Job No.	04819
Project	MAXWELL HILLS
Borehole Location	2587993 mE – 5957824 mN
Surface Elevation	93m
Surface Conditions	

LOG OF TEST PIT TP 35

Geol. Unit	SOIL/ROCK DESCRIPTION	Graphic Log	Unified Symbol	Depth (m)	Consistency	Moisture Condition	Sample Data: Samples	Sample Data: Shear Strength (kPa)	Sample Data: Water Content %	Groundwater	Comments & other Laboratory & Insitu Testing
	TOPSOIL		OL		VSt	M					
COLLUVIUM	SILT (very fine); non–plastic; angular gravels; remnant roots; indented only by strong finger; pressure, Class S3		ML								
	SILT; non–plastic; light grey and brown; difficult to indent by thumb nail, S6; occasional lenses of very fine light grey silt; gravels.			1	H						
				2							
TORLESS SUPERGROUP GREYWACKE	sub–horizontal rock contact. Rock of brown, MW, medium groined SANDSTONE, strong, closely jointed (20mm spacing).					D					
				3							
				4							
				5							

MACHINE TYPE: BACKHOE

TEST PIT TERMINATED AT:

- ☒ Target Depth
- ☐ Refusal
- ☐ Near Refusal
- ☐ Flooding

SAMPLE TYPE:

- B Bulk Sample
- u100 Undisturbed Sample, 100mm ø
- D Disturbed Profile Sample

FIELD SHEAR STRENGTH:

- V Shear Vane
- P Hand Penetrometer
- E Estimate Only

TEST PIT SECTION

Date Logged	30/06/05
Logged By	PR/WSS
Shear Vane No.	491
Shear Vane Testing based on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.

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Job No.	04819
Project	MAXWELL HILLS
Borehole Locotion	2587864 mE – 5957714 mN
Surface Elevotion	81m
Surface Conditians	

LOG OF TEST PIT TP 36

Geol. Unit	SOIL/ROCK DESCRIPTION	Graphic Log	Unified Symbol	Depth (m)	Consistency	Moisture Condition	Sample Data: Samples	Sample Data: Shear Strength (kPa)	Sample Data: Water Content %	Groundwater	Comments & other Laboratory & Insitu Testing
	TOPSOIL		OL		St	D/M					
COLLUVIUM	SILT; non–plastic; light brown; some angular grovels; occasional grey sandy silt filled fissures.		ML	1	VSt			UTP			
	SILT; light brown with grey fissures with limonite and mangonese mottles, Strenght Closs S6, hard.			2	H	M		UTP			
	E.O.P @ 3.9m (TARGET)			3 4 5							

MACHINE TYPE: BACKHOE

TEST PIT TERMINATED AT:

- ☒ Target Depth
- ☐ Refusal
- ☐ Neor Refusal
- ☐ Flooding

SAMPLE TYPE:

- B Bulk Sample
- u100 Undisturbed Sample, 100mm ø
- D Disturbed Profile Sample

FIELD SHEAR STRENGTH:

- V Sheor Vone
- P Hand Penetrometer
- E Estimate Only

TEST PIT SECTION

Date Logged	30/06/05
Logged By	WSS/PR
Shear Vone No.	
Sheor Vone Testing bosed on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.

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Job No.	04819
Project	MAXWELL HILLS
Borehole Location	2587920 mE – 5957632 mN
Surface Elevation	99m
Surface Conditions	

LOG OF TEST PIT TP 36A

Geol. Unit	SOIL/ROCK DESCRIPTION	Graphic Log	Unified Symbol	Depth (m)	Consistency	Moisture Condition	Sample Data: Samples	Sample Data: Shear Strength (kPa)	Sample Data: Water Content %	Groundwater	Comments & other Laboratory & Insitu Testing
	TOPSOIL		OL			M					
COLLUVIUM	SILT; non-plastic; light brown.		ML		H	D		UTP			
	GRAVELLY SILT; cemented; light brown; remnant roots; black fissures; HW clasts; Strength Class S6.			1		D/M					
TORLESSE SUPERGROUP GREYWACKE	brown, uniform, MW, fine grained SANDSTONE; closely jointed (40mm spacing) with brown staining. J1 orientation 28/277° (d/dd). J2 orintation 90/282 (d/dd); breaks into angular chips after many blows from geo-pick, strength class S5 'hard rock'.			2		D					
	E.O.T.P @ 2.0m (REFUSAL)			3							
				4							
				5							

MACHINE TYPE: BACKHOE

TEST PIT TERMINATED AT:

- ☒ Target Depth
- ☐ Refusal
- ☐ Near Refusal
- ☐ Flooding

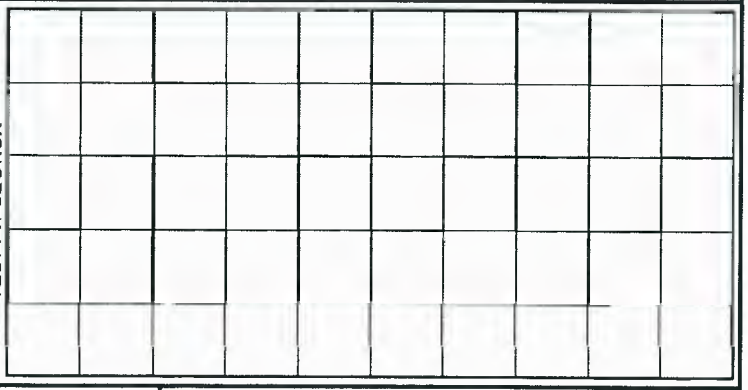
SAMPLE TYPE:

- B Bulk Sample
- u100 Undisturbed Sample, 100mm ø
- D Disturbed Profile Sample

FIELD SHEAR STRENGTH:

- V Shear Vane
- P Hand Penetrometer
- E Estimate Only

TEST PIT SECTION



Date Logged	30/06/05
Logged By	PR/WSS
Shear Vane No.	491
Shear Vane Testing based on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.
d/dd=dip/dip direction

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Job No.	04819
Project	MAXWELL HILLS
Borehole Location	2587643 mE – 5957467 mN
Surface Elevation	73.7m
Surface Conditions	

LOG OF TEST PIT TP 38

Geol. Unit	SOIL/ROCK DESCRIPTION	Graphic Log	Unified Symbol	Depth (m)	Consistency	Moisture Condition	Sample Data: Samples	Sample Data: Shear Strength (kPa)	Sample Data: Water Content %	Groundwater	Comments & other Laboratory & Insitu Testing
COLL'M	TOPSOIL; friable; sub–angular; rootlets.		OL			M					
	SILT; trace cloy; sub–angular to rounded gravels.		ML								
	GRAVELS; trace fines, clast support matrix, SW.		GW								
TORLESSE SUPERGROUP GREYWACKE	ROCK/GRAVEL contact, orientation 40/338° (d/dd) SANDSTONE; highly fractured; brown; fine grained, SW–MW; block stained fracture surfaces; Strength Class R6; rock breaks into angular chips along fractures.			1 2 3 4 5							
	E.O.T.P @ 1.2m (REFUSAL)										

MACHINE TYPE: BACKHOE

TEST PIT TERMINATED AT:

- ☒ Target Depth
- ☐ Refusal
- ☐ Near Refusal
- ☐ Flooding

SAMPLE TYPE:

- B Bulk Sample
- u100 Undisturbed Sample, 100mm ø
- D Disturbed Profile Sample

FIELD SHEAR STRENGTH:

- V Shear Vane
- P Hand Penetrometer
- E Estimate Only

TEST PIT SECTION

Date Logged	30/06/05
Logged By	WSS/PR
Shear Vane No.	491
Shear Vane Testing based on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.

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Job No.	04819
Project	MAXWELL HILLS
Borehole Location	2587785 mE – 5957438 mN
Surface Elevation	90.5m
Surface Conditions	

LOG OF TEST PIT TP 39

Geol. Unit	SOIL/ROCK DESCRIPTION	Graphic Log	Unified Symbol	Depth (m)	Consistency	Moisture Condition	Sample Data: Samples	Sample Data: Shear Strength (kPa)	Sample Data: Water Content %	Groundwater	Comments & other Laboratory & Insitu Testing
	TOPSOIL		OL			M					
COLLUVIUM	SILT; brown with occasional fine gravels.		MI		F						
	SILT; grey with orange mottles; moderately plastic; fines and sub-rounded gravels.			1	H			V211 R36 UTP			CLEGG 11,12,14,14,15
	SILTY GRAVEL; fine-medium, angular with silt, dense.		GP			D					
	SILT; grey with orange mottles.		ML	2							CLEGG 19,26,26,26,26
TORLESSE SUPERGROUP	ROCK			3							
	E.O.T.P 3.9m (Target)			4							
				5							

MACHINE TYPE: BACKHOE

TEST PIT TERMINATED AT:

- ☒ Target Depth
- ☐ Refusal
- ☐ Near Refusal
- ☐ Flooding

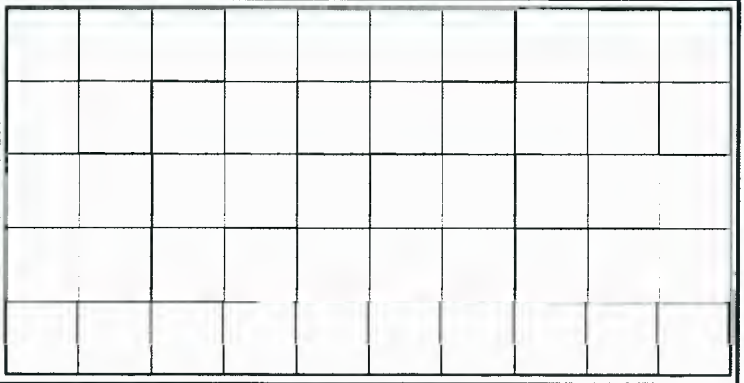
SAMPLE TYPE:

- B Bulk Sample
- u100 Undisturbed Sample, 100mm ø
- D Disturbed Profile Sample

FIELD SHEAR STRENGTH:

- V Shear Vane
- P Hand Penetrometer
- E Estimate Only

TEST PIT SECTION



Date Logged	29/06/05
Logged By	TS/PR
Shear Vane No.	491
Shear Vane Testing based on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.

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Job No.	04819
Project	MAXWELL HILLS
Borehole Location	2589097 mE – 5958368 mN
Surface Elevation	127m.
Surface Conditions	

LOG OF TEST PIT TP 103

Geol. Unit	SOIL/ROCK DESCRIPTION	Graphic Log	Unified Symbol	Depth (m)	Consistency	Moisture Condition	Sample Data: Samples	Sample Data: Shear Strength (kPa)	Sample Data: Water Content %	Groundwater	Comments & other Laboratory & Insitu Testing
COLLUVIUM	silty fine to medium SAND: with rootlets, dry, loose, dark brown		OL	0		M					
COLLUVIUM	silty, fine to medium SAND: locally with some subrounded to angular fine to medium sandstone gravel, silt of low plasticity, dense, moist, light grey spotted brown		SD								
HILLERSDEN GRAVEL	clayey SAND: with some gravel of highly weathered subrounded sandstone		SD								
HILLERSDEN GRAVEL	sandy GRAVEL: with trace silt, and some cobbles and boulders below 0.9m, gravel is well graded, slightly to moderately weathered, moderately strong to strong, subrounded to subangular, sandstone, massive bedding, matrix of sand and fines supports coarse grains, very dense, moist, brown spotted grey		GD	1							SCALA
	E.O.T.P @ 1.2m			2							
				3							
				4							
				5							

MACHINE TYPE: BACKHOE

TEST PIT TERMINATED AT:

- ☒ Target Depth
- ☐ Refusal
- ☐ Near Refusal
- ☐ Flooding

SAMPLE TYPE:

- ☒ Bulk Sample
- u100 Undisturbed Sample, 100mm ø
- D Disturbed Profile Sample

FIELD SHEAR STRENGTH:

- V Shear Vane
- P Hand Penetrometer
- E Estimate Only

TEST PIT SECTION

Date Logged	27/6/05
Logged By	EL
Shear Vane No.	GEO5
Shear Vane Testing based on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.

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Job No.	04819
Project	MAXWELL HILLS
Borehole Location	2589233 mE – 5958308 mN
Surface Elevation	133m
Surface Conditions	

LOG OF TEST PIT TP 104

Geol. Unit	SOIL/ROCK DESCRIPTION	Graphic Log	Unified Symbol	Depth (m)	Consistency	Moisture Condition	Sample Data: Samples	Sample Data: Shear Strength (kPa)	Sample Data: Water Content %	Groundwater	Comments & other Laboratory & Insitu Testing
COL	fine gravelly SAND: with some silt, rootlets, loose, moist, brown		OL			M					
COL	silty fine to coarse SAND: medium dense, moist, brown, very thinly interbedded with sandy SILT.		SM								
PA	silty fine SAND; with rootlets, medium dense, dark brown		SM								
LOESS	silty fine SAND; with rootlets, medium dense, dark brown		SM								
LOESS	fine sandy SILT: homogeneous, stiff, moist, brown to grey mottled orange		ML	1				V88 R19			SCALA; SCALA
				2							GLEGG = 20 @ 1.5m; SCALA
HILLERSDEN GRAVEL	sandy GRAVEL: with trace silt, locally with some cobbles and boulders, gravel is well graded, slightly to highly weathered, moderately strong to strong, subrounded to subangular, sandstone, massive bedding, matrix of sand and fines supports coarse grains, very dense, moist, brown spotted grey.		GD	3							SCALA
	E.O.T.P @ 3.5m			4							
				5							

MACHINE TYPE: BACKHOE

TEST PIT TERMINATED AT:

- ☒ Torget Depth
- ☐ Refusal
- ☐ Near Refusal
- ☐ Flooding

SAMPLE TYPE:

- ☒ Bulk Sample
- u100 Undisturbed Sample, 100mm ø
- D Disturbed Profile Sample

FIELD SHEAR STRENGTH:

- V Shear Vane
- P Hand Penetrometer
- E Estimate Only

GEOLOGICAL UNIT:

- COL = COLLUVIUM
- PA = PALEOSOL

TEST PIT SECTION

Date Logged	27/6/05
Logged By	EL
Shear Vane No.	GEO5
Shear Vane Testing based on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.

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Job No.	04819
Project	MAXWELL HILLS
Borehole Location	2588150 mE – 5957812 mN
Surface Elevation	147.7m
Surface Conditions	

LOG OF TEST PIT TP 140

Geol. Unit	SOIL/ROCK DESCRIPTION
COLLUVIUM	silty SAND: with some subrounded gravels, rootlets, loose, moist, dark brown
	sandy GRAVEL: with some cobbles, gravel is slightly weathered to moderately weathered, subrounded to subangular, rootlets, loose, moist, brown
HILLERSDEN GRAVEL	sandy GRAVEL: with some silt, locally with cobbles and boulders, gravel is well graded, slightly to moderately weathered, strong to moderately strong, subrounded to subangular, sandstone, massive bedding, matrix of sand and fines supports coarse grains, loose, moist, brown grey. Locally cut by subvertical stiff grey moderately plastic clay seams <10mm wide.
	E.O.T.P @ 1.5m

Graphic Log | Unified Symbol | Depth (m) | Consistency | Moisture Condition | Sample Data: Samples | Shear Strength (kPa) | Water Content % | Groundwater | Comments & other Laboratory & Insitu Testing

Unified Symbol: OL, GL

Moisture Condition: M

Depth (m): 1, 2, 3, 4, 5

MACHINE TYPE: BACKHOE

TEST PIT TERMINATED AT:

- ☒ Target Depth
- ☐ Refusal
- ☐ Near Refusal
- ☐ Flooding

SAMPLE TYPE:

- ☒ Bulk Sample
- u100 Undisturbed Sample, 100mm ø
- D Disturbed Profile Sample

FIELD SHEAR STRENGTH:

- V Shear Vane
- P Hand Penetrometer
- E Estimate Only

TEST PIT SECTION

Date Logged	30/06/05
Logged By	EL
Shear Vane No.	GEO5
Shear Vane Testing based on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.

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LOG OF TEST PIT TP 141

Job No.	04819
Project	MAXWELL HILLS
Borehole Location	2588178 mE – 5958035 mN
Surface Elevation	105m
Surface Conditions	

Geol. Unit	SOIL/ROCK DESCRIPTION	Graphic Log	Unified Symbol	Depth (m)	Consistency	Moisture Condition	Sample Data: Samples	Sample Data: Shear Strength (kPa)	Sample Data: Water Content %	Groundwater	Comments & other Laboratory & Insitu Testing
COLLUVIUM	silty SAND: with some subrounded gravels, rootlets, loose, moist, dark brown		OL			M					
	fine sandy SILT of low plasticity: homogeneous, soft, moist, grey		ML								
	gravelly SILT of low plasticity: with some cobbles, gravel is angular to subrounded sandstone, stiff, fissured, moist, brown mottled red		ML	1							SCALA
	silty GRAVEL: with some sand, gravel typically fine to medium, subrounded to angular, moderately weathered of sandstone, very dense, locally porous, moist, light brown spotted grey.		GD	2							
HILLERSDEN GRAVEL	sandy GRAVEL: with some silt, locally with cobbles, gravel is well graded, slightly to moderately weathered, strong to moderately strong, subrounded to subangular, sandstone, massive bedding, matrix of sand and fines supports coarse grains, very dense, moist, brown grey. Local pockets of matrix supported fine to medium gravel		GD	3							
	E.O.T.P @ 3.5m			4							
				5							

MACHINE TYPE: BACKHOE

TEST PIT TERMINATED AT:

- ☒ Target Depth
- ☐ Refusal
- ☐ Near Refusal
- ☐ Flooding

SAMPLE TYPE:

- ☒ Bulk Sample
- u100 Undisturbed Sample, 100mm ø
- D Disturbed Profile Sample

FIELD SHEAR STRENGTH:

- V Shear Vane
- P Hand Penetrometer
- E Estimate Only

GEOLOGICAL UNIT:

LO COL = loess colluvium

TEST PIT SECTION

Date Logged	30/06/05
Logged By	EL
Shear Vane No.	GEO5
Shear Vane Testing based on BS 1377	

OBSERVATIONS:
UTP= unable to penetrate with shear vane.

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APPENDIX B

Laboratory Tests Report

Reference No: 05/1284

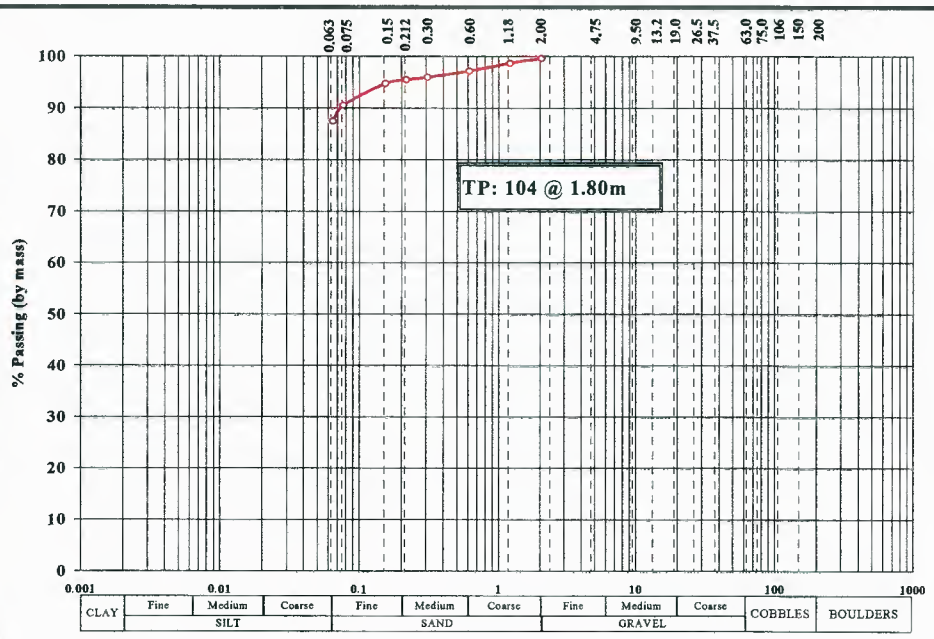
Date: 6 August 2005

TEST REPORT – MAXWELL HILLS INVESTIGATIONS

Client Details:	Riley Consultants Ltd, P.O. Box 4355, Christchurch	**Attention:**	Edwyn Ladley
Job Description:	Maxwell Hills Investigations; J. Marris (Job No 04819)	**Date & Time Sampled:**	27-Jun-05 @ 2.00pm
Sample Description:	CLAYEY SILT with minor sand	**Sampled By:**	Not Stated
Sample Source:	TP 104	**Sampled Depth:**	1.80m
Sample Method:	Unknown	**Sample Label No:**	15973 & 15974

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
150.0	
106.0	
75.0	
63.0	
37.5	
26.5	
19.0	
13.2	
9.50	
4.75	
2.00	100
1.18	99
0.60	97
0.30	96
0.212	95
0.150	95
0.075	90
0.063	87



The material was received in a natural state.
The percentage passing the 63µm test sieve was obtained by difference.

Note:

- IANZ endorsement of this report does not apply to the sampling.
- This report may not be reproduced except in full.

Tested By: P.R. Gibson Date: 28-Jul-05 to 6-Aug-05

Transcriptions Checked By:

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

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new zealand accredited laboratory

Reference No: 05/1284

Date: 6 August 2005

TEST REPORT – MAXWELL HILLS INVESTIGATIONS

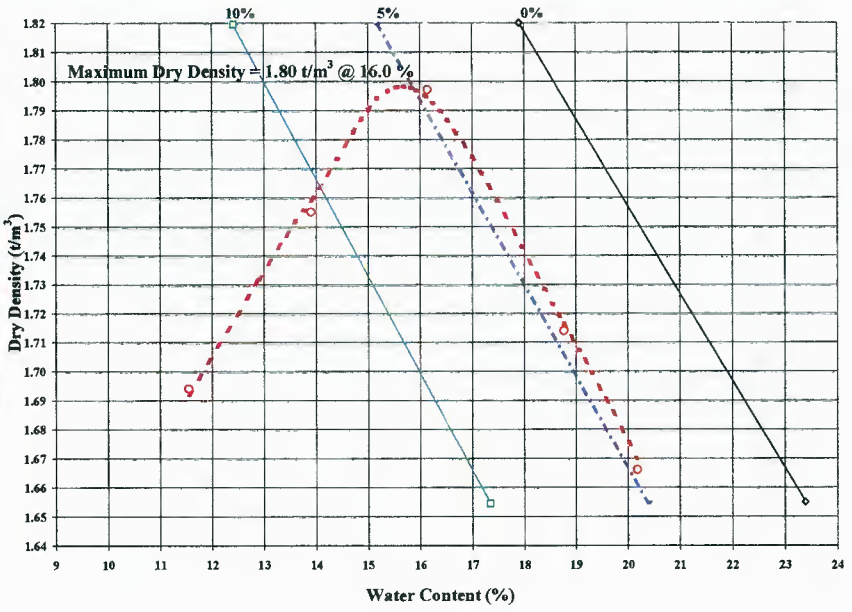
Client Details:	Riley Consultants Ltd, P.O. Box 4355, Christchurch	Attention:	Edwyn Ladley
Job Description:	Maxwell Hills Investigations; J. Marris (Job No 04819)	Date & Time Sampled:	27-Jun-05 @ 2.00pm
Sample Description:	CLAYEY SILT with minor sand	Sampled By:	Not Stated
Sample Source:	TP 104	Sampled Depth:	1.80m
Sample Method:	Unknown	Sample Label No:	15973 & 15974

WATER CONTENT & NZ STANDARD COMPACTION – NZ 4402:1986, Test 2.1 & 4.1.1

Water Content: (As Received)	13.2 %
% Retained (19.0mm Test Sieve)	0.0 %
Maximum Dry Density:	1.80 t/m^3
Optimum Water Content :	16.0 %

Notes:

- The sample received was in a natural state.
- The material tested was whole soil.
- The air voids lines were calculated from an assumed solid density of 2.70 t/m^3.



PLASTICITY INDEX RESULTS - NZS 4402:1986, Test 2.2, 2.3 & 2.4	
Liquid Limit: (LL)	27
Plastic Limit: (PL)	16
Plasticity Index: (PI)	11

Note: The sample received was in a natural state. The material tested was the fraction passing the 425 µm test sieve.

Tested By: P.R. Gibson Date: 28-Jul-05 to 6-Aug-05

Transcriptions Checked By:

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

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Reference No: 05/1284

Date: 6 August 2005

TEST REPORT – MAXWELL HILLS INVESTIGATIONS

Client Details:	Riley Consultants Ltd, P.O. Box 4355, Christchurch	**Attention:**	Edwyn Ladley
Job Description:	Maxwell Hills Investigations; J. Marris (Job No 04819)	**Date & Time Sampled:**	27-Jun-05 @ 2.00pm
Sample Description:	CLAYEY SILT with minor sand	**Sampled By:**	Not Stated
Sample Source:	TP 104	**Sampled Depth:**	1.80m
Sample Method:	Unknown	**Sample Label No:**	15973 & 15974

LABORATORY SOAKED CBR RESULTS – NZS 4402:1986, Test 6.1.1	
Condition of Sample:	Soaked
Surcharge Mass: (kg)	4.0
Time Soaked:	4 days
Swell: (%)	0.2
Water Content as Compacted: (%)	16.5
Water Content From Under Plunger: (%)	16.9
Dry Density As Compacted: (t/m^3)	1.79
CBR Value @ 2.5 mm Penetration:	3.0
CBR Value @ 5.0 mm Penetration:	4.0
Reported CBR Value:	4.0

Notes:

- The material received was in a natural state.
- The material tested was whole soil.
- The sample was compacted to NZ Standard Compaction.
- The rate of penetration was 1.14 mm / min.
- IANZ endorsement of this report does not apply to the sampling.
- This report may not be reproduced except in full.

Tested By: P.R. Gibson **Date:** 28-Jul-05 to 6-Aug-05

Transcriptions Checked By:

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Reference No: 05/1284

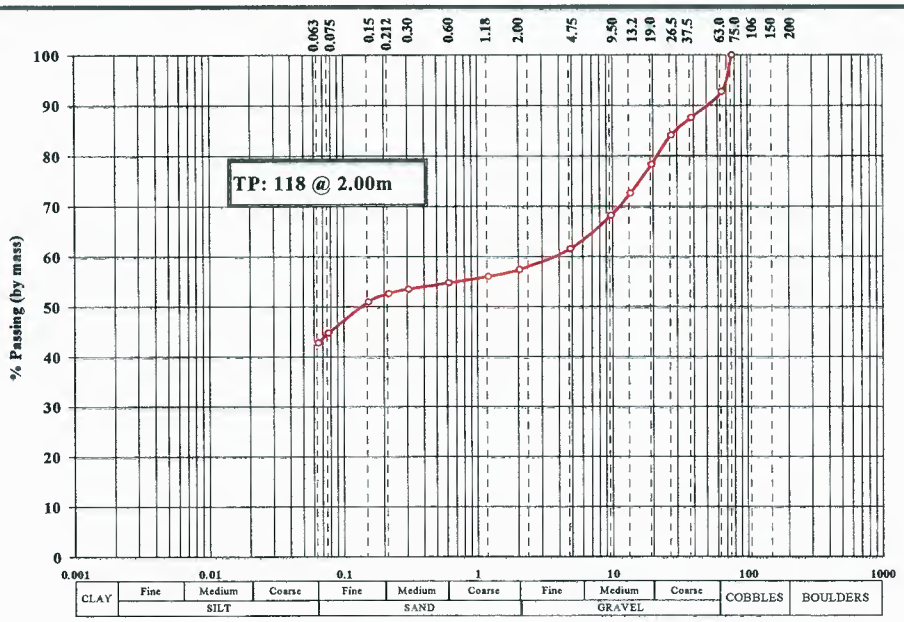
Date: 6 August 2005

TEST REPORT – MAXWELL HILLS INVESTIGATIONS

Client Details:	Riley Consultants Ltd, P.O. Box 4355, Christchurch	**Attention:**	Edwyn Ladley
Job Description:	Maxwell Hills Investigations; J. Marris (Job No 04819)	**Date & Time Sampled:**	28-Jun-05
Sample Description:	SILTY / CLAYEY GRAVEL with some sand	**Sampled By:**	Not Stated
Sample Source:	TP 118	**Sampled Depth:**	2.00m
Sample Method:	Unknown	**Sample Label No:**	15959

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
150.0	
106.0	
75.0	100
63.0	93
37.5	88
26.5	84
19.0	78
13.2	73
9.50	68
4.75	62
2.00	57
1.18	56
0.60	55
0.30	54
0.212	53
0.150	51
0.075	45
0.063	43



The material was received in a natural state

The percentage passing the 63µm test sieve was obtained by difference.

Note:

- **IANZ endorsement of this report does not apply to tbe sampling.**
- **This report may not be reproduced except in full.**

Tested By: P.R. Gibson Date: 28-Jul-05 to 6-Aug-05

Transcriptions Checked By:

All tests reported herein bave been performed in accordance with the laboratory's scope of accreditation

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Reference No: 05/1284

Date: 6 August 2005

TEST REPORT – MAXWELL HILLS INVESTIGATIONS

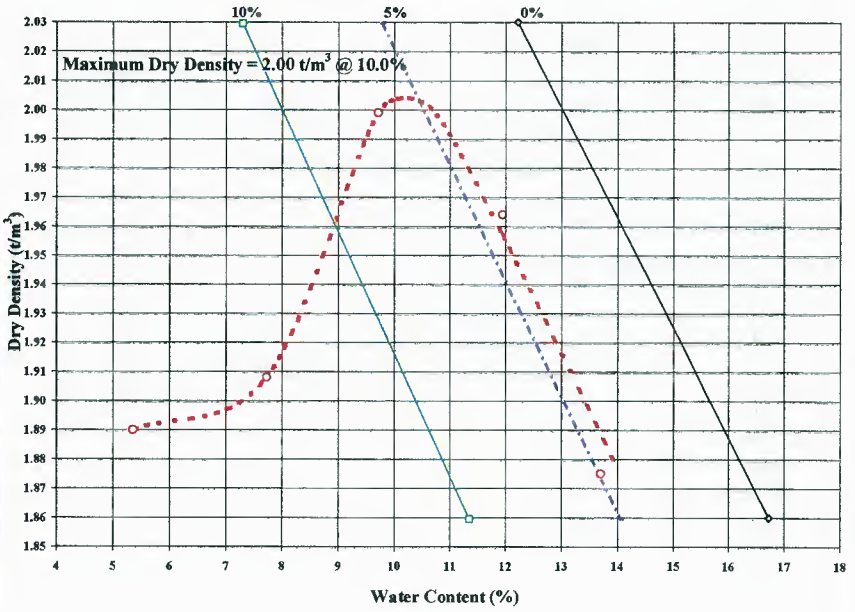
Client Details:	Riley Consultants Ltd, P.O. Box 4355, Christchurch	Attention:	Edwyn Ladley
Job Description:	Maxwell Hills Investigations; J. Marris (Job No 04819)	Date & Time Sampled:	28-Jun-05
Sample Description:	SILTY / CLAYEY GRAVEL with some sand	Sampled By:	Not Stated
Sample Source:	TP 118	Sampled Depth:	2.00m
Sample Method:	Unknown	Sample Label No:	15959

WATER CONTENT & NZ STANDARD COMPACTION – NZ 4402:1986, Test 2.1 & 4.1.1

Water Content: (As Received)	10.0 %
% Retained (19.0mm Test Sieve)	22.0 %
Maximum Dry Density:	2.00 t/m^3
Optimum Water Content :	10.0 %

Notes:

- The sample received was in a natural state.
- The material tested was fraction passing a 19mm test sieve.
- The air voids lines were calculated from an assumed solid density of 2.70 t/m^3.



PLASTICITY INDEX RESULTS - NZS 4402:1986, Test 2.2, 2.3 & 2.4	
Liquid Limit: (LL)	22
Plastic Limit: (PL)	16
Plasticity Index: (PI)	6
Note: The sample received was in a natural state. The material tested was the fraction passing the 425 µm test sieve.	

Tested By: P.R. Gibson Date: 28-Jul-05 to 6-Aug-05

Transcriptions Checked By:

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

434 new zealand accredited laboratory

Reference No: 05/1284

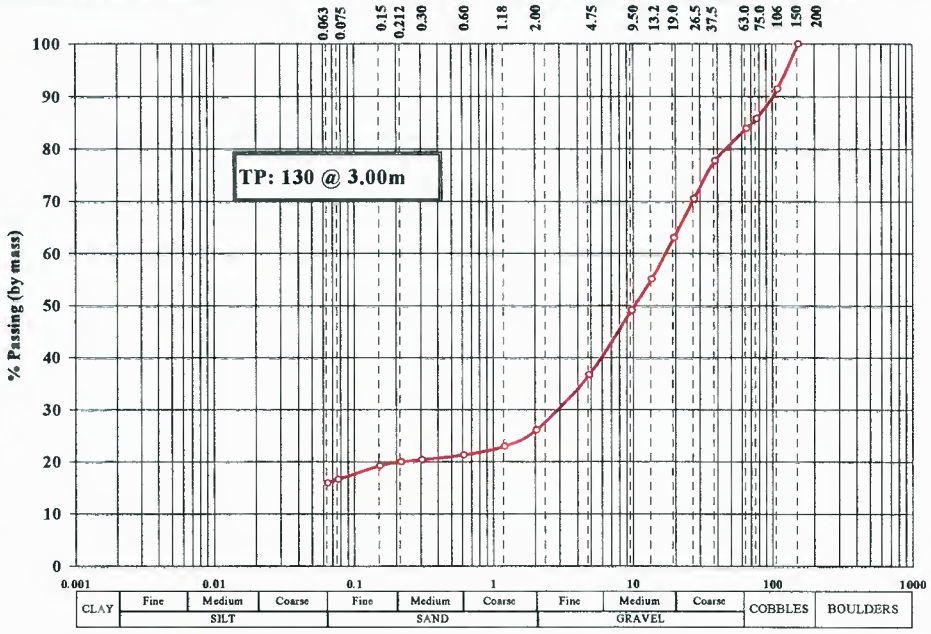
Date: 6 August 2005

TEST REPORT – MAXWELL HILLS INVESTIGATIONS

Client Details:	Riley Consultants Ltd, P.O. Box 4355, Christchurch	Attention:	Edwyn Ladley
Job Description:	Maxwell Hills Investigations; J. Marris (Job No 04819)	Date & Time Sampled:	30-Jun-05
Sample Description:	GRAVEL with some silt and minor sand	Sampled By:	Not Stated
Sample Source:	TP 130	Sampled Depth:	3.00m
Sample Method:	Unknown	Sample Label No:	15981, 15986, 15988, 15990

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
150.0	100
106.0	91
75.0	86
63.0	84
37.5	78
26.5	70
19.0	63
13.2	55
9.50	49
4.75	37
2.00	26
1.18	23
0.60	21
0.30	20
0.212	20
0.150	19
0.075	17
0.063	16



The material was received in a natural state.
The percentage passing the 63µm test sieve was obtained by difference.

Note:

- IANZ endorsement of this report does not apply to the sampling.
- This report may not be reproduced except in full.

Tested By: P.R. Gibson Date: 28-Jul-05 to 6-Aug-05

Transcriptions Checked By:

Approved Signatory

A.P. Julius
Laboratory Manager

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

434

APPENDIX C

GNS letter concerning activity of faults at the north-east site boundary

19 December 2006

GNS Project No:430W1000
GNS Letter 2006/250LR

1 Fairway Drive
Avalon
PO Box 30 368
Lower Hutt
New Zealand
T +64-4-570 1444
F +64-4-570 4600
www.gns.cri.nz

Mr Ed Ladley
Riley Consultants Ltd.
P.O. Box 4355
Christchurch

Re: Letter Report on 'Active Fault Concerns at Maxwell Pass Road Property'

Dear Ed,

Thank you for your enquiry and approach concerning Active Faulting at the Maxwell Pass Road subdivision south of Blenheim (Fig. 1).
This letter has been written to describe the efforts I undertook to understand this system of faults, summarises as follows:

1. Three active fault traces are shown in the area southeast of Maxwell Pass Rd, east of the prpoposed subdivision (see the GNS Active Faults Database (http://maps.gns.cri.nz/website/af/index.html) and Fig. 2).

2. The data for these faults is derived from GNS QMAP (1 to Quarter million scale) mapping; Geology of the Wellington Area by Begg & Johnston (2000). The main rocks in the area of interest are of Cretaceous age, being Pahau Terrane greywacke rocks, and Pliocene Hillersden Gravel.

3. The mapped fault traces themselves have mapped lengths of 1.9, 2.7 and 6.2 km in length. They strike roughly East-West or NW-SE through that area. At its SE end the 6.2 km long, NW-SE trending fault is shown cutting deposits interpreted as Q6a in age (128,000-186,000 yr).

4. The traces are generally mapped across hilly terrain with scarp heights of c. 0.5 metre (M. Johnston, pers. communication, 2006). The faults do cross some stream catchments though no young scarps have been identified in these areas.

I have taken a look at the old 1947 Black and White aerial photo runs that we have here at GNS (Run 1305, frames 62-66). The faults mapped by Begg & Johnston (2000), and shown in the GNS Active Faults Database are visible on these photos.

The three faults converge toward the west and cross the hill country above the nearby Homebrook Station. Curiously, but as observed on the aerial photographs, the east-west trending fault does not continue westward onto the proposed subdivision site. That is, I cannot map a fault from aerial photographs across the proposed site. This is consistent with the previous GNS mapping described above.

Therefore, on the basis of this information there is no active fault surface rupture hazard that can be mapped across the site. No additional fault exploration work needs to be undertaken at this site.

To support this conclusion the following assertions can be made about these features.

1. Active faults are generally defined as faults that cut deposits of age <125,000 years (Q5 age or less). It is likely that these faults are active even though the evidence for them cutting young deposits is minimal. It is likely that some "smoothing" of the landscape has occurred during or since the Last Glacial period (<14,000-24,000 yr), so that the appearance of fault scarps on hillslope country is probably a sign that there has been earthquake fault displacement across those terrains since that time.

2. If we assume that there has been 1-2 movements on those features since that period, then the recurrence time for surface displacements is c. 7000-14,000 yr for these features. N.B. This result is speculative, but without field studies to investigate them, this is a reasonable assumption for the activity of these faults.

3. The faults are in a region of New Zealand that has a number of very active faults; being the Wairau, Awatere, Wellington etc. faults. These faults generally have long well-mapped lengths and recurrence intervals of <2000 yr. The nearby Wairau Fault has an average recurrence interval of c. 1600 yr, but has apparently not moved in c. 2000 yr.
These faults are aligned roughly NE-SW sub-parallel to the current relative plate motion through New Zealand. These faults account for a large proportion of the plate boundary strain release between the Pacific and Australian plates.

4. The faults near Maxwell Pass Road, in contrast, are short, and not directly connected to any major system of faults. Their strike (map direction) suggests that they are not kinematically oriented for preferred strain release, as the other "Marlborough faults" (described in 3) are.

5. The estimate of recurrence time for these faults is relatively long. In terms of the Ministry for the Environment's Guidelines concerning Active Faults, these faults would conservatively fit into Class IV, i.e. recurrence interval 5000-10,000 years. At this level of risk, the construction of Building Code Class 2a and 2b structures, should be permitted activities in both previously subdivided and Greenfield sites when the fault trace location is uncertain or distributed. Note: when the fault location is well-defined the activity status could be controlled or discretionary.

Recommendation:

As stated above, these structures pose a low hazard of surface faulting. I recommend that no further geological work need be undertaken to avoid surface faulting hazards.

I welcome your comments and feedback. This letter may be forwarded to the developer for their consideration.

Yours sincerely

Dr. Robert Langridge,
Earthquake Geologist
GNS Science

This letter report has been reviewed by Dr. Nicola Litchfield for technical and quality control purposes.

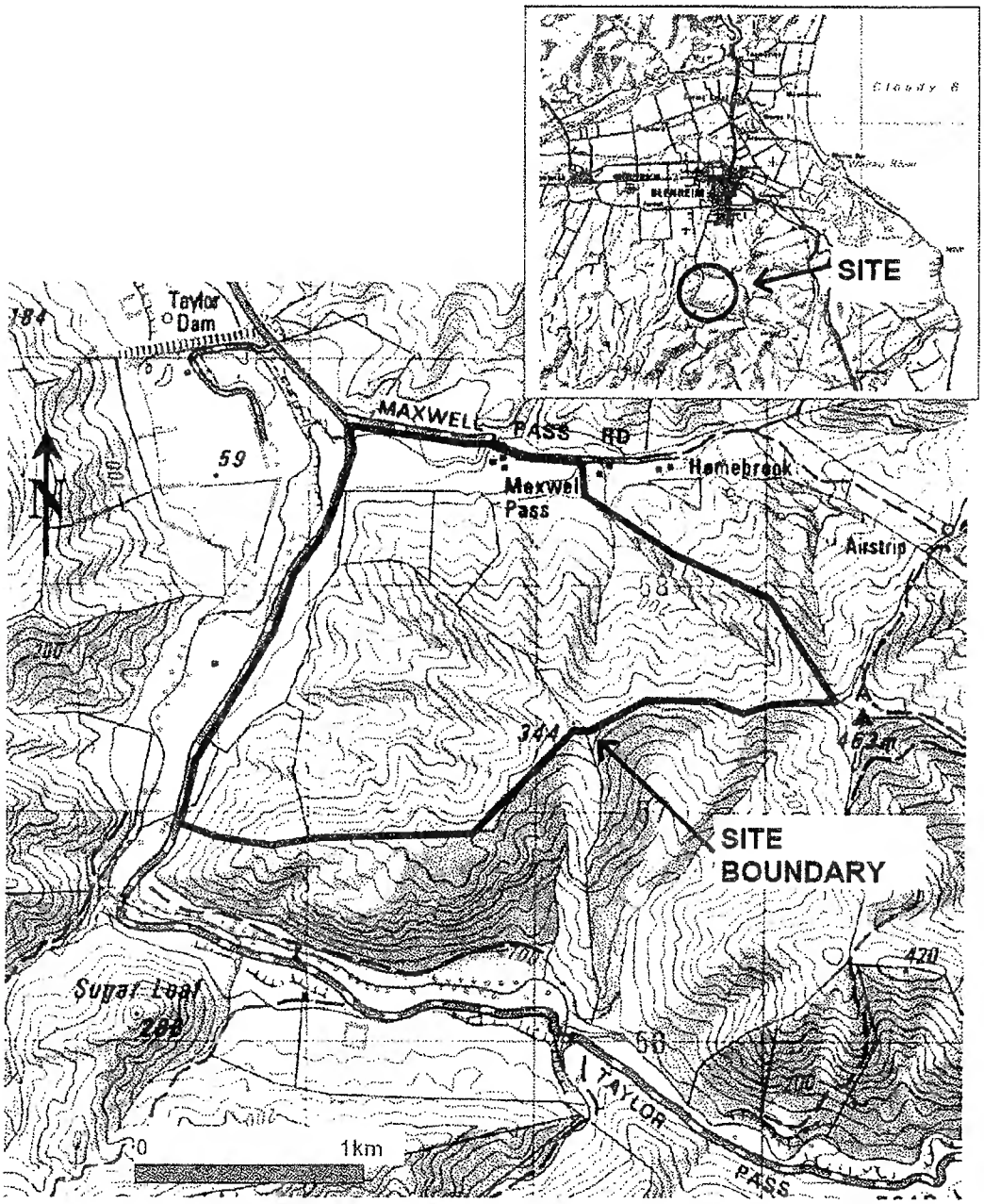


Figure 1. Location map of Maxwell Pass Road subdivision site, south of Blenheim.

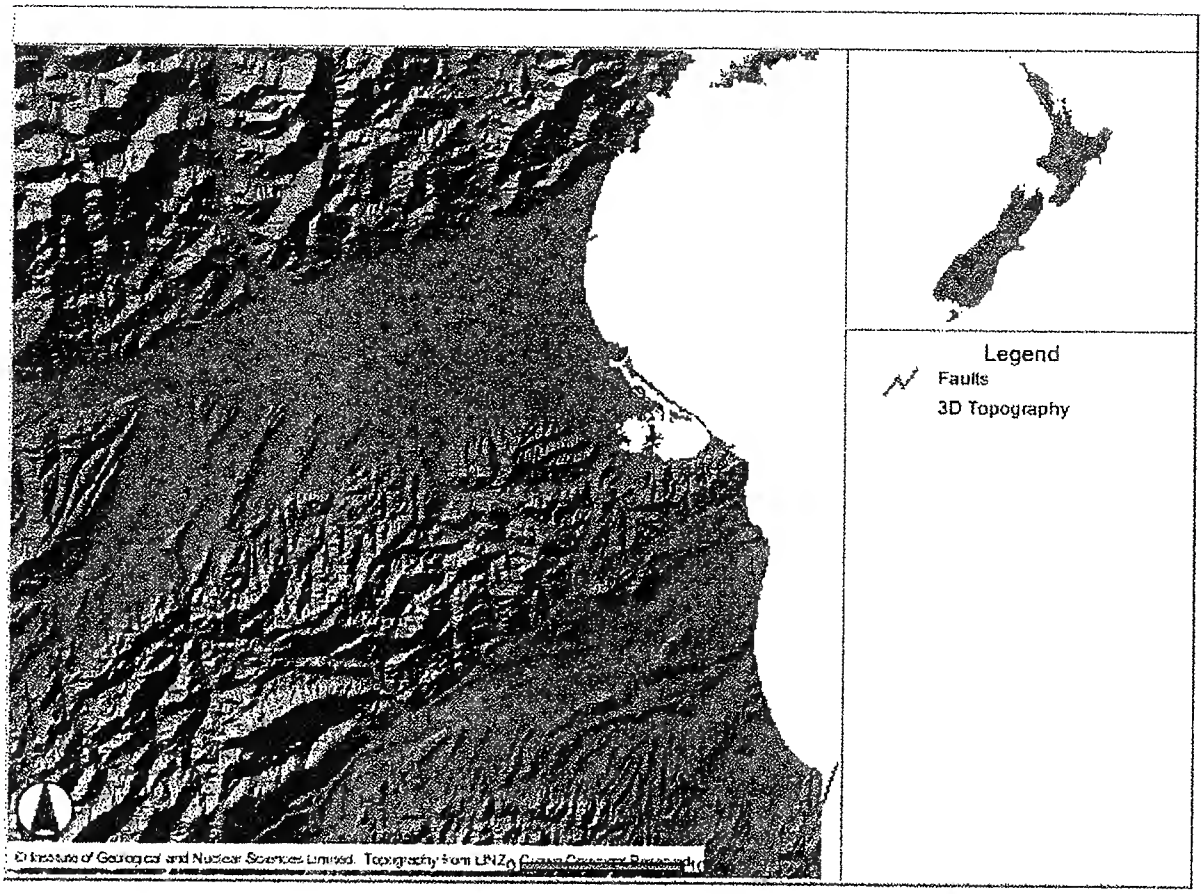


Figure 2. Location map of Maxwell Pass Road faults, extracted from the GNS Active Faults database (http://maps.gns.cri.nz/website/af/index.html). The faults are shown in the right centre of the image to the west of the Vernon Fault and north of the Awatere Fault, crossing Cretaceous to Pliocene hillcountry terrain.

APPENDIX D

Drawings

LEGEND

- TP18 — RILEY TEST PIT (JUNE 2005)
- HA6 — HAND AUGER (JUNE 2005)
- BH2 — MACHINE BOREHOLE (NOVEMBER 2006)
- PLAN CHANGE BOUNDARY

MAXWELL PASS ROAD
MAXWELL STREET
SEC 2 SO 7014
Sec 1 SO 7014
EXTENT OF DEVELOPMENT
1 DP 10421
TAYLOR PASS ROAD
TAYLOR RIVER
BARN
GULLY ONE
GULLY TWO
GULLY THREE
GULLY FOUR
GULLY FIVE
GULLY SIX
GULLY SEVEN
DP 9518
4 D P 9518
5 D P 9518
6 D P 9518
7 D P 9518
8 D P 9518

SCALE 1: 8000
0 80 160 240 320 480 (m)

		DESIGN GAF	CHECKED	APPROVED FOR ISSUE:	
		DRAWN MP	CHECKED	DATE: 10/12/11	
0	FIRST ISSUE	DATE DRAWN MAY 2010			
REV	DESCRIPTION	BY	DATE		

RILEY CONSULTANTS
P.O.BOX 100 253
N.S.M.C.
AUCKLAND
TEL. 09-4897872
FAX. 09-4897873

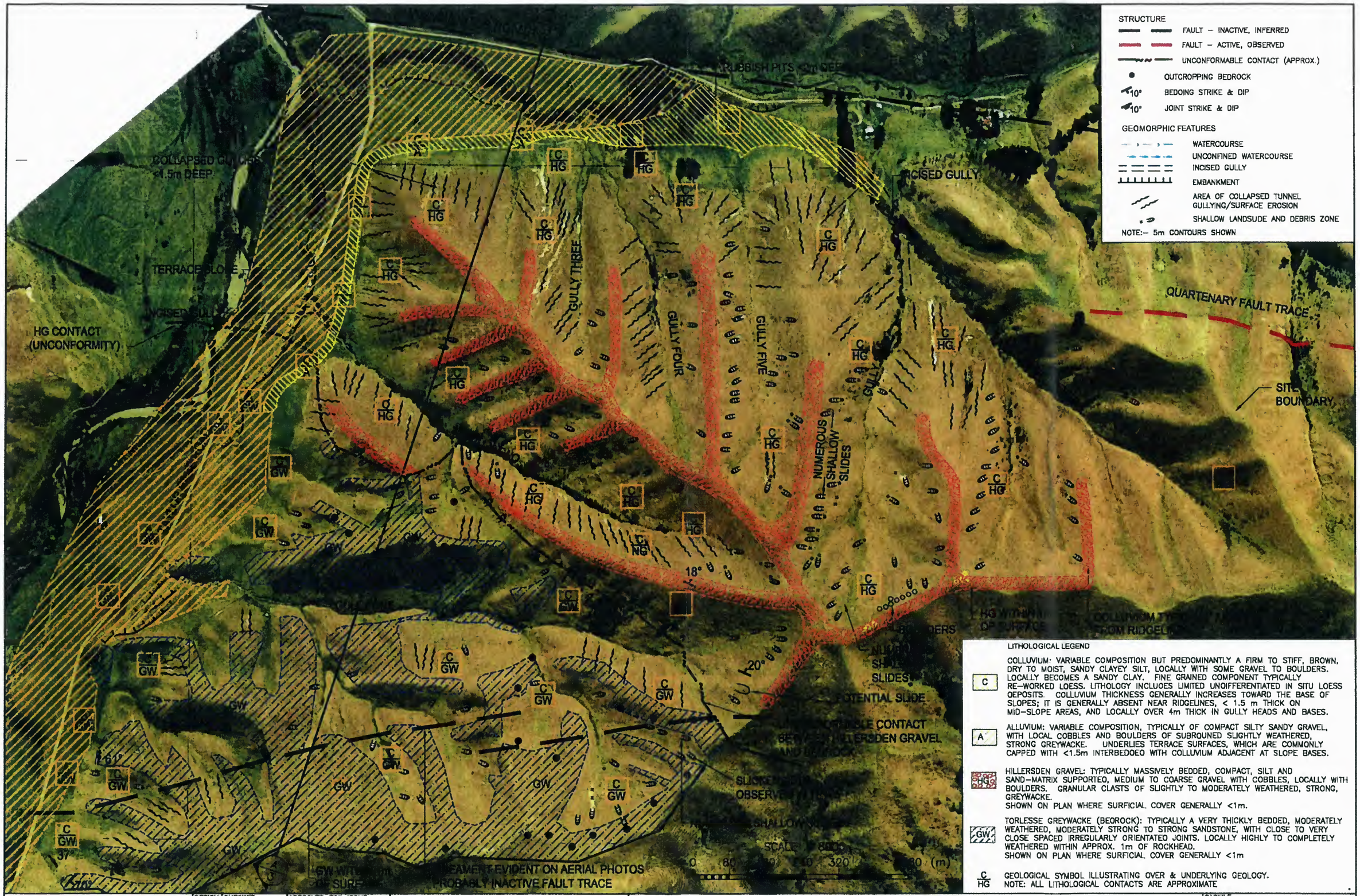
TITLE

KAPITI VIEWS TRUST

MAXWELL HILLS DEVELOPMENT - PRIVATE PLAN CHANGE

GEOTECHNICAL ASSESSMENT - LOCATION OF EXPLORATORY HOLES

CADFILE 04819_6-1
SCALES (A3) 1:8000
DRAWING No. 04819/6GT-1
REV. 0
ACENZ



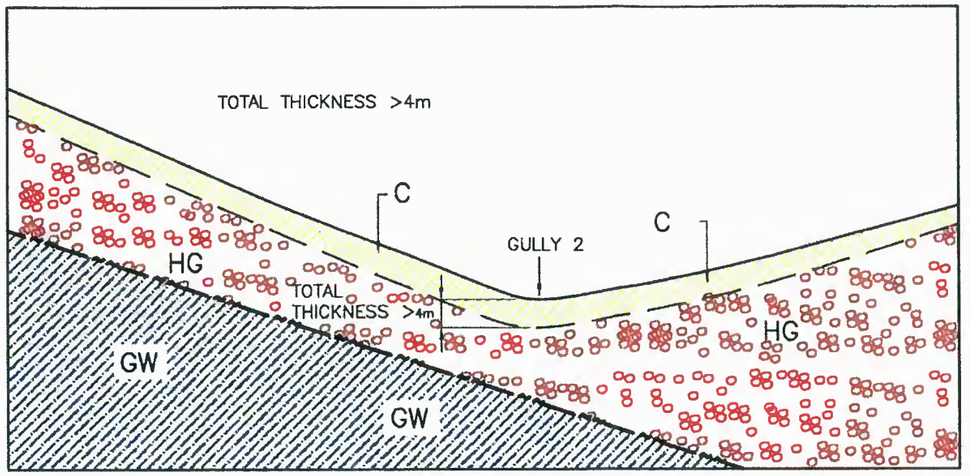
			DESIGN GAF	CHECKED	APPROVED FOR ISSUE:	RILEY CONSULTANTS P.O.BOX 100 253 N.S.M.C. AUCKLAND TEL. 09–4897872 FAX. 09–4897873	TITLE: KAPITI VIEWS TRUST MAXWELL HILLS DEVELOPMENT - PRIVATE PLAN CHANGE GEOTECHNICAL ASSESSMENT - ENGINEERING GEOLOGY PLAN
			DRAWN MP	CHECKED			
0	FIRST ISSUE		DATE DRAWN MAY 2010		DATE: 10/2/11		
REV	DESCRIPTION	BY	DATE				

CADFILE 04819_6–2
SCALES (A3) 1:8000
DRAWING No. 04819/6GT-2
REV. 0

LEGEND

C	COLLUVIUM
A	RECENT ALLUVIUM
HG	HILLERSDEN GRAVEL
GW	GREYWACKE

NOTES:
1. FOR FULL ENGINEERING GEOLOGY DESCRIPTION OF LITHOLOGY REFER DWG. 04819/6GT/2
2. SURFICIAL SOILS NOT SHOWN ON 1:5000 SECTION



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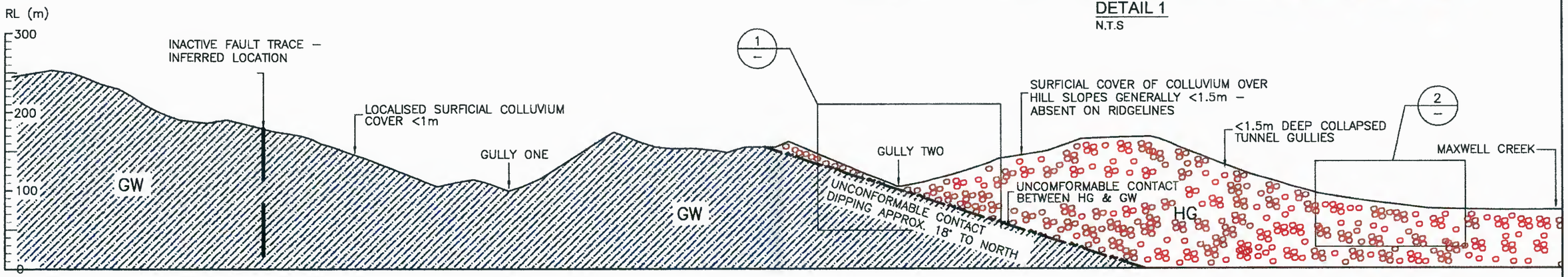
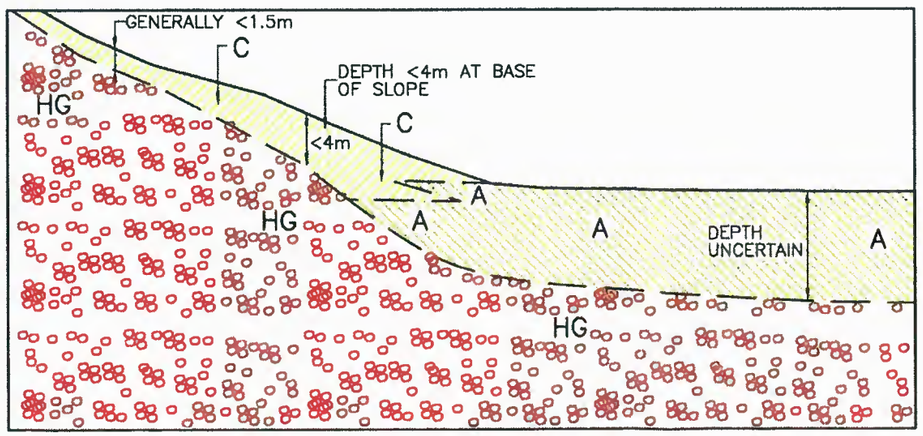
N.T.S



SECTION A 2
SCALE 1:5000



DETAIL 2
N.T.S

SCALE 1: 5000
0 50 100 150 200 300 (m)

REV	DESCRIPTION	BY	DATE
0	FIRST ISSUE		

DESIGN GAF | CHECKED
DRAWN MP | CHECKED
DATE DRAWN MAY 2010

APPROVED FOR ISSUE:
DATE: 10/2/11

RILEY CONSULTANTS
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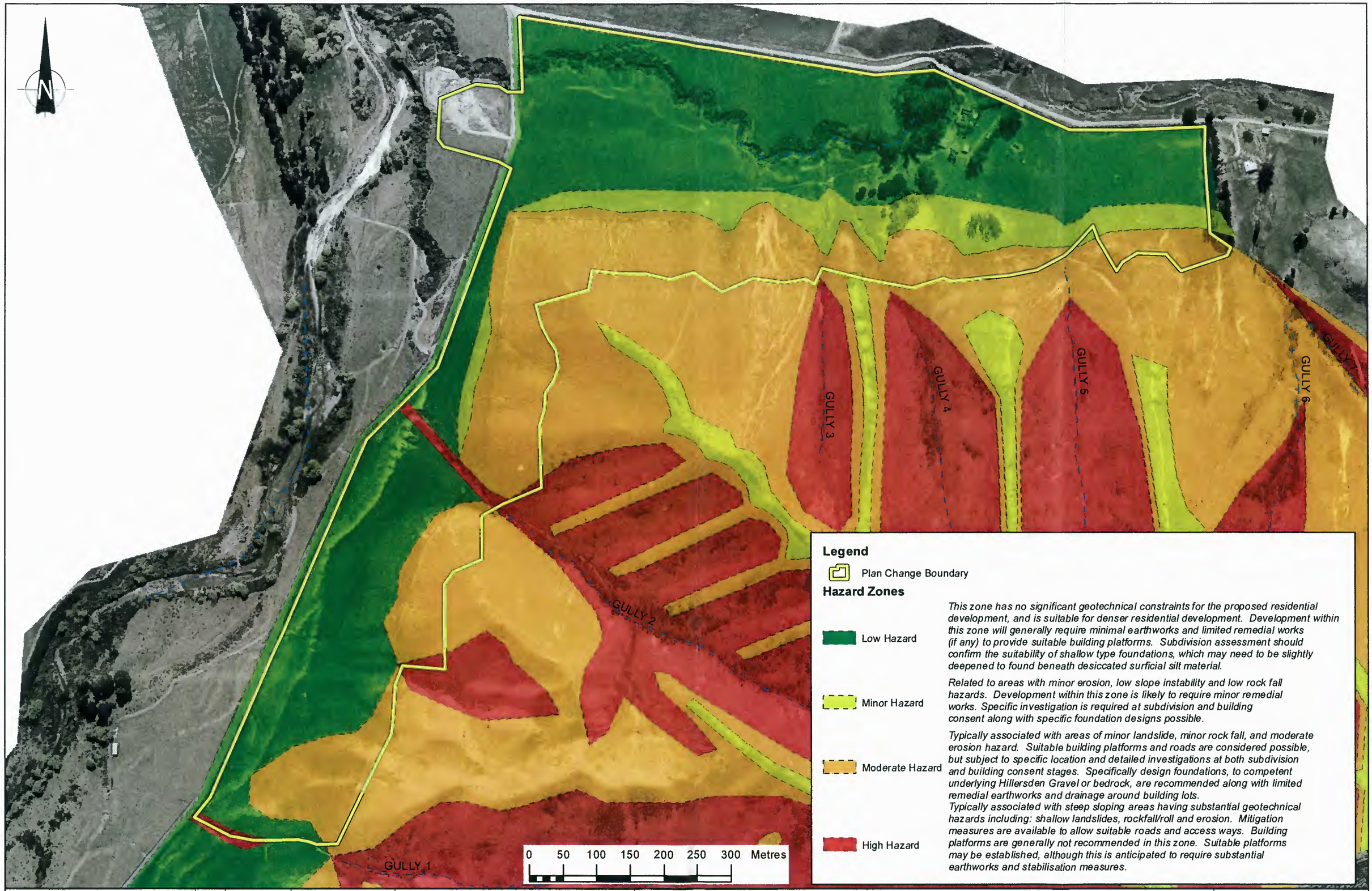
TITLE

KAPITI VIEWS TRUST

MAXWELL HILLS DEVELOPMENT - PRIVATE PLAN CHANGE

GEOTECHNICAL ASSESSMENT - ENGINEERING GEOLOGY CROSS SECTIONS

CADFILE 04819_6-3
SCALES (A3) 1:5000
DRAWING No. 04819/6GT-3
REV. 0



REV	DESCRIPTION	BY	DATE
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DESIGN: SRO | CHECKED:
DRAWN: GAF | CHECKED:
DATE DRAWN: 7/02/2011

APPROVED FOR ISSUE:
DATE:

RILEY CONSULTANTS
P.O. BOX 100 253
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FAX. 09-4897873

TITLE

KAPITI VIEWS TRUST
RURAL RESIDENTIAL DEVELOPMENT - PRIVATE PLAN CHANGE
GEOTECHNICAL ASSESMENT - GEOTECHNICAL HAZARD PLAN

GIS FILE: 04816/6GT.MXD
SCALE: 1:5,000
DRAWING No.: 04819/6GT-4
REV.: 0

APPENDIX F
Flood Assessment Report - Riley Consultants Limited

RILEY CONSULTANTS

MAXWELL HILLS RURAL RESIDENTIAL ZONE PROPOSED PRIVATE PLAN CHANGE FLOOD ASSESSMENT REPORT

Engineers and Geologists

MAXWELL HILLS RURAL RESIDENTIAL ZONE
PROPOSED PRIVATE PLAN CHANGE
FLOOD ASSESSMENT REPORT

Report prepared for:	Kapiti Views Trust
Report prepared by:	Paul Morgan, Christchurch Manager, CPEng
	.....
Report reviewed by:	Brett Black, Director, CPEng
	.....
Report Reference:	04819/6FL-A
Date:	11 February 2011

Copies to:	Kapiti Views Trust	1 copy
	CPG Global	1 copy 1 electronic copy
	Riley Consultants Ltd	1 copy

Issue:	Details	Date
1	Flood Assessment Report	11 February 2011

Riley Consultants Limited, 4 Fred Thomas Drive, Takapuna
PO Box 100 253, NSMC, Auckland, New Zealand
Telephone 64 9 489 7872, Facsimile 64 9 489 7873
riley@riley.co.nz www.riley.co.nz

Contents

Appendices

MAXWELL HILLS RURAL RESIDENTIAL ZONE
PROPOSED PRIVATE PLAN CHANGE
FLOOD ASSESSMENT REPORT

1.0 Introduction

Riley Consultants Ltd (RILEY) has prepared the following flood assessment report at the request of Kapiti Views Trust. This report describes our flood assessment and recommendations for the proposed development. It is intended to support a plan change application to Marlborough District Council (MDC).

The plan change region covers the lower terraced area of the larger lots (Lot 1, DP 9518, Section 2, SO 7014 Lots 1-3, DP357141) held by Kapiti Views Trust.

This report presents the following information:

- Identification of areas at risk of flooding.
- Discussion of potential mitigation in areas at risk from flooding.

To ensure development is sustainable and suitable, an assessment of engineering aspects has been provided by RILEY. This report should be read in conjunction with the following RILEY documents.

Planning Variation	RILEY Reference Number
Wastewater Servicing	04819/6WW-A
Geotechnical Assessment	04819/6GT-A
Stormwater Design	04819/6SW-A

2.0 Site Description

The site is located approximately 2.5km south of the existing urban boundary of Blenheim, Marlborough, and is bounded by Maxwell Pass Road and Taylor Pass Road. The Taylor River runs past the western boundary, with the Taylor Dam (a flood detention structure protecting the Blenheim Township) located a few hundred metres from the site's north-western corner. The site has an area of approximately 286ha.

To assist in discussion of the site, RILEY arbitrarily labelled seven of the main gullies at the site in an earlier geotechnical report. These progress clockwise from 'gully 1' in the south-western corner. The streams within the site, labelled using the same format, are illustrated on the Flood Map.

3.0 Design Standards

3.1 Design Storms

RILEY has referred to the MDC Code of Practice for Subdivision and Development and the New Zealand Standard NZS 4404 Land Development and Subdivision Engineering, to determine the most appropriate design storms for the present development.

The MDC Code of Practice for Subdivision and land Development indicates that the 2% Annual Exceedence Probability (AEP) (1 in 50 years) rainfall event should be used for design of stormwater systems to protect residential property. However, NZS 4404 recommends using the 1% AEP (1 in 100 years) rainfall. The 1% AEP is the standard used for flooding at other locations, and is therefore the recommended design storm for this study.

3.2 Freeboard

NZS 4404 states that the minimum freeboard requirement for habitable buildings is 0.5m but should be increased for steep, rough channels.

It is recommended that a freeboard of 1m is added to the assessed 1% AEP flood level. The increased level of freeboard over typical allowances of 0.5m is due, in part, to the nature of the site, with relatively steep streams.

3.3 Building Setback Distance from Streams

It is recommended that building platforms are set back a minimum of 8m from the streams within the site, in accordance with MDC Rural Residential District Plan requirements.

4.0 Flood Risk

The Taylor River, adjacent to the site, and a number of small streams within the site, require the flood risk to be assessed. The Taylor River, which flows along the western boundary of the site, has an increased flood risk over natural levels due to the flood detention dam constructed downstream to provide protection to Blenheim. The dam attenuates flows, resulting in higher levels in the river upstream of the dam. Maxwell Creek, the most significant stream to flow through the site, is located along the northern boundary. There are several smaller unnamed streams that have their entire catchment within the site.

4.1 Taylor River and Dam

The Taylor River is located to the west of the site and during normal flow conditions the river is significantly below the lowest ground levels. The Taylor Dam is located less than 1km downstream of the site. Under normal flow conditions the dam has a small permanent pond only with river flows passing through a culvert in the base. There is a flood spillway at RL 68.4m designed to operate in a 1% AEP event (1 in 100 year flood).

The attached drawings indicate the crest level at the dam, which is the maximum potential level that the river could reach in his area. The figure shows that only a small area of the site in the west is below the crest level of the dam. The council has recommended that all buildings should be located above this level, and this has been provided for in the development layout. It is noted, however, that the crest level of the dam (RL 70.7m) is 2.3m above the 1% AEP level of the dam (RL 68.4m), which corresponds to the emergency spillway. As the emergency spillway is an overflow weir, using the crest level is considered to be conservative. For this site the difference between the two levels does not significantly change the areas affected by the design flood.

4.2 Maxwell Creek

Maxwell Creek flows along the northern boundary of the site with inflows from streams 3 to 7. Approximately one half of the catchment of Maxwell Creek is located upstream of the site. There are two bridges along this section of the stream. The bridge on Taylor Pass Road has two 1.5m diameter culverts. The bridge on Maxwell Pass Road is 6m wide between the banks of the stream with a deck thickness of 0.6m. The stream has a reasonable fall between the bridges, but upstream of the Maxwell Pass Road Bridge the gradients reduce. The stream is heavily vegetated between the bridges and has significant meanders. Therefore there are a number of factors affecting the flow capacity which will contribute to the flood risk.

4.3 Small Streams within the Site

There are several small streams within the site that flow into Taylor River or Maxwell Creek. The upper parts of the streams are very steep and confined due to the topography. The gradients reduce towards the alluvial flats, which the streams have locally incised to varying degrees. Any flood risk from these streams will most likely be in the lower sections where the flows are higher and the gradients lower.

Based on the contours, streams 1, 2 and 7 are considered to be the only ones that may have floodplains of any significance in their lower reaches. The lower reach of stream 7 flows out of the site into an adjacent property; any flooding from the stream would likely occur within that property.

4.4 Overland Flow

Properties located on lower slopes of the hills may be at risk of overland flow in a 1% AEP event. Interceptor drainage (surface cut-off drains) is provided for the larger catchments and normal site drainage would be appropriate to address this issue for small catchments.

4.5 Culverts

There are two culverts located on Taylor Pass Road and three on Maxwell Pass Road which convey flows from streams within the site. A number of the culverts have significant depths of gravel at the inlet and within the culvert. Culverts are likely points where flow is constricted and should be considered in the assessment.

5.0 Hydrological Assessment

A hydrological analysis was carried out in order to estimate the flood flows for a 1% AEP event at the site. There is a gauge station on the Taylor River located at Borough Weir, just upstream of the site. The gauge has been operating since 1962 and has 44 years of data. The highest flow recorded to date is 197m^3/s. As all the streams at the site are downstream of this gauge it is not possible to directly use this to assist in the assessment of flood flows in the streams.

There are no gauges on any of the small streams being considered in this study, therefore, the analysis of flows is for ungauged catchments. Table 5.1 summarises the catchment characteristics of the various streams within the site and of the Taylor River.

Table 5.1: Catchment characteristics

Catchment	Catchment area (km^2)	Catchment length (km)	Maximum elevation (m)	Average slope (degrees)
Taylor River (Borough Weir)	69	11	800	0.07
Maxwell Creek	4.95	3.3	340	0.08
Stream 1	0.74	1.5	340	0.17
Stream 2	0.34	1.3	330	0.20
Stream 3	0.07	0.6	220	0.25
Stream 4	0.12	0.9	280	0.23
Stream 5	0.17	1.0	310	0.21
Streams 6 and 7	0.67	1.3	400	0.22
Stream 8	0.10	0.6	260	0.33

5.1 Time of Concentration (t_c)

The time of concentration for each catchment is calculated to indicate what the critical duration of rainfall is for a particular catchment. This was estimated using a number of methods including Ramser-Kirpich, Bransby-Williams and the US Soil Conservation Service. From these, estimates of typical t_c were estimated and assumed to be representative of the catchment. For the small streams in the site the t_c was approximately 10 minutes. For Maxwell Creek the t_c was calculated as 30 minutes and 2 to 3 hours for Taylor River at the gauge site.

5.2 Design Rainfall Depths

Design rainfall depths were obtained from the NIWA High Intensity Rainfall Design System (HIRDS) V2 dataset. The rainfall depths for a selection of different events and durations are shown in Table 5.2.

Table 5.2: HIRDS V2 design rainfall depths

AEP event	Duration					
	10 minutes	20 minutes	30 minutes	1 hour	2 hours	6 hours
1%	14.5mm	22.7mm	29.6mm	46.3mm	61.8mm	97.3mm

5.3 Flow Estimation Methodology

Flood flows were estimated using the following three methods:

- Rational Method
- Regional Method (McKercher & Pearson 1989[1])
- TM61

All three methods estimate a peak flow based on relatively simple catchment characteristics.

5.3.1 Rational Method

The rational method is a simplistic equation for calculating peak flow using rainfall intensity, catchment area, and a runoff coefficient. The method is conservative and only applicable to small catchments because it does not take account of catchment storage attenuating the flood. The recommended maximum size of catchment to apply this method is 25km^2 for urban catchments and 10km^2 for rural catchments. The results from this method are sensitive to the choice of runoff coefficient used. A value of 0.4 has been used for the runoff coefficient to take account of soil types, vegetation and the topography of the site.

5.3.2 TM61

Technical Memorandum No. 61 (TM 61) is an empirical method for estimating a design flood peak discharge in ungauged catchments.

5.3.3 Regional Method (McKercher & Pearson 1989)

The regional method is based on flood frequency analysis of gauged catchments and is suitable for rural catchments except where there is snow melt, glacier lake storage or ponding. It should be used for rural catchments greater than 3km^2.

5.4 Flow Estimation Results

The most suitable method for estimation of flows in the small streams with catchments less than 3km^2 is the Rational Method. Either TM61 or the Regional Method is better suited to the larger catchments of Maxwell Creek and Taylor River. Table 5.3 summarises the peak flows estimated for a 1% AEP event for the three different methods.

The highlighted results in Table 5.3 are the design flows recommended for each of the streams. The results are relatively conservative and consistent between the different methods.

MDC indicated that a 1% AEP event at Borough Weir, based on analysis of the 44 years of flow data, is 274m^3/s, which is consistent with the figure calculated using TM61. It is also noted that the Borough Weir is approximately 3km upstream of Taylor Dam and that the flows at the Taylor Dam site (which include other small tributaries and the Maxwell Creek) are estimated to be in the order of 320m^3/s.

[1]McKercher & Pearson 1989, *Flood Frequency in NZ*, Pub. No. 20, Hydrology Centre, Christchurch.

Table 5.3: Peak discharges for 1% AEP

Stream / River	Rational (m^3/s)	TM61 (m^3/s)	Regional Method (m^3/s)
Taylor River (@ Borough Weir)	208 [a]	263	238
Maxwell Creek	33	37	29
Stream 1	7.1	4.7	6.3[b]
Stream 2	3.3	2.6	3.4[b]
Stream 3	0.6	0.3	0.9[b]
Stream 4	1.2	0.7	1.5[b]
Stream 5	1.6	1.0	1.9[b]
Streams 6 and 7	6.5	4.2	5.9[b]
Stream 8	0.9	0.7	1.2[b]

Note:
a) The catchment for Taylor River is larger than the recommended maximum for using the rational method.
b) The catchment area is less than the minimum suggested for the regional method.

6.0 Hydraulic Assessment

A variety of methods were undertaken to assess the flows and flood levels in the streams. A direct analysis of the Taylor River flood levels was not undertaken as the section of river near the site is controlled by the Taylor Dam. MDC has provided information on flows in Taylor River and levels at Taylor Dam.

A model of Maxwell Creek, and streams 1 and 2 was constructed. The other streams have not been modelled due to a combination of the low 1% AEP flows and steep gradient of the channels.

Hydraulic modelling was undertaken using HEC-RAS, a one dimensional modelling package available from the Hydrological Engineering Centre, United States Army Corps of Engineers[2]. This is an industry-wide accepted package suited to carrying out open channel analysis. There was no data available to provide calibration of the models. Given the gradient of the streams, storage on the floodplain is not significant. Consequently, the model was run in steady state for the peak flows from the methods outlined in Section 5.3. The pre- and post-development flows were run for the three streams.

6.1 Taylor Dam

Taylor Dam is a detention dam which, under normal flow conditions, does not impound water. There is a culvert through the dam that passes normal flows. The culvert is of semi-circular shape (2.8m radius). There is an orifice plate of lesser diameter that throttles back the outflow at the culvert. Once the flows in Taylor River exceed the capacity of the culvert the dam begins to fill. There is a higher level overflow spillway which corresponds to a 1% AEP event. MDC has provided the following information with regard to the dam.

[2] Refer to http://www.hec.usace.army.mil/ for more details.

Dam Crest:	RL 70.7m
Emergency Spillway (1% AEP):	RL 68.4m
1% AEP flow:	320m^3/s

There is a gauge on the Taylor River approximately 3km upstream of the dam (Borough Weir).

6.2 Modelling

The three models used to assess Maxwell Creek, and streams 1 and 2 are based on the aerial survey of the site undertaken on 8 December 2006, which produced 1m contours and a basic cross section survey at key locations along the streams. The survey included the dimensions of the culverts and bridges related to these streams. In addition, further cross sections were produced to fill in gaps in the model based on the aerial survey.

6.2.1 Roughness Coefficient Manning's 'n'

The roughness of the stream channels and floodplain was assessed based on Chow[3] and Hicks & Mason[4]. Maxwell Creek is heavily vegetated along the length that flows through the site and has significant meanders. A conservative channel roughness coefficient 'n' of 0.2 has been used for the main channel to account for this. A conservative roughness coefficient 'n' of 0.1 has been used for stream 1 and 2. In general, most of the floodplains are grass pasture which corresponds to a value of 0.04 – 0.05 for 'n'. A summary of the roughness coefficients is included in Table 6.1.

Table 6.1: Manning's n values used in model

Stream	Left Floodplain	Channel	Right Floodplain
Maxwell Creek	0.04 – 0.1	0.2	0.04
Stream 1	0.05	0.1	0.05
Stream 2	0.05	0.1	0.05

6.2.2 Boundary Conditions

As the models are running in steady state only a downstream boundary condition is required. The main control to water levels downstream is the Taylor Dam. The model has been run with the downstream water level set at RL 68.4m (1% AEP level) and at RL 70.7m (dam crest) as discussed in Section 6.1.

The catchment area of Maxwell Creek is 4.9km^2 in comparison to 69km^2 for the Taylor River (at Borough Weir). As a result, the critical duration for each catchment is different (see Section 5.1). Therefore the combined probability of a calculated peak 100 year condition occurring at both Taylor Dam and Maxwell Creek is likely to be less than the 1% AEP being applied as the design criteria. We are not proposing to undertake a combined probability analysis but will use a 1% AEP level in Taylor Dam as the boundary condition which is a conservative approach. The boundary condition based on the crest of the dam has been undertaken for comparison purposes only.

[3] Ven Te Chow,1973, *Open Channel Hydraulics*
[4] D M Hicks & P D Mason, 1998, *Roughness Characteristics of New Zealand Rivers*

7.0 Results

The modelling results give water levels at the surveyed cross sections. The levels between cross sections have then been interpolated and mapped in CAD using the aerial survey data.

7.1 Taylor River

The 100 year flood level in the Taylor River adjacent to the site is RL 68.4m. A 1m freeboard has been added (RL 69.4m) and this has been mapped on RILEY Dwg: 04819/6FL-1 (Unmitigated Flood Assessment), attached. The crest level of the dam is RL 70.7m. Most of the site is above these levels, except for parts of the site along the western boundary between streams 1 and 2, and the downstream end of Maxwell Creek. The flood rise in Taylor River would be relatively slow in comparison to changes in the Maxwell Creek and the smaller streams at site. The flood water is due to ponding upstream of the dam and, therefore, would not have any significant flow velocity at the level of the site.

7.2 Maxwell Creek

The 1% AEP flood level in the Maxwell Creek, based on both a 1% AEP and crest levels in Taylor Dam with an additional 1m freeboard is indicated on RILEY Dwg: 04819/6FL-1, attached.

The 1% AEP floodplain is relatively contained between the bridges on Maxwell Pass Road and Taylor Pass Road. Upstream of Maxwell Pass Road Bridge the flooding fans out across the wider floodplain.

The land on the north side of Maxwell Creek from the road bridge downstream slopes to the west but has a flat gradient in the north-south direction. This creates a potential overland flow path from the bridge down this slope. The attached Unmitigated Flood Assessment shows this area hatched to indicate that it is at risk from overland flow in a 1% AEP event. Water would not pond in this area but is a potential path for sheet flow across the land. An earth bund is proposed to the north of the stream to provide additional protection to property at risk from overland flow in the event of flooding from Maxwell Creek, shown on RILEY Dwg: 04819/6FL-2 (Mitigated Flood Plan), attached.

The flood rise in Maxwell Creek would be relatively quick and take in the order of one hour to reach a peak from the onset of rainfall.

7.3 Small Streams within the Site

The modelling of streams 1 and 2 shows the 1% AEP event does not result in any significant flooding at the site. The flooding is generally contained within the area close to the stream except for the very lower reaches. Flooding in the lower reaches of stream 2 is due to 1% AEP level in Taylor Dam.

Stream 1 has an area at risk from overland flow indicated on the RILEY Unmitigated Assessment Plan, attached, with hatching. When the water levels exceed the bank levels upstream there is a potential overland flow path on the southern side of the stream.

Streams 6 and 7 flow through an adjoining property in the north-east of the site. Based on the contours, flooding could potentially occur in this property in the areas beside Maxwell Pass Road.

7.4 Bridges and Culverts

None of the culverts have sufficient capacity to pass a 1% AEP flow. However, they do not have a significant impact on flooding within the site.

The results from the modelling show that both of the bridges are overtopped in the design event. The bridge on Taylor Pass Road consists of two culverts, which provide a significant constriction to the flow. However, the road level at the bridge is below the 1% flood level of Taylor Dam and, therefore, the bridge does not have a significant effect for this event.

In the event of a large flood in Maxwell Creek without the corresponding high levels in Taylor River, the flow capacity of the bridge is more significant with regard to upstream effects. The water level upstream of the bridge is 1.7m higher than downstream for a 1% AEP event when the level in Taylor River is low.

8.0 Discussion and Mitigation

The results of the flood assessment show that only a small proportion of the site is at risk of flooding. In general these are areas in the west of the site between streams 1 and 2, and land adjacent to Maxwell Creek. There is, however, a more general flood risk from overland flow in areas below sloping hills on the site. Flooding from this source would, in most cases, be relatively minor but needs to be taken account of in the design of the stormwater system.

8.1 Building Platforms and Freeboard Requirements

A 1m freeboard should be added to the 1% AEP flood level assessed, based on the accuracy of the survey data and analysis of flood levels undertaken. This is indicated on the attached plans and is the recommended design level to use for this site.

A building setback of 8m is recommended from all streams on the site, which for the smaller streams will be a greater constraint than the 1% AEP flood extent.

8.2 Potential Mitigation

Based on the flood risk assessment, all building platforms are proposed in areas outside the potential floodplain with the exception of the area north of Maxwell Creek, described in section 8.2.2, where mitigation measures are proposed to effectively exclude this area from the floodplain.

8.2.1 Taylor Dam

The design flood level from Taylor Dam affects areas between streams 1 and 2, in particular around the downstream end of stream 2. For most of the properties affected there is sufficient land located above the design level for a building platform, as there is a terrace at approximately RL 75m. Building platforms in this area are, therefore, proposed only above the dam crest level.

8.2.2 Maxwell Creek

Most of the properties affected only have a small area below the design flood level.

The properties north of the stream are within an area indicated as at risk from overland flow. A bund will be constructed along the right bank for approximately 150m to direct any overland flow back into the Maxwell Creek. The bund will be located above the design flood level to avoid any impacts upstream in the 1% AEP event. The bund should be specifically designed.

8.2.3 Overland Flow

A number of areas within the site, away from the streams, may be at risk from overland flow during the 1% AEP event. Cut-off drains upslope of the properties are likely to be the most suitable mitigation. This will be considered in greater detail within the stormwater report.

9.0 Summary

A flood assessment of the Maxwell Hills Subdivision has been undertaken. The flood risk from Taylor River, Maxwell Creek, several small streams within the site, and overland flow, has been considered. The 1% AEP flood level in the rivers and streams is the suggested standard to be used with a 1m freeboard added. A building setback of 8m is recommended from all streams on the site.

The analysis was based on an aerial survey of the site, site investigation including additional cross section survey, and computer modelling of three of the streams.

The following are the main flood risks and recommended mitigation for the site:

- **Flood Risk:** A small area in the western part of the site between streams 1 and 2, and the downstream reach of Maxwell Creek, are below the design level for Taylor Dam.

  Mitigation: Ensure property layout results in sufficient land available above the design level as discussed above.

- **Flood Risk:** The floodplain of Maxwell Creek for the 1% AEP event has been mapped and shows the flood is relatively contained within the stream valley below Maxwell Pass Road Bridge. Upstream of the bridge the floodplain is wider.

  Mitigation: Ensure that property layout results in sufficient land available above the design level as discussed above.

- **Flood Risk:** The area of the site to the north of Maxwell Creek is at risk from overland flow when the water levels exceed bank levels near the bridge.

  Mitigation: A bund could be constructed along the right bank to direct overland flow back into the stream.

- **Flood Risk:** Various areas of the site may be at risk from overland flow from the slopes above. This issue is discussed in more detail in the stormwater report.

  Mitigation: Cut-off drains installed upslope of properties and normal site drainage to facilitate flows from small remaining catchments.

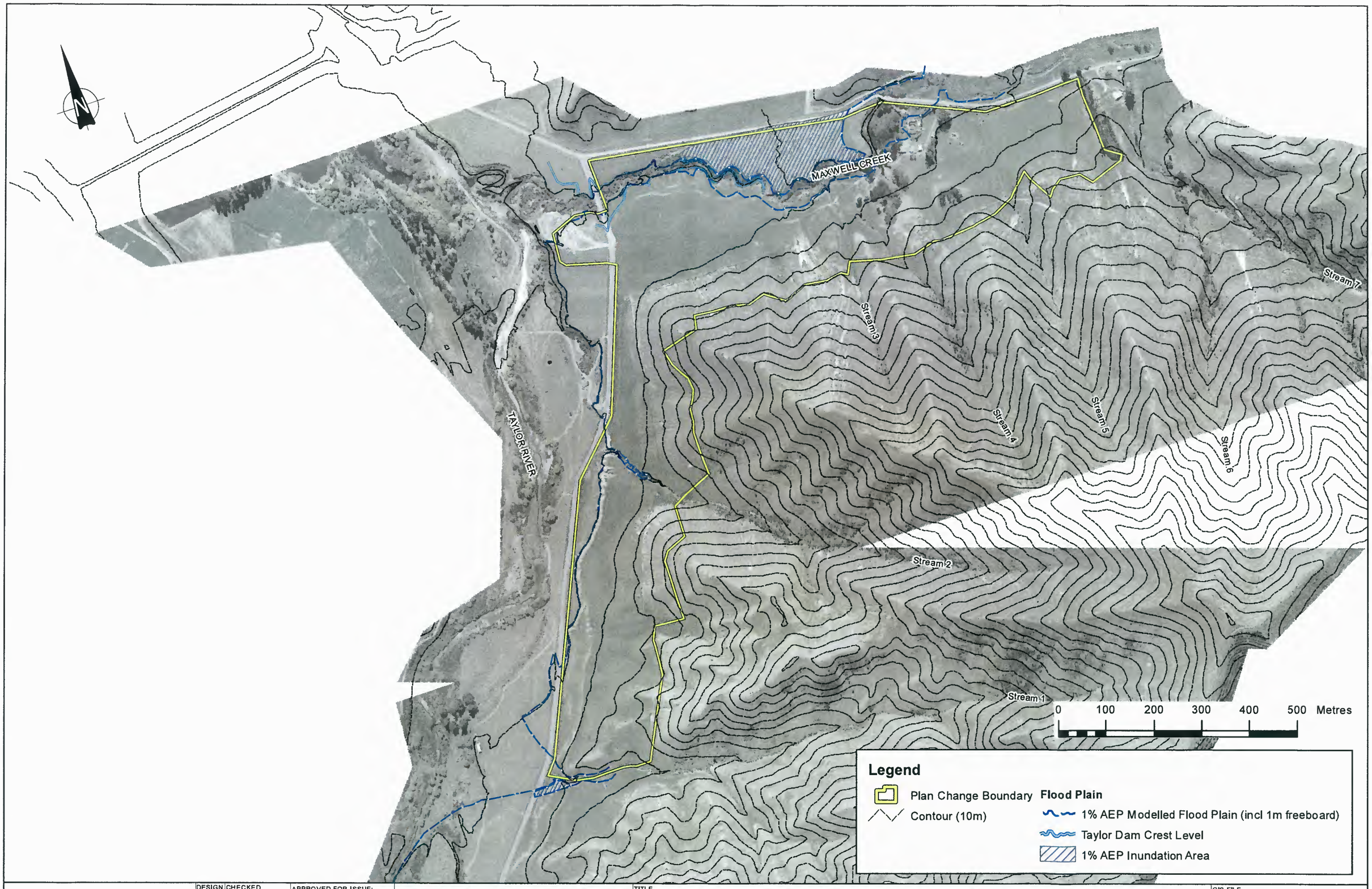
10.0 Limitation

This report has been prepared solely for the benefit of Kapiti Views Trust as our client with respect to the brief and Marlborough District Council in processing the plan change application. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

The hydrological and hydraulic analyses and recommendations contained in this report are based on our understanding and interpretation of the available information. The recommendations are, therefore, subject to the accuracy and completeness of the information available at the time of the study. Should any further information become available, the analyses and findings of this report should be reviewed accordingly.

APPENDIX A

Unmitigated Flood Assessment and Unmitigated Flood Plan



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REV	DESCRIPTION	BY	DATE			DATE:	

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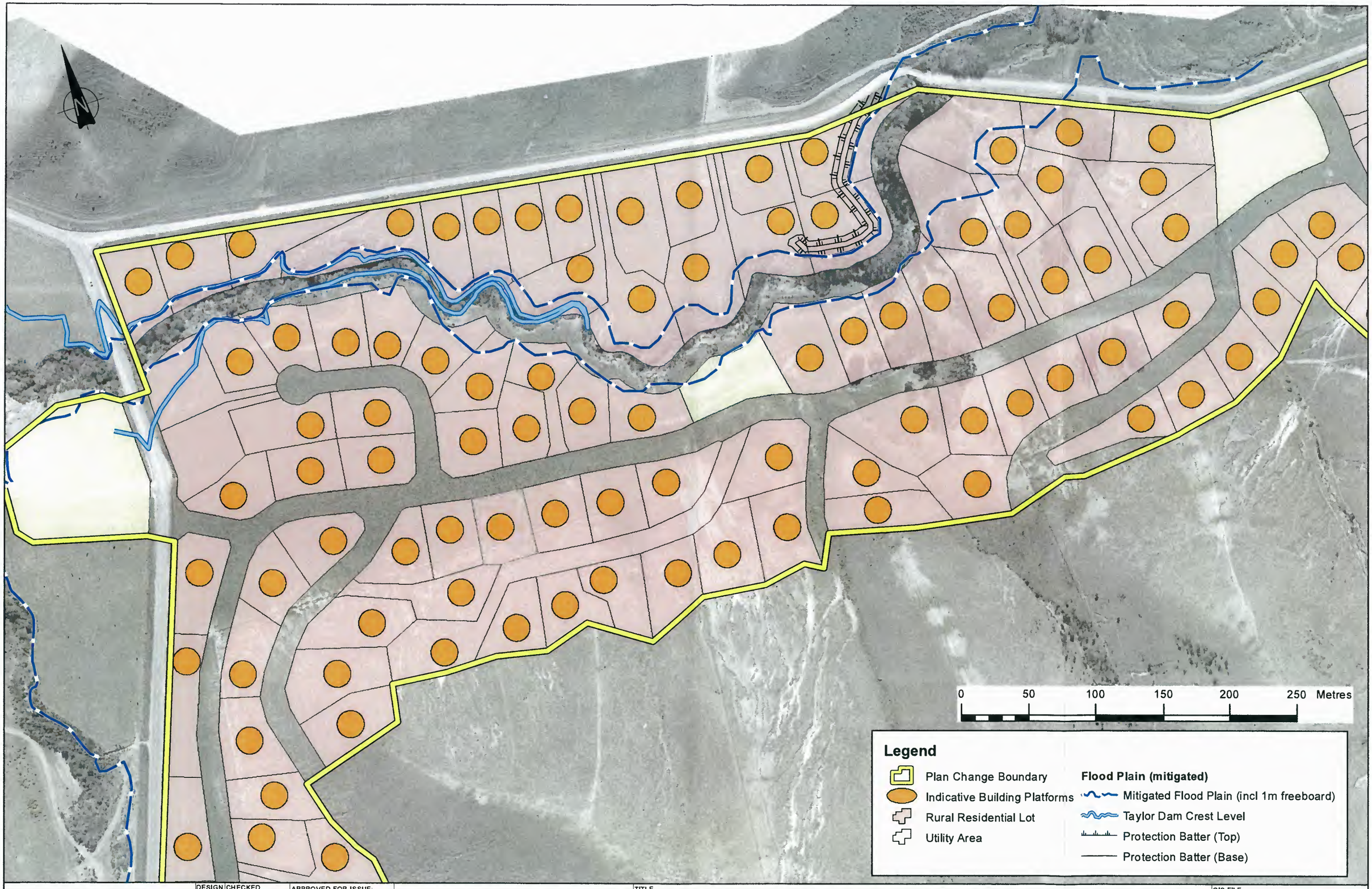
TITLE

KAPITI VIEWS LIMITED
RURAL RESIDENTIAL DEVELOPMENT - PRIVATE PLAN CHANGE
FLOOD ASSESSMENT - UNMITIGATED FLOOD ASSESSMENT

GIS FILE 04819/6FL.MXD		
SCALE 1:7,000		
	DRAWING No. 04819/6FL-1	REV. 0



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DESIGN: PKM | CHECKED:
DRAWN: GAF | CHECKED:
DATE DRAWN: 7/02/2011
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TITLE

KAPITI VIEWS LIMITED
RURAL RESIDENTIAL DEVELOPMENT - PRIVATE PLAN CHANGE
FLOOD ASSESSMENT - MITIGATED FLOOD PLAN

GIS FILE: 04819/6FL.MXD
SCALE: 1:2,500
DRAWING No.: 04819/6FL-2
REV.: 0

APPENDIX G
Schedule of Changes

Schedule of Changes to the Wairau/Awatere Resource Management Plan

SCHEDULE OF CHANGES TO THE WAIRAU AWATERE RESOURCE MANAGEMENT PLAN

It is proposed to change the Wairau Awatere Resource Management Plan (the Plan) as follows:

Note: Where text is proposed to be added to the Plan it is shown as <u>underlined</u>.

Volume 2 Rules

1 Add a new Appendix R Maxwell Hills Zone, including an Outline Development Plan, as attached.

2 Add "**Appendix R Maxwell Hills Zone**" to the Table of Contents after "Appendix Q Schedule of Water Bodies for Riparian Management Purpose"

Volume 3 Planning Maps

3 Amend Planning Map 185 to include the new Maxwell Hills Zone with reference to Appendix R, as attached.

4 Amend the Legend to the Planning Maps to show a key for the Maxwell Hills Zone with specific reference to Appendix R, as attached.

Appendix R Maxwell Hills Zone

1. Zone Statement

The Maxwell Hills Zone is intended to provide a very low density residential living environment in a rural hills setting. This zone adds to the choice of high amenity living environments available to the Wairau/Awatere community. The zone is located 2.5 kilometres from the existing Blenheim urban boundary and about 1 kilometre from the Taylor Dam recreational area. The density of development provided is much lower than the nearby Blenheim urban area but is higher than the density of the existing rural residential zones which are generally around 1 hectare and is intended to provide for the growing demand for lots between 2000- 4000 square metres in area. The zone is intended to take some pressure off the demand for rural residential development in the Wairau Plain and from a visual amenity point of view will enable the development of a hill residential environment that is not visible from Blenheim.

An Outline Development Plan is included for this zone to ensure integrated development of the site with appropriate roading, servicing, recreation and reserve networks.

While several options exist, provision of an adequate water supply will be fundamental to the development of this rural residential area.

1.1 Objective and Policies

Objective 1: An environment that provides a sustainable and alternative choice for residential living for the community while avoiding or mitigating any adverse effects on the amenity values and characteristics of the surrounding rural environment.

Policy 1.1 Provide for the establishment of a residential hills environment through zoning land at Maxwell Hills for very low density residential activity.

Policy 1.2 Ensure that all building development within the Maxwell Hills Zone avoids areas subject to hazards, unless those hazards can be sufficiently mitigated.

Policy 1.3 Provide for the maintenance and enhancement of the amenity and visual character of the locality through sensitive landscape planting, building densities and building design.

Policy 1.4 Provide for a range of small scale non residential activities in conjunction with residential activity to facilitate the social, economic and cultural well being of the community while avoiding and mitigating adverse effects on the environment.

Policy 1.5 Encourage opportunities that will create a more sustainably focused residential environment to that found in traditional residential environments within the District, including but not limited to enabling increased use of solar energy, cycling and pedestrian activity.

2. Rules

Unless otherwise provided below the definitions of Chapter 26.0, the Rules of Chapter 27.0 (General Rules Having Application in All Zones, Rivers, Riverbeds and Lakes) and Chapter 29.0 (Standard Requirements for Subdivision and Development) apply.

2.1 Permitted Activities

The following activities are permitted activities provided that they comply with the Outline Development Plan and the permitted activity conditions specified:

- Residential activity, limited to one dwelling house per lot.
- Homestay, limited to not more than five visitors.
- Professional offices, veterinary clinics and home occupations, provided these are ancillary to the principal residential activity.
- retail sales of:
  farm and garden produce grown, reared or produced on the site.
  handicrafts produced on the site.
- Parks, reserves (owned and administered by a public authority).
- Grazing for maintenance of open space.
- Temporary buildings.
- Discharges

2.2 Conditions for Permitted Activities

2.2.1 Outline Development Plan

2.2.1.1 All development shall be undertaken in accordance with the Outline Development Plan in Clause 2.8.

2.2.2 Vehicle Access

2.2.2.1 For any proposed activity the owner, occupier or developer shall make provision for on-site all-weather vehicle parking. Any driveway formed on a lot for a permitted activity shall not exceed a gradient of 1 in 6.

2.2.2.2 With respect to Maxwell Hills Zone all vehicle access, including driveways and intersections, shall comply with Austroads Guide to Traffic Engineering Practice Part 5 "Intersections at Grade" and the following general rules in Chapter 27.2 (Rules Relating to Transportation) shall not apply:

Rules 27.2.4.4, 27.2.4.5, 27.2.4.6, 27.2.4.7 and 27.2.5

2.2.2.3 Gradients - Excavation

The gradient of any side cut excavation must not exceed an average of 9.5° (1:6) and must not exceed 11.3° (1:5) along any length of more than 20 metres.

2.2.2.4 Water Control and Culverts

Stormwater controls, watertable cut-offs, and culverts are to be installed to ensure that erosion does not occur on the inside edge of the cut. No culvert size less than 300 mm may be used to drain any side-cut excavation.

2.2.2.5 Stabilisation

Batters and side castings are to be stabilised by appropriate measures such as retaining, seeding, compacting, drainage and/or other methods of revegetation.

2.2.2.6 Run-off

Run-off from watertables or surfaces of side cut excavations is to be directed to stable land areas.

2.2.1.7 Access to Taylor Pass Road

Residential lots which adjoin Taylor Pass Rd shall not have vehicle access to or from Taylor Pass Road.

2.2.3 Parking Space Requirements

Refer to Chapter 27, Rule 27.2.3.

2.2.4 Amenities

2.2.4.1 Residential Site Density - Residential Activity

The minimum net site area for each residential unit shall be:

(i) A minimum of 2,000m^2;
(ii) Of such shape that it will contain a circle of 15 metres diameter; and
(iii) Dedicated for the exclusive use and occupation of the unit and contiguous with it.

2.2.4.2 Open Space - Residential Activity, Home Occupations, Homestays

The maximum percentage of net site area which may be covered by buildings shall be: 30% or 600m^2, whichever is the least.

2.2.4.3 Maximum Building Height - All Activities

The maximum permitted height of any building or structure shall be 8 metres.

2.2.4.4 Sunlight and Privacy for Neighbours - All Activities

2.2.4.4.1 No part of any building shall exceed a height equal to the recession plane angle determined by the application of Figures 2 and 3 of the Definition Chapter. To determine the maximum permitted height in relation to boundaries on the site the diagram in Figure 2 (Recession Plane Indicator) must be viewed within the site, and