SURROUNDING AREA





Site entry to Beach Haven Road



Looking east along Beach Haven Road from site entry - towards Local Centre



Looking west down Beach Haven Road from site entry - towards Ferry. Note: Bus stops in each direction outside of site



Looking east along Beach Haven Road from corner of Cresta Avenue

PUBLIC TRANSPORT





SUBJECT SITE





CURRENT ZONING





PROPOSED ZONING





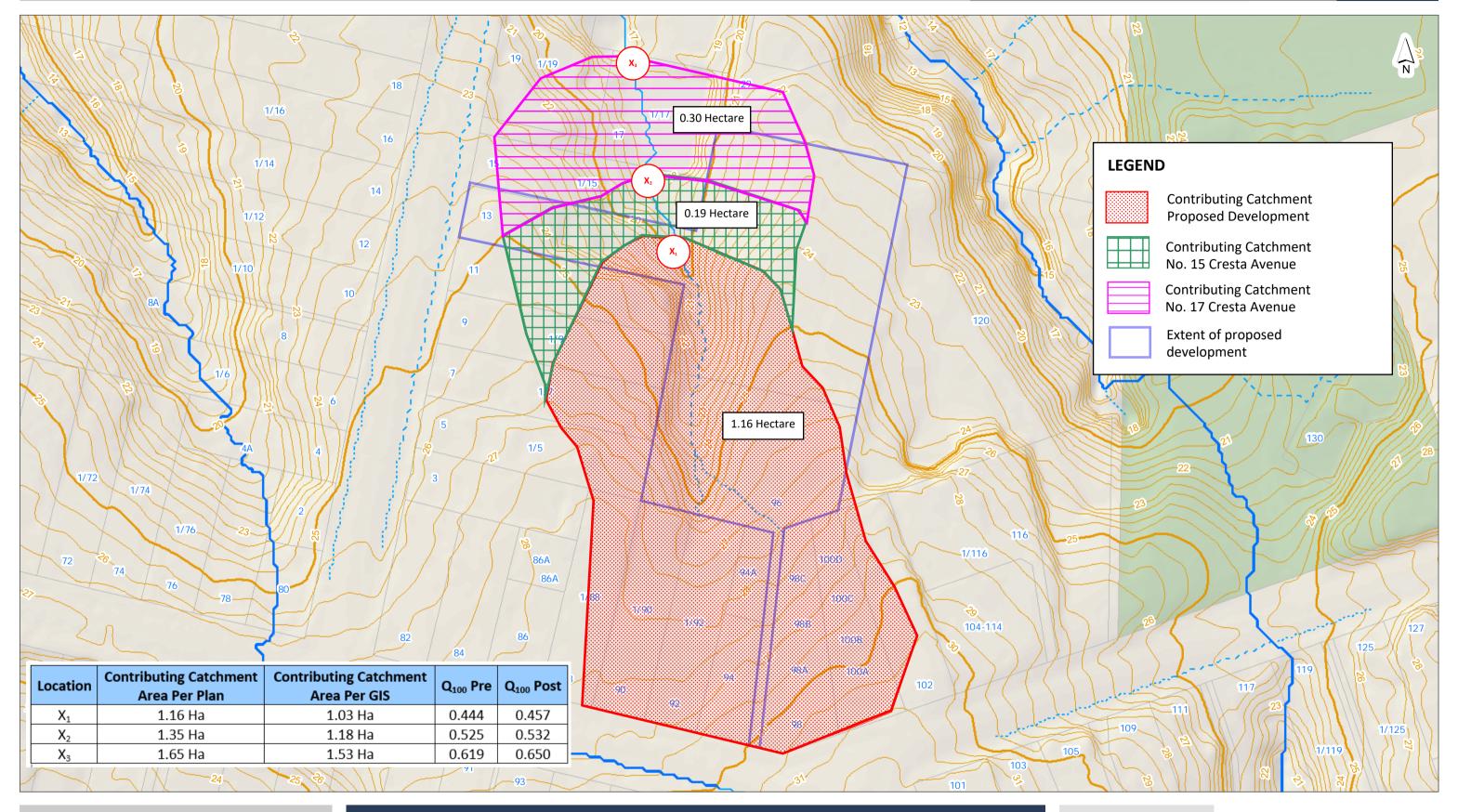
B&A

Urban & Environmental

Appendix C

Engineering Calculations

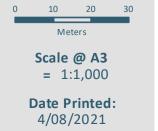
Auckland Council Map



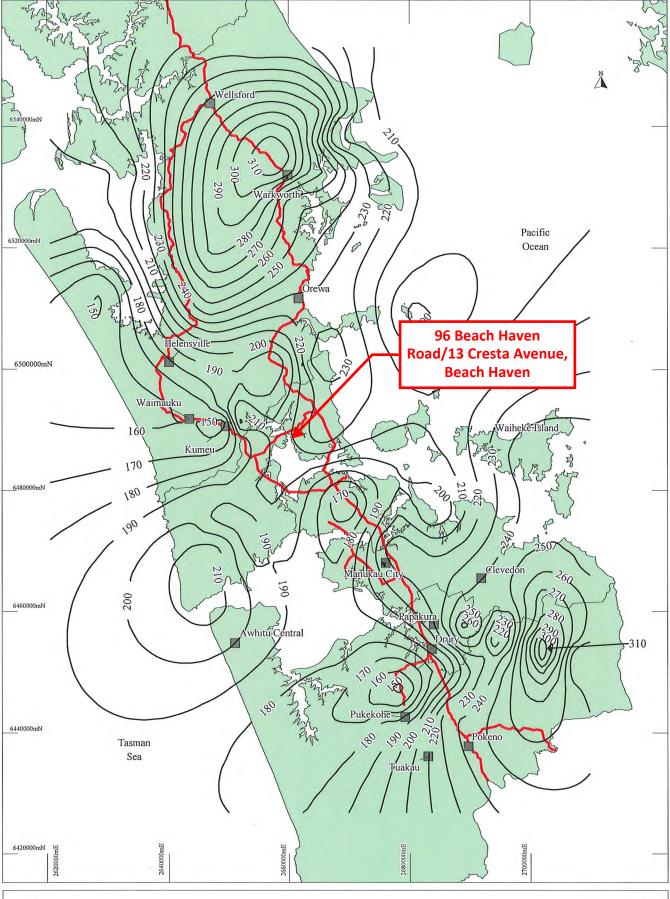
DISCLAIMER:

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Overland Flowpath Catchment Plan









Workspace: N:(civil)\25\2507757\gis\mapinfo\wor\100yrari.wor Date: 25/08/1999

Legend: — 90 — Rainfall Contour (mm)
— State Highways

Figure A.6 100 Year ARI Daily Rainfall Depth

> Scale: 1:600,000 (at A4) (Revised 25/08/1999)



TP108 Rainfall - Overland Flowpath

Job location: 96 Beach Haven Road/13 Cresta Avenue, Beach Haven

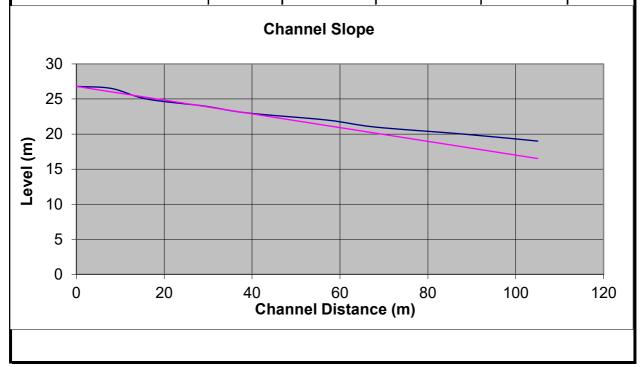
Rainfall Depth 210 mm
ARI 100 years

Duration	Duration	Depth	Intensity
hr	mins	mm	mm/hr (Q ₁₀)
0.166	10.0	28.26	170.22
0.333	20.0	43.45	130.49
0.5	30	53.59	107.19
1	60	75.55	75.55
2	120	102.04	51.02
6	360	156.00	26.00
12	720	200.15	16.68
24	1440	245.28	10.30
48	2880	494.48	10.30
72	4320	741.73	10.30

Job	96 Beach Haven Road/13 Cresta Avenue, Beach Haven
Job No	200626-01
Designer	Natalie Naidoo
Date	6/08/2021

SLOPE CALCULATIONS - EQUAL AREA METHOD - TP10

Description	Level (m)	Incremental distance (m)	Running distance (m)	"Area" from TP108	Average Slope Level
Inlet point	26.8	0	0		27
	26.5	8	8	213.2	26
	25	8	16	206	25
	24	13	29	318.5	24
	23	10	39	235	23
	22	18	57	405	21
	21	11	68	236.5	20
	20	16	88	328	18
	19	17	105	331.5	17
			105	0	17
			105	0	17
			105	0	17
			105	0	17
			105	0	17
Channel length (m) Average Channel Slope	-0.09801		105	2273.7	



Auckland Council Map



DISCLAIMER:

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Overland Flowpath Cross Sections





Hydrographs- SCS Method - Predevelopment flow from Proposed Development

Project Description

96 Beach Haven Road/13 Cresta Avenue
Beach Haven

Rainfall Depth (mm)

245.28 100 YEAR ARI

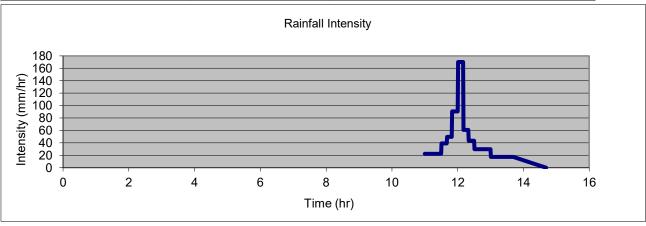
Notes:

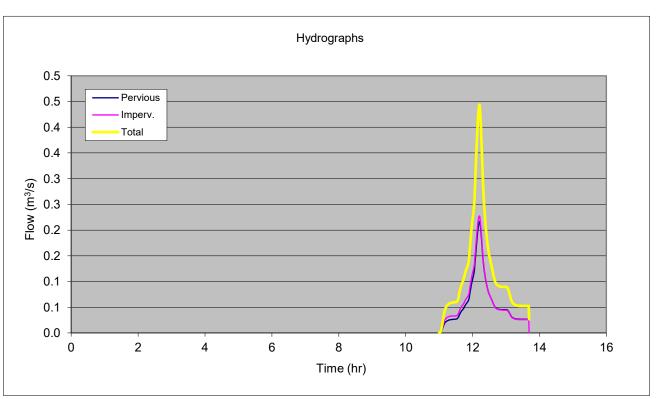
1. Inputs

Catchment Data	Pervious Area	Impervious Area
Area (ha)	0.6264	0.5336
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	101	101
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	89.2	5.2

2. Typical inputs for CN, Ia, CF
are in 'Typical Inputs' Sheet.
3. Method based on ARC TP108.

Outputs			Total
Runoff (mm)	175.2	240.2	205.1
Peak Flow (m ³ /s)	0.216	0.228	0.444
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.83
Runoff Coefficient - Volume	0.71	0.98	0.84





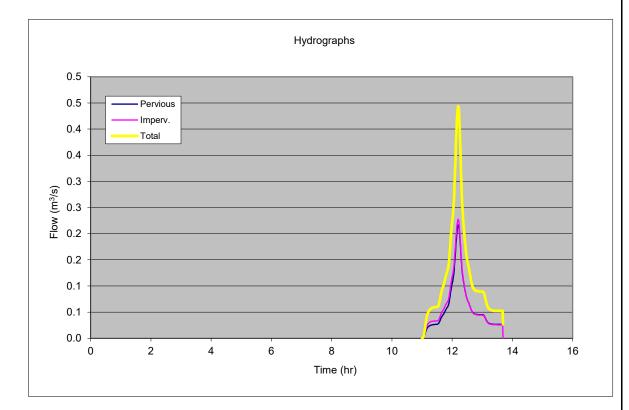
Hydrographs- SCS Method:

Project Description

96 Beach Haven Road/13 Cresta Avenue Beach Haven

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 1.70%



Time (hr)	Flow (m ³ /s)
11.001	0.000
11.347	0.058
11.491	0.060
11.601	0.076
11.694	0.098
11.776	0.115
11.850	0.130
11.918	0.161
11.981	0.210
12.040	0.246
12.096	0.320
12.150	0.403
12.201	0.444
12.230	0.430
12.259	0.387
12.290	0.330
12.320	0.278
12.352	0.240
12.384	0.214
12.417	0.191
12.451	0.170
12.486	0.154
12.522	0.143
12.559	0.133
12.597	0.121
12.637	0.108
12.678	0.099
12.721	0.094
12.767	0.092
12.814	0.090
12.864	0.090
12.917	0.089
12.975	0.089
13.037	0.088
13.106	0.075
13.184	0.060
13.277	0.054
13.398	0.053
13.690	0.027
-1.000	0.000



CHANNEL CAPACITY SECTION PRE-DEVELOPMENT A-A

PROJECT NO: 200626-01

PROJECT NAME: 96 Beach Haven Road/

13 Cresta Avenue

Cross Sections

DATE: 6.08.2021
BY: Natalie Naidoo
REF: Overland Flowpath

INPUTS OUTPUTS

Case (A or B)	В
Case A	

Case AFlow (m³/s) 0.444

 Case B
 10%

 Slope (So)
 10%

 Water level (m)
 23.53

Water level (m) 23.53 0.13
MFFL 23.68

Channel Geo	ometry	Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	23.7	0.03		Short Grass
0.5	23.5	0.03		Short Grass
1	23.4	0.03		Short Grass
2	23.4	0.03		Short Grass
2.5	23.50	0.03		Short Grass
3	23.7	0.03		Short Grass
-1				

The table can input 10 (x,y) co-ordinates. The (x,y) pairs should be in order Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e. $n=(\sum (P_1n_1^{1.5}+....)/P)^{0.67}$

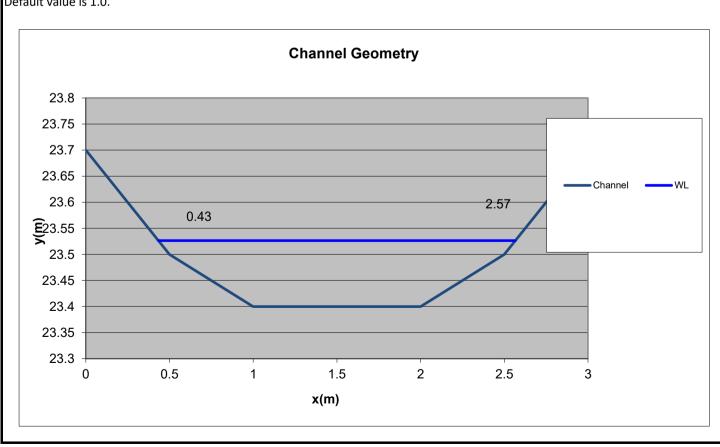
Sinuosity is the relative length of that flow channel element compared to other elements and input S_o . Default value is 1.0.

Normal Flow Conditions	5	
Flow (m ³ /s)	0.445	ОК
Velocity (m/s)	2.173	
S _o or S _f	0.1000	
Energy (m)	23.767	
Froude No	2.239	
Bed Stress (Pa)	92.885	
Equivalent "n"	0.030	
Equivalent k _s (mm)	N/A	

Geometry for wetted conditions		
Depth (d-m)	23.527	
Area (A-m²)	0.205	
Width (B-m)	2.132	
Perimeter (P-m)	2.163	

Critical Flow Conditions		
Flow (m ³ /s)	0.199	INCREASE CH
Velocity (m/s)	0.971	
Energy (m)	23.575	

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5





CHANNEL CAPACITY SECTION PRE-DEVELOPMENT

B-B

PROJECT NO: 200626-01

PROJECT NAME: 96 Beach Haven Road/

13 Cresta Avenue

DATE: 6.08.2021
BY: Natalie Naidoo
REF: Overland Flowpath

Cross Sections

INPUTS OUTPUTS

0.13

Case (A or B)	В	
Case A		
Flow (m ³ /s)	0.444	

 Case B

 Slope (So)
 10%

 Water level (m)
 21.53

MFFL 21.68

Channel Geo	ometry	Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	22	0.03		Short Grass
0.5	21.5	0.03		Short Grass
1	21.4	0.03		Short Grass
2	21.4	0.03		Short Grass
2.5	21.50	0.03		Short Grass
3	22	0.03		Short Grass
-1				

The table can input 10 (x,y) co-ordinates. The (x,y) pairs should be in order Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e. $n=(\sum (P_1n_1^{1.5}+....)/P)^{0.67}$

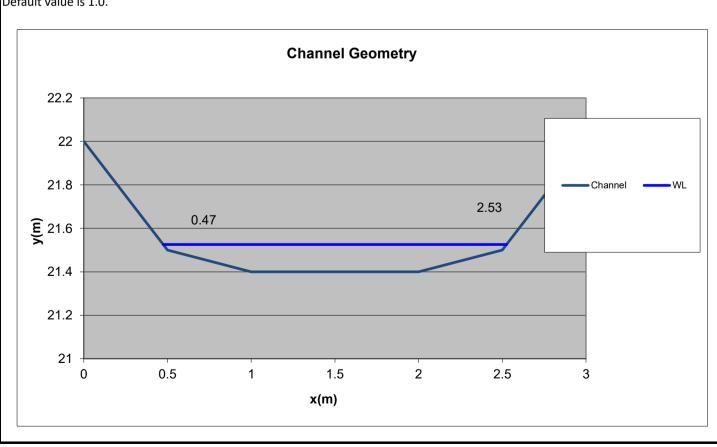
Sinuosity is the relative length of that flow channel element compared to other elements and input S_o . Default value is 1.0.

Normal Flow Conditions	5	
Flow (m ³ /s)	0.445	ОК
Velocity (m/s)	2.201	
S _o or S _f	0.1000	
Energy (m)	21.773	
Froude No	2.240	
Bed Stress (Pa)	94.730	
Equivalent "n"	0.030	
Equivalent k _s (mm)	N/A	

Geometry for wetted conditions		
Depth (d-m)	21.526	
Area (A-m²)	0.202	
Width (B-m)	2.051	
Perimeter (P-m)	2.092	

Critical Flow Conditions		
Flow (m ³ /s)	0.199	INCREASE CH
Velocity (m/s)	0.983	
Energy (m)	21.575	

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5





CHANNEL CAPACITY SECTION PRE-DEVELOPMENT C-C

PROJECT NO: 200626-01

PROJECT NAME: 96 Beach Haven Road/

13 Cresta Avenue

Cross Sections

DATE: 6.08.2021
BY: Natalie Naidoo
REF: Overland Flowpath

OUTPUTS

INPUTS

Case (A or B)	В
Case A	

Case B

Flow (m³/s)

 Slope (S_o)
 10%

 Water level (m)
 20.03

 MFFL
 20.18

0.444

		20.10		
Channel Geo	ometry	Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	20.5	0.03		Property/Parcels
0.5	20.00	0.03		Property/Parcels
1	19.9	0.03		Property/Parcels
2	19.9	0.03		Property/Parcels
2.5	20.00	0.03		Property/Parcels
3	20.5	0.03		Property/Parcels
-1				

The table can input 10 (x,y) co-ordinates. The (x,y) pairs should be in order Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e. $n=(\sum (P_1n_1^{1.5}+....)/P)^{0.67}$

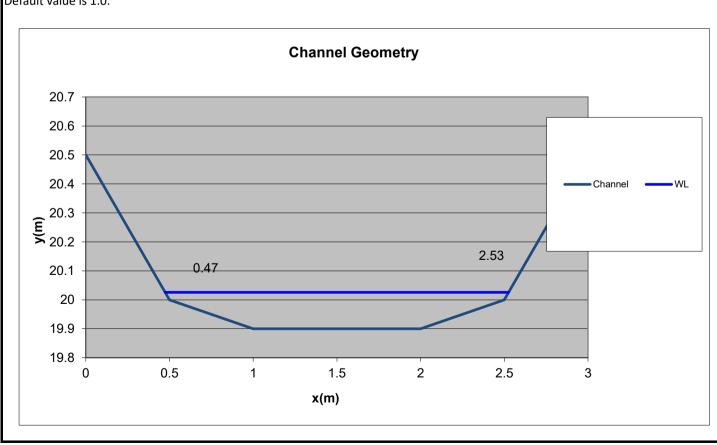
Sinuosity is the relative length of that flow channel element compared to other elements and input $\rm S_{o}$. Default value is 1.0.

Normal Flow Conditions	S	
Flow (m ³ /s)	0.445	ОК
Velocity (m/s)	2.201	
S _o or S _f	0.1000	
Energy (m)	20.273	
Froude No	2.240	
Bed Stress (Pa)	94.730	
Equivalent "n"	0.030	
Equivalent k _s (mm)	N/A	

Geometry for wetted conditions		
Depth (d-m)	20.026	
Area (A-m²)	0.202	
Width (B-m)	2.051	
Perimeter (P-m)	2.092	

Critical Flow Conditions		
Flow (m ³ /s)	0.199	INCREASE CH
Velocity (m/s)	0.983	
Energy (m)	20.075	

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



Hydrographs- SCS Method - Post Development Flow from the Proposed Development

Project Description

96 Beach Haven Road/13 Cresta Avenue
Proposed Development

Rainfall Depth (mm)

245.28 100 YEAR ARI

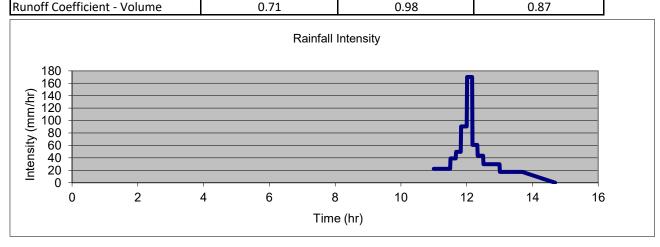
Notes:

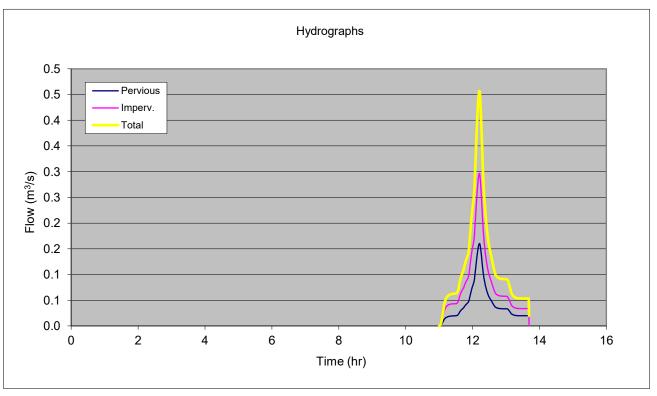
1. Inputs

Catchment Data	Pervious Area	Impervious Area
Area (ha)	0.464	0.696
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	101	101
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	89.2	5.2

2. Typical inputs for CN, Ia, CF are in 'Typical Inputs' Sheet.3. Method based on ARC TP108.

Outputs			Total
Runoff (mm)	175.2	240.2	214.2
Peak Flow (m ³ /s)	0.160	0.297	0.457
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.86
D ff C ff: -: + - \/ -	0.71	0.00	0.07





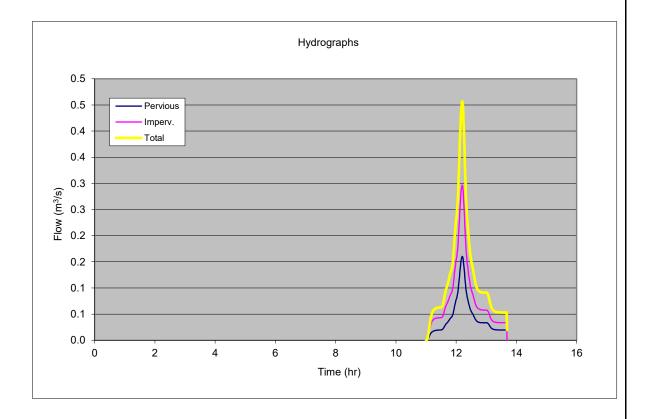
Hydrographs- SCS Method:

Project Description

96 Beach Haven Road/13 Cresta Avenue Proposed Development

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 2.02%



Time (hr) 11.001 11.347 11.491 11.601 11.694 11.776 11.850 11.918 11.981 12.040 12.096 12.150 12.201 12.230 12.259 12.290 12.320 12.352 12.384 12.417 12.451 12.486 12.522 12.559 12.597 12.637 12.678 12.721 12.767 12.814 12.864 12.917 12.975 13.037 13.106 13.184 13.277 13.398 13.690

-1.000



CHANNEL CAPACITY SECTION POST DEVELOPMENT A-A

PROJECT NO: 200626-01

PROJECT NAME: 96 Beach Haven Road/

13 Cresta Avenue

Cross Sections

DATE: 5.08.2021
BY: Natalie Naidoo
REF: Overland Flowpath

INPUTS OUTPUTS

Case (A or B)	В	
Case A		
Flow (m³/s)	0.457	

Case B Slope (S_o)

 Water level (m)
 23.55
 0.15

 MFFL
 23.70

5%

				_
Channel Geo	ometry	Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	23.7	0.03		Short Grass
0.5	23.5	0.03		Short Grass
1	23.4	0.03		Short Grass
2	23.4	0.03		Short Grass
2.5	23.49	0.03		Short Grass
3	23.7	0.03		Short Grass
-1				

The table can input 10 (x,y) co-ordinates. The (x,y) pairs should be in order Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e. $n=(\sum (P_1n_1^{1.5}+....)/P)^{0.67}$

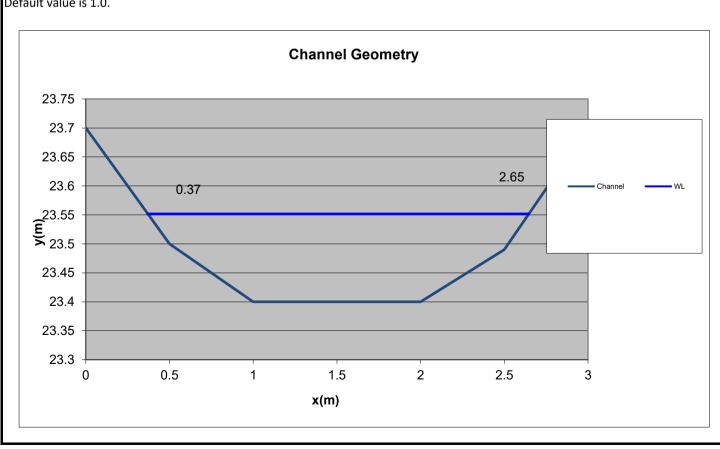
Sinuosity is the relative length of that flow channel element compared to other elements and input S_o . Default value is 1.0.

Normal Flow Conditions	5	
Flow (m ³ /s)	0.458	ОК
Velocity (m/s)	1.738	
S _o or S _f	0.0500	
Energy (m)	23.705	
Froude No	1.630	
Bed Stress (Pa)	55.817	
Equivalent "n"	0.030	
Equivalent k _s (mm)	N/A	

Geometry for wetted conditions		
Depth (d-m)	23.552	
Area (A-m²)	0.264	
Width (B-m)	2.276	
Perimeter (P-m)	2.316	

Critical Flow Conditions		
Flow (m ³ /s)	0.281	INCREASE CH
Velocity (m/s)	1.066	
Energy (m)	23.610	

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5





CHANNEL CAPACITY SECTION POST DEVELOPMENT

B-B

PROJECT NO: 200626-01

PROJECT NAME: 96 Beach Haven Road/

13 Cresta Avenue

Cross Sections

DATE: 5.08.2021 BY: Natalie Naidoo REF: **Overland Flowpath**

OUTPUTS

INPUTS

Case (A or B)	В		
Case A			
Flow (m ³ /s)	0.457		

Case B Slope (S_o)

5% 0.15 Water level (m) 21.55 MFFL 21.70

				_
Channel Geo	ometry	Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	22	0.03		Short Grass
0.5	21.5	0.03		Short Grass
1	21.4	0.03		Short Grass
2	21.4	0.03		Short Grass
2.5	21.50	0.03		Short Grass
3	22	0.03		Short Grass
-1				

The table can input 10 (x,y) co-ordinates. The (x,y) pairs should be in order Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e. $n=(\sum (P_1 n_1^{1.5}+....)/P)^{0.67}$

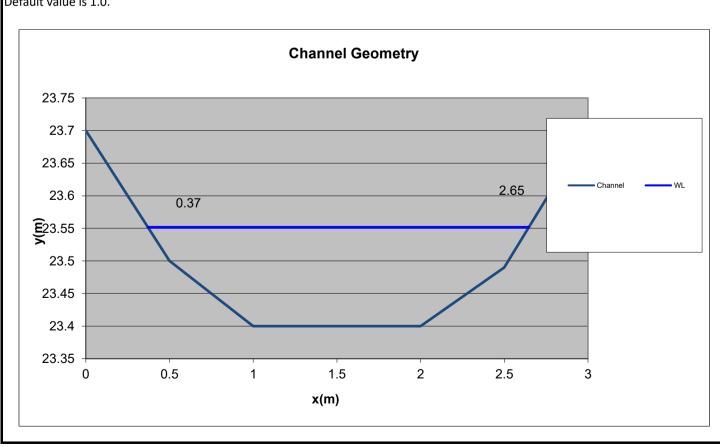
Sinuosity is the relative length of that flow channel element compared to other elements and input So. Default value is 1.0.

Normal Flow Conditions	S	
Flow (m ³ /s)	0.458	ОК
Velocity (m/s)	1.785	
S _o or S _f	0.0500	
Energy (m)	21.714	
Froude No	1.632	
Bed Stress (Pa)	58.108	
Equivalent "n"	0.030	
Equivalent k _s (mm)	N/A	

Geometry for wetted conditions		
Depth (d-m) 21.552		
Area (A-m²)	0.257	
Width (B-m)	2.104	
Perimeter (P-m) 2.167		

Critical Flow Conditions		
Flow (m ³ /s)	0.281	INCREASE CH
Velocity (m/s)	1.094	
Energy (m)	21.613	

Typical "n" values		
Concrete	0.013	
Gunite	0.017	
Smooth earth	0.02	
Clean channel	0.03	
Natural Channel	0.035-0.065	
Floodplain	0.05-0.15	
Overland flow (grass)	0.2-0.5	





CHANNEL CAPACITY SECTION POST DEVELOPMENT C-C - REVISION 1

PROJECT NO: 200626-01

DATE:

PROJECT NAME: 96 Beach Haven Road/

13 Cresta Avenue

16.06.2022

Cross Sections

BY: Natalie Naidoo REF: **Overland Flowpath**

OUTPUTS

INPUTS

Case (A or B)	В	
Case A		
Flow (m³/s)	0.457	

Case B

Slope (S_o) 5%

Water level (m) 0.10 20.00 MFFL 20.15

VIIIL		20.13	
Channel Geo	ometry	Mannings	Sinuosity
x (m)	y (m)	"n" value	
0	20.5	0.013	
0.5	20.00	0.013	
1	19.9	0.013	
2	19.9	0.013	
2.5	20.00	0.013	
3	20.5	0.013	
-1			

The table can input 10 (x,y) co-ordinates. The (x,y) pairs should be in order

Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e. $n=(\sum (P_1n_1^{1.5}+....)/P)^{0.67}$

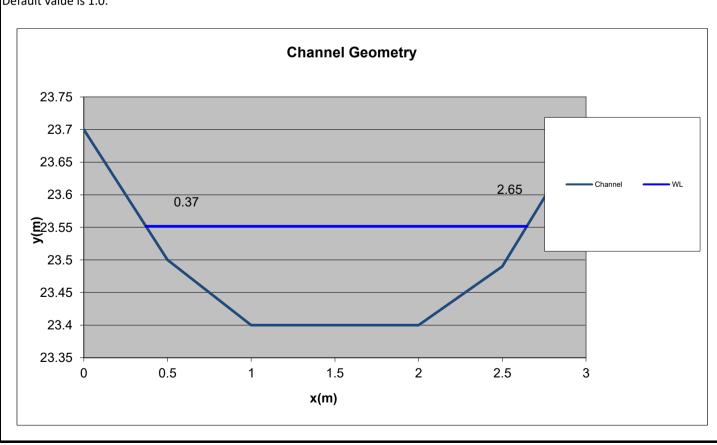
Sinuosity is the relative length of that flow channel element compared to other elements and input So. Default value is 1.0.

Normal Flow Condition	ns	
Flow (m ³ /s)	0.458	ОК
Velocity (m/s)	3.027	
S _o or S _f	0.0500	
Energy (m)	20.468	
Froude No	3.516	
Bed Stress (Pa)	36.687	
Equivalent "n"	0.013	
Equivalent k _s (mm)	1.75	

Geometry for wetted conditions			
Depth (d-m) 20.001			
Area (A-m²)	0.151		
Width (B-m)	2.001		
Perimeter (P-m) 2.02			

Critical Flow Conditions		
Flow (m ³ /s)	0.130	INCREASE CH
Velocity (m/s)	0.861	
Energy (m)	20.038	

Typical "n" values		
Concrete	0.013	
Gunite	0.017	
Smooth earth	0.02	
Clean channel	0.03	
Natural Channel	0.035-0.065	
Floodplain	0.05-0.15	
Overland flow (grass)	0.2-0.5	



Hydrographs- SCS Method - Predevelopment Flow from No. 15 Cresta Avenue

Project Description 96 Beach Haven Road/13 Cresta Avenue No. 15 Cresta Avenue

Rainfall Depth (mm)

245.28 100 YEAR ARI

Notes:

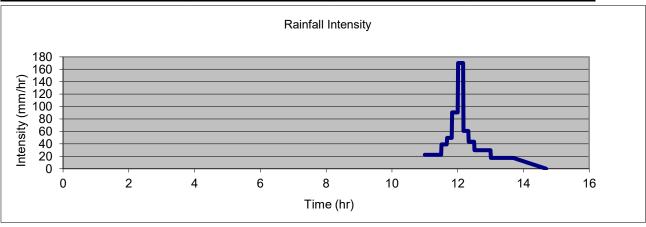
1. Inputs

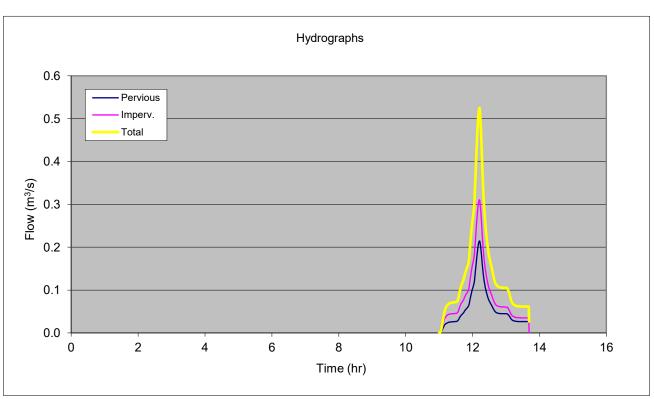
Catchment Data	Pervious Area	Impervious Area
Area (ha)	0.621	0.729
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	120	120
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	89.2	5.2

2. Typical inputs for CN, Ia, CF
are in 'Typical Inputs' Sheet.
2 Mathed based on ADC TD100

3. Method based on ARC TP108.

Outputs			Total
Runoff (mm)	175.2	240.2	210.3
Peak Flow (m ³ /s)	0.215	0.311	0.525
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.85
Runoff Coefficient - Volume	0.71	0.98	0.86





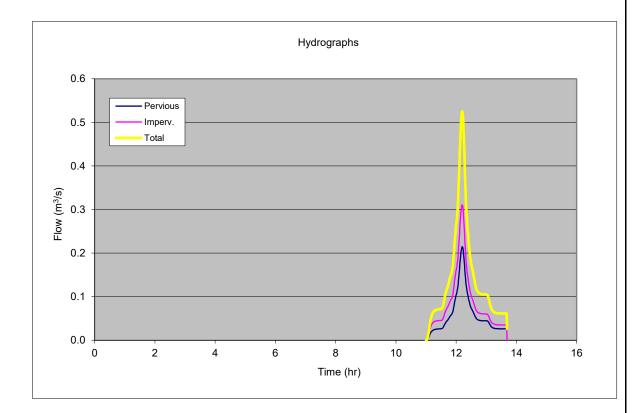
Hydrographs- SCS Method:

Project Description

96 Beach Haven Road/13 Cresta Avenue No. 15 Cresta Avenue

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 1.88%



Time (hr)	Flow (m ³ /s)
11.001	0.000
11.347	0.070
11.491	0.072
11.601	0.091
11.694	0.117
11.776	0.138
11.850	0.155
11.918	0.192
11.981	0.250
12.040	0.292
12.096	0.380
12.150	0.478
12.201	0.525
12.230	0.509
12.259	0.457
12.290	0.390
12.320	0.328
12.352	0.284
12.384	0.253
12.417	0.226
12.451	0.201
12.486	0.182
12.522	0.169
12.559	0.157
12.597	0.142
12.637	0.127
12.678	0.117
12.721	0.111
12.767	0.108
12.814	0.106
12.864	0.106
12.917	0.105
12.975	0.105
13.037	0.104
13.106	0.089
13.184	0.071
13.277	0.064
13.398	0.062
13.690	0.026
-1.000	0.000



CHANNEL CAPACITY SECTION PRE-DEVELOPMENT NO. 15 CRESTA AVE.

PROJECT NO: 200626-01

PROJECT NAME: 96 Beach Haven Road/

13 Cresta Avenue

Cross Sections

DATE: 6.08.2021
BY: Natalie Naidoo
REF: Overland Flowpath

INPUTS OUTPUTS

Case (A or B)	В	
Case A		
Flow (m ³ /s)	0.525	

Case B

 Slope (S_o)
 7%

 Water level (m)
 17.66

 MFFL
 17.81

		17.01		
Channel Geo	ometry	Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	18	0.1		Property/Parcels
0.5	17.7	0.1		Property/Parcels
1	17.3	0.1		Property/Parcels
2	17.3	0.1		Property/Parcels
2.5	17.70	0.1		Property/Parcels
3	18	0.1		Property/Parcels
-1				

The table can input 10 (x,y) co-ordinates. The (x,y) pairs should be in order Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e. $n=(\sum (P_1n_1^{1.5}+....)/P)^{0.67}$

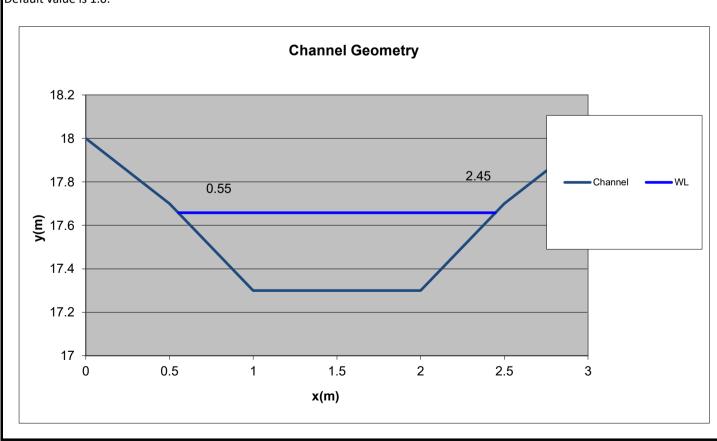
Sinuosity is the relative length of that flow channel element compared to other elements and input S_o . Default value is 1.0.

Normal Flow Conditions		
Flow (m ³ /s)	0.529	ОК
Velocity (m/s)	1.021	
S _o or S _f	0.0700	
Energy (m)	17.711	
Froude No	0.623	
Bed Stress (Pa)	165.808	
Equivalent "n"	0.100	
Equivalent k _s (mm)	N/A	

Geometry for wetted conditions		
Depth (d-m)	17.658	
Area (A-m²)	0.518	
Width (B-m)	1.895	
Perimeter (P-m) 2.146		

Critical Flow Conditions		
Flow (m ³ /s)	0.849	ОК
Velocity (m/s)	1.638	
Energy (m)	17.795	

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



Hydrographs- SCS Method - Post Development Flow from No. 15 Cresta Avenue

Project Description

96 Beach Haven Road/13 Cresta Avenue

No. 15 Cresta

Rainfall Depth (mm)

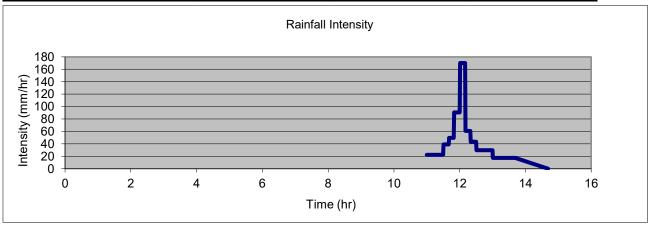
245.28 100 YEAR ARI

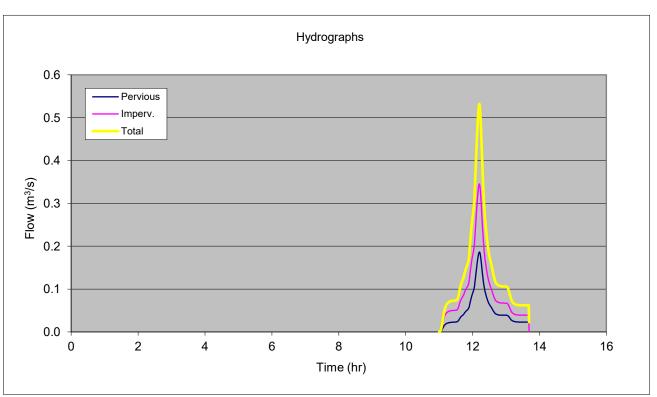
Notes:

- 1. Inputs
- 2. Typical inputs for CN, Ia, CF are in 'Typical Inputs' Sheet.
- 3. Method based on ARC TP108.

Catchment Data	Pervious Area	Impervious Area
Area (ha)	0.54	0.81
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	120	120
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	89.2	5.2

Outputs	Total		
Runoff (mm)	175.2	240.2	214.2
Peak Flow (m ³ /s)	0.187	0.345	0.532
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.86
Runoff Coefficient - Volume	0.71	0.98	0.87





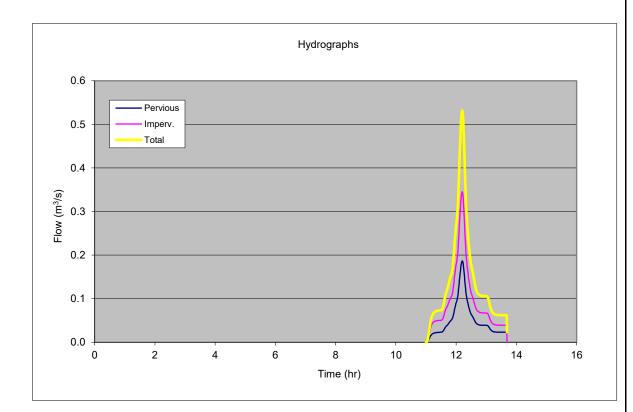
Hydrographs- SCS Method:

Project Description

96 Beach Haven Road/13 Cresta Avenue No. 15 Cresta

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 2.02%



Time (hr)	Flow (m ³ /s)
11.001	0.000
11.347	0.072
11.491	0.073
11.601	0.092
11.694	0.119
11.776	0.140
11.850	0.158
11.918	0.196
11.981	0.254
12.040	0.296
12.096	0.385
12.150	0.484
12.201	0.532
12.230	0.515
12.259	0.463
12.290	0.395
12.320	0.332
12.352	0.287
12.384	0.256
12.417	0.228
12.451	0.203
12.486	0.184
12.522	0.170
12.559	0.159
12.597	0.144
12.637	0.129
12.678	0.118
12.721	0.112
12.767	0.109
12.814	0.107
12.864	0.107
12.917	0.106
12.975	0.106
13.037	0.105
13.106	0.089
13.184	0.071
13.277	0.064
13.398	0.062
13.690	0.023
-1.000	0.000



CHANNEL CAPACITY SECTION POST DEVELOPMENT NO. 15 CRESTA AVE.

PROJECT NO: 200626-01

PROJECT NAME: 96 Beach Haven Road/

13 Cresta Avenue

DATE: 5.08.2021 BY: Natalie Naidoo REF: **Overland Flowpath Cross Sections**

INPUTS OUTPUTS

Case (A or B)	В
Case A	

Flow (m³/s) 0.532

Case B

Slope (S_o) 7% Water level (m) 17.67 0.37

MFFL		17.82		
Channel Geo	ometry	Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	18	0.1		Property/Parcel
0.5	17.7	0.1		Property/Parcel
1	17.3	0.1		Property/Parcel
2	17.3	0.1		Property/Parcel
2.5	17.70	0.1		Property/Parcel
3	18	0.1		Property/Parcel
-1				

The table can input 10 (x,y) co-ordinates. The (x,y) pairs should be in order Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e. $n=(\sum (P_1 n_1^{1.5}+...)/P)^{0.67}$

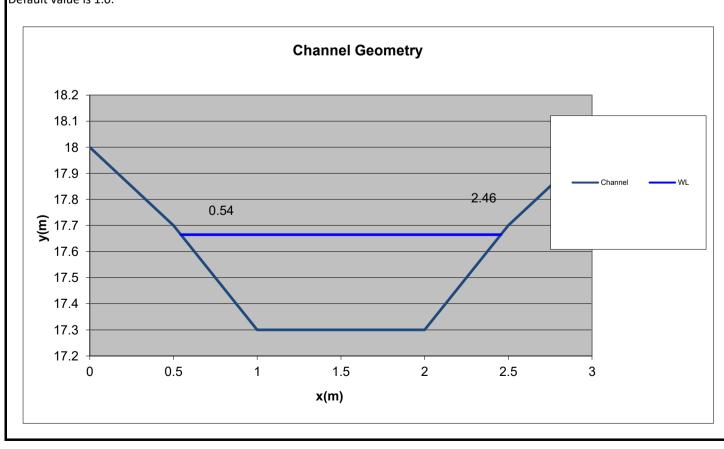
Sinuosity is the relative length of that flow channel element compared to other elements and input So. Default value is 1.0.

Normal Flow Conditions		
Flow (m ³ /s)	0.548	ОК
Velocity (m/s)	1.031	
S _o or S _f	0.0700	
Energy (m)	17.719	
Froude No	0.625	
Bed Stress (Pa)	168.315	
Equivalent "n"	0.100	
Equivalent k _s (mm)	N/A	

Geometry for wetted conditions	
Depth (d-m)	17.665
Area (A-m²)	0.532
Width (B-m)	1.913
Perimeter (P-m)	2.169

Critical Flow Conditions		
Flow (m ³ /s)	0.878	ОК
Velocity (m/s)	1.651	
Energy (m)	17.804	

Typical "n" values		
Concrete	0.013	
Gunite	0.017	
Smooth earth	0.02	
Clean channel	0.03	
Natural Channel	0.035-0.065	
Floodplain	0.05-0.15	
Overland flow (grass)	0.2-0.5	



Hydrographs- SCS Method - Predevelopment Flow from No. 17 Cresta Avenue

Project Description

96 Beach Haven Road/13 Cresta Avenue

No. 17 Cresta Avenue

Rainfall Depth (mm)

245.28 100 YEAR ARI

Notes:

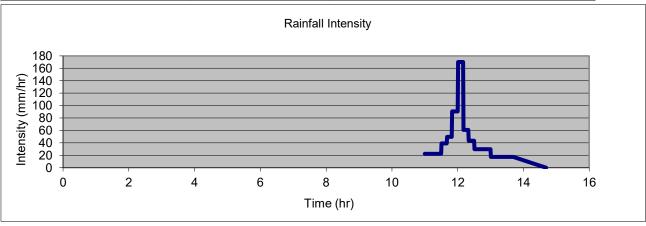
1. Inputs

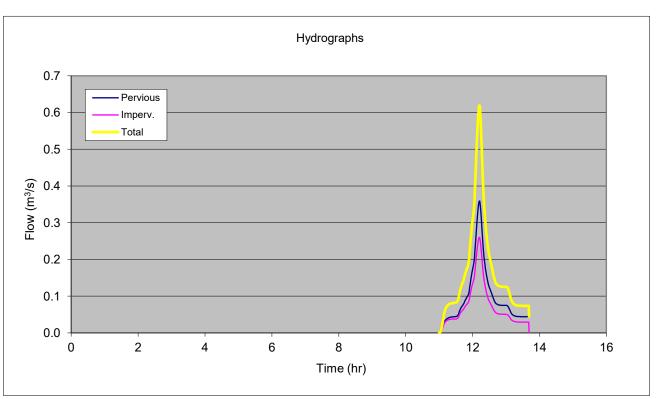
Catchment Data	Pervious Area	Impervious Area
Area (ha)	1.0395	0.6105
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	157	157
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	89.2	5.2

2. Typical in	puts for	r CN, Ia, CF
are in 'Typ	ical Inp	uts' Sheet.
		4 D C TD 4 C C

3. Method	d based or	ARC TP108

Outputs			Total
Runoff (mm)	175.2	240.2	199.3
Peak Flow (m ³ /s)	0.359	0.260	0.619
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.82
Runoff Coefficient - Volume	0.71	0.98	0.81





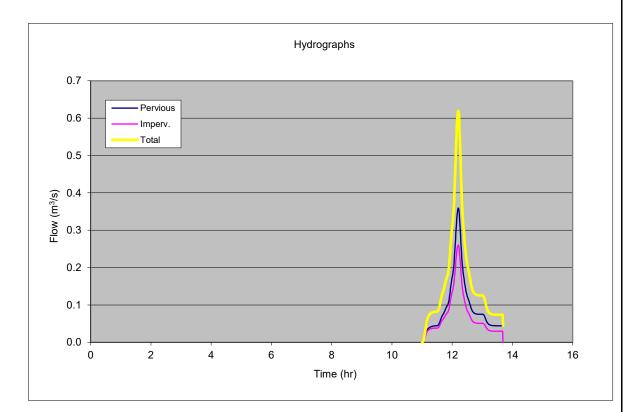
Hydrographs- SCS Method:

Project Description

96 Beach Haven Road/13 Cresta Avenue No. 17 Cresta Avenue

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 1.48%



Time (hr)	Flow (m ³ /s)
11.001	0.000
11.347	0.080
11.491	0.082
11.601	0.104
11.694	0.135
11.776	0.159
11.850	0.180
11.918	0.223
11.981	0.291
12.040	0.341
12.096	0.445
12.150	0.562
12.201	0.619
12.230	0.601
12.259	0.541
12.290	0.462
12.320	0.389
12.352	0.336
12.384	0.300
12.417	0.268
12.451	0.239
12.486	0.216
12.522	0.201
12.559	0.187
12.597	0.169
12.637	0.152
12.678	0.139
12.721	0.132
12.767	0.129
12.814	0.127
12.864	0.126
12.917	0.126
12.975	0.126
13.037	0.124
13.106	0.106
13.184	0.084
13.277	0.076
13.398	0.074
13.690	0.044
-1.000	0.000



CHANNEL CAPACITY SECTION PRE-DEVELOPMENT NO. 17 CRESTA AVE.

PROJECT NO: 200626-01

PROJECT NAME: 96 Beach Haven Road/

13 Cresta Avenue

DATE: 6.08.2021
BY: Natalie Naidoo
REF: Overland Flowpath
Cross Sections

OUTPUTS

INPUTS		
Case (A or B)	В	
Case A		
Flow (m ³ /s)	0.619	
Case B		
Slope (S _o)	3%	
Water level (m)	17.47	0.47
MFFL	17.62	

		27.02		_
Channel Geo	ometry	Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	17.5	0.1		Property/Parcels
0.5	17.3	0.1		Property/Parcels
1	17	0.1		Property/Parcels
2	17	0.1		Property/Parcels
2.5	17.30	0.1		Property/Parcels
3	17.5	0.1		Property/Parcels
-1				

The table can input 10 (x,y) co-ordinates. The (x,y) pairs should be in order Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e. $n=(\sum (P_1n_1^{1.5}+....)/P)^{0.67}$

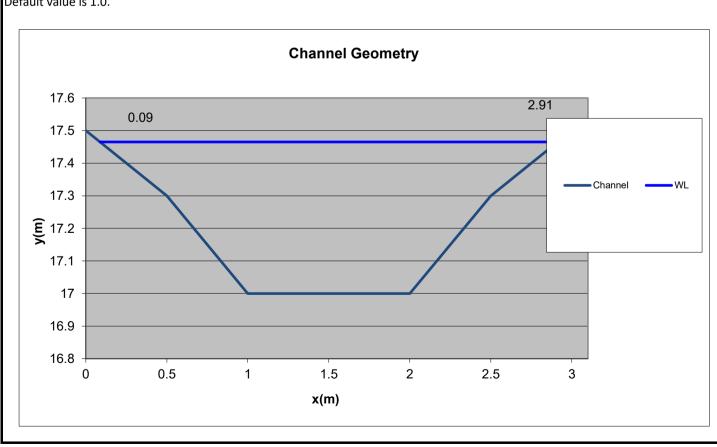
Sinuosity is the relative length of that flow channel element compared to other elements and input S_o . Default value is 1.0.

Normal Flow Conditions	S	
Flow (m ³ /s)	0.622	ОК
Velocity (m/s)	0.734	
S _o or S _f	0.0300	
Energy (m)	17.492	
Froude No	0.428	
Bed Stress (Pa)	81.704	
Equivalent "n"	0.100	
Equivalent k _s (mm)	N/A	

Geometry for wetted conditions		
Depth (d-m)	17.465	
Area (A-m²)	0.848	
Width (B-m)	2.825	
Perimeter (P-m)	3.055	

Critical Flow Conditions		
Flow (m ³ /s)	1.455	OK
Velocity (m/s)	1.716	
Energy (m)	17.615	

Typical "n" values			
Concrete	0.013		
Gunite	0.017		
Smooth earth	0.02		
Clean channel	0.03		
Natural Channel	0.035-0.065		
Floodplain	0.05-0.15		
Overland flow (grass)	0.2-0.5		



Hydrographs- SCS Method - Post Development Flow from No. 17 Cresta Avenue

Project Description 9

96 Beach Haven Road/13 Cresta Avenue No. 17 Cresta Avenue

Rainfall Depth (mm)

245.28 100 YEAR ARI

Notes:

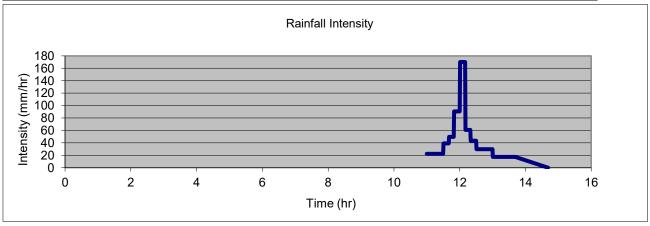
1. Inputs

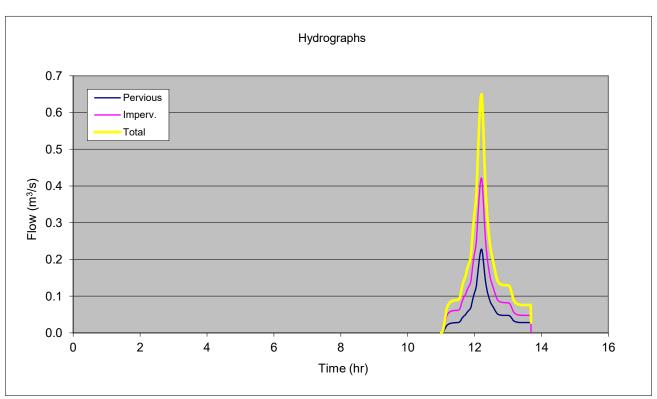
Catchment Data	Pervious Area	Impervious Area
Area (ha)	0.66	0.99
Runoff No (CN)	74	98
Initial Loss (Ia-mm)	5	0
Channel Length (L-m)	157	157
Channel Slope (Sc-m/m)	0.1	0.1
Channel Factor (CF-0.6 to 1.0)	0.8	0.6
T: (C	40.0	40.0
Time of Concentration (tc-min)	10.0	10.0
Soil storage (S-mm)	l 89.2	I 5.2

2. Typical inputs for CN, Ia, CF
are in 'Typical Inputs' Sheet.
Nothed based on ADC TD100

პ.	Method	pased	on ARC	11108.

Outputs			Total
Runoff (mm)	175.2	240.2	214.2
Peak Flow (m ³ /s)	0.228	0.422	0.650
Time (hr) at Peak Flow	12.20	12.20	12.20
Rainfall (mm/h) over tc	165.26	165.26	165.26
Runoff Coefficient - Peak	0.75	0.93	0.86
Runoff Coefficient - Volume	0.71	0.98	0.87





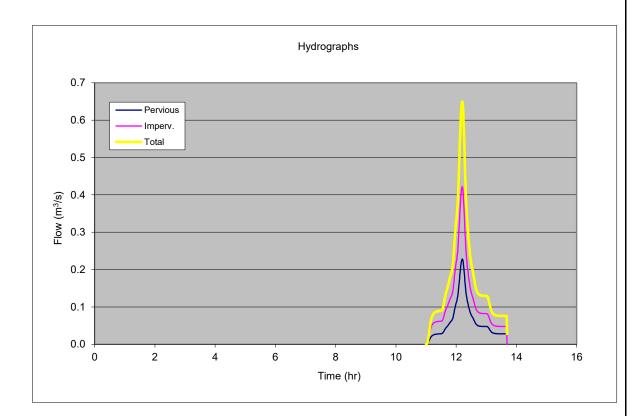
Hydrographs- SCS Method:

Project Description

96 Beach Haven Road/13 Cresta Avenue No. 17 Cresta Avenue

Total Hydrograph in tabular form: (based on simualtion from above)

Volumetric error in scaling 2.02%



Time (hr)	Flow (m ³ /s)
11.001	0.000
11.347	0.088
11.491	0.090
11.601	0.113
11.694	0.146
11.776	0.172
11.850	0.193
11.918	0.239
11.981	0.311
12.040	0.362
12.096	0.471
12.150	0.592
12.201	0.650
12.230	0.630
12.259	0.566
12.290	0.482
12.320	0.406
12.352	0.351
12.384	0.312
12.417	0.279
12.451	0.248
12.486	0.224
12.522	0.208
12.559	0.194
12.597	0.175
12.637	0.157
12.678	0.144
12.721	0.137
12.767	0.133
12.814	0.131
12.864	0.130
12.917	0.130
12.975	0.130
13.037	0.128
13.106	0.109
13.184	0.087
13.277	0.079
13.398	0.076
13.690	0.028
-1.000	0.000



CHANNEL CAPACITY SECTION POST DEVELOPMENT NO. 17 CRESTA AVE.

PROJECT NO: 200626-01

PROJECT NAME: 96 Beach Haven Road/

13 Cresta Avenue

Cross Sections

DATE: 5.08.2021 BY: Natalie Naidoo REF: **Overland Flowpath**

INPUTS OUTPUTS

Case (A or B)	В	
Casa A		
Case A		
Flow (m ³ /s)	0.650	

Case B Slope (S_o)

Water level (m) 0.48 17.48 MFFL 17.63

3%

		17.00		
Channel Geo	ometry	Mannings	Sinuosity	
x (m)	y (m)	"n" value		
0	17.5	0.1		Property/Parcel
0.5	17.3	0.1		Property/Parcel
1	17	0.1		Property/Parcel
2	17	0.1		Property/Parcel
2.5	17.30	0.1		Property/Parcel
3	17.5	0.1		Property/Parcel
-1				

The table can input 10 (x,y) co-ordinates. The (x,y) pairs should be in order Terminate list by making x = -1.0

Flow distribution is based on velocity and energy gradient common to all parts of the channel. i.e. $n=(\sum (P_1 n_1^{1.5}+....)/P)^{0.67}$

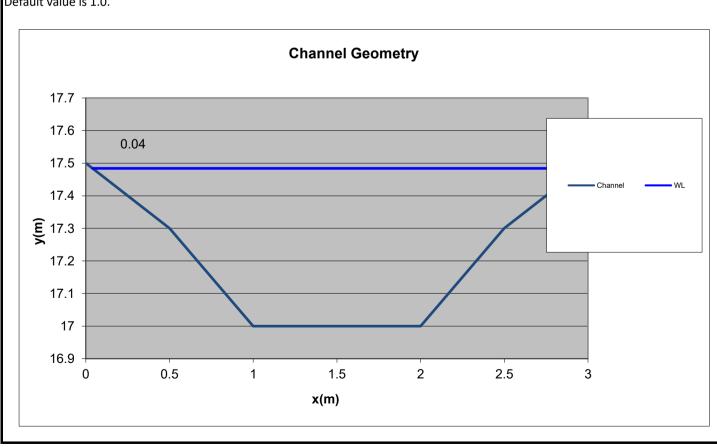
Sinuosity is the relative length of that flow channel element compared to other elements and input So. Default value is 1.0.

Normal Flow Conditions	S	
Flow (m ³ /s)	0.676	ОК
Velocity (m/s)	0.749	
S _o or S _f	0.0300	
Energy (m)	17.513	
Froude No	0.430	
Bed Stress (Pa)	84.144	
Equivalent "n"	0.100	
Equivalent k _s (mm)	N/A	

Geometry for wetted conditions		
Depth (d-m)	17.484	
Area (A-m²)	0.903	
Width (B-m)	2.920	
Perimeter (P-m)	3.157	

Critical Flow Conditions		
Flow (m ³ /s)	1.572	ОК
Velocity (m/s)	1.741	
Energy (m)	17.639	

Typical "n" values	
Concrete	0.013
Gunite	0.017
Smooth earth	0.02
Clean channel	0.03
Natural Channel	0.035-0.065
Floodplain	0.05-0.15
Overland flow (grass)	0.2-0.5



Appendix D

Lander Geotechnical – Geotechnical Report



14 April 2021 Ref No: J01675 (Rev1)

Bentley Studios Limited

Attention: Mr L Da-Silva

Dear Leon

RE: Geotechnical Investigation Report for Private Plan Change at 96 Beach Haven Road & 13 Cresta Avenue, Beach Haven

1 PROJECT BRIEF

This report has been prepared for Bentley Studios Limited in support of an application to the Auckland Council for a Private Plan Change (PPC).

1.1 I have undertaken a review of the private plan change, on behalf of Auckland Council in relation to the geotechnical effects.

I hold a NZCE (Civil) and BE (Civil; Hons 1st class, 1st division) and am a Chartered Professional Engineer. My work experience includes significant land subdivisions across South Auckland over the past 20 years on steep and/or compressible ground. I hold the position of Managing Director and Principal Geotechnical Engineer at Lander Geotechnical Consultants Limited based in Manukau.

- 1.2 In writing this report, the following documents have been reviewed:
 - Geotechnical Due Diligence Desktop Study, CMW Geosciences Ltd, Ref No. AKL2020-0310AA Rev.0, dated 30 November 2020.

2 SCOPE AND OBJECTIVES

The scope of this report encompasses the geotechnical suitability and stability of the land associated with the PPC;

- Geotechnical setting and ground conditions for the site, including assessment of natural features and geohazards that may affect future residential development upon the land.
- Geotechnical guidance for future earthworks based on ground conditions likely to be encountered during site stripping and bulk cut operations.
- Broad stability of the site to safely support typical residential structures for likely end use.
- Available historical aerial photographs to infer fills and/or land modification that may have occurred within the watercourse near the north-eastern corner of the site.
- Shallow surface investigations have only been completed within the site boundaries and it is unknown as the characteristics of the soils encountered within the existing watercourse near the north-eastern corner of the site.

Phone: (09) 262 1528; (09) 262 1526 Email: contactus@landergeotechnical.co.nz



 Review groundwater depths and complete a 14 day assessment for reference to the Auckland Unitary Plan (AUP) permanent drawdown effects assessment (E7.) to be completed at a later stage (e.g. during a subdivision Resource Consent stage) if required, once the nature of development concepts (e.g. building and earthworks) are known.

3 SITE DESCRIPTION AND DEVELOPMENT PROPOSALS

Number 96 Beach Haven Road, Beach Haven is legally described as Lot 1 DP 157383, with an area of 2251m². Along the northern boundary of this site sits 13 Cresta Avenue with the legal description of Lot 2 DP 157383 comprising an area of 4896m². Land gradients across the site are generally flat around 1(v) in 6(h), but steepen to 1(v) in 4(h) towards the gully located along the western boundary of the site which appears to contains the overland flow path from south to north.

There are currently two dwellings located on each site with two separate garage structures located at 96 Beach Haven Road. A stormwater line runs along the western and southern boundary of 96 beach Haven Road as well as a sewer line that cuts through 13 Cresta Avenue.

We understand that the site is proposed for a zone change for the development of future residential housing which will likely require minor earthworks i.e. cuts and fills to develop the proposed housing foundation platforms

4 FIELDWORK AND FINDINGS

4.1 Fieldwork Programme

Our fieldwork was conducted on 4 February 2021 which involved drilling of 16 hand auger boreholes with target depths of between 3.0m and 5.0m in the positions indicated on the appended site plan (refer Figure 1). Three piezometer standpipes were also installed in HA05, HA11 and HA16.

Results of all in-situ tests, detailed descriptions and depths of strata encountered during drilling of the boreholes are appended.

4.2 Geology

A review of GNS digital QMaps indicates that the site is located within the East Coast Bays Formation (ECBF) of the Waitemata Group flysch deposits which consist of alternating beds of sandstones and mudstones. These deposits generally weather to a dark grey, partially weathered 'transitional' soils before weathering completely to orange, light grey and brown silts, clays and sands

4.3 Findings

4.3.1 Topsoil

Topsoil was encountered in each of the hand auger boreholes to a depth of between 100m to 800mm (the latter isolated to HA15) but averaged around 300mm.

4.3.2 Residual East Coast Bays Formation

Residual East Coast Bays Formation (ECBF) soils were noted in each hand auger borehole underlying surficial topsoil and alluvial deposits. These deposits consisted of grey, black, orange and



brown clays and silts. Undrained shear strength readings were generally greater than 75 kPa (Stiff) and up to more than 216 kPa (Hard).

4.3.3 Transitional East Coast Bays Formation

The transitional ECBF was encountered within HA12 underlying the residual ECBF at a depth of 3.85m. These soils were described grey silty Clay and undrained shear strengths within this formation were hard as the shear vane was unable to penetrate the soil.

4.3.4 Groundwater

Groundwater was encountered in HA09 and HA15 at depths of 4.0m and 3.0m respectively. Piezometers standpipes were installed in hand auger boreholes, HA05, HA11 and HA16. Results are tabulated below in table 1.

It is worth noting HA05 was tampered with after its installation and was found partially removed from the ground only allowing a monitoring depth of 3.5m BEGL before an obstruction was met. Additionally during the final round of groundwater monitoring HA16 recorded elevated levels of groundwater compared to the other piezometers, this outlying data point has been determined to have been caused due to excess runoff from a period of heaving rainfall just prior to its measurement and is deemed inaccurate (i.e. higher than the actual groundwater level).

Table 1: Groundwater Levels Following Drilling

Borehole	Groundwater Depth	Standing Ground	Standing Groundwater Depth (m BEGL)									
	Encountered During Drilling (m BEGL)	4 February 2021 (Completion of drilling)	9 February 2021 (5 Days)	12 February 2021 (15 Days)	19 February 2021 (22 Days)							
HA05	N/A	N/A	N/A	N/A	N/A							
HA11	N/A	N/A	4.05	3.85	3.85							
HA16	N/A	N/A	4.10	3.70	1.70							

5 LABORATORY RESULTS

Atterberg limit soils testing of material from HA11 at a depth of 0.5-1.0m returned the following index properties to aid in the determination of an expansive site class for this site.

• Liquid Limit: 103

Plastic Limit: 40

Linear Shrinkage: 22%

Moisture Content 31.4%



6

6 PROJECT EVALUATIONS AND RECOMMENDATIONS

Based on our site observations and field investigations we are of the opinion the site contains no insurmountable geotechnical hazards that would prevent future residential intensification.

Specific comments and recommendations follow:

6.1 Foundations for Buildings

6.1.1 Bearing Capacity and Settlement Potential

A geotechnical ultimate bearing capacity of 300 kPa should generally be available for all shallow and pad foundations constructed on engineer certified filling and on the natural ground. Anticipated differential settlements are assessed to be within the required building code limits.

Please note, following earthworks, if existing fill is found to underlay any future building platforms then it will need to be undercut and replaced with engineer certified fill (i.e. compacted GAP65 hardfill), subject to engineering direction from the observing geo-professional.

6.1.2 Expansive Site Class

Based on the Atterberg Limit laboratory testing, refer Section 6, visual-tactile assessment of the soils and knowledge of the area, the preliminary assessed expansive site class for this site is H(High); as defined in MBIE Acceptable Solutions and Verification Methods for NZ Building Code Clause B1 Structures, effective 28 November 2019) with characteristic ground movement (Y_s) of up to 78mm.

This site class should be re-assessed during the detailed design (i.e. at Building Consent stage) via Shrink-Swell testing as outlined in MBIE (extract attached)

6.2 Pavement Subgrade

Given the generally very stiff surficial subsoils present across the site, we consider that a design CBR value of 4% maybe adopted for the natural soils if this is a design requirement for driveways. As CBR values are affected by moisture content and trafficking, we recommend that subgrades are only trimmed to final level immediately prior to placing base course and that a programme of Scala Penetrometer testing be carried out during construction to confirm the design value.

6.3 Preliminary Earthworks Comments

Generally speaking, following the removal/ demolition of the existing dwellings and structures located on site, all debris and excavation which is surplus to requirements should be removed from site, in addition if any existing deep topsoil and pre-existing non engineered fill deposits were encountered on site will require undercutting and replacement with engineered fill if located beneath the proposed building platforms, at the discretion of the observing geo-professional.

All vegetation should be removed, and topsoil stripped well clear of the proposed works and stockpiled clear of the building platform also.

This should be re-addressed at a later phase (e.g. a Resource Consent Application).



7 FURTHER WORK

Further geotechnical assessments should be undertaken to support any subsequent Resource Consent or Building Consent applications commensurate with the nature of future development proposals.

8 LIMITATIONS

This report has been prepared solely for the use of our client, Bentley Studios Limited, their professional advisers and the relevant Territorial Authorities in relation to the specific project described herein. No liability is accepted in respect of its use for any other purpose or by any other person or entity. All future owners of this property should seek professional geotechnical advice to satisfy themselves as to its ongoing suitability for their intended use.

The opinions, recommendations and comments given in this report result from the application of normal methods of site investigation. As factual evidence has been obtained solely from boreholes which by their nature only provide information about a relatively small volume of subsoils, there may be special conditions pertaining to this site which have not been disclosed by the investigation and which have not been taken into account in the report.

If variations in the subsoils occur from those described or assumed to exist, then the matter should be referred back to us immediately.

For and on behalf of Lander Geotechnical Consultants Limited

S.G. Lander

Alland.

Principal Geotechnical Engineer CMEngNZ, CPEng

Attachments:

Figure 01: Site Investigation Plan Hand Auger Boreholes Records Laboratory Results

MBIE Acceptable Solutions and Verifications Methods for NZ Building Code Clause B1 Structure (extract)

Legend and/or Notes: 5m Hand Auger Borehole 3m Hand Auger Borehole 2000860795 2000377472 5m Hand Auger Borehole with Piezometer HA11

BASEMAP: AUCKLAND COUNCIL GEOMAPS DATABASE [RETRIEVED 12.02.21]

	description	drawn	approved	date	
revision					
rev					1

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client:	BENTLEY STUDIO LIMITED
project:	96 BEACH HAVEN ROAD & 13 CRESTA AVENUE BEACH HAVEN
title:	CITE INVECTION DI AN

project no: J01675 | figure no: 01

Client: BENTLEY STUDIOS LIMITED Project Location: 96 BEACH HAVEN ROAD & 13 CRESTA AVENUE BEACH HAVEN Job Number: J01675 Borehole Location: Refer to site plan SOIL DESCRIPTION TOPSOIL slightly clayey SILT, light grey mottled orange/brown. Very stiff, moist, low plasticity [RESIDUAL EAST COAST BAYS FORMATION] with trace fine sand Auger Borehole No. HAO: Sheet 1 of Avenue Head: Logged By: Processor: Date: 04.02.21 From No. Hao: Sheet 1 of Avenue Head: Logged By: Pocessor: Date: 04.02.21 Sample and Laboratory / Oth Test Details Test Details Topsoil with trace fine sand Description: Refer to site plan Topsoil slightly clayey SILT, light grey mottled orange/brown. Very stiff, moist, low plasticity [RESIDUAL EAST COAST BAYS FORMATION] with trace fine sand Description: Refer to site plan Soll DESCRIPTION Topsoil slightly clayey SILT, light grey mottled orange/brown. Very stiff, moist, low plasticity [RESIDUAL EAST COAST BAYS FORMATION] becoming hard
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TOPSOIL slightly clayey SILT, light grey mottled orange/brown. Very stiff, moist, low plasticity [RESIDUAL EAST COAST BAYS FORMATION] with trace fine sand with trace fine sand becoming hard becoming hard UTP
TOPSOIL slightly clayey SILT, light grey mottled orange/brown. Very stiff, moist, low plasticity [RESIDUAL EAST COAST BAYS FORMATION] with trace fine sand with trace fine sand becoming hard becoming hard UTP
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RESIDUAL EAST COAST BAYS FORMATION
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Comments: Borehole Diameter: Topsoil Sand Sandstone Plutonic ++
Groundwater not encountered. UTP = unable to penetrate. Checked: Clay Checked:
LANDER OTF - unable to perietrate. Checked: Clay C Organic Limestone

Client :		BE	NTLEY STUDIOS	LIMI	TED			Aug	jer B	oreho	le No			HA02
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		Ground	ents: water not encountere	d.	50mm	Topsoil Fill	>> // -	Sand Gravel		Sandstone	2 Z Z	• -	tonic Core	<u> </u>
LANI	DER		unable to penetrate. end of borehole.		Checked:	Clay -		Organic	<u>inan</u> <u>inan</u>	Limeston		囯		
georech	mical		Sila of bordiloid.		JM	Silt X	KXX KXX	umice	> 4 4 4 > 4 4 4	Volcanic			T	

Client :	BENTLEY STUDIOS LII				Aug	er Bo	oreho	le No.		HA07
Project Location	on: 96 BEACH HAVEN ROA	AD & 13 CREST	A AVENUE							of 16
	BEACH HAVEN			Vane	Head:	Logge	d By:	Process	or: Date	:
Job Number:	J01675			30	07	F	RZ	RZ	04	.02.21
Borehole mN	mE G	round R.L.			lε	ig ivel	oa) _{Iual}	≥	Sample	and
Location: Description	n: Refer to site plan			Legend	Depth (m)	ındin ər Le	ar(kF resid	sitivi	Laborator	/ Other
	SOIL DESCRIPTION			Fé	Deg	Standing Water Level	Vane Shear(kPa) _{peak / residual}	Soil Sensitivity	Tes Deta	
_ TOPSOIL	OOIL DECORM TION			//////	1					
_ 10F30IL -					<u></u>					
FOB at 0.3m. Too hard:	to auger further. Scala penetrome	ter test commence	ed and found		+				- 3	
effective refusal (ER) at	0.4m.				- 0.5			Ī	- 20+ (ER)	
-					- "				Scala Penetrom	eter
-					F				Test	
-					+				(blows/10	Omm)
- -					- 1.0					
- -					t					
-					-					
- -					- 1.5					
-					-					
- -					ļ.					
_					- 2.0					
- -					ļ.					
-					-					
- -					- 2.5					
-					F					
-					F					
-					 					
- -					-3.0					
-					L					
-					-					
- -					- 3.5					
-					-					
- -					ļ.					
_					-4.0					
- -					F					
-					-					
- -					-4.5					
-					F					
-					F					
-										
-					- 5.0					
- -					L					
-					-					
- -					- 5.5					
-					-					
- -					F					
-	T			1	-6.0	<u> </u>		ļl	•1	++++++
	Comments:	Borehole Diameter:	Topsoil	}}}}}	Sand	,,,,,,,,,,	Sandstone	22222	Plutonic	++++++
LANDED	Groundwater not encountered. UTP = unable to penetrate.	50mm	Fill //			*****	Siltstone	222222	No Core	\vdash
LANDER geotechnical	EOB = end of borehole.	Checked:	Clay		Jigariic (1)	*****	Limestone	-	<u> </u>	\vdash
		JM	Silt (XX	XXXXX XXXXX XXXXX	Pumice		Volcanic		ž	

Client :		BE	NTLEY STUDIOS I	LIMITED			Aug	er B	oreho	le No			HA08
Project	Locatio	n: 96	BEACH HAVEN RO	DAD & 13 CRES	TA AVENUE						Sheet	8 (of 16
Job Nu	mber:		1675			Vane	Head: 750	Logge	ed By: NM	Process PL		Date: 04.0	2.21
Borehole	mN		mE	Ground R.L.									
Location:	Description:		Refer to site plan			Legend	Depth (m)	nding r Lev	Vane Shear(kPa)	Soil Sensitivity			Other
		so	IL DESCRIPTION	I		Leç	Dep	Standing Water Level	Shea Shea	Sens		Test Details	
_ TOPSOIL						$\frac{1}{1}$	$\downarrow -$						
_							}						
silty CLAY, COAST BA	light brown. I YS FORMAT	lard, dry ION]	to moist, medium plas	sticity [RESIDUAL	EAST	-8-8-8	<u> </u>		040				
- becoming g	rey and oran	ge/brown	mottled light brown, r	moist		-8-8-8 -8-8-8	`⊢		216+				
- becoming g	rey streaked	orange/b	rown			-×-×-× -×-×-×	F						
becoming ir	nsensitive					-x-x-x -x-x-x	· –		201/111	1.8			
						-x-x-x	: †						
_						-8-8-8 -8-8-8	ŧ						
becoming very	ery stiff	. 4				-×-×-×	1		182/105	1.7			
- becoming of	range/brown	streaked	grey			-×-×-× -×-×-×	⊹						
-						-×-×-× -×-×-×	:E						
_						-8-8-8	2.0		139/108	1.3			
E						-×-×-×	_						
						-8-8-8	: - -						
- -						-x-x-x -x-x-x	- 2.5		139/102	1.4			
-						-x-x-x]						
						-2-2-2	1		170/120	11			
F						-x-x-x -x-x-x			170/120	1.4			
F						-8-8-8 -8-8-8	÷├						
- -						-×-×-× -×-×-×	-35		127/99	1.3			
becoming his	igh plasticity					-×-×-× -×-×-×	†						
						-8-8-8	:-						
_						-x-x-x	-4.0		167/130	1.3			
F						-×-×-×	1						
-						-x-x-x -x-x-x	: 1						
becoming he	ard					-8-8-8	- 4.5		216+				
_						-8-8-8	ŧ						
_						-×-×-×	:-						
_ EOB at 5.0r	ո. Target Deր	oth.					- 5.0		201/139	1.4			
-							_						
_							- -5.5						
							F 3.3						
-							-						
_							- 6.0						
		Comme		Borehole Diameter) · opso	>>1	Sand		Sandston	 	Pluto	-	+++
LAND	DER	1	water not encountered unable to penetrate.	I. 50mm Checked:	Fill Clay -	1	Gravel Organic	WWW	Siltstone	222	+	Core	
geotech		EOB =	end of borehole.	JM	TX	$\frac{1}{2}$	Pumice		Valennia	- 	•		

Client :	E	BENTLEY STUDIOS	LIMITED			Aug	er B	oreho	le No		HA09
Project	Location : g	06 BEACH HAVEN R BEACH HAVEN	OAD & 13 CRESTA	A AVENUE						Sheet	9 of 16
Job Nu		01675			Vane F	lead: 53	Logge	d By: JM	Process		Oate: 04.02.21
Borehole	mN	mE	Ground R.L.				 	1			
Location:	Description:	Refer to site plan			Legend	Depth (m)	nding r Le	Vane Shear(kPa)	Soil Sensitivity		mple and atory / Other
	S	OIL DESCRIPTIO	N		l ec	Deg	Standing Water Level	She V	Sens		Test Details
_ TOPSOIL					111	<u> </u>					
_ silty CLAY,	orange mottled light	t grey. Hard, moist, high	plasticity [RESIDUA	L EAST	-x-x-x -x-x-x	_					
_ COAST BA	YS FORMATION]				-×-×-×	- 0.5		040			
-					-×-×-× -×-×-×	- 0.5		216+			
F					-x-x-x	F					
- - hasaming m	and arataly appoiting				-x-x-x	<u> </u>		213/58	3.7		
-	noderately sensitive				-×-×-×	- 1.0		213/30	3.7		
with trace fire	ne sand				-x-x-x	‡					
-					-8-8-8	}					
becoming ver	ery stiff, insensitive				-x-x-x -x-x-x	- 1.5		173/89	1.9		
<u> </u>					-x-x-x -x-x-x	t					
F					-×-×-×	F					
_					-x-x-x -x-x-x	— 2.0		164/99	1.7		
_					-x-x-x -x-x-x	-					
becoming m	nedium to high plasti	icity, with minor fine sar	d		-x-x-x	Ė					
-					-x-x-x	- 2.5		130/83	1.6		
becoming m	noist to wet				-3-3-3	ļ					
-					-8-8-8	}					
becoming m	noderately sensitive				-x-x-x -x-x-x	-3.0		178/85	2.1		
	,				-x-x-x	┡					
becoming w	et, with some fine s	and			-x-x-x	F					
L					-x-x-x	- 3.5		160/67	2.4		
-					-x-x-x -x-x-x	- 3.3		100/07	2.4		
_					-8-8-8	‡					
		range mottled light grey	. Very stiff, wet, low p	olasticity		-	\Box				
becoming giwith modera	rey, saturated, with i itely thin bed of woo	minor woody inclusions d				- 4.0		178/45	4.0		
						L					
-						ŀ					
- hecoming a	rey/brown, without w	roody inclusions				- 4.5		159/51	3.1		
- becoming gi	rey/brown, without w	voody inclusions				ŀ					
-						ļ.					
EOB at 5.0n	n. Target Depth.					- 5.0		190/49	3.9		
-						F					
F						F					
-						- 5.5					
F						F					
_						ļ.					
_				,	<u> </u>	- 6.0				<u> </u>	
		ments:	Borehole Diameter:	Topsoil) s	and		Sandston	 	Pluto	nic + + + +
	Grour 4.0m.	ndwater encountered at		Fill	'	ravel	WWW	Siltstone	222	Z No C	ore
geotech	UTP :	= unable to penetrate.	Checked: JM	Clay –	$\frac{\sqrt{x}\sqrt{x}}{\sqrt{x}}$	rganic	****** ******	Limestone	 	휘	
	EOB	= end of borehole.	JIVI		X X X Pi	umice	****	Volcanic	- $ $ $ -$	Υ	

Client :		BE	NTLEY STUDIOS	LIMIT	ED			Aug	er B	oreho	le No			HA10
Project	Locatio	n: 96	BEACH HAVEN RO	OAD	& 13 CRESTA	A AVENUE	≣					Sheet	10	of 16
Job Nu	ımber:		1675				_ I	Head: 07	Logge	ed By: RZ	Process RZ		Date: 04.0	02.21
Borehole	mN		mE	Grou	ınd R.L.				 					
Location:	Description		Refer to site plan				Legend	Depth (m)	Standing Water Level	Vane Shear(kPa)	Soil Sensitivity			/ Other
		so	IL DESCRIPTION	N			Le	Pe	Sta	She	Sen		Test Detail	
_ TOPSOIL							1//	#_						
silty CLAY, o	orange/brown	and ligh	t grey mottled light ora	ange.	Hard, dry, med	ium plastici	ty -×-×-	* * -						
- [KESIDOAL	EAST COAC	or DATS	PORMATION				-x-x- -x-x-			UTP				
becoming m	noist						-x-x- -x-x-	` -						
							-x-x-	-						
becoming or	range mottled	l light gre	ey				-×-×- -×-×-	- 1.0		201+				
F							-x-x- -x-x-	<u>*</u>						
-							-x-x- -x-x-	<u>*</u> -						
becoming ve	ery stiff, insen	sitive					-×-×-	- 1.5		170/124	1.4			
_							-×-×-	× -						
							-x-x- -x-x-	<u>*</u> †		470/400	4.0			
E							-x-x-	× -		173/132	1.3			
-							-×-×- -×-×-							
_							-×-×- -×-×-	– 2.5		147/109	1.3			
becoming hi	gh plasticity						-x-x- -x-x-	×Ę						
-							-x-x- -x-x-	- 1						
- -							-×-×- -×-×-			112/72	1.6			
-							-x-x- -x-x-	<u>*</u> -						
becoming st	iff						-×-×- -×-×-	×		92/72	1.3			
							- <u>×-</u> ×-	<u> </u>		92/12	1.5			
-							-x-x- -x-x-	<u>*</u>						
becoming ve	ery stiff						-×-×-	. Г		118/78	1.5			
- becoming m	ledium piastic	city, with	some fine sand				-x-x-	×1 ×+						
with minor fine	ne sand						-x-x- -x-x-	<u>*</u> L						
becoming hat	ard						-×-×-	× - 4.5		201+				
-							-×-×- -×-×-	×L						
-							-×-×-	- -5.0		201+				
EOB at 5.0m	n. Target Dep	oth.						<u> </u>						
								_						
_								- 5.5						
F								F						
F								F						
		Comme	ents:	В	orehole Diameter:	Topsoil	\\\\	-6.0 Sand	<u> </u>	Sandston	 	Plu	tonic	+++
		Ground	water not encountered		50mm	Fill	>> //	Gravel		Siltstone	222	•	Core	+++
LAND	DER	1	unable to penetrate. end of borehole.		Checked:	Clay	$\frac{1}{\sqrt{2}}$	Organic	CWCWCW CWCWCW Sababa	Limeston		\$		
					JM	Silt	\mathbb{R}^{2}	Pumice		Volcanic	\downarrow	\sim		

Client :		BENT	TLEY STUDIOS	LIMITED				Aug	er B	oreho	le No			HA11
Project Loc	catio		EACH HAVEN R CH HAVEN	OAD & 13 C	RESTA AVE	ENUE						Sheet	11	of 16
Job Numbe	er:	J016					Vane	Head: 900	Logge	ed By: RG	Process PL		Date: 04.0)2.21
Borehole mN		n	nE	Ground R.L.				Ê	g sel	ba) Iual			amala	and
	cription	: Re	fer to site plan				Legend	Depth (m)	Standing Water Level	Vane Shear(kPa)	Soil Sensitivity		ample ratory Test	Other
		SOIL	DESCRIPTION	N			Le	ا م	St	She	Ser		Detail	
_ TOPSOIL								1						Details:
clayey SILT, light g	arev m	ottled orang	ne/brown Very stiff	moist low to	medium nlas	ticity	IXX FXXX	<u></u>				0.0m-0 Bento		al
moderately sensitiv	ive [RE	SIDUAL EA	ST COAST BAYS F	ORMATION]	mediam pias	uoity,		- 0.5		152/44	3.5	0.5m-5.0m Screened	- with	Filter
<u> </u>								₫ <u>-</u> ₫-				Sock		
becoming orange s	streake	ed light grev	,					<u>}</u>				Dist	ple 1 urbed	
-	Sucan	od light groy						- 1.0		155/55	2.8	0.5-	1.0m	
E								<u>1</u>						
-								<u> </u>						
becoming insensiting	tive							⊆ 1.5		149/97	1.5			
F								<u> </u>						
- -										138/91	1.5			
-							$\frac{(\times \times)}{(\times \times)}$	1		100/01	1.0			
silty CLAY, orangelimonite	e streal	ked grey. Ve	ery stiff, moist, high	plasticity, inse	ensitive, with	trace	-x-x-x	_						
_							-×-×-×	- 2.5		108/72	1.5			
-								F						
F							-8-8-8	+						
- -							-x-x-x -x-x-x	- 3.0		105/72	1.5			
<u>-</u>							-×-×-×	-						
- -							-8-8-8	- - 3.5		105/69	1.5			
_							-x-x-x -x-x-x	<u> </u>		100/00	1.0	Stand		r Level
E							-x-x-x	_				as on		21 and
becoming stiff							-x-x-x	-4.0		72/41	1.8	Stand	ding	
F							-x-x-x	F				as or	า 09.02	r Level .21
F							-x-x-x	F				(4.05	m)	
becoming very stiff	ff						-×-×->	- 4.5		127/77	1.6			
<u>-</u>							-×-×-> -×-×->	+						
at 5.0m, becoming			tive				-8-8-5	: I		110/52	2.1			
_ EOB at 5.0m. Targ	get Dep	oth.						3.0						
t								F						
<u>-</u>								- 5.5						
-								E						
-								F						
9 05		Comment	·e·	Borehole Dia	ameter: Topso		$\frac{1}{\sqrt{Y}}$	-6.0	<u></u>	Sandston	 	Plut	onic	+++
		Groundwa	ter not encountere				> 	Gravel		Siltstone	222	• -	Core	+++
LANDER	_	1	able to penetrate. d of borehole.	Chec		E	c ×××	Organic	CACACA CACACA	_				
A DESCRIPTION OF A				JN	Silt	$- \hat{\mathbf{x}} $	^^ } F	Pumice		Volcanic	400	\sim		

Client :	ı	BENTLEY STUDIOS	LIM	ITED			Aug	er Bo	oreho	le No		HA12
Project	Locatio	on: 96 BEACH HAVEN F	ROAE	0 & 13 CREST/	A AVENUE						Sheet	12 of 16
Job Nu	ımber:	J01675				Vane I	Head: 53	Logge	d By: IM	Process PL	or: Da	ate: 04.02.21
Borehole	mN	mE	Gro	ound R.L.			Ê	g	ba) Iual	St	Son	anlo and
Location:	Description	: Refer to site plan				Legend	Depth (m)	Standing Water Level	Vane Shear(kPa) _{peak / residual}	Soil Sensitivity	Labora	nple and tory / Other Test
		SOIL DESCRIPTION	N			Le	De	Sta	She	Sen		etails
_ TOPSOIL							-					
silty CLAY	with trace fine	e sand, orange mottled light g	rev V	/erv stiff moist m	nedium to	-3-3-3	‡					
high plastic	ity, sensitive	[RESIDUAL EAST COAST BA	AYS F	FORMATION]	iodidiii to	-x-x-x -x-x-x	- 0.5		167/24	7.0		
-						-x-x-x -x-x-x	}					
-						-×-×-×	ŧ					
 becoming n 	noderately se	ensitive , without fine sand				-8-8-8	_1.0		191/55	3.5		
- becoming in	ilgii piasticity	, without line sallu				-x-x-x -x-x-x	-					
F						-x-x-x -x-x-x	F					
- -						-x-x-x -x-x-x	- 1.5		157/80	2.0		
-						-x-x-x -x-x-x	‡					
-						-x-x-x -x-x-x	╁					
becoming ir	nsensitive					-x-x-x -x-x-x	2.0		160/111	1.4		
-						-x-x-x	<u> </u>					
_						-×-×-×	- 2.5		141/93	1.5		
-						-8-8-8	<u> </u>		141/33	1.0		
Ŀ						-x-x-x -x-x-x	Ł					
_						-x-x-x -x-x-x	- 3.0		179/105	1.7		
becoming n	noist to wet					-8-8-8	<u> </u>					
-						-x-x-x -x-x-x	‡					
becoming s	tiff, moderate	ely sensitive				-8-8-8	- 3.5		96/43	2.2	Scala Penetr	ometer
_ silty CLAY v	with trace fine	e sand, grey. Hard, moist to w	et, me	edium to high pla	sticity	-x-x-x -x-x-x	ł				Test (Blows	/100mm)
	coming dark	grey/blue d to Auger Further. Scala pend	etrom	eter test commer	nced and		├ .		UTP		- 4 - 4	
found effect	tive refusal (ER) at 4.1m.	ouom	otor tool common	loca una		- 4.0				– 12 – 20+ (E	ER)
F							Ė					
_							- -4.5					
-												
-							-					
-							-5.0					
F							F					
ļ.							- -					
-							- 5.5					
Ł							_					
F							F					
_		Comments:		Borehole Diameter:	Topsoil	 	—6.0	<u></u>	Sandstone	• • •	Pluton	ic +++
		Groundwater not encountered	ed.	50mm	Fill	>> 1	Gravel		Siltstone	2 Z Z :	-	<u> </u>
	DER	UTP = unable to penetrate. EOB = end of borehole.		Checked:	Clay -		rganic	$\frac{\lambda \lambda \lambda}{\Lambda \Lambda \lambda}$	Limestone		3	
georeer	IIIVal	EOD - GIU OI DOI ETIDIE.		JM	Silt X	$egin{array}{c} K X X X \\ K X X X \end{array}$	umice	· * * * * * * * * * * * * * * * * * * *	Volcanic		_ 	

Project Location: 98 DEEACH HAVEN JOHN WITH THE ACT OF THE LOCATION SHOWN THE ACT OF THE LOCATION JOHN WITH THE ACT OF THE LOCATION JOHN THE LOCATION JOHN THE ACT OF THE LOCATION JOHN THE LOCATION JOHN THE ACT OF THE LOCATION JOHN THE LOCATION J	Client :		BE	NTLEY STUDIOS	LIMI	TED			Aug	er B	oreho	le No			HA13
Job Number: J01875 Soft Processor: Cate:	Project	Locatio	n: 96	BEACH HAVEN R	OAD	& 13 CRESTA	A AVENUE						Sheet	13	of 16
Borshole Location Description: Refer to site plan SOIL DESCRIPTION SOIL DESCRIPTION TOPSOIL Silv CLAY, crange, brown and light grey motited. Hard, dry, medium plasticity pressibulat, EAST COAST BAY'S FORMATION	Job Nu	ımber:								1		l			02.21
TOPSOIL ality CLAY, orange, brown and light grey motified. Hard, dry, medium plasticity [RESIDUAL EAST COAST BAYS FORMATION] becoming orange motified light grey becoming orange motified light grey with trace fine sand becoming very stiff, moderately sensitive becoming stiff, high plasticity, insensitive, without fine sand becoming light brown, with some woody inclusions becoming light prown, with some woody inclusions becoming orange motified light grey/white, without woody inclusions becoming light grey becoming light grey comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Checked: Casy Case Casy Case Casy Cas		Ì		mE	Gro	und R.L.			Ê						
TOPSOIL ality CLAY, orange, brown and light grey motified. Hard, dry, medium plasticity [RESIDUAL EAST COAST BAYS FORMATION] becoming orange motified light grey becoming orange motified light grey with trace fine sand becoming very stiff, moderately sensitive becoming stiff, high plasticity, insensitive, without fine sand becoming light brown, with some woody inclusions becoming light prown, with some woody inclusions becoming orange motified light grey/white, without woody inclusions becoming light grey becoming light grey comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. UTP = unable to penetrate. Comments: Groundwater not encountered. UTP = unable to penetrate. Checked: Casy Case Casy Case Casy Cas		Description		Refer to site plan				gend	oth (n	anding er Lev	ar(kP	soil		ratory	/ Other
alty CLAY, orange, brown and light grey motted. Hard, dry, medium plasticity PRESIDUAL EAST COAST BAYS FORMATION] becoming moist becoming orange mottled light grey with trace fine sand becoming very stiff, moderately sensitive becoming stiff, high plasticity, insensitive, without fine sand becoming gifth trown, with some woody inclusions becoming orange mottled light grey/white, without woody inclusions becoming light grey becoming light grey Comments: Groundwater not encountered. UTP = unable to persiste. Somm Fig. 50 caret Somm Fig. 50 caret Comments: Groundwater not encountered. UTP = unable to persiste. Comments: Groundwater not encountered. UTP = unable to persiste. Somm Fig. 50 caret Somm Fig. 50 caret Comments: Comments: Groundwater not encountered. UTP = unable to persiste. Comments: Comments: Groundwater not encountered. UTP = unable to persiste. Somm Fig. 50 caret Comments:			so	IL DESCRIPTIOI	N			Leç	Deg	Sta	She, <	Sens			
RESIDUAL EAST COAST BAYS FORMATION	_ TOPSOIL							1//	1						
RESIDUAL EAST COAST BAYS FORMATION	_								<u></u>						
becoming orange motited light grey with trace fine sand with trace fine sand becoming very stiff, moderately sensitive becoming stiff, high plasticity, insensitive, without fine sand becoming stiff, high plasticity, insensitive, without fine sand becoming light brown, with some woody inclusions becoming grange motited light grey/white, without woody inclusions becoming grange motited light grey/white, without woody inclusions becoming orange motited light grey/white, without woody inclusions becoming grange motited light grey becoming orange motited light grey becoming orange motited light grey Comments: Groundwater not encountered. Comments: Groundwater not encountered. Comments: Groundwater not encountered. Comments: Groundwater not encountered. Comments: Co					dry, ı	medium plasticit	у		5]						
becoming orange motited light grey with trace fine sand becoming very stiff, moderately sensitive with trace fine sand becoming stiff, high plasticity, insensitive, without fine sand becoming light brown, with some woody inclusions becoming light brown, with some woody inclusions becoming orange motited light grey/white, without woody inclusions becoming orange motited light grey/white, without woody inclusions becoming orange motited light grey/white, without woody inclusions becoming orange motited light grey becoming orange motited light grey Comments: Groundwater not encountered. Comments: Groundwater not encountered. Comments: Groundwater not encountered. UTP = unable to penetrate. Comments:	F.							-x-x-	- 0.5 -		UIP				
with trace fine sand - with trace fine sand - becoming very stiff, moderately sensitive - becoming stiff, high plasticity, insensitive, without fine sand - becoming light brown, with some woody inclusions - becoming orange mottled light grey/white, without woody inclusions - becoming orange mottled light grey/white, without woody inclusions - becoming orange mottled light grey - comments: - comme	+							= = .	-						
with trace fine sand with trace fine sand becoming very stiff, moderately sensitive becoming stiff, high plasticity, insensitive, without fine sand becoming light brown, with some woody inclusions becoming range motited light grey/white, without woody inclusions becoming light grey becoming orange motited light grey/white, without woody inclusions becoming orange motited light grey comments: Comments: Groundwater not encountered. Somn Fig. 3.5 Sard 3.5 Sardstor 2.2 2 Ne Core Plutarie 1.5 Comments: Groundwater not encountered. UTP = unable to penetrate. EOB at 5.0m. Target Depth. Comments:	becoming or	range mottled	l light gre	у				-x-x-	Г		201+				
with trace fine sand	_							-3-3-	<u>×</u> †						
with trace fine sand	E							-×-×-	×						
with trace fine sand becoming very stiff, moderately sensitive becoming stiff, high plasticity, insensitive, without fine sand becoming light brown, with some woody inclusions becoming orange mottled light grey/white, without woody inclusions becoming orange mottled light grey becoming o	_										201+				
with trace fine sand becoming very stiff, moderately sensitive becoming stiff, high plasticity, insensitive, without fine sand becoming light brown, with some woody inclusions becoming orange mottled light grey/white, without woody inclusions becoming orange mottled light grey becoming o	-							-x-x- -x-x-	<u>×</u> + <u>×</u> +						
with trace fine sand becoming very stiff, moderately sensitive becoming stiff, high plasticity, insensitive, without fine sand becoming light brown, with some woody inclusions becoming orange mottled light grey/white, without woody inclusions becoming light grey becoming orange mottled light grey/white, without woody inclusions becoming orange mottled light grey becoming orange m	-							-x-x-	<u> </u>						
with trace fine sand becoming very stiff, moderately sensitive becoming stiff, high plasticity, insensitive, without fine sand becoming light brown, with some woody inclusions becoming orange mottled light grey/white, without woody inclusions becoming very stiff becoming light grey becoming light grey becoming orange mottled light grey/white, without woody inclusions becoming light grey becoming orange mottled light grey becoming light	<u>-</u>							-3-3-	_ 2.0		201+				
becoming very stiff, moderately sensitive Second Sec	with trace fire	ne sand							-						
becoming stiff, high plasticity, insensitive, without fine sand becoming light brown, with some woody inclusions becoming orange mottled light grey/white, without woody inclusions becoming light grey becoming light grey becoming orange mottled light grey comments: 130/112 1.2 1.32/75 1.8 1.8 1.6 1.5	F							-×-×-	<u>×</u> -						
becoming light brown, with some woody inclusions becoming orange mottled light grey/white, without woody inclusions becoming light grey becoming light grey becoming light grey	becoming ve-	ery stiff, mode	erately se	ensitive				-x-x- -x-x-	× – 2.5 × –		184/89	2.1			
becoming light brown, with some woody inclusions becoming orange mottled light grey/white, without woody inclusions becoming light grey becoming light grey becoming light grey	-							-8-8-	<u>*</u>						
becoming light brown, with some woody inclusions becoming orange mottled light grey/white, without woody inclusions becoming light grey becoming light grey becoming light grey becoming orange mottled light grey becoming light grey b	<u></u>	iee latala alaa e			1			-x-x-	<u>×</u> +		05/50	4.0			
becoming orange mottled light grey/white, without woody inclusions becoming light grey becoming light grey becoming orange mottled light grey becoming orange mottled light grey becoming orange mottled light grey 130/112 1.2 130/112 1	F		-		and						95/58	1.6			
becoming light grey becoming light grey becoming orange mottled light grey becoming light grey	-			-					-						
becoming light grey becoming orange mottled light grey 132/75 1.8 158/109 1.4 158/109 1.4 176/115 1.5 Comments: Groundwater not encountered. UTP = unable to penetrate. EOB = end of borehole. UTP = unable to penetrate. EOB = end of borehole. Checked: Clay - Organic www.w. Limestone MM	_	-	l light gre	y/white, without wood	dy inc	lusions		-3-3-	- 35		130/112	12			
becoming orange mottled light grey 132/75 1.8 1.8 1	F	-						-8-8-	<u>\$</u> }		100/112	1.2			
becoming orange mottled light grey A	-	grit grey						-×-×-	×⊢						
EOB at 5.0m. Target Depth. Comments: Groundwater not encountered. UTP = unable to penetrate. EOB = end of borehole.	-							1-7-7-	v.1		132/75	1.8			
EOB at 5.0m. Target Depth. Topsoil Sand Sand	becoming or	range mottled	l light gre	У				-x-x- -x-x-	<u>*</u> 1						
EOB at 5.0m. Target Depth. Topsoil Sand Sandstone Plutonic + + +	-							1-2-2-	24						
EOB at 5.0m. Target Depth. Table Table Topsoil Sand Sandstone Plutonic Topsoil Sand Sandstone Plutonic Topsoil Sand Sandstone Plutonic Topsoil Sand Sandstone Plutonic Topsoil Sandstone Topsoil	-							-8-8-	× - 4.5		158/109	1.4			
EOB at 5.0m. Target Depth. -5.5 Comments: Groundwater not encountered. UTP = unable to penetrate. GOB = end of borehole. Comments: Groundwater not encountered. UTP = unable to penetrate. EOB = end of borehole. M 176/115 1.5 176/115 1.5 176/115 1.5	-							-8-8-	<u>×</u> ⊢						
EOB at 5.0m. Target Depth. -5.5 -6.0 Comments: Groundwater not encountered. UTP = unable to penetrate. EOB = end of borehole. Borehole Diameter: 50mm Fill Gravel Sand Gravel Siltstone 2 2 2 2 No Core Checked: EOB = end of borehole.	F							-x-x-	<u>₹</u> -						
Comments: Groundwater not encountered. UTP = unable to penetrate. EOB = end of borehole. Borehole Diameter: Topsoil Sand Gravel	EOB at 5.0m	n. Target Dep	oth.					 	- 5.0		176/115	1.5			
Comments: Groundwater not encountered. UTP = unable to penetrate. EOB = end of borehole. Borehole Diameter: Topsoil Sand Gravel	<u> </u>								<u> </u>						
Comments: Groundwater not encountered. UTP = unable to penetrate. EOB = end of borehole. Borehole Diameter: Topsoil Sand Gravel	-								- -						
Comments: Groundwater not encountered. UTP = unable to penetrate. EOB = end of borehole. Borehole Diameter: Topsoil Sand Sand Plutonic + + + + Sandstone Gravel Siltstone 2 2 2 2 No Core Checked: Clay Organic Sandstone 2 2 2 2 No Core	F								- 5.5						
Comments: Groundwater not encountered. UTP = unable to penetrate. EOB = end of borehole. Borehole Diameter: Topsoil Sand Sand Plutonic + + + + Sandstone Gravel Siltstone 2 2 2 2 No Core Checked: Clay Organic Sandstone 2 2 2 2 No Core	F								F						
Comments: Groundwater not encountered. UTP = unable to penetrate. EOB = end of borehole. Borehole Diameter: Topsoil Sand Sand Sand Sand Sand Sand Sand Sand	_								- 6.0						
LANDER geotechnical UTP = unable to penetrate. EOB = end of borehole. Checked: Clay Checked: Checked: Clay Checked: C			Comme	ents:			Topsoil	$\overline{\mathcal{M}}$			Sandstone		Plu	tonic	+++
geotechnical EOB = end of borehole.	I A AL) E D	1		d.		 <u> </u>-	1		www	Siltstone	+	-	Core	
				•			Tx	\overline{KXXX}	- 5		-	 	9		

Client :		BE	NTLEY STUDIOS	LIMI	TED			Aug	er B	oreho	le No			HA14
Project	Locatio	n: 96	BEACH HAVEN R	OAD	& 13 CRESTA	A AVENUE	: <u> </u>					Sheet	14	of 16
Job Nu	ımber:		1675				1	Head: 750	Logge	ed By: NM	Process		Date:	02.21
Borehole	mN		mE	Gro	und R.L.				 					
Location:	Description:		Refer to site plan				Legend	Depth (m)	nding r Lev	Vane Shear(kPa)	Soil Sensitivity			/ Other
		so	IL DESCRIPTION	N			Lec	Dep	Standing Water Level	Shea Peak	Sens		Test Detail	
TOPSOIL							$\overline{\mathcal{M}}$	4						
_ clayey SILT	, light brown.	Hard, dr	y to moist, low to no p	olastic	city [RESIDUAL I	EAST	 	<u>}</u>						
COAST BA	YS FORMATI ed and light g	ONI rey mottl	ed light brown					₹ 1		040				
F.								∑] − 0.5 ∑ -		216+				
-	ed mottled lig						ŢŶŶ	\$						
	nedium plastic							3 1-0 1.0		188/108	1.7			
_ silty CLAY, _ insensitive	grey streaked	l orange/	brown. Very stiff, moi	ist, m	edium to high pla	asticity,	-x-x- -x-x- -x-x-	<u>.</u> }						
L							-×-×-	×						
_							-x-x- -x-x-	- 1		177/68	1.7			
becoming or	range/brown s	streaked	grey				-×-×-	×+ ×+						
-							-x-x- -x-x-	×E						
_							-x-x-	2.0		154/139	1.1			
 becoming re 	ed and orange	/brown s	streaked grey				-x-x- -x-x-	<u>×</u> L						
F							-×-×- -×-×-	<u>×</u> +						
- -							-x-x- -x-x-	× – 2.5 × –		170/120	1.4			
becoming or	range/brown s	streaked	grey				-x-x- -x-x-	<u>:</u> }						
becoming hi	igh plasticity						-8-8-	×-		167/107	4.2			
F							-×-×-			167/127	1.3			
-							-×-×- -×-×-	≅.† ≥.†						
_							-×-×- -×-×-	-35		182/139	1.3			
_							-x-x- -x-x-	<u> </u>						
Ł							-8-8-	<u>ĕ</u> ⊢						
-							-x-x-	× -4.0		145/120	1.2			
F							-×-×-	<u>*</u> 1						
-							-x-x- -x-x-	24						
-							-x-x-	4.5		142/139	1.0			
_							-x-x-	×						
_							-×-×- -×-×-	<u>*</u> -						
_ EOB at 5.0m	n. Target Dep	th.					ļ <u></u>	— 5.0		139/108	1.3			
-								-						
_								- -5.5						
_								F 3.3						
-								F						
_								-6.0						
		Comme			Borehole Diameter:	Topsoil	/// /	Sand		Sandston	 	Plu	tonic	+++
LAND	DER		water not encountered unable to penetrate.	d.	50mm Checked:	Fill Clay -	1	Gravel Organic	WWW	Siltstone	222	Z No	Core	
geotech			end of borehole.		JM	Tx	$\frac{1}{\sqrt{2}}$	Pumice		Volcopio	,	-		

Client :		BE	NTLEY STUDIOS	LIMI	ΓED			Aug	jer B	oreho	le No			HA15
Project	Locatio	n: 96	BEACH HAVEN RO	OAD	& 13 CRESTA	A AVENUI	≣					Sheet	15	of 16
Job Nu	ımber:		1675					Head:	Logge	ed By: RZ	Process		Date: 04.0	02.21
Borehole	mN		mE	Grou	und R.L.					1				
Location:	Description:	ļ	Refer to site plan				Legend	Depth (m)	Standing Water Level	Vane Shear(kPa)	Soil Sensitivity			/ Other
		so	IL DESCRIPTION	N			Le	De	Sta	She	Sen		Test Detail	
_ TOPSOIL								1						
-) ‡						
_								– 0.5		132/106	1.2			
-								1						
silty CLAY, o	orange and bi	rown mot	tled. Hard, moist, med	dium	plasticity [RESII	DUAL EAS	г 	2 + 2+						
- COAST BAT	15 FURIVIATI	ONJ					-x-x-	1.0		201+				
becoming or	range and ligh	nt grey m	otted, with trace fine	sand			-8-8-	- <u>×</u> -						
becoming ver	ory stiff incon	citivo					- <u>×-</u> ×-							
- becoming ve	ery sun, msen	Silive					-x-x-	× – 1.5		115/81	1.4			
F							-x-x-							
becoming m	oderately ser	nsitive					- <u>×-</u> ×-	2.0		124/55	2.3			
becoming hi	igh plasticity,	without s	and				-x-x- -x-x-	-≅-L						
-							-8-8-	-≅E	\Box					
becoming in	sensitive						-8-8-	× – 2.5		104/72	1.4			
-							-x-x-	: <u>*</u> } : <u>*</u> }						
becoming st	iff saturated						-×-×-	- <u>×</u> -⊢		86/52	1.7			
	, cataratea						-x-x- -x-x-			00/32	1.7			
L							-x-x-	<u>-</u> ≱⊦						
- becoming ha	ard, grey						-×-×-	× - 3 5		201+				
F							-x-x-	<u>-</u> ≱⊦						
-							-x-x- -x-x-	<u>:</u> }-						
becoming ve							-×-×-	4.0		118/63	1.9			
becoming or	range mottled	grey					-x-x- -x-x-	-×-L						
becoming has	ard						-3-3-	-≅-F		201+				
-							-x-x- -x-x-	<u>-</u> ≽⊢						
							-x-x-	<u>₹</u> -						
EOB at 5.0m	n. Target Dep	th.					-8-8-	5.0		201+				
-								E						
_								-						
E								- 5.5						
E								E						
-						IS.	1	— 6.0	<u> </u>			<u> </u>		
		Comme	ents: water encountered at		Borehole Diameter: 50mm	Topsoil		Sand		Sandston		• -	tonic Core	+++
LAND	DER	3.0m.	mater encountered at inable to penetrate.	·	Checked:	Fill Clay		Gravel Organic	enera Energy	Siltstone Limestone	+	I NO	oute	
geotech	nnical		end of borehole.		JM	- 	(XXX) (XXX)	Pumice			- 	* -		

Client :	BENTLEY STUDIOS L	IMITED			Aug	er B	oreho	le No		HA16
Project Loca	ation: 96 BEACH HAVEN RC	OAD & 13 CRESTA	AVENUE							16 of 16
Job Numbe				Vane F		Logge F	ed By: RG	Process PL		te: 04.02.21
Borehole mN	mE	Ground R.L.			Ê	e a	'a) ual	>		
Location: Descri	iption: Refer to site plan			Legend	Depth (m)	Standing Water Level	Vane Shear(kPa)	Soil Sensitivity	Laborat	ple and ory / Other
	SOIL DESCRIPTION			l ec	De	Sta	She V	Sens		ēst etails
_ TOPSOIL				111	 				Piezome	ter Details:
	e streaked grey. Very stiff, moist, low COAST BAYS FORMATION]	to medium plasticity			-				0.0m-0.5 Bentonite	
- -					- 0.5		193+		0.5m-5.0m Screened Sock	with Filter
- - becoming medium រ -	plasticity				-					
- -					- 1.0		193+			
[<u> </u>					
with trace coarse as	and sized white pumiceous inclusions			[XXX [XXX [XXX	- 1.5		193+		-	vater Level
_	streaked grey. Very stiff, moist, medi		sensitive	<u> </u>	-				as on 19 (1.70m)	9.02.21
- with black organic s	treaks, with trace fine sand			-x-x-x -x-x-x -x-x-x	- 2.0		144/86	1.7		
clayey SILT, orange sensitive, with trace	e mottled light grey. Very stiff, moist,	medium plasticity, mod	derately	-x-x-x -x-x -x-x-x	- 2.5		127/50	2.5		
- Schallve, with trace	mione				<u>-</u> -					
becoming stiff, inse	nsitive				- 3.0		97/52	1.9		
- -					-					
silty CLAY, orange trace limonite	streaked light grey. Stiff, moist, medi	um plasticity, insensitiv	e, with	-x-x-x -x-x-x -x-x-x	3.5		86/52	1.7	Standing	g water Level
-				-x-x-x -x-x-x	<u>-</u>				as on 12 (3.70m)	2.02.21
becoming moderate-	ly sensitive			-x-x-x -x-x-x -x-x-x	- 4.0		75/36	2.1	as on 0	water Level 9.02.21
-				-x-x-x -x-x-x	 - -				(4.10m)	
becoming insensitivbecoming grey	e			-x-x-x -x-x-x -x-x-x	- 4.5		97/64	1.5		
- -				-x-x-x -x-x-x	- - - 5.0		75/41	1.8		
_ EOB at 5.0m. Targe	et Depth.				<u> </u>		1 3/41			
- -					_					
_ -					- 5.5					
Ė					<u> </u>					
-		1 1	15.5		- 6.0	<u> </u>	<u> </u>	<u> </u>		
	Comments: Groundwater not encountered	F0	opsoil Fill	' 	and ravel		Sandston	e 2 2 2	Plutonic No Core	++++
LANDER	UTP = unable to penetrate.	·	Clay		rganic	***	<u> </u>	+		<u> </u>
geotechnical	EOB = end of borehole.	JM	Silt XX	ਨਨੀ	umice		Volcanic	 	* 	



Our Ref: 1009521.1123.0.0/Rep1 Customer Ref: J01675 19 February 2021

Lander Geotechnical Consultants Limited Level 3, 3 Osterley way Manukau Auckland 2104

Attention: Rosie Garrill

Dear Rosie

96 Beach Haven & 13 Cresta Avenue Beach Haven

Laboratory Test Report

Samples from the above mentioned site have been tested as received according to your instructions and the results are included in this report. Results apply only to the sample(s) tested.

Descriptions are enclosed for your information, but are not covered under the IANZ endorsement of this report.

This report has been prepared for the benefit of Lander Geotechnical Consultants Limited, with respect to the particular brief given to us and it cannot be relied upon in other contexts or for any other purpose without our prior review and agreement.

This report may be reproduced only in full.

Samples not destroyed during testing will be retained for one month from the date of this report before being discarded. If we can be of any further assistance, feel free to get in touch. Contact details are provided at the bottom of this page.

GEOTECHNICS LTD	
Report prepared by:	Authorised for Geotechnics by:
Tulch	
Tylah Wararope	Paul Burton
Laboratory Technician	Project Director
Report checked by:	
HHH	All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Ryan Milligan Project Manager Approved Signatory

19-Feb-21

 $t:\qeotechnicsgroup\projects\1009521\1009521.1123\workingmaterial\20210219.96\ beach\ haven\ \&\ 13\ cresta\ avenue\ beach\ haven\ .tvwa.docx$

15C Amber Crescent Judea

Tauranga 3110 New Zealand

p +64 7 571 0280

Geotechnics Project Number 1009521.1123.0.0 W21TG-0027 **QESTLab Work Order ID** J01675

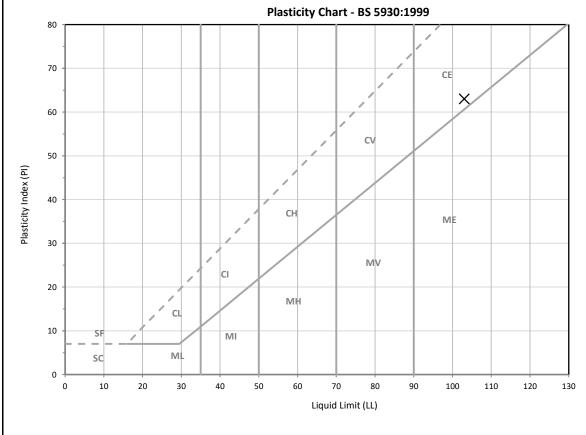
Customer Project ID

Determination of Liquid & Plastic Limit, Plasticity Index - NZS 4402: 1986 Tests 2.2 (4 Point), 2.3 & 2.4

		TEST DETAILS		
LOCATION	Description	96 Beach Haven & 13 Cresta A	venue Beach Haven	
	Data	N/A		
AMPLE	Geotechnics ID	S21TG000063		
	Reference	HA11	Top Depth	0.5m
	Sampled By	Others, Tested As Received	Bottom Depth	1.0m
	Description	Silty CLAY, with trace rootlets; plasticity.	light brown mixed orange	brown. Dry to moist, extremely hi
PECIMEN	Reference	N/A	Depth	N/A
	Description	N/A		

TEST RESULTS

Liquid Limit 103 **Plastic Limit** 40 Plasticity Index 63



A Line

Page 2 of 4

- — B Line

Soil Type M - Silt

C - Clay S - Sand

Plasticity

L - Low

I - Intermediate

H - High

V - Very High

E - Extremely High

TEST REMARKS

• The material used for testing was natural, fraction passing a 425um sieve. • This test result is IANZ accredited. • Date tested 18/02/2021

Approved Signatory Ryan Milligan 19/02/2021 Date

Our Ref: 1009521.1123.0.0/Rep1



15C Amber Crescent

Judea

Tauranga 3110

New Zealand

p +64 7 571 0280

Page 3 of 4 1009521.1123.0.0

Geotechnics Project Number

QESTLab Work Order ID

W21TG-0027

J01675 **Customer Project ID**

Determination of the Linear Shrinkage - NZS 4402:1986 Test 2.6

TEST DETAILS						
LOCATION	Description	96 Beach Haven & 13 Cresta Ave	96 Beach Haven & 13 Cresta Avenue Beach Haven			
	Data	N/A				
SAMPLE	Geotechnics ID	S21TG000063				
	Reference	HA11	Top Depth	0.5m		
	Sampled By	Others, Tested As Received	Bottom Depth	1.0m		
	Description	Silty CLAY, with trace rootlets; light brown mixed orange brown. Dry to moist, extremely high plastic				
SPECIMEN	Reference		Depth			
	Description					

Linear Shrinkage 22%

TEST REMARKS

Our Ref: 1009521.1123.0.0/Rep1

• This test result is IANZ accredited. • Date tested 17/02/2021

Approved Signatory Ryan Milligan

Date 19/02/2021



Tauranga 15C Amber Crescent Judea Tauranga 3110 New Zealand

p +64 7 571 0280

Report No: MAT:S21TG000063

lssue No: 1

Material Test Report

Customer: Lander Geotechnical **Address:** Level 3, 3 Osterley Way

Manukau, 2104

Project: 96 Beach Haven & 13 Cresta Avenue Beach Haven

Project No.: 1009521.1123.0.0

Customer Reference No.: J01675

Report Authorised By: Ryan Milligan

Approved By: Ryan Milligan

(Development Manager)
Date of Issue: 19/02/2021

Please reproduce this report in full when transmitting to others or including in internal reports.

Sample Details

Location 96 Beach Haven & 13 Cresta Avenue Beach Haven

Geotechnics ID S21TG000063

Sample Reference HA11

Sample Description Silty CLAY, with trace rootlets; light brown mixed orange brown. Dry to moist, extremely high plasticity.

Sample Depth 0.5m **Bottom Depth** 1.0m

Test Results

Description	Method	Result	Limits
Moisture Content [NZS 4402:1986 Test 2.1]			
Moisture Content (%)		31.4	
Date Tested		15/02/2021	

Comments

This test result is IANZ accredited.

If samples have been taken, and were not destroyed during testing, they will be retained for one month from the date of this report before being discarded.

3.2 Slab-on-ground in expansive soils

3.2.1 NZS 3604 Clause 1.1.2 Buildings covered by this Standard

Amend 1.1.2(a) to read:

"Buildings founded on good ground or on expansive soils where the requirements of 1.1.5 are met"

3.2.2 NZS 3604 New Clause Add new: "Clause 1.1.5 Buildings on expansive soils

Buildings on expansive soils shall be supported on slab-on-ground foundations complying with 7.5.13 and in addition to 1.1.2 shall be limited as follows:

- (a) single storey, stand-alone household unit, and
- (b) maximum length or width of floor of 24.0 m including any attached garage, and
- (c) simple plan shapes such as rectangular, L, T or boomerang, and
- (d)concrete slab-on-ground with a minimum thickness of 100 mm and a minimum concrete compressive strength of 20 MPa, and
- (e) simple roof forms, incorporating hips, valleys, gables or mono pitches, and
- (f) maximum overall height of 7.0 m to roof apex from lowest cleared ground level, and
- (g) maximum roof height of 3.0 m, and
- (h)roof slope between 10° and 35° from the horizontal, and
- (i) maximum span of roof truss 12.0 m, and
- external walls maximum of 2.4 m height studs, other than gable end walls and walls to mono-pitched roofs, which shall not exceed 4.0 m.

COMMENT:

Floor plans

Where floor plans incorporate re-entrant corners then continuity of the exterior ground beam shall be maintained by continuing it as an internal beam, with the exterior beam details continued for a length of at least 1.0 m into the internal beam. This is only applicable where internal beams are specified in Tables 7.4A and 7.4B. This is aimed to bring the solution in NZS 3604 in line with Clause 5.3.8 of AS 2870:2011.

Ground movement

Provision for the additional ground movement effects from trees near to foundations in expansive soils should be considered. Trees remove moisture from the soil for a radius equal to the height of the tree. This causes expansive soils to shrink to varying degrees, and when near houses leads to differential settlement occurring under foundations. Movement of the foundations may lead to cracks in the building and door jamming.

Where existing trees (including trees that have been recently removed) are located closer to the foundations than 1.5 times the mature height of a tree, then additional geotechnical advice should be obtained. Planting of new trees should be avoided near foundations of new buildings or neighbouring buildings on sites with expansive soils.

3.2.3 NZS 3604 Clause 7.5.1

Add the following paragraph at the end of Clause 7.5.1:

"Slabs on expansive soils for buildings meeting the requirements of 1.1.5 shall, in addition to meeting the requirements of 7.5.1 to 7.5.12, meet the requirements of 7.5.13. Where there is conflict the requirements of 7.5.13 shall apply."

3.2.4 NZS 3604 New clause, tables and figures

Add new: Clause 7.5.13 Slab-on-ground in expansive soils

7.5.13.1 Identification of expansive soils

7.5.13.1.1 Should reasonable enquiry as outlined in 3.1.3 show any signs of expansive soils, the expansive soil class, as defined in AS 2870, shall be established by one or all of:

- (a) enquiry to the local territorial authority, and/or
- (b) reference to the certificate of suitability issued in terms of NZS 4431, and/or
- (c) a soil test undertaken by a suitably qualified soils engineer.

7.5.13.1.2 Expansive soil class shall be defined as:

- (a) Slightly 'S', having an I_{SS} range of 0–1.9%, and a 500 year design characteristic surface movement return (y_S) of 22 mm, or
- (b) Moderately 'M', having an I_{SS} range of 2.0–3.7% and a 500 year design characteristic surface movement return (y_S) of 44 mm, or

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- (c) Highly 'H', having an I_{SS} range of 3.8–6.5% and a 500 year design characteristic surface movement return (y_S) of 78 mm, or
- (d) Extremely 'E', having an I_{SS} range of 6.6–7.5% and a 500 year design characteristic surface movement return (y_S) of 90 mm.

7.5.13.2 Maximum aspect ratio of concrete slabs

The aspect ratio of the concrete slabs or bays of concrete slabs, such as in the case of L, T or boomerang concrete slab shapes, shall not exceed 5 to 1 (length to width).

7.5.13.3 Foundation details

- 7.5.13.3.1 For the identified expansive soil class the foundation details, external and internal thickenings shall be as follows.
- (a) For light wall claddings refer to Table 7.4A and Figure 7.22.
- (b) For medium wall or heavy wall claddings refer to Table 7.4B and Figure 7.23.
- 7.5.13.3.2 Situations where no internal thickenings shall be required are limited to a rectangular slab with long side not exceeding 17.0 m. Where this limit is exceeded, add additional internal thickenings across the slab with the same cross section dimensions and reinforcing as the external footing, so that the centre to centre spacing of thickenings is always less than 17.0 m.

COMMENT:

Design constraints:

- a) The characteristic surface movements and the corresponding expansivity classifications have been calculated based on design for ultimate limit state (ULS) conditions for a 1 in 1000 year "extreme" drought event, and the serviceability limit state (SLS) conditions for a 1 in 500 year drought event.
- b) Maximum soil movements are calculated to be based on a 500 year return period for SLS, and a 1000 year return period for ULS*;
 - (*NB: This differed from the recommendations contained within BRANZ Study Report 120A (BSR120A) which used a 300 year return period for the design level drought conditions)

- c) Climate parameters adopted from BSR120A of $\Delta u = 1.2 \text{ pF, Hs} = 1.5 \text{ m, and a crack depth of } 0.5 \text{ Hs}$
- d) The I_{SS} (soil stability index) ranges attributed to the expansivity classifications as defined in 3.2.4 above have been calculated using the parameters presented in BSR120A and Equation 2.3.1 of AS 2870:2011.
- e) Sites subject to parameters that differ from those mentioned above, in particular sites where the crack depth is less than 0.75 m, such as cut natural ground or clay backfill, require specific engineering assessment to confirm their appropriate site classification.
- f) The effects of nearby trees (whether existing, recently removed, or future planting) are not considered in these solutions. It is recommended that specific geotechnical engineering advice is obtained where a tree is within a lateral distance of 1.5 times its mature height of the foundations.

Maintenance of foundations in expansive soils

Normal maintenance is that work generally recognised as necessary to achieve the expected performance over time of the foundation located on expansive soils. Unless otherwise specified by the designer and noted on the drawings, basic normal maintenance tasks should ensure that:

- a) the drainage and wetting of the site is controlled so that extremes of wetting and drying of the soils are prevented, and
- b) the position and operation of gardens adjacent to the dwelling are controlled, and the planting of trees near to foundations is suitably restricted, and
- c) any leaks which develop in plumbing, storm water or sanitary sewage systems are repaired promptly.

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Table 7.4A Reinforced concrete foundations in expansive soils for light wall claddings Clause 7.5.13 and Figure 7.22						
Expansive soil class	Slightly 'S'	Moderately 'M'	Highly 'H'	Extremely 'E'		
Soil embedment (De)	375 mm	525 mm	575 mm	625 mm		
Top steel (A _s top)	2/D 16	2/ D16	2/ D16	2/ D16		
Bottom steel (A _s bottom)	1/ D16	1/ D25	1/ D20	1/ D25		
Stirrups	R6/ 125 crs.	R6/ 125 crs.	R6/300 crs.	R6/300 crs.		
Maximum spacing of internal thickenings	no internal thickening	no internal thickening	2.5 m crs.	2.5 m crs.		
Depth of thickening (D1)	-	-	400 mm	450 mm		
Base width (B1)	-	-	300 mm	350 mm		
Top steel (A _s top)	-	-	2/ D20	2/ D20		
Bottom steel (A _s bottom)	-	-	2/ D16	2/ D20		
Stirrups	-	-	R6/150 crs.	R6/ 150 crs.		

Table 7.4B Reinforced concrete foundations in expansive soils for medium wall and heavy wall claddings Clause 7.5.13 and Figure 7.23						
Expansive soil class	Slightly 'S'	Moderately 'M'	Highly 'H'	Extremely 'E'		
Soil embedment (De)	500 mm	550 mm	775 mm	800 mm		
Top steel (A _s top)	2/ D16	2/ D20	2/ D20	3/ D20		
Bottom steel (A _S bottom)	2/ D16	2/ D16	2/ D20	2/ D20		
Stirrups	R6/ 125 crs.	R6/250 crs.	R6/300 crs.	R6/300 crs.		
Maximum spacing of internal thickenings	-	2.5 m crs.	2.5 m crs.	2.5 m crs.		
Depth of thickening (D1)	-	350 mm	450 mm	500 mm		
Base width (B1)	-	300 mm	300 mm	350 mm		
Top steel (A _s top)	-	2/ D16	3/ D20	3/ D20		
Bottom steel (A _s bottom)	-	2/ D16	2/ D16	2/ D20		
Stirrups	-	R6/ 125 crs.	R6/150 crs.	R6/ 150 crs.		

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Appendix E

Easdale Surveyors – Topographical Survey Plans

