

Rangitaiki River Stopbanks Assessment

Section 2

Left Bank 9100 to 9300m

Prepared for

Environment Bay of Plenty

April 2006



Contents

1	Introduction	1
2	Site Description	1
3	Subsurface Investigations	1
4	Laboratory Test Results	2
5	Analyses	
	5.1 Discussion	3
	5.2 Flood Hydrograph	3
	5.3 Soil Model	3
	5.4 Cross Section 2	4
	5.5 Cross Section 1	5
	5.6 Cross Section 3	6
7	Conclusions	6

Figures

- Figure 1 Plan
- Figure 2 Cross Section 2
- Figure 3 Cross Section 1
- Figure 4 Cross Section 3
- Figure 5 100 Year Flood Flow Hydrograph
- Figure 6 Cross Section 2 Seepage Analysis

Appendices

- Appendix A Hand Auger Logs
- Appendix B Laboratory Tests

1 Introduction

Twelve potential problem areas have been identified along the Rangitaiki River stopbanks (Ice Geo & Civil Report, September 2005). This report addresses the area considered to be the second most critical, the left bank from 9100m to 9300m.

This report presents the following information:

- the results of insitu investigations,
- the results of laboratory tests,
- the results of seepage analyses for the 100 year return period flood and
- a possible remedial measure.

This report is the property of our client, Environment Bay of Plenty and Ice Geo and Civil. The comments within relate only to the length of stopbank along the Rangitaiki River left bank from 9100 to 9300m.

2 Site Description

During the flood of July 2004 the residents of 163 College Road noted that the ground at the back of the house became spongy. Following the flood some paving stones and a corner of a deck sank. There were no observations of dirty water flowing from the ground. This site is close to the northern boundary of the Edgecumbe urban area and is about 60m from the District Council sports fields.

At this location the stopbank is at RL6.2 and there is a very narrow or no river berm. Where there is a berm it has been used as a borrow area and the upper natural low permeability layers have been removed. There is typically about 20m between the landward toe of the stopbank and the back boundaries of the houses along College Road (Figure 1). There is a fall of up to 1.4m from the toe of the stopbank to the edge of College Road about 100m away. The lack of a river berm and the fall away from the stopbank could contribute to this length of stopbank being less stable than other areas.

3 Subsurface Investigations

The insitu investigations initially consisted of six hand augers continued to up to 5.4m depth. Two further hand augers were carried out upstream and downstream of the initial augers to check the extent of the required remedial measures. Figure 1 shows the location of the holes and the hand auger logs are included in Appendix A.

Figures 2 to 4 show the assumed soil profiles of three sections through the stopbank. The sections were surveyed by EBoP staff. Table 1 summarises the soil layers found on an approximate long section behind the stopbank.

Table 1: Soil Profile

(depths to base of layer (m))					
auger	HA8	HA5	HA2	HA6	HA7
distance (m)	0	35	58	79	114
silt	0.8	0.6	0.8	0.8	0.75
fine sandy silt	1.4	1.6	1.2	1.1	1.1
silty fine sand	1.6	1.8	1.6	1.8	2.1
fine sandy silt	1.8	2.0	2.0	2.0	
silty fine – med sand	2.3	2.3		2.1	
fine sandy silt	2.5				2.7
grey silt	2.75	2.7	2.7	2.6	
fine sand	2.9	3.0	2.95	2.9	3.0
pum silt, rare lapilli	>4.0	>4.0	>5.4	>4.0	3.6
silty fine sand					>3.9

The surface silt layer was found to be 0.6 to 1.0m thick, typically 0.8m. This is underlain by a 0.3 to 1.0m thick layer of sandy silt with a moderately low permeability. There is a general trend of increasing thickness of these two layers in the upstream direction. Below these upper layers are multiple layers of silty sands, silts and fine to medium sand. Some of the silt layers contain organic material. The highest permeability layer is considered to be the layer of fine sand found at about 2.7m depth and typically 300mm thick. There are predominantly silts below this layer. Some fine pumice lapilli were found at depth but these seemed to be mixed with a pumiceous silt.

The ground water level was found to be between about 2.5 and 3.0m depth in November.

4 Laboratory Test Results

Hydrometer particle grading tests were carried out on four samples from the hand augers (Appendix B). These were to provide information on the permeability of the soil layers. The grading test results are summarised in Table 2.

Table 2: Particle Grading Results

Sample	Description	D₁₀ (mm)	D₆₀ (mm)
HA1 1.9m	brown silt, trace clay	0.0018	0.016
HA1 2.6m	brown silty fine sand /sandy silt	0.0085	0.07
HA2 1.6m	brown fine sandy silt	0.006	0.055
HA3	stopbank fill	0.003	0.04

5 Analyses

5.1 Discussion

The hand augers carried out provide subsoil profiles in only isolated locations. The hand auger logs show considerable variation in the soil layers and it is possible that in terms of the seepage response to a flood in the river there are worse combinations of soil layers than those identified. The seepage analyses carried out must therefore be considered indicative only.

The problem identified on site appears to be one of heave. The most common remedial measures for heave are the addition of a surcharge on the ground surface or the construction of a pressure relief trench (or wells). At the College Road location the use of a surcharge is impractical due to the number of buildings within the area of the potential problem. The use of a pressure relief trench between the back boundaries of the properties and the toe of the stopbank has therefore been investigated. The resulting reduction in uplift pressure beneath the critical low permeability surface layer is small but may be enough to prevent uplift problems in areas where the surface layer is thinner than average, or it has been affected by building activities. Any reduction in water pressure will reduce the unquantifiable risk of concentrated seepage at the edge of concrete floors and foundations causing piping problems.

5.2 Flood Hydrograph

EBoP has provided a 100 year return period flood flow hydrograph for the Rangitaiki River at their benchmark number 22 (Figure 5). This is an eight day hydrograph which rises to a peak of RL5.8 on the third day of the flood. This would allow about 0.4m of freeboard at the site. In the 100 year flood the water level stays close to the peak level for two days before beginning to drop. During the July 2004 the residents say the water was close to the top of the stopbank but the level was high for less than a day with a rapid drop due to the breach upstream of Edgecumbe.

5.3 Soil Model

The soil layers found in the hand augers were simplified in the models used for the seepage and stability analyses (Figure 6). The thin layers of silts, silty sands and sandy silts were modelled as one layer with a representative horizontal permeability but a lower vertical permeability. The various silt layers beneath the fine sand were also combined. Table 3 summarises the saturated soil parameters assumed. Some sensitivity analyses were carried out varying the permeabilities and vertical to horizontal permeability ratios. It was conservatively assumed that there is a layer of pumice lapilli below the depth of investigations.

The Geo-Slope Seep/W (Version 5) computer package used for the seepage analyses contains a library of soil grading curves with corresponding hydraulic conductivity and water content versus water pressure relationships. The particle gradings observed on site were compared to those in the Seep library and the closest fit chosen as the soil model to be used in the seepage analysis.

Table 3: Assumed Soil Permeabilities

layer	soil	k_h (m/s)	k_v (m/s)	k_v/k_h
1	stopbank fill	2×10^{-6}	1×10^{-6}	0.5
2	brown silt	5×10^{-7}	5×10^{-7}	1.0
3	sandy silt	5×10^{-6}	5×10^{-6}	1.0
4	layered sandy silt/silt/silty sand	1×10^{-5}	1×10^{-6}	0.5
5	fine sand	1×10^{-5}	1×10^{-5}	1.0
6	silt with organics	5.0×10^{-7}	5.0×10^{-7}	1.0
7	sandy lapilli	1×10^{-4}	5×10^{-5}	0.5

5.4 Cross Section 2

Seepage

Cross Section 2 is in the middle of the area investigated and runs through 163 College Rd. As this was where problems were observed in July 2004 this cross section was analysed first.

An initial static seepage analysis was carried out assuming a ground water level of RL2.1 on the inland side of the model and a river level of RL2.0. A transient seepage analysis was then carried out modelling the full eight days of the 100 year flood. A two hour time step was used.

An allowance was made in the soil model for seepage from the ground surface inland from the stopbank. At about 3.5 days it was found that close to where the paving stones settled the water pressure below the upper silt layer was 8.5 kPa (HA1). The upper silt layer here was found to be 0.7m thick which corresponds to a weight of about 11kPa. If the silt layer is only 0.6m thick as found in some other places the soil weight would be only 9kPa and the factor of safety against heave less than 1.1. This small difference between the weight of the silt and the pressure below it would account for the spongy feel of the ground. Some shallow excavation could have been carried out for the placement of paving stones which would have allowed increased seepage through the silt layer.

The water pressures below the silt layer appear to decrease in both directions away from the location of HA1. The estimated maximum exit gradient from the ground surface is 0.2 which is not considered great enough to cause piping.

If water can not escape from the ground surface due to an impermeable surface such as a concrete slab, the water pressure could build up to more

than twice that when surface seepage is allowed. Seepage could then be concentrated at an edge or crack, possibly causing some loss of fine soil particles.

Remedial Measures

An analysis was carried out modelling a pressure relief trench about 3m deep reaching into the fine sand layer. The trench was located about 10m away from the toe of the stopbank. It was found that the water pressure below the upper silt at the HA1 location was reduced sufficiently to increase the factor of safety against heave to 1.2 if the silt is only 0.6m thick.

A rough estimate of the amount of seepage from the trench is 1m³ per lineal metre of trench over the eight day duration of the flood.

Stability

The steepest part of the river bank within the study section appears to be at Cross Section 2 where it is standing at 37°. A stability analysis was carried out simulating the end of the flood peak with a high water table within the stopbank and the river at RL4.2. The assumed soil parameters are given in Table 4:

Table 4: Assumed Soil Parameters

layer	soil	density (kN/m ³)	effective cohesion (kPa)	friction angle (degrees)
1	stopbank fill	16	2	33
2	brown silt	15.5	5	27
3	sandy silt	15.5	2	27
4	layered sandy silt/silt/silty sand	15.5	2	30
5	fine to medium sand	14	0	35
6	silt with organics	15.5	5	27
7	sandy lapilli	15	0	35

The minimum factor of safety obtained for a circular failure surface within the river bank was 1.8. The minimum factor of safety for a failure which included the stopbank crest was 2.1. Stopbank stability is therefore considered to be acceptable.

5.5 Cross Section 1

Cross Section 1 is at the HA5 location, 23m upstream from Cross Section 2. The upper two low permeability layers are about 400mm thicker than at Cross Section 2. A seepage analysis was carried out using the same seepage parameters as for Cross Section 2. The maximum pressure found beneath the upper silt layer was 7kPa. If the silt layer is only 600mm thick, as at HA5,

this would give a factor of safety against heave of 1.3, compared to 1.1 at Cross Section 1. The maximum hydraulic exit gradient was estimated at 0.5.

HA8 was augered 35m upstream of Cross Section 1 to check the thickness of the upper low permeability layers. The upper silt was found to be 800mm thick and there were no clean sand layers within the depth of auger hole. It is therefore considered that remedial measures are not required beyond HA5.

5.6 Cross Section 3

Cross Section 3 is at the HA6 location, 21m downstream from Cross Section 2. The upper two low permeability layers are about 100mm thinner than at Cross Section 2. The seepage analysis estimated a maximum pressure beneath the upper silt layer of 10kPa which gives a factor of safety against heave of about 1.2 if the silt layer is 800mm thick. The introduction of a pressure relief well 10m from the toe of the embankment improves the factor of safety to 1.3.

HA7 was augered 35m downstream of HA6 and it was found that the soils are predominantly silty sands or sandy silts with only thin layers of clean sand and silt. Cross Section 3 was modified to reflect the HA7 soil profile and it was found that pressures up to 9.5kPa could be developed below the upper silt. The upper silt layer at HA7 was 750mm thick which gives a factor of safety against heave of 1.2.

It is therefore considered that a pressure relief trench should extend from the boundary of the sports field upstream to HA5.

7 Conclusions

1. The investigations and analyses carried out confirm that within the study length there are potential problems with heave of the surface silt layer where this is slightly thinner than average.
2. The construction of a 2.5m deep pressure relief trench about 10m from the toe of the stopbank should make sufficient reduction in the seepage pressures at the back of the neighbouring properties and to increase the factor of safety against heave to 1.2.
3. It is considered that the pressure relief trench should extend upstream about 60m from the playing field boundary to the HA5 location. It is considered that the risk of failure within the playing fields is less than within the private properties as there is no building work to affect the upper silt layer and no impermeable surface which could concentrate seepage flows.

M. O'Halloran
BE, PhD, Dip BA, MIPENZ (Geotechnical), CPEng IntPE

10 April 2006

Appendix A

Hand auger logs

Appendix B

Laboratory Tests

1 Introduction

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5	fine sand	1×10^{-5}	1×10^{-5}	1.0
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7	sandy lapilli	1×10^{-4}	5×10^{-5}	0.5

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A rough estimate of the amount of seepage from the trench is 1m³ per lineal metre of trench over the eight day duration of the flood.

Stability

The steepest part of the river bank within the study section appears to be at Cross Section 2 where it is standing at 37°. A stability analysis was carried out simulating the end of the flood peak with a high water table within the stopbank and the river at RL4.2. The assumed soil parameters are given in Table 4:

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this would give a factor of safety against heave of 1.3, compared to 1.1 at Cross Section 1. The maximum hydraulic exit gradient was estimated at 0.5.

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5.6 Cross Section 3

Cross Section 3 is at the HA6 location, 21m downstream from Cross Section 2. The upper two low permeability layers are about 100mm thinner than at Cross Section 2. The seepage analysis estimated a maximum pressure beneath the upper silt layer of 10kPa which gives a factor of safety against heave of about 1.2 if the silt layer is 800mm thick. The introduction of a pressure relief well 10m from the toe of the embankment improves the factor of safety to 1.3.

HA7 was augered 35m downstream of HA6 and it was found that the soils are predominantly silty sands or sandy silts with only thin layers of clean sand and silt. Cross Section 3 was modified to reflect the HA7 soil profile and it was found that pressures up to 9.5kPa could be developed below the upper silt. The upper silt layer at HA7 was 750mm thick which gives a factor of safety against heave of 1.2.

It is therefore considered that a pressure relief trench should extend from the boundary of the sports field upstream to HA5.

7 Conclusions

1. The investigations and analyses carried out confirm that within the study length there are potential problems with heave of the surface silt layer where this is slightly thinner than average.
2. The construction of a 2.5m deep pressure relief trench about 10m from the toe of the stopbank should make sufficient reduction in the seepage pressures at the back of the neighbouring properties and to increase the factor of safety against heave to 1.2.
3. It is considered that the pressure relief trench should extend upstream ~~about 60m~~ ^{100m} from the playing field boundary to the HA5 location. It is considered that the risk of failure within the playing fields is less than within the private properties as there is no building work to affect the upper silt layer and no impermeable surface which could concentrate seepage flows.

M. O'Halloran
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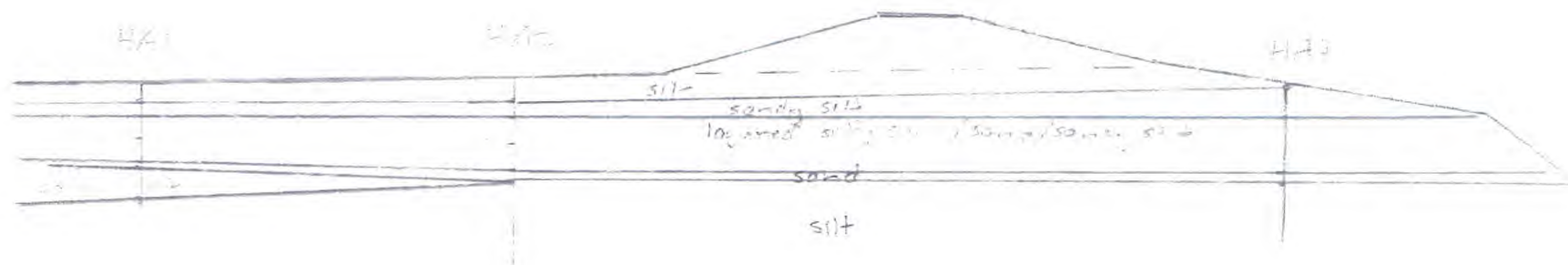
10 April 2006



Figure 1

Plan showing hand auger locations

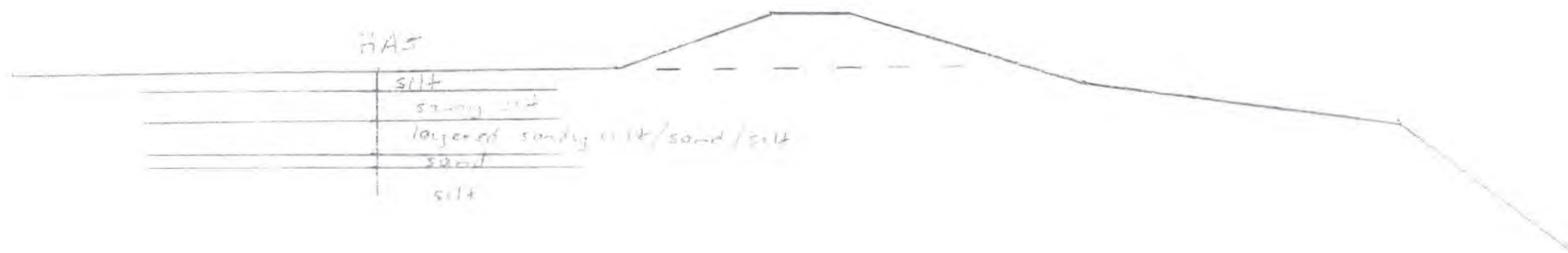


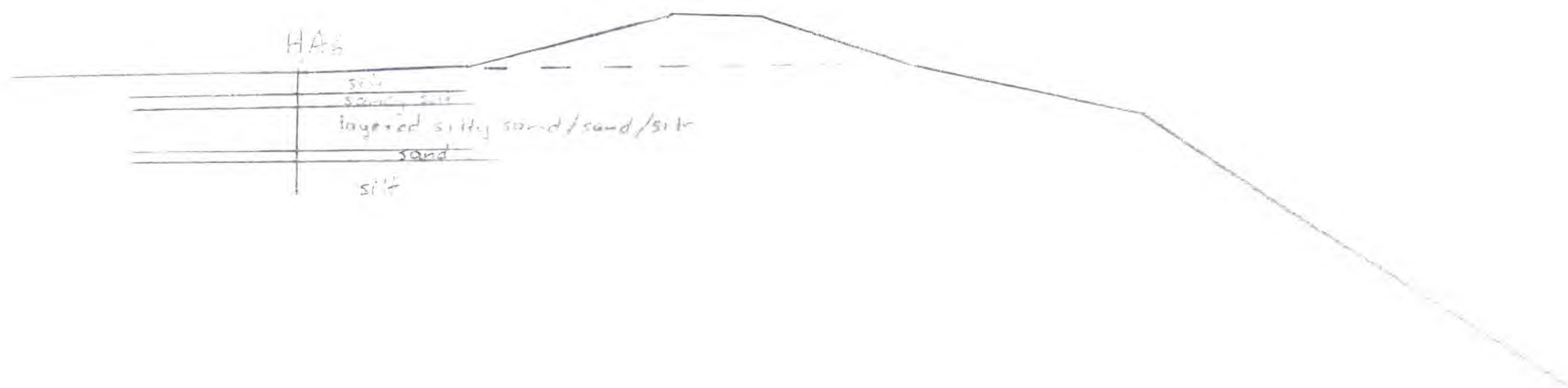


Cross section 2
Scale 1:200

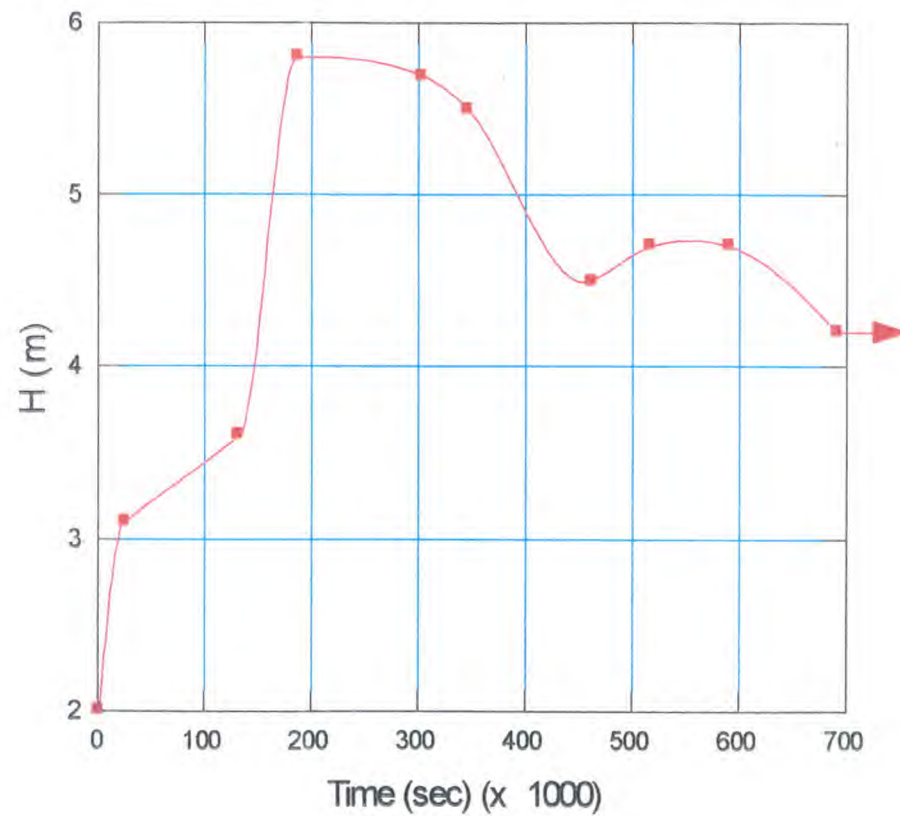
Rangitaiki River Stopbank
Section 2: LB 9100 – 9300m

Figure 2





Cross section 3
Scale 1:200



100 year flood flow hydrograph
Scale 1:200

Figure 6: Cross Section 2 Analysis

Name: section 2 cs2ext 100 yr.gsz

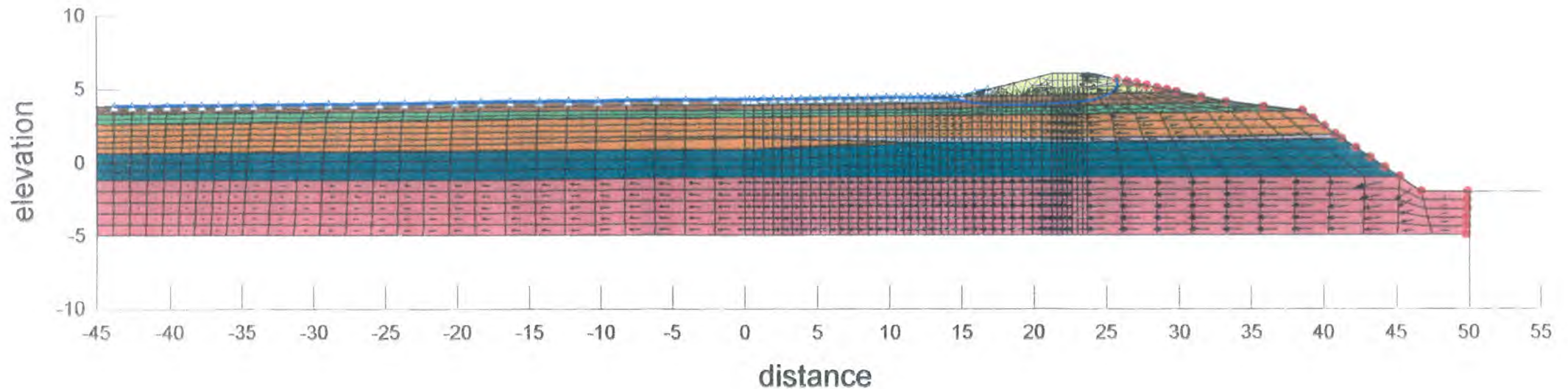
Comments: Cross Section 2 100 yr flood

Name: section 2 cs2ext 100 yr.gsz

Date: 15/02/2006 Time: 9:32:50 a.m.

80 hour time step

Material #:	1	Description:	Hyd K Fn: 1	Vol WC Fn: 1	Ky/Kx Ratio: 0.5	Direction of Kx: 0
Material #:	2	Description:	Hyd K Fn: 2	Vol WC Fn: 2	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #:	3	Description:	Hyd K Fn: 3	Vol WC Fn: 3	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #:	4	Description:	Hyd K Fn: 4	Vol WC Fn: 4	Ky/Kx Ratio: 0.5	Direction of Kx: 0
Material #:	5	Description:	Hyd K Fn: 5	Vol WC Fn: 5	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #:	6	Description:	Hyd K Fn: 6	Vol WC Fn: 6	Ky/Kx Ratio: 1	Direction of Kx: 0
Material #:	7	Description:	Hyd K Fn: 7	Vol WC Fn: 7	Ky/Kx Ratio: 0.5	Direction of Kx: 0



Appendix A

Hand auger logs

Hand Auger Log

Test Number: HA1

Job Name: Rangitahi Section 2

Date: 22/11/05

Tested by: M.OH

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	C _u (kPa)						
0.2									X	X			brown SILT, damp	
0.4									X	X			0.3 brown mottled orange + grey SILT, firm, damp	
0.6									X				0.4 mixed with Taranaki Ash dark grey brown SILT	
0.8									X	X			0.7 grey with some orange staining fine sandy SILT, damp	0.8 +
1.0									X					
1.2									X				1.2 grey with brown staining fine sandy SILT / silty fine SAND, moist	1.5 +
1.4									X				1.6 iron rich layer moist → wet	
1.6									X				1.8 grey fine SAND	
1.8									X				1.85 brown SILT, trace clay + fine sand	1.9 +
2.0									X					
2.2									X				2.5 grey fine SAND, wet	
2.4									X				2.6 grey silty SAND / sandy SILT, trace timber, wet	2.6 +
2.6									X					
2.8									X				3.0 grey sandy SILT with some organics, sparsely	
3.0									X				3.4 green grey SILT	
3.2									X				3.5 fine pumice lapilli	
3.4									X				3.6 EOB. losing sample.	
3.6									X					
3.8									X					
4.0									X					
	0	20	40	60	80	100	120	C _u (kPa)						

Hand Auger Log

Test Number: HAZ

Job Name: Rangitahiri Section 2

Date: 22/11/05

Tested by: M.O.H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	Cu(kPa)						
0.2									X	X			brown SILT	
0.4									X	X			0.3 some Torowaro Ash	
0.6									X	X			0.5 dark grey brown SILT,	
0.8									X	X			damp.	
1.0									X	X			0.8 grey with some orange	
1.2									X	X			staining fine sandy SILT,	
1.4									X	X			damp	
1.6									X	X			1.2 grey with brown staining	
1.8									X	X			fine sandy SILT/silty fine	
2.0								1.9	X	X			SAND, moist.	
2.2									X	X			1.6 brown stained grey	
2.4									X	X			fine sandy SILT	
2.6									X	X			2.0 orange stained grey	
2.8									X	X			SILT, wet, sensitive.	
3.0									X	X			spongy	
3.2									X	X			2.7 grey fine SAND, wet	
3.4									X	X			2.8 grey fine to med. SAND	
3.6									X	X			2.95 grey SILT with some	
3.8									X	X			organics	
4.0									X	X			3.5 becoming lighter grey	
									X	X			with pinkish marbling	
									X	X			5.4 EOB losing sample.	

Hand Auger Log

Test Number: **HA3**

Job Name: **Rangitiki
Section 2**

Date: **22/11/05**

Tested by: **N.O.H**

Blows/50mm		soil description	
m	C _u (kPa)		
0.2		X	brown fine sandy SILT
0.4		X	0.2 grey brown fine sandy SILT, hard
0.6		X	0.5 EOB, hard
0.8			
1.0			
1.2			
1.4			
1.6			
1.8			
2.0			
2.2			
2.4			
2.6			
2.8			
3.0			
3.2			
3.4			
3.6			
3.8			
4.0			

C_u (kPa)

Hand Auger Log

Test Number: HA4

Job Name: Rangitiki
Section 2

Date: 22/11/05

Tested by: N.O.H

		Blows/50mm										C _u (kPa)	soil description
m		0	2	4	6	8	10	12					
												X X	brown SILT
0.2												X X	0.1 brown & light grey mottled fine sandy SILT, fill?
0.4												X X	0.4 dark brown fine sandy SILT, damp
0.6												X X	0.5 brown & grey mottled natural sand? silty fine SAND, damp
0.8												X X	0.6 brown & grey fine sandy SILT
1.0												X X	1.0 orange mottled grey silty fine SAND
1.2												X X	1.2 grey fine SAND, light
1.4												X X	1.4 orange staining, damp.
1.6												X X	1.5 orange stained grey silty fine SAND
1.8												X X	1.8 grey SILT, some organics
2.0												X X	moist → wet.
2.2												X X	2.0 grey fine SAND, moist
2.4												X X	2.1 grey fine sandy SILT, moist
2.6												X X	2.5 grey fine → med. SAND
2.8												X X	2.6 grey silty fine → med SAND
3.0												X X	2.8 grey SILT, some organics, moist
3.2												X X	
3.4												X X	
3.6												X X	
3.8												X X	
4.0												X X	4.1 light pinkish grey SILT
												X X	4.3 grey SILT
												X X	4.4 pocket fine sand. lepili over brown silty fine SAND with organics

Hand Auger Log

Test Number: HA5

Job Name: Rangitikei
Section 2

Date: 22/11/05

Tested by: N.O.H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	C _u (kPa)						
													X	brown SILT
0.2													X	
													X	
0.4														0.3 Turawera Ash
													X	
0.6													X	0.4 dark brown grey fine sandy SILT
													X	
0.8													X	0.6 grey mottled orange silty fine SAND/ sandy SILT
													X	
1.0													X	
													X	
1.2													X	
													X	
1.4													X	
													X	
1.6													X	1.6 Fe rich layer, damp-moist
													X	
1.8													X	1.7 grey fine SAND
													X	
2.0													X	1.8 grey with orange staining fine sandy SILT, moist
													X	→ wet
2.2													X	2.0 grey fine → mod. hum. SAND
													X	
2.4													X	2.3 grey SILT, wet
													X	
2.6													X	
													X	
2.8													X	2.7 grey fine SAND, wet
													X	
3.0													X	
													X	3.0 grey SILT, some organics
3.2													X	
													X	
3.4													X	
													X	
3.6													X	
													X	
3.8													X	3.7 some fine lapilli + purplish grey mottles
													X	3.8 light purplish grey SILT
4.0													X	3.9 grey SILT
													X	4.0 EOB

Hand Auger Log

Test Number: HA 6

Job Name: Rangitikei
Section 2

Date: 22/11/05

Tested by: NCH

Blows/50mm										soil description
in	0	2	4	6	8	10	12	C _u (kPa)		
0.2									X X	brown SILT
0.4									X X-X	0.3 orange mottled grey SILT + Taranaki Ash
0.6									X X	0.5 dark brown / grey SILT damp
0.8									X X	0.8 orange stained light grey fine SAND, some silt
1.0									X X-X	0.9 orange mottled grey fine sandy SILT, damp
1.2									X X	1.1 orange stained grey fine silty SAND
1.4									X X	1.6 Fe incl layer
1.6									X X	1.8 orange stained grey SILT
1.8									X X	2.0 grey fine SAND
2.0									X X	2.1 orange stained grey SILT
2.2									X X	2.6 grey fine SAND
2.4									X X	2.7 grey fine med. SAND
2.6									X X	2.8 grey fine SAND
2.8									X X	2.9 grey SILT, some organics, moist, soft
3.0									X X	4.0 EOB
3.2									X X	
3.4									X X	
3.6									X X	
3.8									X X	
4.0									X X	
	0	20	40	60	80	100	120	C _u (kPa)		

Hand Auger Log

Test Number: 14A7

Job Name: Rangitachi Section 2

Date: 26/01/06

Tested by: N.W.H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	Cu(kPa)						
0.2									X					brown SILT, some clay, moist
									X					
0.4										X				0.4
									X	X				dark grey SILT, moist
0.6										X				
									X	X				
0.8										X				0.75 orange stained grey
									X					silty fine SAND/ sandy
1.0										X				silt
									X					1.1
1.2										X				orange stained grey
										X				silty fine sand.
1.4											X			
											X			
1.6											X			
											X			
1.8												X		
												X		
2.0												X		
												X		
2.2										X	X			2.1 grey fine sandy SILT, moist
											X			
2.4										X	X			
											X			
2.6										X	X			
											X			
2.8										X				2.7 orange stained grey silty fine SAND
											X			
3.0										X	X			3.0 brown & grey SILT, some organics, wet
										X	X			3.1 green grey SILT, wet
3.2											X			
											X			3.3 grey fine med pure SAND & w fine lapilli
3.4										X	X			3.35 grey SILT, wet
											X			
3.6										X	X			3.6 grey silty fine SAND
										X				
3.8											X			
											X			
4.0											X			3.9 EOB, losing sample.

Hand Auger Log

Test Number: H A 8

Job Name: Rangitiki Section 2

Date: 27/01/06

Tested by: D.O.H

Blows/50mm													soil description	
m	0	2	4	6	8	10	12	C _u (kPa)						
0.2													X	brown SILT + Tararua Ash dry
													X	
0.4													X	0.4 dark grey SILT, damp
													X	
0.6													X	0.8 orange mottled grey fine sandy SILT, damp
													X	
0.8													X	1.0 orange mottled grey silty fine SAND, damp
													X	
1.0													X	1.2 orange mottled grey silty fine SAND, damp
													X	
1.2													X	1.4 orange mottled grey silty fine SAND, damp
													X	
1.4													X	1.6 orange mottled grey fine sandy SILT
													X	
1.6													X	1.8 orange mottled grey silty fine → med SAND
													X	
1.8													X	2.0 orange mottled grey fine sandy SILT, moist
													X	
2.0													X	2.2 orange mottled grey SILT, moist, sensitive
													X	
2.2													X	2.4 grey silty fine SAND, med
													X	
2.4													X	2.6 grey SILT, some organics, med
													X	
2.6													X	2.8 light grey pumice SILT, rare fine lapilli
													X	
2.8													X	3.0 EOB
													X	
3.0													X	
3.2													X	
3.4													X	
3.6													X	
3.8													X	
4.0													X	
	0	20	40	60	80	100	120	C _u (kPa)						

Appendix B

Laboratory Tests

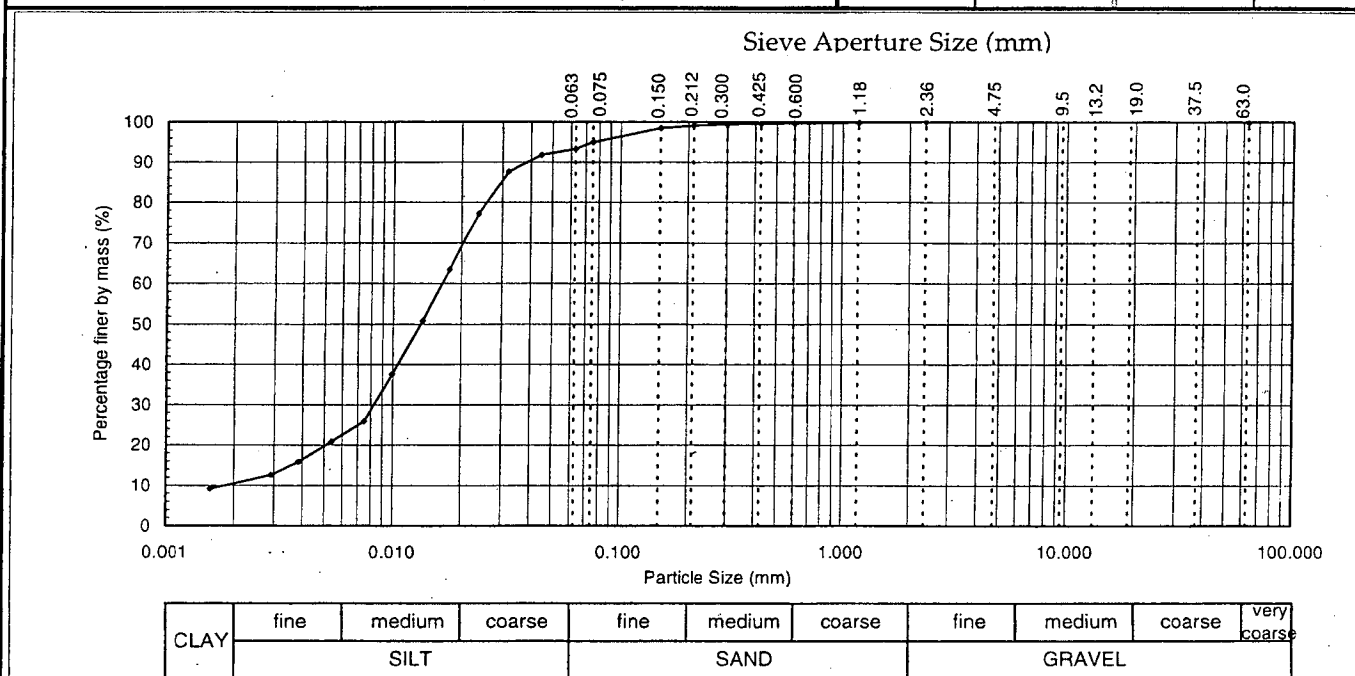
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT



Project : Rangitaiki Stopbanks-Section 2
 Location : Rangitaiki
 Client : Ice Geo & Civil Ltd, Papamoa
 Client/Sample Ref :
 Contractor :
 Hole No: HA1 Depth: 1.90 metres
 Sampled by : Client
 Date received : 5/12/05
 Sampling method : Sample bag
 Sample condition : As received
 Sample description : Brown Silt. Trace clay and fine sand.
 Solid Particle Density (t/m³): 2.44 Assumed
 Water Content (as received): 52.4 %

Project No: 2-68229.82
 Lab Ref No: 05/229/004
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	99	0.0445	92	0.0075	26
37.5	--	2.36	100	0.212	99	0.0320	88	0.0054	21
19.0	--	1.18	100	0.150	98	0.0237	77	0.0039	16
13.2	--	0.600	100	0.075	95	0.0177	63	0.0029	13
9.5	--	0.425	100	0.063	93	0.0135	51	0.0016	9
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0100	38		



Test Methods:	Notes:
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)	
Particle Size Analysis: NZS 4402 1986 Test 2.8.4 (Hydrometer)	pH of suspension : 8.0 Whatmans Full Range pH indicator paper

Date Tested: 8/12/05

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Date Reported: 9/12/05

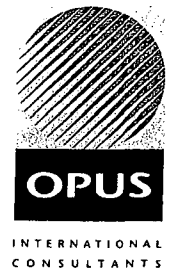
IANZ Approved Signatory

Designation : Senior Civil Engineering Technician
 Date : 9/12/05



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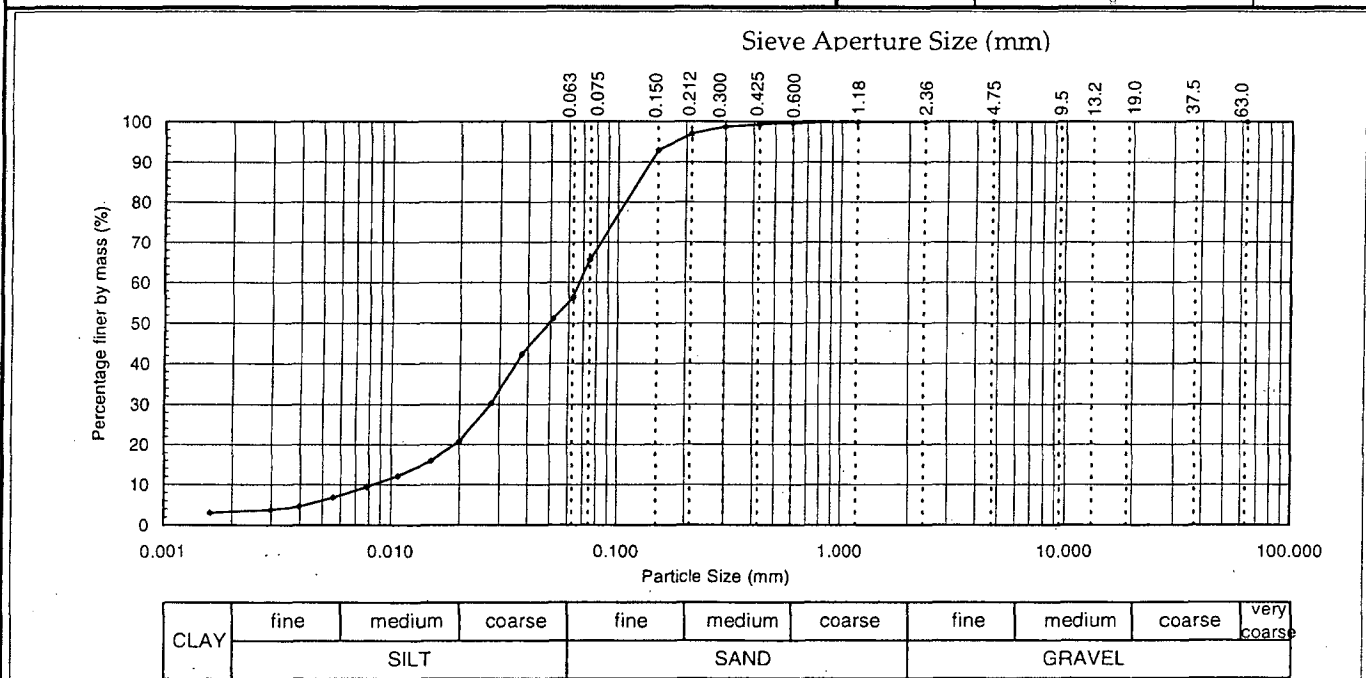
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT



Project : Rangitaiki Stopbanks-Section 2
 Location : Rangitaiki
 Client : Ice Geo & Civil Ltd, Papamoa
 Client/Sample Ref :
 Contractor :
 Hole No: HA1 Depth: 2.60 metres
 Sampled by : Client
 Date received : 5/12/05
 Sampling method : Sample bag
 Sample condition : As received
 Sample description : Dk. Brown fine sandy Silt.
 Solid Particle Density (t/m^3): 2.44 Assumed
 Water Content (as received): 56.5 %

Project No: 2-68229.82
 Lab Ref No: 05/229/004
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	100	0.300	99	0.0513	51	0.0078	9
37.5	--	2.36	100	0.212	97	0.0375	42	0.0056	7
19.0	--	1.18	100	0.150	93	0.0276	30	0.0040	5
13.2	--	0.600	100	0.075	66	0.0202	21	0.0030	4
9.5	--	0.425	99	0.063	56	0.0149	16	0.0016	3
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0107	12		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)	
Particle Size Analysis: NZS 4402 1986 Test 2.8.4 (Hydrometer)	pH of suspension : 8.0 Whatmans Full Range pH indicator paper

Date Tested: 8/12/05

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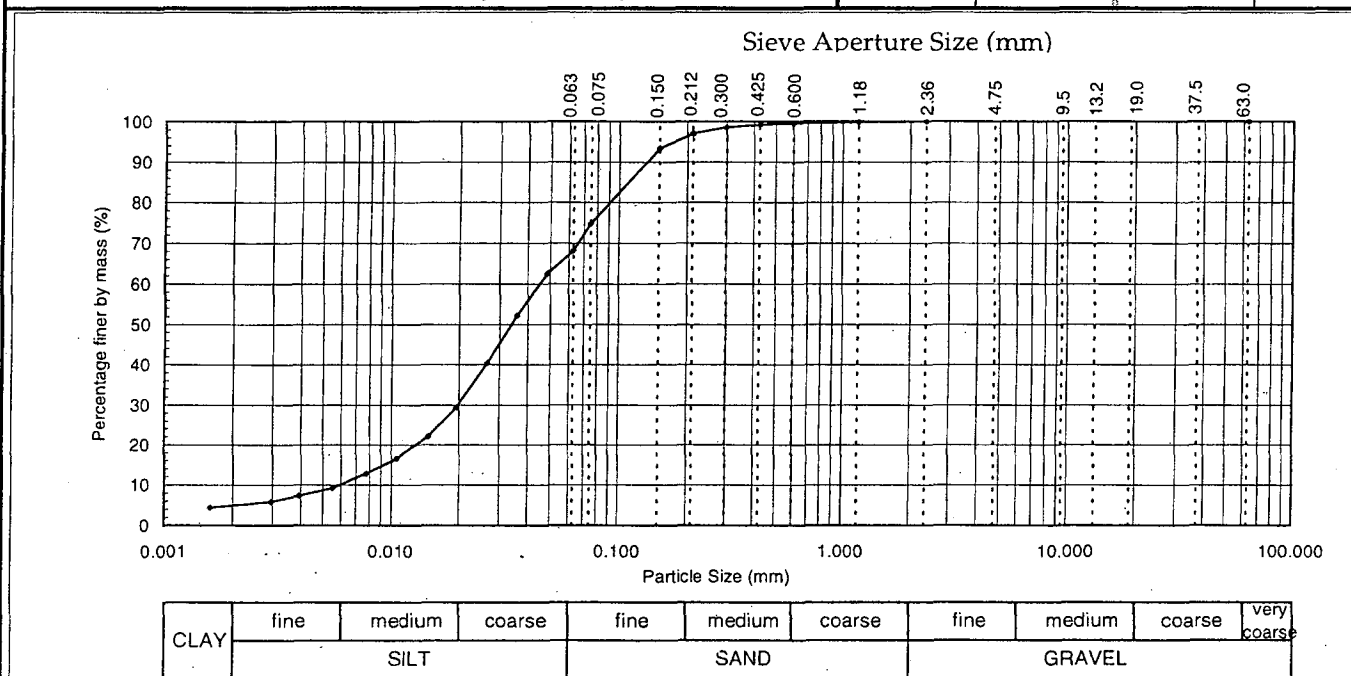
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT

Project : Rangitaiki Stopbanks-Section 2
 Location : Rangitaiki
 Client : Ice Geo & Civil Ltd, Papamoa
 Client/Sample Ref :
 Contractor :
 Hole No: HA2 Depth: 1.60 metres
 Sampled by : Client
 Date received : 5/12/05
 Sampling method : Sample bag
 Sample condition : As received
 Sample description : Brown fine sandy Silt.
 Solid Particle Density (t/m^3): 2.44 Assumed
 Water Content (as received): 46.9 %



Project No: 2-68229.82
 Lab Ref No: 05/229/004
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	99	0.0486	62	0.0077	13
37.5	--	2.36	100	0.212	97	0.0359	52	0.0055	9
19.0	--	1.18	100	0.150	93	0.0266	40	0.0039	7
13.2	--	0.600	100	0.075	75	0.0195	29	0.0030	6
9.5	--	0.425	99	0.063	68	0.0146	22	0.0016	4
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0105	17		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)	
Particle Size Analysis: NZS 4402 1986 Test 2.8.4 (Hydrometer)	pH of suspension : 8.0 Whatmans Full Range pH indicator paper

Date Tested: 8/12/05

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Designation : Senior Civil Engineering Technician

Date : 9/12/05



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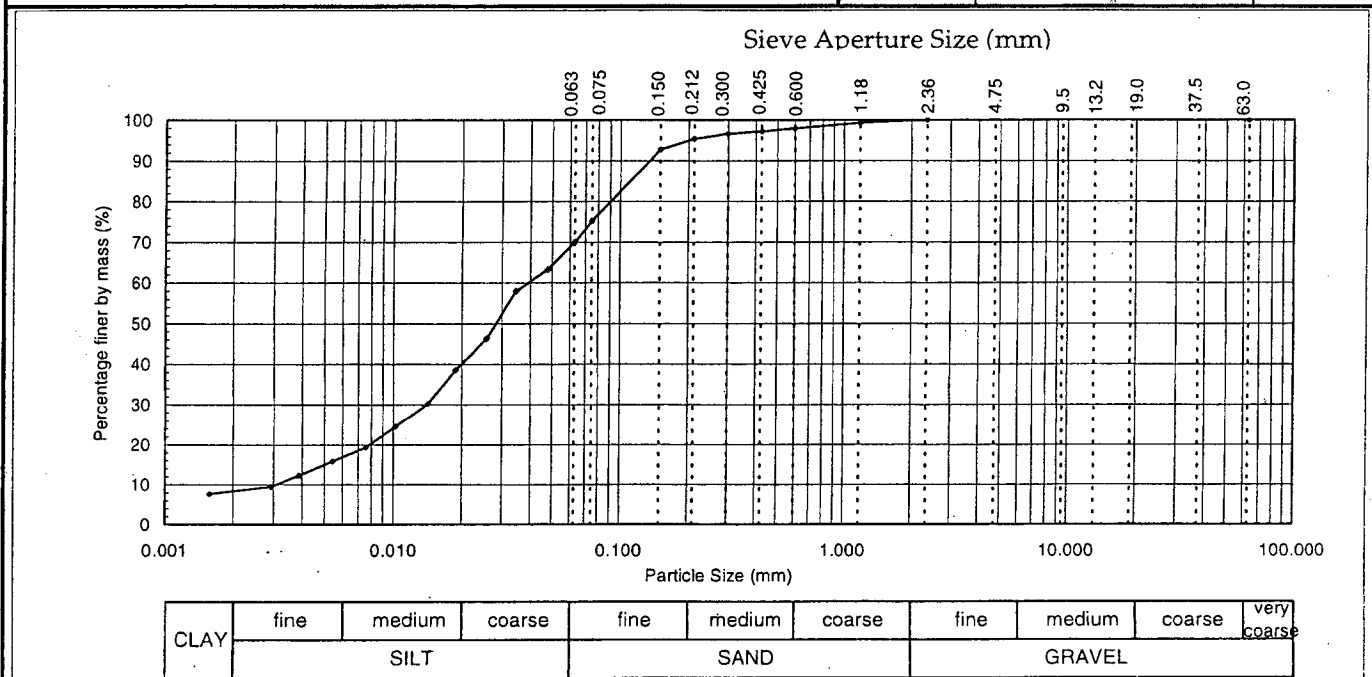
PARTICLE SIZE ANALYSIS (HYDROMETER METHOD) TEST REPORT

Project : Rangitaiki Stopbanks-Section 2
 Location : Rangitaiki
 Client : Ice Geo & Civil Ltd, Papamoa
 Client/Sample Ref :
 Contractor :
 Hole No: HA3 Depth: 0.30 metres
 Sampled by : Client
 Date received : 5/12/05
 Sampling method : Sample bag
 Sample condition : As received
 Sample description : V. dk. Brown fine sandy Silt.
 Solid Particle Density (t/m^3): 2.44 Assumed
 Water Content (as received): 25.3 %



Project No: 2-68229.82
 Lab Ref No: 05/229/004
 Client Ref:

Sieve Analysis						Hydrometer Analysis			
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)	Particle Size (mm)	Passing (%)
63.0	--	4.75	--	0.300	97	0.0478	63	0.0076	19
37.5	--	2.36	100	0.212	95	0.0346	58	0.0054	16
19.0	--	1.18	99	0.150	93	0.0258	46	0.0039	12
13.2	--	0.600	98	0.075	75	0.0188	39	0.0029	9
9.5	--	0.425	97	0.063	70	0.0142	30	0.0016	8
Note: "--" denotes sieve not used and/or hydrometer analysis not tested						0.0102	25		



Test Methods	Notes
Particle Size Analysis: NZS 4402:1986: Test 2.8.4 (Hydrometer Method)	
Particle Size Analysis: NZS 4402 1986 Test 2.8.4 (Hydrometer)	pH of suspension : 8.0 Whatmans Full Range pH indicator paper

Date Tested: 8/12/05

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