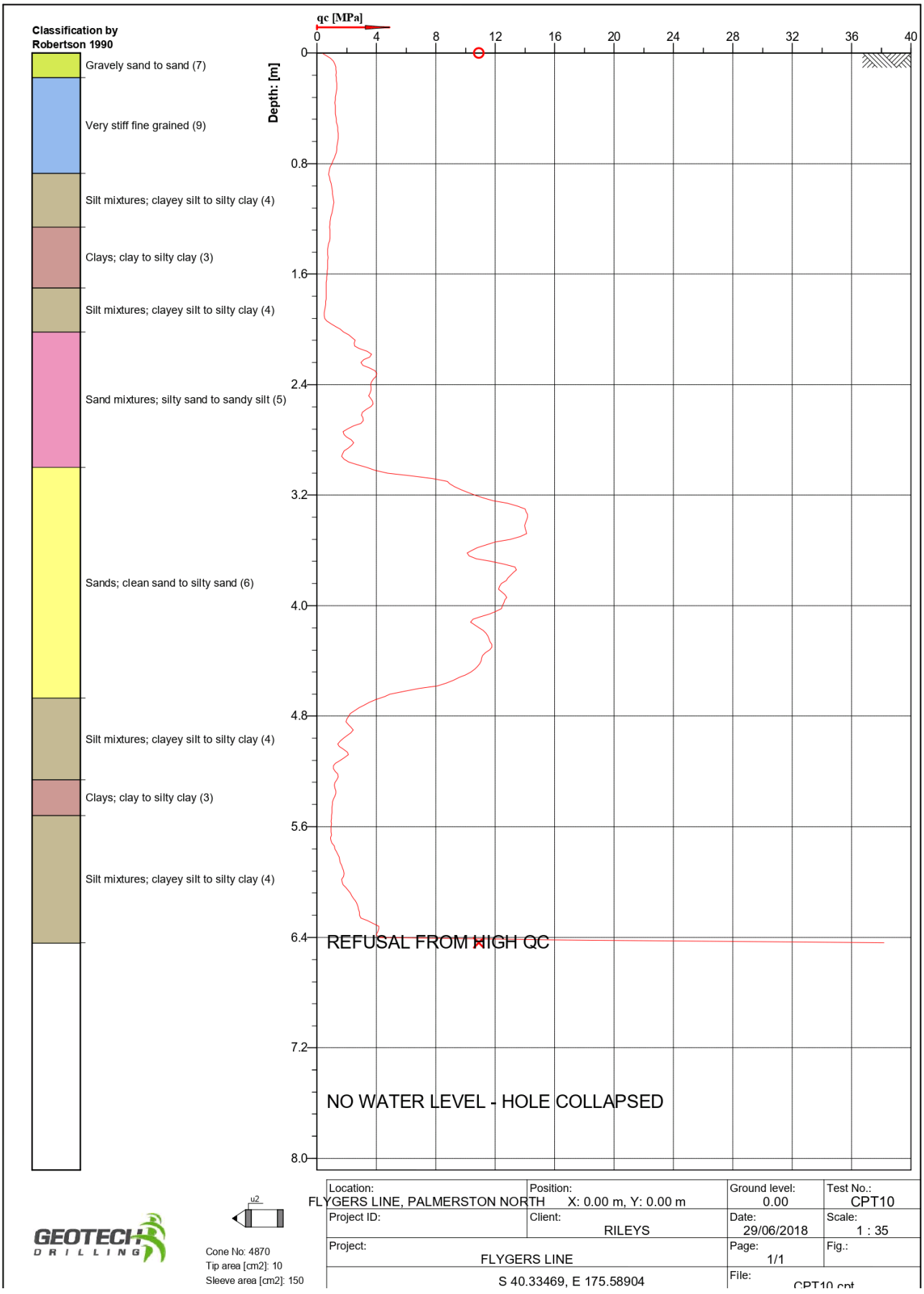

Classification by Robertson 1990
Gravely sand to sand (7)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Sand mixtures; silty sand to sandy silt (5)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
qc [MPa]
0 4 8 12 16 20 24 28 32 36 40
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
REFUSAL FROM HIGH QC
NO WATER LEVEL - COLLAPSED HOLE
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT09
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33505, E 175.59158
File: CPT09.cpt

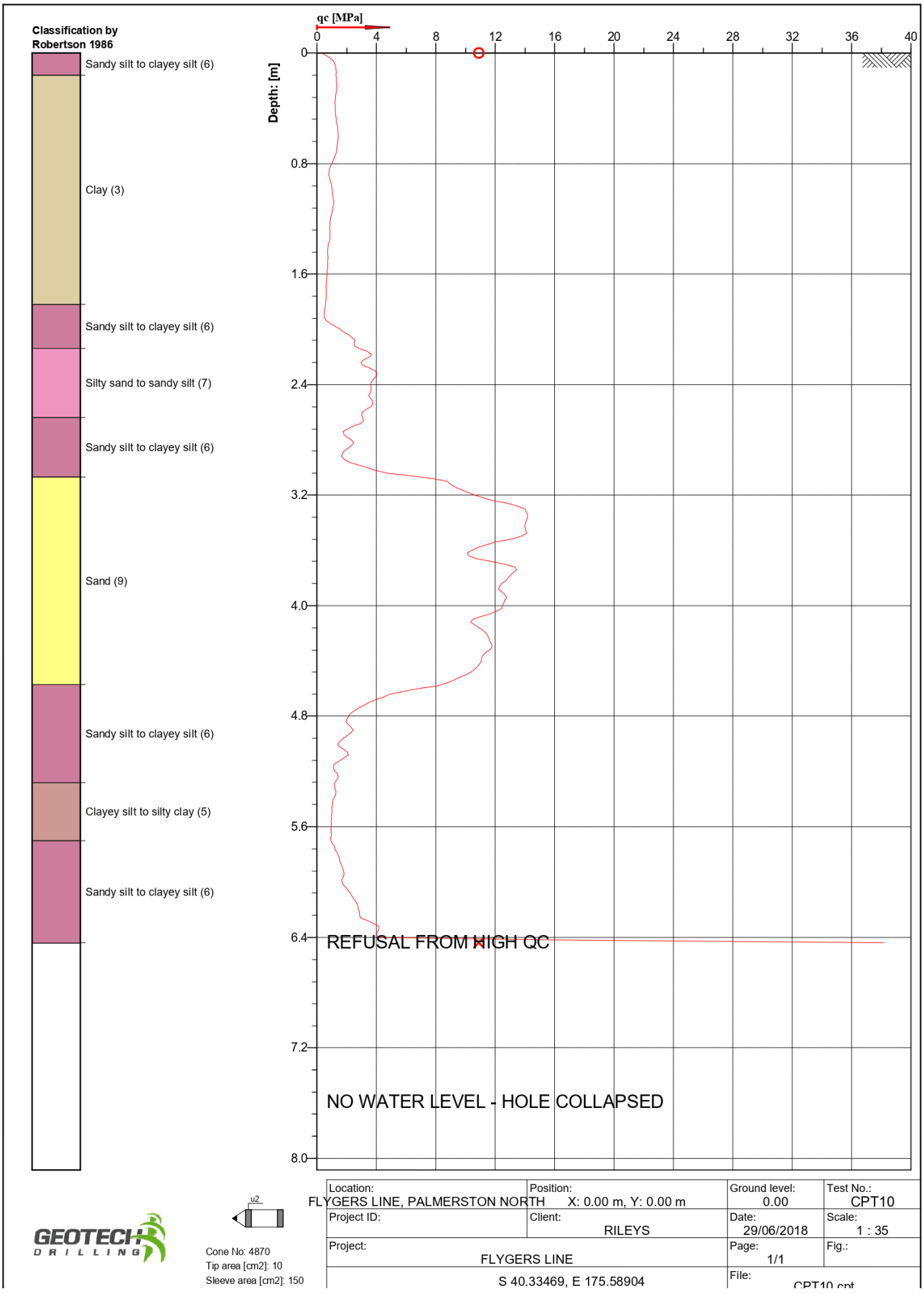

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clay (3)
Silty clay to clay (4)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Sand (9)
Silty sand to sandy silt (7)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
REFUSAL FROM HIGH QC
NO WATER LEVEL - COLLAPSED HOLE
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT09
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33505, E 175.59158
File: CPT09.cpt

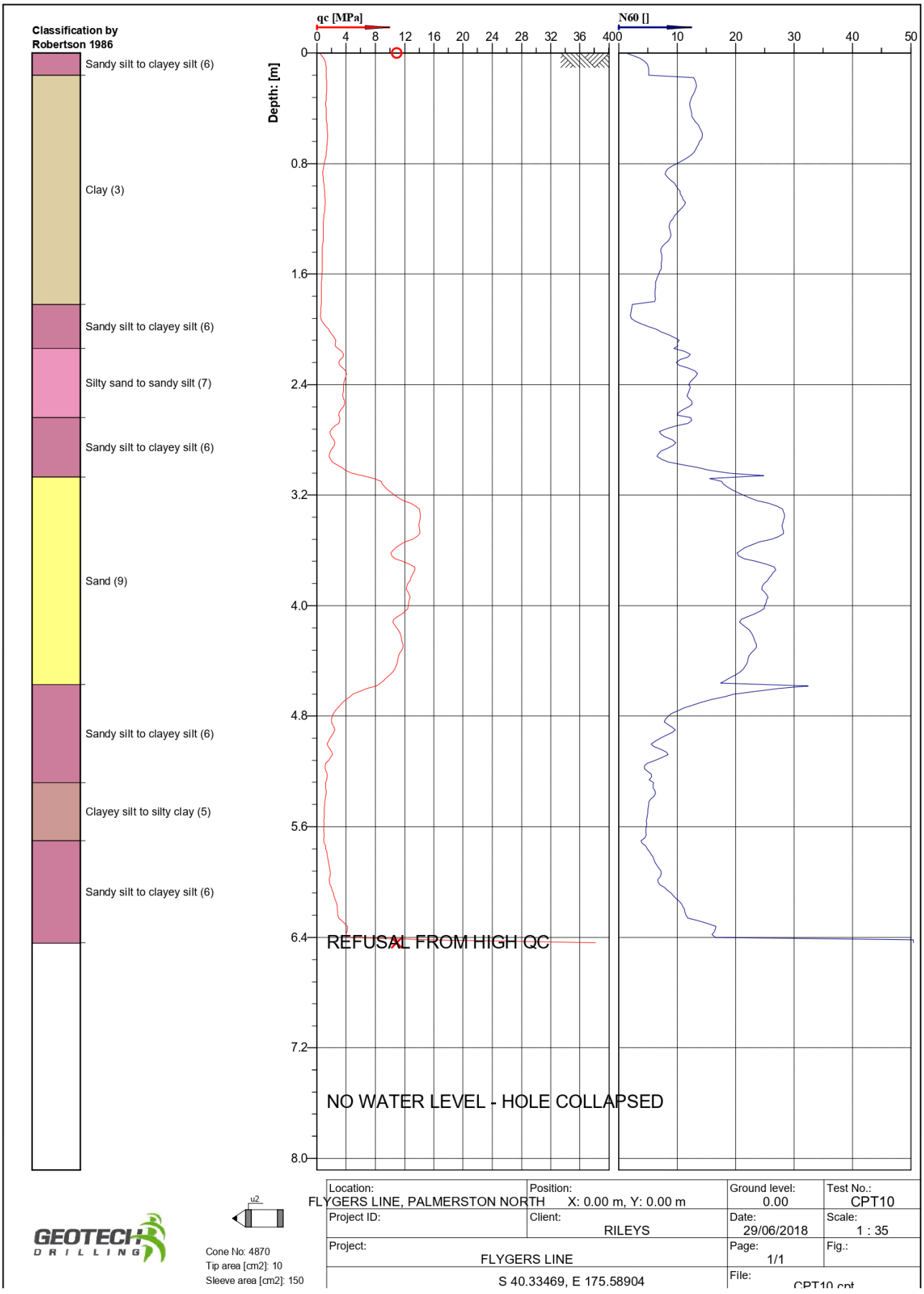

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clay (3)
Silty clay to clay (4)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Sand (9)
Silty sand to sandy silt (7)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
0 4 8 12 16 20 24 28 32 36 400
N60 []
10 20 30 40 50
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
72.78
REFUSAL FROM HIGH QC
NO WATER LEVEL - COLLAPSED HOLE
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT09
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33505, E 175.59158
File: CPT09.cpt

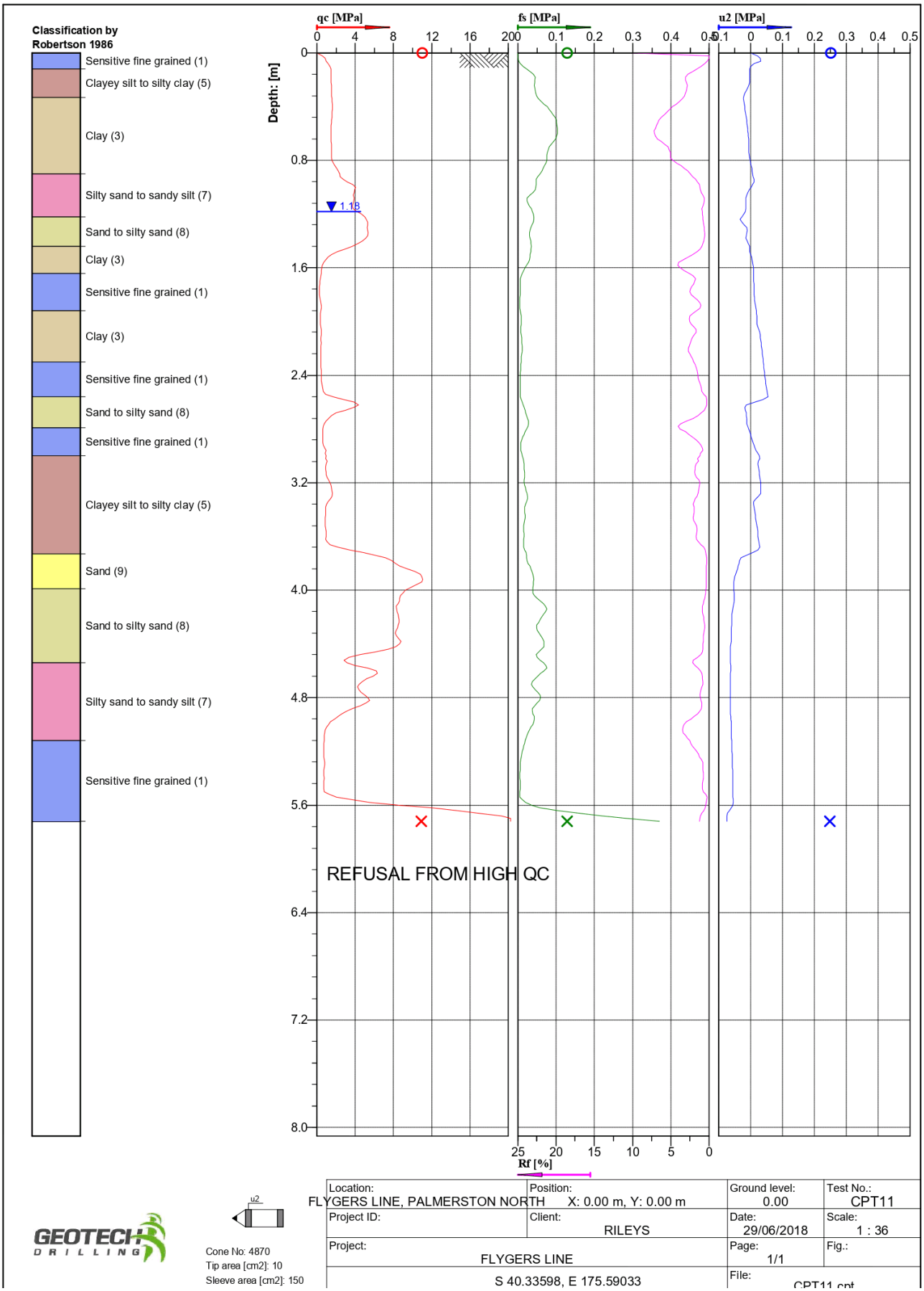

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clay (3)
Silty clay to clay (4)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Sandy silt to clayey silt (6)
Sand (9)
Sandy silt to clayey silt (6)
Silty clay to clay (4)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
Rf [%]
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT10
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33469, E 175.58904
File: CPT10.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

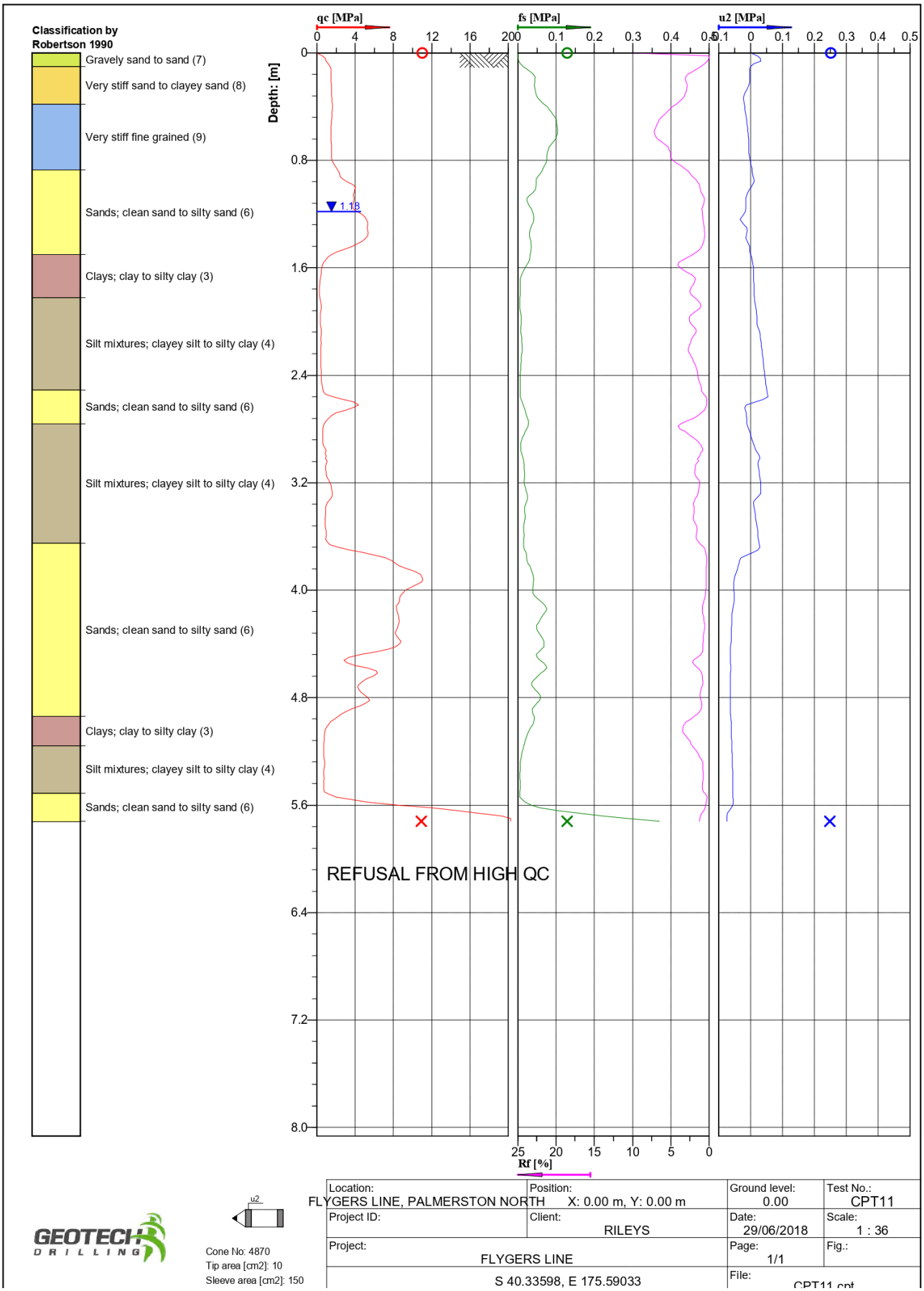

Classification by Robertson 1990
Gravely sand to sand (7)
Very stiff fine grained (9)
Silt mixtures; clayey silt to silty clay (4)
Clays; clay to silty clay (3)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Clays; clay to silty clay (3)
Silt mixtures; clayey silt to silty clay (4)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
Rf [%]
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT10
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33469, E 175.58904
File: CPT10.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

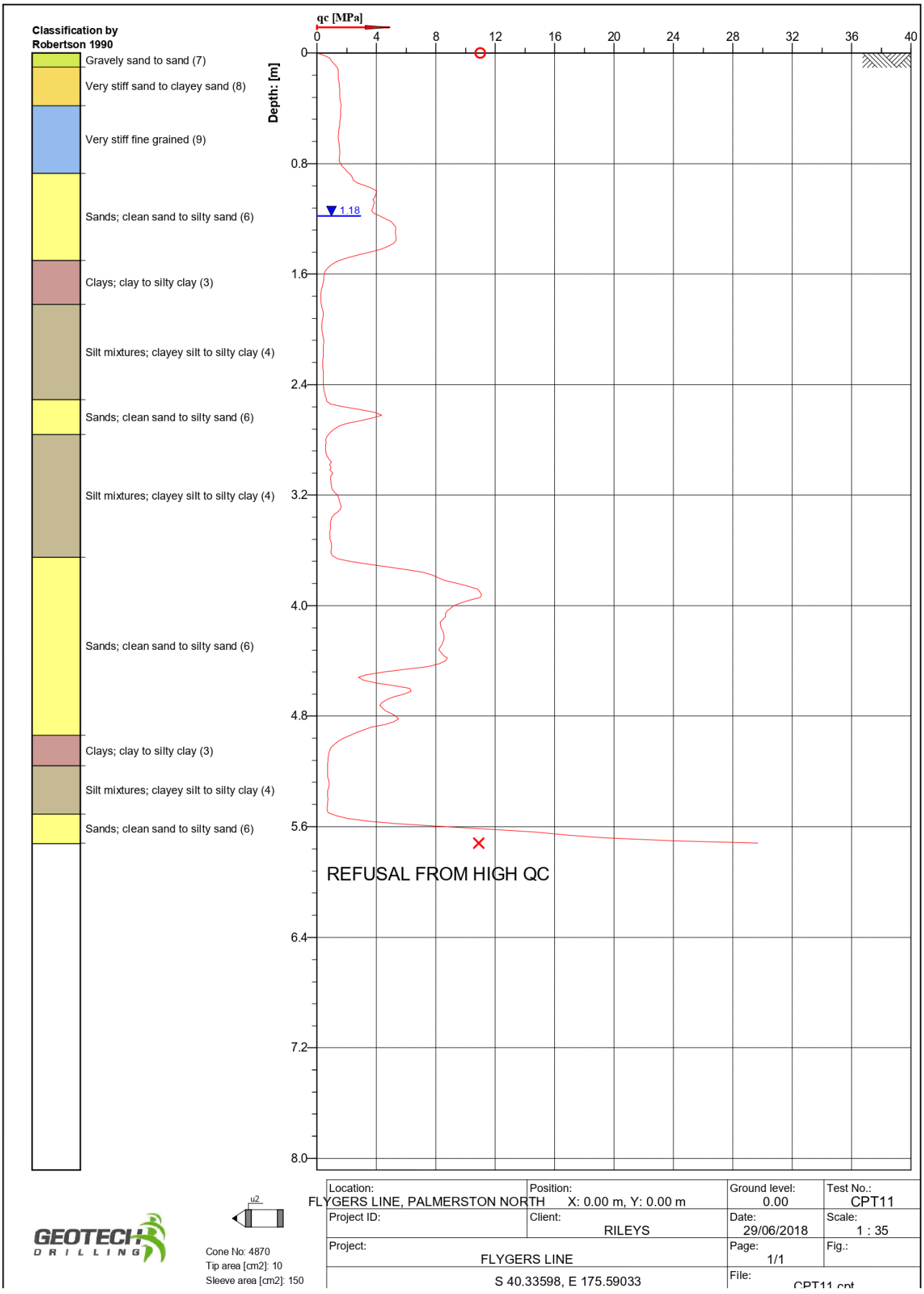

Classification by Robertson 1990
Gravely sand to sand (7)
Very stiff fine grained (9)
Silt mixtures; clayey silt to silty clay (4)
Clays; clay to silty clay (3)
Silt mixtures; clayey silt to silty clay (4)
Sand mixtures; silty sand to sandy silt (5)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Clays; clay to silty clay (3)
Silt mixtures; clayey silt to silty clay (4)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT10
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33469, E 175.58904
File: CPT10.cpt

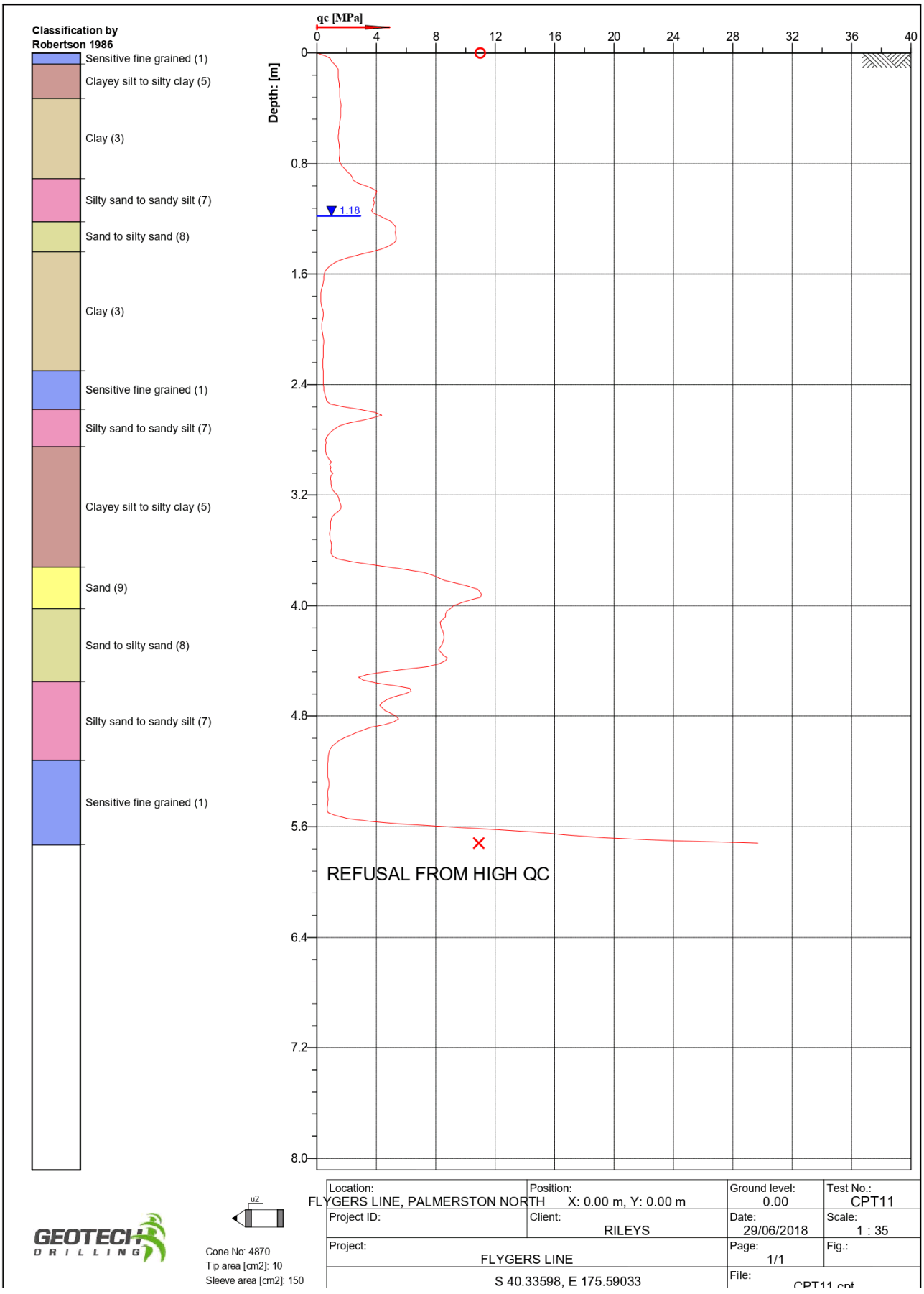

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clay (3)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Sandy silt to clayey silt (6)
Sand (9)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT10
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33469, E 175.58904
File: CPT10.cpt

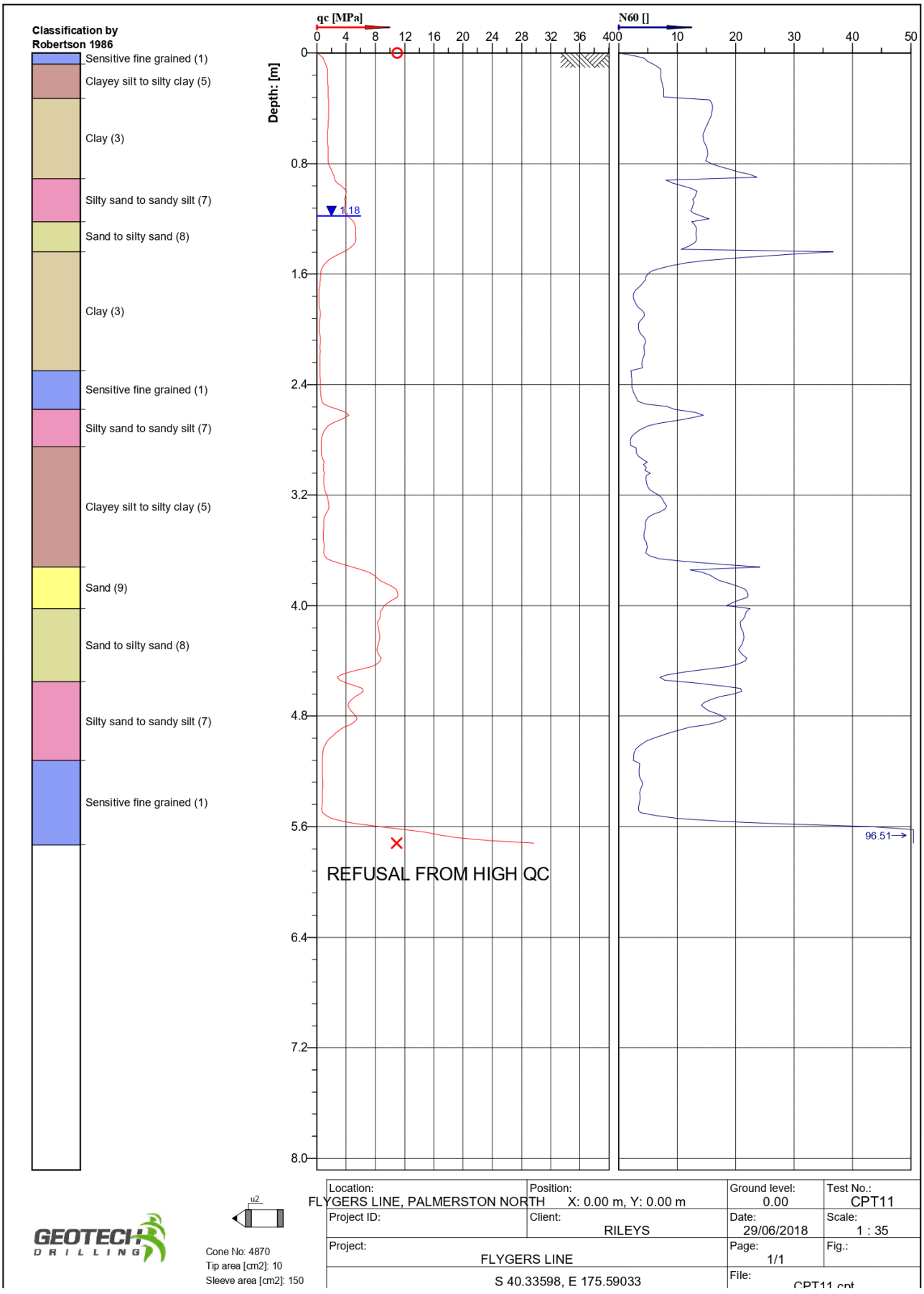

Classification by Robertson 1986
Sandy silt to clayey silt (6)
Clay (3)
Sandy silt to clayey silt (6)
Silty sand to sandy silt (7)
Sandy silt to clayey silt (6)
Sand (9)
Sandy silt to clayey silt (6)
Clayey silt to silty clay (5)
Sandy silt to clayey silt (6)
qc [MPa]
0 4 8 12 16 20 24 28 32 36 400
N60 []
10 20 30 40 50
Depth: [m]
0 0.8 1.6 2.4 3.2 4.0 4.8 5.6 6.4 7.2 8.0
REFUSAL FROM HIGH QC
NO WATER LEVEL - HOLE COLLAPSED
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT10
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33469, E 175.58904
File: CPT10.cpt


Classification by Robertson 1986
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Clay (3)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Clay (3)
Sensitive fine grained (1)
Clay (3)
Sensitive fine grained (1)
Sand to silty sand (8)
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Sand (9)
Sand to silty sand (8)
Silty sand to sandy silt (7)
Sensitive fine grained (1)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
1.18
REFUSAL FROM HIGH QC
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
GEOTECH DRILLING
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT11
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33598, E 175.59033
File: CPT11.cpt


Classification by Robertson 1990
Gravely sand to sand (7)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Sands; clean sand to silty sand (6)
Clays; clay to silty clay (3)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
Clays; clay to silty clay (3)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
1.18
REFUSAL FROM HIGH QC
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
GEOTECH DRILLING
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT11
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33598, E 175.59033
File: CPT11.cpt


Classification by Robertson 1990
Gravely sand to sand (7)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Sands; clean sand to silty sand (6)
Clays; clay to silty clay (3)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
Clays; clay to silty clay (3)
Silt mixtures; clayey silt to silty clay (4)
Sands; clean sand to silty sand (6)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
1.18
REFUSAL FROM HIGH QC
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT11
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33598, E 175.59033
File: CPT11.cpt


Classification by Robertson 1986
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Clay (3)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Clay (3)
Sensitive fine grained (1)
Silty sand to sandy silt (7)
Clayey silt to silty clay (5)
Sand (9)
Sand to silty sand (8)
Silty sand to sandy silt (7)
Sensitive fine grained (1)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
1.18
REFUSAL FROM HIGH QC
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT11
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33598, E 175.59033
File: CPT11.cpt


Classification by Robertson 1986
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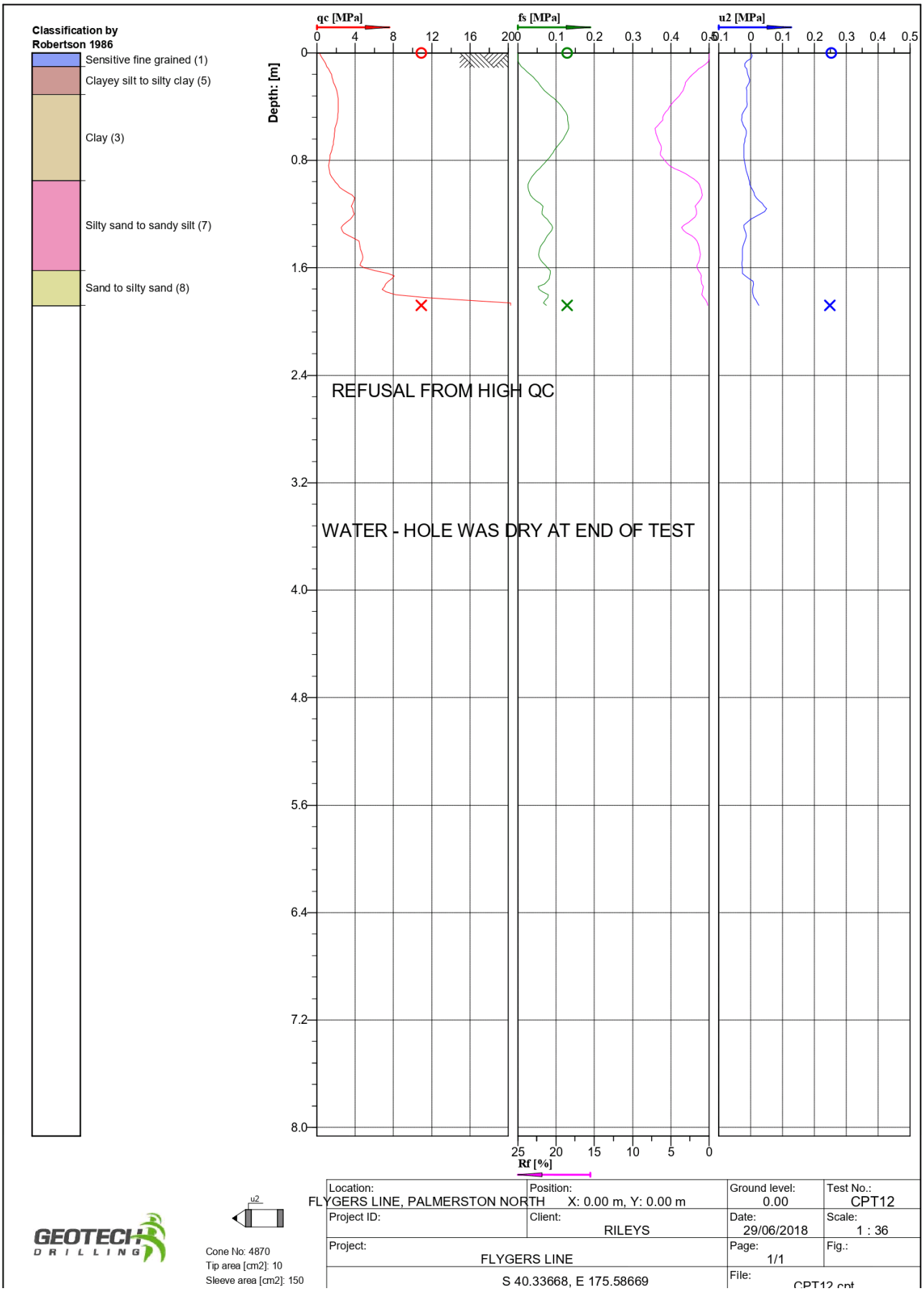
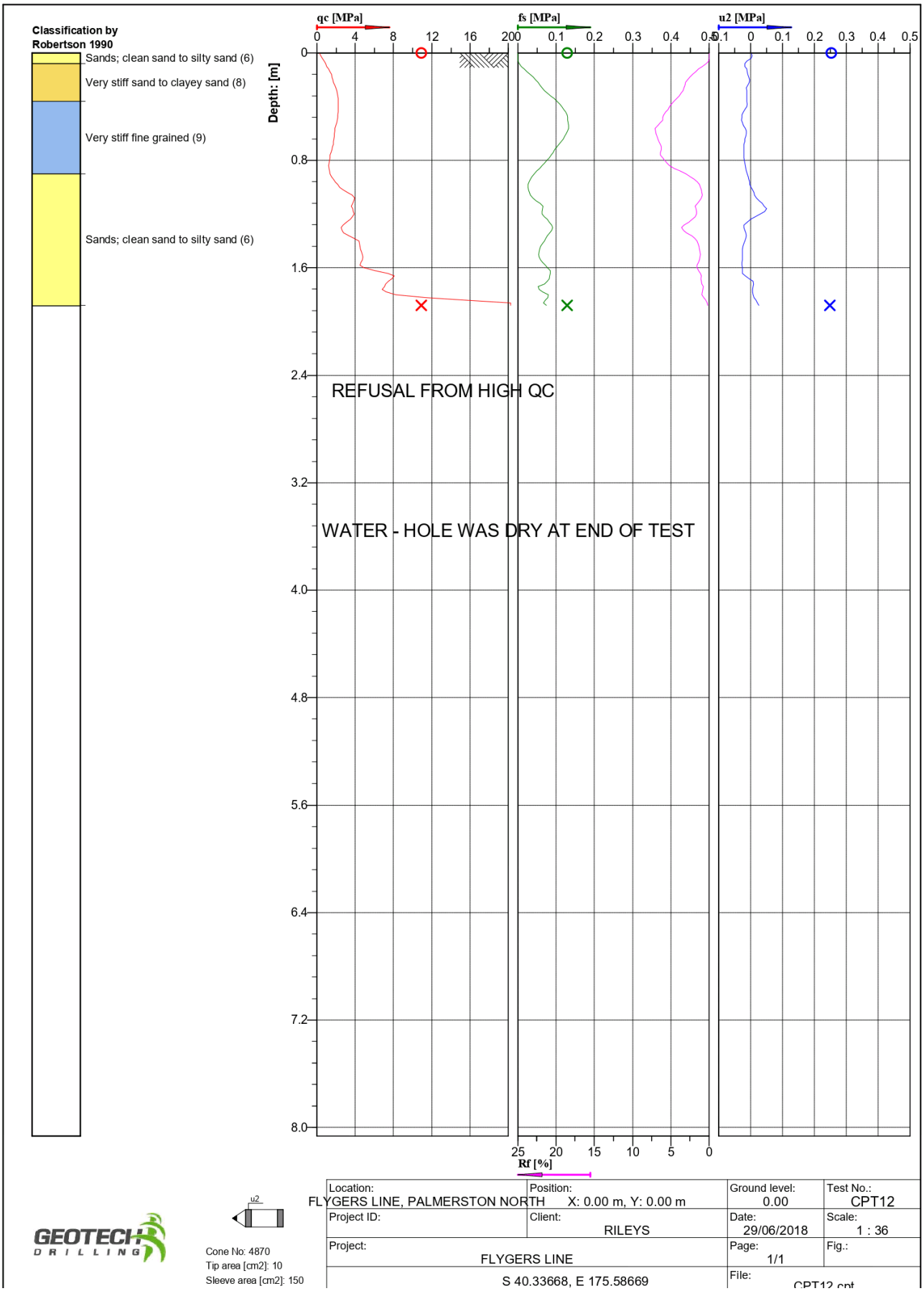
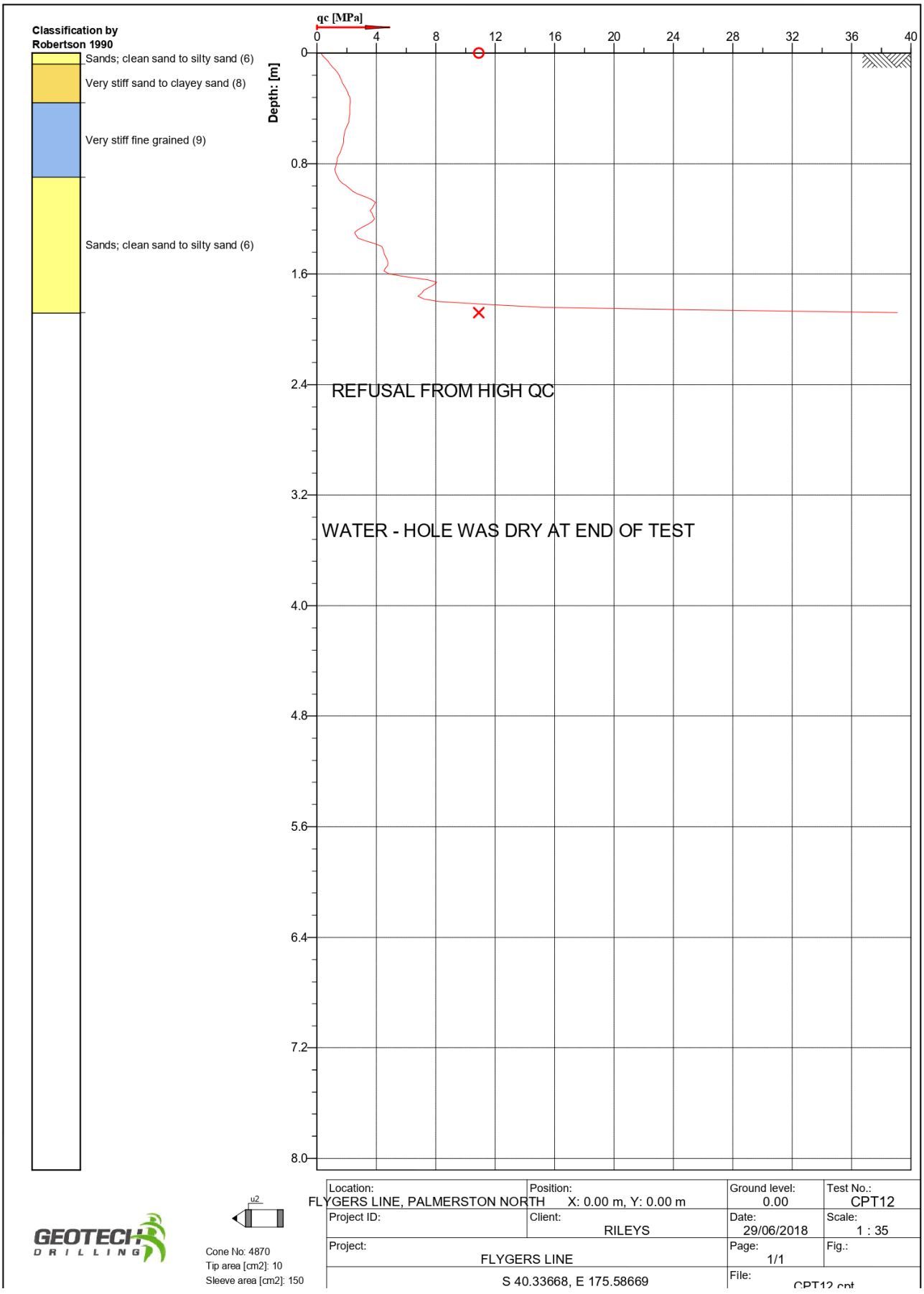
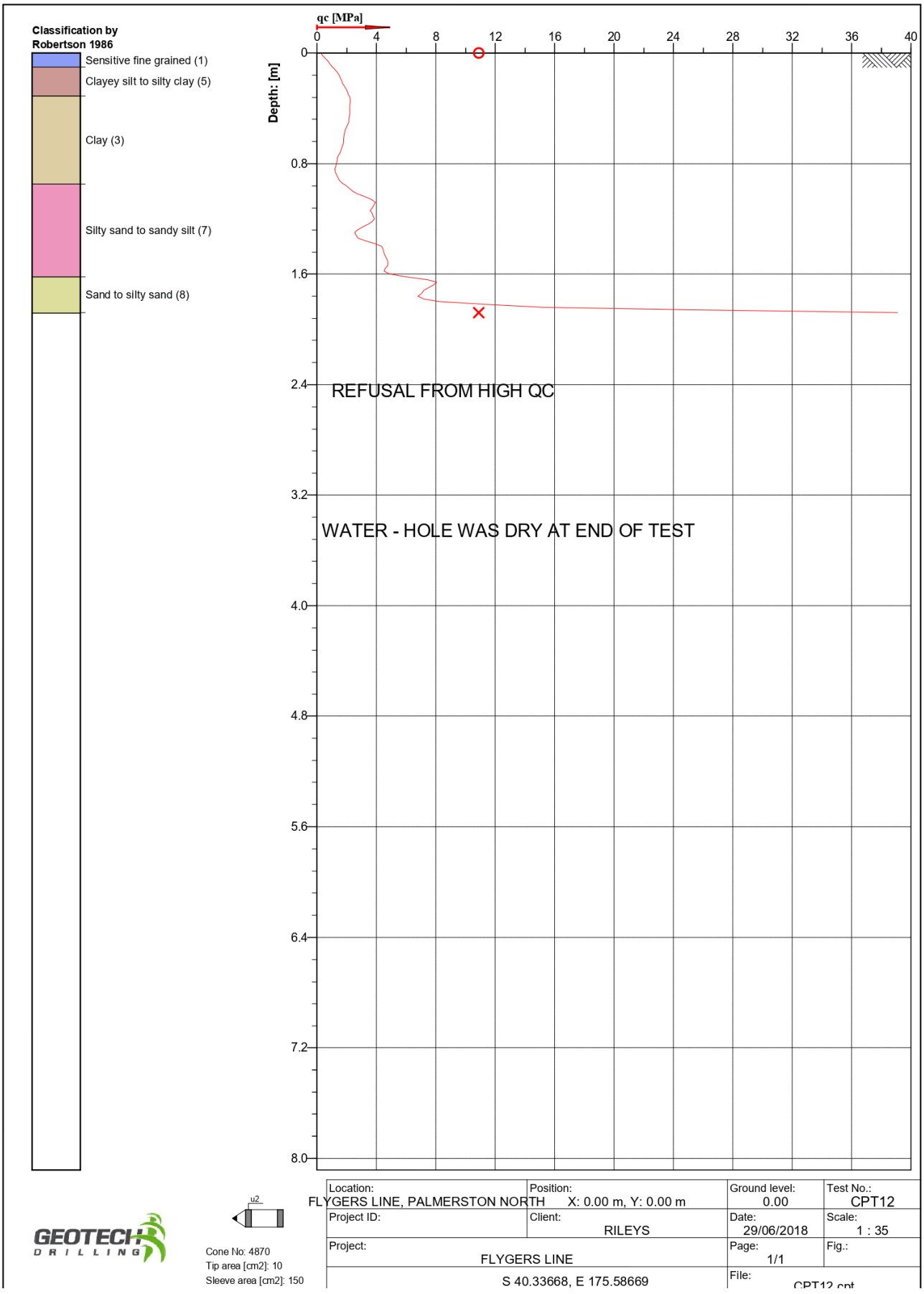
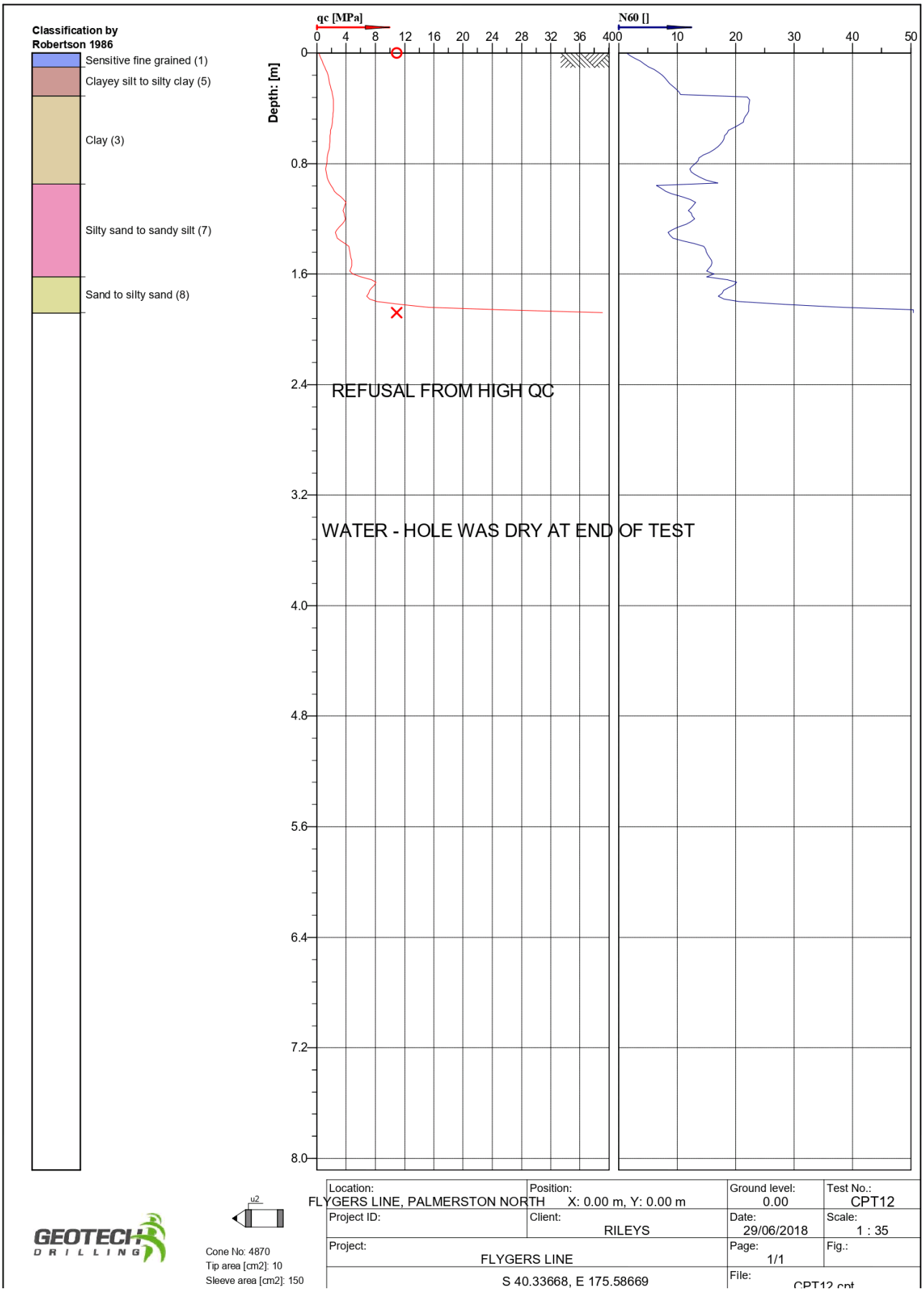
Clayey silt to silty clay (5)
Clay (3)
Silty sand to sandy silt (7)
Sand to silty sand (8)
Clay (3)
Sensitive fine grained (1)
Silty sand to sandy silt (7)
Clayey silt to silty clay (5)
Sand (9)
Sand to silty sand (8)
Silty sand to sandy silt (7)
Sensitive fine grained (1)
qc [MPa]
N60 []
Depth: [m]
1.18
96.51
REFUSAL FROM HIGH QC
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT11
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33598, E 175.59033
File: CPT11.cpt


Classification by Robertson 1986
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Clay (3)
Silty sand to sandy silt (7)
Sand to silty sand (8)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
REFUSAL FROM HIGH QC
WATER - HOLE WAS DRY AT END OF TEST
Rf [%]
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT12
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33668, E 175.58669
File: CPT12.cpt


Classification by Robertson 1990
Sands; clean sand to silty sand (6)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Sands; clean sand to silty sand (6)
qc [MPa]
fs [MPa]
u2 [MPa]
Depth: [m]
REFUSAL FROM HIGH QC
WATER - HOLE WAS DRY AT END OF TEST
Rf [%]
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT12
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 36
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33668, E 175.58669
File: CPT12.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150


Classification by Robertson 1990
Sands; clean sand to silty sand (6)
Very stiff sand to clayey sand (8)
Very stiff fine grained (9)
Sands; clean sand to silty sand (6)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
REFUSAL FROM HIGH QC
WATER - HOLE WAS DRY AT END OF TEST
u2
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT12
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33668, E 175.58669
File: CPT12.cpt


Classification by Robertson 1986
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Clay (3)
Silty sand to sandy silt (7)
Sand to silty sand (8)
qc [MPa]
0
4
8
12
16
20
24
28
32
36
40
Depth: [m]
0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
REFUSAL FROM HIGH QC
WATER - HOLE WAS DRY AT END OF TEST
u2
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT12
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33668, E 175.58669
File: CPT12.cpt


Classification by Robertson 1986
Sensitive fine grained (1)
Clayey silt to silty clay (5)
Clay (3)
Silty sand to sandy silt (7)
Sand to silty sand (8)
qc [MPa]
N60 []
Depth: [m]
REFUSAL FROM HIGH QC
WATER - HOLE WAS DRY AT END OF TEST
Location: FLYGERS LINE, PALMERSTON NORTH
Position: X: 0.00 m, Y: 0.00 m
Ground level: 0.00
Test No.: CPT12
Project ID:
Client: RILEYS
Date: 29/06/2018
Scale: 1 : 35
Project: FLYGERS LINE
Page: 1/1
Fig.:
S 40.33668, E 175.58669
File: CPT12.cpt
GEOTECH DRILLING
Cone No: 4870
Tip area [cm2]: 10
Sleeve area [cm2]: 150

RILEY CONSULTANTS Engineers and Geologists

Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax:

DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Near CPT 2 (Western Most MH)	MH1

Job No.:	Start Date: 16-01-19 Finish Date: 16-01-19	Ground Level (m):	Co-Ordinates ():
170672			E 175.6 N 40.3

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	15.34 m	1 of 2

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Air Voids (%)	Lab Testing: Density (t/m3)	Lab Testing: Unlaxial Comp Strength (kPa)	Lab Testing: Tests/Comments	Field Testing
	0.20	Holocene Alluvial Deposits	TOPSOIL; light brown; fine rootlets.			Sonic				DM M							
	1		SILT, trace to minor clay; mixed greyish orange. Moist, slightly plastic. 1.15 m - 1.95 m SILT, some fine sand; brown.														
	1.95																SPT 1.50 m 1, 1, 1, 1, 2, 2; N=6
	2		Sandy SILT; dark grey. Slightly cohesive; sand, fine to medium; slightly cohesive. 2.60 m - 3.45 m Fine sand with some silt; dark grey.							M							
	3										16/01/2019						SPT 3.00 m 1, 2, 2, 4, 6, 6; N=18
	3.70		3.45 m - 3.70 m Sandy SILT; dark grey; sand, fine.														
	3.90																
	4.00																
	4 4.10		SILT, minor to some clay; dark grey. Slight to moderate plasticity.							S							
	4.40		SILT; dark grey. Slightly plastic; trace organic inclusions.														
	4.95		Silty SAND; dark grey; sand, fine to medium.														SPT 4.50 m 0, 0, 0, 0, 0, 1; N=1
	5																
	5.40		SAND; dark grey; medium to fine.														
	5.90		Silty SAND; dark grey; slightly cohesive.														
	6																
	6.38		Clayey SILT; light bluish grey. Slight to moderate plasticity.														SPT 6.00 m 2, 2, 11, 19, 20, 0/0mm; N=50+
	6.90		SILT, minor clay, minor sand; light grey; sand, fine to medium.														
	7																
	8		SAND; dark bluish grey. Wet; sand, medium to coarse. GRAVEL; rounded, well graded, fine to medium grain; <50mm diameter.														SPT 7.50 m 8, 10, 10, 11, 12, 17; N=50
	9		GRAVEL, some sand; rounded, well graded, fine to medium grain 8.95 m Thin band of SILT with some clay.														SPT 9.00 m 7, 8, 11, 9, 14, 13; N=47
	9.45																
	10		Silty sandy GRAVEL; gravel, fine to medium grain; <70mm diameter; well graded.														
	11																SPT 10.50 m 11, 19, 20, 19, 11/30 mm; N=50+
	11.90																

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

MAP N 0 m 25 m 50 m 1:2,500

Remarks

All dimensions in metres Scale 1:70	Driller: Geotech Drilling	Rig Type: Sonic		Shear Vane No.:	Logged by: GJ	Checked by:

RILEYAKL GLB Log RILEY MH (REV2) - NO SOIL STRENGTH 170672 - MACHINE HOLE LOGS.GPJ <<DrawingFile>> 20/02/2019 14:52 Produced by gINT Professional

RILEY CONSULTANTS
Engineers and Geologists

Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax:

DRILL HOLE LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Near CPT 2 (Western Most MH)	MH1

Job No.:	Start Date: 16-01-19 Finish Date: 16-01-19	Ground Level (m):	Co-Ordinates ():
170672			E 175.6 N 40.3

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	15.34 m	2 of 2

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Drilling Method	Core Recovery (%) 25 50 75	RQD (%)	Piezometer	Soil Moisture	Groundwater	Samples	Lab Testing: Air Voids (%)	Lab Testing: Density (t/m3)	Lab Testing: Uniaxial Comp Strength (kPa)	Lab Testing: Tests/Comments	Field Testing
	12.45	Holocene Alluvial Deposits	Clayey SILT, trace fine gravel and sand; light brownish orange. Slightly to moderately plastic. *(continued)*			Sonic											SPT 12.00 m 2, 2, 2, 3, 3, 3; N=11
	13.10		Silty SAND; light grey. Slightly cohesive; sand, fine.														
			SILT, minor clay, minor sand; light grey. Slightly plastic.														SPT 13.50 m 1, 2, 3, 4, 3, 5; N=15
	14.00		Silty sandy GRAVEL; grey; gravel, well graded, rounded <100mm diameter. 14.40 m Grades to light brown.														
	15.34		EOH @ 15.34 m														SPT 15.00 m 14, 14, 20, 20, 20, 10/35mm Nc=50+

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge

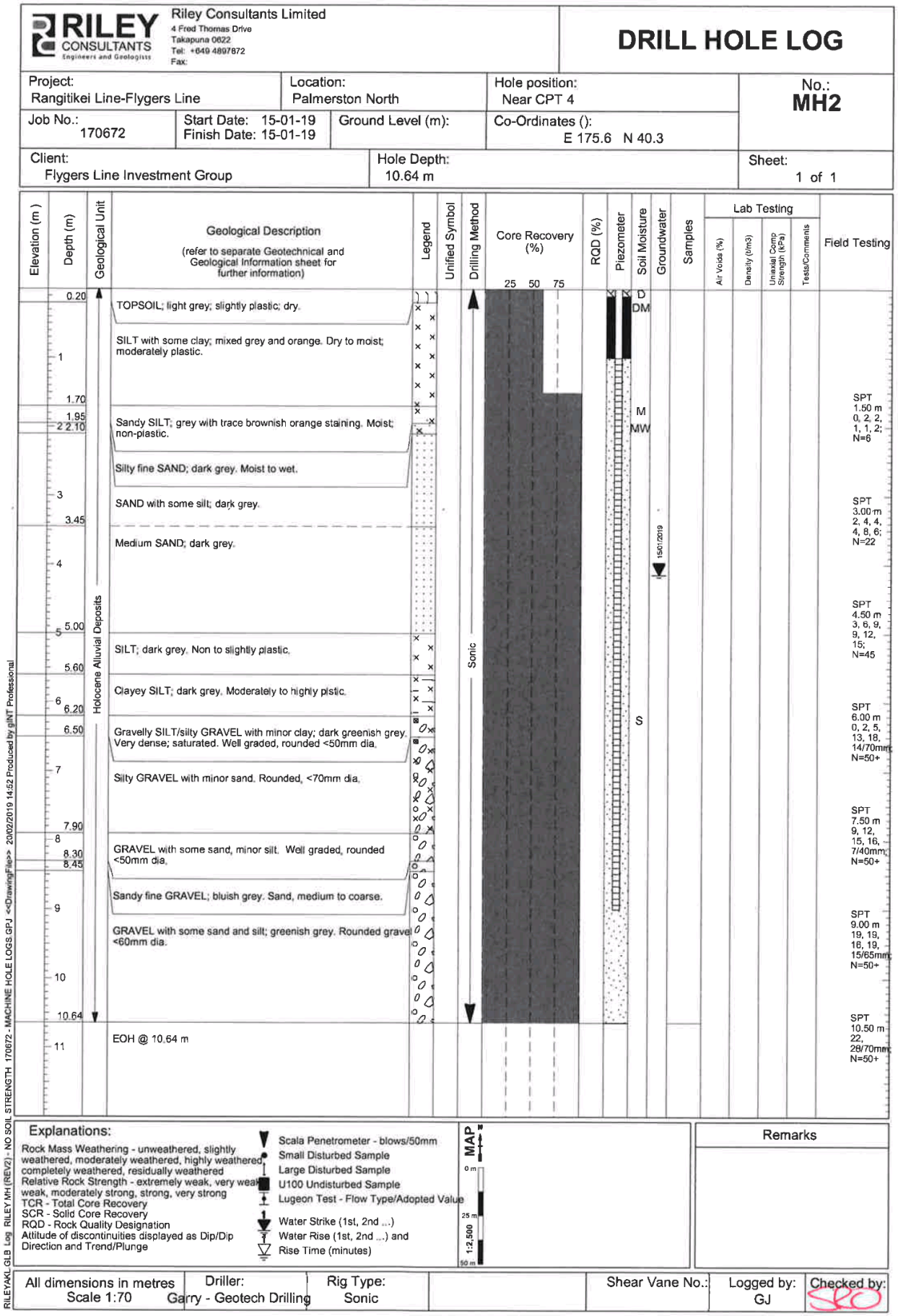
Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

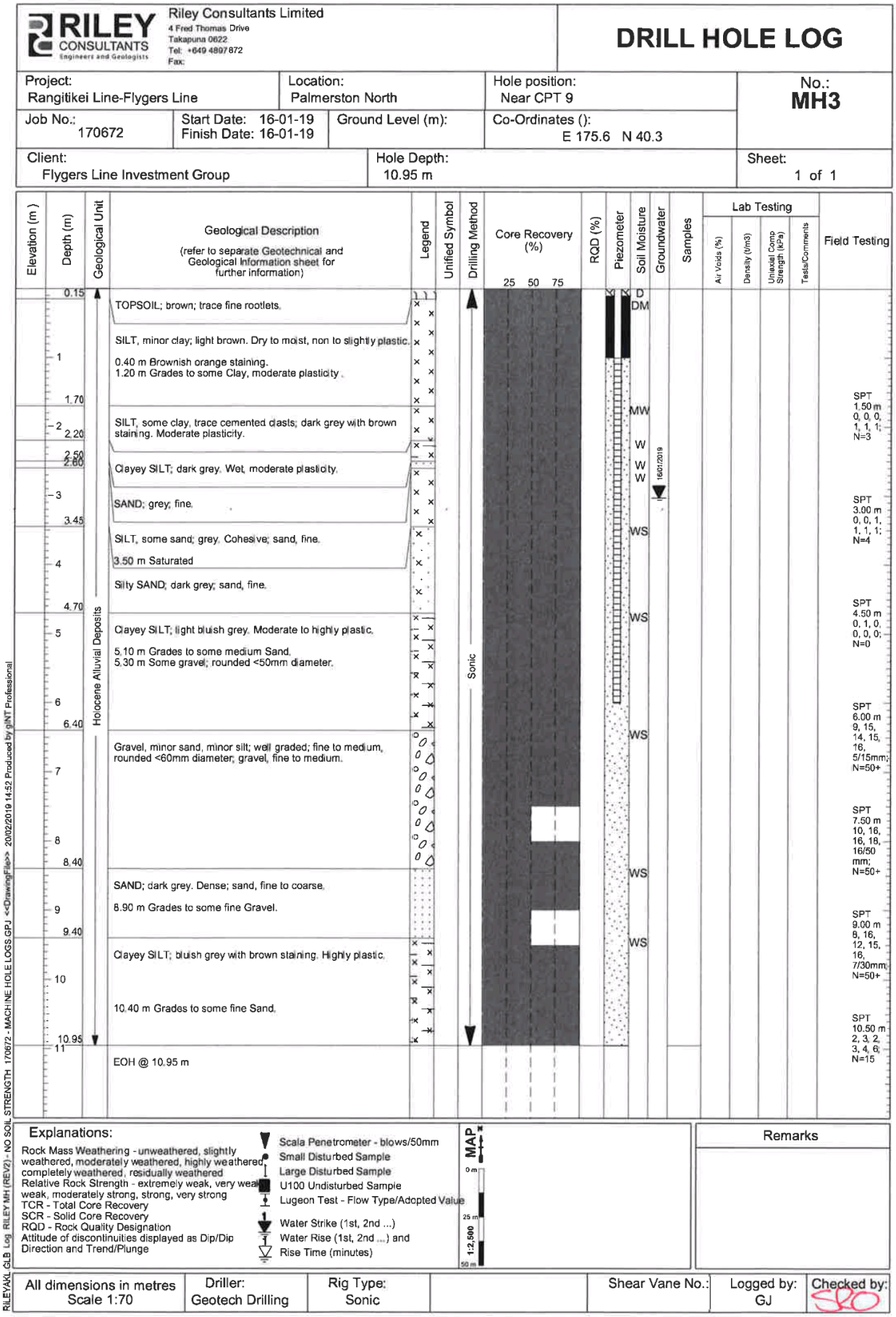
MAP N 0 m 25 m 1:2,500 50 m

Remarks

All dimensions in metres Scale 1:70	Driller: Geotech Drilling	Rig Type: Sonic		Shear Vane No.:	Logged by: GJ	Checked by: SBO

RILEYAKL.GLB Log RILEY MH (REV2) - NO SOIL STRENGTH 170672 - MACHINE HOLE LOGS.GPJ <<DrawingFile>> 20/02/2019 14:52 Produced by gINT Professional


RILEY CONSULTANTS
Engineers and Geologists
Riley Consultants Limited
4 Fred Thomas Drive
Takapuna 0622
Tel: +649 4897872
Fax:
DRILL HOLE LOG
Project: Rangitikei Line-Flygers Line
Location: Palmerston North
Hole position: Near CPT 4
No.: MH2
Job No.: 170672
Start Date: 15-01-19
Finish Date: 15-01-19
Ground Level (m):
Co-Ordinates (): E 175.6 N 40.3
Client: Flygers Line Investment Group
Hole Depth: 10.64 m
Sheet: 1 of 1
Elevation (m)
Depth (m)
Geological Unit
Geological Description
(refer to separate Geotechnical and Geological Information sheet for further information)
Legend
Unified Symbol
Drilling Method
Core Recovery (%)
25 50 75
RQD (%)
Piezometer
Soil Moisture
Groundwater
Samples
Lab Testing
Air Voids (%)
Density (t/m3)
Unixaial Comp Strength (kPa)
Tests/Comments
Field Testing
0.20 TOPSOIL; light grey; slightly plastic; dry.
SILT with some clay; mixed grey and orange. Dry to moist; moderately plastic.
1.70
1.95
2.10 Sandy SILT; grey with trace brownish orange staining. Moist; non-plastic.
Silty fine SAND; dark grey. Moist to wet.
3 SAND with some silt; dark grey.
3.45
Medium SAND; dark grey.
4
5.00
5 SILT; dark grey. Non to slightly plastic.
5.60
Clayey SILT; dark grey. Moderately to highly plstic.
6
6.20
6.50 Gravelly SILT/silty GRAVEL with minor clay; dark greenish grey. Very dense; saturated. Well graded, rounded <50mm dia.
7 Silty GRAVEL with minor sand. Rounded, <70mm dia.
7.90
8
8.30
8.45 GRAVEL with some sand, minor silt. Well graded, rounded <50mm dia.
Sandy fine GRAVEL; bluish grey. Sand, medium to coarse.
9 GRAVEL with some sand and silt; greenish grey. Rounded gravel <60mm dia.
10
10.64
11 EOH @ 10.64 m
Holocene Alluvial Deposits
Sonic
D
DM
M
MW
S
15/01/2019
SPT 1.50 m 0, 2, 2, 1, 1, 2; N=6
SPT 3.00 m 2, 4, 4, 4, 8, 6; N=22
SPT 4.50 m 3, 6, 9, 9, 12, 15; N=45
SPT 6.00 m 0, 2, 5, 13, 18, 14/70mm; N=50+
SPT 7.50 m 9, 12, 15, 16, 7/40mm; N=50+
SPT 9.00 m 19, 19, 16, 19, 15/65mm; N=50+
SPT 10.50 m 22, 28/70mm; N=50+
Explanations:
Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge
Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and
Rise Time (minutes)
MAP
0 m
25 m
1:2,500
50 m
Remarks
All dimensions in metres
Scale 1:70
Driller: Garry - Geotech Drilling
Rig Type: Sonic
Shear Vane No.:
Logged by: GJ
Checked by:
RILEYAKL.GLB Log RILEY MH (REV2) - NO SOIL STRENGTH 170672 - MACHINE HOLE LOGS.GPJ <<DrawingFile>> 20/02/2019 14:52 Produced by gINT Professional


RILEY CONSULTANTS
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Fax:
DRILL HOLE LOG
Project: Rangitikei Line-Flygers Line
Location: Palmerston North
Hole position: Near CPT 9
No.: MH3
Job No.: 170672
Start Date: 16-01-19
Finish Date: 16-01-19
Ground Level (m):
Co-Ordinates (): E 175.6 N 40.3
Client: Flygers Line Investment Group
Hole Depth: 10.95 m
Sheet: 1 of 1
Elevation (m)
Depth (m)
Geological Unit
Geological Description
(refer to separate Geotechnical and Geological Information sheet for further information)
Legend
Unified Symbol
Drilling Method
Core Recovery (%)
25 50 75
RQD (%)
Piezometer
Soil Moisture
Groundwater
Samples
Lab Testing
Air Voids (%)
Density (t/m3)
Uniaxial Comp Strength (kPa)
Tests/Comments
Field Testing
0.15
TOPSOIL; brown; trace fine rootlets.
SILT, minor clay; light brown. Dry to moist, non to slightly plastic.
0.40 m Brownish orange staining.
1.20 m Grades to some Clay, moderate plasticity.
1.70
SILT, some clay, trace cemented clasts; dark grey with brown staining. Moderate plasticity.
2.20
2.50
2.60
Clayey SILT; dark grey. Wet, moderate plasticity.
SAND; grey; fine.
3.45
SILT, some sand; grey. Cohesive; sand, fine.
3.50 m Saturated
Silty SAND; dark grey; sand, fine.
4.70
Clayey SILT; light bluish grey. Moderate to highly plastic.
5.10 m Grades to some medium Sand.
5.30 m Some gravel; rounded <50mm diameter.
6.40
Gravel, minor sand, minor silt; well graded; fine to medium, rounded <60mm diameter; gravel, fine to medium.
8.40
SAND; dark grey. Dense; sand, fine to coarse.
8.90 m Grades to some fine Gravel.
9.40
Clayey SILT; bluish grey with brown staining. Highly plastic.
10.40 m Grades to some fine Sand.
10.95
EOH @ 10.95 m
Holocene Alluvial Deposits
Sonic
D
DM
MW
W
W
W
WS
WS
WS
WS
WS
16/01/2019
SPT 1.50 m 0, 0, 0, 1, 1, 1; N=3
SPT 3.00 m 0, 0, 1, 1, 1, 1; N=4
SPT 4.50 m 0, 1, 0, 0, 0, 0; N=0
SPT 6.00 m 9, 15, 14, 15, 16, 5/15mm; N=50+
SPT 7.50 m 10, 16, 16, 18, 16/50 mm; N=50+
SPT 9.00 m 8, 16, 12, 15, 16, 7/30mm; N=50+
SPT 10.50 m 2, 3, 2, 3, 4, 6; N=15
Explanations:
Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative Rock Strength - extremely weak, very weak, weak, moderately strong, strong, very strong
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Attitude of discontinuities displayed as Dip/Dip Direction and Trend/Plunge
Scala Penetrometer - blows/50mm
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Lugeon Test - Flow Type/Adopted Value
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and
Rise Time (minutes)
MAP
0 m
25 m
1:2,500
50 m
Remarks
All dimensions in metres
Scale 1:70
Driller: Geotech Drilling
Rig Type: Sonic
Shear Vane No.:
Logged by: GJ
Checked by:
RILEYAKL GLB Log RILEY MH (REV2) - NO SOIL STRENGTH 170672 - MACHINE HOLE LOGS.GPJ <<DrawingFile>> 20/02/2019 14:52 Produced by gINT Professional

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HAND AUGER LOG

Project: Rangitikei Line-Flygers Line	Location: Palmerston North	Hole position: Northwestern corner of site	No.: HA1
Job No.: 170672	Start Date: 28-06-18 Finish Date: 28-06-18	Ground Level (m):	Co-Ordinates ():
Client: Flygers Line Investment Group	Hole Depth: 1.00 m		Sheet: 1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; Silt; grey; roots; NVO.						D	1	
	0.35	Holocene Alluvial Deposits	SILT, some clay; light grey and orange. Wet, moderately plastic; NVO.						W	2	
	0.80		SILT, minor clay; light grey and orange mixed. Wet, slightly plastic.						W		
	0.90		Silty SAND; grey. Saturated, non plastic; NVO.					▼	S	3	
	1.00		EOH @ 1.00 m								

Explanations:
Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER
- [ ] None
- [X] Slow Seep (depth 0.9 m)
- [ ] Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks
NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Near western boundary	**HA2**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	28-06-18 / 28-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; Silt; grey. Moist, non plastic; NVO.						D	4	
	0.35	Holocene Alluvial Deposits	SILT, trace to minor clay; grey with orange staining. Moist to wet, slightly plastic; NVO.						MW	5	
	0.50		SILT with minor clay; greyish orange. Moist to wet, slightly plastic; NVO.						MW		
	0.80		SILT with trace fine sand; greyish orange. Wet, non plastic; NVO.						W		
	0.95		Silty SAND; grey. Saturated, non plastic; NVO.						S	6	
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Southwestern portion of site	HA3

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	28-06-18 / 28-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; grey. Silt, rootlets. Moist, non plastic; NVO.						M	7	
	0.30	Holocene Alluvial Deposits	SILT, trace clay; light grey and orange mixed. Moist, slightly plastic; NVO.						M	8	
			0.70 m Wet.								
	0.90		Silty SAND; grey. Saturated; NVO.						S	9	
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central portion of site	HA4

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	Start Date: 28-06-18 Finish Date: 28-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
	0.25	Holocene Alluvial Deposits	TOPSOIL; light grey. Moist; NVO.						M		
	0.60		SILT, trace clay; light grey with orange staining. Moist, non to slightly plastic; NVO.						M		
	0.90		SILT, minor clay, minor sand; light grey and orange. Moist, slightly plastic; NVO.						M		
	1.00		SILT, minor fine sand, trace clay; grey. Wet, non to slightly plastic; NVO.						W		
			EOH @ 1.00 m								

Explanations:
Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered
Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense
Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample
Scala Penetrometer - blows/50mm
Permeability Test
Schmidt Hammer
Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER
- None
- Slow Seep (depth)
- Rapid Inflow (depth)

HOLE TERMINATED DUE TO:
Target Depth

Remarks
NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central portion of site	**HA5**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	28-06-18 / 28-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; grey, roots. Moist; NVO.						M		
	0.30	Holocene Alluvial Deposits	SILT, minor clay, trace sand; light grey with orange staining. Moist, slightly plastic; NVO.						M		
			0.90 m Grades to mixed grey and brown; wet.								
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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HAND AUGER LOG

Project: Rangitikei Line-Flygers Line	Location: Palmerston North	Hole position: Central site near Flygers Line	No.: HA7
Job No.: 170672	Start Date: 29-06-18 Finish Date: 29-06-18	Ground Level (m):	Co-Ordinates ():
Client: Flygers Line Investment Group	Hole Depth: 1.00 m		Sheet: 1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; silt; grey. Moist, non plastic; NVO.						M		
	0.25		SILT, trace clay, trace sand; grey. Moist, non plastic; NVO.						M		
	0.50	Holocene Alluvial Deposits	SILT, minor clay; light greyish orange. Moist to wet, slightly plastic; NVO.						MW		
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central site	**HA8**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; grey. Moist; NVO.						M	10	
	0.25	Holocene Alluvial Deposits	SILT, minor clay; light grey with light orange. Moist, slightly plastic; NVO.						M	11	
	0.60		SILT, minor to some clay; greyish orange mixed. Moist to wet, slightly plastic.						MW		
	0.85		SILT, minor sand, trace clay; light greyish orange. Wet; NVO.						W	12	
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

Small Disturbed Sample
Large Disturbed Sample
U100 Undisturbed Sample

Scala Penetrometer - blows/50mm
Permeability Test
Schmidt Hammer
Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
Water Strike (1st, 2nd ...)
Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO:
Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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HAND AUGER LOG

Project: Rangitikei Line-Flygers Line	Location: Palmerston North	Hole position: Southern portion of site	No.: HA9
Job No.: 170672	Start Date: 29-06-18 Finish Date: 29-06-18	Ground Level (m):	Co-Ordinates ():
Client: Flygers Line Investment Group	Hole Depth: 1.00 m		Sheet: 1 of 1

Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Soil Moisture	Samples
0.25	Holocene Alluvial Deposits	TOPSOIL; grey. Moist, non plastic. NVO.	M	13
0.70		SILT, trace sand; light grey with orange staining. Moist, non plastic; NVO.	M	14
1.00		Silty SAND; grey. Saturated, non plastic; NVO.	S	15
		EOH @ 1.00 m		

Soil Shear Strength (kPa): 50 100 150 200
Scala Penetrometer (blows / 50 mm): 3 6 9 12 15
Groundwater

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- [ ] None
- [X] Slow Seep (depth 0.8 m)
- [ ] Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Northern corner of site	**HA10**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; grey. Moist, non plastic; NVO.						M		
	0.20										
		Holocene Alluvial Deposits	SILT, trace clay; Moist, slightly plastic; NVO.						M		
	0.60										
			SILT, minor clay, trace grit; grey and brownish orange mix. Moist, moderately plastic; NVO.						M		
	1.00										
-1			EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO:
Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

RILEYAKL.GLB Log RILEY HA (AKL) NO MAP 170672 - MACHINE HOLE LOGS.GPJ <<DrawingFile>> 22/02/2019 12:44 Produced by gINT Professional

Riley Consultants Limited
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Takapuna 0622
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Fax: +649 4897873

HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central northeastern boundary	**HA11**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; grey. Moist, non plastic.						M		
	0.25										
		Holocene Alluvial Deposits	SILT, trace clay; light grey and orange. Moist, slightly plastic; NVO.						M		
	0.70										
			SILT, some clay; greyish orange mixed. Moist to wet, moderately plastic; NVO.						MW		
	1.00										
			EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Eastern portion of site near sheds	HA12

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
	0.20	Holocene Alluvial Deposits	TOPSOIL; dark grey. Moist, non plastic; NVO.						M		
	0.50		SILT, trace clay, trace sand; light grey. Moist, non plastic; NVO.						M		
	0.90		Sandy SILT; light grey. Wet, non plastic; NVO.						W		
	1.00		SILT, some clay; light grey. Saturated, moderately plastic; NVO.						S		
	1		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- None
- Slow Seep (depth)
- Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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RILEY CONSULTANTS Engineers and Geologists

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HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central northern portion of site	**HA13**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; grey. Moist; NVO.						M	16	
	0.30	Holocene Alluvial Deposits	SILT, minor clay, trace sand; grey and orange mixed. Moist, slightly plastic; NVO.						M	17	
			0.80 m Grades to minor to some clay, trace grit; grey brownish orange mixed. Moist, slightly plastic; NVO.							18	
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...) and Rise Time (minutes)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO:
Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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HAND AUGER LOG

Project:	Location:	Hole position:	No.:
Rangitikei Line-Flygers Line	Palmerston North	Central site	**HA14**

Job No.:	Start Date: / Finish Date:	Ground Level (m):	Co-Ordinates ():
170672	29-06-18 / 29-06-18		

Client:	Hole Depth:	Sheet:
Flygers Line Investment Group	1.00 m	1 of 1

Elevation (m)	Depth (m)	Geological Unit	Geological Description (refer to separate Geotechnical and Geological Information sheet for further information)	Legend	Unified Symbol	Soil Shear Strength (kPa) 50 100 150 200	Scala Penetrometer (blows / 50 mm) 3 6 9 12 15	Groundwater	Soil Moisture	Samples	Tests
			TOPSOIL; NVO.							19	
	0.20	Holocene Alluvial Deposits	SILT, trace clay; light grey and orange. Moist, non plastic; NVO.						M	20	
	0.90		Silty SAND; brownish orange grey. Wet to saturated; NVO.						WS	21	
	1.00		EOH @ 1.00 m								

Explanations:

Rock Mass Weathering - unweathered, slightly weathered, moderately weathered, highly weathered, completely weathered, residually weathered

Relative soil Strength - very soft/very loose, soft/loose, firm/medium dense, stiff/dense, very stiff/very dense

- Small Disturbed Sample
- Large Disturbed Sample
- U100 Undisturbed Sample
- Scala Penetrometer - blows/50mm
- Permeability Test
- Schmidt Hammer
- Insitu Vane Shear Strength (kPa) V=Peak, R=Residual, UTP=Unable to penetrate
- Water Strike (1st, 2nd ...)
- Water Rise (1st, 2nd ...) and Rise Time (minutes)

GROUNDWATER

- ☐ None
- ☐ Slow Seep (depth)
- ☐ Rapid Inflow (depth)

HOLE TERMINATED DUE TO: Target Depth

Remarks

NVO - No Visual or Olfactory Contamination was observed.

All dimensions in metres Scale 1:9		Shear Vane No.	Logged by: GJ	Checked by: GJ

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APPENDIX B

Laboratory Test Results

PLASTICITY INDEX TEST REPORT

WSP OPUS

Project:	**Rangitikie Line**
Location:	**Rangitikie Line**
Client:	**Riley Consultants Ltd**
Contractor:	**Not Stated**
Sampled by:	**Not Stated**
Sampling method:	**Not Stated**
Sample description:	**Brownish Grey; silty CLAY**
Sample condition:	**As Received**
Sample reference:	**MH3**
Sample depth:	**2.1m**

Date sampled: **Not Stated**

Project number:	**1-LA014.00**
Lab ref number:	**AL3490/1**
Client ref number:	**170672**
Folder number:	**-**

Test Results

As rec'd water content:	**45.0%**
Liquid limit:	**69**
Plastic limit:	**27**
Plasticity Index:	**42**

Test methods		Notes
Water Content:	NZS 4402 : 1986, Test 2.1	Test performed on: Fraction passing 0.425mm test sieve
Liquid Limit:	NZS 4402 : 1986, Test 2.2	Sample descriptions are not covered by IANZ accreditation.
Plastic Limit:	NZS 4402 : 1986, Test 2.3	
Plasticity Index:	NZS 4402 : 1986, Test 2.4	

Date tested: 05/02/19
Date reported: 08/02/2019

Sampling is not covered by IANZ Accreditation. Results apply only to sample tested.
This report may only be reproduced in full

IANZ Approved Signatory
Thirushen Pillay
Designation: *Senior Civil Engineering Technician*
Date: 08/02/2019

IANZ ACCREDITED LABORATORY
Tests indicated as not accredited are outside the scope of the laboratory's accreditation

WSP Opus
Auckland Laboratory
Quality Management Systems Certified to ISO 9001

7A Ride Way, Albany
Private Bag 101982, NS Mail Centre, North Shore City 0745, New Zealand

Telephone +64 9 415 4660
Website www.wsp-opus.co.nz

APPENDIX C

Liquefaction Outputs

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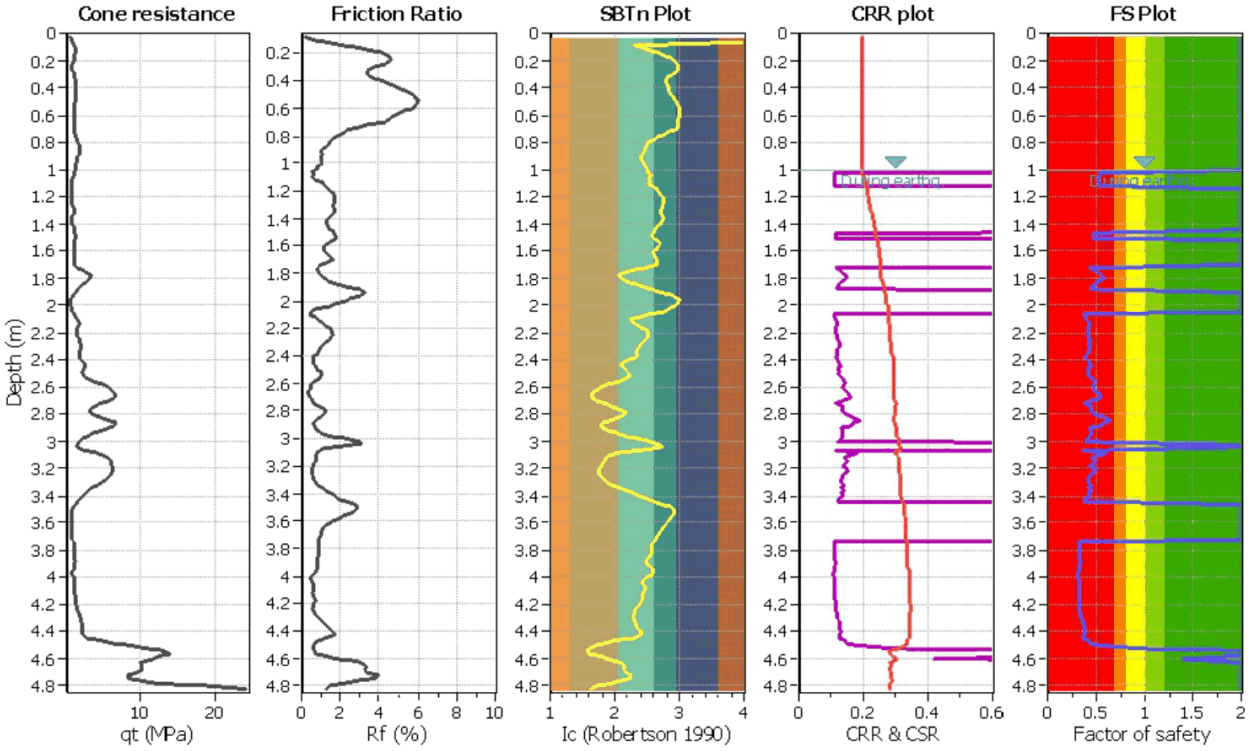
LIQUEFACTION ANALYSIS REPORT

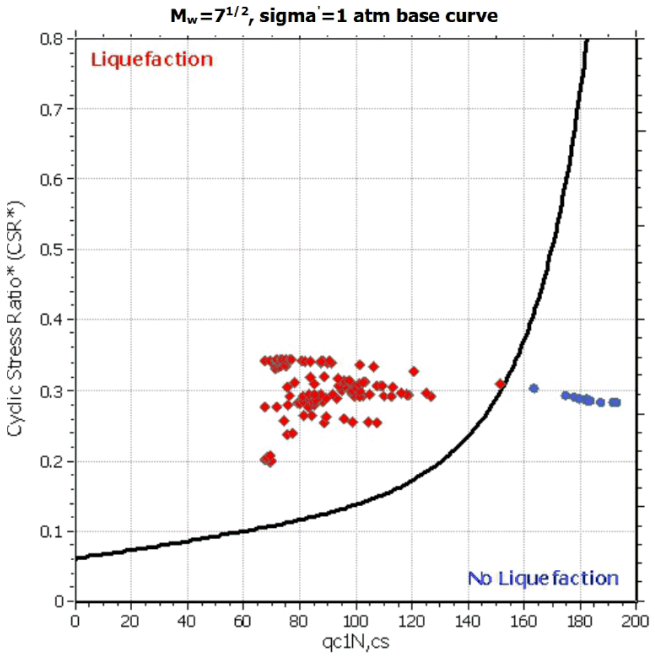
Project title : 170672 **Location : Flygers Line**

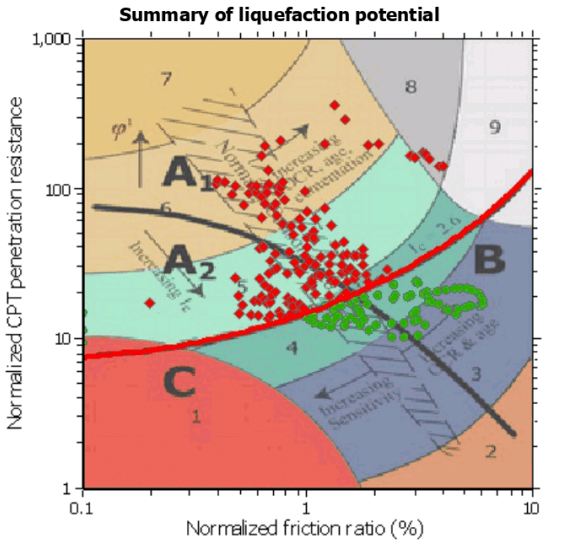
CPT file : CPT01

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

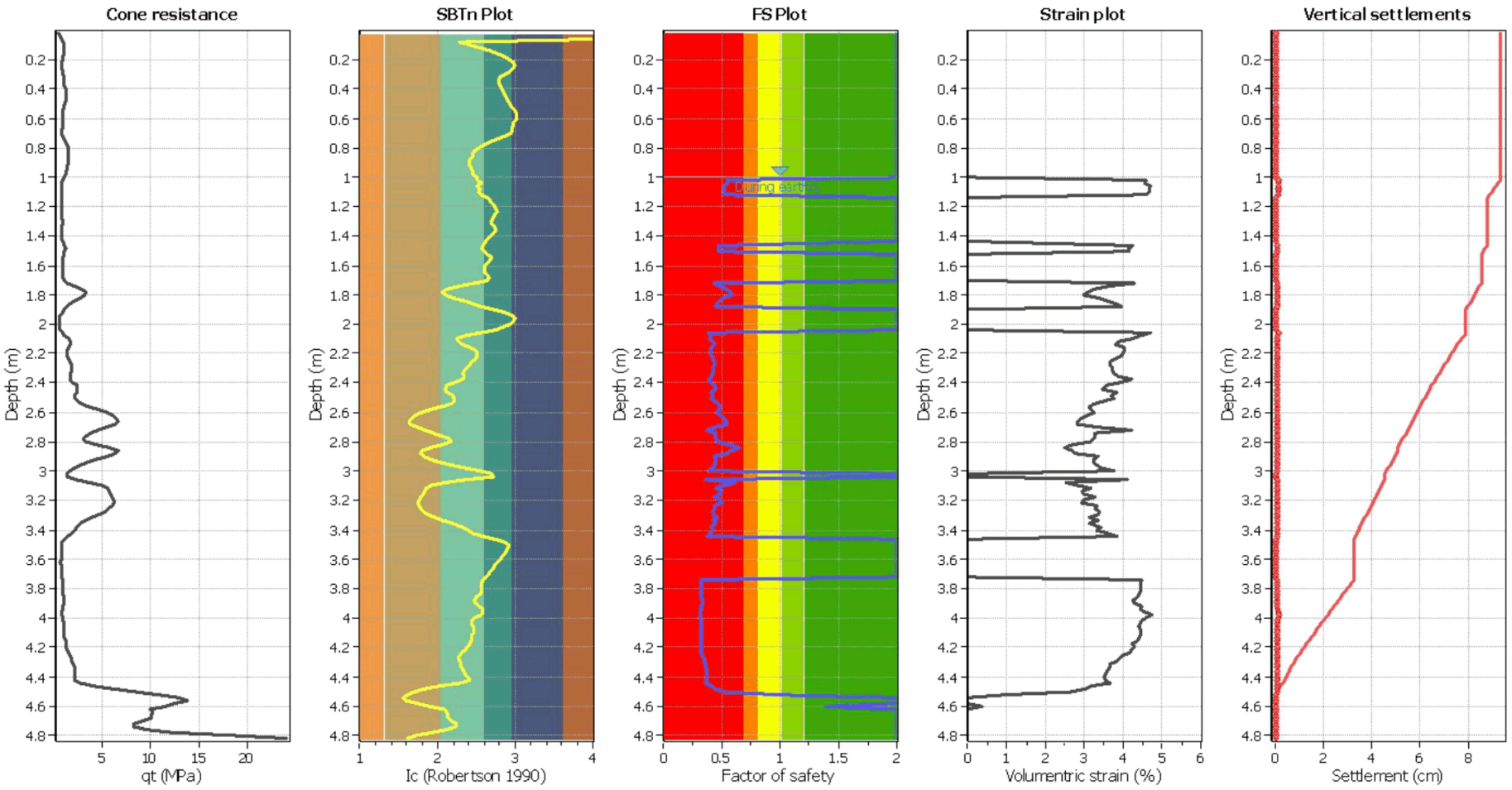






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

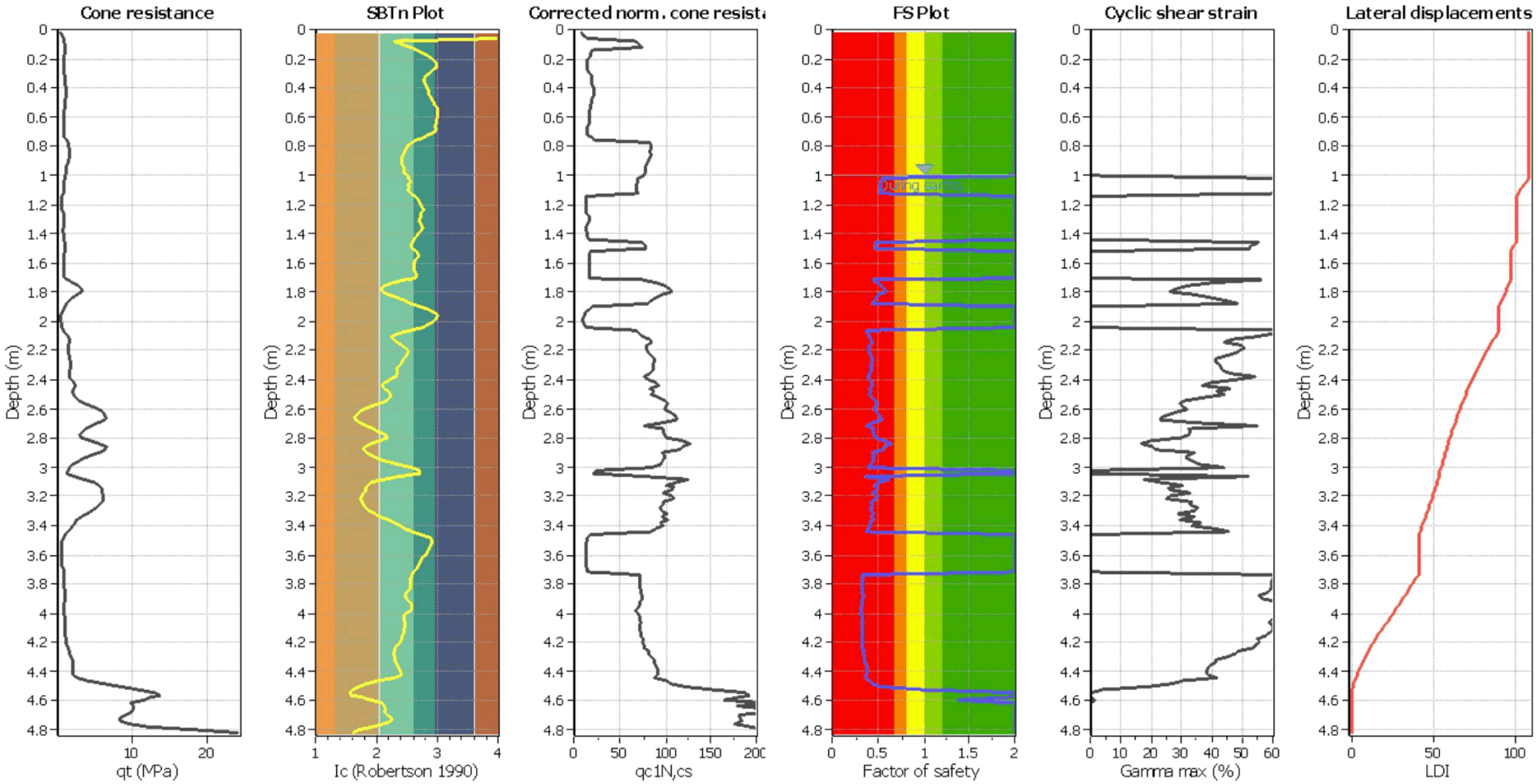
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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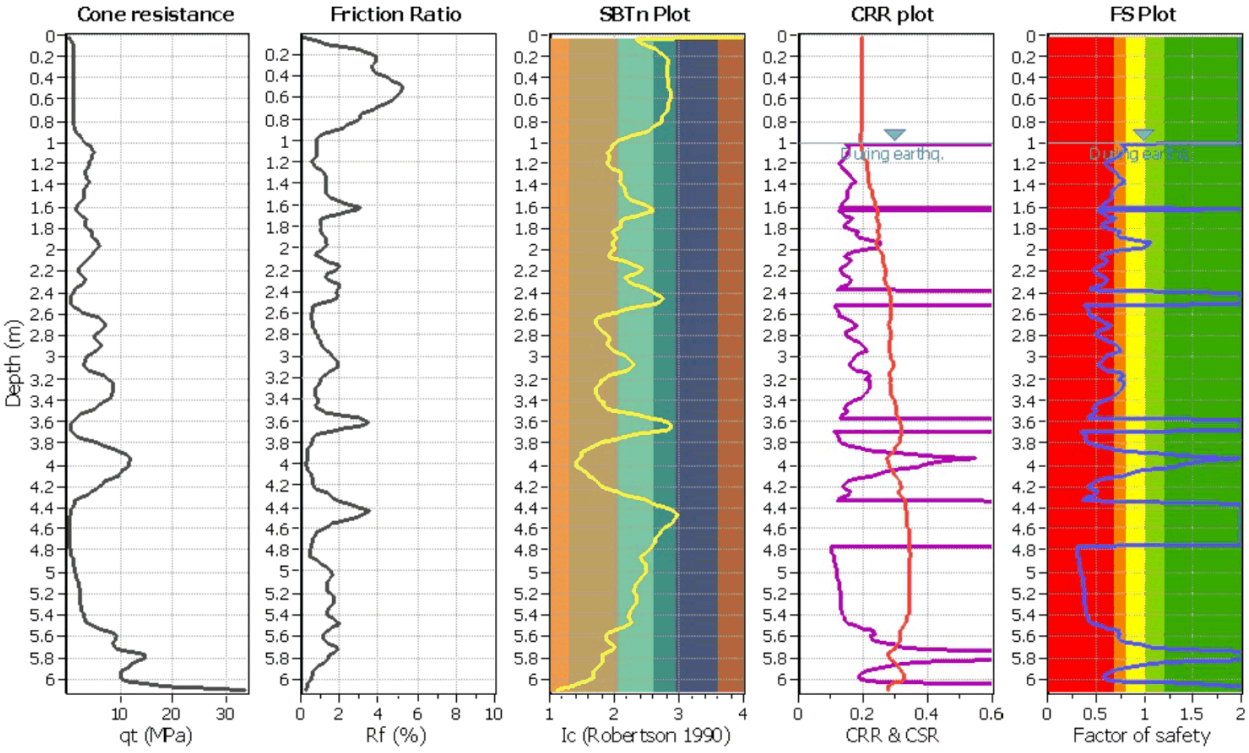
LIQUEFACTION ANALYSIS REPORT

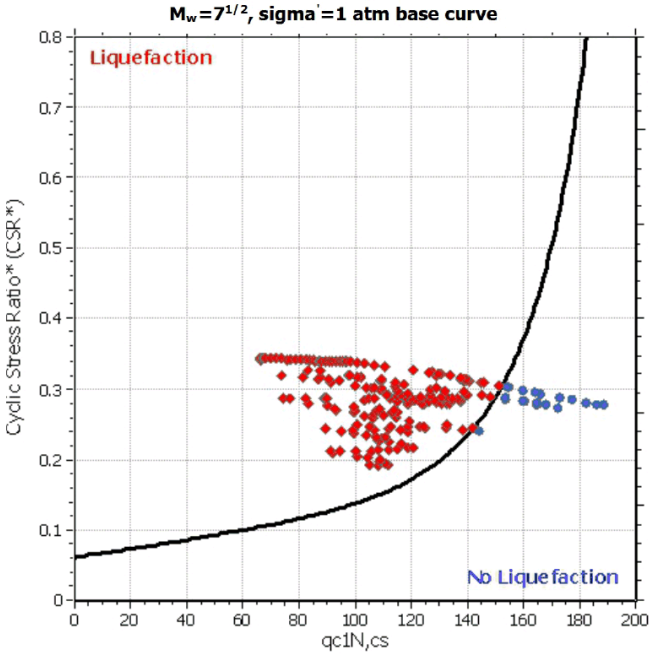
Project title : 170672 **Location : Flygers Line**

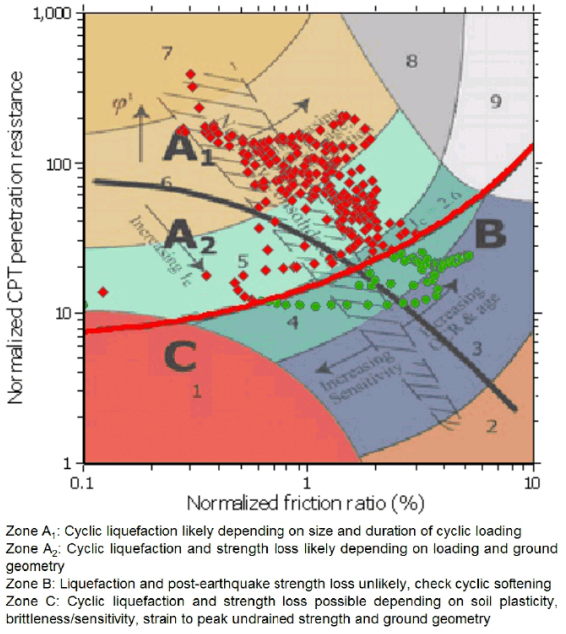
CPT file : CPT02

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

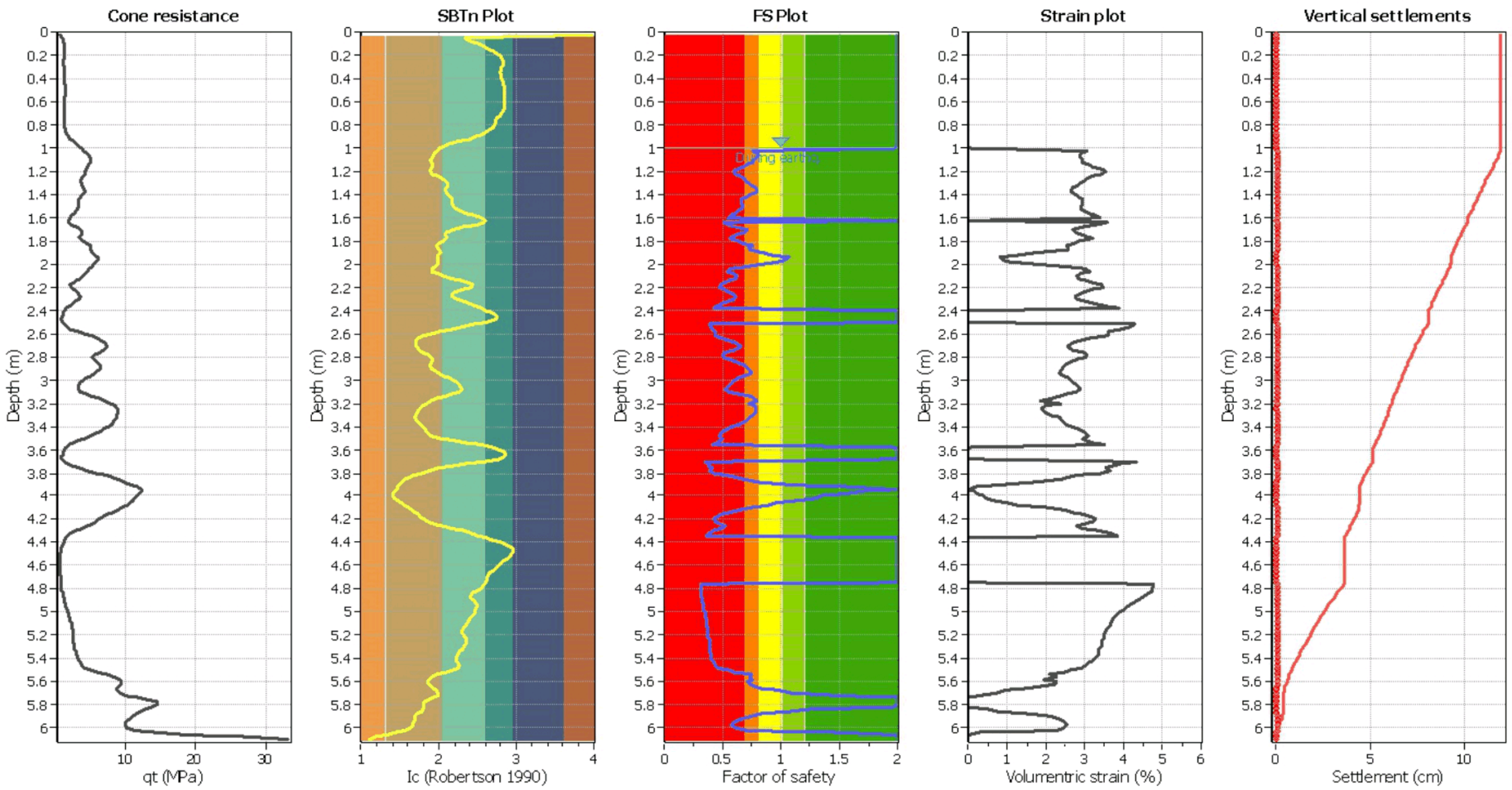






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

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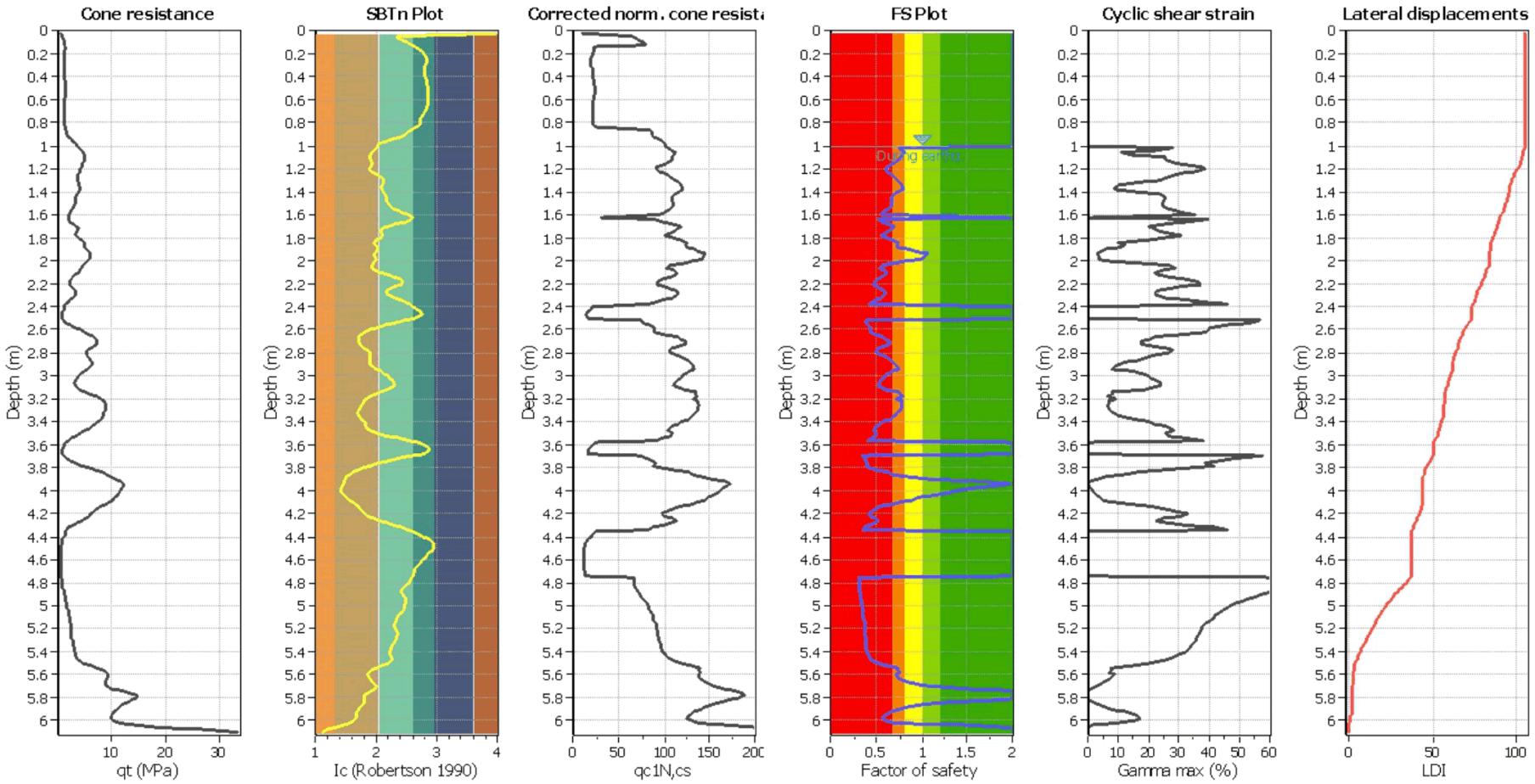
Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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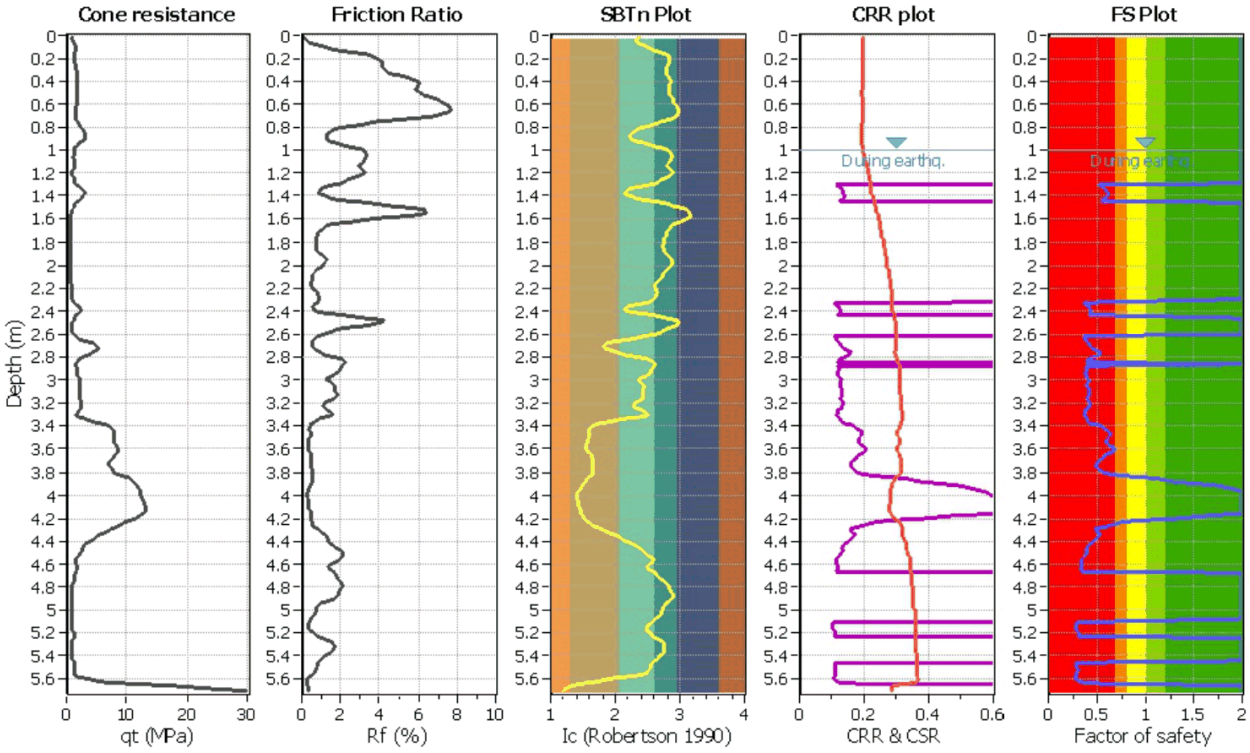
LIQUEFACTION ANALYSIS REPORT

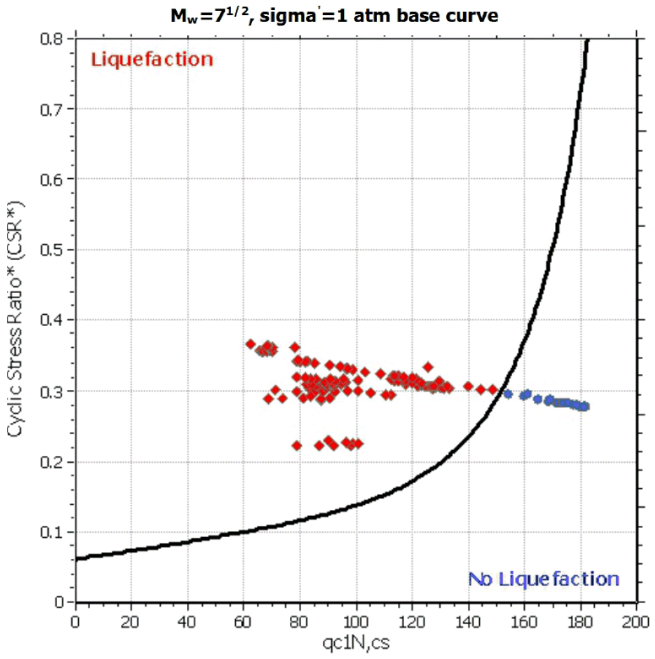
Project title : 170672 **Location : Flygers Line**

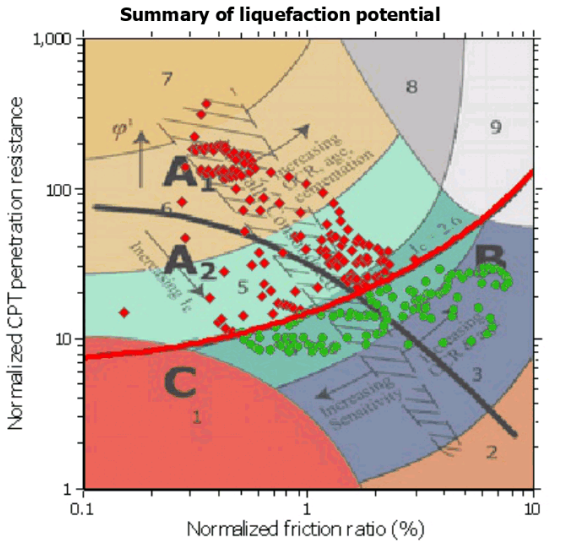
CPT file : CPT03

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

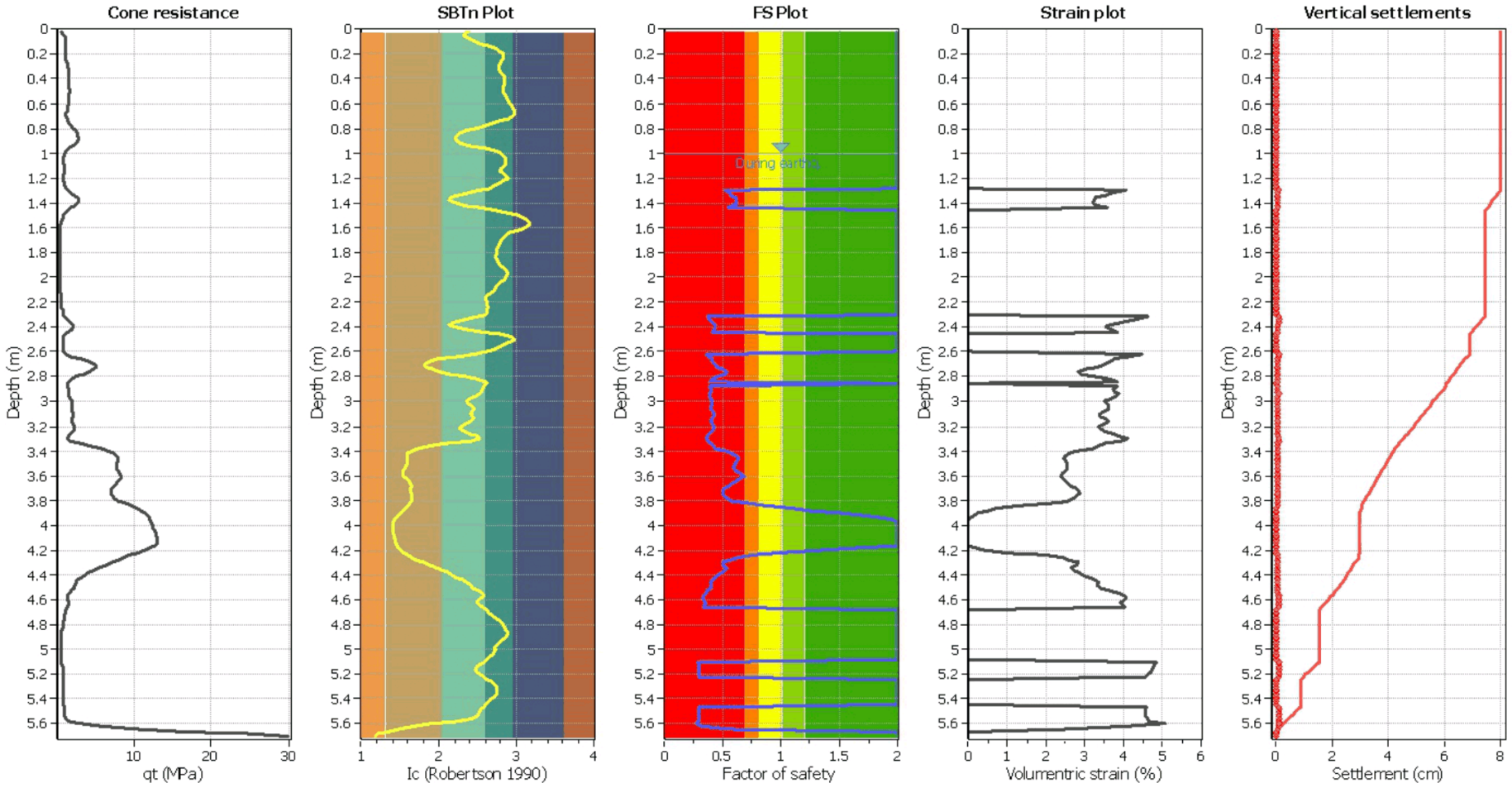






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

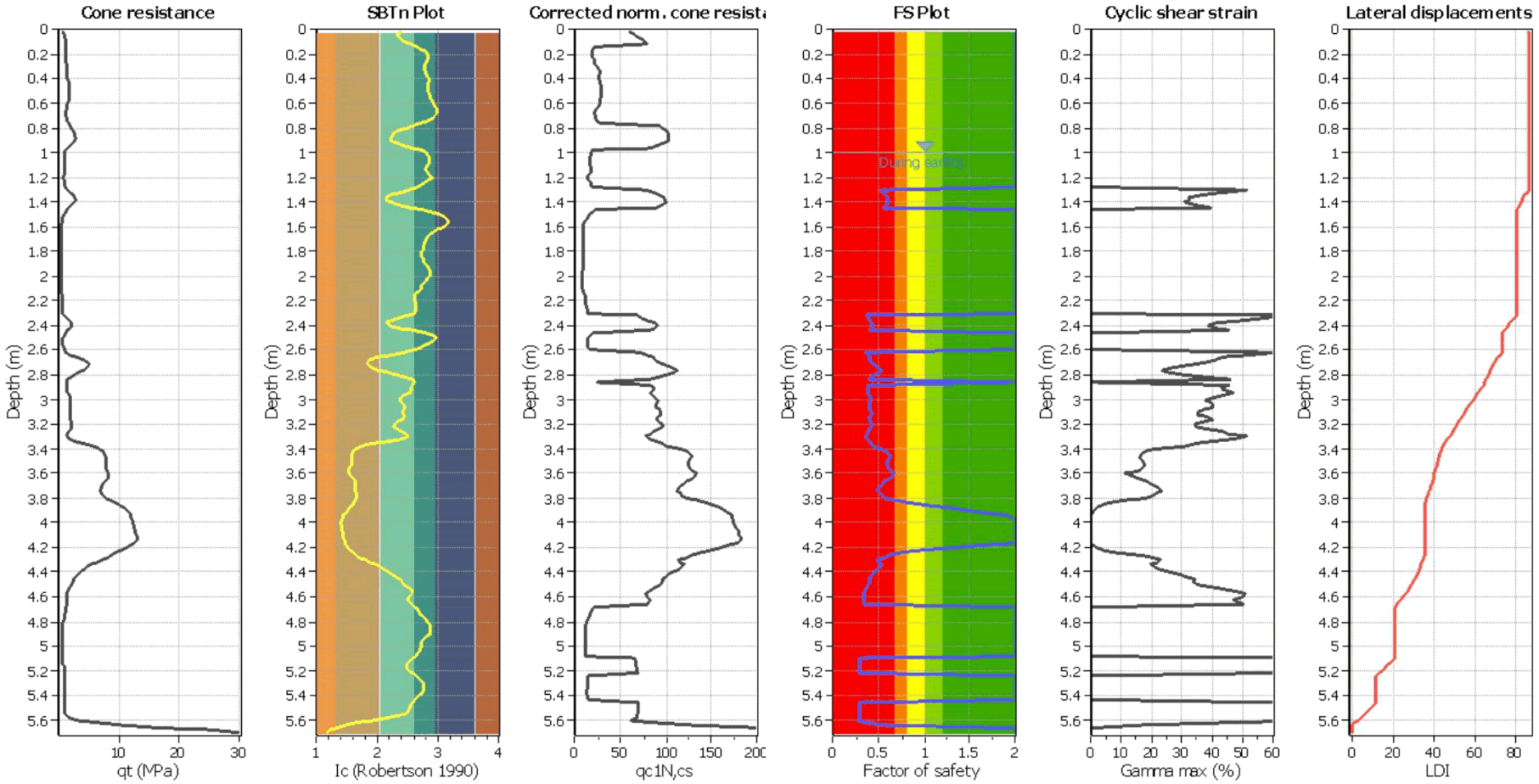
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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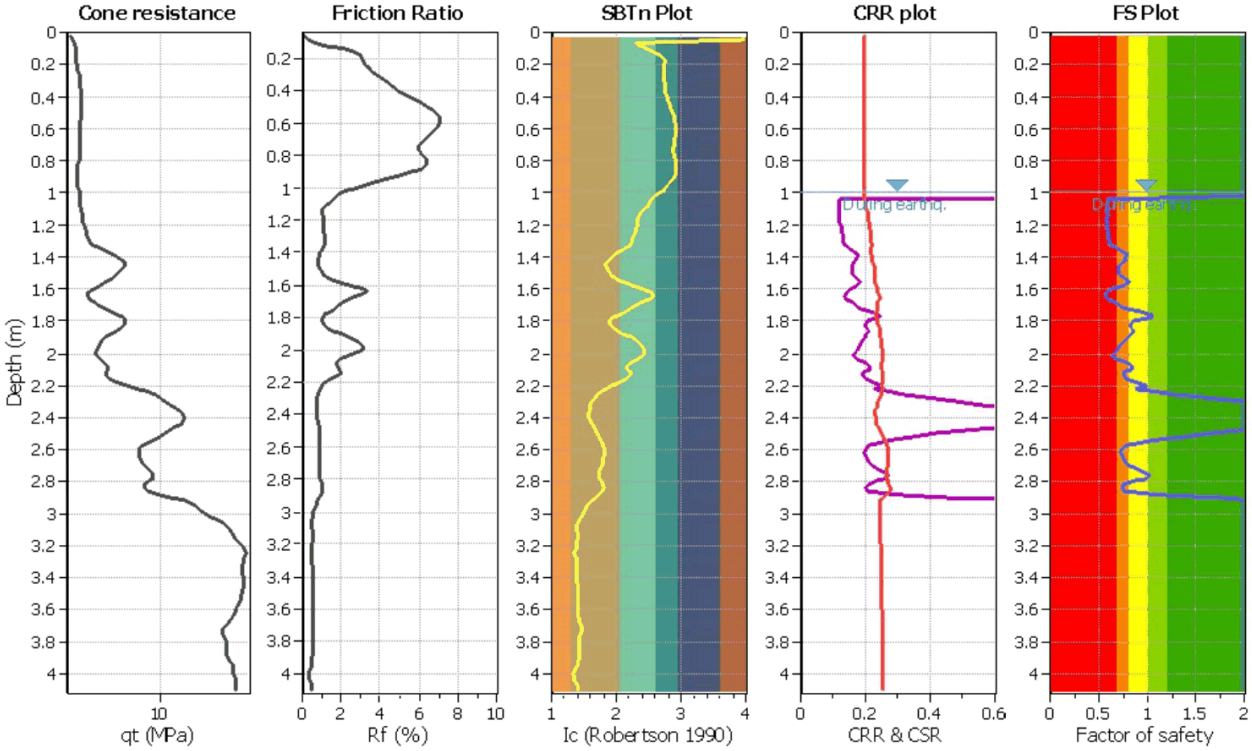
LIQUEFACTION ANALYSIS REPORT

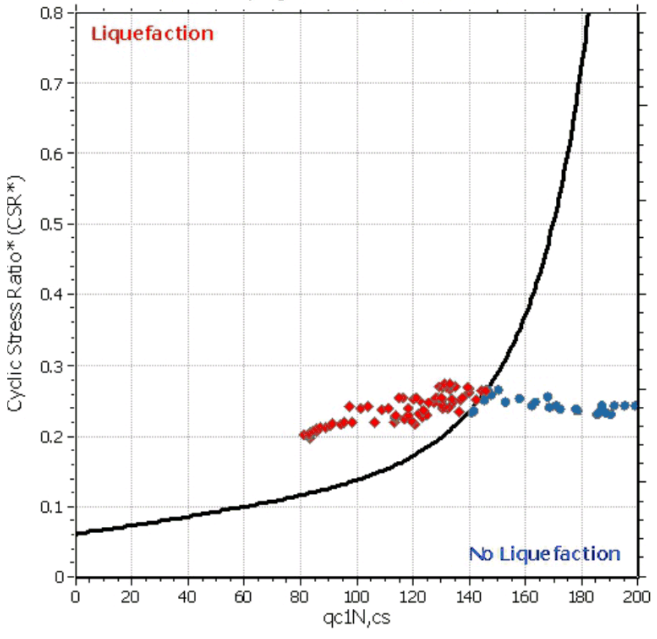
Project title : 170672 **Location : Flygers Line**

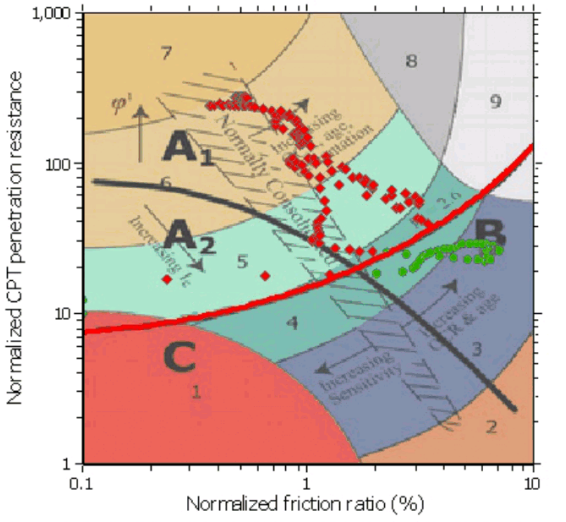
CPT file : CPT04

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

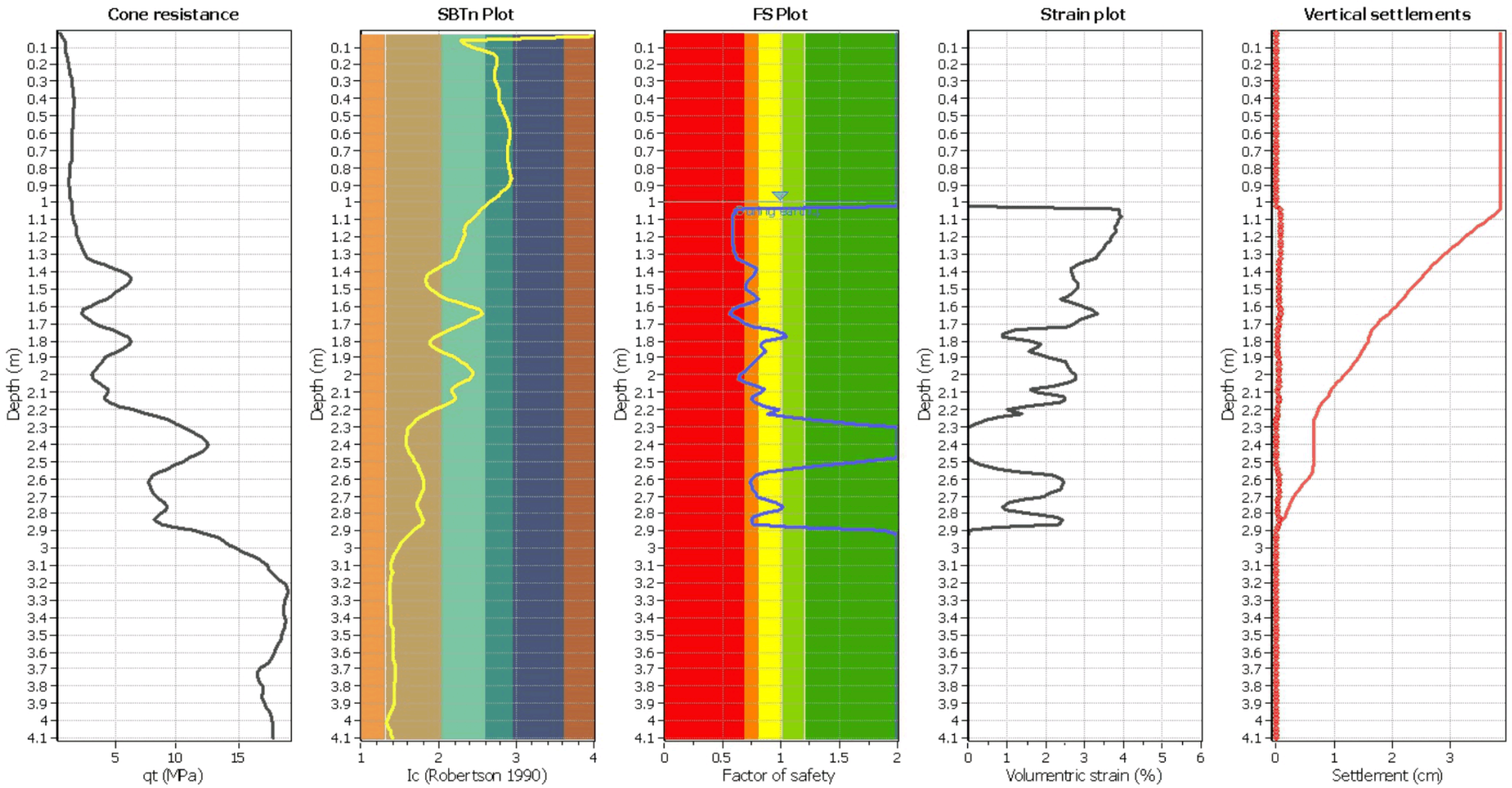






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

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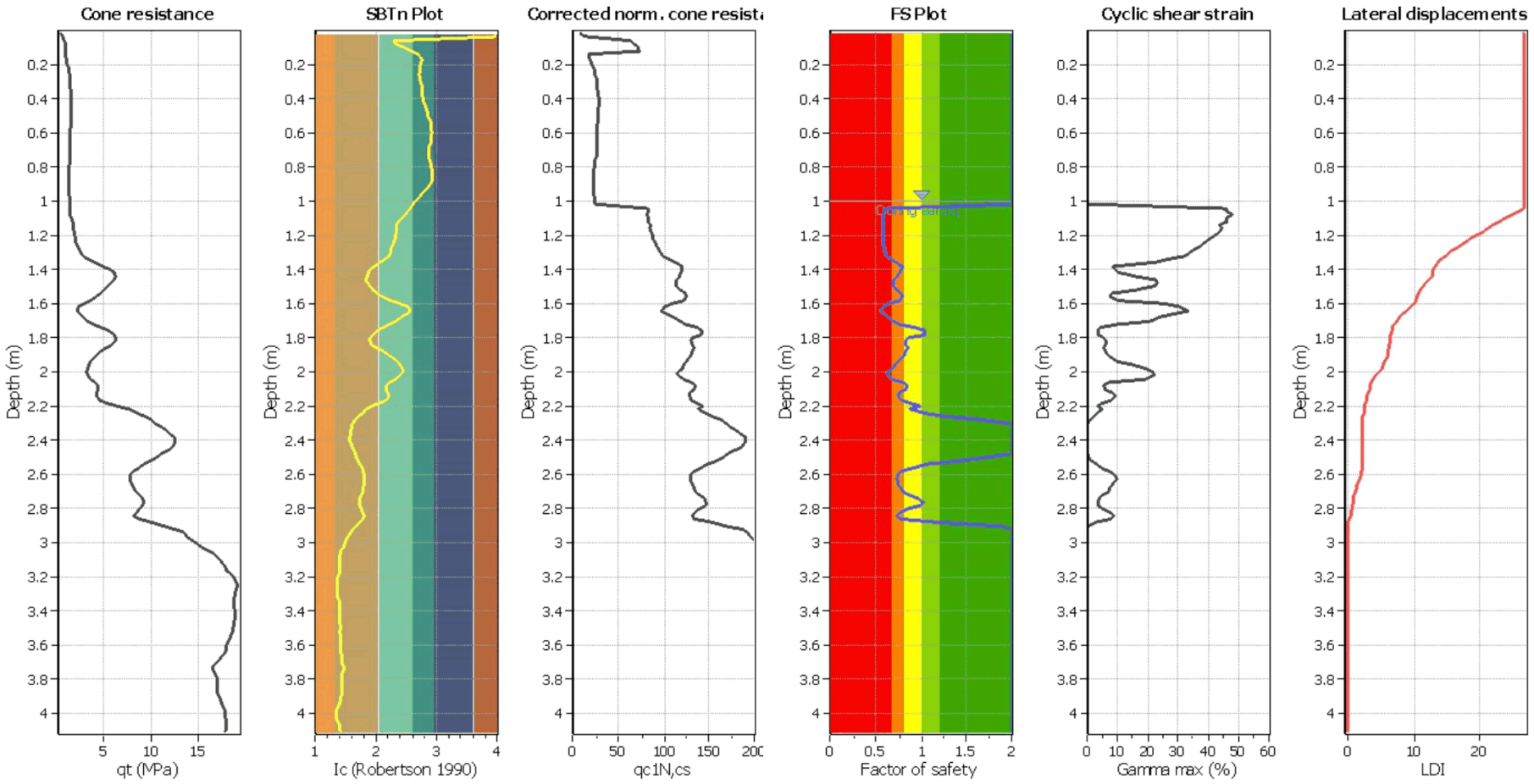
Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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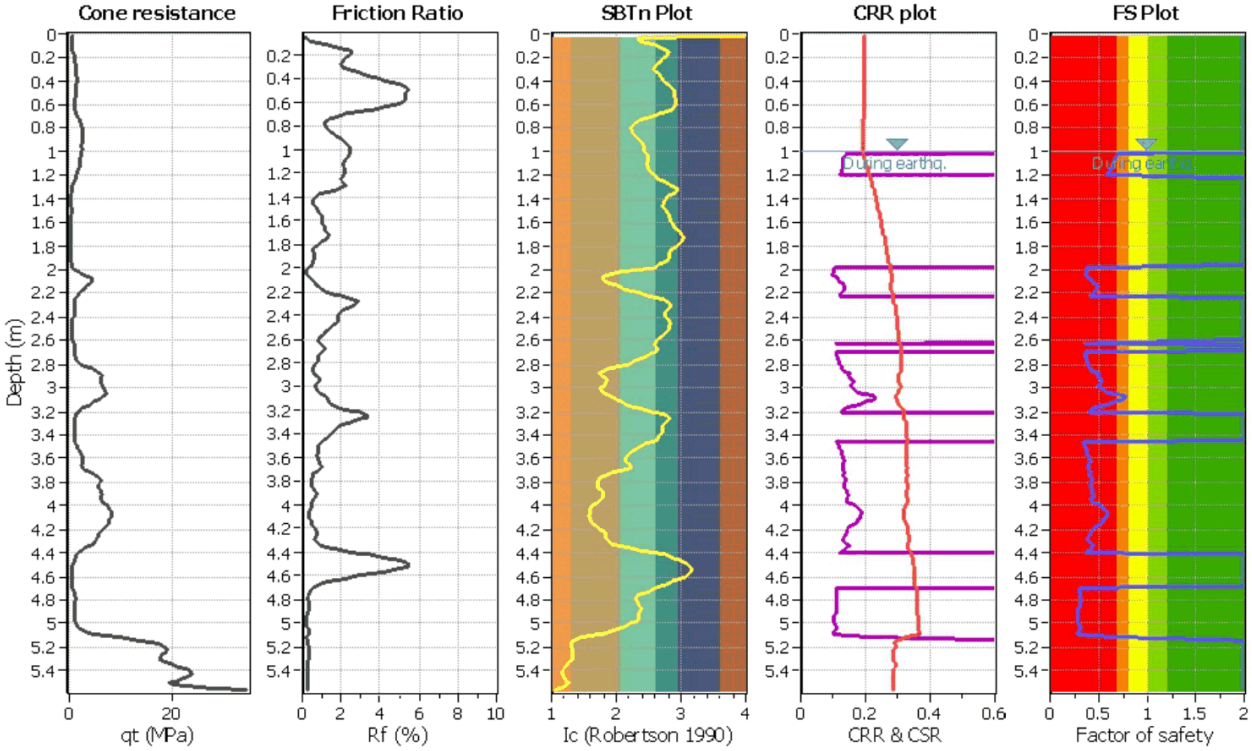
LIQUEFACTION ANALYSIS REPORT

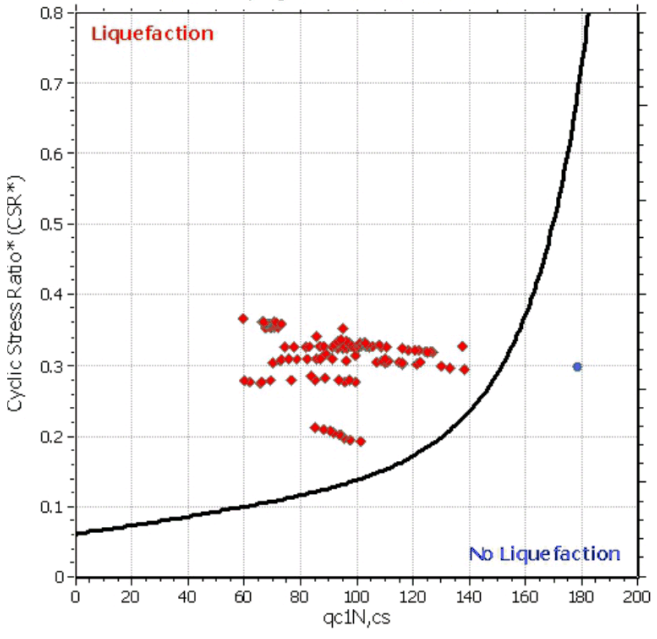
Project title : 170672 **Location : Flygers Line**

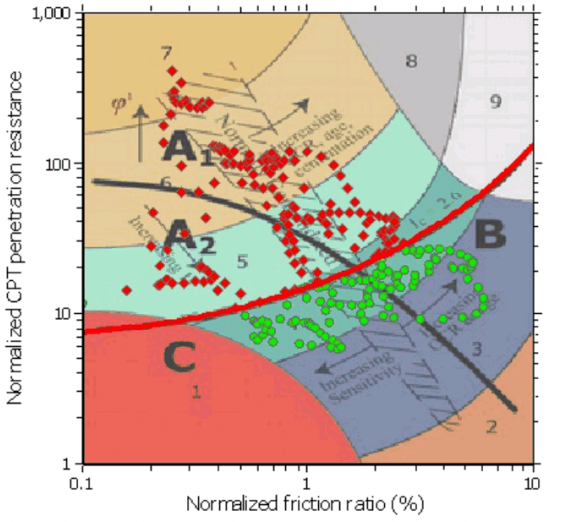
CPT file : CPT05

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

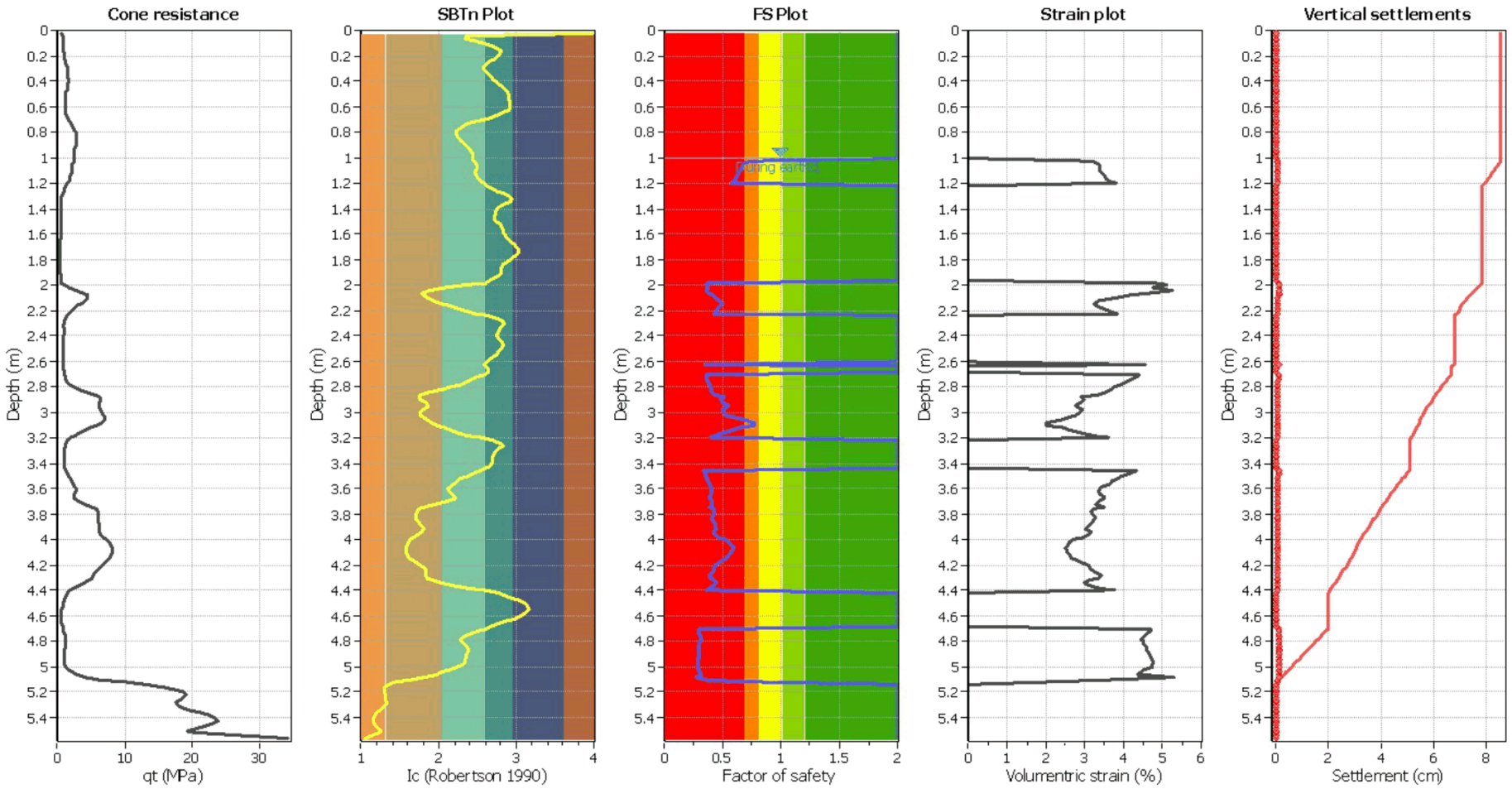






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

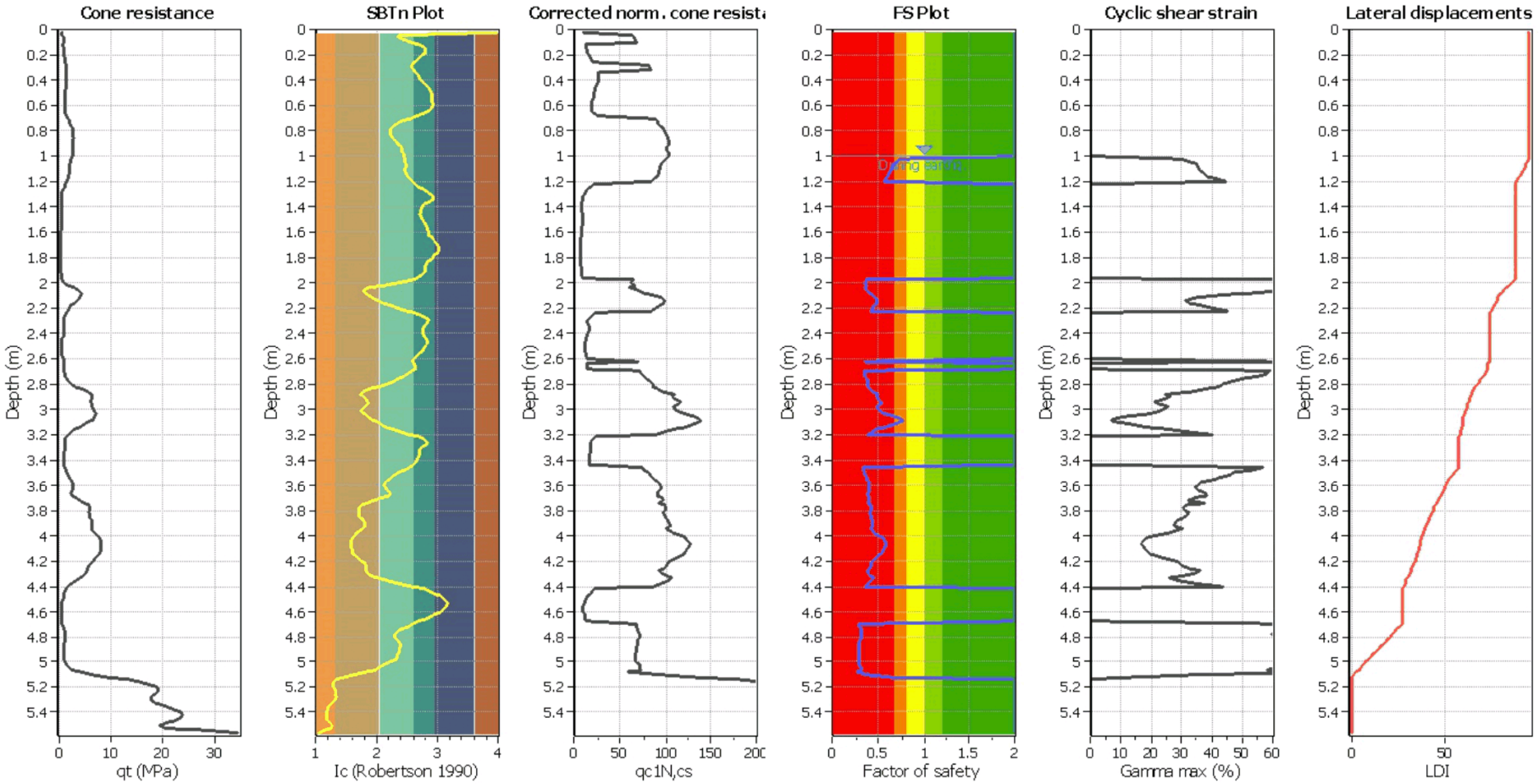
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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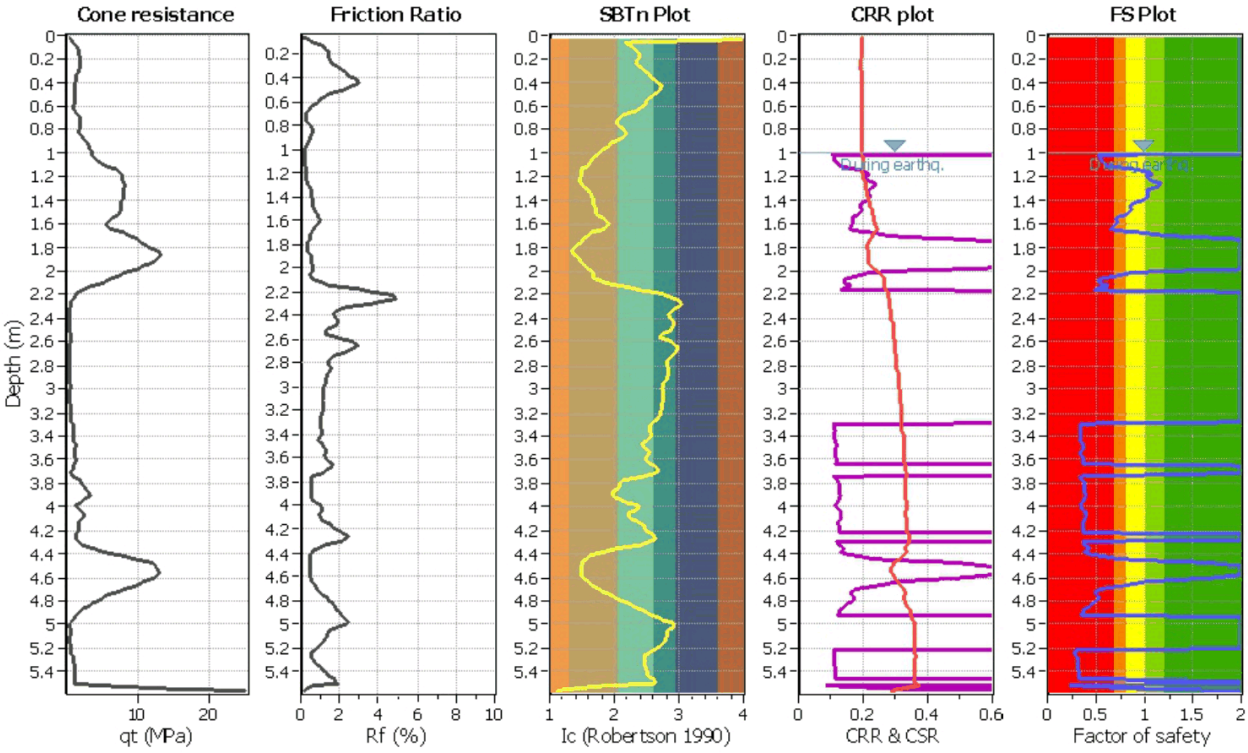
LIQUEFACTION ANALYSIS REPORT

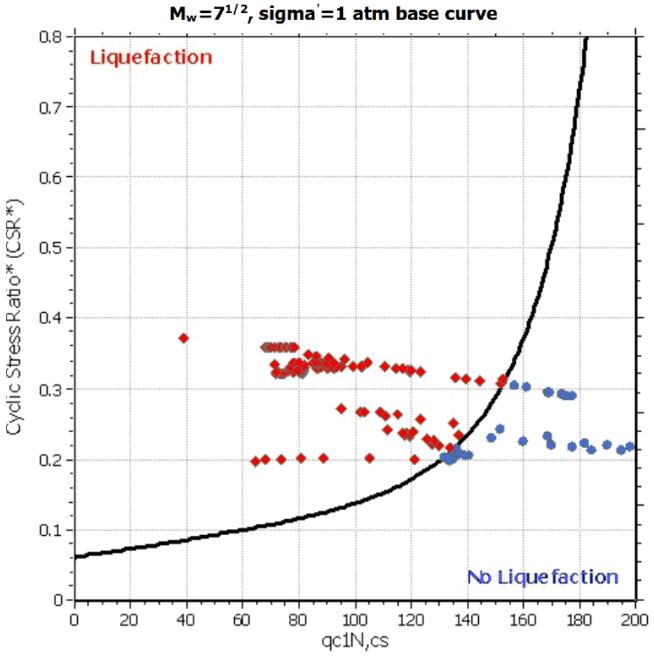
Project title : 170672 **Location : Flygers Line**

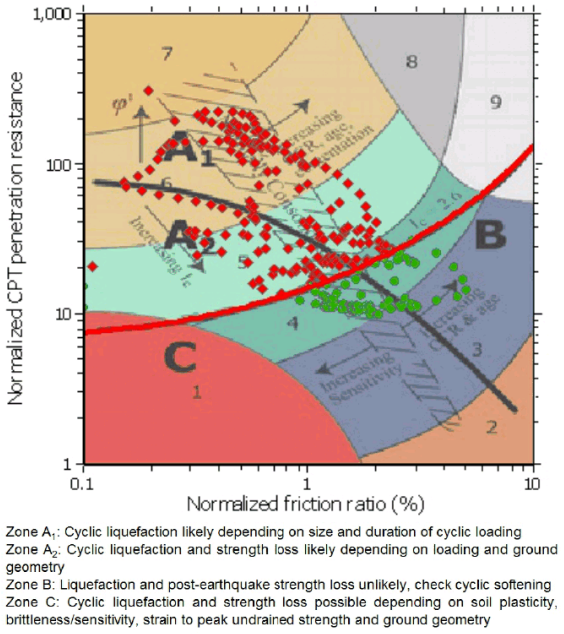
CPT file : CPT06

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

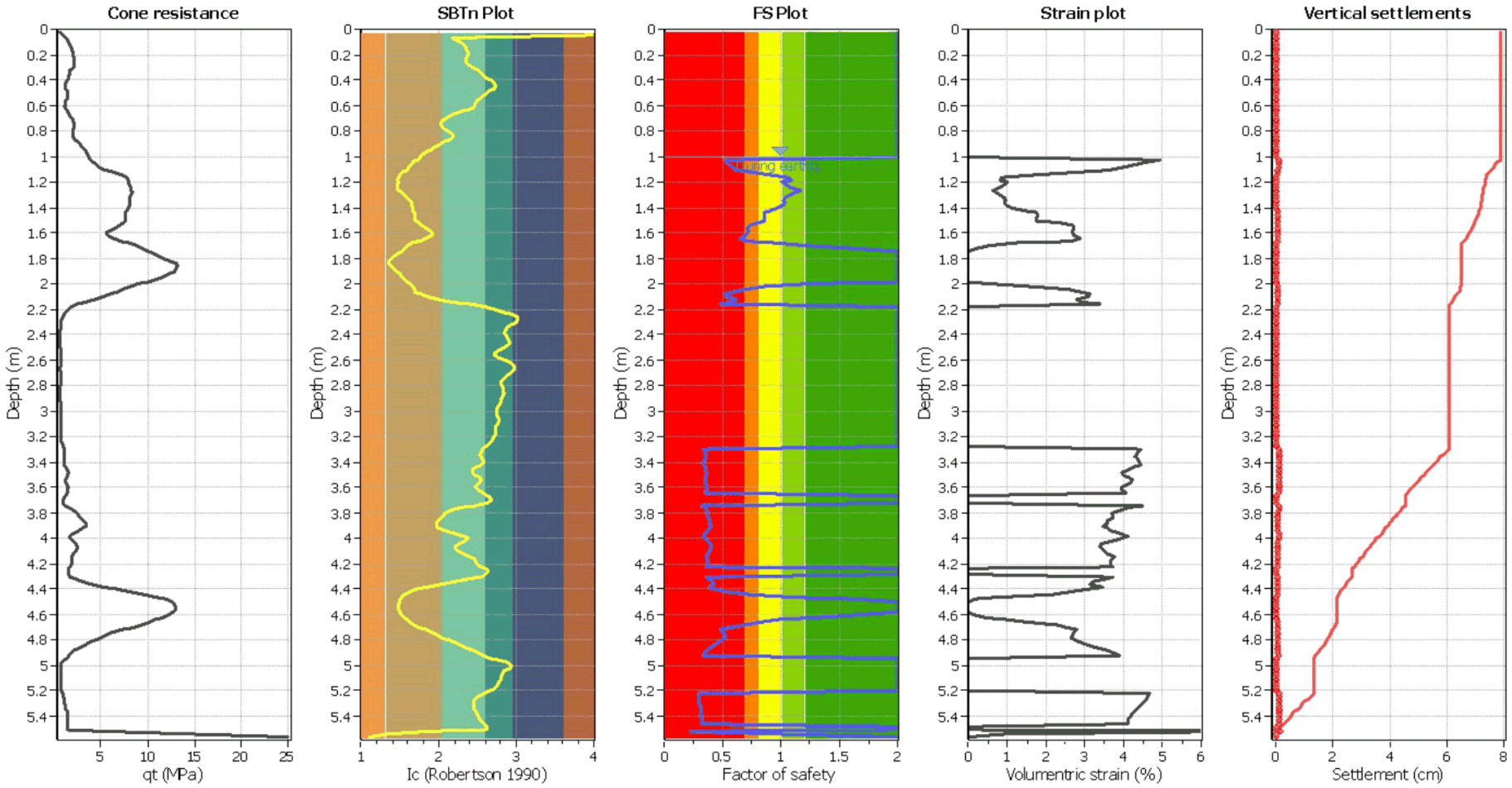






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

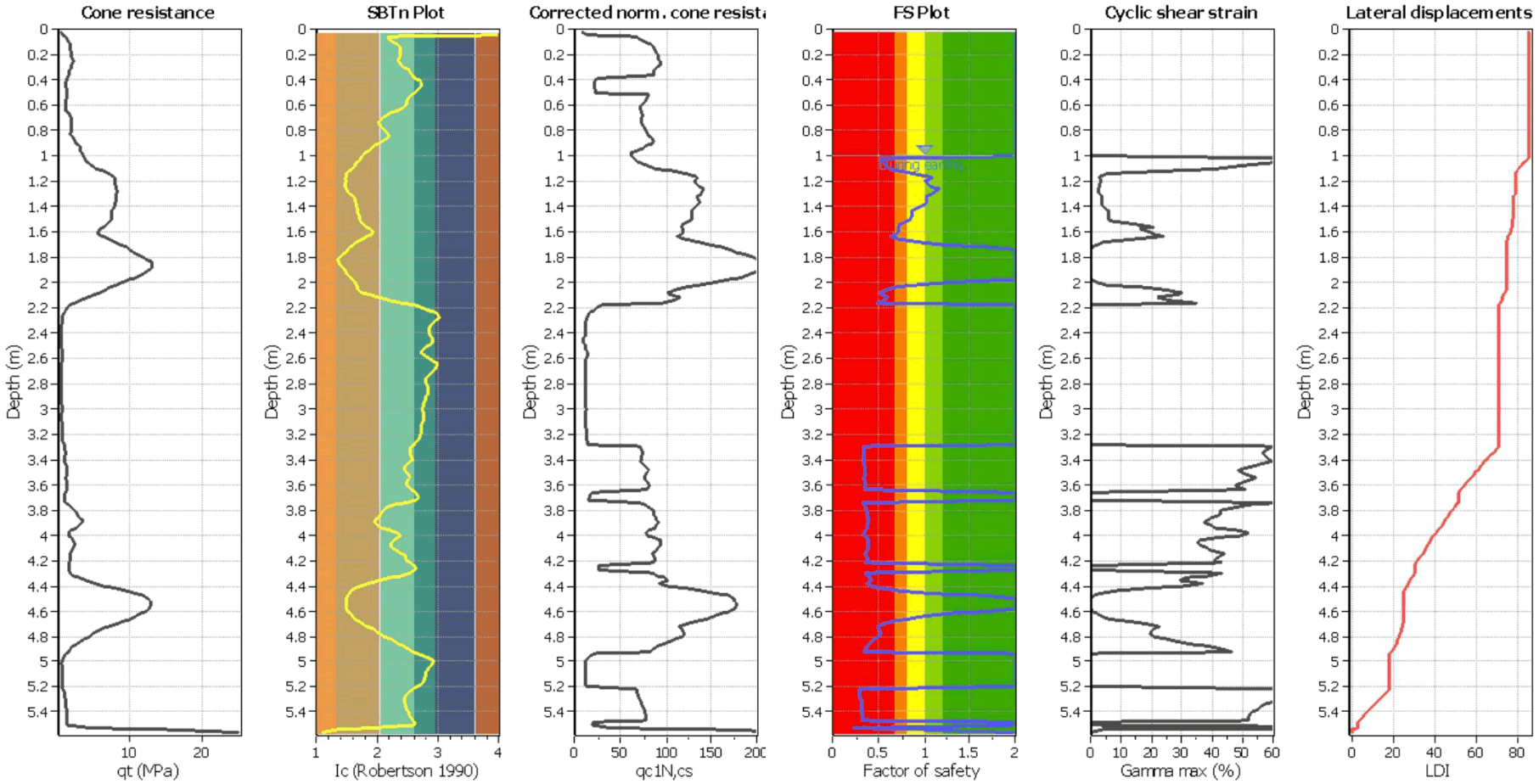
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
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F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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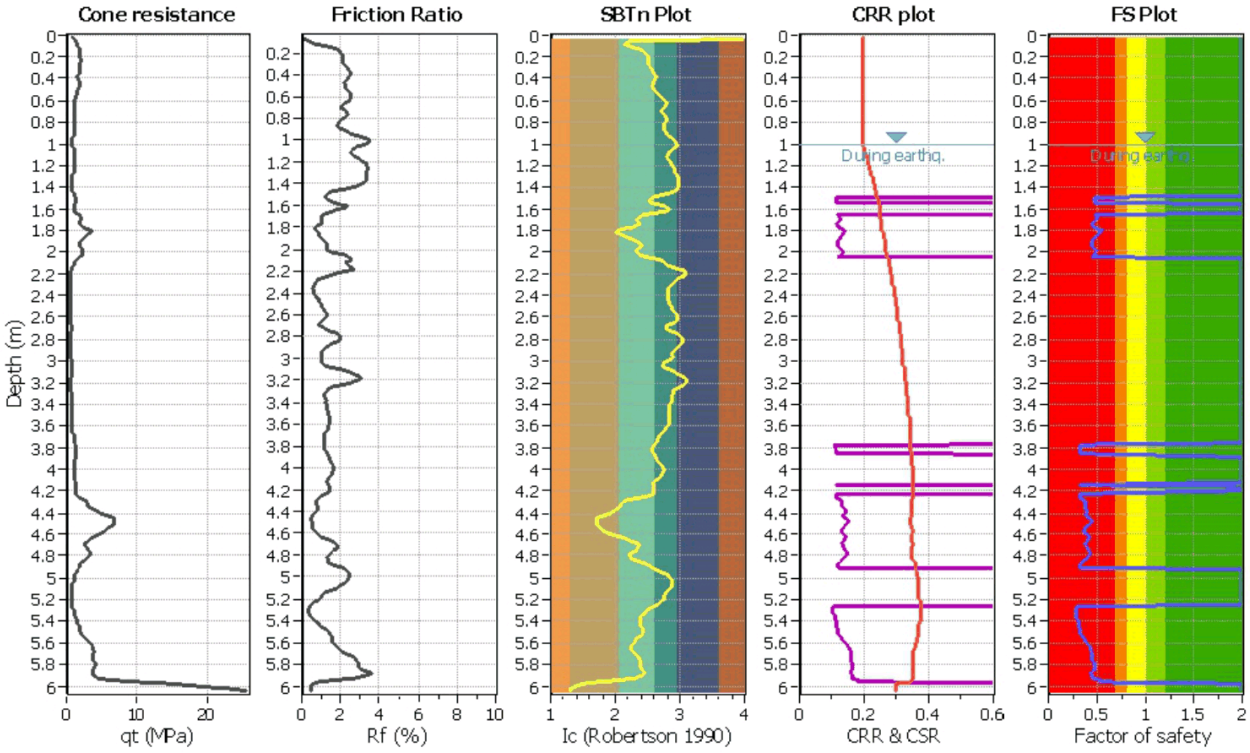
LIQUEFACTION ANALYSIS REPORT

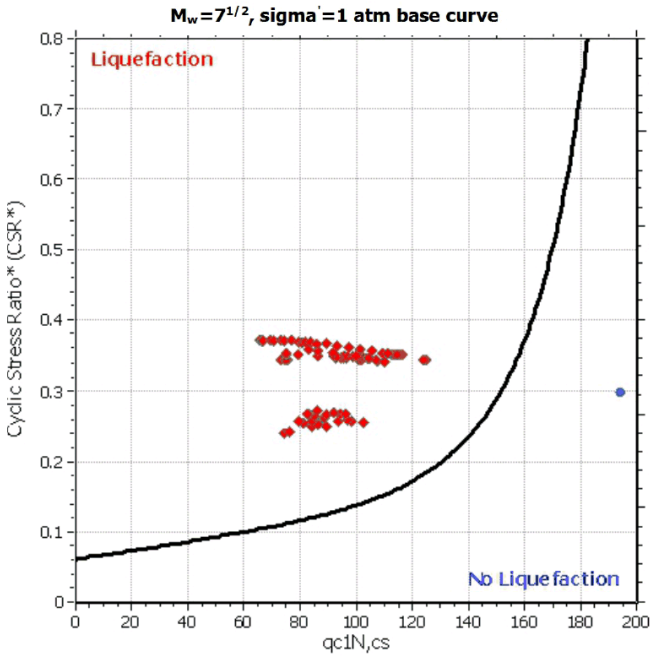
Project title : 170672 **Location : Flygers Line**

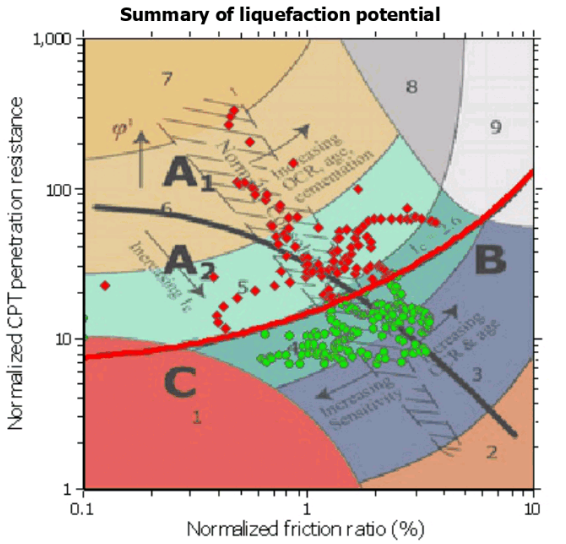
CPT file : CPT07

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

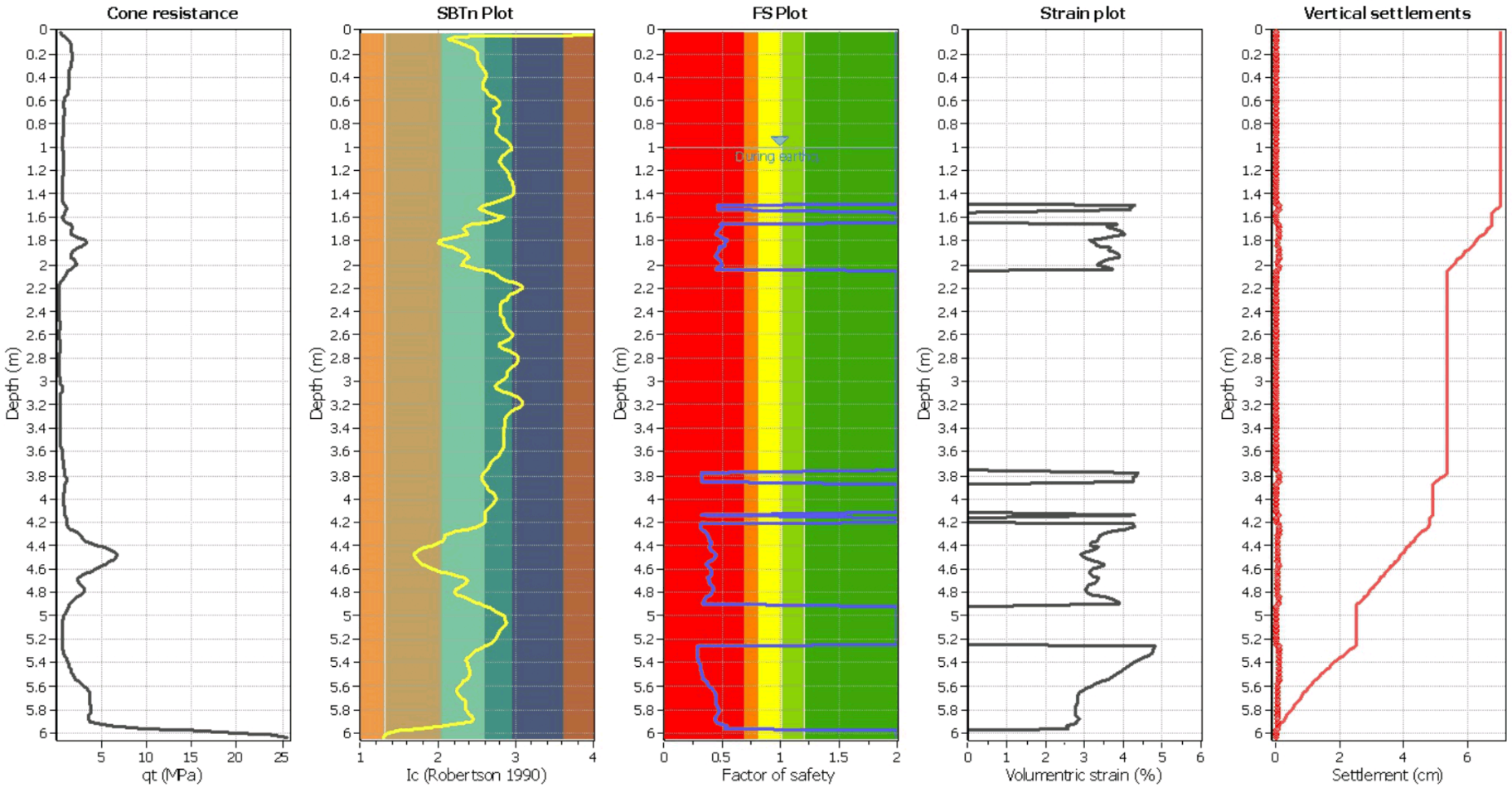






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

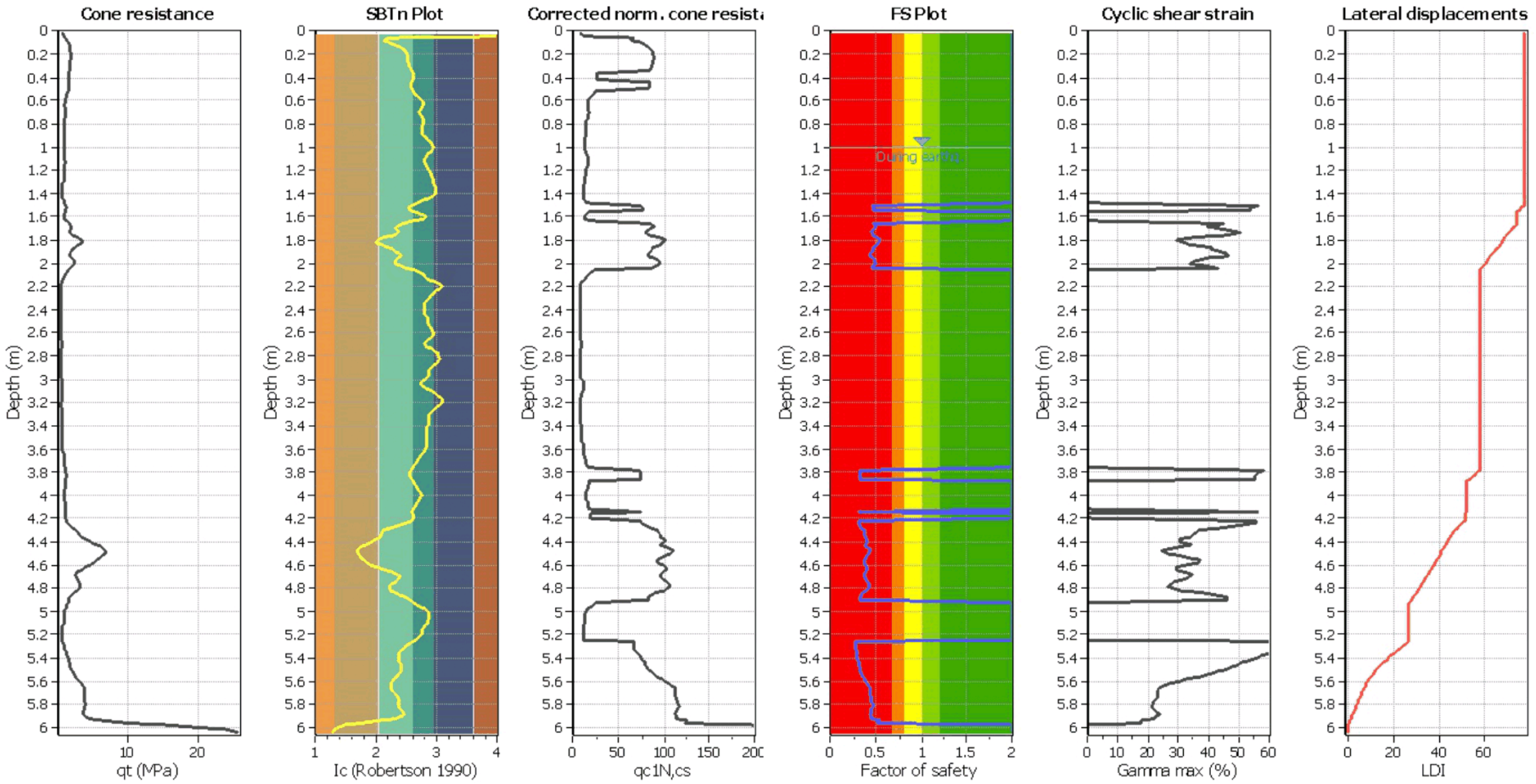
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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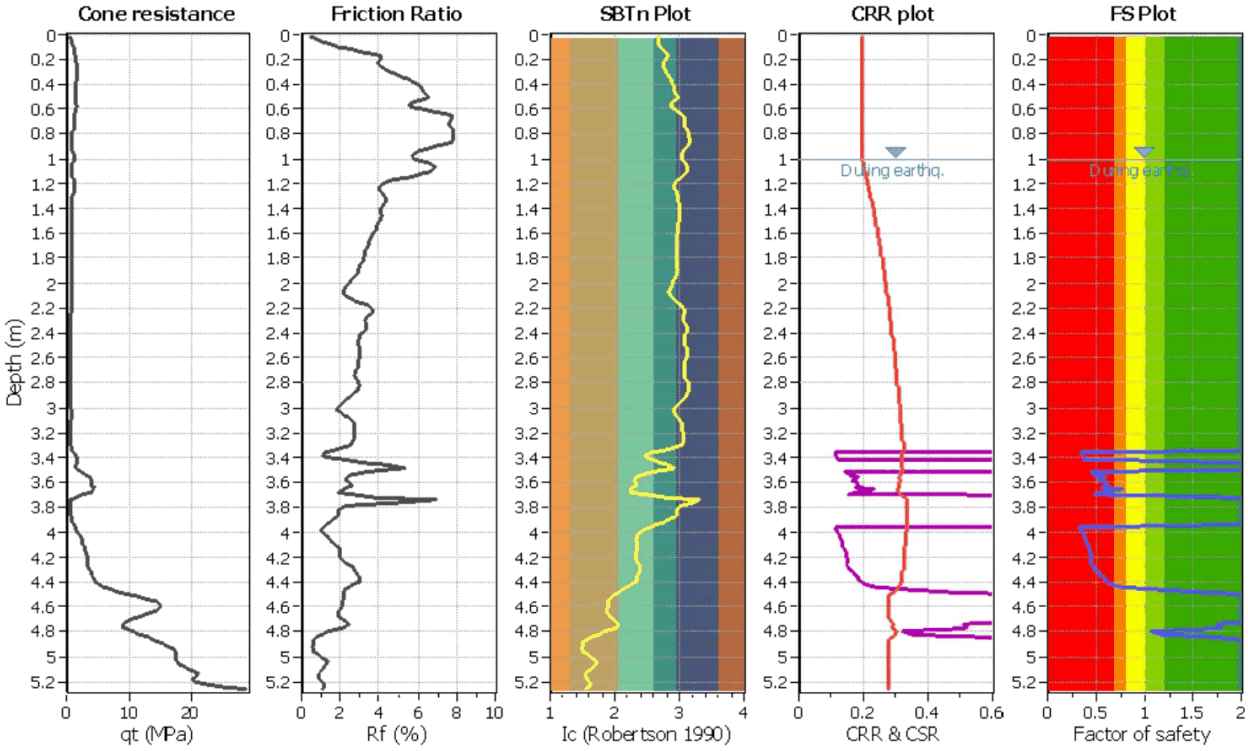
LIQUEFACTION ANALYSIS REPORT

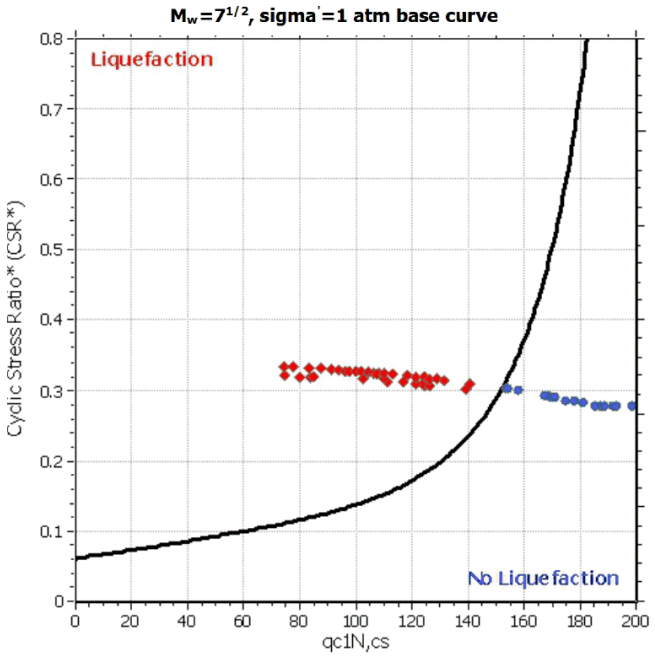
Project title : 170672 **Location : Flygers Line**

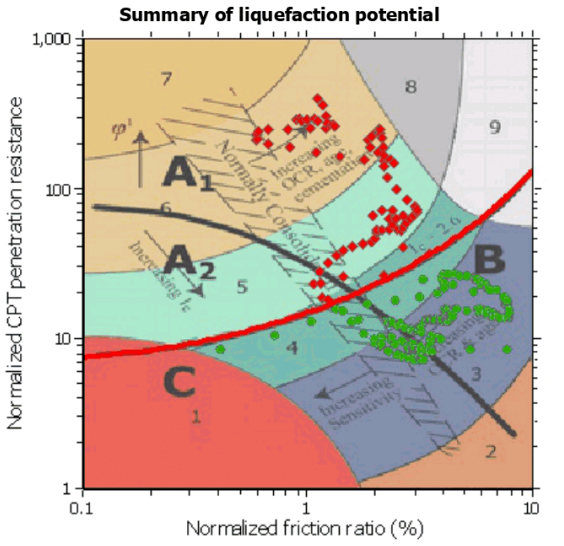
CPT file : CPT08

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

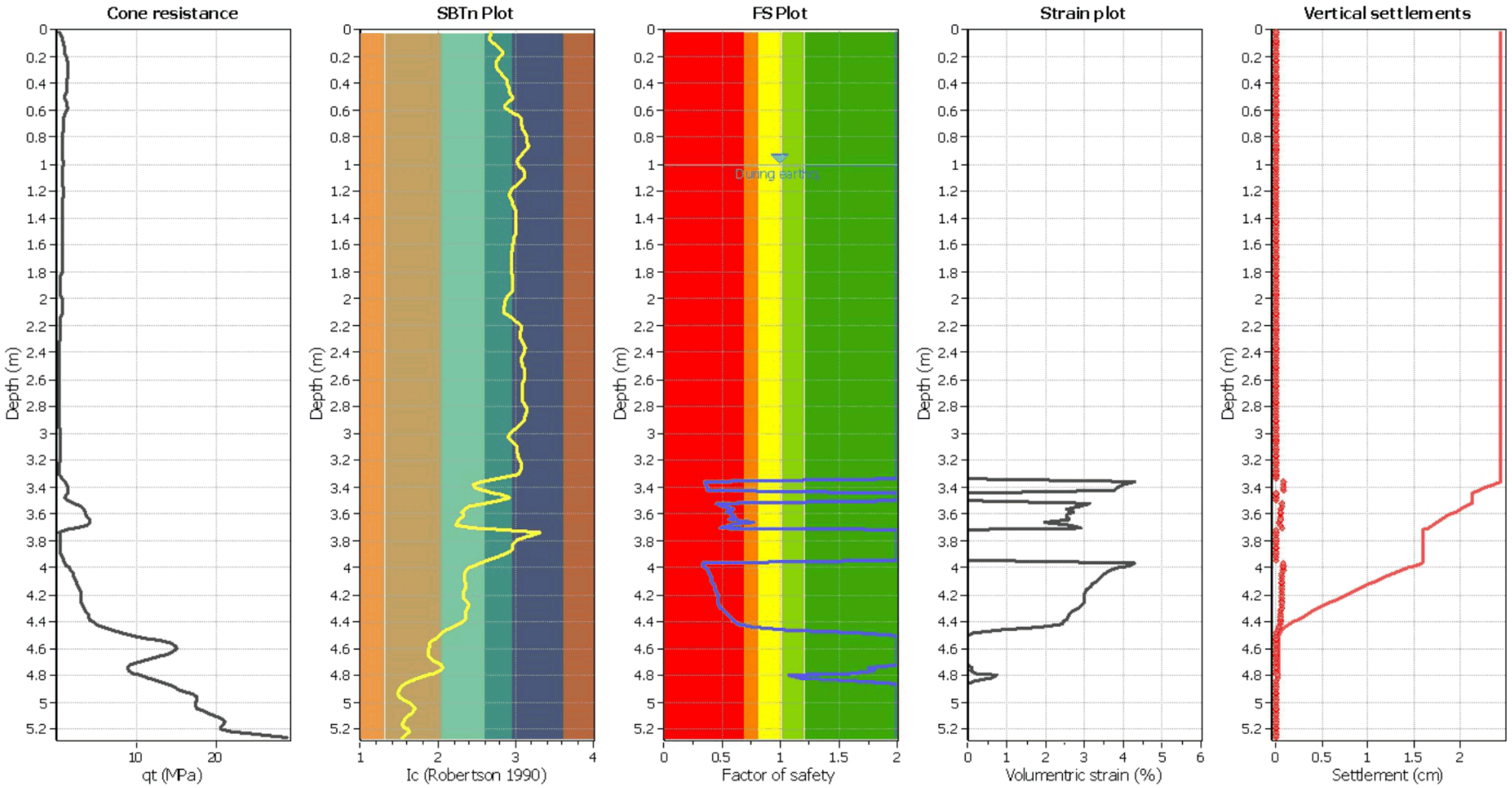






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

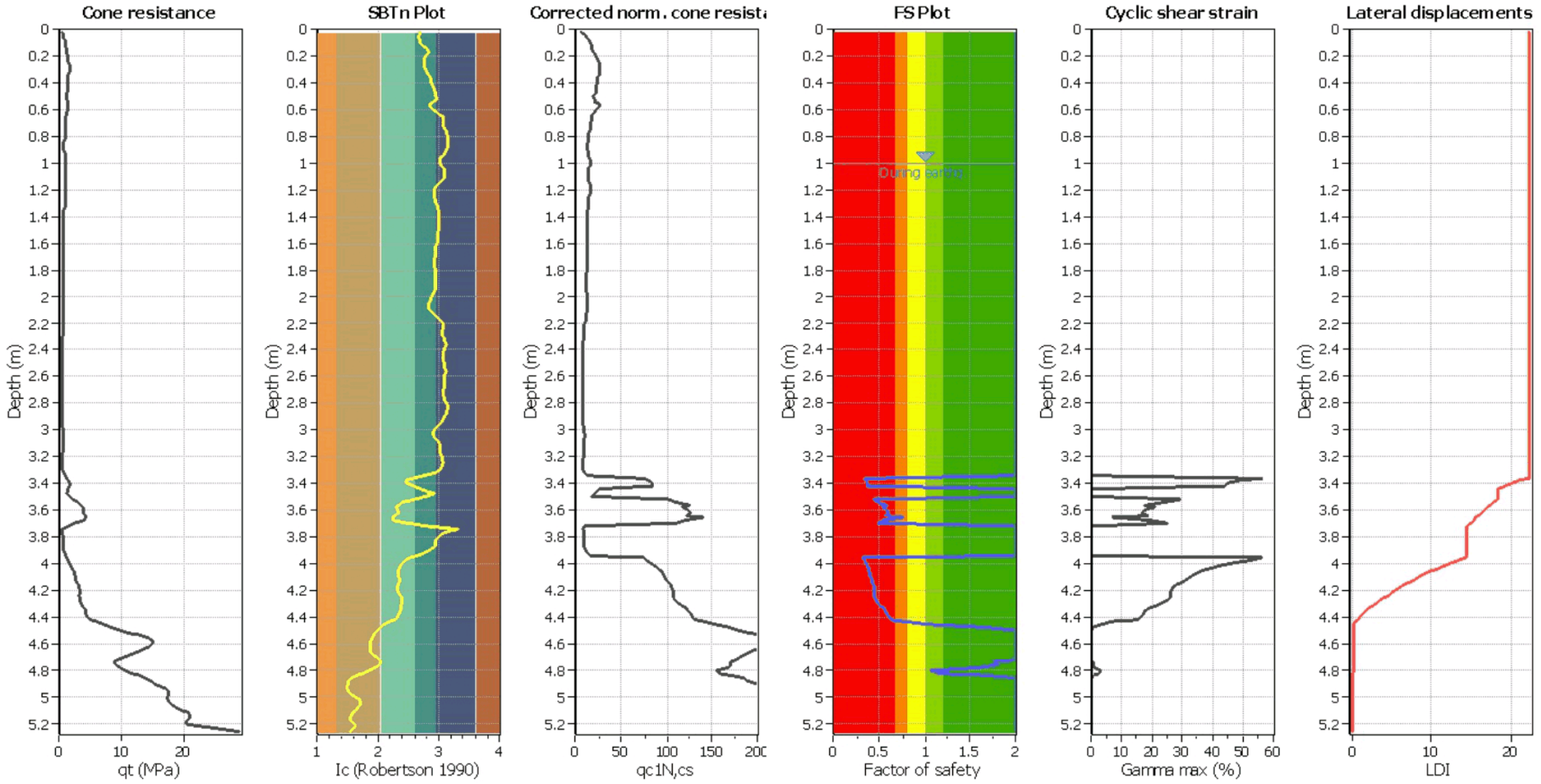
Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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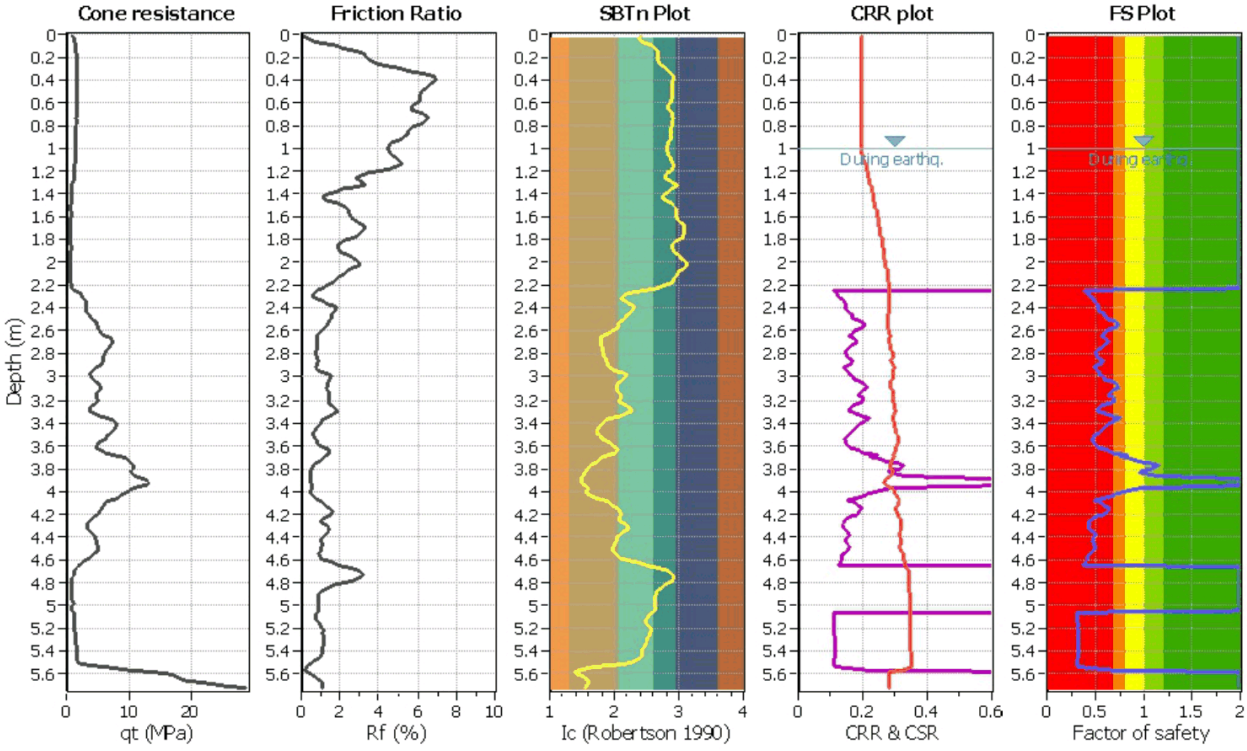
LIQUEFACTION ANALYSIS REPORT

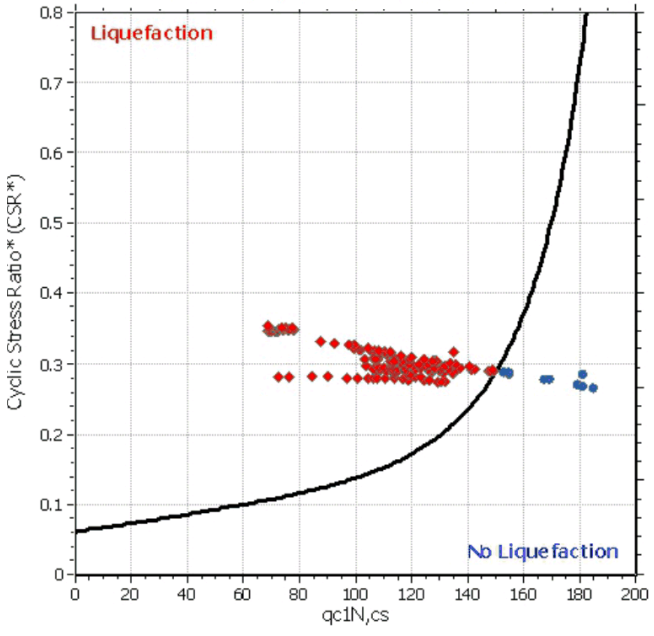
Project title : 170672 **Location : Flygers Line**

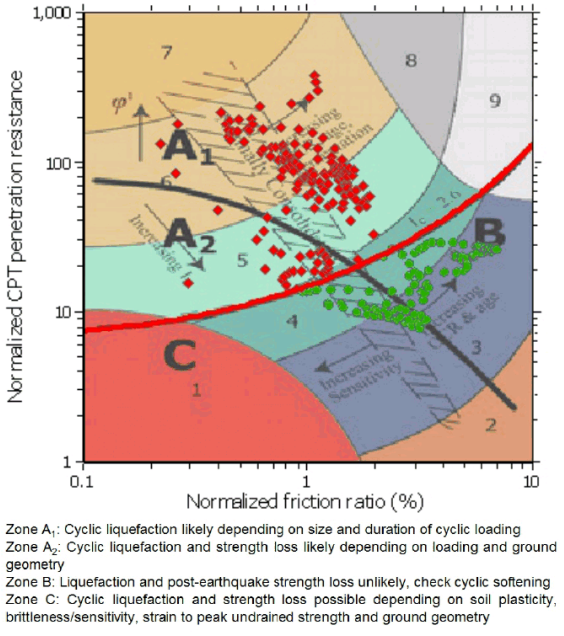
CPT file : CPT09

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

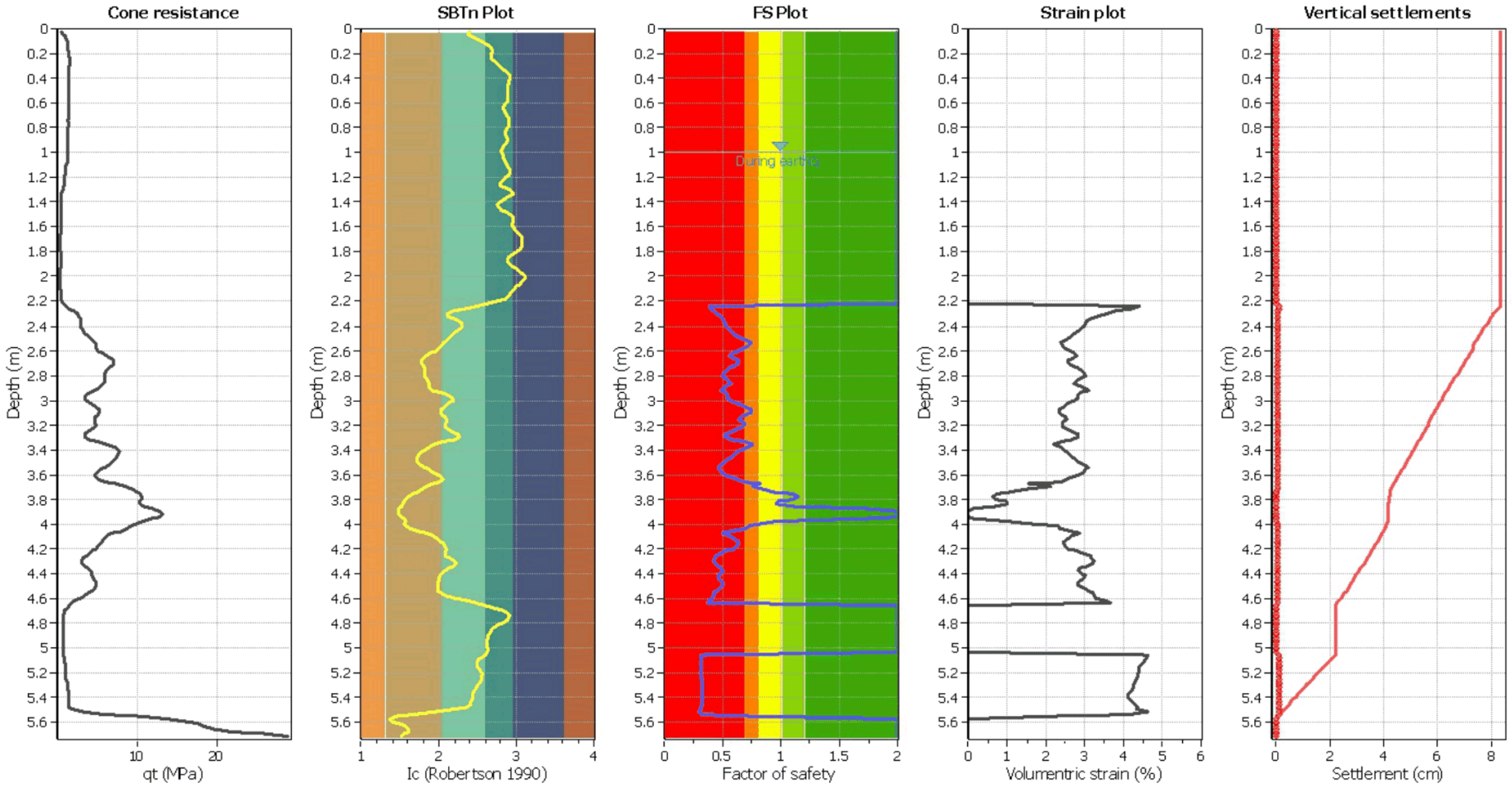






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

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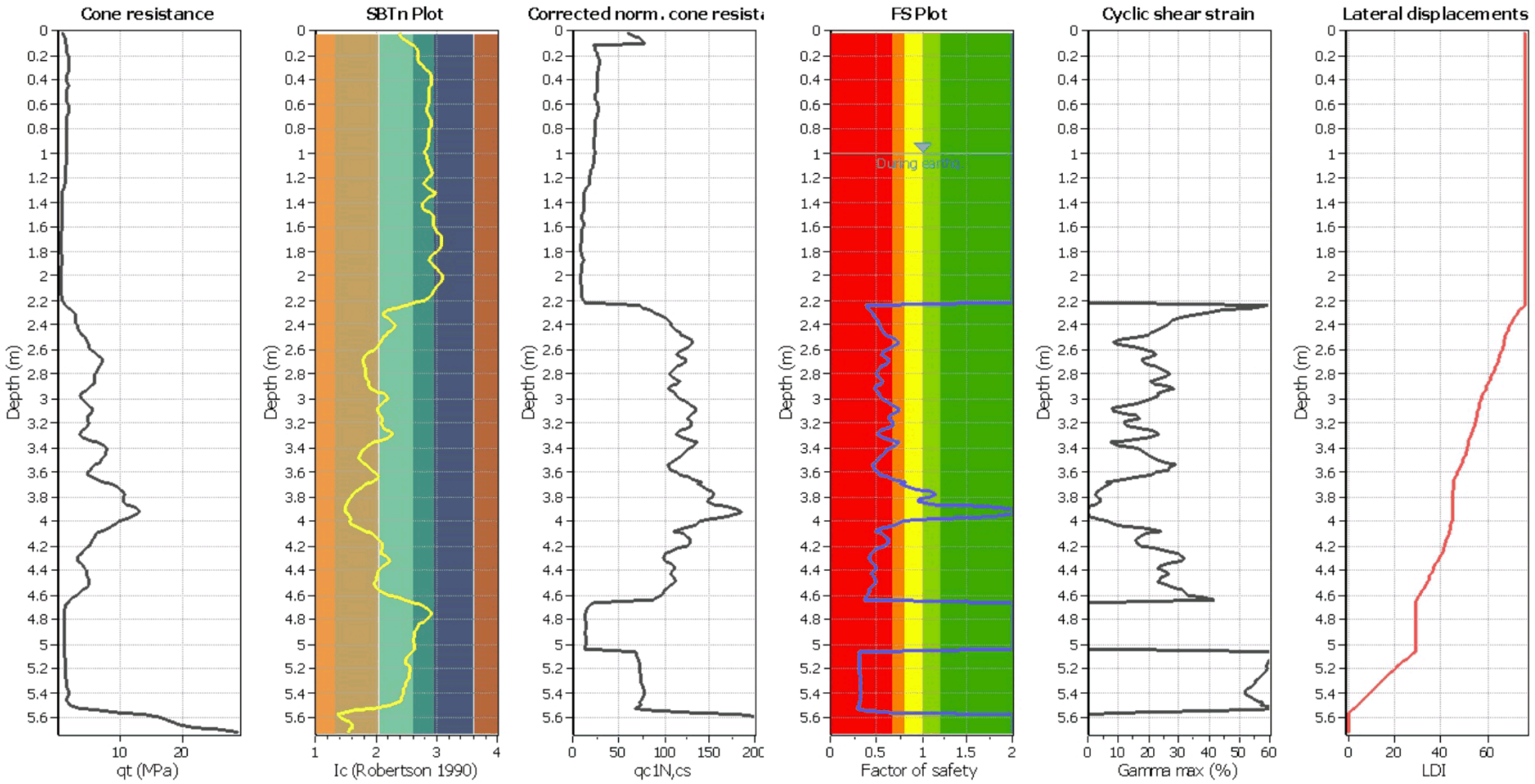
Estimation of post-earthquake lateral Displacements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
$q_{c1N,cs}$: Equivalent clean sand normalized CPT total cone resistance
F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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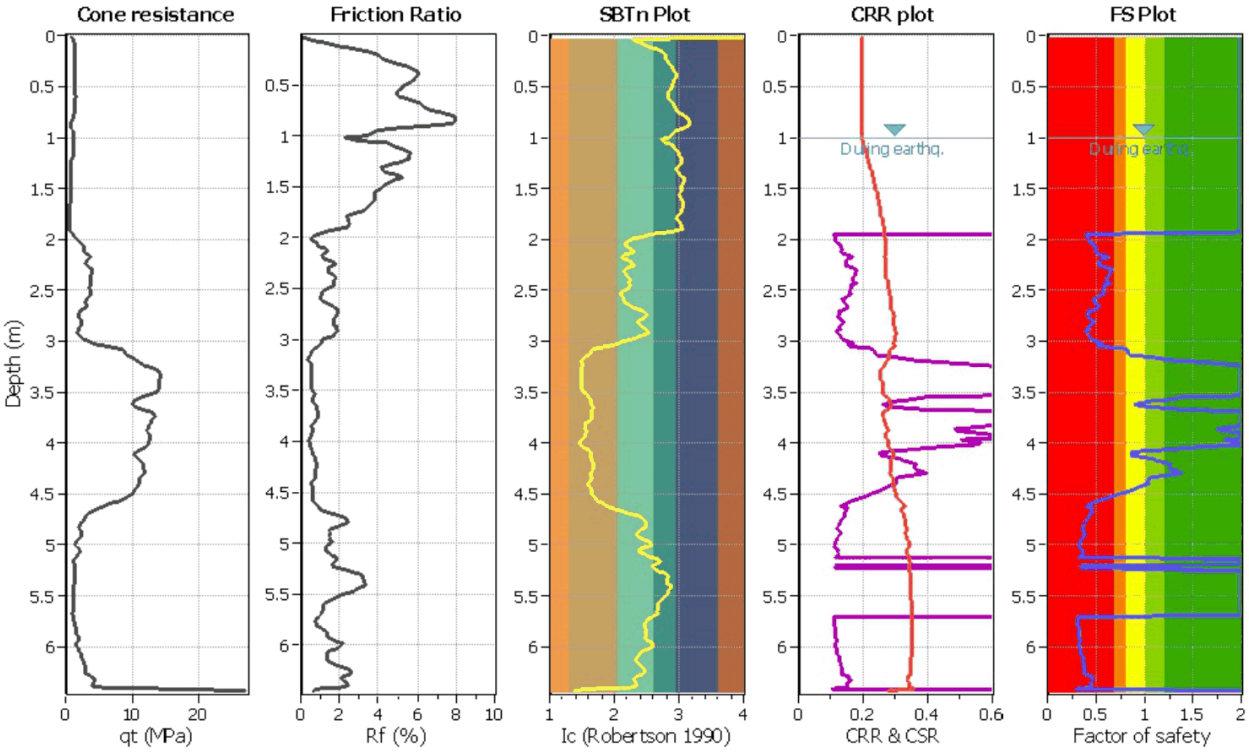
LIQUEFACTION ANALYSIS REPORT

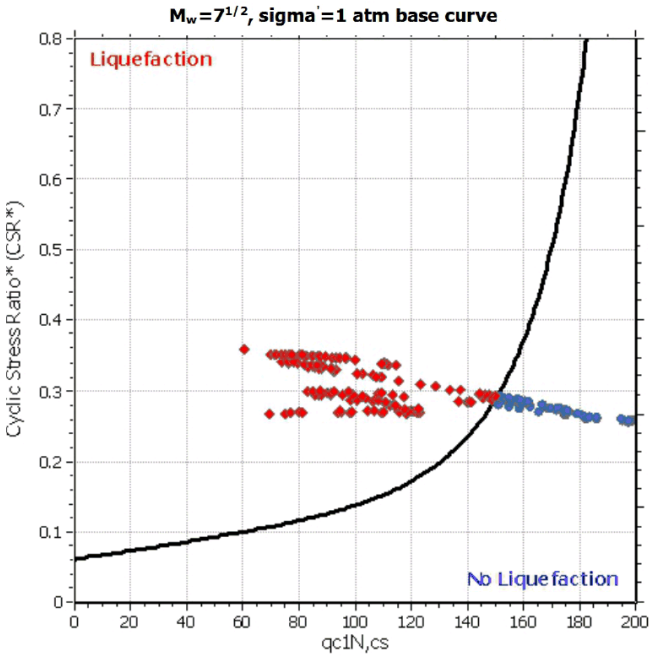
Project title : 170672 **Location : Flygers Line**

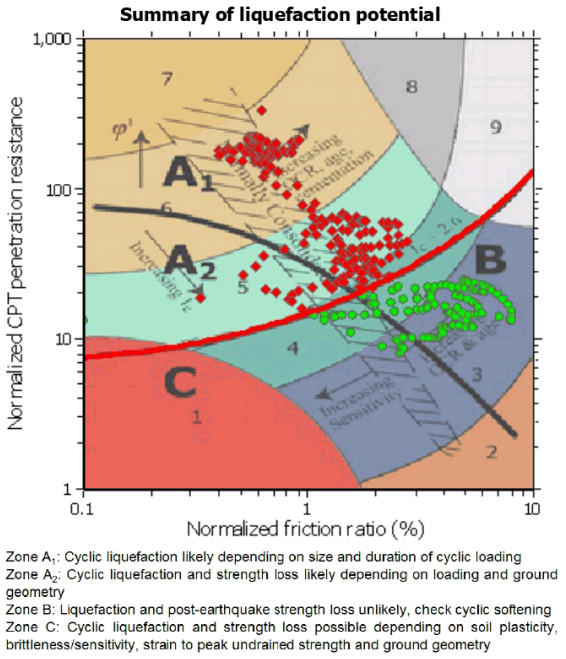
CPT file : CPT10

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

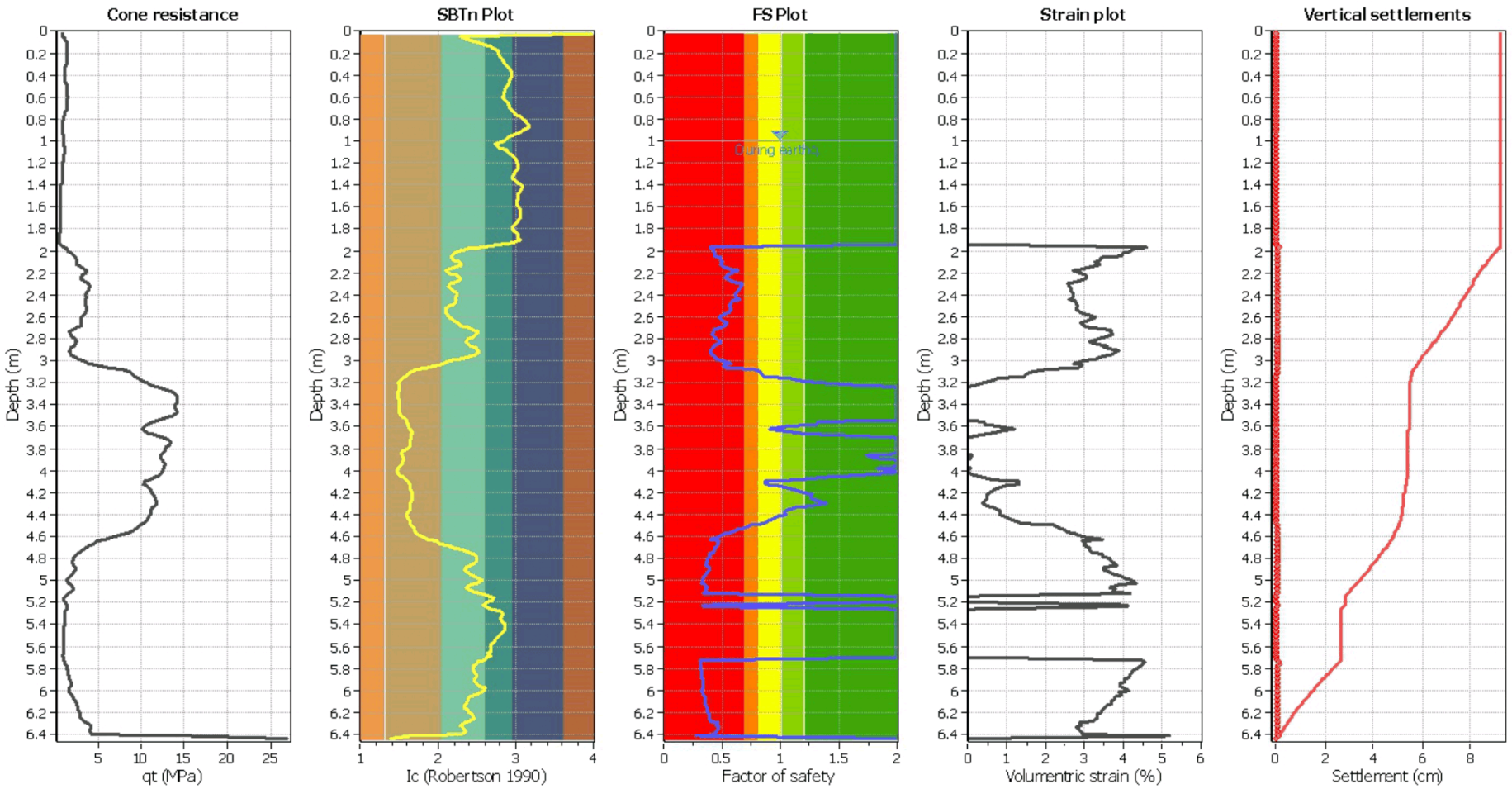






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

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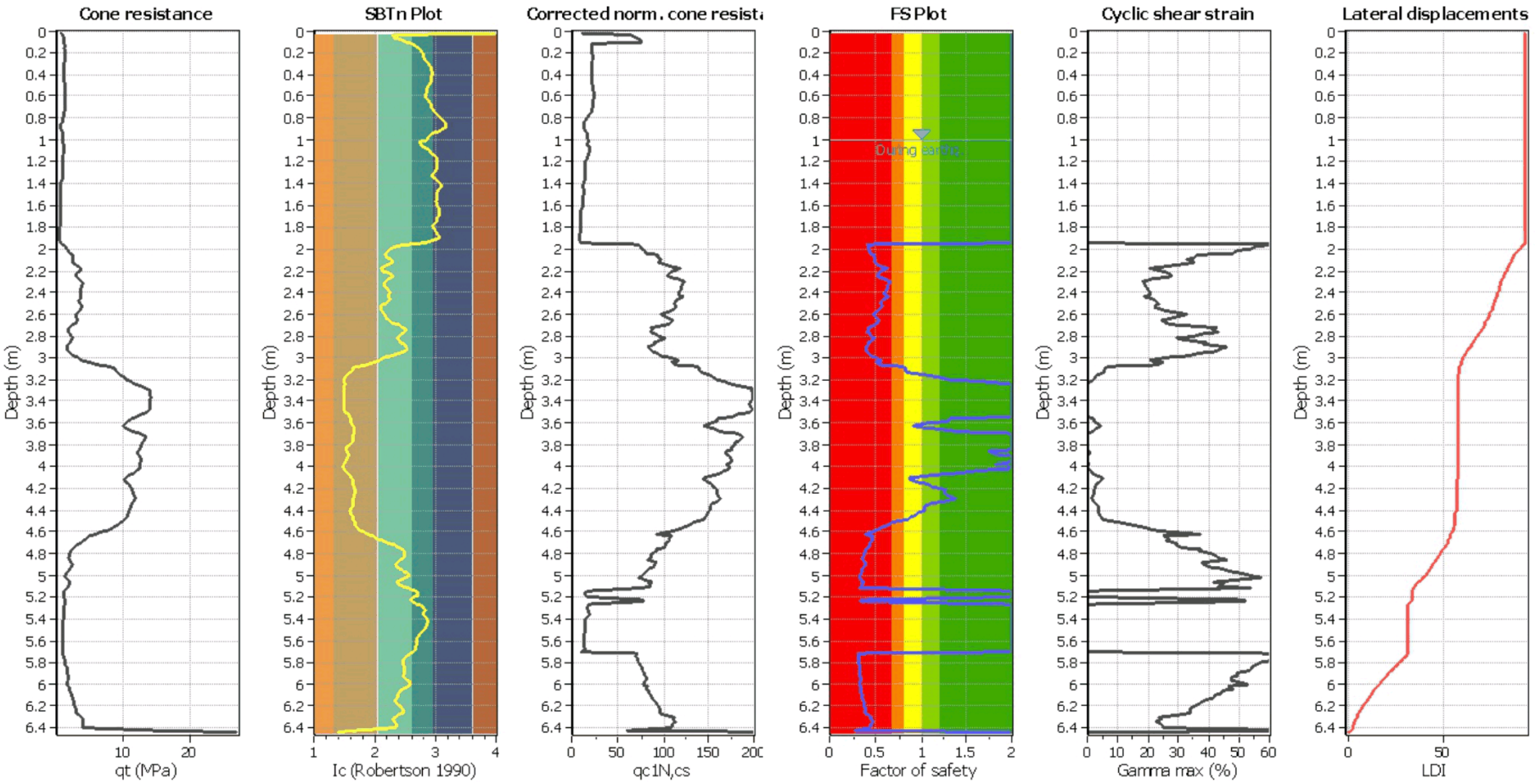
Estimation of post-earthquake lateral Displacements



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F.S.: Factor of safety
γ_{max}: Maximum cyclic shear strain
LDI: Lateral displacement index

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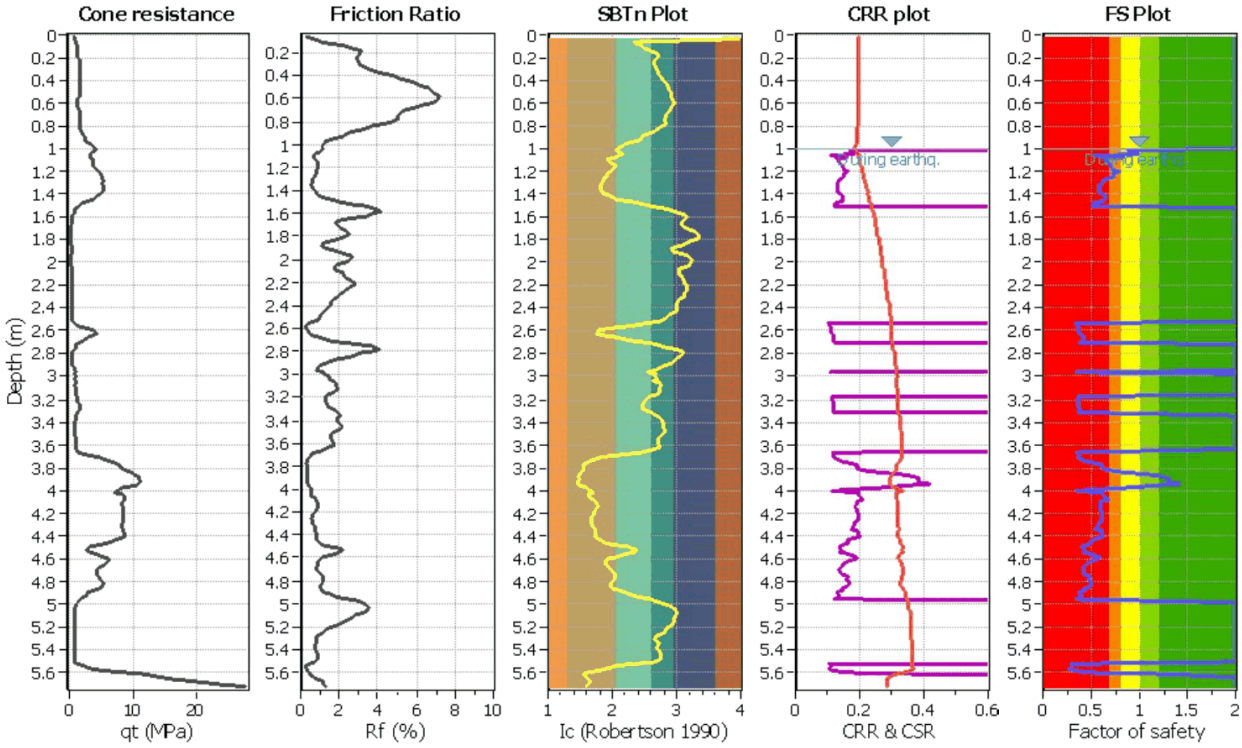
LIQUEFACTION ANALYSIS REPORT

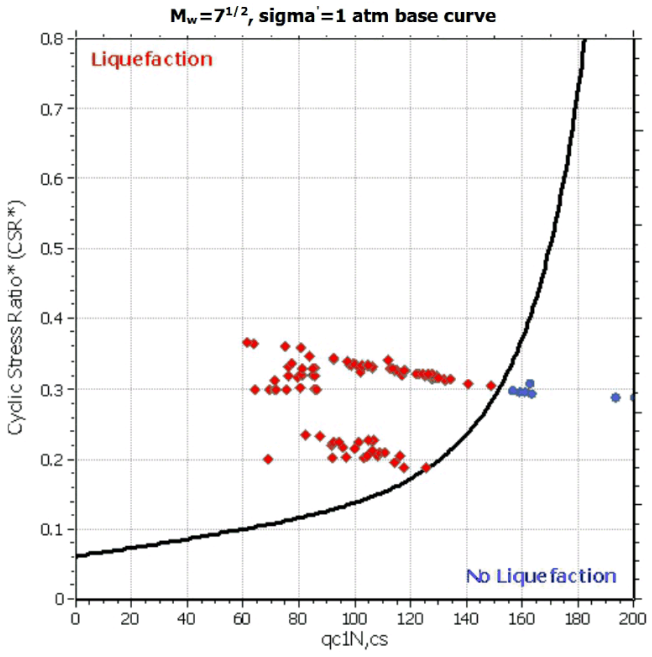
Project title : 170672 **Location : Flygers Line**

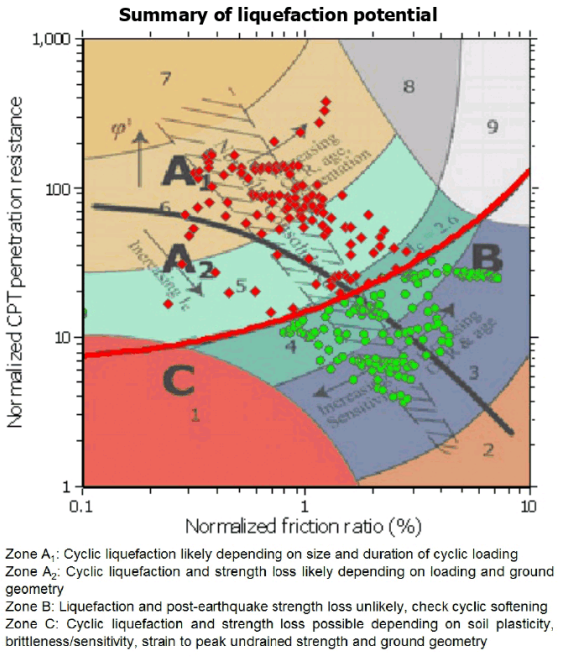
CPT file : CPT11

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		







Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
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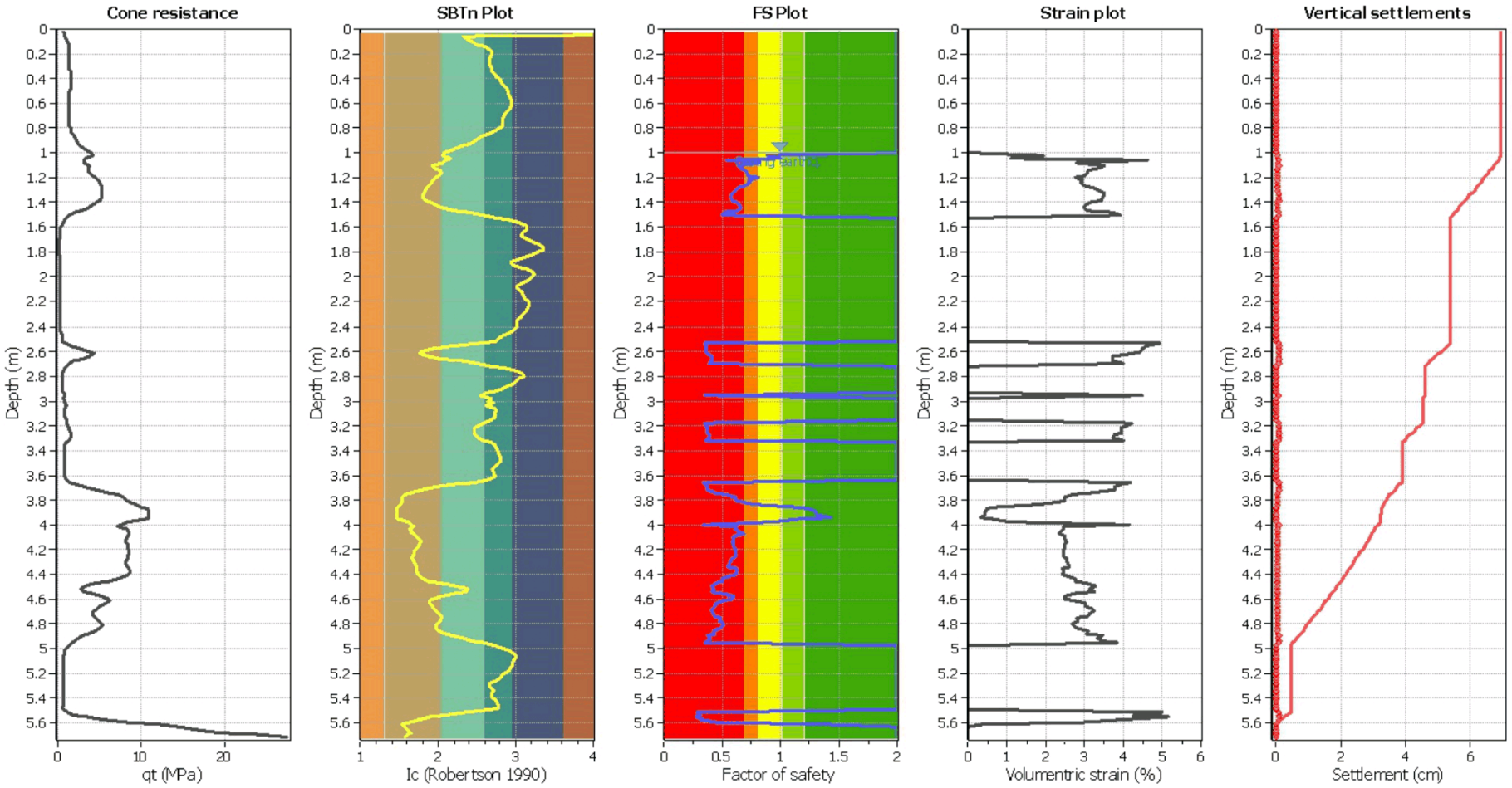
Estimation of post-earthquake settlements



Abbreviations

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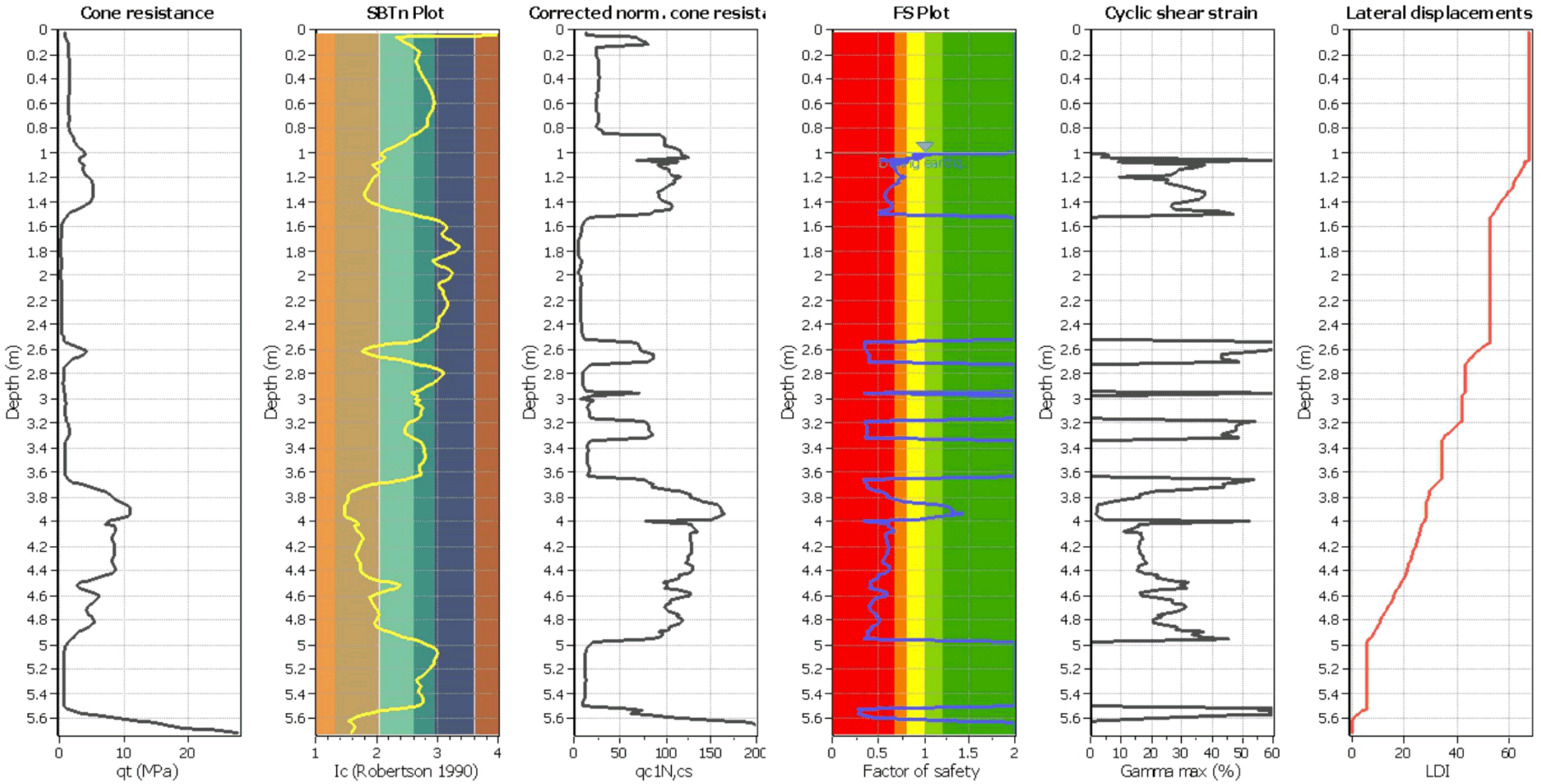
Estimation of post-earthquake lateral Displacements



Abbreviations

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γ_{max}: Maximum cyclic shear strain
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LIQUEFACTION ANALYSIS REPORT

Project title : 170672 **Location : Flygers Line**

CPT file : CPT12

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	Sands only
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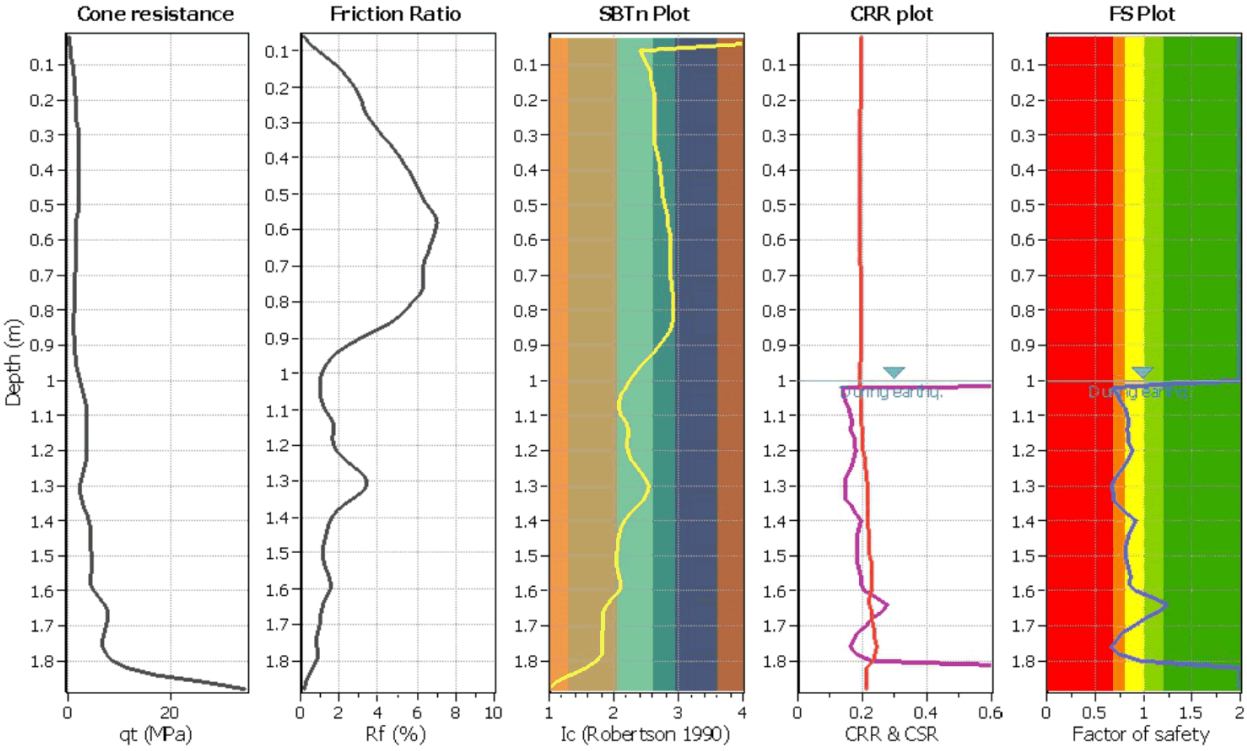
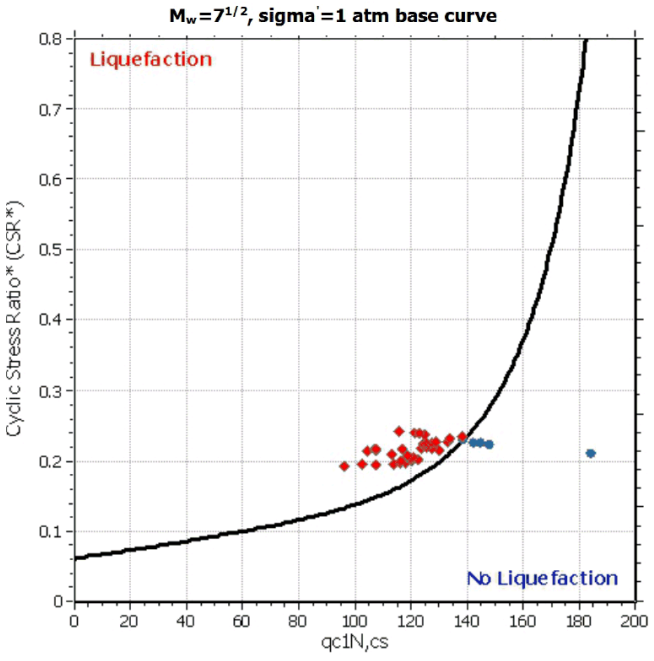
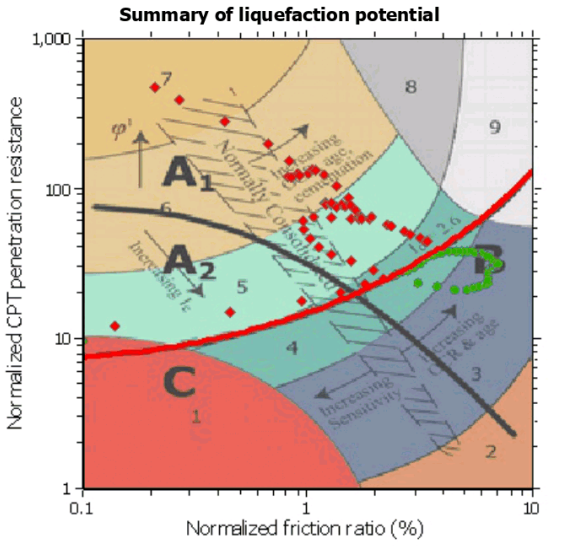
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.90	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.34	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		







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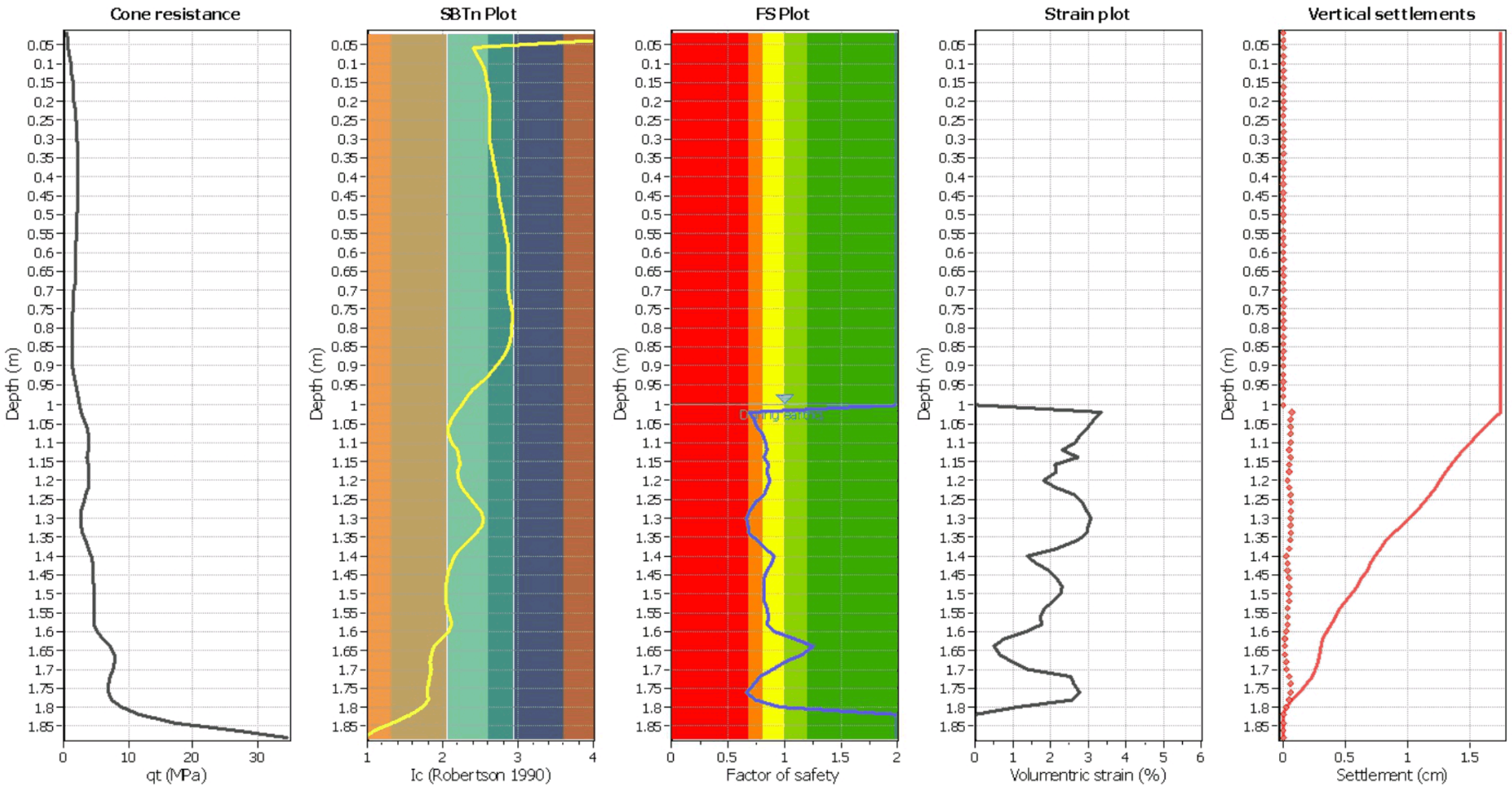

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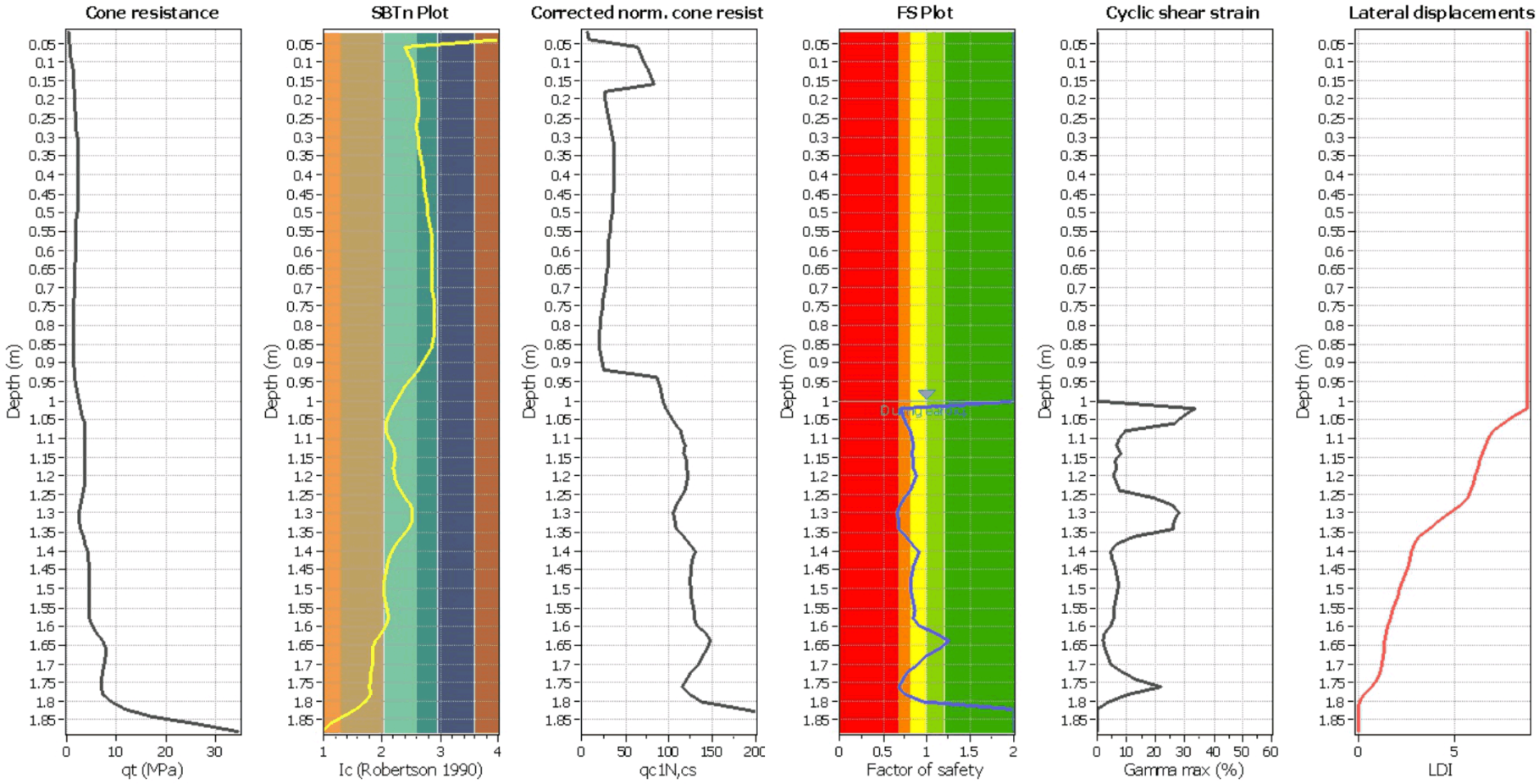
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

PALMERSTON NORTH CITY COUNCIL
ITEM 7 - ATTACHMENT 1

Estimation of post-earthquake lateral Displacements



Abbreviations

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F.S.: Factor of safety
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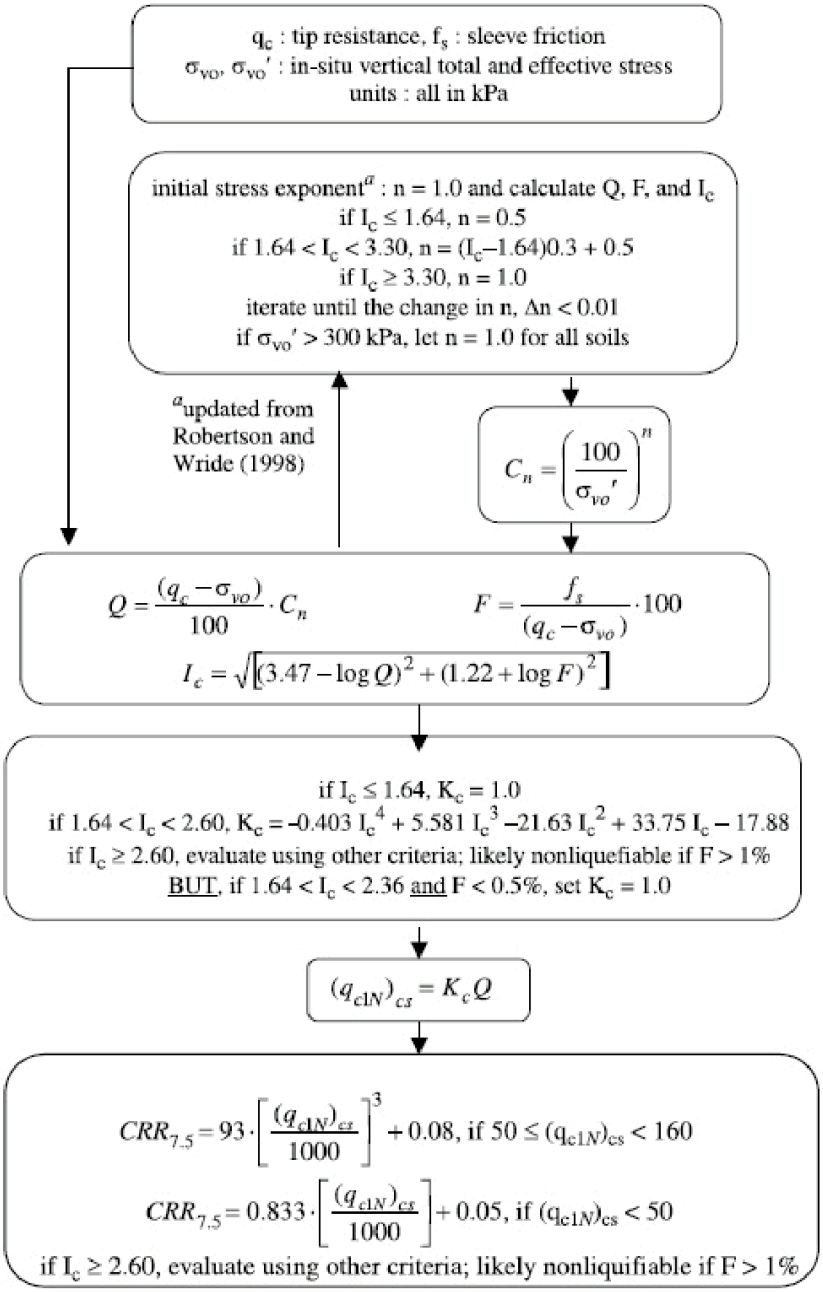
Procedure for the evaluation of soil liquefaction resistance, NCEER (1998)

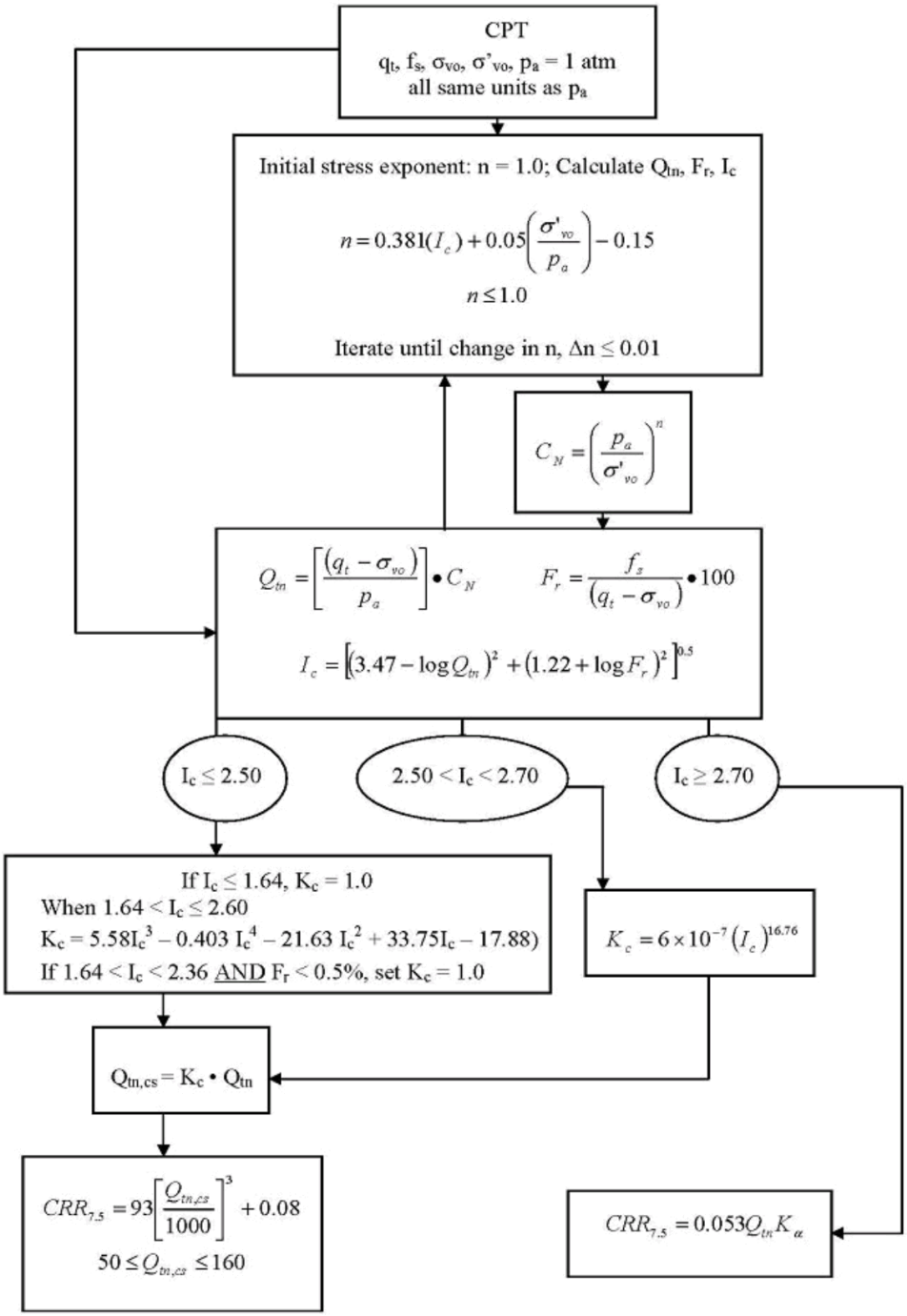
Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. The procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:



[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

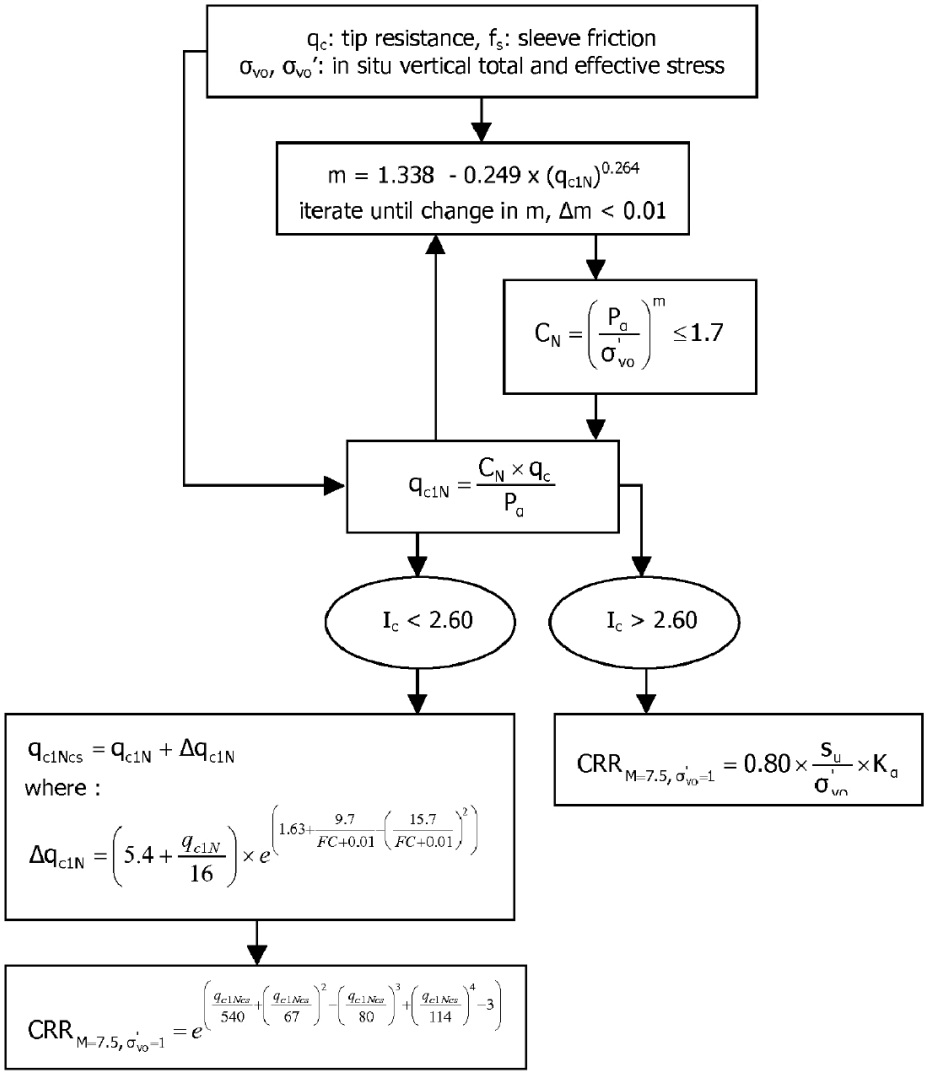
Procedure for the evaluation of soil liquefaction resistance (all soils), Robertson (2010)

Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. This procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:

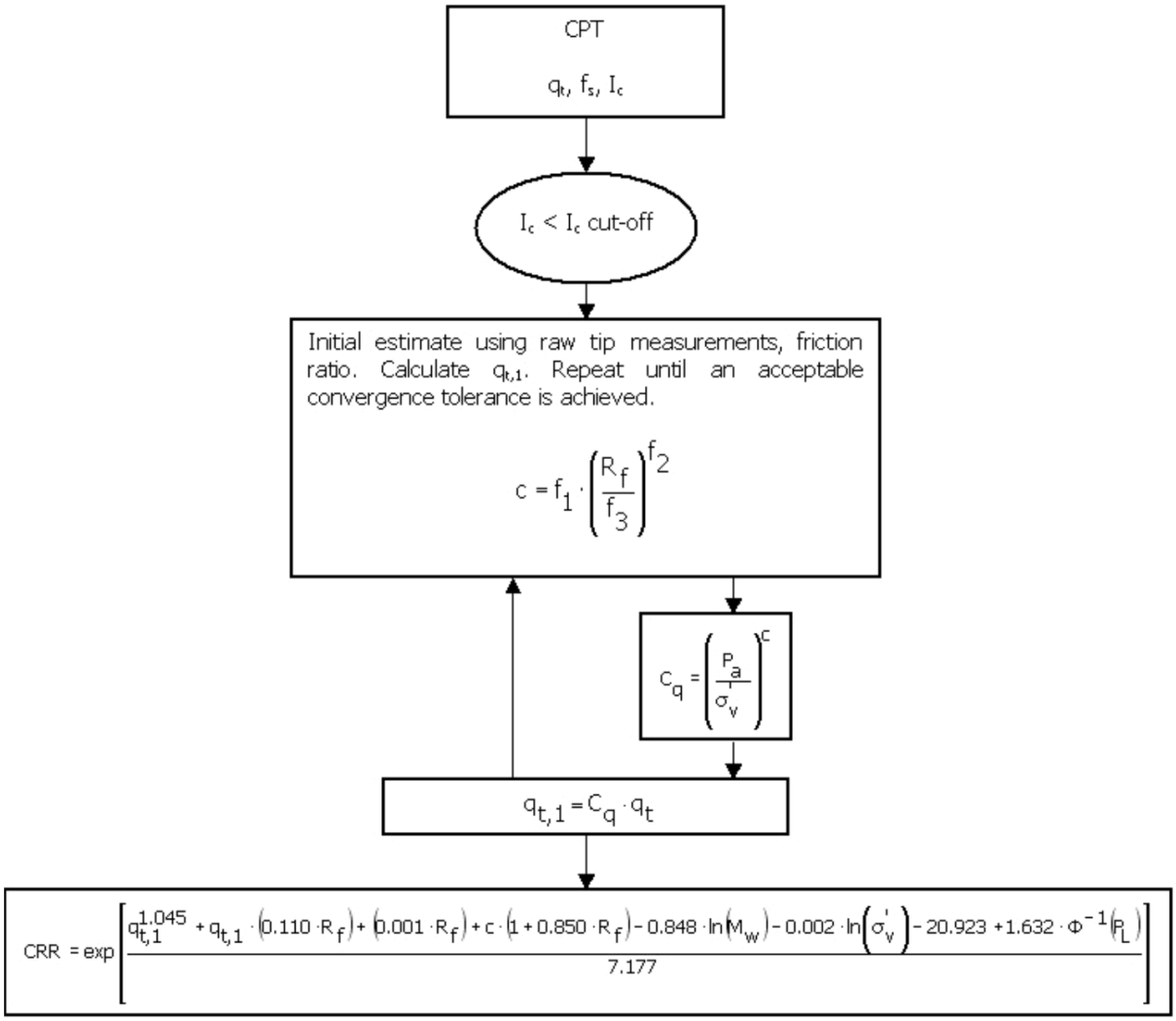


[1] P.K. Robertson, 2009. "Performance based earthquake design using the CPT", Keynote Lecture, International Conference on Performance-based Design in Earthquake Geotechnical Engineering – from case history to practice, IS-Tokyo, June 2009

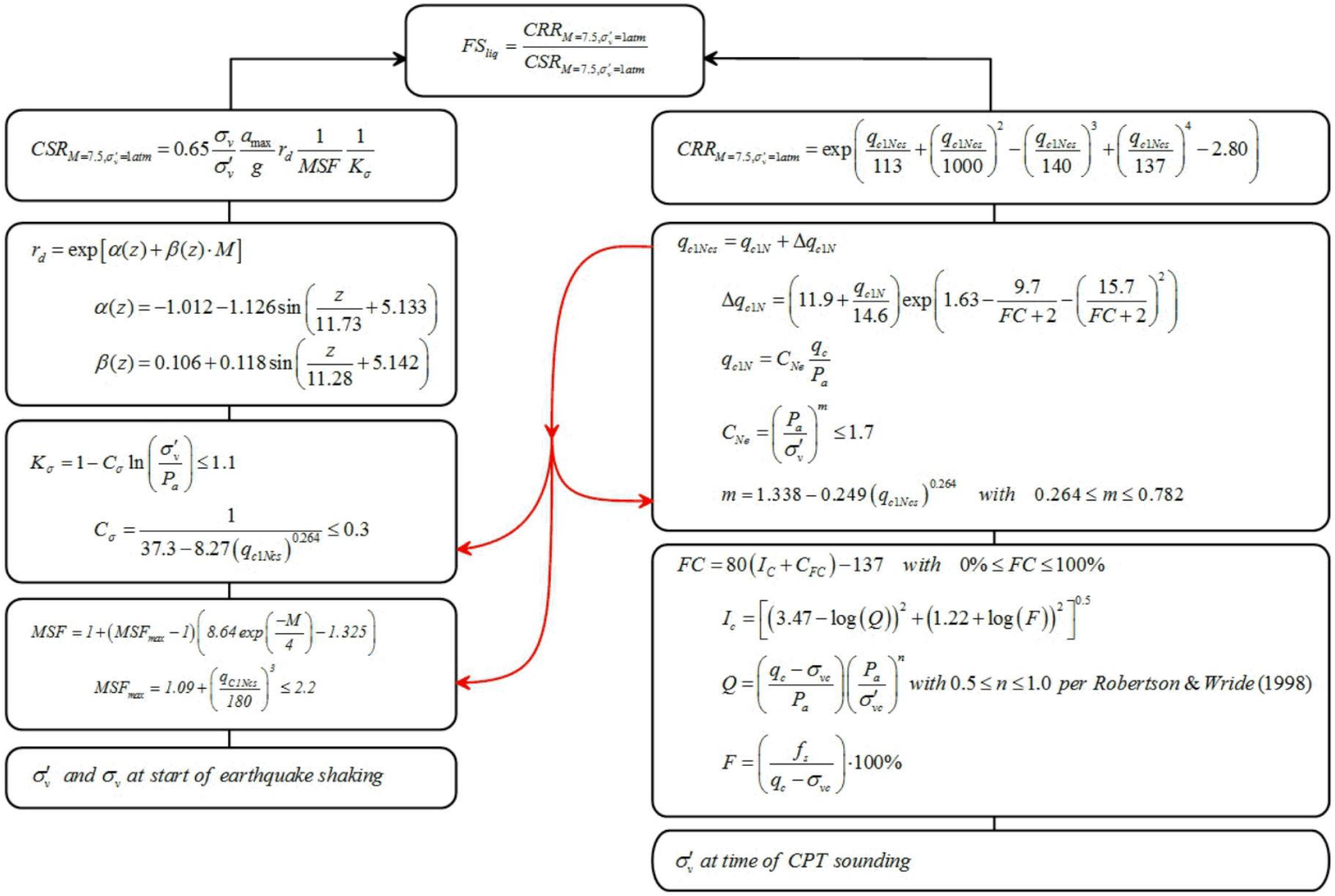
Procedure for the evaluation of soil liquefaction resistance, Idriss & Boulanger (2008)



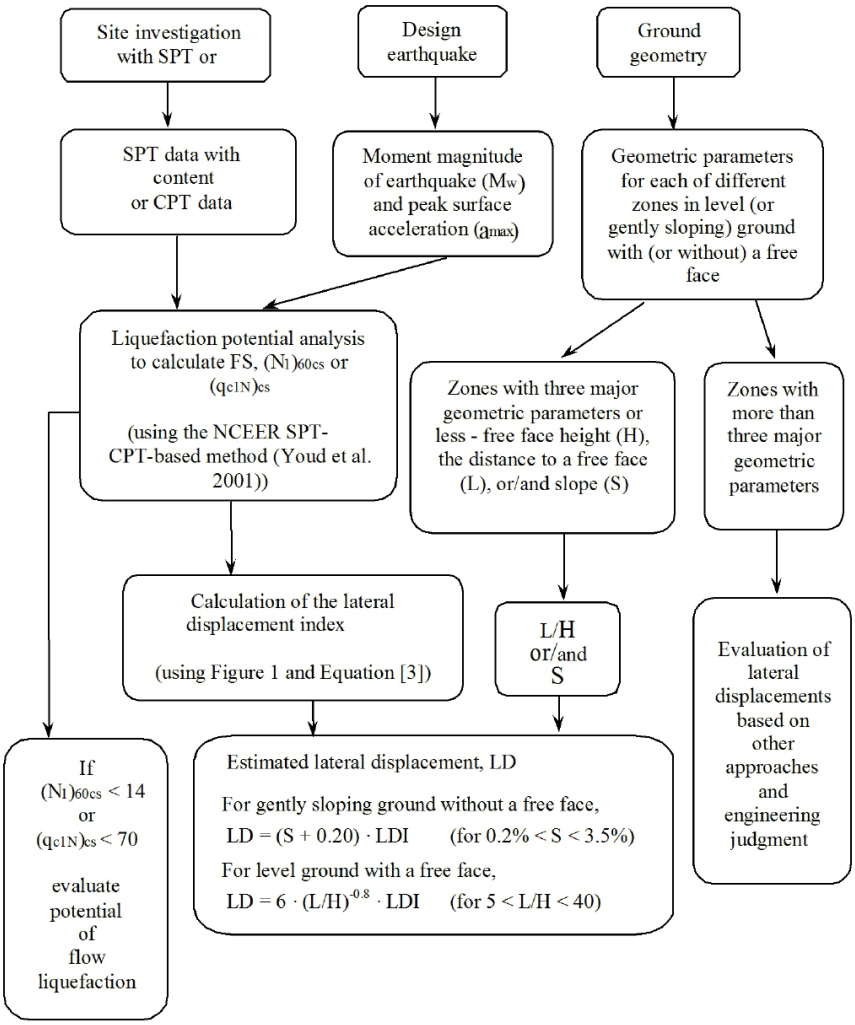
Procedure for the evaluation of soil liquefaction resistance (sandy soils), Moss et al. (2006)



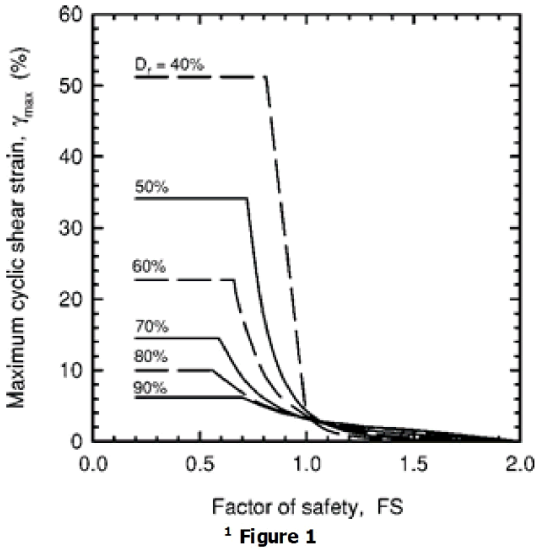
Procedure for the evaluation of soil liquefaction resistance, Boulanger & Idriss(2014)



Procedure for the evaluation of liquefaction-induced lateral spreading displacements



[1] Flow chart illustrating major steps in estimating liquefaction-induced lateral spreading displacements using the proposed approach



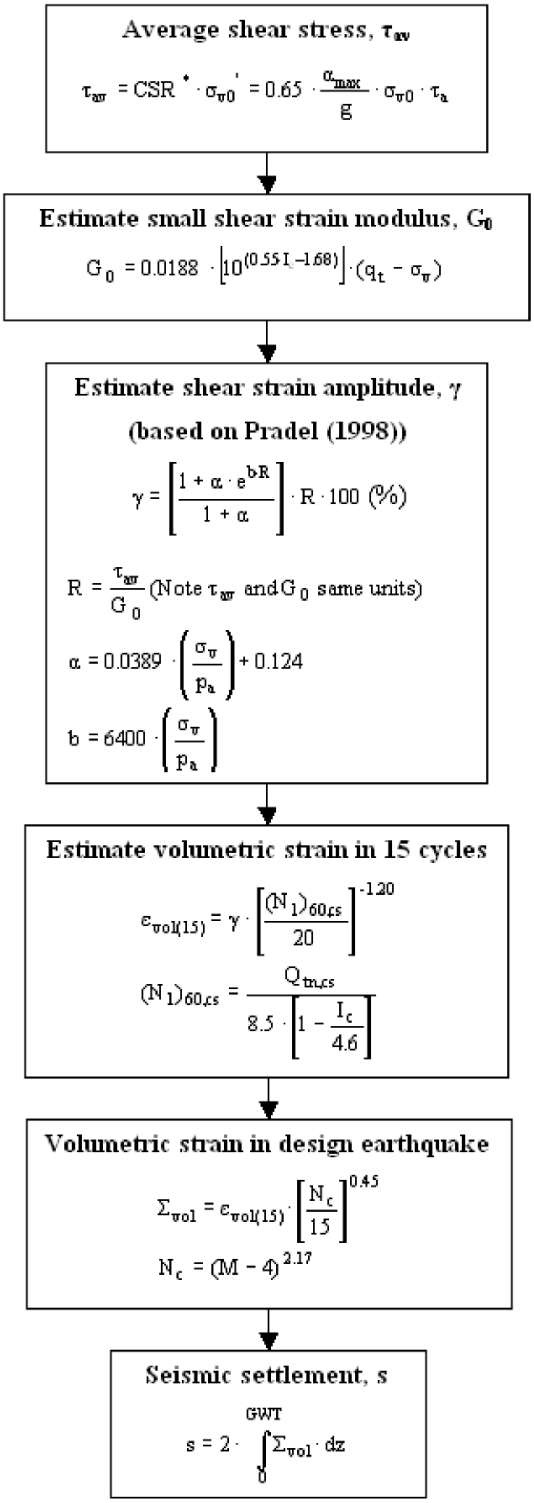
[1] Figure 1

$$LDI = \int_0^{z_{max}} \gamma_{max} dz$$

[1] Equation [3]

[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

Procedure for the estimation of seismic induced settlements in dry sands



Robertson, P.K. and Lisheng, S., 2010, "Estimation of seismic compression in dry soils using the CPT" FIFTH INTERNATIONAL CONFERENCE ON RECENT ADVANCES IN GEOTECHNICAL EARTHQUAKE ENGINEERING AND SOIL DYNAMICS, Symposium in honor of professor I. M. Idriss, San Diego, CA

Liquefaction Potential Index (LPI) calculation procedure

Calculation of the Liquefaction Potential Index (LPI) is used to interpret the liquefaction assessment calculations in terms of severity over depth. The calculation procedure is based on the methology developed by Iwasaki (1982) and is adopted by AFPS.

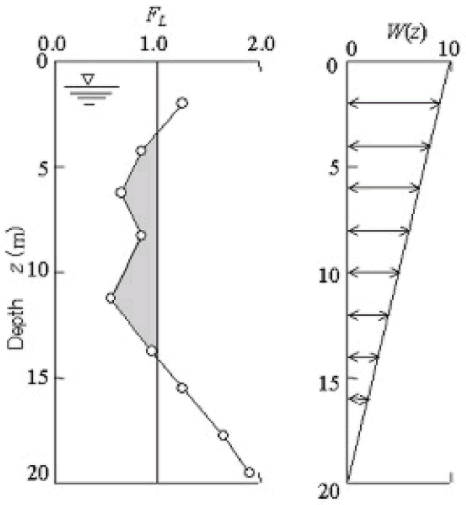
To estimate the severity of liquefaction extent at a given site, LPI is calculated based on the following equation:

$$\textbf{LPI} = \int_0^{20} (10 - 0{,}5_z) \times F_L \times d_z$$

where:
F_L = 1 - F.S. when F.S. less than 1
F_L = 0 when F.S. greater than 1
z depth of measurment in meters

Values of LPI range between zero (0) when no test point is characterized as liquefiable and 100 when all points are characterized as susceptible to liquefaction. Iwasaki proposed four (4) discrete categories based on the numeric value of LPI:

- LPI = 0 : Liquefaction risk is very low
- 0 < LPI <= 5 : Liquefaction risk is low
- 5 < LPI <= 15 : Liquefaction risk is high
- LPI > 15 : Liquefaction risk is very high



Graphical presentation of the LPI calculation procedure

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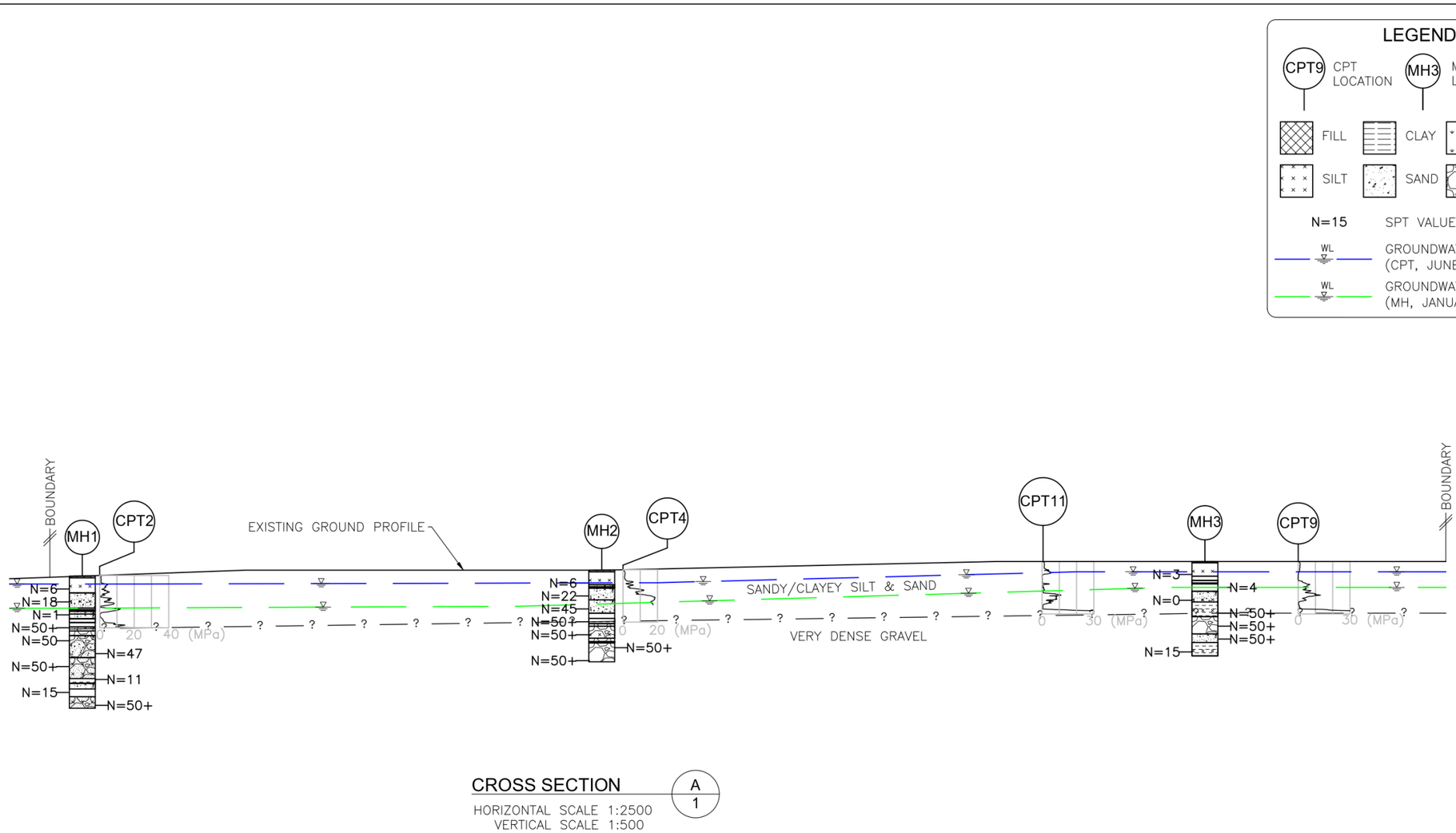
- R. E. S. Moss, R. B. Seed, R. E. Kayen, J. P. Stewart, A. Der Kiureghian, K. O. Cetin, CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 1, 2006
- I. M. Idriss and R. W. Boulanger, 2008. Soil liquefaction during earthquakes, Earthquake Engineering Research Institute MNO-12

APPENDIX D

RILEY Dwgs: 170672-1 and -2



		DESIGN LES	CHECKED LES	APPROVED FOR ISSUE:	RILEY CONSULTANTS P.O.BOX 100 253 NORTH SHORE AUCKLAND 0745 TEL. 09-4897872 FAX. 09-4897873	TITLE FLYGERS LINE INVESTMENT GROUP LIMITED RANGITIKEI LINE AND FLYGERS LINE, PALMERSTON NORTH GEOTECHNICAL INVESTIGATION - SITE PLAN	CADFILE 170672-1
		DRAWN GJ	CHECKED DT	D TATE			SCALES (A3) 1:2500
1	FIRST ISSUE	WY	13.02.19	DATE DRAWN FEB 2019	DATE: 21/02/19		ACENZ DRAWING No. 170672-1 REV. 1
REV	DESCRIPTION	BY	DATE				



CROSS SECTION A 1

HORIZONTAL SCALE 1:2500
VERTICAL SCALE 1:500

FOR INFORMATION

		DESIGN LES	CHECKED LES	APPROVED FOR ISSUE: D TATE	RILEY CONSULTANTS P.O.BOX 100 253 NORTH SHORE AUCKLAND 0745 TEL. 09-4897872 FAX. 09-4897873	TITLE FLYGERS LINE INVESTMENT GROUP LIMITED RANGITIKEI LINE AND FLYGERS LINE, PALMERSTON NORTH GEOTECHNICAL INVESTIGATION - CROSS SECTION A	CADFILE 170672-2 SCALES (A3) AS SHOWN
		DRAWN GJ	CHECKED JM	DATE: 21/02/19			ACENZ DRAWING No. 170672-2 REV. 1
1	FIRST ISSUE	WY	13.02.19	DATE DRAWN FEB 2019			
REV	DESCRIPTION	BY	DATE				

APPENDIX 7

LATERAL SPREADING ASSESSMENT

TOTAL GROUND ENGINEERING LTD

LATERAL SPREADING ASSESSMENT

Rangitikei Line & Flygers Line, Palmerston North

Document Number:	J00367AA
Revision:	Rev0
Prepared For:	Flygers Investment Group Limited
Date of Issue:	19 November 2020

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1. Introduction 2
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5. Lateral Spreading Analysis 6
5.1 Liquefaction 6
5.2 Lateral Spreading 7
6. Conclusions and Recommendations 9

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Executive Summary

Total Ground Engineering Ltd (TGE) have been engaged to carry out supplementary investigations and analysis to support a plan change for the proposed residential subdivision at the intersection of Rangitikei Line and Flygers Line Roads, Palmerston North.

Riley Consultants (Riley)carried out detailed investigations and analyses which identified that the site was subject to liquefaction under the ultimate limit state seismic loads. The surface effects of the liquefaction were considered minor and foundation recommendations were made. However, there was some uncertainty about the depth of groundwater and the subsequent risk and possible extent of lateral spreading and Riley recommended further investigation and analysis of the lateral spreading issue.

TGE have carried out supplementary investigations which confirm the depth of groundwater adopted by Riley Consultants and their analysis of liquefaction triggering and induced settlements. We have analysed the extent of lateral spreading adopting accepted liquefied strength ratios and concluded that lateral spreading is confined to a 55 m wide zone from the centreline of the proposed watercourse. Three options are proposed that prevent lateral spreading from affecting subdivided lots.

This report should be considered supplementary to the original Riley Consultants report.

1. Introduction

Total Ground Engineering Ltd (TGE) have been engaged by Flygers Investment Group Limited (the client) to carry out a supplementary geotechnical investigations and analysis of lateral spreading at Flygers Line Road, Palmerston North. The location of the site is shown in Figure 1.

This report provides supplementary analysis recommended in the Geotechnical Assessment by Riley Consultants (Riley ref 170672-D) prepared to support the proposed re-zoning and residential subdivision of the site. The proposed subdivision comprises realigning the existing drainage system and formation of a multi-lot subdivision. A proposed scheme plan has been provided and is attached in Appendix A.



Figure 1, Locality Plan

The Riley report investigated the geotechnical risks at the site. Riley carried out detailed investigations including cone penetrometer testing to evaluate liquefaction risk. Their analysis indicated that liquefaction was likely under the ultimate limit state loads but the surface damage and likely differential settlement was minor. They concluded that the site was suitable for residential development with provided additional investigation and analysis of lateral spreading was undertaken which would clarify the foundation types which could be adopted across the subdivision (TC2 or TC3).

We have now carried out the additional investigation and analyses to confirm the extent of lateral spreading. We present three options allowing the residential lots to be isolated from the effects of lateral spreading under the ULS event.

This report should be read in conjunction with the Riley Report.

2. Site Description

The site is legally described as Lot 2 DP 389924 and is located approximately 2 km north of the Palmerston North Central Business District. Residential housing and farmland boarder the site with access via the western side of State Highway three, Rangatikei Line.

Currently, the site is used for cropping as shown in Figure 2. The site is near-level to gently-sloping toward the southeast with several natural and manmade shallow drainage channels transecting the site.

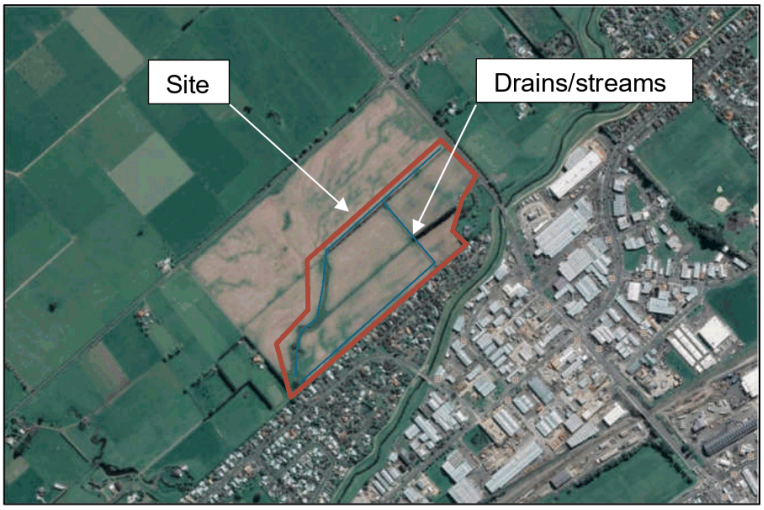


Figure 2, Google Earth image showing approximate extend of development and drainage systems

3. Site geology and regional liquefaction risk

A detailed description of the site geology and subsoil conditions is contained in the Riley Report. We summarise the geological conditions below, however, for a full description of the ground conditions the reader should refer to the Riley Report.

Reference has been made to the New Zealand Geology Web Map on the GNS website, http://data.gns.cri.nz/geology/, accessed 10th November 2020.

The site geology has been mapped as Holocene aged River Deposits (coloured light yellow in Figure 3) bounded to the east of the site by Late Pleistocene river deposits (coloured yellow in Figure 3) These Alluvial Deposits are described as Alluvial gravel, sand, silt, mud and clay with local peat, including modern riverbeds.



Figure 3, Snapshot of NZ Geological Map

GNS Science produced a report titled "*Assessment of liquefaction and related ground failure hazards in Palmerston North, New Zealand*" (GNS Report 2011/108, July 2011) which identifies the site within a broad area encompassing much of suburban Palmerston North in a zone at moderate risk of liquefaction.

4. Investigations and ground conditions

4.1 Original Investigations by Riley

The site was investigated by Riley Consultants Ltd between June 2018 and January 2019 comprising twelve CPTs to refusal at a maximum depth of 6.5m. Three sonic machine boreholes to depths ranging between 10.0m and 15.0m were carried out to investigate the dense gravels below the Holocene sediments.

Fourteen shallow hand augered boreholes where carried out as part of their ground contamination investigation.

The Riley investigation encountered groundwater at levels varying between 0.8m and 4.2m and referred to the GNS report which indicated a groundwater depth of 3m to 4m. For analysis of liquefaction, Riley adopted a conservative estimate of 1m depth.

4.2 Supplementary Investigations by TGE

Liquefaction assessment is sensitive to groundwater level. In order to confirm the groundwater levels, TGE carried out a field investigation on 23 September 2020 comprising the following:

- Three hand augured boreholes and associated in-situ soil testing (i.e. vane shear strength and scala penetrometer testing); and
- Installation of three piezometers for the purpose of ground water monitoring.

The location of the Riley boreholes (black icons) and the TGE hand augers (orange icons) and the location of developed cross sections are shown in Figure 4 extracted from the Test Location Plan attached in Appendix B.

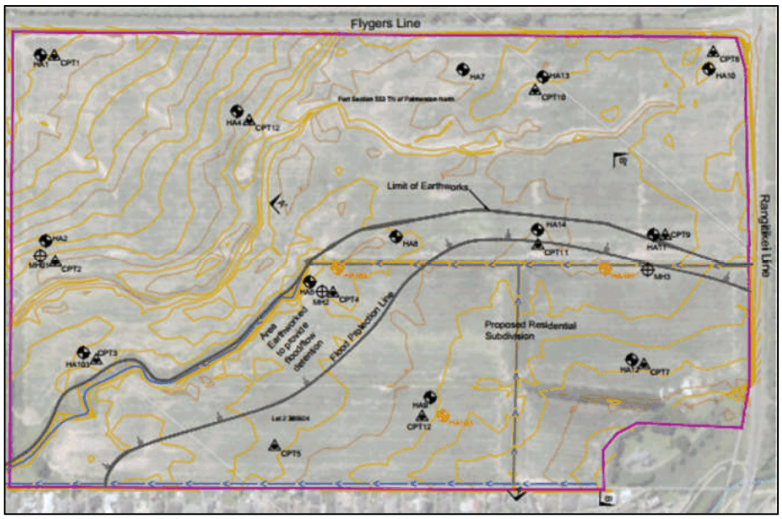


Figure 4, TGE test locations shown as orange icons

Soil conditions were logged by a TGE Engineering Geologist, in accordance with the New Zealand Geotechnical Society's, *Guideline for the Description of Soil and Rock for Engineering Purposes* (2005).

In-situ shear vane tests were carried out at 0.5 m intervals to measure the undrained shear strength of fine-grained cohesive materials. Vane shear tests were carried out in accordance with the New Zealand Geotechnical Society Guideline for handheld shear vane test, (2001). Peak and remoulded shear strength values shown on field logs have been factored in terms of BS1377.

Dynamic Cone Penetrometer (Scala) testing was carried out at selected depths in the boreholes to determine soil density. Scala testing was carried out in accordance with NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer.

Handauger borelogs and scala penetrometer logs are attached in Appendix B.

4.3 Ground Conditions

The subsurface conditions encountered during our field investigation generally comprised a layer of Holocene aged river deposits being stiff to very stiff silts with subordinate fractions of sands and clays interbedded with lenses of medium dense to dense sands, overlying dense to very dense river gravels at depth, in general accordance with the mapped geology and previous field investigations. The geological profile is shown in Figure 5 extracted from cross section A-A' attached in Appendix C.

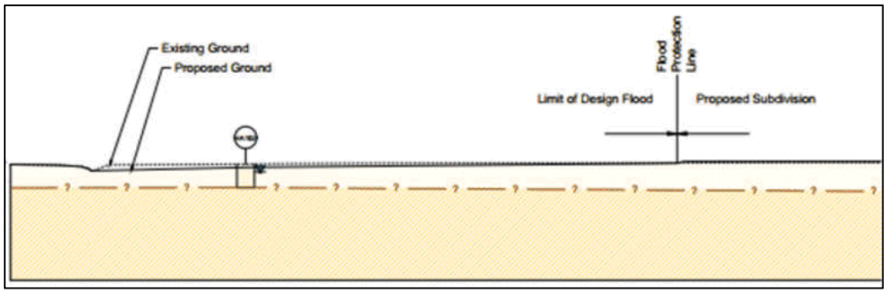


Figure 5, Cross section A-A' showing approx 4.0m-5.0m of silts and sands overlying dense river gravels

A summary of the geological profile is provided below;

Topsoil Topsoil was encountered to a depth of 0.2 m to 0.3 m.

Holocene aged River Deposits Alluvial soils were encountered below topsoil to a depth of 4.0m to 5.0m. These Alluvial soils comprised of stiff to very stiff silts with subordinate fractions of sand and clays, interbedded with layers of fine to medium silty sand to sand. The fine-grained alluvial soils are generally described as slightly to moderately plastic and moist to saturated. Peak vane shear strengths ranged between 69 kPa to greater than 200 kPa within the fine grain cohesive material while Scala penetrometer testing in the non-cohesive material returned values ranging between 3 blows to 29 blows per 100mm penetration, and where generally above 4 blows per 100mm penetration.

Scala Penetrometer testing conducted from the base of the hand augers encountered effective refusal at depths between 3.8 m and 5.6 m, inferred to be the contact with dense river gravels at depth.

Groundwater Groundwater was encountered in the augered boreholes on the day of drilling and subsequently measured in the piezometers ranging between 0.85 m and 1.3 m depth.

5. Lateral Spreading Analysis

5.1 Liquefaction

Riley Consultants classified the site as Class D (deep soil site) resulting in a ULS peak ground acceleration of 0.34g. They went on to analyse the risk of liquefaction and concluded that layers of saturated sands and silts in the upper layer of alluvium would liquefy in the ULS event.

Liquefaction Severity Numbers were calculated indicating moderate expression of liquefaction at the surface with sand boils likely and minor differential settlement of structures. Riley considered that residential dwellings with foundations in accordance with MBIE's TC2 category would be appropriate.

Riley used empirical methods to evaluate lateral spread which yielded set-back distances of 100 m from the water-course. Lesser set-backs were considered possible but were contingent on elevating the dwelling foundations to TC3 category. The conclusion was that more in-depth lateral spreading analysis should be carried out.

We concur with the liquefaction analysis methodology and results obtained by Riley and generally concur with their conclusions. We have completed the additional investigations and describe our in-depth analysis of lateral spreading below.

5.2 Lateral Spreading

We have analysed the risk of lateral spread after the ULS event using the slope stability package Slope/w. We have assumed that the upper layer of Holocene alluvial sediments, beneath a 1 m deep groundwater level, liquefies. Olson and Stark (2002) proposed a liquefied strength ratio s_u/σ'_{vo} ranging from 0.05 to 0.12 (Figure 6) with an average of 0.09. For analysis we have conservatively adopted a ratio of $s_u/\sigma'_{vo} = 0.075$.

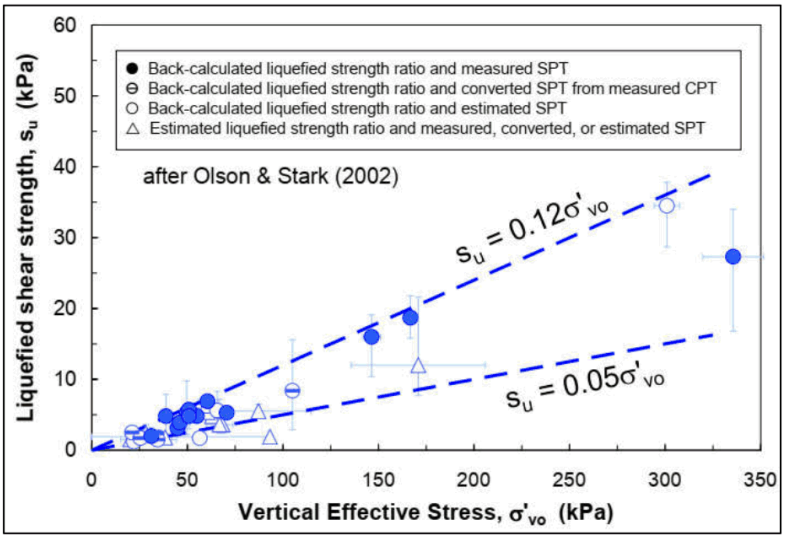


Figure 6. Liquefied strength ratio from back-analysed flow failures.

Figure 7 shows the factor of safety for shallow laterally spreading failure surfaces through the widest section of the proposed channel on Section A-A'.

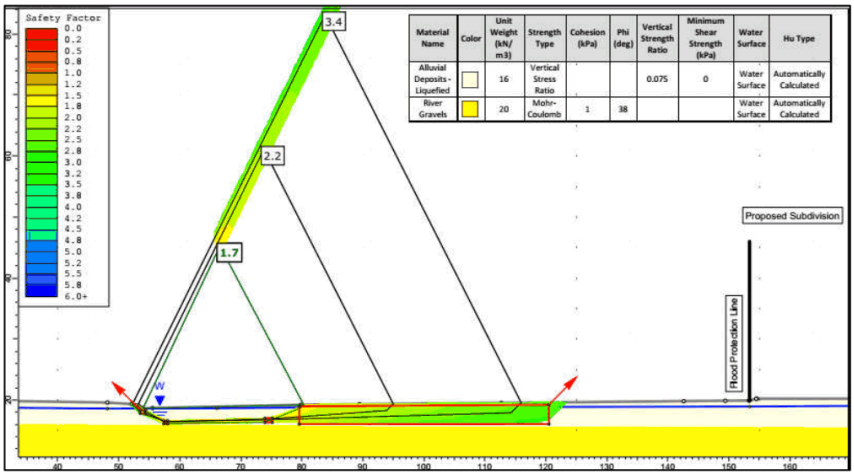


Figure 7. Section A-A'. Factor of safety for lateral spreading.

Analysis shows that at Section A-A' where the proposed overland flow channel is broad, and the gradient of the surface is shallow, the factor of safety for lateral spreading exceeds 1.0 and there is little risk of lateral spreading, especially beyond the flood protection line.

At Section B-B' the overland flow channel narrows with a consequently steeper gradient. Figure 8 indicates that lateral spreading would encroach beyond the flood protection line into the subdivision. Adopting a factor of safety of 1.2 as the minimum criteria under ULS seismic loading would result in a building restriction line being imposed within the propose subdivision. We refer to this as Option 1 whereby the lots would need to be reconfigured with a likely reduction in the number of lots, all remaining outside the building restriction line.

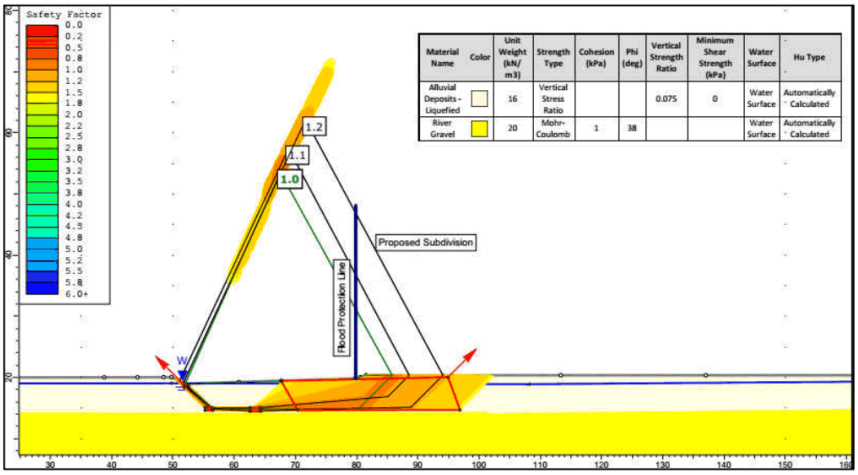


Figure 8. Section B-B'. Lateral Spreading; Option 1.

In order for potential lateral spreading to remain within the flood protection zone, we have widened the overland flow path, reducing the slope gradient until the slip-surface associated with the minimum factor of safety is within the flood zone. Figure 9 shows the results of this scenario which we refer to as Option 2.

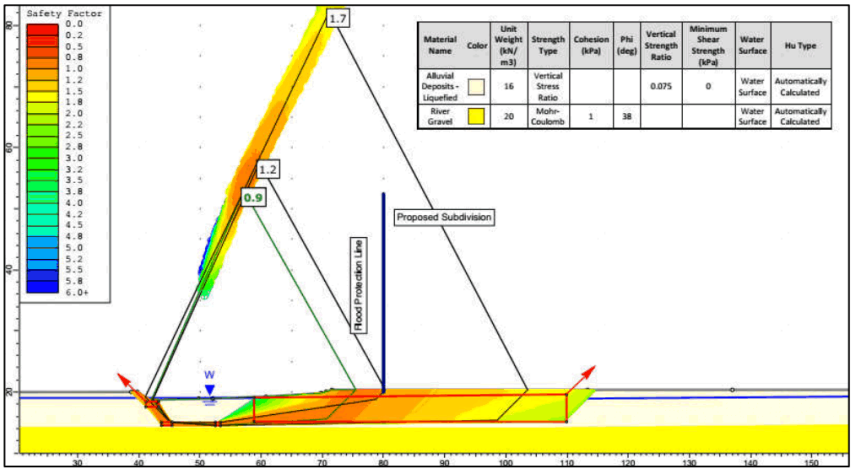


Figure 9. Section B-B'. Lateral Spreading; Option 2.

For Option 3, we have re-analysed the proposed narrow floodpath, with an 8m wide zone of "improved" soil which remains un-liquefied. The improved zone is obscured by the green shaded zone of analysis results shown in Figure 10. The analysis demonstrates that the zone of improved material acts as a shear-key preventing lateral spreading extending into the proposed subdivision.

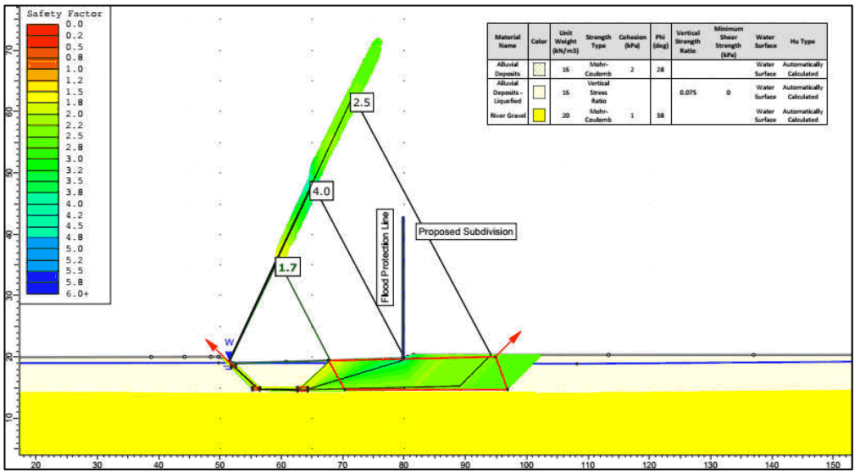


Figure 10. Section B-B'. Lateral Spreading; Option 3.

Options for improving the soil to provide the shear key against lateral spreading are discussed below.

In summary, analysis shows that lateral spreading under the ULS seismic loading encroaches into the proposed subdivision where the overland flow channel becomes narrow to the northeast of the site. We propose three options for mitigating this risk below.

6. Conclusions and Recommendations

Riley Consultants concluded that shallow subsoils at the site could liquefy to depths of approximately 6m under the ULS seismic loading. The effects at the surface would be minor and the site would be equivalent to the TC2 land category adopted by MBIE in Christchurch. However, additional analysis of lateral spreading was recommended.

Our investigations confirm the groundwater levels assumed by Riley Consultants and our analysis indicates that under the current earthworks scheme, Option 1 would comprise a building exclusion line, 55 m from the limit of earthworks as shown in Figure 11.

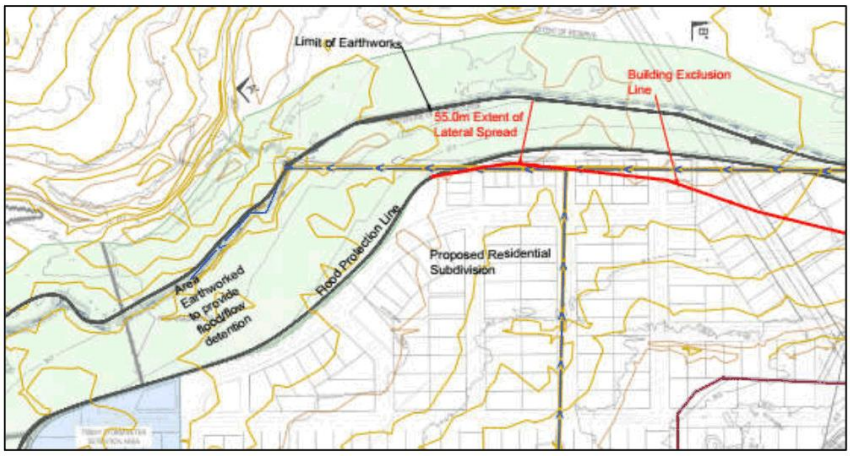


Figure 11. Option 1. Impose Building Restriction Line.

Option 2 would comprise widening the overland flow channel to a minimum width of 55 m from the flood protection line as shown in Figure 12. This would allow the current lot layout to be maintained.

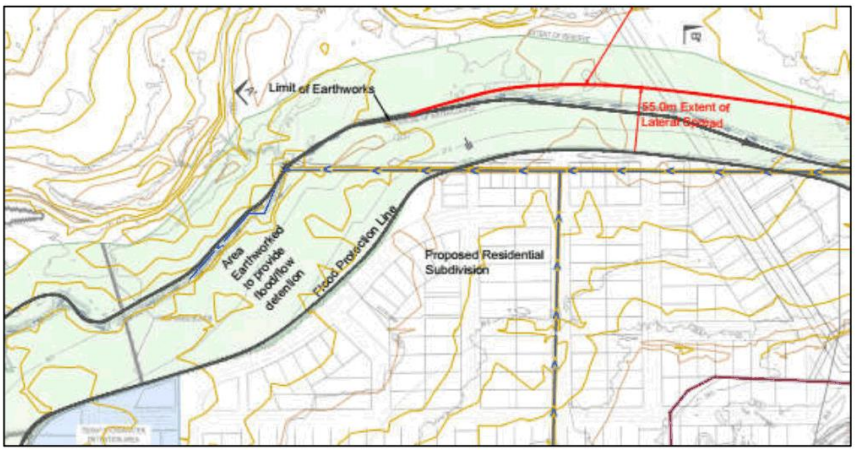


Figure 12. Option 2. Translate extent of earthworks. Maintain lot arrangement.

Figure 13 shows Option 3 comprising an 8 m wide band of ground improvement which would isolate the proposed subdivision from lateral spread by acting as a shear key.

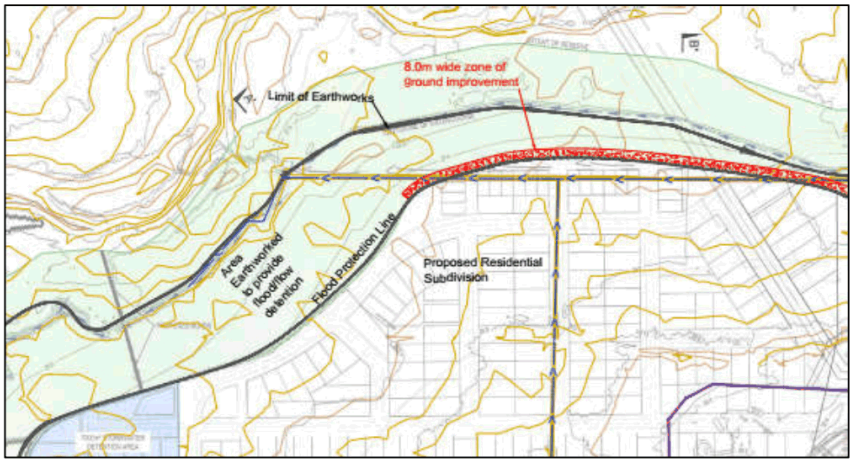


Figure 13. Install ground improvement. Maintain lot arrangement.

For Option 3, there are several methods which could be adopted as follows:

1. Excavate and replace the sediments with river gravels. Temporary stability of the saturated alluvial soils could result in a wide excavation and some excavation trials would be prudent.
2. Dynamic compaction. Densifying the materials could be achieved by heavy dynamic compaction. Square or triangular "rollers" have been used successfully, but trials and testing would be required to demonstrate the effectiveness of this method through the entire column of alluvial sands and silts. There is a high degree of uncertainty attached to this option.
3. Stone columns. Installing stone columns through the alluvial sands and silts, would provide a high-shear composite zone with capacity for high pore pressures to be rapidly relieved by the stone columns.

We trust this report meets your requirements. Please contact the undersigned if you have any questions.

Yours Faithfully

Prepared by:

Jared Healey

Engineering Geologist

BSc(Geology), PGDipSci(Earth Science)

Total Ground Engineering

Reviewed and Authorised by:

Neil Jacka

Principal Geotechnical Engineer

CMEngNZ, CPEng

Total Ground Engineering

Limitation

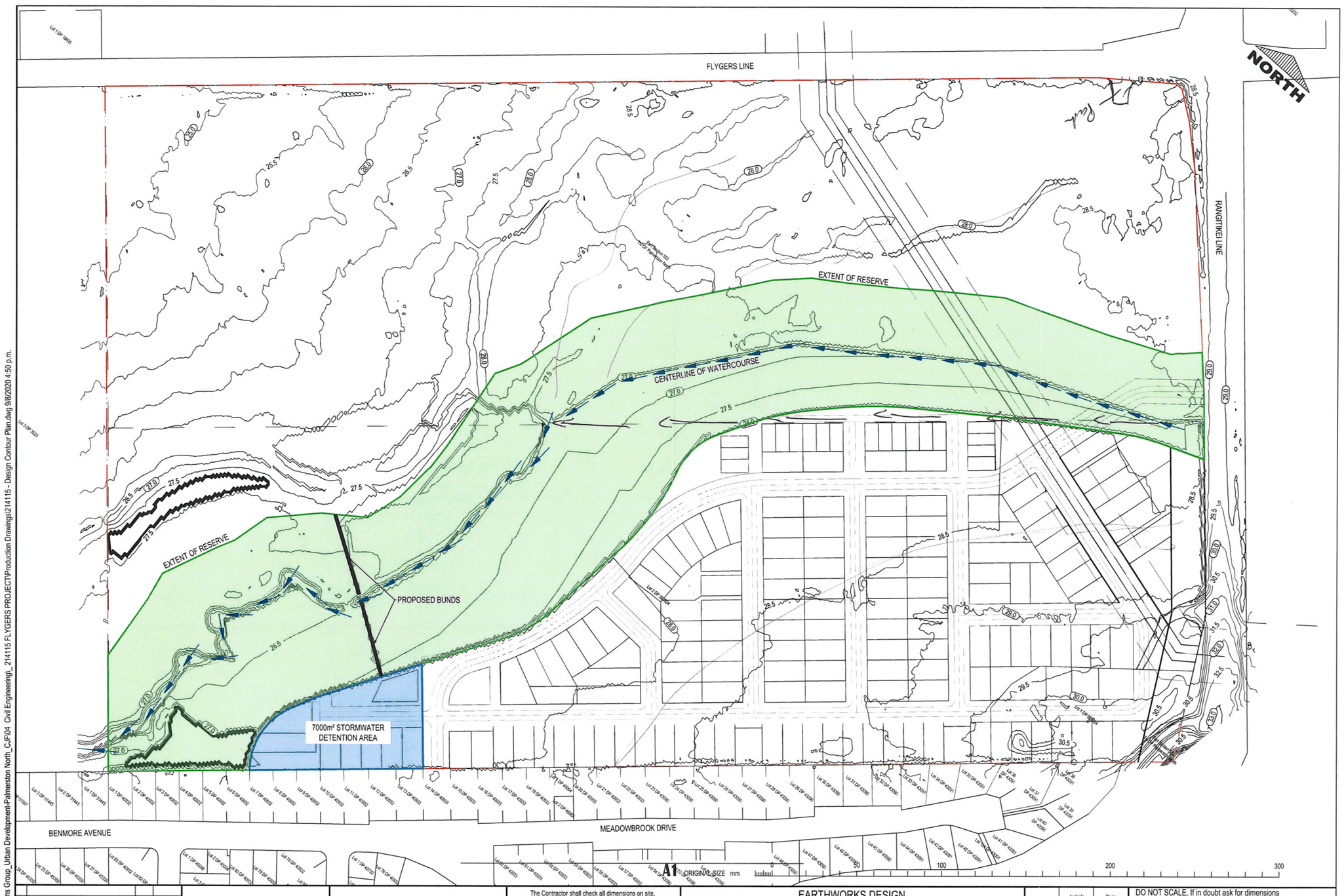
This report has been prepared by Total Ground Engineering for our client's use in accordance with the proposed development plans and agreed scope of work. Any use or reliance by any other person, to which Total Ground Engineering has not given its prior written consent, is at that person's own risk.

The findings, recommendations and comments presented in this report are based on common methods of site investigation. The site investigation has been undertaken at discrete locations and ground conditions away from these locations could vary.

Appendices

Appendix A. Reference Information
Appendix B. Investigation Plan and Borelogs
Appendix C. Geological Sections
Appendix D. Analysis Outputs
Appendix E. Remediation Options

Appendix A
Reference Information



J:\200\214\214115 Higgins Group_Urban Development-Palmerston North_CJP\04 Civil Engineering_214115 FLYGERS PROJECT\Production Drawings\214115 - Design Contour Plan.dwg 9/8/2020 4:50 p.m.

Rev	Details	Drawn	Date
P1	ISSUED FOR APPROVAL	JWW	08/09/20

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EARTHWORKS DESIGN
FLYGERS LINE
PALMERSTON NORTH

FINISHED GROUND CONTOURS
HIGGINS GROUP

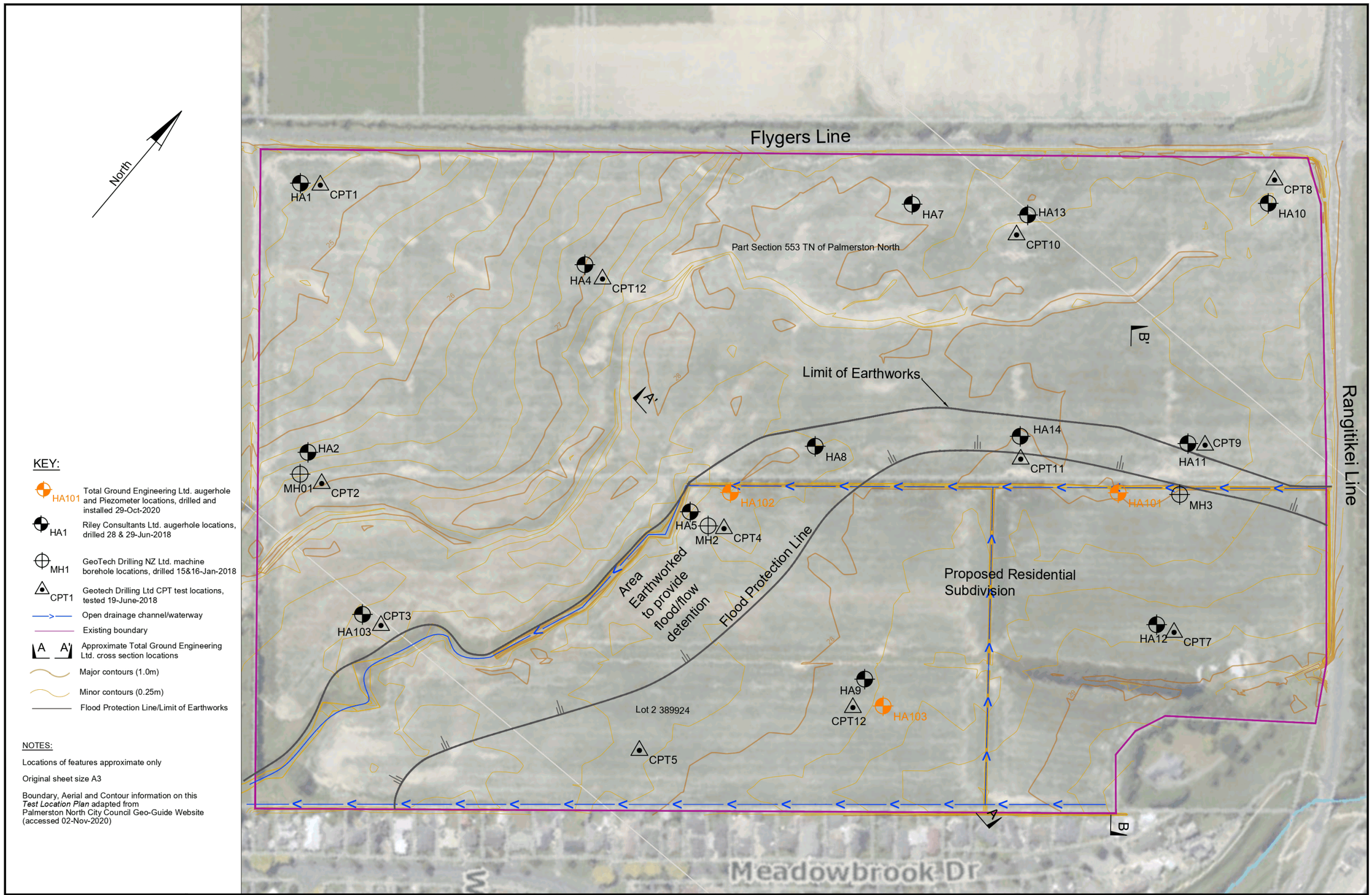
	Initials	Date
Surveyed		
Designed	KBJ	09/20
Drawn	JWW	09/20
Checked	KBJ	09/20
Approved		

DO NOT SCALE, If in doubt ask for dimensions

Scales A1	Scales A3	Job No.
1:1250	1:2500	214115

CAD Path/File	Sheet	of	Sheets	Rev.
214115 - Design Contour Plan	1		1	P1

Appendix B
Investigation Plan and Borelogs



KEY:

- HA101 — Total Ground Engineering Ltd. augerhole and Piezometer locations, drilled and installed 29-Oct-2020
- HA1 — Riley Consultants Ltd. augerhole locations, drilled 28 & 29-Jun-2018
- MH1 — GeoTech Drilling NZ Ltd. machine borehole locations, drilled 15&16-Jan-2018
- CPT1 — Geotech Drilling Ltd CPT test locations, tested 19-June-2018
- Open drainage channel/waterway
- Existing boundary
- A A' — Approximate Total Ground Engineering Ltd. cross section locations
- Major contours (1.0m)
- Minor contours (0.25m)
- Flood Protection Line/Limit of Earthworks

NOTES:

Locations of features approximate only

Original sheet size A3

Boundary, Aerial and Contour information on this *Test Location Plan* adapted from Palmerston North City Council Geo-Guide Website (accessed 02-Nov-2020)

AMENDMENTS		
DATE	REV	DESCRIPTION
02/11/2020	A	Report Issue

Check all dimensions and levels on site before commencing construction.

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Test Location Plan

Flygers Line Road
PALMERSTON NORTH

TOTAL GROUND ENGINEERING

Physical Address:
27D Waipareira Ave, Henderson, 0610

Postal Address:
PO Box 27294, Glen Eden, 0604
Auckland, New Zealand

Website: www.totalgroundengineering.com

Drawing No.	Drawn by:	Date:
J00367/ 1	J Healey	02/Nov/2020
Scale: 1: 2500 (A3)	Checked by: N Jacka	Revision: A

Filename: J00367-Drawings.dwg

TOTAL GROUND ENGINEERING

Client: Flygers Investment Group
Project: Residential Subdivision
Address: Flygers Line Road, Palmerston North

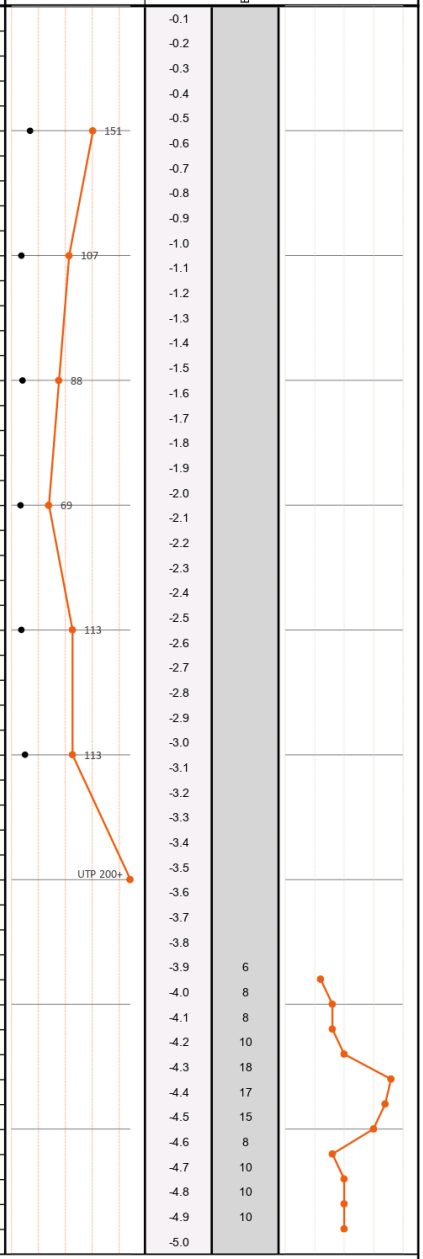
Augerhole No. HA101
Sheet No. 1 of 1

Drill Type:	50mmØ Hand Auger	Project No:	J00367	Logged By:	JH
Drilled By:	JH	Coordinates:	NZTM2000 E1820104.47 N5531754.65	Shear Vane No:	2982
Date Started:	29-Oct-20	Ground Conditions:	Near Level Soil	Calibration Factor:	1.571
Date Finished:	29-Oct-20	Groundwater Level (m):	0.85m (29-Oct-20)	Calibration Date:	18-Sep-20

Stratigraphy	Depth (m)	Graphic Log	Soil description in accordance with *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes*, NZ Geotechnical Society Inc., 2005
TS			SILT, trace fine to medium sand, trace clay, brown, firm, moist, non-plastic [TOPSOIL]
HOLOCENE ALLUVIAL DEPOSITS	0.5		SILT, trace to minor clay, trace fine to medium sand, light grey with dark orange streaks, very stiff, moist, slightly plastic [HOLOCENE ALLUVIAL DEPOSITS]
	1.0		some clay, trace fine sand, light grey with trace orange streaks and mottles
	1.5		Fine to medium SAND, trace silt, brownish orange with dark orange bands, loose to medium dense, wet
	2.0		SILT, some clay, minor fine to medium sand, light grey, stiff, wet, moderately plastic
	2.5		some clay to clayey, some decomposed fibrous organic inclusions, light grey with dark brown inclusions
	3.0		50mm bands of decomposed wood
	3.5		some clay, trace fine sand, dark grey, very stiff
	4.0		hard
	4.5		Fine to medium SAND, trace silt, dark grey, medium dense
	5.0		dense
			very dense
			dense
			SILT, minor fine sand, trace clay, dark grey, hard, saturated, non-plastic
			End of Augerhole 5.0m [TARGET DEPTH]

Groundwater Level (m): GW = 0.85m (29-Oct-20)

In-situ Field Testing



In-situ field testing in accordance with the following Standards:
Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer
Shear Vane Testing: Guideline for Hand Held Shear Vane Test, NZGS, August 2001

Total Ground Engineering Ltd. 27D Waipareira Ave, Henderson, 0610
PO Box 27294, Glen Eden, 0604, Auckland, New Zealand
Phone: +64 9 216 7330
Website: www.totalgroundengineering.com

TOTAL GROUND ENGINEERING

Client:	Flygers Investment Group	Augerhole No.	HA102
Project:	Residential Subdivision	Sheet No.	1 of 1
Address:	Flygers Line Road, Palmerston North		

Drill Type:	50mmØ Hand Auger	Project No:	J00367	Logged By:	JH
Drilled By:	JH	Coordinates:	NZTM2000 E1819877.81 N5531574.05	Shear Vane No:	2982
Date Started:	29-Oct-20	Ground Conditions:	Near Level Soil	Calibration Factor:	1.571
Date Finished:	29-Oct-20	Groundwater Level (m):	1.3m (29-Oct-20)	Calibration Date:	18-Sep-20

Stratigraphy	Depth (m)	Soil description in accordance with *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes*, NZ Geotechnical Society Inc., 2005
TOPSOIL		SILT, trace fine to medium sand, light brown, stiff, moist, non-plastic [TOPSOIL]
HOLOCENE ALLUVIAL DEPOSITS	0.5	SILT, some clay, trace fine to medium sand, light grey with orange bands and dark orange mottles, very stiff, moist, slightly to moderately plastic [HOLOCENE ALLUVIAL DEPOSITS]
	1.0	Silty fine to medium SAND, light grey with orange streaks, loose to medium dense, wet
	1.5	Clayey SILT, trace fine to medium sand, light bluish grey with dark orange streaks, stiff, saturated, moderately plastic
	2.0	Fine to medium SAND, trace silt, dark grey, medium dense, saturated
	2.5	SILT, minor clay, minor fine sand, dark grey, stiff, wet, slightly plastic
	3.0	some clay, minor to some decomposed organic inclusions, moderately plastic
	3.5	Fine to medium SAND, trace silt, dark grey, medium dense, saturated
	4.0	End of Augerhole 4.0m [TOO DENSE TO AUGER]
	4.5	
	5.0	End of Augerhole 5.0m [TARGET DEPTH]

Groundwater Level (m): GW = 1.3m (29-Oct-20)

In-situ Field Testing

Shear Strength (kPa): Peak: ●; Remoulded: ●; 0 50 100 150 200

Dynamic Cone (Scala) Penetrometer

Depth (m)	Blow Count
-0.1	
-0.2	
-0.3	
-0.4	
-0.5	
-0.6	
-0.7	
-0.8	
-0.9	
-1.0	
-1.1	
-1.2	
-1.3	
-1.4	
-1.5	
-1.6	
-1.7	
-1.8	
-1.9	
-2.0	
-2.1	3
-2.2	3
-2.3	4
-2.4	5
-2.5	6
-2.6	6
-2.7	7
-2.8	8
-2.9	
-3.0	
-3.1	
-3.2	
-3.3	
-3.4	21
-3.5	21
-3.6	21
-3.7	24
-3.8	24
-3.9	
-4.0	
-4.1	
-4.2	
-4.3	
-4.4	
-4.5	
-4.6	
-4.7	
-4.8	
-4.9	
-5.0	

Scala Blow Count / 100mm: 0 5 10 15 20

Shear Strength: 179, 119, 88, UTP 200+

In-situ field testing in accordance with the following Standards:

Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer

Shear Vane Testing: Guideline for Hand Held Shear Vane Test, NZGS, August 2001

Total Ground Engineering Ltd. 27D Waipareira Ave, Henderson, 0610
PO Box 27294, Glen Eden, 0604, Auckland, New Zealand
Phone: +64 9 216 7330
Website: www.totalgroundengineering.com

TOTAL GROUND ENGINEERING

Client: Flygers Investment Group
Project: Residential Subdivision
Address: Flygers Line Road, Palmerston North

Augerhole No. HA103
Sheet No. 1 of 1

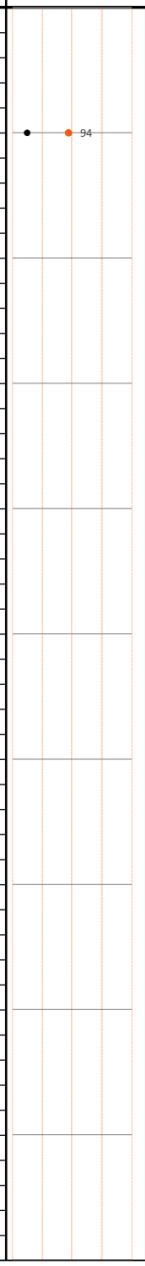
Drill Type:	50mmØ Hand Auger	Project No:	J00367	Logged By:	JH
Drilled By:	JH	Coordinates:	NZTM2000 E1820074.56 N5531533.63	Shear Vane No:	2982
Date Started:	29-Oct-20	Ground Conditions:	Near Level Soil	Calibration Factor:	1.571
Date Finished:	29-Oct-20	Groundwater Level (m):	1.02m (29-Oct-20)	Calibration Date:	18-Sep-20

Stratigraphy	Depth (m)	Graphic Log	Soil description in accordance with *Guideline for the Field Classification and Description of Soil and Rock for Engineering Purposes*, NZ Geotechnical Society Inc., 2005
TOPSOIL	0.0		SILT, minor fine to medium sand, minor clay, light brown, stiff, moist, slightly plastic [TOPSOIL]
HOLOCENE ALLUVIAL DEPOSITS	0.5		SILT, minor fine to medium sand, trace clay, light grey with dark orange mottles, stiff, moist, non to slightly plastic [HOLOCENE ALLUVIAL DEPOSITS]
	1.0		Fine to medium SAND, brown, medium dense, wet
	1.5		brownish orange grey, dense
	2.0		medium dense
	3.0		
	3.5		
	4.0		SILT, minor clay, minor fine to medium sand, dark grey, very stiff, hard, saturated, slightly plastic
	4.5		Fine to medium SAND, trace silt, dark grey, very dense, saturated
	5.0		SILT, minor clay, minor fine to medium sand, dark grey, hard, saturated, slightly plastic
			End of Augerhole 5.0m [TARGET DEPTH]

Groundwater Level (m): GW = 1.02m (29-Oct-20)

In-situ Field Testing

Shear Strength (kPa) — Peak: / Remoulded: (0 50 100 150 200)



Dynamic Cone (Scala) Penetrometer

Depth (m)	Blow Count	Scala Blow Count / 100mm
-0.1		
-0.2		
-0.3		
-0.4		
-0.5		
-0.6		
-0.7		
-0.8		
-0.9		
-1.0		
-1.1	3	
-1.2	5	
-1.3	9	
-1.4	12	
-1.5	9	
-1.6	11	
-1.7	9	
-1.8	15	
-1.9	13	
-2.0		
-2.1	8	
-2.2	12	
-2.3	7	
-2.4	3	
-2.5	3	
-2.6	3	
-2.7	3	
-2.8	4	
-2.9	4	
-3.0		
-3.1	5	
-3.2	5	
-3.3	3	
-3.4	6	
-3.5	6	
-3.6	6	
-3.7	8	
-3.8	8	
-3.9	9	
-4.0	15	
-4.1	16	
-4.2	14	
-4.3	12	
-4.4	15	
-4.5	18	
-4.6	19	
-4.7	29	
-4.8	25	
-4.9		
-5.0		

In-situ field testing in accordance with the following Standards:
Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer
Shear Vane Testing: Guideline for Hand Held Shear Vane Test, NZGS, August 2001

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Website: www.totalgroundengineering.com

TOTAL GROUND ENGINEERING

Client: Flygers Investment Group
Project: Residential Subdivision
Address: Flygers Line Road, Palmerston North

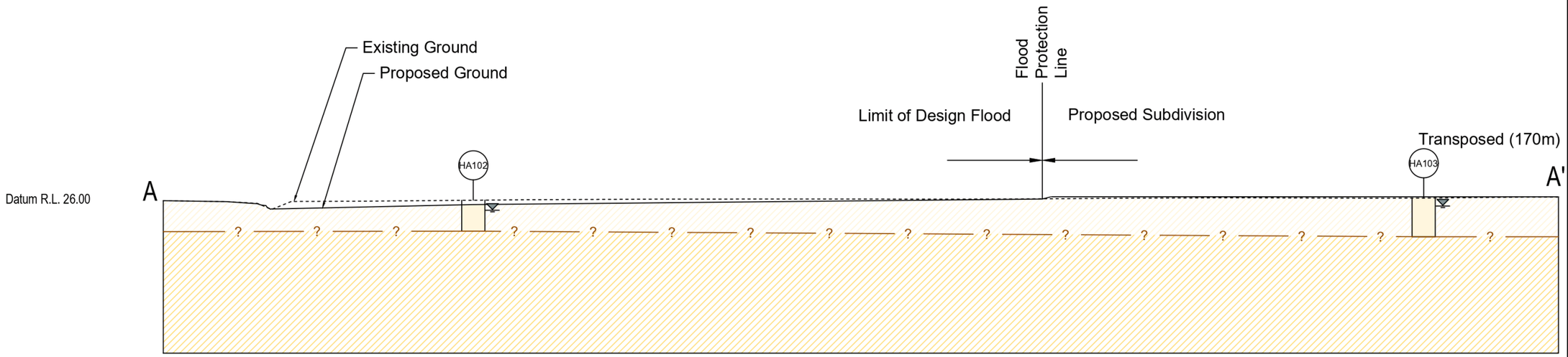
Scala Penetrometer Testing

Date tested: 29-Oct-20 Tested By: JH

Test ID	HA101									
Test from (m)	5.0									
Depth (m)	Blows/100mm penetration									
0.1	3									
0.2	3									
0.3	3									
0.4	6									
0.5	23									
0.6	40+									
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										
Test depth (m)	5.6									

In-situ field testing in accordance with Scala Penetrometer Testing: NZS 4402:1988, Test 6.5.2, Dynamic Cone Penetrometer

Appendix C
Geological Sections



CUT/FILL	0.00	-0.02	-0.86	-0.70	-0.57	-0.54	-0.49	-0.42	-0.33	-0.23	-0.12	-0.05	0.21	0.16	0.13	0.17	0.18	0.09	0.03
EXISTING LEVEL	27.54	27.31	27.45	27.51	27.60	27.68	27.72	27.74	27.75	27.75	27.74	27.77	27.83	27.88	27.91	27.88	27.87	27.95	28.01
PROPOSED LEVEL	27.54	27.29	26.59	26.81	27.04	27.13	27.23	27.33	27.43	27.52	27.62	27.72	28.05	28.05	28.04	28.04	28.04	28.04	28.04
CHAINAGE	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00

Legend:

HA101 — Total Ground Engineering hand augerhole locations

Groundwater Level

Scala penetrometer from base of augerhole

Geologic Unit:

Holocene Alluvial Deposits

River Gravels

KEY:

Proposed Ground

Exisiting Ground

0 20 40 60 80m

Scale 1: 500

AMENDMENTS		
DATE	REV	DESCRIPTION
06/11/2020	A	Report Issue

Check all dimensions and levels on site before commencing construction.

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Cross Section
A - A'
Flygers Line Road
PALMERSTON NORTH

TOTAL GROUND ENGINEERING

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Postal Address:
PO Box 27294, Glen Eden, 0604
Auckland, New Zealand

Website: www.totalgroundengineering.com

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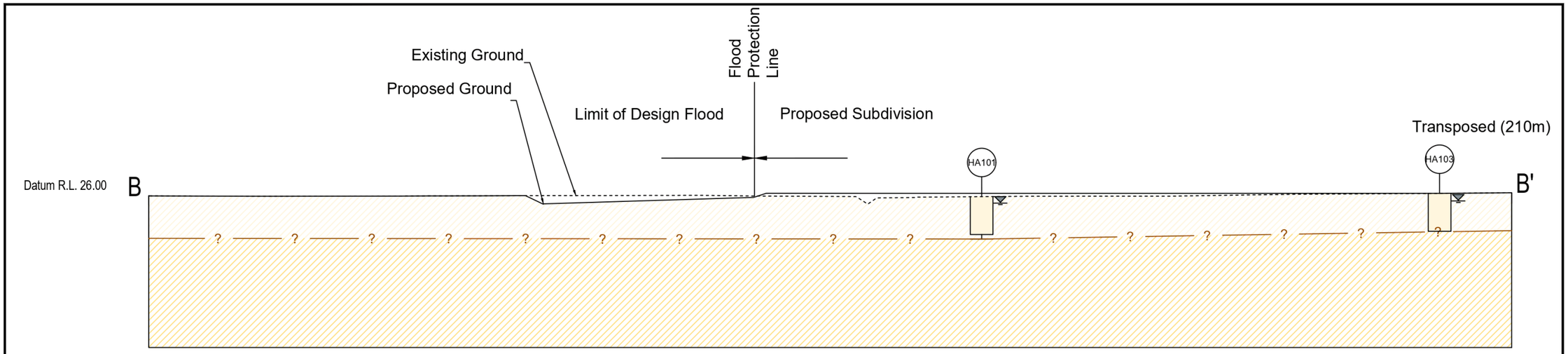
J00367/ 2	J Healey	06-Nov-2020
Scale: 1: 500 (A3) H:V = 1:1	Checked by: N Jacka	Revision: A

Filename: J00367-Drawings.dwg



CUT/FILL	0.00	0.00	0.00	0.00	0.00	-0.11	-0.86	-0.57	-0.15	0.41	0.57	0.44	0.38	0.37	0.30	0.15	0.07	0.01	0.00
EXISTING LEVEL	28.15	28.12	28.11	28.13	28.15	28.18	28.19	28.22	28.14	28.08	27.92	28.05	28.11	28.11	28.19	28.34	28.42	28.48	28.56
PROPOSED LEVEL	28.15	28.12	28.11	28.13	28.15	28.06	27.34	27.64	27.99	28.49	28.49	28.49	28.49	28.49	28.49	28.49	28.49	28.49	28.56
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00

Legend:

HA101 — Total Ground Engineering hand augerhole locations

Groundwater Level

Scala penetrometer from base of augerhole

Geologic Unit:

Holocene Alluvial Deposits

River Gravels

KEY:

Proposed Ground

Exisiting Ground

0 20 40 60 80m

Scale 1: 500

AMENDMENTS		
DATE	REV	DESCRIPTION
09/11/2020	A	Report Issue

Check all dimensions and levels on site before commencing construction.

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Cross Section
B - B'
Flygers Line Road
PALMERSTON NORTH

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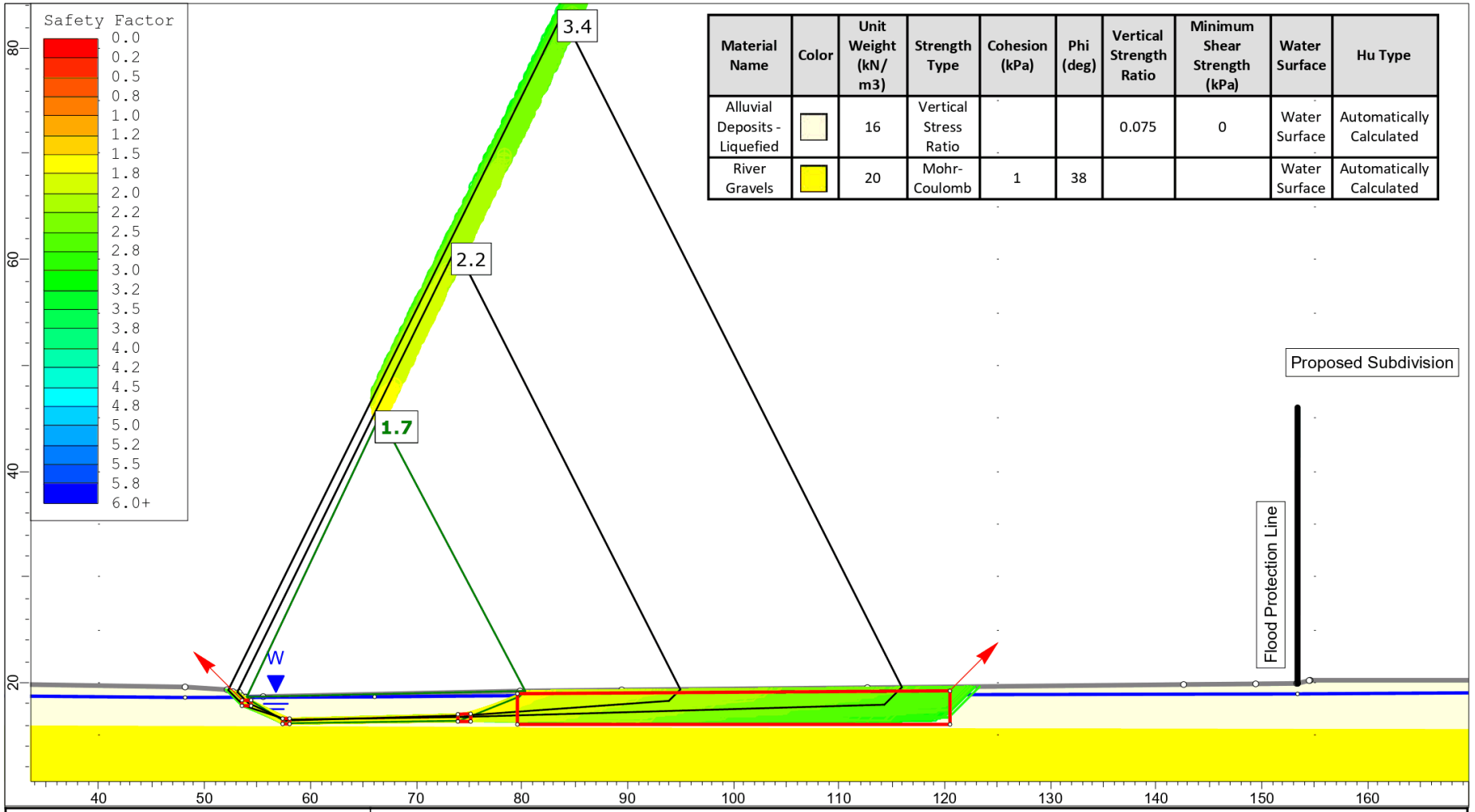
Drawing No.	Drawn by:	Date:
J00367/ 3	J Healey	09-Nov-2020
Scale: 1: 500 (A3) H:V = 1:1	Checked by: N Jacka	Revision: A

Filename: J00367-Drawings.dwg

Appendix D
Analysis Outputs

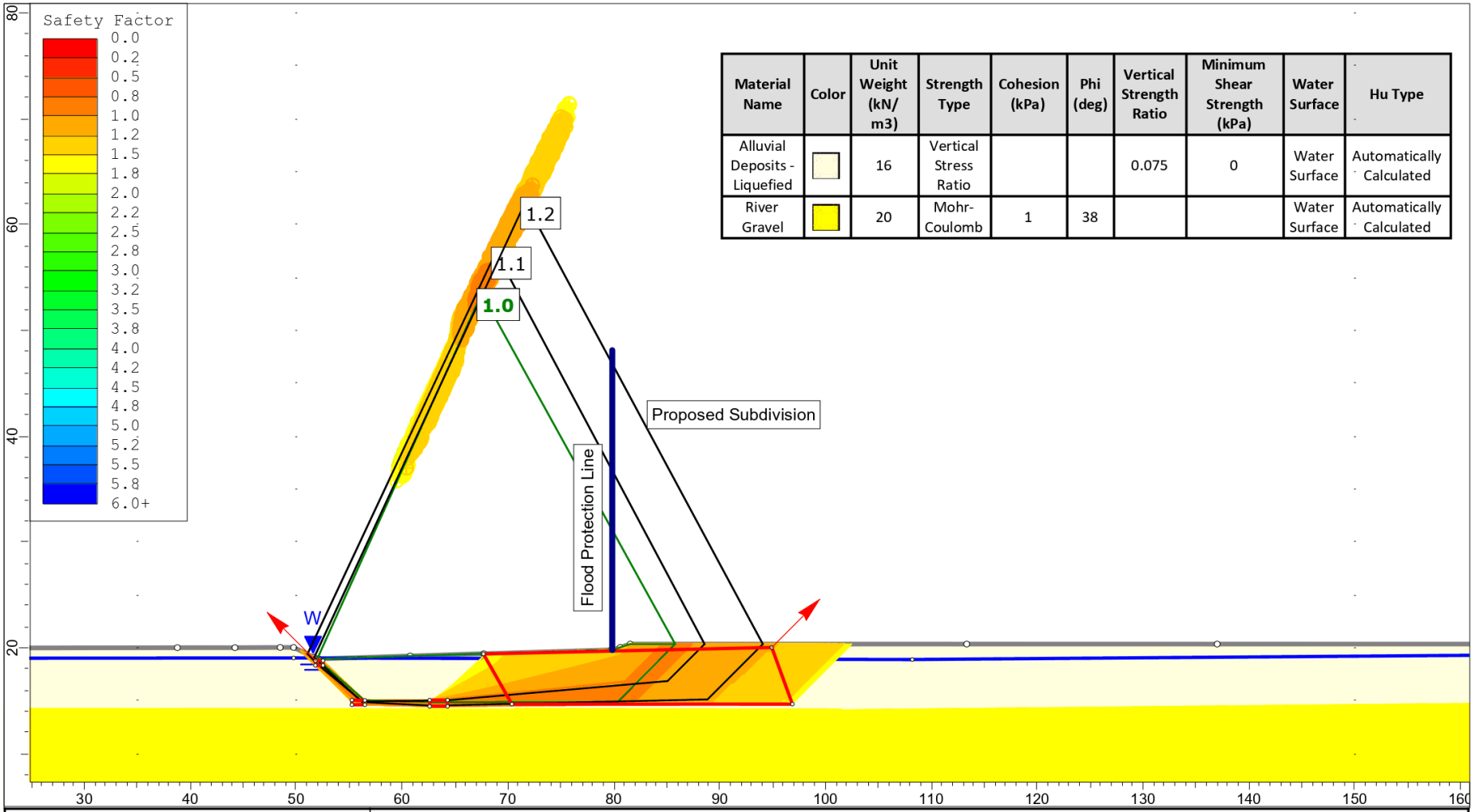


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (kPa)	Water Surface	Hu Type
Alluvial Deposits - Liquefied		16	Vertical Stress Ratio			0.075	0	Water Surface	Automatically Calculated
River Gravels		20	Mohr-Coulomb	1	38			Water Surface	Automatically Calculated

TOTAL GROUND ENGINEERING

SLIDEINTERPRET 9.009

Project	Ranitikei Line & Flygers Line - Plan Change		
Group	Proposed Contours A-A'	*Scenario*	Post EQ Liquefaction: Initial Proposal
Drawn By	J Healey	*Company*	Total Ground Engineering Ltd
Date	November 2020	*File Name*	J00367_Section A-A'_r0.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (kPa)	Water Surface	Hu Type
Alluvial Deposits - Liquefied		16	Vertical Stress Ratio			0.075	0	Water Surface	Automatically Calculated
River Gravel		20	Mohr-Coulomb	1	38			Water Surface	Automatically Calculated

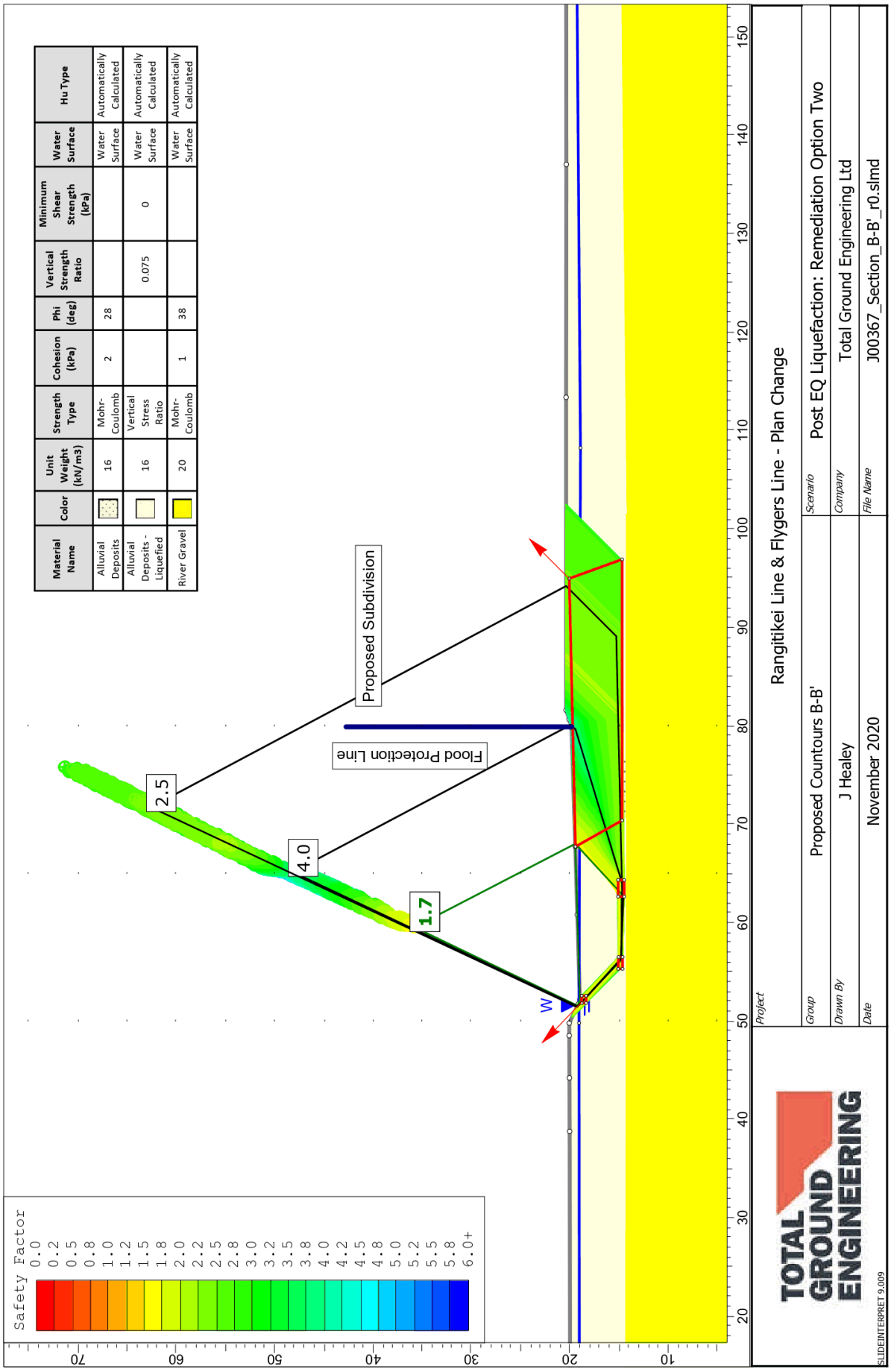
TOTAL GROUND ENGINEERING

SLIDEINTERPRET 9.009

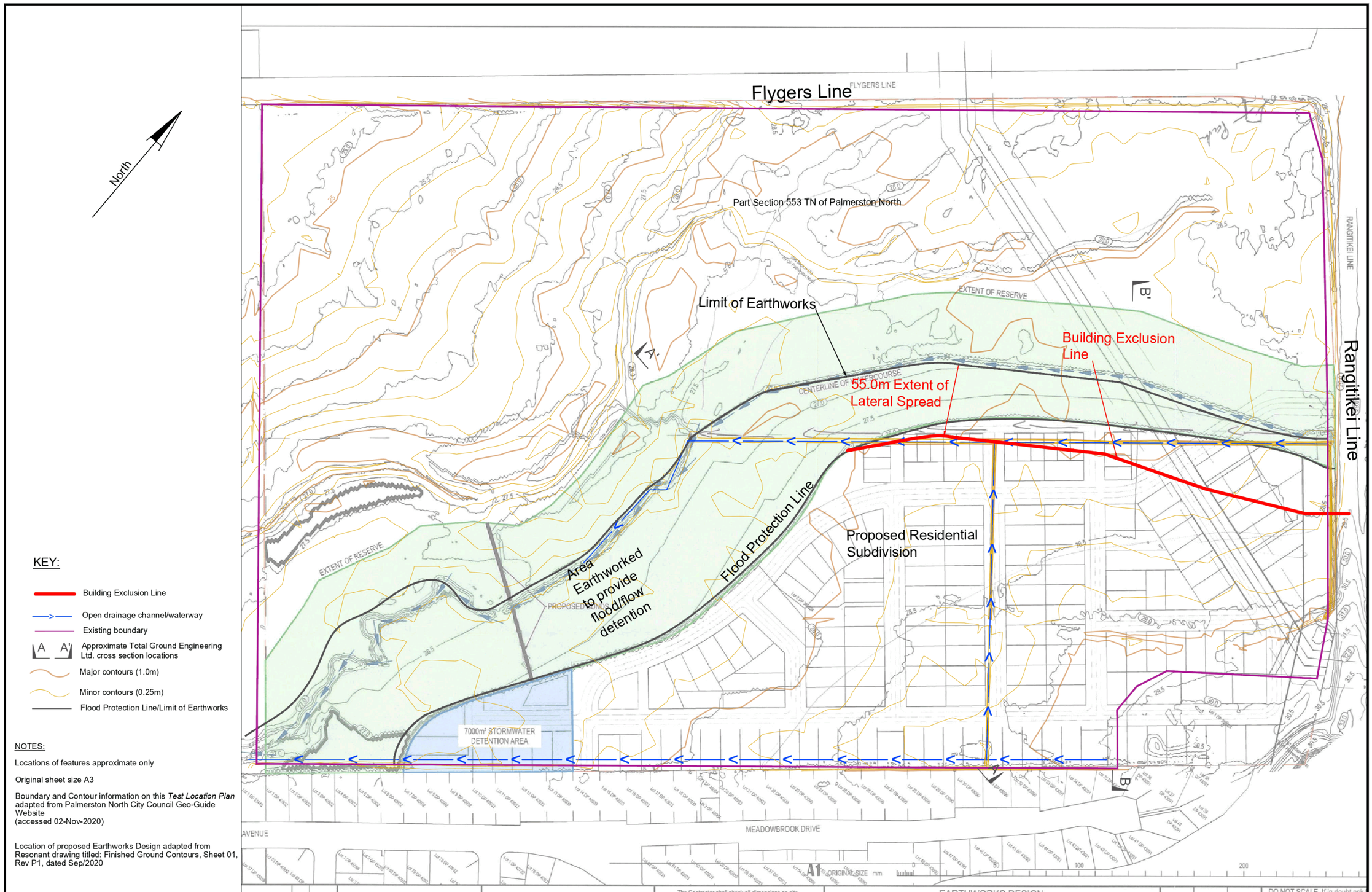
Project	Rangitikei Line & Flygers Line - Plan Change		
Group	Proposed Countours B-B'	*Scenario*	Post EQ Liquefaction: Initial Proposal
Drawn By	J Healey	*Company*	Total Ground Engineering Ltd
Date	November 2020	*File Name*	J00367_Section_B-B'_r0.slmd

PALMERSTON NORTH CITY COUNCIL

Material Name
Color
Unit Weight (kN/m3)
Strength Type
Cohesion (kPa)
Phi (deg)
Vertical Strength Ratio
Minimum Shear Strength (kPa)
Water Surface
Hu Type
Alluvial Deposits - Liquefied
16
Vertical Stress Ratio
0.075
0
Water Surface
Automatically Calculated
River Gravel
20
Mohr-Coulomb
1
38
Water Surface
Automatically Calculated
Proposed Subdivision
Flood Protection Line
1.7
1.2
0.9
W
Safety Factor
0.0
0.2
0.5
0.8
1.0
1.2
1.5
1.8
2.0
2.2
2.5
2.8
3.0
3.2
3.5
3.8
4.0
4.2
4.5
4.8
5.0
5.2
5.5
5.8
6.0+
Rangitikei Line & Flygers Line - Plan Change
Project
Group
Remediation Option One Contours_B-B'
Scenario
Post EQ Liquefaction: Remediation Option One
Drawn By
J Healey
Company
Total Ground Engineering Ltd
Date
November 2020
File Name
J00367_Section_B-B'_r0.slmd
TOTAL GROUND ENGINEERING
SLIDEINTERPRET 9.009


Material Name
Color
Unit Weight (kN/m3)
Strength Type
Cohesion (kPa)
Phi (deg)
Vertical Strength Ratio
Minimum Shear Strength (kPa)
Water Surface
Hu Type
Alluvial Deposits
16
Mohr-Coulomb
2
28
Water Surface
Automatically Calculated
Alluvial Deposits - Liquefied
16
Vertical Stress Ratio
0.075
0
Water Surface
Automatically Calculated
River Gravel
20
Mohr-Coulomb
1
38
Water Surface
Automatically Calculated
Proposed Subdivision
Flood Protection Line
2.5
4.0
1.7
W
Safety Factor
0.0
0.2
0.5
0.8
1.0
1.2
1.5
1.8
2.0
2.2
2.5
2.8
3.0
3.2
3.5
3.8
4.0
4.2
4.5
4.8
5.0
5.2
5.5
5.8
6.0+
Rangitikei Line & Flygers Line - Plan Change
Project
Group
Proposed Countours B-B'
Scenario
Post EQ Liquefaction: Remediation Option Two
Drawn By
J Healey
Company
Total Ground Engineering Ltd
Date
November 2020
File Name
J00367_Section_B-B'_r0.slmd
TOTAL GROUND ENGINEERING
SLIDEINTERPRET 9.009

Appendix E
Remediation Options



KEY:

- Building Exclusion Line
- Open drainage channel/waterway
- Existing boundary
- A A' Approximate Total Ground Engineering Ltd. cross section locations
- Major contours (1.0m)
- Minor contours (0.25m)
- Flood Protection Line/Limit of Earthworks

NOTES:

Locations of features approximate only

Original sheet size A3

Boundary and Contour information on this *Test Location Plan* adapted from Palmerston North City Council Geo-Guide Website (accessed 02-Nov-2020)

Location of proposed Earthworks Design adapted from Resonant drawing titled: Finished Ground Contours, Sheet 01, Rev P1, dated Sep/2020

AMENDMENTS

DATE	REV	DESCRIPTION
12/11/2020	A	Report Issue

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Initial Proposal : Building Exclusion Line

Flygers Line Road
PALMERSTON NORTH

TOTAL GROUND ENGINEERING

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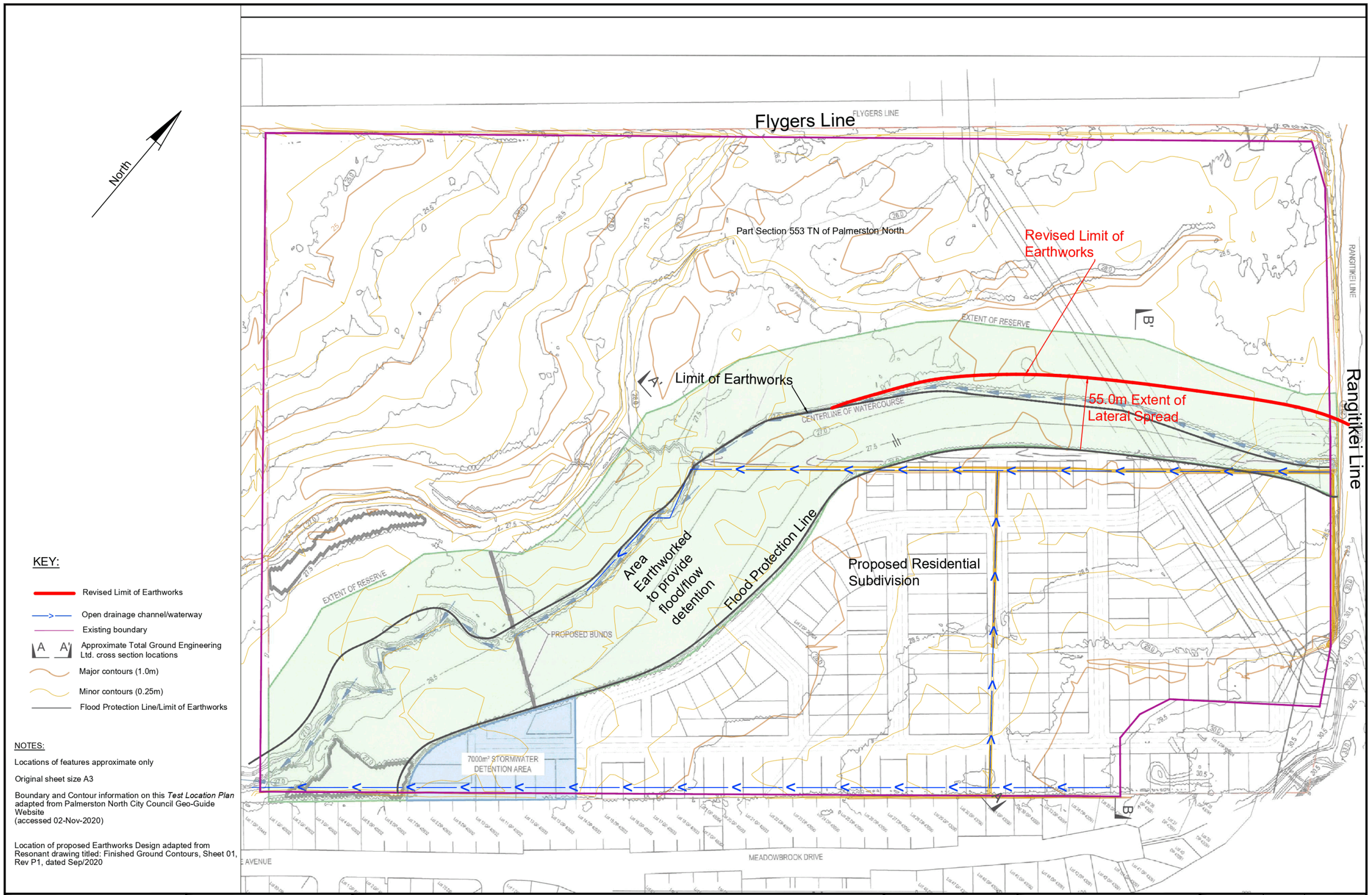
Website: www.totalgroundengineering.com

Drawing No.	Drawn by:	Date:
J00367/ 4	J Healey	12/Nov/2020
Scale: 1: 2500 (A3)	Checked by: N Jacka	Revision: A

Filename: J00367-Drawings.dwg



AMENDMENTS		
DATE	REV	DESCRIPTION
12/11/2020	A	Report Issue

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Remediation Option 1

Flygers Line Road
PALMERSTON NORTH

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Postal Address:
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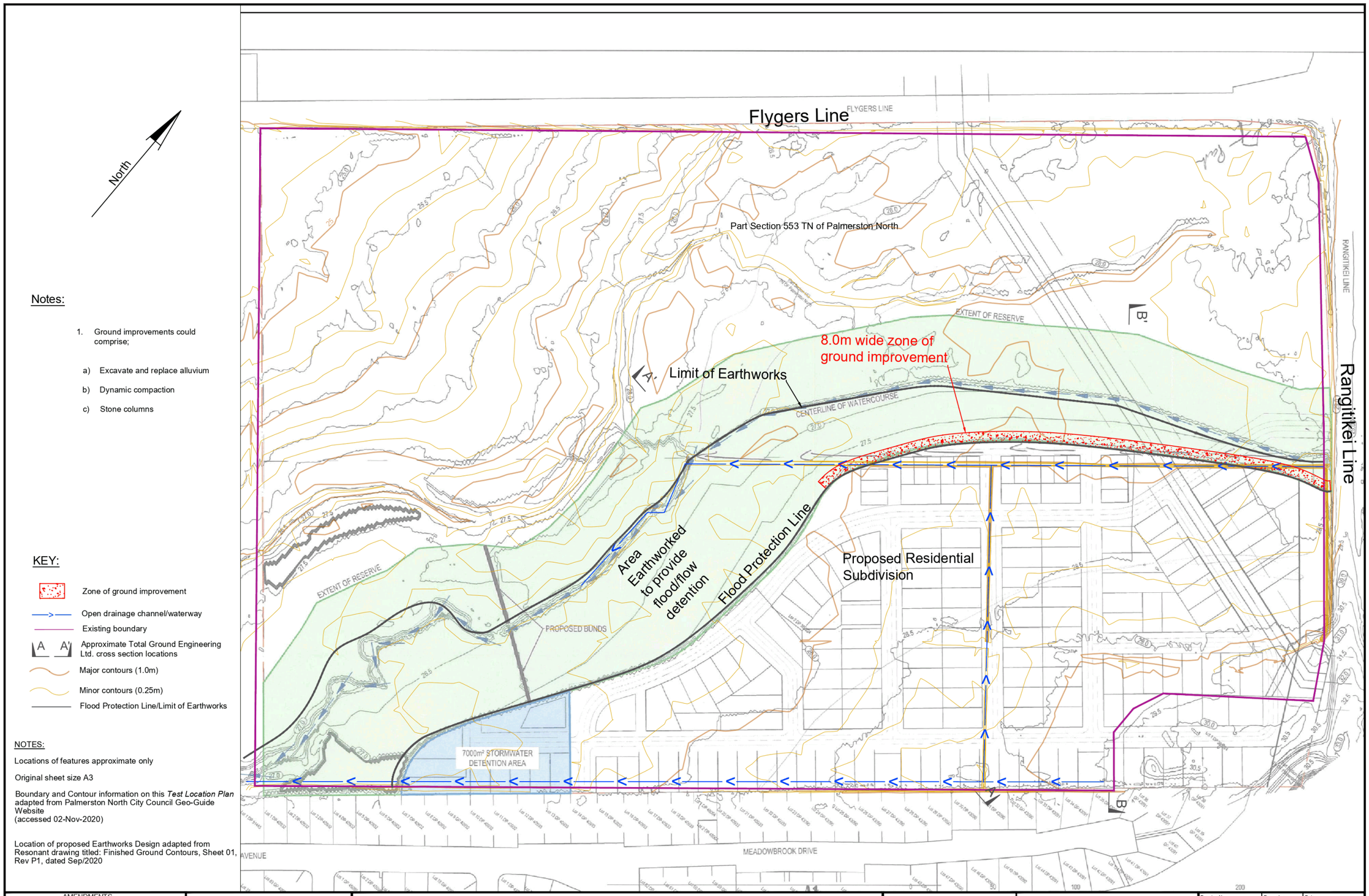
Auckland, New Zealand

Website: www.totalgroundengineering.com

Drawing No.	Drawn by:	Date:
J00367/ 5	J Healey	12/Nov/2020
Scale: 1: 2500 (A3)	Checked by: N Jacka	Revision: A

Filename: J00367-Drawings.dwg



Notes:

1. Ground improvements could comprise;
   a) Excavate and replace alluvium
   b) Dynamic compaction
   c) Stone columns

KEY:

- Zone of ground improvement
- Open drainage channel/waterway
- Existing boundary
- A A' Approximate Total Ground Engineering Ltd. cross section locations
- Major contours (1.0m)
- Minor contours (0.25m)
- Flood Protection Line/Limit of Earthworks

NOTES:

Locations of features approximate only

Original sheet size A3

Boundary and Contour information on this *Test Location Plan* adapted from Palmerston North City Council Geo-Guide Website
(accessed 02-Nov-2020)

Location of proposed Earthworks Design adapted from Resonant drawing titled: Finished Ground Contours, Sheet 01, Rev P1, dated Sep/2020

AMENDMENTS		
DATE	REV	DESCRIPTION
12/11/2020	A	Report Issue

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Remediation Option 2

Flygers Line Road
PALMERSTON NORTH

TOTAL GROUND ENGINEERING

Physical Address:
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Postal Address:
PO Box 27294, Glen Eden, 0604
Auckland, New Zealand

Website: www.totalgroundengineering.com

Drawing No:	Drawn by:	Date:
J00367/ 6	J Healey	12/Nov/2020
Scale: 1: 2500 (A3)	Checked by: N Jacka	Revision: A

Filename: J00367-Drawings.dwg

APPENDIX 8

REPORT ON SOIL PRODUCTIVITY: 165-243 FLYGERS LINE AND 609 AND 611 RANGITIKEI LINE

PERRIN AG CONSULTANTS LTD

Report on Soil Productivity 165-243 Flygers Line and 609 and 611 Rangitikei Line Palmerston North

Flygers Investment Group Ltd c/- Resonant Consultants

Report prepared by
Perrin Ag Consultants Ltd

August 2020

perrin ag
NEW ZEALAND AGRI-BUSINESS ADVISORS

Prepared by Perrin Ag Consultants Ltd

Registered Farm Management Consultants
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Rotorua 3010
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Phone: +64 7 349 1212
Email: consult@perrinag.net.nz
www.perrinag.net.nz

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Written by John Stantiall

Phone: +64 274 769 428

Email: johns@perrinag.net.nz

1 Executive Summary

- An application has been made to Palmerston North City Council by Flygers Investment Group Ltd seeking to rezone part of the land at 165-243 Flygers Line and 609 and 611 Rangitikei Line, Palmerston North.
- The land comprises of LOT 2 DP 389924, LOT 1 DP 389924 & Part Section 553 Town of Palmerston North, (40.1614 ha total).
- Perrinag Consultancy Ltd has been engaged to check and provide an opinion on the soil types on the property.
- The Land Use Capability (LUC) units on this site are IIw2, and IIs1, which indicate a flat contour, but potential land use is limited by wetness and fragments of iron pan. Due to limitations of wetness, drying out in summer and the presence of an ironstone pan, these are not the most versatile soils and lean towards the lower end of the LUC class 2.
- The poorly-drained soil types on this property are Kairanga silt loam, and Te Arakura sandy loam, shallow phase, which are poorly or imperfectly drained and have a continuing slight wetness limitation after drainage. Water tends to lie in the winter and are susceptible to compaction and pugging, restricting winter grazing by heavy cattle. These soils tend to dry out in the summer.
- The free-draining soil type on this property is Karapoti brown sandy loam, gravelly phase, which is well to somewhat extensively drained. The gravel and drying out in the summer limits intensive or horticultural use for this soil.
- The soils are true to the map and are poorly-drained and unsuitable for horticultural or vegetable growing uses. They can still be used for arable crops (maize, barley, wheat) and will support grazing of livestock on pasture. While these soil types are valuable for pastoral farming and arable cropping, they are not rare.
- There are no commercial gardens, orchards or other horticultural enterprises in the vicinity.
- The land is currently being used for growing maize but is capable of other farming uses.
- The surrounding land in the district supports various land uses. The larger blocks include sheep and cattle breeding and finishing; horse agistment; maize and cereal cropping and dairy support. The smaller lifestyle blocks include dairy support; cropping, horse grazing and agistment and prime livestock production.
- In this proposed rezoning the balance of the area remaining is still big enough (approx. 27 ha) to allow the continuation of the current range of land use options.

2 Proposed Rezoning

165-243 Flygers Line and 609 and 611 Rangitikei Line, Palmerston North.

2.1 Background

- An application has been made to Palmerston North City Council by Flygers Investment Group Ltd seeking rezone part of the land at 165-243 Flygers Line and 609 and 611 Rangitikei Line, Palmerston North. A copy of the rezoning proposal is included in Appendix I.

- The land comprises of:

Legal Description	Valuation Reference	Area (ha)
LOT 2 DP 389924	14461 276 00	19.2015
LOT 1 DP 389924	14461 277 00	0.8623
Part Section 553 Town of Palmerston North	14461 275 00	20.0976
Total Area		**40.1614**

- Perrinag Consultancy Ltd has been engaged to check and provide an opinion on the soil types on the property.

2.2 Site Inspection

- The property was visited on 14 August 2020. Neil O'Hara, project manager on behalf of Flygers Investment Group Ltd met the author on-site and provided a plan of the rezoning proposal which included the property boundaries.

- The soils were checked against those mapped by digging holes to check the soil profile and photographing them for reference.

DRAFT

3 Soil Description

The Soil Resource Map and soil profile photos are included in Appendix II.

The poorly-drained soil types on this property are Kairanga silt loam, and Te Arakura sandy loam, shallow phase, which are poorly or imperfectly drained and have a continuing slight wetness limitation after drainage. Water tends to lie in the winter and are susceptible to compaction and pugging, restricting winter grazing by heavy cattle. These soils tend to dry out in the summer.

The free-draining soil type on this property is Karapoti brown sandy loam, gravelly phase, which is well to somewhat extensively drained. The gravel and drying out in the summer limits intensive or horticultural use for this soil.

The soils are true to the map and are poorly-drained and unsuitable for horticultural or vegetable growing uses. They can still be used for arable crops (maize, barley, wheat) and will support grazing of livestock on pasture.

The author has estimated from the old local county soil maps (Kairanga, Manawatu and Pohangina) that 33% or 93,000 ha may be a reasonable assessment of imperfectly to poorly drained soils on Class II landforms within the Manawatu District Council (MDC) area (includes rural areas in PNCC transferred from MDC or any of the old County Councils) (Appendix II). Hence, while these soil types are valuable for pastoral farming and arable cropping, they are not rare.

The following descriptions are taken from Soil Bureau Bulletin 33, Soils and Agriculture in Kairanga County:

Ref.	Soil Name	Description
4	Kairanga silt loam	This is a poorly drained soil, with many yellowish-brown mottles on areas that have been subject to infrequent flooding in historic times. The alluvial soil lies wet in winter and under heavy stocking pressure the topsoil become pugged. Apart from fertiliser, the main requirement is drainage.
7c	Karapoti brown sandy loam, gravelly phase	Well to somewhat extensively drained on old levee ridges, underlain by gravels or stones within 30 cm of the surface.
8b	Te Arakura sandy loam, shallow phase	Poorly drained gley soil formed from alluvium on the river flats. Thin horizontal iron-stained bands may occur in the lowest horizon. The gravels come within 45 cm of the surface. Can be tile and mole drained. Tends to dry out in the summer.

Reference:
Cowie, J.D. 1978. Soils and Agriculture in Kairanga County, North Island, New Zealand. New Zealand Soil Bureau Bulletin 33.

DRAFT

4 Land Use Capability Classes (LUC)

The Land Use Capability classes are shown in Appendix III.

Land Use Capability (LUC) is "...land categorised into eight classes according to its long-term capability to sustain one or more productive uses." "Classes I-IV are classified as arable land, while LUC Classes V-VIII are non-arable. The limitations or hazards to use increase, and the versatility of use decreases, from LUC Class I to LUC Class VIII". "This can be thought of as a rating of 'best' to 'worst 'land for common productive purposes."

Reference: Land Use Capability Survey Handbook, 3rd Edition. (This document is available on www.landcareresearch.co.nz).

The Land Use Capability units on this site are IIw2, and IIs1, which indicate a flat contour, but potential land use is limited by wetness and fragments of iron pan, as well as a moisture deficit in summer. Due to limitations of wetness, drying out in summer and the presence of an ironstone pan, these are not the most versatile soils and lean towards the lower end of the LUC class 2.

There are no commercial gardens, orchards or other horticultural enterprises in the vicinity.

IIw2	Te Arakura sandy loam, Kairanga silt loam.	Flat river terraces with deep, fertile soils which have a continuing slight wetness limitation after drainage.
IIs1	Karapoti brown sandy loam, gravelly phase.	Flat-gently undulating river levees with recent, free-draining sandy-textured soils

Reference:
Fletcher, J. R. 1981. New Zealand Land Resource Inventory Survey: Taranaki-Manawatu Region: land use capability extended legend. National Water and Soil Conservation Organisation, Water & Soil Division, Ministry of Works and Development. Wellington.

Care must be taken with cultivation or grazing heavy cattle in winter to ensure compaction of the poorly drained soils does not occur and that soil structure is not damaged for long periods. Damaged soil will have deep pugging or hoof prints throughout, which make it very rough to walk or drive across. The real impact, however is on loss of pasture production. "Degraded soils have a low load-bearing capacity. As a result, pastures on these soils are easily trampled into the mud when wet. This makes them both inaccessible and unpalatable to stock. Trampling can reduce pasture utilisation by 20-40 percent." *(Shepherd, T.G. 2000. Visual Soil Assessment. Volume 1. Field guide for cropping and pastoral grazing on flat-rolling country. Horizons.mw & Landcare Research, Palmerston North.)*

DRAFT

5 Current Usage

The land is being used mainly for maize growing by the current owners.



6 Restrictions on Range of Options for Land Use

In this proposal, the cropable land will be reduced from 40 ha to approximately 27 ha. The remaining 27 ha will still allow any current livestock system to operate and will still allow crops to be sown and harvested.

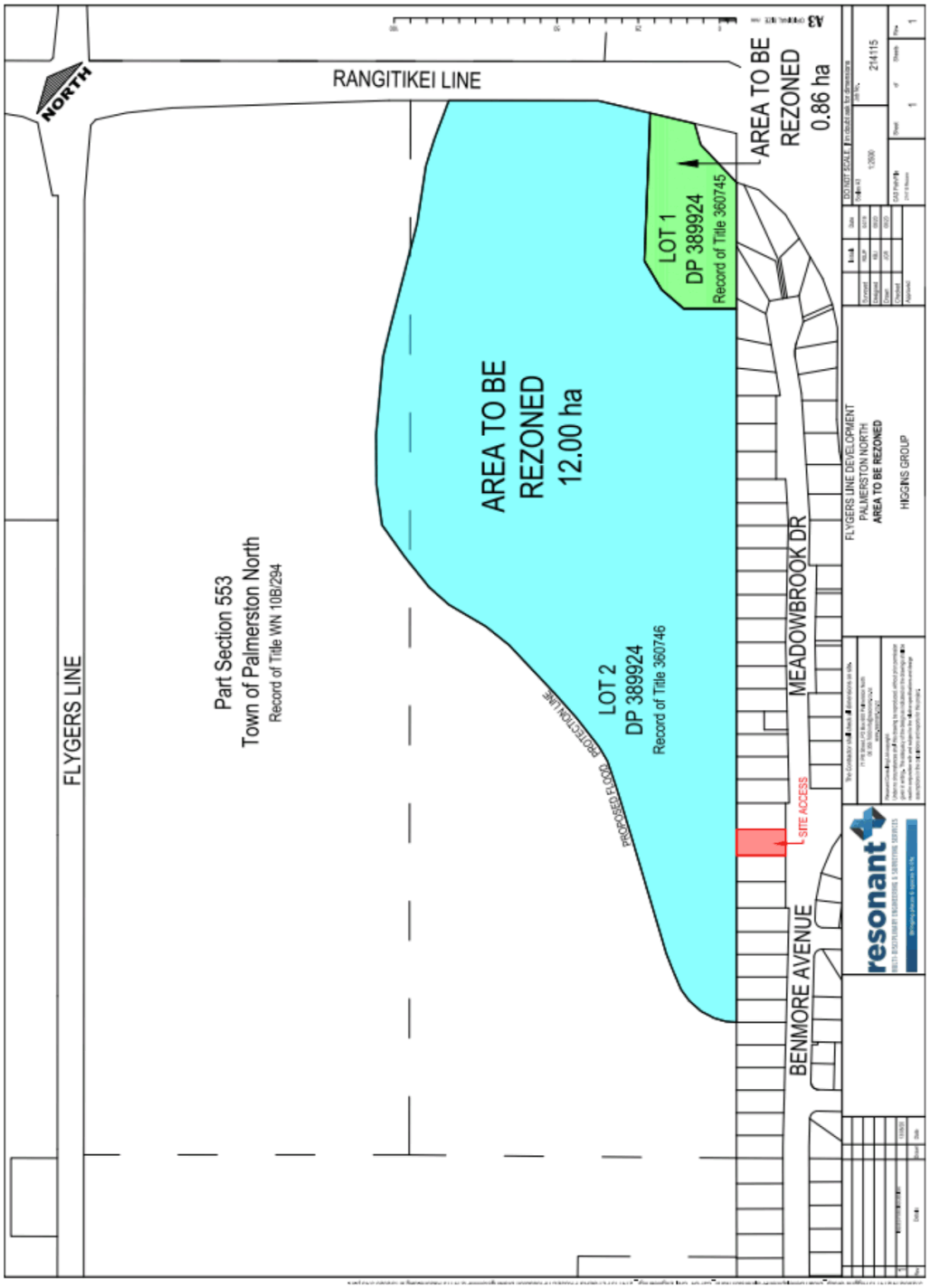
7 Summary

The reduction in productive income needs to be balanced with the need for more housing in or near Palmerston North. The advantages of this site include:

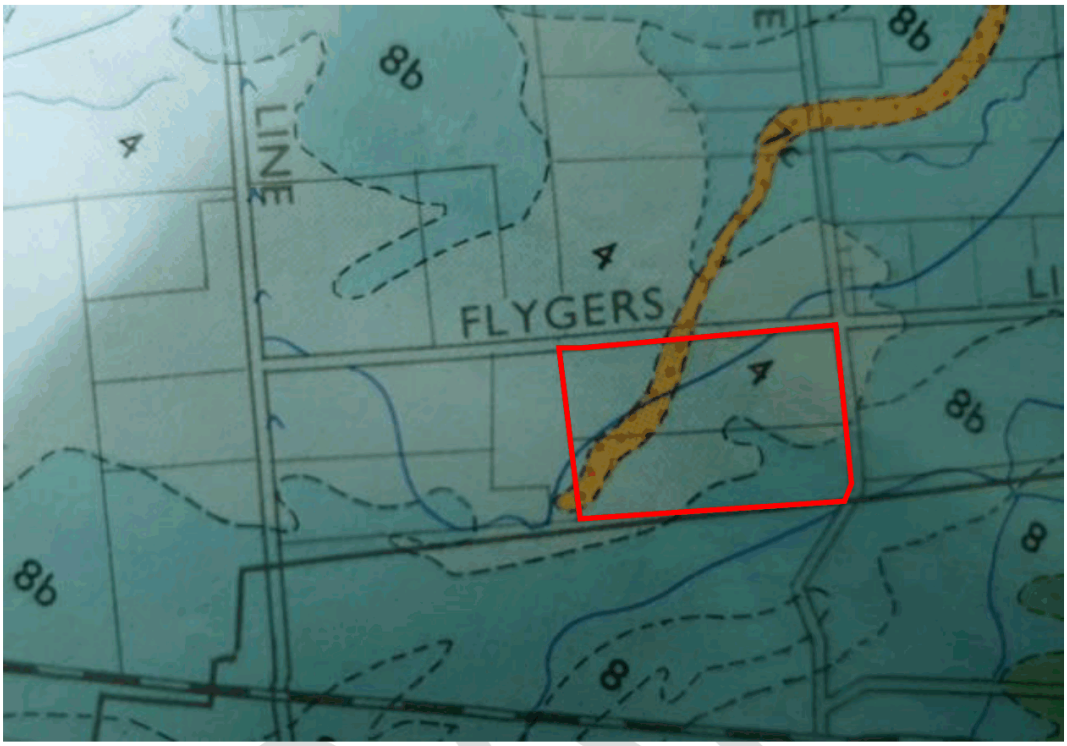
- The proposed land use for housing development will provide approximately 157 new houses and bounders the existing residential area and as such does not fragment urban development.
- The soils are true to the map; are poorly-drained and unsuitable for horticultural or vegetable growing uses. They can still be used for arable crops (maize, barley, wheat) and will support grazing of livestock on pasture.
- The balance is still big enough (approx. 27 ha) that there is no restriction to the range of land use options.

DRAFT

Appendix I: Proposed Area to be Re-zoned



Appendix II: Soil Map



Cowie, J.D. 1978. Soils and Agriculture of the Kairanga County, North Island, New Zealand. NZ Soil Bureau. Bulletin 33. Original Scale: 1: 63360

Poorly drained soils in the Manawatu District Council and Palmerston North City Council (rural area)

Soil Series	Parewanui	Kairanga	Te Arakura	Ohakea	Tokomaru	Milson	Marton	Total	% of	County
	Gley Recent Soils	Gley Recent Soils	Gley Soils	Yellow-Grey Earths				Area (ha)	County	Total ha*****
	Poorly drained	Poorly drained	Poorly drained	Poorly drained						
	Accumulating	Accumulating	Non-accumulating	Soils of Terraces and Fans						
County Mapped										
Kairanga *		8,500	6,950	9,100				**24,550**	**53%**	**46,600**
Manawatu **	1,700	2,180	795	6,265	4,865	970	1,635	**18,410**	**27%**	**68,600**
Pohangina ***	-	45	-	640	-	220	395	**1,300**	**11%**	**11,407**
Kiwitea (part)******				50			172	**222**	**11%**	**2,000**
PN City										**4,302**
	1,700	**10,725**	**7,745**	**6,955**	**13,965**	**1,190**	**2,202**	**44,482**	**33%**	**132,909**
									Oroua	49,200
									balance Kiwitea	91,000
									Area accounted for	**273,109**
									Current MDC area	**278,000**

Note: The total area for Pohangina County excludes the 83% portion in Ruahine Ranges.
The old Oroua or Kiwitea Counties have not been soil mapped.

*Cowie, J.D. 1978. Soils and Agriculture in Kairanga County, North Island, New Zealand. New Zealand Soil Bureau Bulletin 33.

**Cowie, J.D, Rijkse, W.C. 1977. Soils of Manawatu County, North Island, New Zealand. New Zealand Soil Bureau Bulletin 30.

***Rijkse, W.C. 1977. Soils of Pohangina County, North Island, New Zealand. New Zealand Soil Bureau Bulletin 42.

**** Senarath, A., Palmer, A. 2005. Soils of the Kiwitea District, Northern Manawatu.

Institute of Natural Resources Massey University. Soil and Earth Sciences Occasional Publication No. 5.

*****https://kids.kiddle.co/List_of_former_territorial_authorities_in_New_Zealand



Location of soil profile sites

Photo evidence of the two main soil profiles confirming they are poorly drained as evidenced by the orange-brown mottles in the topsoil:



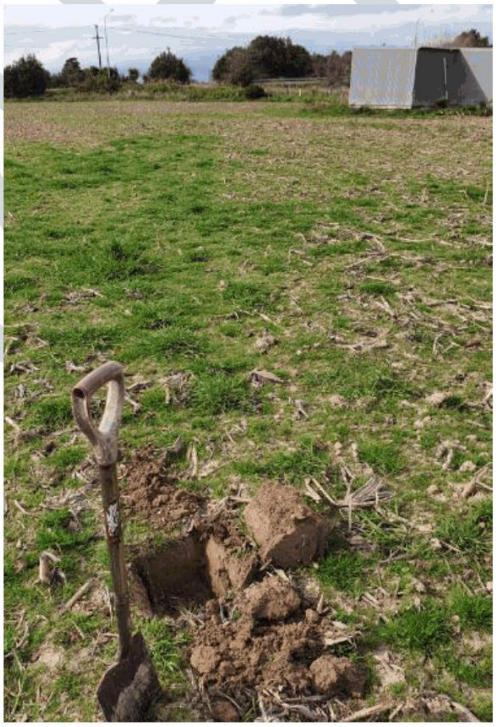
Site 1: Kairanga silt loam





Site 2: Kairanga silt loam





Site 3: Te Arakura sandy loam



Site 4: Te Arakura sandy loam



Site 5: Karapoti brown sandy loam

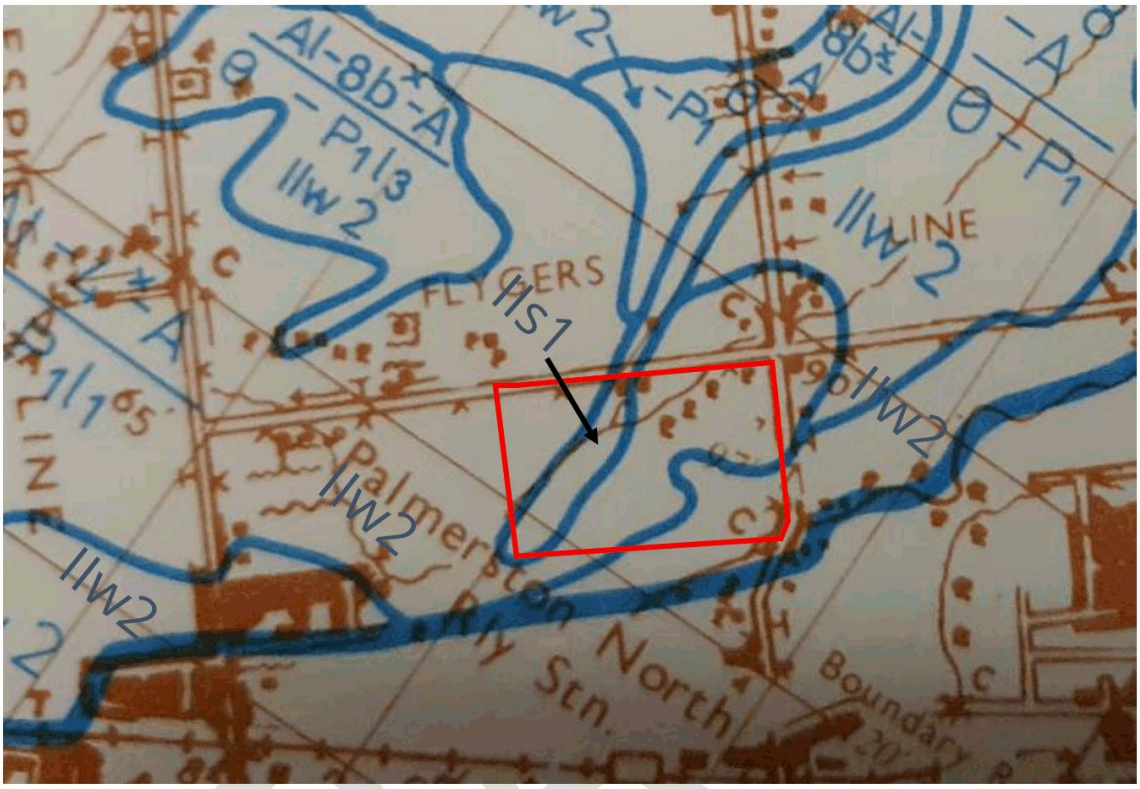


Site 6: Karapoti brown sandy loam



Site 7: Karapoti brown sandy loam

Appendix III: Land Use Capability (LUC) Map


Al-8b-A
P1/3
IIw2
IIS1
IIw2
IIw2
IIw2

THOMAS PLANNING

APPENDIX 9

PROPOSED PLAN CHANGE FLYGERS LINE

ACOUSAFE LTD.

PROPOSED PLAN CHANGE

FLYGERS LINE

For

Flygers Investment Group Limited

N2620 – Draft D1

17 August 2020

ACOUSAFE CONSULTING & ENGINEERING LTD



Nigel Lloyd
Director of Acoustic Services

Mobile: 0274 480 282
E-mail: nigel@acousafe.co.nz

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3. The Proposed Plan Change 1
4. District Plan – Noise Rules 2
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7. Rural Activities in the Kakatangiata Urban Growth Area ..... **Error! Bookmark not defined.**
8. Pioneer Highway ..... **Error! Bookmark not defined.**
9. Main North Island Trunk Railway Line **Error! Bookmark not defined.**
10. The Proposed Ring Road ..... **Error! Bookmark not defined.**
11. Kartsport Manawatu ..... **Error! Bookmark not defined.**
12. Awapuni Resource Recovery Park ..... **Error! Bookmark not defined.**
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1. Introduction

The Flygers Line District Plan Change provides for a Residential Zone to the north of Palmerston North City. The brief is to research requirements with respect to noise mitigation for the proposal and to prepare a suitable report on the noise effects. This report will be used to compliment and inform the Section 32 analysis report

This report recommends the application of the Residential Zone noise limits to the Plan Change Area and considers the reverse sensitivity impacts of the noise of State Highway 3. Reverse sensitivity impacts occur where essential infrastructure exists that might be curtailed in some way by the development of noise sensitive activities.

There are no District Plan requirements for set backs from local roads and no separate assessment is made of traffic noise on Flygers Line.

2. Description of Area and Identifying Noise Issues

The extent of the proposed Plan Change Area is shown by the red line in Figure 1.

The land is currently a greenfield site with SH3 at the eastern end and Flygers line forming the northern boundary. The site is rural in character and would support farming activities.

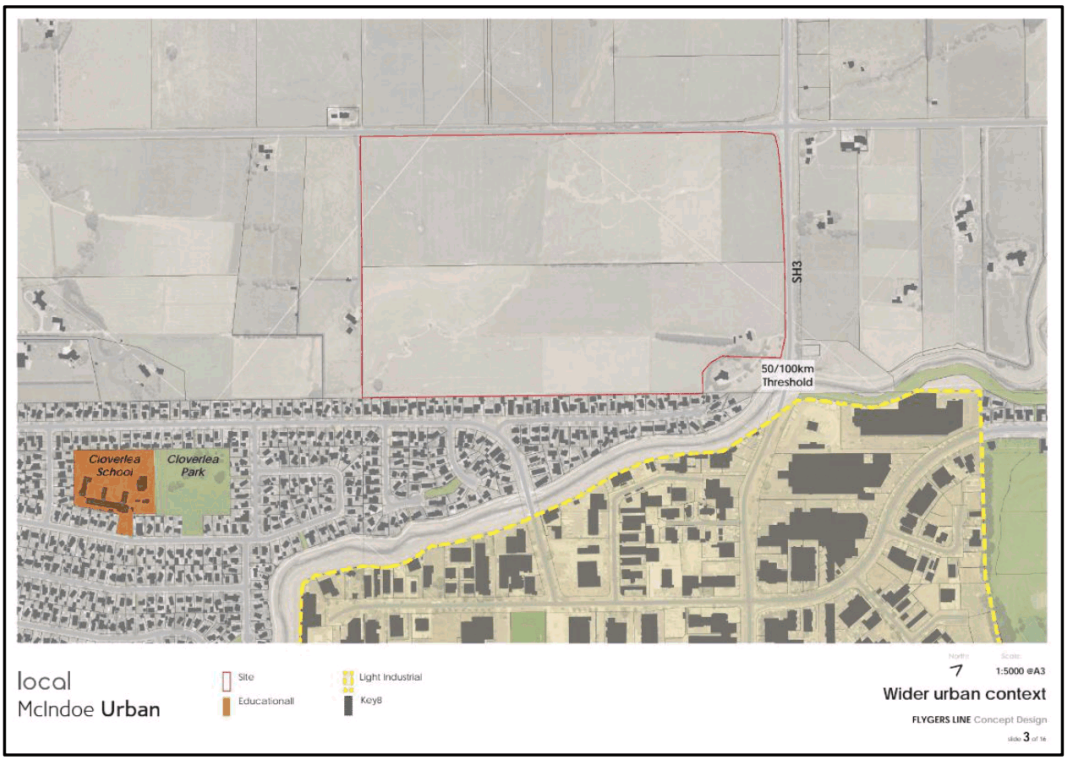

Figure 1. Extent of Plan Change Area (red line)

3. District Plan – Noise Rules

The Plan Change Area is zoned Rural. The southern boundary is with Residential Zone dwellings on Meadowbrook Drive and Benmore Avenue, and the western boundary and land to the north is zoned Rural.

There is land zoned Industrial which is further to the south, but this is on the opposite side of the existing Meadowbrook Drive Residential Zone. On that basis the Plan Change will not have any further reverse sensitivity impacts on any activities in the Industrial Zone.

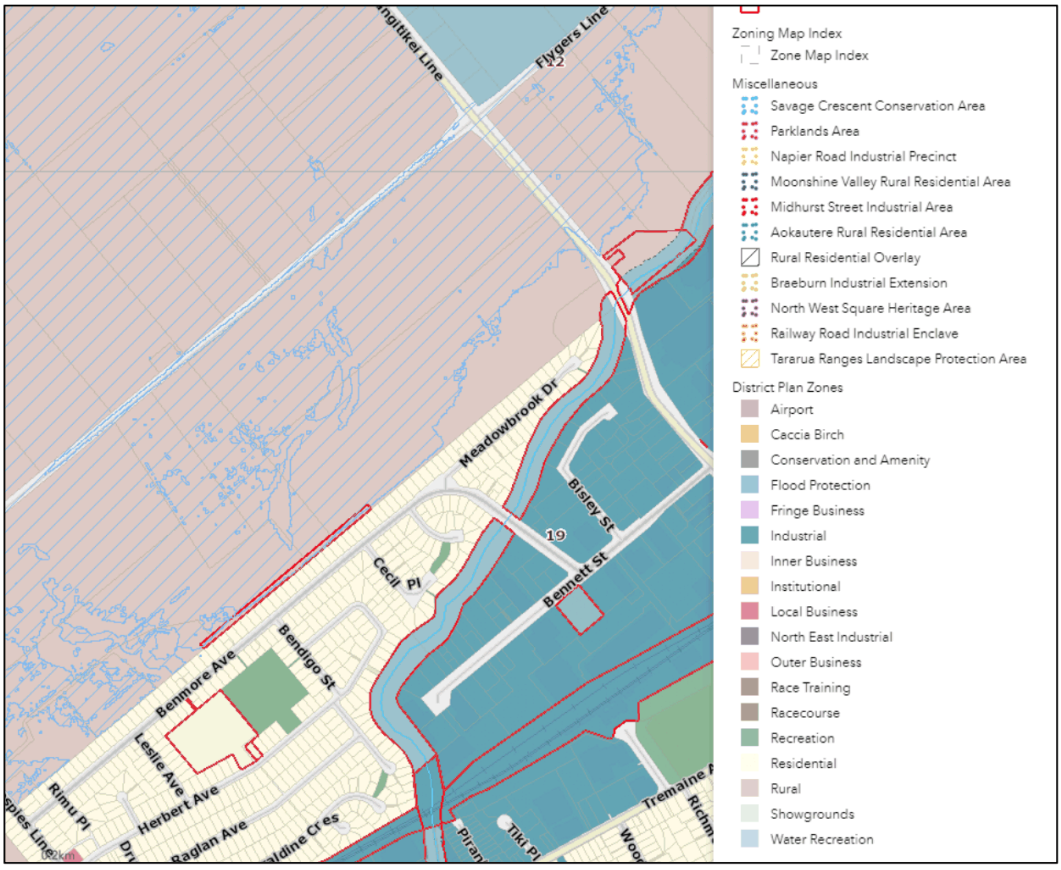

Figure 2. Current Zoning of Flygers Line Plan Change Area

The Rural Zone noise rule is R9.11.1 as follows:

> Sound emissions from any activity in the Rural Zone when measured at or within the boundary of any land zoned for residential purposes or at or within the boundary of any land in the Rural Zone (other than land from which the noise is emitted or a road) shall not exceed the following:
>
> | | |
> |---|---|
> | 7.00 am to 7.00 pm | 50 dB $L_{Aeq\ (15mins)}$ |
> | 7.00 pm to 10.00 pm | 45 dB $L_{Aeq\ (15\ mins)}$ |
> | 10.00 pm to 7.00 am | 40 dB $L_{Aeq\ (15\ mins)}$ |

Night-time L_{max} 10.00 pm – 7.00 am 70 dBA L_{max}

Explanation

Rural areas are in essence working environment within which there are pockets of residential activity. The rules are intended to provide for normal agricultural activities while controlling noise from a range of other activities which also exist in the rural area, e.g. home occupations. This control does not apply to specific rural activities in rural areas which should be managed by applying the Section 16 requirements of the RMA in the circumstances that they arise. Reference should be made to Section 6, Noise, for those rural activities that are excluded from the above controls and for further general information on noise.

The noise rules for non-residential activities in the Residential Zone are set out in R10.8.1 as follows:

Sound emissions from any fixed mechanical plant, or from any non-residential activity, when measured at or within the boundary of any other site (other than land from which the noise is emitted or a road) shall not exceed the following::

7.00 am to 10.00 pm	45 dB $L_{Aeq(15mins)}$
10:00 pm to 7:00 am	40 dB $L_{Aeq(15mins)}$
Night-time L_{max} 10:00 pm to 7:00 am	65 dBA L_{max}

Methods for monitoring and assessing noise are set out in Section 6.2 of the District Plan.

We consider that the noise limits and the activity statuses that are generally applied throughout the Residential Zone can be applied to the Flygers Line Plan Change Area once it becomes rezoned to Residential.

The change to the Residential Zone Rules will result in noise limits becoming 5 decibels stricter during the day and at night with no change during the evening. Certain rural activities (listed in R9.5.1 and R9.5.2) are excluded from control by the noise rules when they are in the Rural Zone as set out in R6.2.6.2 but will lose their exclusion if this changes to Residential. The activities may carry on (as existing uses) until the scale or intensity changes.

4. Other Zone Interfaces

The Residential Zone also borders many other zones in the District. There will be two new zone boundary interfaces (Rural and Residential). The District Plan does not provide for protection at these interfaces i.e. from the Residential Zone to the Rural Zones, given the lesser need for noise protection outside of the Residential Zone.

There are many interfaces between Rural and Residential zoned land and the District noise rules provide adequate protection at those interfaces.

5. Rangitikei Line (SH3)

Rangitikei (SH3) passes along the western edge of the Flygers Line Plan Change Area. The 50km/hr to 100km/hr threshold is close to the southwest corner of the Plan Change Area and, as such, the speed limit is 100km/hr on the neighbouring SH3.

The 2019 traffic flows obtained from NZTA indicate a typical traffic volume of approximately 12,844 vehicle per day. With an increase of 2.4% per year this would approximate 16,700 vpd by 2030.

Given these traffic volumes and the 100km/hour traffic speed the NZTA recommended buffer[1] is 40 metres. The calculated noise level at 40 metres is 62 dB $L_{Aeq(24\ hr)}$. The acceptable internal noise level is 40 dB $L_{Aeq(24\ hr)}$ so this requires a building (at 40 metres) to reduce the noise by 22 dB to provide an acceptable inside noise level. A noise reduction of 22 dB is normally provided by a modern dwelling with thermally double-glazed windows if those windows are kept closed.

In calculating the effects area, it is reasonable to assume that dwellings constructed more than 80 metres from the State Highway will benefit from the screening provided by buildings constructed between those dwellings and vehicles on the State Highway. On that basis we recommend that the effects area should be 80 metres from the carriageway edge. This will require dwellings constructed between the 40 metre buffer and the 80 metre effects area boundary to be noise insulated and ventilated to allow windows to be kept closed against noise should residents wish.

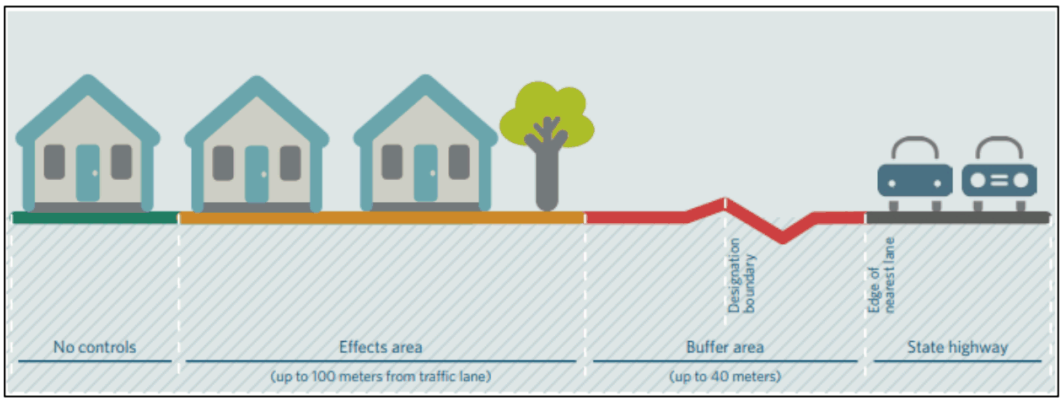

Figure 3. NZTA Recommended Buffer and Effects Area

The following noise buffer and noise insulation rule has been adopted from other rules recommended for different residential areas in Palmerston North.

> *Acoustic Insulation and Setbacks for the Flygers Line Residential Area*
>
> *Any building (other than accessory buildings) containing a noise sensitive activity constructed within 80 metres of the nearest carriageway edge of State Highway 3 shall be designed, constructed and maintained in accordance with a design report prepared by a suitably qualified and experienced acoustical engineer stating that the design as proposed will achieve compliance with an internal noise level of 40 dB $L_{Aeq(24hr)}$ in habitable rooms.*

[1] https://www.nzta.govt.nz/assets/resources/effects-on-noise-sensitive-land/effects-on-noise-sensitive-land-use.pdf

Provided that no such building is to be located within 40 metres of the nearest carriageway edge of State Highway 3.

The ventilation requirements of R10.6.1.5(e)(iii) shall also apply.

Rule R10.6.1.5(e)(iii) states:

Where bedrooms with openable windows are proposed in buildings requiring acoustic insulation, a positive supplementary source of fresh air ducted from outside is required at the time of fit-out. For the purposes of this requirement, a bedroom is any room intended to be used for sleeping. The supplementary source of air is to achieve a minimum of 7.5 litres per second per person.

As stated above, the noise insulation requirement is normally inherent in a well-constructed dwelling and the provision of alternative ventilation would be the only difference (with dwellings also often including mechanical ventilation in their design).

6. Conclusions

The Proposed Plan Change is for a residential area at Flygers Line to the north of Palmerston North City. This report identifies where noise issues may arise, particularly for State Highway 3 noise and considers reverse sensitivity issues.

It is recommended that the noise provisions of the Residential Zone be adopted for the Proposed Plan Change Area. This provides for the establishment of residential activity and protection of residential amenity during the transition stage (from rural to residential).

Recommendations have been made for a 40-metre set back from the SH3 carriageway edge for any dwelling and for a 80 metre effects area where dwellings will need to be appropriately noise insulated and ventilation provided. Such noise mitigation will not be onerous.

THOMAS PLANNING

APPENDIX 10

WHISKEY CREEK PROPOSED PRIVATE PLAN CHANGE TRANSPORTATION ASSESSMENT

HARRIET FRASER TRAFFIC ENGINEERING AND TRANSPORTATION PLANNING

Harriet Fraser Traffic Engineering & Transportation Planning

PO Box 40170
Upper Hutt
5140
M 027 668 5872
E harriet@harrietfraser.co.nz

7 April 2021

Kevin Judd
Resonant

Via email: **KevinJ@resonant.co.nz**

Dear Kevin

Whiskey Creek Proposed Private Plan Change
Transportation Assessment

Further to your request, I am pleased to provide below a transportation assessment for land on Rangitikei Line in Palmerston North which is proposed to be rezoned for residential purposes through a proposed private plan change process. The assessment that follows includes a review of the existing local transportation characteristics and a summary of the potential traffic effects associated with the development of the site for residential purposes under the proposed Residential zoning.

In summary, the findings of the assessment show that the proposed rezoning would allow for the site to be developed for residential purposes in a manner which is consistent with the District Plan traffic and transportation related objectives and policies.

1. Background

The proposed Plan Change is for the block of land shown in Figure 1.

As shown, the land lies on the northwest edge of the city immediately to the north of the Mangaone Stream. The site has road frontage onto Rangitikei Line. The site is zoned Rural and is currently used for agricultural purposes.

The assessment that follows is based on the assumption that the block of land could potentially yield up to around 157 residential lots. The following tasks have been undertaken as part of the data collection exercise:

- site visits (2017, 2020 and 2021) to the local roading network including Benmore Avenue, Meadowbrook Drive, Rangitikei Line and Flygers Line; and
- weekday traffic surveys of the Benmore Avenue/ Meadowbrook Drive intersection during each of the morning and afternoon traffic peaks in 2017.



Figure 1: Extent of Proposed Plan Change

2. Local Traffic Environment

2.1 SH3 Rangitikei Line

The proposed subdivision site has a 160m long frontage onto SH3 Rangitikei Line. The site is approximately 50m to the north of the bridge over the Mangaone Stream and approximately 260m to the south of the intersection with Flygers Line. This section of SH3 has a 100km/h speed limit and has a single traffic lane in each direction with sealed shoulders as shown in Photos 1 and 2.



Photos 1 & 2: Looking South and North along Rangitikei Line Respectively

Rangitikei Line is defined as a Major Arterial in the Palmerston North District Plan which describes the function of such roads as follows:

> *Major Arterials are of strategic importance to the Region. They provide interconnections between areas within the City and distribute traffic from major intercity links. Access is generally at grade but may be limited. Urban traffic volumes are typically greater than 20,000 vehicles per day and rural 5,000 vehicles per day with a significant number of heavy vehicles. Typical urban operating speeds are 50 to 70km/h and rural 80 to 100km/h.*

Traffic count data held by NZTA shows 2016 traffic volumes of 11,447 vehicles per day on SH3 at Flygers Line. Of these around 5% were heavy vehicles. Traffic growth over recent years has amounted to around 2.4% per annum.

2.2 Benmore Avenue

Benmore Avenue has a 50km/h speed limit and has a single traffic lane in each direction as shown in Photos 3 and 4. As shown, there are generous sight lines in each direction along Benmore Avenue from Meadowbrook Drive. An aerial image of the existing intersection is shown in Figure 2.





Photos 3 & 4: Looking East and West along Benmore Avenue Respectively from Meadowbrook Drive



Figure 2: Benmore Avenue/ Meadowbrook Drive Intersection

The carriageway width is around 11.2m kerb to kerb with a marked centreline and occasional parked cars along the kerb. Bus services run along Benmore Avenue providing public transport access to the hospital and central City. Benmore Avenue is defined as a Collector Road in the Palmerston North District Plan which describes the function of such roads as follows:

> *Collector Roads provide circulation in local areas and links to arterial roads, while balancing these needs with pedestrian and local amenity values. These roads provide access for all modes of transport including public transport. Typical traffic flows are between 3,000 and 10,000 vehicles per day.*

Traffic count data held by Council indicates that there are traffic volumes of around 3,300 vehicles per day on Benmore Avenue with up to 390 vehicle movements per hour at peak times. As such the existing traffic flows on Benmore Avenue are at the lower end of the anticipated range for Collector Roads.

Traffic count data collected in 2017 showed weekday morning and weekday evening traffic flows at the intersection between Benmore Avenue and Meadowbrook Drive as shown in Table 1.

Approach	Weekday Morning Peak (7.45-8.45am) (vph)	Weekday Evening Peak (4.30-5.30pm) (vph)
Meadowbrook Drive L	25	7
R	5	7
Benmore Avenue (W) L	0	15
T	284	132
Benmore Avenue (E) T	127	344
R	9	19
TOTAL	450	524

Table 1: Observed Traffic Flows Benmore Avenue/ Meadowbrook Drive

With 55 houses accessed off Meadowbrook Drive, the weekday morning and afternoon trip generation rates are 0.71 and 0.87 vehicle movements per hour per household respectively.

2.3 Walking and Cycling Links

Figure 3 shows an extract from the Council's walkway and cycleway map. As shown, paths in the vicinity of the site include in light green, the existing shared path along the Mangaone Stream and in dark green, on-road cycle lanes.

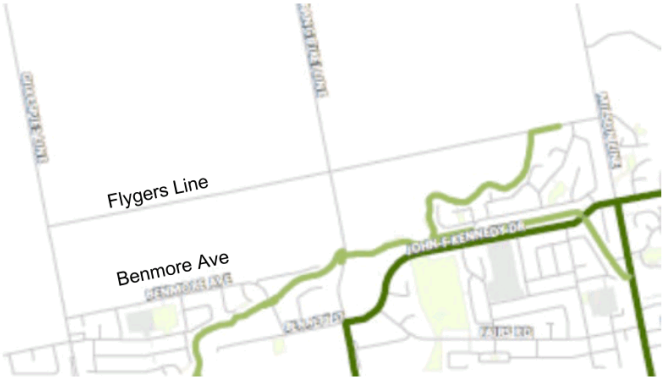

Figure 3: Cycling and Shared Path Network (Extract from Council's Active and Public Transport Plan)

2.4 Public Transport

The nearest bus stops to the site are on Benmore Avenue to the west of Waltham Court, around a 160m walk from the proposed residential area.

2.5 Local Road Safety Record

A search was undertaken of the NZTA crash database for the areas shown in Figures 4 and 5 for the period 2016 to date.

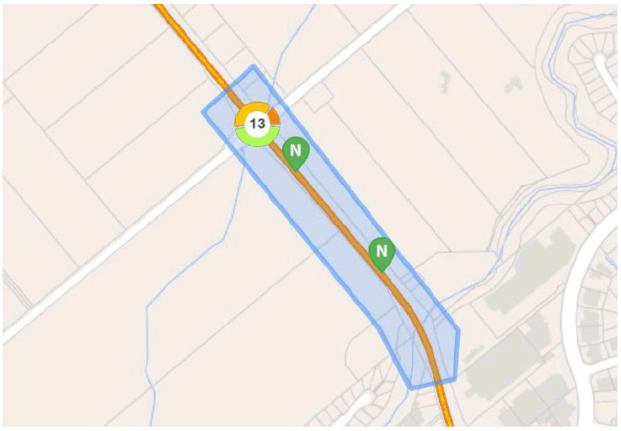

Figure 4: SH3 Rangitikei Line (Mangaone Stream to Flygers Line)

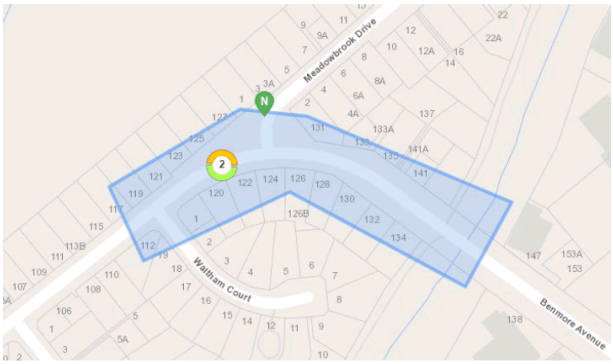

Figure 5: Benmore Avenue

As shown there have been 13 reported crashes during this period at or close to the intersection of Rangitikei Line (SH3) and Flygers Line. Of these two were serious injury, five minor injury and six non-injury. Neither of the two non-injury mid-block crashes on Rangitikei Line between the Mangaone Stream and Flygers Line involved turning vehicles.

Two non-injury and one minor injury crash were reported close to the Meadowbrook Drive intersection with Benmore Avenue. Of these crashes, one involved the crash factor of alcohol test above the limit or test refused and another the crash factor of intentional collision.

3. Proposed Plan Change

The proposed Structure Plan is included here as Figure 6. The key transportation related aspects of the Structure Plan can be summarised as follows:

- primary road connection to Benmore Avenue with a four arm roundabout created with Meadowbrook Drive;
- secondary road connection to SH3 with a left in/ left out only arrangement;
- extensive shared path network within the site which connects with the existing shared path along the edge of the Mangaone Stream at one end and with the footpath network on Benmore Avenue at the other end; and
- an indicative internal road layout that provides route choice options within the subdivision.

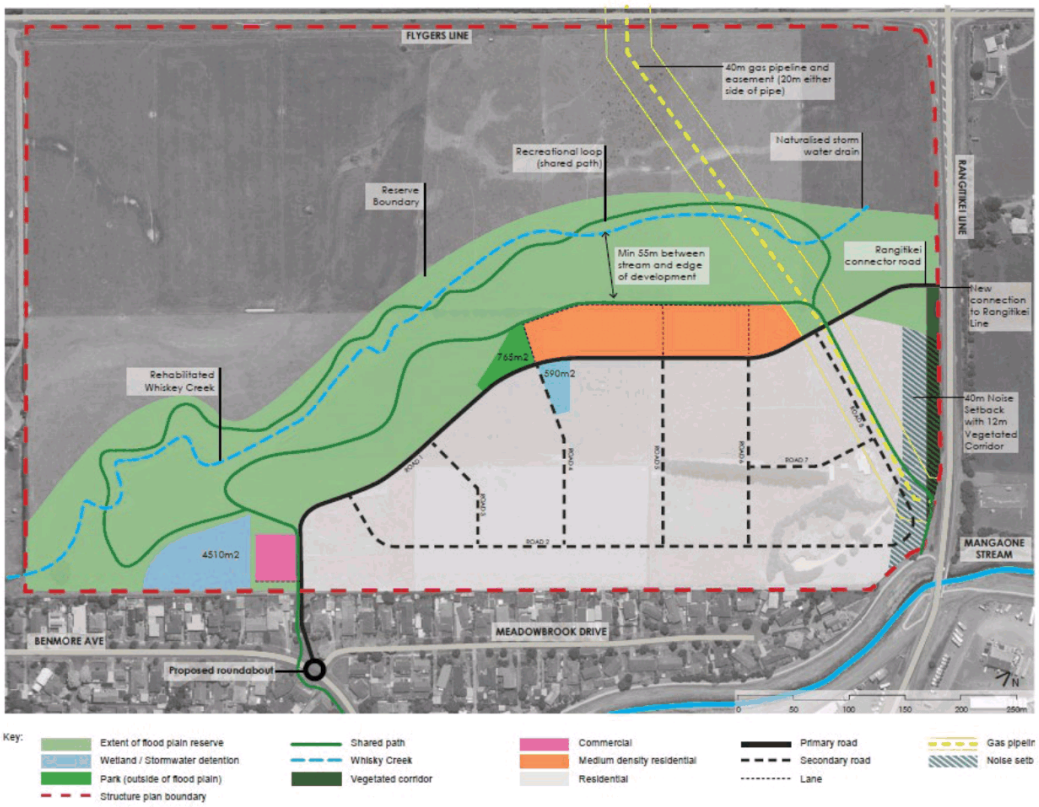

Figure 6: Proposed Structure Plan

There are three types of street within the internal road hierarchy, the collector road that connects Benmore Avenue to Rangitikei Line, the local roads that provide access to area to the south of the collector road and lanes which provide access to housing on the northern side of the collector road. The collector road has a 16.2m legal width reducing to 13.6m alongside the reserve. The local roads have a legal width of 15.2m and the lanes are 4.5m wide and are intended to operate as a shared space with vehicular traffic travelling in a one-way direction. Cross-sections of the collector and local road street types are included in Figure 7 below.

The Plan Change documents show the potential to accommodate up to 157 dwellings along with a commercial area (1,200m^2 GFA). Trip generation rates of 1.0 vehicle movements per household in the peak hours and 10 vehicle movements per day per household have been adopted to include some allowance for vehicle activity associated with the commercial space. As included earlier, weekday morning and afternoon trip generation rates of 0.7 and 0.9 vehicle movements per hour per household respectively were recorded for Meadowbrook Drive. As such it is anticipated that the site could generate the following traffic activity:

- 1,570 vehicle movements per day; and
- 157 vehicle movements per hour during the weekday traffic peaks.

Based on the traffic count of the intersection of Benmore Avenue and Meadowbrook Drive it is forecast that the directional split will be 75% (118vph) outwards during the weekday morning peak and inward during the weekday evening peak. With 25% (40vph) inwards during the weekday morning peak and outward during the weekday evening peak. Using a combination of the distribution from the traffic counts of the intersection of Benmore Avenue and Meadowbrook Drive, sample turning counts for vehicles turning out of Bennett Street onto Rangitikei Street and John F Kennedy Drive along with the assumption that for

up to one third of the houses inward trips may be quicker via the left turn in from Rangitikei Line than via Benmore Avenue, the forecast trip distribution is shown in Table 2.

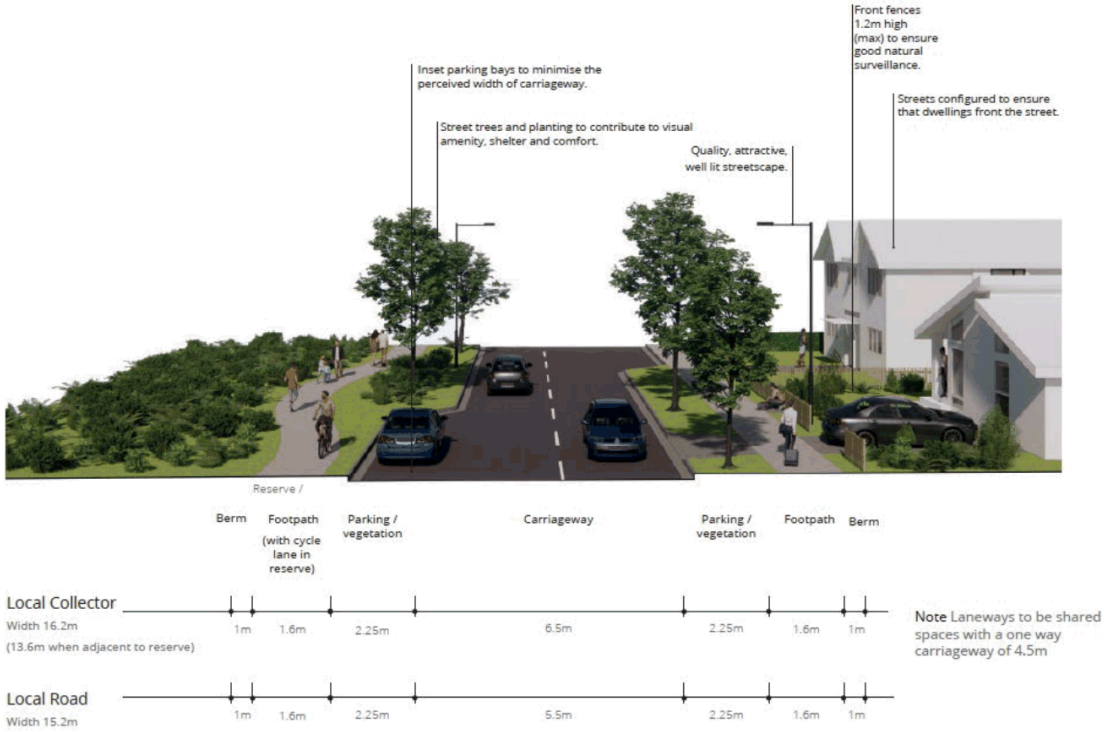

Figure 7: Proposed Street Cross-Sections (from Urban Design Report)

	Weekday Morning Peak (7.45-8.45am) (vph)	Weekday Evening Peak (4.30-5.30pm) (vph)
Outwards		
L to Benmore Ave	89	17
R to Benmore Ave	20	20
L to Rangitikei Line	9	3
Inwards		
L from Benmore Ave	4	52
R from Benmore Ave	24	44
L from Rangitikei Line	12	22
TOTAL	158	158

Table 2: Forecast Traffic Flows

The key potential off-site traffic effects associated with the proposed plan change and associated residential development are:

- safe connection to SH3 Rangitikei Line;
- safe and efficient connection to Benmore Avenue and Meadowbrook Drive; and
- safe and efficient movement of additional traffic through the local road network.

Each of these potential traffic effects are discussed in turn below.

3.1 SH3 Rangitikei Line

Given the 100km/h speed limit, proximity to the Flygers Line intersection to the north and the Mangaone Stream bridge to the south, along with the poor crash history at the Flygers Line intersection, the proposed connection to Rangitikei Line is left in/ left out only. In this location approximately midway between the bridge and Flygers Line, the sight line for exiting drivers towards northbound SH3 traffic is maximised while ensuring an appropriate degree of separation from the nearby Flygers Line intersection. At the detailed design stage it will be necessary to ensure that the design prevents any risk of drivers making right turns in this location.

With regard to likely turning volumes and as included in Table 2, no more than 22 vehicle movements per hour are expected for each of the left turns. This level of traffic activity can be safely and efficiently accommodated. It is recommended that the detailed design of the internal collector road is used to discourage through traffic from travelling through the subdivision to access SH3 to the north.

3.2 Benmore Avenue/ Meadowbrook Drive

The proposed Structure Plan includes the new collector road connecting onto the existing Meadowbrook Drive intersection with Benmore Avenue and forming a four arm roundabout. A concept design for the roundabout is included here as Figure 8. As for the existing intersection, the roundabout would be around 350m from the Bennett Street intersection and around 90m from the Waltham Court intersection. The road reserve is wide in this location and it is anticipated that adequate sightlines can be achieved between the approaches. A roundabout in this location will usefully assist in reducing vehicle speeds, noting that Council is separately investigating adding speed control devices further to the west on Benmore Avenue. Raised treatments could be used on the approaches or the whole intersection could be raised to further reduce vehicle speeds and increase safety for pedestrians and cyclists along with residents accessing nearby properties. Such treatments would be considered as part of the detailed design process and would be subject to road safety audit procedures.

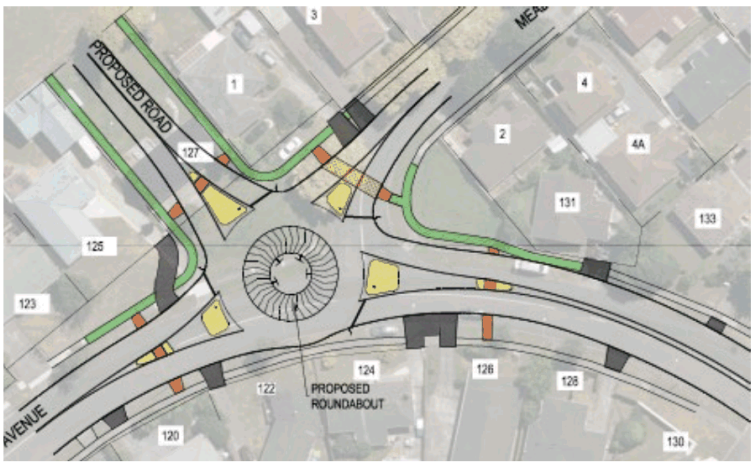

Figure 8: Concept Design for Roundabout

The intersection between Meadowbrook Drive and Benmore Avenue has been analysed with a four arm roundabout and the development traffic using the SIDRA intersection analysis tool. The AM peak results are shown in Table 3 and the PM peak results in Table 4. Allowance has been included for 10% traffic growth for through movements on Benmore Avenue since the 2017 intersection count was completed.

Approach	Traffic Flow (vph)	Average Delay per Vehicle (sec)	Level of Service	95th percentile queue (veh)
Meadowbrook Dv	31	7	A	0
New Road	110	5	A	1
Benmore Ave (W)	317	6	A	1
Benmore Ave (E)	173	3	A	1
TOTAL	631	5	A	-

Table 3: Meadowbrook Drive/ Benmore Avenue Roundabout AM Peak

Approach	Traffic Flow (vph)	Average Delay per Vehicle (sec)	Level of Service	95th percentile queue (veh)
Meadowbrook Dv	15	5	A	0
New Road	38	6	A	0
Benmore Ave (W)	212	6	A	1
Benmore Ave (E)	441	3	A	2
TOTAL	706	4	A	-

Table 4: Meadowbrook Drive/ Benmore Avenue Roundabout PM Peak

As shown, a roundabout is expected to be able to readily accommodate the additional traffic. The detailed design of the roundabout will need to include particular consideration of the nearby residential driveways and the safe accommodation of pedestrians and cyclists. Some existing kerbside parking will be removed but sections of kerbside parking will remain available nearby.

3.3 Wider Local Road Network

It is forecast that up to some additional 72vph will travel along Benmore Avenue to and from the direction of Gillespies Line during the weekday evening traffic peak. This amounts to an increase of on average around one vehicle movement per minute. No discernible change in the performance of Benmore Avenue is expected and the traffic flows will remain comfortably within the range anticipated for a Collector Road.

There is some existing peak hour traffic congestion at the signalised intersection of Rangitikei Street (SH3) with Bennett Street and John F Kennedy Drive. The proposed plan change could result in around some additional 89vph on the Bennett Street approach during the weekday morning peak. With an average cycle time of around two minutes, on average there would be around three additional vehicles on the approach during each cycle of the traffic signals. There are two lanes at the stop line so there would be expected to be one or two additional vehicles per lane per cycle of the traffic signals. This level of additional traffic will not be discernible from day to day traffic fluctuations through the intersection. The grid layout of the roading network also means that future and existing residents have the option of accessing the city via Benmore Avenue towards the west and then Gillespies Line and Botanical Road.

During site visits it was noted that there is some kerbside parking along the northern side of Bennett Street on the approach to Rangitikei Street. This parking was observed to restrict the storage space at the intersection, in particular due to the large number of trucks accessing the intersection. Separate to this proposal, the Council may wish to consider removing the parking along this section of Bennett Street, between the bus stop and Rangitikei Line, around four or five spaces.

4. District Plan Transportation Requirements

The proposed plan change involves the rezoning of the site from Rural Zone to Residential Zone. Objectives and policies included in the District Plan which have an influence on transportation matters within this site include:

District Plan Provision	Comment on Alignment
City View Objectives	
1. *Planning for residential, industrial, commercial and rural-residential growth sustains a compact, orderly and connected urban form which avoids the adverse environmental effects of uncontained urban expansion into the rural zone.*	The site will connect directly into the urban road network at the intersection of Benmore Avenue and Meadowbrook Drive.
3. *The integrated and efficient provision of, and access to, infrastructure, network utilities and local services is facilitated for all residents.*	Roading connections included to both the local and arterial road network.
9. *Subdivisions, buildings and infrastructure are designed and constructed to promote a coordinated, healthy and safe environment.*	With the introduction of a roundabout at the Benmore Avenue/ Meadowbrook Drive intersection and left in/ left out only to SH3 the connections to the external road network are expected to be able to operate safely.
23. *Infrastructure operates in a safe and efficient manner, and the effects of activities which could impact on the safe and efficient operation of this infrastructure are avoided, remedied or mitigated.*	The traffic associated with the residential activity that would be facilitated by the plan change is not expected to have a significant effect on the safety or performance of the local road network.
24. *All forms of transport, including public transport, walking, cycling and private vehicles are adequately provided for to assist with sustainable energy use and a healthy lifestyle.*	Active modes and private vehicles can be readily accommodated within the site. It is anticipated that public transport will be accessed from the existing bus stops on Benmore Avenue.
25. *Infrastructure and physical resources of regional or national importance are recognised and provided for by enabling their establishment, operation, maintenance, upgrading and protection from the effects of other activities.*	The connection onto SH3 is to be restricted to left in/left out only to ensure the ongoing safety of the highway.
Subdivision Objective 2 ***To ensure that subdivision is carried out in a manner which recognises and gives due regard to the natural and physical characteristics of the land and its future use and development, and avoids, remedies or mitigates any adverse effects on the environment.***	
Policies	
2.1 To require lots to have areas and dimensions to meet the needs of users and to sustain the land resource by ensuring that:	
1. *Lots in the Residential Zone have the necessary area and dimensions to enable the siting and construction of a dwelling and accessory buildings, the provision of private outdoor space, service courts, vehicle access and parking in accordance with the relevant Permitted Activity Performance Standards.*	The indicative site layout includes lot sizes and shapes that allow for vehicle access to on-site parking. Noting that the NPS Urban Development 2020 removes the requirement to provide on-site parking in Palmerston North.
2.2 To ensure that all new lots have safe and adequate vehicle access from the roading network by providing that:	
1. *Every lot is to have access from a formed existing road, or a new road to be formed, to enable vehicles to enter the site with the dimensions of access sufficient to accommodate the level of vehicle usage anticipated. The access should be*	The indicative site layout allows for each lot to have its own access to frontage roading. Given the individual accesses to single residential lots with frontages to local or

District Plan Provision	Comment on Alignment
designed to enable vehicles to turn within the lot and to leave it in a forward direction.	collector roads the Permitted Activity Performance Standard for on-site turning does not apply.
2. *The construction is to be to a standard and of materials to support the anticipated traffic, require minimum maintenance and to control and dispose of stormwater runoff.*	Noted.
3. *Any allotment with frontage to a Major or Minor Arterial road which has no alternative means of access to an existing public road in the local road network, shall have access arrangements approved by Council, in terms of an Access Management Structure Plan.*	The site includes access to both the local and arterial network and Waka Kotahi NZTA have been consulted with regarding the SH3 connection.
2.3 To ensure safe, convenient and efficient movement of people, vehicles and goods in a high quality environment with minimum adverse effects by providing that:	
1. *The layout of the transport network shall, as appropriate for their position in the roading hierarchy, ensure that people, vehicles and goods can move safely, efficiently and effectively, minimise any adverse effect on the environment, make provision for network utility systems and make provision for amenity values. The layout of the transport network shall:*	
• *provide adequate vehicular access to each lot;*	The indicative site layout allows for each lot to have its own access to frontage roading.
• *link to, and provide for, and be compatible with the existing and future transport networks, taking into account orderly and integrated patterns of development and adjoining developments;*	Links provided to both local and arterial road network.
• *connect to all adjoining roads, providing for choice of routes where practicable;*	As above.
• *identify significant destinations and provide for safe and convenient access to these by all modes;*	Indicative site layout includes footpaths connecting with local road network.
• *encourage multi-modal street links, providing pedestrian links; and*	As above plus connections to existing shared paths included.
• *provide adequate access for emergency vehicles.*	Internal road layout allows for emergency vehicle access to all properties.
2. *The development provides for a high quality public realm considering;*	
• *the potential for the street to be a place of recreational walking and cycling;*	Provision for footpaths on local and collector roads. Traffic volumes will be such that cyclists can safely share the carriageway with vehicles.
• *the safety and visibility of pedestrians;*	Pedestrians are provided for on footpaths or shared paths.
4. *The structure of a road shall:*	
• *have a design life of at least 25 years based on Equivalent Design Axle, or equivalent design methods;*	Noted.
• *be constructed from materials suitable for the intended use;*	Noted.
• *maintain adequate surface smoothness; and*	Noted.
• *be protected from the adverse effects of surface and ground water.*	Noted.
6. *Urban roads are to be well lit by specifically designed street lighting, are to be constructed to such standards and in such materials as will result in minimum maintenance having regard to the anticipated levels and types of traffic.*	Lighting will be able to be provided to the required standard.
2.4 To improve land utilisation, to safeguard people, property and the environment from the adverse effects of unstable land by ensuring that:	

District Plan Provision	Comment on Alignment
3. *When land is subdivided that the resultant lots contain safe and adequate building sites and have roading and access suitable for activities.*	Resilience is achieved with both the two connection points to the external road network and the layout of the internal road network which provides route choice options for accessing individual properties if needed.
Residential Zone Objective 1 ***To enable the sustainable use and development of the Residential Zone to provide for the City's current and future housing needs.*** ***Policies***	
1.3 To promote the efficient use of the urban infrastructure and other physical resources.	Efficient road connections to existing road network achieved.
1.4 To ensure network infrastructure and services are available to support residential development and intensification.	As above.
Land Transport Objective 1 ***The City's land transport networks are maintained and developed to ensure that people and goods move safely and efficiently through and within the City.*** ***Policies***	
1.1 Identify and apply the roading hierarchy to ensure the function of each road in the City is recognised and protected in the management of land use, development and the subdivision of land.	The internal road network includes local roads and a collector road. The development traffic is primarily directed towards Benmore Avenue which has a collector function.
1.2 All roads in the City have function and design characteristics consistent with their place in the roading hierarchy.	As above.
1.3 Maintain and upgrade the existing roads in the City and provide for new roads to meet the current and future needs of the City.	Apart from the new roundabout at the intersection of Benmore Avenue and Meadowbrook Drive and construction of the connection to SH3 no other changes are needed to the existing road network.
1.4 The road network stormwater control system shall protect the road, road users and adjoining land from the adverse effects of water from roads and minimise any adverse effect on the environment.	Noted.
1.5 Require all new public roads, private roads, accessways and privateways to be designed and constructed to meet performance standards relating to the safety and efficiency of vehicle movement, and to ensure the safe use of the road transport network for all users, particularly in respect of:	
a) *Road width and alignment which should be sufficient for two vehicle lanes except where traffic volumes are insufficient;*	Allowed for in road cross-sections.
b) *The formation and surface sealing of all roads, accessways and privateways to standards appropriate to the volume of traffic expected to be carried;*	Readily achievable.
c) *Provision for necessary network utility facilities within roads; and*	Anticipated.
d) *Safe design and construction of roads, road access points and intersections, including alignment, gradient, vehicle parking, manoeuvring and turning requirements.*	As shown in the indicative site layout a safe design for the internal roading and access arrangements is expected.
1.6 Encourage the development of safe and accessible pedestrian paths and cycleways, as well as convenient and accessible cycle parking, to support the opportunity for people to use active and non-vehicular modes of transport throughout the City.	Extensive shared path network included within the site with connections to the existing shared path along the Mangaone

District Plan Provision	Comment on Alignment
1.7 To support and encourage the provision of public transport and its use throughout the City as an integral part of the transportation system.	Stream and footpaths along Benmore Avenue. The site is within walking distance of the existing bus route along Benmore Avenue.
1.8 Convenient, safe and accessible car parking, loading and manoeuvring facilities are available for residents, staff, visitors and customers for all activities without creating congestion or conflicts with moving vehicles, pedestrians or cyclists on adjacent roads.	Anticipated that private on-site and kerbside parking will be available. Rubbish collection trucks will be able to efficiently circulate through the internal road layout.
Land Transport Objective 2 ***The land transport network is safe, convenient and efficient while avoiding, remedying or mitigating adverse effects in a way that maintains the health and safety of people and communities, and the amenity values and character of the City's environment.*** ***Policies***	
2.1 Restrict the through movement of traffic where the movement has adverse visual, noise and safety effects on the adjoining areas by using the road hierarchy to direct higher volume and heavy traffic movements on identified arterial routes and discouraging this traffic from other areas, such as residential areas.	The restriction of turns at the SH3 connection will help with ensuring that only local traffic from the subdivision use this connection. Other measures can be included in the detailed design at resource consent stage to deter through traffic travelling through the subdivision.
2.2 Avoid, remedy or mitigate the impact of roads and parking areas on visual amenity values of the community by requiring the provision of landscaping.	Addressed in the urban design assessment.
2.4 Avoid adverse effects on amenity and character by ensuring that new roads are well designed and visually complement the character of the surrounding area.	Addressed in the urban design assessment.
Land Transport Objective 3 ***The safety and efficiency of the land transport network is protected from the adverse effects of land use, development and subdivision activities.*** ***Policies***	
3.1 Avoid, remedy or mitigate the adverse effects of increased traffic or changes in traffic type, which would compromise the safe and efficient operation of any road, or the safe and convenient movement of pedestrians and cyclists on roads.	This assessment has shown that the existing road network will continue to operate safely and efficiently.
3.2 Require vehicle crossing places and vehicle entrances from public roads to be located, constructed, and maintained to standards appropriate to the expected traffic volume, pedestrian movement and speed environment of each road.	Detail to be included at resource consent stage.
3.3 Ensure that buildings and activities do not compromise the necessary clear sight lines for trains and road vehicles at level rail crossings, or of vehicles at road intersections.	Road cross-sections and building setbacks will allow for satisfactory sight lines at internal intersections. This will be demonstrated at resource consent stage.
3.4 Ensure adequate on-site parking and manoeuvring space is provided for each type of activity in a safe and visually attractive manner.	Detail to be included at resource consent stage.
3.5 Ensure that buildings and activities make provision for adequate and safe on-site loading.	Loading provisions for the commercial area will need to be considered at the resource consent stage. The internal road layout is

District Plan Provision	Comment on Alignment
	such that rubbish collection trucks will be able to efficiently circulate through the site.

As such the proposed plan change and the residential activity that it would facilitate are well aligned with the transport related objectives and policies of the District Plan.

5. Summary and Conclusion

The findings and recommendations of this assessment can be summarised as follows:

- a four arm roundabout at the intersection of Benmore Avenue and Meadowbrook Drive can be expected to perform well;
- the design of the internal collector road will need to deter use by through traffic from outside the development;
- the connection with SH3 should be left in and left out only and located to ensure safe intersection sight distances are achieved; and
- the demands for left turns into and out of the site from SH3 is not expected to exceed 30vph for either movement.

As such, primary access to the site is expected to be able to be accommodated to/from Benmore Avenue via a new roundabout arrangement with Meadowbrook Drive. A secondary access to SH3 Rangitikei Line usefully provides an alternative access point to the road network and provided that the internal roading is designed to avoid through traffic will be lightly trafficked.

In conclusion, the site can be rezoned to Residential Zone and developed for residential purposes with the development meeting the transportation related objectives and policies of the District Plan.

Please do not hesitate to be in touch should you require clarification of any of the above.

Yours faithfully

Harriet Fraser

Harriet Fraser

APPENDIX 11

PROPOSED PLAN CHANGE WHISKEY CREEK: WATER AND WASTEWATER, GAS MAIN AND EARTHWORKS ASSESSMENTS

RESONANT LTD

resonant

MULTI-DISCIPLINARY ENGINEERING & SURVEYING SERVICES

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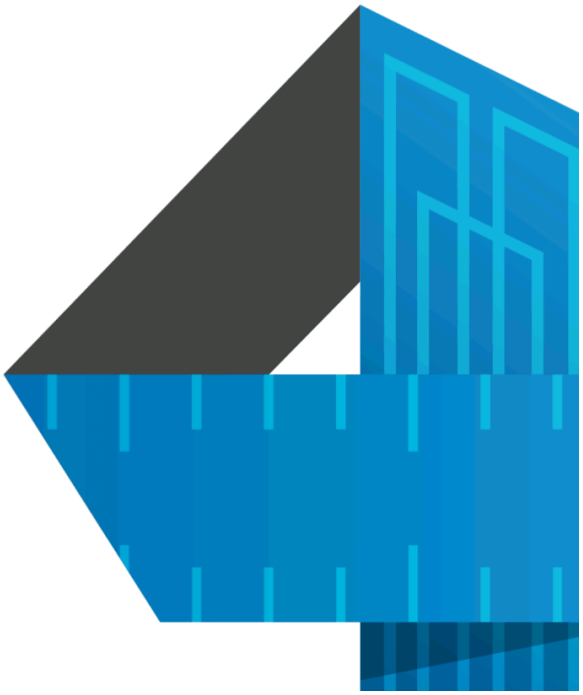
PROPOSED PLAN CHANGE

WHISKEY CREEK, PALMERSTON NORTH

- Water and Wastewater Servicing Assessment
- Gas Main
- Earthworks Assessment



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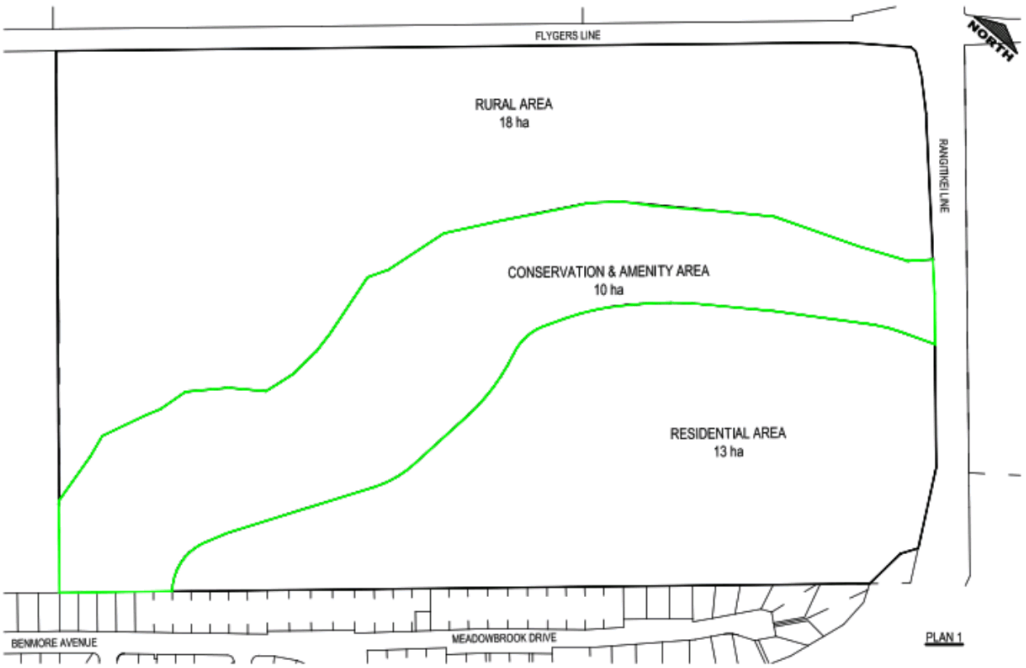
3 Water Supply Services Assessment 6
4 Gas Main 7
5 Earthworks Assessment 8
6 Summary 10

1 Introduction

This report sets out the servicing requirements for the proposed Whiskey Creek Residential Area. These assessments have been carried out with the assistance of the Palmerston North City Council. We also consider the gas main that bisects the site and the proposed earthworks.

The proposed area to be rezoned Residential is approximately 13 hectares of a 40 hectare site. Some 10 hectares will be rezoned Conservation and Amenity with the remaining 18 hectares continuing to be Rural, see Plan 1.

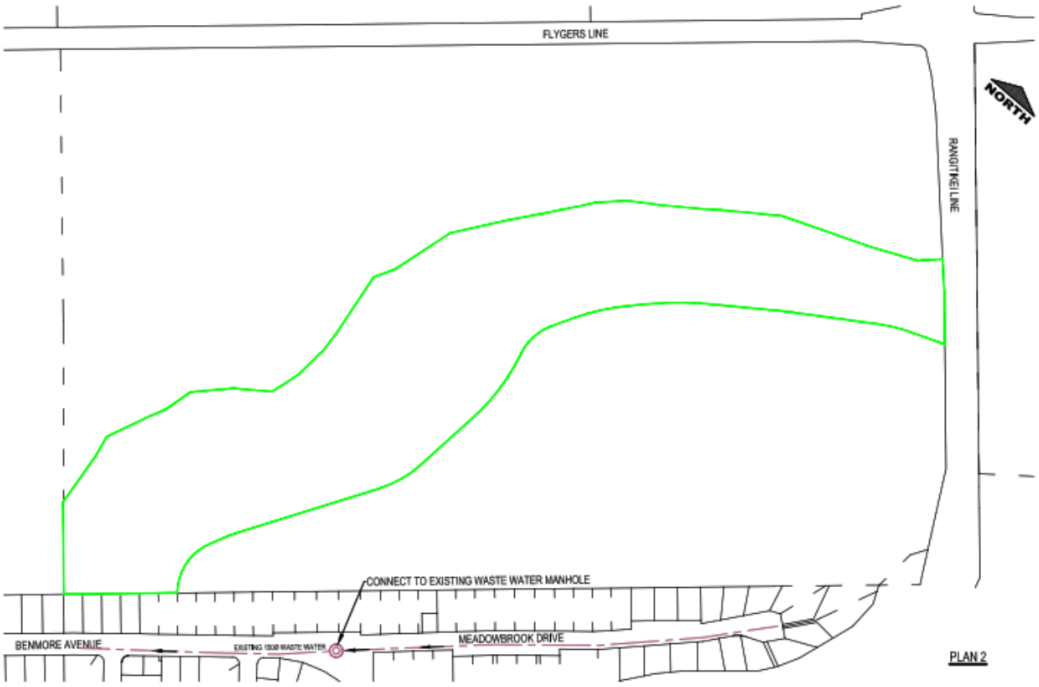


Plan 1

2 Wastewater Services Assessment

The existing wastewater network in the area is shown on Plan 2. Presently a 150mm ø main, installed in the 1970's, is located within Benmore Avenue. This sewer main flows to the south west and eventually discharges into the Wastewater Treatment Plant in Totara Road, some 5km away.

The depth of the wastewater system adjacent the proposed roundabout, is in the order of 2 metres deep.



Plan 2

Two servicing options were considered to service the estimated 160 lots proposed within the residential land. These being a gravity drainage system and a pressure system.

A typical gravity system includes a 100mm ø rigid lateral pipe to each property. These laterals connect to a 150mm ø rigid main pipe within the roadway. These pipes are graded to fall towards the connection point of the existing system. If the connection point is too high a lifting pump chamber is required to discharge the sewage into the existing system.

A pressure system requires each lot to have installed a small pump chamber which is fitted with a grinder pump. Sewage is pumped into a 50mm ø flexible pipe within the street which in turn discharges into the connection point. No lifting pump is required, as the system relies on pressure.

Due to the proposed ground levels of the land in question, it was calculated that there wasn't sufficient elevation for a gravity system to drain the site without the need for a pump lifting station. It was also considered that any gravity system could increase the peak flow effects on the down stream network, due to the users discharging sewage at peak times.

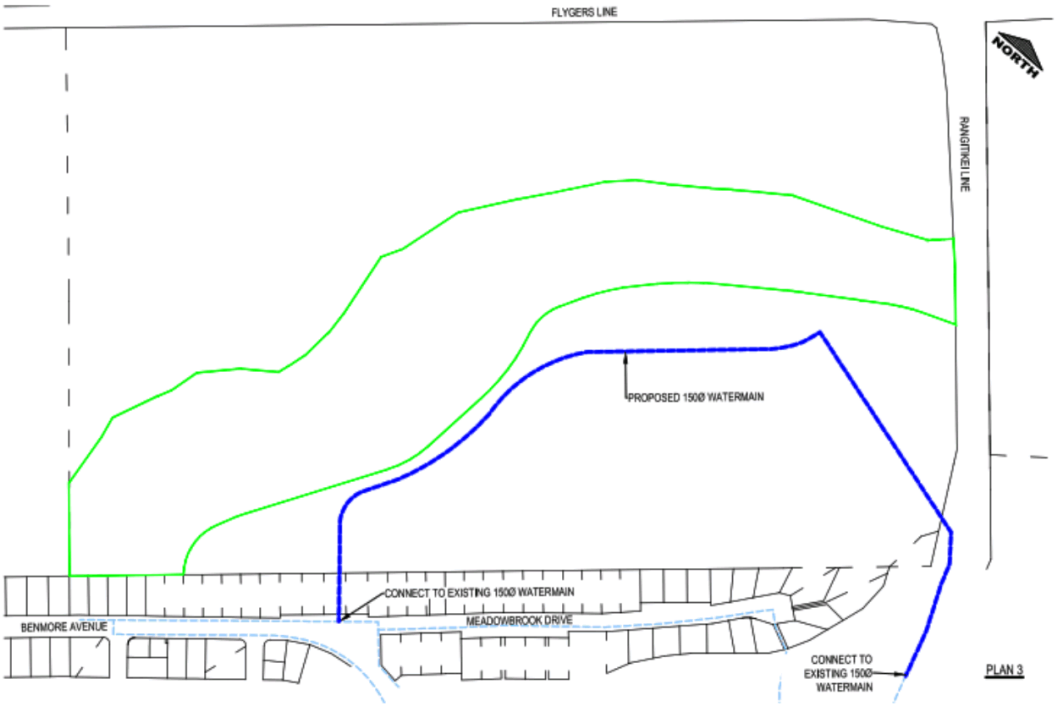
The pressure sewer system would be able to service the entire development without the need for a lifting station. The individual pump systems are able to be time coordinated so that the discharge from the site can be timed to occur outside peak flow hours, which would not cause any downstream capacity issues. Pressure sewer systems are also less susceptible to the effects of water infiltration, liquefaction and ground movement.

Discussions have been held with Council over the proposed sewage disposal options, with Council agreeing that the pressure system is their preferred option.

We expect that the cost to install the pressure sewer system would be met by the developer. The works would be completed to Council's present Land Development Standards.

3 Water Supply Services Assessment

The present water supply system in this sector of Palmerston North is shown on Plan 3. Separate 150mm ø water mains exist in Benmore Avenue, directly opposite our development, and at the northern end of Rangitikei Line, respectively.



Plan 3

It is proposed to extend the watermain at the northern end of Rangitikei Line by 150m to the eastern corner of our site. This extended watermain will be looped through the development to Benmore Avenue by a new 150mm ø main.

Previous discussions held with Council have advised that it is envisaged that the above proposal will provide a compliant water supply system for the development.

It is noted that the present Council's level of service for residential water supply is a minimum service pressure of 350kPa and a minimum peak flow capacity of 25L/s for fire-fighting purposes.

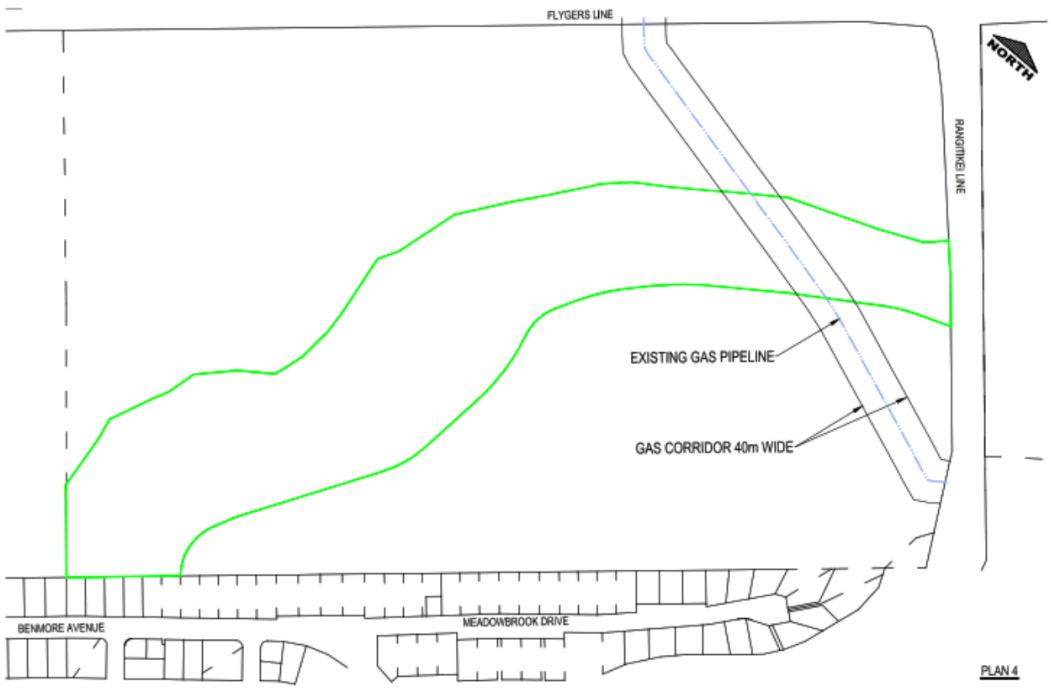
As with the wastewater system, the cost to extend the 150mm ø water main to the site along with the connecting loop 150mm ø water main to Benmore Avenue will be covered by the developers.

4 Gas Main

As shown on Plan 4, a major gas line traverses through the site in the northern quadrant. First Gas (being the controlling authority) have confirmed their requirements with respect to this development, being that the main be contained within the berm area of the roading corridor, or any other public areas where possible, and that a 20-metre safe separation distance is provided either side of the main to any new residential housing.

The position and depth of the gas main has been located on site, with the proposed development layout reflecting this.

It is acknowledged that any development within the vicinity of the gas main will require specific consideration from First Gas.



Plan 4

5 Earthworks Assessment

Presently 7ha of the site is considered free from inundation, see Plan 5. To increase the area available for residential development earthworks are proposed on the eastern side of Whiskey Creek. The extent, volume and depth of those earthworks are also shown on Plan 5. As shown, the area of earthworks is approximately 10 hectares in size, with 23,000m^3 of material cut from beside Whiskey Creek. This material is to be used to raise the fill area to be above the flood level.

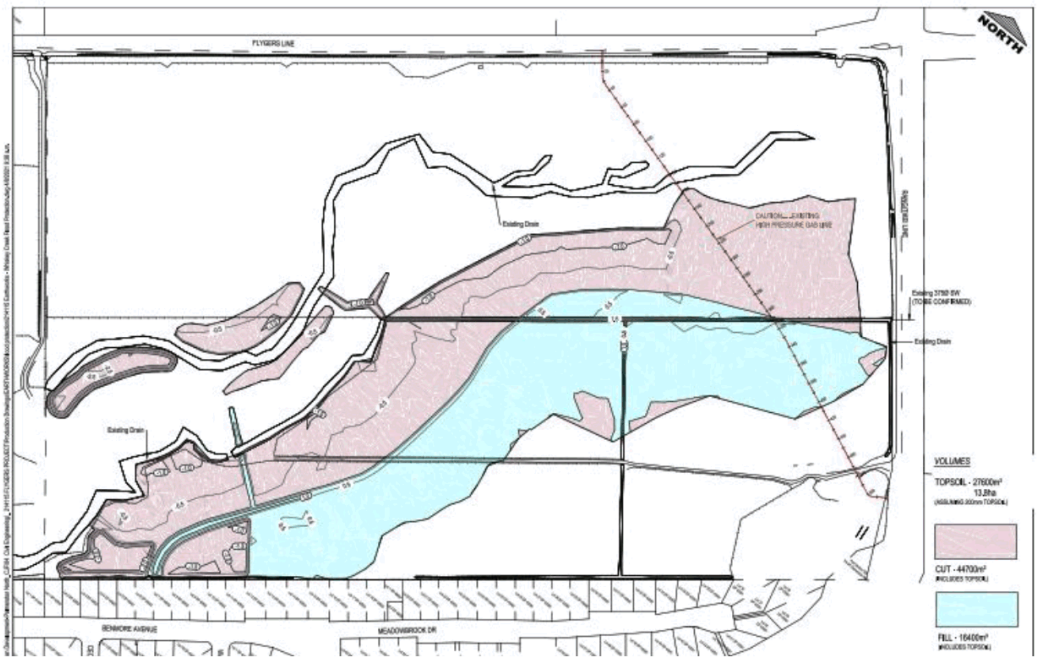
Filling will occur directly behind 1 and 3 Meadowbrook Drive and 113, 115, 117, 119, 121, 123 and 125 Benmore Avenue. Any fill placed will be at a level to ensure no damming effects to any overland flow from these properties.

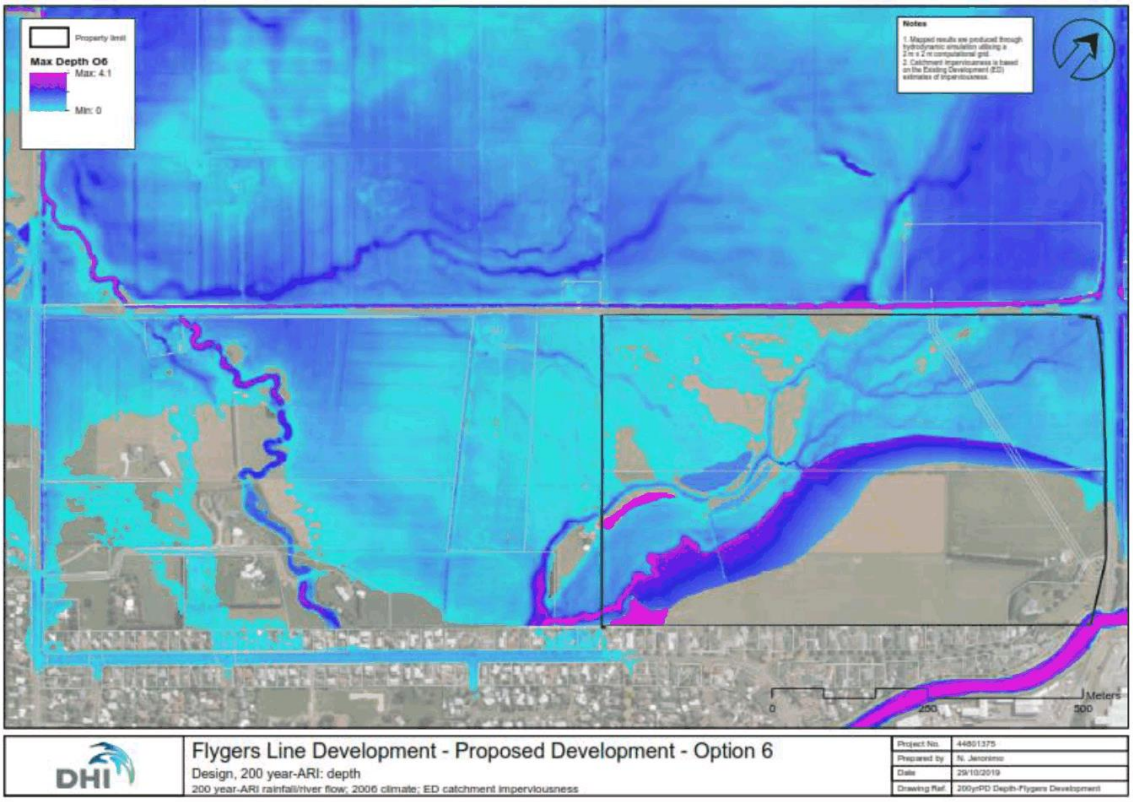
These earthworks also alter the drainage pattern for any significant flood event which passes through the block. A flood model was prepared which concluded that the flooding effects downstream due to the ground remodeling were less than minor. We refer you to the DHI Flood Assessment Report. The attached Plan 6 details the proposed extent of the flooding. As a result of the proposed earthworks, the extent of the land available for development increases to 13ha.

All earthworks will be compacted to the necessary standards to ensure these filled areas are suitable for residential developments. All relevant Erosion and Sediment Controls will be installed to mitigate any effects.

In parallel with the rezoning application, land use earthworks consents are to be submitted to both Horizons Regional Council and the Palmerston North City Council seeking approval to modify the land to the new levels.

Plan 5




Property limit
Max Depth O6
Max: 4.1
Min: 0
Notes
0
250
500
Meters
DHI
Flygers Line Development - Proposed Development - Option 6
Design, 200 year-ARI: depth
200 year-ARI rainfall/river flow; 2006 climate; ED catchment imperviousness
Project No.
Prepared by
Date
Drawing Ref.

Plan 6

6 Summary

Assessing the water and wastewater servicing for the Whiskey Creek Residential Area, we conclude that:

- Functional and compliant service systems can be provided.
- The costs to provide the systems are the responsibility of the developer and we presume no Council funding is required.
- The preferred option for wastewater servicing is a pressure sewer system.

Regarding the existing gas main and the proposed earthworks, we confirm that:

- The effects of the gas main can be mitigated by the imposition of a 20m building offset.
- No minor effects are caused by the proposed earthworks on the downstream, nor the adjacent property owners.

THOMAS PLANNING

APPENDIX 12

WHISKEY CREEK PLAN CHANGE
STORMWATER MANAGEMENT PLAN:

MITCH HYDRO LTD



Whiskey Creek Plan Change, Palmerston North

Stormwater Management Plan for Flygers Investment Group Limited

Mitch Hydro Limited | April 2021

Mitch Hydro

Whiskey Creek Plan Change, Palmerston North

Stormwater Management Plan for Flygers Investment Group Limited



Approved for release by

Paul Mitchell
Director, Hydrologist
CPEng

Date: 15 April 2021
Ref: 2017.03
Status: Issue 2

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Appendix A Existing Layout

Appendix B Fully Developed Layout

Appendix C Stormwater Mitigation

Appendix D Flygers Line Spillway (Horizons)

1 Introduction

Mitch Hydro Limited (Mitch Hydro) has been engaged by Flygers Investment Group Limited to develop a Stormwater Management Plan (SMP) for the proposed Whiskey Creek Plan Change, Palmerston North.

2 Objectives

The main objectives are summarised below:

1. Research requirements with respect to stormwater mitigation for the proposed development;
2. Attend, via a video link, 1 or 2 workshops to discuss the site and assist in agreeing on a possible structure plan; and
3. Prepare a Stormwater Management Plan (SMP) that identifies, discusses and mitigates the stormwater effects of the land being rezoned.

The SMP will compliment and inform the Section 32 analysis report.

3 Scope

The scope will include the following key items:

1. Initial discussions with the project team;
2. Site visit to assess:
    a. Existing stormwater infrastructure constraints / performance and flood hazards:
    b. Site-specific options for stormwater mitigation (quantity and quality); and
    c. Any other relevant issues.
3. Develop methodology for SMP;
    a. Review existing land uses;
    b. Type and condition of existing pervious areas;
    c. Existing drainage infrastructure and condition; and
    d. Any other relevant issues.
4. Catchment hydrology;
    a. Rainfall;
    b. Geology;
    c. Climate change;
    d. Existing land use;
    e. Fully developed (unmitigated) land use.
5. Undertake mitigation assessment for the proposed increase in impervious areas (roofs, pavements and roads):
    a. Confirm design approach; and
    b. Assess / demonstrate effectiveness of proposed mitigation options.

6. The issue of a technical report, which outlines the above considerations, demonstrates 'Hydrologic Neutrality' and makes recommendations for the preferred stormwater concept designs.

4 Methodology

4.1 Initial Discussions

Paul Mitchell (Mitch Hydro) has been involved in the project since June 2017 including:

- Catchment walkover, survey and assessment of the site drainage, downstream Palmerston North City Council (PNCC) stormwater connection adjacent to No. 91 Benmore Avenue, and overland flow paths;
- Meeting with Jon Bell (Horizons) on 27 March 2018 to discuss the potential effects and preferred modelling approach;
- Discussions with project team, DHI and review of 2D modelling outputs; and
- Project meeting (5 November 2019) with Grant Higgins (Flygers Investment Group), Kevin Judd (Resonant CEO), Paul Thomas (Thomas Planning), Nuno Jeronimo (DHI), David Murphy (PNCC) and Veni Demado (PNCC), and Jon Bell (Horizons).

4.2 Site Visit

Paul Mitchell initially visited the site on 16 March 2018 to familiarise with the general layout. He revisited the site on 27 March 2018, with (then) KOA[1] survey staff, to walkover the catchment, and to assess / survey the network of open channel drains and their connection with the downstream PNCC stormwater main.

4.3 Existing Drainage

The approximately 39 ha site is bounded by Rangitikei Line to the north-east, Flygers Line to the north-west, and the floodway stop-bank north of Benmore Avenue properties to its south-east.

The site is located in the lower Whiskey Creek catchment. The site is currently being used for pastoral farming, with cattle herds observed in the paddocks. The ground surface is generally in good condition (Figure 1) with some erosion and pitting observed on the banks and slopes adjacent to the large, remnant open channels.

The area drains roughly east to west until it is intercepted by the remnant Whiskey Creek open channels draining to the south, which culminate at the floodway stop-bank adjacent to No. 91 Benmore Avenue, where the PNCC 900mm diameter stormwater main commences (Figure 2).

[1] Kevin O'Connor and Associates Limited



Figure 1: General condition of pasture (March 2018)



Figure 2: PNCC 900mm dia. stormwater connection adjacent to No. 91 Benmore Avenue

The entire site is affected by localised catchment flooding, but more significantly by Mangaone Stream spillway events, which spill from the Flygers Line spillway some 1.4 km upstream. The spillway was designed by the (then) Manawatū Catchment Board (now Horizons) in 1982 to reduce flooding through Palmerston North.

During Flygers Line spillway events there are multiple flow controls across site, including the two open channels (Whiskey Creek and tributary) plus sheet flow across driveways and roads etc. The February 2004 and June 2015 flood events both flooded across the Rangitikei Line / Flygers Line intersection. The spill flows drain to the Taonui Basin and downstream to the Oroua and Manawatū Rivers.

4.4 Geology

The surficial soils of the proposed site (Figure 3) are mostly Kairanga silt loam, with a small area of Te Arakura fine sandy loam, and the coarser Karapoti sandy loam (gravelly phase) in the Whiskey Creek remnant stream channel. These soils are typically poorly draining.



Figure 3: Surficial Soils

Applying the United States Soil Conservation Service (SCS) rainfall-runoff method, the surficial soils are categorised as 'poorly draining' Class C. During significant rainfalls events, the soils are high yielding in terms of runoff.

5 Rainfall – Runoff Modelling

5.1 Introduction

The United States Soil Conservation Service (SCS) method has been applied in this study. This method is commonly used in New Zealand to demonstrate the runoff characteristics of both greenfield and existing urbanised catchments. It is considered an industry standard method having been formally adopted in 1999 by the (then) Auckland Regional Council (TP 108).

The modelling applied in this study has considered the existing and fully developed scenarios as 'lumped' catchments. This is because of the preliminary nature of the design layouts and the further refinement envisaged during subsequent consenting stages. These assessments will provide a preliminary level of understanding of the effects of the proposed Plan Change on stormwater runoff and the recommended mitigation approach.

5.2 Design Rainfalls

The HIRDS V4 design rainfall depths have been applied in this study. HIRDS V4 is a generalised procedure to obtain spatially and temporally consistent depth-duration-frequency design rainfalls for any location in New Zealand, utilising data collected by NIWA and local territorial authorities.

These rainfalls have been applied in many flood assessments in the Manawatū and around New Zealand. We have also applied the RCP 6.0 (2081-2100) climate scenario to provide for climate change effects over the life of the infrastructure.

The events considered in this study are the 2-year, 5-year, 10-year, 20-year, 50-year, 100-year and 200-year Average Recurrence Interval (ARI) events. Climate adjusted design rainfalls are listed in Table 1.

Table 1: Whiskey Creek Design Rainfall (including climate to 2100)

ARI (Years)	Annual Exceedance Probability (AEP) %	HIRDS V4 (RCP 6.0) 24-hour rainfall depth (mm)
2	39	57
5	20	73
10	10	86
20	5	98
50	2	116
100	1	130
200	0.5	144

5.3 Existing Catchment Runoff

As noted above, the surficial soils are categorised as 'poorly draining' Class C (Table 2).

Table 2: SCS Curve numbers for Class C Soils

Land Use	Condition	Curve Number (CN)
Bush / Garden	Good	70
Pasture / Grass	Good	74
Gravel Roads	NA	82
Impervious	Roof / pavement	98

The area to be rezoned (refer plan in Appendix A) is limited to approximately 12.86 ha and comprises of Lot 1 DP 389924 (0.86 ha) with existing dwelling; and Lot 2 DP 389924 (12.0 ha) mainly in pasture. The existing scenario will address the runoff from the combined 12.86 ha site.

The 12.86 ha site drains approximately east to west until it intercepts with the Whiskey Creek open channels, which are outside of the proposed development area. The catchment is likely to be ephemeral, and is relatively flat with an approximate slope of 0.0043m/m (1 in 230) and a time of concentration of approximately 38 minutes.

The existing land use is summarised in Table 3, which indicates that the impervious and bush areas are equally small with almost the entire site in pasture and a weighted curve number of CN 74.0. A simplified HEC-HMS model for the existing catchment is shown in Figure 4.

Table 3: Existing Catchment Characteristics

Curve Number						Slope (m/m)	Tc (minutes)	Initial Losses
Area (ha)					Weighted CN			
Roof / paved (CN 98)	Metal Driveway (CN 82)	Pasture / Grass (CN 74)	Bush / Garden (CN 70)	Total Site				
0.063	0.096	12.101	0.600	12.86	74.0	0.0043	38	5.0

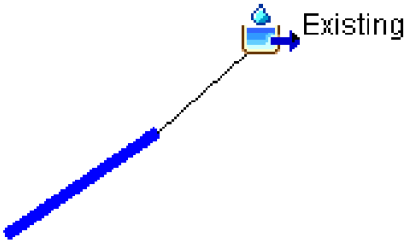


Figure 4: HEC-HMS Existing Model

5.4 Fully Developed Catchment

5.4.1 Plan Layout

The fully developed (Resonant) layout is included in Appendix B. There are some minor differences between the modelled layout in Appendix B and the McIndoe Urban 'Indicative Masterplan' layout (refer Figure 5 below).

Both layouts are indicative (only) and indicate similar land uses, number of lots and implied imperviousness. For the purposes of the modelling, we have assumed that the stormwater conveyance for the development would be by kerb and channel, and by reticulated stormwater pipe.

The location, sizing and hydraulic connectivity of the stormwater network will be confirmed during subsequent consenting stages.

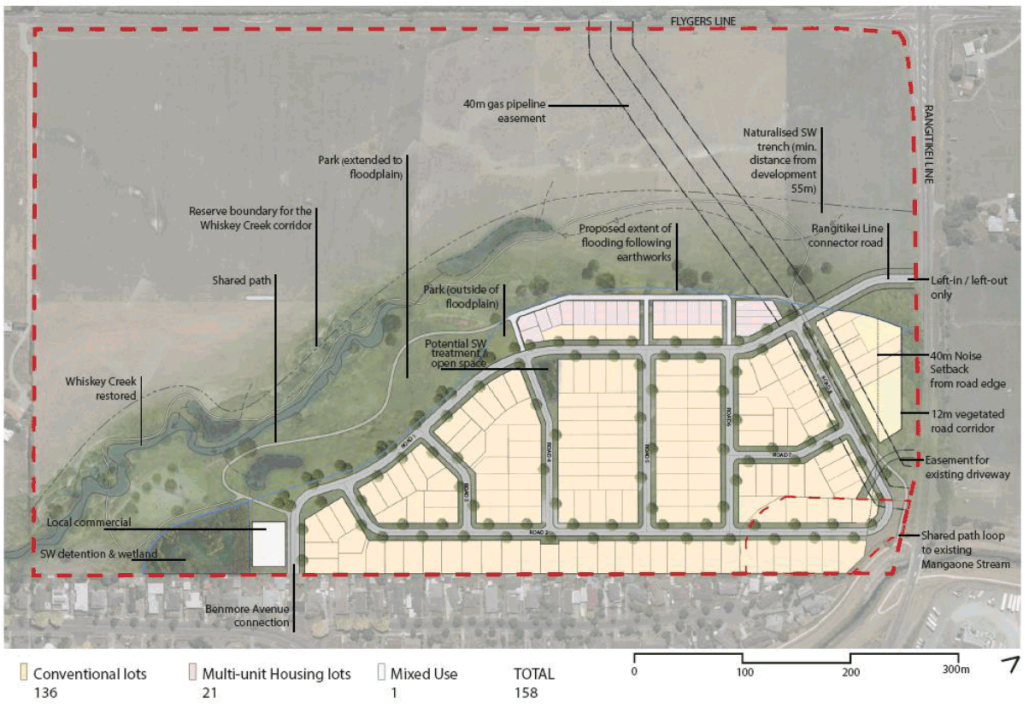


Figure 5: McIndoe Urban Indicative Masterplan (Figure 21, 2021)

5.4.2 Land Use Assumptions

The indicative layout (Appendix B) includes approximately 170 lots ranging in size from 171m² to 1050m². The predominant lot size is at or about 450m², which also coincides as the average lot size. The following assumptions[2] with regard to site coverage have been applied in the stormwater modelling:

- Maximum impervious (building) area:
  - 40% for lot areas <500m²;
  - 200m² on sites 500-572m²;
  - 35% for lot areas >572m²; and
- Maximum total imperviousness per lot (average 65%):
  - Lot size 171m² to 366m² 75%
  - Lot size 367m² to 449m² 70%
  - Lot size 450m² to 561m² 65%
  - Lot size 562m² to 1050m² 60%
- Grass minimum 15%; and
- Garden / trees minimum 10%.

The south-western extent of the development site (approx. 7000m²) has been assessed as a reserve and suitable for stormwater flood detention. The remainder of the site, includes approximately 162 lots as indicated in Table 4. The land use for the fully developed catchment of 12.86 ha is detailed in Table 5, which indicates an increase in the weighted curve number as a result of the development from CN 74.0 to CN 87.1.

The time of concentration also reduces slightly from approximately 38 minutes (existing) to 33 minutes (fully developed). We have assumed a curve number of CN 90 for the detention area, which may also contain commercial areas, roads and other lots depending on the final area requirements of the flood detention pond.

Table 4: Lot Numbers and Sizes

Lot Size (m²)	Number	Area m²						Total impervious %
		Gross	Roof	Paving	Grass	Garden / Trees	Total / Weighted	
171-366	20	4023	1609	1408	603	402	4023	75%
450-491	117	52909	21164	13227	13227	5291	52909	65%
526-561	8	4366	1600	1238	1092	437	4366	65%
576-650	13	7955	2784	1989	2387	796	7955	60%
770-1050	4	3722	1303	931	1117	372	3722	60%
Total	**162**	**72975**	**28460**	**18792**	**18425**	**7298**	**72975**	**65%**
Curve Number			**98**	**98**	**74**	**70**	**89.1**	**NA**

[2] Refer PNCC District Plan Section 10 (May 2018), Residential Zone - Permitted Activities 10.6.1 (d) ii Site Coverage

Table 5: Fully Developed Catchment Characteristics

Land Use	Area m²	Area ha	CN
Road / footpath	21600	2.160	98.0
Lots	72975	7.298	89.1
Road berms	14025	1.403	74.0
Park / Reserve	13000	1.300	70.0
Flood detention area	7000	0.700	90.0
Total	**128600**	**12.86**	**87.1**

A simplified (lumped) HEC-HMS model for the fully developed catchment is shown in Figure 6.

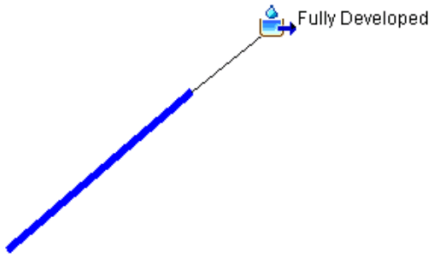


Figure 6: HEC-HMS Fully Developed Model

6 Stormwater Mitigation

6.1 Stormwater Quantity

6.1.1 Flood Scenarios

Runoff from the existing 12.86 ha site currently drains to the remnant Whiskey Creek catchment and downstream to the existing PNCC 900mm diameter stormwater connection adjacent to No. 91 Benmore Avenue. This situation will remain unchanged as a result of the proposed Plan Change. The two flood scenarios for assessment include:

1. Local storm events affecting the Palmerston North stormwater catchment; and
2. Mangaone Stream flooding when the Flygers Line spillway operates and spills water across Rangitikei Line / Flygers Line to Whiskey Creek and the downstream Taonui Basin.

Stormwater mitigation for the two scenarios is outlined in the following sections.

6.1.2 Secondary Flow Paths

The Stormwater Mitigation plan (Appendix C) provides an indicative pipe layout and probable secondary flow paths. It is proposed that any secondary flow would be contained within the roading corridor. The frequency and magnitude of secondary flow would be determined when the stormwater piped network is confirmed during subsequent consenting stages.

6.1.3 Flood Detention Pond

The performance of the proposed flood detention pond has been assessed within 'XPSTORM'. XPSTORM is a comprehensive 1D-2D modelling software package which includes both open channel and closed conduit systems. It is ideal for optimising the design of stormwater piped systems including flood detention storages. The XPSTORM model of the fully developed 'mitigated' catchment is shown in Figure 7.

The flood modelling assumes that all runoff from the development is routed through the pond. The pond is provisionally proposed as 1.5m deep[3], 90m long by 50m wide with minimum 3:1 embankment batters. The total area of the pond (including a 3m wide buffer zone) is estimated to be in the order of 5000m². Further details are included in Table 6. The provisional level-area curve for the pond is plotted in Figure 8 and listed in Table 9 of Appendix C.

[3] Subject to confirmation of local groundwater levels

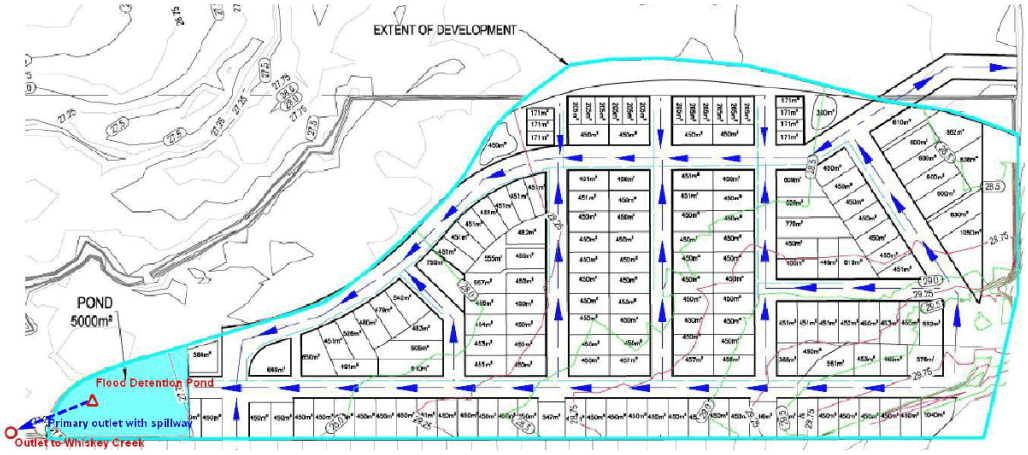


Figure 7: Fully Developed XPSTORM 'Mitigated' catchment model

Table 6: Whiskey Creek Flood Detention Pond (PROVISIONAL)

Variable	Dimension
Pond dimensions	90m long x 50m wide
Pond base level	RL 26.25m
Embankment crest level at outlet	RL 27.75m
Approximate storage volume at spillway crest level	3700m³
Embankment batters	Minimum 3:1
Culvert outlet diameter	300mm
Culvert outlet invert level	RL 26.25m
Culvert outlet invert to convey to Whiskey Creek	RL 26.20m
Whiskey Creek invert level at property boundary (approx. 100m downstream)	RL 25.0m
Spillway (2.5m wide broad-crested weir)	Crest Level 27.25m
	Operates in 50-year ARI and greater events
	Passes the 100-year ARI event at RL 27.45m (0.30m freeboard to embankment crest)
	Passes the 200-year ARI event with 0.23m freeboard to crest level

It is proposed that the outlet would discharge into the reserve and drain via an open channel swale, or similar, over a distance of approximately 100m downstream to the remnant Whiskey Creek channel (approx. invert RL 25.0m) immediately upstream of the south-western property boundary. The PNCC 900mm diameter stormwater connection is a further approximate 110m downstream with its invert at approx. RL 24.2m.

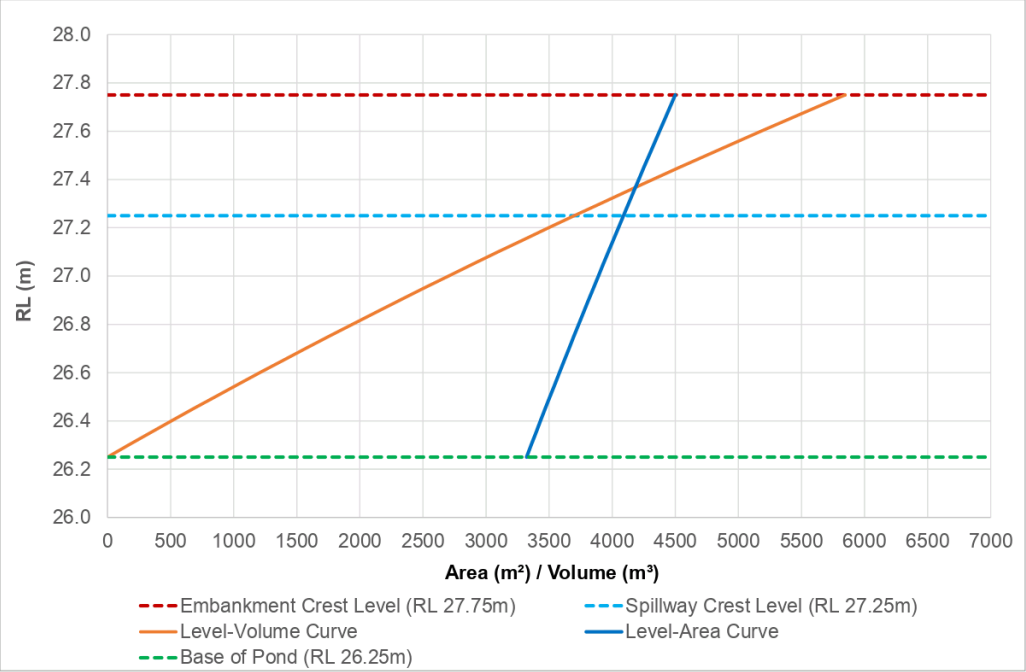


Figure 8: Whiskey Creek Flood Detention Pond – Level-Area-Volume Curve (PROVISIONAL)

Summary model outputs are included in Table 7, which indicate reductions in the peak discharges in all events up to the 100-year ARI event. Spill flow commences in the 50-year ARI event; and the dam does not overtop in the 200-year ARI event. Further refinement of the pond design and performance would be undertaken during the consenting stage. The flood runoff volumes are included in Table 8, which indicates an increased runoff volume of approximately 3400m³ in the 100-year ARI (1% AEP) event.

Flood hydrographs (2-yr ARI to 200-year ARI) are plotted in Figure 9 to Figure 15, and pond levels in Figure 16.

Table 7: XPSTORM Flood Mitigation Model Results

Event (ARI, years)	Peak Flow (m³/s)					Pond Level (RL, m)	Freeboard (m)
	Existing	Fully Developed (Unmitigated)	Pond Outflow				
			Culvert Flow	Spill Flow	Total Outflow		
2	0.15	0.37	0.13	0.00	0.13	26.67	1.08
5	0.24	0.54	0.16	0.00	0.16	26.89	0.86
10	0.31	0.66	0.18	0.00	0.18	27.06	0.69
20	0.39	0.80	0.20	0.00	0.20	27.24	0.51
50	0.51	0.99	0.21	0.19	0.40	27.37	0.38
100	0.61	1.1	0.22	0.38	0.60	27.45	0.30
200	0.71	1.3	0.23	0.61	0.84	27.52	0.23

Table 8: 24-hour Design Flood Runoff Volume

Event (ARI, years)	Runoff Volume (m^3)		
	Existing	Fully Developed (Unmitigated)	Increase
2	2324	4033	1709
5	3663	5848	2185
10	4762	7270	2508
20	5934	8729	2795
50	7646	10793	3147
100	9107	12512	3406
200	10580	14210	3630

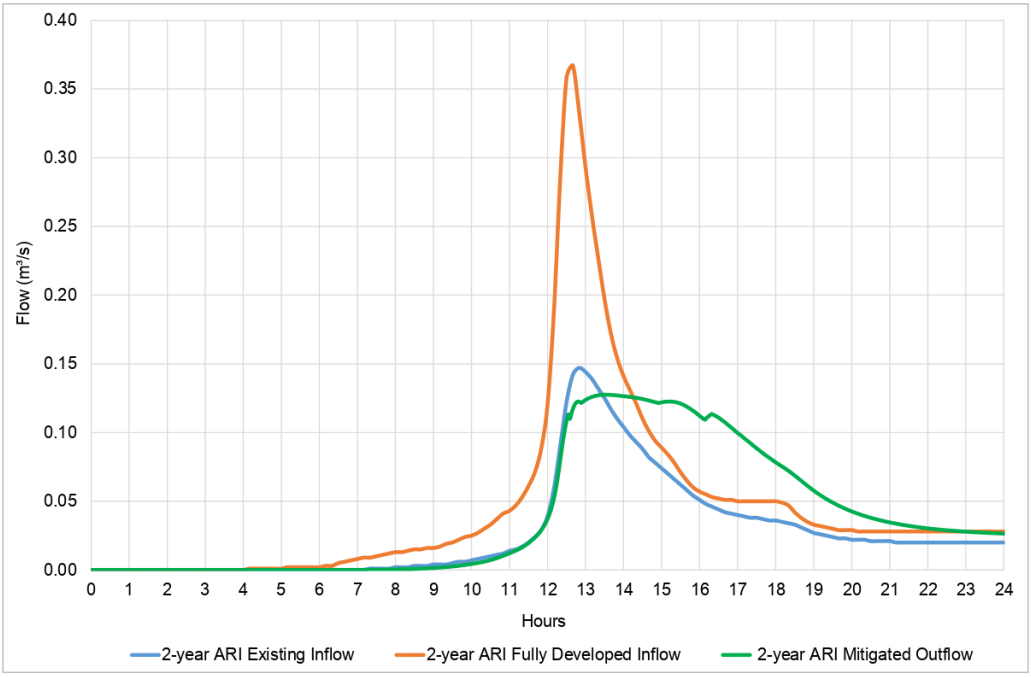


Figure 9: 2-year ARI Peak Discharges

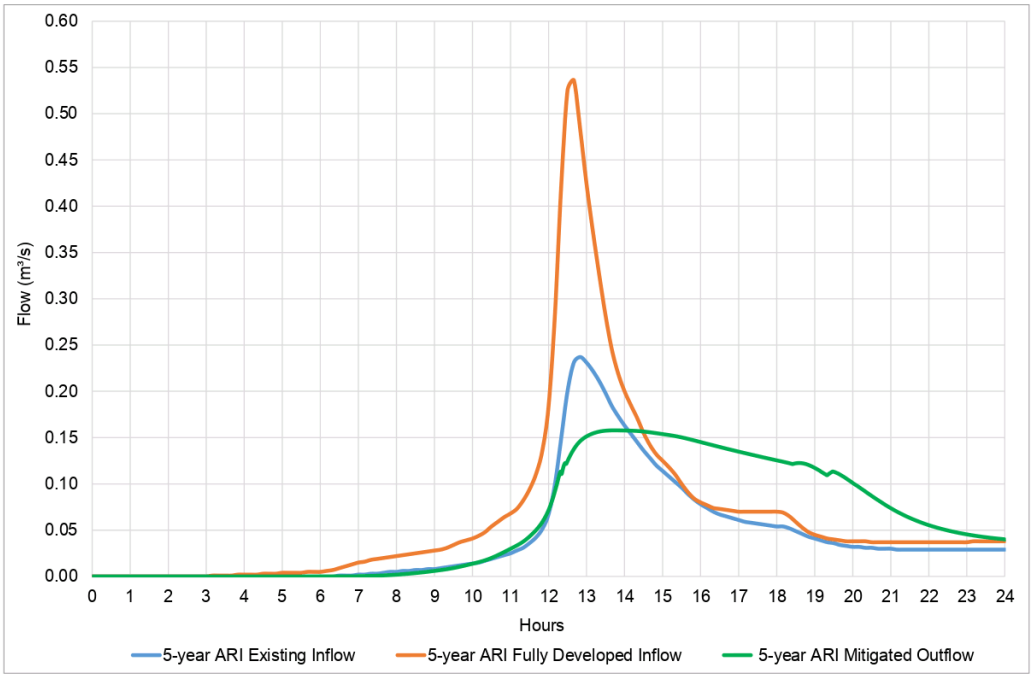


Figure 10: 5-year ARI Peak Discharges

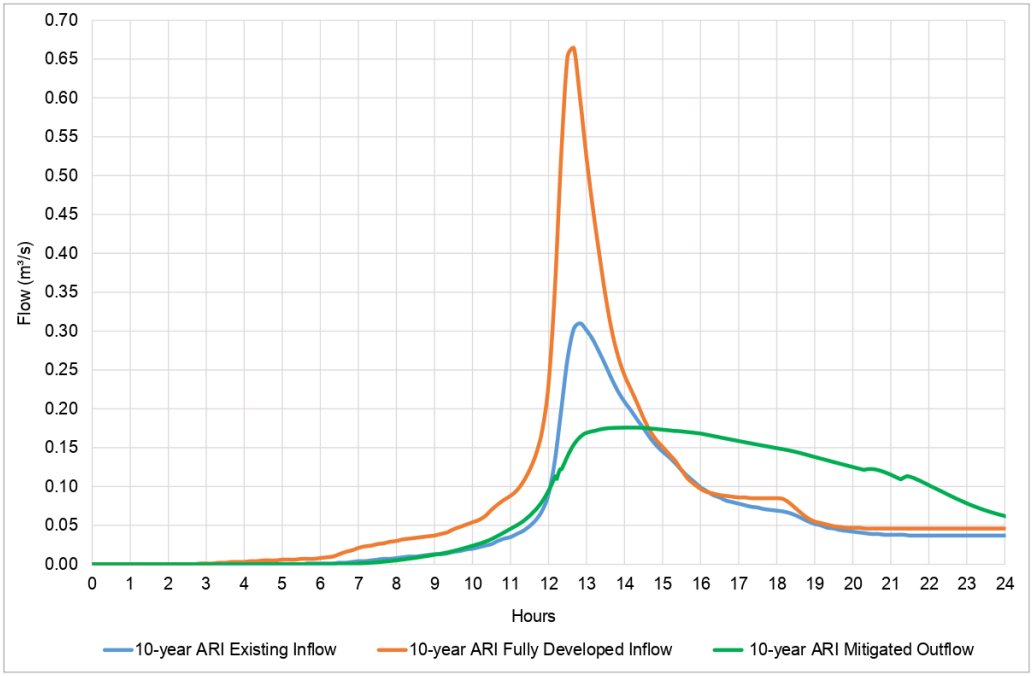


Figure 11: 10-year ARI Peak Discharges

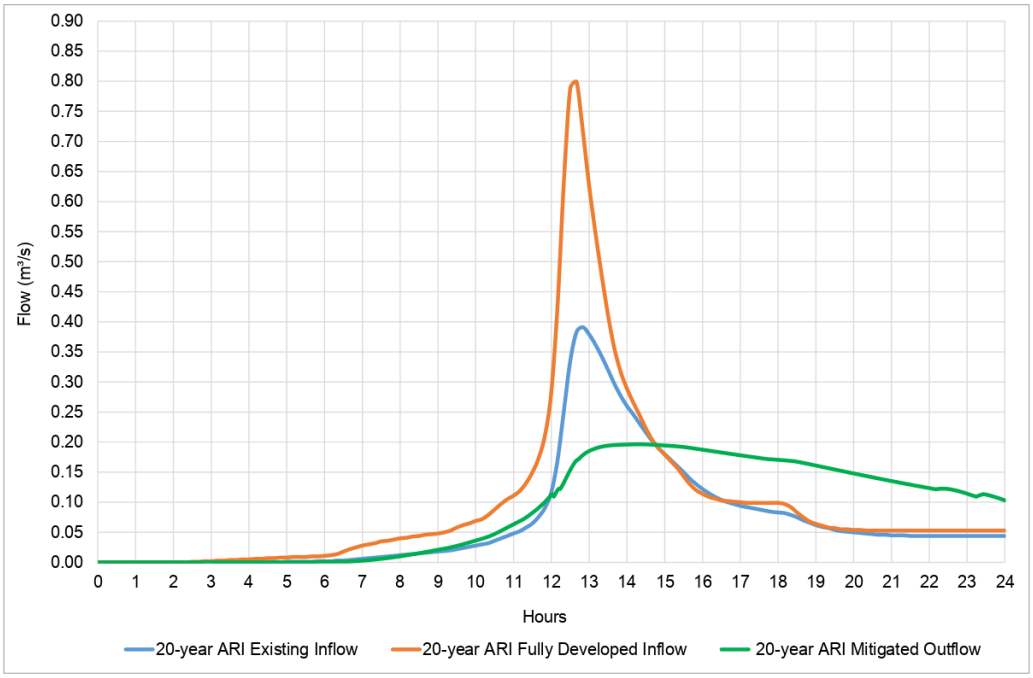


Figure 12: 20-year ARI Peak Discharges

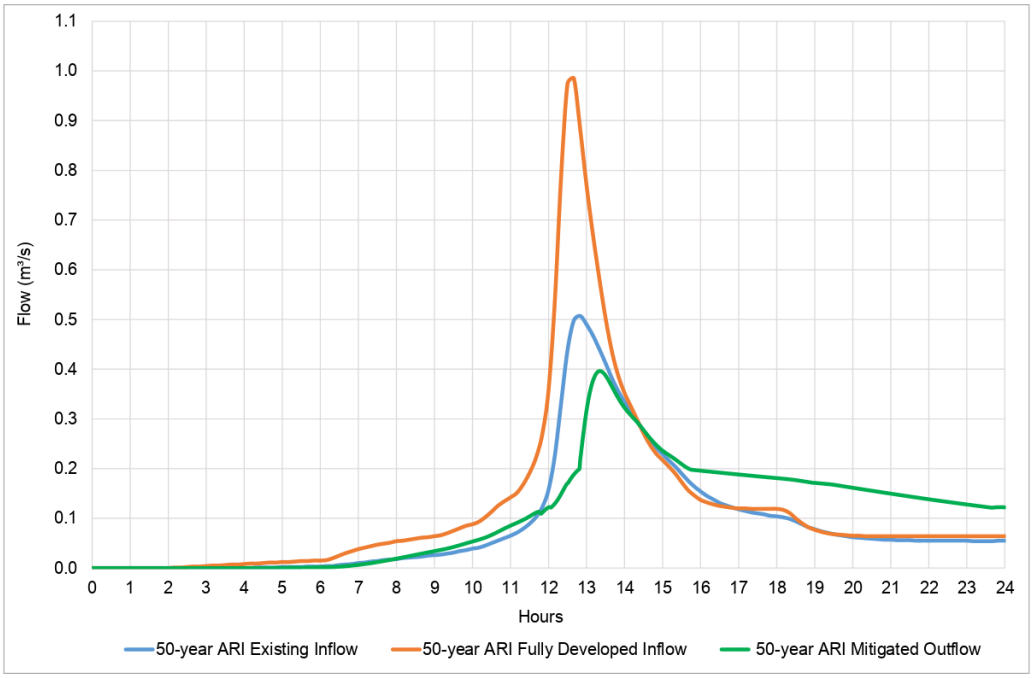


Figure 13: 50-year ARI Peak Discharges

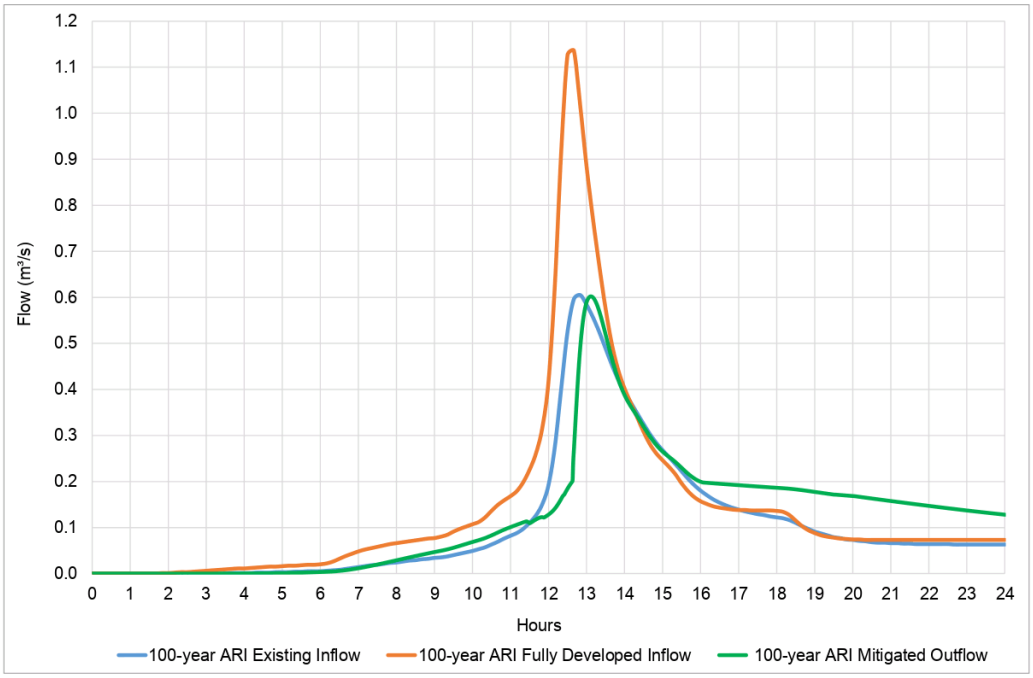


Figure 14: 100-year ARI Peak Discharges

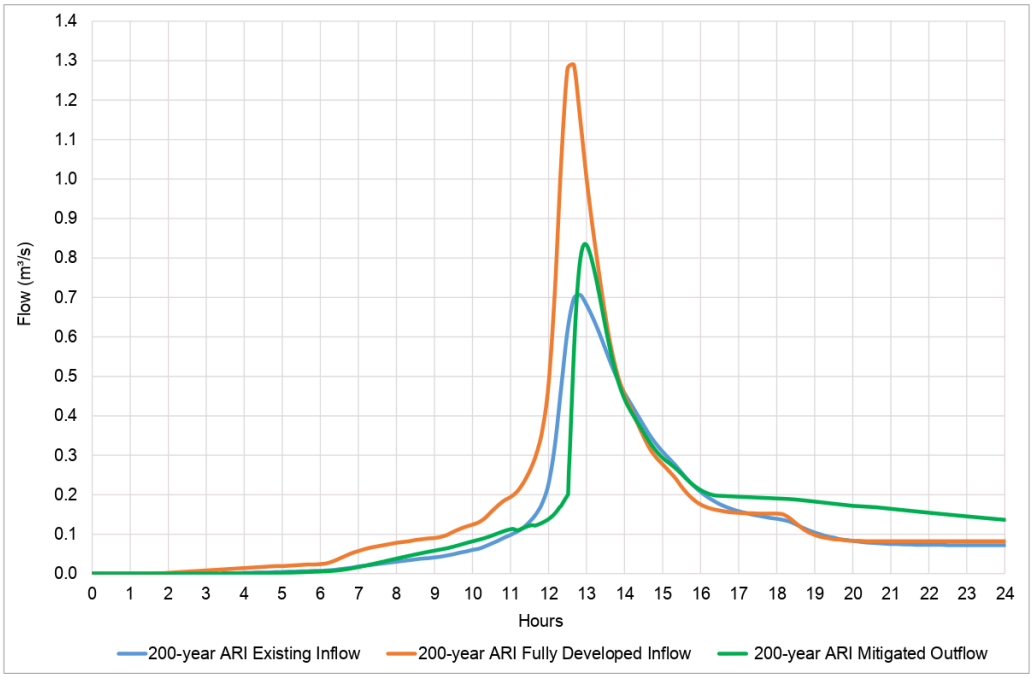


Figure 15: 200-year ARI Peak Discharges

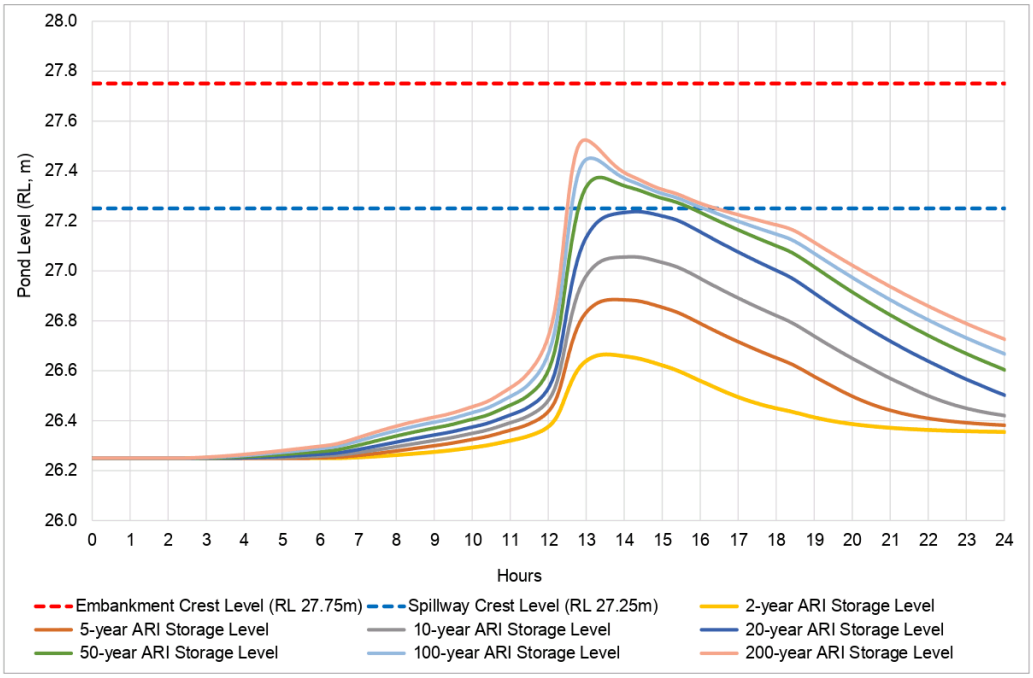


Figure 16: Flood Detention Pond – Design Flood Levels

6.1.4 Other Mitigation Options

Stormwater quantity mitigation options that would reduce the size of the proposed flood detention pond would include source controls, such as reduced imperviousness per lot, roof-water tanks and / or underground detention storages.

The average roof area for the development (refer Table 4) is approximately 176m². Allowing 1800 litres per 100m of roof area indicates a total storage of just over 500m³, which would reduce the required pond storage volume by approximately 14%.

Additional controls to reduce the total imperviousness (currently assessed as an average of 65% per lot) would also have a beneficial effect on reducing the detention pond footprint.

Underground flood detention storages (e.g. Cirtex or similar) could also be considered for discrete residential and / or commercial areas within the development.

These options will be considered in more detail at the subdivision consent stage with a view to introducing stormwater to the reserve at the northern end of the development to enhance stream revitalisation.

6.2 Stormwater Quality

Stormwater quality treatment could be achieved for the development by way of:

- A constructed wetland; or
- Rain gardens in the road berms.

We emphasise that the constructed wetland option is an alternative to, and not in addition to, the rain gardens.

The Structure Plan also identifies an additional location at the intersection of Roads 1 and 4 as back-up area for stormwater detention / treatment i.e. in the event that it is required.

6.2.1 Constructed Wetland

A constructed wetland[4] could be developed downstream of the proposed flood detention pond in the remnant Whiskey Creek channel prior to discharging to the PNCC stormwater connection at Benmore Avenue. The earthworks associated with the wetland would need to be sympathetic to the impact on flood levels in the floodway.

6.2.2 Rain Gardens

Rain gardens / bioretention devices in the road berms could be applied to provide stormwater quality treatment of discrete residential and / or commercial areas or as a catchment-wide solution for the entire development.

These 'source controls' would provide stormwater quality treatment of the runoff from the road and lot paved surface areas prior to discharging to the piped stormwater system. Direct connection of roof water from all lots to the stormwater mains in the road would reduce the size requirements of the rain gardens.

Auckland Council GD01 (2017) provides guidance on the sizing of bioretention devices for water quality 'treatment only'. Applying this standard, the bioretention devices are typically sized at 2% of the impervious paved (road and driveway) catchment area. Individual device locations, size and media layers would be confirmed during the consenting phase when the stormwater network design is known.

6.3 Hydraulic Connectivity

The hydraulic connectivity of the rain gardens with the stormwater network, flood detention pond and possible constructed wetland would be proven during subsequent consenting stages.

[4] Consistent with Wellington Water (2019)

7 Flygers Line Spillway Events

The Mangaone Stream 'Flygers Line' spillway (refer Horizons extract in Appendix D) has been designed to commence operation when flow at the Milson Line flow gauge reaches 124m³/s (4.4m). Horizons has categorised this flow as a 10% AEP (10-year ARI) event.

The spillway was originally (1982) designed to spill up to 68m³/s in the 1% AEP (100-year ARI) event, however, following the significant February 2004 flood event this was revised upwards to 113m³/s.

The spillway has operated four times since it was constructed in 1984/1985 (~35 years):

1. 25 August 1986 (operated prematurely due to lupin growth in the downstream channel artificially raising water levels at the weir);
2. 24 July 1988;
3. 16 February 2004; and
4. 20-21 June 2015.

Discounting the August 1986 event, the spillway would normally have operated three times in approximately 35 years i.e. slightly less frequently than the intended '1 in 10 year' design criteria.

To consider the relative timing of the Mangaone Stream at Milson Line (Site 32557, 154 km²) catchment and Flygers Line spillway operation i.e. relative to the much smaller Plan Change catchment (0.13 km²), we have assessed the most recent i.e. February 2004 and June 2015 spillway events. Rainfall and flow data are provided by Horizons.

7.1 16 February 2004 Flood

The 16 February 2004 flood event (Figure 17) was a long-duration storm in the Mangaone Stream catchment. Approximately 20mm of (antecedent) rainfall fell between late afternoon on 11 February and the morning of 14 February. The most intense rainfall commenced around 9.00pm on 14 February; and ended shortly after 3.30am on 16 February. A total of approximately 135mm of rainfall was recorded at the Valley Road gauge over the approximate 31-hour storm duration.

While the magnitude of rainfall varies between the Valley Road and Milson Line rain gauges, the temporal pattern appears to be very similar.

The Mangaone Stream started to rise from a low flow of approximately 0.5m³/s at 11am on 15 February; and peaked nearly 20 hours later at around 190m³/s just prior to 7am on 16 February.

The data indicate that the Flygers Line spillway would have operated over an approximate 10-hour period i.e. commencing around 2.45am on 16 February (flow exceeded 124m³/s at the Milson Line gauge) and ceasing about 1pm later that day (flow reduced below 100m³/s).

The total spilled volume during this approximate 1% AEP flood event is estimated at approximately 1.5 Mm³ i.e. assuming that the spillway commenced spilling at 124m³/s (at the Milson Line gauge), the downstream Mangaone Stream channel passed

approximately 140m³/s at the peak (as noted in Appendix D), and the spillway ceased to spill at approximately 100m³/s (at the Milson Line gauge).

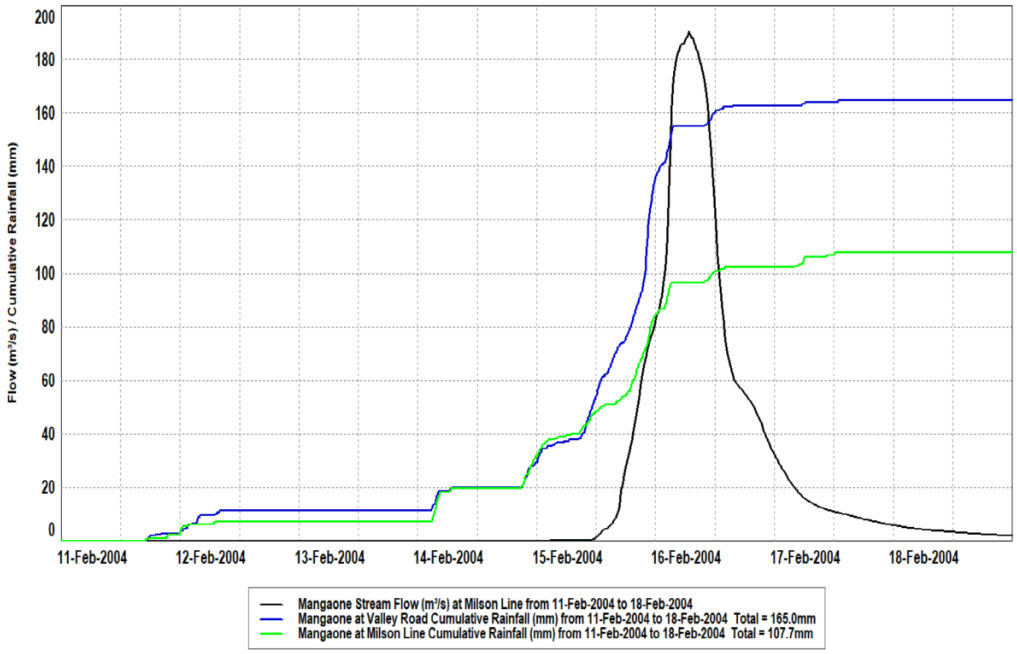


Figure 17: Mangaone Stream Flood (16 February 2004)

7.2 20-21 June 2015 Flood

The 20-21 June 2015 flood event (Figure 18) was also a long-duration storm in the Mangaone Stream catchment. The rainfall event commenced shortly before 9.00am on 19 June and ended shortly before midnight on 20 June. A total of approximately 138mm of rainfall was recorded at the Valley Road gauge over the approximate 39-hour storm duration.

The Mangaone Stream started to rise from a low flow of approximately 0.5m³/s around 11am on 19 June; with an initial peak of approximately 152.8m³/s occurring at 2.45pm on 20 June (approx. 28 hours later), and a subsequent, slightly greater peak of 153.4m³/s occurring at 2.45am on 21 June i.e. some 40 hours after the storm commenced.

The data indicate that the Flygers Line spillway would have operated over an approximate 20-hour period i.e. commencing around 11am on 20 June (flow exceeded 124m³/s at the Milson Line gauge) and ceasing about 7am on 21 June (flow reduced below 100m³/s).

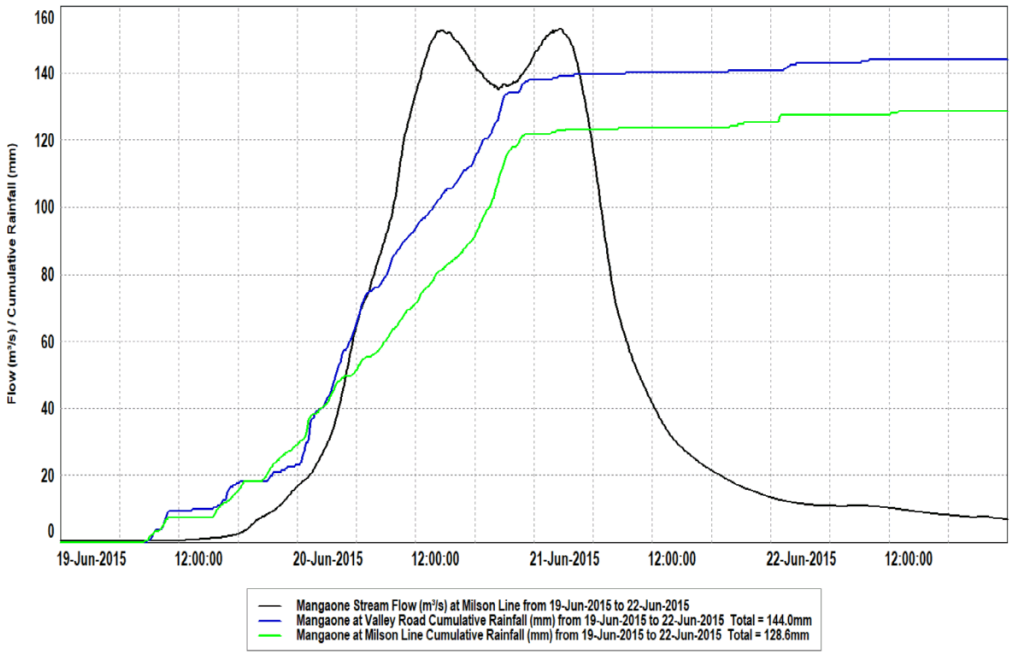


Figure 18: Mangaone Stream Flood (20-21 June 2015)

7.3 Design Considerations

The above data confirm that:

- The Flygers Line spillway has:
  - A 10% probability of operating every year; and has
  - Operated three times over the last 35 years.
- There are no major differences in the timing of rainfall as observed in the upper Mangaone catchment (at Valley Road) and in the lower Palmerston North city catchment (at Milson Line).
- During a 10% AEP (or lesser probability) flood event the:
  - Mangaone Stream catchment[5] (154 km²) has a time of concentration in the order of 30-40 hours.
  - Much smaller fully developed Plan Change catchment (0.13 km²) has a time of concentration of approximately 33 minutes.
- The total increased runoff volume in the 1% AEP event (as a result of the proposed Plan Change) of approximately 3400m³ (refer Table 8) is in the order of 0.2% of the total spilled volume down the Flygers Line spillway (1.5 Mm³) during the February 2004 event.
- The mitigated peak outflows from the proposed Flygers flood detention pond

[5] Measured at Milson Line (Site 32557)

would be very unlikely to coincide with the peak discharge from the Flygers Line spillway.

- The design of the proposed flood detention pond should consider the probable tailwater effect of flood levels in Whiskey Creek during Flygers Line (10% AEP and lesser probability) spillway events.

8 Conclusions

We conclude that:

1. The relatively small 0.13 km² fully developed catchment:
    a. Is likely to be ephemeral and would not provide a permanent flow.
    b. Would provide intermittent, limited duration, discharges during most rainfall events.
2. Stormwater effects as a result of the proposed 12.86 ha, mainly residential, development could be mitigated as follows:
    a. Stormwater Quantity:
        i. An approximate 1.5m deep, 90m long by 50m wide flood detention pond with 3:1 battered slopes, with a 300mm diameter primary outlet providing approximately 3700m³ of storage at the spillway crest level;
        ii. Source controls including roof-water tanks, underground storages and / or reduced imperviousness to reduce the size of the flood detention pond.
    b. Stormwater Quality:
        i. A constructed wetland downstream of the flood detention pond in the remnant Whiskey Creek channel; or
        ii. Rain gardens in the road berms.
3. The proposed flood detention pond provides hydraulic neutrality with reductions in the peak discharges (relative to the existing) in all events up to the 100-year ARI (1% AEP) event.
4. The Flygers Line spillway has:
    a. A 10% probability of operating every year; and has
    b. Operated three times over the last 35 years.
5. During a 10% AEP (or lesser probability) flood event the:
    a. Mangaone Stream catchment[6] (154 km²) has a time of concentration in the order of 30-40 hours.
    b. Much smaller, fully developed Whiskey Creek Plan Change catchment (0.13 km²) has a time of concentration of approximately 30-40 minutes.

[6] Measured at Milson Line (Site 32557)

6. The mitigated peak outflows from the proposed flood detention pond would be unlikely to coincide with the peak discharge from the Flygers Line spillway to the Taonui Basin.
7. The increased runoff volume in the 1% AEP event as a result of the Plan Change is also minimal i.e. in the order of 0.2% of the total spilled volume down the Flygers Line spillway during the February 2004 (approx. 1% AEP) event.
8. The design of the proposed flood detention pond should consider the probable tailwater effect of flood levels in Whiskey Creek during Flygers Line (10% AEP and lesser probability) spillway events.
9. Further refinement of the stormwater network including the rain gardens, flow conveyance, secondary flow paths, flood detention pond and possible constructed wetland is recommended during subsequent consenting stages.

9 Limitation

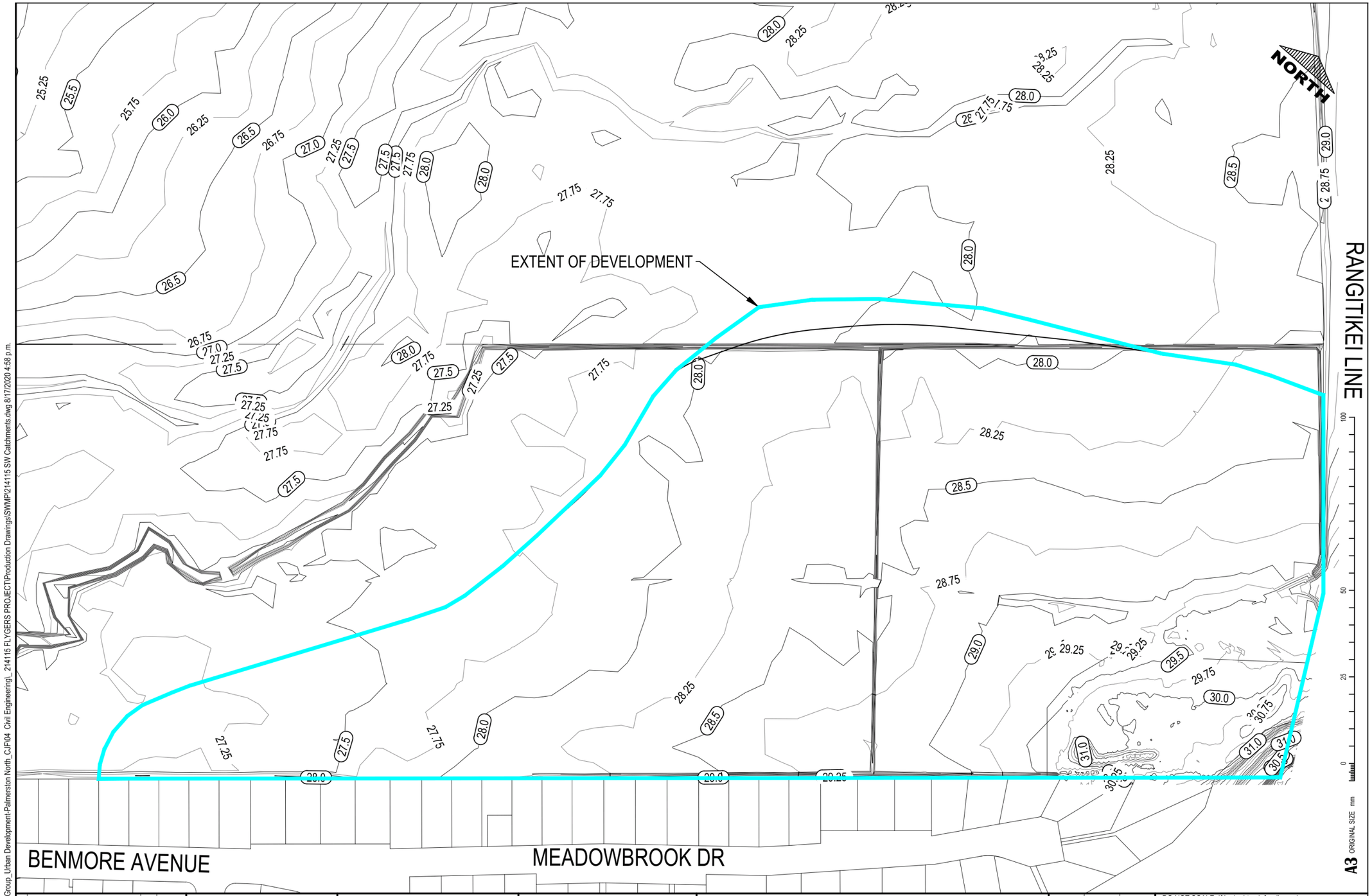
This report has been prepared solely for the benefit of Flygers Investment Group Limited as our client with respect to the brief. The reliance by other parties on the information or opinions contained in this report shall, without our prior review and agreement in writing, be at such parties' sole risk.

The opinions, conclusions and recommendations in this report are based on our interpretation of the available data. Should further information become available then these should be reviewed.

10 References

ARC TP108, 1999	'Guidelines for stormwater runoff modelling in the Auckland Region, Technical Publication 108. Prepared for Auckland Regional Council by Beca Carter Hollings and Ferner Limited, April 1999.'
Auckland Council (GD01), 2017	'Stormwater Management Devices in the Auckland Region, Guideline Document 2017/001 Version 1, December 2017.'
Wellington Water, 2019	'Water Sensitive Design for Stormwater: Treatment Device Design Guideline, Wellington Water, Version 1.1, December 2019.'

Appendix A Existing Layout



J:\2020\214214115 Higgins Group_Urban Development-Palmerston North_CJF04 Civil Engineering_ 214115 FLYGERS PROJECT\Production Drawings\SWMP\214115 SW Catchments.dwg 8/17/2020 4:58 p.m.

Rev	Details	Drawn	Date
1	ISSUED FOR DISCUSSION		17/08/20

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STORMWATER CATCHMENTS
RANGITIKEI LINE - FLYGERS LINE
PALMERSTON NORTH
EXISTING CONTOURS

HIGGINS GROUP

	Initials	Date
Surveyed	RSJP	04/19
Designed	KBJ	08/20
Drawn	JGR	08/20
Checked		
Approved		

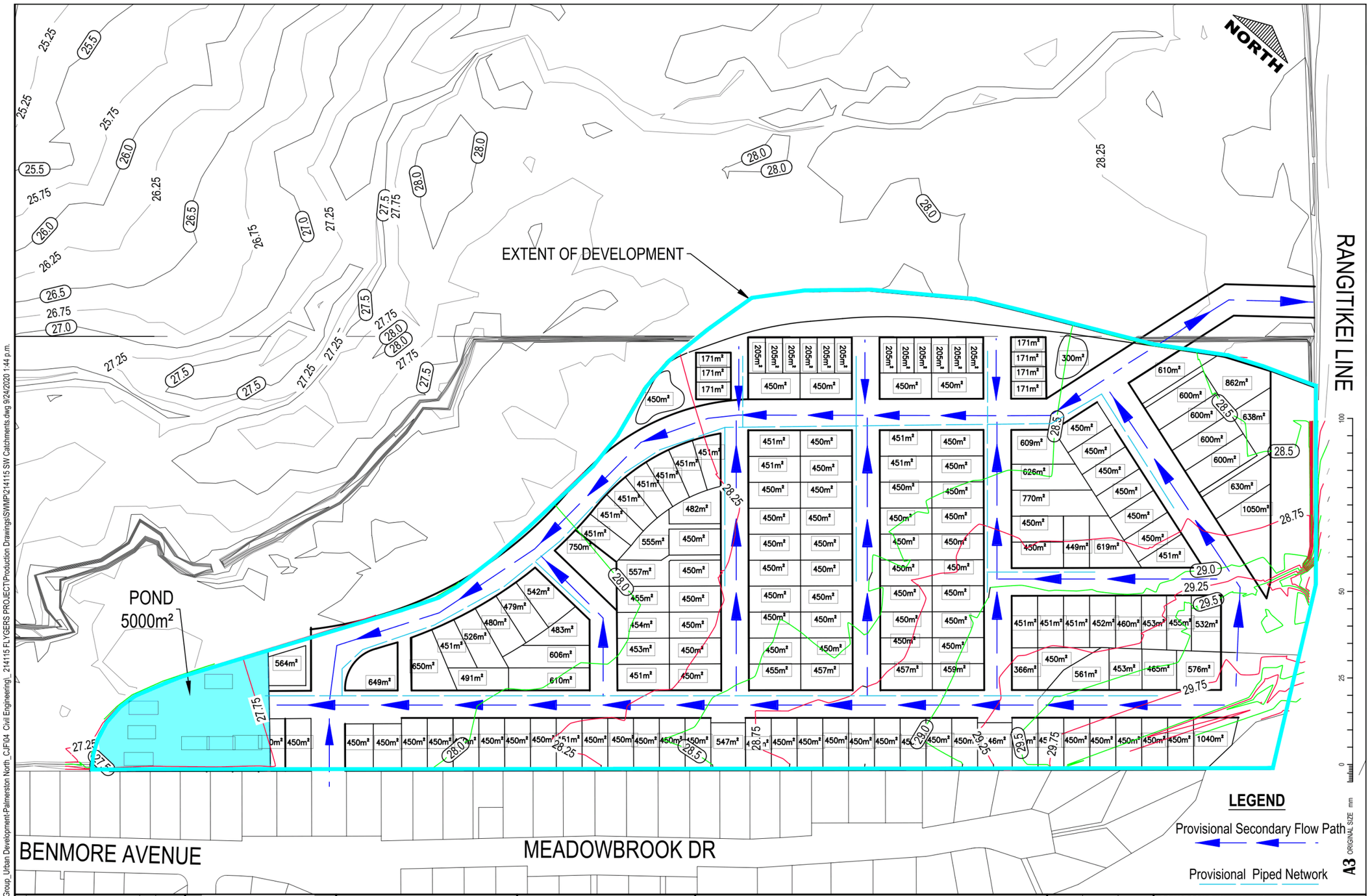
DO NOT SCALE, If in doubt ask for dimensions

Scales A3	Job No.
1:2000	214115

CAD Path/File	Sheet	of	Sheets	Rev.
214115 SW Catchments	1	2		1

A3 ORIGINAL SIZE mm

Appendix B Fully Developed Layout



Rev	Details	Drawn	Date
1	ISSUED FOR DISCUSSION		24/9/20

Mitch Hydro

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STORMWATER CATCHMENTS
RANGITIKEI LINE - FLYGERS LINE
PALMERSTON NORTH
STORMWATER MITIGATION

HIGGINS GROUP

	Initials	Date
Surveyed	RSJP	04/19
Designed	KBJ	08/20
Drawn	JGR	08/20
Checked		
Approved		

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Scales A3: 1:2000

Job No.: 214115

CAD Path/File: 214115 SW Catchments

Sheet 2 of 2 Sheets

Rev. 1

Appendix C Stormwater Mitigation

Table 9: Flood Detention Pond Level-Area-Volume Curve (PROVISIONAL)

RL	Length (m)	Width (m)	Area (m²)	Volume (m³)	Comment
26.25	81.00	41.00	3321	0	Pond base
26.30	81.30	41.30	3358	167	
26.35	81.60	41.60	3395	336	
26.40	81.90	41.90	3432	506	
26.45	82.20	42.20	3469	679	
26.50	82.50	42.50	3506	853	
26.55	82.80	42.80	3544	1030	
26.60	83.10	43.10	3582	1208	
26.65	83.40	43.40	3620	1388	
26.70	83.70	43.70	3658	1570	
26.75	84.00	44.00	3696	1754	
26.80	84.30	44.30	3734	1939	
26.85	84.60	44.60	3773	2127	
26.90	84.90	44.90	3812	2317	
26.95	85.20	45.20	3851	2508	
27.00	85.50	45.50	3890	2702	
27.05	85.80	45.80	3930	2897	
27.10	86.10	46.10	3969	3095	
27.15	86.40	46.40	4009	3294	
27.20	86.70	46.70	4049	3496	
27.25	87.00	47.00	4089	3699	Spillway Crest
27.30	87.30	47.30	4129	3904	
27.35	87.60	47.60	4170	4112	
27.40	87.90	47.90	4210	4321	
27.45	88.20	48.20	4251	4533	
27.50	88.50	48.50	4292	4747	
27.55	88.80	48.80	4333	4962	
27.60	89.10	49.10	4375	5180	
27.65	89.40	49.40	4416	5400	
27.70	89.70	49.70	4458	5622	
27.75	90.00	50.00	4500	5846	Embankment Crest

Appendix D Flygers Line Spillway (Horizons)

The Mangaone Stream has a 180 square kilometre catchment, originating in hill country to the north east of Palmerston North. The 10 kilometre reach at the downstream end is located within Palmerston North. This reach is stop banked, with extensive development on the protected area.

Even although the Mangaone stream is much smaller than the Manawatu River, damage costs resulting from a stopbank breach would be large. The LMS Special Project report shows a map (Figure 5) of three flooding scenarios. The scenarios correspond to three compartments, separated by the stream stopbanks and by the railway embankment. It is unlikely that all three compartments would flood in the same event, because three independent failures would be needed for that. The compartment with the highest potential damage cost is to the north of the railway embankment, and includes the Bennett Street industrial area. In 1994 the damage costs were estimated at $62 million. That is direct damage costs only, and does not include indirect and intangible damages.

The capacity of the Palmerston North reach of the Mangaone Stream is very limited, even though it is stopbanked. The largest flood that can be conveyed is much smaller than the 1% AEP, let alone the 0.2% AEP. The proximity of development means that the cost of upgrading to either of these standards would be prohibitive. Up to 13 bridges would have to be raised and lengthened, and stopbanks would have to be set back, necessitating the purchase of many houses and industrial buildings adjacent to the stopbank.

However the Mangaone stopbanks at Palmerston North are probably the most secure stopbanks in the Lower Manawatu Scheme, with an annual probability of failure less than for any other LMS stopbanks. This is despite the limited channel capacity. It is because two spillways are incorporated into the Mangaone stopbanks upstream of Palmerston North. During major floods they spill enough water to ensure that the stopbanks protecting the city are never overtaxed.

1.1.1 The spillways

The spillway referred to as the "Roberts Line spillway" is located on the Derby Creek stopbank, which is a return bank from the Mangaone. It is a simple spillway, formed by a 250 metre length of stopbank that is lower than adjacent stopbanks. It operates during any flood that exceeds 140 cumecs at Milson Line. This is a 7% AEP (15 year) flood.

The spilled water flows approximately towards the south west. For the first 2.5 kilometres it flows parallel to the Mangaone Stream, and only a short distance away. The Mangaone Stream then turns left towards the airport, but the overland flow path continues straight ahead, eventually reaching the Taonui Basin pond. On the way it is joined by water from the Flygers Line spillway.

The right stopbank downstream of the spillway is not up to the height needed to contain a 1% AEP flood, although it would probably have a reasonable chance of containing a 2% AEP. There is no proposal to upgrade this stopbank, because any overtopping or breach water is not expected to do much damage. It would travel only a very short distance before joining the main overland flow from the spillway.

The Flygers Line spillway is located 250 metres upstream of Flygers Line. It is a few hundred metres to the south west of the western end of the airport runway, and is the

zig-zag shaped feature that can be seen from the air when taking off towards or approaching from the west. It was constructed during the summer of 1984 – 85.

It is not a simple spillway, it is a flow regulating structure. Compared to a simple spillway, the structure will release water less often, and in any flood smaller than the 1% AEP flood it will release a smaller quantity of water. It commences operation when the Milson Line flow reaches 124 cumecs, which is a 10% AEP (10 year) flood. This corresponds to 4.4 metres at the Milson Line recorder. The 1% AEP was taken (conservatively) as 192 cumecs, which means that 68 cumecs had to be spilled in the design event.

The spillway consists of a concrete sill 262 metres long, and zig-zag shaped in plan view (to minimize land occupied by overflows). Figure 10.3.1 below shows the spillway viewed from the downstream end. It carries 45 horizontally hinged gates of varying length, and 320 millimetres high. They are shaped so that rising water holds the gate shut by acting as a counterweight until it reaches the top of the gate, when the horizontal water pressure exerted on the vertical section of the gate becomes sufficient to tip it over. The design is found on Drawing 2496, Sheets 1 to 10.

Figure 10.3.1 Flygers Line spillway from downstream end



The intentions of the 1982 design were twofold:

- The structure should spill nothing for all flows less than 124 cumecs at Milson Line, and it should spill all water in excess of the 124 cumecs. i.e. upstream of the spillway, the flow can increase to more than 124 cumecs. Downstream, the flow can increase up to 124 cumecs, but must not increase thereafter; and

- The spillway should operate no more often than necessary. Without the gates mounted on the concrete sill, spilling would occur as soon as the stream flow exceeded 100 cumecs. The purpose of the horizontally hinged gates was to contain the water until the 124 cumec flow is exceeded.

Without the gates, overflows would occur three times as often as is actually the case. For every flood that exceeds 124 cumecs, there are two floods between 100 and 124 cumecs. Those two floods rise above the concrete sill, but do not release water because they do not rise high enough to tip gates.

Figures 10.3.2 and 10.3.3 below show how the gate action works. The flow increases until the water level rises to the top of some of the gates. The first gate tips, and as stream flow increases more gates tip one at a time until the flood peak is reached, after which no more gates tip. As the stream flow reduces, the flow over the spillway reduces and finally stops. The gates can then be stood up again, which has to be done manually. There is no machinery that does this. However the gates are light enough that one person can do the job manually.

Figure 10.3.1 Schematic cross section showing Flygers spillway gate operation

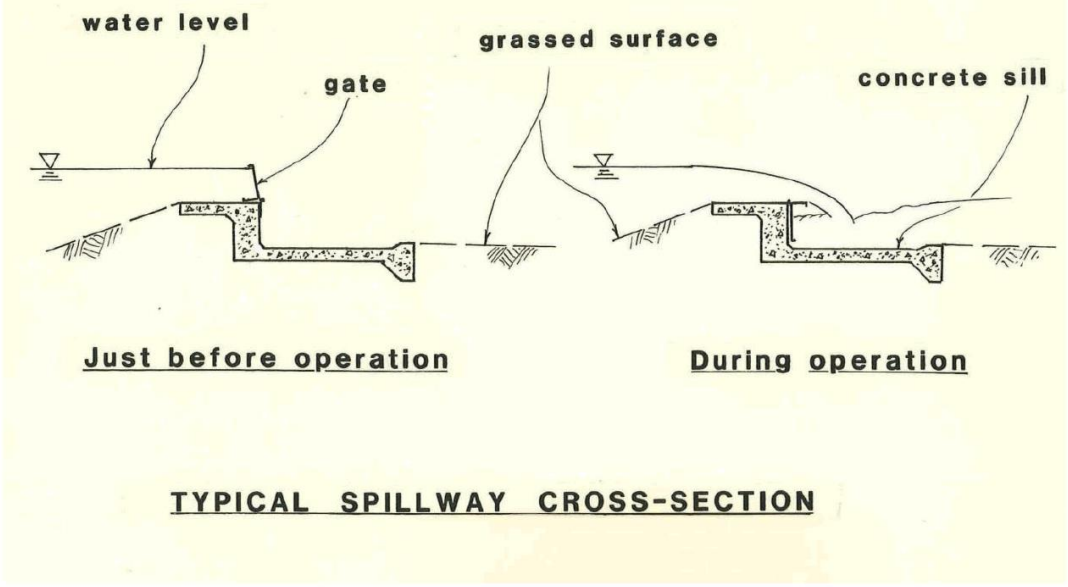
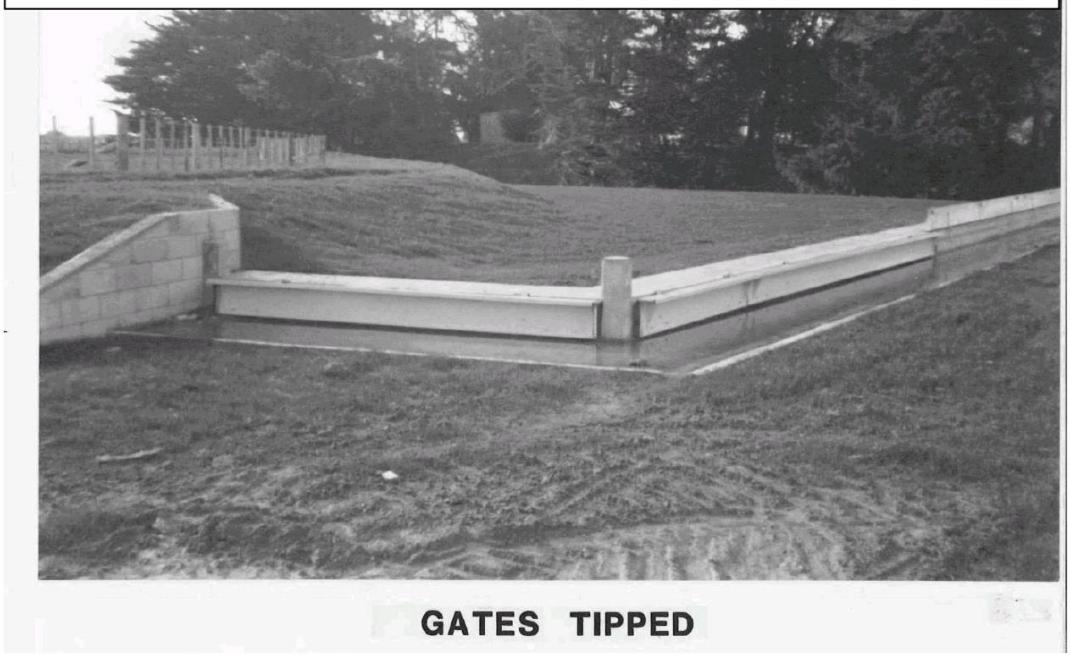


Figure 10.3.3 Flygers spillway gates – Upstream gates open, others closed



The original design flow over the spillway was 68 cumecs, but after February 2004 that had to be revised up to 113 cumecs. As discussed in section 4.5, the flow of a 0.2% AEP flood is larger than the 1% AEP at Bunnythorpe, but is exactly the same at Milson Line, because the right stopbanks near Roberts Line are certain to fail and

release the extra water, so the 113 cumec spillway flow applies to any flood larger than a 1% AEP.

After the spillway flow exceeds 68 cumecs, the flow in the channel through the city will increase a little, up to about 133 cumecs. The new design flood level at the spillway will then be 100 millimetres higher than the old level. Fortunately the elevated water level does not persist very far downstream, because the channel roughness is less than assumed in the 1982 design. The 1982 roughness was based on flood levels from several floods in the years before 1982. Maintenance in recent years has been to a standard higher than that of 1982.

1.1.2 Performance of the Flygers Line Spillway and Mangaone Stream in the February 2004 flood

Flows over the spillway were partially obstructed by a maize crop planted in the floodway immediately downstream of the structure. The crop had been permitted on the basis that in over thirty years of record no significant flood had ever occurred during the months December to May inclusive. Clearly floods may be less likely at some times than others, but they are never impossible, and it is now clear that no crops should be permitted where they can obstruct outflows from the Flygers Line Spillway.

At the peak of the February 2004 flood, the channel through the city probably carried close to 140 cumecs. However, because of the good maintenance and hence low roughness, there was plenty of freeboard. Even with the extra flow, the water level was lower than the design level everywhere between the Rangitikei Line Bridge and the Pioneer Highway Bridge. The smallest observed freeboard was 290 millimetres, on the right bank just upstream of the Flygers Line Bridge.

1.1.3 The Mangaone Floodway

When the water leaves the structure, the spread of floodwaters is limited to a physically defined floodway for the first 800 metres. See Drawing 2496 Sheet 1. This was a condition of the water right obtained for the works under the 1968 Act. On the left bank this is achieved with a stopbank. On the right bank it is achieved partly by stopbanking and partly by the high ground of Whiskey Creek's natural levee.

The land protected by the right stopbank is agricultural land, much of which is floodable when the Roberts Line spillway operates. Thus this stopbank is only useful for the few flood that are larger than a 10% AEP but smaller than a 7% AEP. The downstream end of this stopbank was left low so that it did not excessively impede overland flows from the Roberts Line spillway.

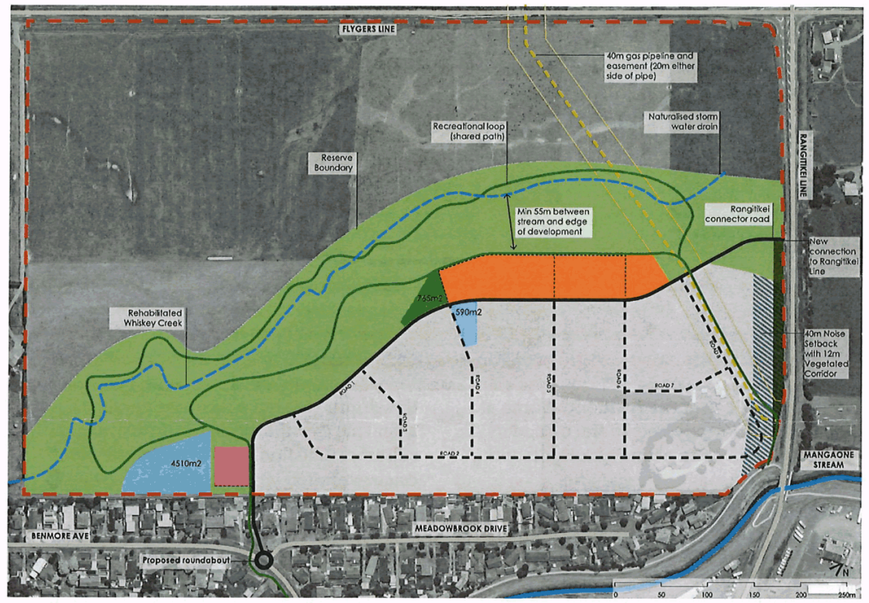
The left floodway stopbank protects two houses. During the February 2004 flood the stopbank experienced a little overtopping, although there was no significant damage. This stopbank is programmed for upgrading.

There are two fences crossing the floodway. The first is 50–100 metres from the structure. It is designed so that the wires can be quickly and easily detached from the posts, and lifted and fastened above the flow. The next fence is about 300 metres downstream in the floodway. It is a boundary fence, and the landowners wanted a fence more robust than the detachable wire system. Each time the spillway operated, the boundary fence collected debris, part of the fence was pushed over by the force of the flowing water, and was reinstated after the flood.

1.1.4 Spillway operations

The spillway has operated three times, on 25 August 1986, 24 July 1988 and 16 February 2004. The 1986 flow should not have been sufficient to trigger spillway operation, but a lupin infestation had developed adjacent to the stream a few hundred metres downstream of the Flygers Line Bridge. The water level in the stream was elevated by over a metre at the upstream end of the lupin, and the backwater effect was still present at the spillway 500 to 600 metres upstream, enough to operate the gates.

The lupin remained undetected until too late, because it was located downstream of a bend, and was not visible from the road. The land was purchased by the Manawatu Catchment Board, and has been kept clear of lupin since then.



The Proposal

A team of urban design experts, landscape architects, engineers and planners has been commissioned to prepare a development concept for the land. The concept is shown on the draft Structure Plan above.

The key features of the design concept are:

- The ability to provide for approximately 160 dwellings with sections likely to average around 450 m2.
- Connection to Benmore Avenue at the existing Meadowbrook Drive intersection with a roundabout.
- A road connection to Rangitikei Line which will be restricted to left in left out movements.
- The development of a new public open space and reserve along the edge of the development based on rehabilitation of the ephemeral Whisky Creek tributary.
- A location for comprehensive medium density development on the reserve edge for about 20 dwellings.
- A location for a small neighbourhood centre accessible to the existing residential area.
- An integrated stormwater system to minimise any effects on the existing City stormwater system.
- Incorporation of the existing high pressure gas pipeline into road reserve.
- A 40 m building set back from Rangitikei Line.

Have your say

Consultation

The team is embarking on public consultation before preparing a Proposed District Plan Change to provide for the development which will include the Structure Plan. The Plan policies and rules for the development will be incorporated into Chapter 7A of the District Plan which deals with Greenfield Residential Areas.

Technical studies have been completed on hydraulic modelling, geotechnical conditions, liquefaction risk, risk of contaminated land soil capability, traffic effects, noise assessment and stormwater management.

A cultural impact assessment has also been prepared by Rangitane o Manawatu.

These reports have all guided the development of the design concept.

Feedback

Feedback on this concept is welcomed. This can be sent to **Rachel Findon at Resonant Ltd, PO Box 600, Palmerston North** or sent by e.mail to **RachelF@resonant.co.nz** The closing date for feedback is Friday 26th February.

Drop In Sessions

The team will also be available to discuss the development at two drop in sessions which will be held in the Cloverlea School Hall.

These will be from 6.00pm to 9.00 pm on Friday 19th February and 10.00 am to 1.00 pm on Saturday 20th February.

Where To From Here

Your feedback will be considered alongside other targeted consultation and the plan change request will then be prepared. The Council will then consider whether to accept the plan change request and it will then be publicly notified for submissions. These will be considered at a hearing and a decision made. This process is expected to take up to 12 months. In the meantime if there is general support for the proposal a consent for the earthworks may be advanced ahead of the plan change in order enable faster progress.



Feedback Form

Name

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Address

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Contact email / phone number

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Comments

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Hand in at a drop In session or mail to:

Rachel Findon at Resonant Ltd, PO Box 600, Palmerston North

Whiskey Creek

RESIDENTIAL AREA

PROPOSED PLAN CHANGE PUBLIC CONSULTATION
NEW RESIDENTIAL SUBDIVISION PROPOSED FOR CLOVERLEA

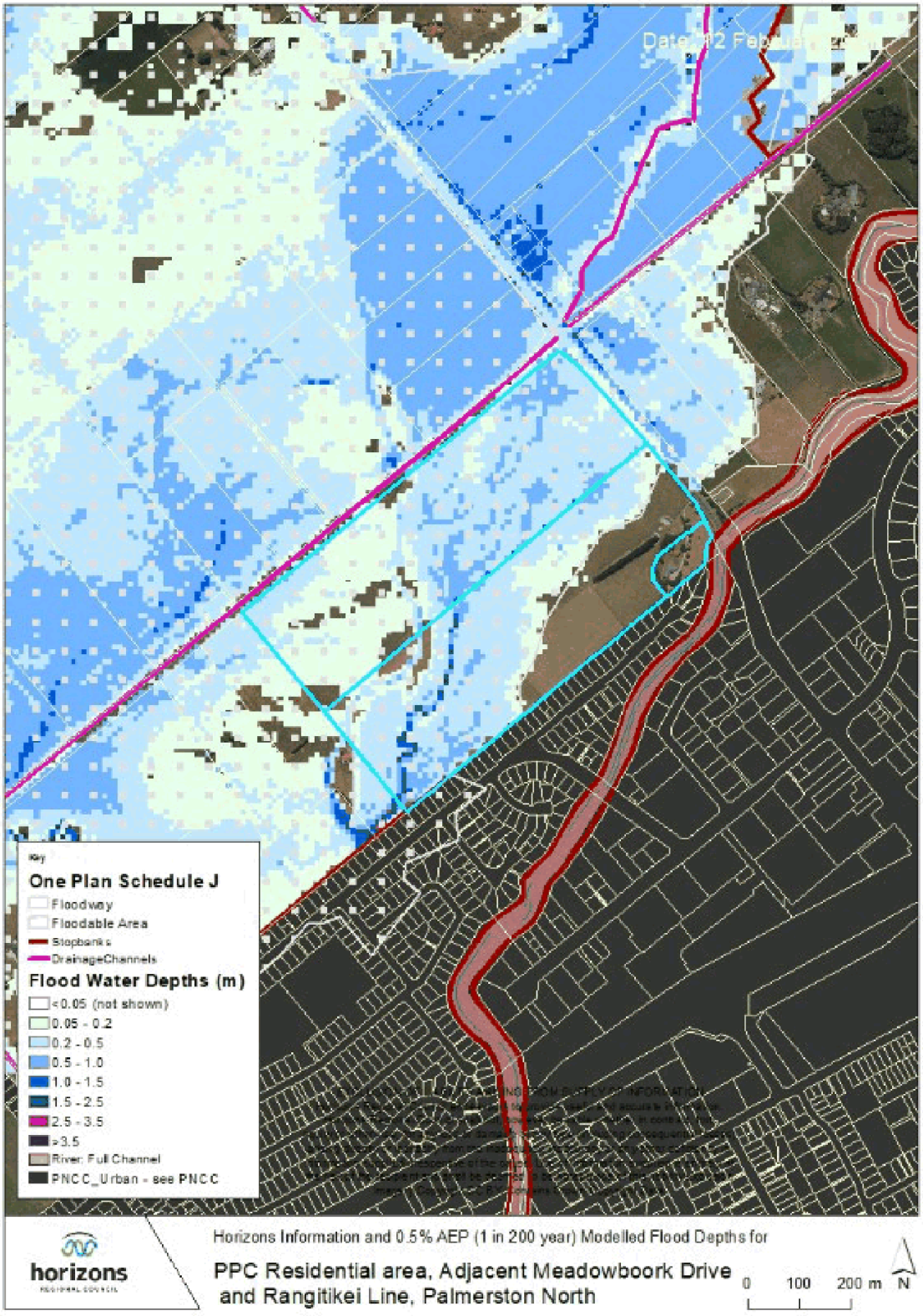
The existing edge of the residential area at Cloverlea has largely been determined by the land that is flood prone as a result of the Manawatu Drainage Scheme and particularly the Flygers Line Floodway.

There are, however, some areas that are not flood prone and one of these is an area of rural land adjacent Meadowbrook Drive and Rangitikei Line. The site is currently identified as a future growth area in the current City Development Strategy.

The owners of that land, along with other development partners, have investigated whether that area can be increased by way of earthworks to achieve a feasible development area without adversely affecting the operation of the drainage scheme. The floodway is required about once every ten years and involves water crossing Rangitikei Line from the north east.

The area is reasonably flat and small changes in ground levels of less than 1 metre would increase the developable area while maintaining the flood ponding function. This aspect has been carefully studied and modelled and has confirmed that with specific design the flood hydrology can be maintained.

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One Plan Schedule J
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Floodable Area
Stopbanks
DrainageChannels
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0.05 - 0.2
0.2 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.5
2.5 - 3.5
>3.5
River: Full Channel
PNCC_Urban - see PNCC
horizons
Horizons Information and 0.5% AEP (1 in 200 year) Modelled Flood Depths for
PPC Residential area, Adjacent Meadowbook Drive and Rangitikei Line, Palmerston North
0
100
200 m
N