Waitaki
DISTRICT COUNCIL
TE KAUNIHERA Ā ROHE O WAITAKI
Growing strong communities.

Phone 03 433 0300
Web www.waitaki.govt.nz
Office 20 Thames Street
Private bag 50058
Oamaru 9444

09 September 2021

Forrester Heights Geotechnical reports

Please provide any geotechnical reports concerning potential development of the portion of Cape Wanbrow commonly called "Forrester Heights."

Council Officers have reviewed your request and attached documents in response.

Yours sincerely,

Information Management Officer

Received by MB 10/..

28 SEP 2005

27 September 2005

Mr Shaun Perrin
Contracts Manager
Waitaki District Council
Private Bag 50058
20 Thames Street
OAMARU

OPUS
INTERNATIONAL
CONSULTANTS

6cc107.00 - v06dd

Dear Shaun

Test Street Subdivision - General Review

Further to your brief of 15 September 2005, we have reviewed the proposed consent application for subdivision at Test Street, including the Tonkin and Taylor Geotechnical Report. We have the following comments:

Site Geomtery with regards to NZS 4404.

NZS4404 generally requires an access road grade of 1:10, locally steeper up to 1:8. The proposed access road has a persistent grade of 1:8, which may have ramifications regarding access for refuse trucks, fire wagons and heavy vehicles. The Council should consider whether they wish to make an exception to this general requirement for road access grade on this site.

NZS4404 also makes recommendations on minimum road radii, based upon superelevation and prevailing traffic speed. The proposed access includes a tight radius corner of approximately 20m. According to NZS4404, this supposes a maximum speed of 20km/h, which might be appropriate. NZS4404 also suggests a widening of 2.0m above the proposed 6.0m road width for a corner of this radius; however the proposal does not indicate any local widening of the road at the corner.

Geotechnical Report

Limited Testing carried out

The Tonkin and Taylor geotechnical report is based upon 2 mechanically excavated trial pits at the eastern end of the site (proposed Lot 9) and a number of extremely shallow (<0.25m deep) hand-excavated pits throughout the remainder of the site. The 2 mechanically excavated pits encountered soft or very soft soils, whilst the hand excavated pits were all halted in stiff to very stiff soils.

Whilst this testing regime is suitable for initial assessment of general ground conditions, the possibility of further soft ground conditions across the general area of the site cannot be excluded on the basis this investigation. It is possible that shallow ground water may soften soils below the depth investigated. Whilst the assumed soil parameters (phi=33°) may be appropriate for very stiff silts, they may be overly optimistic for softer saturated soils. Also, ground water is assumed to be deep across the site, yet there appears to be no evidence to support this.

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Dunedin Office

144 Rattray Street
Private Bag 1913
Dunedin, New Zealand

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No scala penetrometer tests appear to have been carried out, and the presumption of 100kPa allowable bearing capacities (300kPa ultimate capacities) must be verified with site-specific testing at the time of construction.

Scala Penetrometer test could also be used to infer a likely design CBR. A design CBR of up to 7% is proposed. This must be verified with appropriate testing, which should include laboratory remoulded CBR tests at both natural moisture contents. These should also be soaked if there is any possibility that pavement subgrade may be subject to wetting.

Eastern Section of Site

The maximum slope of 2:1 (26.5°) on Lot 9 is described as having shallow scarps and "under-runners", which may also be signs of a larger scale slope failure. We would recommend a site-specific geotechnical report in the event that this Lot is to be developed. This site specific geotechnical assessment could include a slope model with more pessimistic soil strength and ground water parameters, and possible surcharge effects from building construction.

Also, the tight corner encroaches upon this area and some retaining structures may be required to provide the required road width and grade. These will require specific design, in light of the soft soils encountered in that locale.

Fill Construction

The geotechnical report proposes allowable fill slopes of 2:1 for the road construction. We recommend that this fill is made either with imported selected granular fill, or that extremely tight controls are made upon the placement of reworked loess soils. Loess is an extremely sensitive soil, and in our experience the reworked strengths of this material can be dramatically lower than when in-situ, both in terms of stable slope height and design CBR for road construction. In either case, wherever fill construction will provide structural support, it must be engineered with proven methods and site verification tests.

These preliminary comments are based only upon the information provided. No site visit has been made.

If you require any further advice, or wish further input, we will be delighted to offer our services.

Regards,

Lee Paterson
Structural / Geotechnical Engineer.

URS

24 December 2009
Project No. 42172547

Waitaki District Council
Private Bag 50058
Oamaru 9444

Attention: Dougall McIntyre
Property and Parks Manager

Dear Dougall

Subject: Ground Investigations at Forrester Heights, Oamaru

1 Introduction

URS New Zealand Limited (URS) has undertaken a geotechnical ground investigation at the Forrester Heights Subdivision in Oamaru at the request of Waitaki District Council. Tasks undertaken as part of this investigation include:

- Logging of site test pits to NZ Geotechnical Society Inc. "Field Description of Soil and Rock", 2005, to confirm loess and rock levels on site for the proposed subdivision.
- A brief desk study of available material on the site

This letter summarises the findings of the ground investigation

2 Site Description

The site is approximately 225m by 100m between Test Street and Avon Street in Oamaru, to the east of currently residential properties, overlooking Oamaru Harbour. The site slopes to the north towards the harbour.

2.1 Geological Setting

The site is underlain by Pleistocene windblown Loess deposits, with occasional raised beach deposits. Below this is Eocene age volcanic rock types including tuffs, agglomerates and basaltic pillow lavas.

3 Test Pitting

Nine test pit locations (TP1 to TP9) were initially considered for excavation (Figure 1), along the proposed roadway. The locations were chosen as the deepest points in cuttings for the proposed roadway. These depths varied between 3m and 6m. Two locations (TP4 and TP5) were eliminated from the proposed investigation due to their proximity to TP6 (within 20m). TP9 was also eliminated when the potential location was found to be on a public footpath and within a couple of meters of an existing roadway cutting, which would potentially be made unstable by excavation.

URS New Zealand Limited
URS House, 287 Durham Street
Christchurch, 8013
PO Box 4479, Christchurch 8140
New Zealand
T: 64 3 374 8500
F: 64 3 377 0655

The remaining locations (TP1, TP2, TP3, TP6, TP7 and TP8) were excavated on the 15th and 16th December 2009.

Test pit logs and photographs are attached to this report, together with a plan showing the pit locations.

The depths of all the pits were targeted to reach the elevation of the base of the proposed road cutting. TP2, TP6, TP7 and TP8 were excavated to the planned depths, encountering topsoil and loess. TP1 and TP3 were terminated above their respective target depths on refusal following hard digging. TP1 encountered rock at a depth of 3.8m. Excavation of TP3 was difficult due to hard ground conditions from relatively shallow depths, and was eventually terminated at 3.9m below ground level.

All test pits encountered loess below topsoil. Topsoil depths varied from nil to 0.2m. Loess was encountered to a maximum depth of 4.5m (TP2, which was terminated at target depth).

The loess encountered was generally clay/silt, light brown, homogeneous, firm to very stiff, dry to slightly damp, and of varying plasticity.

Groundwater was not encountered in any of the test pits.

All pits remained stable, with no signs of potential collapse.

4 Conclusions

Loess was identified in all pits immediately below topsoil. The Loess extended from ground level to depths corresponding to the base of the road cutting in all locations investigated except for TP1 and TP3.

TP1 encountered rock at 3.8m below ground level, which is above the expected road cutting base level.

Excavation of the Loess in TP3 was difficult from a relatively shallow depth due to the soil being hard and dry. Refusal was reached at a depth of 3.9m below ground level.

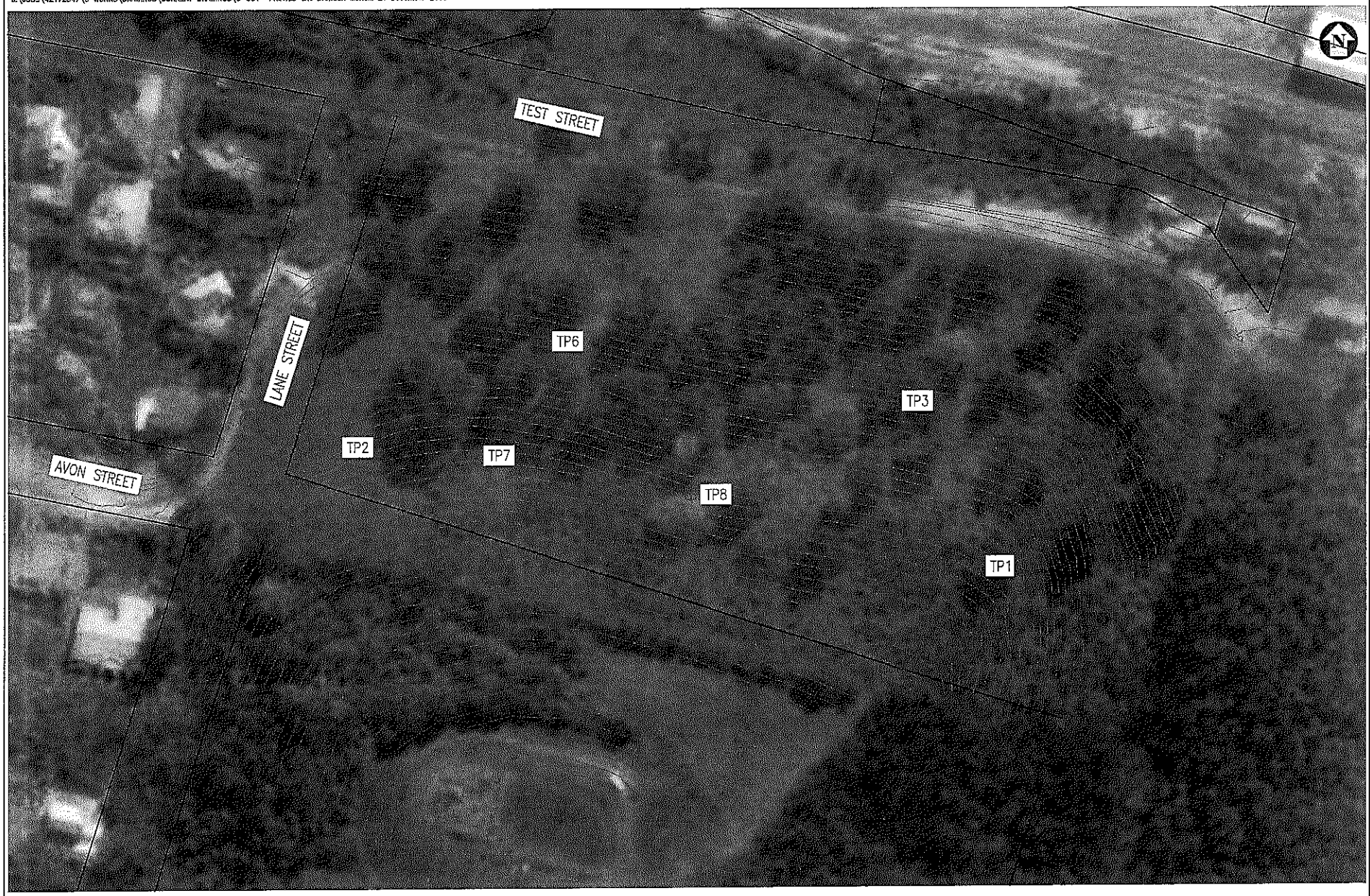
Yours sincerely
URS New Zealand Limited

Christina McPherson
Geotechnical Engineer

Gary Cross
Senior Associate

Enclosures: Site Plan
Test Pit Logs
Test Pit Photographs

J:\JOBS\42172547\5 WORKS\DRAWINGS\CURRENT DRAWINGS\G-001 PRINTED BY: Brendon McNeill 21 December 2009



URS

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DIMENSIONS ARE IN METRES

WAITAKI DISTRICT COUNCIL
GROUND INVESTIGATION
FORRESTER HEIGHTS, OAMARU

LOCATION PLAN

TEST PIT LOG — TP1

URS New Zealand Limited
287 Durham Street, Christchurch
Phone: 64.3.374.8500
Fax: 64.3.377.0655

Project No.: 42172547			Project Reference: Forrester Heights, Oamaru
Contractor: Whitestone		Grid: / Datum:	
Excavation Method: 20 tonne excavator	Logged By: CM Checked By: Date Started: 16-12-09 Date Finished: 16-12-09	Relative Level: mRL Coordinates: mN / mE	Client: Waitaki District Council
		Permit No:	Location: Chainage 340

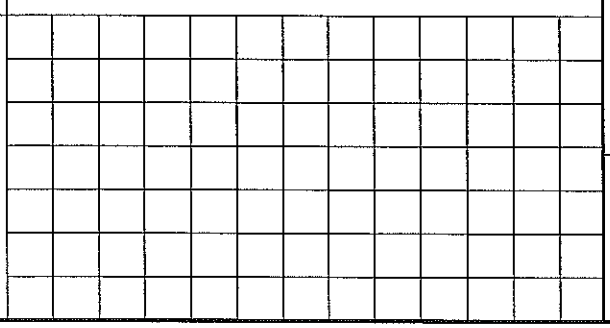
DESCRIPTION OF STRATA	GRAPHIC LOG	DEPTH (m)	GROUND WATER DATA AND COMMENTS
CLAY/SILT with some rootlets, dark brown. Firm, dry, highly plastic.		0.0	
CLAY/SILT, light brown, homogeneous. Firm to stiff, dry, low plasticity.			Dry.
becomes light yellow brown at 0.9m.		1.0	Dry.
		2.0	Dry.
CLAY/SILT, light grey brown to light brown. Firm, slightly damp, low plasticity.			Slightly damp.
		3.0	Slightly damp.
Dark grey, mottled white, medium grained AGGLOMERATE, moderately strong.			Dry.
Test pit terminated at 3.8m.		4.0	

COMMENTS

Pit walls stable

Refusal at 3.8m, on fine grained granite, locally known as "rotten rock" by contractors.

TEST PIT SECTION



TEST PIT TERMINATED AT:

Target Depth	☐
Refusal	☒
Flooding	☐
Caving/collapse	☐

SAMPLE TYPE:

Bag Sample	BAG
Tube Sample	TUBE
Vane Sample	VANE

TEST PIT LOG — TP2

URS New Zealand Limited 287 Durham Street, Christchurch	Phone: 64.3.374.8500 Fax: 64.3.377.0655	Project No.: 42172547	Project Reference: Forrester Heights, Oamaru
Contractor: Whitestone		Grid: Datum:	
Excavation Method: 20 tonne excavator	Logged By: CM Checked By: Date Started: 15-12-09 Date Finished: 15-12-09	Relative Level: mRL Coordinates: mN mE Permit No:	Client: Waitaki District Council Location: Chainage 520

DESCRIPTION OF STRATA	GRAPHIC LOG	DEPTH (m)	GROUND WATER DATA AND COMMENTS
CLAY/SILT, brown. Firm to stiff, dry, highly plastic.		0.0	Dry.
CLAY/SILT, light brown, homogeneous. Stiff, dry.		1.0	Dry.
		2.0	Dry.
		3.0	Dry.
		4.0	Dry.
Test pit terminated at 4.5m.			Dry.

COMMENTS

Pit walls stable

TEST PIT SECTION

TEST PIT TERMINATED AT:

Target Depth	X
Refusal	
Flooding	
Caving/collapse	

SAMPLE TYPE:

Bag Sample	BAG
Tube Sample	TUBE
Vane Sample	VANE

GEOTECH TEST PIT - NZGS DESC FORRESTER HEIGHTS TEST PITS.GPJ WCCNZ.GDT 21/12/09

TEST PIT LOG — TP3

URS New Zealand Limited 287 Durham Street, Christchurch	Phone: 64.3.374.8500 Fax: 64.3.377.0655	Project No.: 42172547	Project Reference: Forrester Heights, Oamaru
Contractor: **Whitestone**		Grid: Datum:	
Excavation Method: **20 tonne excavator**	Logged By: **CM** Checked By: Date Started: **15-12-09** Date Finished: **15-12-09**	Relative Level: **mRL** Coordinates: **mN** **mE** Permit No:	Client: **Waitaki District Council** Location: **Chainage 250**

DESCRIPTION OF STRATA	GRAPHIC LOG	DEPTH (m)	GROUND WATER DATA AND COMMENTS
CLAY/SILT, light brown. Stiff to hard, dry, highly plastic.		0.0	Dry.
		1.0	Dry.
		2.0	Dry.
CLAY/SILT with traces of sand, medium brown. Stiff, slightly damp, highly plastic.		3.0	Slightly damp.
Slightly clayey SILT, white. Stiff to hard, dry.			Dry.
			Dry.
Test pit terminated at 3.9m.		4.0	

COMMENTS

Pit walls stable

Slow digging due to hard ground

Refusal at 3.9m, no pieces of material could be brought to surface for identification, suspected igneous material.

TEST PIT SECTION

TEST PIT TERMINATED AT:

Target Depth	☐
Refusal	☒
Flooding	☐
Caving/collapse	☐

SAMPLE TYPE:

Bag Sample	BAG
Tube Sample	TUBE
Vane Sample	VANE

GEOTECH TEST PIT - NZGS DESC FORRESTER HEIGHTS TEST PITS.GPJ WCCNZ.GDT 21/12/09

TEST PIT LOG — TP6

URS New Zealand Limited
287 Durham Street, Christchurch
Phone: 64.3.374.8500
Fax: 64.3.377.0655

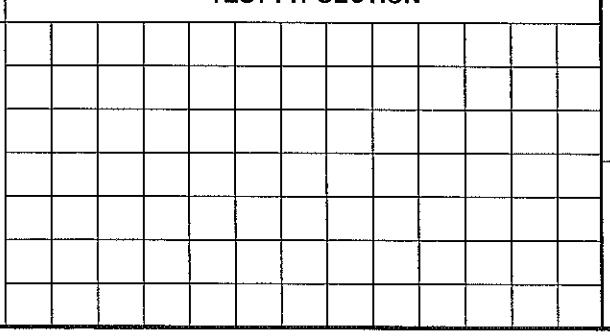
Project No.: 42172547	Project Reference: Forrester Heights, Oamaru
Contractor: Whitestone	Grid: / Datum:
Excavation Method: 20 tonne excavator	Logged By: CM; Checked By: ; Date Started: 15-12-09; Date Finished: 15-12-09
Relative Level: mRL; Coordinates: mN mE	Client: Waitaki District Council
Permit No:	Location: Chainage 150

DESCRIPTION OF STRATA	GRAPHIC LOG	DEPTH (m)	GROUND WATER DATA AND COMMENTS
SILT, light brown, homogeneous. Stiff, slightly damp, moderate plasticity.		0.0	Slightly damp.
with rare patches of white staining around rootlets at 1.2m.		1.0	Slightly damp.
		2.0	Slightly damp.
		3.0	Slightly damp.
Test pit terminated at 3.5m.		4.0	Slightly damp.

COMMENTS

Pit walls stable

TEST PIT SECTION



TEST PIT TERMINATED AT:

Target Depth	X
Refusal	
Flooding	
Caving/collapse	

SAMPLE TYPE:

Bag Sample	BAG
Tube Sample	TUBE
Vane Sample	VANE

TEST PIT LOG — TP7

URS New Zealand Limited
287 Durham Street, Christchurch
Phone: 64.3.374.8500
Fax: 64.3.377.0655

Project No.: 42172547			Project Reference: Forrester Heights, Oamaru
Contractor: Whitestone		Grid: / Datum:	
Excavation Method: 20 tonne excavator	Logged By: CM Checked By: Date Started: 15-12-09 Date Finished: 15-12-09	Relative Level: mRL Coordinates: mN / mE	Client: Waitaki District Council
		Permit No:	Location: Chainage 480

DESCRIPTION OF STRATA	GRAPHIC LOG	DEPTH (m)	GROUND WATER DATA AND COMMENTS
CLAY/SILT, dark brown. Firm to stiff, dry, highly plastic.		0.0	
CLAY/SILT, light brown, homogeneous. Stiff, dry, moderate plasticity.			Dry.
becomes light yellowish brown at 0.5m.		1.0	Dry.
		2.0	Dry.
Test pit terminated at 3m.		3.0	Dry.
		4.0	

COMMENTS

Pit walls stable

TEST PIT SECTION

TEST PIT TERMINATED AT:

Target Depth	X
Refusal	
Flooding	
Caving/collapse	

SAMPLE TYPE:

Bag Sample	BAG
Tube Sample	TUBE
Vane Sample	VANE

GEOTECH TEST PIT - NZGS DESC FORRESTER HEIGHTS TEST PITS.GPJ WCCNZ.GDT 21/12/09

TEST PIT LOG — TP8

URS New Zealand Limited
287 Durham Street, Christchurch
Phone: 64.3.374.6500
Fax: 64.3.377.0655

Project No.: 42172547			Project Reference: Forrester Heights, Oamaru
Contractor: Whitestone		Grid: / Datum:	
Excavation Method: 20 tonne excavator	Logged By: CM Checked By: Date Started: 15-12-09 Date Finished: 15-12-09	Relative Level: mRL Coordinates: mN / mE	Client: Waitaki District Council
		Permit No:	Location: Chainage 420

DESCRIPTION OF STRATA	GRAPHIC LOG	DEPTH (m)	GROUND WATER DATA AND COMMENTS
CLAY/SILT, dark brown, homogeneous. Firm to stiff, dry, moderate plasticity.		0.0	Dry.
becomes brown at 0.1m.			
becomes light brown at 0.8m.		1.0	Dry.
		2.0	Dry.
		3.0	Dry.
Test pit terminated at 3.1m.		4.0	

COMMENTS

Pit walls stable

TEST PIT SECTION

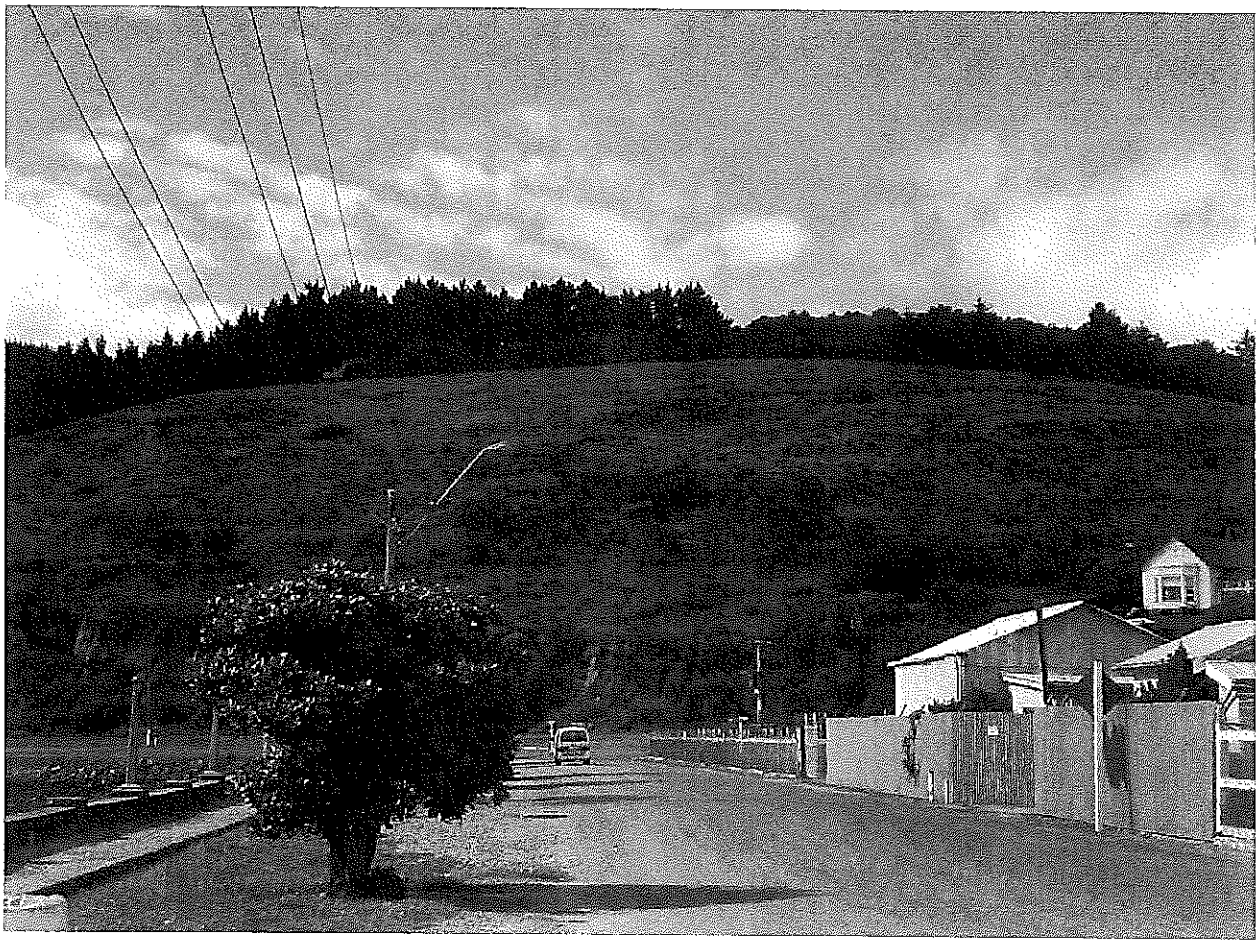
TEST PIT TERMINATED AT:

Target Depth	X
Refusal	
Flooding	
Caving/collapse	

SAMPLE TYPE:

Bag Sample	BAG
Tube Sample	TUBE
Vane Sample	VANE

GEOTECH TEST PIT - NZGS DESC FORRESTER HEIGHTS TEST PITS.GPJ WCCNZ.GDT 21/12/09



Forrester Heights, Oamaru

URS New Zealand
Engineering and Environmental Management

TITLE

Test Pit Photographs

PROJECT: **42172547** REV: **A**

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Test Pit TP1

URS New Zealand
Engineering and Environmental Management

TITLE

Test Pit Photographs

PROJECT: **42172547** REV: **A**

S:\JOBS\48484\009\1000 - Site Investigations

Test Pit TP2

URS New Zealand
Engineering and Environmental Management

TITLE

Test Pit Photographs

PROJECT: **42172547** REV: **A**

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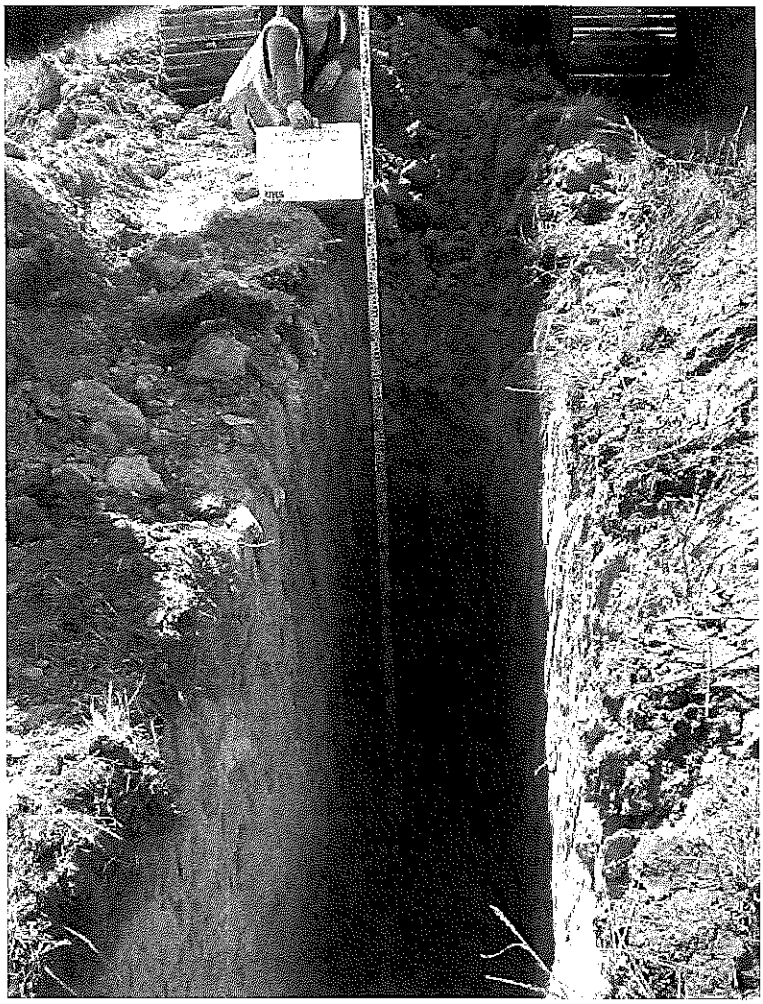

Test Pit TP3

URS New Zealand
Engineering and Environmental Management

TITLE

Test Pit Photographs

PROJECT: **42172547** REV: **A**

S:\JOBS\48484\009\1000 - Site Investigations

Test Pit TP6

URS New Zealand
Engineering and Environmental Management

TITLE

Test Pit Photographs

PROJECT: **42172547** REV: **A**

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Test Pit TP7

URS New Zealand
Engineering and Environmental Management

TITLE

Test Pit Photographs

PROJECT: **42172547** REV: **A**

Test Pit TP8

URS New Zealand
Engineering and Environmental Management

TITLE

Test Pit Photographs

PROJECT: **42172547** REV: **A**

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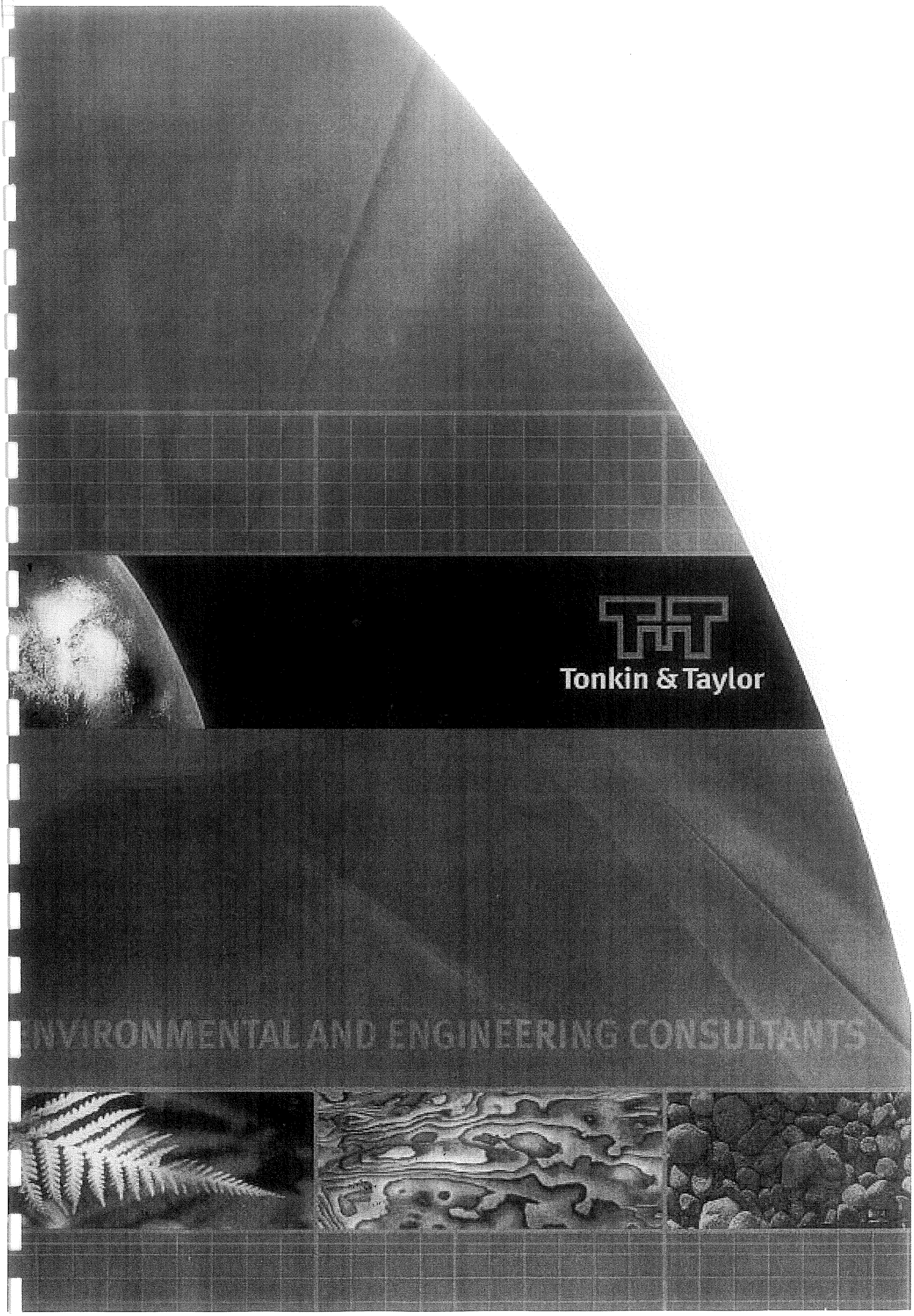
Tonkin & Taylor
ENVIRONMENTAL AND ENGINEERING CONSULTANTS

REPORT

WAITAKI DISTRICT COUNCIL

Geotechnical Investigations
Test Street Subdivision, Oamaru

Report prepared for:

WAITAKI DISTRICT COUNCIL

Report prepared by:

TONKIN & TAYLOR LTD

Distribution:

WAITAKI DISTRICT COUNCIL

CLARK FORTUNE MCDONALD & ASSOCIATES

TONKIN & TAYLOR LTD (FILE)

March 2005

Job no: 890917

Table of contents

1. Introduction

1.1. General

This report presents the results of geotechnical investigations carried out by Tonkin & Taylor Ltd for a subdivision bounded by Test Street, Lane Street and Avon Street, Oamaru. The work was carried out for Waitaki District Council in accordance with a brief received from Clark Fortune McDonald & Associates, dated 28 January 2005. Tonkin & Taylor Ltd's proposal dated 31 January 2005 outlines the scope of work and conditions of engagement.

1.2. Development

The proposed development is for subdivision of the site into 27 allotments and associated access road, as shown in Fig 1, Appendix A. No specific plans for buildings are available at this stage, although conceptual plans indicate that many will require significant cuts (3-4 m) as a consequence of the moderate slopes on site.

2. Site Description

2.1. General

The site is legally described as SEC'S 1-23, BLK 31 and SEC'S 1-22 BLK 32 and is shown in Fig 1, Appendix A. The upper part of the site includes the eastern part of the currently unformed continuation of Avon Street.

Access to the site is currently best achieved from Test Street or from the reserve to the south, however the access road for the subdivision will feed from the current eastern termination of Avon Street.

This report also addresses geotechnical issues associated with of triangular section of land, situated directly below Test Street, as shown in Fig 1, Appendix A.

2.2. Topography and Surface Drainage

Topographic contours can be seen in Fig. 1, Appendix A. The majority of the site slopes at moderate inclination towards Oamaru Harbour, with a northerly aspect. Most slopes are no greater than 2.5:1 (horizontal : vertical), however, Lot 9 is steeper (2:1) owing to its position on the flank of an incised gully. The difference in elevation between the upper and lower parts of the site is approximately 50 m.

The triangular section of land below Test Street slopes gently towards a cliff face that is approximately 10 m high and composed entirely of loess.

There are no significant watercourses present on the site, although the eastern boundary coincides with the true left flank of an incised gully that is expected to carry surface water only at times of high rainfall.

2.3. Vegetation and Land Use

The site is currently unoccupied and is covered in scrub, mature trees, and rough pasture.

3. Investigations

An engineering geologist has conducted a site appraisal to assess the geomorphology and surficial conditions. Two test pits have been excavated in the gully area located at the eastern side of the subdivision. Fifteen additional hand dug test pits have been established to assess near-surface conditions and to enable penetrometer testing of the soils. Seventeen Scala penetrometer tests were carried out, the results of which are contained in test pit logs, Appendix B. Locations and logs of test pits are given in Appendices A and B respectively.

Although not part of the subdivision, the land below Test Street was also evaluated to assess its suitability for possible future development.

4. Subsurface Conditions

4.1. Geological Setting

The site is located adjacent to Oamaru Harbour on the northern flank of Cape Wanbrow, a volcanic promontory formed by a combination of submarine and subaerial volcanism, which was active in Eocene times. The volcanic rock types include tuffs, agglomerates and pillow lavas of basaltic composition (Waiareka Volcanics).

The volcanic rocks are overlain by thick accumulations of windblown loess and occasional remnant raised beach deposits, both of which are Pleistocene in age. The main geomorphological features of the area are steep cliffs, typical of marine headland environments.

No active fault traces were observed in the field nor have any been reported in this vicinity. Seismic hazard in East Otago is relatively low by New Zealand standards, however some potential exists for major earthquakes. Strong ground shaking throughout the South Island is likely to be associated with a rupture of the Alpine Fault, located along the West Coast of South Island. There is a high probability that an earthquake with an expected Magnitude of over 7.5 will occur along the Alpine Fault within the next 50 years.

4.2. Stratigraphy

A geological model for the site is presented in Figs 2a-2d, Appendix A. The stratigraphy comprises a surface layer of topsoil and roots underlain by thick loess. Locations and logs of test pits (including penetrometer results) are presented in Appendices A and B respectively.

The site is in general covered by up to 300 mm of topsoil and roots that comprise slightly moist, brown organic silt with plant fragments and roots.

The topsoil is pervasively underlain by loess. This comprises light brown to brown mottled silt with occasional roots. The loess is generally stiff to very stiff over the entire subdivision, however within the gully area on the eastern margin of the site the loess is saturated in places and is locally soft and wet. Test pit walls in this area readily collapsed.

The loess occasionally hosts under-runners as a result if its dispersive nature. The under-runners were mainly observed on the 25° east-facing slopes of Lot 9 and were

up to 1 m deep and 0.5 m wide. These are interpreted to be responsible for the weakening and high moisture content of the loess observed in Test Pit 1. Where present, under-runners tend to promote localised slope instability, with numerous minor scarps (< 1 m high) developed.

The base of the loess was not encountered, however, based on exposure in the cliff face below the site, it is interpreted to be at least 5 -10 m thick. Below this, the site is expected to be underlain by volcanic lithologies (Waireka Volcanics).

4.3. Groundwater

The soil types in the test pits are generally slightly moist across the site indicating that the regional groundwater table is not shallow.

Localised seepage was observed in Test Pit 1, where under-runners are interpreted to be focussing surface runoff. Significant under-runners were observed only on Lot 9, however they may be present elsewhere (e.g. suspected on Lot 1). The largest examples are likely to be confined to Lot 9.

The magnitude of flow in under-runners is likely to increase following periods of persistent rainfall.

4.4. Slope Stability

Minor slope instability was noted. This was mainly evident on Lot 9 where under-runners have destabilised the loess with the resulting slumping and subsidence forming scarps <1 m in height. Other minor scarps (< 0.5 m high) were apparent over the upper part of the site, however these are probably attributable to minor solifluction processes.

The area of land directly below Test Street is situated adjacent to a cliff that is up to 10 m high. The cliff has been severely eroded by under-runners and piping and large voids are apparent from below. Although the slopes are gentle to moderate in this area, major subsidence is possible and sinkholes could conceivably form at the margins of the cliff. Old concrete foundations are apparent in this area, and show evidence of subsidence.

5. Engineering Considerations

5.1. General

Recommendations and opinions in this report are based on the data sources noted above. The nature and continuity of subsoil conditions away from the exposures and test pits are inferred. However, it must be appreciated that actual conditions could vary from the assumed model.

5.2. Strength and Deformation Parameters

Design Profile

The design profile for the site is given in Table 5.1 below.

Unit	Thickness (m)	Bulk Density γ (kN/m^3)	Effective Cohesion c' (kPa)	Effective Friction ϕ' (deg)	Elastic Modulus E (kPa)	Poisson's Ratio v
Topsoil – organic SILT.	0 - 0.3	N.A.	N.A.	N.A.	N.A.	N.A.
Loess – stiff to very stiff SILT.	5 - 10 m	17	2	33	15,000	0.3
Loess with under runners – very soft to firm SILT.	<3 m	17	0	30	3,000-8,000	0.3

Table 5-1. Preliminary Geotechnical Parameters

5.3. Site Preparation

During earthworks operations all topsoil and organic matter should be removed from beneath access pavements or building platforms in accordance with NZS 4431:1989.

Once scrub and trees have been cleared, any obvious near-surface under runners should be undercut and backfilled. This form of erosion indicates that the soils are dispersive, hence particular care will need to be taken to ensure no seepage conduits are allowed to remain to instigate further erosion. All surface water should be effectively intercepted. Should any potential for seepage be suspected to remain at existing under-runners, backfilling with loess that has been stabilised with the addition of 1-2% lime will provide an effective solution.

5.4. Excavations and Retaining

No specific excavations are indicated at this stage however the moderate slopes suggest that most dwellings will require excavations.

All excavations are expected to be in stiff to very stiff loess. Provided the loess remains well drained and cuts are less than about 2 m, temporary and permanent batters of 0.5:1 (horizontal : vertical) will be appropriate. Higher batters should be specifically designed, preferably with benching, and permanent batters should be quickly revegetated to reduce potential for rilling in these dispersive soils.

Any topsoil should be entirely removed at the crest of the cuts to ensure the temporary stability of these materials, or alternatively they could be battered suitably (flatter than 1.5:1).

If any placement of fill is proposed (e.g to form flat platforms or road batters), this should be undertaken in accordance with NZS 4431: 1989. All topsoil will need to be removed from the fill subgrade.

If cuts greater than 2 m are proposed then specific geotechnical comment is recommended for each structure. Any retaining and/or backfill operations should be timed to commence as soon as practical after any section of cut is completed.

5.5. Roading

No specific plans are yet available for the access road. Cuts in loess should be formed as discussed above, with subsoil interception drains at their toes where seepage is indicated. Underdrained fill batters may be formed at 2:1. Particular care will need to be taken for the steep sidling horseshoe bend at the eastern side of the site, as under-runners are known to be present here.

Design CBR for the loess can be about 7 or more for well drained conditions, but will reduce to about 2 where seepage can develop. Visual assessment after the subgrade is formed, should be undertaken, noting drainage and consequent potential for seasonal moisture variations, for adoption of final design CBR.

5.6. Settlement and Foundations

Upon removal of topsoil, all foundations on natural in situ ground are expected to be on stiff to very stiff loess, which will provide good bearing for conventional spread footings (100 kPa allowable bearing on footings 300 mm wide and not less than 300 m deep). Any foundation areas affected by seepage will require specific assessment.

The building platform for Lot 9 is likely to be in a region where under-runners have been observed to 1 m depth. Most of these should be removed by excavations, however if present beneath the excavation, they will need to be undercut and replaced as discussed above. It is recommended that a specific geotechnical evaluation of Lot 9 be undertaken, once scrub has been removed and the building footprint decided.

Minor under-runners should also be expected over the remainder of the site, and earthworks supervisors should be briefed to note and report any features uncovered.

Site-specific investigations should be carried out in accordance with NZS 3604 for individual lot developments when foundation layouts are available.

5.7. Seismic Design

The site is classified as Subsoil Category (b) ie, Intermediate seismic rating in terms

No significant reduction in bearing capacity is expected for earthquake loading.

5.8. Slope Stability

The under-runners observed on the 25° east-facing slopes of Lot 9 are up to 1 m deep and 0.5 m wide. These are interpreted to be responsible for the weakening and high moisture content of the loess observed in Test Pit 1. Where present, under-runners tend to promote localised slope instability, with numerous minor scarps (< 1 m high) developed.

Small scarps (< 0.5 m high) are present elsewhere on the property, however no under-runners were observed in association with these and they are likely to be the result of minor solifluction.

The area of land directly below Test Street is situated adjacent to a 10 m high cliff that has been severely eroded by under-runners and piping. Large voids are apparent from below. No buildings are currently proposed in this area, however if they are planned in future they could be at risk from sinkhole development as a result of subsidence into voids below. This risk is likely to be most pronounced within 5 m of the cliff crest, however the persistence of these features will need to be properly assessed (possibly with drilling). Although the slopes are gentle to moderate in this area sinkholes could conceivably form at the margins of the cliff, and safety factors for slope stability are low. There is potential for substantial regression of the cliffline with a strong seismic event. Old concrete foundations are apparent in this area, and these show evidence of subsidence. A nominal building setback line is recommended so that any structure remains beyond a 1.75:1 line drawn from the cliff base but not closer than 10 m from the cliff top. The setback line is nominated as a precautionary guide only and could possibly be reduced if further site-specific geotechnical investigations are carried out.

5.9. Neighbouring Structures/Hazards

Distances to adjoining structures: There are no neighbouring structures within close proximity of any of the site boundaries. The only buildings adjacent to the site are located some 15-20 m beyond the western boundary. Test Street is located directly down slope of the northern boundary.

Aquifers: No aquifer resource will be adversely affected by the development.

Erosion and Sediment Control: Owing to the silt-rich composition of loess, sediment control measures should be implemented. Effective systems for erosion control are runoff diversion drains and contour drains, while for sediment control, options are earth bunds, silt fences, hay bales, vegetation buffer strips and sediment ponds. Only the least amount of subsoil should be exposed at any stage and vegetation re-established as soon as practicable, or mulch applied. Details for implementation are given in Appendix B within the following link

http://www.aucklandcity.govt.nz/council/documents/district/Ann14.pdf

with further detail related to construction sites in

http://www.itd.idaho.gov/manuals/Online_Manuals/BMP/

Dust: The site contains fine-grained sediments with the potential to generate dust. Regular dampening with sprinklers should be effective.

Natural Hazards:

The subdivision is located in an area with potential for under-runners and appropriate supervision of all earthworks and treatment is required.

The subdivision is located well upslope of a cliff face that is up to approximately 10 m high and shows evidence of slope failure and potential for sinkhole development as described above. This feature is located well away from the proposed subdivision and no adverse consequences are anticipated. However, if future development is planned for the land below Test Street, then the considerations outlined in Section 5.8 will apply.

6. Conclusions and Recommendations

- Subsurface materials at the Test Street Subdivision site consist of shallow topsoil overlying stiff to very stiff loess, with bedrock at considerable depth.
- The loess is dispersive. Siltation control is required with revegetation recommended at the earliest practical opportunity. Effective interception of surface water is required and groundwater seepage should be cut off with subsoil drains.
- Excavations in well-drained loess are expected to perform satisfactorily at batters of 0.5:1 to at least 2 m. Specific designs for higher cuts are recommended.
- Compacted fills should be formed at 2:1.
- Good bearing for conventional spread footings is available for most of the subdivision area.
- Where under-runners are developed, these will need to be undercut and replaced by certified fill, lime stabilised where seepage cannot be positively intercepted.

7. Applicability

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

During construction, excavations should be examined by an inspector or engineer competent to confirm that subsurface conditions encountered are compatible with the inferred conditions on which this report has been based and assess any support requirements. It is important that we be contacted if there is any variation in subsoil conditions from those described in this report.

TONKIN & TAYLOR LTD

Environmental and Engineering Consultants

Report prepared by:	Authorised for Tonkin & Taylor by:
.....	.....
Mark Walrond	Graham Salt
ENGINEERING GEOLOGIST	GEOTECHNICAL GROUP COORDINATOR

MTW

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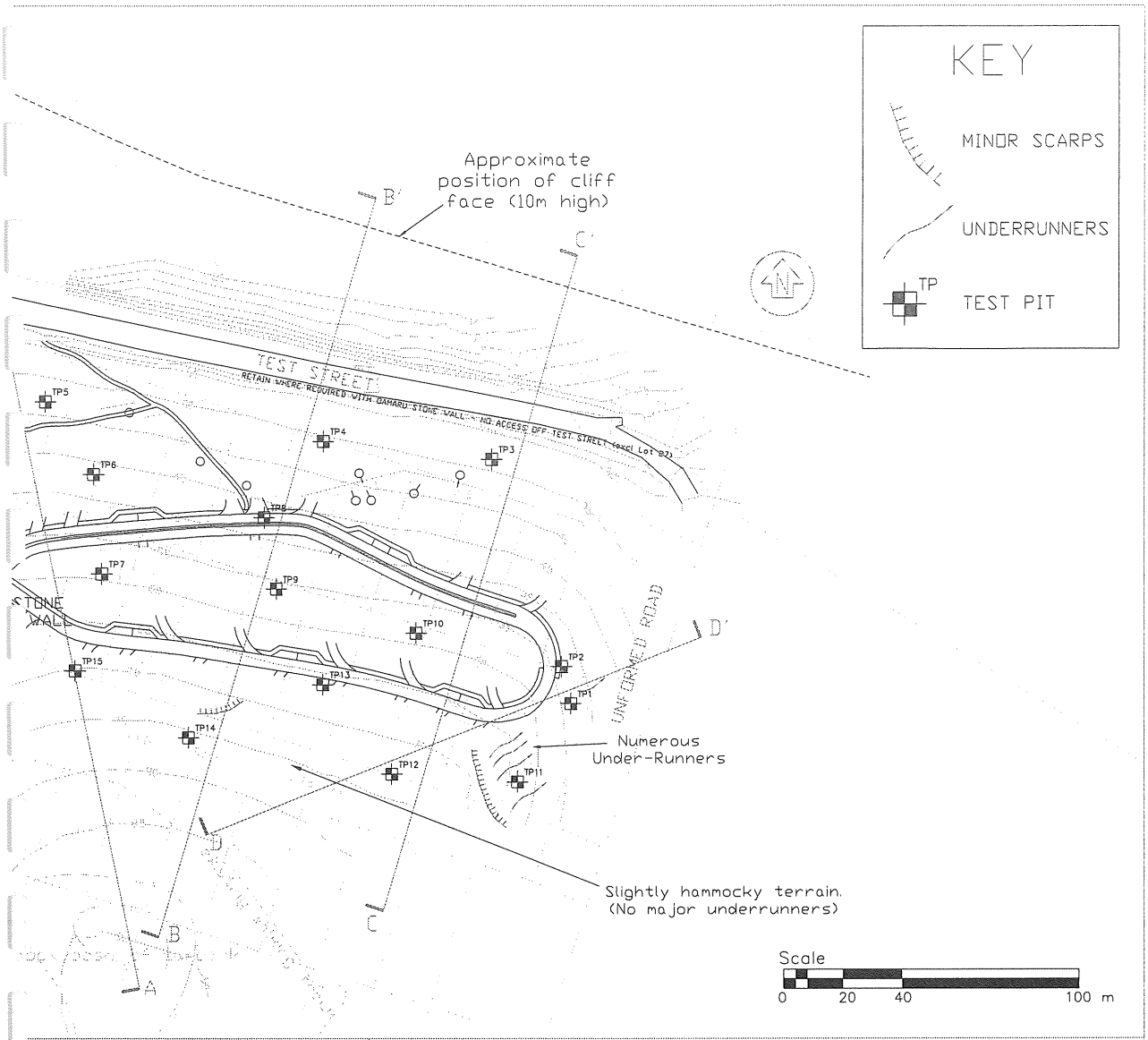
Appendix A: Site Plan and Cross Sections



DRAWN	KAB	22/03/05	
DRAFTING CHECKED			
APPROVED			
CADFILE :			
SCALES (AT A4 SIZE)			
PROJECT No. 890917	FIG. No. Fig. 1a		REV. 0

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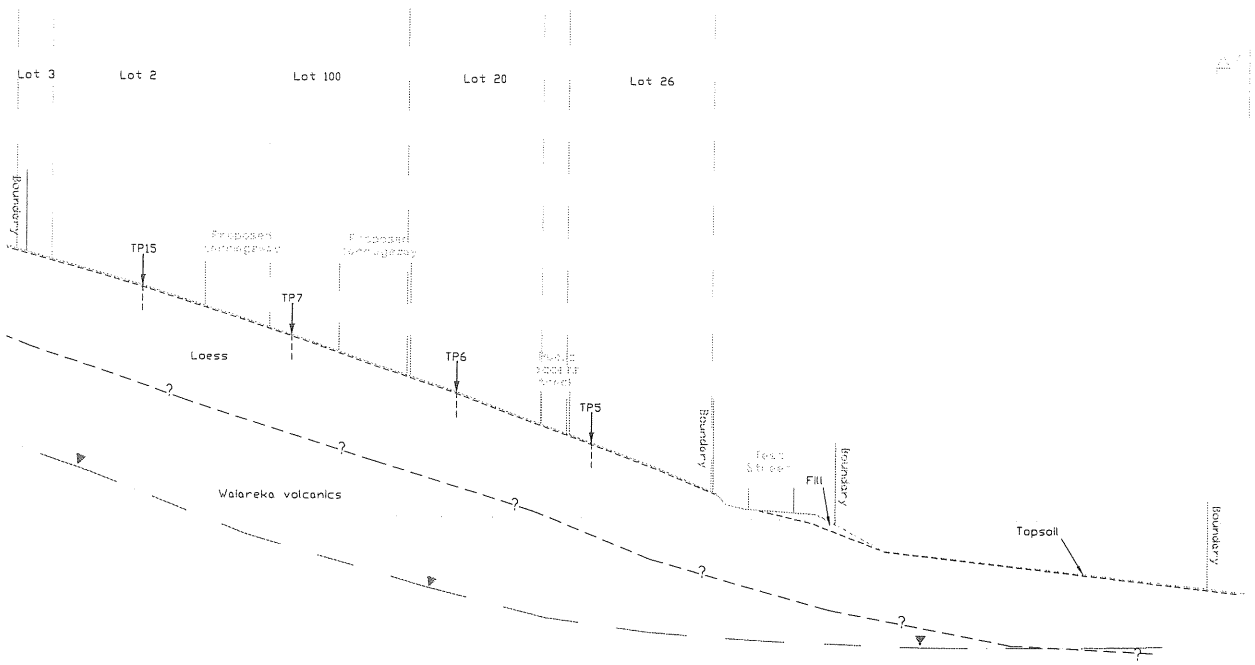
■ DUNEDIN
□ CHRISTCHURCH
□ WHANGAREI

WAITAKI DISTRICT COUNCIL
Geotechnical Investigations
TEST STREET SUBDIVISION, OAMARU
Site Plan



Scale
0 4 10 20 50 m

DRAWN	KAB	23/03/05	WAITAKI DISTRICT COUNCIL Geotechnical Investigations TEST STREET SUBDIVISION, OAMARU Section A – A'
DRAFTING CHECKED			
APPROVED			
CADFILE :			
SCALES (AT A4 SIZE)			
PROJECT No. 890917	FIG. No Fig. 2a	REV. 0	

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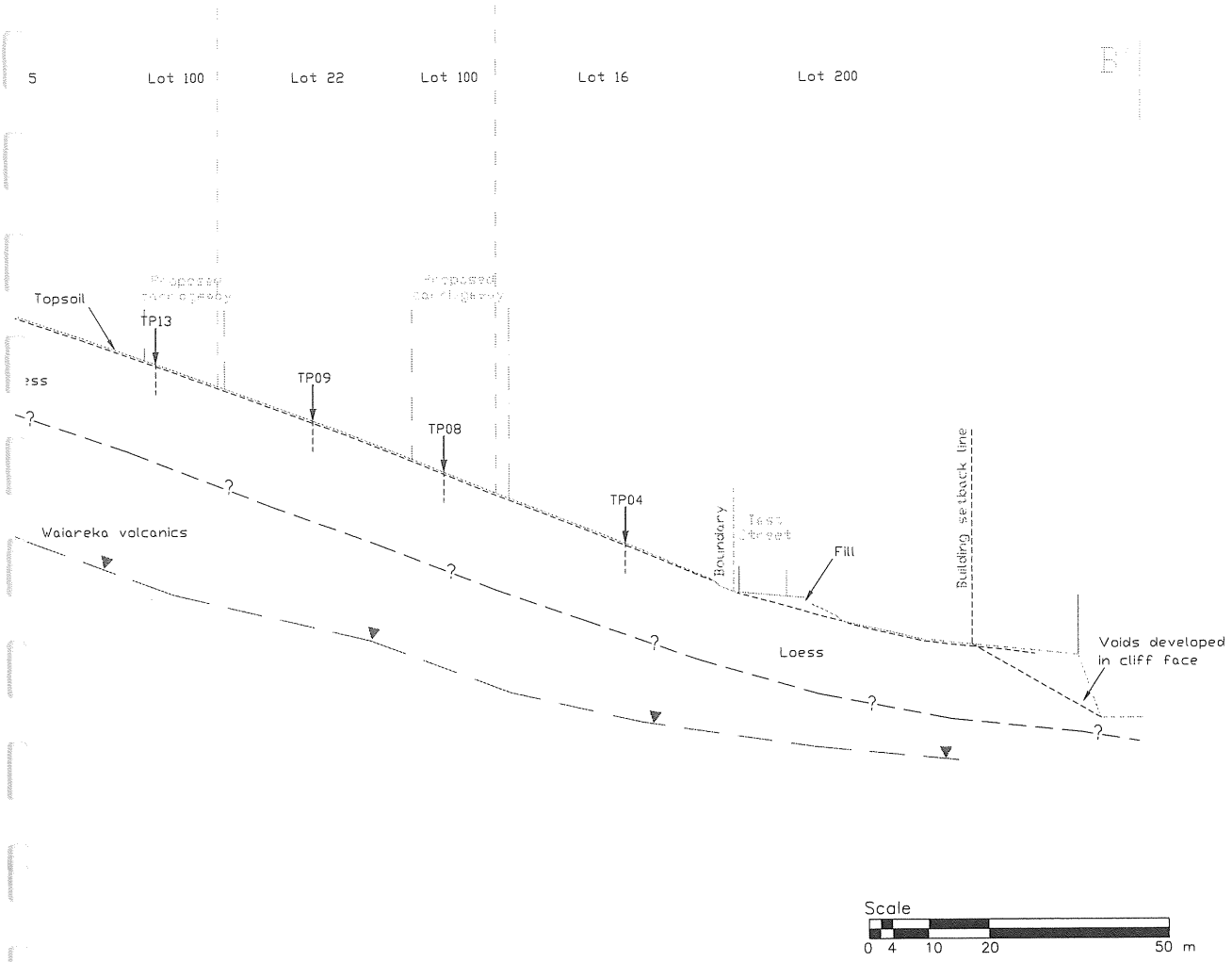

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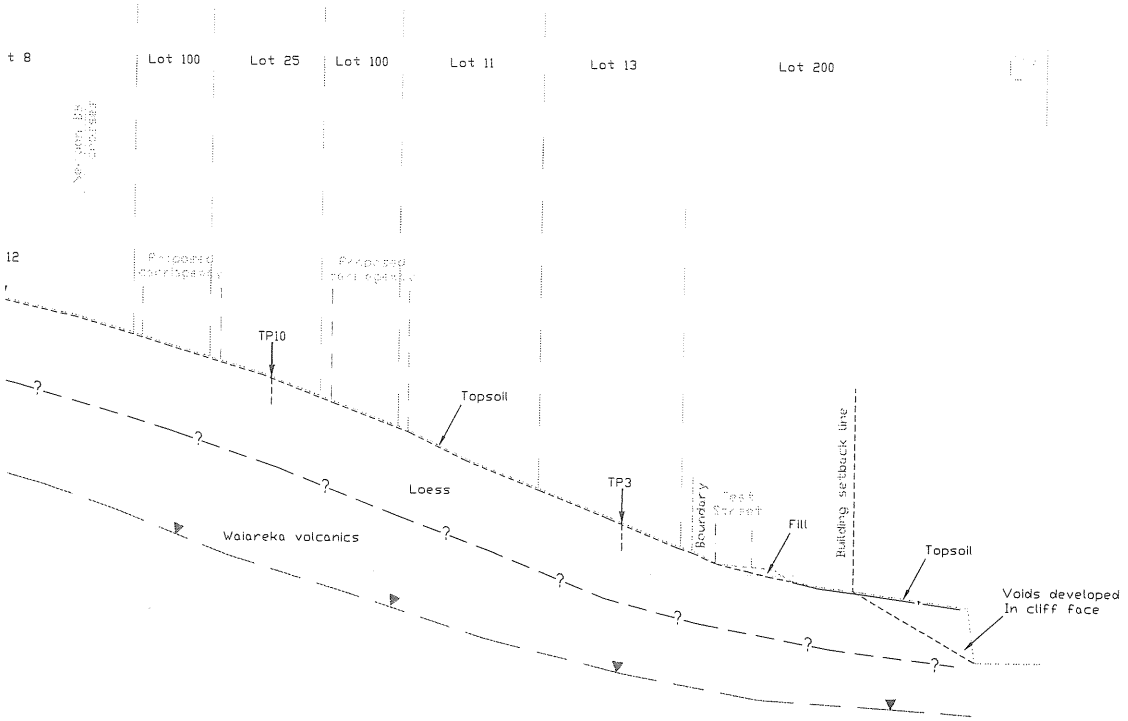
	APPROVED		
	CADFILE :		
	SCALES (AT A4 SIZE)		
	PROJECT No. 890917	FIG No. Fig. 2b	REV. 0

WAITAKI DISTRICT COUNCIL
Geotechnical Investigations
TEST STREET SUBDIVISION, OAMARU
Section B – B'



Scale

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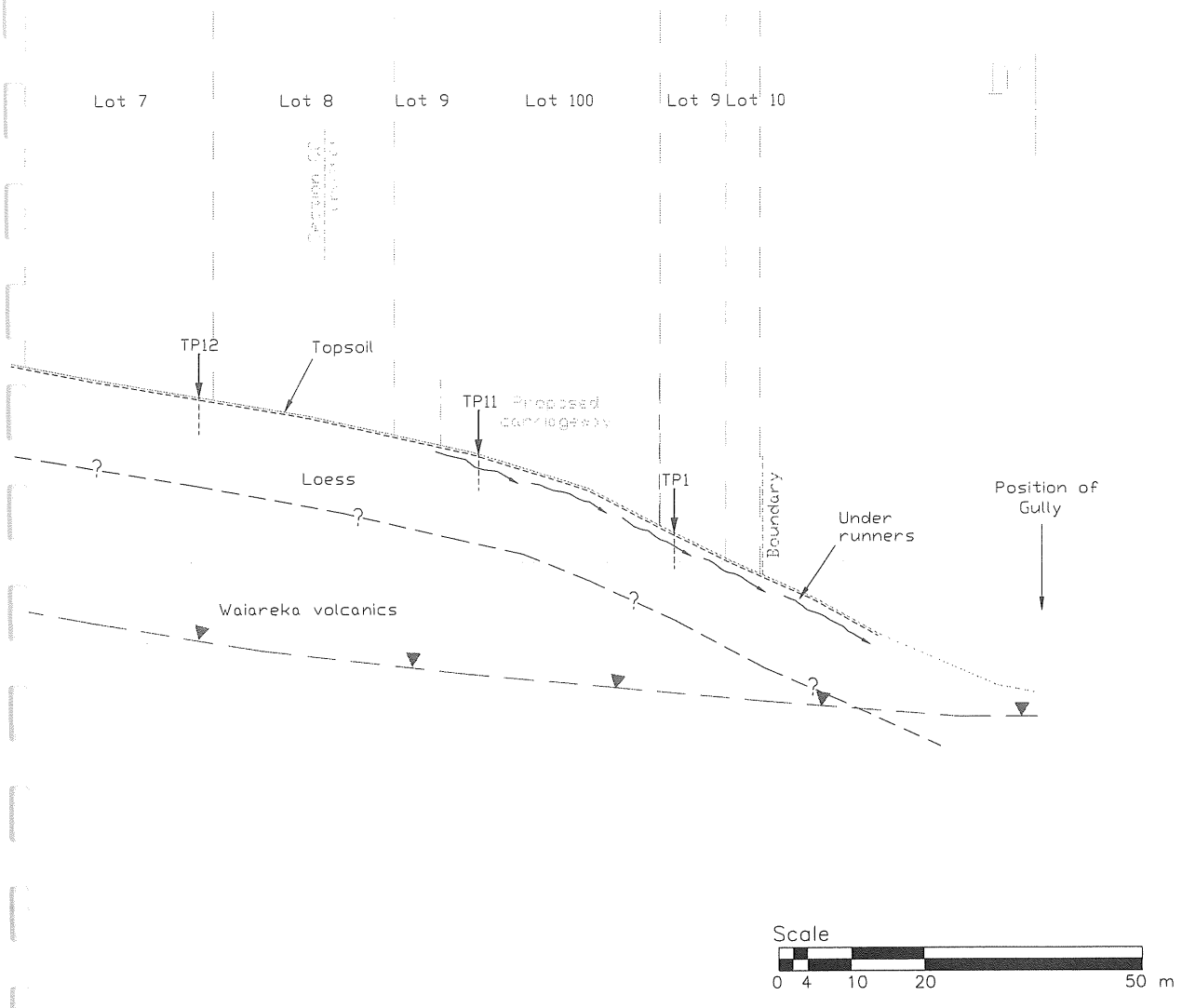
	APPROVED		
	CADFILE :		
	SCALES (AT A4 SIZE)		
	PROJECT No. 890917		

WAITAKI DISTRICT COUNCIL
Geotechnical Investigations
TEST STREET SUBDIVISION, OAMARU
Section C – C'

FIG No. Fig. 2c

REV. 0



Scale

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DRAWN	KAB	23/03/05	WAITAKI DISTRICT COUNCIL
DRAFTING CHECKED			Geotechnical Investigations
APPROVED			TEST STREET SUBDIVISION, OAMARU
CADFILE :			Section D – D'
SCALES (AT A4 SIZE)			
PROJECT No. 890917			FIG. No. Fig. 2d
			REV. 0

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Appendix B: Test Pit Logs

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EXCAVATION LOG

EXCAVATION NUMBER: **TP 1**

PROJECT: CFM Test		Job Number: 890917
LOCATION: Lot 9-10	Inclination:	Direction:

CO-ORDINATES: See site plan mE	EQUIPMENT: Hitachi 14 tonne	OPERATOR: Steve McLeod
Method: See site plan mN	INFOMAP NO.	COMPANY: Whitestone Ltd
ELEVATION: m	DIMENSIONS:	HOLE STARTED: 15-Feb-05
Method: N/A	EXCAV. DATUM:	HOLE FINISHED: 15-Feb-05

PENETRATION					ENGINEERING DESCRIPTION				GEOLOGICAL
PENETRATION (N)	GROUNDWATER / SEEPAGE	INSTALLED INSTRUMENTS	SAMPLES	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
				0.2		pt	organic SILT with plant fragments and roots		TOPSOIL
	NO SEEPAGE BUT SOILS WET TO MOIST			0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0		ML	light brown to yellow-brown, mottled clayey SILT, dilatant, very soft to soft (sticking to bucket), test pit walls gradually fall in, decreased water at 3 m (moist), rare hardened nodules (20 mm max) at 2.5 m - 3.1 m, Scala: 57mm/blow	moist to wet	LOESS
				3.2			Total Depth = 3.1 m		

PURPOSE:	Logged By: MTW
	Checked Date:
PHOTO REF.:	Sheet: 1 of 1

Tonkin & Taylor

TONKIN & TAYLOR LTD
EXCAVATION LOG

EXCAVATION NUMBER: **TP 2**

PROJECT: CFM Test		Job Number: 890917
LOCATION: Lot 9-10	Inclination:	Direction:

CO-ORDINATES: See site plan mE	EQUIPMENT: Hitachi 14 tonne	OPERATOR: Steve McLeod	
Method: See site plan mN	INFOMAP NO.	COMPANY: Whitestone Ltd	
ELEVATION: m	DIMENSIONS:	HOLE STARTED: 15-Feb-05	
Method: N/A	EXCAV. DATUM:	HOLE FINISHED: 15-Feb-05	

PENETRATION					ENGINEERING DESCRIPTION				GEOLOGICAL
PENETRATION (N)	GROUNDWATER / SEEPAGE	INSTALLED INSTRUMENTS	SAMPLES	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS	MOISTURE CONDITION	SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION
				0.2		pt	organic SILT with plant fragments and roots		TOPSOIL
	NO SEEPAGE			0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0		ML	light brown to brown, mottled SILT with occasional roots, upper 200 mm soft, firm beyond 0.5 m, excavation difficult beneath 1.5 m, sides stand well, some hardened nodules (< 20 mm) at 2.5 to 3 m, Scala: 22 mm/blow	moist	LOESS
				3.2			Total Depth = 3 m		

PURPOSE:	Logged By:	MTW
	Checked Date:	
PHOTO REF.:	Sheet:	1 of 1

EXCAVATION LOGS (hand-dug test pits)

See Fig 1 for locations.

Date: 15 Feb 2005
Job No. 890917

TP 3

0 – 0.2 m	TOPSOIL (organic silt with plant fragments).
0.2 m +	LOESS **(Scala = <13 mm/blow)** – light brown to yellow brown very stiff SILT with occasional roots.

TP 4

0 – 0.3 m	TOPSOIL (organic silt with plant fragments)
0.3 m +	LOESS **(Scala = 19 mm/blow)** – light brown to yellow brown stiff SILT with occasional roots.

TP 5

0 – 0.25 m	TOPSOIL (organic silt with plant fragments)
0.25 m +	LOESS **(Scala = <11 mm/blow)** – light brown to yellow brown very stiff SILT with occasional roots.

TP 6

0 – 0.2 m	TOPSOIL (organic silt with plant fragments)
0.2 m +	LOESS **(Scala = <12 mm/blow)** – light brown to yellow brown very stiff SILT with occasional roots.

TP 7

0 – 0.1 m	TOPSOIL (organic silt with plant fragments)
0.1 m +	LOESS **(Scala = <8 mm/blow)** – light brown to yellow brown very stiff SILT with occasional roots.

TP 8

0 – 0.3 m	TOPSOIL (organic silt with plant fragments)
0.3 m +	LOESS **(Scala = <13 mm/blow)** – light brown to yellow brown very stiff SILT with occasional roots.

TP 9

0 – 0.2 m	TOPSOIL (organic silt with plant fragments)
0.2 m +	LOESS **(Scala = <13 mm/blow)** – light brown to yellow brown very stiff SILT with occasional roots.

TP 10

0 – 0.2 m	TOPSOIL (organic silt with plant fragments)
0.2 m +	LOESS **(Scala = <12 mm/blow)** – light brown to yellow brown very stiff SILT with occasional roots.

TP 11

0 – 0.3 m	TOPSOIL (organic silt with plant fragments)
0.3 m +	LOESS **(Scala = <16 mm/blow)** – light brown to yellow brown stiff SILT with occasional roots. Loess in this vicinity contains under-runners observed to 1m deep and 0.5m wide.

TP 12

0 – 0.25 m	TOPSOIL (organic silt with plant fragments)
0.25 m +	LOESS **(Scala = <16 mm/blow)** – light brown to yellow brown stiff SILT with occasional roots.

TP 13

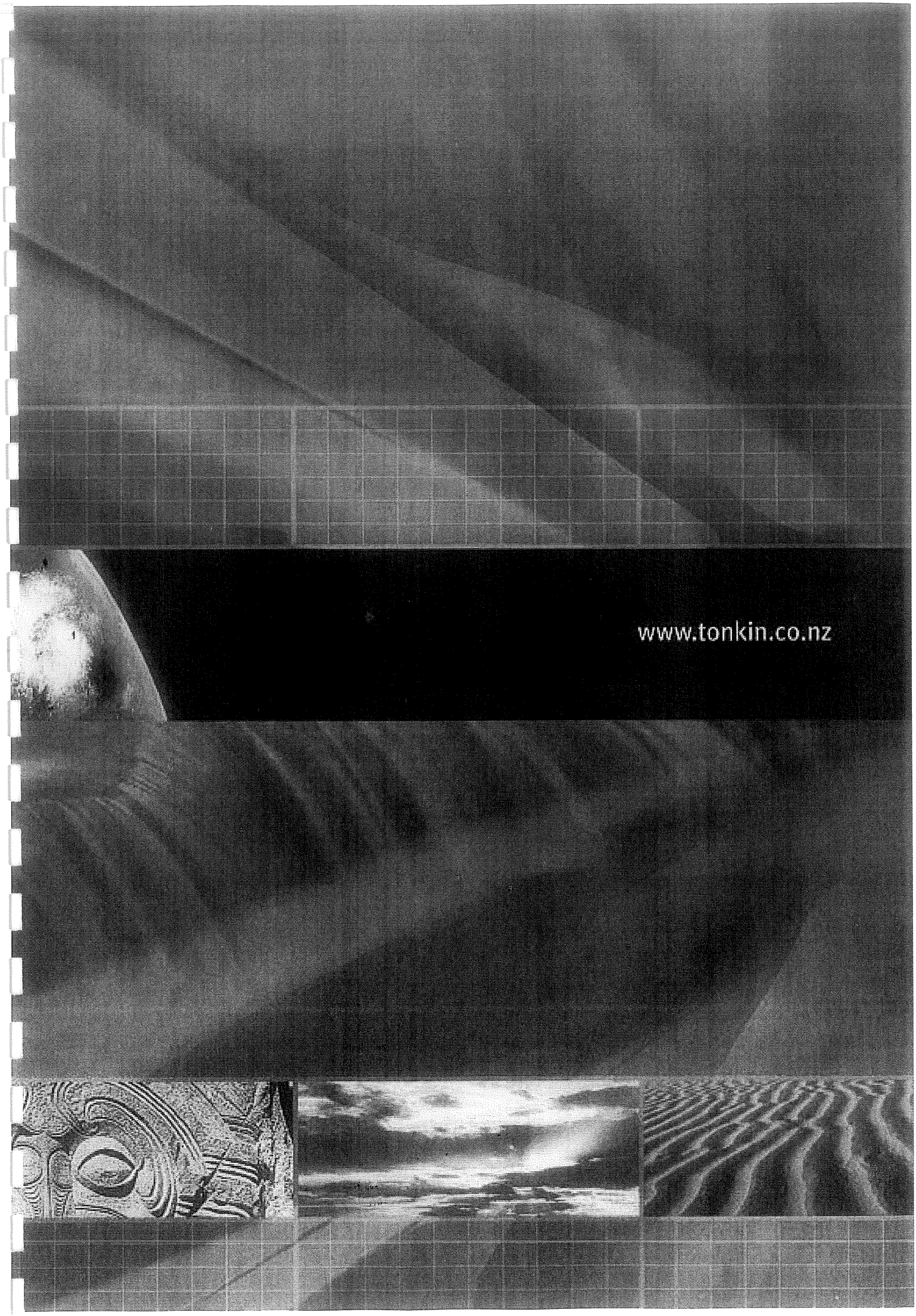
0 – 0.2 m	TOPSOIL (organic silt with plant fragments)
0.2 m +	LOESS **(Scala = <13 mm/blow)** – light brown to yellow brown very stiff SILT with occasional roots.

TP 14

0 – 0.25 m	TOPSOIL (organic silt with plant fragments)
0.25 m +	LOESS **(Scala = <13 mm/blow)** – light brown to yellow brown very stiff SILT with occasional roots.

TP 15

0 – 0.25 m	TOPSOIL (organic silt with plant fragments)
0.25 m +	LOESS **(Scala = <12 mm/blow)** – light brown to yellow brown very stiff SILT with occasional roots.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