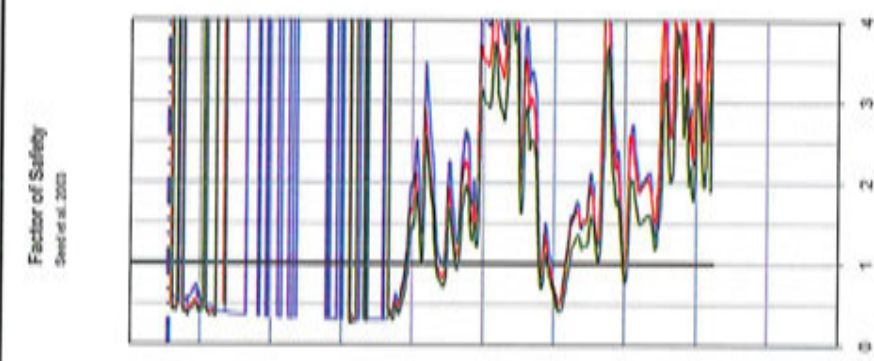
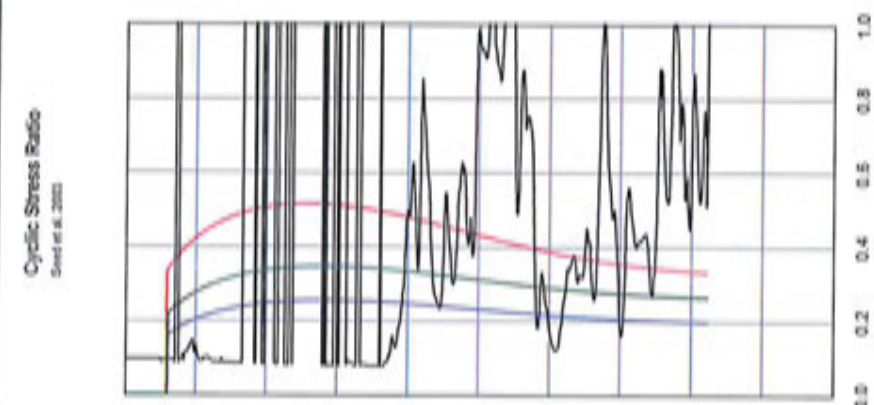
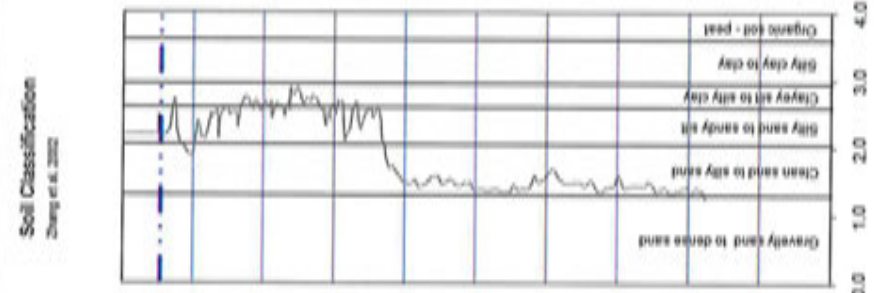
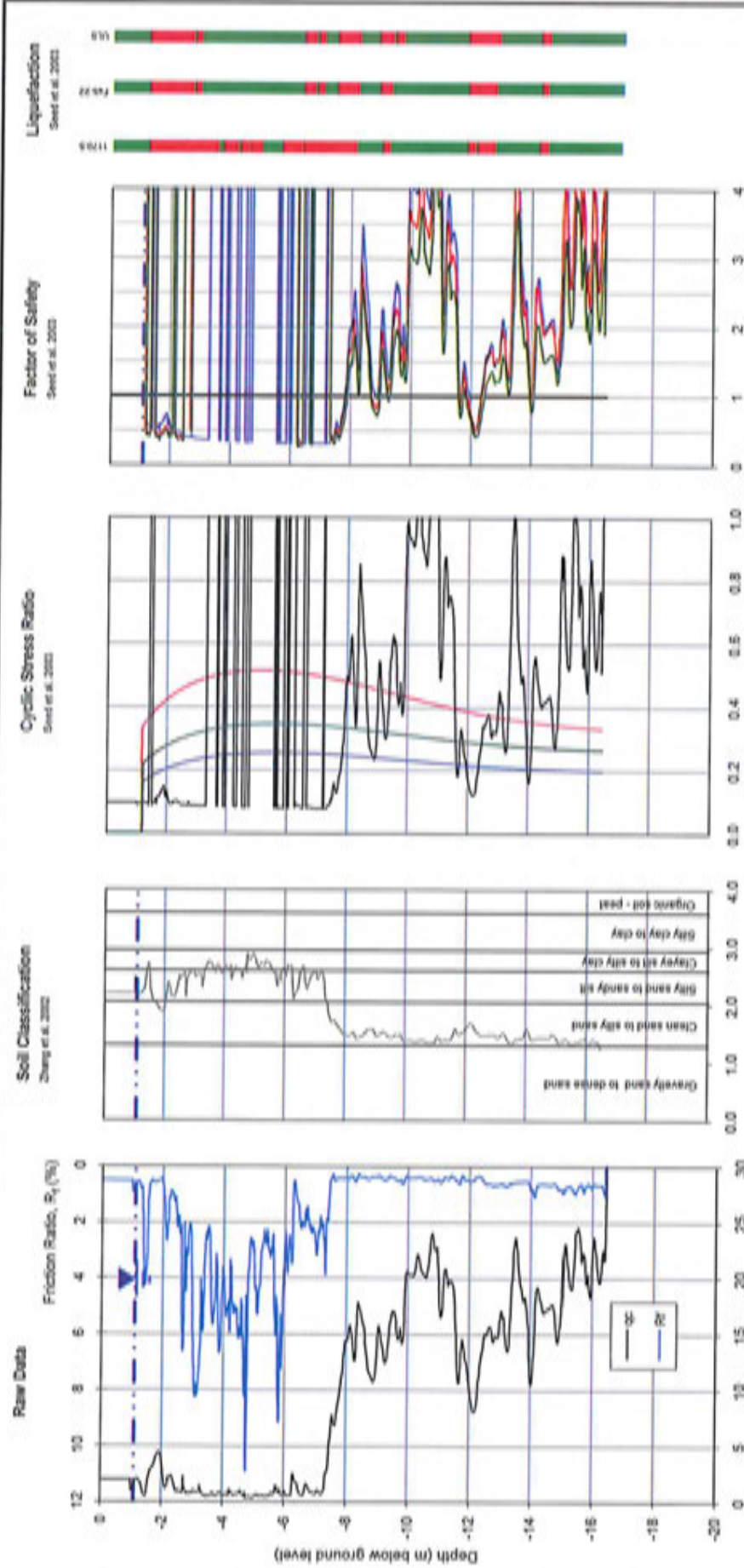


**Appendix K: Liquefaction Analyses Results**



CPT tip resistance,  $t_p$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

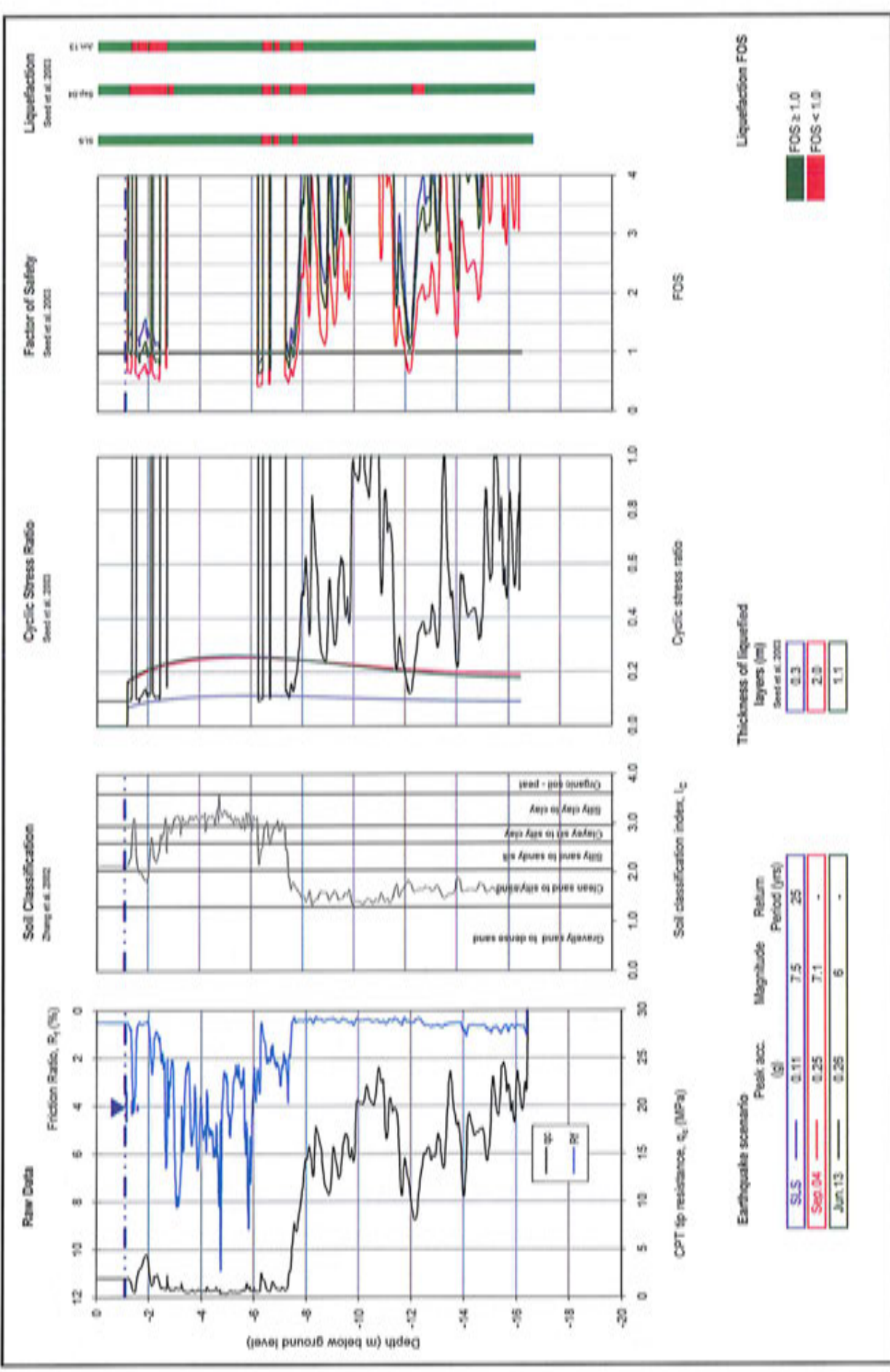
Peak acc. ( $\bar{a}$ )	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	8.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

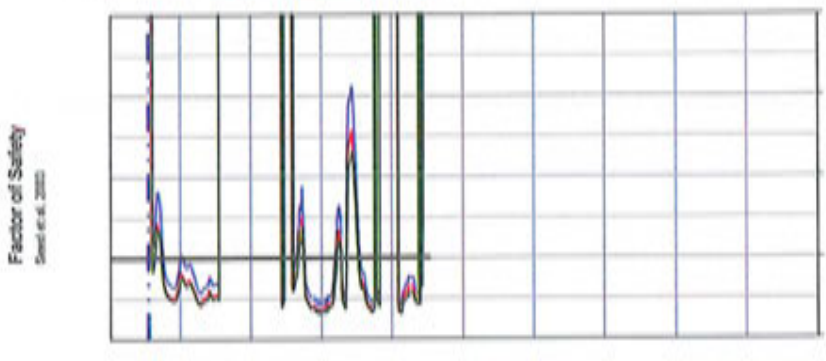
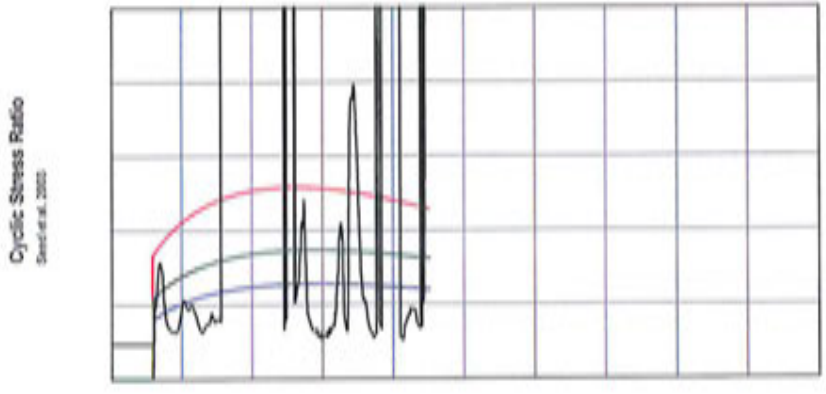
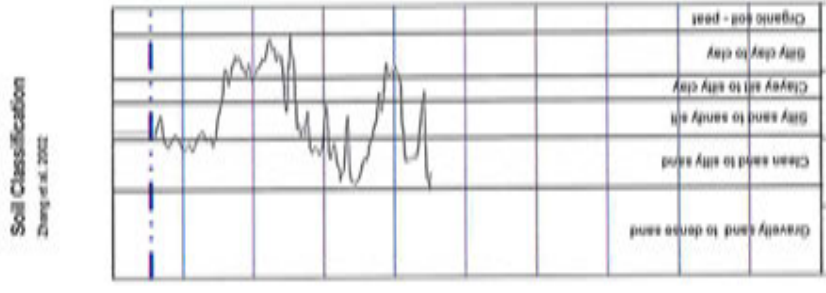
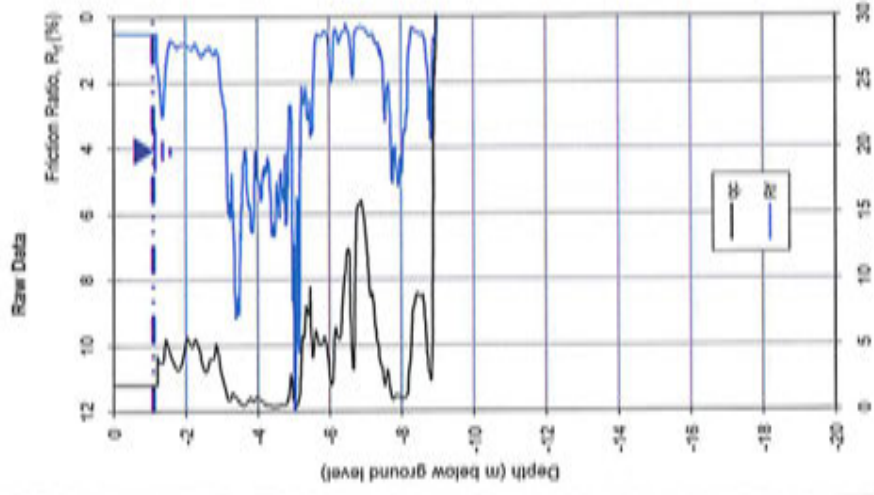
4.9
2.7
3.1

Liquefaction FOS

FOS $\geq 1.0$
FOS $< 1.0$



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	SUBJECT PROJECT <b>Christchurch City Council</b> <b>Geotechnical Assessment for Christchurch Central City</b>		DATE 6/12/2011
	FILE <b>CPT-CBD-01</b>		ANALYSED RAP
Liquefaction Assessment from CPT Results		JOB NUMBER S2006.301	CHECKED AFF



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb.22	0.52	6.2	-
U.S.	0.34	7.5	500

Thickness of liquefied layers (m)

Scenario	Thickness (m)
1170.5	3.8
Feb.22	4.1
U.S.	4.2

Liquefaction FOS

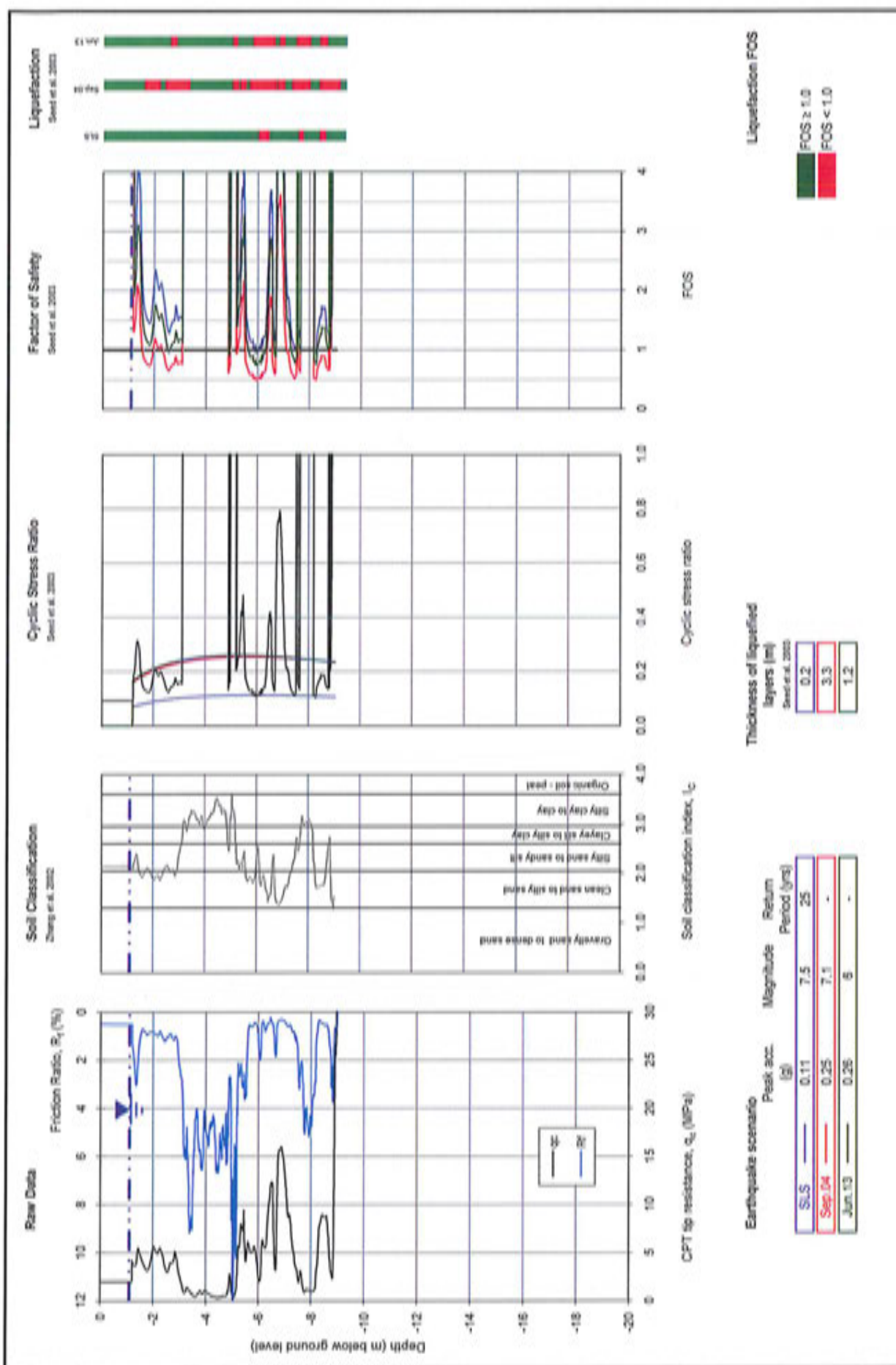


**Teekin & Taylor Ltd**  
Environmental & Engineering Consultants

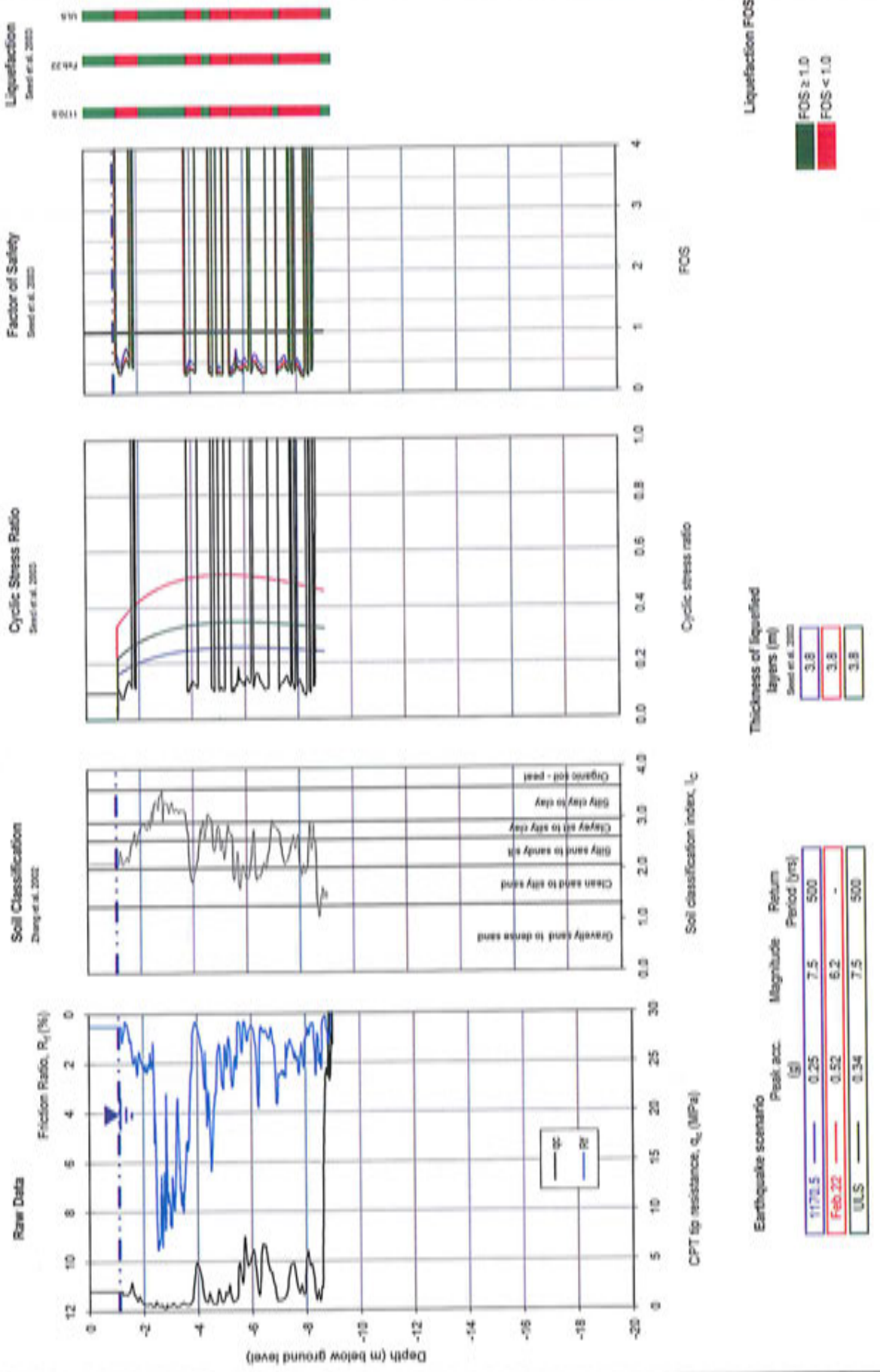
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT NUMBER: S2000\_301

DATE: 01/22/2011  
ANALYSED: R&P  
CHECKED: AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOGS NO. <b>CPT-CBD-02</b>	DATE 5/12/2011
	TITLE Liquefaction Assessment from CPT Results	JOB NUMBER 52000.301	ANALYSED RAP
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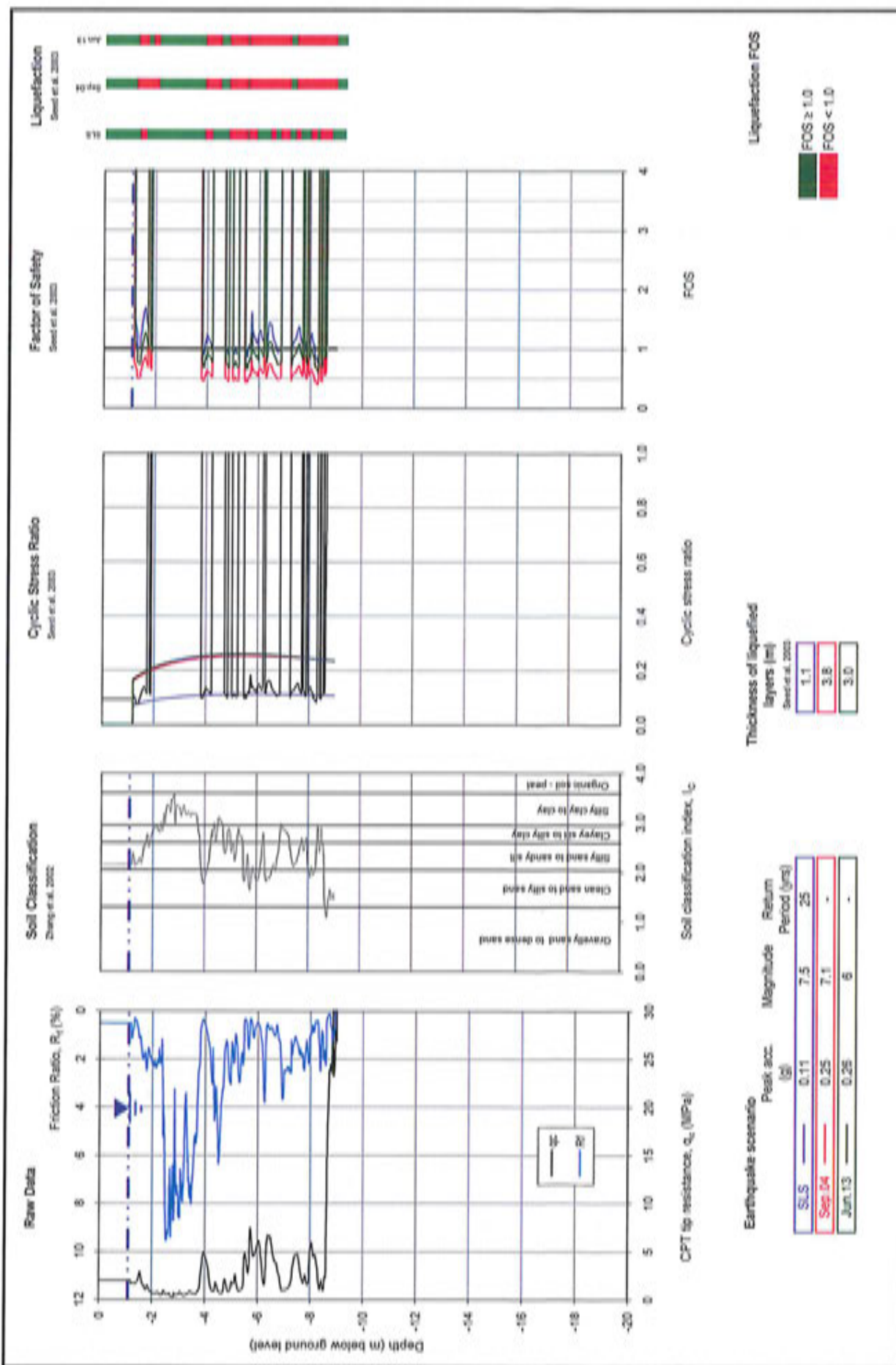
**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

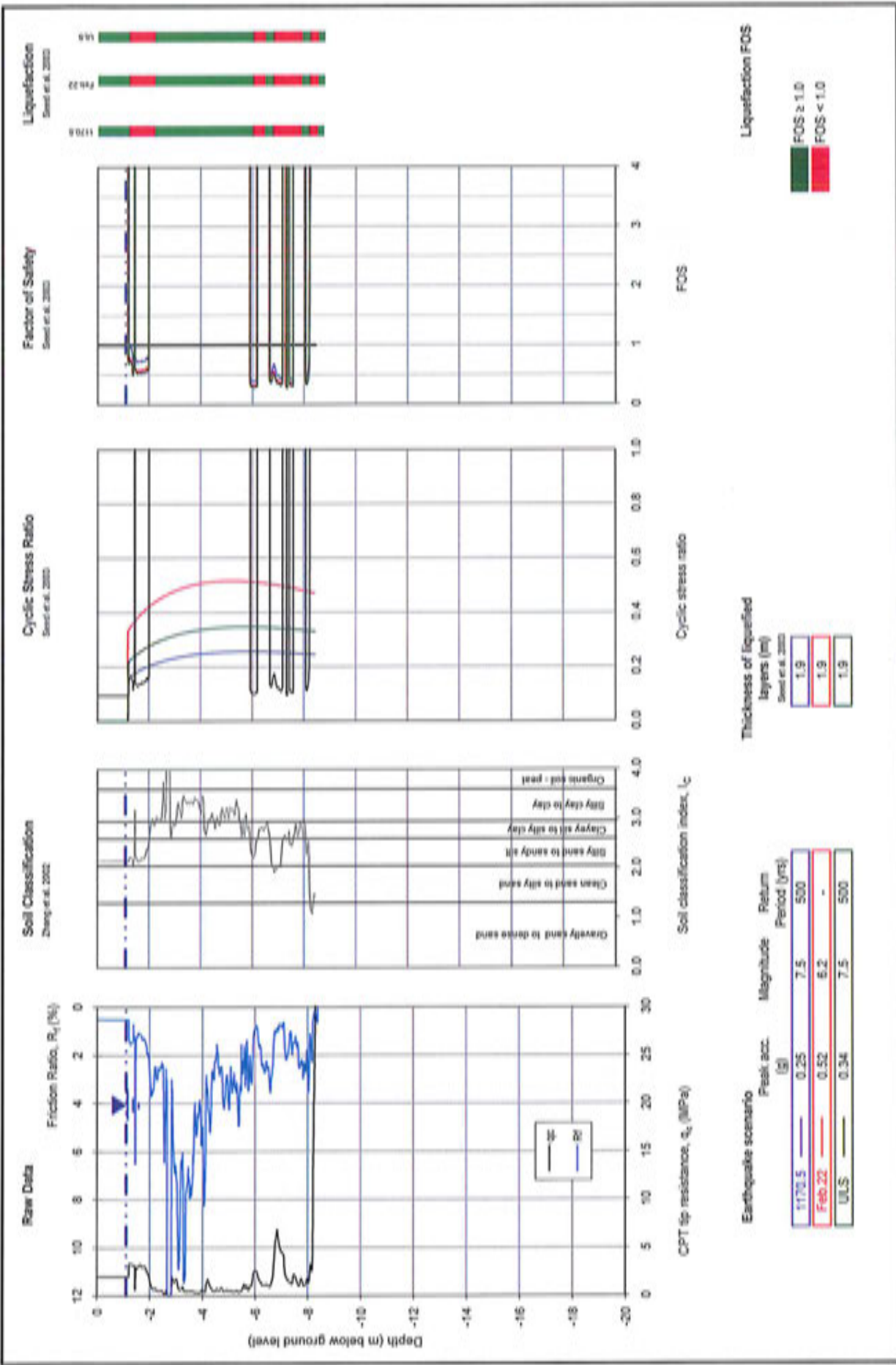
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**JOB NUMBER**  
S2000.304

**DATE** 5/10/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
**DATE** 5/10/2011  
**ANALYSED** RAP  
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**FILE**  
Liquefaction Assessment from CPT Results

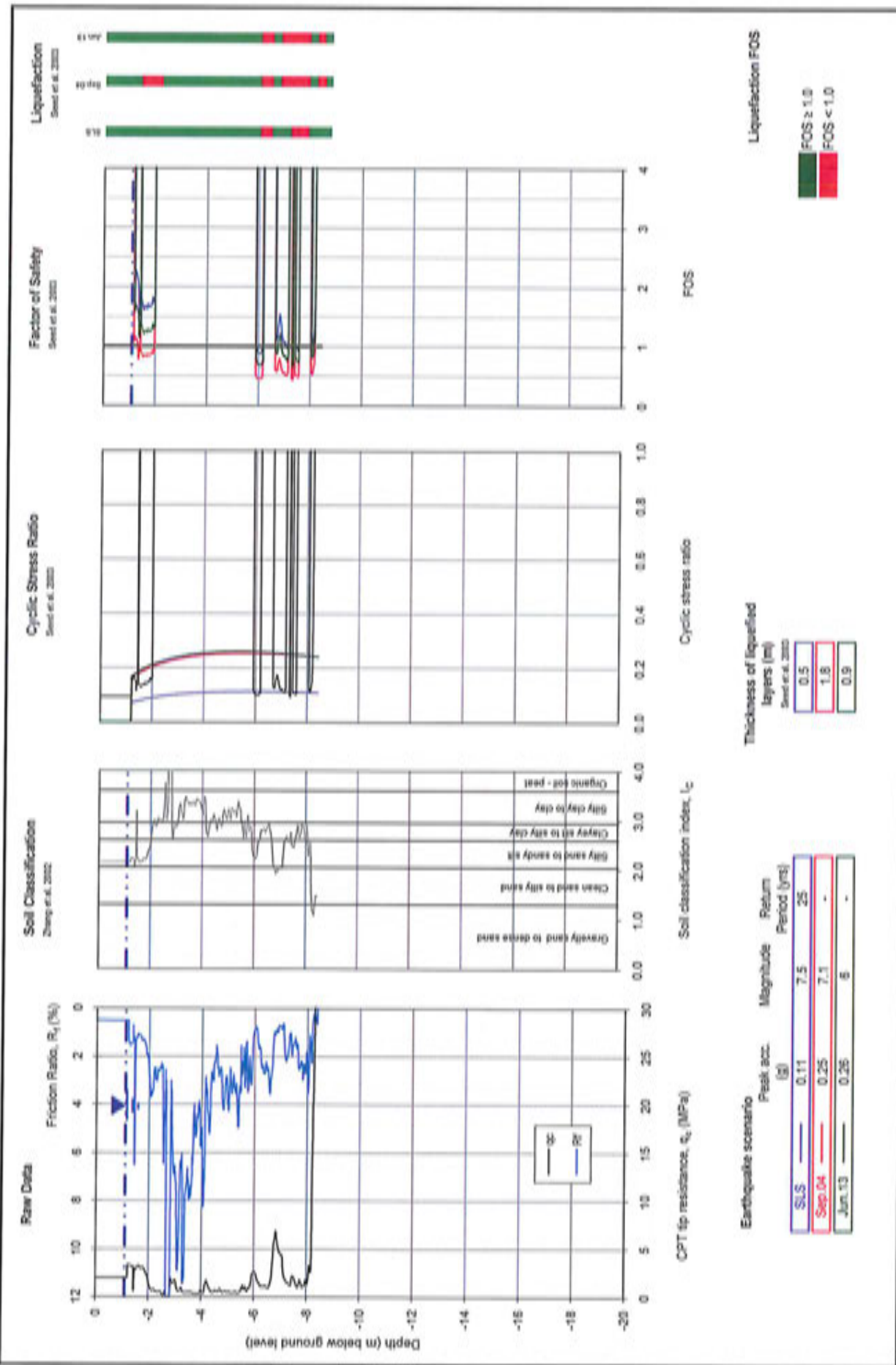


 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-03</b>	DATE 6/12/2011
	FILE Liquefaction Assessment from CPT Results	CASE NUMBER 52006.301	ANALYSED RAP
			CHECKED AFF

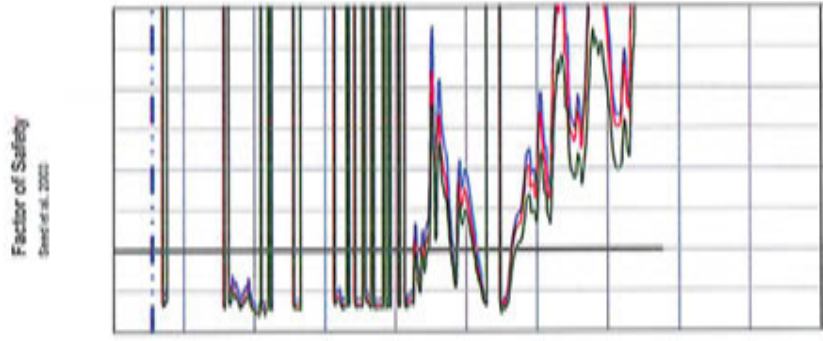
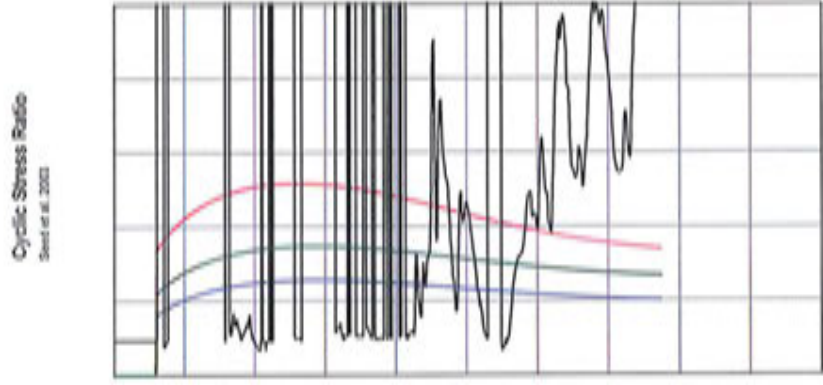
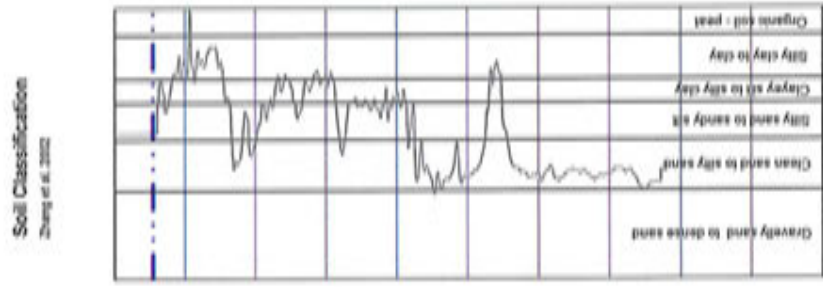
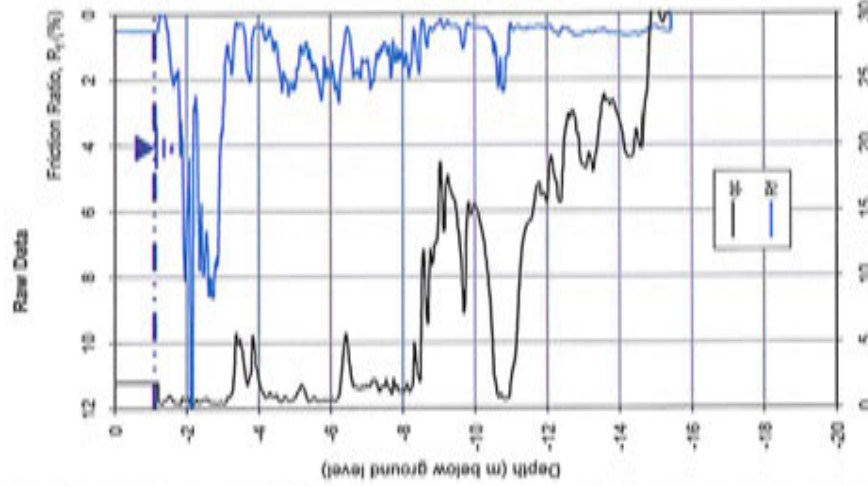


 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE: 5/12/2011 ANALYSED: RAP CHECKED: AFF
	PROJECT: CPT-CBD-04 JOB NUMBER: 52000_301	Liquefaction Assessment from CPT Results	





 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT/PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City		<b>DATE</b> 6/12/2011 <b>ANALYSED</b> RAP <b>CHECKED</b> AFF
	<b>LOCATION</b> CPT-CBD-04		<b>JOB NUMBER</b> 52006_301
<b>Liquefaction Assessment from CPT Results</b>			



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1172.5	0.25	7.5	500
Feb 22	0.52	6.2	-
U.L.S.	0.34	7.5	500

Thickness of liquefied layers (m)
3.9
4.1
4.4

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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Environmental & Engineering Consultants

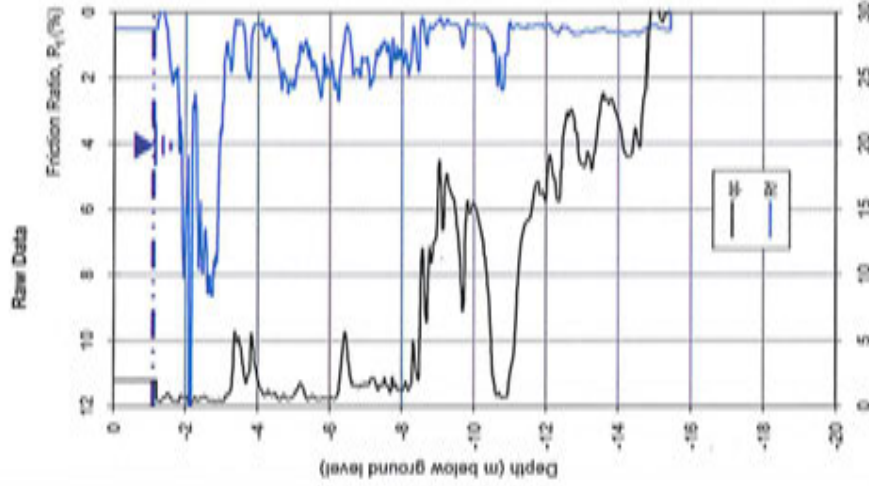
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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
FILE

JOB NUMBER  
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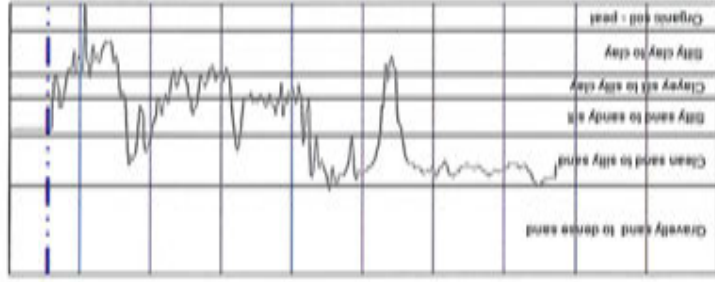
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ANALYSED  
RAP

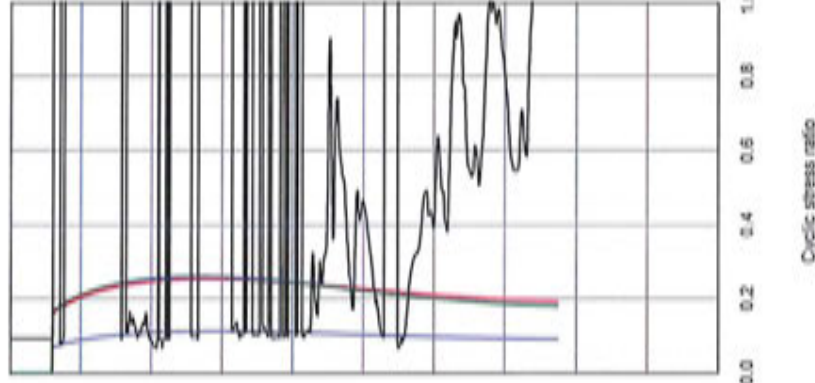
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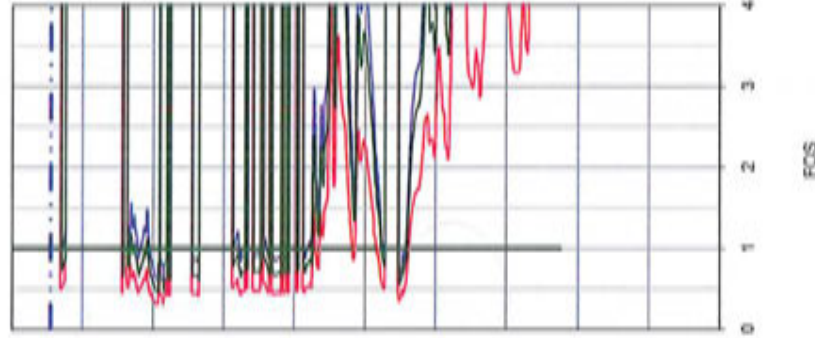
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep. 04	0.25	7.1	-
Jun. 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
2.2
3.7
3.2

Liquefaction FOS

FOS > 1.0
FOS < 1.0



Tonkin & Taylor Ltd  
Environmental &  
Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-05

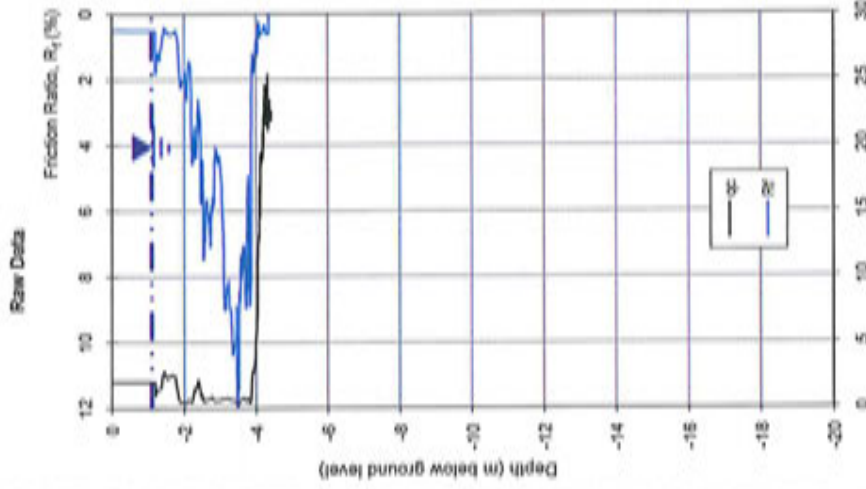
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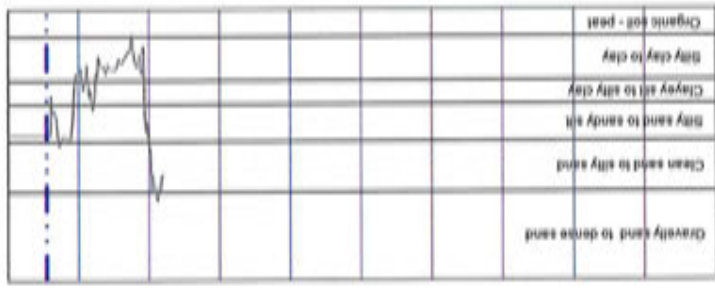
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DATE 6/12/2011  
ANALYSED RAP  
CHECKED AFF

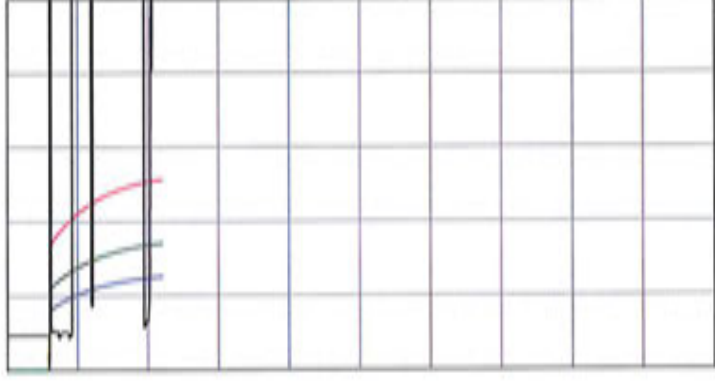
Liquefaction Assessment from CPT Results



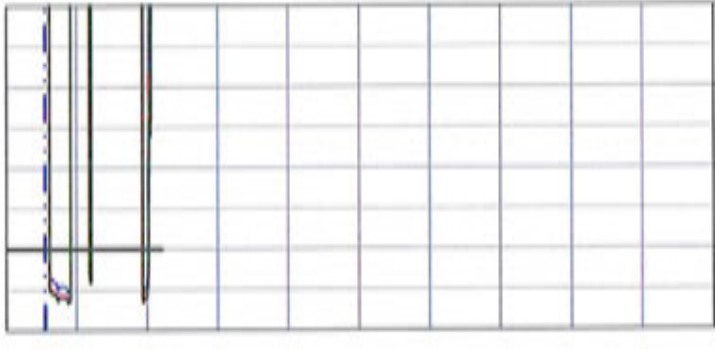
Soil Classification  
Zhang et al. 2002



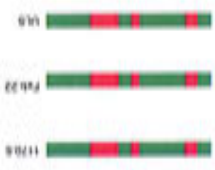
Cyclic Stress Ratio  
Seed et al. 2003



Factor of Safety  
Seed et al. 2003



Liquefaction  
Seed et al. 2003



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1172.5	7.5	500
Feb.22	6.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

0.8
0.8
0.8

Liquefaction FOS



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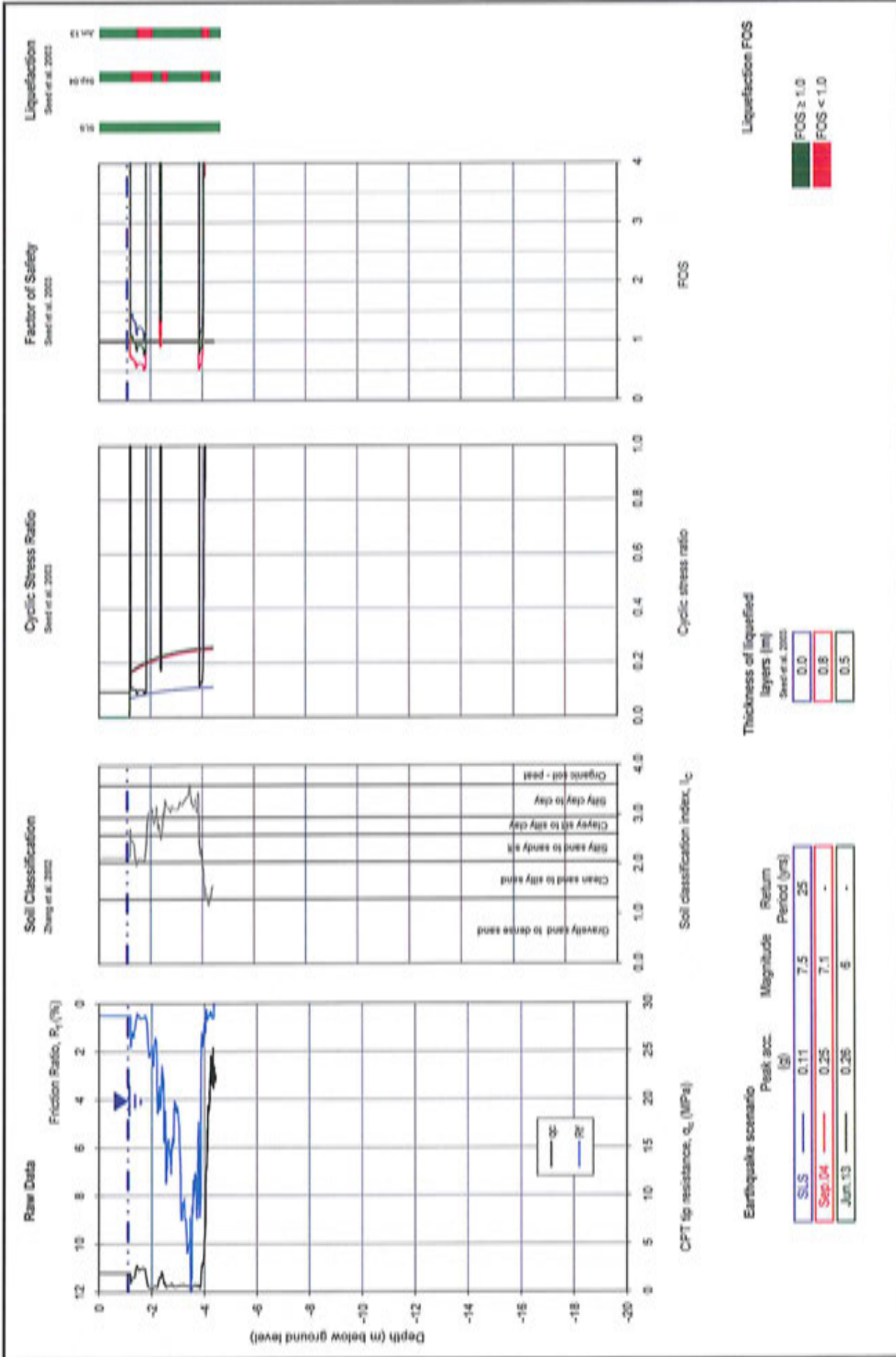
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT  
**CPT-C8D-06**

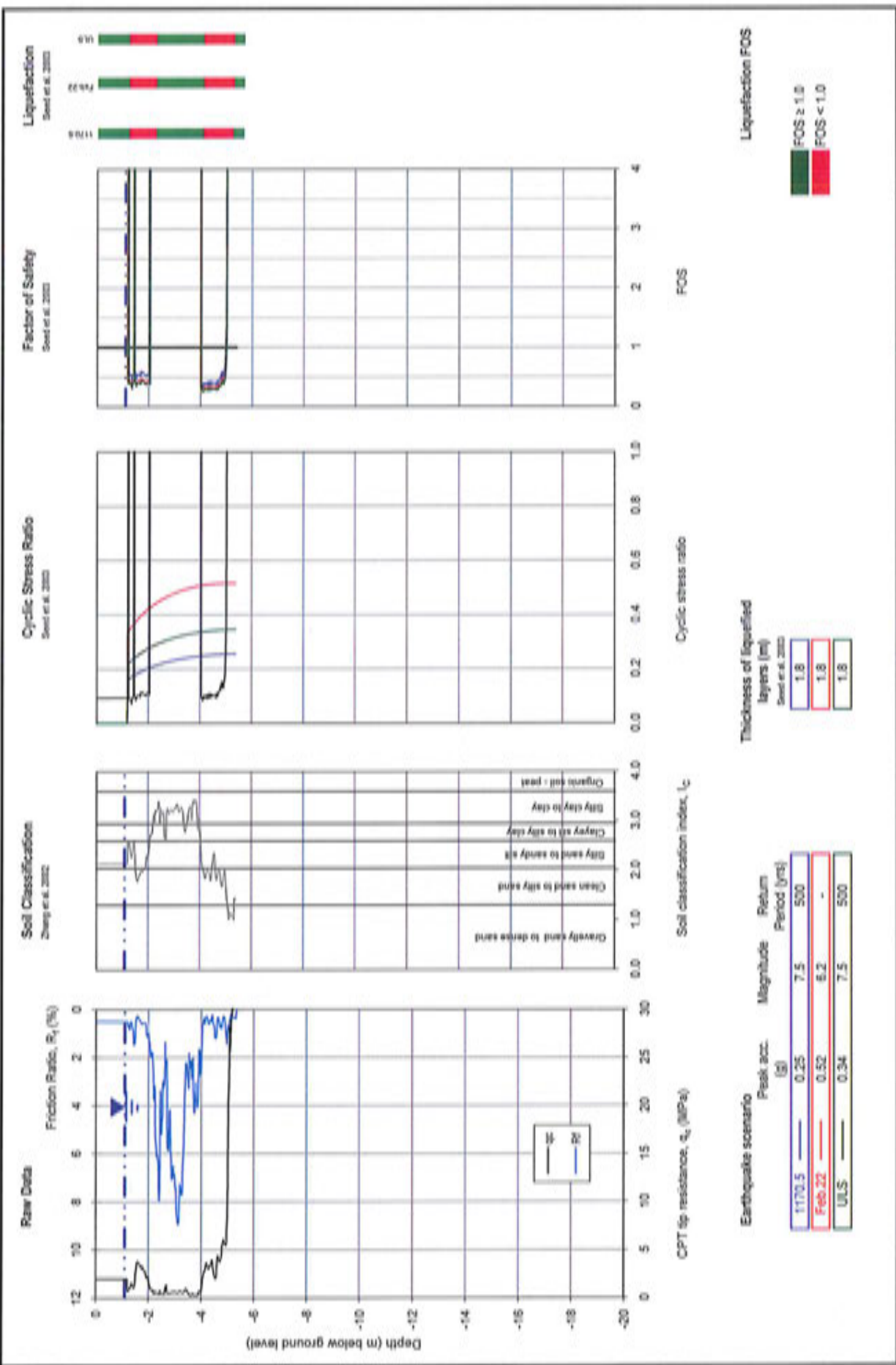
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DATE: 6/12/2011  
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CHECKED: AFF

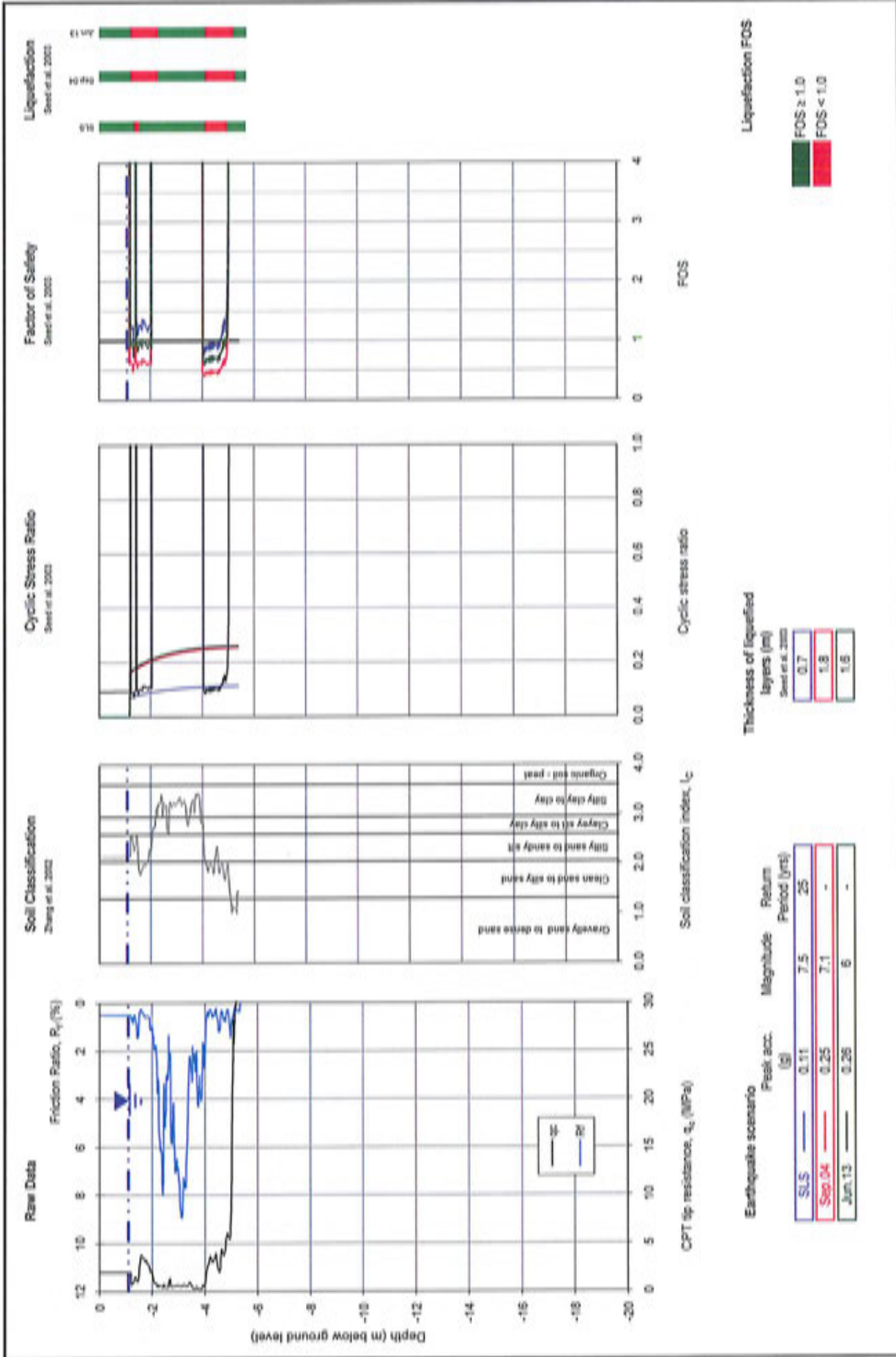
Liquefaction Assessment from CPT Results



 Tonkin & Taylor Ltd Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council Geotechnical Assessment for Christchurch Central City</b>		LOCATION <b>CPT-CBD-06</b>	DATE 6/12/2011
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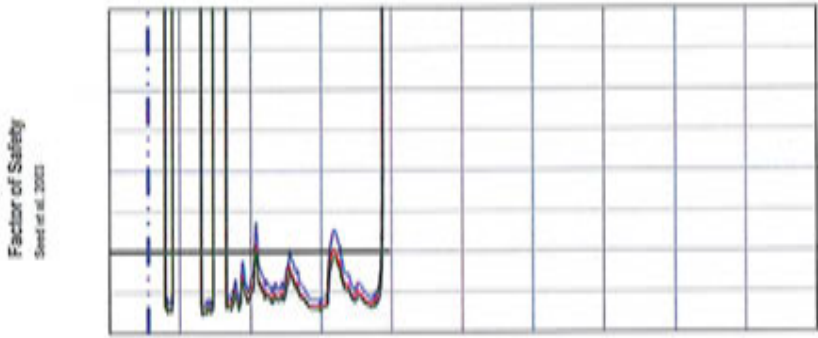
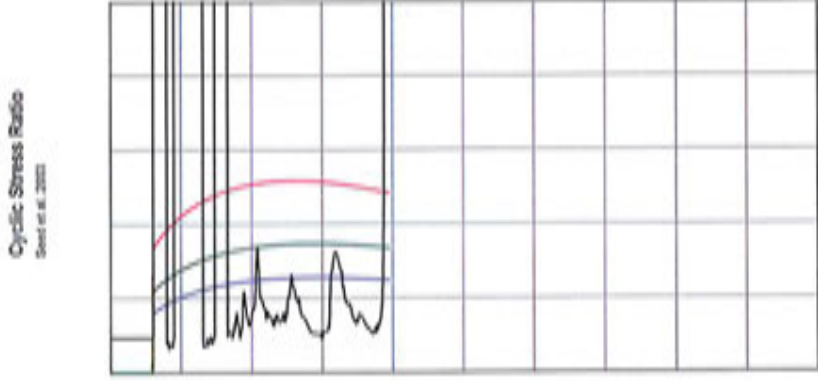
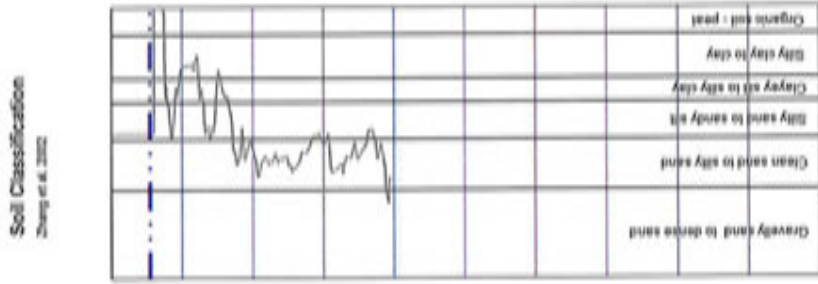
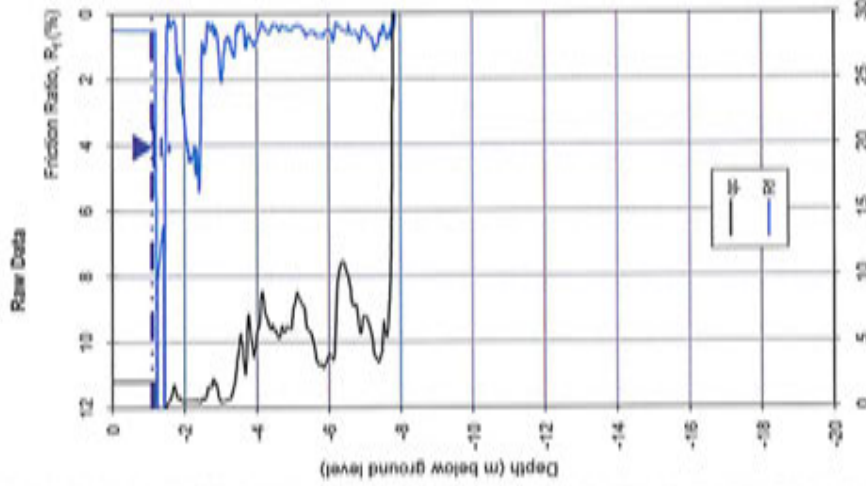


 <b>Tomlin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE: 6/12/2011 ANALYSED: RBP CHECKED: AFF
	CLIENT PROJECT <b>CPT-CBD-07</b>	LOCATION Christchurch Central City	JOB NUMBER S2000.301
Liquefaction Assessment from CPT Results			



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	DATE: 6/12/2011 ANALYSED: RAP CHECKED: AFF
		PROJECT: CPT-CBD-07 JOB NUMBER: S2006.301

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
4.5
4.8
5.0

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION  
CPT-CBD-08

JOB NUMBER  
52000.301

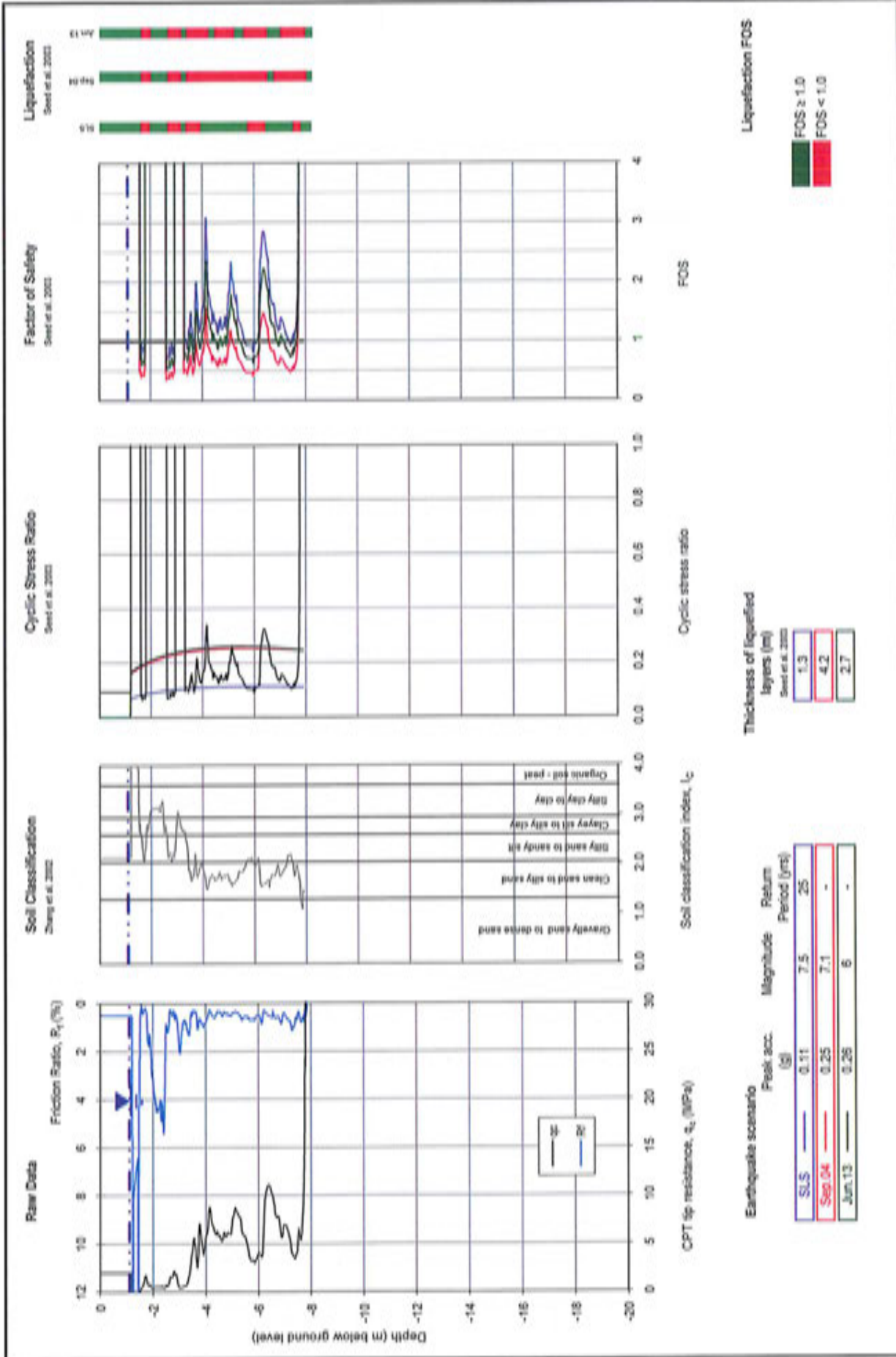
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ANALYSED  
RAP

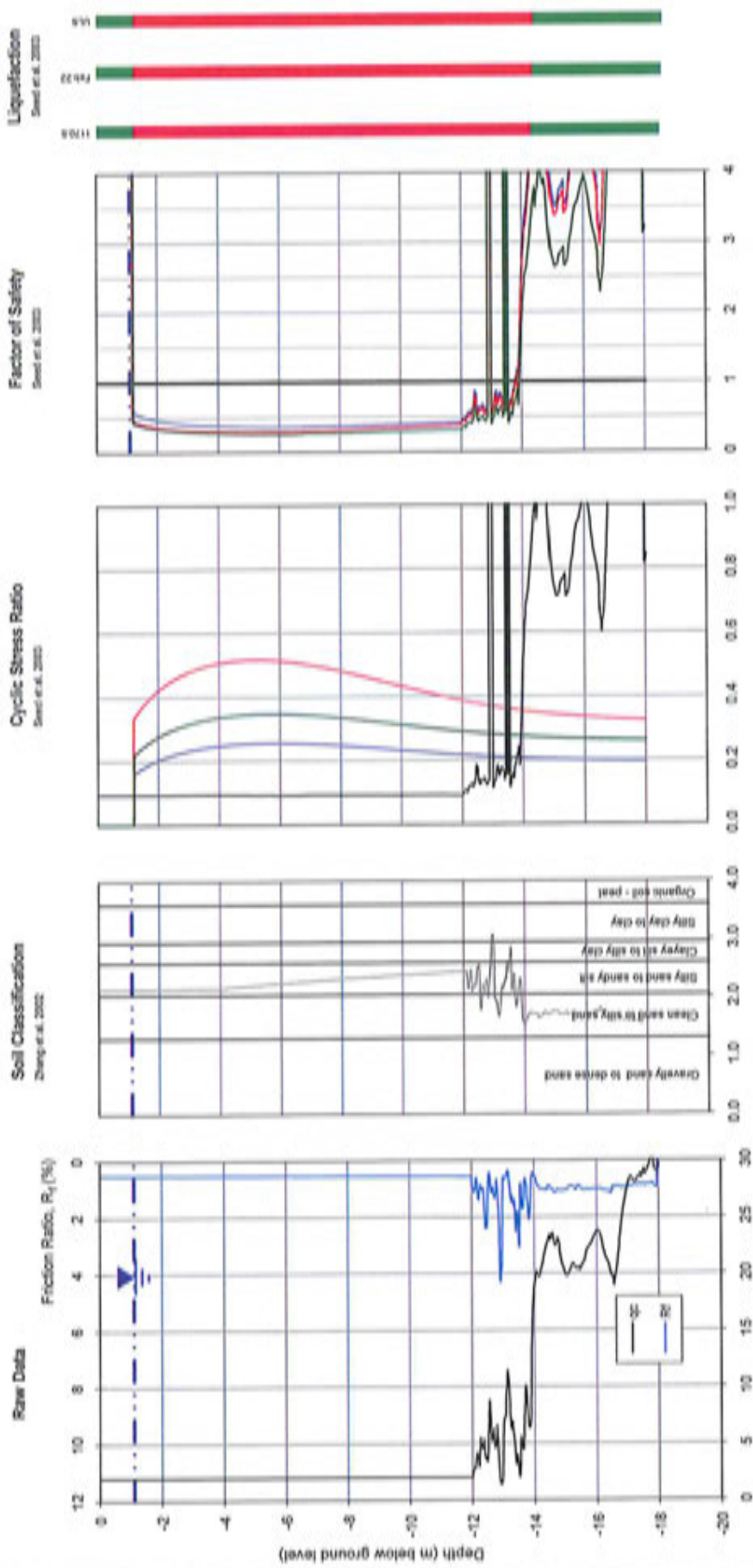
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Liquefaction Assessment from CPT Results



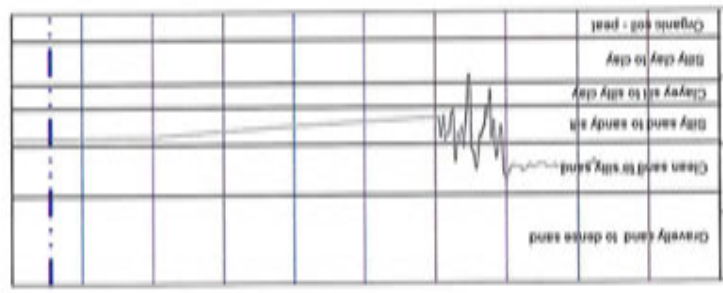


 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	SUBJECT <b>Christchurch City Council          Geotechnical Assessment for Christchurch Central City</b>	LOCATION <b>CPT-CBD-08</b>	DATE 6/12/2011
			ANALYSED RAP
			CHECKED AFF
			JOB NUMBER S2006.301
Liquefaction Assessment from CPT Results			

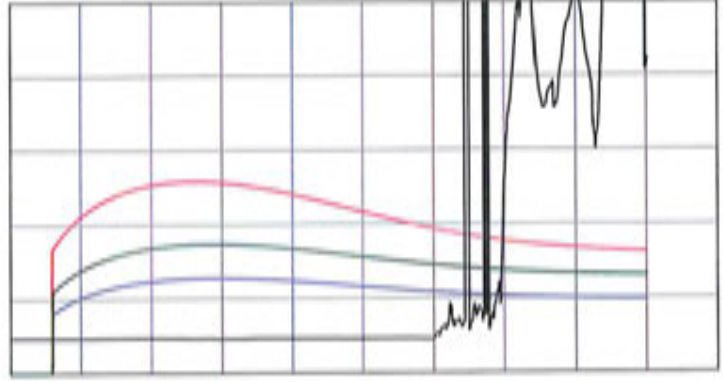


Raw Data  
Friction Ratio,  $R_f$  (%)

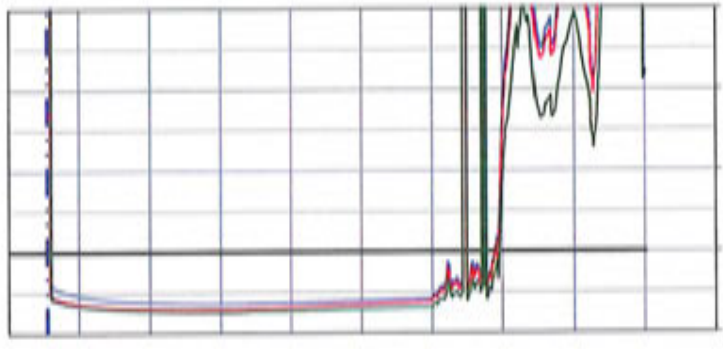
Soil Classification  
Sheng et al. 2002



Cyclic Stress Ratio  
Seed et al. 2003



Factor of Safety  
Seed et al. 2003



Liquefaction  
Seed et al. 2003



FOS

Cyclic stress ratio

Soil classification index,  $I_c$

CPT tip resistance,  $q_t$  (MPa)

Thickness of liquefied layers (m)  
Seed et al. 2003

1170.5	12.4
F60.22	12.5
ULS	12.5

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
F60.22	6.2	-
ULS	7.5	500

Liquefaction FOS

Green	FOS $\geq$ 1.0
Red	FOS $<$ 1.0



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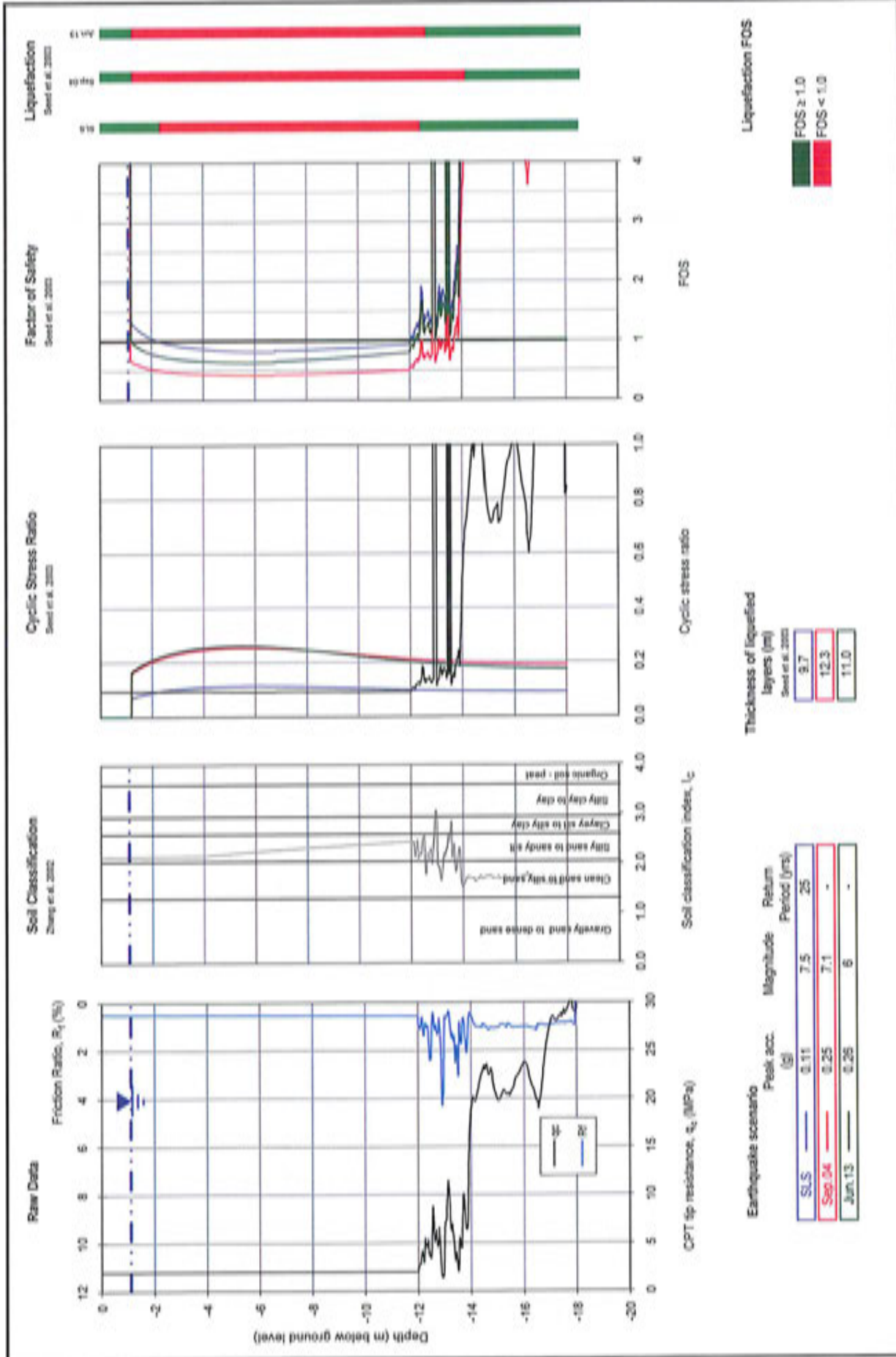
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-08P

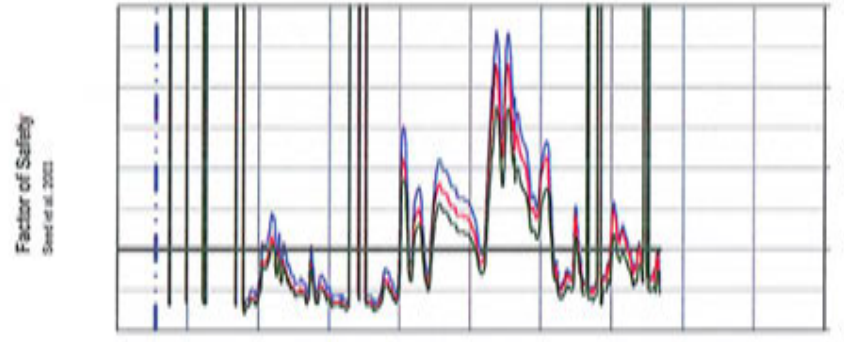
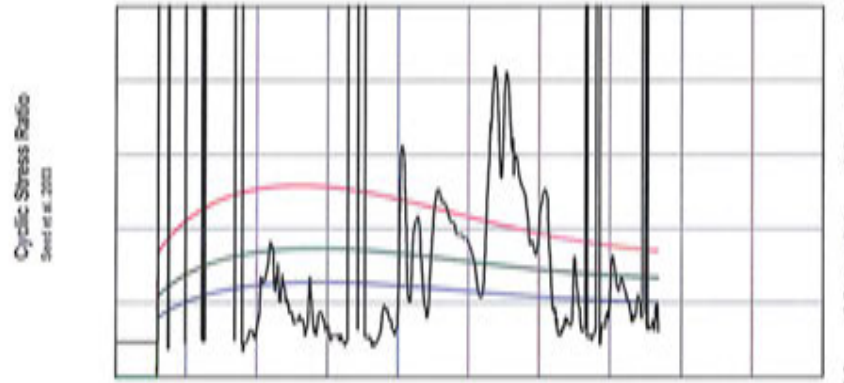
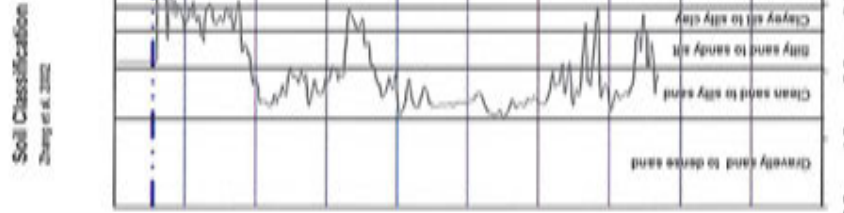
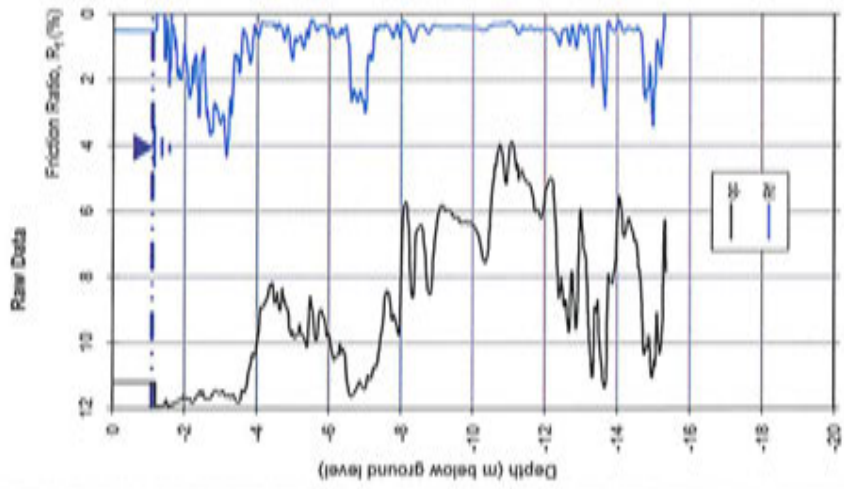
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DATE  
5/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council          Geotechnical Assessment for Christchurch Central City</b>	LOCATION <b>CPT-CBD-08P</b>	DATE 7/12/2011
	TITLE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 52000.301	ANALYSED RMP CHECKED AFF



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1.170.5	7.5	500
Feb.22	6.2	-
U.S	7.5	500

Thickness of liquefied layers (m)

5.9
6.7
7.3



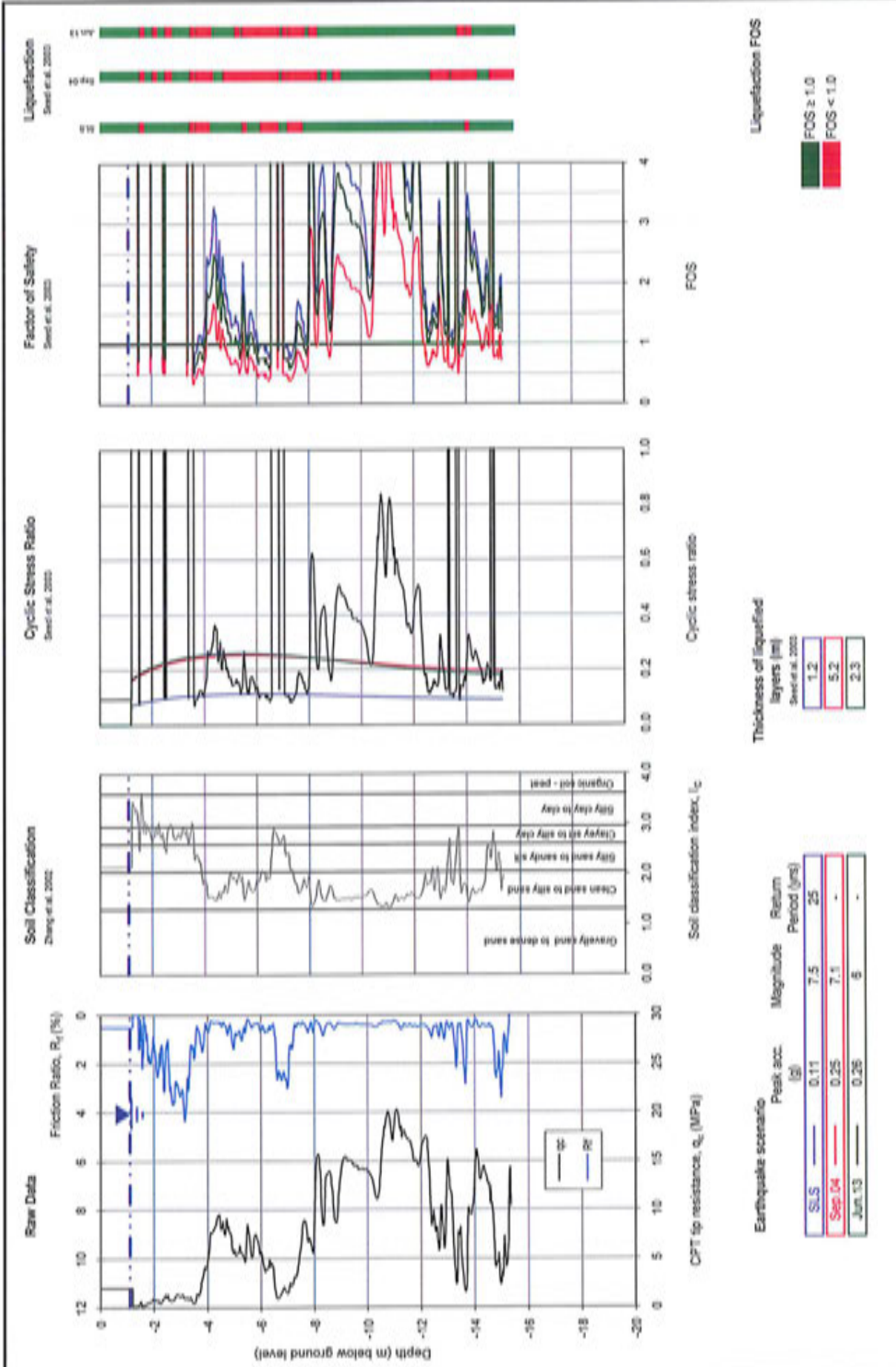
**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

CLIENT PROJECT  
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

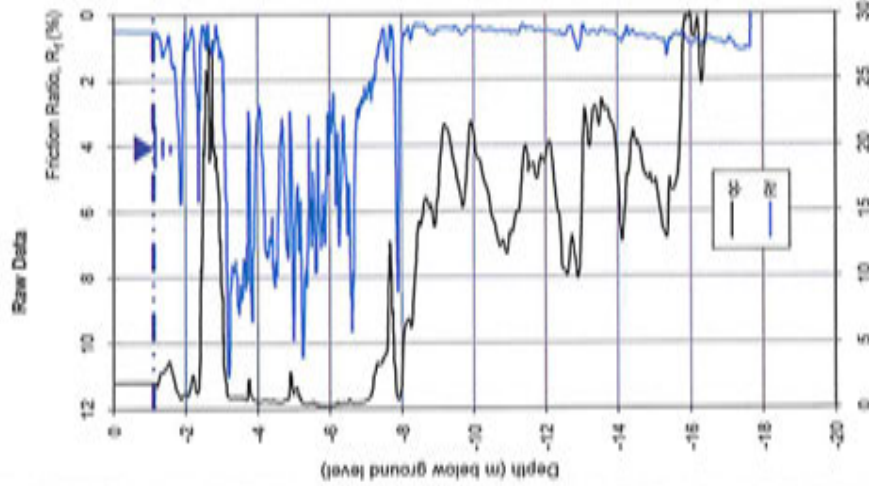
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JOB NUMBER  
52000\_301

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

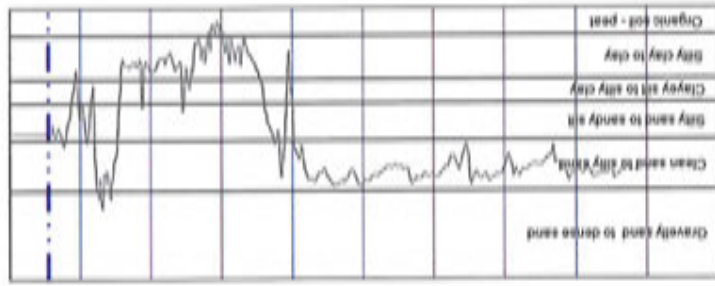
Liquefaction Assessment from CPT Results



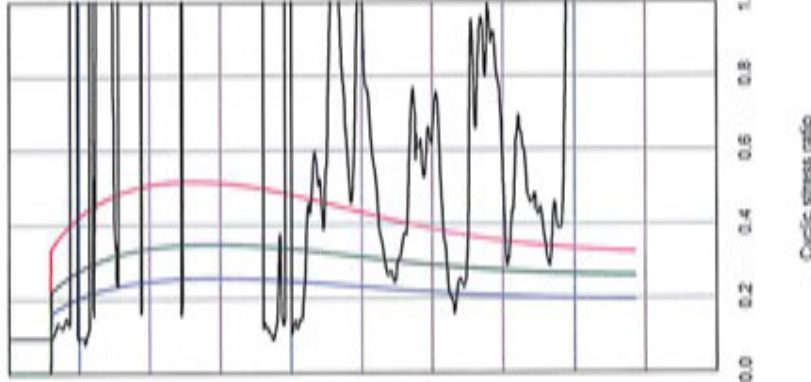
 Tonkin & Taylor Ltd Environmental & Engineering Consultants	SUBPROJECT <b>Christchurch City Council Geotechnical Assessment for Christchurch Central City</b>	LOCATION <b>CPT-CBD-09</b>	DATE 7/12/2011
	FILE Liquefaction Assessment from CPT Results	JOB NUMBER S2000_301	ANALYSED RAP



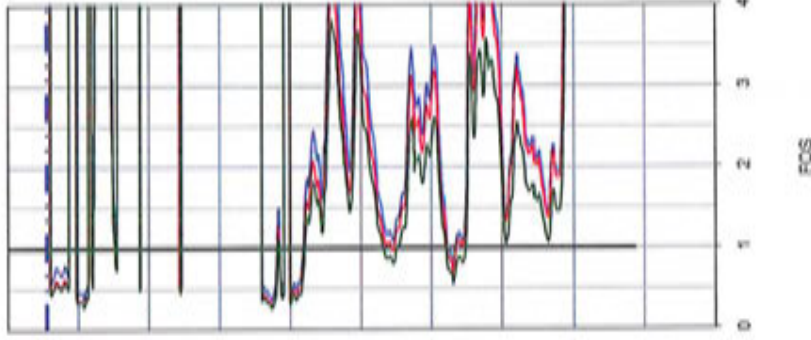
Soil Classification  
Zhang et al., 2002



Cyclic Stress Ratio  
Seed et al., 2003



Factor of Safety  
Seed et al., 2003



Liquefaction  
Seed et al., 2003



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb.22	0.52	6.2	-
U.L.S.	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
2.1
2.4
3.0

Liquefaction FOS

FOS > 1.0
FOS < 1.0



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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-10

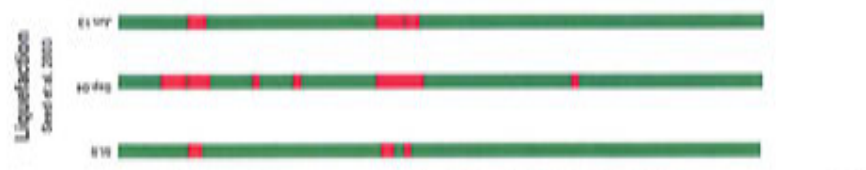
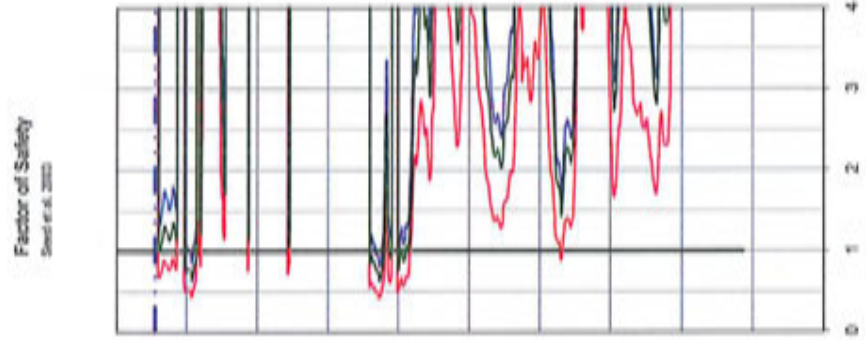
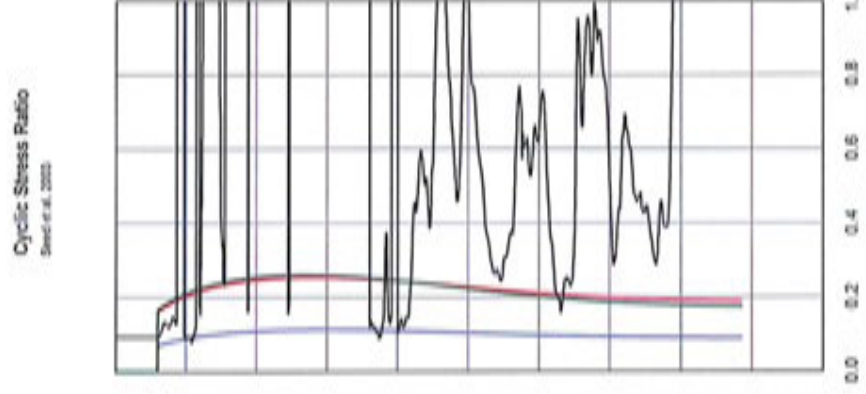
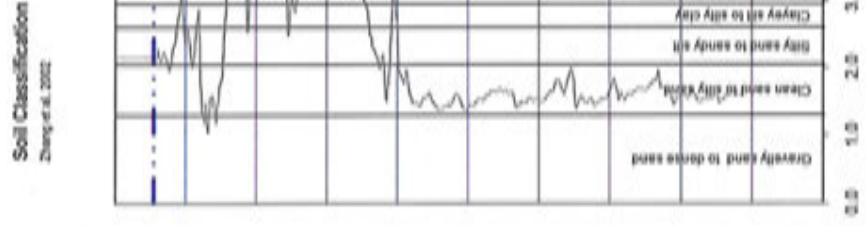
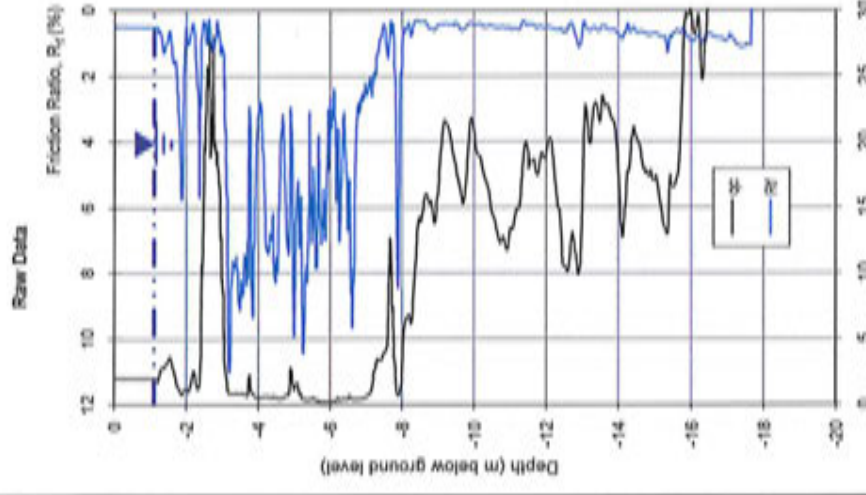
DATE  
6/12/2011

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JOB NUMBER  
S2000\_301

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.26	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.3
1.9
0.9

Liquefaction FOS



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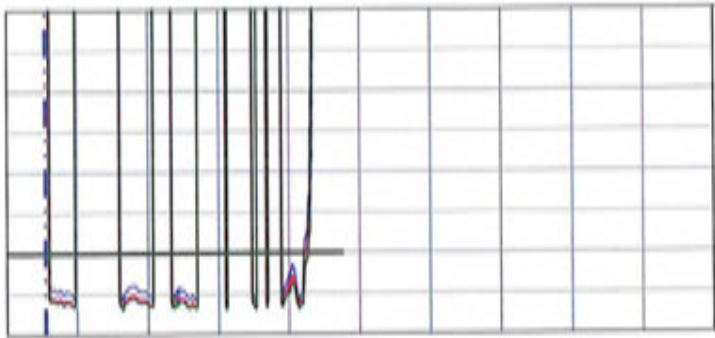
CLIENT PROJECT  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
LIQUEFACTION ASSESSMENT FROM CPT RESULTS

LOCATION  
CPT-CBD-10  
JOB NUMBER  
52000\_301

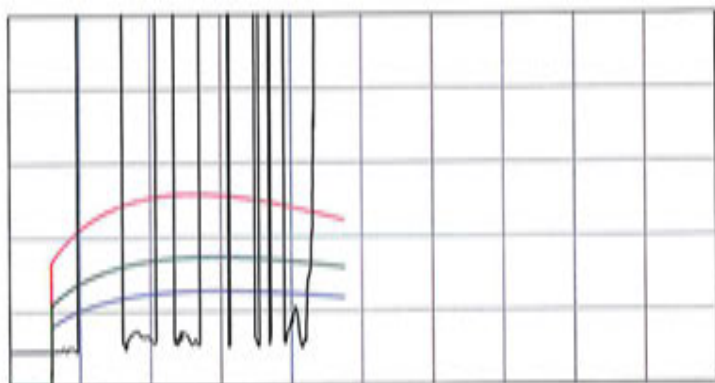
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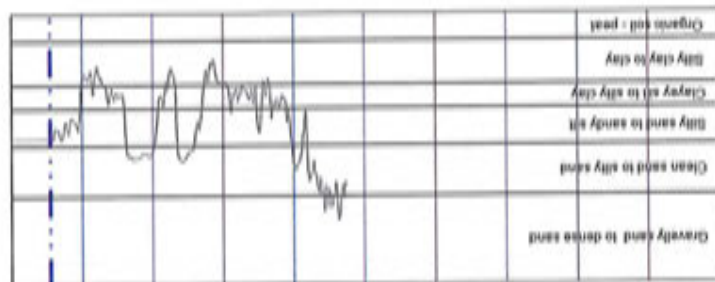
Factor of Safety  
Seed et al. 2002



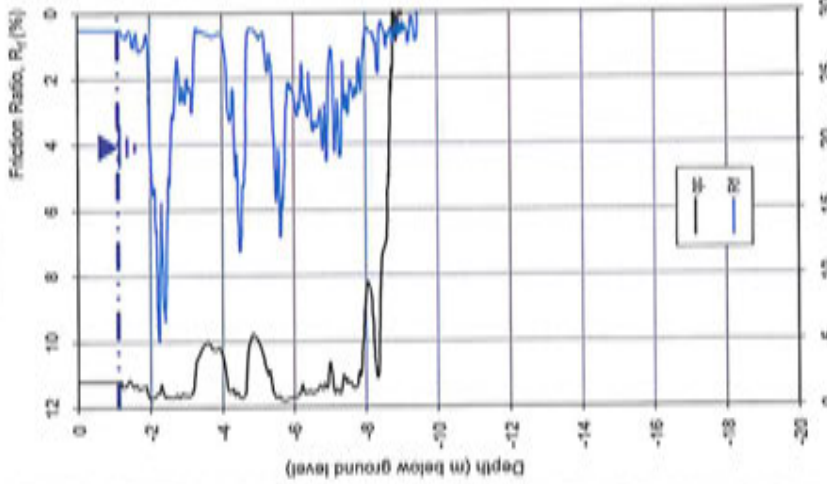
Cyclic Stress Ratio  
Seed et al. 2002



Soil Classification  
Zhang et al. 2002



Raw Data



FOS

Cyclic stress ratio

Soil classification index, I<sub>c</sub>

CPT tip resistance, q<sub>t</sub> (MPa)

Liquefaction FOS



Thickness of liquefied layers (m)

9/11	3.3
9/14	3.3
9/11	3.4

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
0.25	7.5	500
0.52	6.2	-
0.34	7.5	500



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Geotechnical Assessment for Christchurch Central City

LOCATION  
CPT-CBD-11

FILE  
JOB NUMBER  
S2000\_301

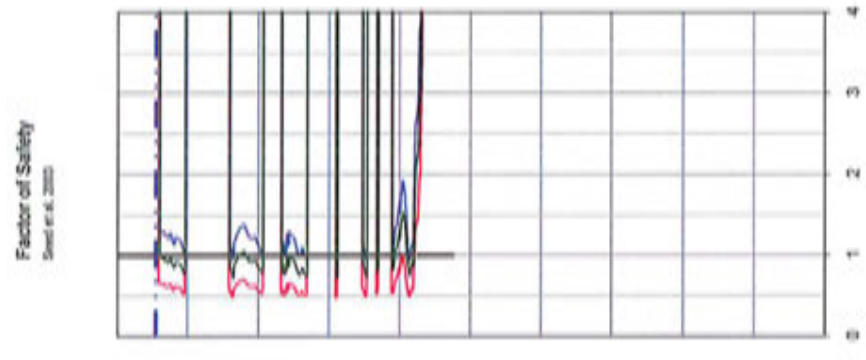
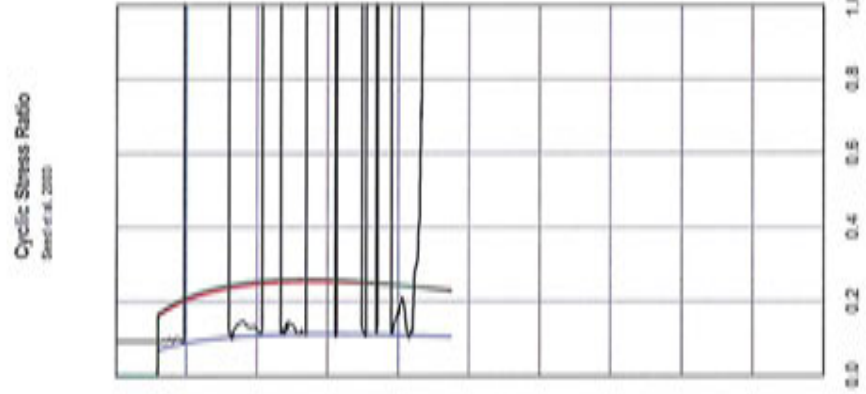
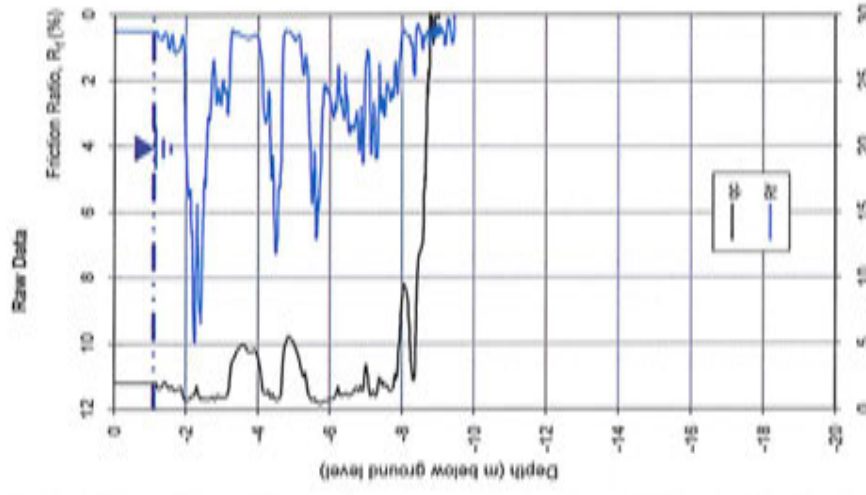
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ANALYSED  
RAP

CHECKED  
AFF

Liquefaction Assessment from CPT Results





CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun.13	0.25	6	-

Thickness of liquefied layers (m)

0.3
3.3
2.7

Liquefaction FOS

FOS > 1.0
FOS < 1.0



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LOCATION

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LOT NUMBER

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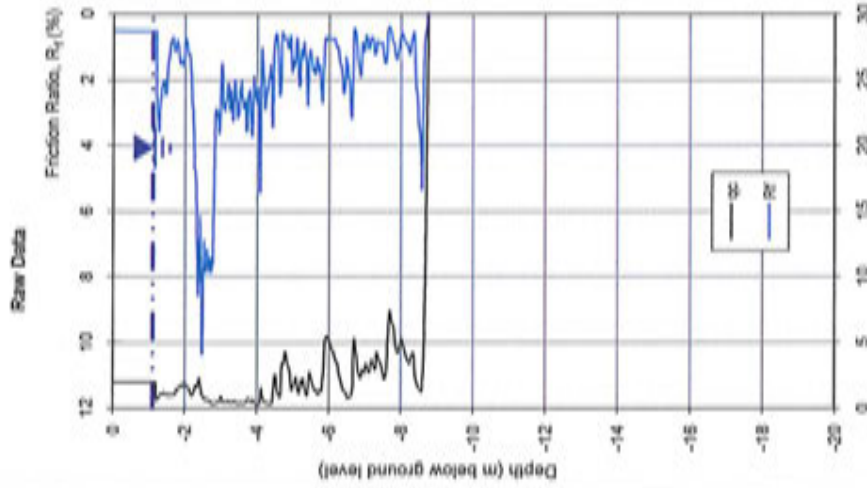
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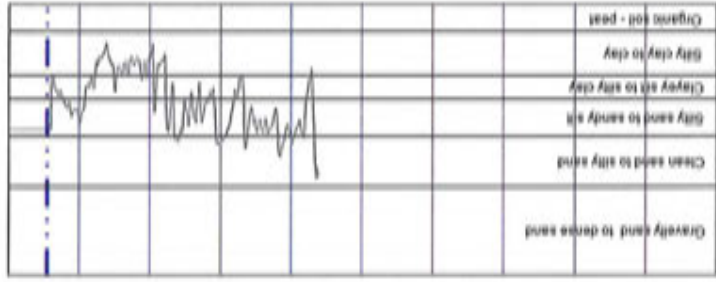
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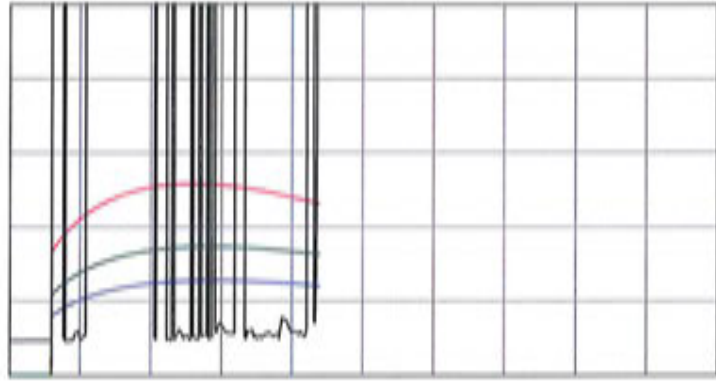
Liquefaction Assessment from CPT Results



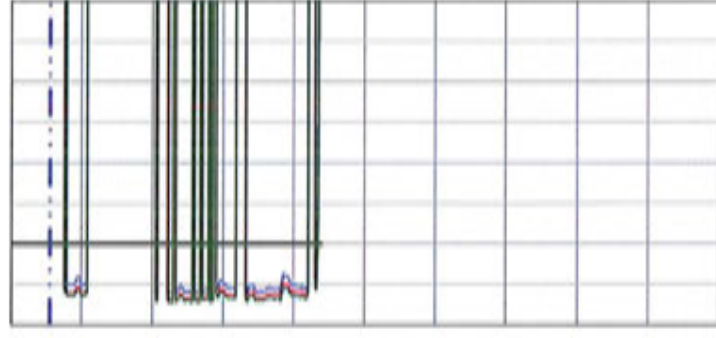
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb. 22	0.52	6.2	-
U.S.	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
4.1
4.1
4.1

Liquefaction FOS



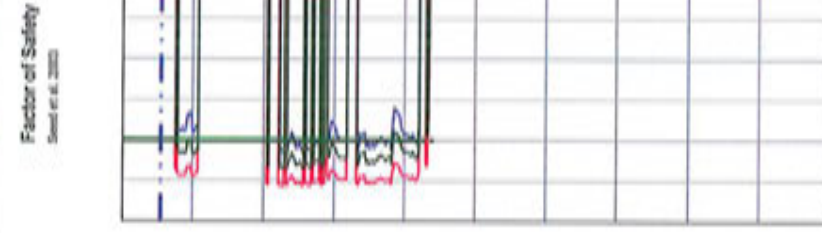
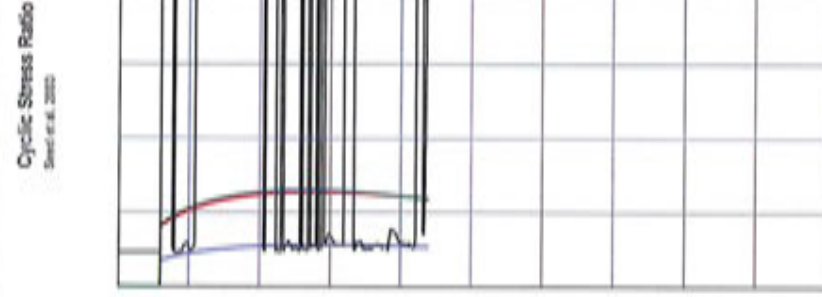
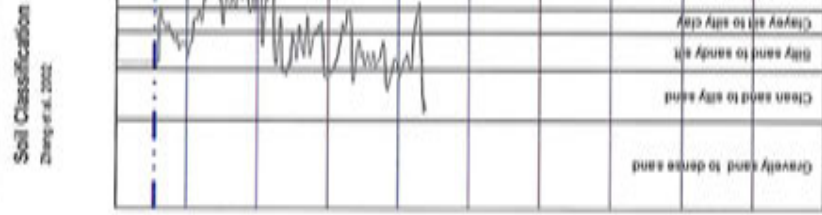
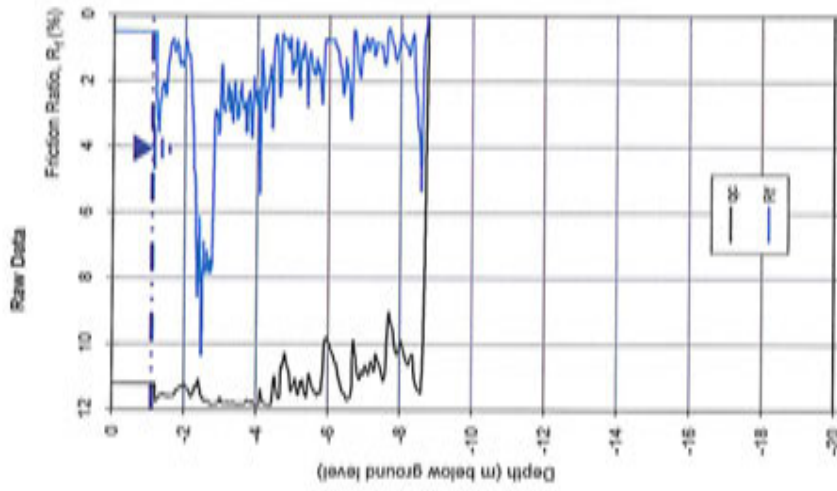
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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

LOCATION  
**CPT-CBD-12**  
JOB NUMBER  
52000\_301

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_p$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.26	6	-

Thickness of liquefied layers (m)

1.7
4.1
3.8

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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LOCATION

CPT-CBD-12

DATE

7/12/2011

ANALYSED

RAP

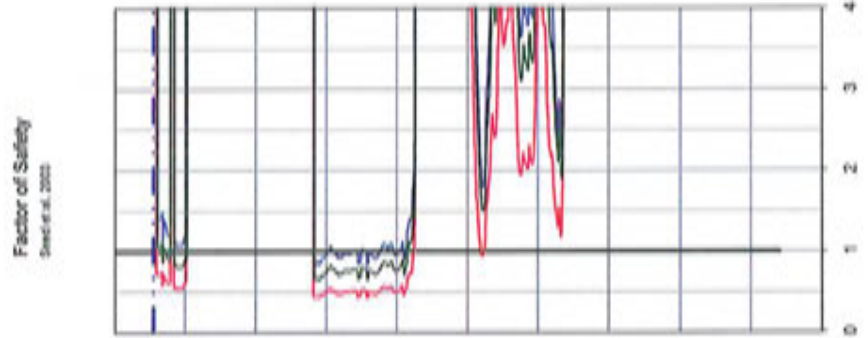
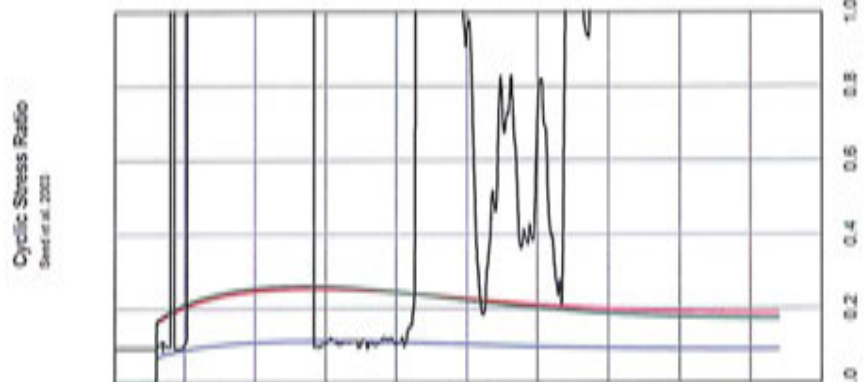
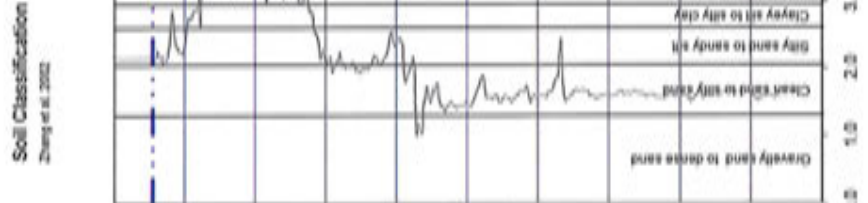
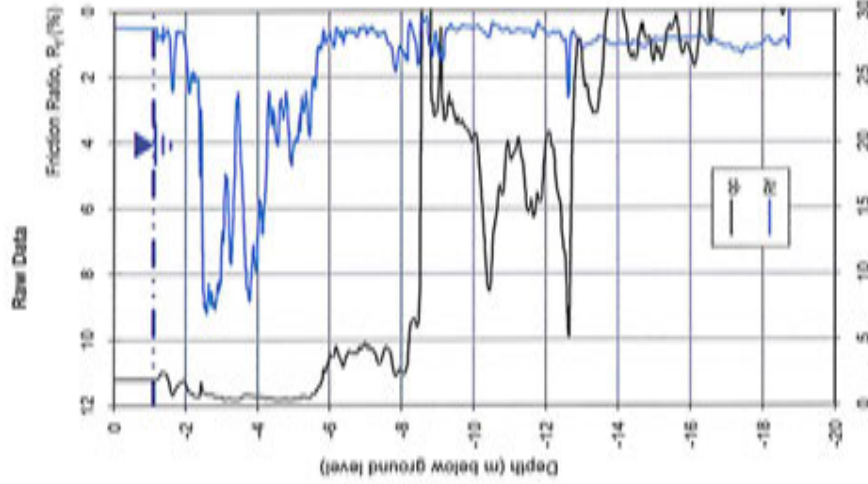
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FILE

52008.301

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)	
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.26	6	-

Thickness of liquefied layers (m)

SLS	1.8
Sep 04	3.7
Jun 13	3.2

Liquefaction FOS

FOS $\geq$ 1.0	Green
FOS $<$ 1.0	Red



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LOCATION

CPT-CBD-13

JOB NUMBER

52000\_301

DATE

7/12/2011

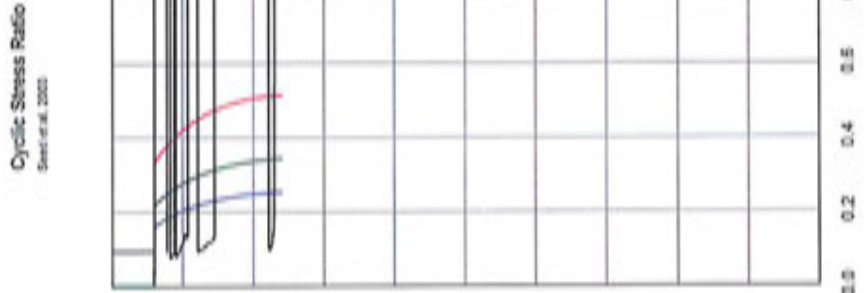
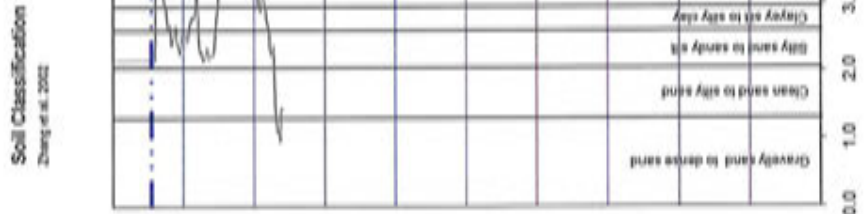
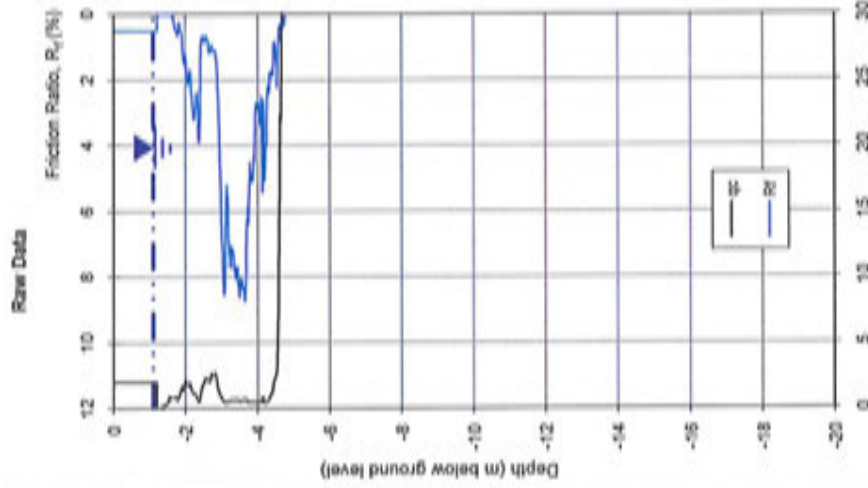
ANALYSED

RAP

CHECKED

AFF

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1:170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

1.1
1.1
1.1

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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LOCATION  
CPT-CBD-14

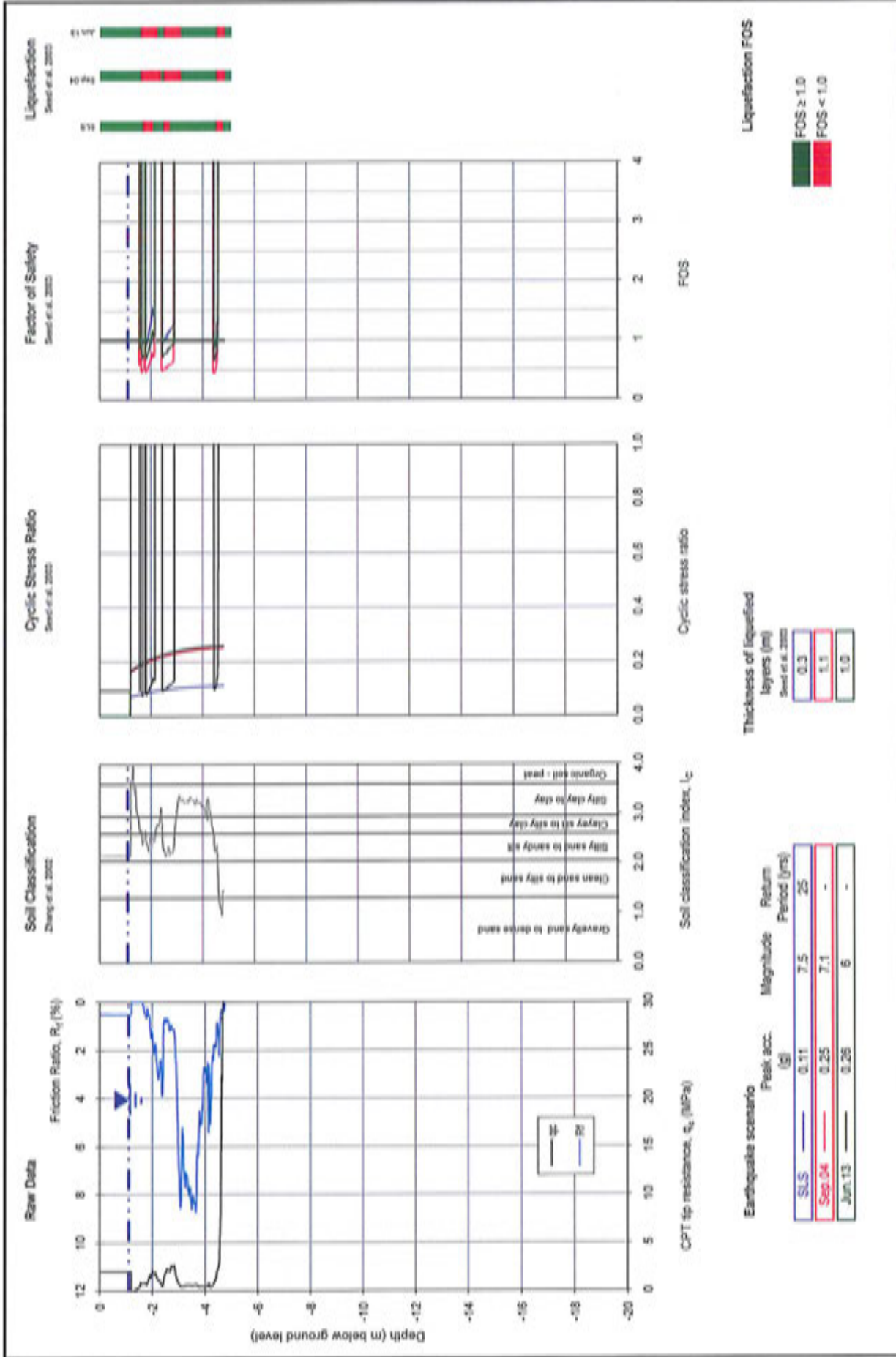
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DATE  
6/12/2011

ANALYSED  
RAP

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AFF

Liquefaction Assessment from CPT Results



Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Exp. 04	0.25	7.1	-
Jun. 13	0.26	6	-

Thickness of liquefied layers (m)

Scenario	Thickness (m)
SLS	0.3
Exp. 04	1.1
Jun. 13	1.0

Liquefaction FOS

Color	FOS Range
Green	FOS $\geq$ 1.0
Red	FOS $<$ 1.0



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Liquefaction Assessment from CPT Results

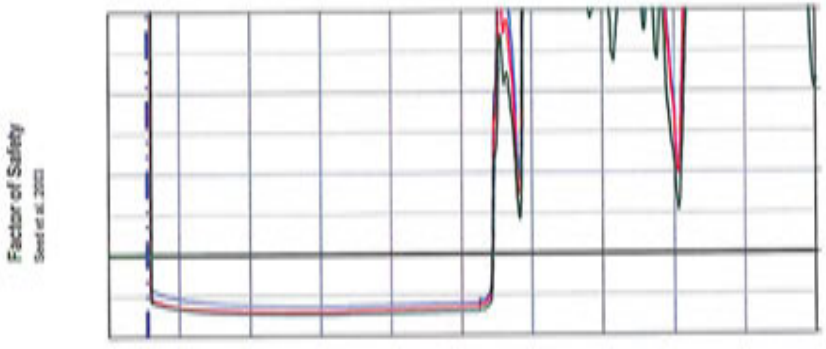
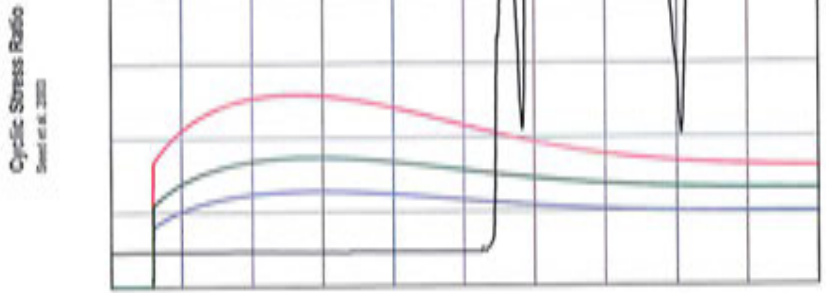
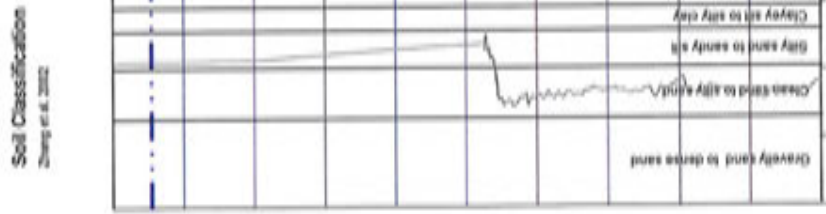
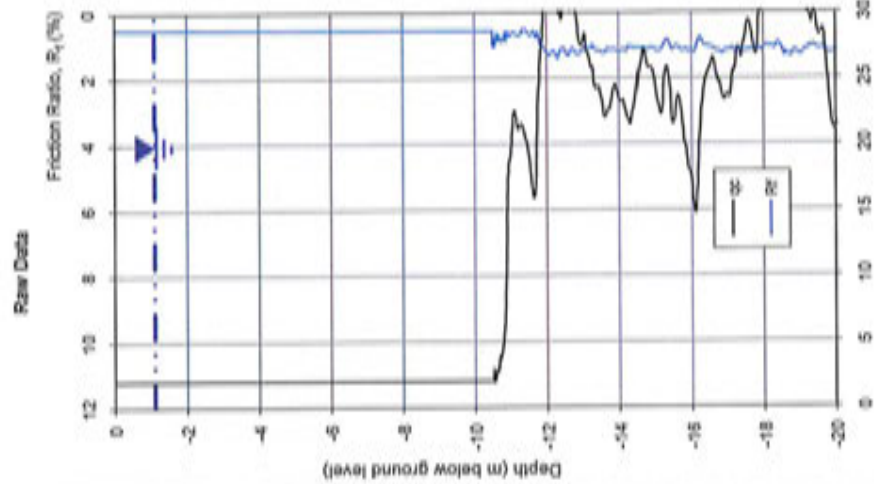
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CHECKED: AFF

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PROJECT NUMBER: 52000.301

**CPT-CBD-14**

DATE: 11/12/2011  
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CHECKED: AFF



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5
Feb 22	0.52	6.2
ULS	0.34	7.5

Thickness of liquefied layers (m)

9.7
9.7
9.8

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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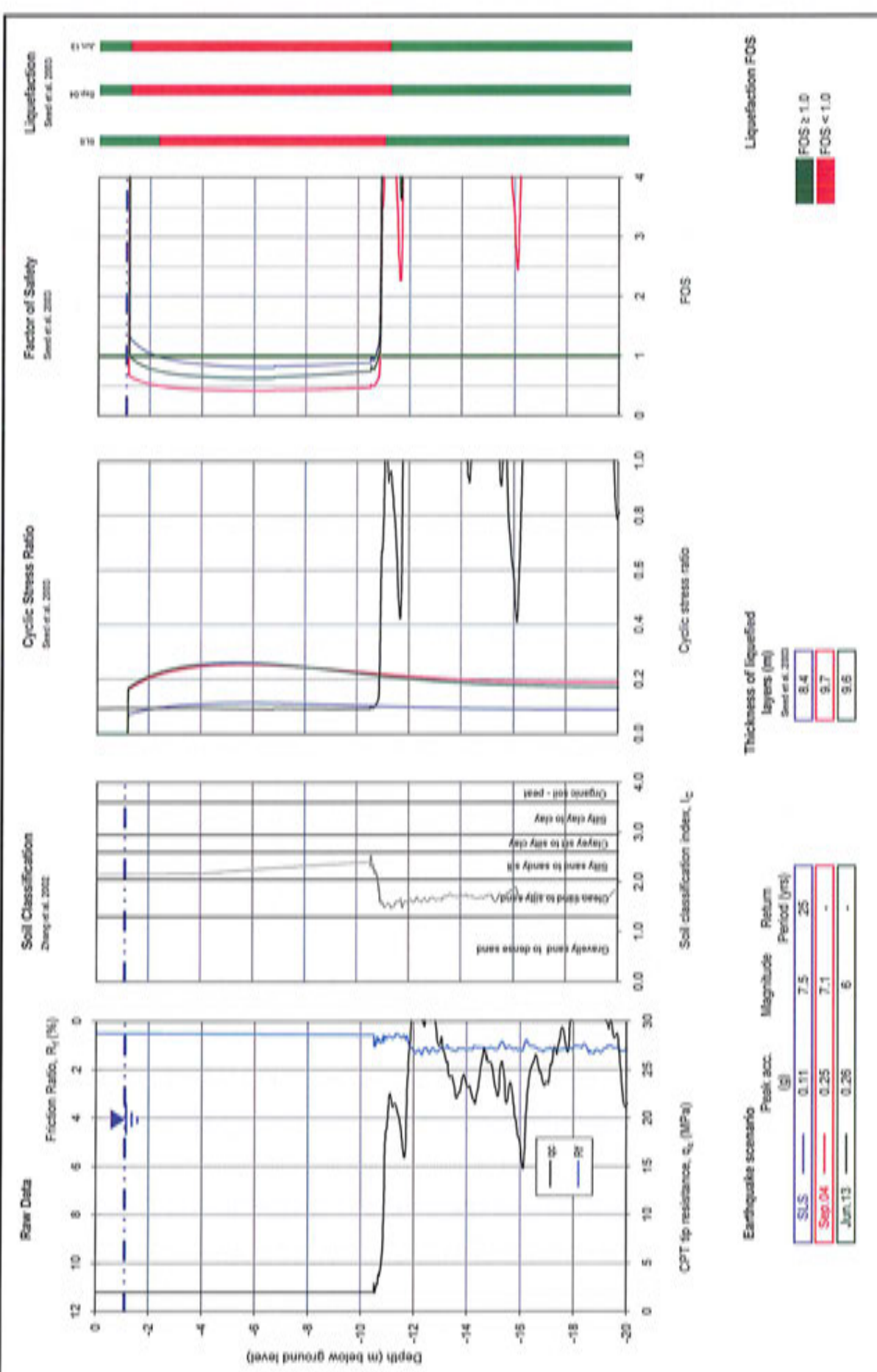
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Geotechnical Assessment for Christchurch Central City

LOCATION: CPT-CBD-14P

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

JOB NUMBER: 52000.301

FILE: Liquefaction Assessment from CPT Results



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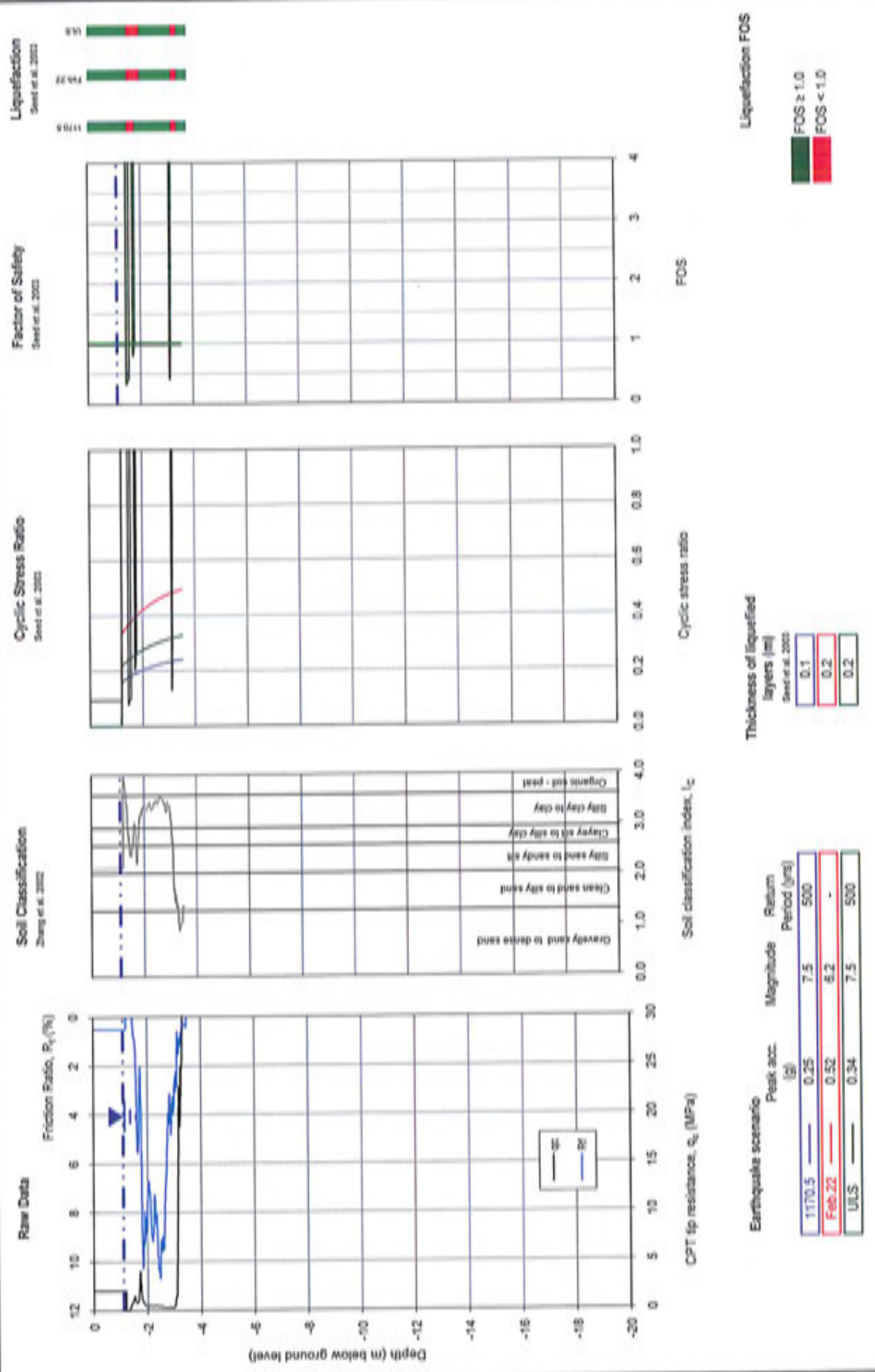
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Geotechnical Assessment for Christchurch Central City

**LOCATION**  
CPT-CBD-14P  
**JOB NUMBER**  
52000\_301

**DATE** 27/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

Liquefaction Assessment from CPT Results





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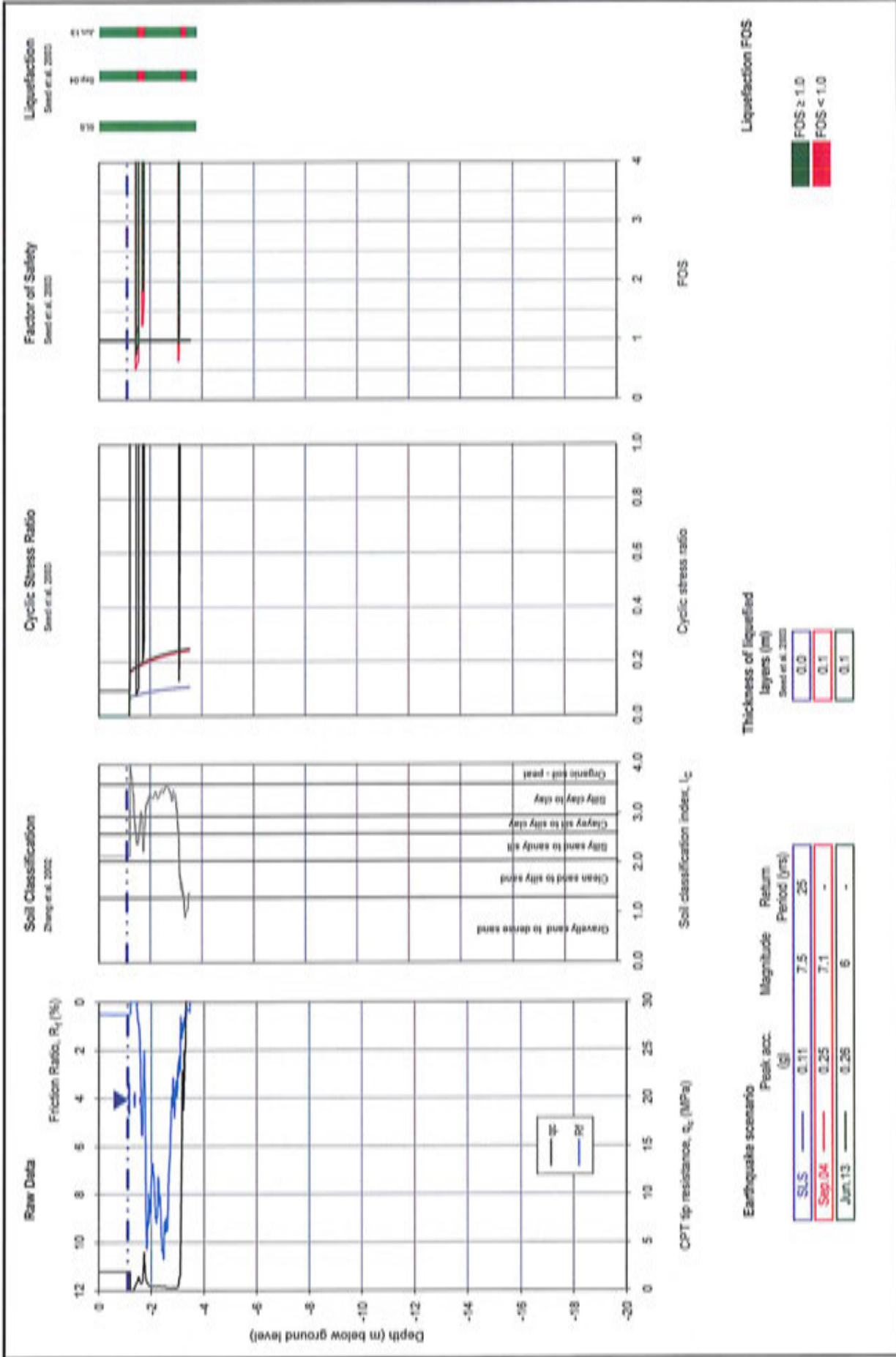
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 Geotechnical Assessment for Christchurch Central City

**PROJECT**  
 CPT-CBD-15

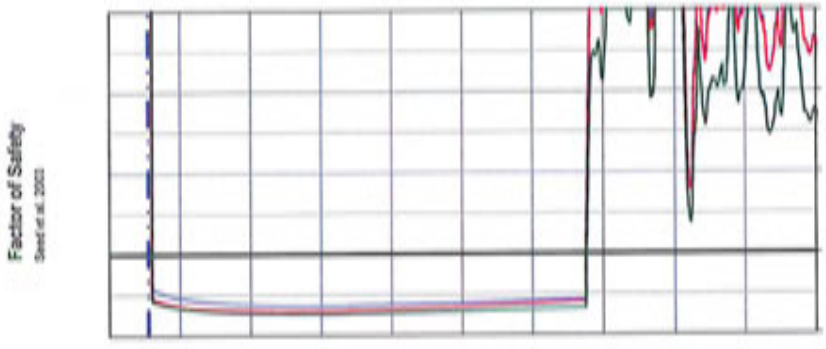
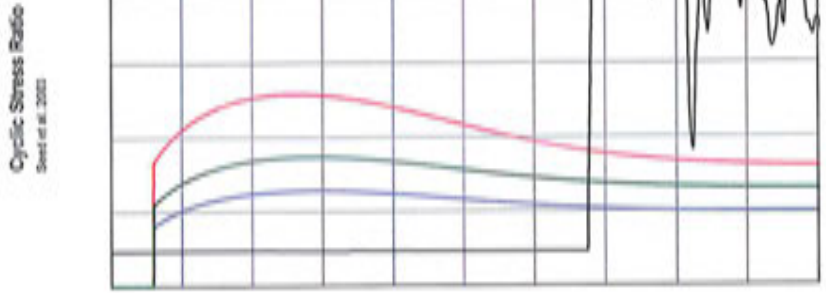
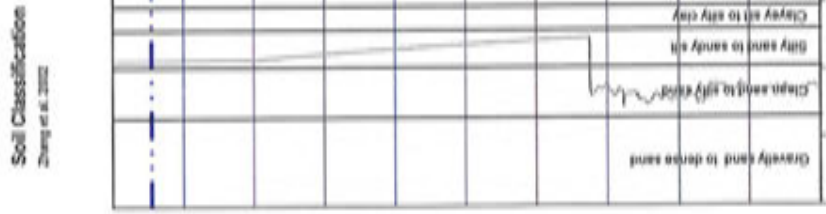
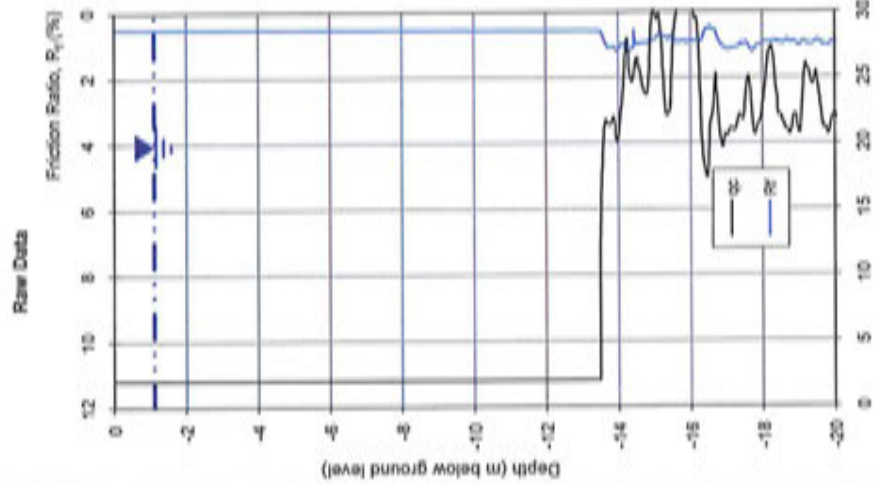
**DATE** 6/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

**JOB NUMBER**  
 52000\_301

**LIQUEFACTION ASSESSMENT FROM CPT RESULTS**



 <p><b>Tonkin &amp; Taylor Ltd</b> Environmental &amp; Engineering Consultants</p>	<p><b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City</p>	<p>DATE: 31/12/2011</p> <p>ANALYSED: RAP</p> <p>CHECKED: AFF</p>
		<p>PROJECT: CPT-CBD-15</p> <p>JOB NUMBER: S2000.301</p>
<p>FILE: Liquefaction Assessment from CPT Results</p>		



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
F60.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

13.1
13.1
13.2

Liquefaction FOS

FOS  $\geq$  1.0  
FOS  $<$  1.0



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CLIENT PROJECT  
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Geotechnical Assessment for Christchurch Central City

LOCATION  
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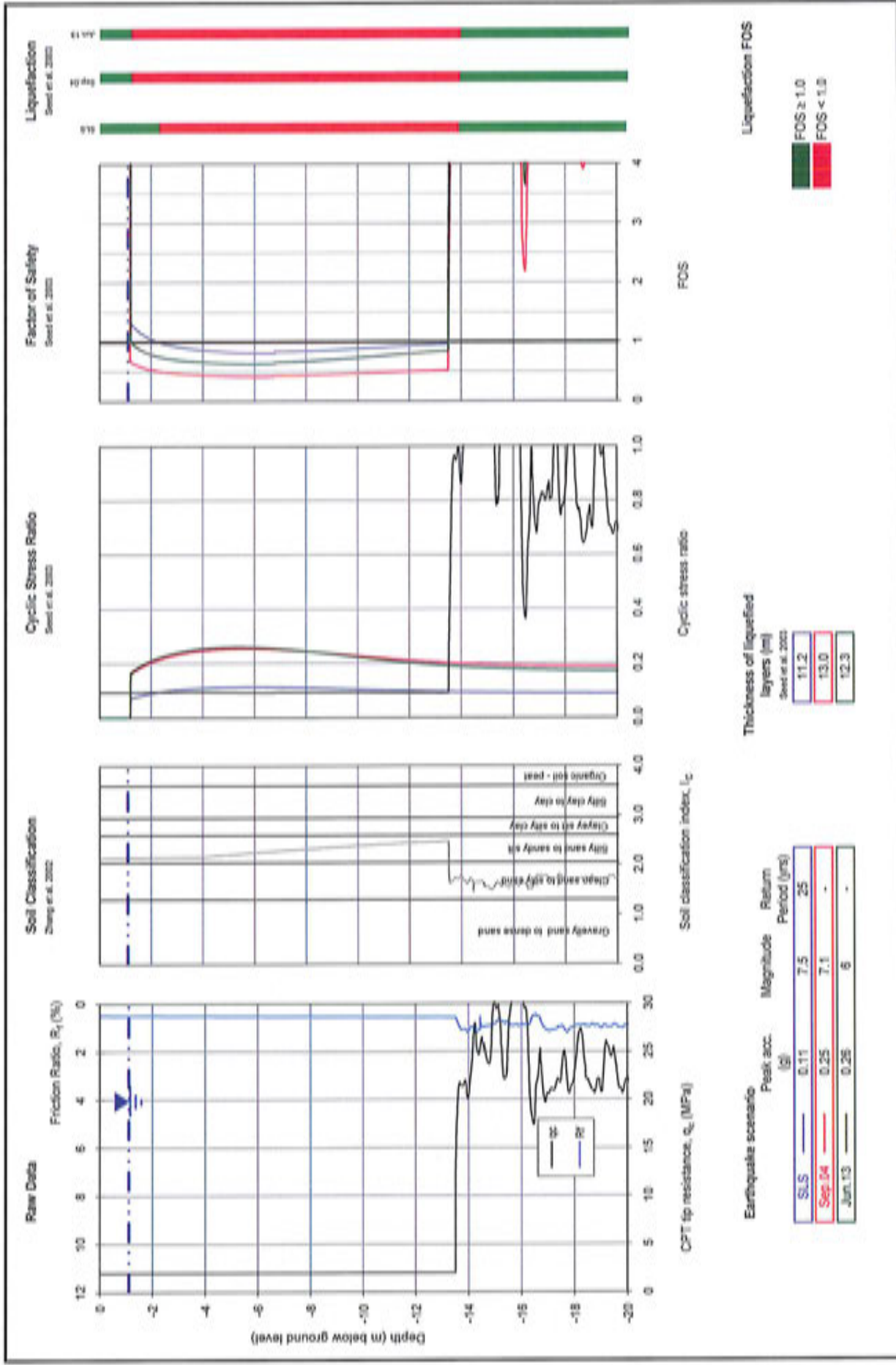
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ANALYSED  
RAP

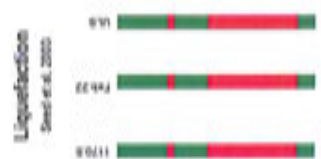
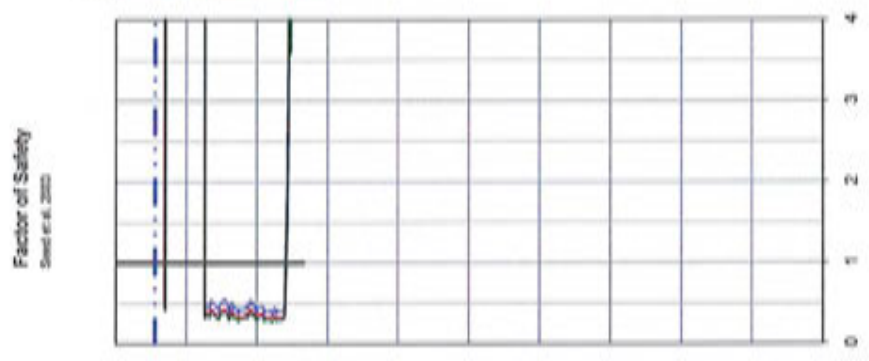
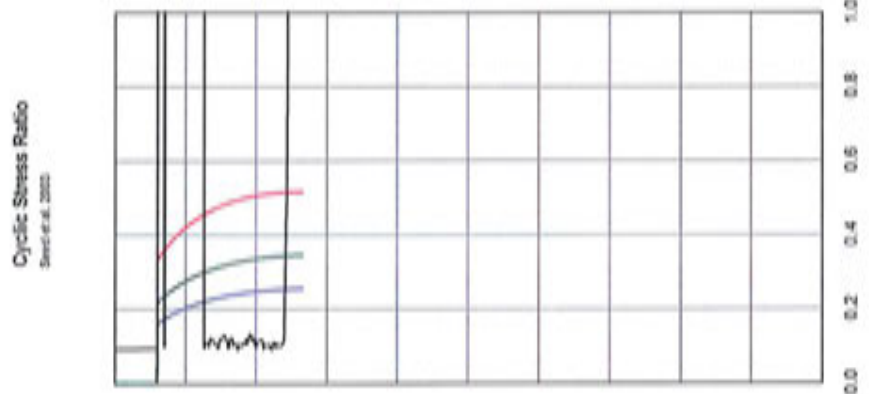
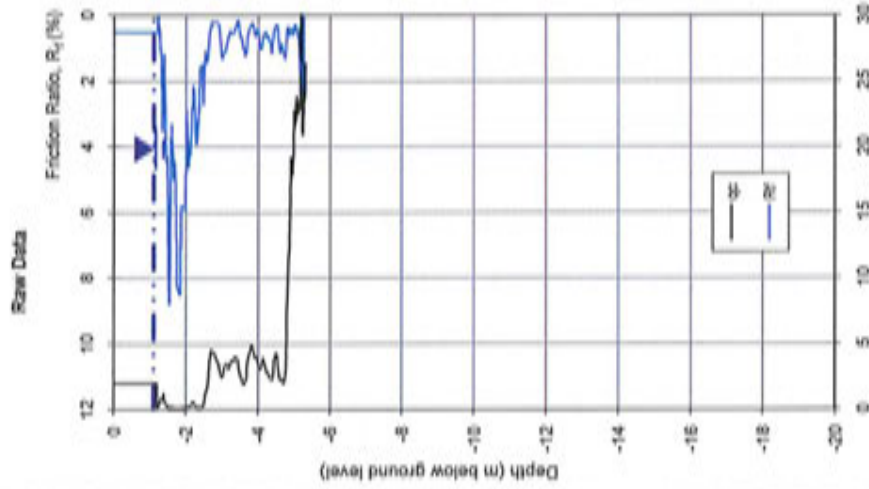
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JOB NUMBER  
S2000.301

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council          Geotechnical Assessment for Christchurch Central City</b>		LOCATION <b>CPT-CBD-15P</b>
	FILE <b>Liquefaction Assessment from CPT Results</b>		JOB NUMBER <b>52000.301</b>
	ANALYSED <b>RAP</b>	CHECKED <b>AFF</b>	DATE <b>7/12/2011</b>



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

2.3
2.3
2.3



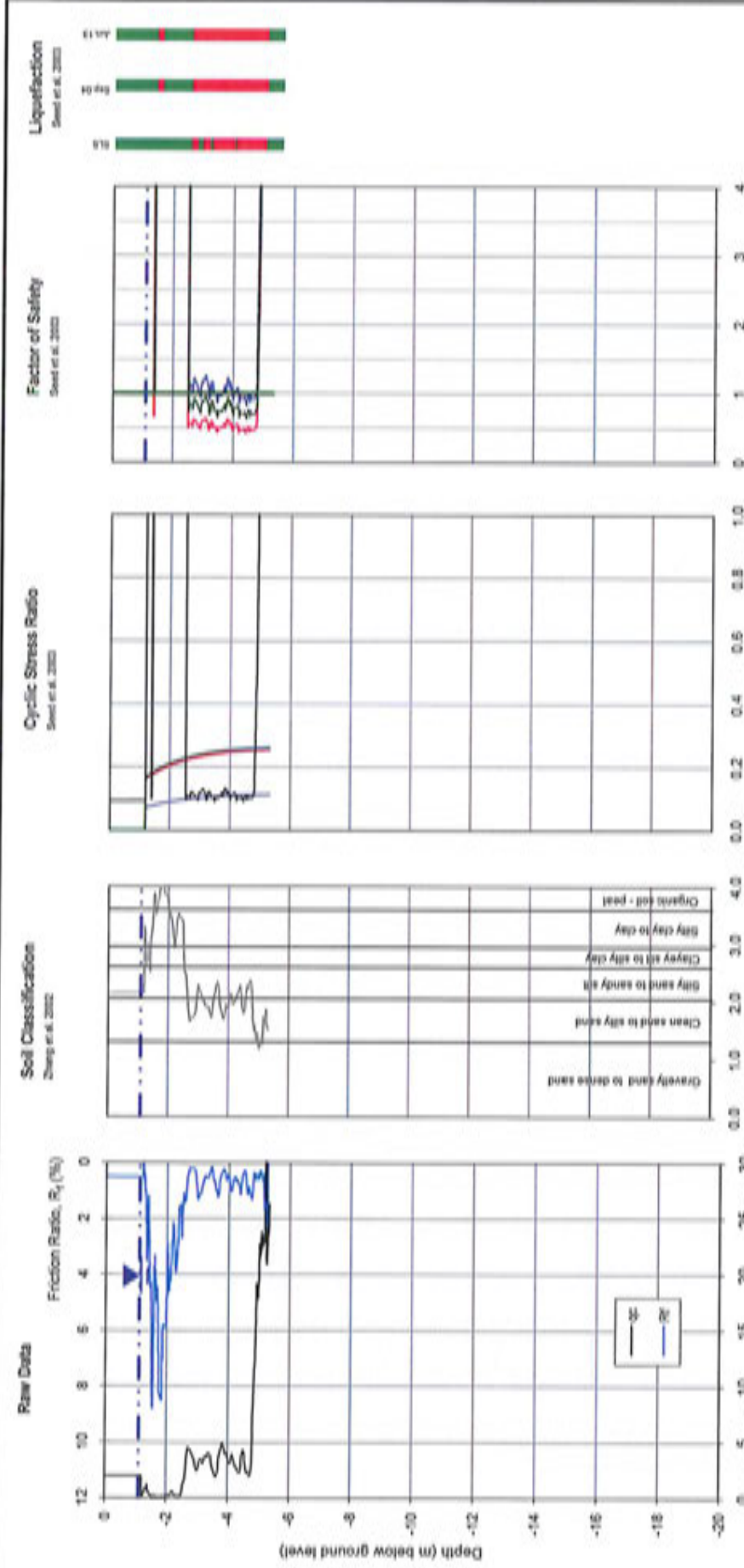
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Geotechnical Assessment for Christchurch Central City

LOCATION  
**CPT-CBD-16**  
JOB NUMBER  
52000.16/1

DATE  
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RAP  
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AFF

Liquefaction Assessment from CPT Results



**Earthquake scenario**


Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.25	6	-

**Thickness of liquefied layers (m)**  
Seed et al. 2002

1.0
2.3
2.3

**Liquefaction FOS**

FOS $\geq 1.0$
FOS $< 1.0$



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**CLIENT PROJECT**

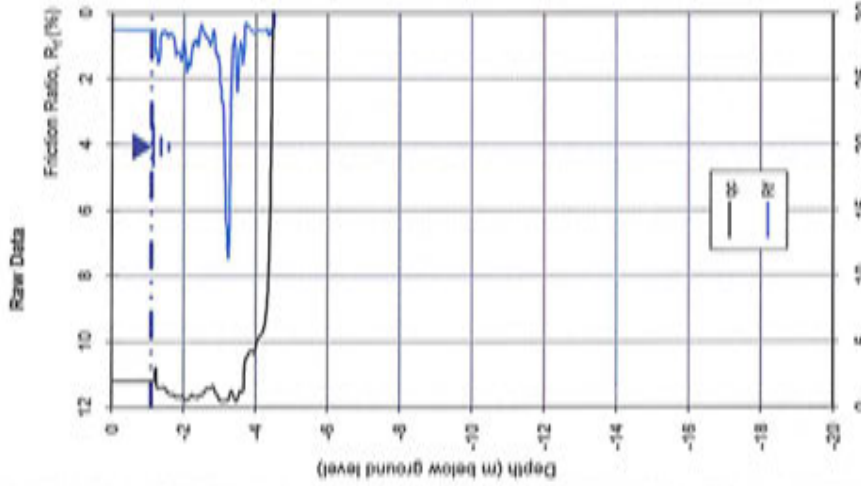
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CPT-CBD-16

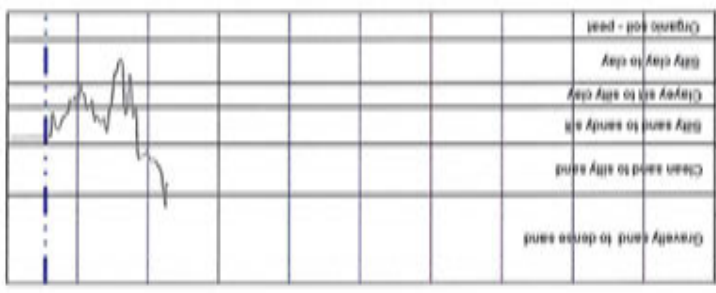
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**JOB NUMBER** 52000.301

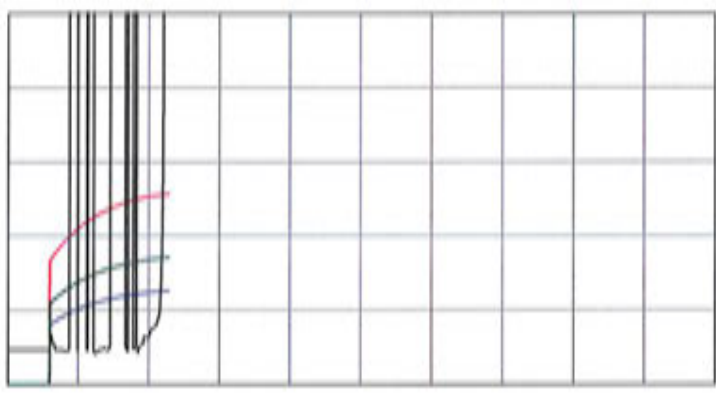
**Liquefaction Assessment from CPT Res ults**



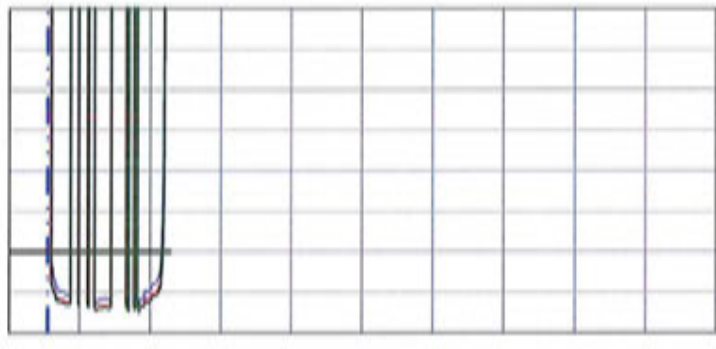
Soil Classification  
Zhang et al. 2002



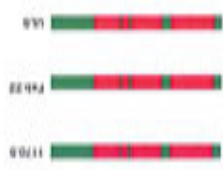
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $t_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1:170.5	7.5	500
Feb. 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

1.9
2.0
2.0

Liquefaction FOS



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-17

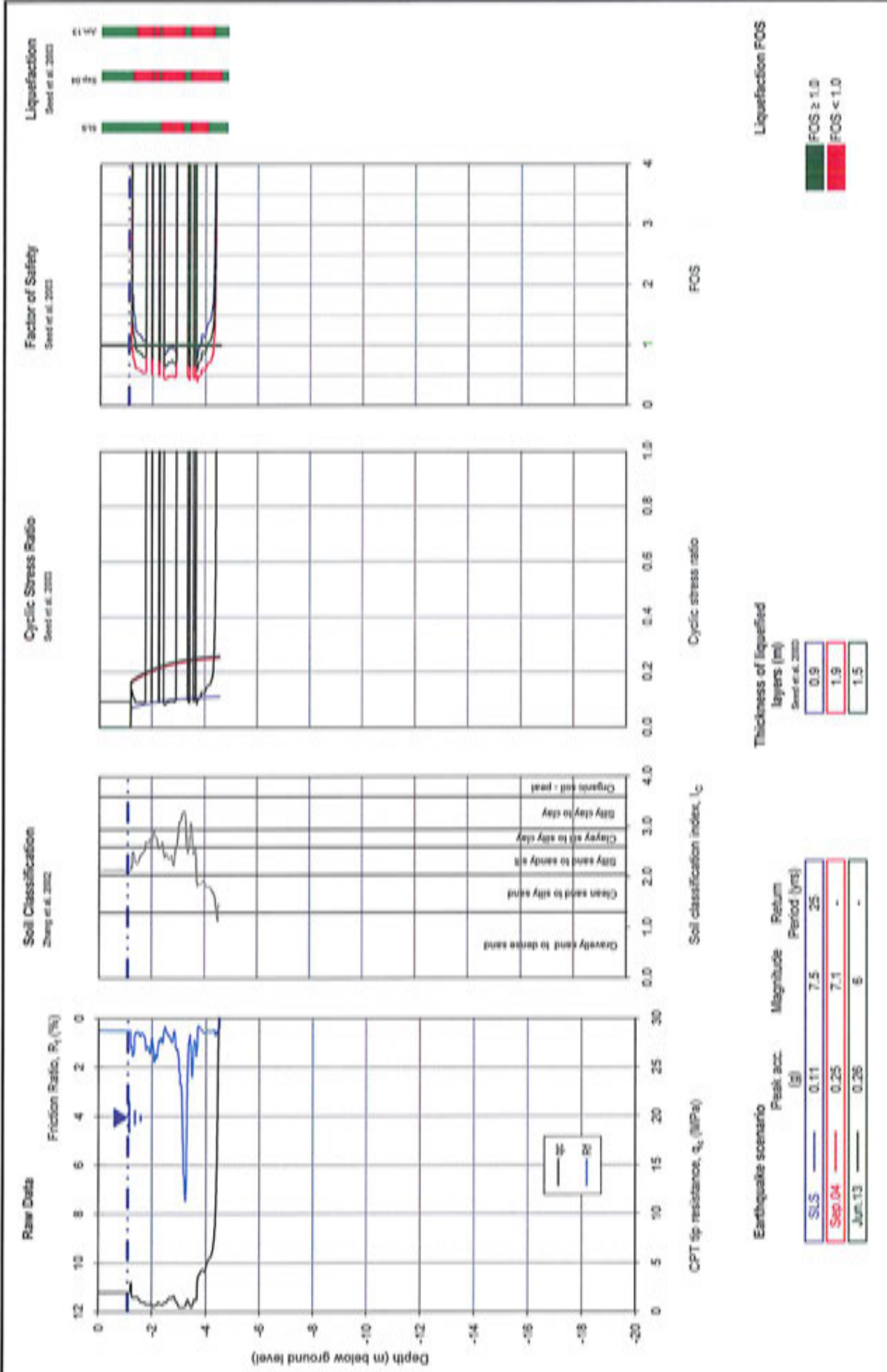
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Liquefaction Assessment from CPT Results

JOB NUMBER

52000\_301

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF



**Tonkin & Taylor Ltd**  
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CLIENT REFERENCE

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

**CPT-CBD-17**

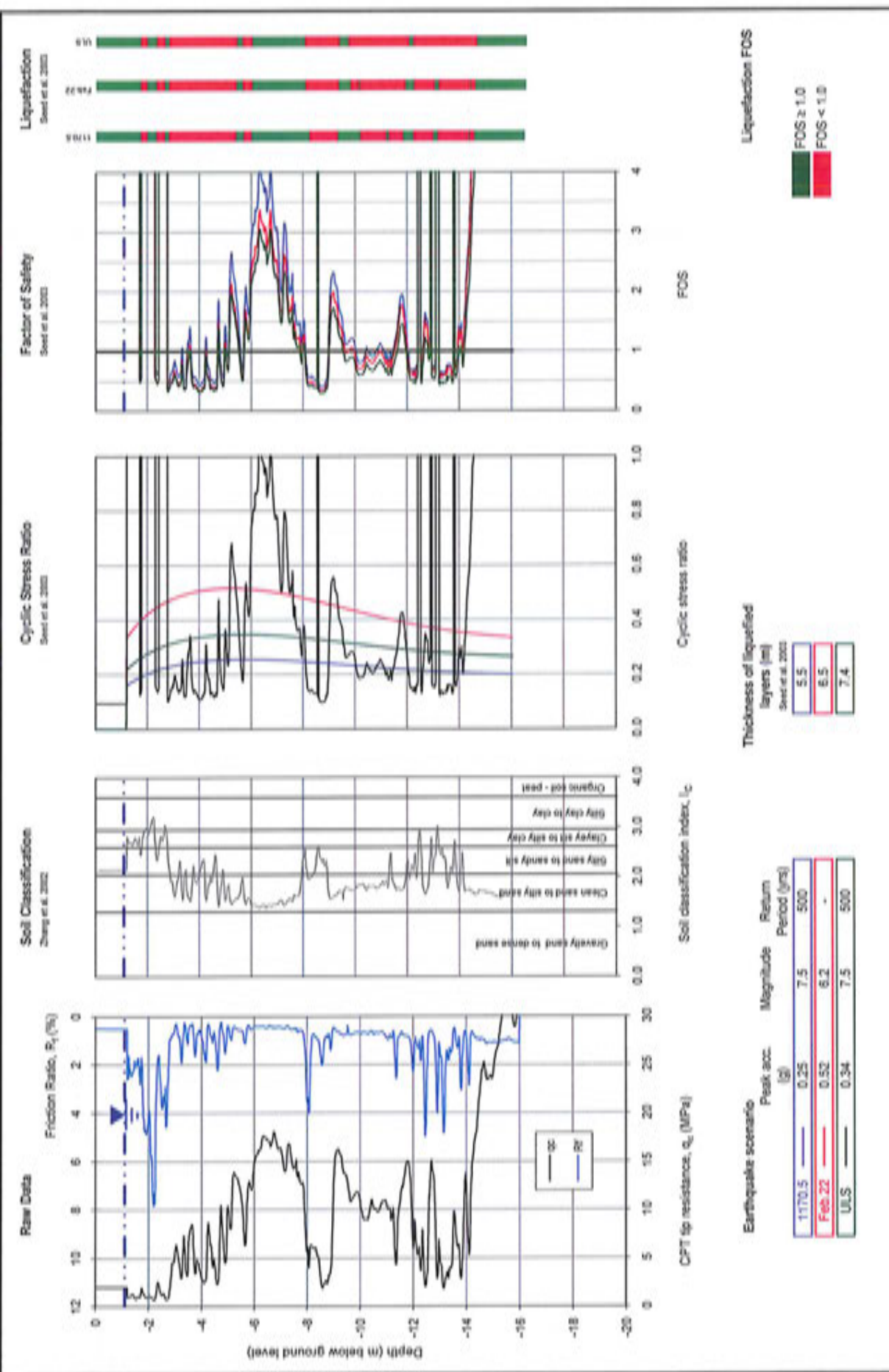
JOB NUMBER


52000.001

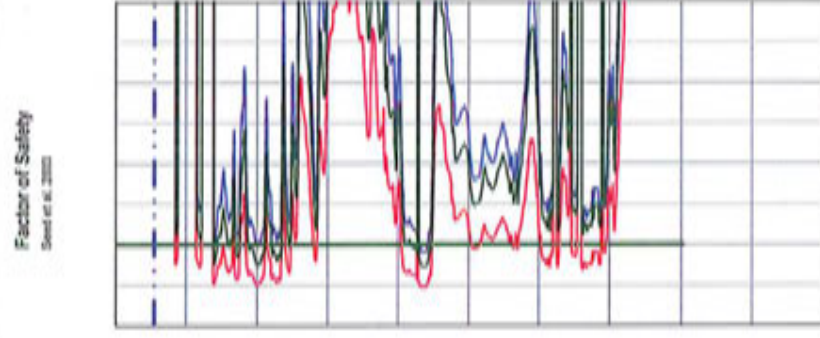
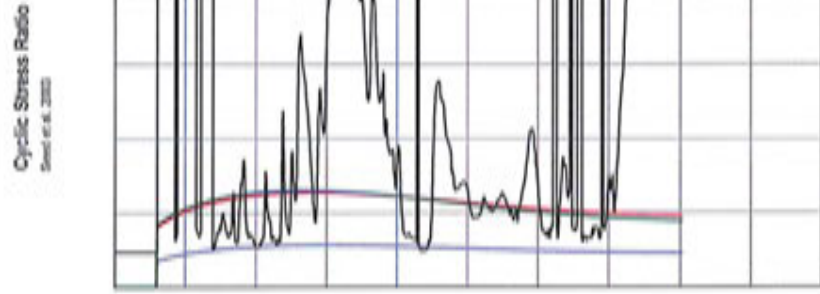
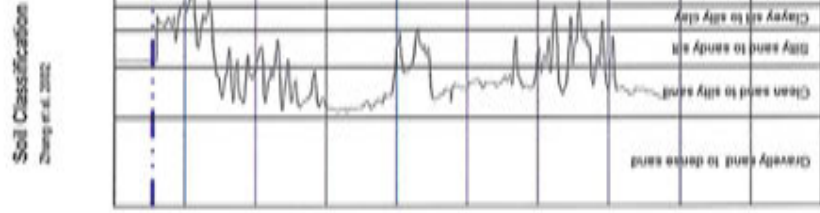
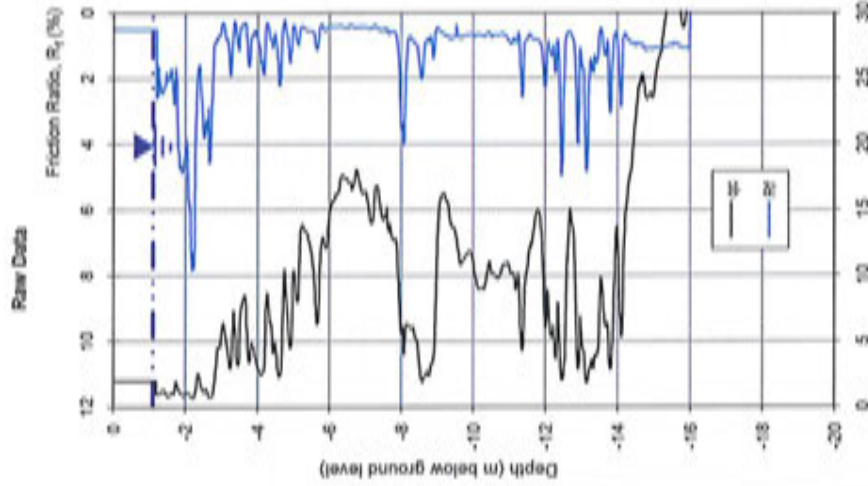
DATE 7/12/2011  
ANNULSED RAP  
CHECKED AFF

Liquefaction Assessment from CPT Results





 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT REQUEST <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-18</b>	DATE 6/12/2011
	TITLE Liquefaction Assessment from CPT Results	JOB NUMBER 52000.381	ANALYSED RAP
			CHECKED AFF



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
0.11	7.5	25
0.25	7.1	-
0.26	6	-

Thickness of liquefied layers (m)

0.3
4.4
1.5

Liquefaction FOS

FOS > 1.0
FOS < 1.0



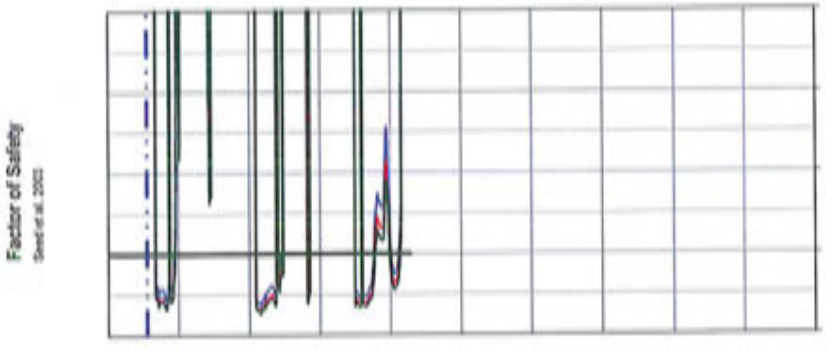
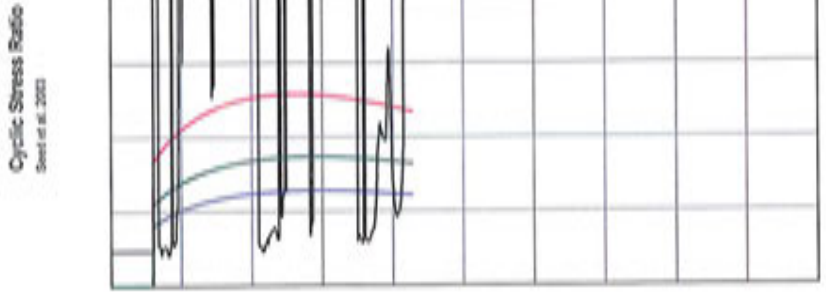
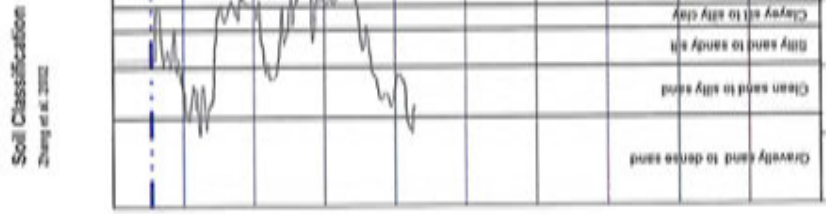
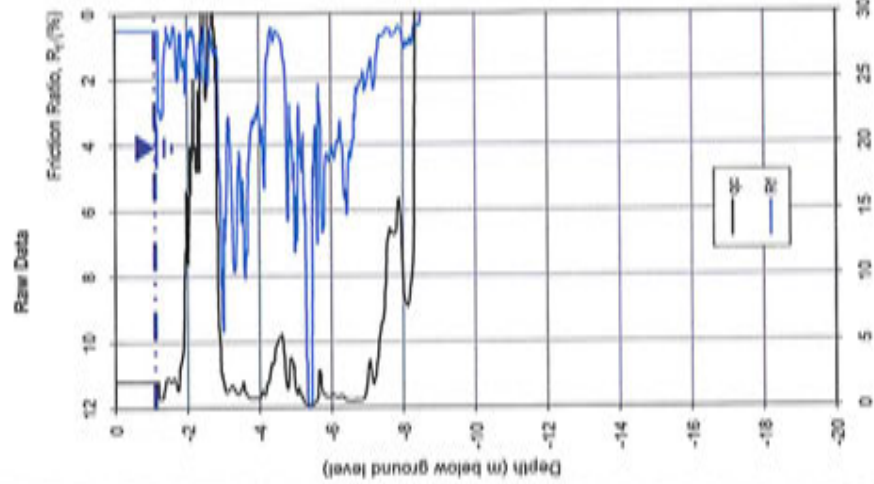
Tonkin & Taylor Ltd  
Environmental &  
Engineering Consultants

CLIENT PROJECT  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION  
CPT-CBD-18

DATE 7/12/2011  
ANALYSED RAP  
CHECKED AFF  
JOB NUMBER 52000\_301

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5
Feb 22	0.52	6.2
ULS	0.34	7.5

Thickness of liquefied layers (m)

Thickness (m)
2.0
2.1
2.2

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



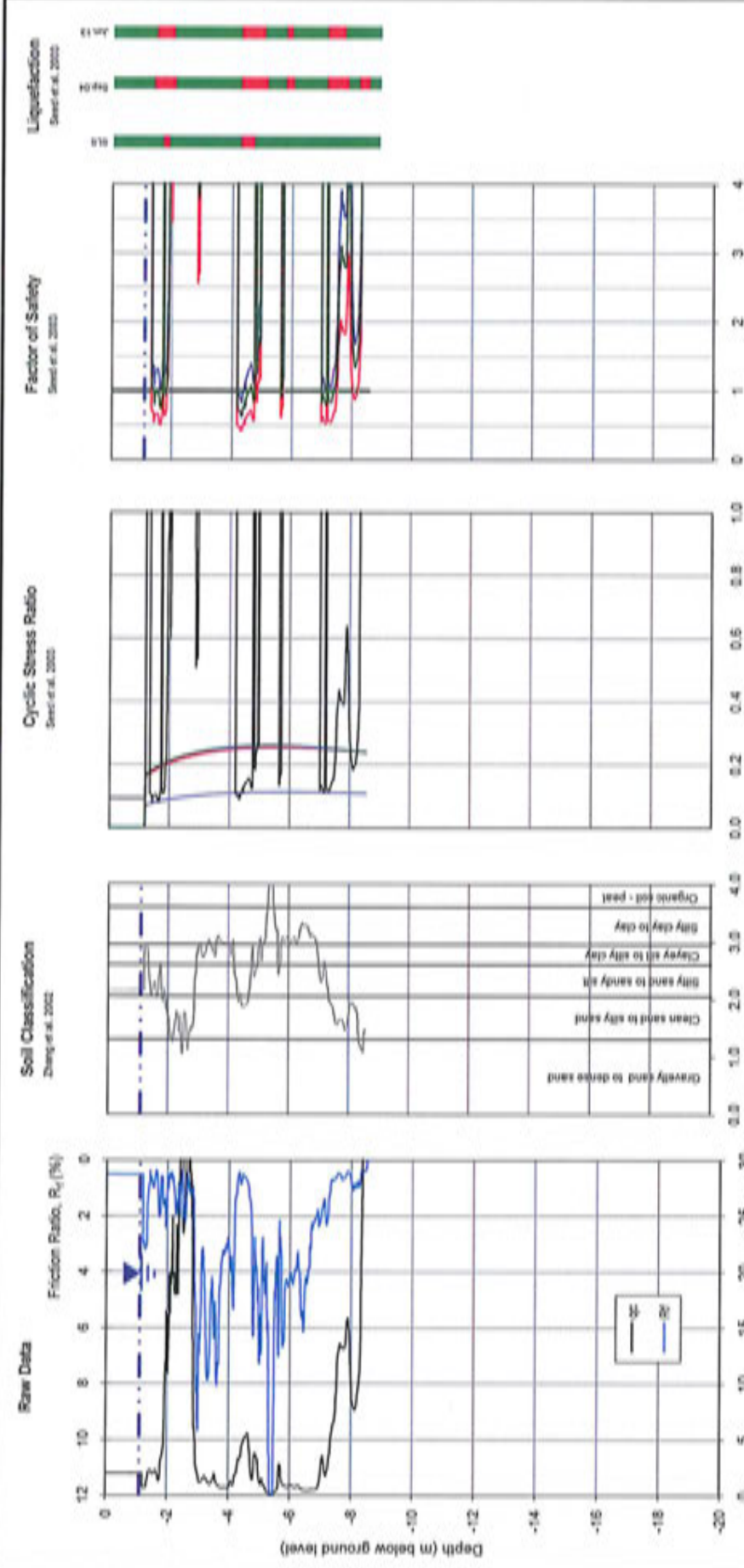
**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT: CPT-CBD-19  
JOB NUMBER: 52000\_301

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

**Earthquake scenario**

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 34	0.25	7.1	-
Jun 13	0.25	6	-

**Thickness of liquefied layers (m)**  
Seed et al. 2002

0.2
1.8
1.2

**Liquefaction FOS**

FOS $\geq$ 1.0
FOS $<$ 1.0



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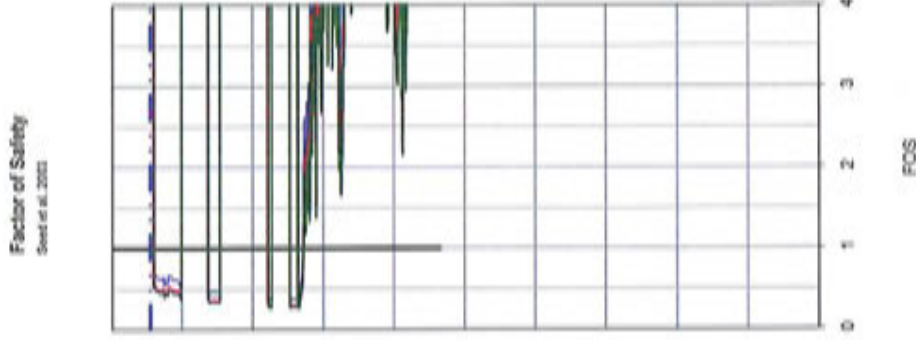
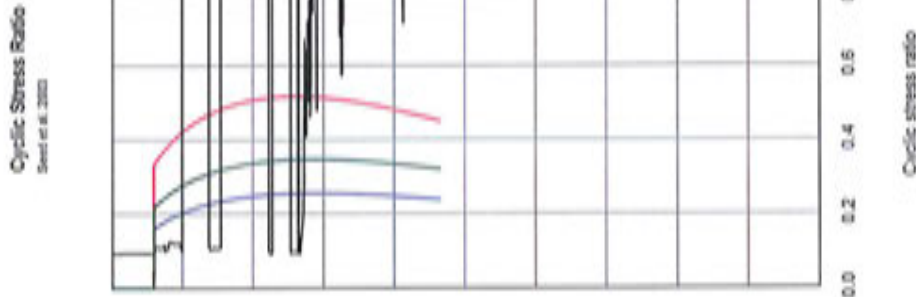
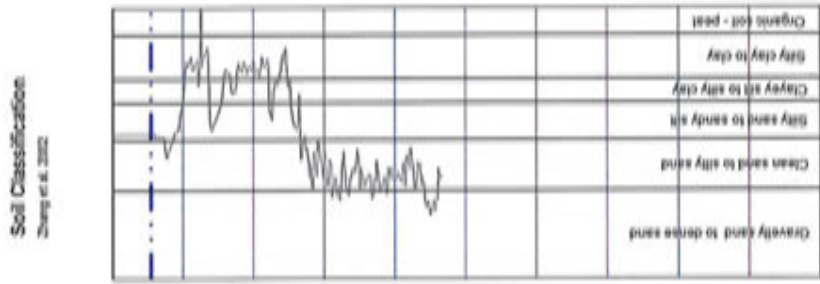
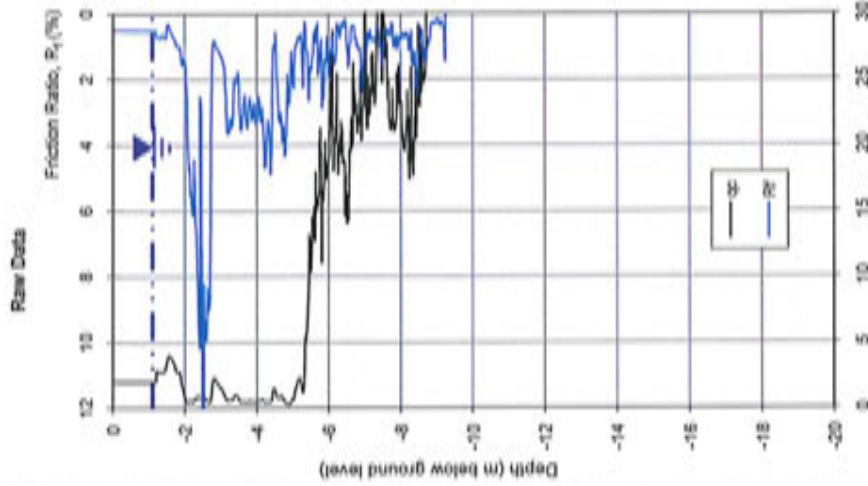
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**PROJECT**  
CPT-CBD-19

**FILE**  
52000\_301

**DATE** 31/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
**RAP** AFF

**Liquefaction Assessment from CPT Results**



CPT sp resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

1.6
1.6
1.6

Liquefaction FOS



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Geotechnical Assessment for Christchurch Central City

PROJECT NUMBER  
CPT-CBD-20

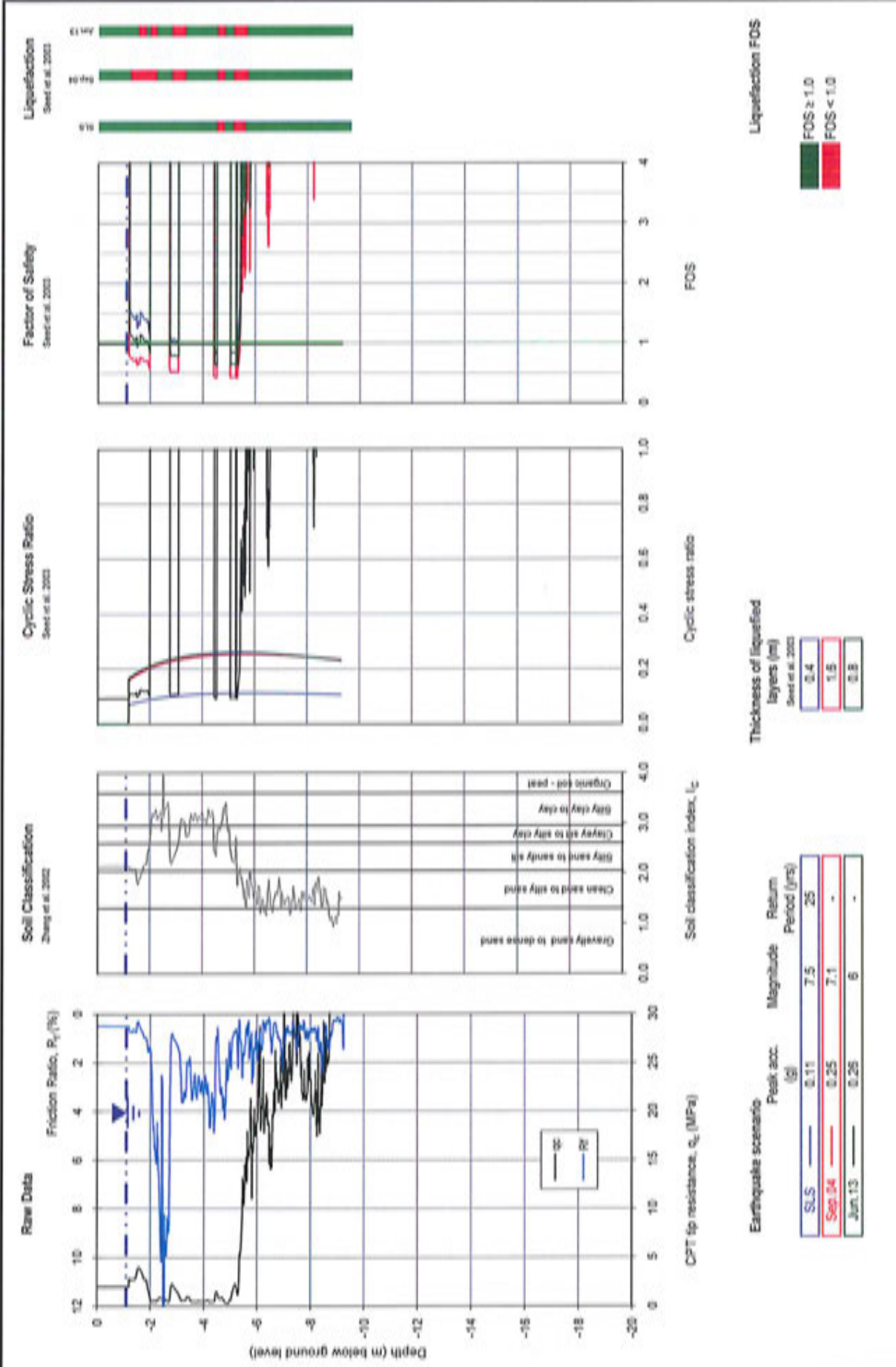
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DATE  
6/12/2011

ANALYSED  
RAP

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AFF

Liquefaction Assessment from CPT Results



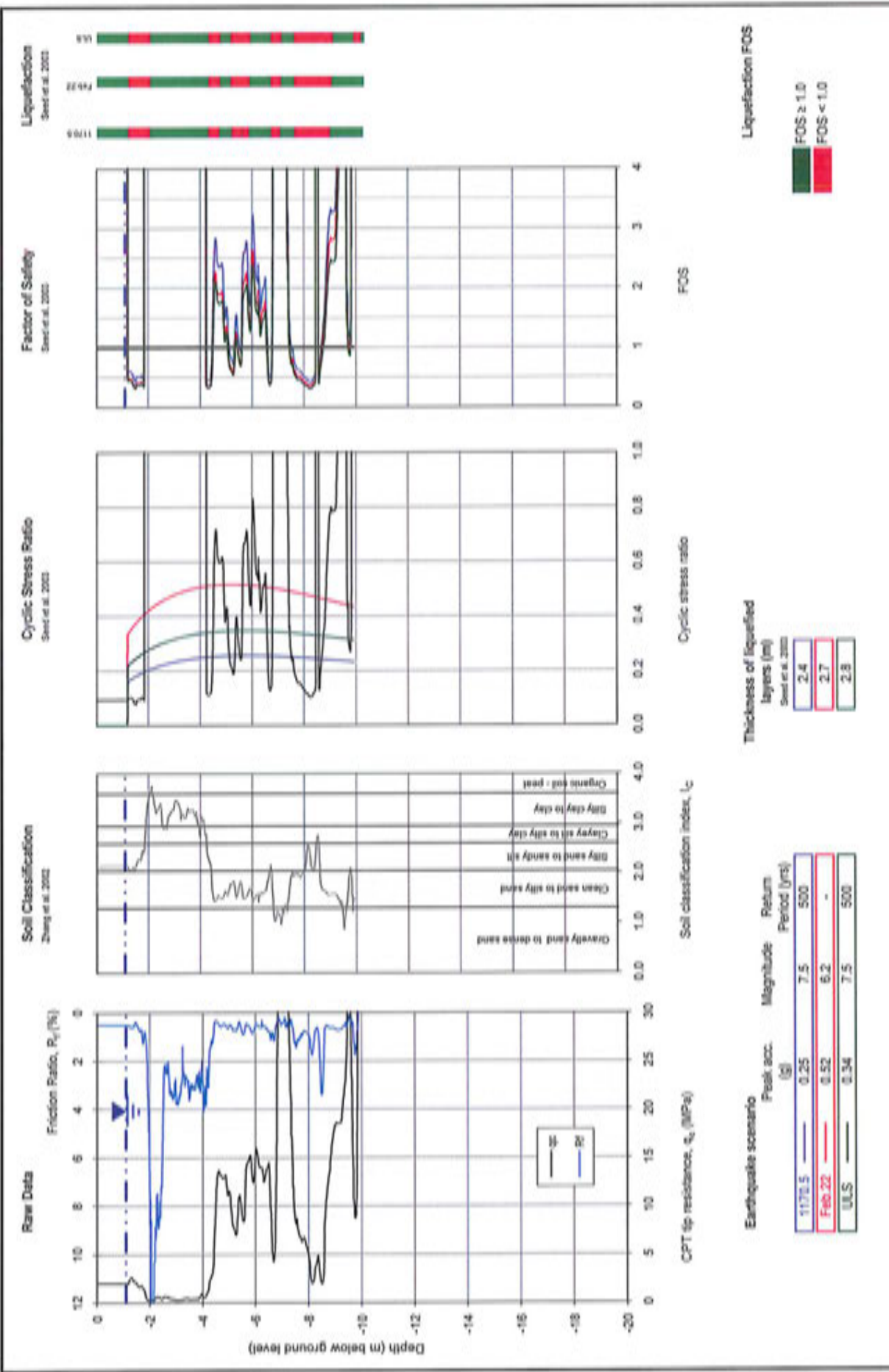
**Tonkin & Taylor Ltd**  
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**CLIENT PROJECT**  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

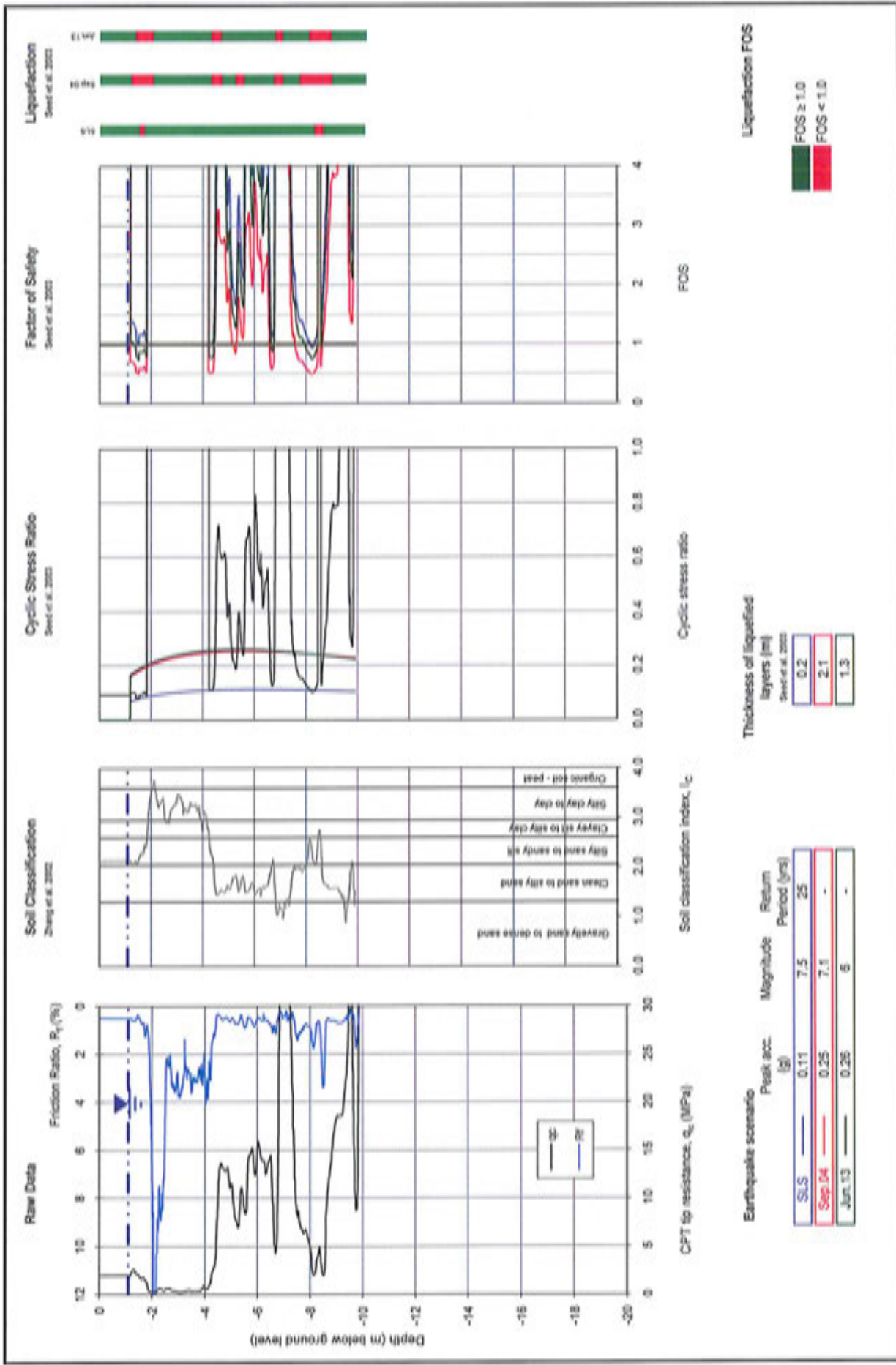
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Liquefaction Assessment from CPT Results

**JOB NUMBER**  
52000\_301

**DATE** 7/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
**DATE** 7/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

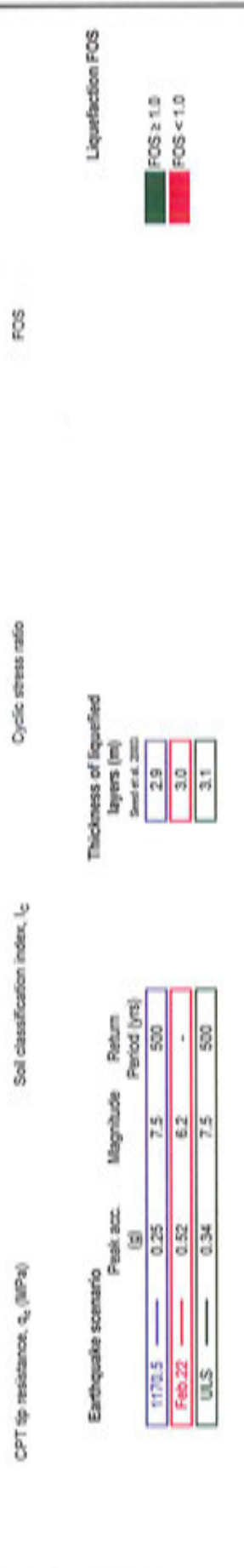
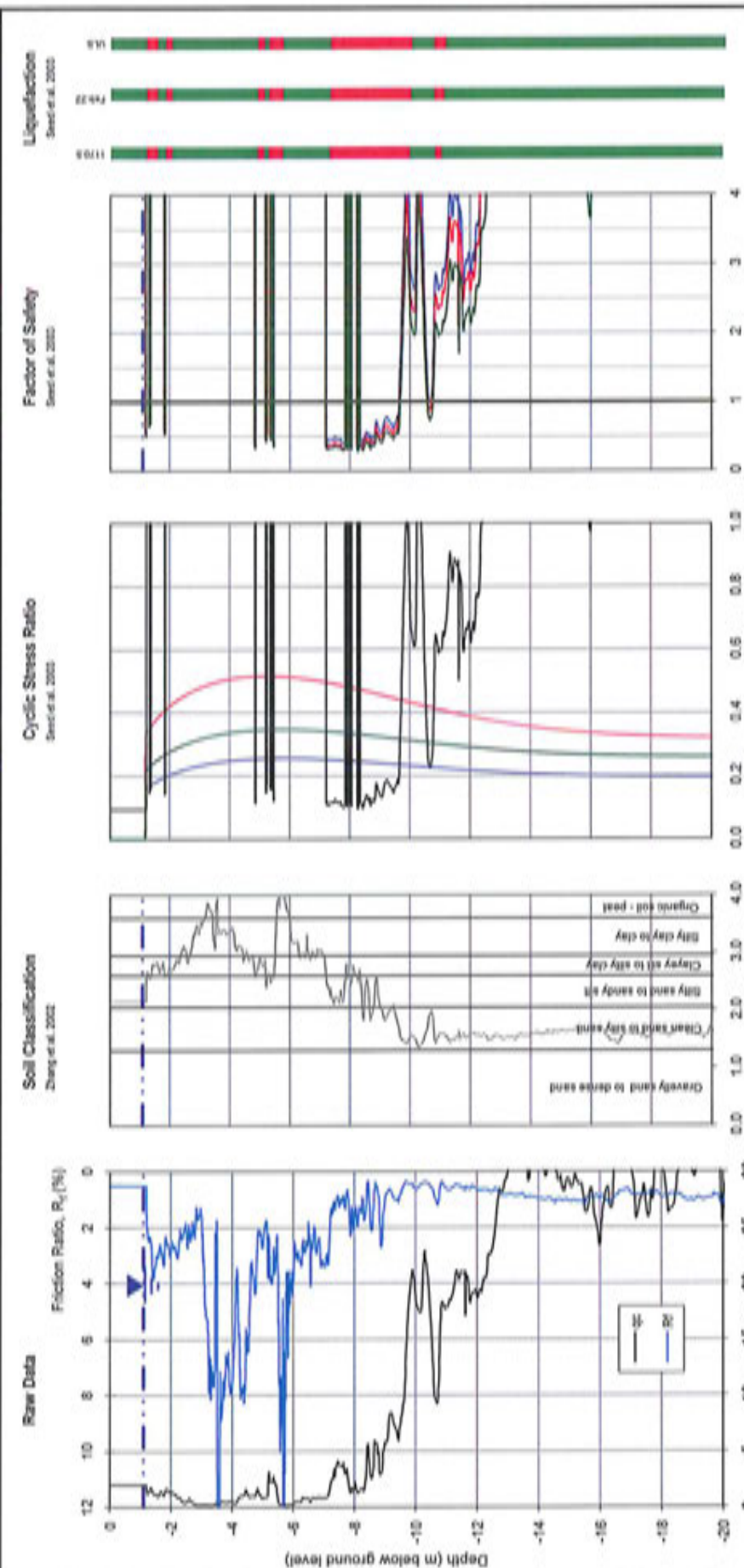


 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE 6/12/2011
	Liquefaction Assessment from CPT Results		ANALYSED RAP
PROJECT NUMBER 52000_301		JOB NUMBER CPT-CBD-21	CHECKED AFF



 Tonkin & Taylor Ltd Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-21</b>	DATE 7/12/2011
	FILED Liquefaction Assessment from CPT Results	JOB NUMBER S2000.301	ANALYSED RAP
			CHECKED AFF







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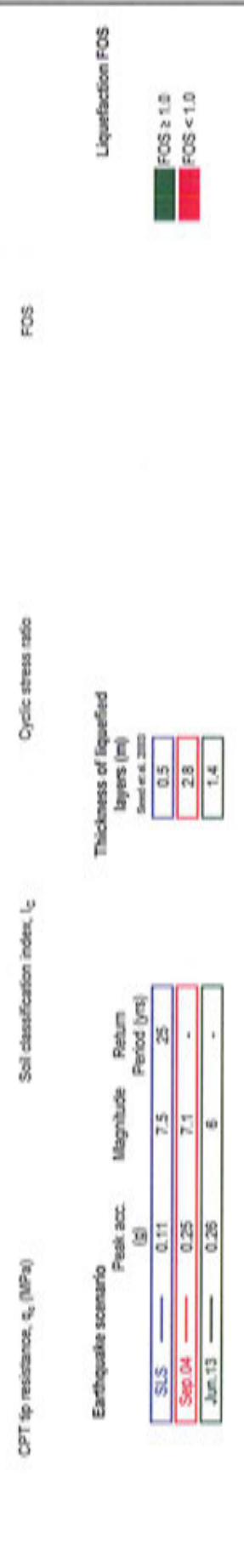
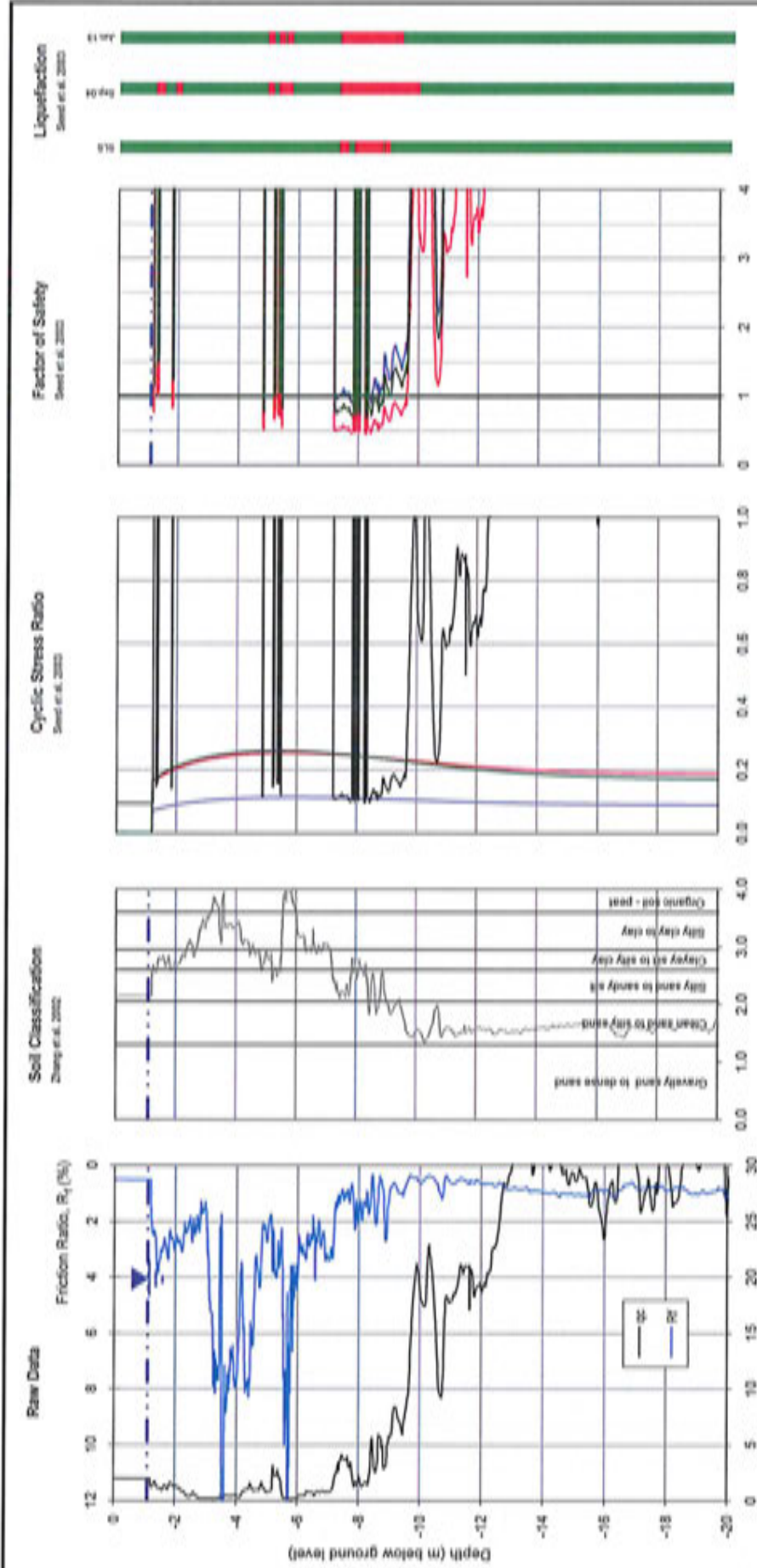
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

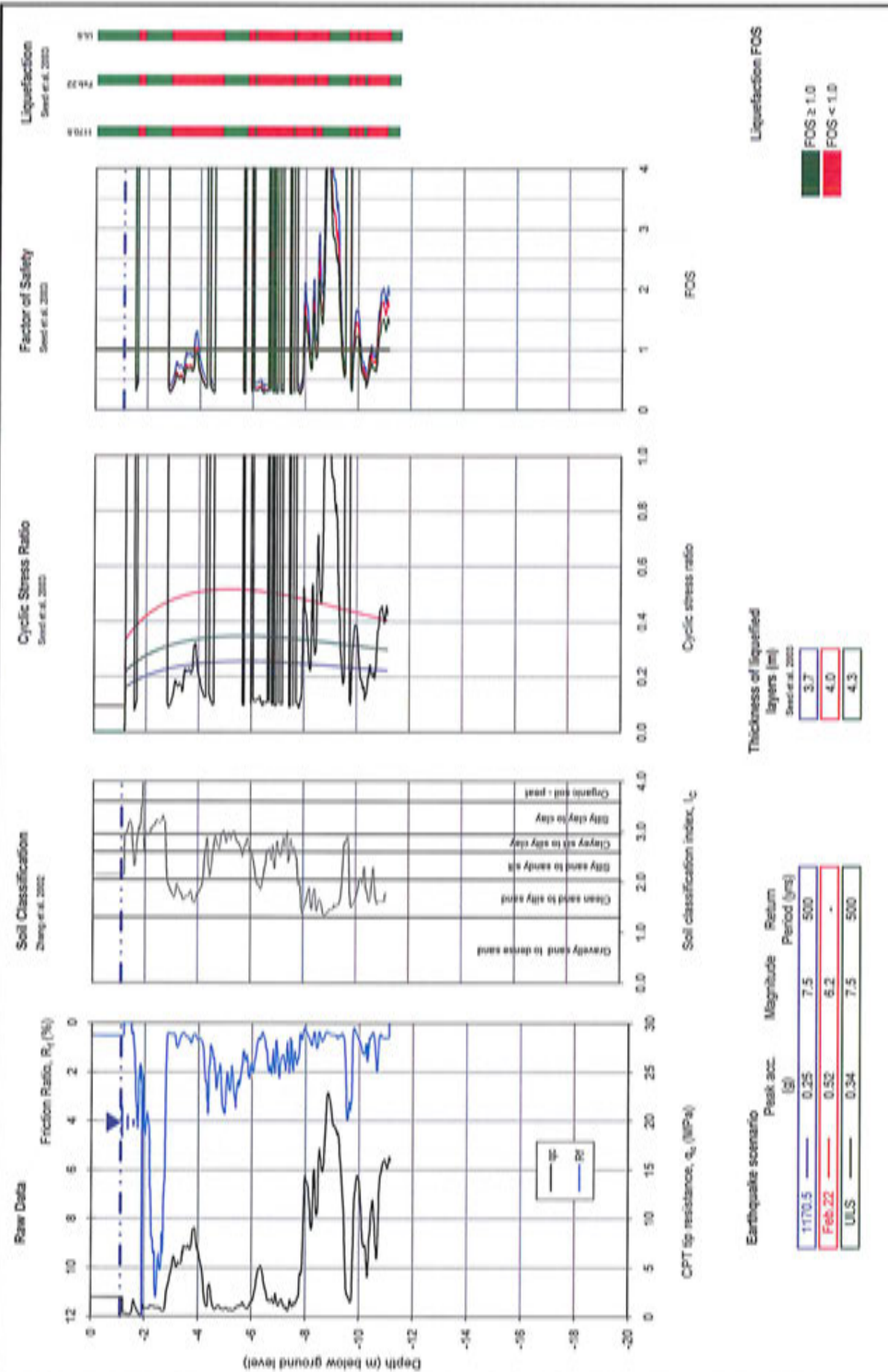
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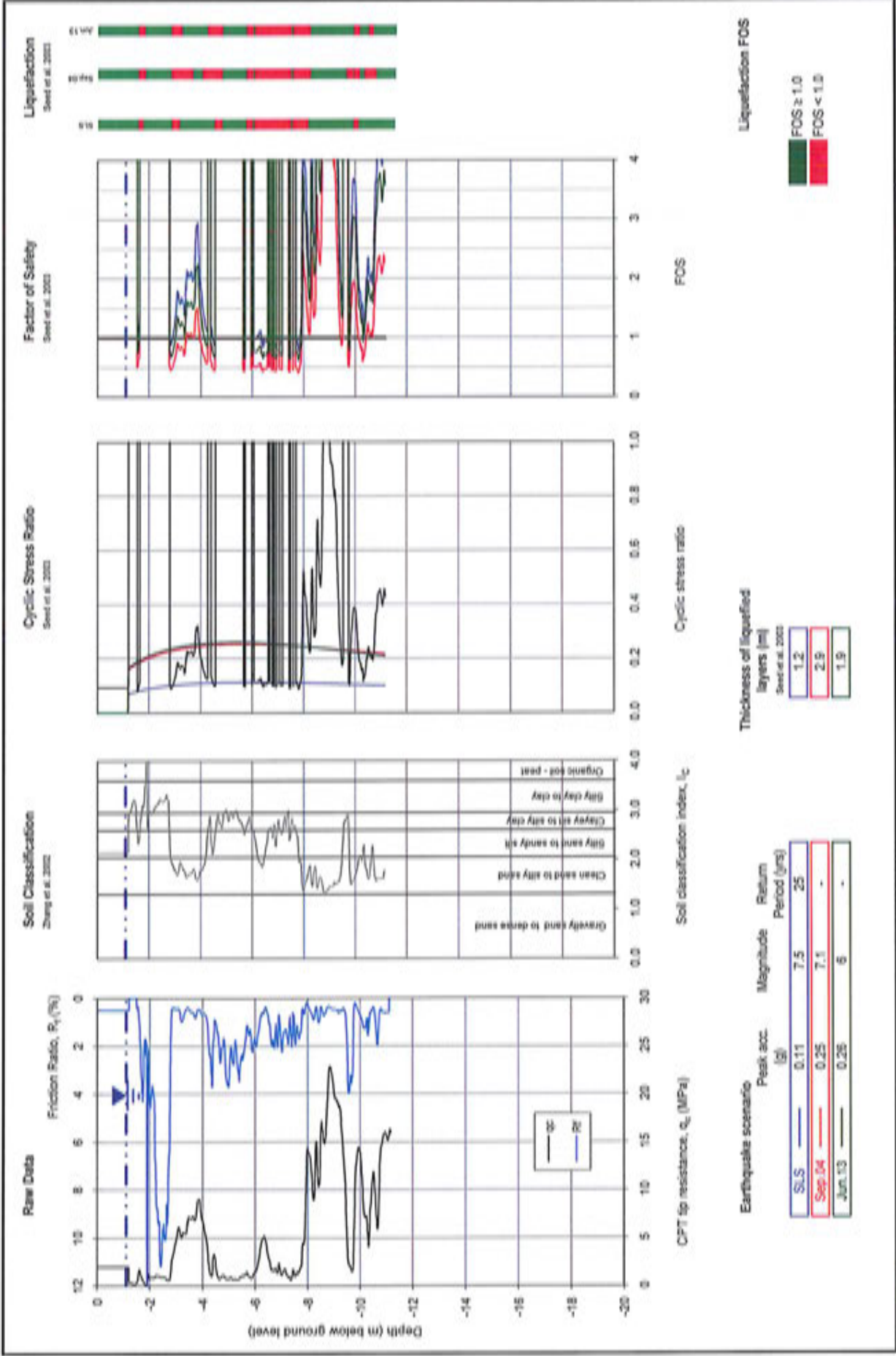
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JOB NUMBER: 52000\_301

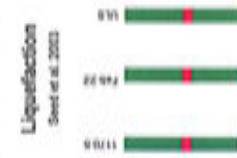
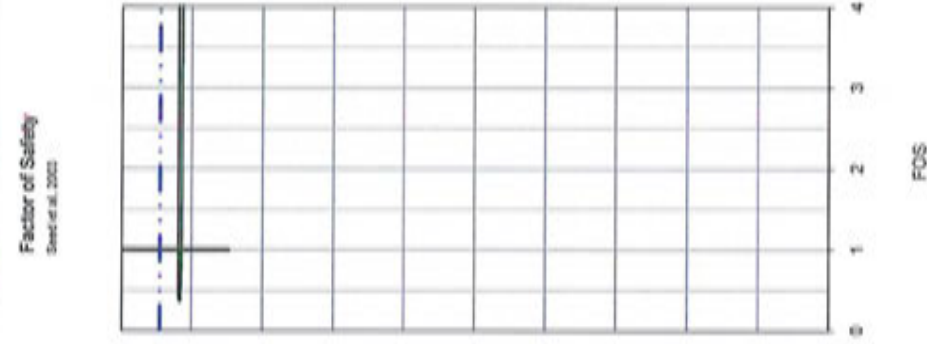
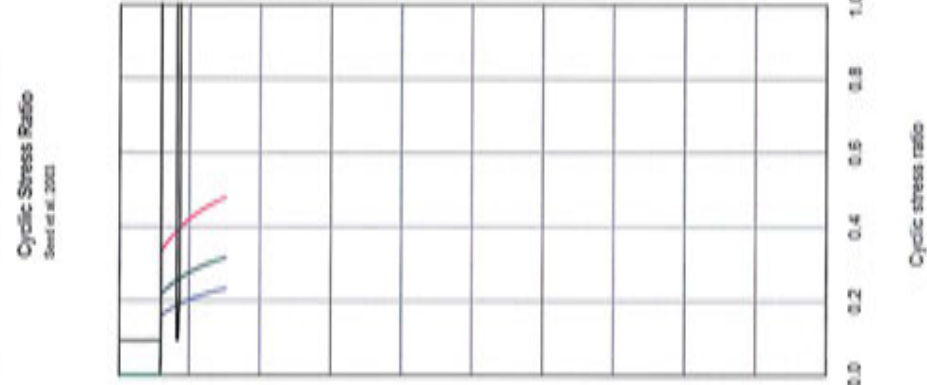
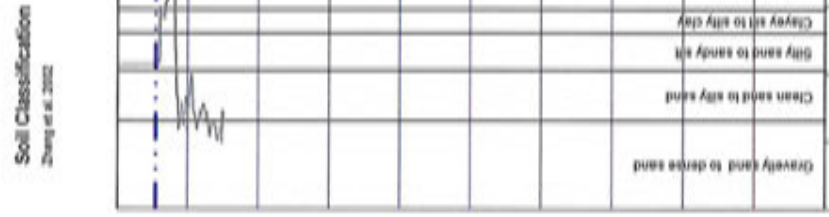
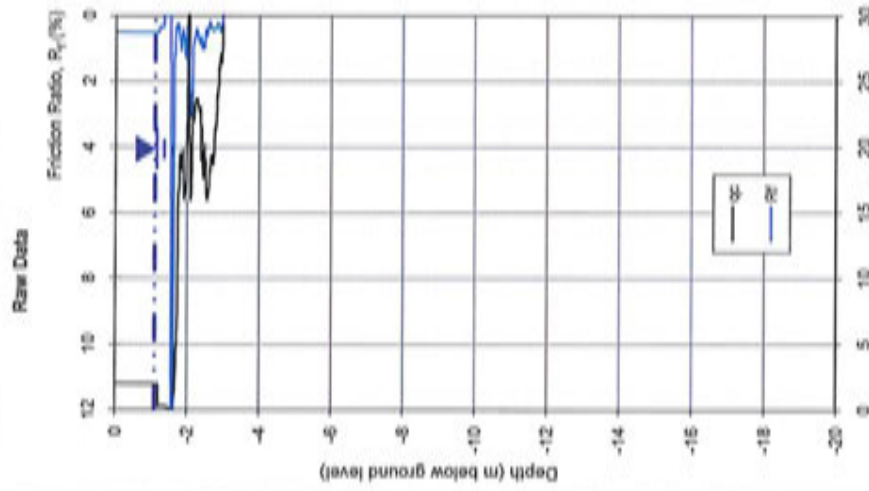
FILE: Liquefaction Assessment from CPT Results







 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	SOURCE <b>CPT-CBD-23</b> JOB NUMBER 52000.301	DATE 7/12/2011	ANALYSED RAP
		CHECKED AFF	CHRISTCHURCH CITY COUNCIL GEOTECHNICAL ASSESSMENT FOR CHRISTCHURCH CENTRAL CITY LIQUEFACTION ASSESSMENT FROM CPT RESULTS



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

0.1
0.1
0.1

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

LOCATION

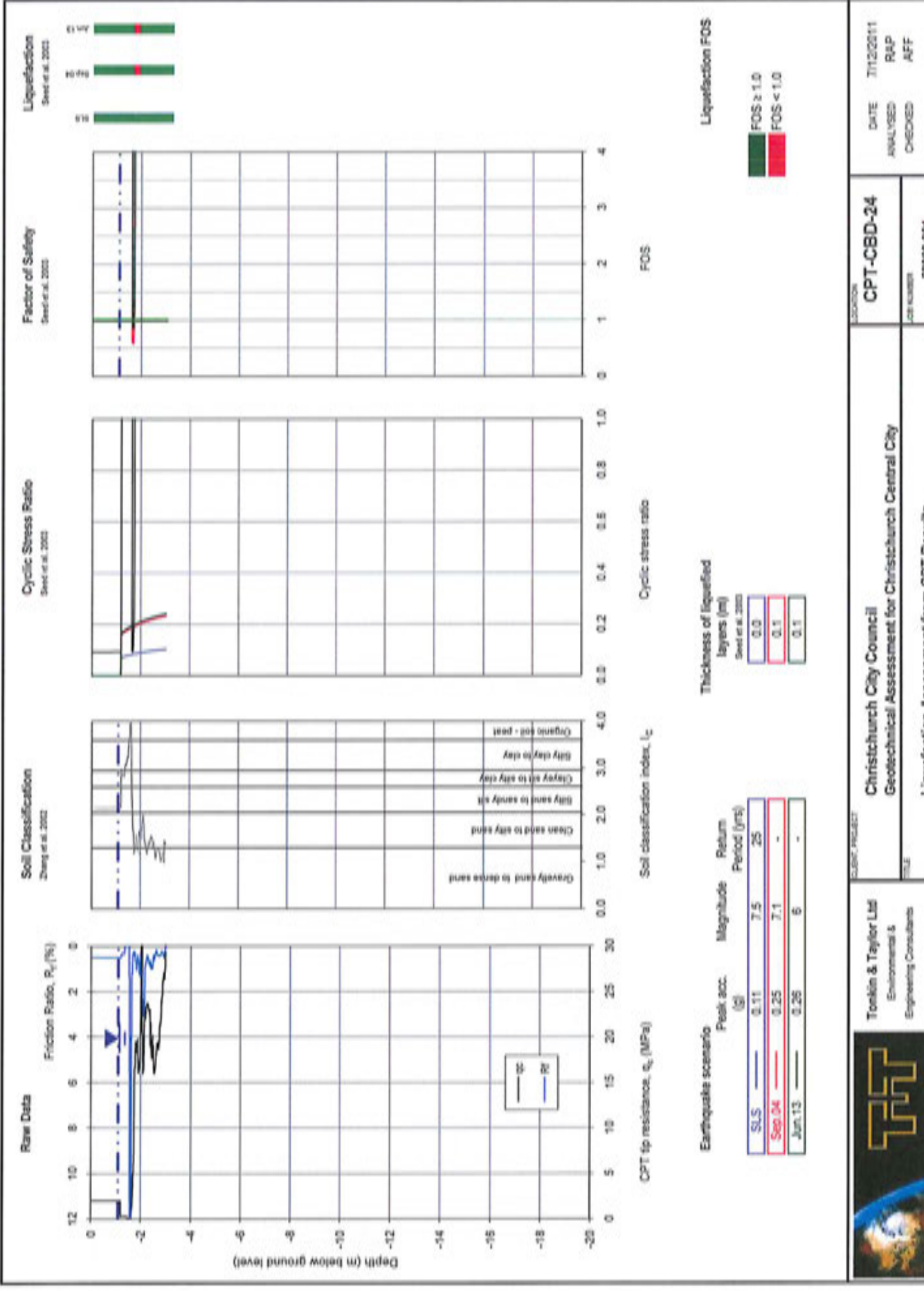
**CPT-CBD-24**

JOB NUMBER

52000.301

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
AFF

Liquefaction Assessment from CPT Results



**CPT tip resistance,  $q_t$  (MPa)**

**Soil classification index,  $I_c$**

**Thickness of liquefied layers (m)**  
Said et al. 2003

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Seo 04	0.25	7.1	-
Jun. 13	0.26	6	-

**Liquefaction FOS**

FOS $\geq$ 1.0	FOS $<$ 1.0
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**CLIENT PROJECT**  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

**TITLE**  
Liquefaction Assessment from CPT Results

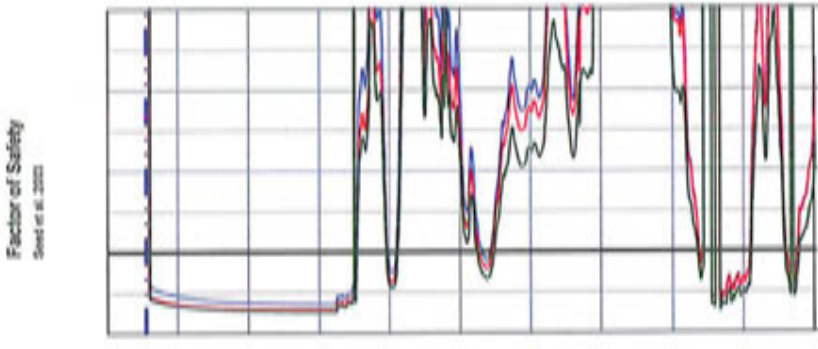
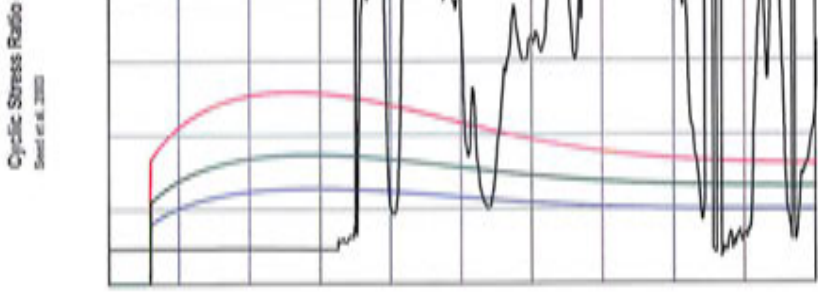
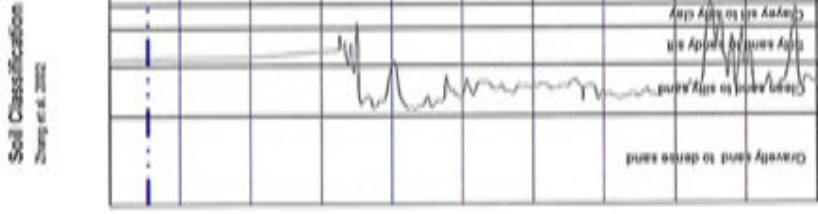
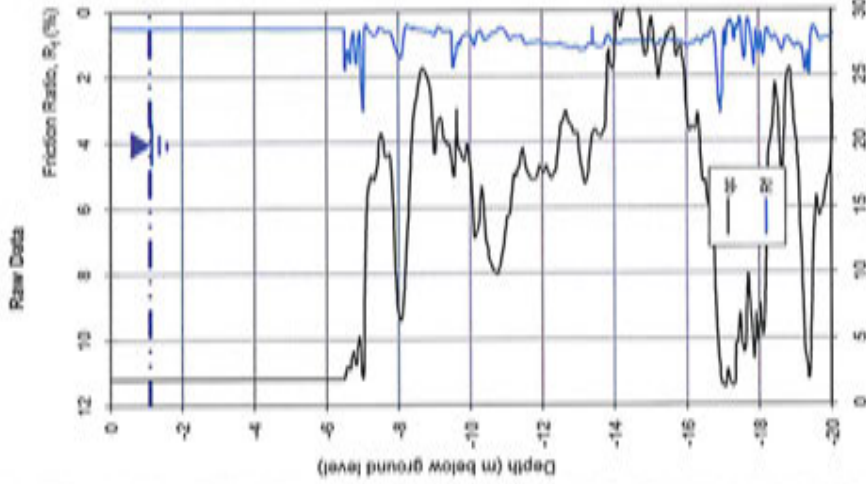
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CPT-CBD-24

**JOB NUMBER**  
52000\_301

**DATE**  
7/12/2011

**ANALYSED**  
RAP

**CHECKED**  
AFF



CPT tip resistance,  $t_p$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

7.8
7.9
8.4



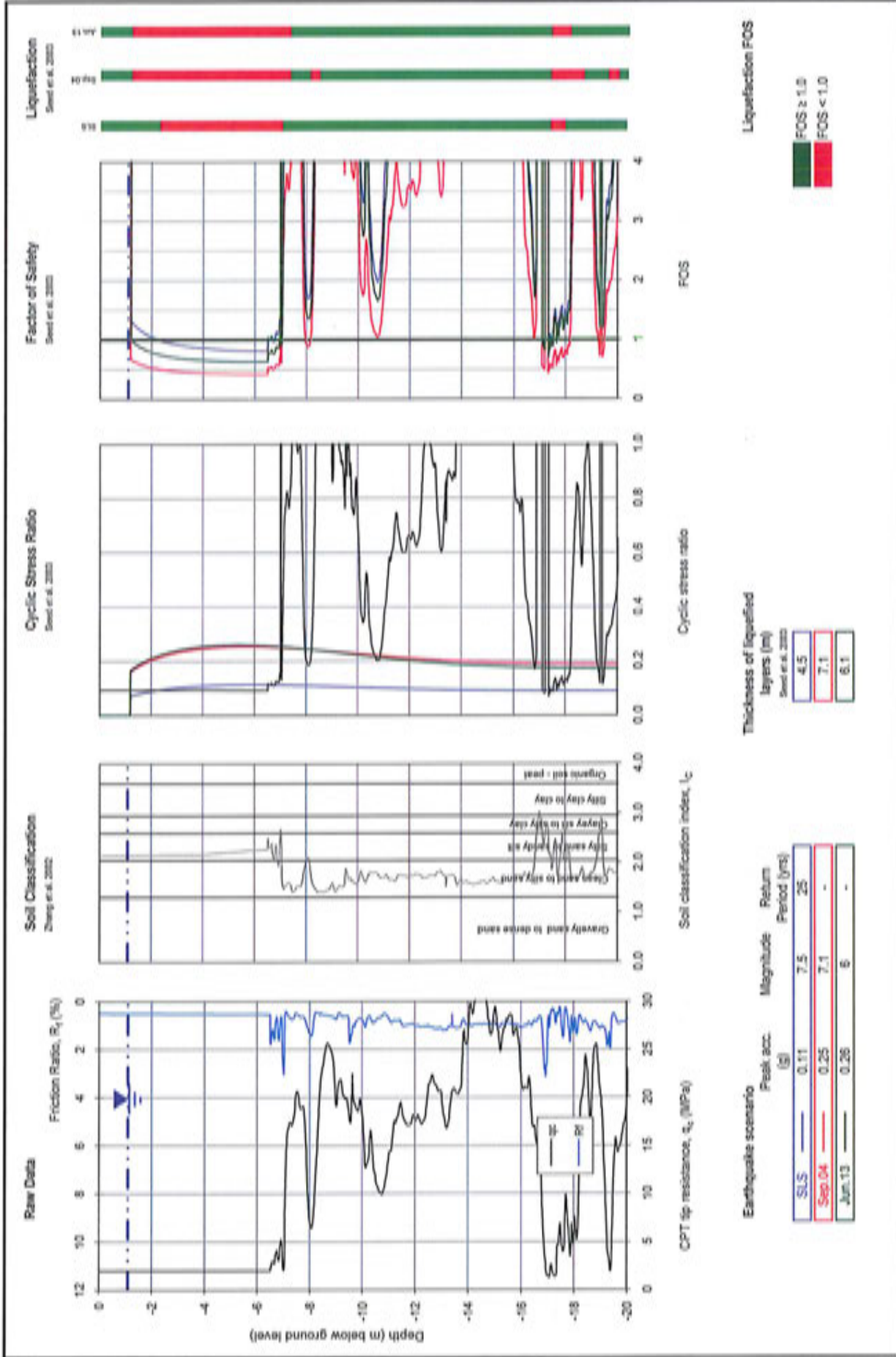
Tonkin & Taylor Ltd  
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Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

SECTION  
**CPT-CBD-24P**  
JOB NUMBER  
52000.301

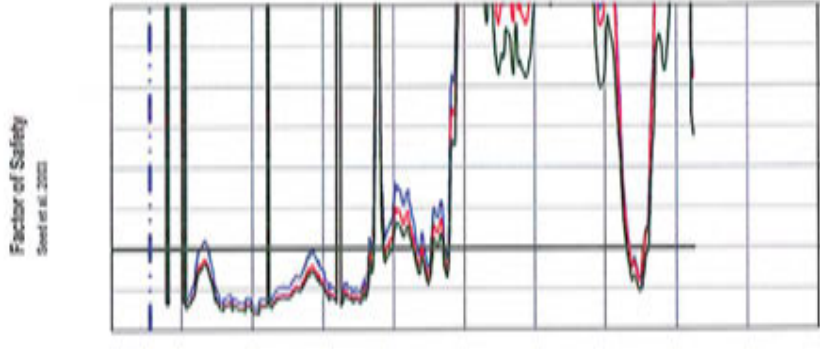
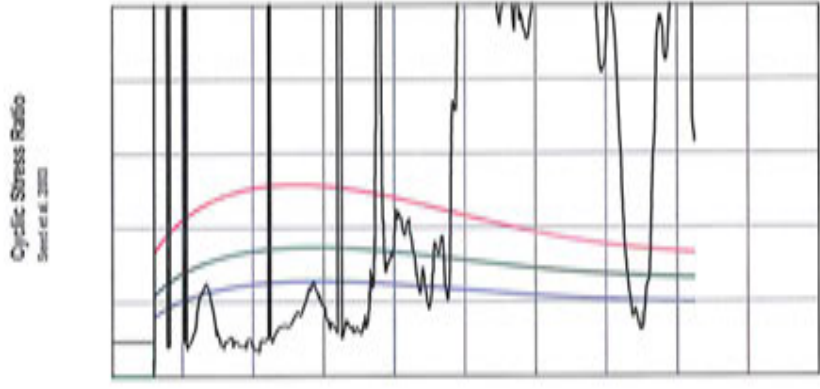
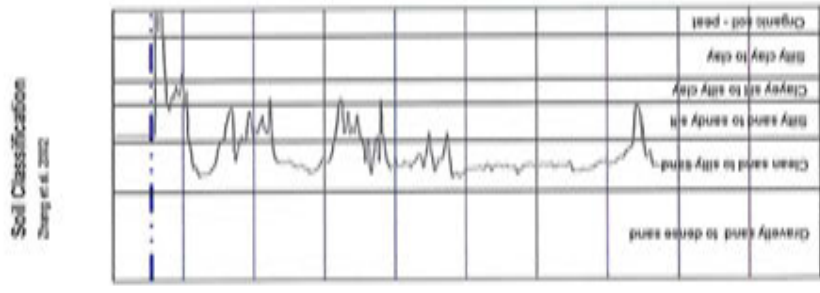
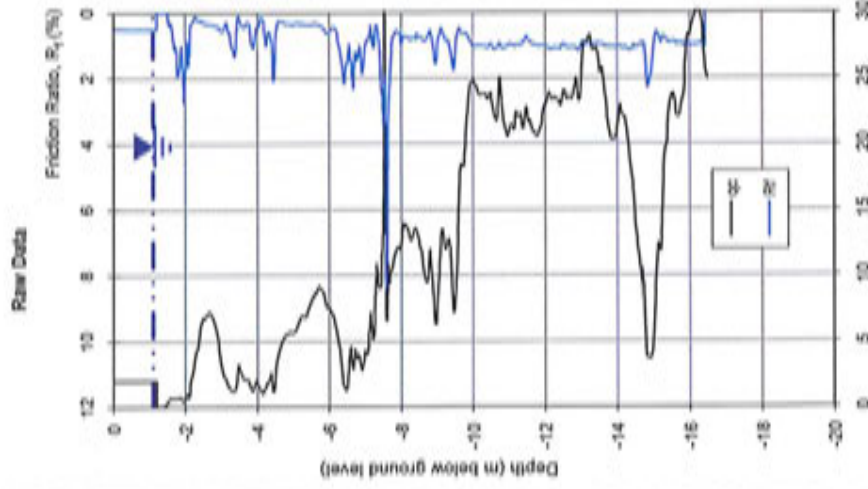
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6/12/2011  
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RAP  
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Liquefaction Assessment from CPT Results



 Tonkin & Taylor Ltd Environmental & Engineering Consultants	SUBJECT PROJECT <b>Christchurch City Council Geotechnical Assessment for Christchurch Central City</b>	LOCATION <b>CPT-CBD-24P</b>	DATE 7/12/2011
	FILE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 52000.301	APPROVED RAP
			CHECKED AFF





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

5.7
6.3
6.9

Liquefaction FOS

FOS  $\geq$  1.0  
FOS  $<$  1.0



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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

TITLE  
Liquefaction Assessment from CPT Results

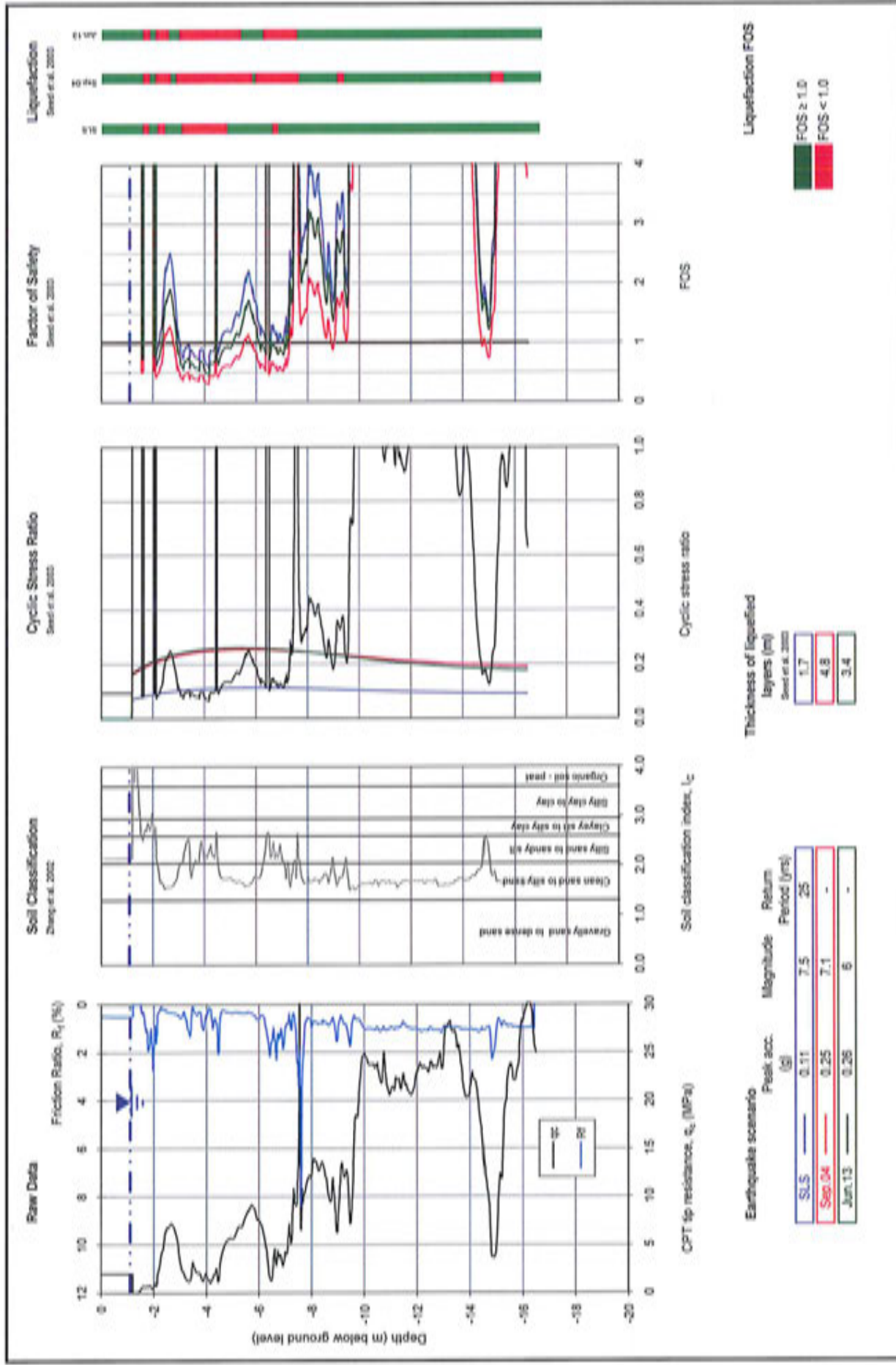
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JOB NUMBER  
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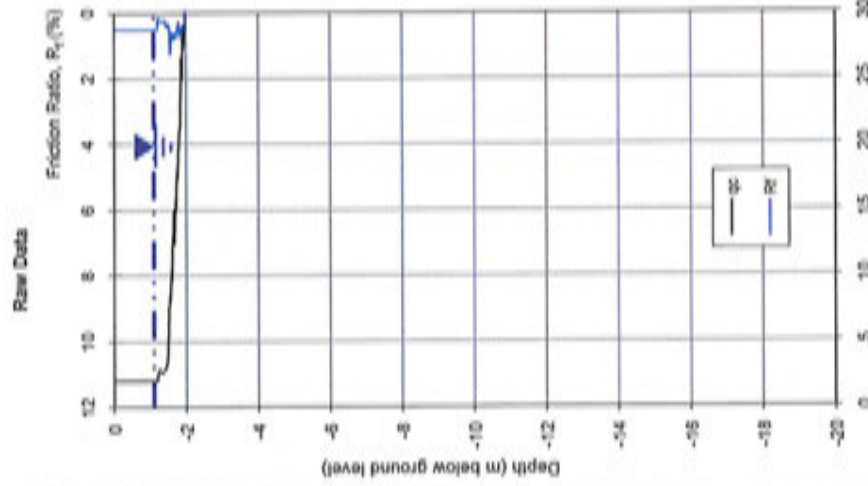
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6/12/2011

ANALYSED  
RAP

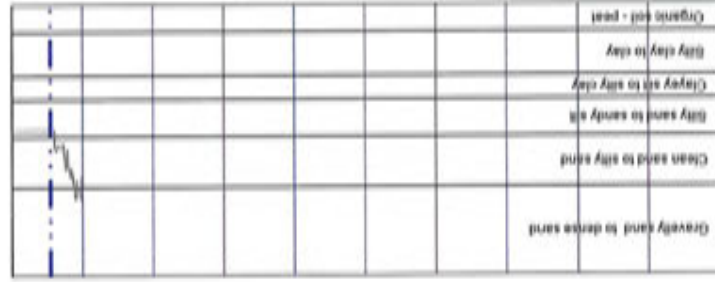
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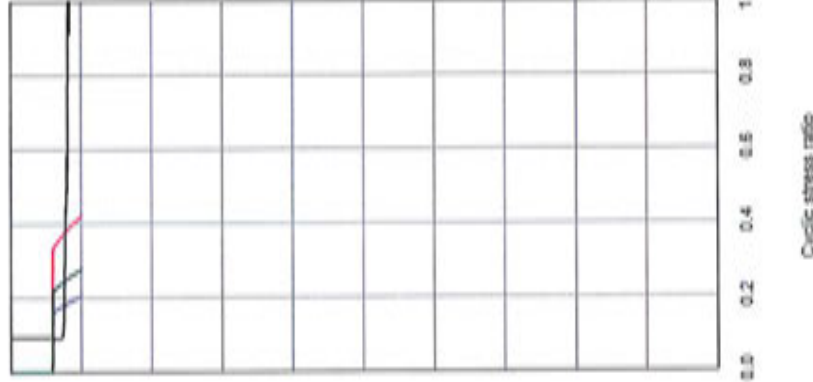
 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	SUBJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City Liquefaction Assessment from CPT Results	DATE 7/11/2011
		ANALYSED RAP
	JOB NUMBER S2000.301	CHECKED AFF



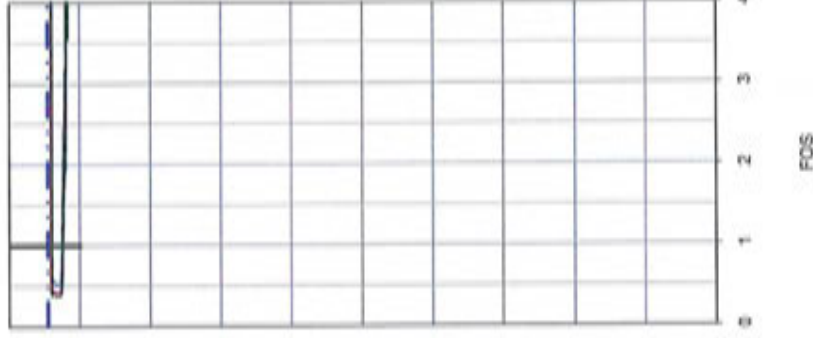
**Soil Classification**  
Zheng et al. 2002



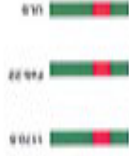
**Cyclic Stress Ratio**  
Seed et al. 2002



**Factor of Safety**  
Seed et al. 2002



**Liquefaction**  
Seed et al. 2002



**CPT tip resistance,  $q_c$  (MPa)**

**Soil classification index,  $I_c$**

**Cyclic stress ratio**

**FOS**

**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

**Thickness of liquefied layers (m)**  
Seed et al. 2002

0.3
0.3
0.3

**Liquefaction FOS**



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CLIENT PROJECT

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

LOCATION

**CPT-CBD-26**

FILE

Liquefaction Assessment from CPT Results

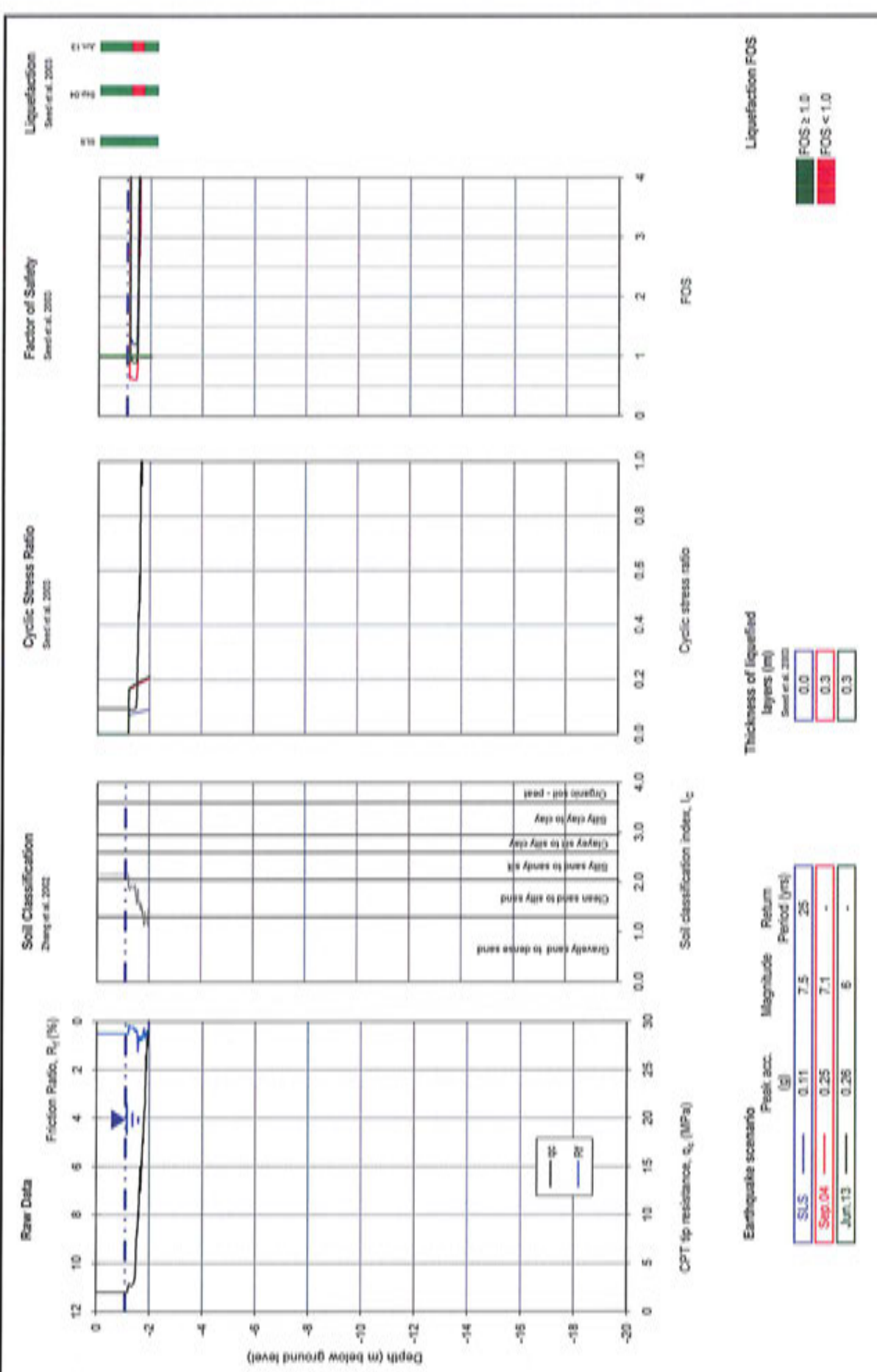
JOB NUMBER

52000\_301

DATE  
6/12/2011

ANALYSED  
RAP

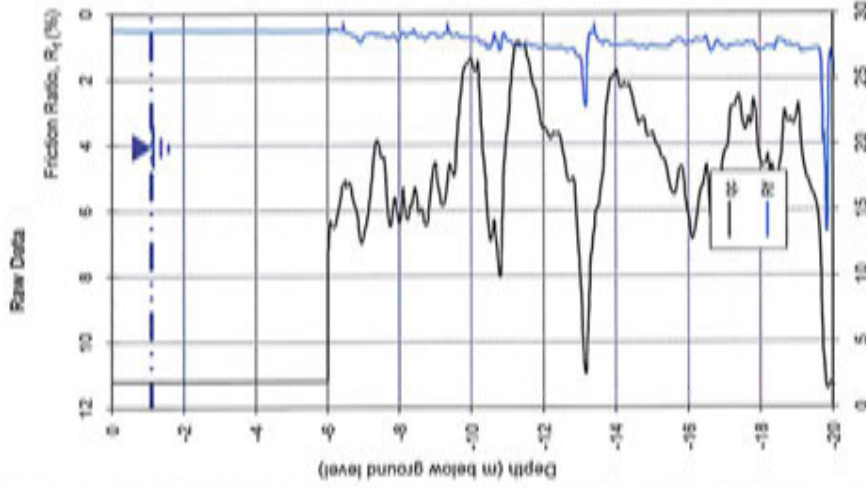
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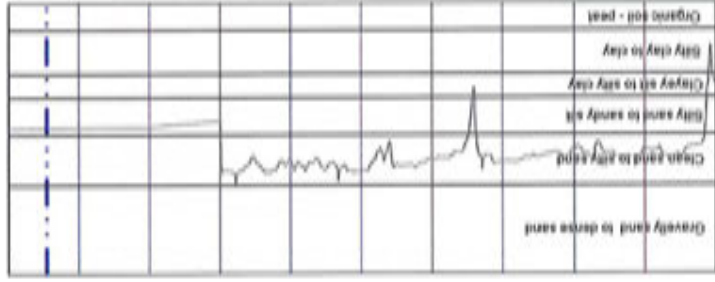
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Engineering Consultants

PROJECT: Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
LOCATION: CPT-CBD-26  
TITLE: Liquefaction Assessment from CPT Results  
JOB NUMBER: 52000.001

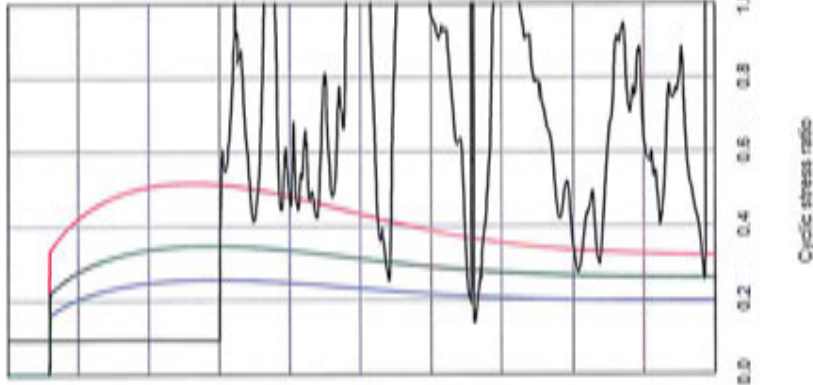
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ANALYSED: RAP  
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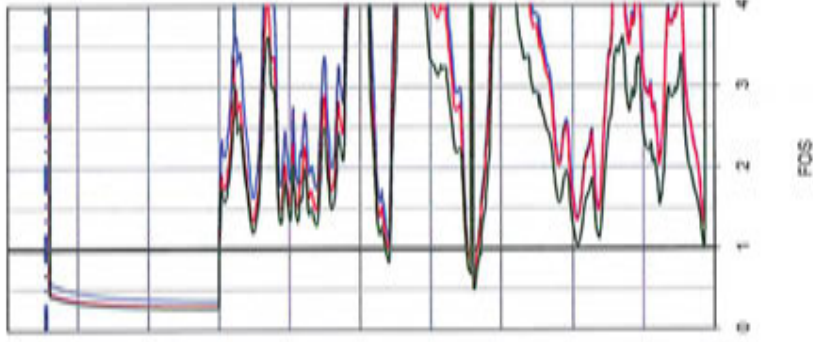
Soil Classification  
Zheng et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb. 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

5.0
5.1
5.4

Liquefaction FOS



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Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-26P

TITLE

Liquefaction Assessment from CPT Results

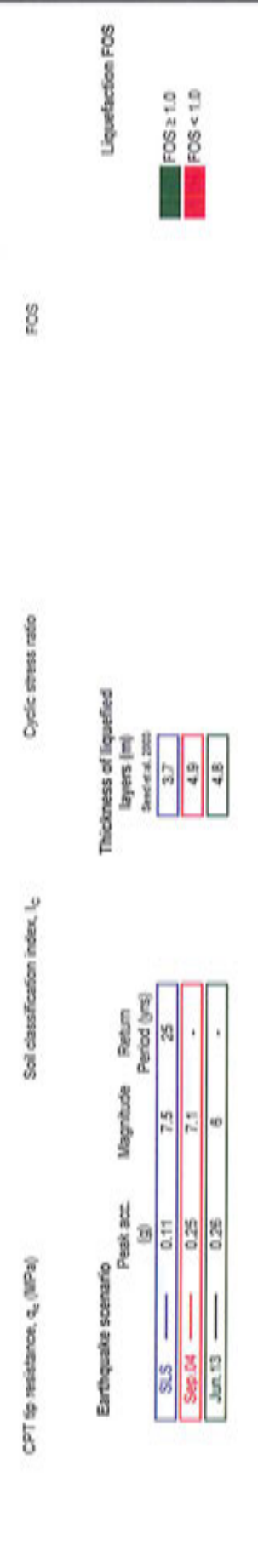
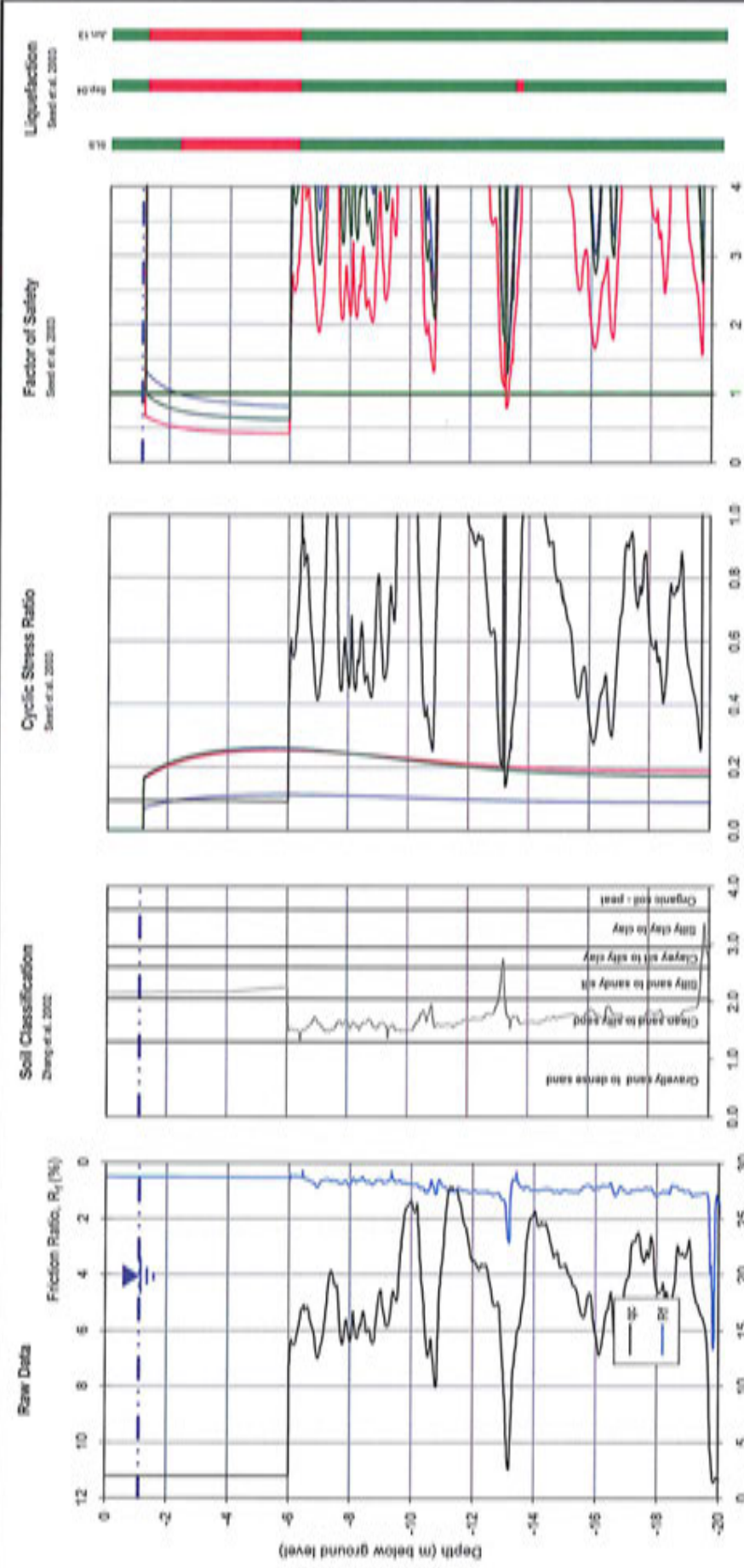
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52000\_301

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5/12/2011

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RAP

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AFF



Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Op. 04	0.25	7.1	-
Jan. 13	0.25	6	-

Soil classification index, $I_c$	Thickness of liquefied layers (m)
Cravily sand to dense sand	3.7
Clean sand to silty sand	4.9
Silty sand to silty silt	4.8
Clayey silt to silty clay	-
Silty clay to clay	-
Organic soil - peat	-

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Op. 04	0.25	7.1	-
Jan. 13	0.25	6	-

Soil classification index, $I_c$	Thickness of liquefied layers (m)
Cravily sand to dense sand	3.7
Clean sand to silty sand	4.9
Silty sand to silty silt	4.8
Clayey silt to silty clay	-
Silty clay to clay	-
Organic soil - peat	-

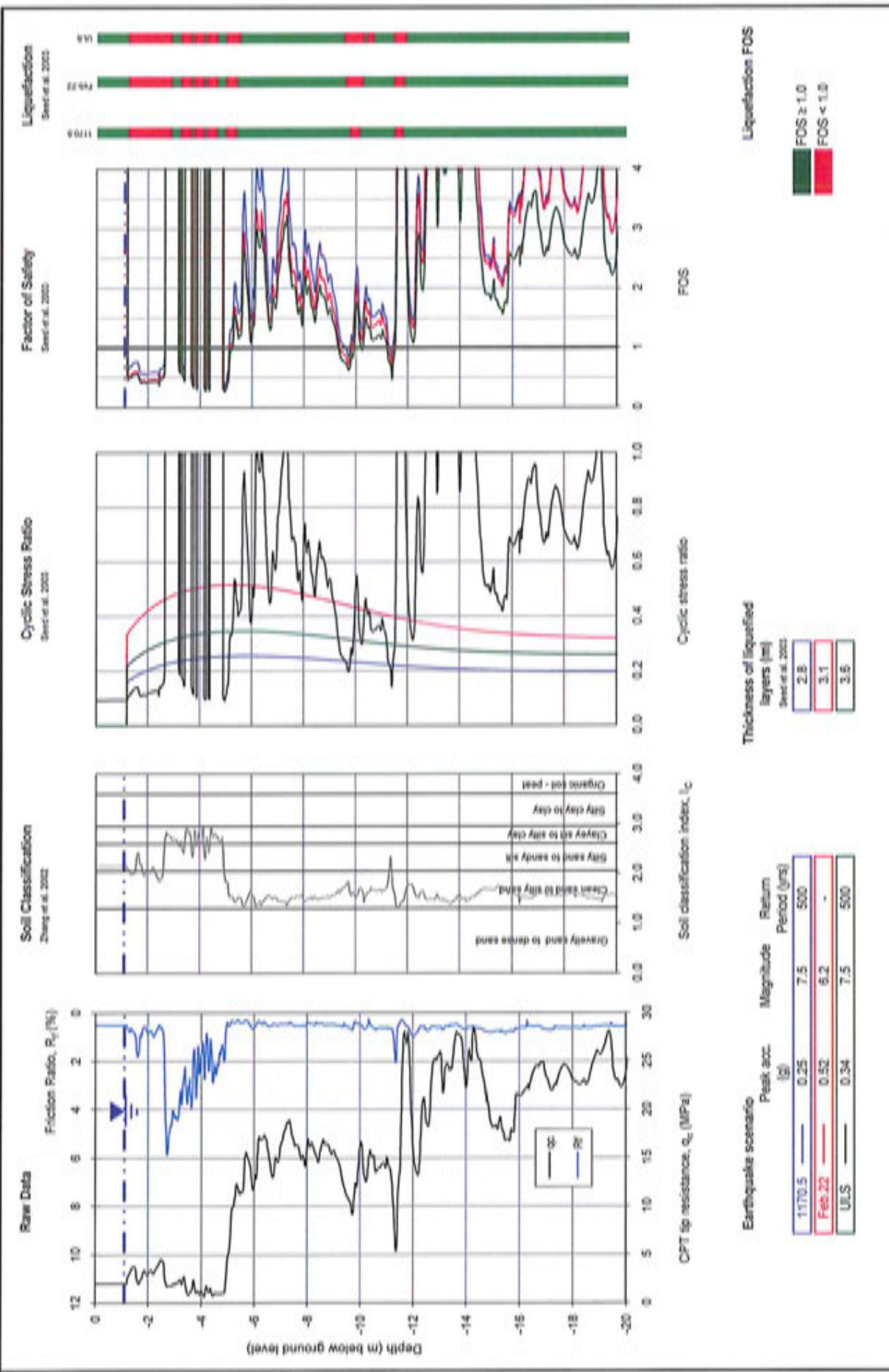


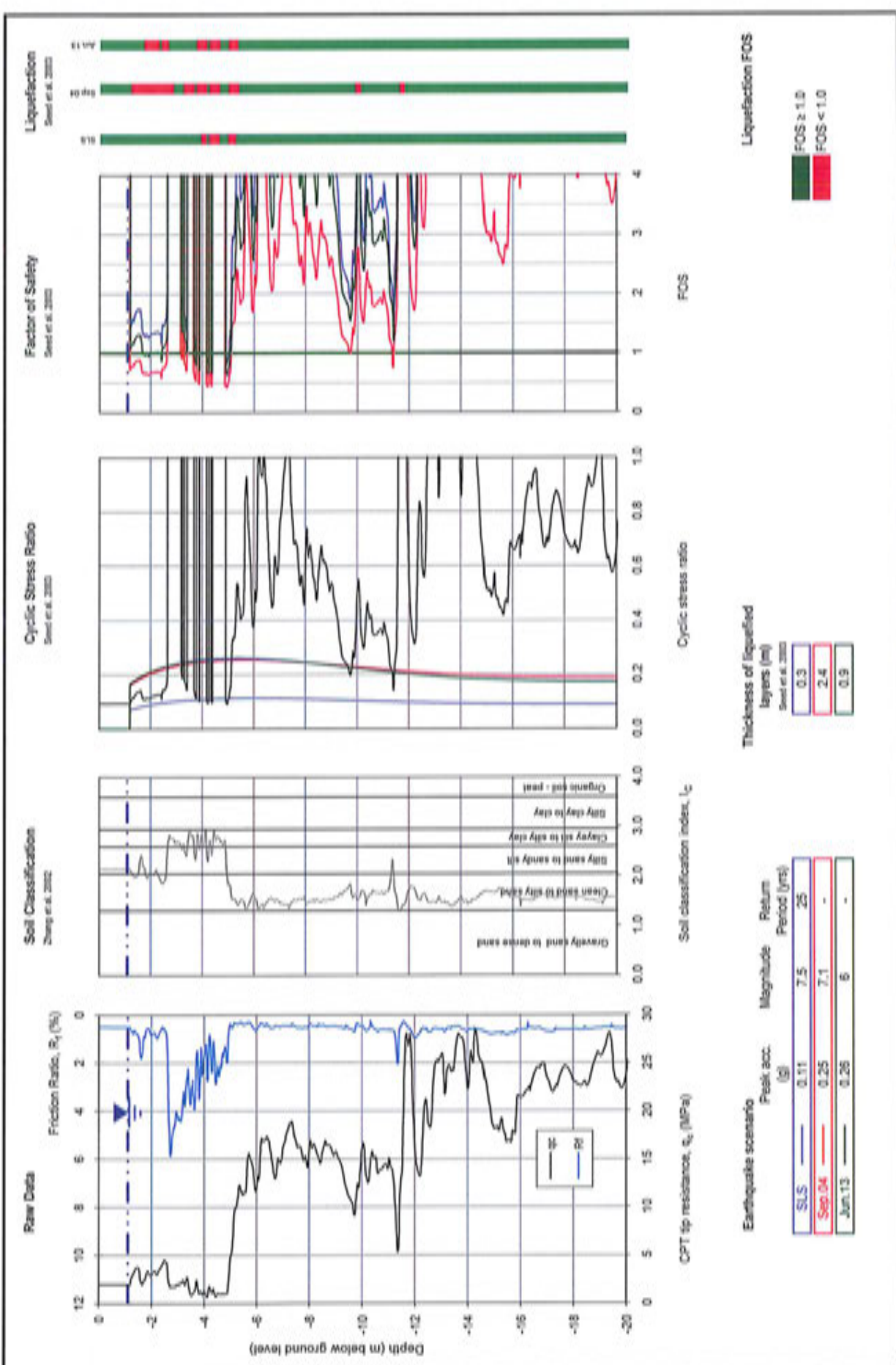
**Toolkin & Taylor Ltd**  
 Environmental & Engineering Consultants

**CLIENT/PROJECT**  
 Christchurch City Council  
 Geotechnical Assessment for Christchurch Central City  
 Liquefaction Assessment from CPT Results

**LOCATION**  
 CPT-CBD-26P

DATE	7/12/2011
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JOB NUMBER	52000.301





Earthquake scenario

Peak acc.	Magnitude	Return Period (yrs)
SLS	0.11	7.5
Sep. 04	0.25	7.1
Jun. 13	0.26	6

Thickness of liquefied layers (m)

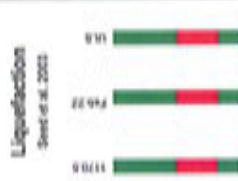
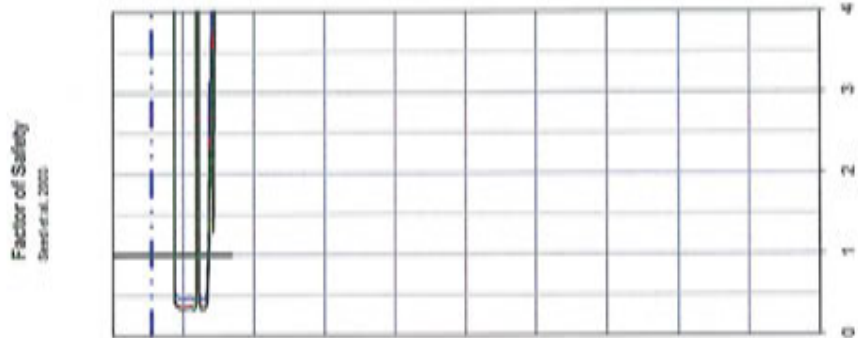
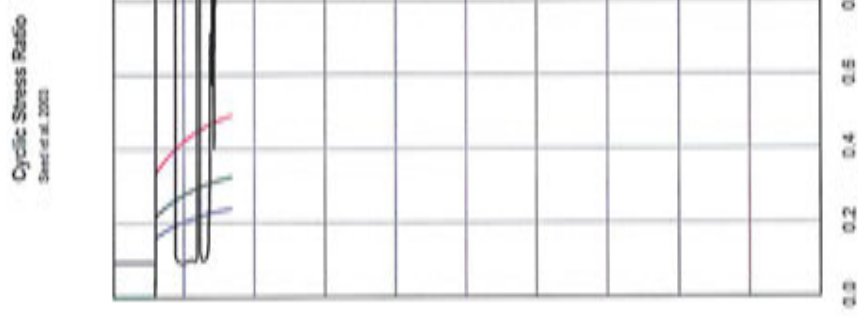
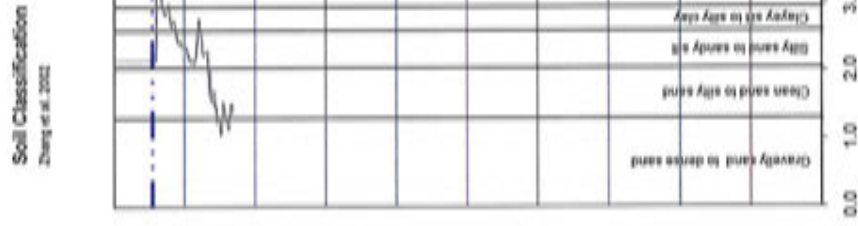
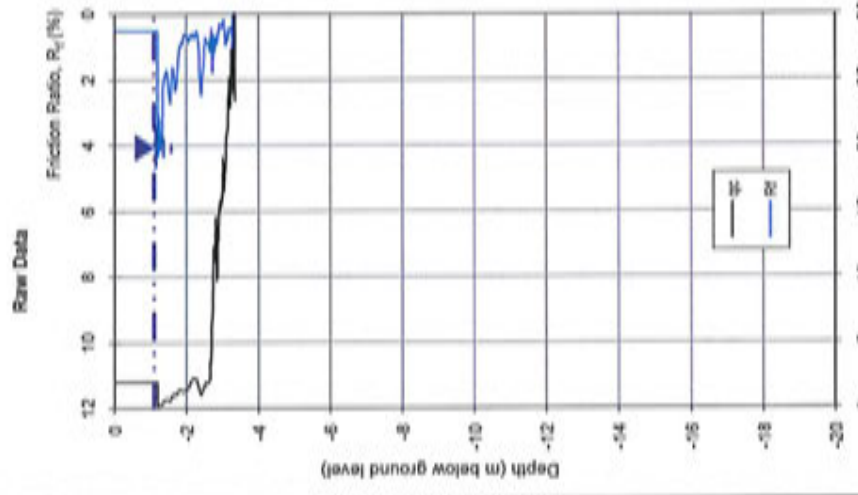
0.3
2.4
0.9

Liquefaction FOS

FOS > 1.0  
FOS < 1.0

 <p><b>Tonkin &amp; Taylor Ltd</b> Environmental &amp; Engineering Consultants</p>	<p>CLIENT PROJECT</p> <p><b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City</p>		<p>DATE</p> <p>27/12/2011</p>
	<p>LOCATION</p> <p><b>CPT-CBD-27</b></p>		<p>ANALYSED</p> <p>RAP</p>
<p>FILE</p> <p>Liquefaction Assessment from CPT Results</p>		<p>JOB NUMBER</p> <p>S2000_301</p>	<p>CHECKED</p> <p>AFF</p>





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1:170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

0.9
0.9
0.9

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



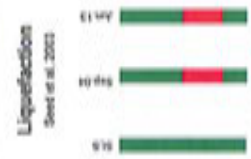
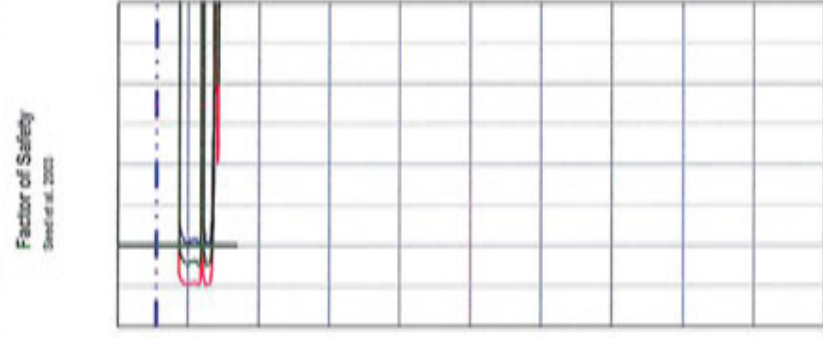
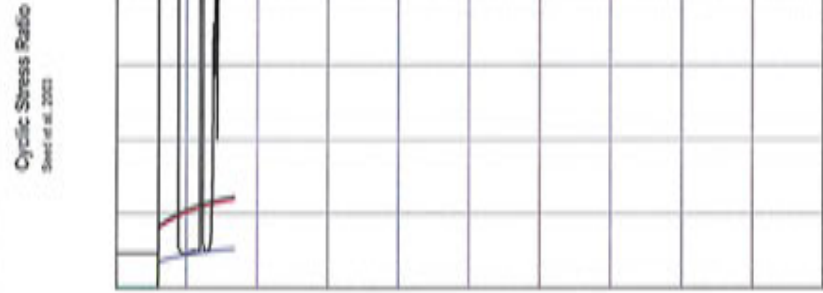
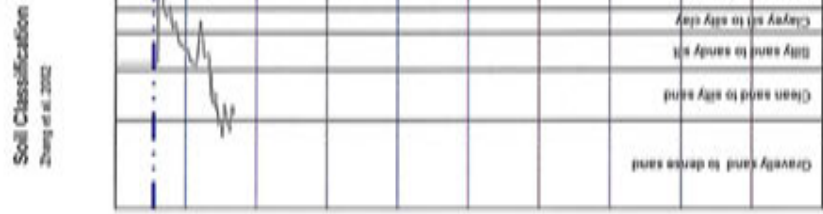
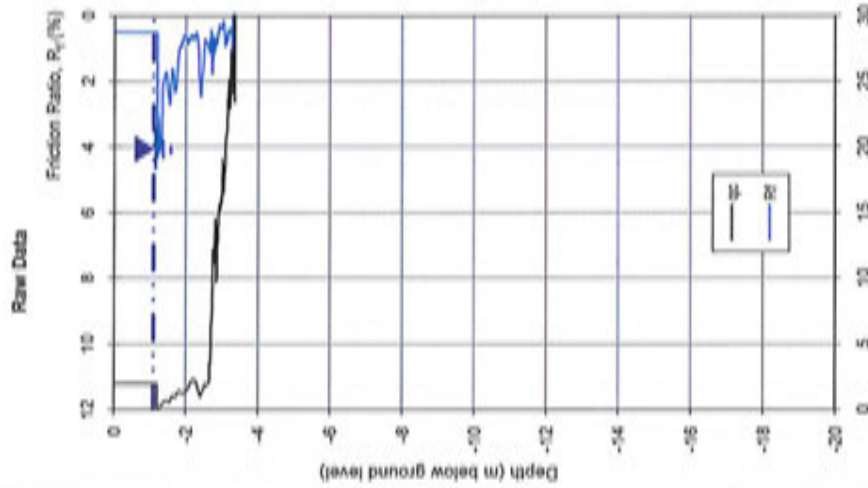
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CPT-CBD-28  
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52008.301

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Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.04	0.25	7.1	-
Jun.13	0.26	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.0
0.9
0.9

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



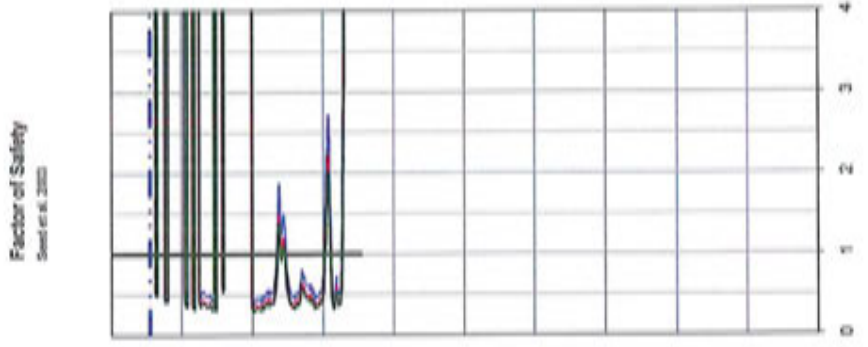
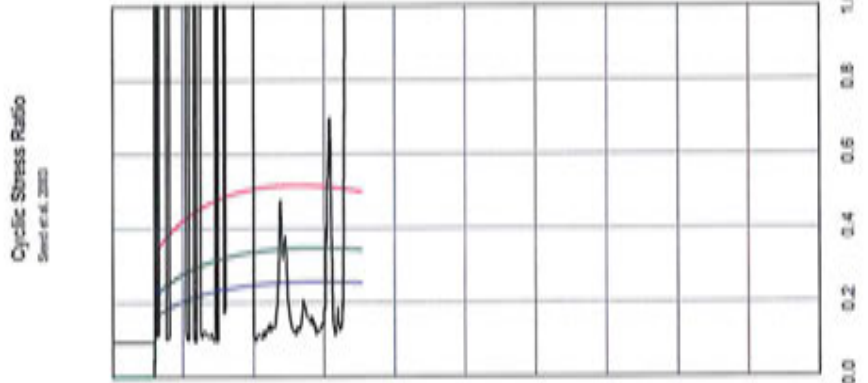
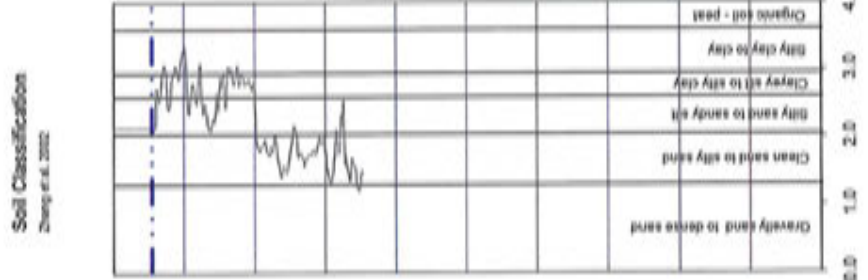
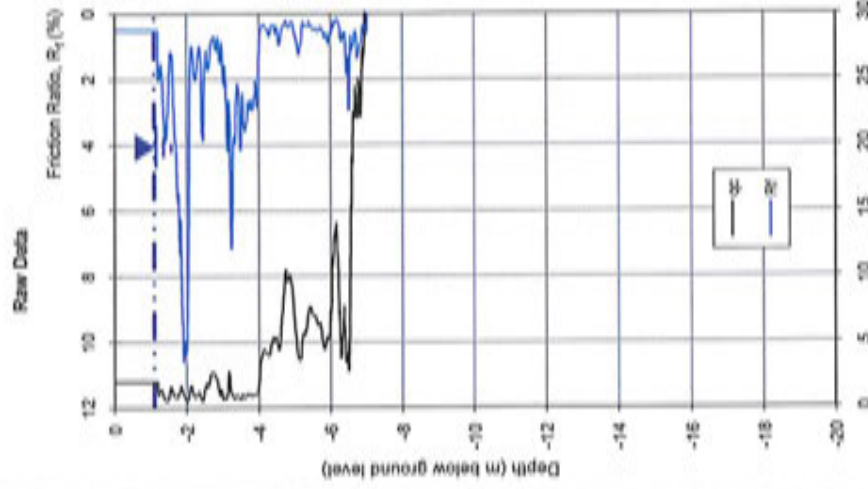
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Geotechnical Assessment for Christchurch Central City

PROJECT: CPT-CBD-28

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
JOB NUMBER: 52000.301

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_p$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

2.9
3.0
3.1

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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CPT-CBD-29

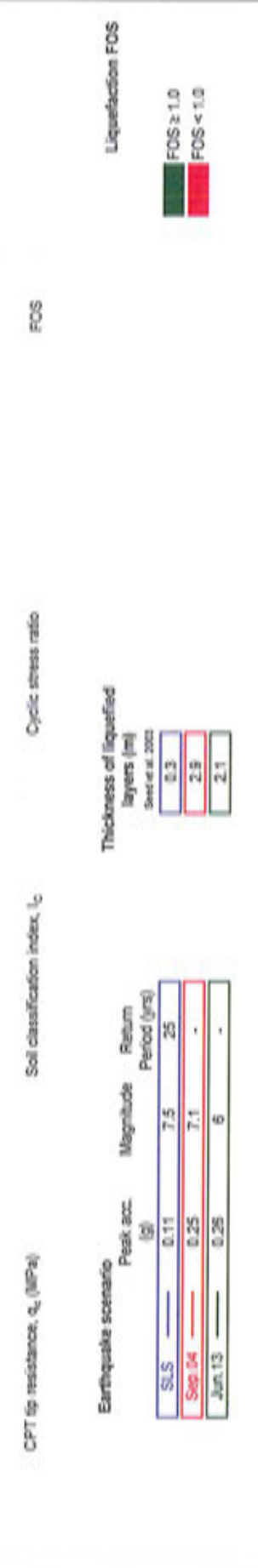
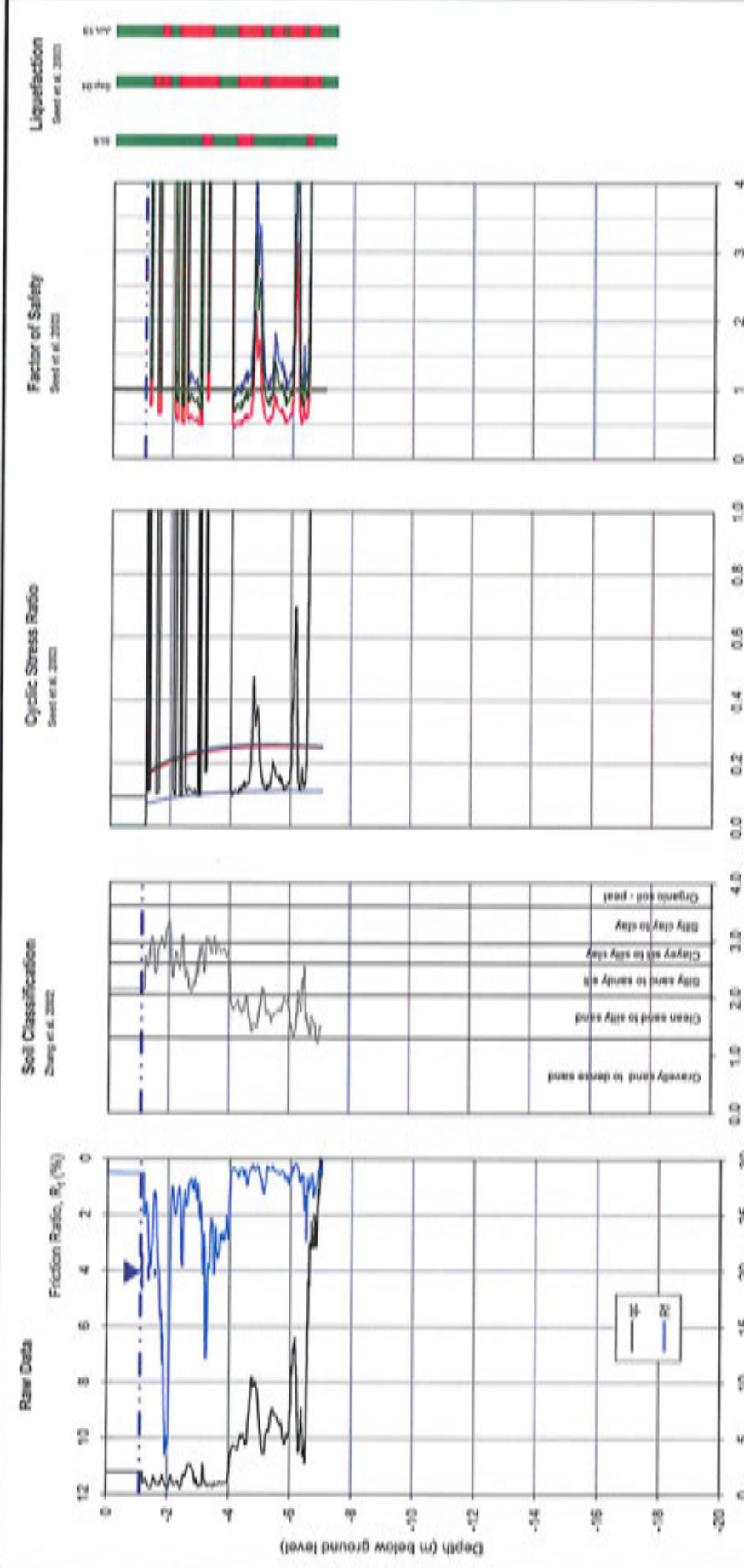
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DATE  
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AFF

Liquefaction Assessment from CPT Results





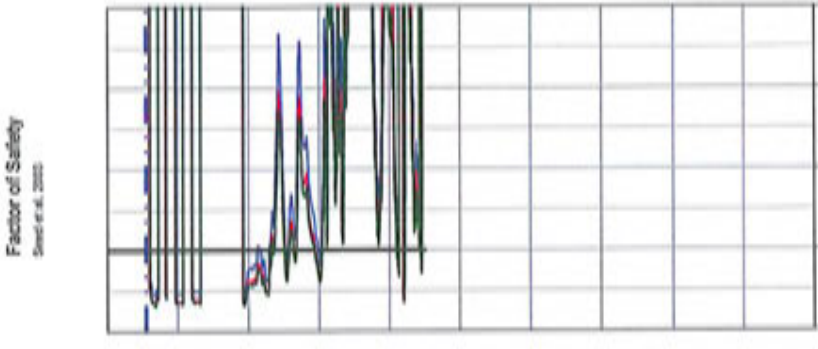
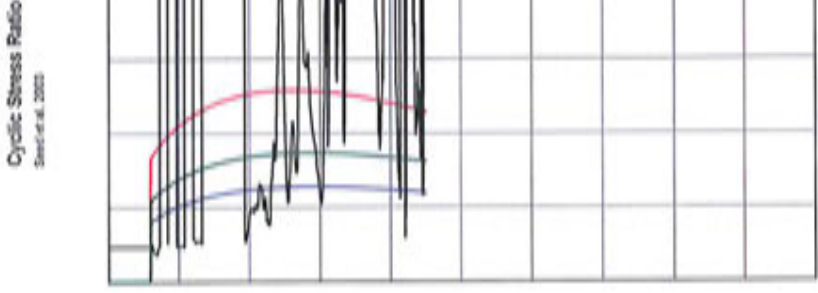
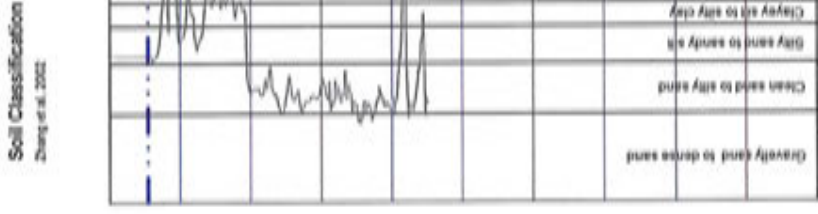
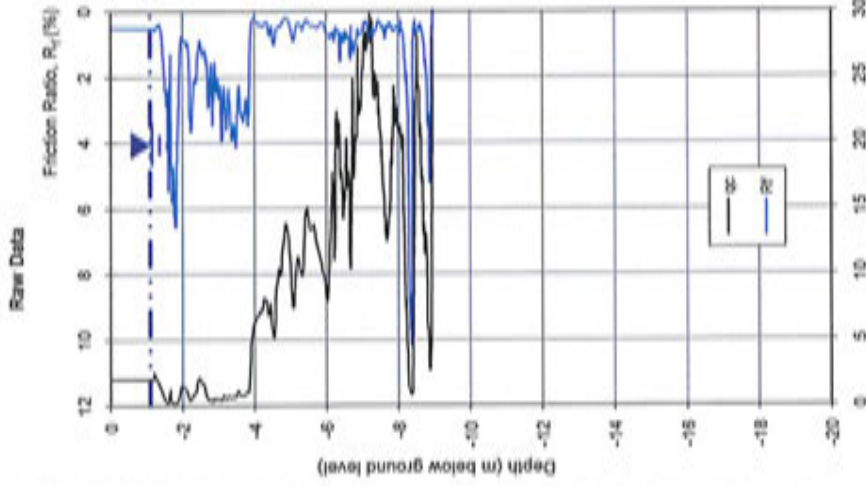
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Geotechnical Assessment for Christchurch Central City

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ANALYSED: RAP  
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JOB NUMBER: 52000\_301

SUBJECT PROJECT: Christchurch City Council Geotechnical Assessment for Christchurch Central City

FILE: Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
0.25	7.5	500
0.52	6.2	-
0.34	7.5	500
ULS	-	-

Thickness of liquefied layers (m)

1.6
2.0
2.1

Liquefaction FOS



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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT LOCATION  
CPT-CBD-29a

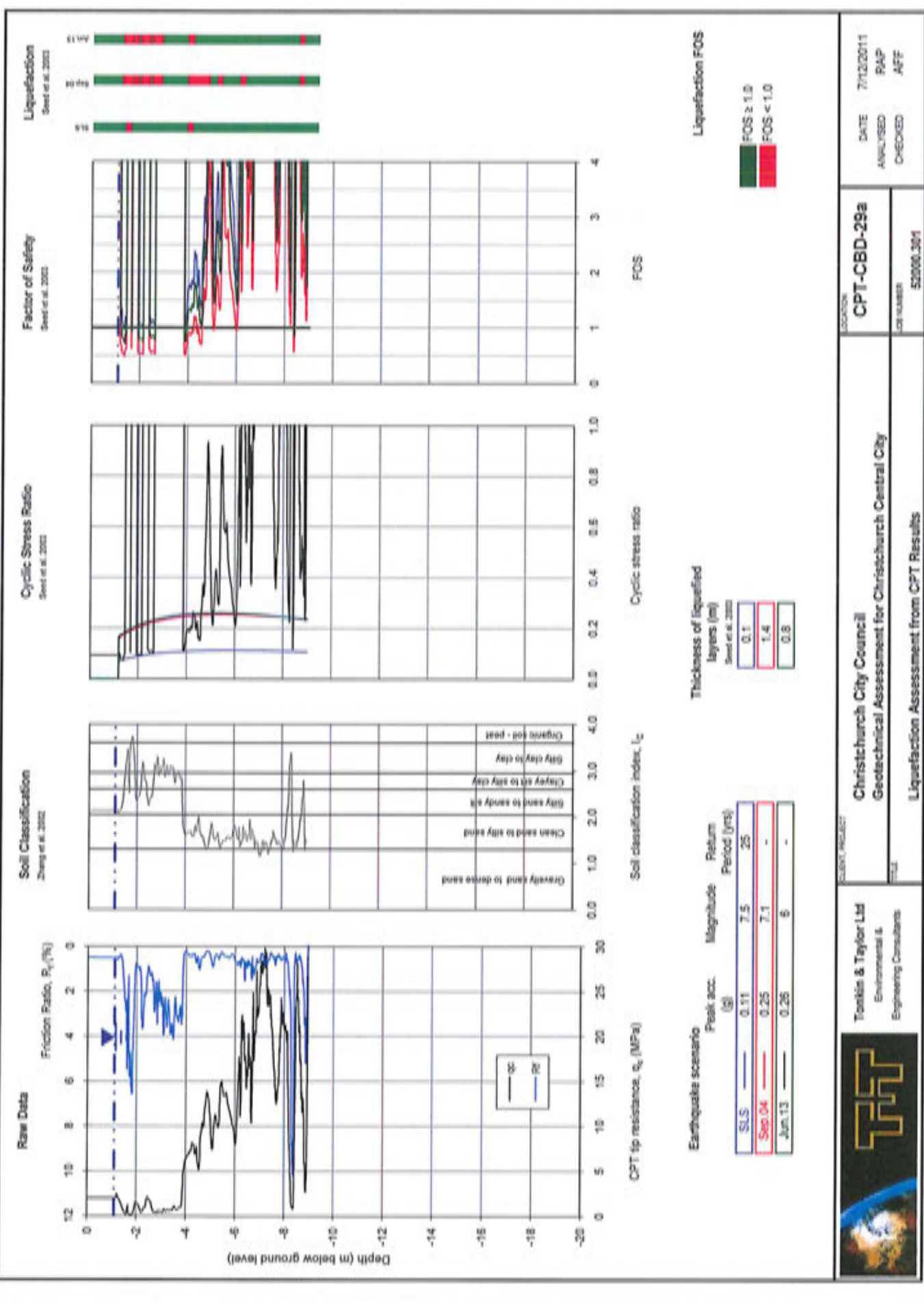
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52000.301

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6/12/2011

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RAP

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Liquefaction Assessment from CPT Results



Raw Data  
Friction Ratio,  $R_f$  (%)

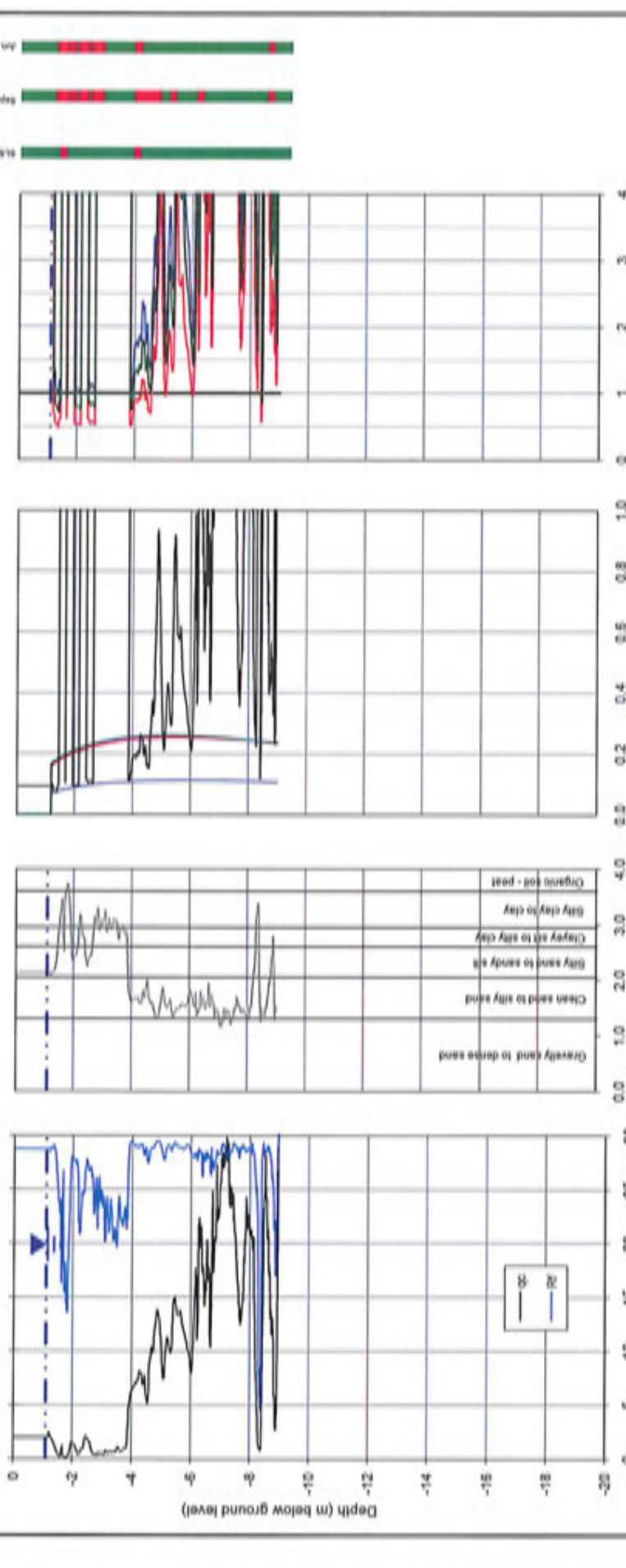
Factor of Safety  
Seed et al. 2003

Cyclic Stress Ratio  
Seed et al. 2003

Soil Classification  
Zheng et al. 2002

Factor of Safety  
Seed et al. 2003

Liquefaction  
Seed et al. 2003



CPT tip resistance,  $q_c$  (MPa)  
Soil classification index,  $I_c$   
Cyclic stress ratio  
FOS

Earthquake scenario

	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep. 04	0.25	7.1	-
Jun. 13	0.25	6	-

Thickness of liquefied layers (m)  
Seed et al. 2003

0.1
1.4
0.8

Liquefaction FOS

FOS $\geq 1.0$
FOS $< 1.0$



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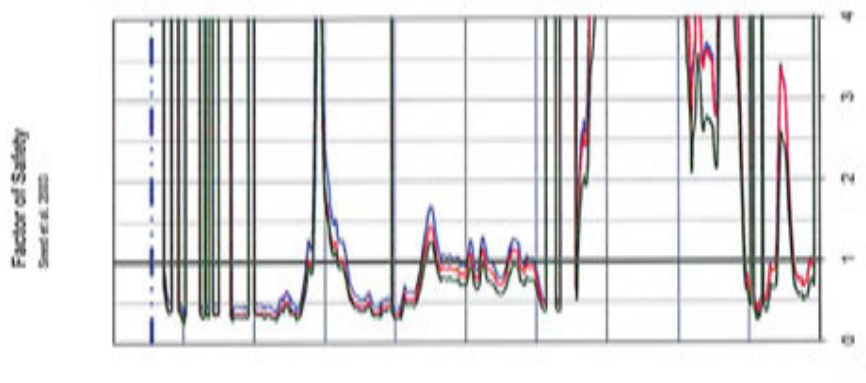
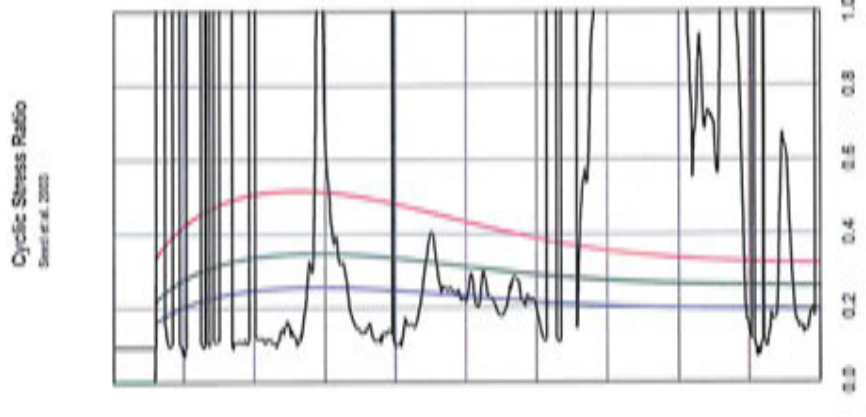
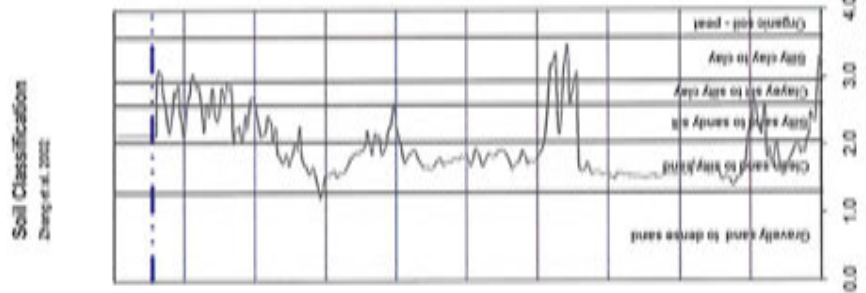
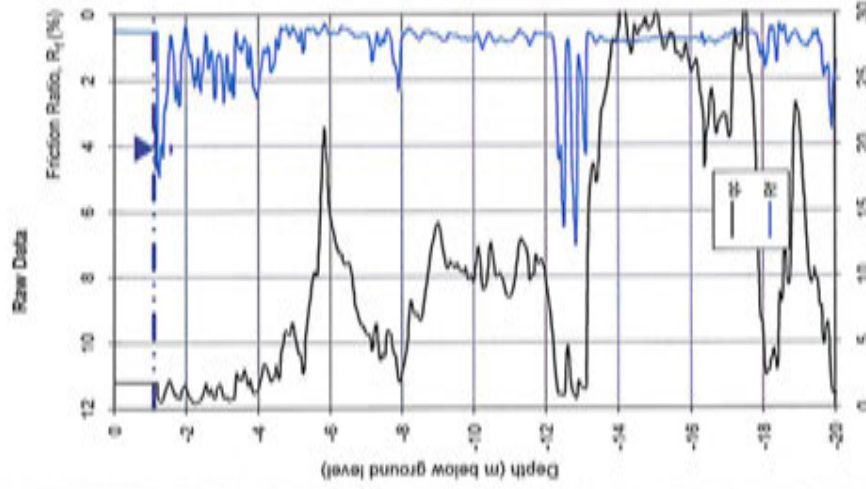
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**CPT-CBD-29a**

DATE: 7/12/2011  
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AFF

PROJECT NUMBER: 52000\_301

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5
Feb.22	0.52	6.2
ULS	0.34	7.5

Thickness of liquefied layers (m)

8.1
9.6
10.8

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0

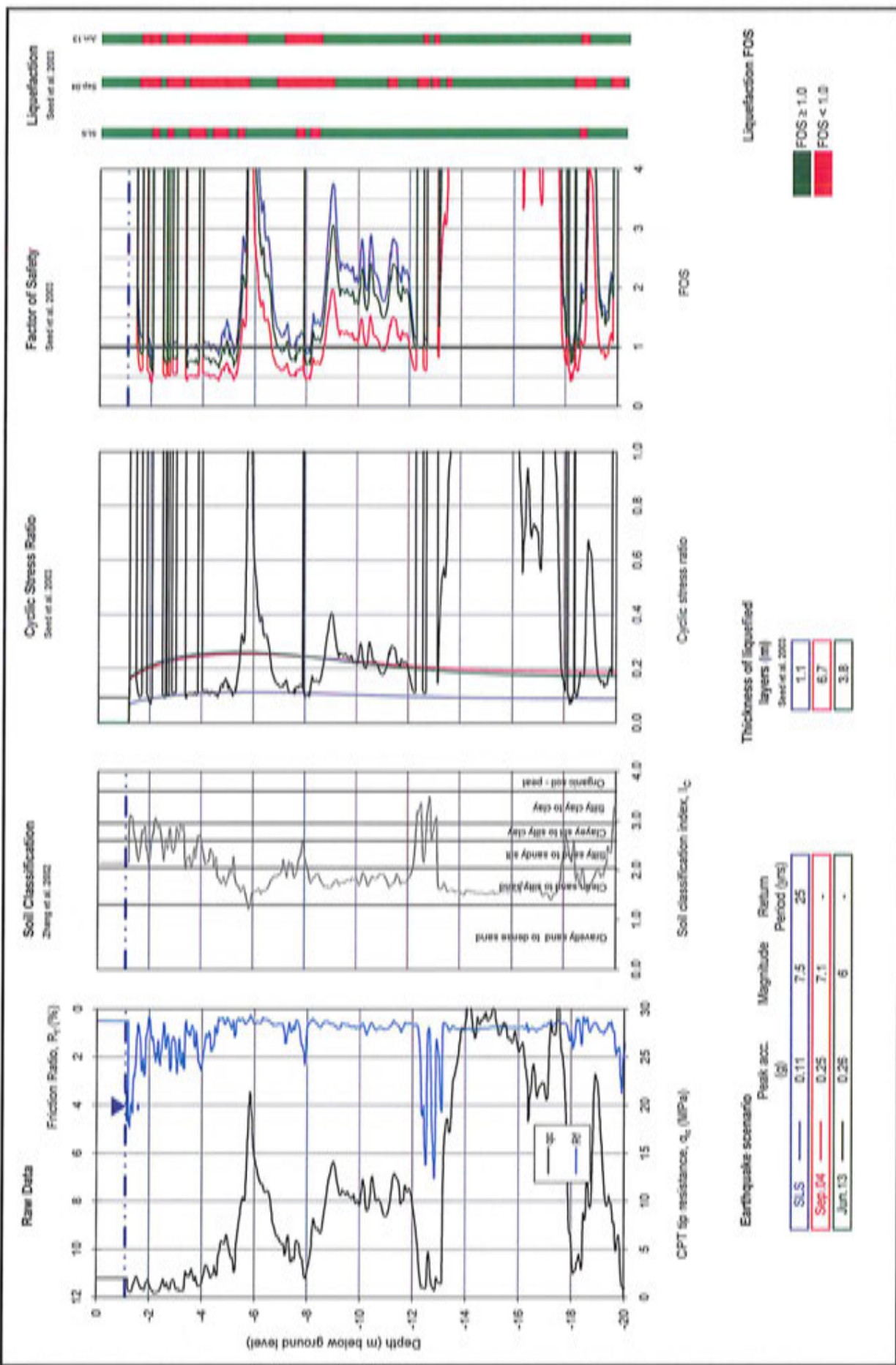


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Liquefaction Assessment from CPT Results

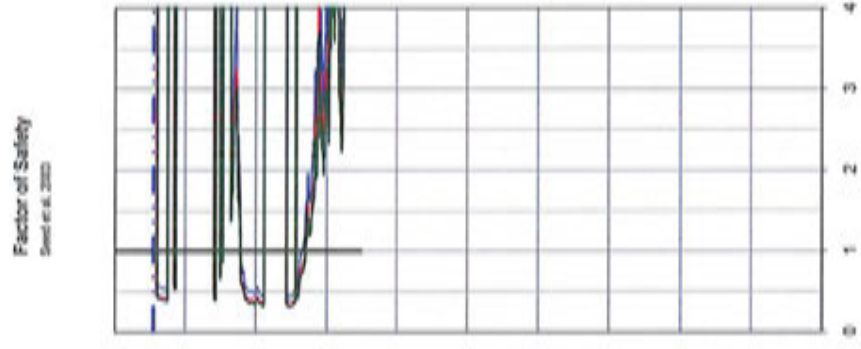
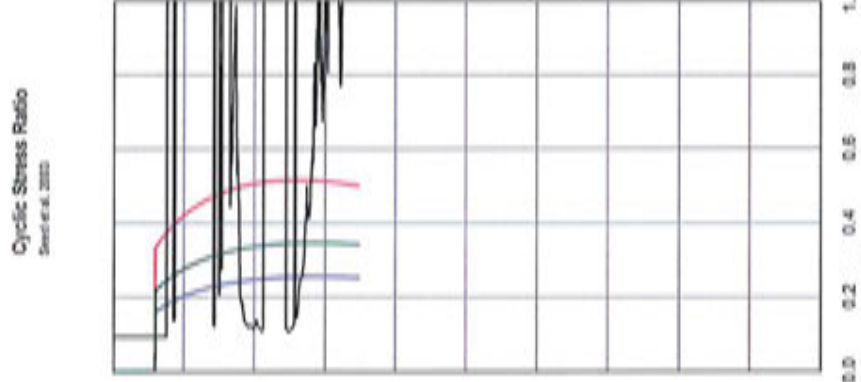
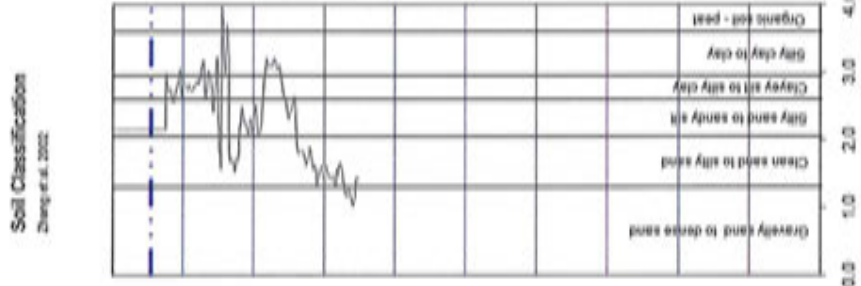
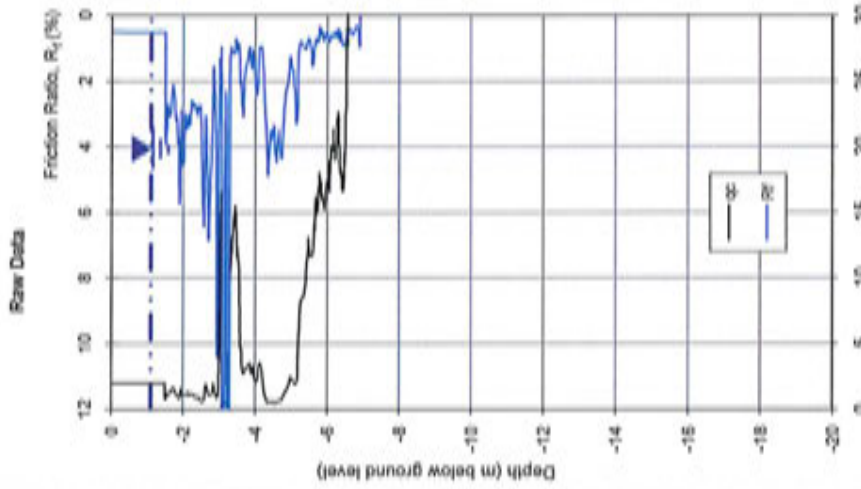
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JOB NUMBER  
52000.301

DATE  
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	CLIENT PROJECT: <b>CPT-CBD-30</b>	JOB NUMBER: 52000_301	LIAISON: CPT-CBD-30
TABLE Liquefaction Assessment from CPT Results			





CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb 22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
1.5
1.5
1.5

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



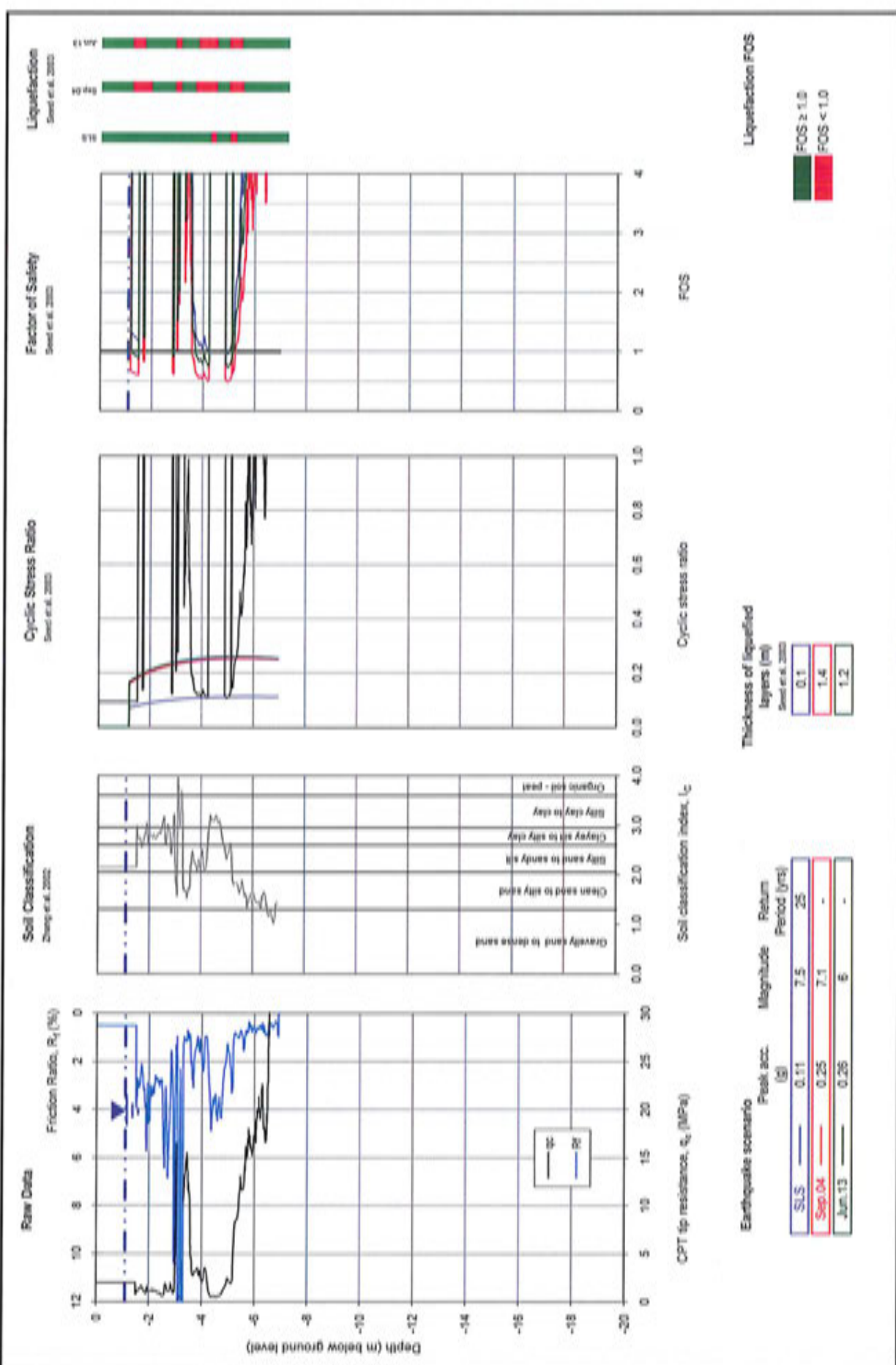
Tonkin & Taylor Ltd  
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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

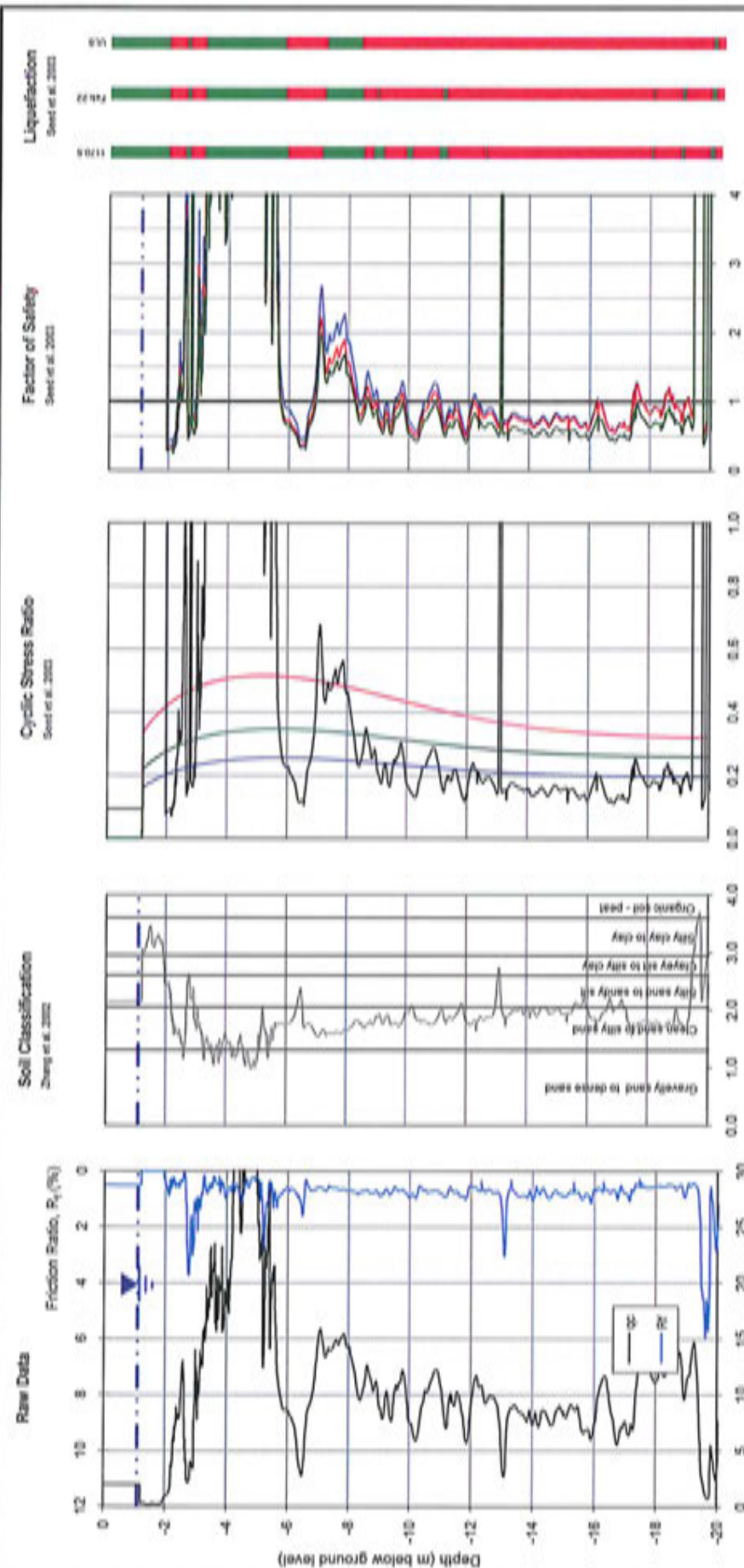
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JOB NUMBER  
52000.301

DATE 6/12/2011  
ANALYSED RAP  
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Liquefaction Assessment from CPT Results

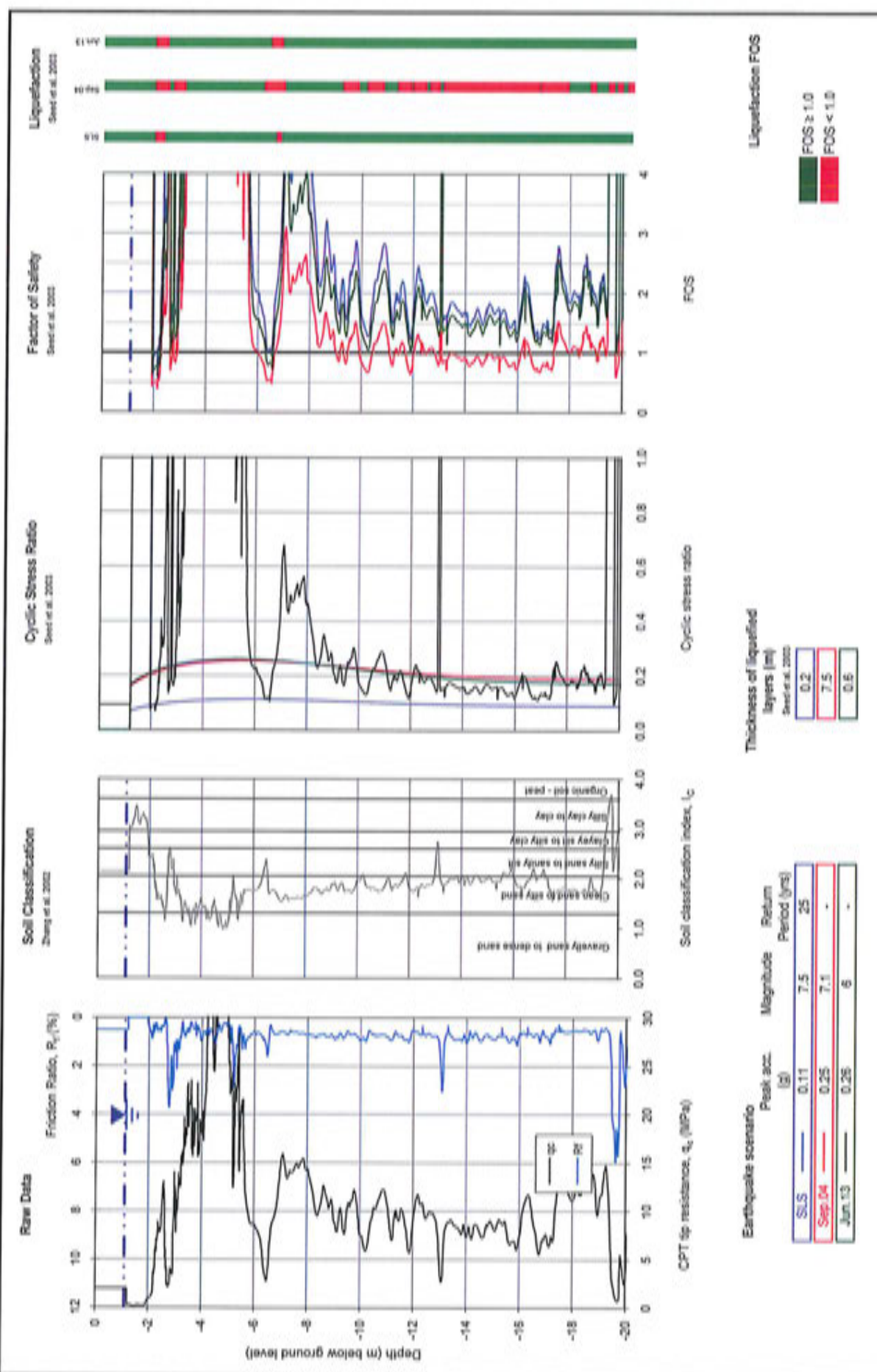


 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	DATE: 7/12/2011 ANALYSED: RAP CHECKED: AFF
		LOCATION: <b>CPT-CBD-31</b> JOB NUMBER: 52000.361
Liquefaction Assessment from CPT Results		



<b>Client</b> Tonkin & Taylor Ltd Environmental & Engineering Consultants	<b>Client Project</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City	<b>Drawn</b> CPT-CBD-32	<b>Date</b> 6/12/2011
		<b>LOS NUMBER</b> 52000.301	<b>Analysed</b> RAP
<b>Liquefaction Assessment from CPT Results</b>		<b>Checked</b> AFF	<b>Checked</b> AFF





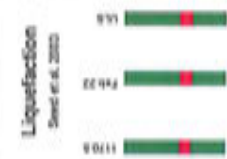
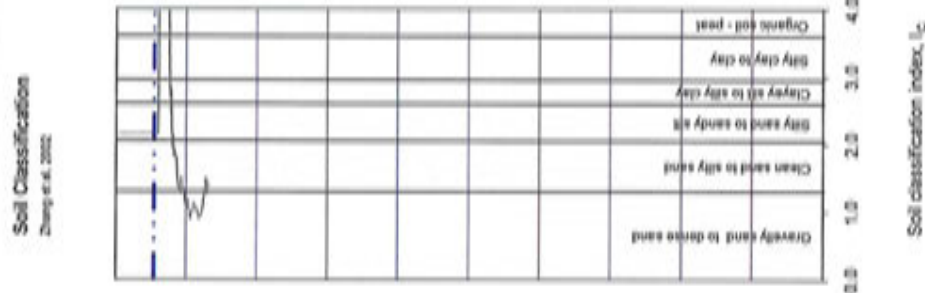
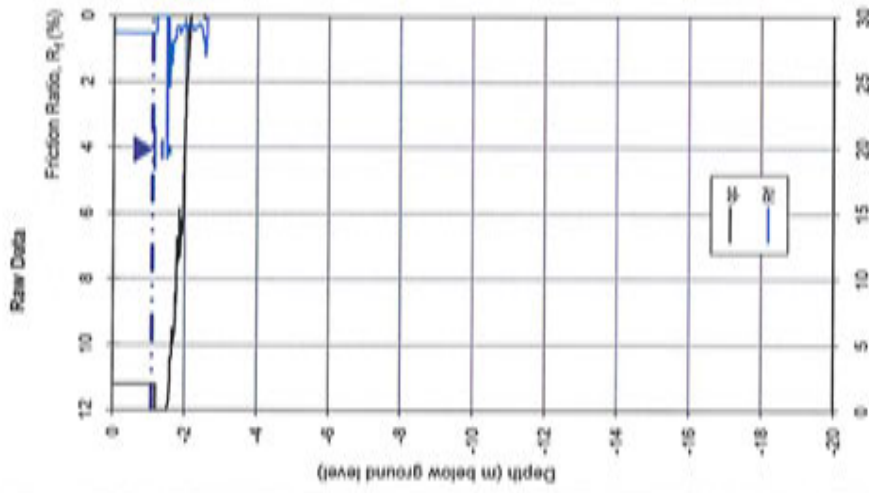
**Tonkin & Taylor Ltd**  
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**CLIENT PROJECT**  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

**TITLE**  
Liquefaction Assessment from CPT Results

**PROJECT NUMBER**  
CPT-CBD-32

**DATE** 17/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
**DATE** AFF



CPT tip resistance,  $q_c$  (MPa)

**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
0.25	7.5	500
0.52	6.2	-
0.34	7.5	500

**Thickness of liquefied layers (m)**  
Seed et al. 2002

0.1
0.1
0.2

**Liquefaction FOS**

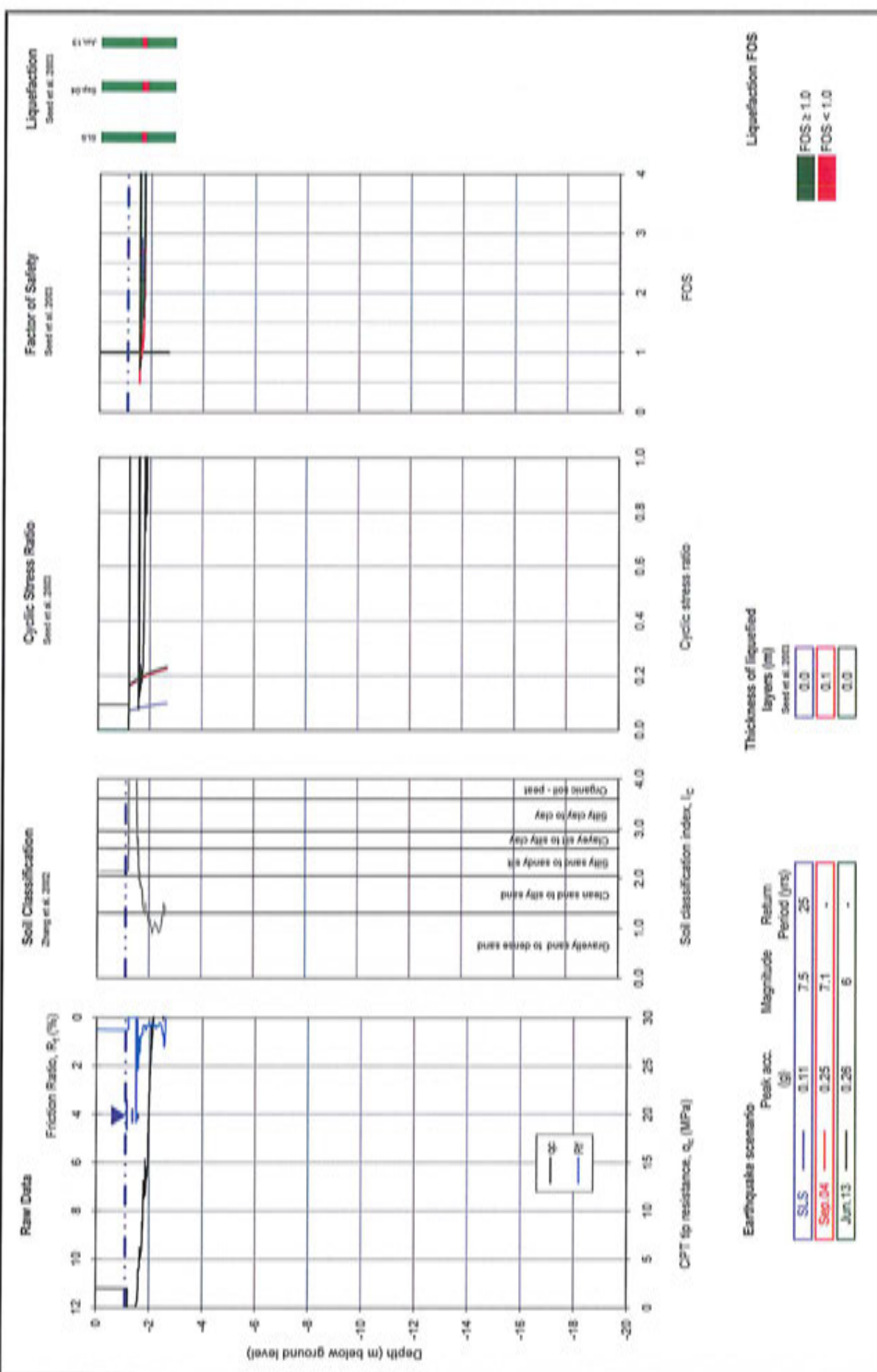
FOS  $\geq$  1.0 (Green)  
FOS  $<$  1.0 (Red)



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CLIENT PROJECT	LOCATION
Christchurch City Council Geotechnical Assessment for Christchurch Central City	<b>CPT-CBD-33</b>
FILE	JOB NUMBER 52000.301

DATE	6/12/2011
ANALYSED	RAP
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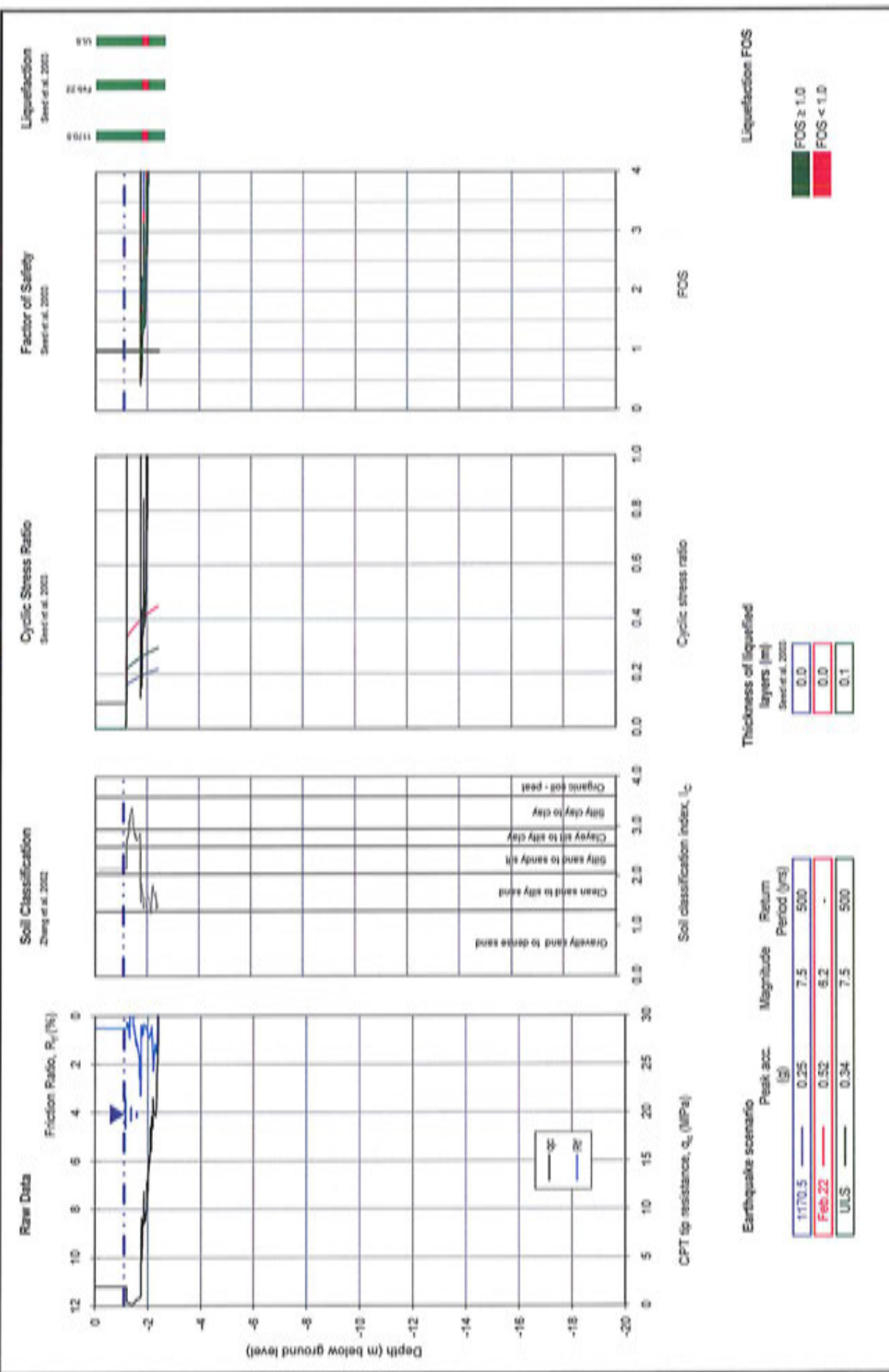
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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**CPT-CBD-33**  
JOB NUMBER: 52000\_301

DATE: 27/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
AFF

Liquefaction Assessment from CPT Results





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Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

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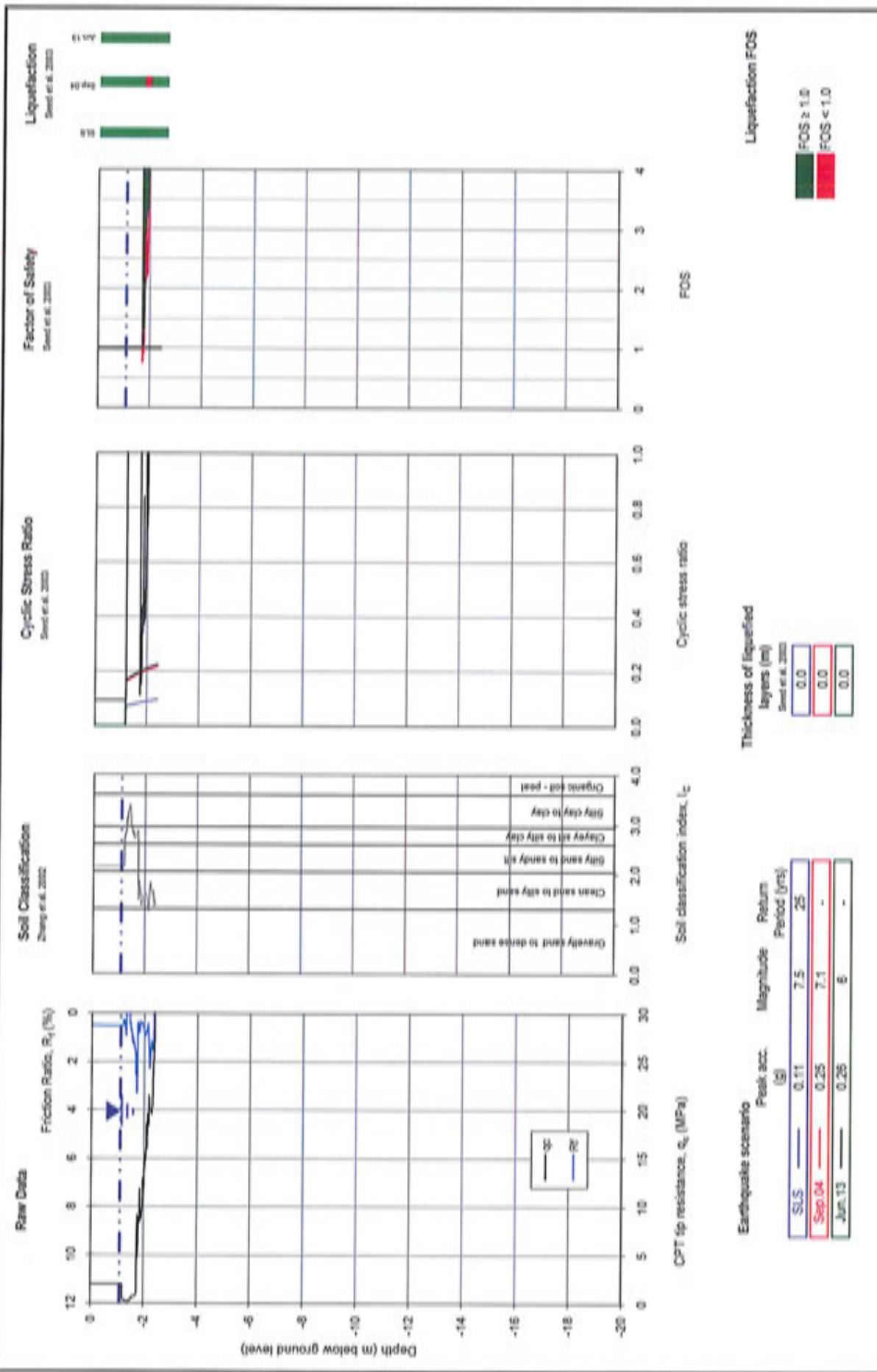
CLIENT PROJECT


**CPT-CBD-34**

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Liquefaction Assessment from CPT Results





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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

DATE: 7/12/2011  
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CLIENT PROJECT

**Christchurch City Council**

**CPT-CBD-34**

DATE: 7/12/2011  
ANALYSED: RMP  
CHECKED: AFT

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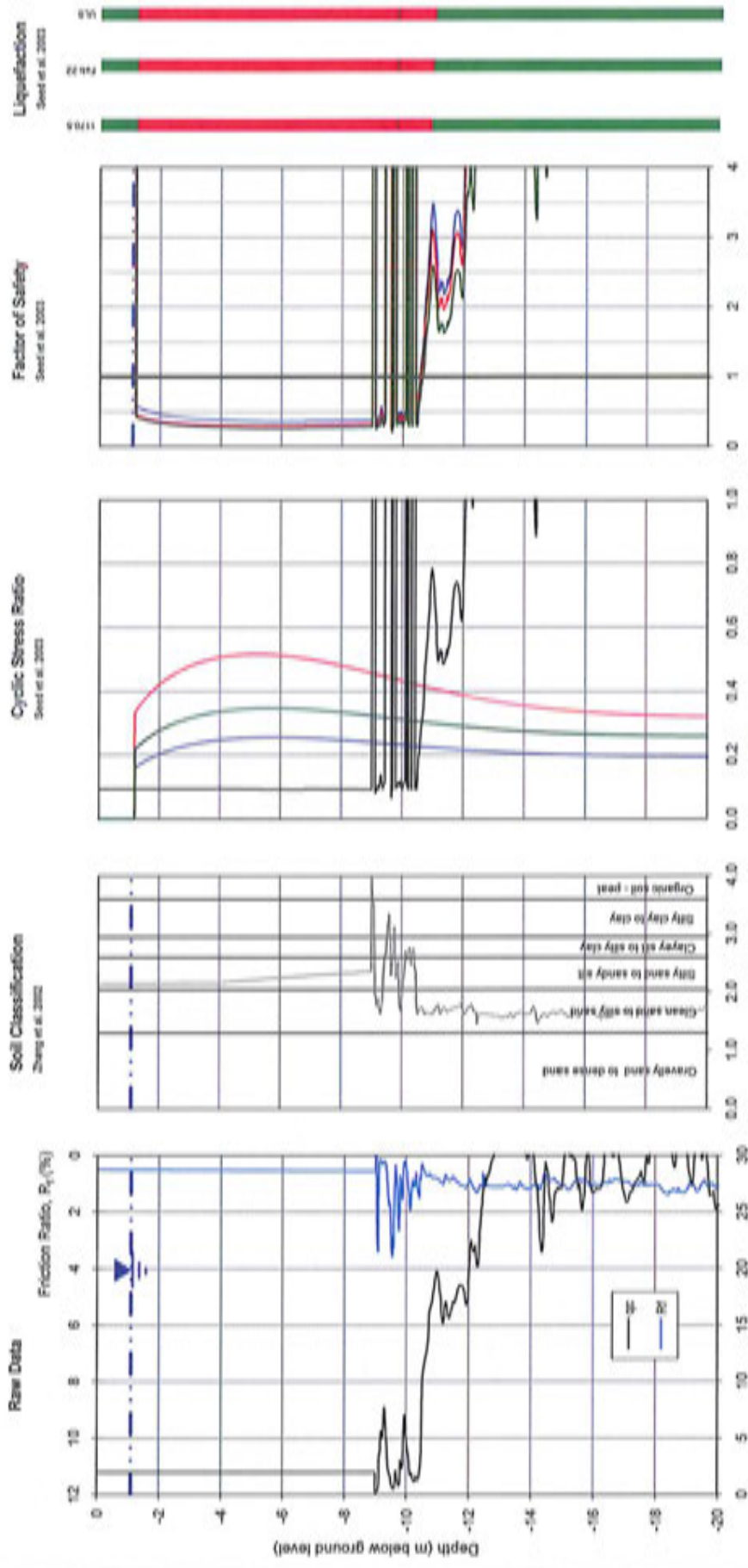
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Environmental & Engineering Consultants

**CLIENT PROJECT**  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

**LOCATION**  
CPT-CBD-34P

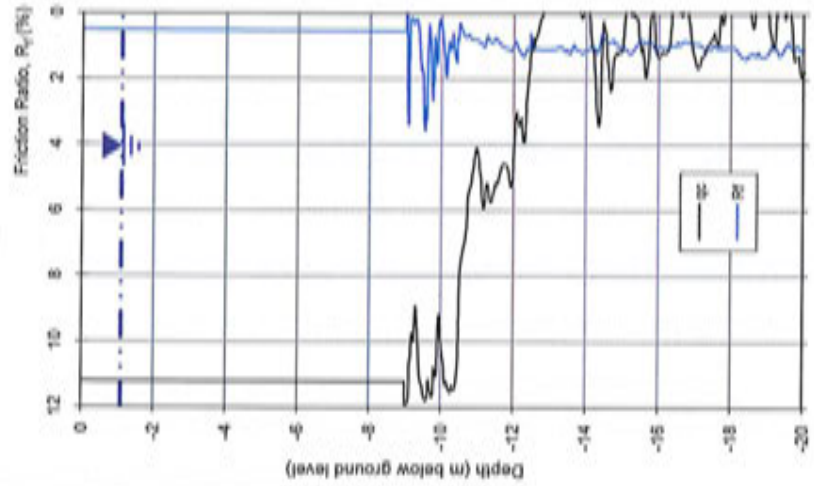
**JOB NUMBER**  
52000.301

**DATE**  
5/12/2011

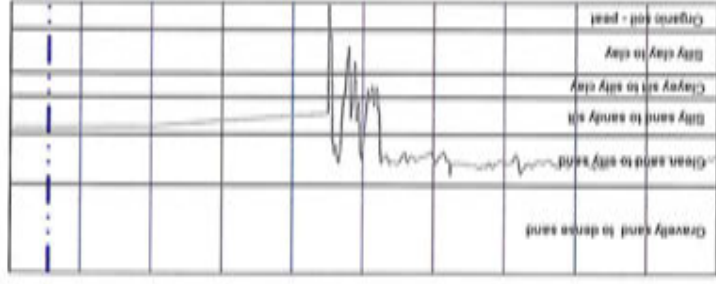
**ANALYSED**  
RAP

**CHECKED**  
AFF

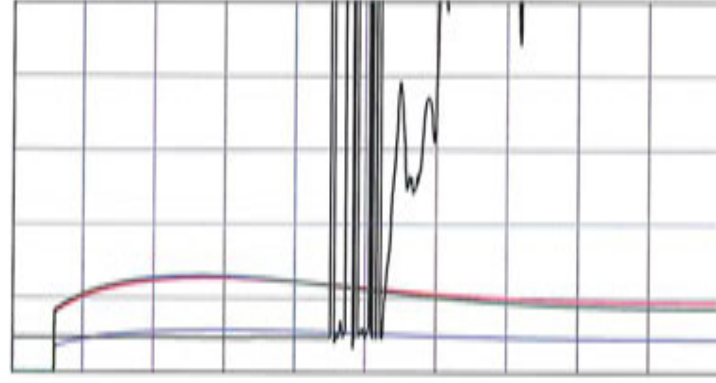
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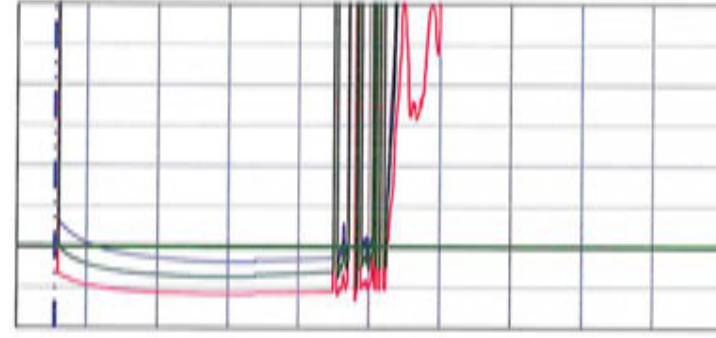
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Exp 04	0.25	7.1	-
Jan. 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
7.2
8.8
8.7

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



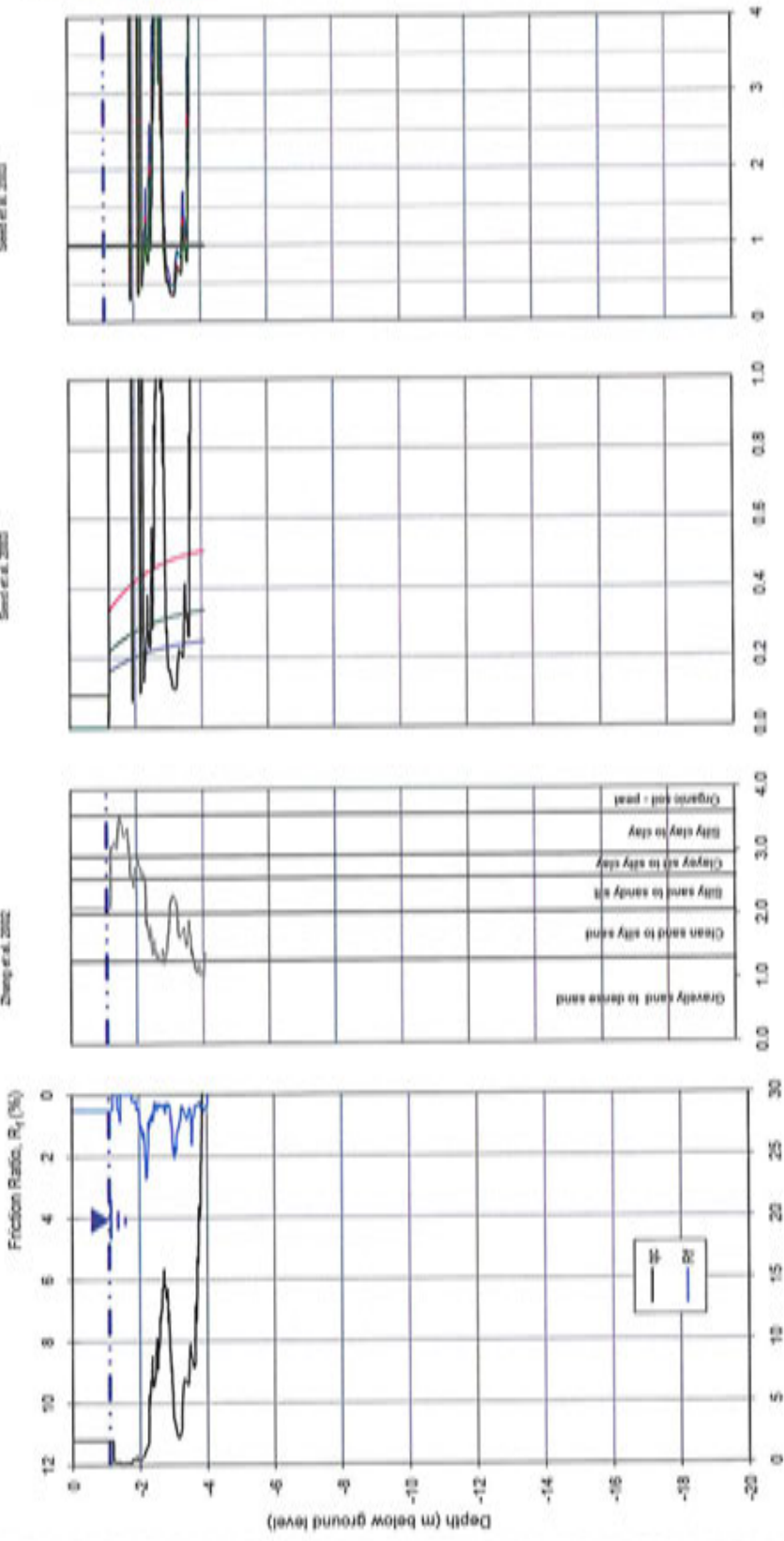
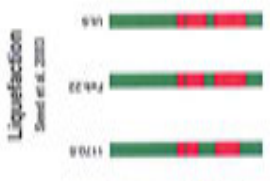
Toekin & Taylor Ltd  
Environmental & Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-34P

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
JOB NUMBER: S2000\_301

Liquefaction Assessment from CPT Results

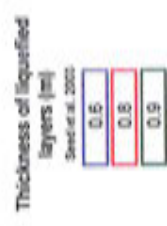


FOS

Cyclic stress ratio

Soil classification index,  $I_c$

CPT tip resistances,  $q_t$  (MPa)



**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
U.S.	7.5	500



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CLIENT PROJECT

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

LOCATION

**CPT-CBD-35**

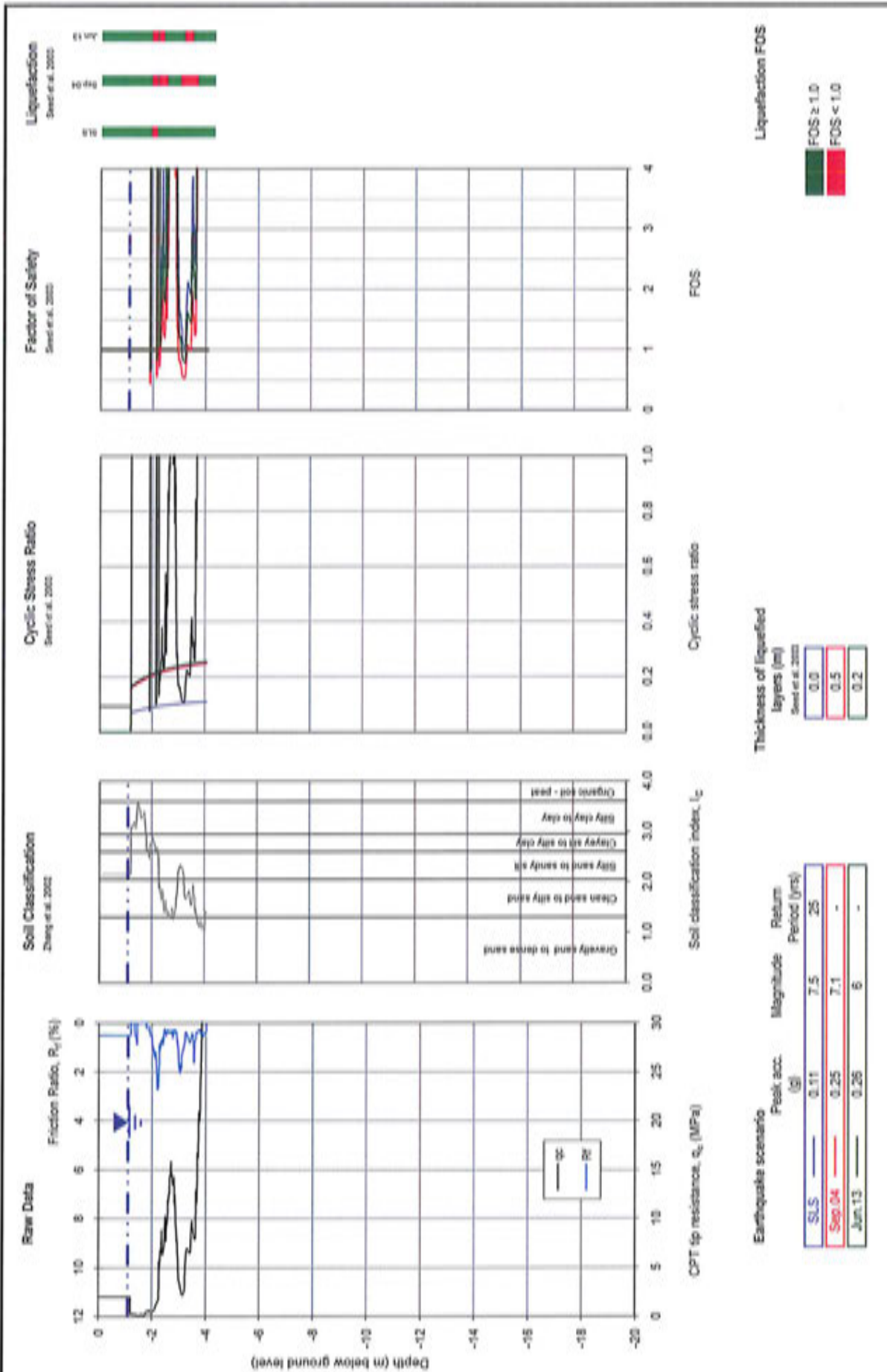
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S2000\_301

DATE  
8/12/2011

ANALYSED  
RAP

CHECKED  
AFF

Liquefaction Assessment from CPT Results



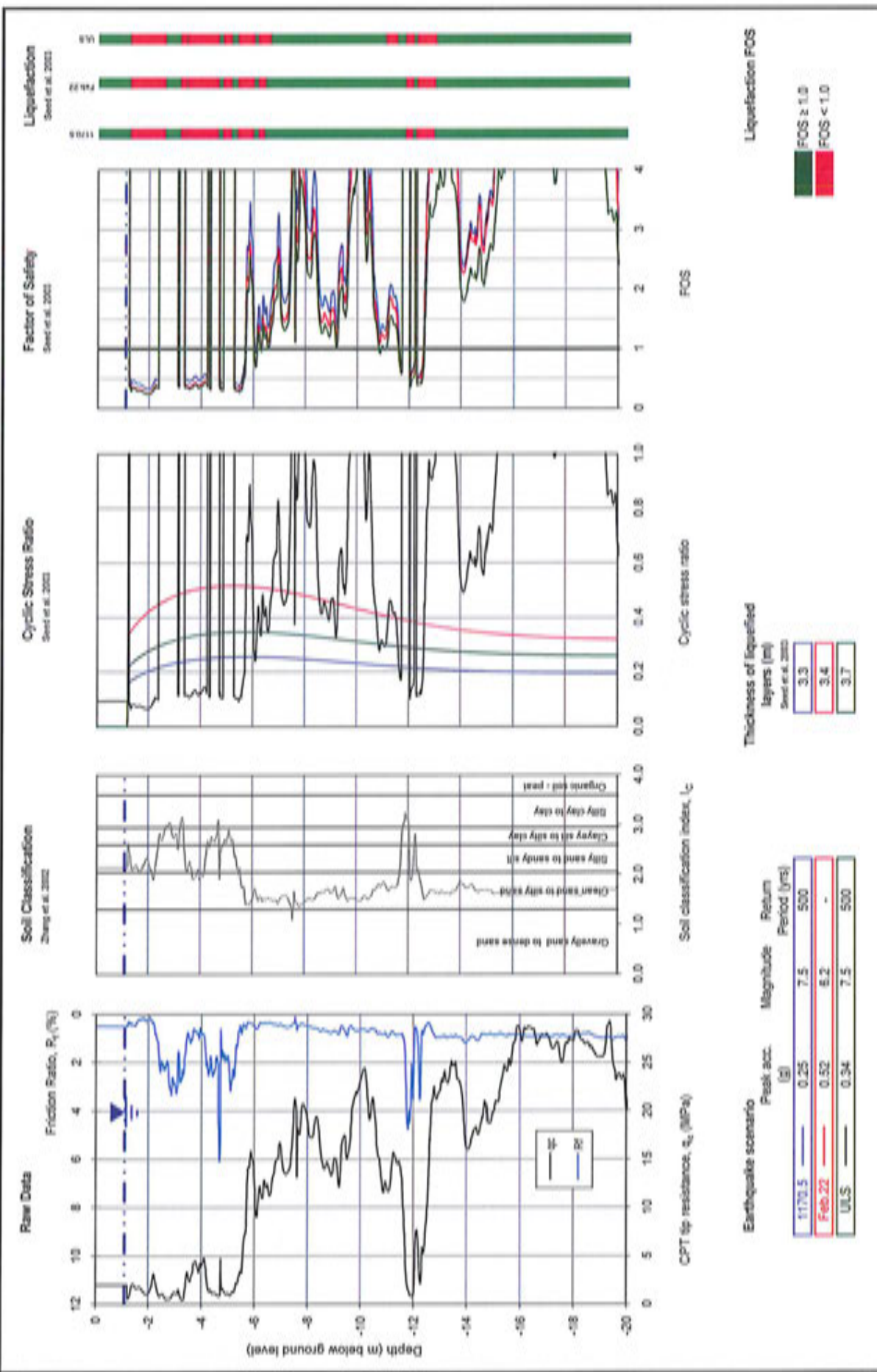
**Tronkin & Taylor Ltd**  
Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**CPT-CBD-35**  
JOB NUMBER: S2000.301

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Liquefaction Assessment from CPT Results



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Environmental & Engineering Consultants

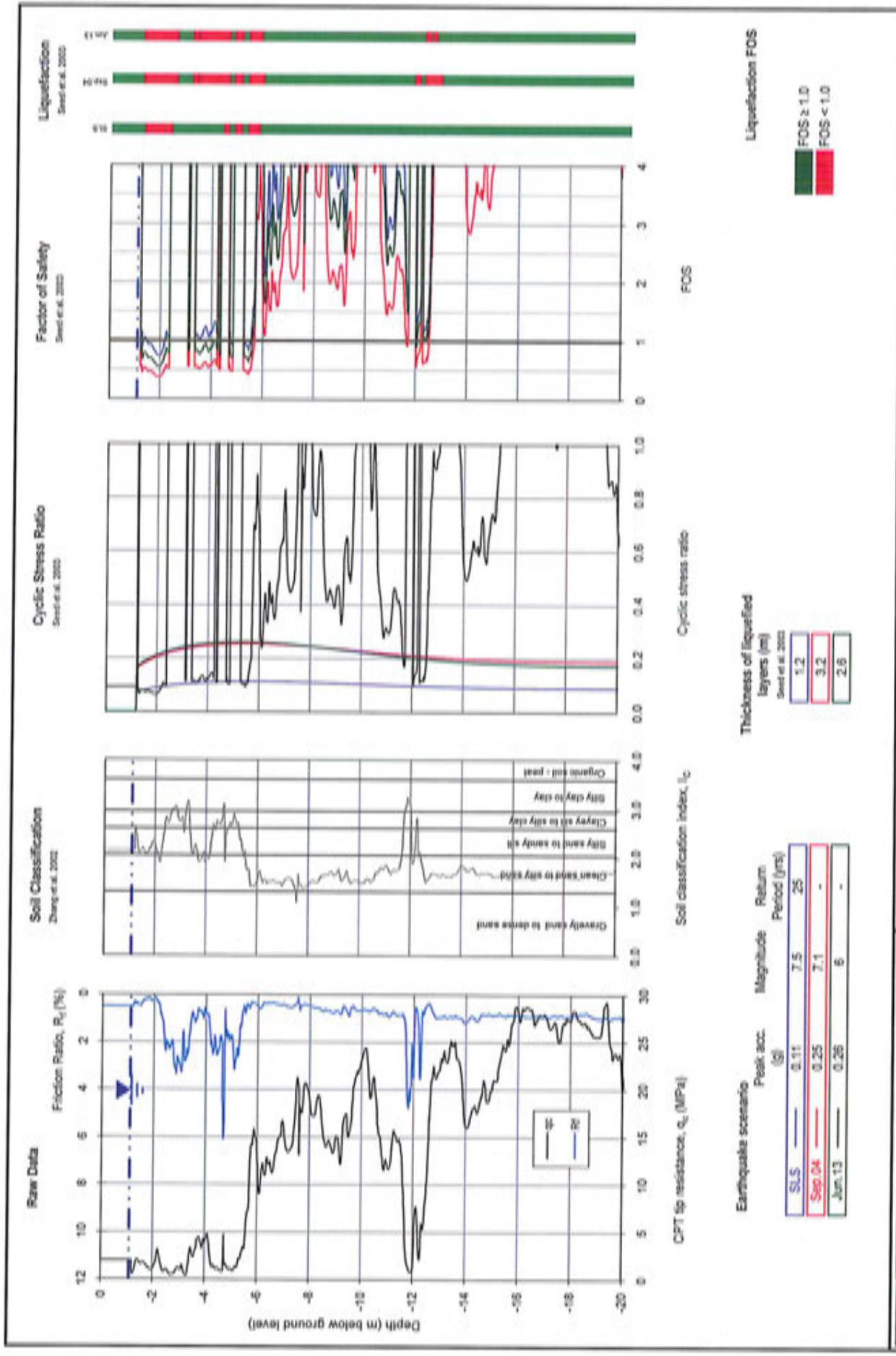
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

Location: **CPT-CBD-36**

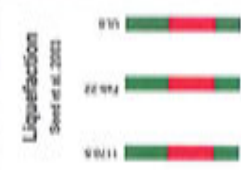
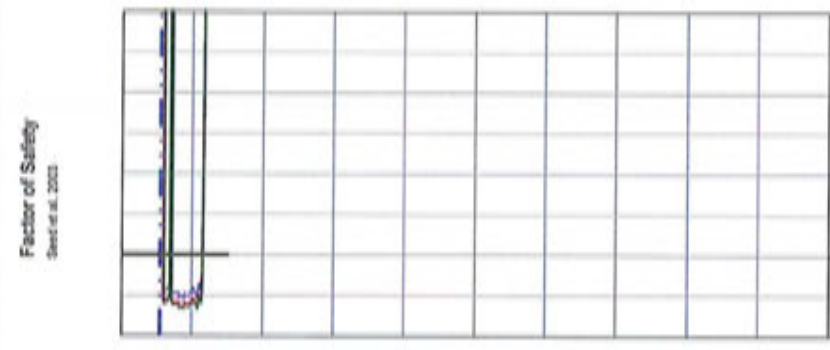
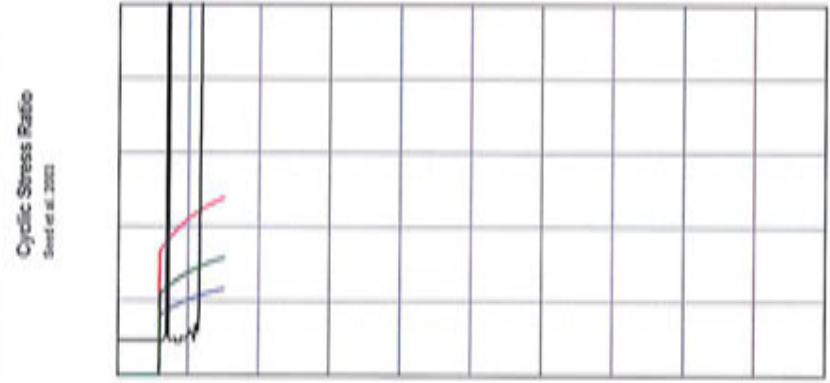
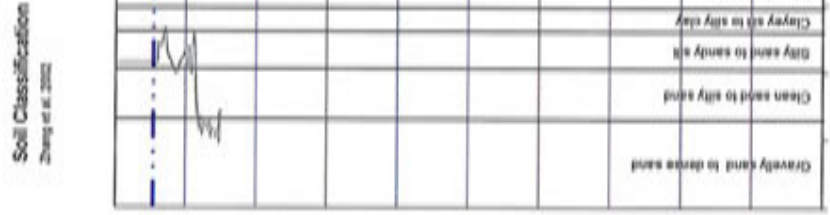
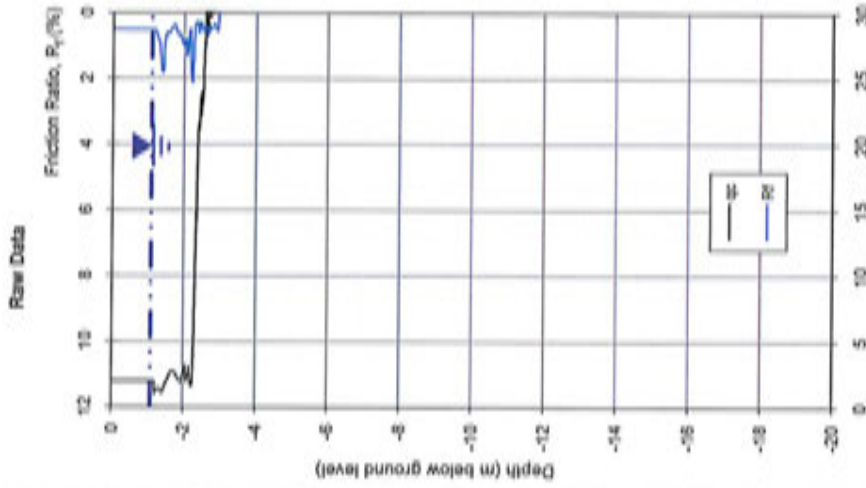
Job Number: **52000.301**

Title: **Liquefaction Assessment from CPT Results**

DATE: 6/12/2011  
ANALYSED: RAB  
CHECKED: AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City Liquefaction Assessment from CPT Results	<b>LOCATION</b> <b>CPT-CBD-36</b>	<b>DATE</b> 7/12/2011 <b>ANALYSED</b> RAP <b>CHECKED</b> AFF
		<b>JOB NUMBER</b> 52000.301	



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

**Earthquake scenario**

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
11/0.5	0.25	7.5	500
Feb. 22	0.52	6.2	-
ULS	0.34	7.5	500

**Thickness of liquefied layers (m)**  
Seed et al. 2002

1.0
1.0
1.1

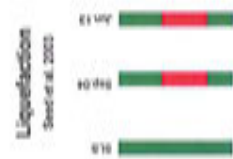
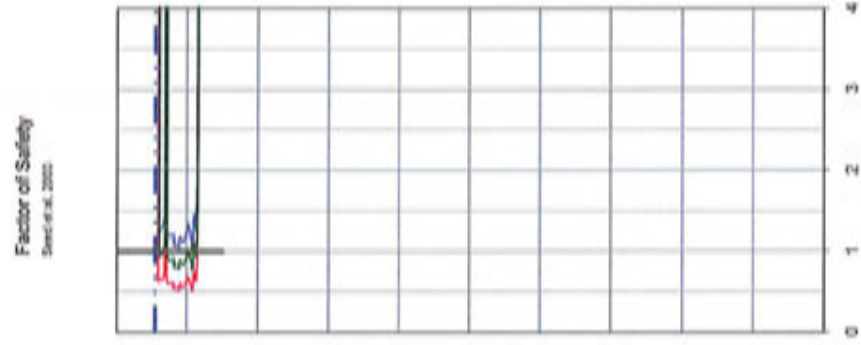
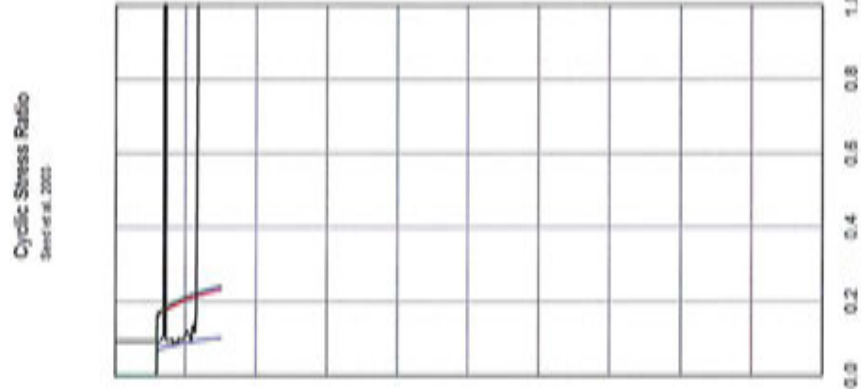
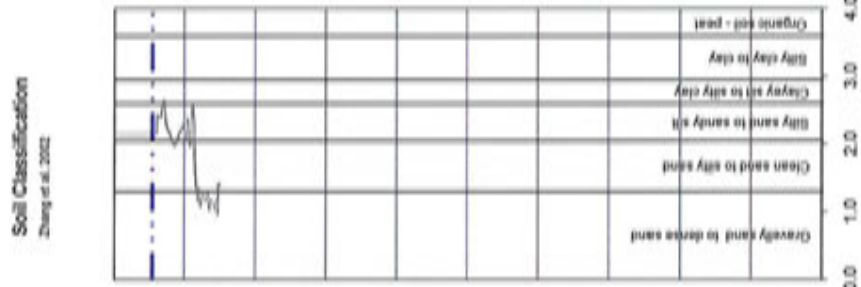
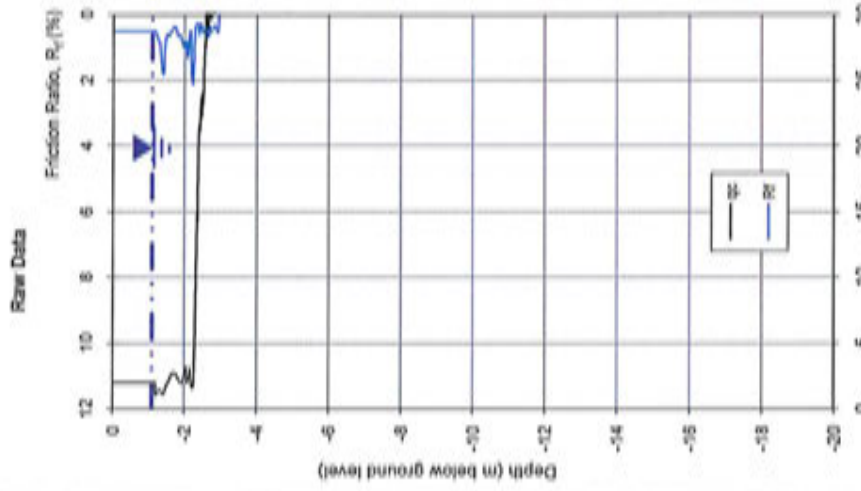
**Liquefaction FOS**

FOS $\geq$ 1.0
FOS $<$ 1.0



**T & T**  
Environmental & Engineering Consultants

CLIENT PROJECT	PROJECT	DATE	ANALYSED	CHECKED	DATE
Christchurch City Council Geotechnical Assessment for Christchurch Central City	<b>CPT-CBD-37</b>	6/12/2011	RAP	RAP	6/12/2011
Liquefaction Assessment from CPT Results	LOT NUMBER	52000.301	CHECKED	AFF	



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jan 13	0.25	6	-

Thickness of liquefied layers (m)

Scenario	Thickness (m)
SLS	0.0
Sep 04	1.0
Jan 13	0.9

Liquefaction FOS

Scenario	FOS
SLS	≥ 1.0
Sep 04	< 1.0
Jan 13	< 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-37

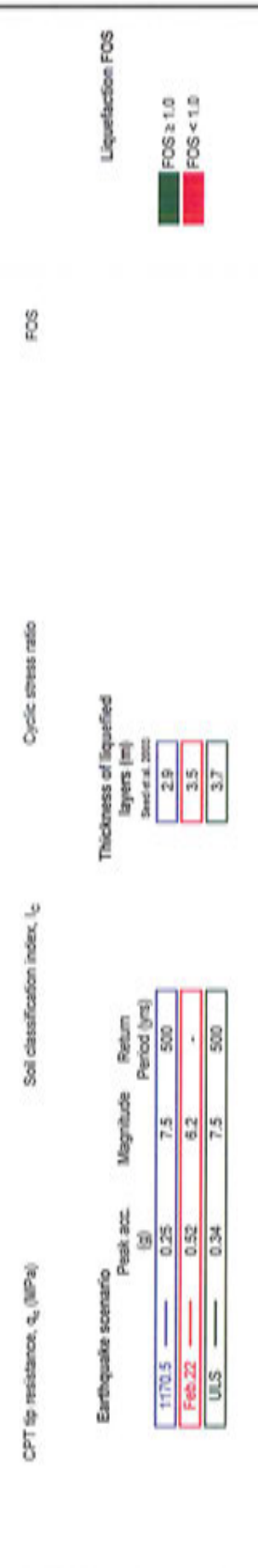
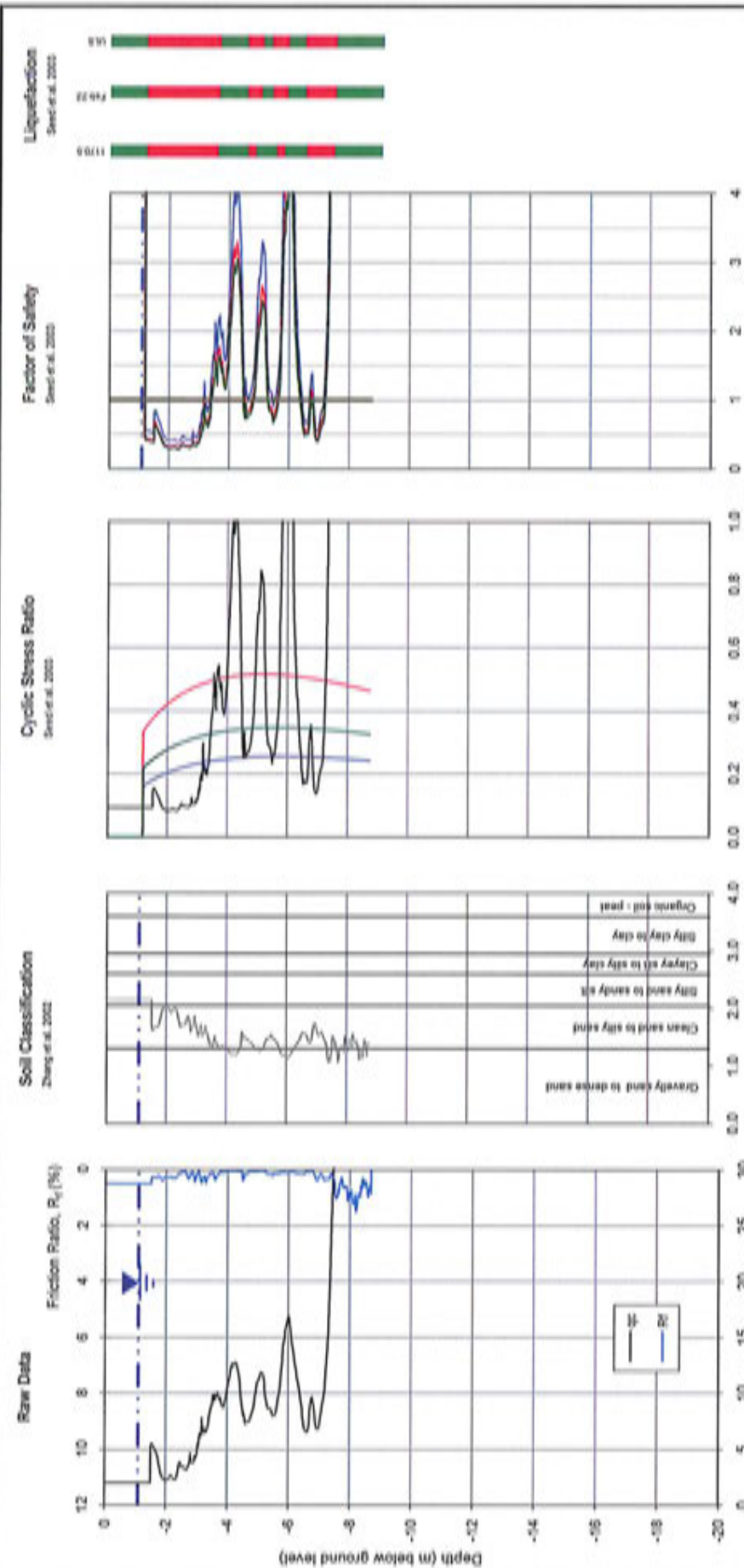
JOB NUMBER


52000.301

Liquefaction Assessment from CPT Results

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF







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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

CLIENT PROJECT: **CPT-CBD-37P**

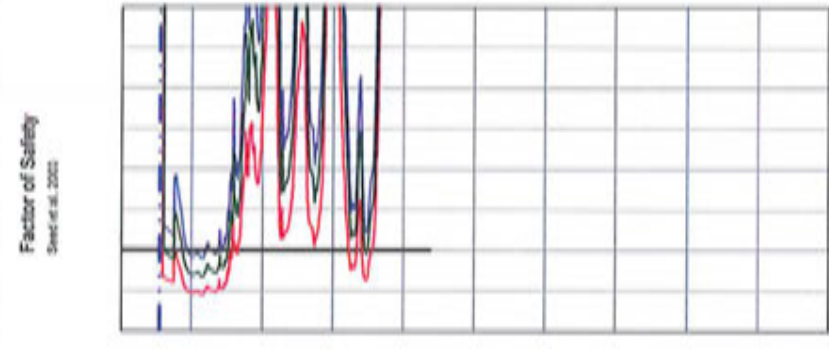
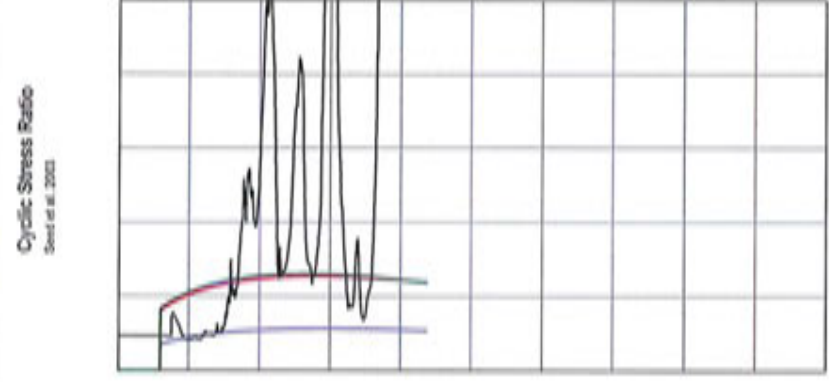
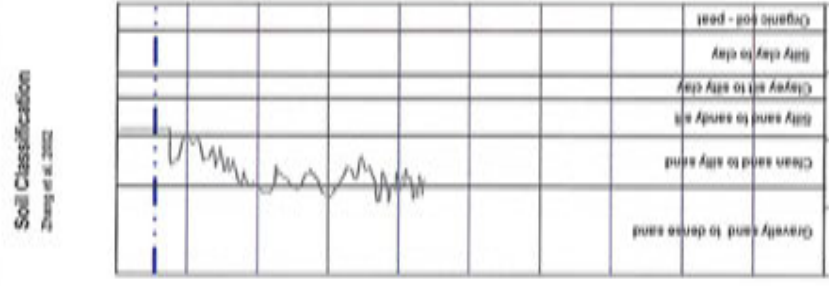
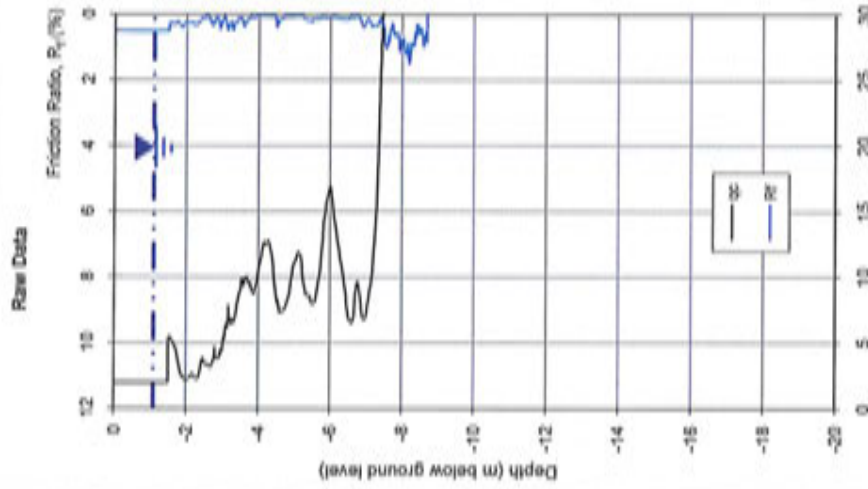
DATE: 6/12/2011

ANALYSED: RAP

CHECKED: AFF

JOB NUMBER: 52000.301

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.26	6	-

Thickness of liquefied layers (m)

0.7
2.5
1.8

Liquefaction FOS

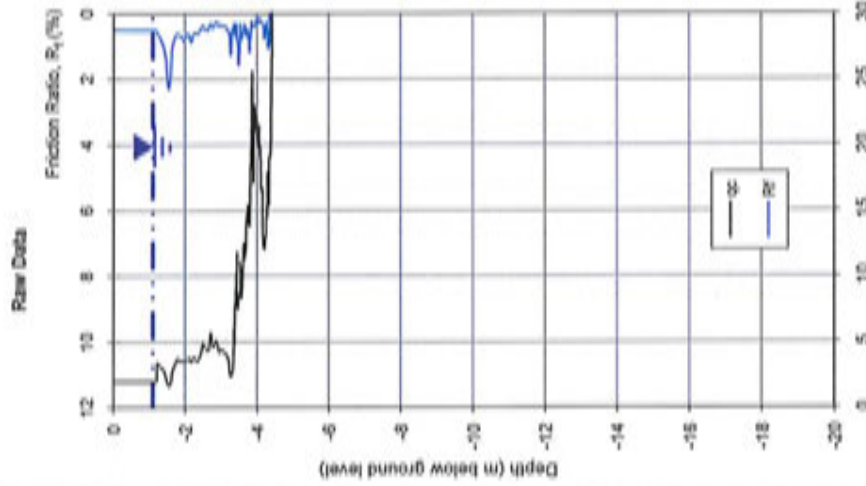
FOS $\geq$ 1.0
FOS $<$ 1.0



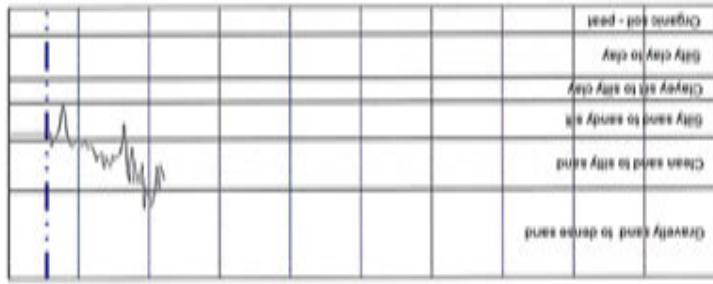
**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

CLIENT PROJECT	LOCATION
Christchurch City Council Geotechnical Assessment for Christchurch Central City	<b>CPT-CBD-37P</b>
DATE	7/12/2011
ANALYSED	RAP
CHECKED	AFF
JOB NUMBER	52000.301

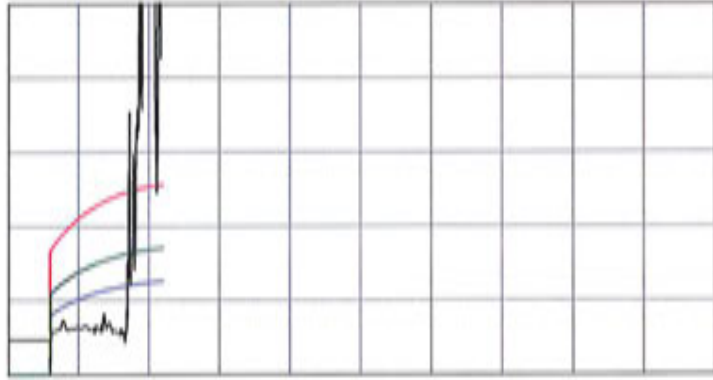
Liquefaction Assessment from CPT Results



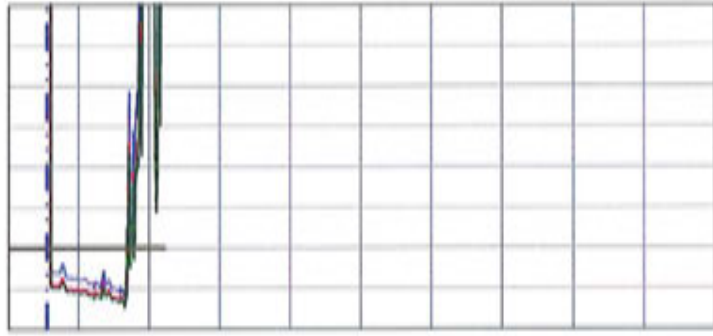
Soil Classification  
Zheng et al. 2002



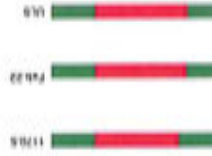
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Seed et al. 2002
2.2
2.2
2.3

Liquefaction FOS



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-38

TITLE

Liquefaction Assessment from CPT Results

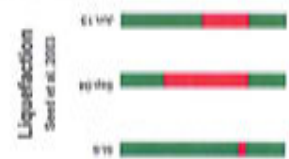
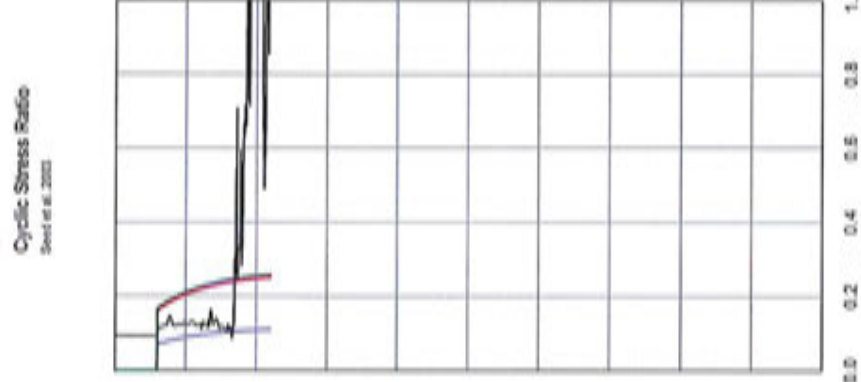
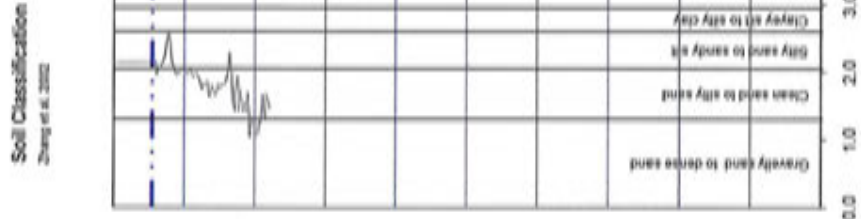
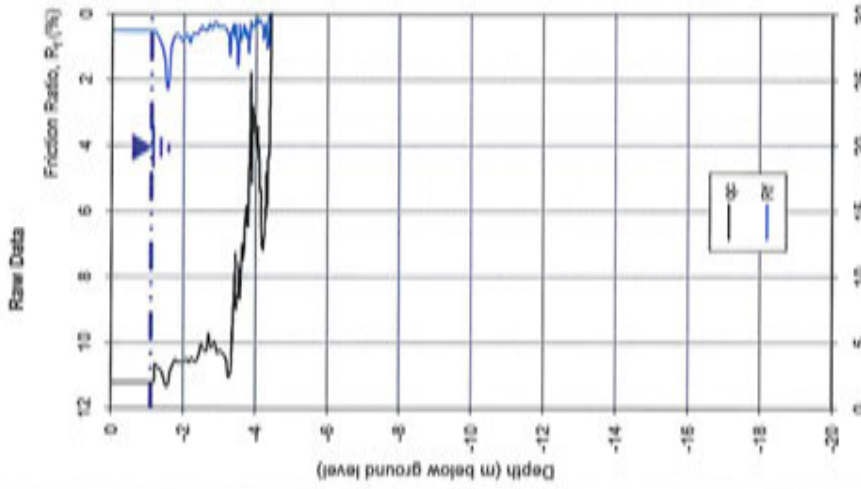
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ANALYSED  
CHECKED

DATE  
RAP  
AFF

6/12/2011



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Exp. DA	0.25	7.1	-
Exp. 13	0.25	6	-

Thickness of liquefied layers (m)

0.0
2.2
0.9



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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

LOCATION

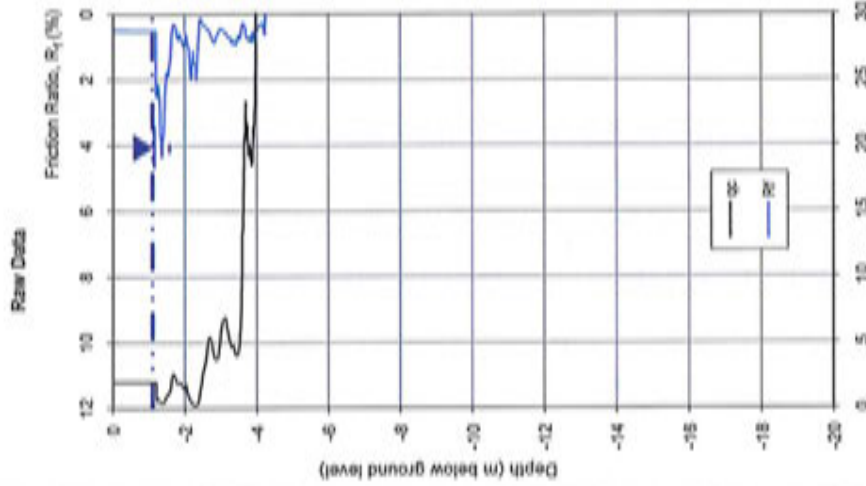
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JOB NUMBER

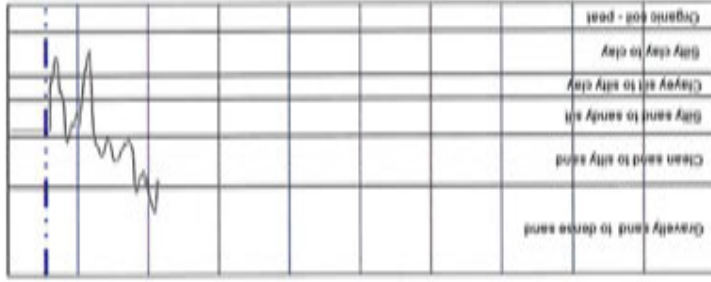
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DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF

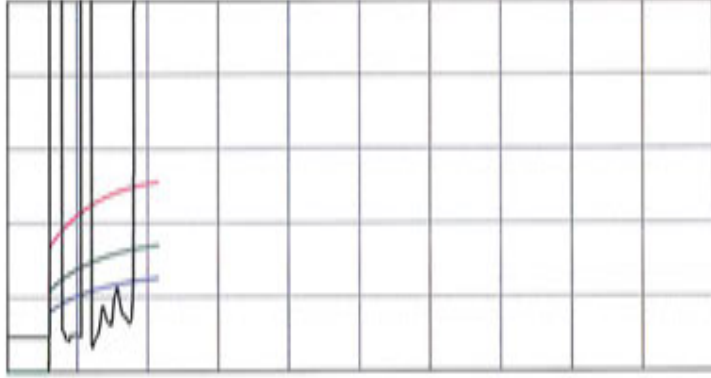
Liquefaction Assessment from CPT Results



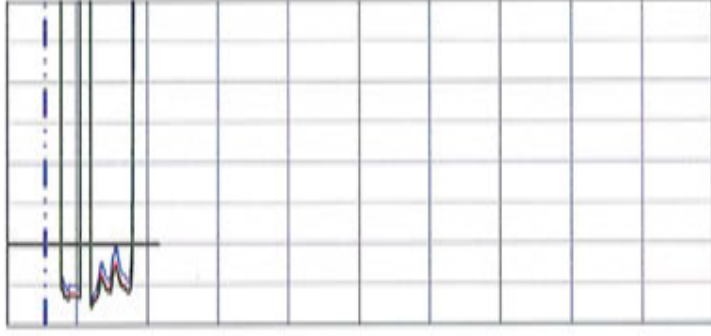
Soil Classification  
Zhang et al. 2002



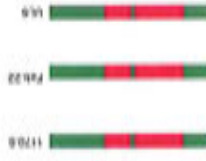
Cyclic Stress Ratio  
Seed et al. 2003



Factor of Safety  
Seed et al. 2003



Liquefaction  
Seed et al. 2003



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

1.7
1.7
1.7

Liquefaction FOS



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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-39

TITLE

Liquefaction Assessment from CPT Results

LOT NUMBER

52000-301

ANALYSED

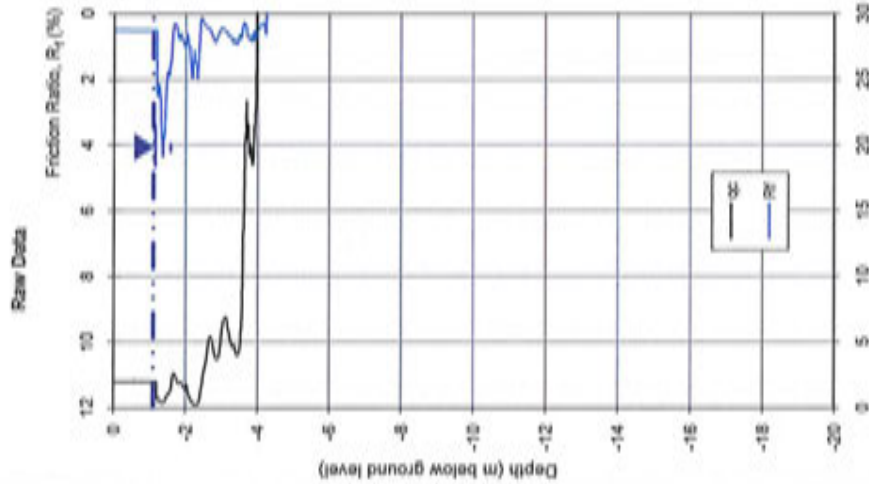
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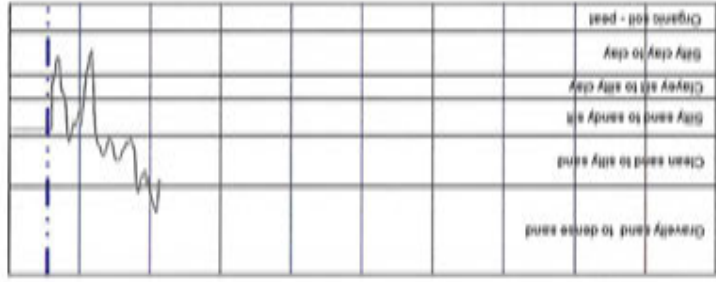
RAP

AFF

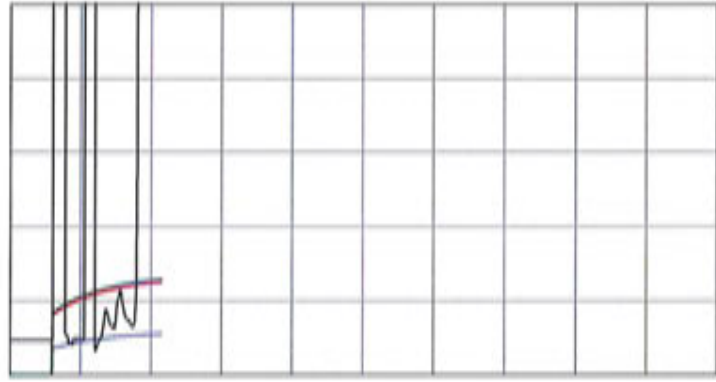
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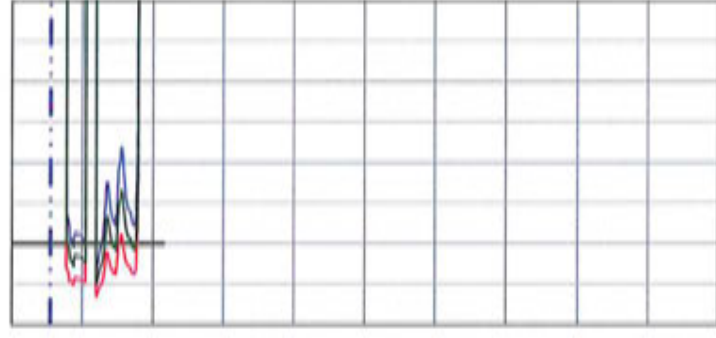
Soil Classification  
Zhang et al. 2002



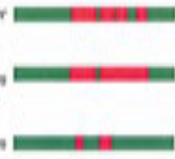
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep. 24	0.25	7.1	-
Jun. 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.2
1.5
1.0

Liquefaction FOS



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

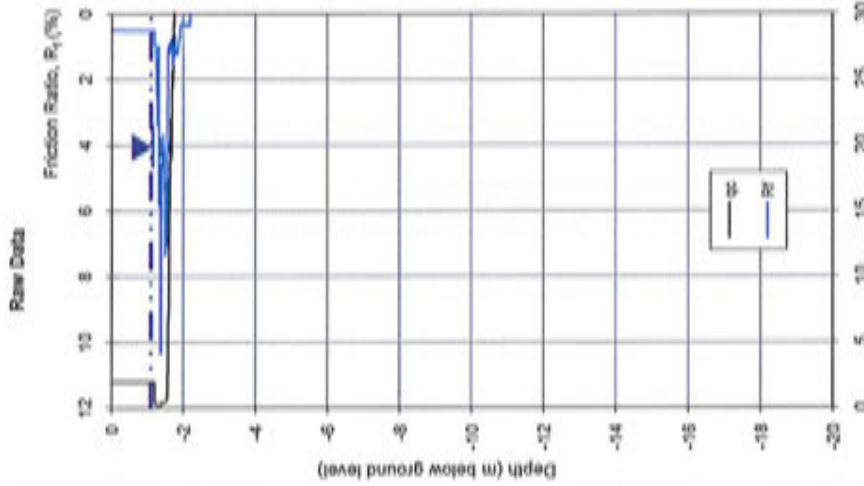
CPT-CBD-39

JOB NUMBER

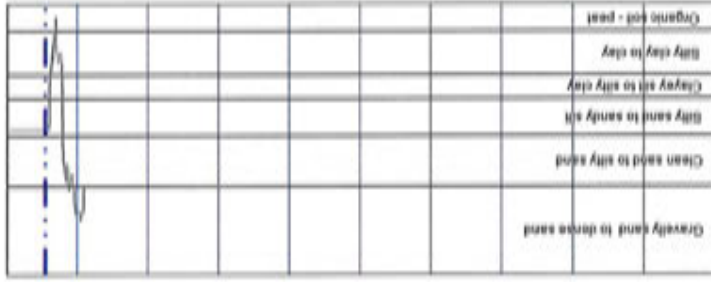
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DATE: 11/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
AFF

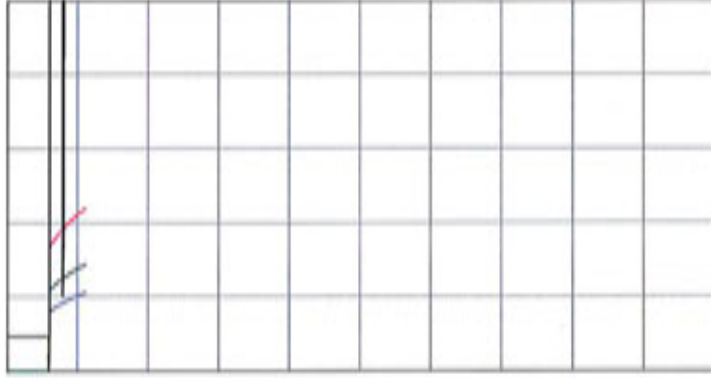
Liquefaction Assessment from CPT Results



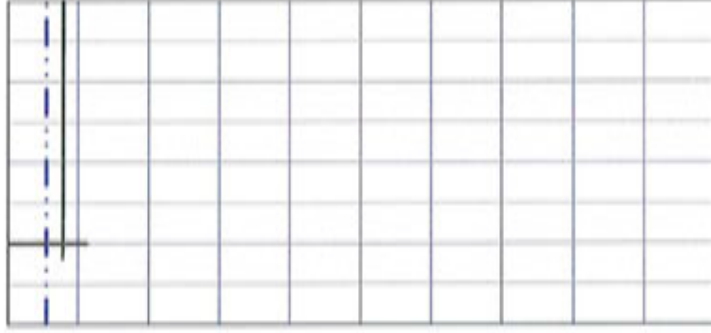
Soil Classification  
Zhang et al. 2002



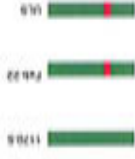
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1/170.5	0.25	7.5	500
Feb.22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.0
0.0
0.0

Liquefaction FOS



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Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-40

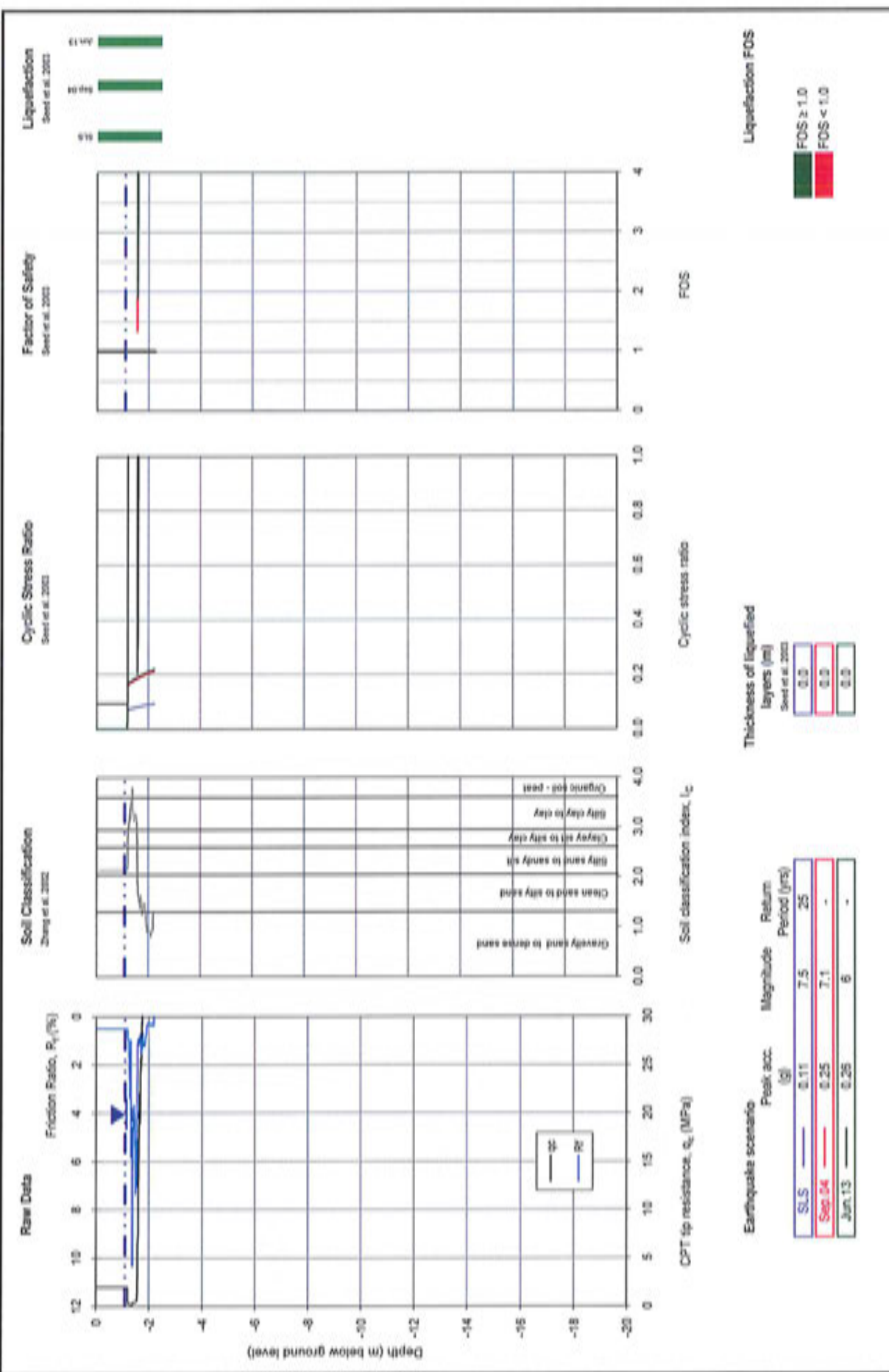
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S2000.301

DATE  
6/12/2011

ANALYSED  
RAP

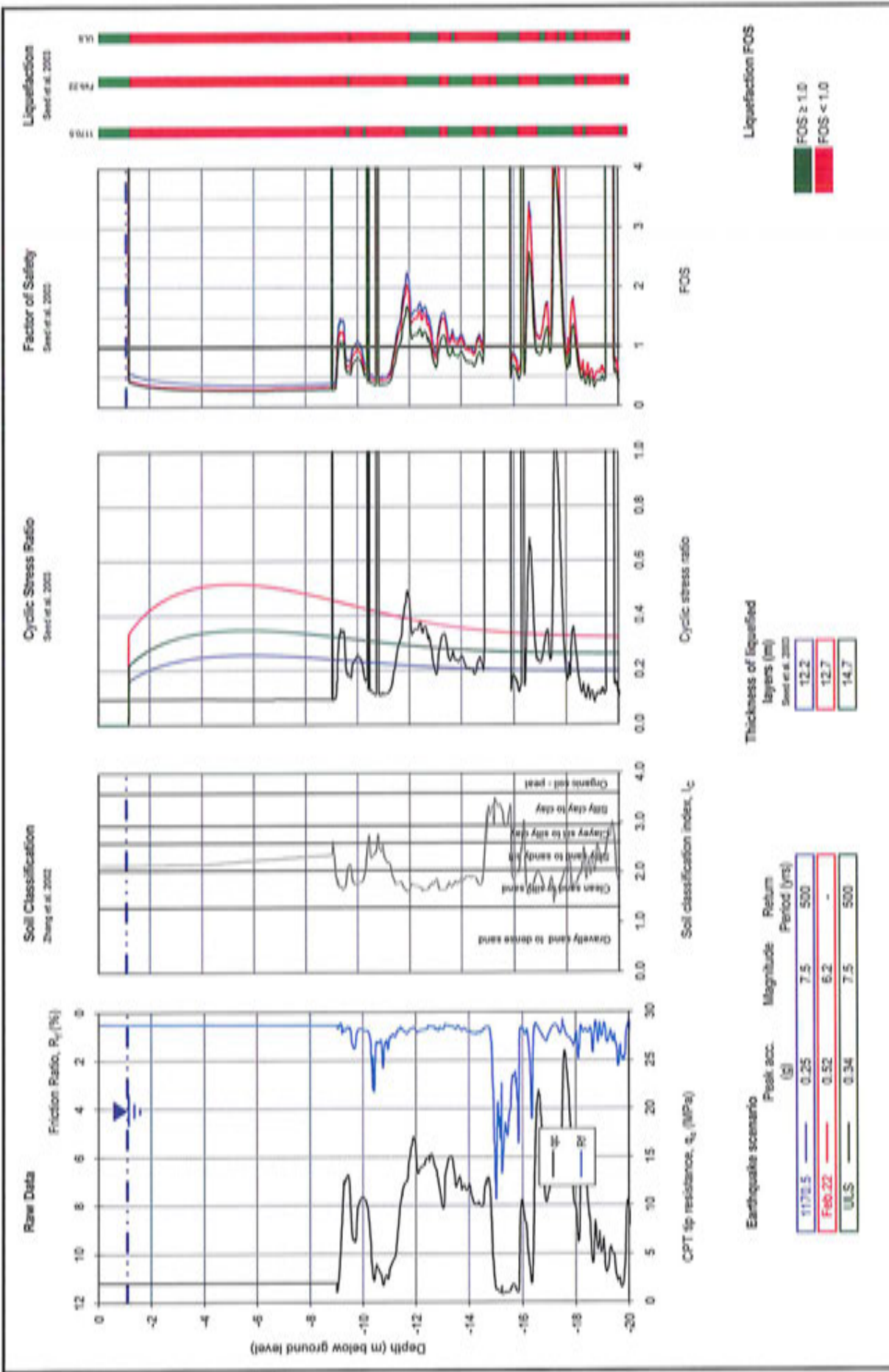
CHECKED  
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Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	DATE 7/12/2011
	FILE Liquefaction Assessment from CPT Results	ANALYSED RAP
	LOCATION <b>CPT-CBD-40</b>	CHECKED AFF
	JOB NUMBER S2000_301	

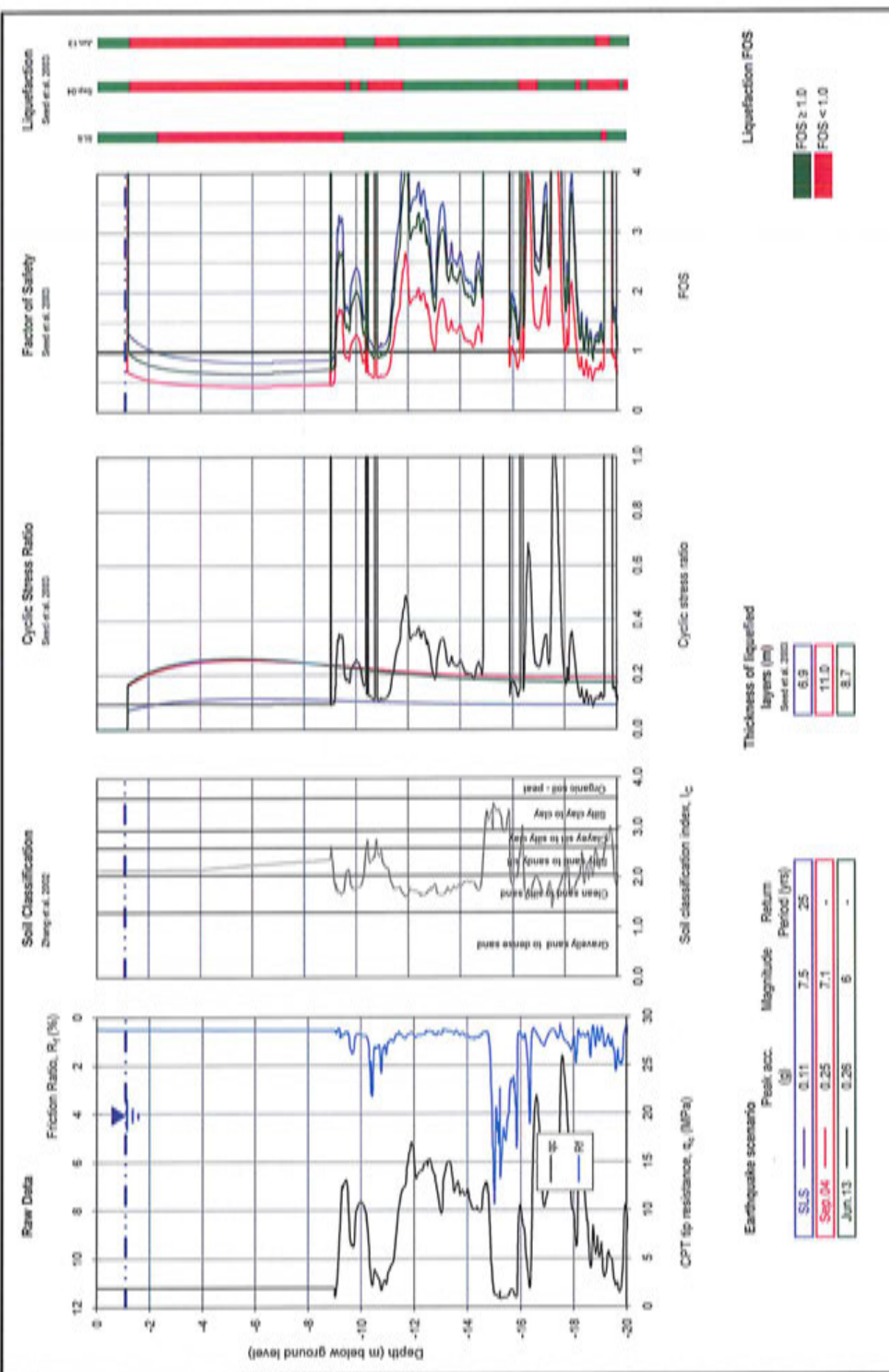




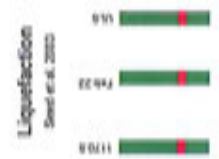
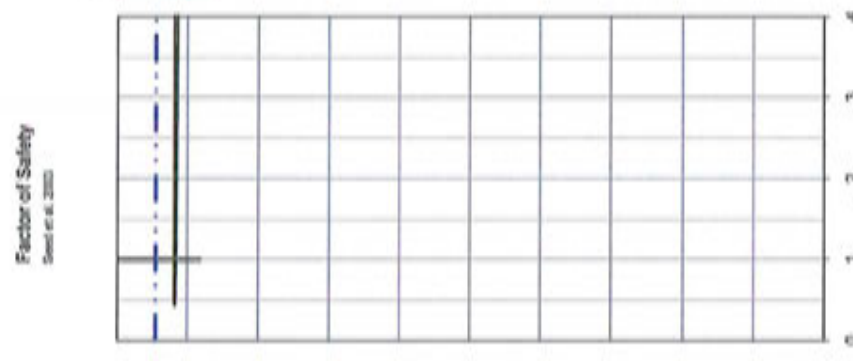
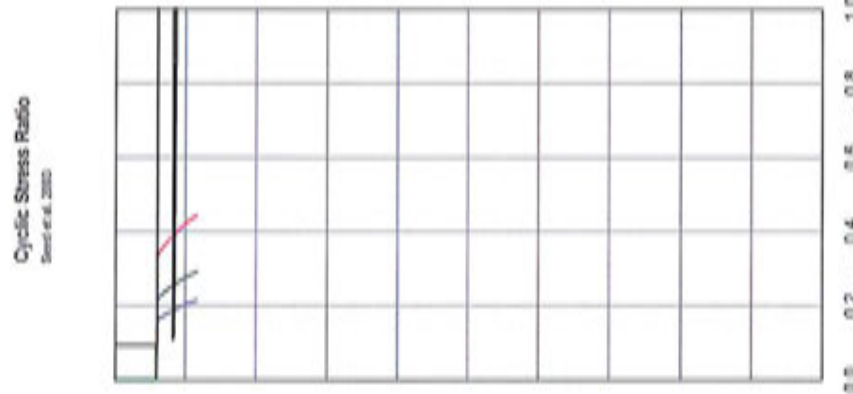
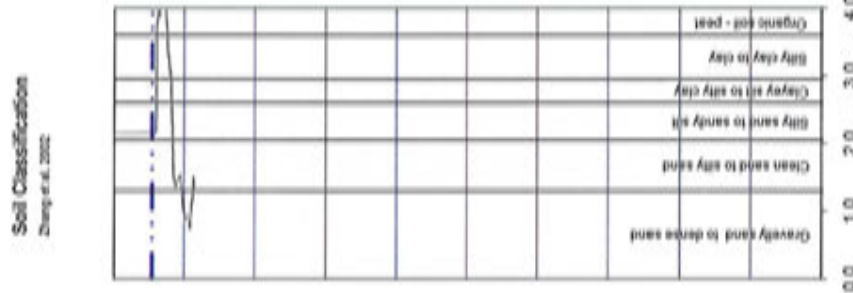
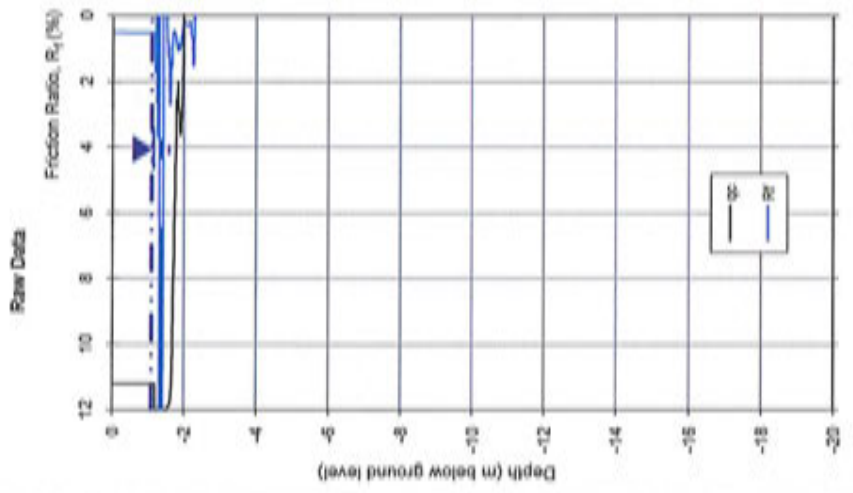
 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE 6/12/2011
	PROJECT <b>CPT-CBD-40P</b>		ANALYSED RAP
FILE Liquefaction Assessment from CPT Results		JOB NUMBER S2000_301	CHECKED AFF

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
11/7.5	0.25	7.5	500
Feb.22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)
12.2
12.7
14.7



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE: 7/12/2011 ANALYSED: RAP CHECKED: AFF
	CLIENT PROJECT: <b>CPT-CBD-40P</b>	LOCATION: Christchurch Central City	JOB NUMBER: 52000_301
TITLE: Liquefaction Assessment from CPT Results			



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1178.5	7.5	500
<b>F60.22</b>	<b>0.52</b>	<b>6.2</b>
ULS	0.34	7.5
		500

Thickness of liquefied layers (m)

0.0
0.1
0.1

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



Tonkin & Taylor Ltd  
Environmental & Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

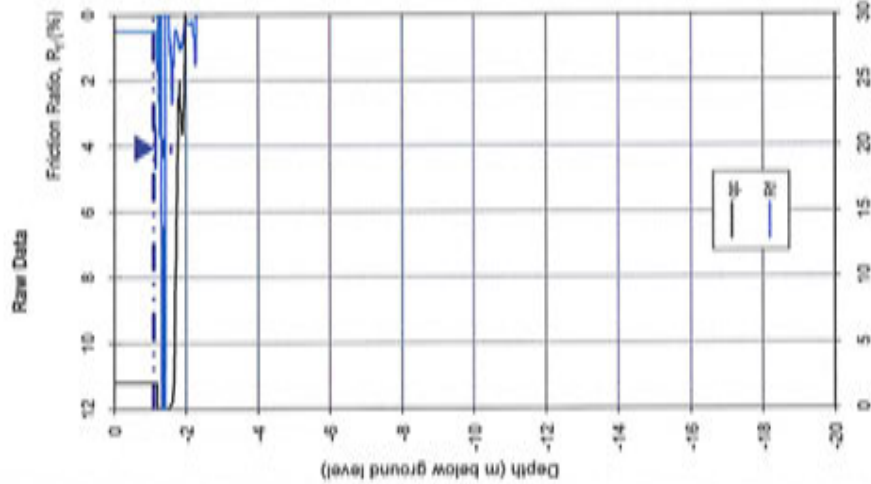
CPT-CBD-41

JOB NUMBER

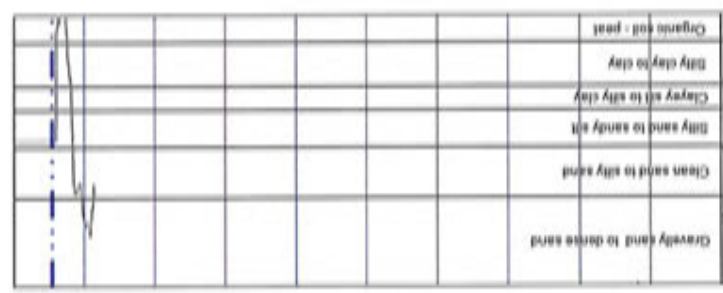
52000.301

Liquefaction Assessment from CPT Results

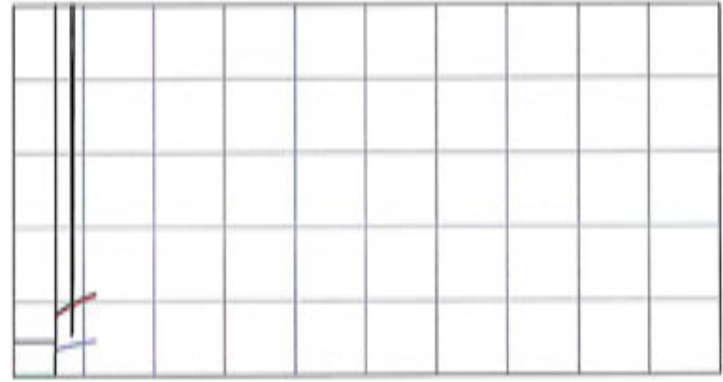
DATE 6/12/2011  
ANALYSED RAP  
CHECKED ACF



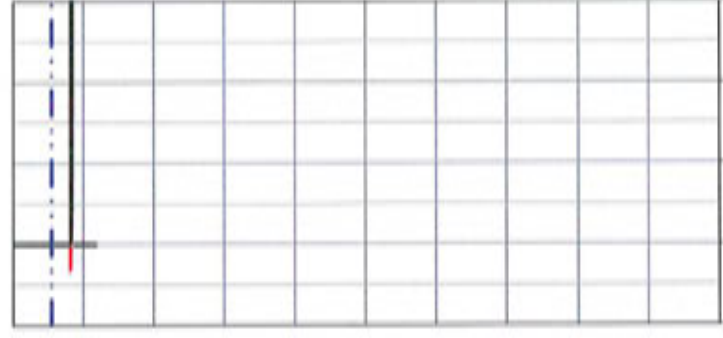
Soil Classification  
Zheng et al. 2002



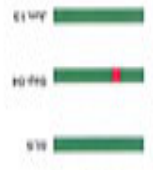
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT  $f_p$  resistance,  $f_p$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	7.5	25
Sep 04	7.1	-
Jun 13	6	-

Thickness of liquefied layers (m)

0.0
0.0
0.0

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



Tomlin & Taylor Ltd  
Environmental & Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

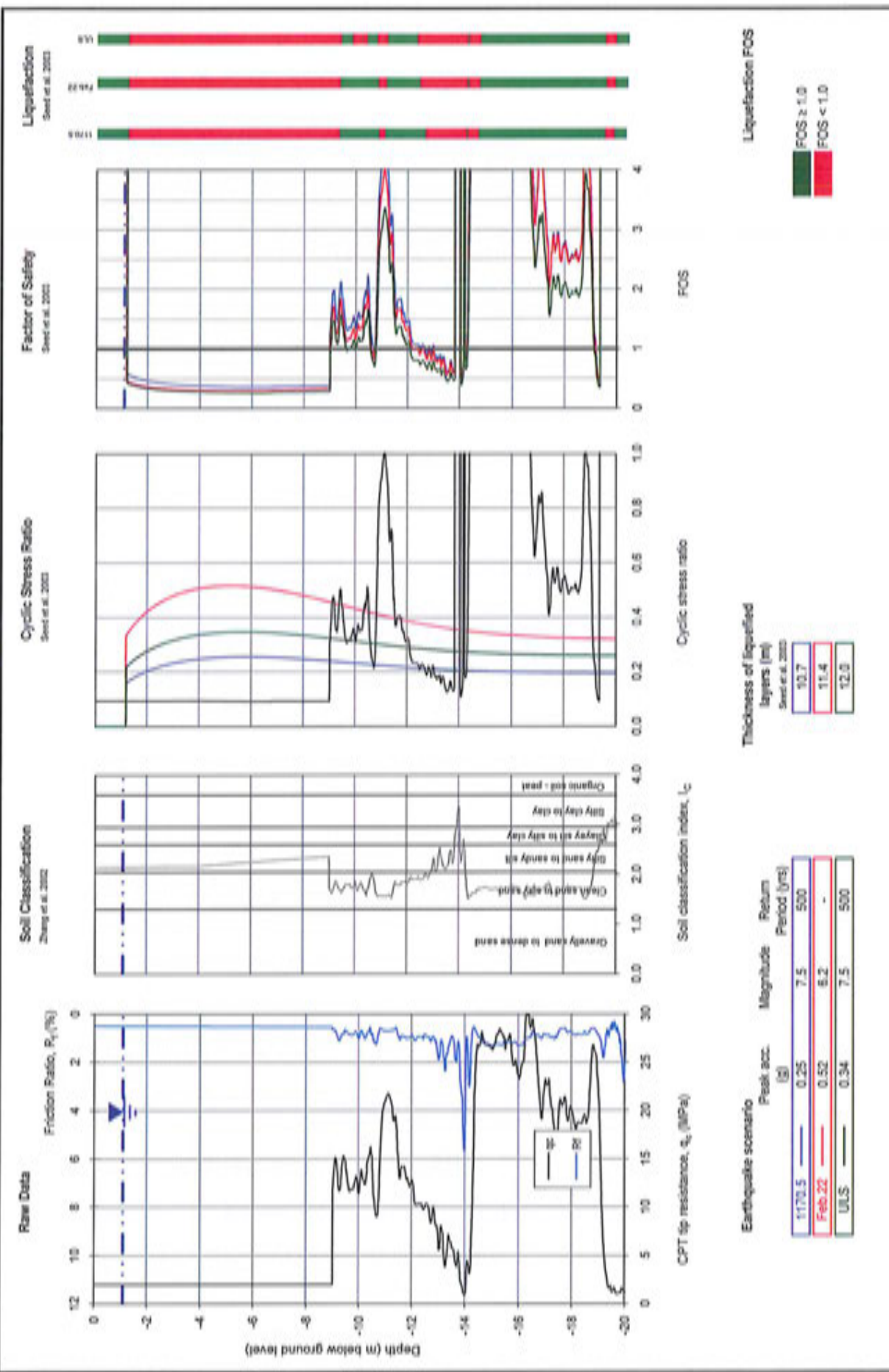
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JOB NUMBER

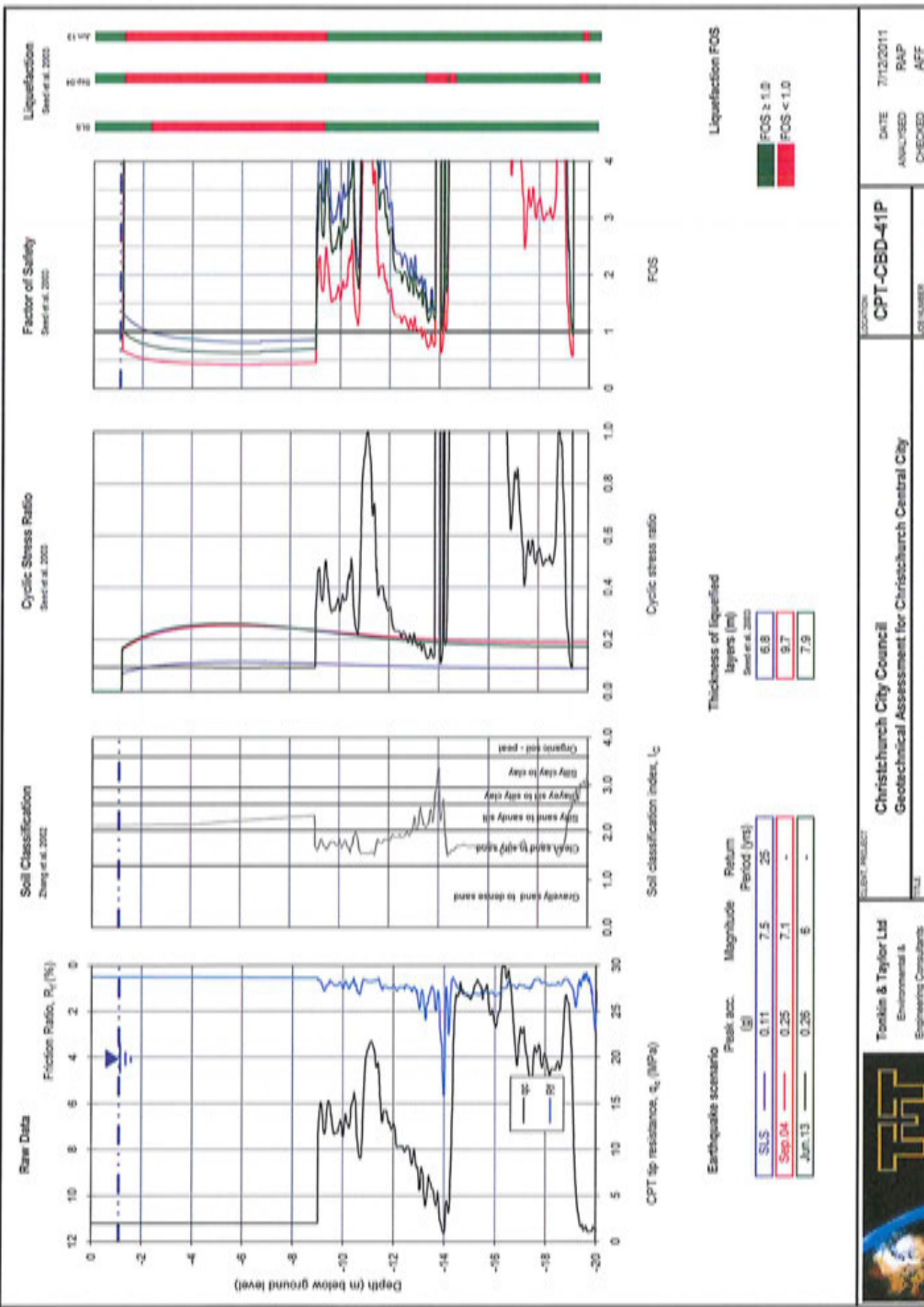
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DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City Liquefaction Assessment from CPT Results	<b>LOCATION</b> <b>CPT-CBD-41P</b>	<b>DATE</b> 6/12/2011 <b>ANALYSED</b> RAP <b>CHECKED</b> ACF
	<b>JOB NUMBER</b> 52000.301		



**Taylor & Taylor Ltd**  
Environmental & Engineering Consultants

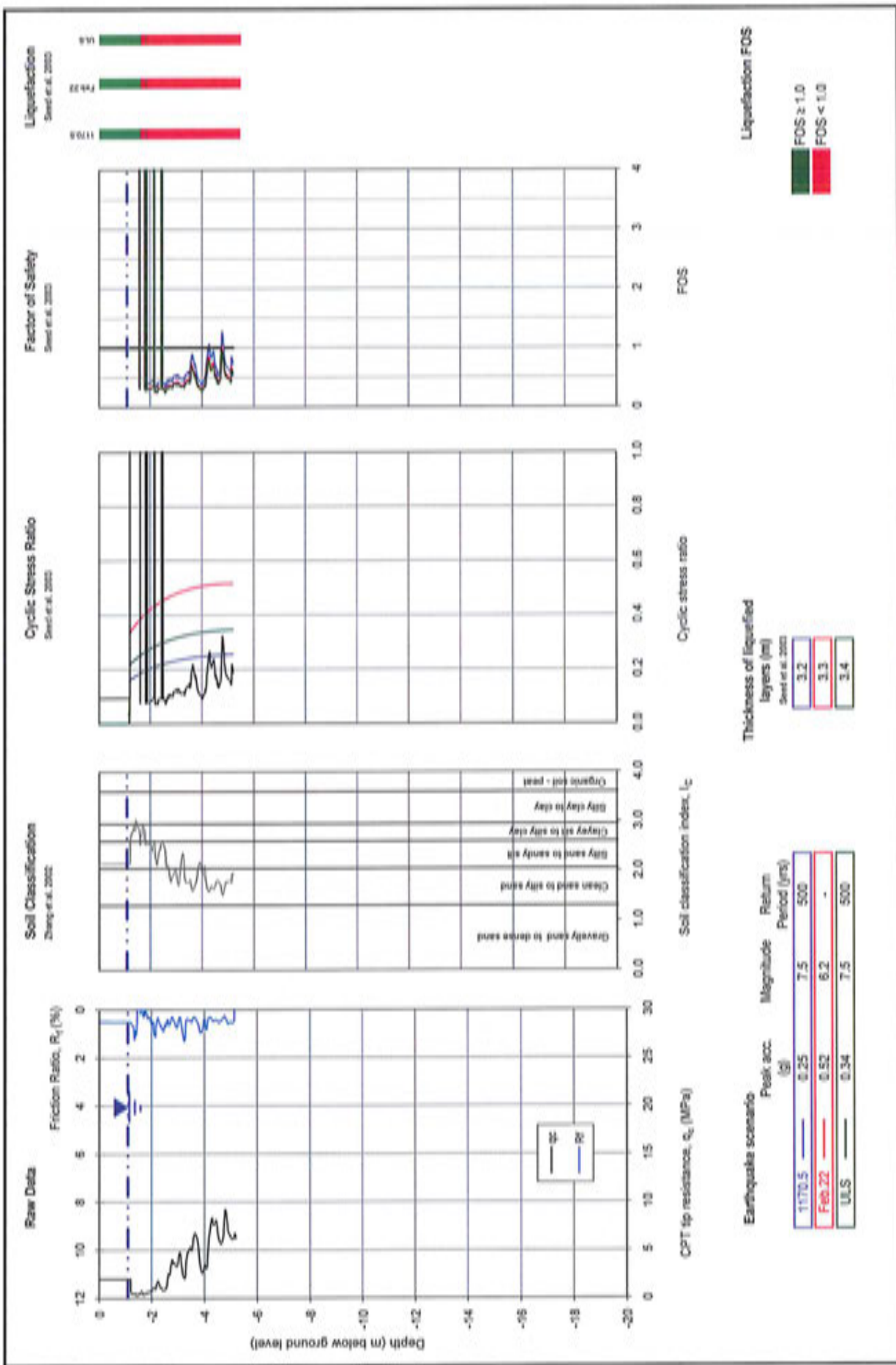
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**PROJECT**  
CPT-CBD-41P

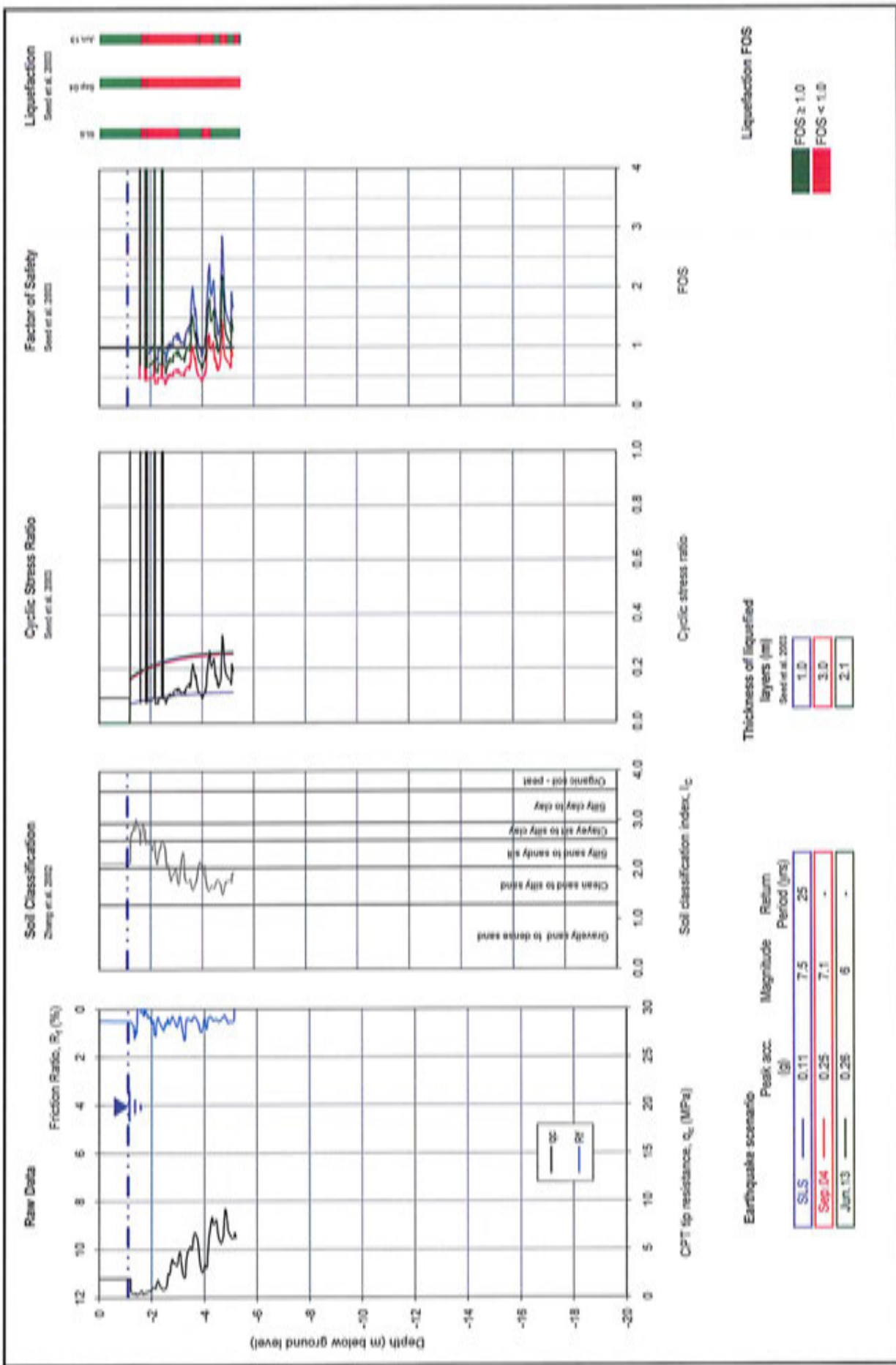
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S2000.301

**CLIENT PROJECT**

**DATE** 7/12/2011  
**ANALYSED** RHP  
**CHECKED** AFF  
**APP**

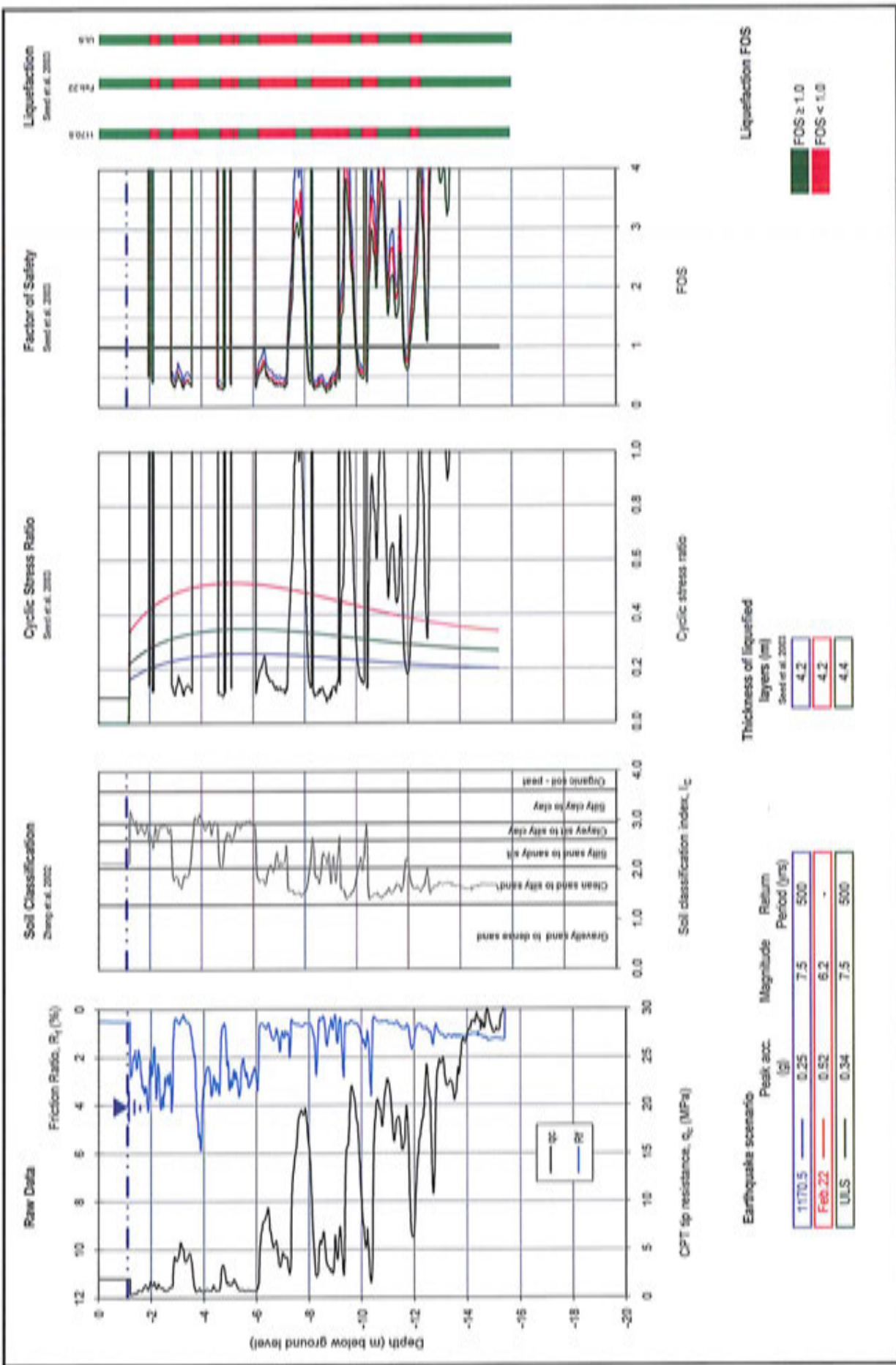


 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City		<b>LOCATION</b> <b>CPT-CBD-42</b>	<b>DATE</b> 6/12/2011
	<b>TITLE</b> Liquefaction Assessment from CPT Results		<b>JOB NUMBER</b> 52000.2011	<b>ANALYSED</b> RAP
				<b>CHECKED</b> AFF

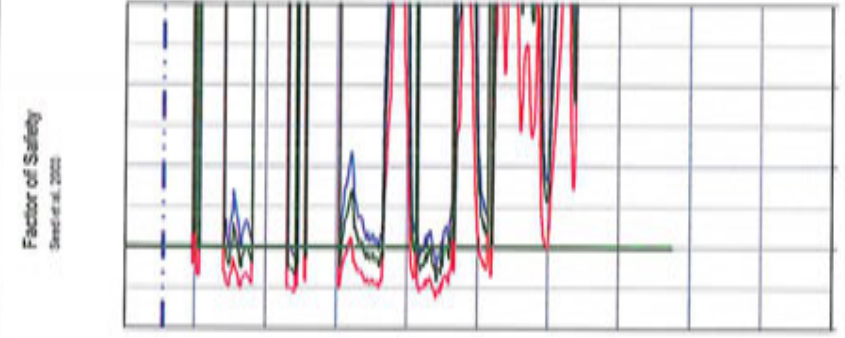
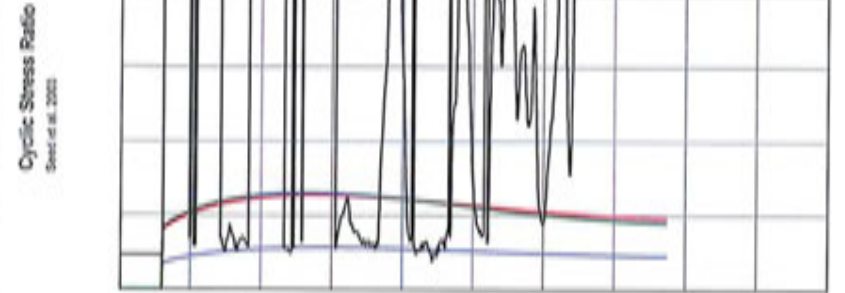
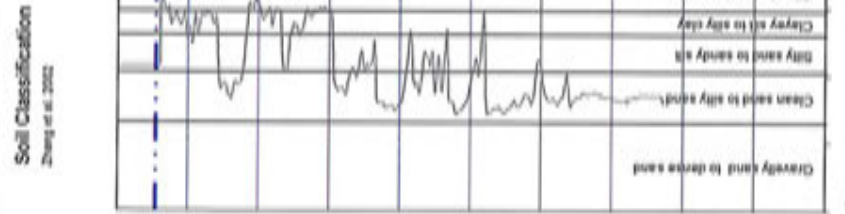
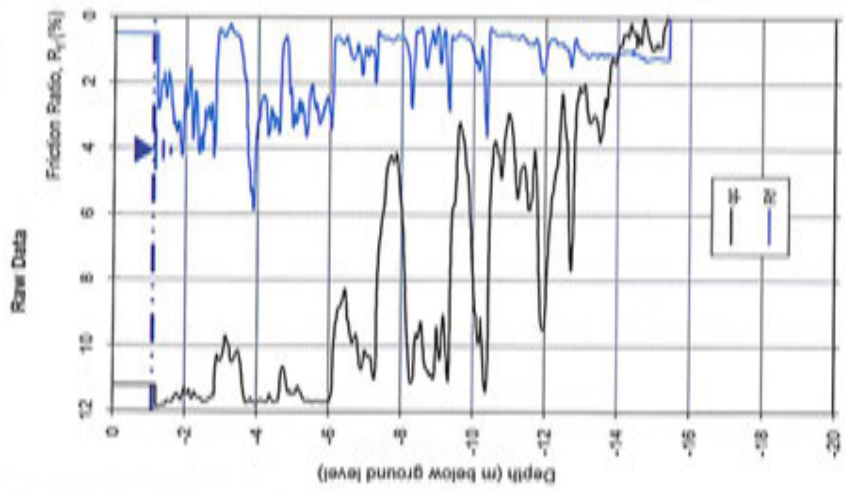


 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City	<b>LOCATION</b> CPT-CBD-42	<b>DATE</b> 7/12/2011
	<b>FINAL</b> Liquefaction Assessment from CPT Results	<b>JOB NUMBER</b> S2000.201	<b>ANALYSED</b> RMP <b>CHECKED</b> AFF





 <b>Tomlin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE 6/12/2011
	Liquefaction Assessment from CPT Results		ANALYSED RAP
CLIENT PROJECT <b>CPT-CBD-43</b>		LOCATION CPT-CBD-43	CHECKED AFF
TITLE Liquefaction Assessment from CPT Results		JOB NUMBER 52000.301	



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.04	0.25	7.1	-
Jun.13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.7
3.8
2.4

Liquefaction FOS

Liquefaction FOS
FOS > 1.0
FOS < 1.0



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Environmental & Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

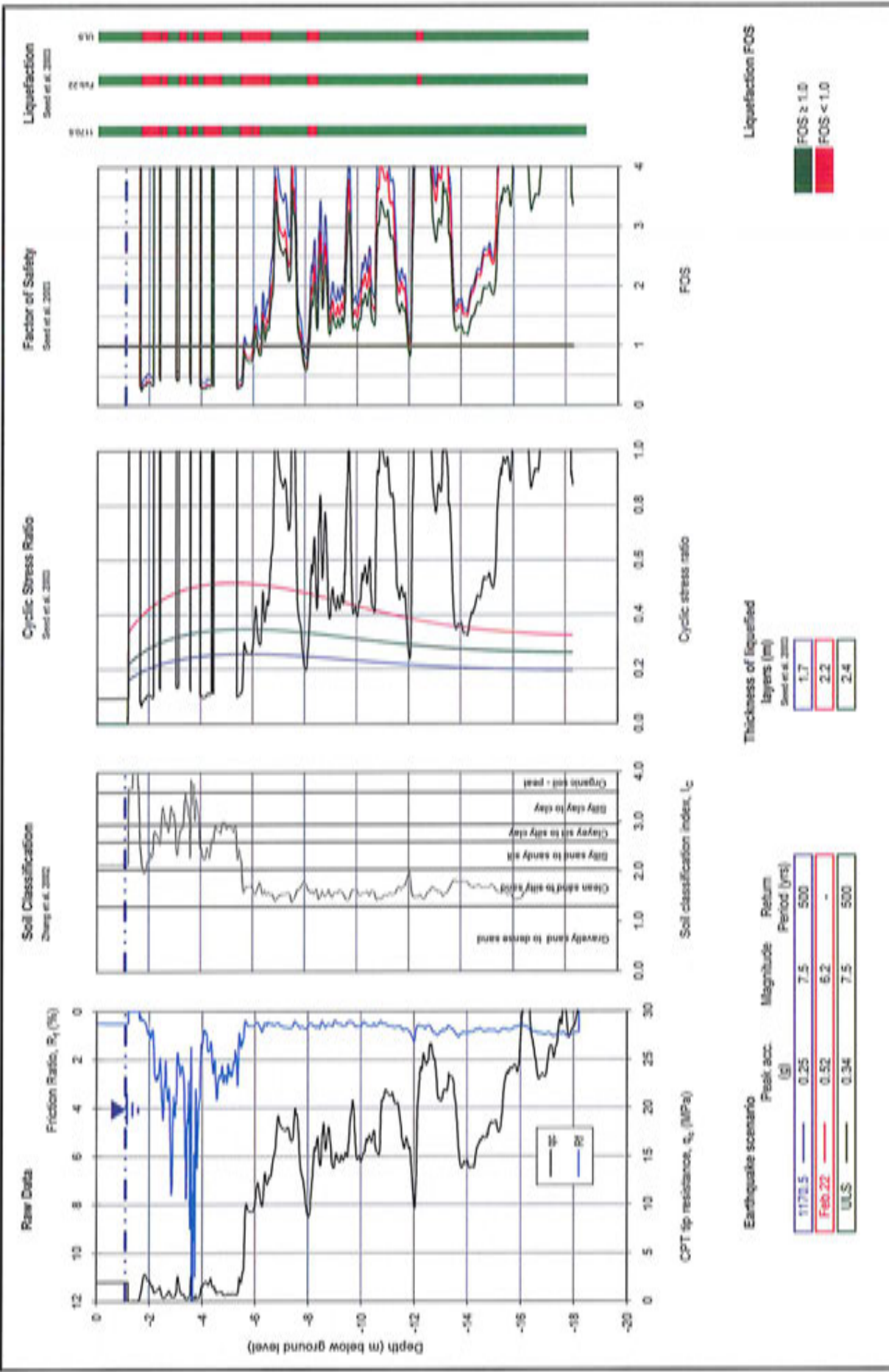
CPT-CBD-43

JOB NUMBER

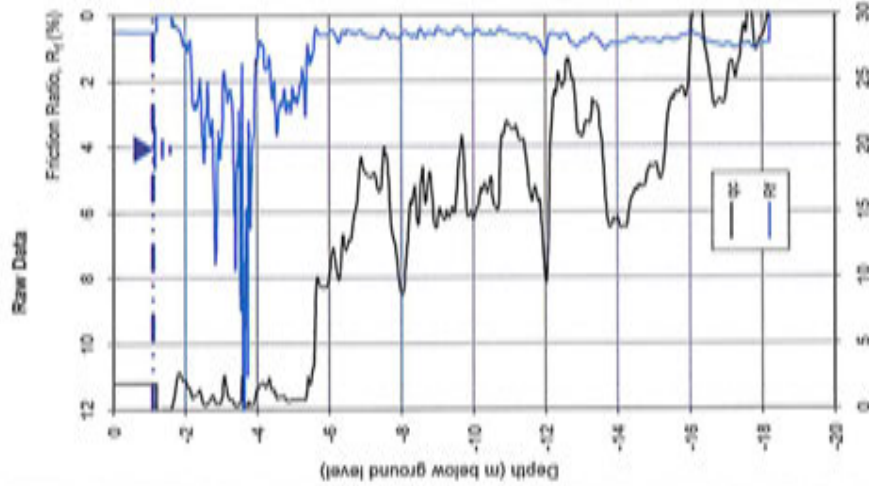
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DATE 7/12/2011  
ANALYSED RAP  
CHECKED AFF

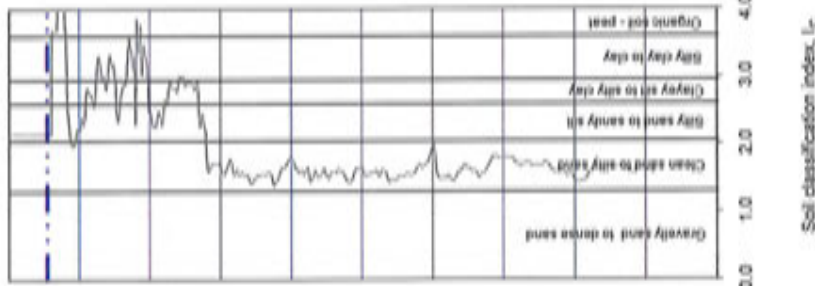
Liquefaction Assessment from CPT Results



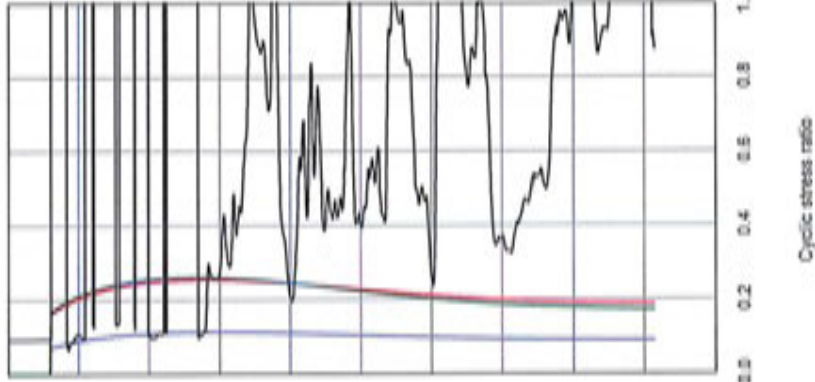
 <b>Toekin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		LOCATION <b>CPT-CBD-45</b>	DATE 6/12/2011
	FILE Liquefaction Assessment from CPT Results		JOB NUMBER 52000_301	ANALYSED RAP
				CHECKED AFF



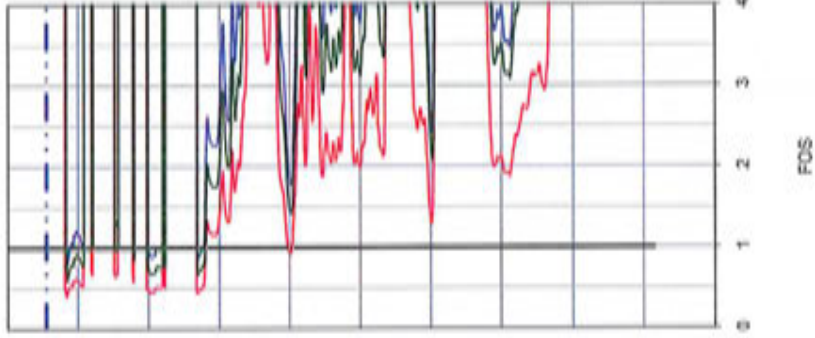
Soil Classification  
Zhang et al., 2002



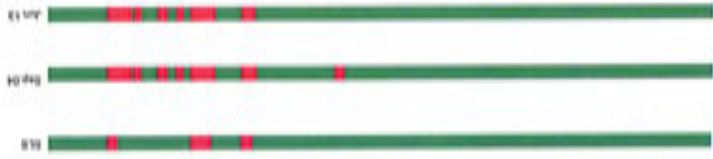
Cyclic Stress Ratio  
Seed et al., 2003



Factor of Safety  
Seed et al., 2003



Liquefaction  
Seed et al., 2003



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sept 04	0.25	7.1	-
Jun 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.6
1.5
1.3

Liquefaction FOS

FOS $\geq 1.0$
FOS $< 1.0$



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Environmental &  
Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-45

JOB NUMBER

52000.301

DATE

7/12/2011

ANALYSED

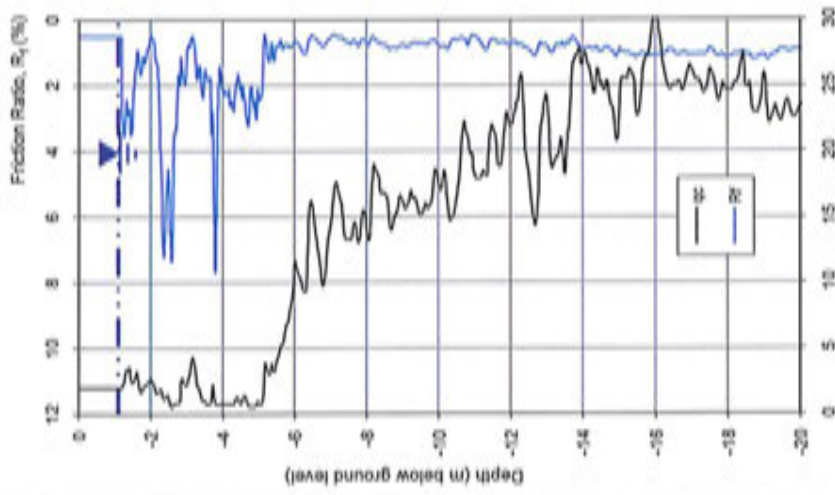
RAP

CHECKED

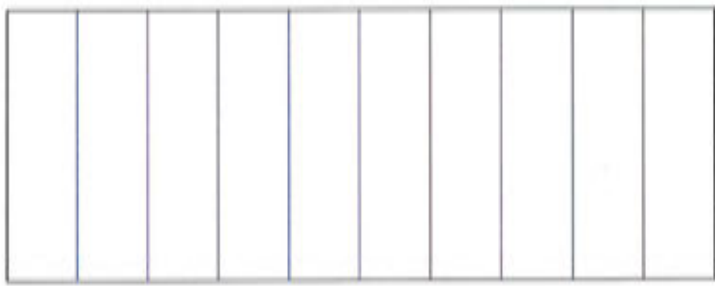
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Liquefaction Assessment from CPT Results

Raw Data



Soil Classification  
Zheng et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002

Factor of Safety  
Seed et al. 2002

Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_c$  (MPa)

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb.22	0.52	6.2	-
U.L.S.	0.34	7.5	500

Thickness of liquefied layers (m)

4.2
4.5
5.4

Liquefaction FOS



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Environmental &  
Engineering Consultants

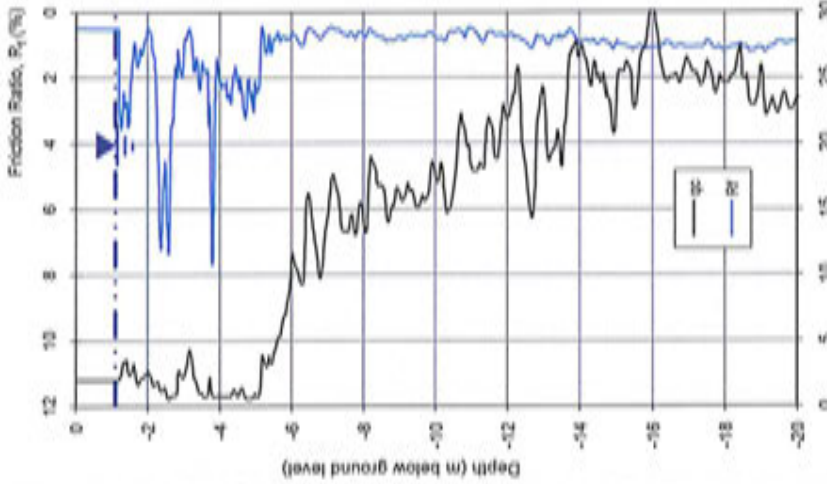
CLIENT PROJECT  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION  
CPT-CBD-46

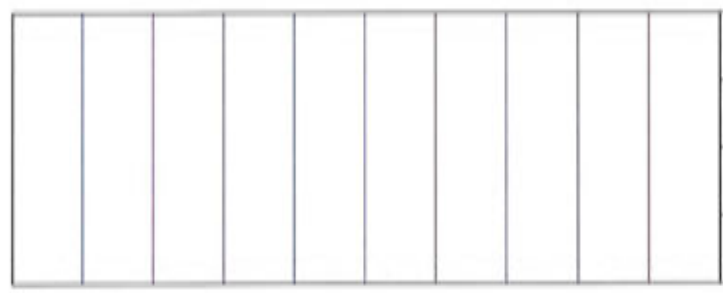
FILE  
JOB NUMBER  
52000.201

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF  
AFF

Raw Data



Soil Classification  
Zheng et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002

Factor of Safety  
Seed et al. 2002

Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 24	0.25	7.1	-
Jun 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.2
3.3
1.5

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT NUMBER  
CPT-CBD-46

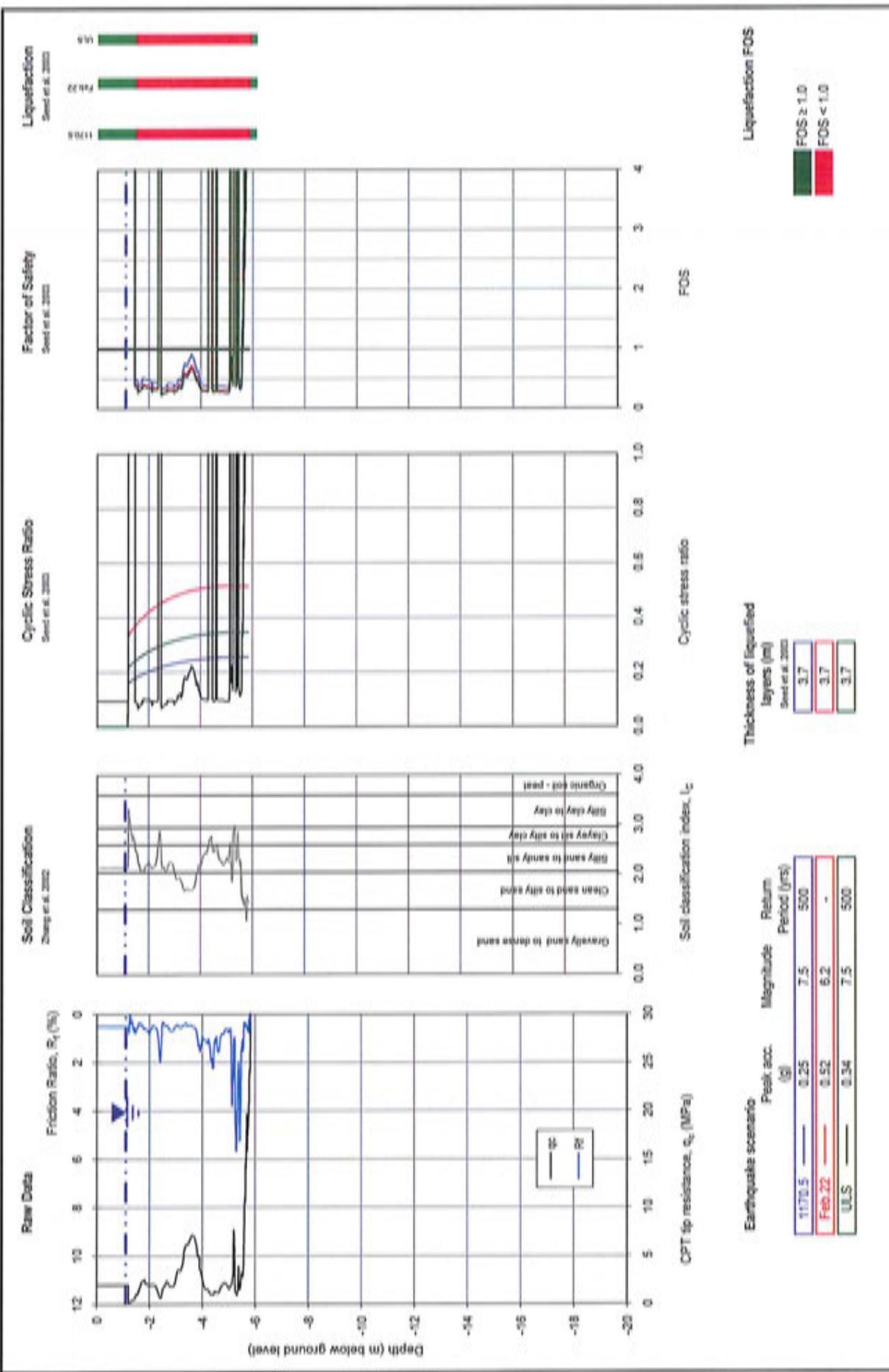
JOB NUMBER  
52000\_301

DATE  
7/12/2011

ANALYSED  
RAP

CHECKED  
AFF

Liquefaction Assessment from CPT Results



**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

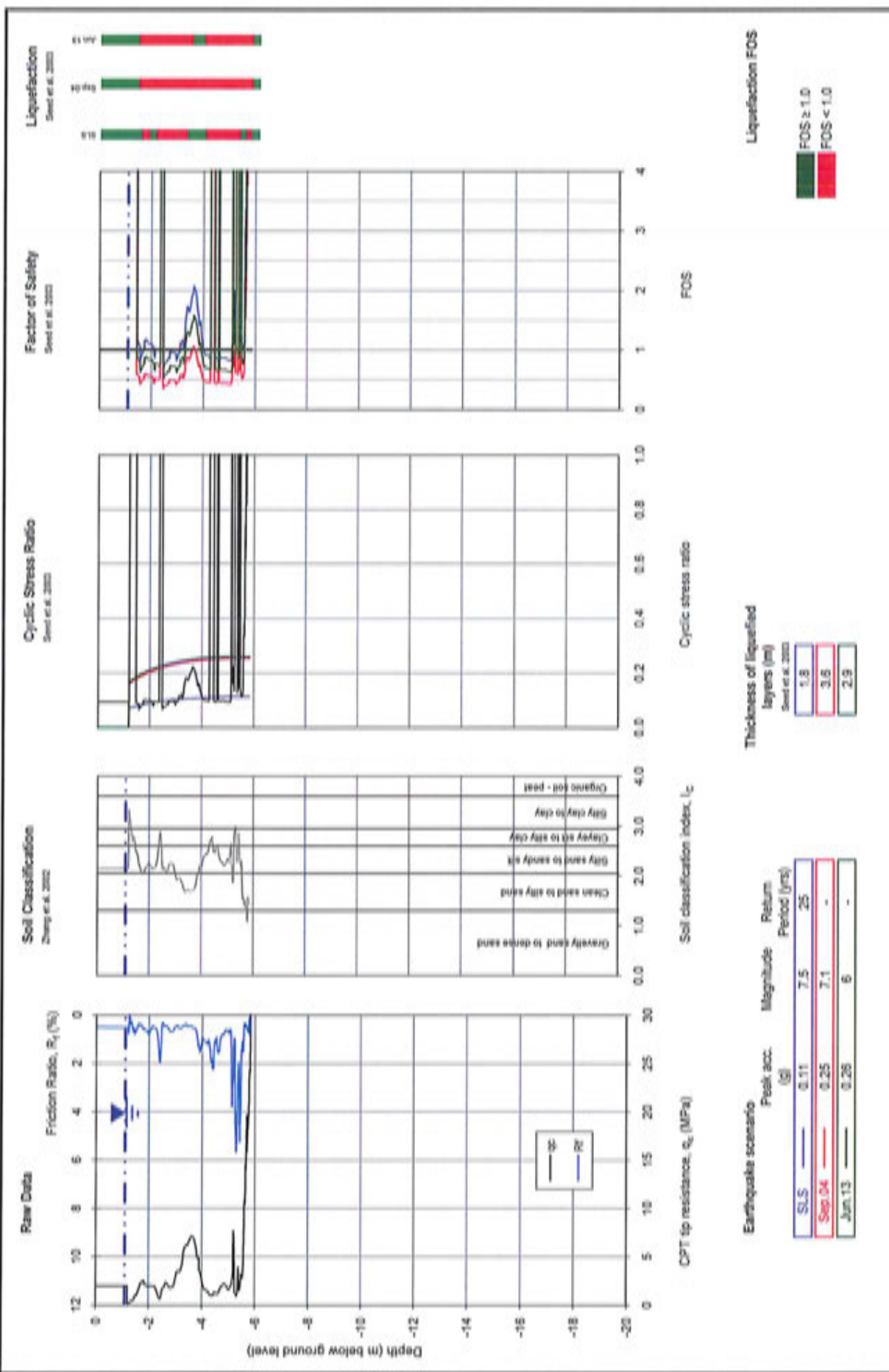
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**PROJECT**  
CPT-C8D-47

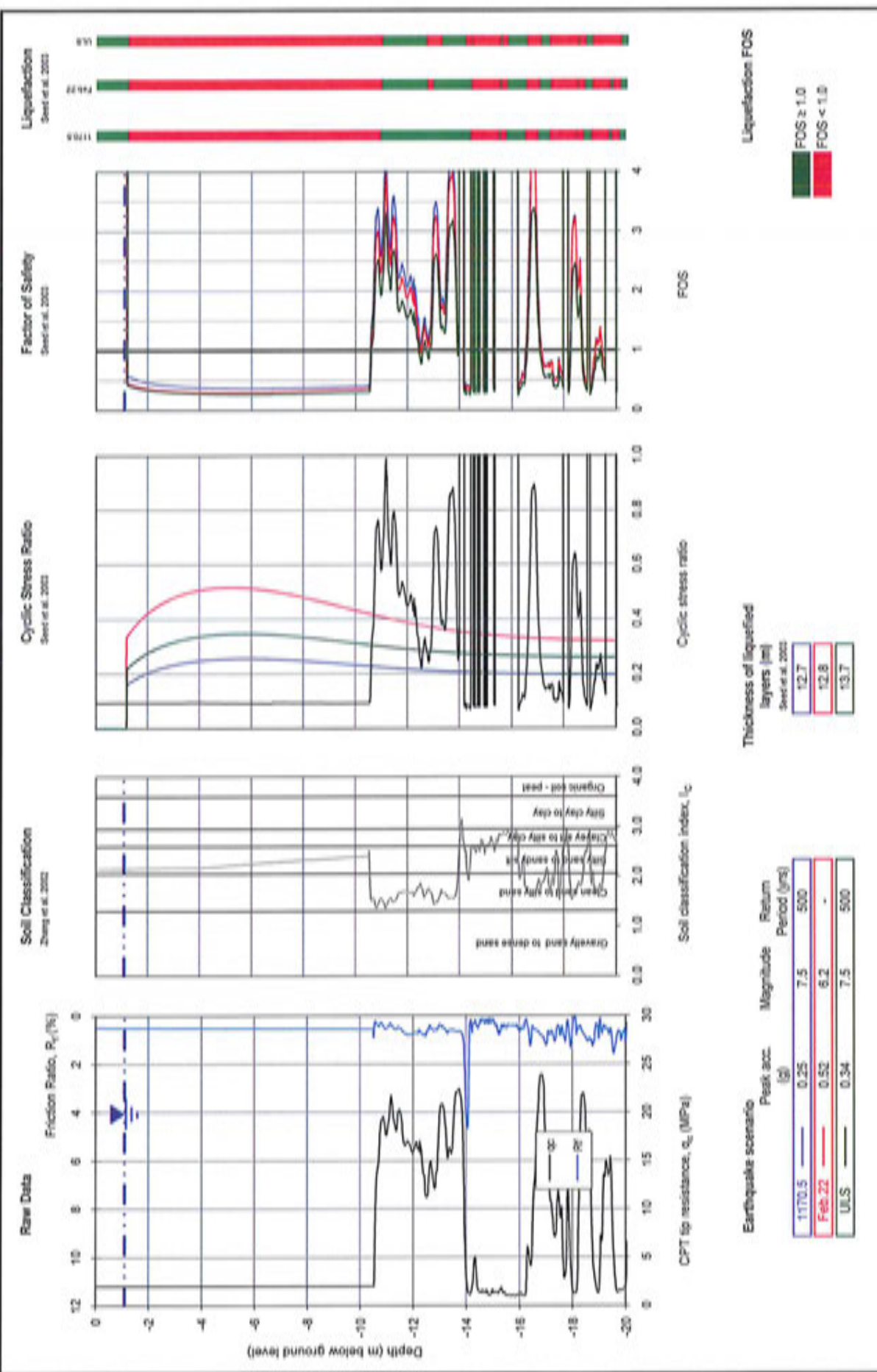
**JOB NUMBER**  
S2000.301

**DATE** 6/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

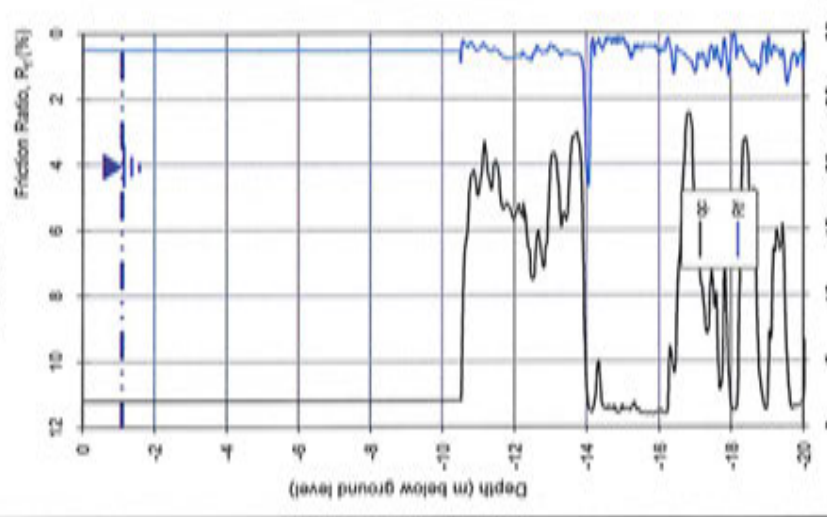
Liquefaction Assessment from CPT Results



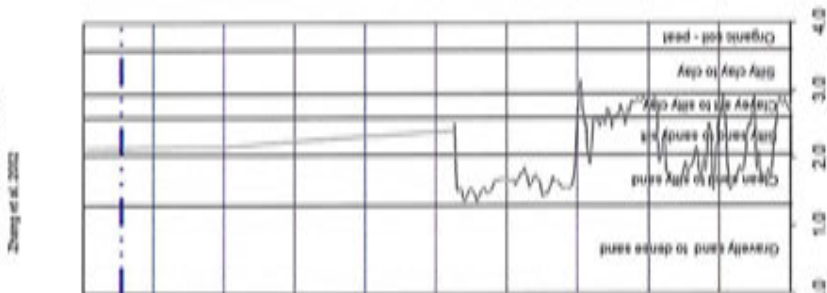




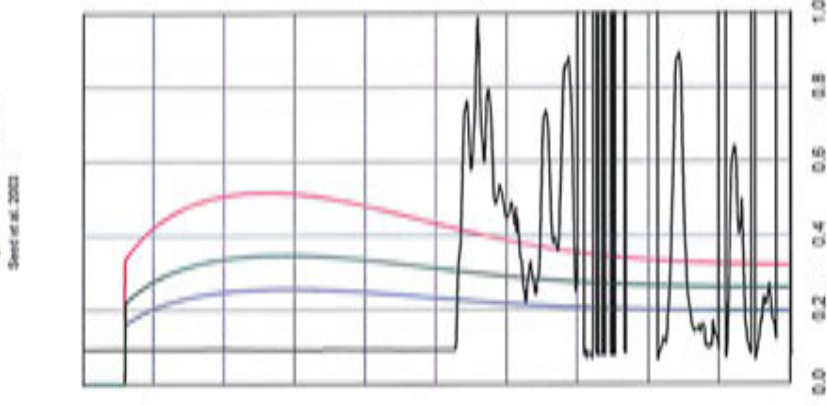
Raw Data



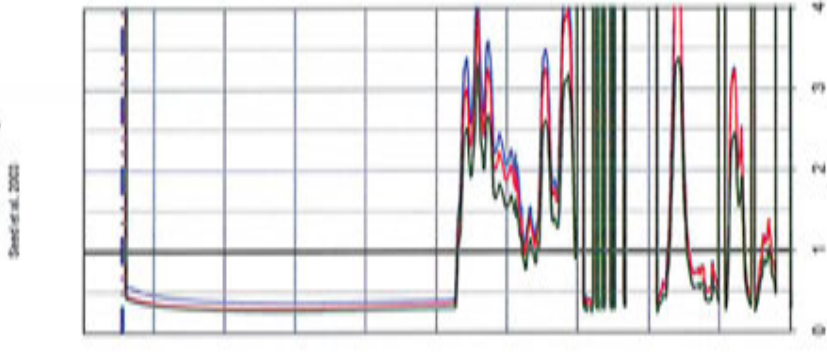
Soil Classification



Cyclic Stress Ratio



Factor of Safety



Liquefaction



Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

12.7
12.8
13.7

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



Tonlin & Taylor Ltd  
Environmental & Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION  
CPT-CBD-47P

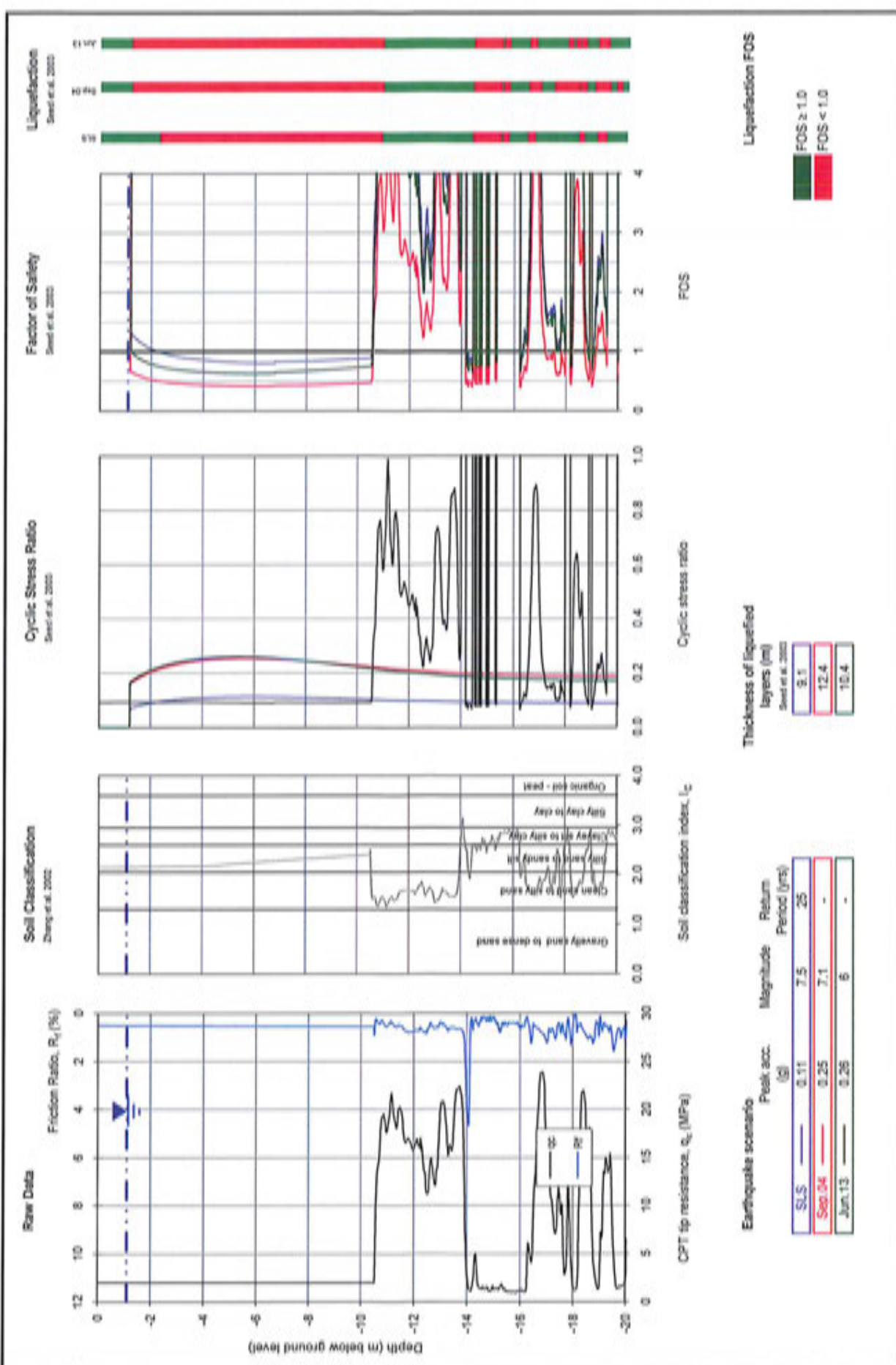
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DATE  
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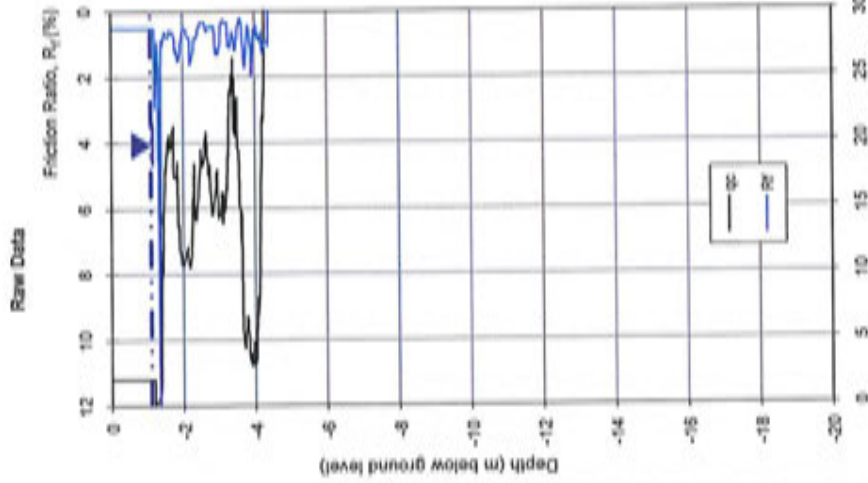
ANALYSED  
RAP

CHECKED  
AFF

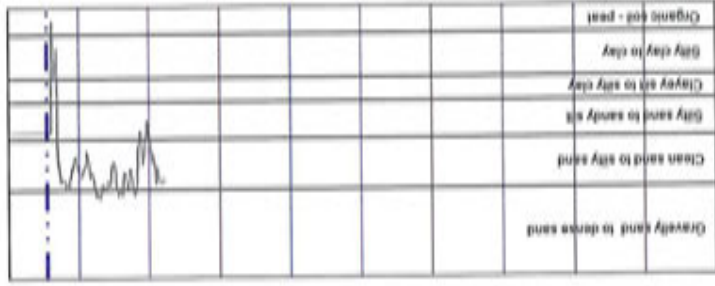
Liquefaction Assessment from CPT Results



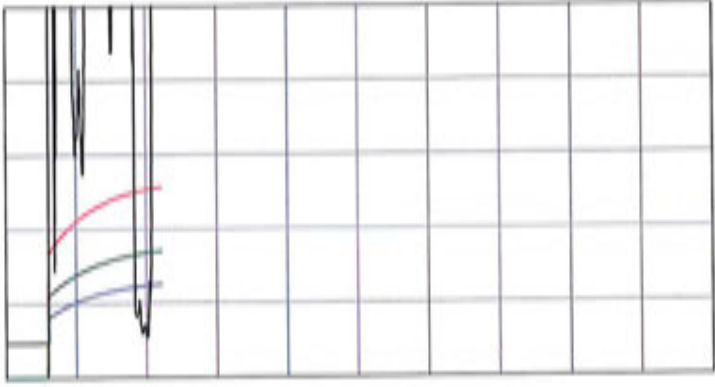
 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> <b>Geotechnical Assessment for Christchurch Central City</b>		LOCATION <b>CPT-CBD-47P</b>	DATE 7/12/2011
	TITLE <b>Liquefaction Assessment from CPT Results</b>		JOB NUMBER 52000_301	ANALYSED RAP
				CHECKED AFF



**Soil Classification**  
Zhang et al. 2002



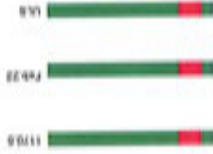
**Cyclic Stress Ratio**  
Seed et al. 2003



**Factor of Safety**  
Seed et al. 2003



**Liquefaction**  
Seed et al. 2003



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb 22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.4
0.5
0.5

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

CLIENT / PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION  
**CPT-CBD-48**

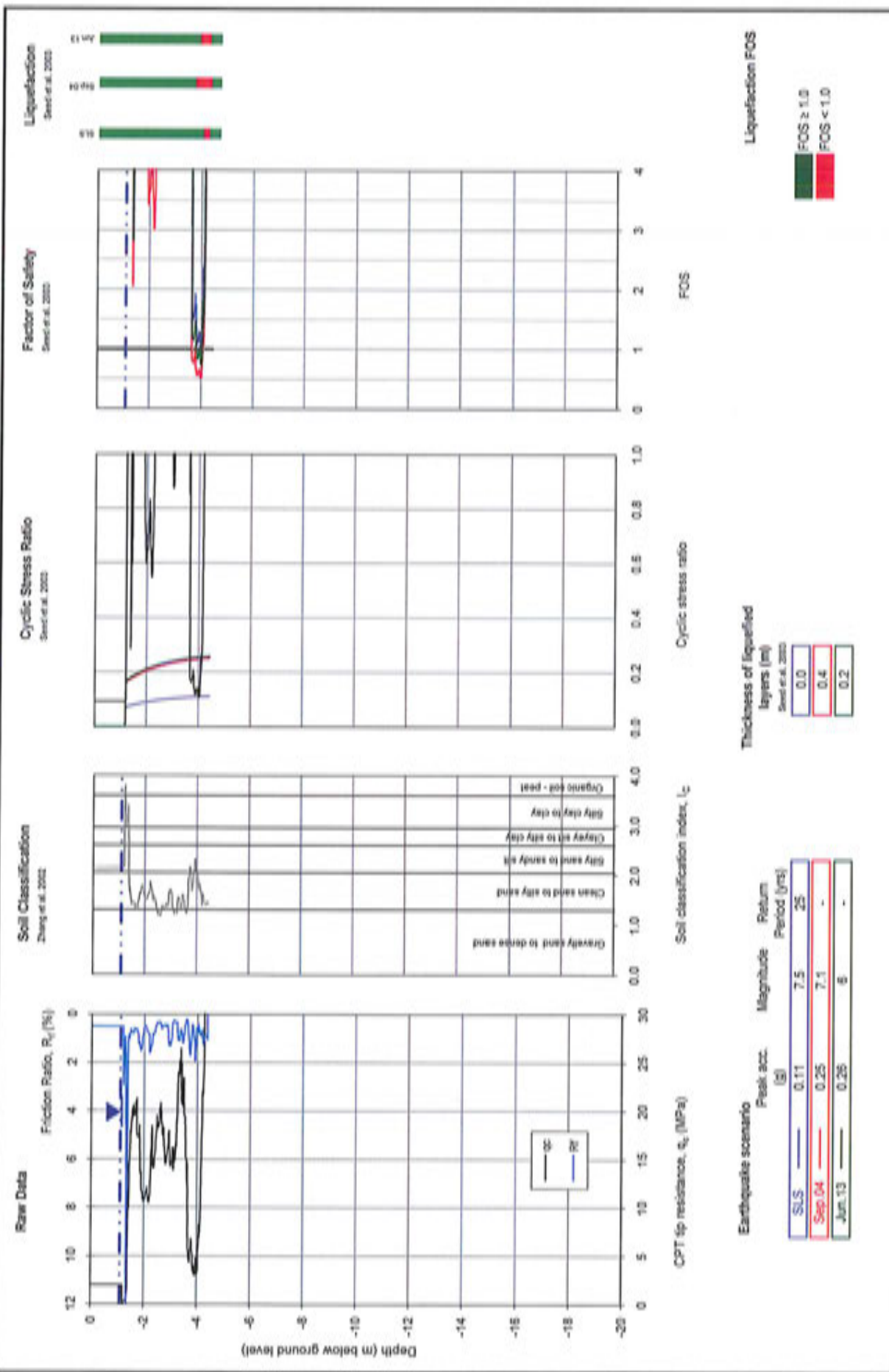
DATE  
5/12/2011

ANALYSED  
RAP

CHECKED  
AFT

LOT NUMBER  
52000.301

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		LOCATION <b>CPT-CBD-48</b>	DATE 7/10/2011
	FILE Liquefaction Assessment from CPT Results		JOB NUMBER 52000_301	ANALYSED RMP CHECKED AFF

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.25	8	-

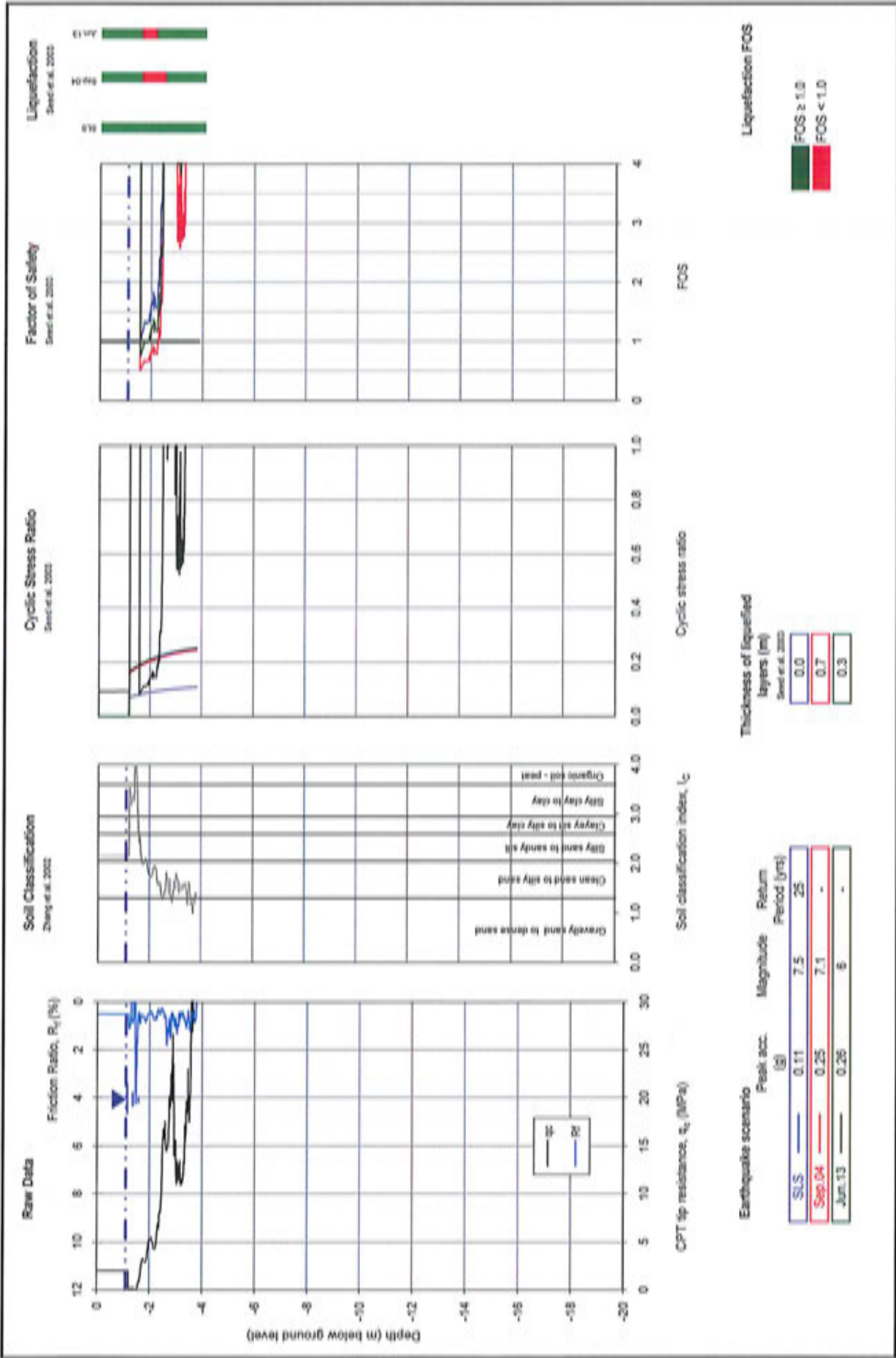
Thickness of liquefied layers (m)

0.0
0.4
0.2

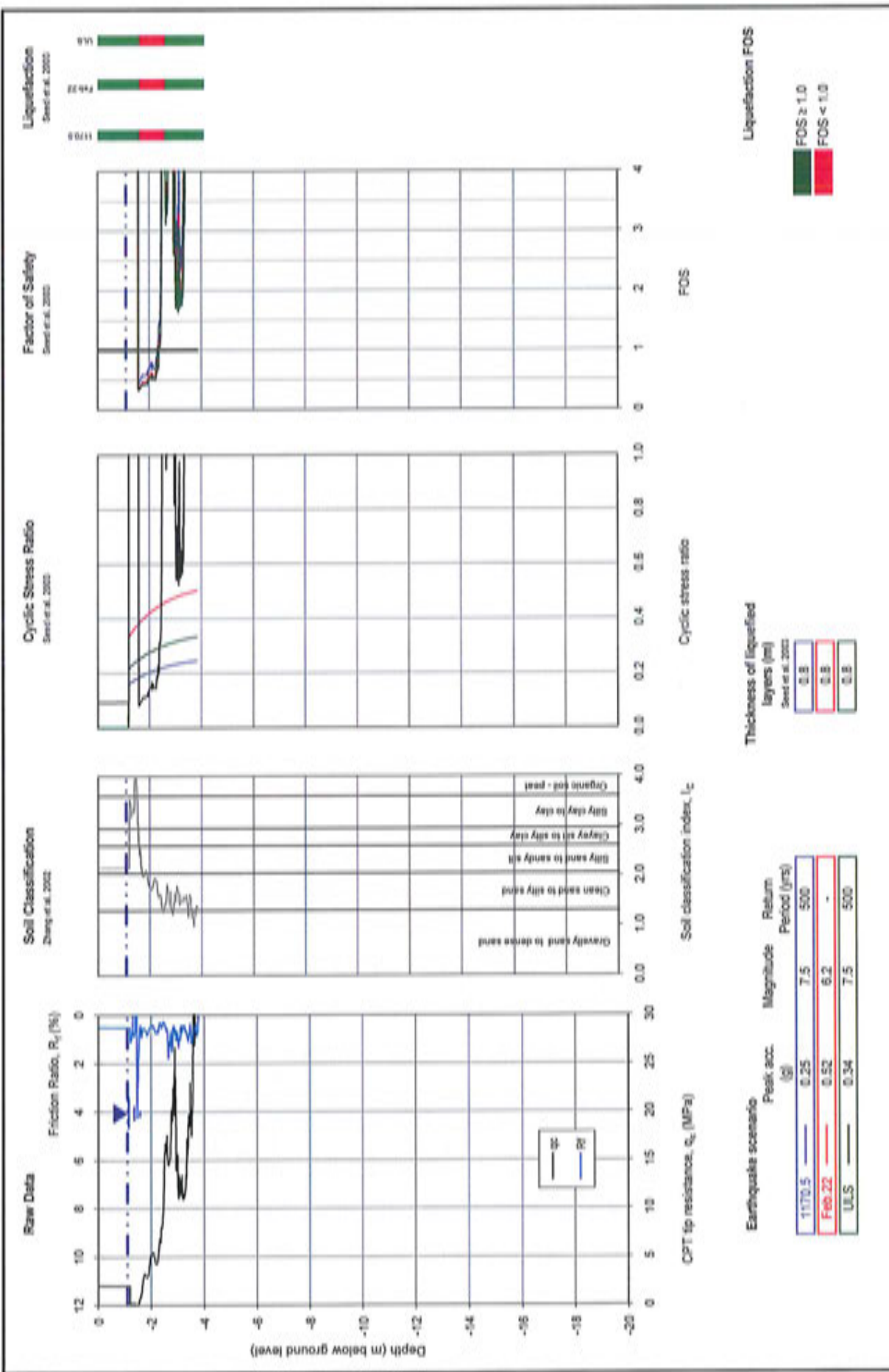
Liquefaction FOS

FOS ≥ 1.0
FOS < 1.0





 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> <b>Geotechnical Assessment for Christchurch Central City</b>	CLIENT PROJECT <b>CPT-CBD-49</b>	DATE 7/12/2011
	FILE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 52000.301	ANALYSED RAP
			CHECKED AFF



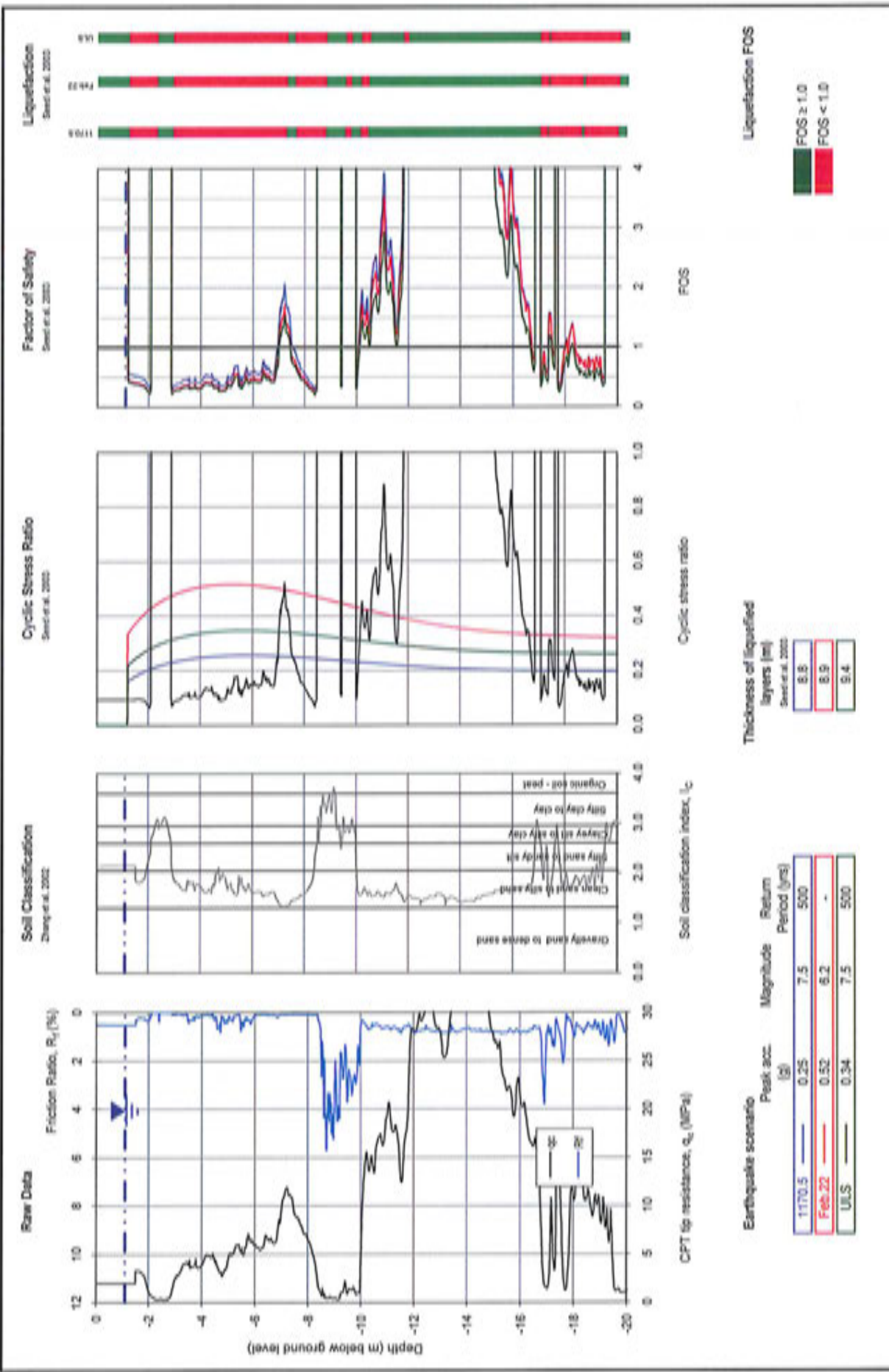
**Tomlin & Taylor Ltd**  
Environmental & Engineering Consultants

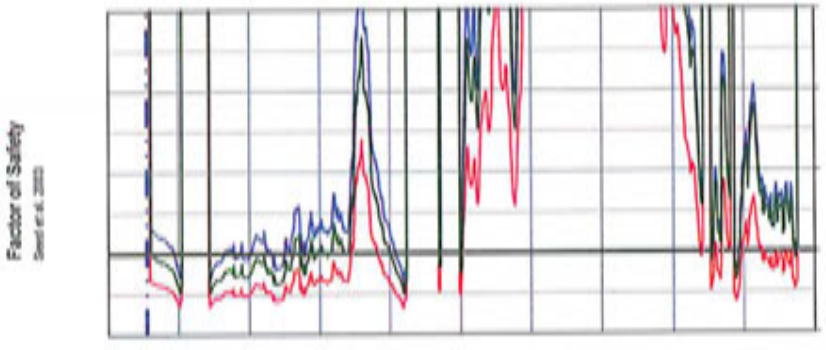
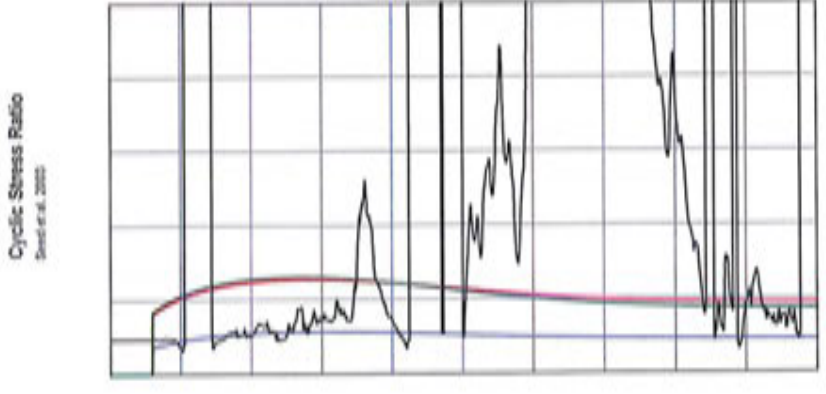
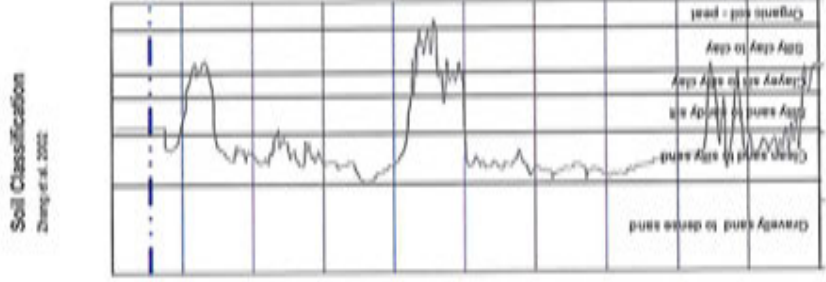
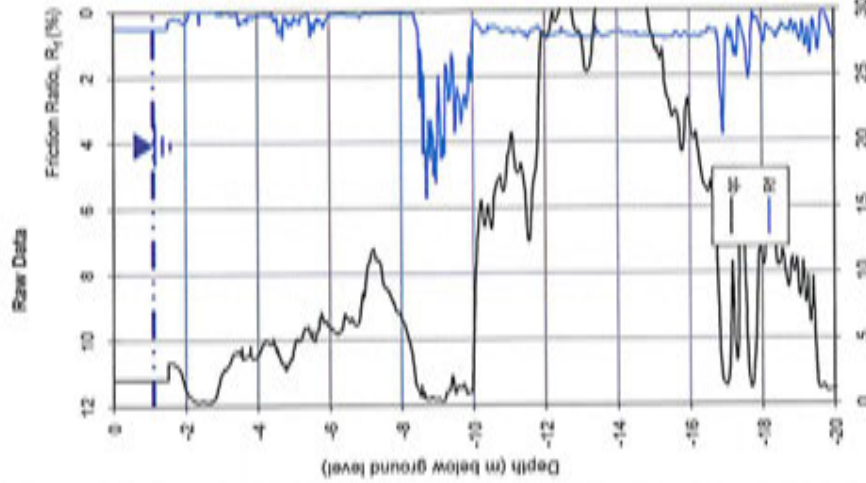
**CLIENT PROJECT**  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

**LOCATION**  
CPT-CBD-49  
JOB NUMBER  
52000.301

**DATE** 6/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

**RESULTS**  
Liquefaction Assessment from CPT Results





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.14	0.25	7.1	-
Jun.13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
2.1
8.1
4.8

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-49P

LOT NUMBER  
S20000.1001

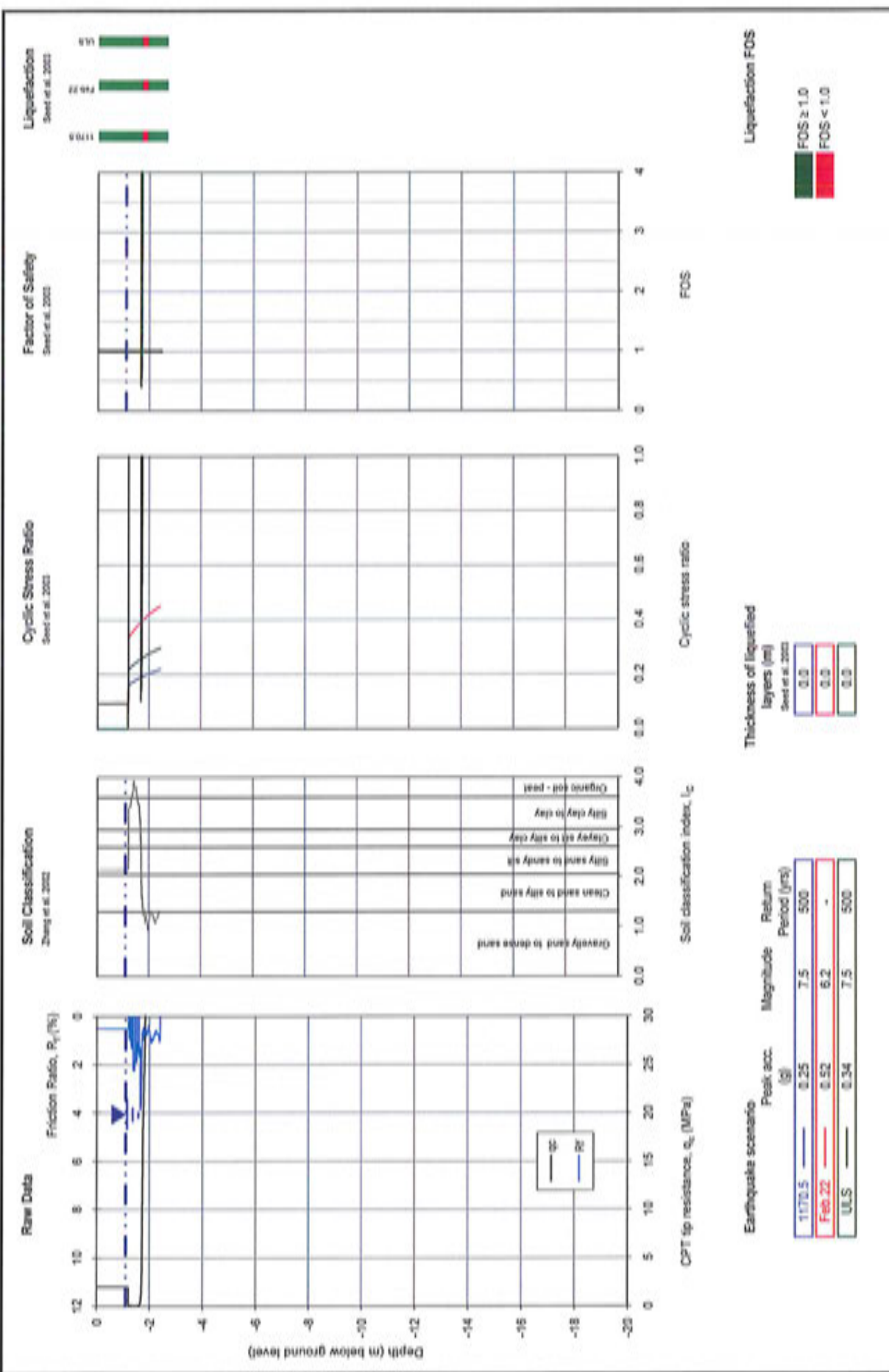
DATE  
7/12/2011

ANALYSED  
RAP

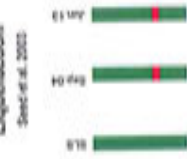
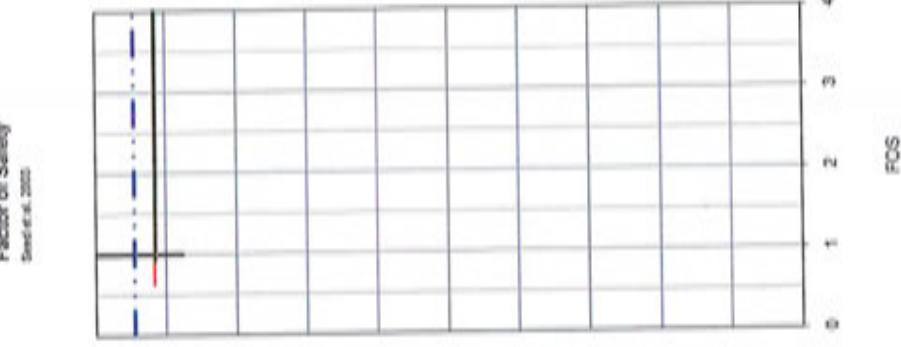
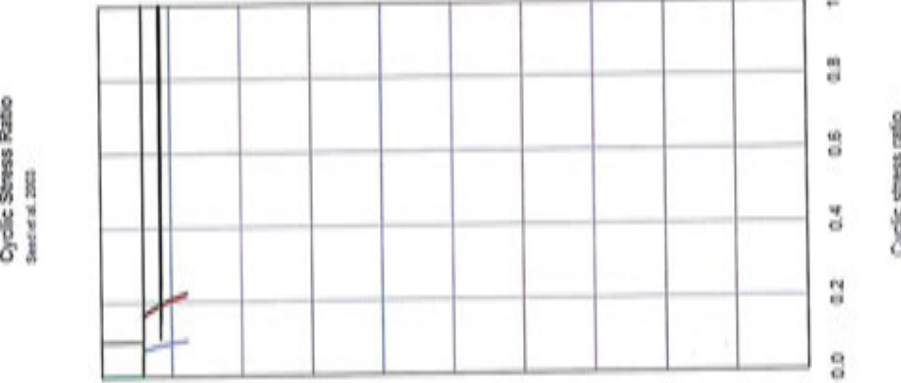
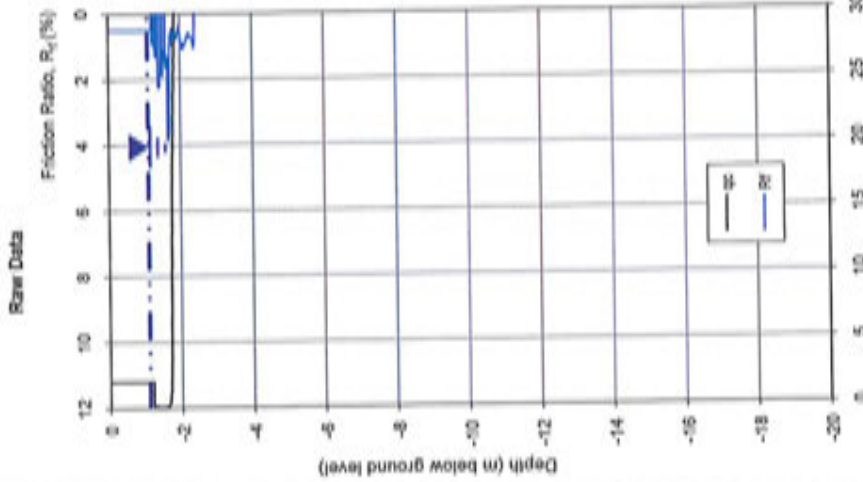
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Liquefaction Assessment from CPT Results





 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE: 6/12/2011 ANALYSED: RRP CHECKED: AFF
	CLIENT PROJECT: <b>CPT-CBD-50</b>	LOCATION: Christchurch Central City	JOB NUMBER: 52000_301
Liquefaction Assessment from CPT Results			



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep. 04	0.25	7.1	-
Jun. 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.0
0.0
0.0

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0

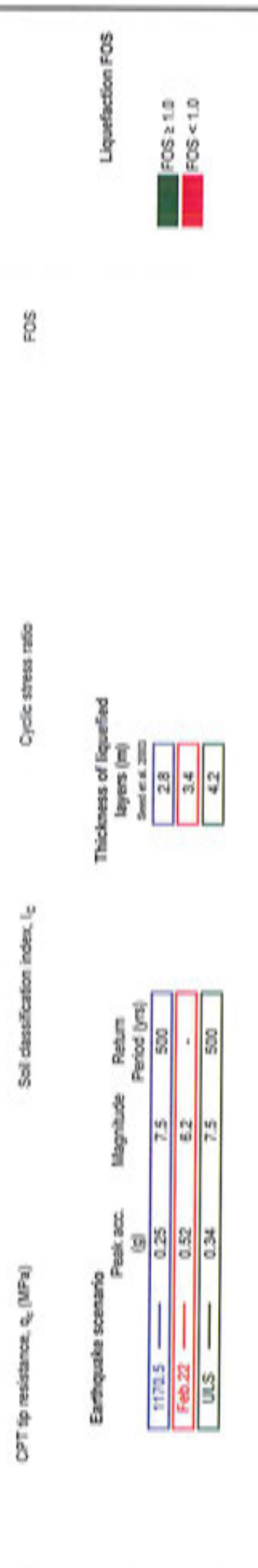
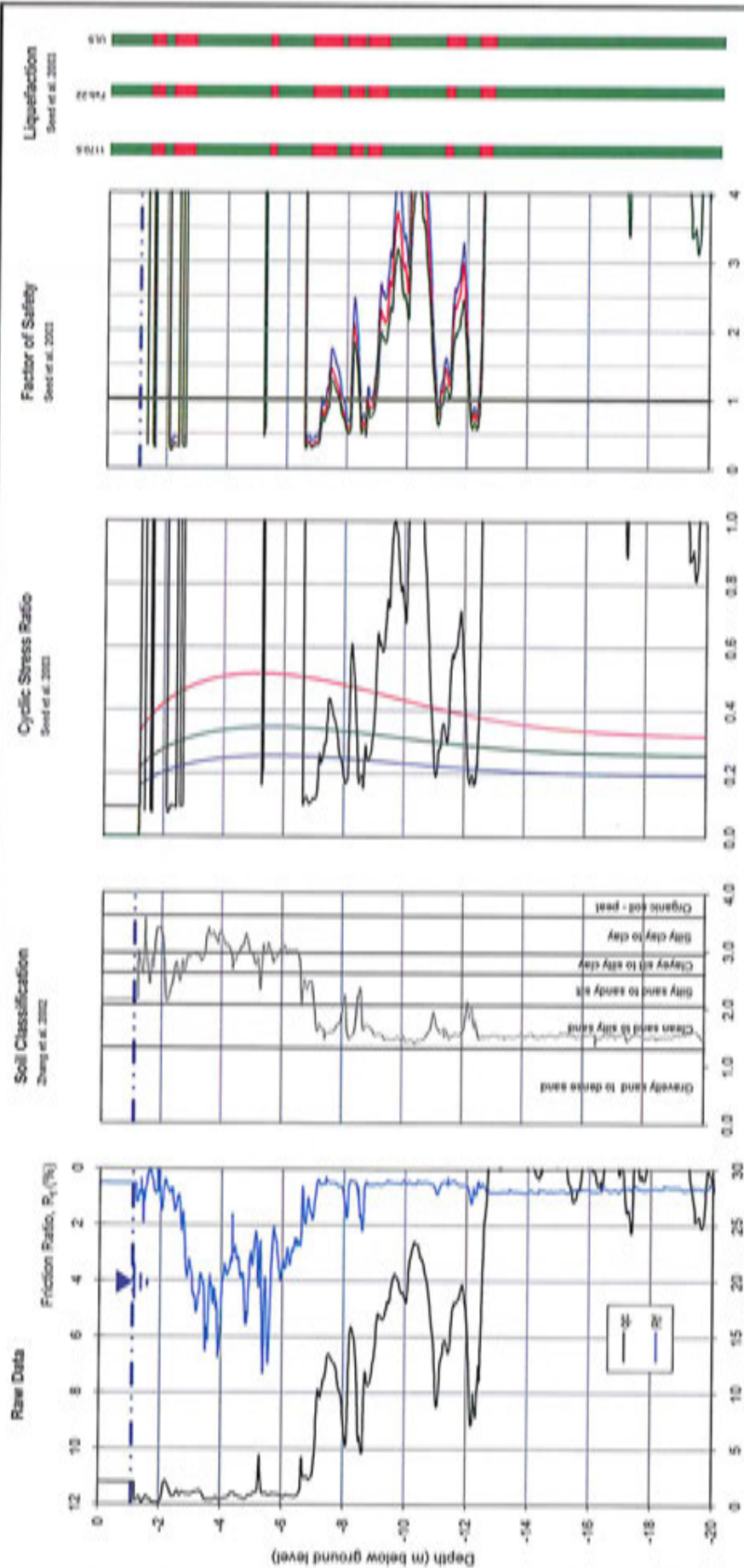


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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

PROJECT  
CPT-CBD-50  
JOB NUMBER  
S2000.301

DATE  
7/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF





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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**CPT-CBD-51**

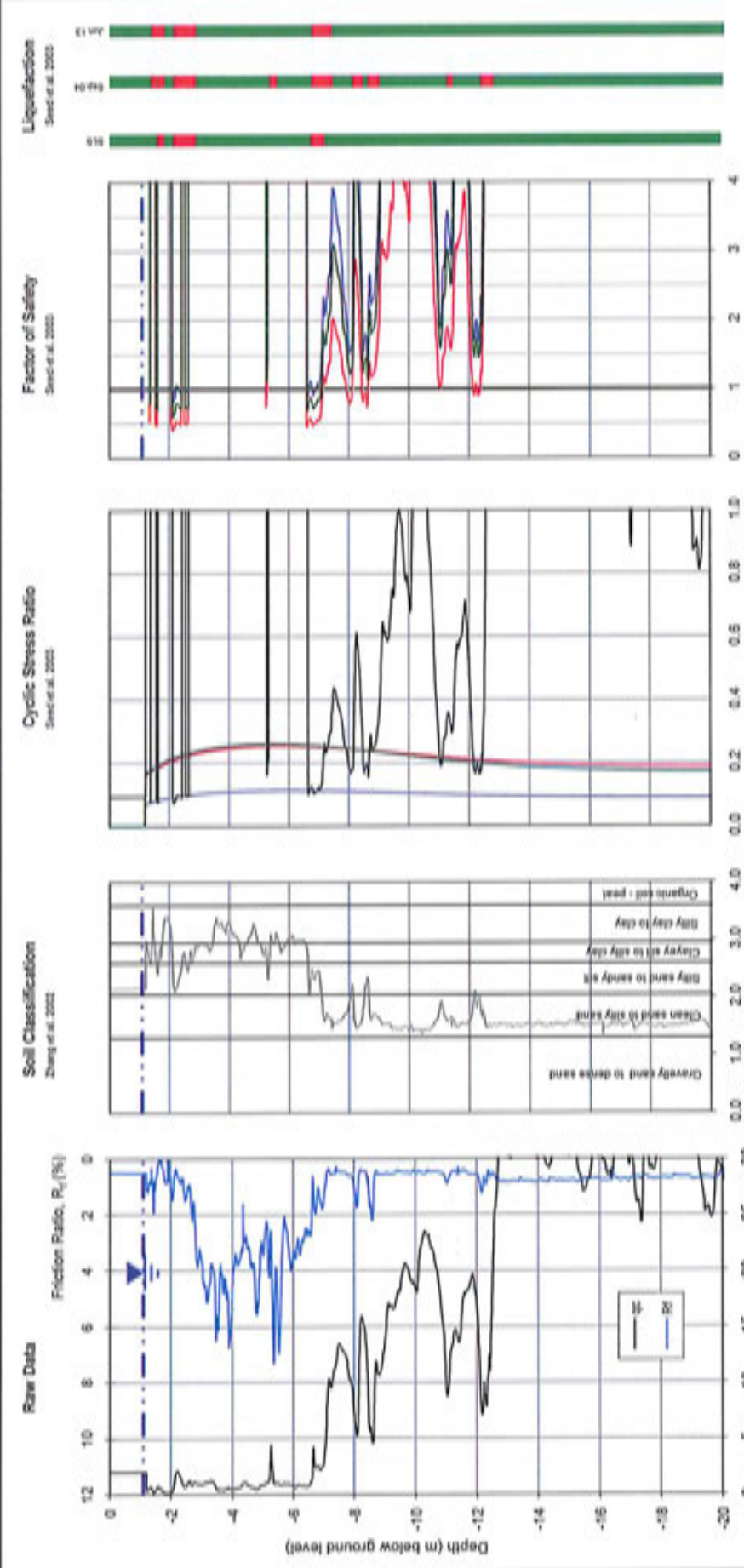
DATE: 6/12/2011

ANALYSED: RAP

CHECKED: AFF

JOB NUMBER: 52000.301

Liquefaction Assessment from CPT Results





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Geotechnical Assessment for Christchurch Central City

Liquefaction Assessment from CPT Results

DATE: 31/12/2011  
ANALYSED: RAP  
CHECKED: AFF

**PROJECT**

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

**LOCATION**

CPT-CBD-51

**DATE**

31/12/2011

**CLIENT**

Christchurch City Council

**PROJECT**

CPT-CBD-51

**DATE**

31/12/2011

**FILE**

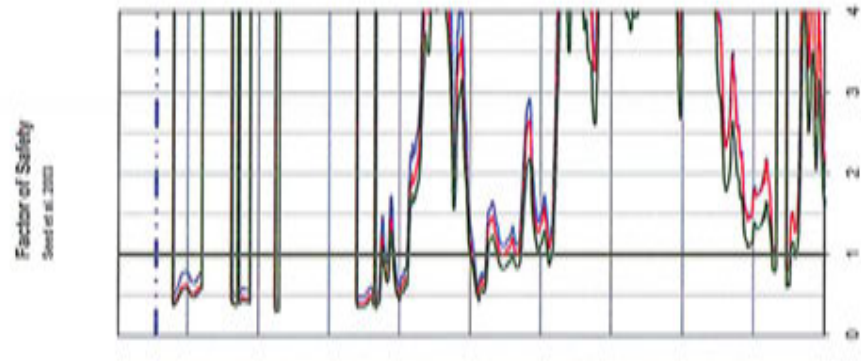
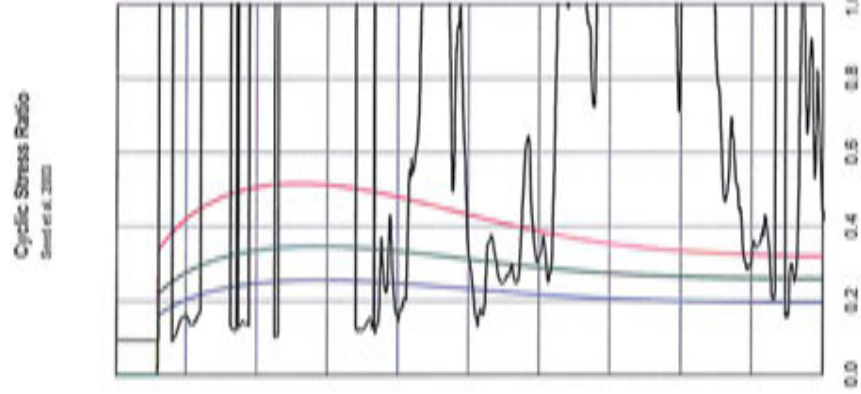
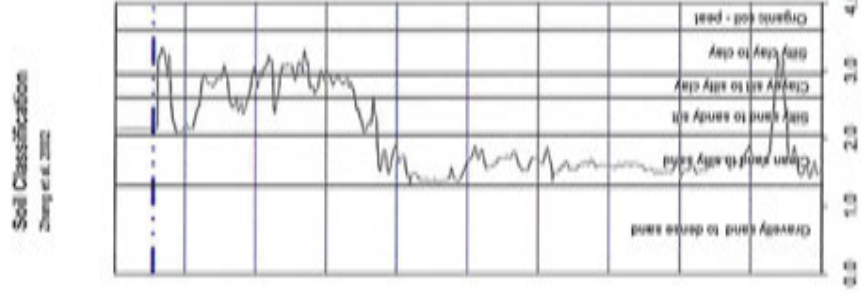
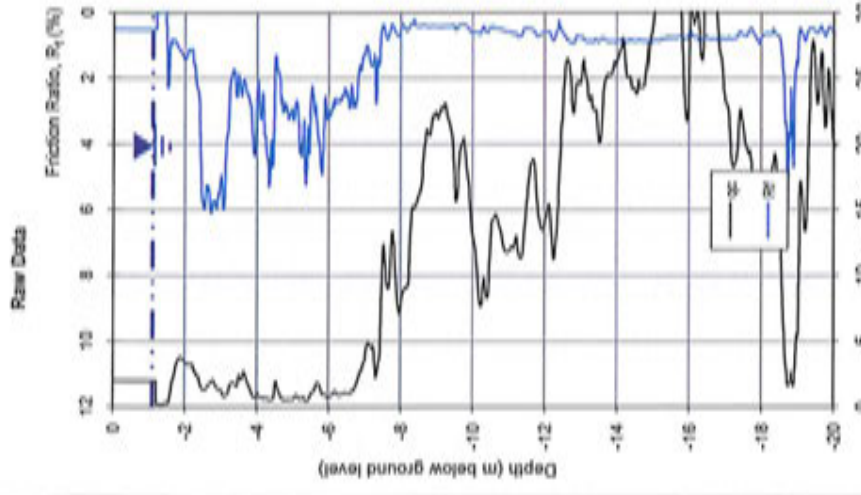
Liquefaction Assessment from CPT Results

**JOB NUMBER**

52000.301

**CHECKED**

AFF



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
4.4
4.7
8.4

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-52

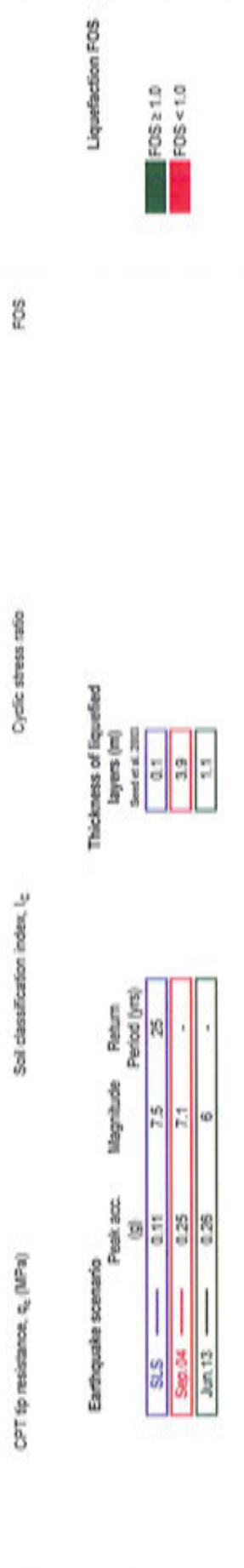
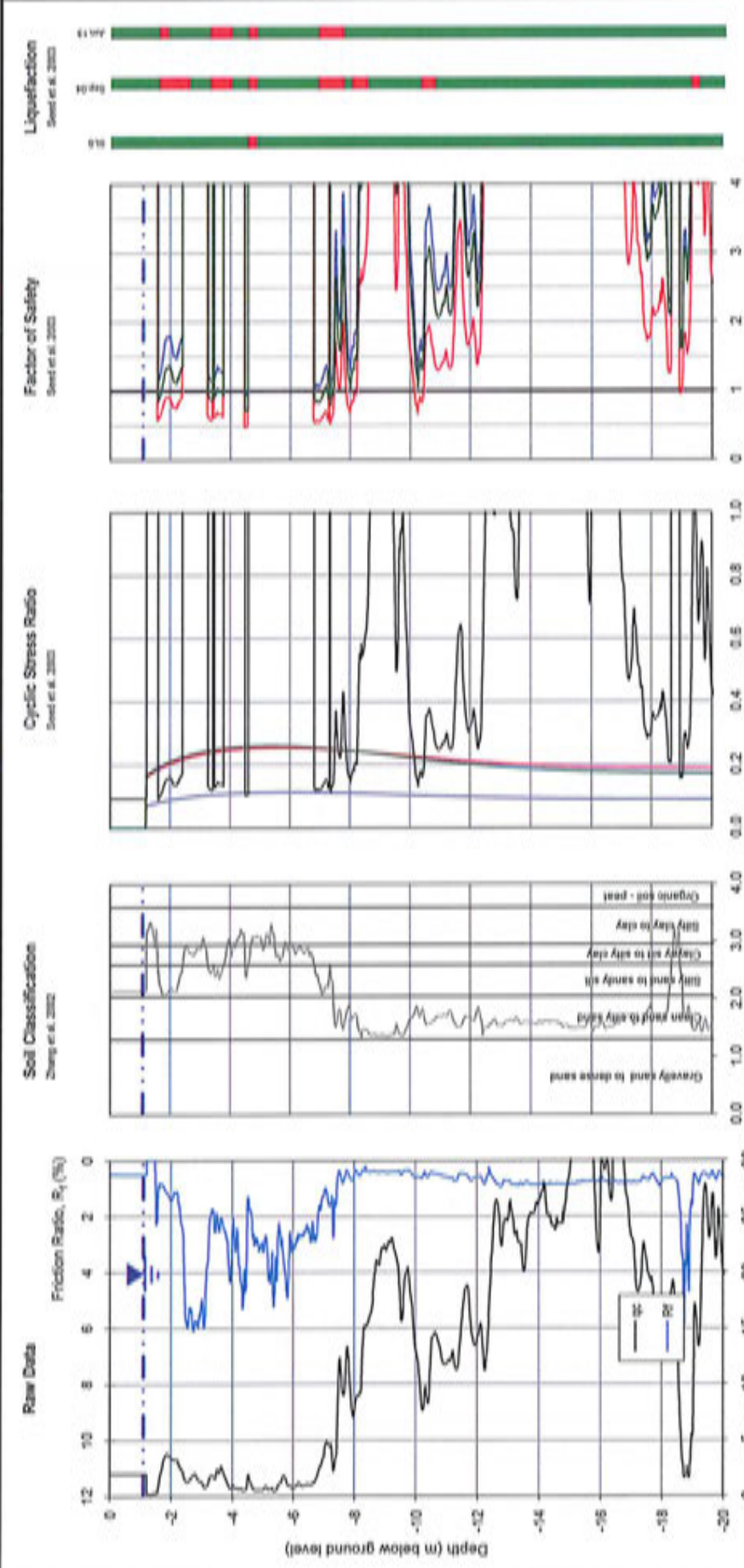
FILE


Liquefaction Assessment from CPT Results

JOB NUMBER

52000\_301

DATE	6/12/2011
ANALYSED	RAP
CHECKED	AFF





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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

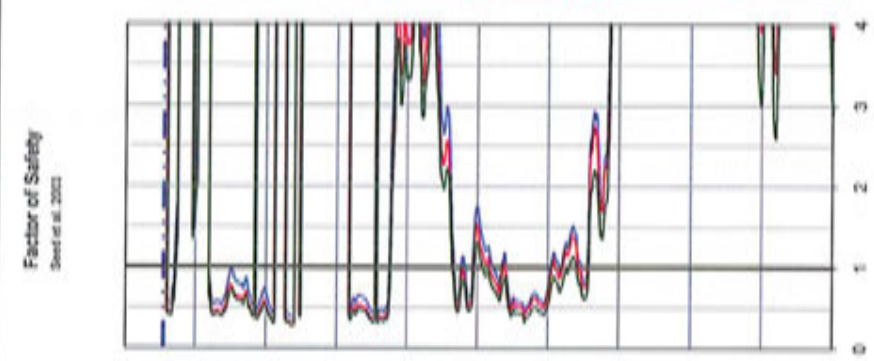
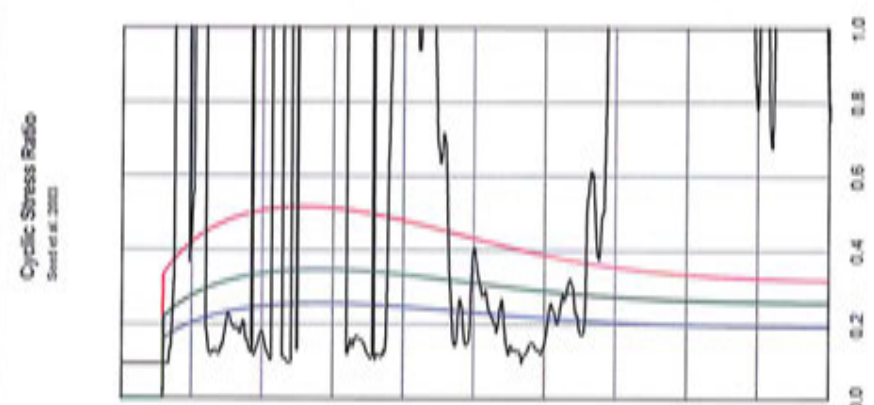
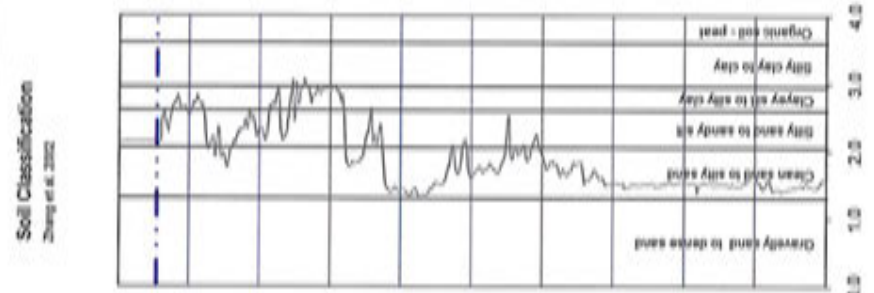
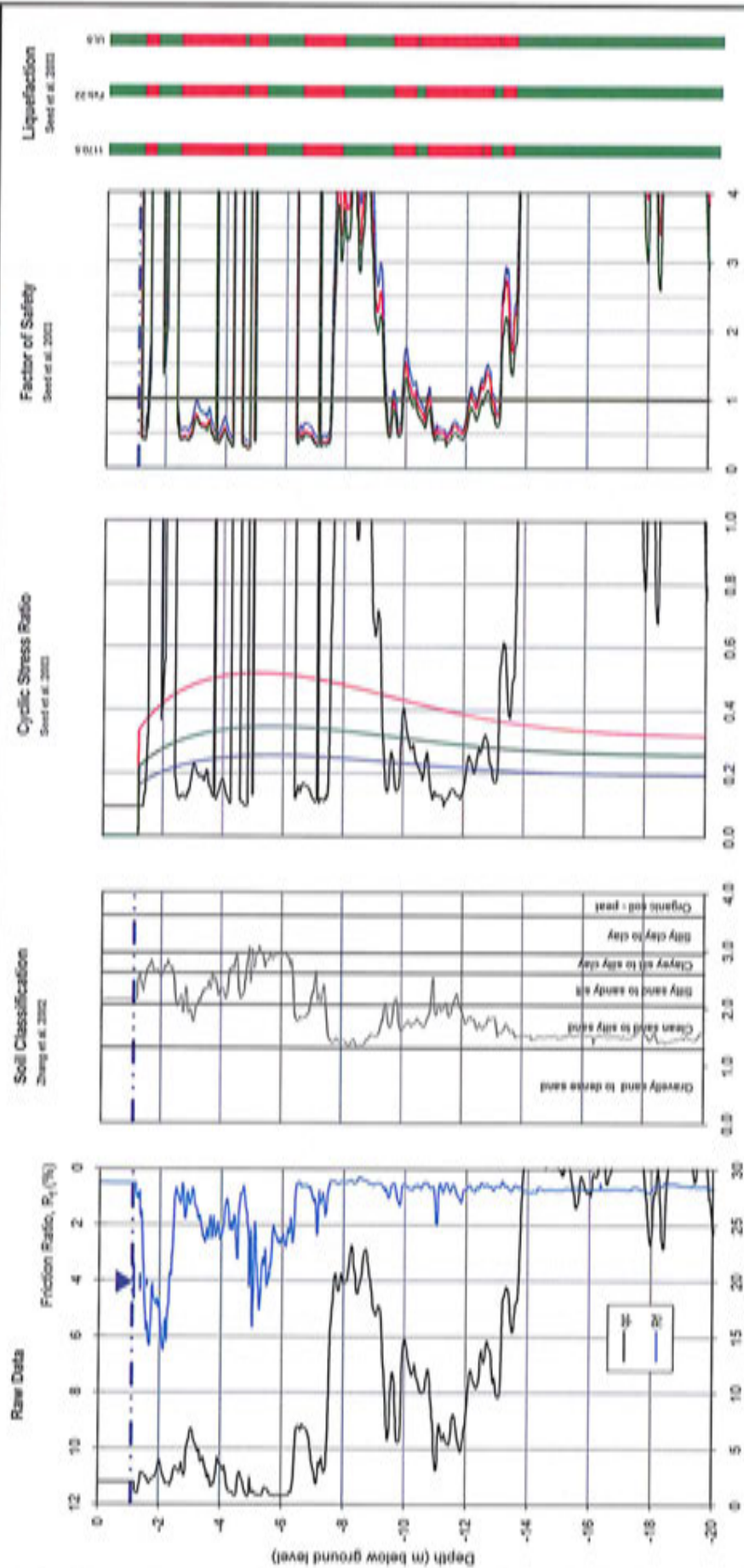
DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF

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**SECTION**  
CPT-CBD-52

**PROJECT**  
Liquefaction Assessment from CPT Results

JOS NUMBER: 520008.301



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1172.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

7.7
8.3
9.1

Liquefaction FOS

FOS > 1.0
FOS < 1.0



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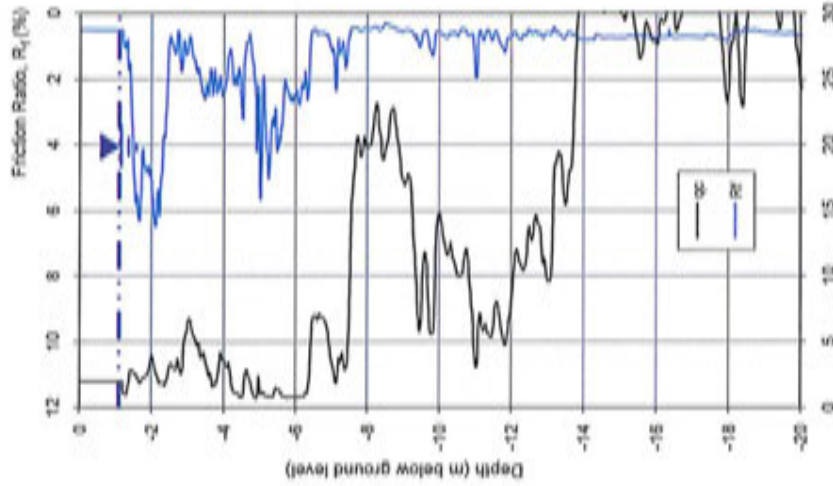
CLIENT PROJECT  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

DOCUMENT  
CPT-CBD-53  
LOT NUMBER  
52000.301

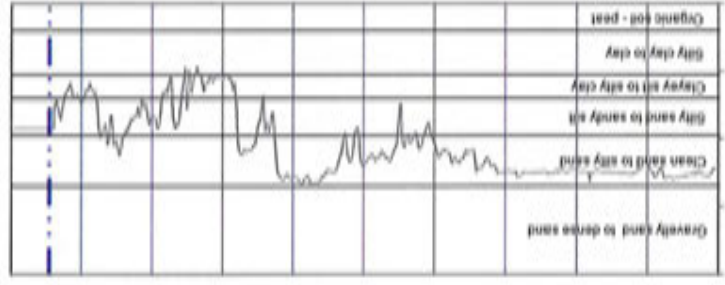
DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results

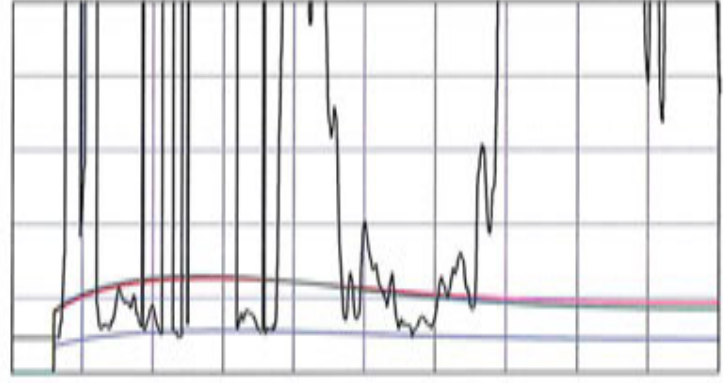
**Raw Data**  
Friction Ratio,  $R_f$  (%)



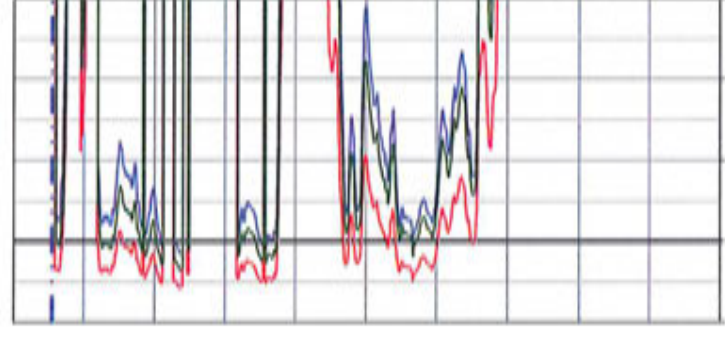
**Soil Classification**  
Zhang et al. 2002



**Cyclic Stress Ratio**  
Seed et al. 2002



**Factor of Safety**  
Seed et al. 2002



**Liquefaction**  
Seed et al. 2002



**Earthquake scenario**

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sec. 54	0.25	7.1	-
Jun. 13	0.25	6	-

**Thickness of liquefied layers (m)**  
Seed et al. 2002

SLS	0.4
Sec. 54	0.7
Jun. 13	2.2

**Liquefaction FOS**

FOS $\geq 1.0$	Green
FOS $< 1.0$	Red



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CLIENT PROJECT

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

LOCATION

**CPT-CBD-63**

FILE

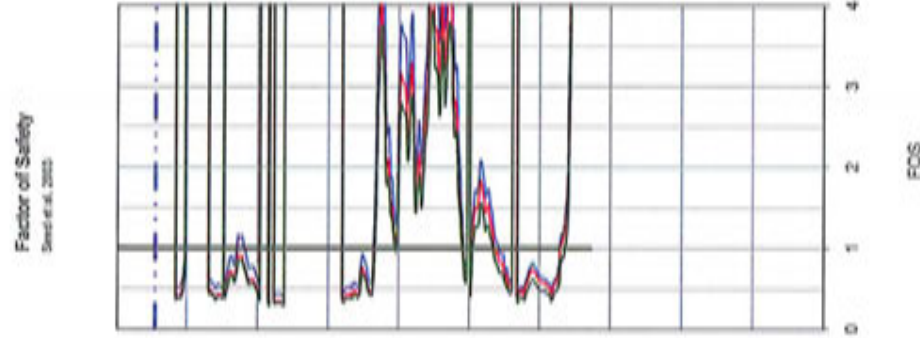
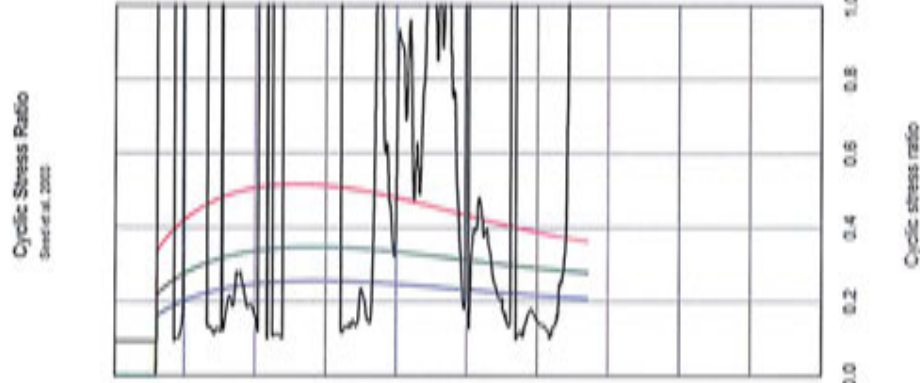
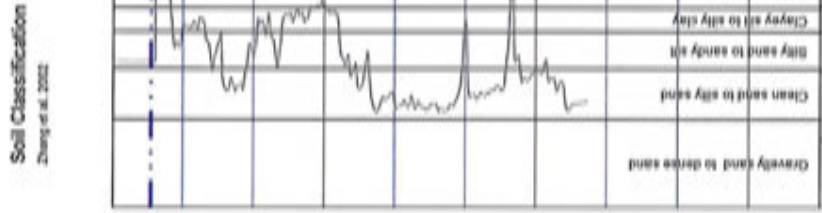
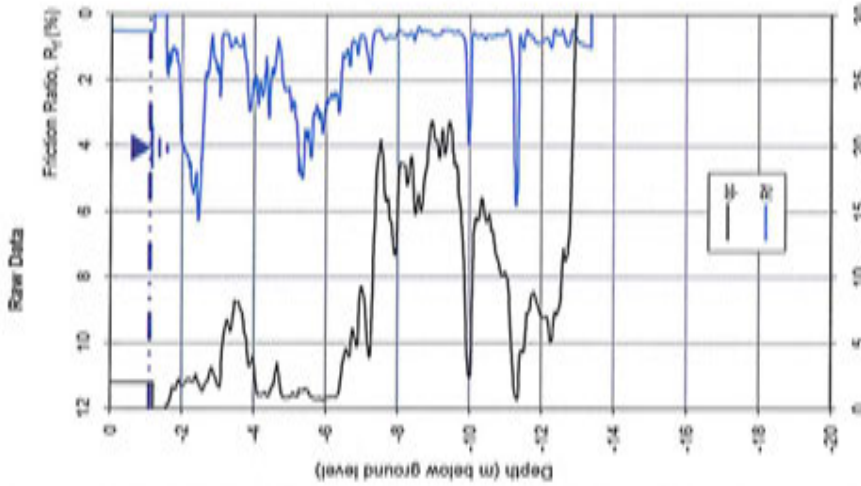
JOB NUMBER

52000.301

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
AFF

Liquefaction Assessment from CPT Results





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
0.25	7.5	500
0.52	6.2	-
0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
4.5
4.8
5.1

Liquefaction FOS

FOS > 1.0
FOS < 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-54

DATE

5/2/2011

ANALYSED

RAP

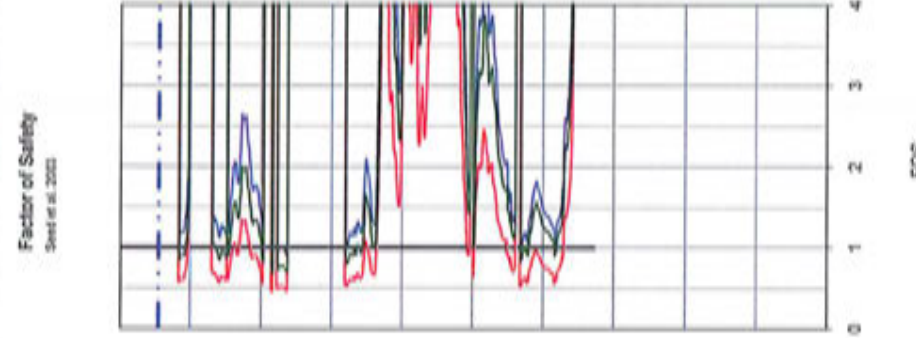
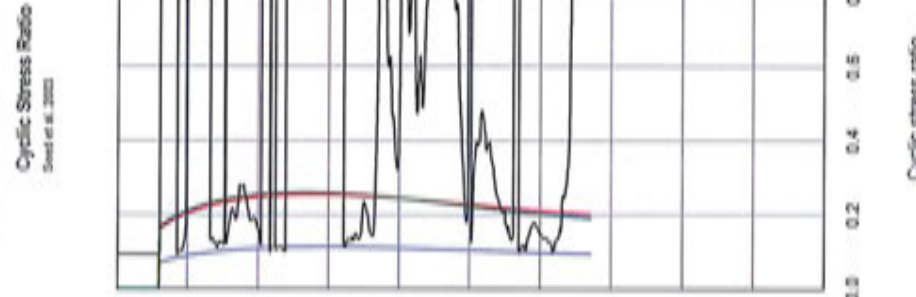
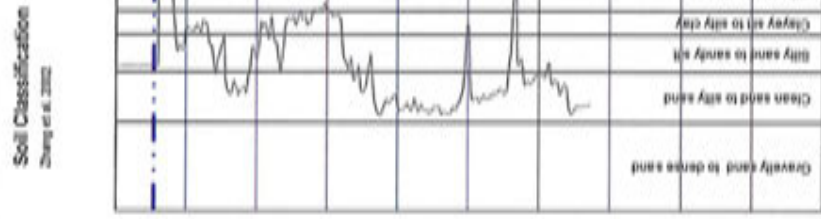
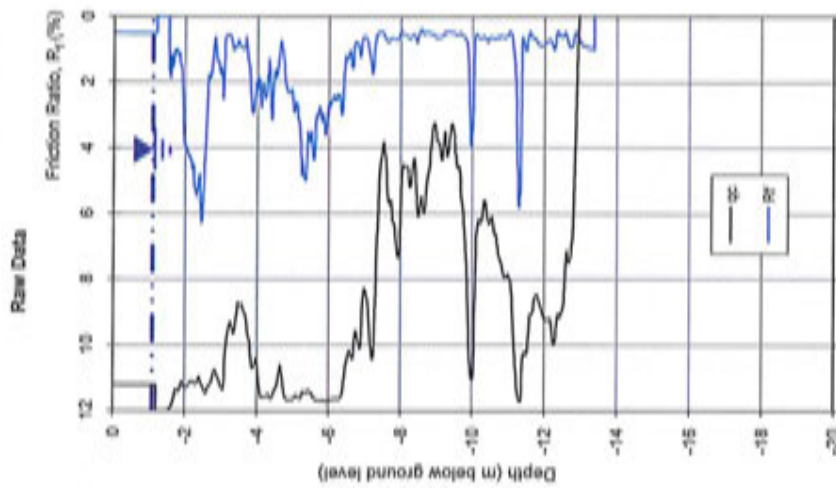
CHECKED

AFF

JOB NUMBER

52000\_301

DATE 5/2/2011  
ANALYSED RAP  
CHECKED AFF



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5 - 25
Sep.04	0.25	7.1
Jun.13	0.26	6

**Thickness of liquefied layers (m)**  
Seed et al. 2002

0.3
4.0
1.5

**Liquefaction FOS**

FOS  $\geq$  1.0  
FOS  $<$  1.0



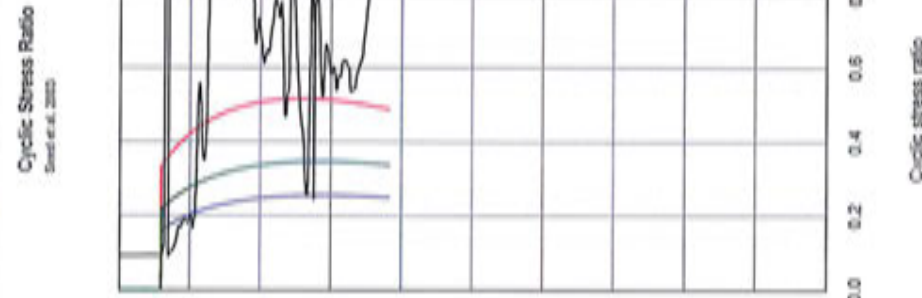
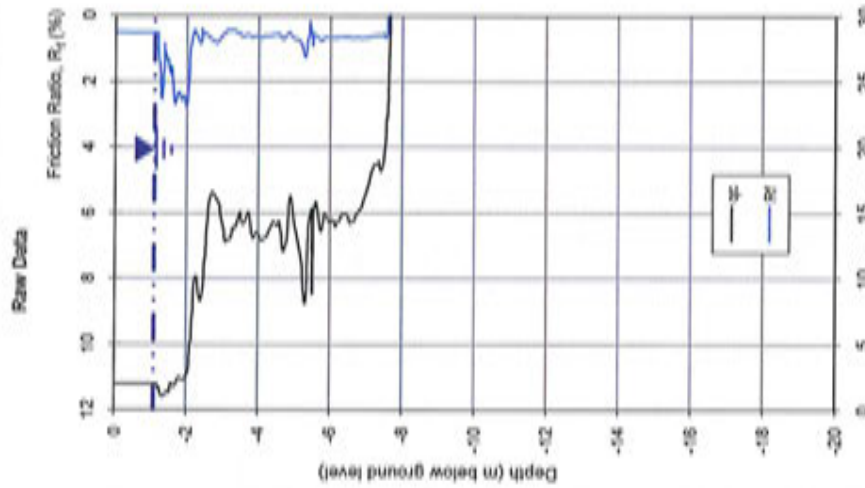
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Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**CLIENT PROJECT**  
CPT-CBD-54

**JOB NUMBER**  
52000.301

**DATE** 7/13/2011  
**ANALYSED** RAP  
**CHECKED** AFF



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
0.25	6.2	-
0.52	7.5	500

Thickness of liquefied layers (m)

0.8
1.0
1.0

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

LOCATION

**CPT-CBD-55**

ICE NUMBER

52000.301

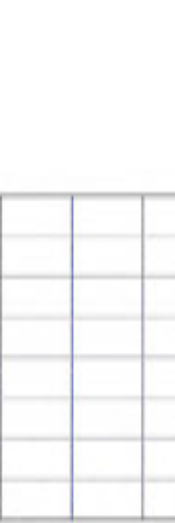
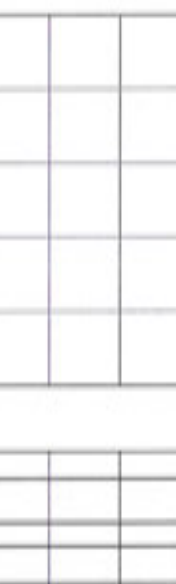
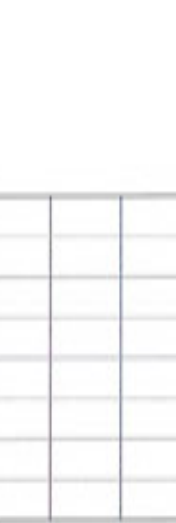
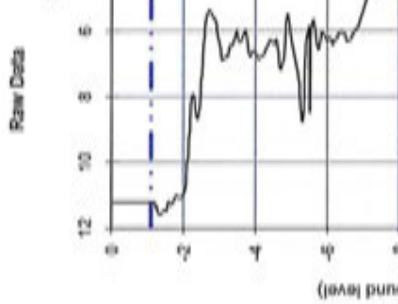
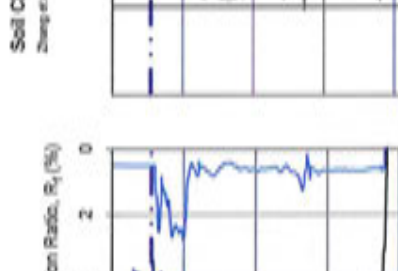
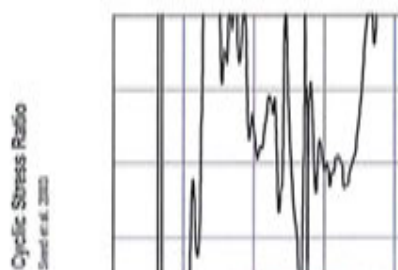
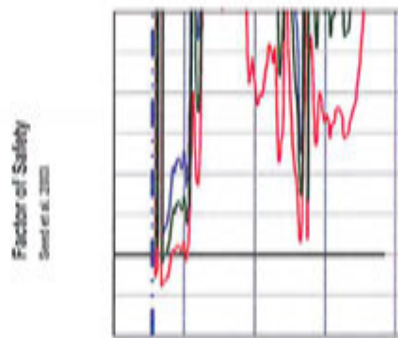
Liquefaction Assessment from CPT Results

DATE  
6/12/2011

ANALYSED  
RAP

CHECKED  
AFF

**Raw Data**  
Friction Ratio,  $R_f$  (%)




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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

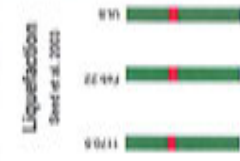
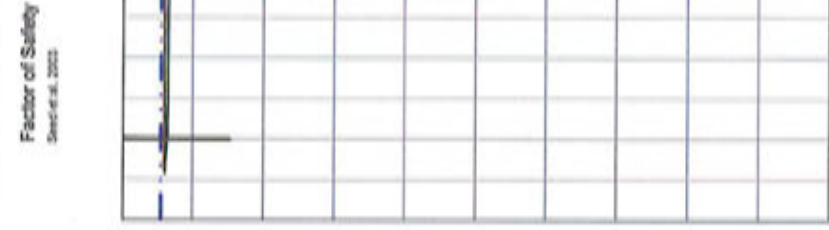
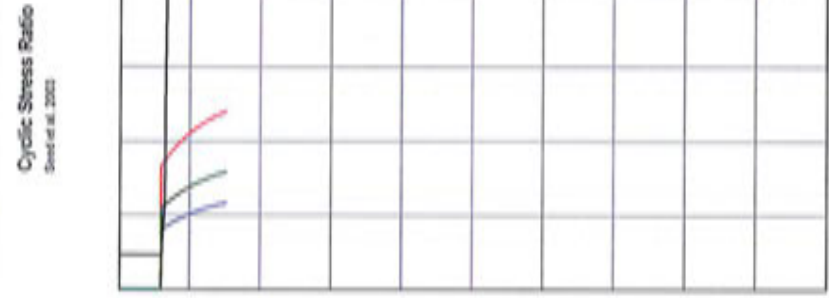
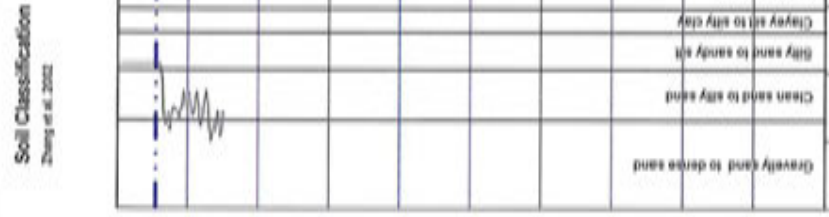
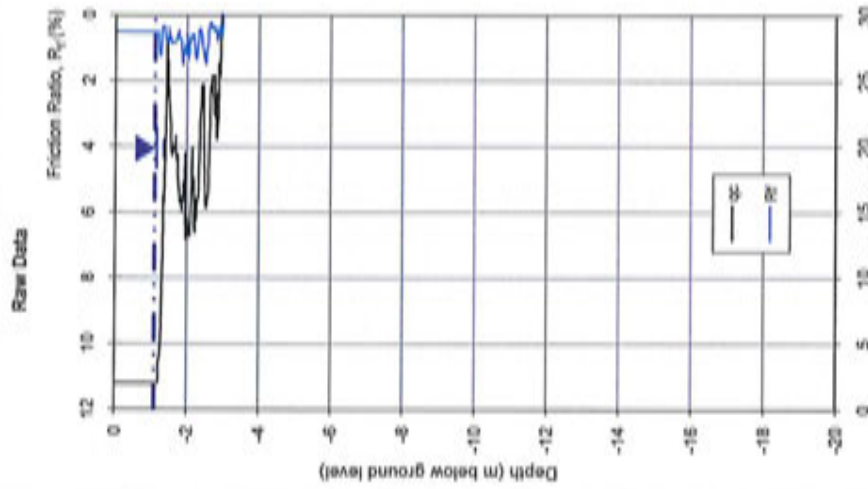
**CPT-CBD-55**

PROJECT REQUEST: FILE

LOCATION: LOT NUMBER: 52000.301

DATE: 7/12/2011  
APPROVED: RAP  
CHECKED: AFF  
AFF

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1172.5	0.25	7.5
Feb.22	0.52	5.2
U.L.S.	0.34	7.5

Thickness of liquefied layers (m)

0.0
0.1
0.1

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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Environmental & Engineering Consultants

CLIENT/PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-56

DATE

5/12/2011

ANALYSED

RAP

JOB NUMBER

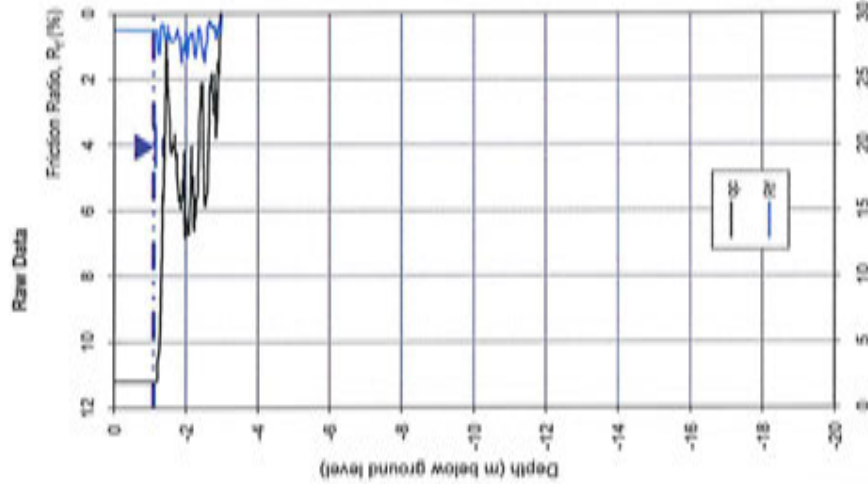
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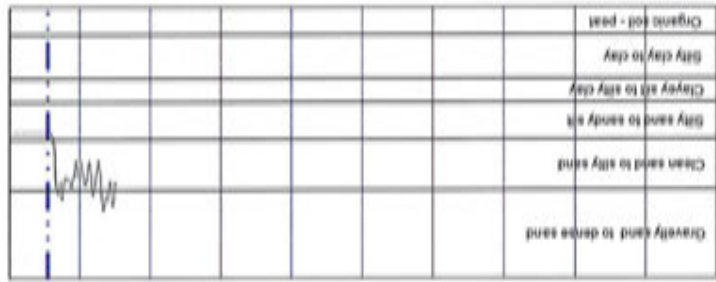
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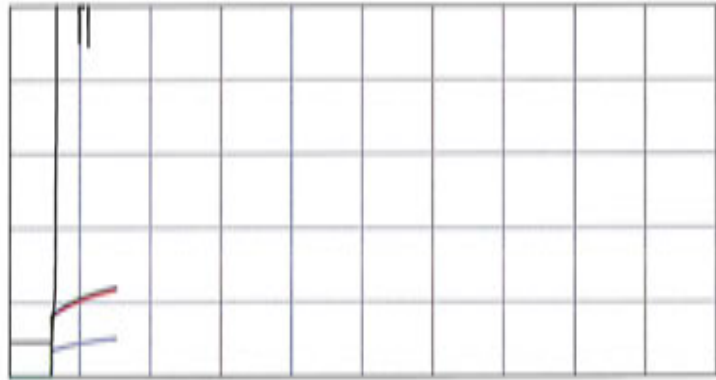
Liquefaction Assessment from CPT Results



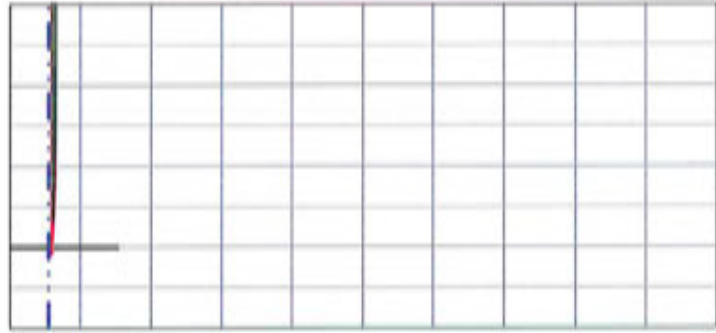
**Soil Classification**  
Zhang et al. 2002



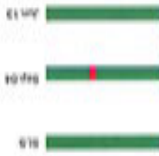
**Cyclic Stress Ratio**  
Seed et al. 2002



**Factor of Safety**  
Seed et al. 2002



**Liquefaction**  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.04	0.25	7.1	-
Jun.13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.0
0.0
0.0

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



**Tonkin & Taylor Ltd**  
Environmental &  
Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-56

FILE

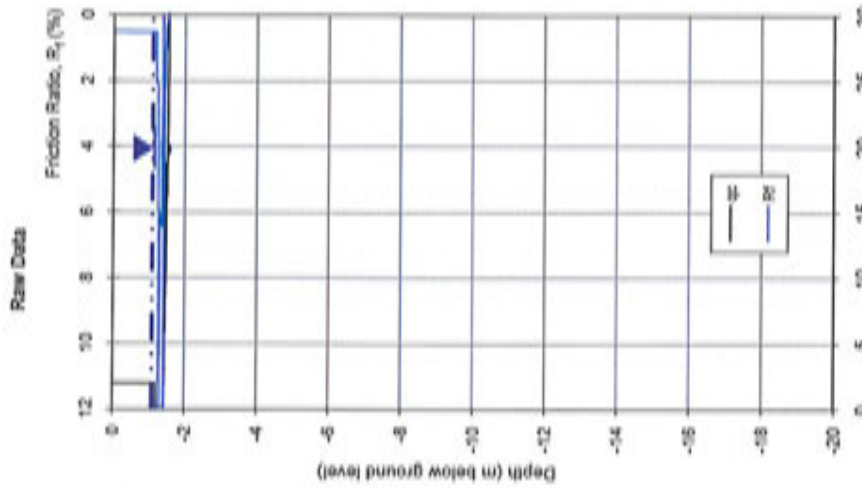
Liquefaction Assessment from CPT Results

LOT NUMBER  
520000.304

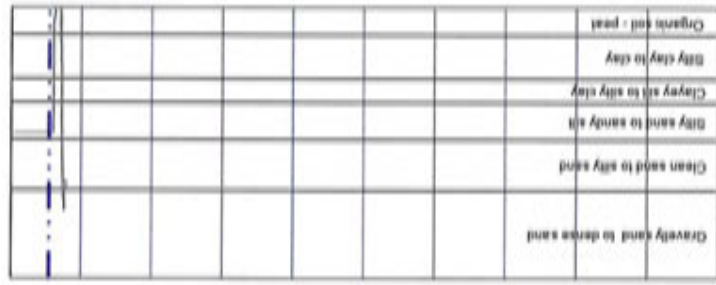
DATE  
7/12/2011

ANALYSED  
RAP

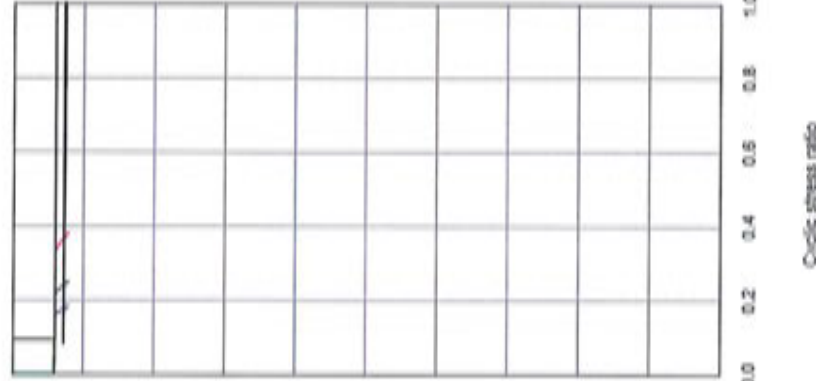
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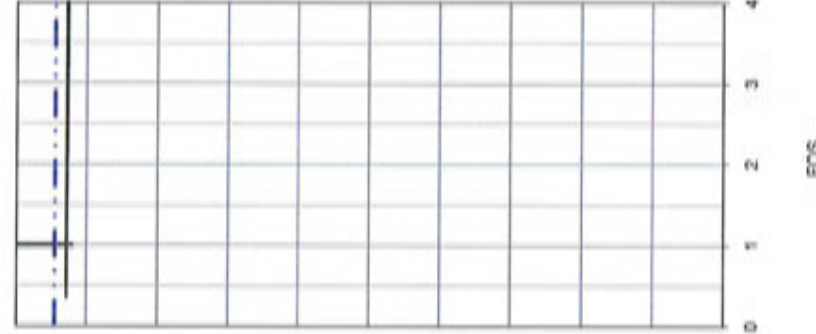
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb 22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

0.0
0.0
0.0

Liquefaction FOS



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Environmental & Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-57

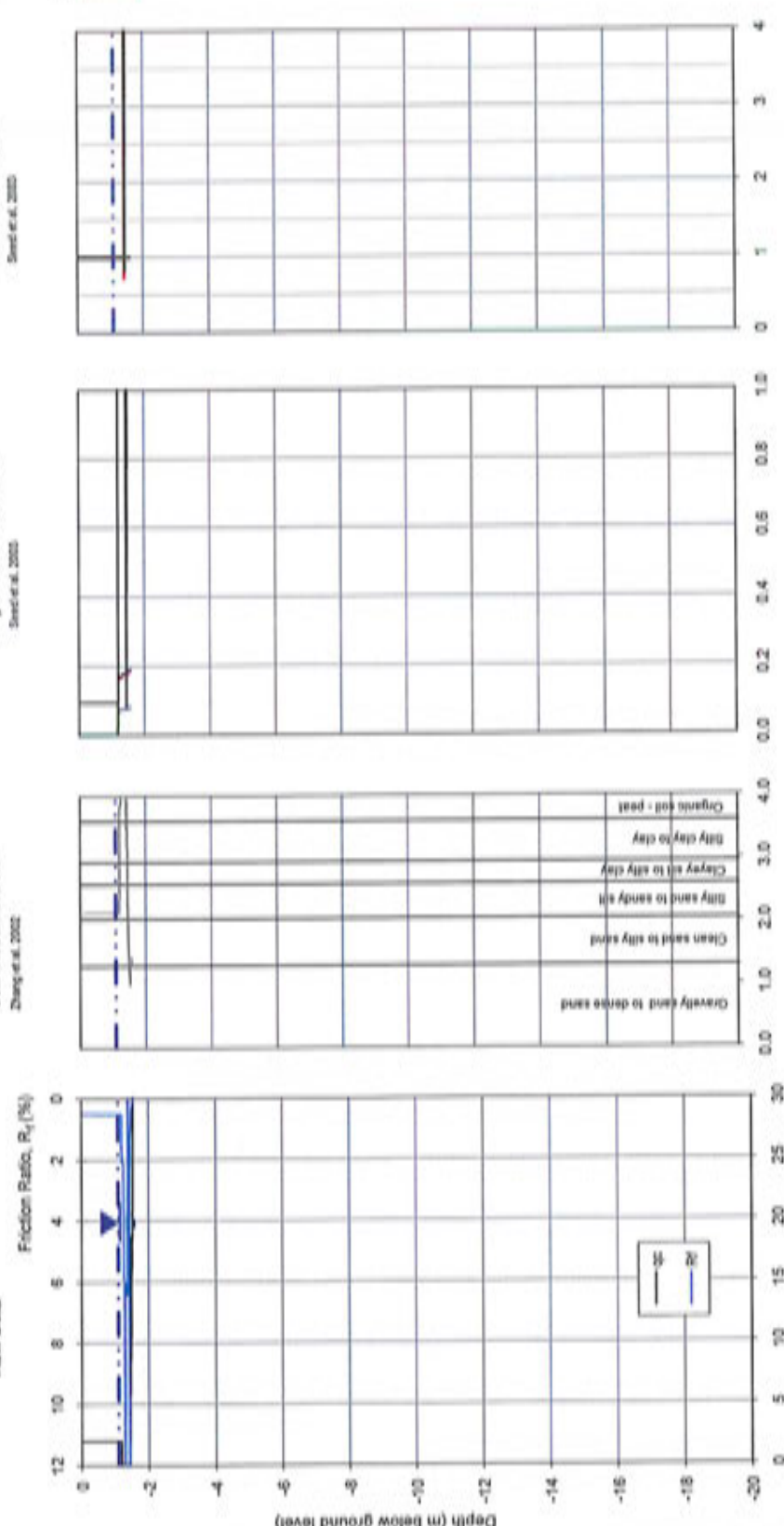
FILE

52000.301

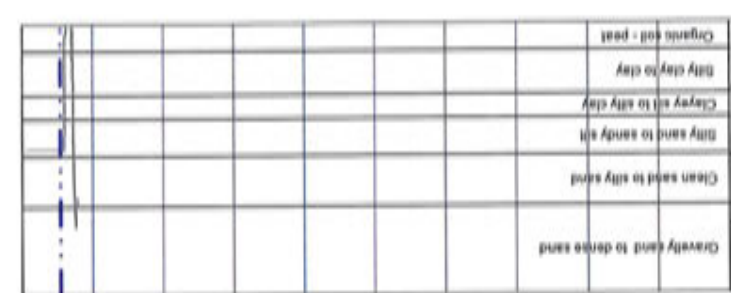
DATE 6/12/2011  
ANALYSED RAP  
CHECKED AFF

Liquefaction Assessment from CPT Results

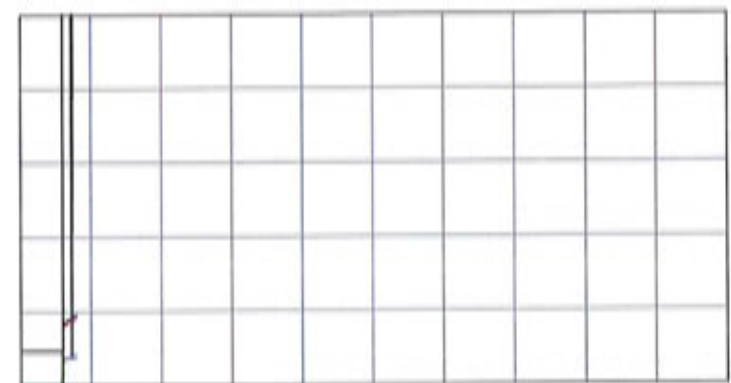
**Raw Data**  
Friction Ratio,  $R_f$  (%)



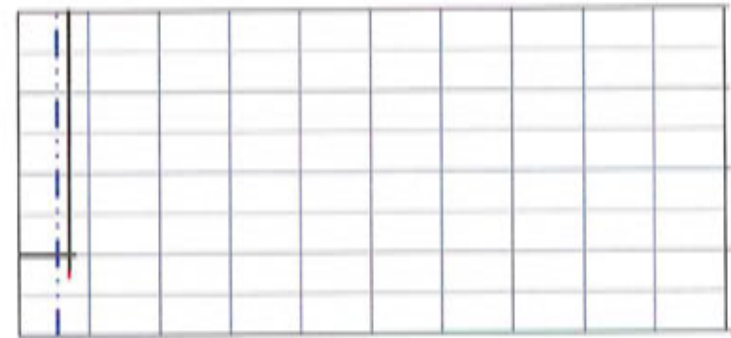
**Soil Classification**  
Zhang et al. 2002



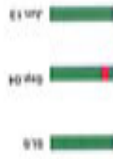
**Cyclic Stress Ratio**  
Seed et al. 2002



**Factor of Safety**  
Seed et al. 2002



**Liquefaction**  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun.13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.0
0.0
0.0

Liquefaction FOS



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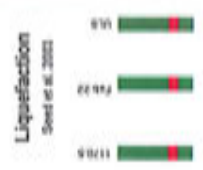
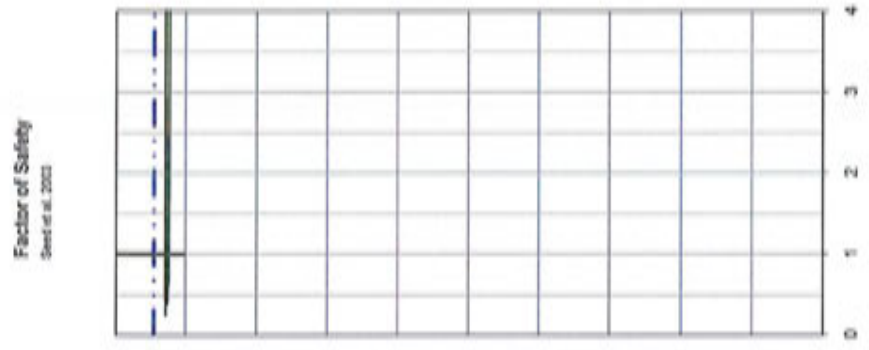
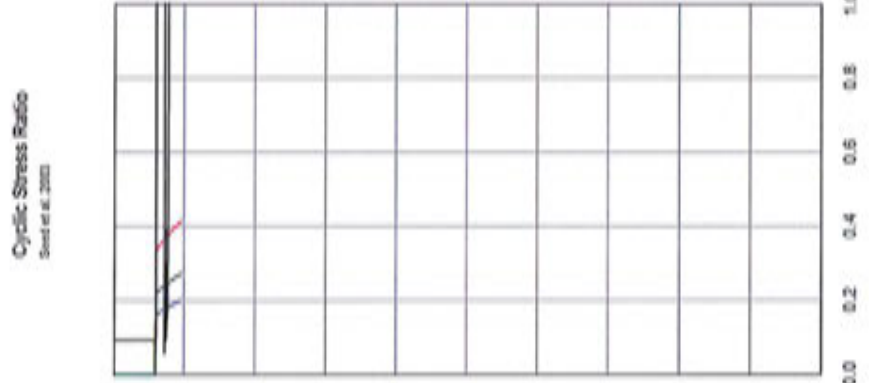
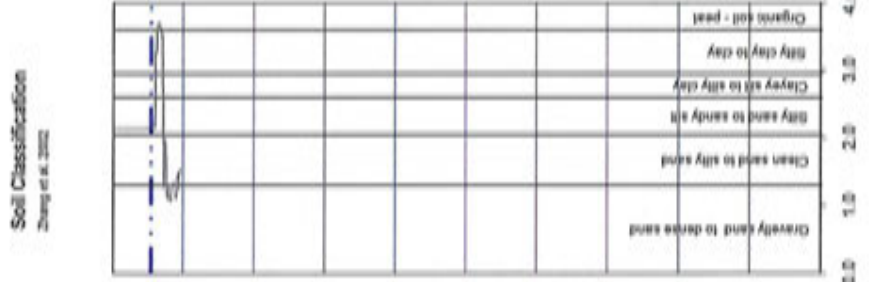
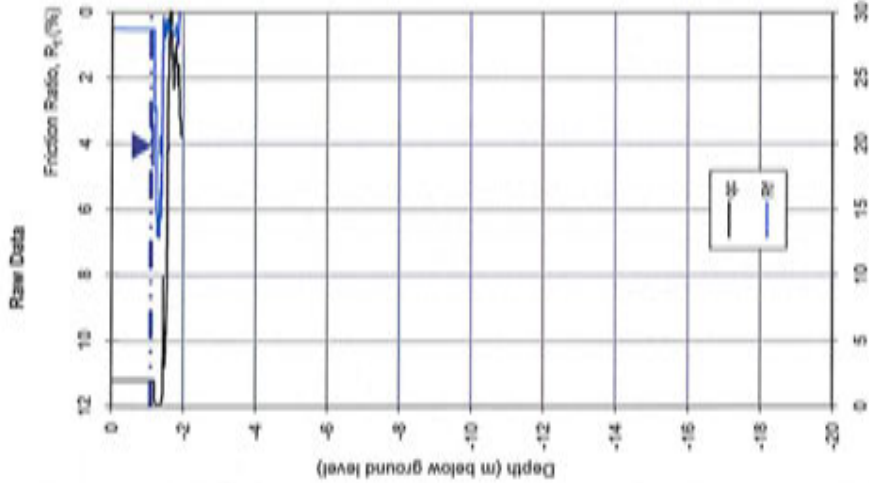
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**CPT-CBD-57**  
JOB NUMBER: 520000.301

DATE: 7/10/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.1
0.1
0.1

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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Environmental & Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-58

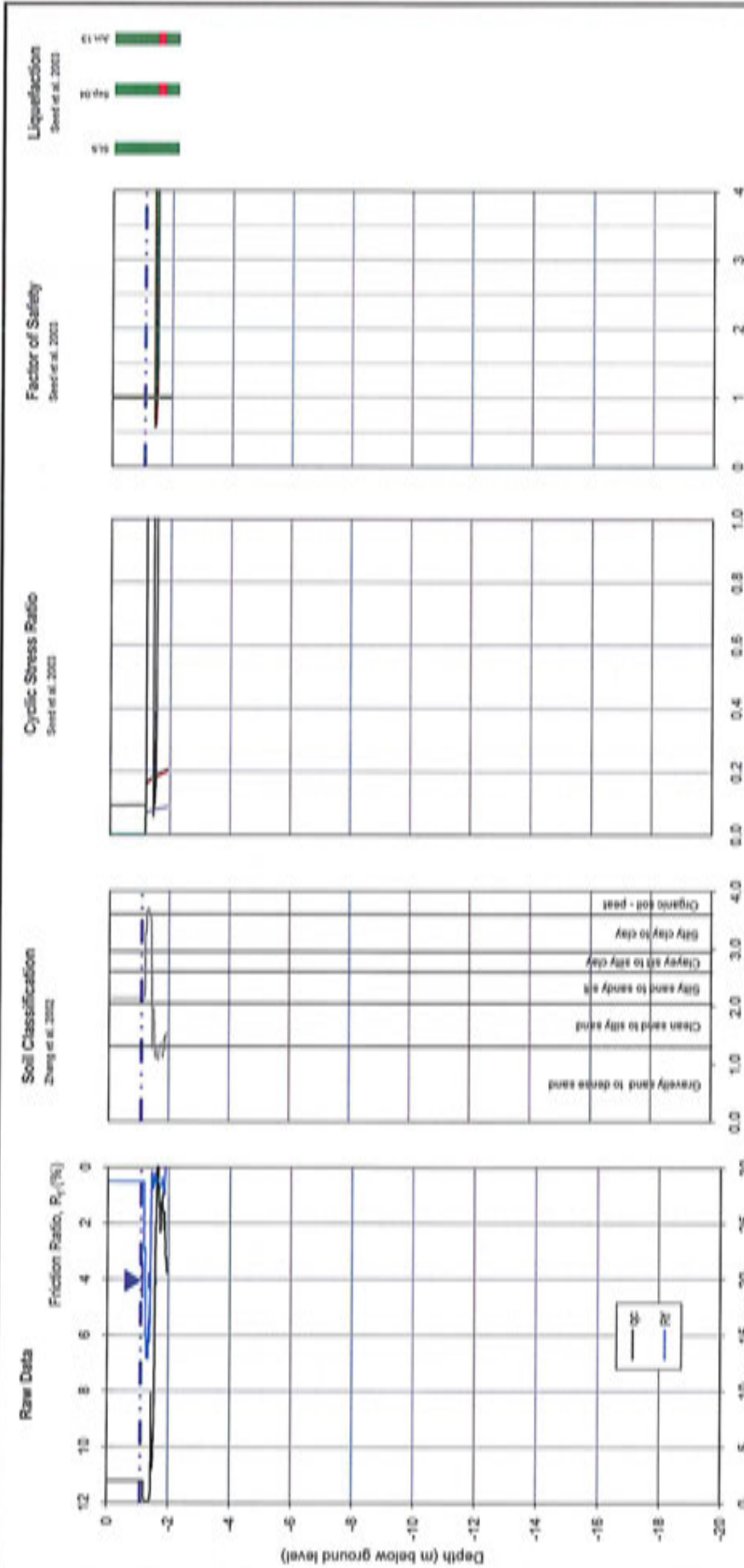
FILE

Liquefaction Assessment from CPT Results

LOT NUMBER

52000.301

DATE 6/12/2011  
ANALYSED RAP  
CHECKED AFF



CPT tip resistances,  $q_p$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.25	6	-

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

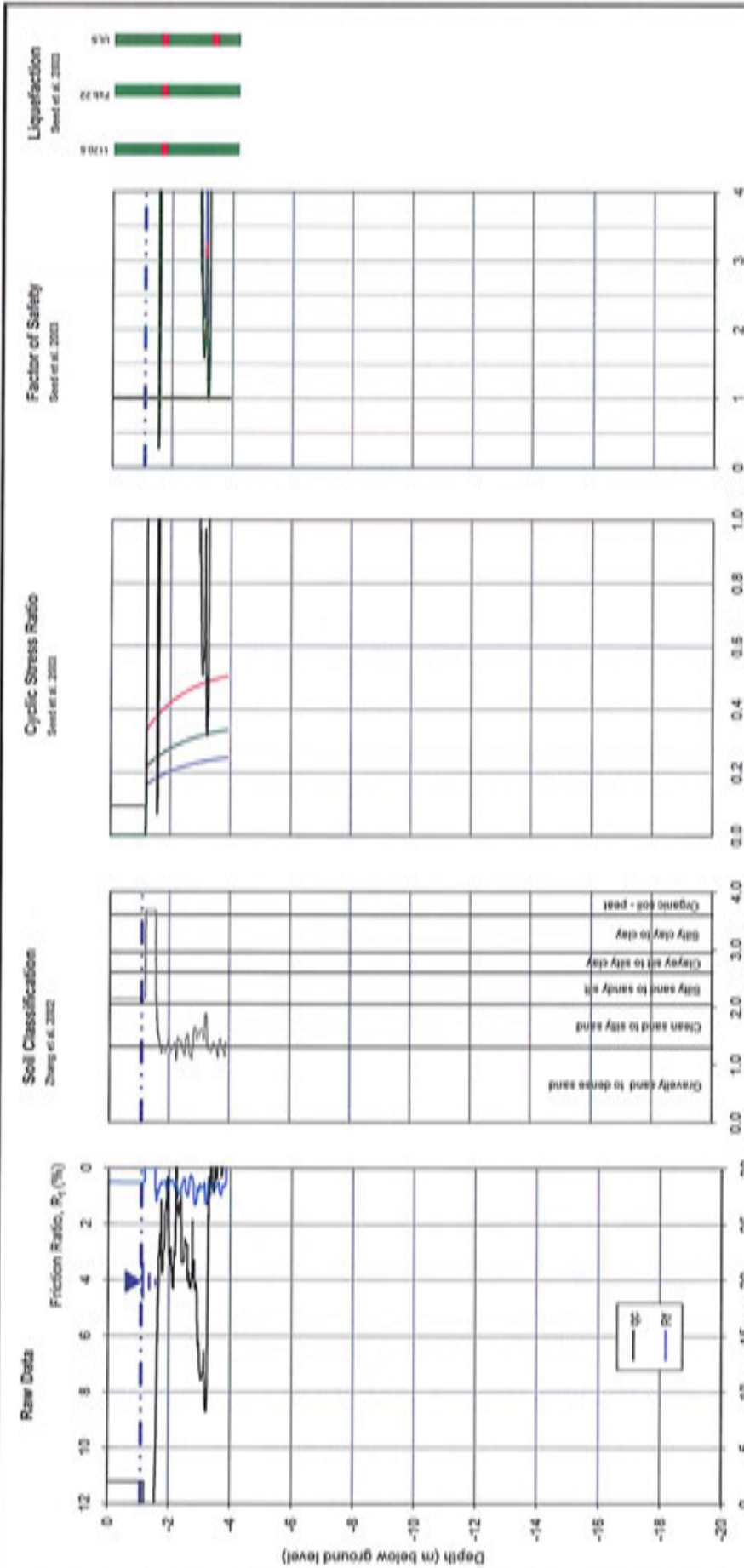
Location: CPT-CBD-58

Job Number: 52000.001

Liquefaction Assessment from CPT Results

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Environmental & Engineering Consultants

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
APP: AFF



CPT tip resistance,  $q_t$  (MPa)      Soil classification index,  $I_c$       Cyclic stress ratio      FOS

Earthquake scenario


Peak acc. (g)	Magnitude	Return Period (yrs)
1172.5	0.25	7.5
Feb. 22	0.52	6.2
ULS	0.34	7.5

Thickness of liquefied layers (m)

0.0
0.0
0.1

Liquefaction FOS

FOS $\geq 1.0$
FOS $< 1.0$



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Environmental & Engineering Consultants

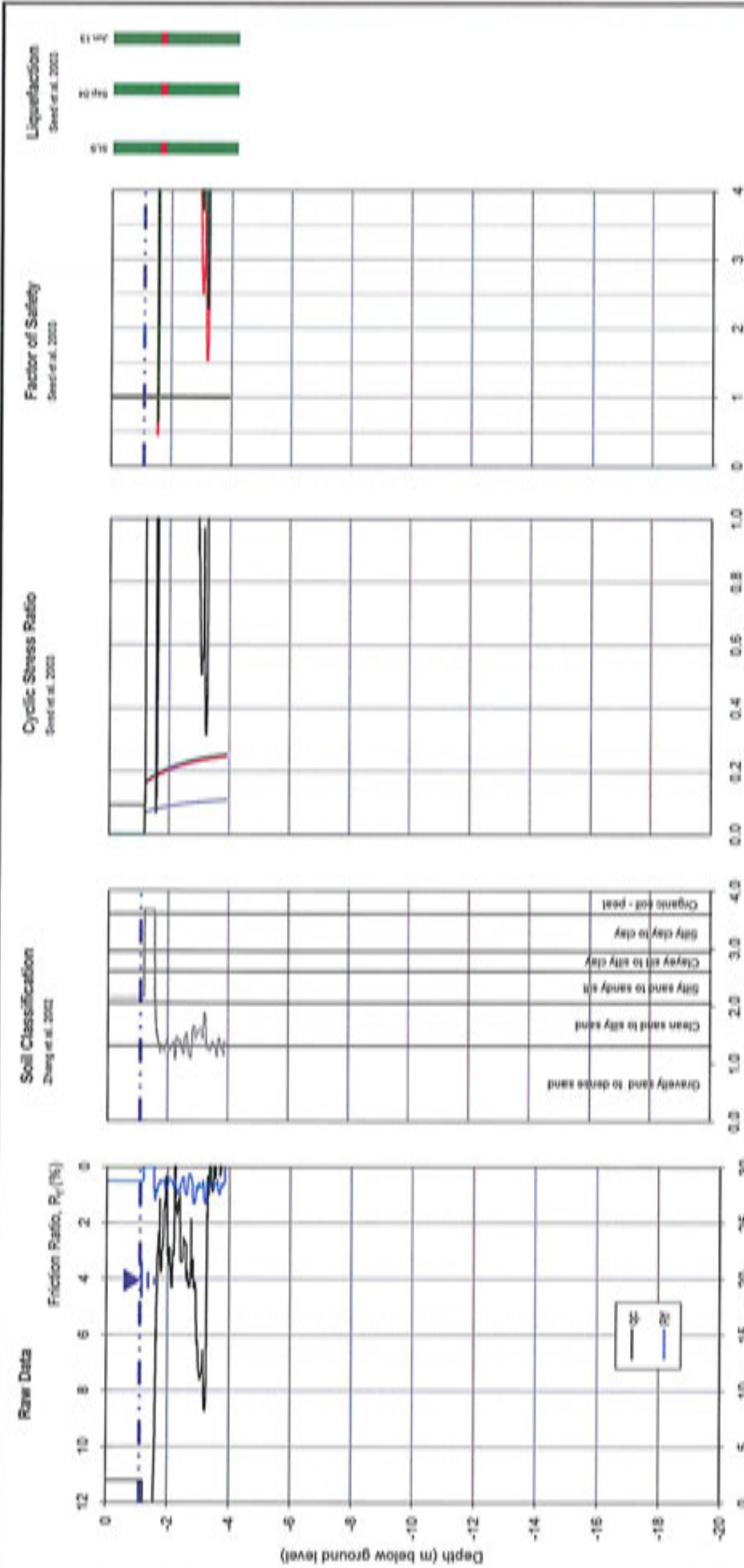
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**CPT-CBD-58a**

DATE: 5/12/2011  
ANALYSED: RAP  
CHECKED: AFF

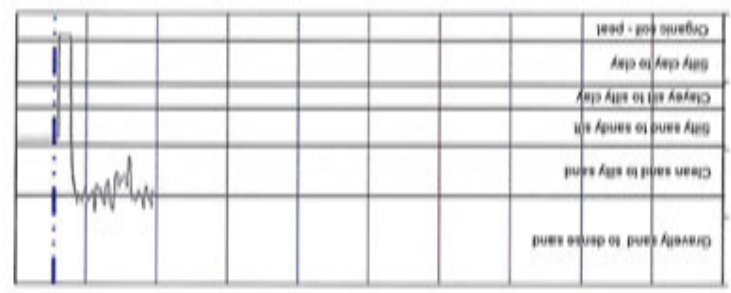
JOB NUMBER: 52000.301

Liquefaction Assessment from CPT Results

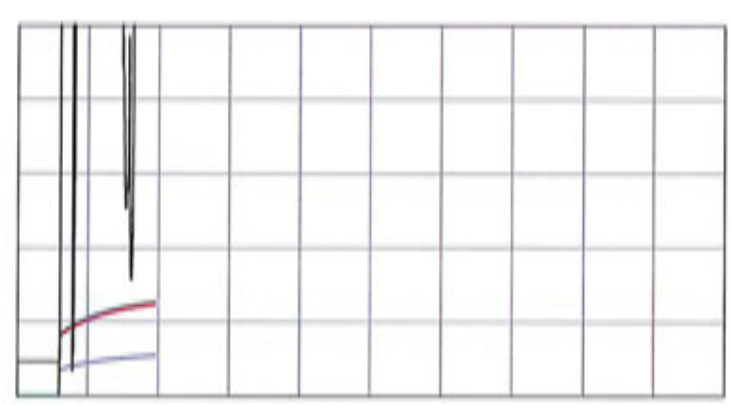


Raw Data  
Friction Ratio,  $R_f$  (%)

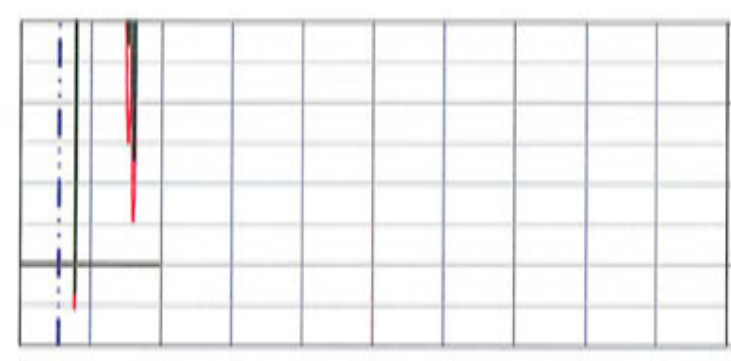
Soil Classification  
Zhang et al. 2002



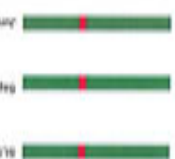
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sup.04	0.25	7.1	-
Jun.13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.0
0.0
0.0

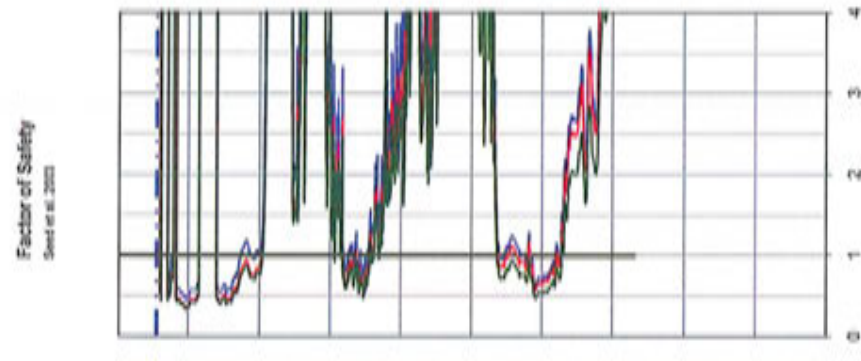
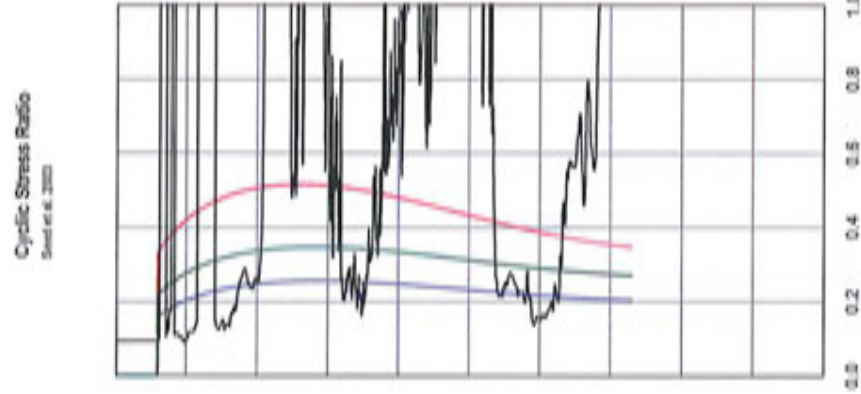
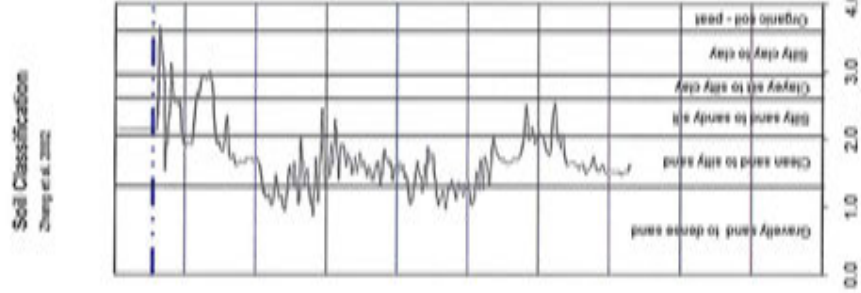
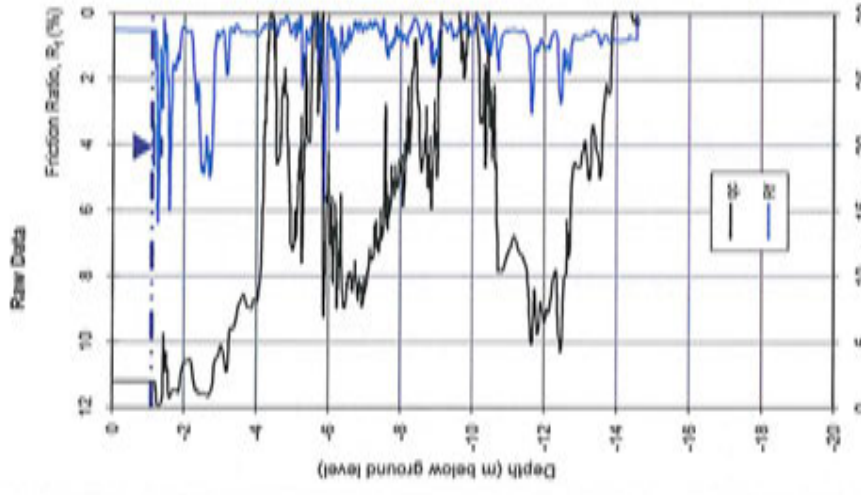
Liquefaction FOS



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Environmental & Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
JOB NUMBER: S2000\_301  
PROJECT: CPT-CBD-58a



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

3.2
4.3
4.9



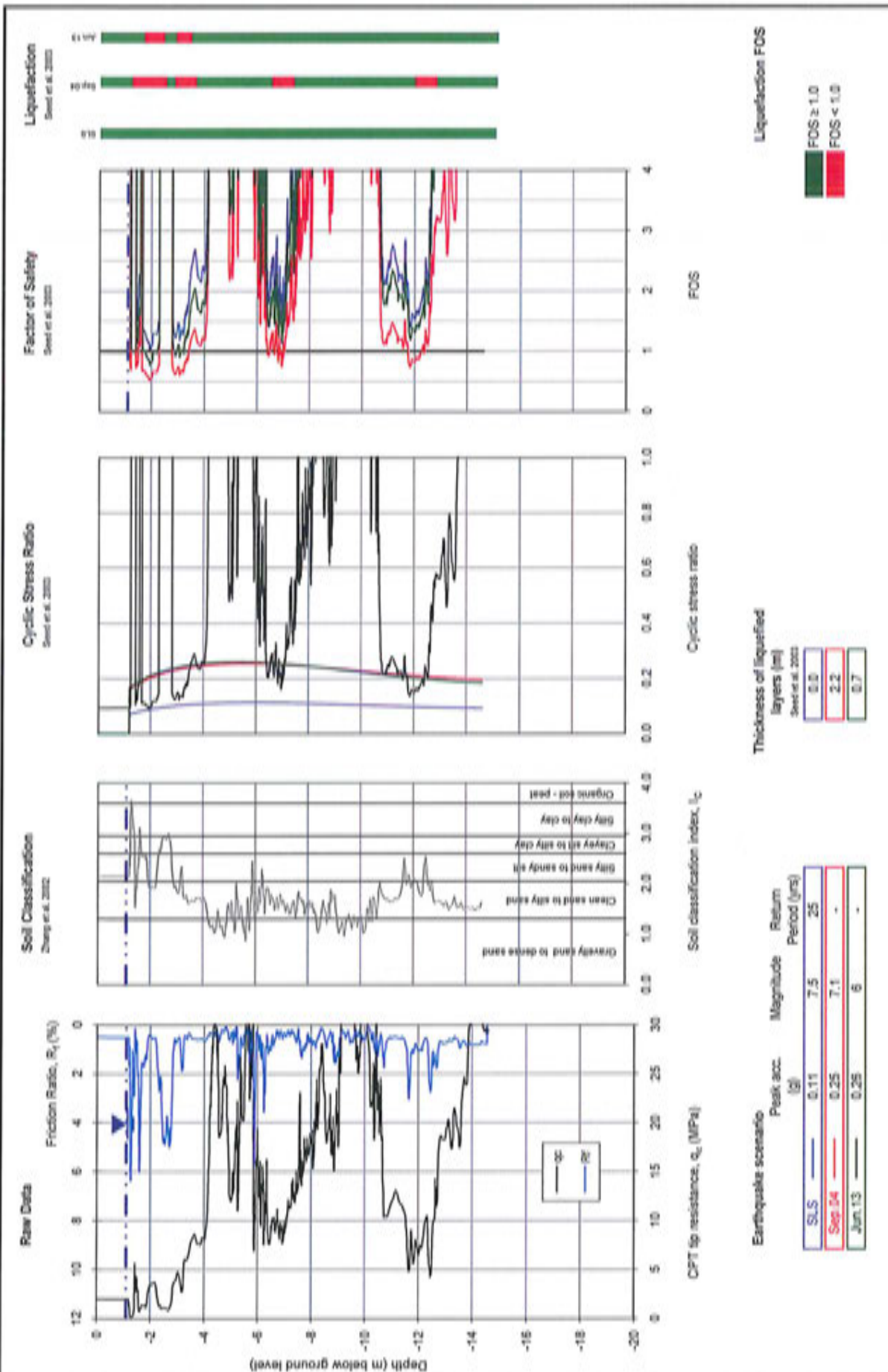
Tonkin & Taylor Ltd  
Environmental & Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT LOCATION  
CPT-CBD-59  
JOB NUMBER 52000\_301

DATE 5/12/2011  
ANALYSED RAP  
CHECKED AFF  
AFF

Liquefaction Assessment from CPT Results



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Environmental &  
Engineering Consultants

CLIENT PROJECT  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

FILE  
Liquefaction Assessment from CPT Results

WORKBOOK  
CPT-C8D-59

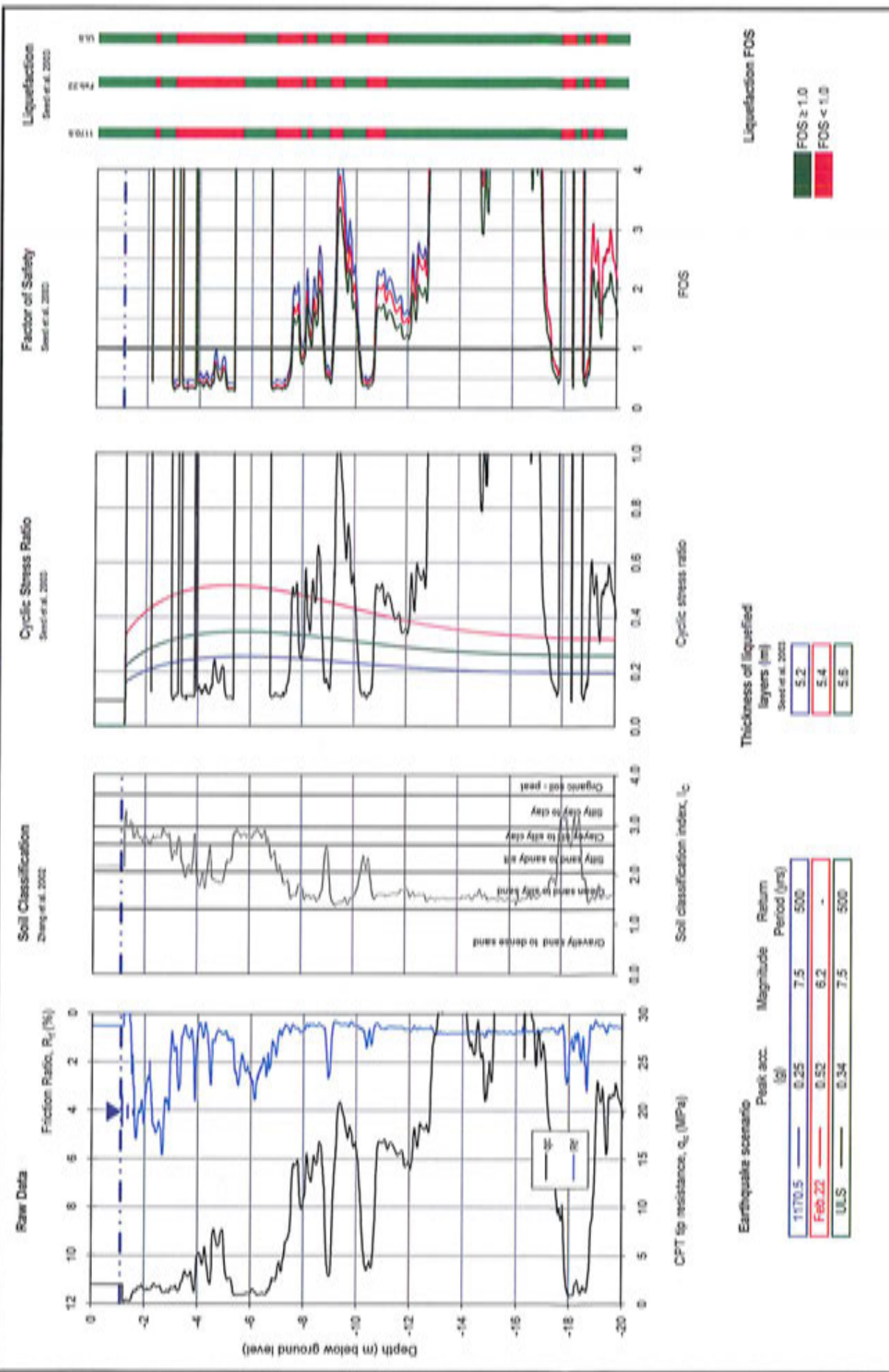
JOB NUMBER  
S2000\_301


DATE  
7/12/2011

ANALYSED  
RAP

CHECKED  
AFF

AFF





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Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

Liquefaction Assessment from CPT Results

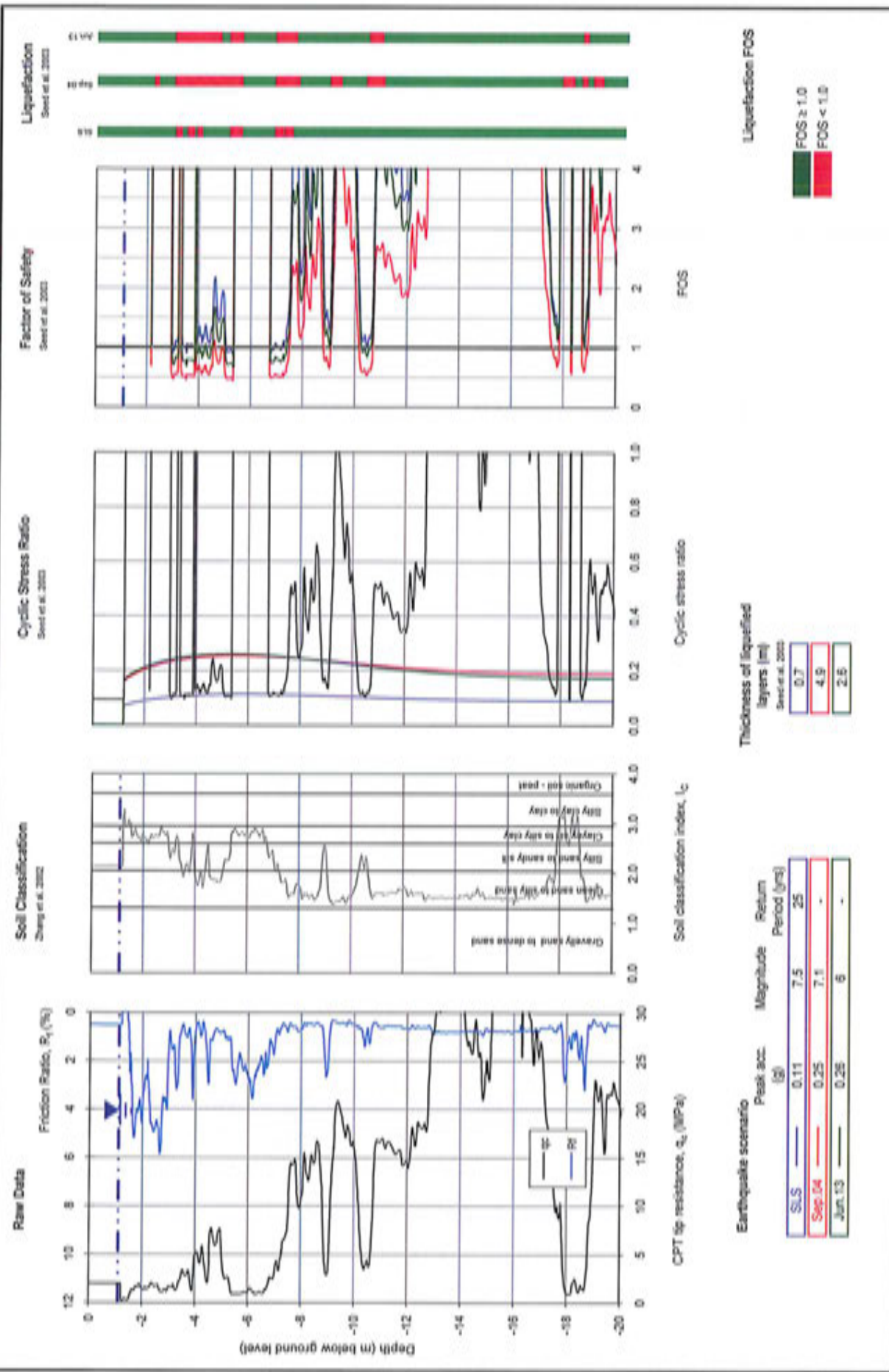
CLIENT PROJECT: **CPT-CBD-60**

DATE: 6/12/2011

ANALYSED: RAP

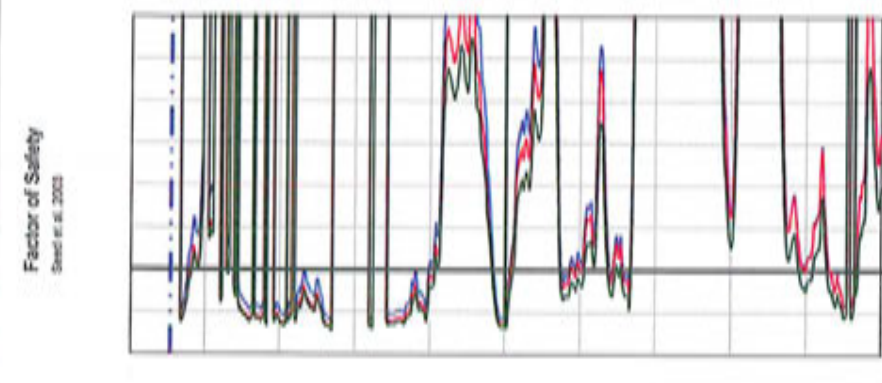
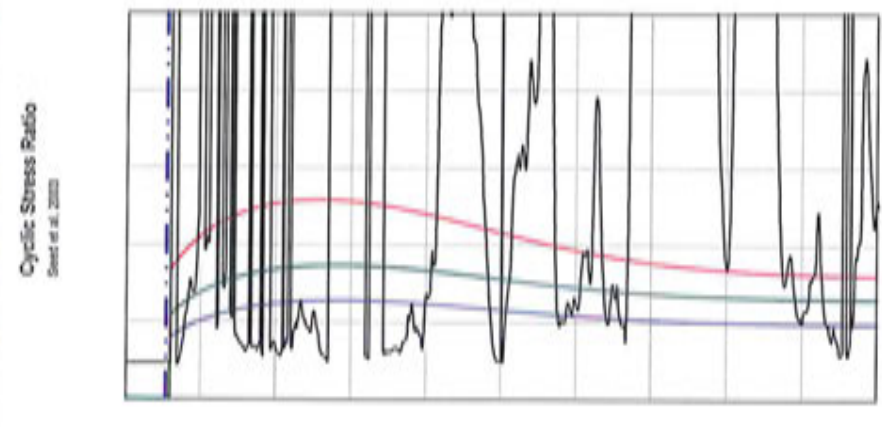
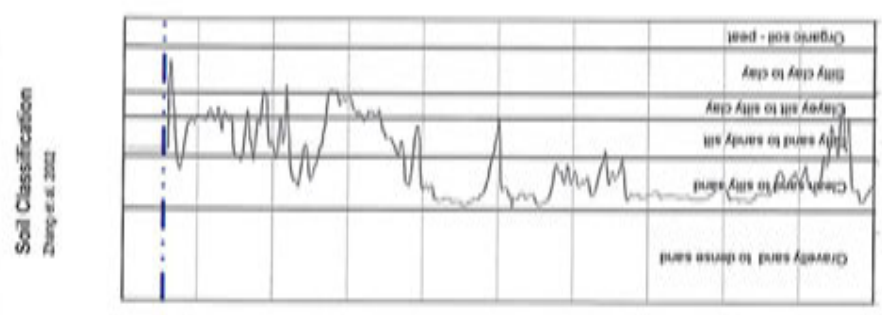
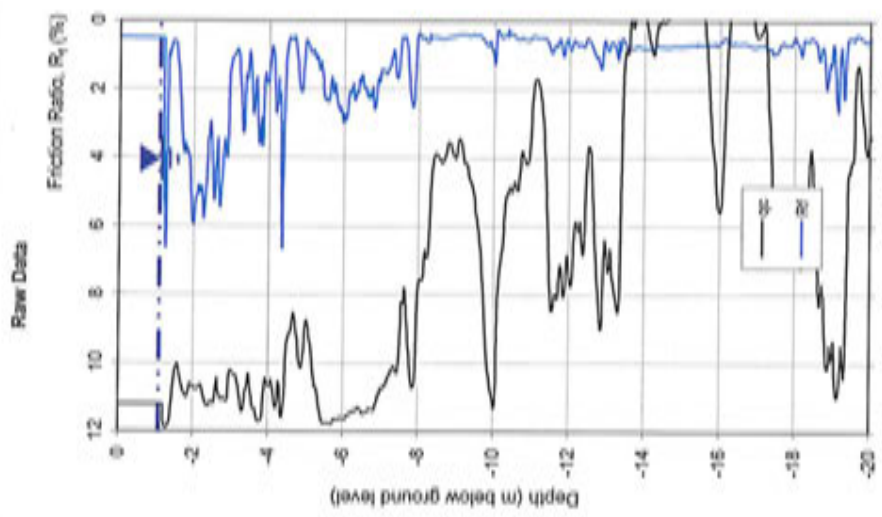
CHECKED: AFF

JOB NUMBER: S2000\_301



 Tonkin & Taylor Ltd Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	DESIGN <b>CPT-CBD-60</b>	DATE: 7/12/2011 ANALYSED: RAP CHECKED: AFF
	Liquefaction Assessment from CPT Results		JOB NUMBER 52000.301





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

6.4
7.1
8.7

Liquefaction FOS

█ FOS  $\geq$  1.0  
█ FOS  $<$  1.0



**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

SUBJECT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

**CPT-CBD-61**

JOB NUMBER

52000.301

DATE

7/12/2015

ANALYSED

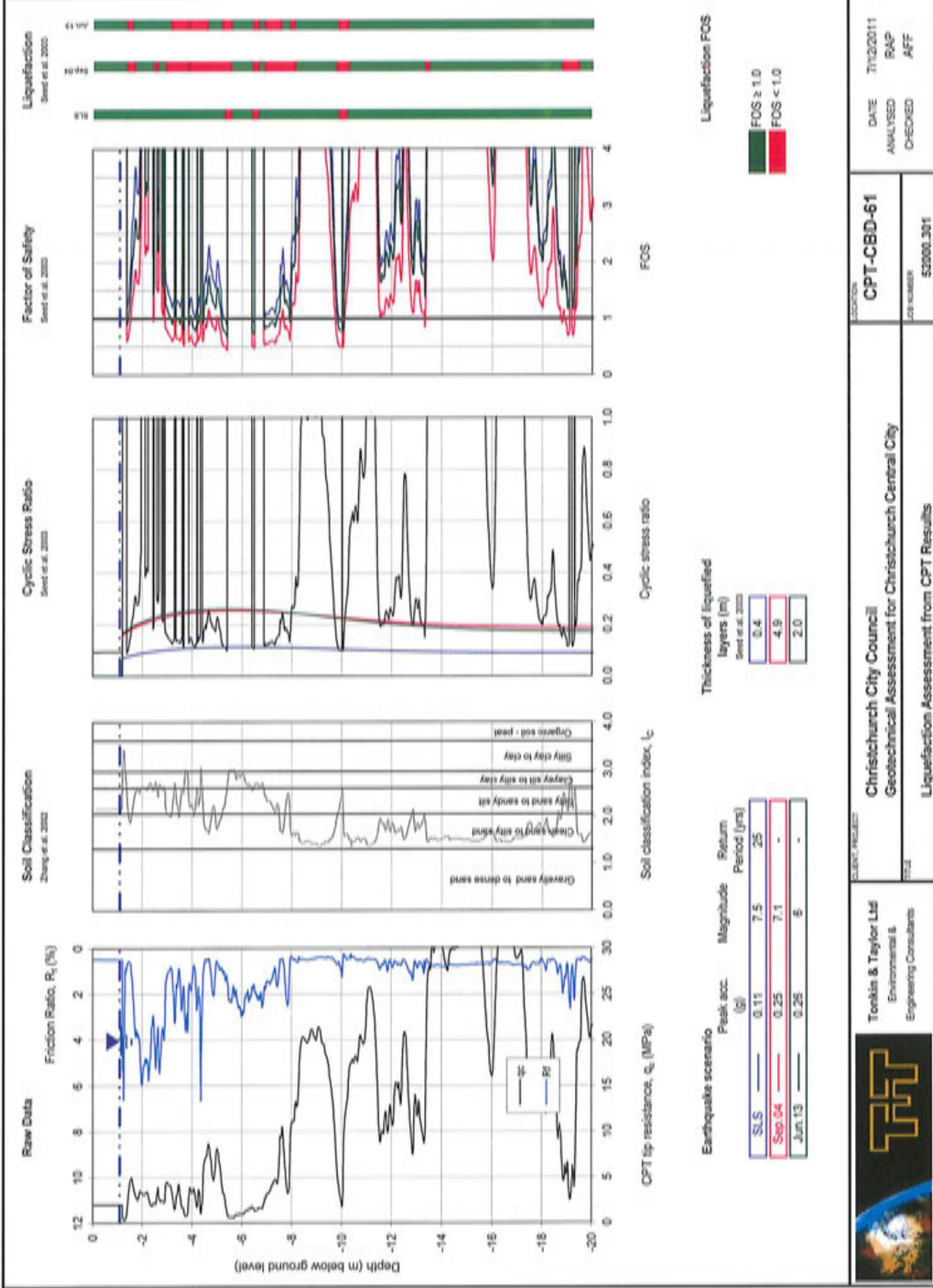
RAP

CHECKED

AFF

FILE

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.4
4.9
2.0

Liquefaction FOS

FOS $\geq 1.0$
FOS $< 1.0$



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Environmental & Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION  
CPT-CBD-61

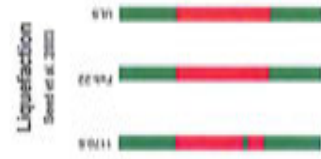
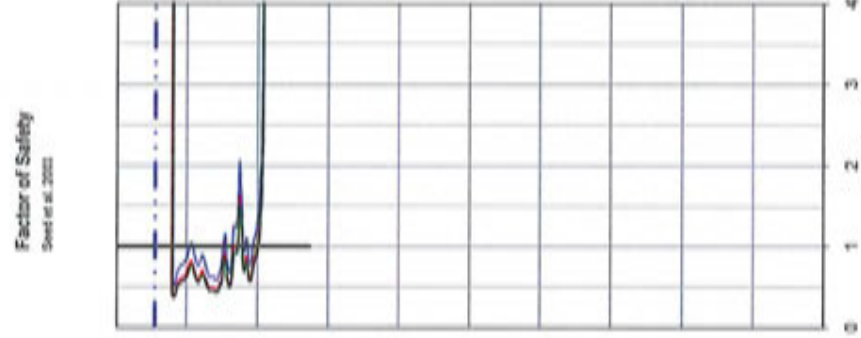
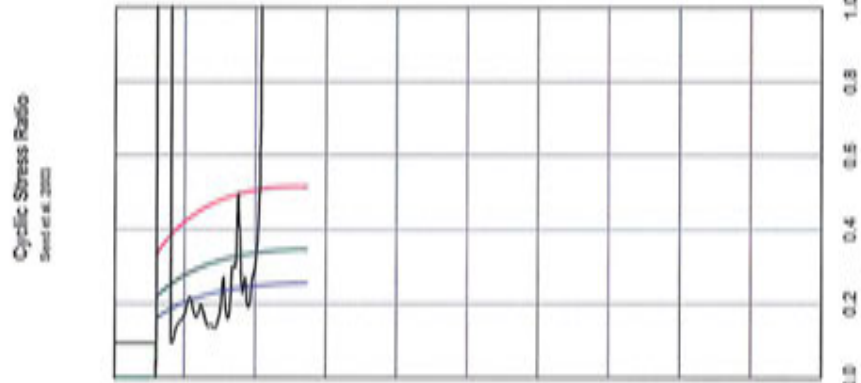
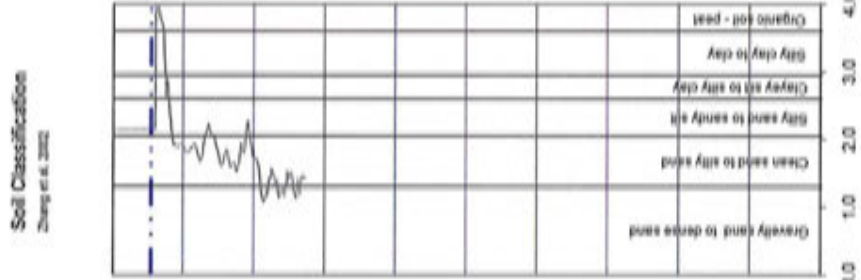
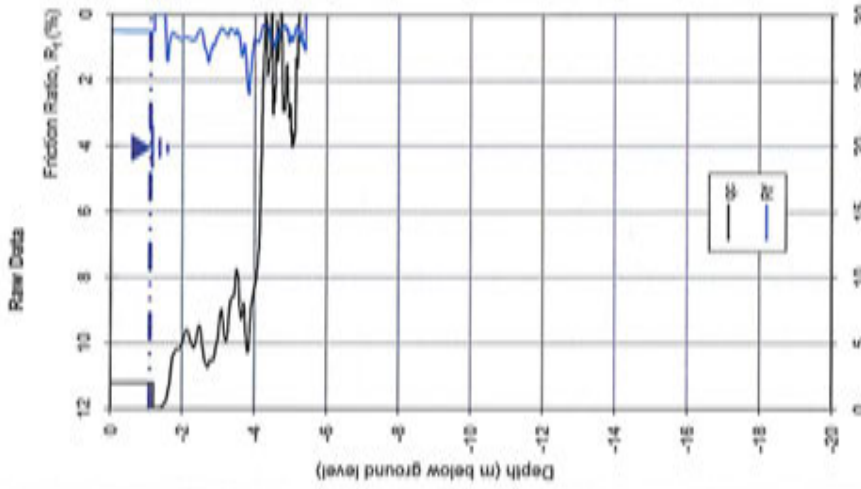
JOB NUMBER  
S2000\_301

DATE  
7/12/2011

ANALYSED  
RAP

CHECKED  
AFF

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

1.7
2.2
2.3

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



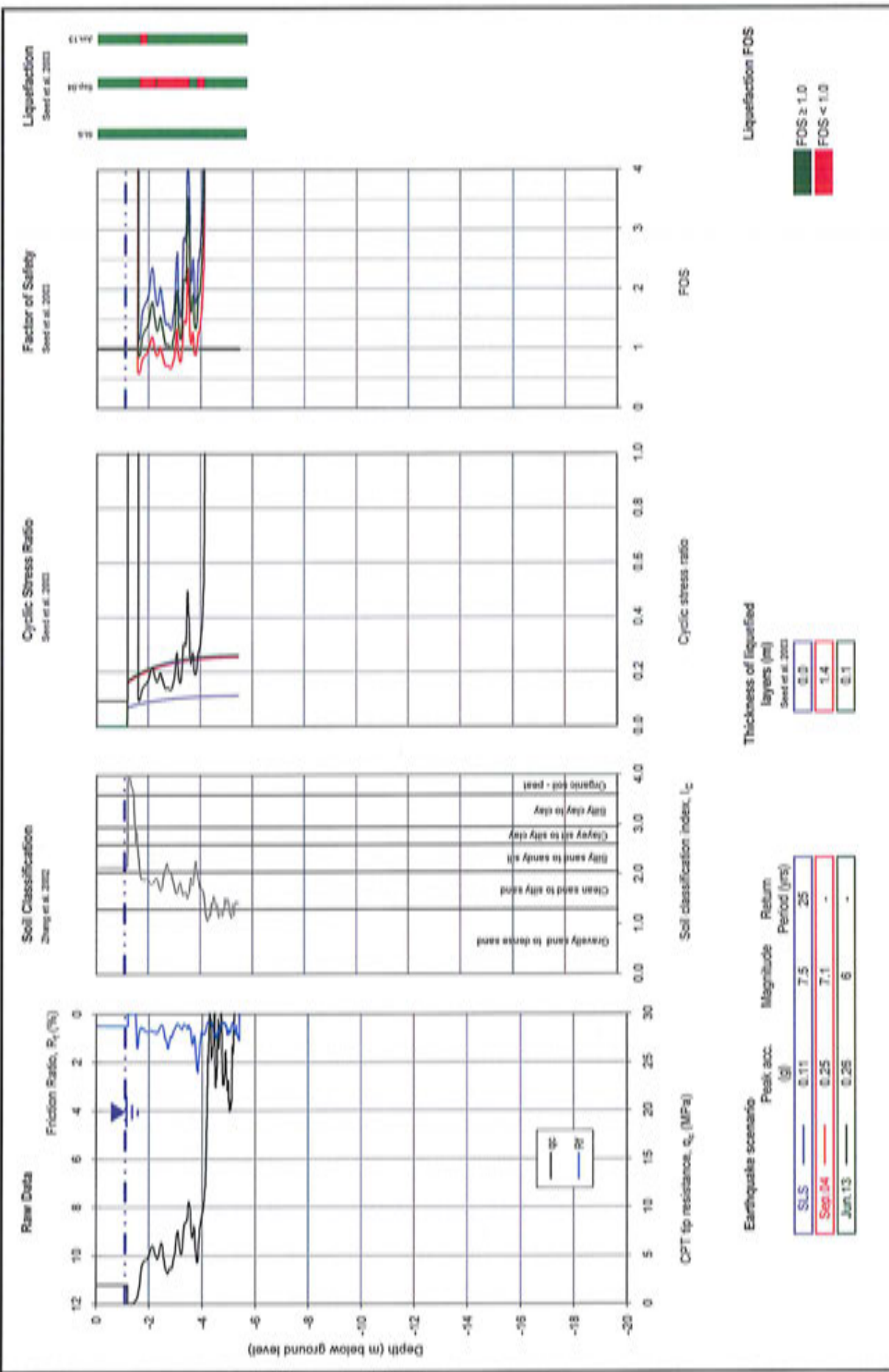
Tonkin & Taylor Ltd  
Environmental & Engineering Consultants

CLIENT / PROJECT: Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION: CPT-CBD-62  
JOB NUMBER: 520000\_301

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results



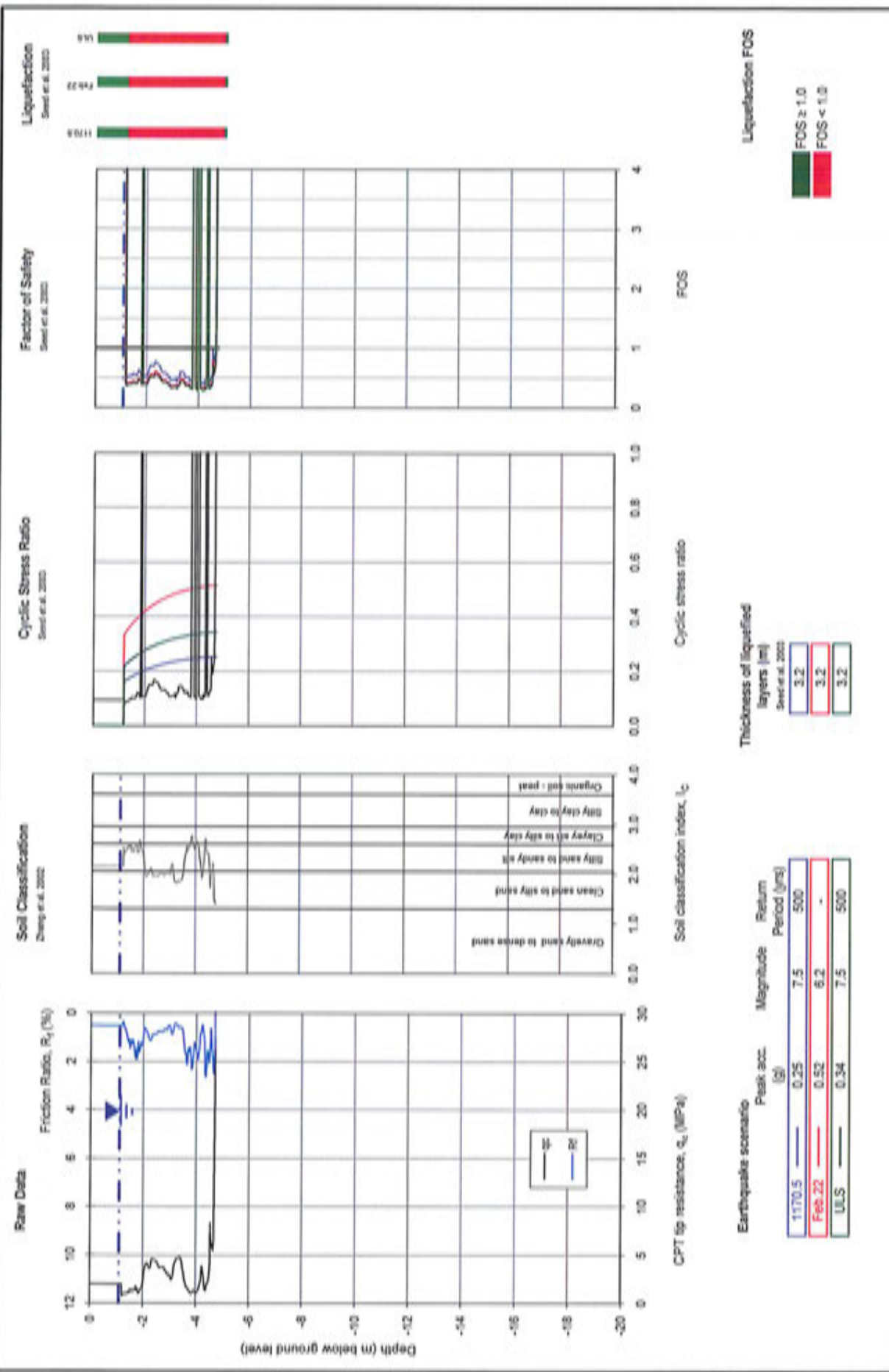
**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

**CLIENT REQUEST**  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

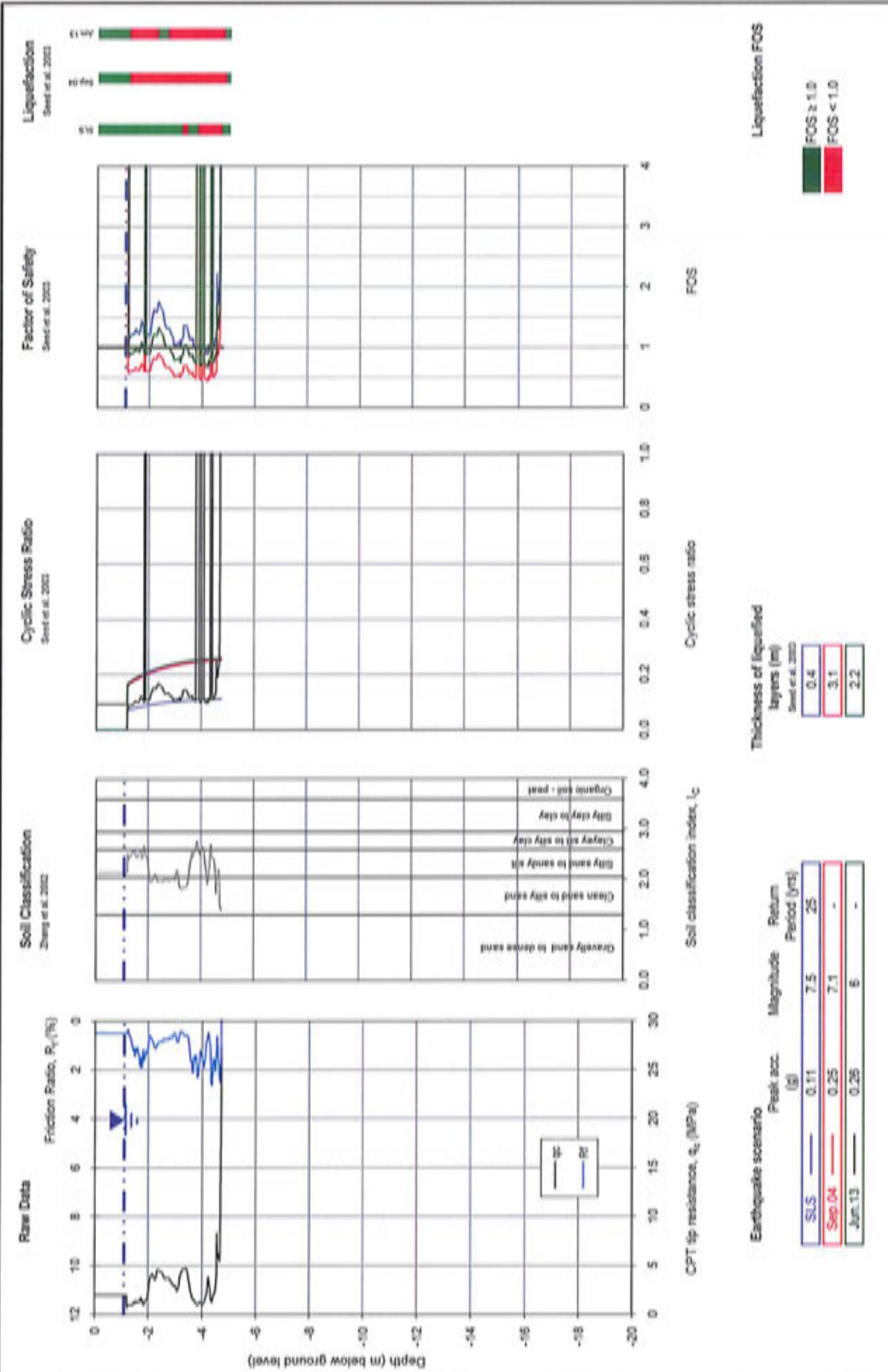
**PROJECT RESULTS**  
Liquefaction Assessment from CPT Results


**SECTION**  
CPT-CBD-62

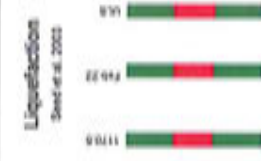
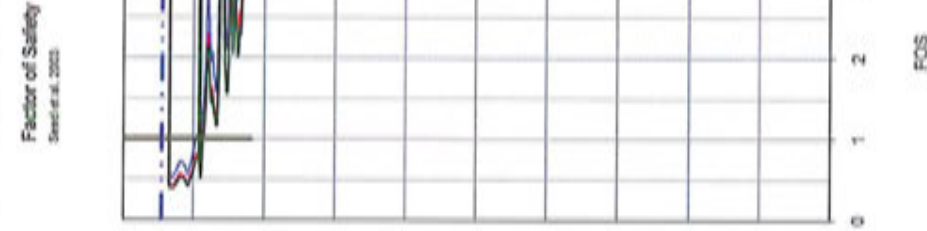
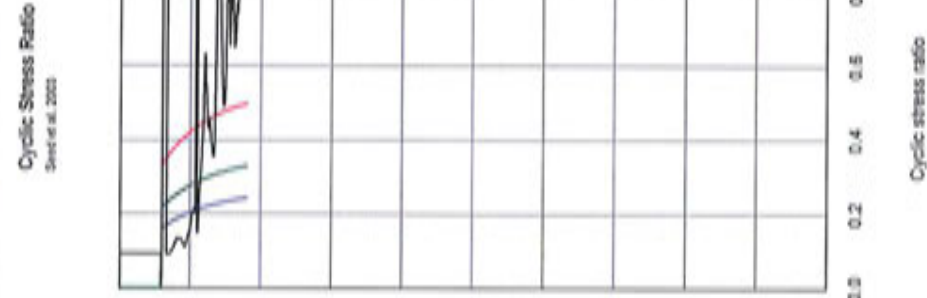
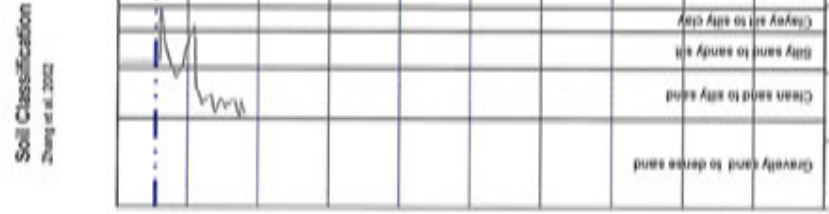
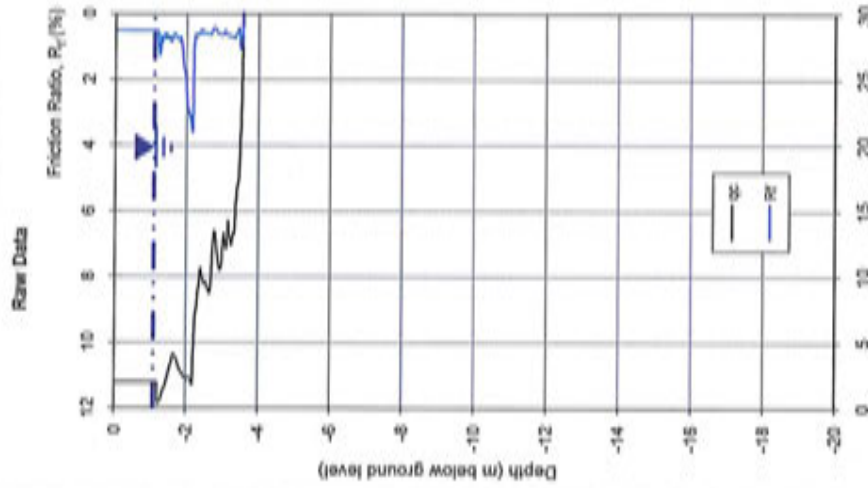
**DATE** 7/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
**JOB NUMBER** 52000\_301



<p><b>Tonkin &amp; Taylor Ltd</b> Environmental &amp; Engineering Consultants</p>	<p><b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City</p>	<p>CLIENT PROJECT</p>	<p>DATE: 6/12/2011</p>
		<p>FILE</p>	<p>ANALYSED: RAP</p>
<p>Liquefaction Assessment from CPT Results</p>		<p>LOCATION</p>	<p>CHECKED: AFF</p>
<p>CPT-C8D-63</p>		<p>JOB NUMBER</p>	<p>52000.301</p>



 <b>Tookin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council          Geotechnical Assessment for Christchurch Central City</b>	LOCATION <b>CPT-CBD-63</b>	DATE 7/12/2011
	TITLE <b>Liquefaction Assessment from CPT Results</b>	LOT NUMBER 52000_301	ANALYSED RAP
			CHECKED AFF



CPT tip resistance,  $t_c$  (MPa)

**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	8.2	-
U.L.S.	7.5	500

**Thickness of liquefied layers (m)**  
Seed et al. 2002

0.8
0.9
0.9

**Liquefaction FOS**

FOS $\geq$ 1.0
FOS $<$ 1.0



**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

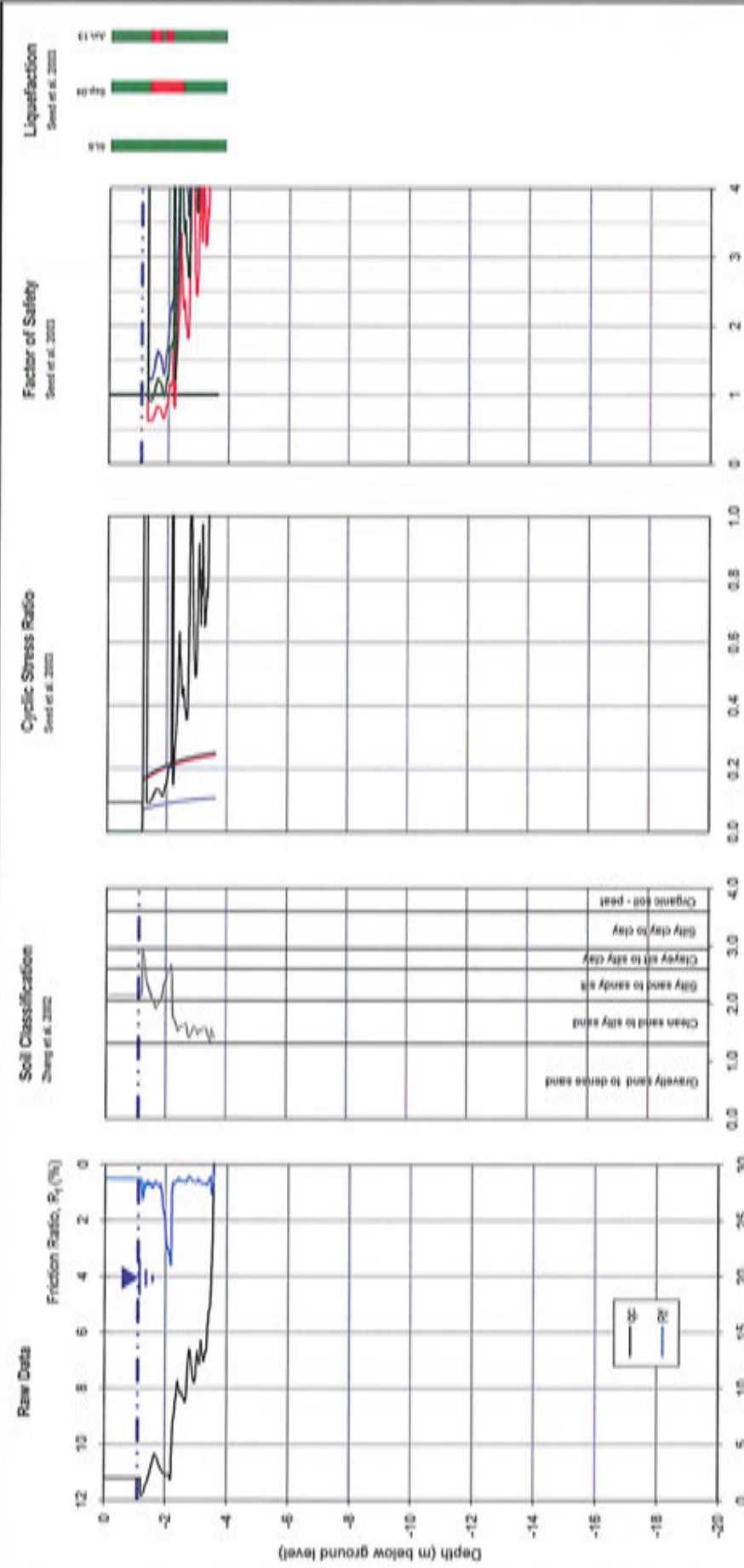
**CPT-CBD-64**

JOB NUMBER

52008.301

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT NUMBER: S2000.301

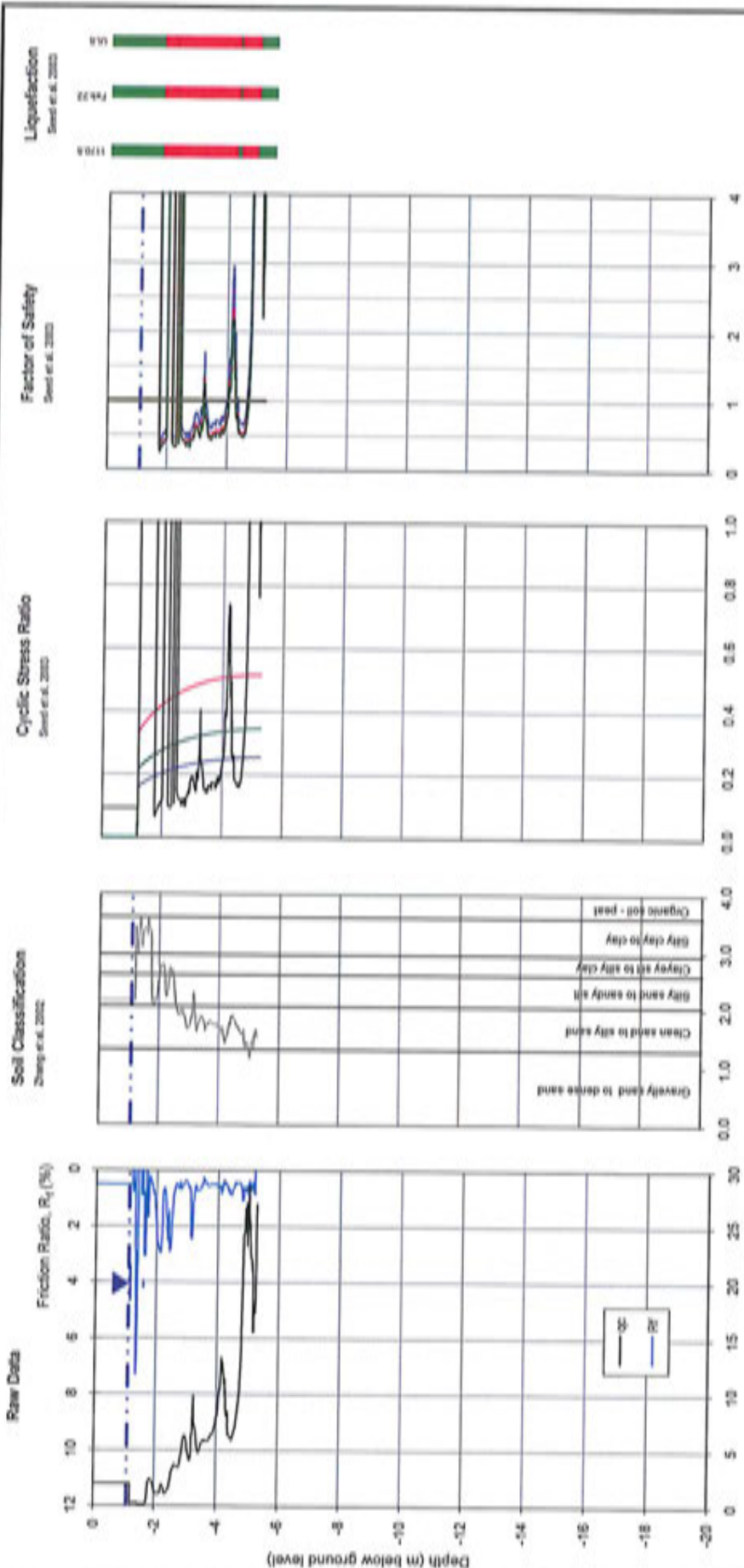
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ANALYSED: RAP  
CHECKED: AFF

Location: CPT-CBD-64  
JOB NUMBER: S2000.301

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Liquefaction Assessment from CPT Results





**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
1:170.5	7.5	500
Feb. 22	6.2	-
U.L.S.	7.5	500

**Thickness of liquefied layers (m)**  
Seed et al. 2002

2.2
2.4
2.4



**TFT**  
Tookin & Taylor Ltd  
Environmental & Engineering Consultants

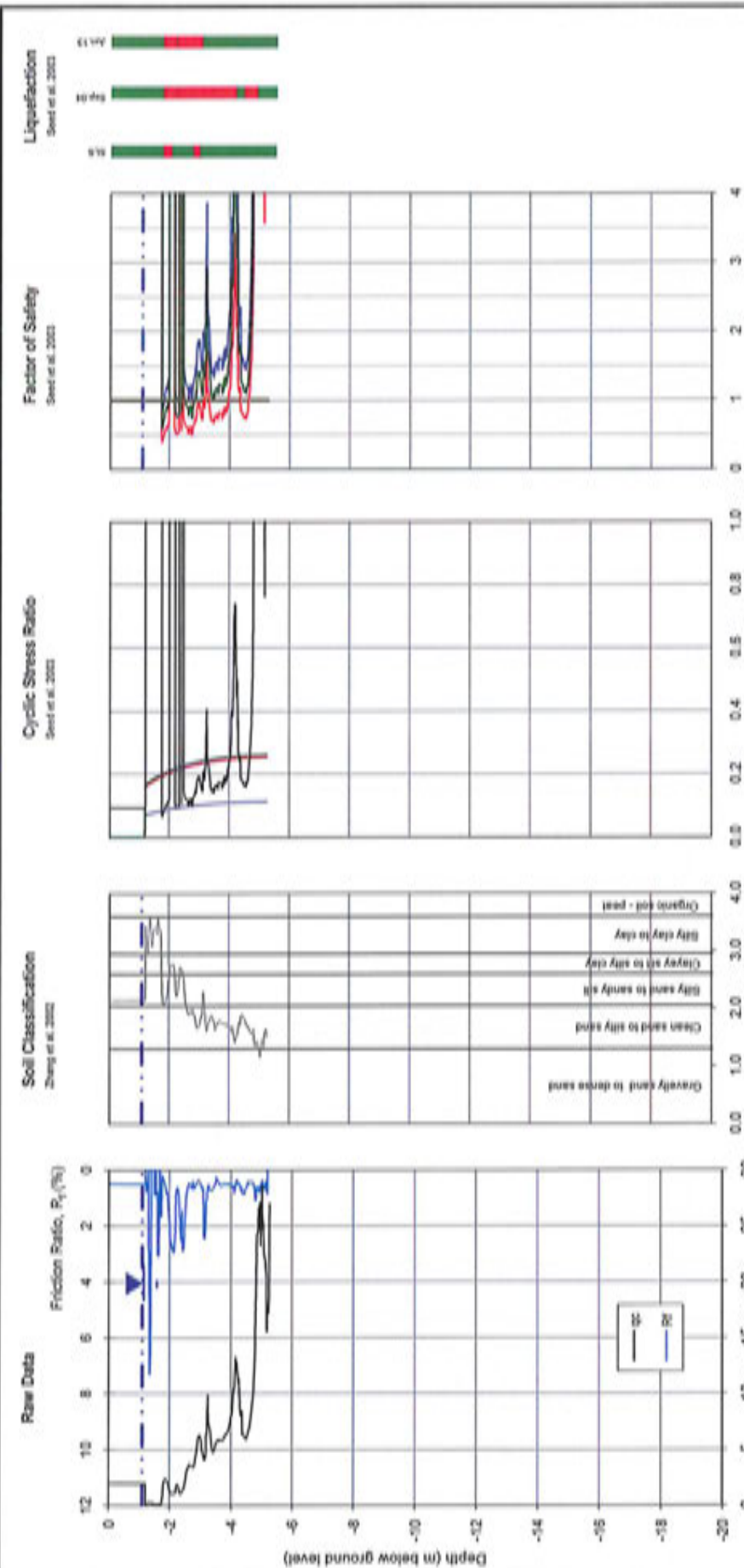
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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

**LOCATION**  
CPT-CBD-65

**DATE** 6/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
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**FILE**  
Liquefaction Assessment from CPT Results

**JOB NUMBER** 50000.361



**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

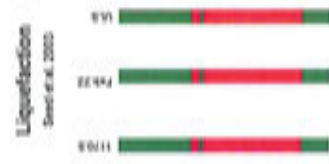
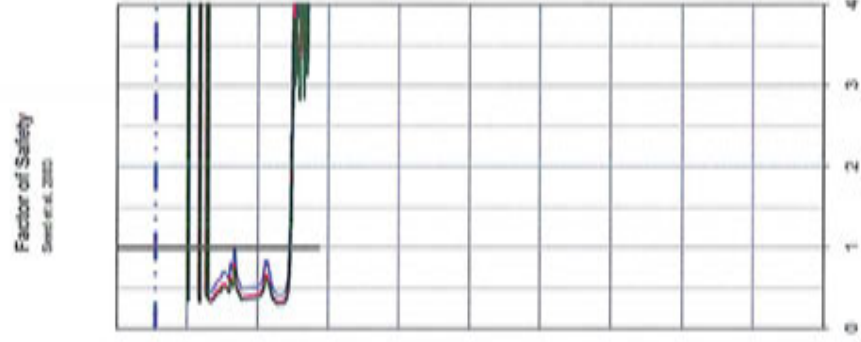
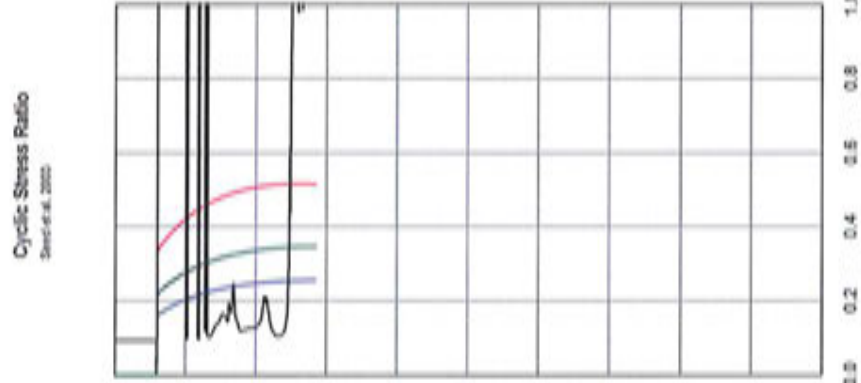
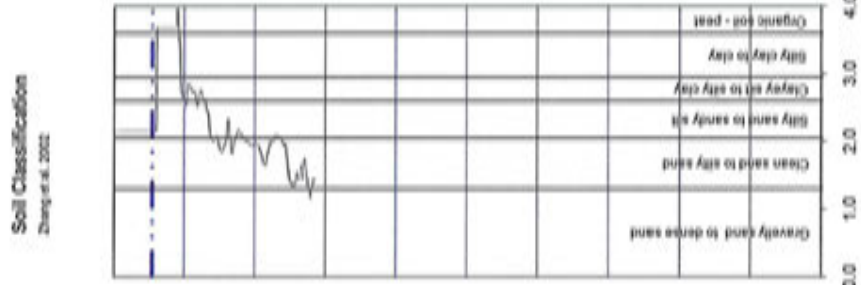
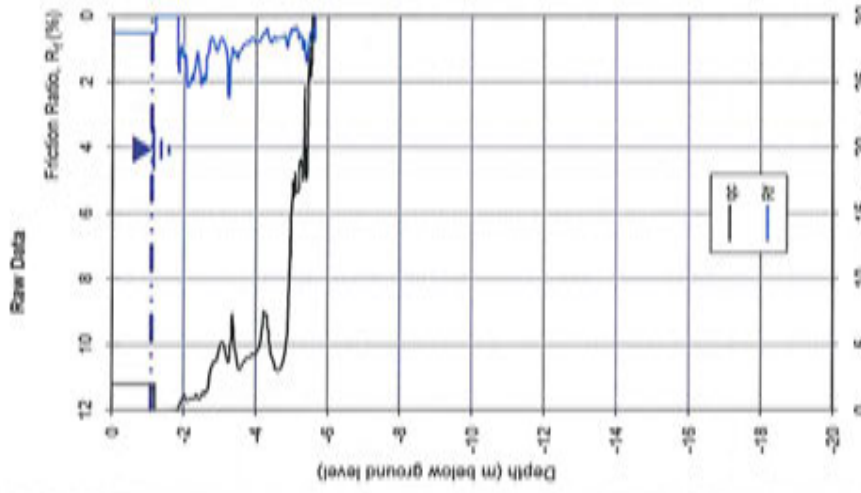
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Liquefaction Assessment from CPT Results

**LOCATION**  
CPT-CBD-65

**DATE** 11/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

**FILE**  
JOB NUMBER: 52000\_301

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CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1178.5	7.5	500
F60.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

2.4
2.4
2.4

Liquefaction FOS



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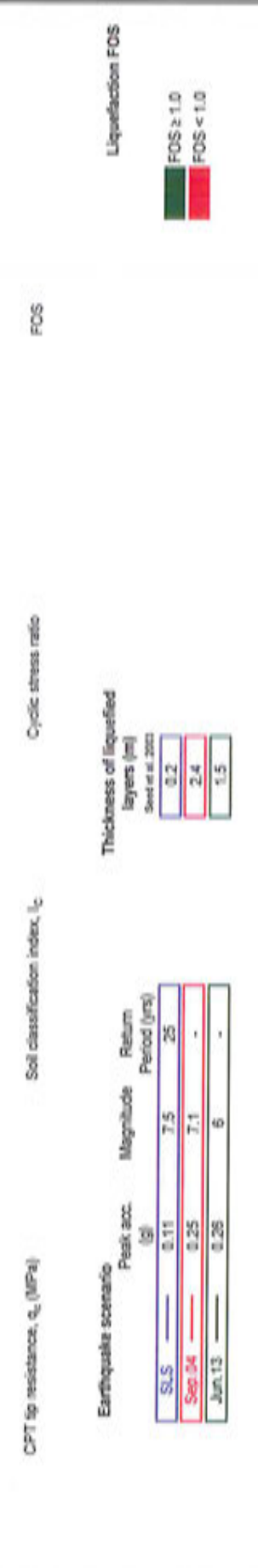
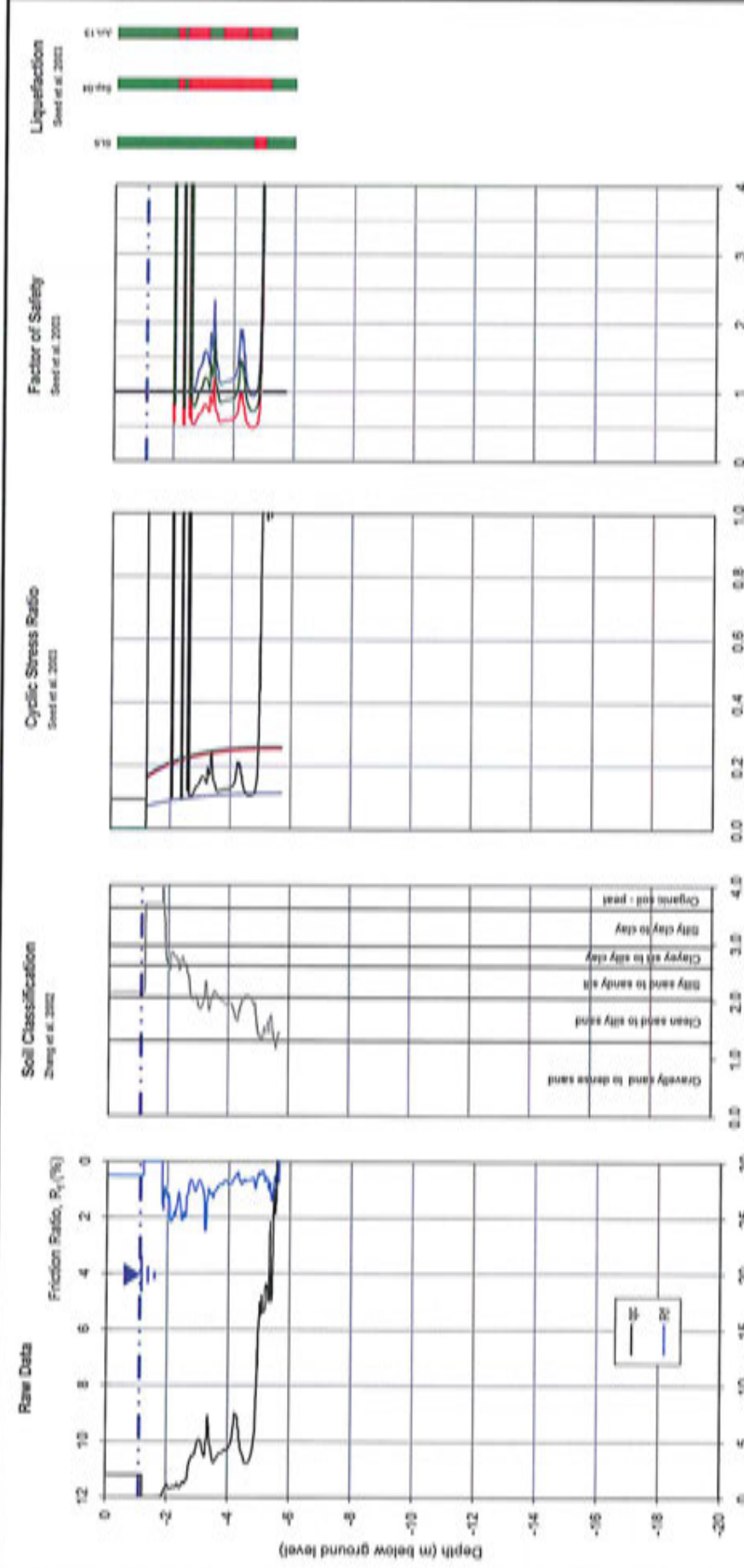
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-65a

FILE  
JOB NUMBER  
52000.301

Liquefaction Assessment from CPT Results

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF



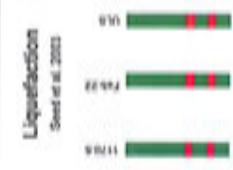
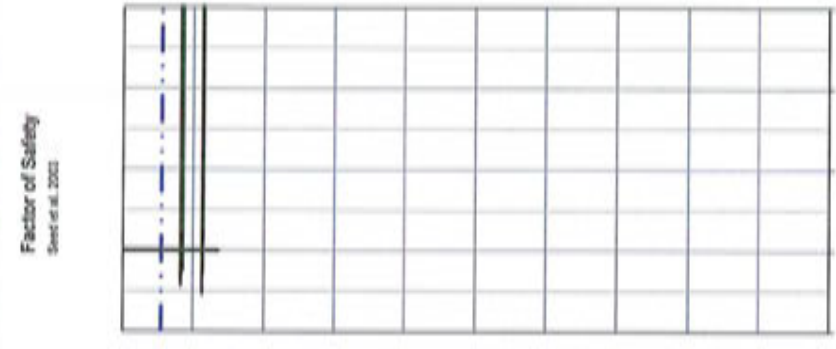
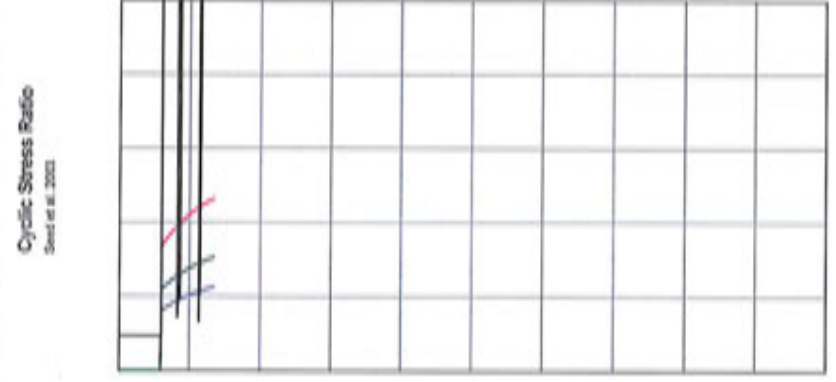
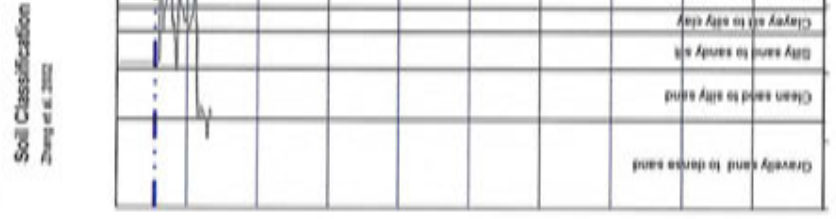
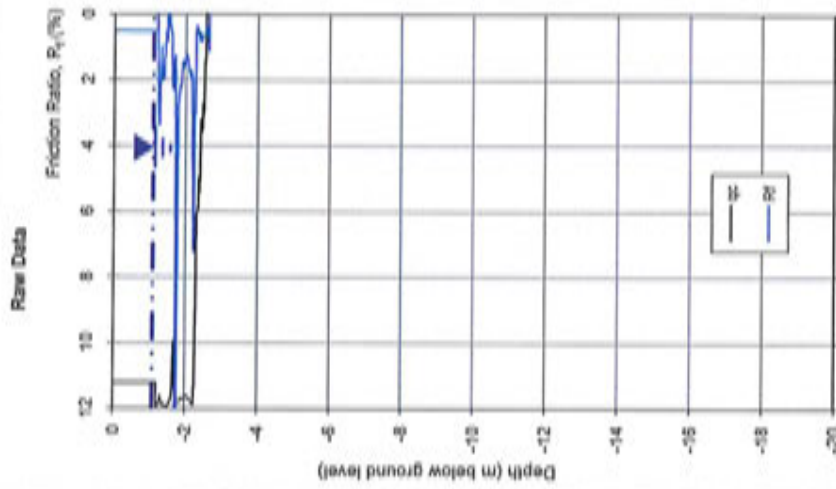
**Tookin & Taylor Ltd**  
Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**PROJECT**  
Liquefaction Assessment from CPT Results

**LOCATION**  
CPT-CBD-65a

**DATE** 27/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
**JOB NUMBER** S2000\_301



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. ( $g$ )	Magnitude	Return Period (yrs)
1:170.5	7.5	500
Feb. 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.0
0.1
0.1

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



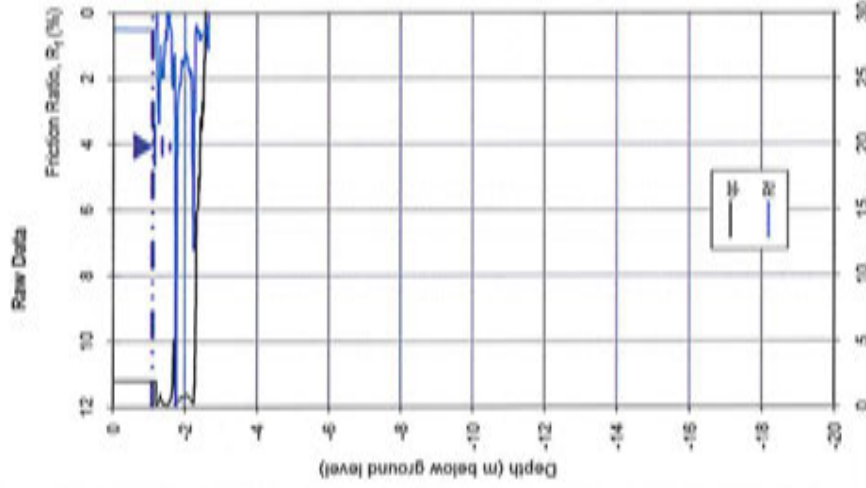
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Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

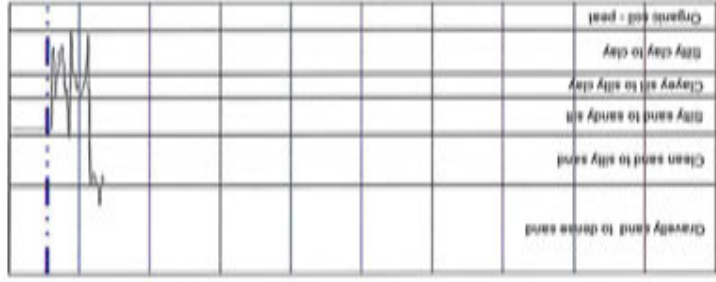
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JOB NUMBER: 52000\_301

DATE: 6/12/2011  
ANALYSED: RAP  
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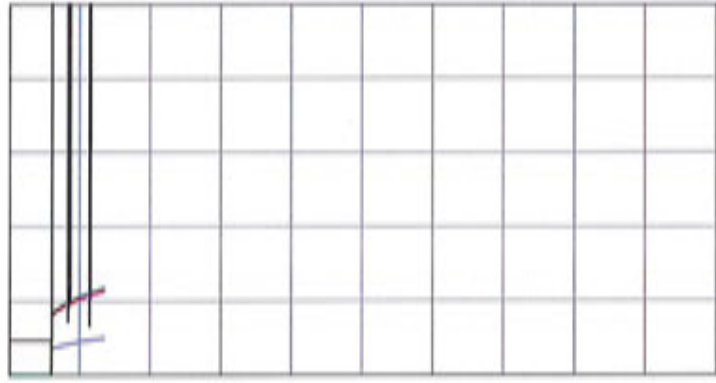
Liquefaction Assessment from CPT Results



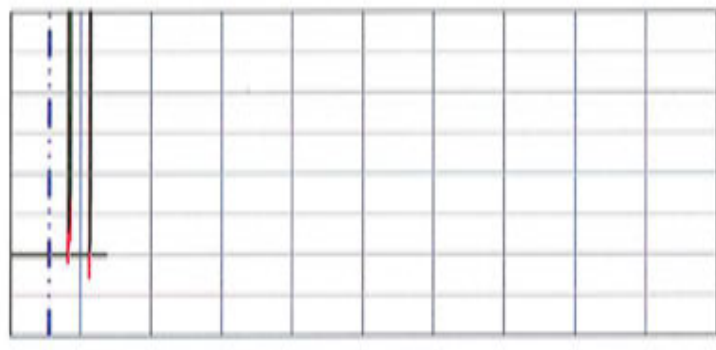
Soil Classification  
Zhang et al. 2002



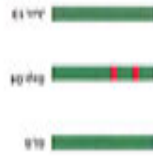
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.04	0.25	7.1	-
Jun.13	0.25	8	-

Thickness of liquefied layers (m)

Scenario	Thickness (m)
SLS	0.0
Sep.04	0.0
Jun.13	0.0

Liquefaction FOS



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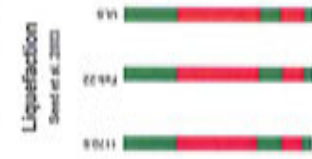
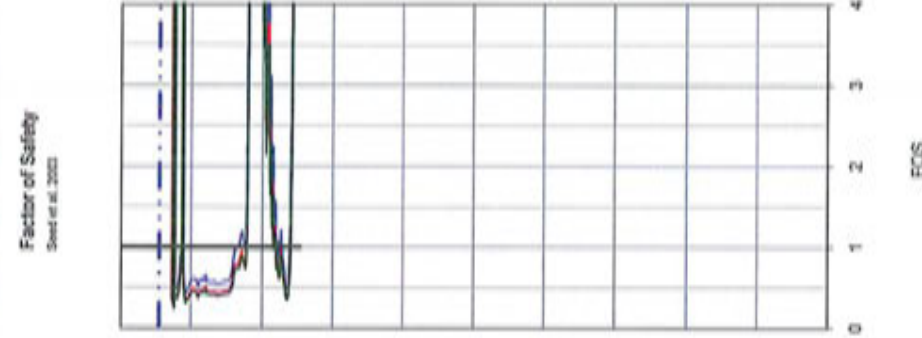
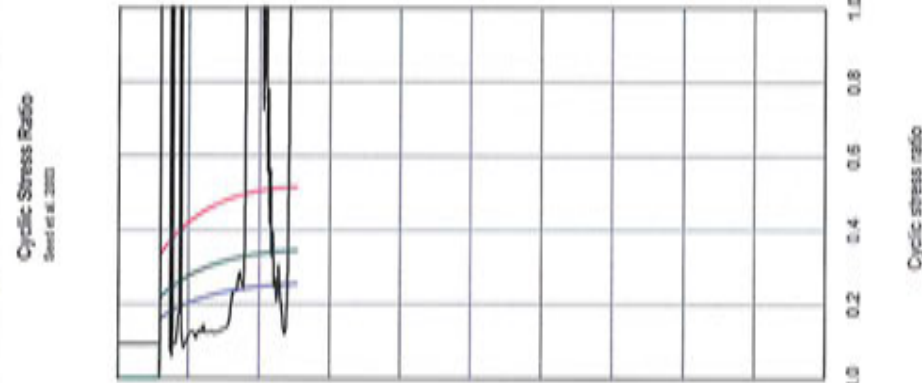
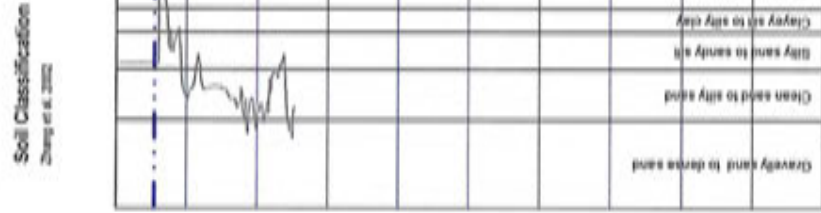
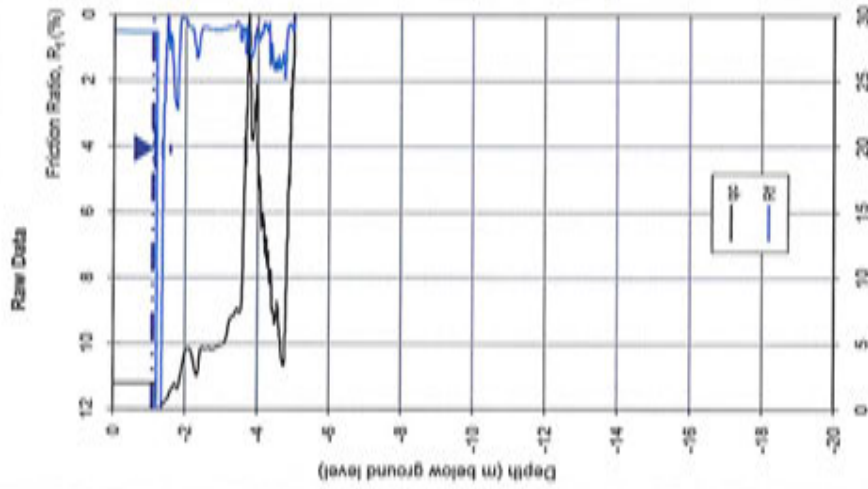
CPT-CBD-66

JOB NUMBER

52000\_301

DATE 7/12/2011  
ANALYSED RAP  
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Liquefaction Assessment from CPT Results



CPT  $f_{sp}$  resistance,  $f_{sp}$  (kPa)

Earthquake scenario

Peak acc. ( $g$ )	Magnitude	Return Period (yrs)
1:170.5	7.5	500
Feb. 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

2.1
2.4
2.5

Liquefaction FOS

FOS > 1.0
FOS < 1.0



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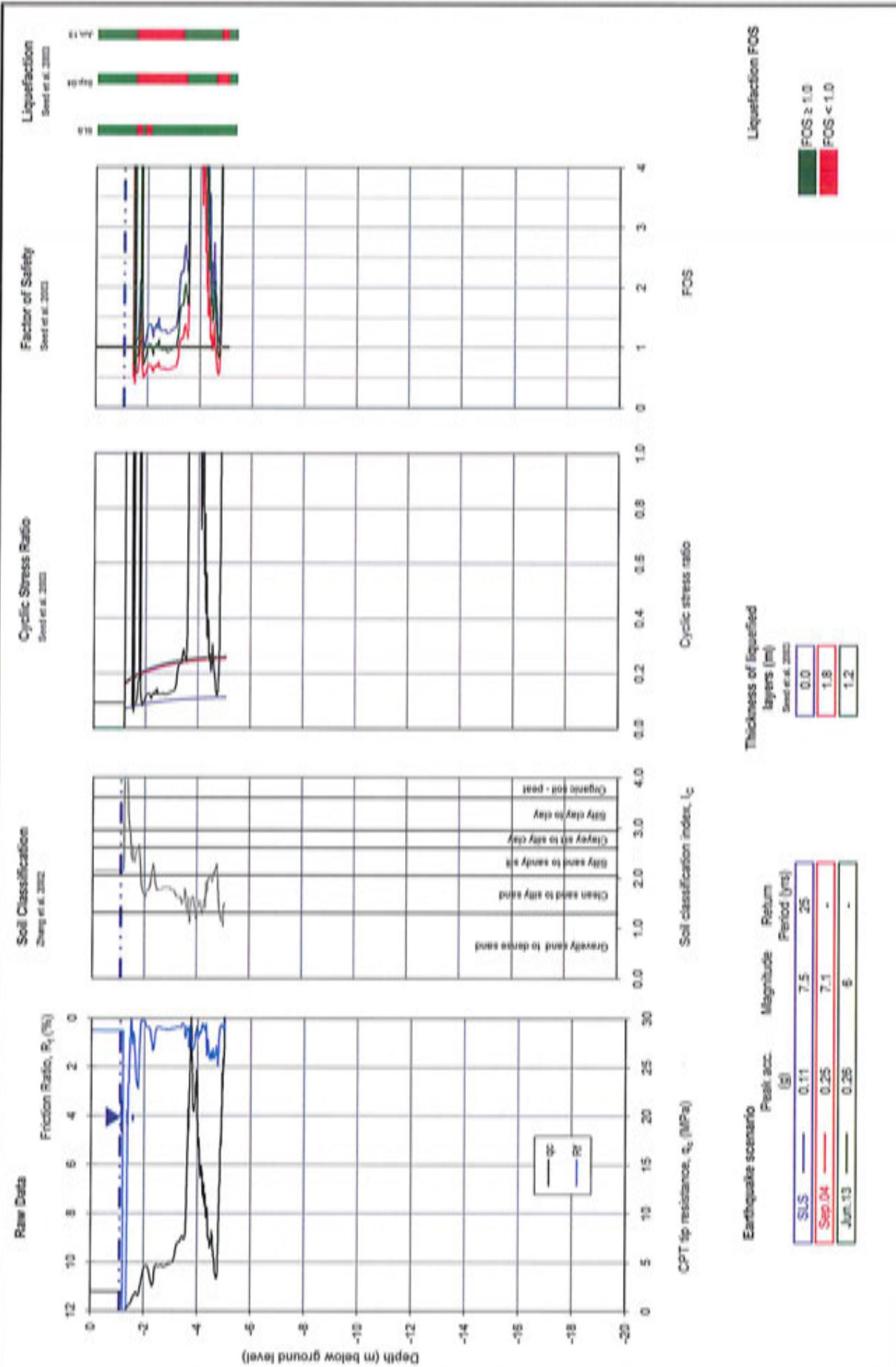
CLIENT PROJECT  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION  
CPT-CBD-67

DATE 6/12/2011  
ANALYSED RAP  
CHECKED AFF

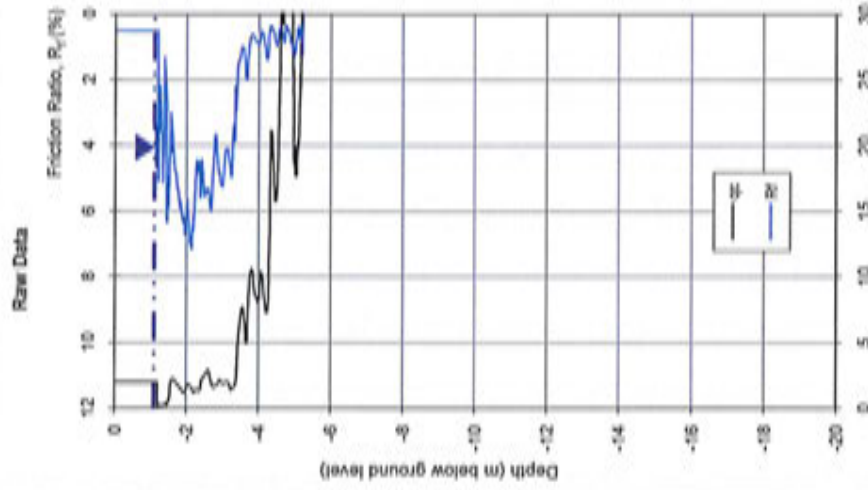
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Liquefaction Assessment from CPT Results

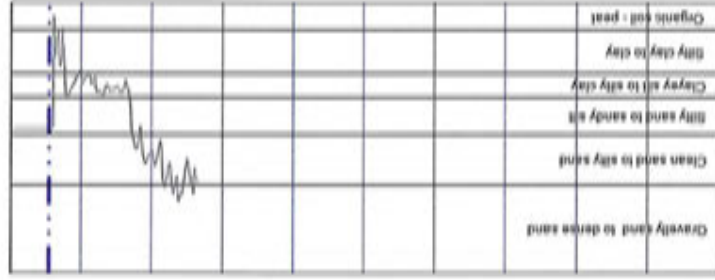


 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT/PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City		<b>LOCATION</b> CPT-CBD-67	<b>DATE</b> 7/12/2011
	<b>FILE</b> Liquefaction Assessment from CPT Results		<b>JOB NUMBER</b> 52000.301	<b>ANALYSED</b> RAP
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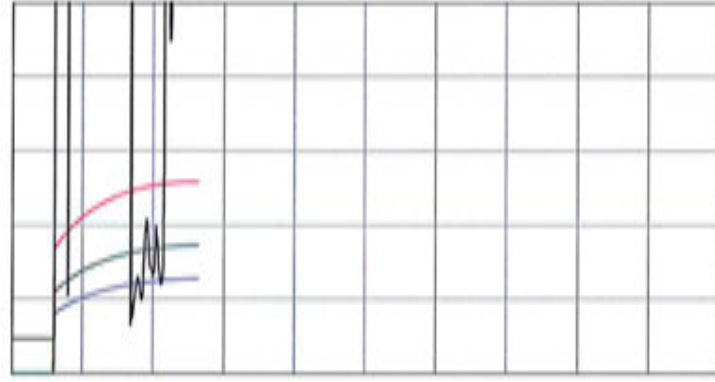




Soil Classification  
Zheng et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1:170.5	7.5	500
Feb. 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.3
0.7
0.8

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS < 1.0



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Environmental & Engineering Consultants

CLIENT PROJECT

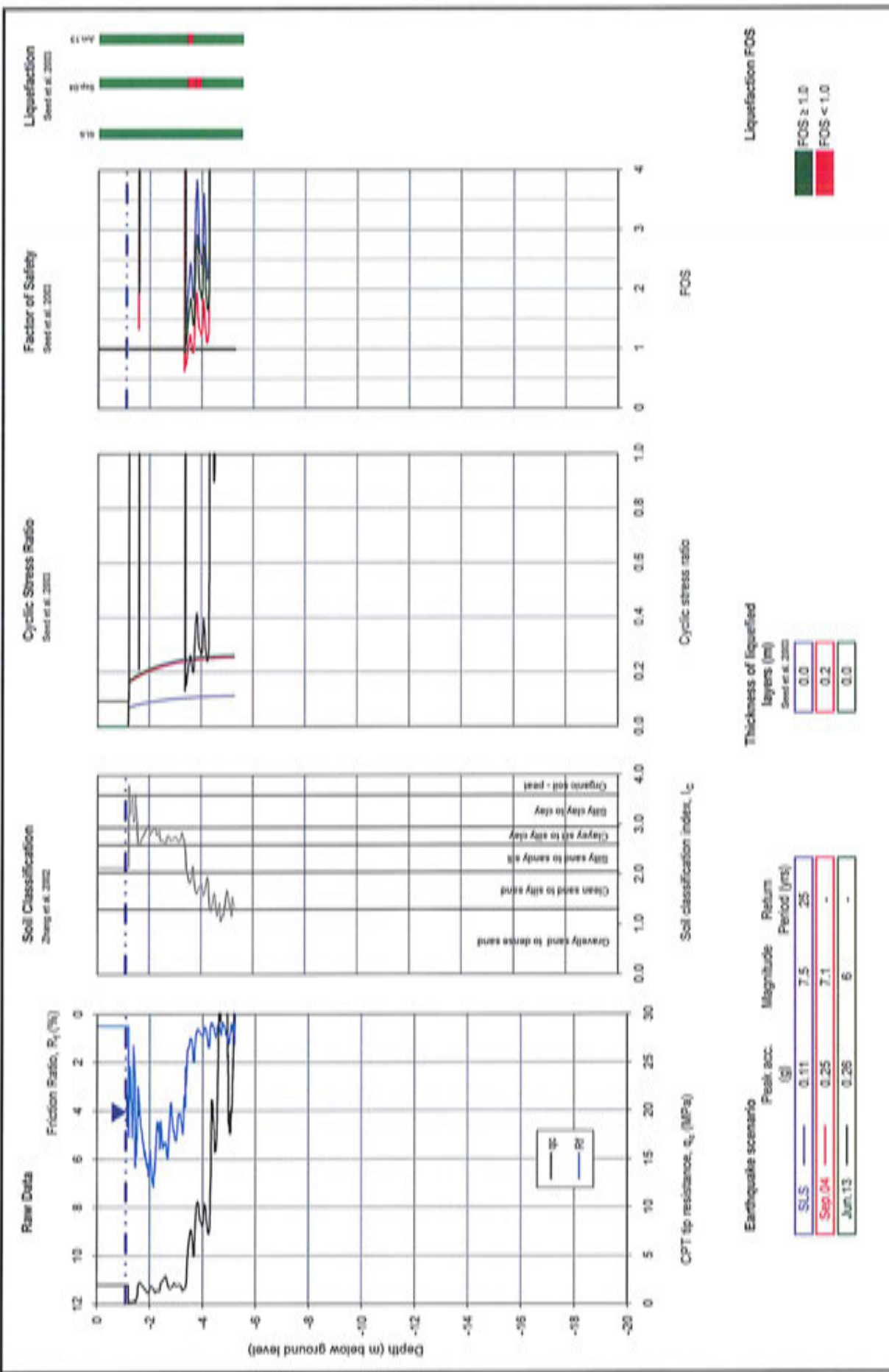
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

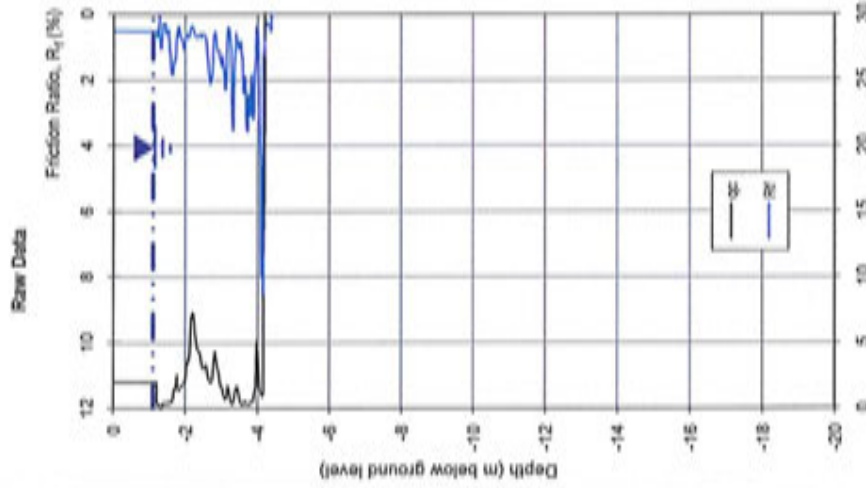
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DATE 6/12/2011  
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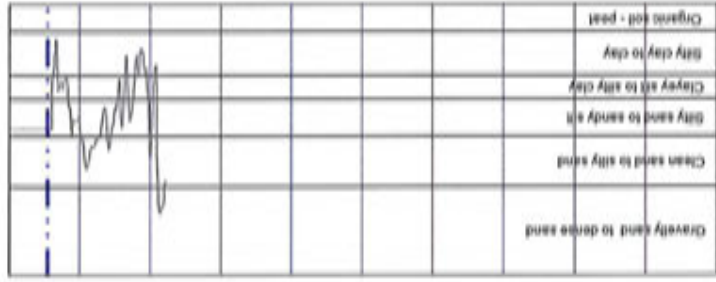
JOB NUMBER 52000\_301

Liquefaction Assessment from CPT Results

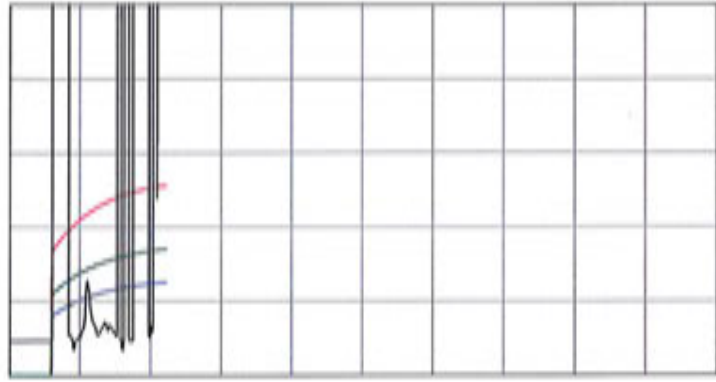




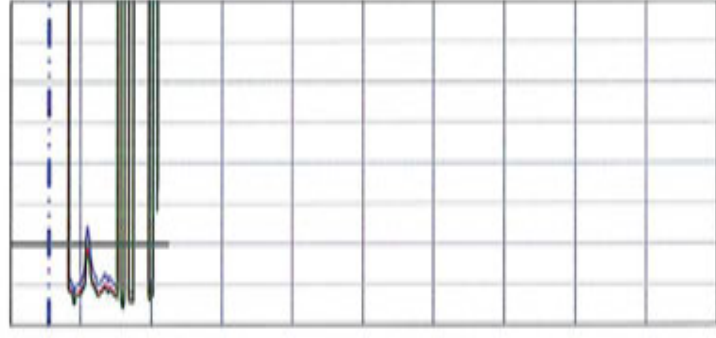
Soil Classification  
Zhang et al. 2002



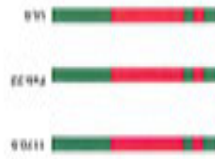
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb. 22	6.2	-
U.S.	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
1.5
1.7
1.7

Liquefaction FOS



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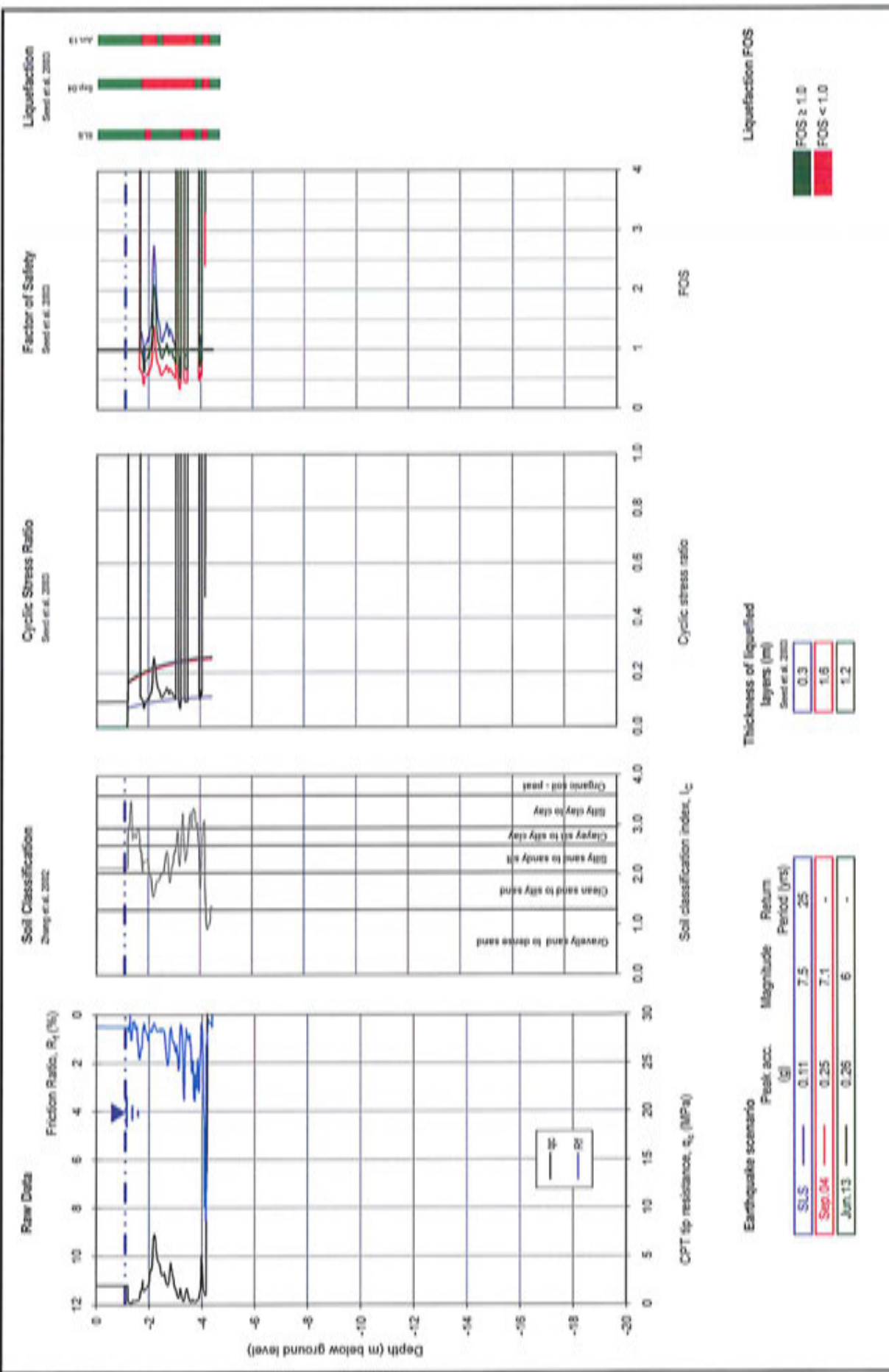
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-69

FILE  
JOB NUMBER  
52000\_301

DATE  
6/12/2011  
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RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results



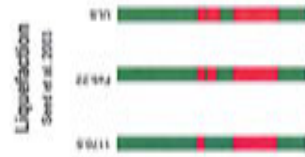
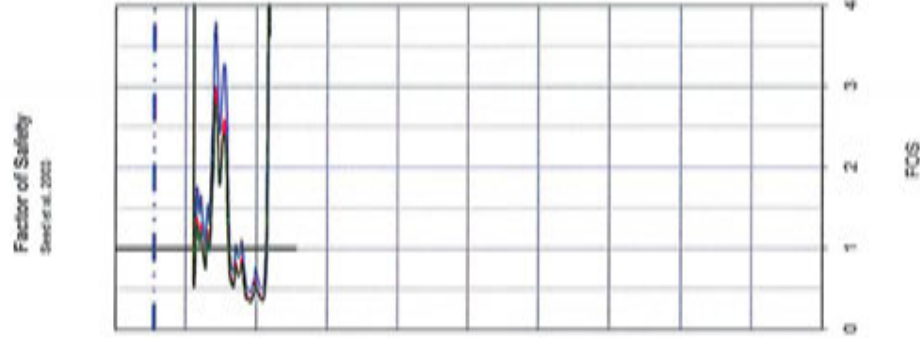
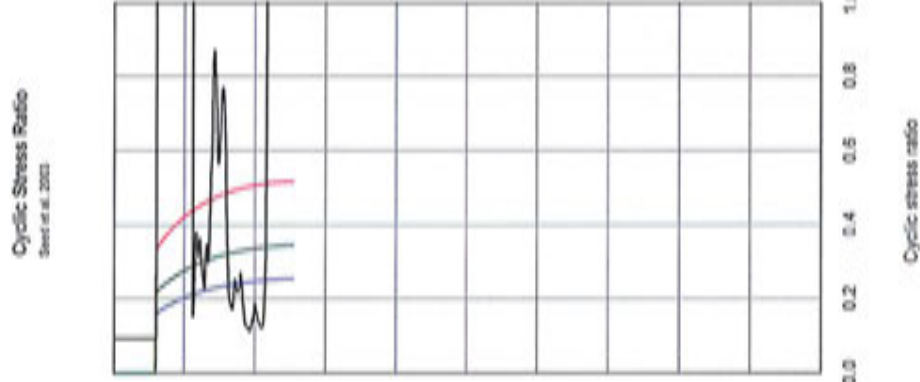
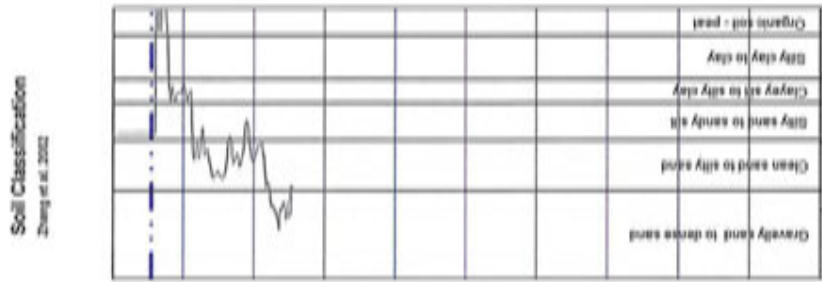
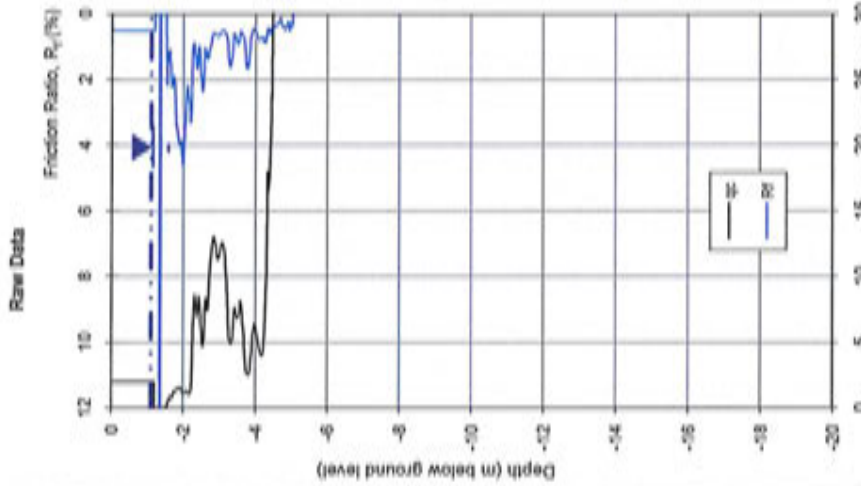
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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**SECTION**  
CPT-CBD-69

**DATE** 7/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

**JOB NUMBER** 52000\_301  
**Liquefaction Assessment from CPT Results**



CPT  $\phi_p$  resistance,  $\phi_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb.22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
1.0
1.2
1.3

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-70

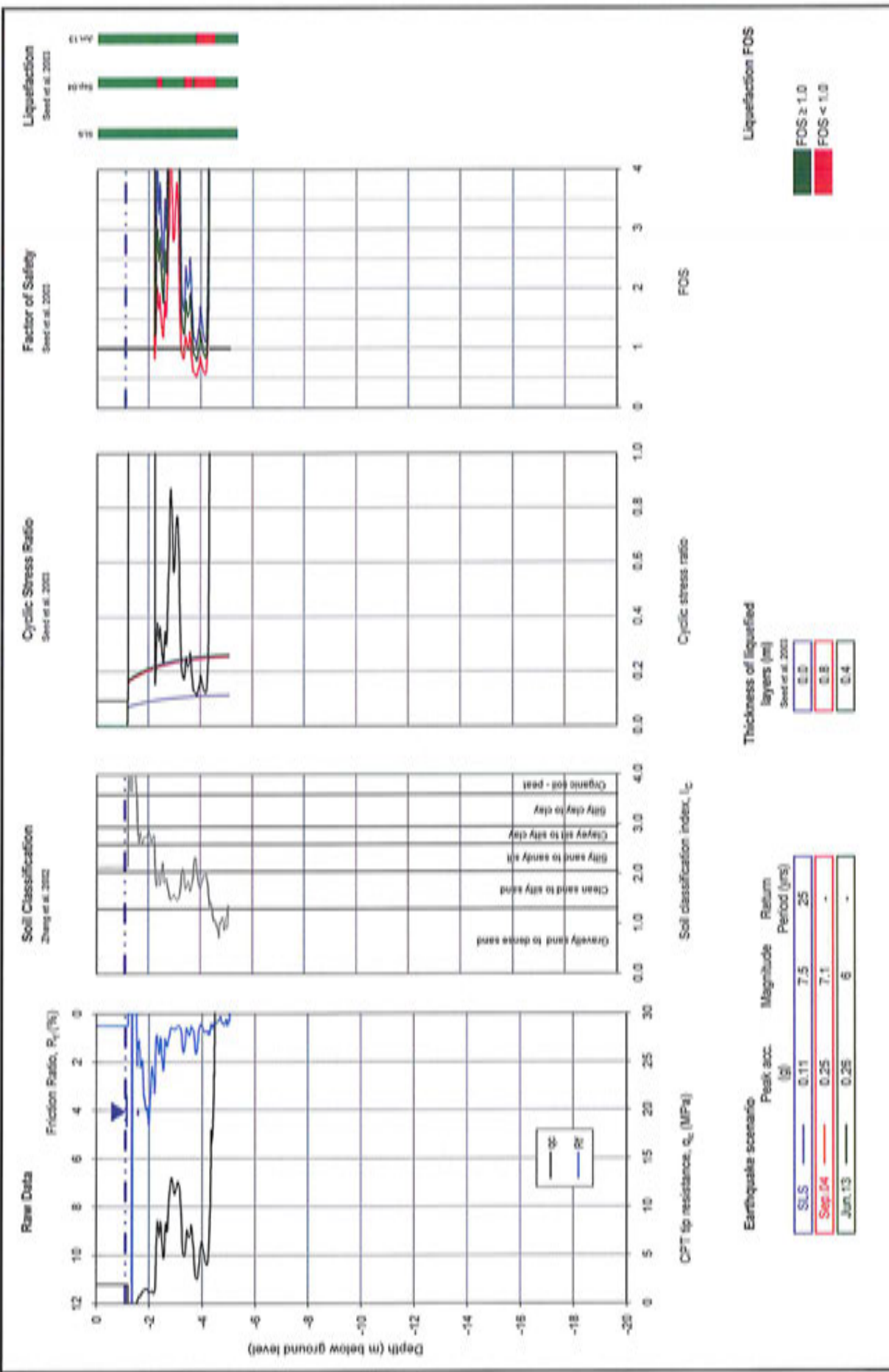
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Liquefaction Assessment from CPT Results

JOB NUMBER

52000.301

DATE 6/12/2011  
ANALYSED RAB  
CHECKED AFF



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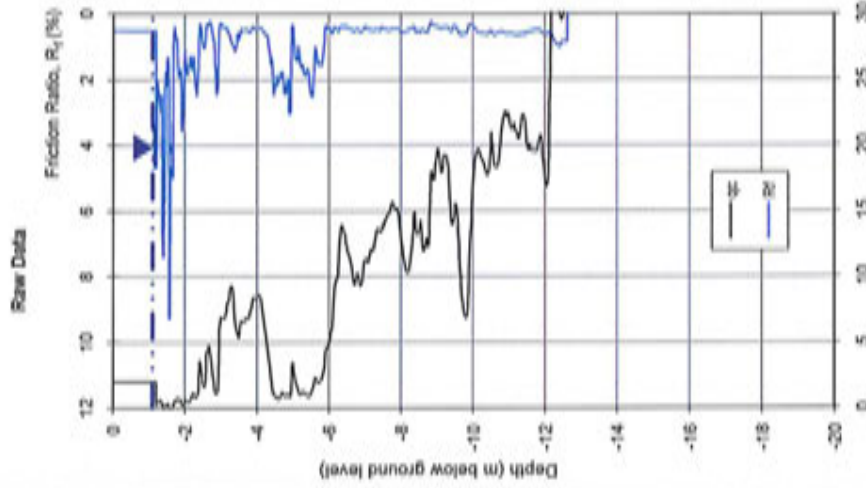
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Geotechnical Assessment for Christchurch Central City

TITLE: Liquefaction Assessment from CPT Results

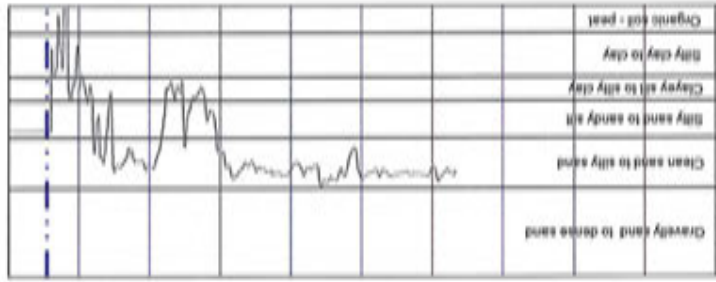
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JOB NUMBER: 52000.301

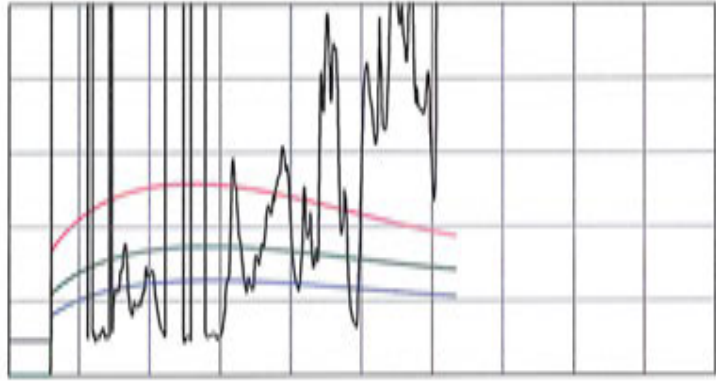
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ANALYSED: RAP  
CHECKED: AFF



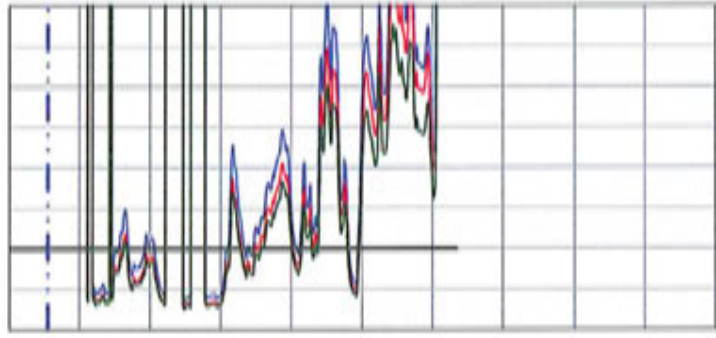
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb. 22	6.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
2.9
3.8
4.2

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0

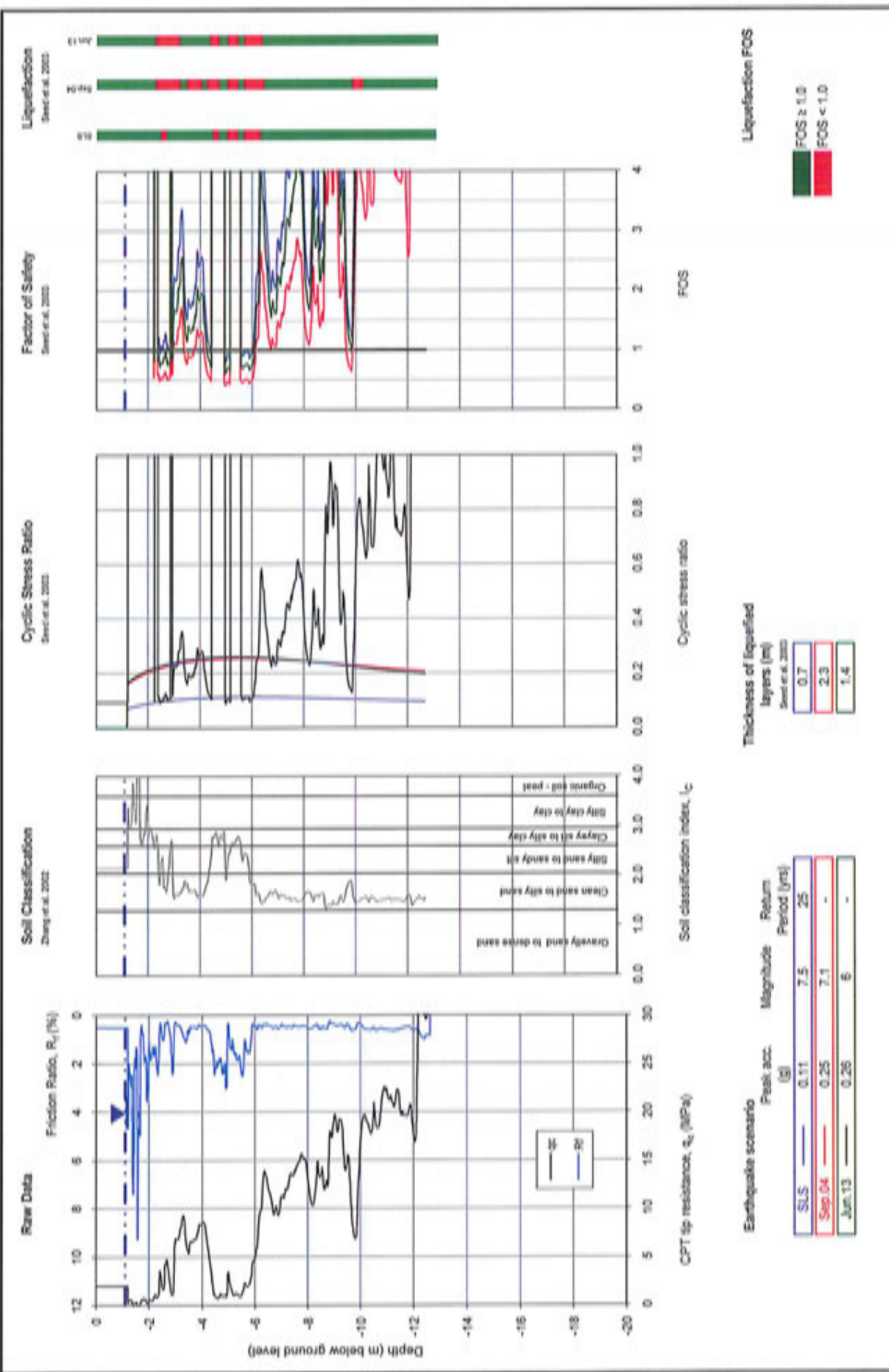


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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

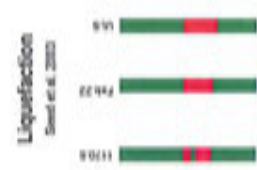
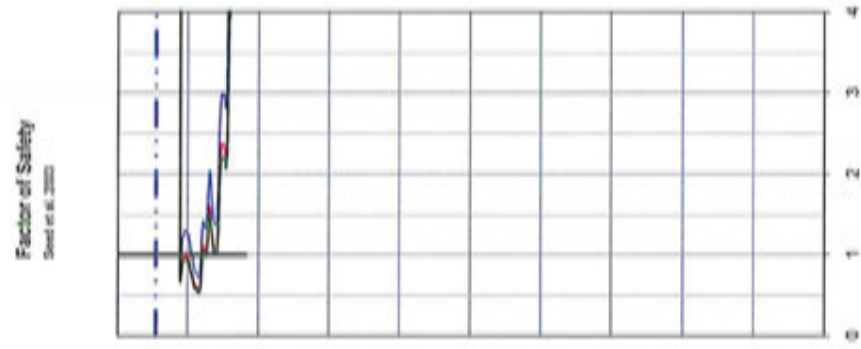
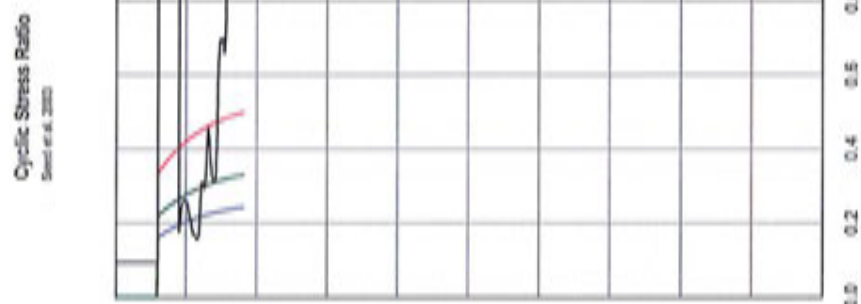
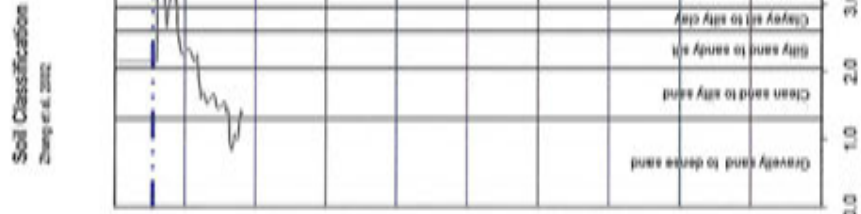
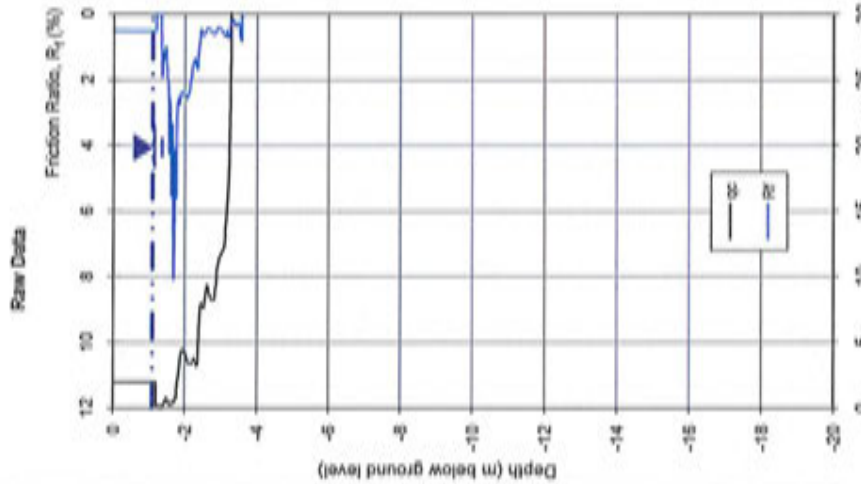
PROJECT  
CPT-CBD-71  
JOB NUMBER  
520000.301

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF  
AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE: 7/12/2011 ANALYSED: RAP CHECKED: AFF
	PROJECT REFERENCE: <b>CPT-CBD-71</b>	JOB NUMBER: 52000_301	LOCATION: CPT-CBD-71
Liquefaction Assessment from CPT Results			JOB NUMBER: 52000_301





CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

Soil type	Thickness (m)
Gravelly sand to dense sand	0.3
Clean sand to silty sand	0.5
Silty sand to sandy sil	0.7

Liquefaction FOS

FOS	Color
$\geq 1.0$	Green
$< 1.0$	Red



**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

CLIENT PROJECT

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

LOCATION

**CPT-CBD-72**

DATE

6/12/2011

ANALYSED

RAP

CHECKED

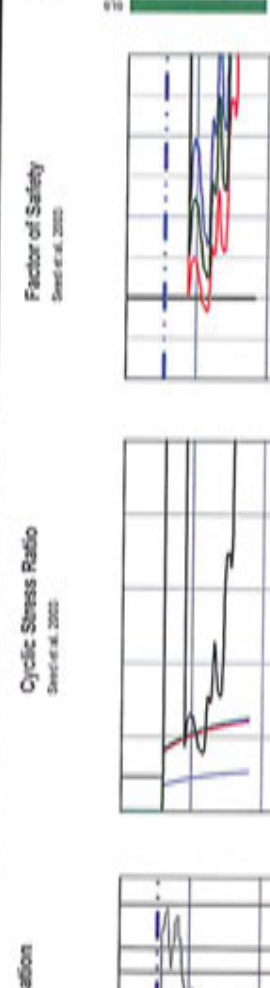
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JOB NUMBER

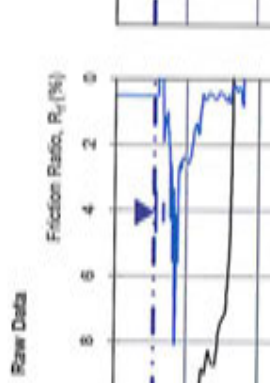
52000\_301

Liquefaction Assessment from CPT Results

**Raw Data**  
Friction Ratio,  $R_f$  (%)



**Soil Classification**  
Zhang et al. 2002



**Cyclic Stress Ratio**  
Seed et al. 2003



**Factor of Safety**  
Seed et al. 2003



**Soil Classification**  
Zhang et al. 2002



**Factor of Safety**  
Seed et al. 2003



**Liquefaction**  
Seed et al. 2003



**Soil Classification**  
Zhang et al. 2002



**Factor of Safety**  
Seed et al. 2003



**Earthquake scenario**

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.25	6	-

**Thickness of liquefied layers (m)**  
Seed et al. 2003

0.0
0.2
0.0

**CPT tip resistance,  $q_t$  (MPa)**



**Soil classification index,  $I_c$**



**Cyclic stress ratio**



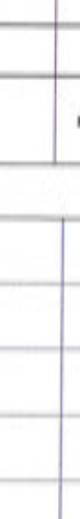
**Liquefaction FOS**

FOS > 1.0
FOS < 1.0

**Thickness of liquefied layers (m)**  
Seed et al. 2003

0.0
0.2
0.0

**Soil Classification**  
Zhang et al. 2002



**Factor of Safety**  
Seed et al. 2003





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Geotechnical Assessment for Christchurch Central City

**CPT-CBD-72**

DATE: 7/12/2011

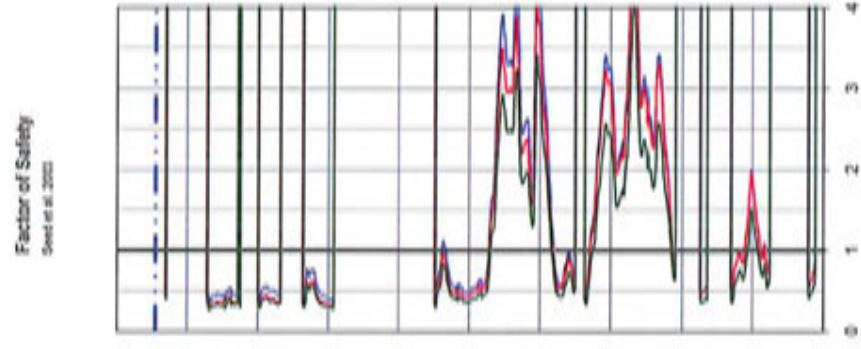
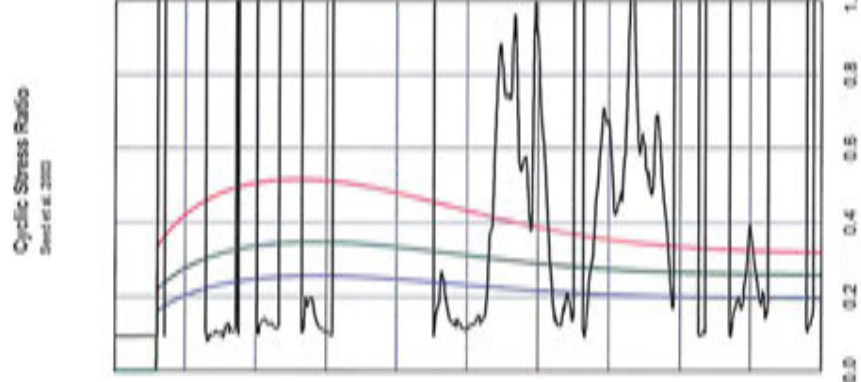
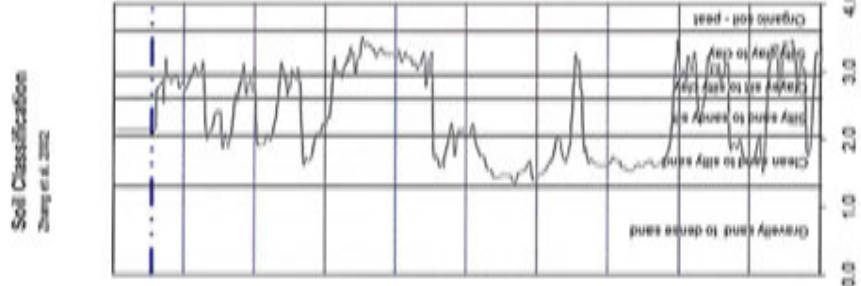
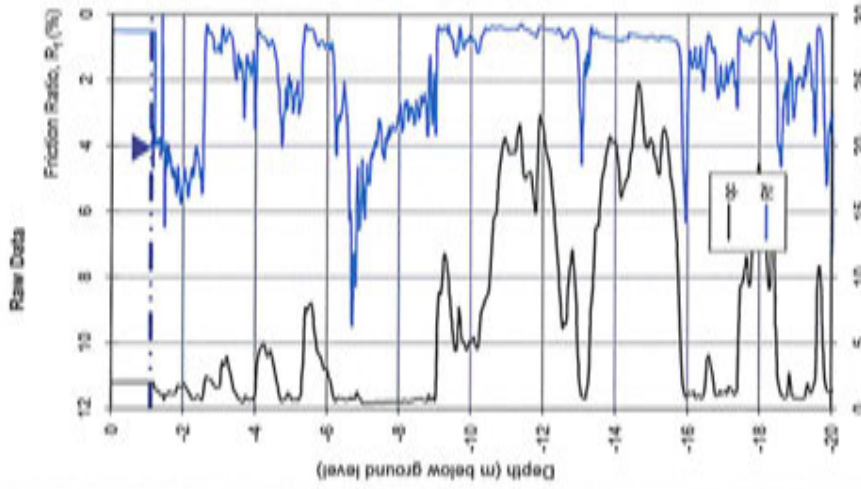
ANALYSED: RAP

CHECKED: AFF

LOCATION: CPT-CBD-72

JOB NUMBER: S2003.391

PROJECT: Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb 22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

5.8
6.0
6.4

Liquefaction FOS

Legend: FOS  $\geq 1.0$  (green), FOS  $< 1.0$  (red)



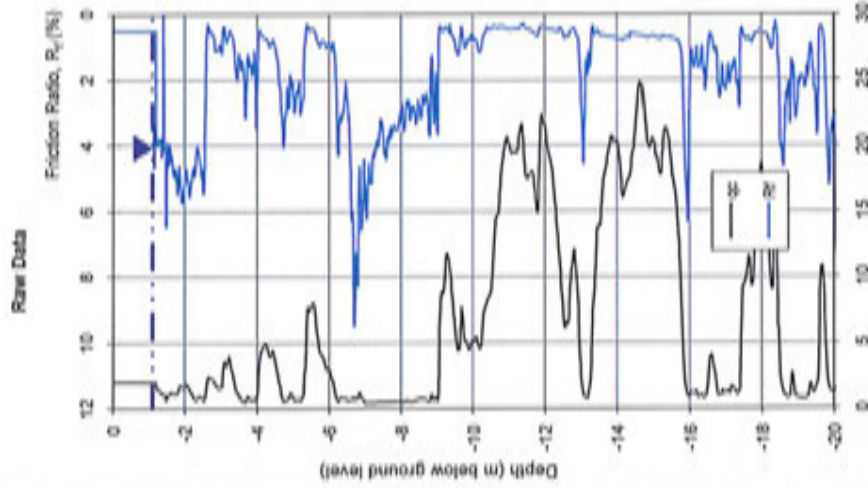
Tonkin & Taylor Ltd  
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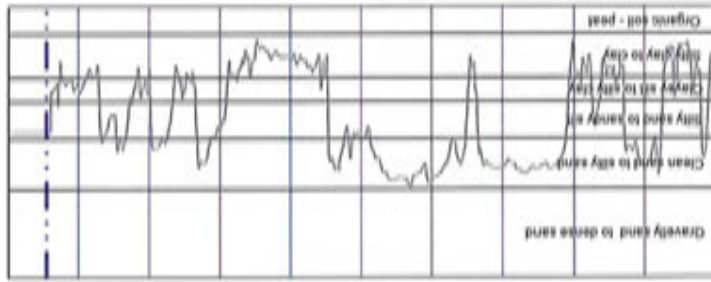
LOCATION: CPT-CBD-73  
JOB NUMBER: S20000.301

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

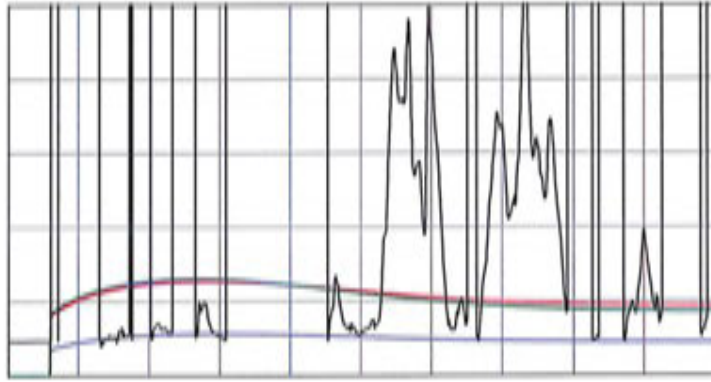
Liquefaction Assessment from CPT Results



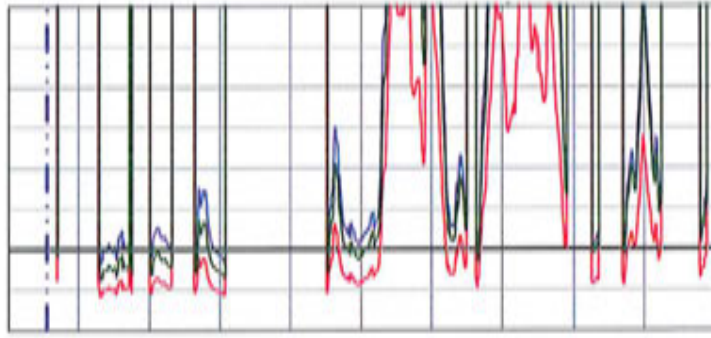
Soil Classification  
Zheng et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun.13	0.26	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.8
5.0
2.8

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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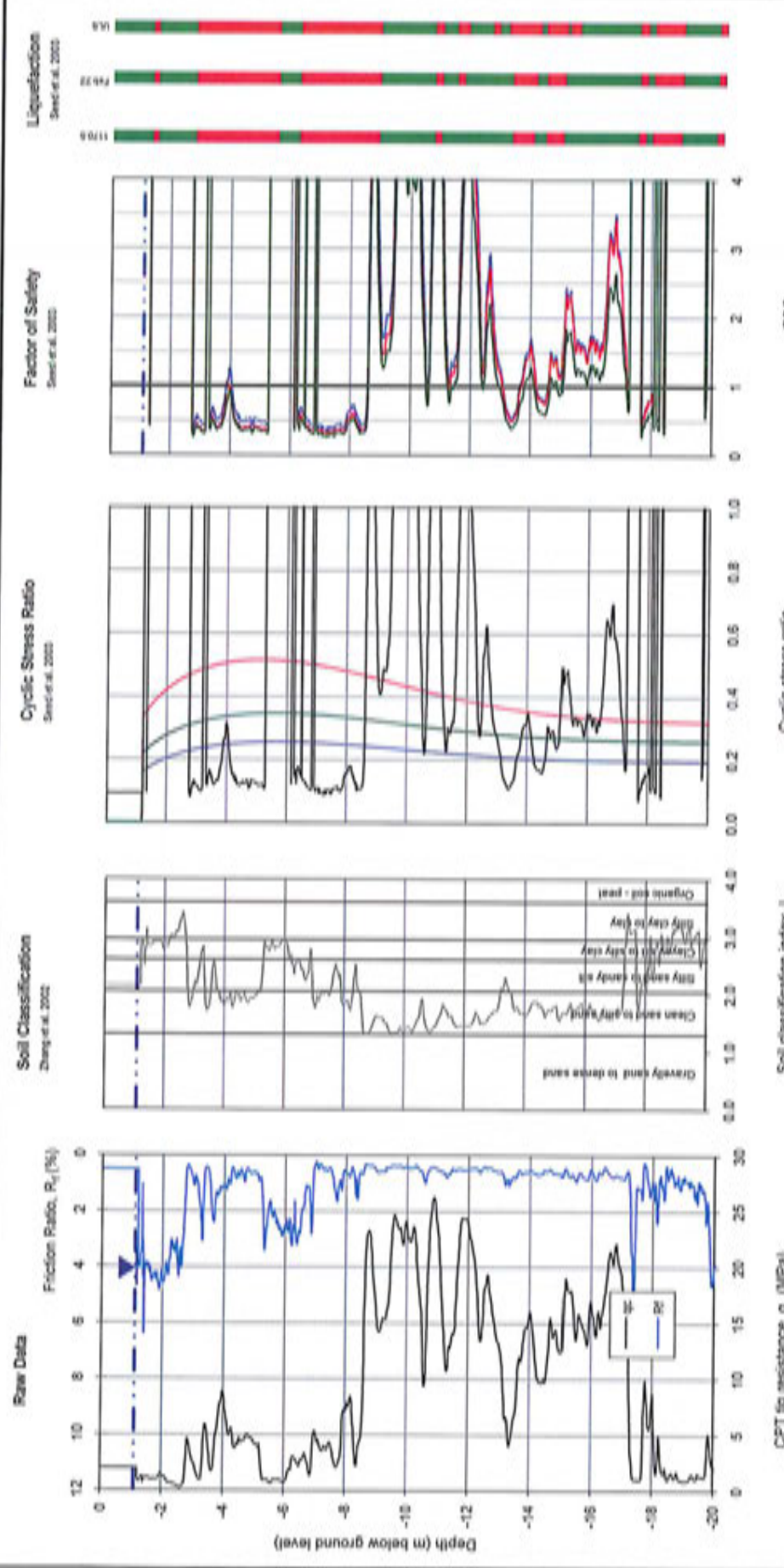
LOCATION

CPT-CBD-73

JOB NUMBER  
S2000.301

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results



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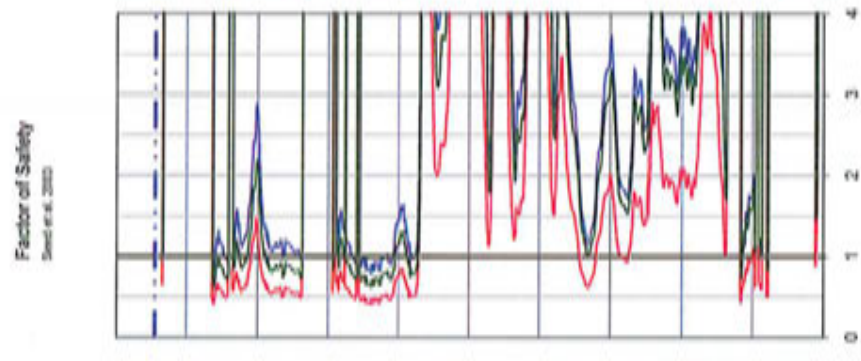
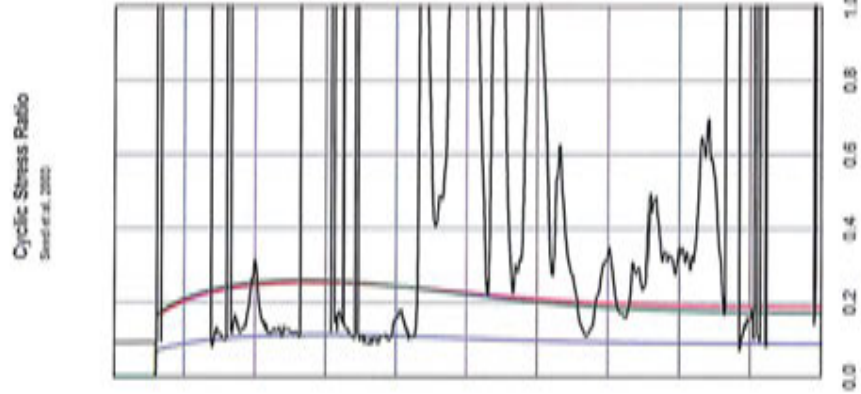
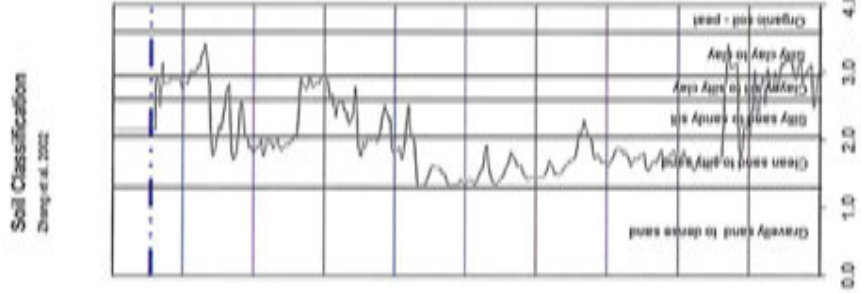
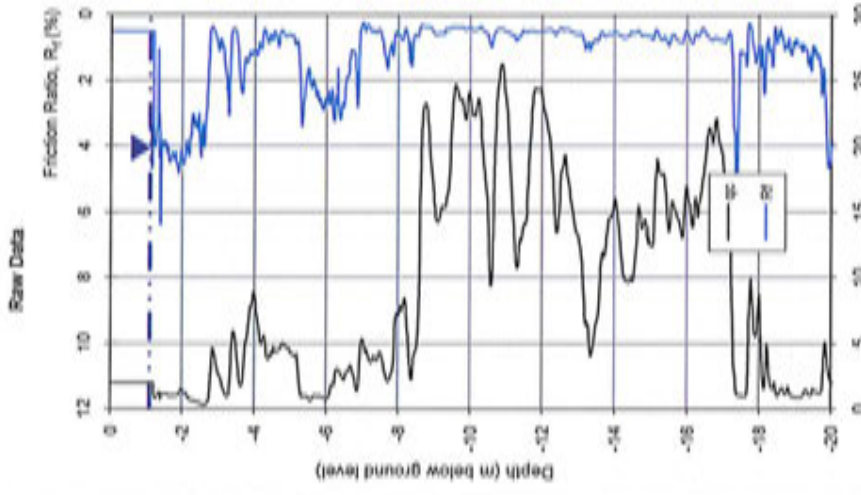
**CLIENT PROJECT**  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

**LOCATION**  
CPT-CBD-74

**FILE NUMBER**  
52000\_381

**LIQUEFACTION ASSESSMENT FROM CPT RESULTS**

**DATE** 6/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
**AFF**



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.04	0.25	7.1	-
Jan.13	0.25	6	-

Thickness of liquefied layers (m)

Scenario	Thickness (m)
SLS	1.4
Sep.04	5.7
Jan.13	3.6

Liquefaction FOS

█ FOS  $\geq$  1.0  
█ FOS  $<$  1.0



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CLIENT/PROJECT

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LOCATION

CPT-CBD-74

JOB NUMBER

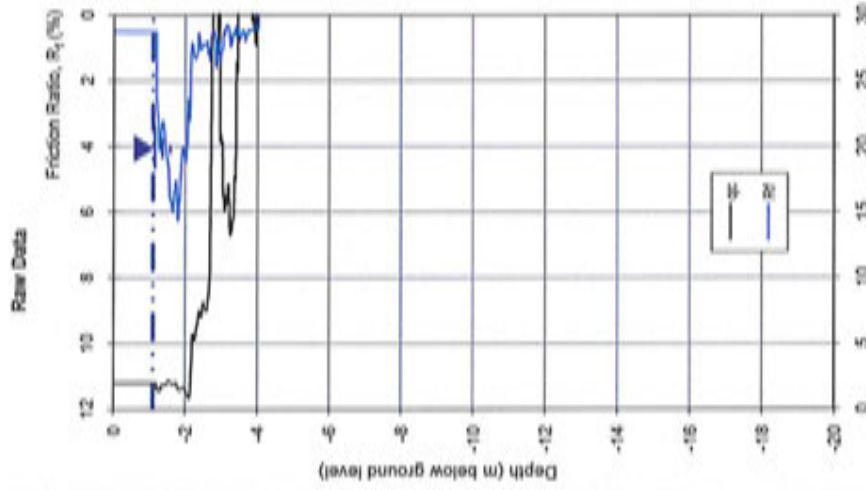
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DATE  
7/12/2011

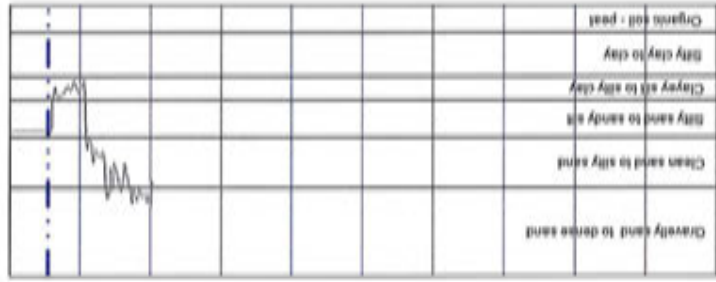
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RAP

CHECKED  
AFF

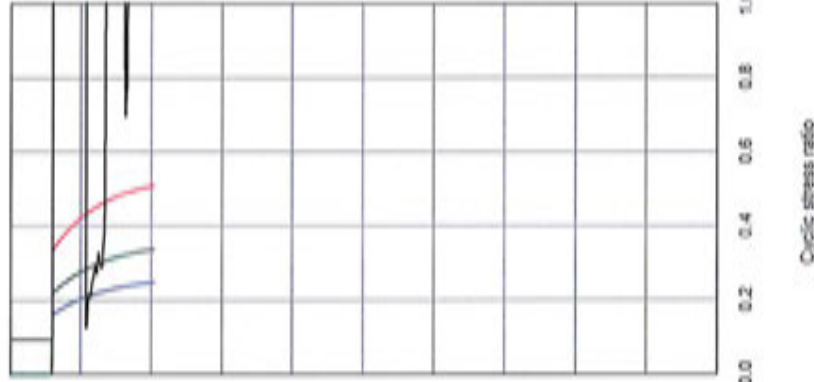
Liquefaction Assessment from CPT Results



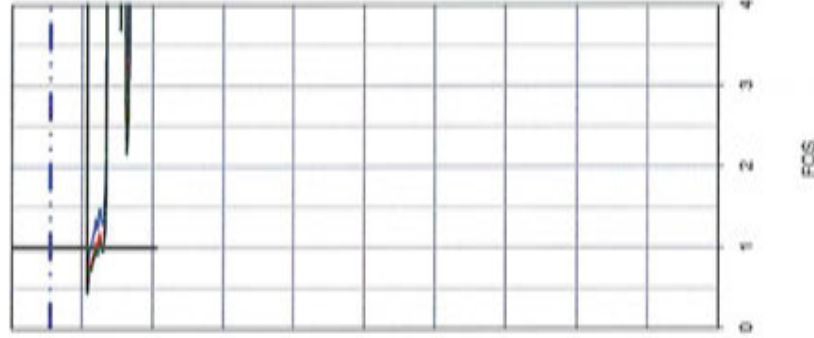
Soil Classification  
Zheng et al. 2002



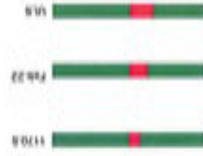
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

FOS

Cyclic stress ratio

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb. 22	6.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

Thickness (m)
0.1
0.3
0.4

Liquefaction FOS



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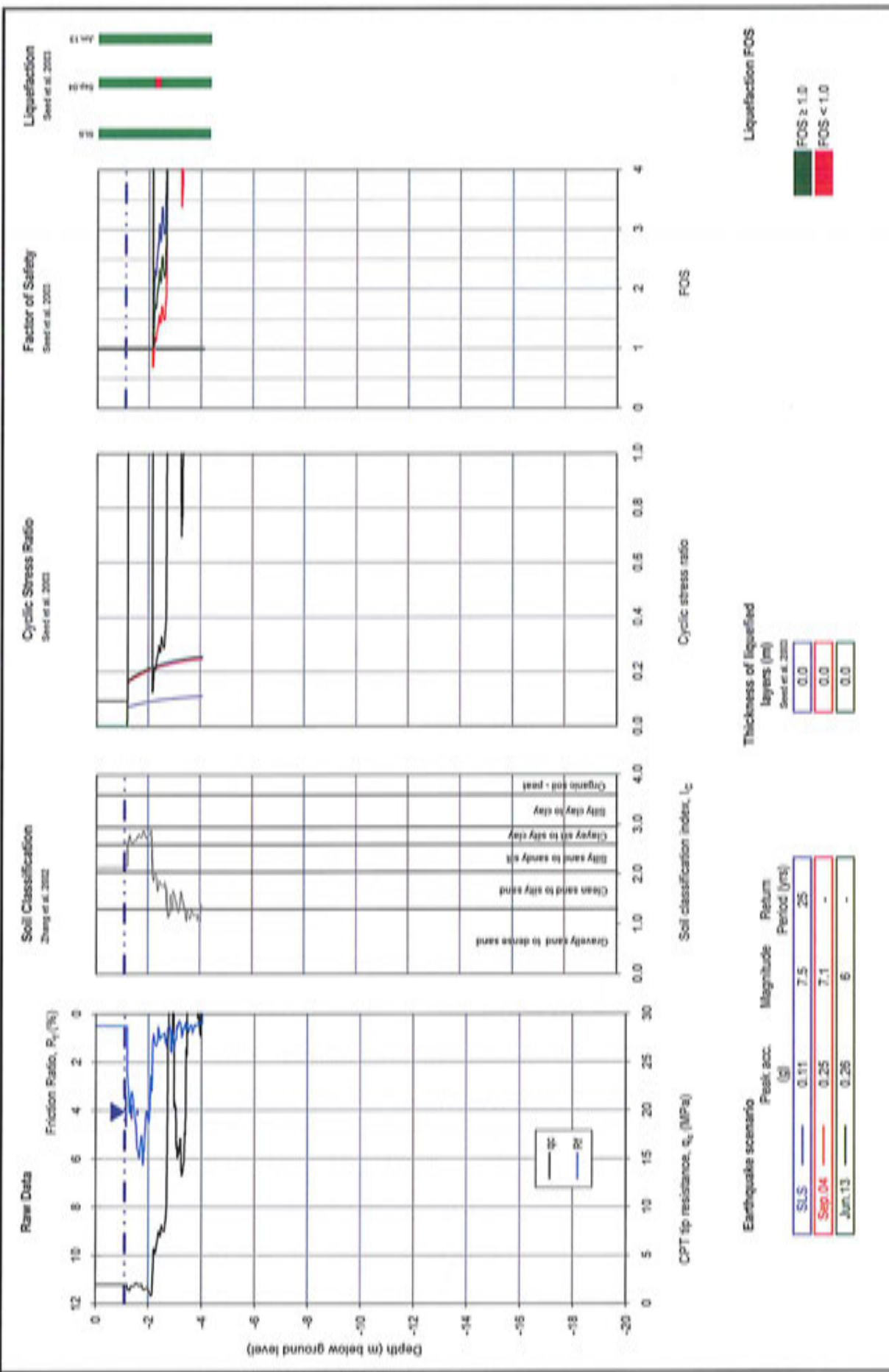
CLIENT PROJECT

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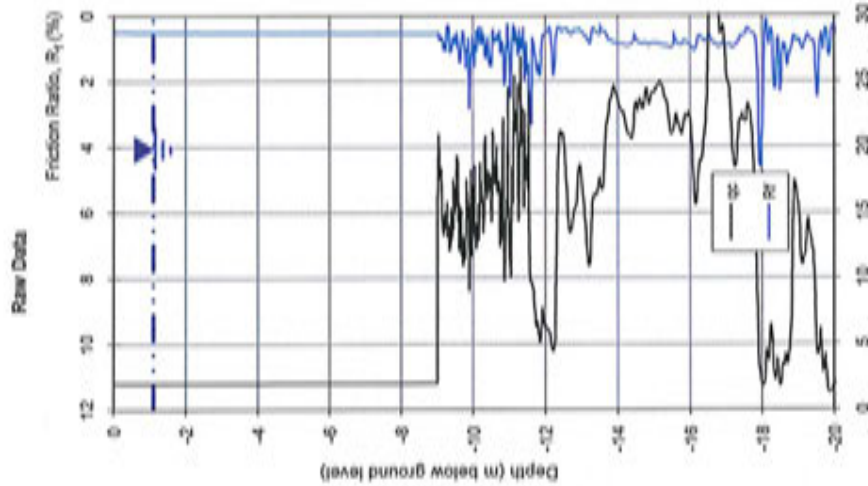
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CPT-CBD-75

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
JOB NUMBER: 52000.301

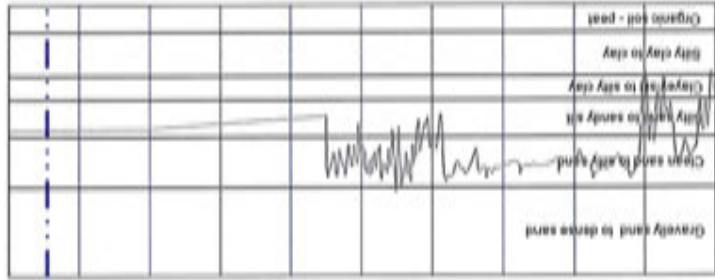
Liquefaction Assessment from CPT Results



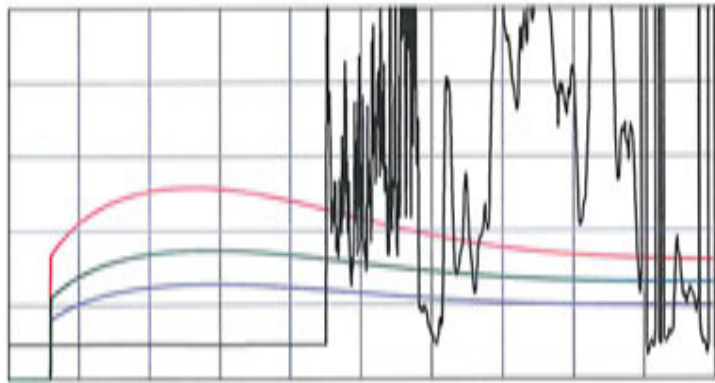




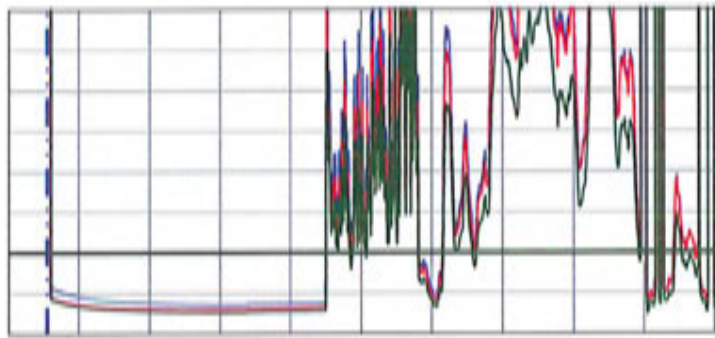
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness (m)
9.8
9.8
10.6

Liquefaction FOS



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LOCATION

CPT-CBD-75P

DATE

6/12/2011

ANALYSED

RAP

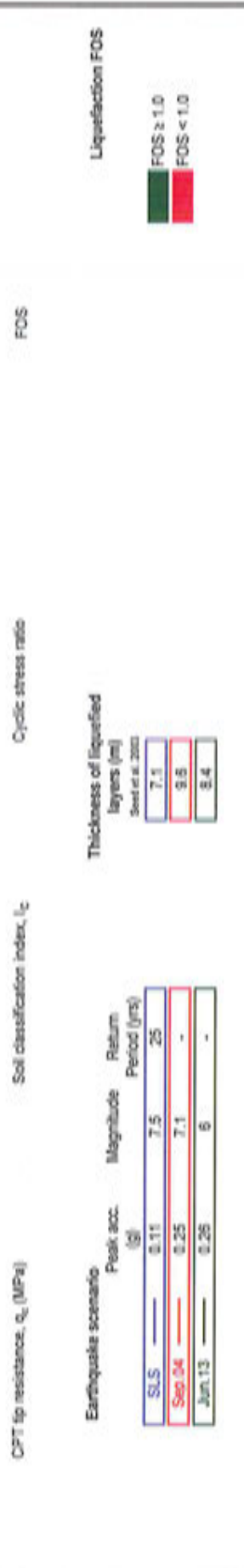
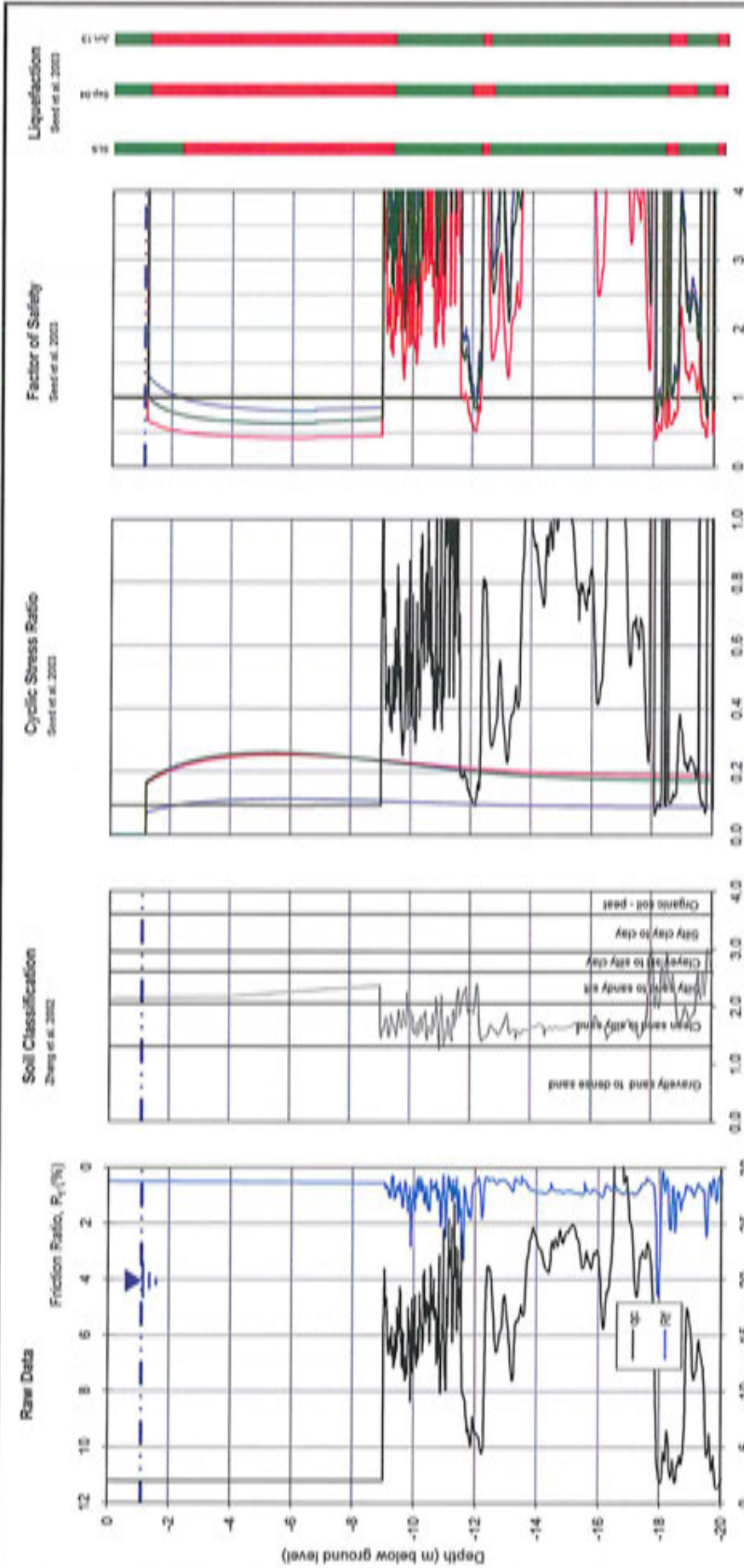
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AFF

LOT NUMBER

52000\_301

Liquefaction Assessment from CPT Results





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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

DATE: 31/12/2011  
ANALYSED: RAP  
CHECKED: AFF

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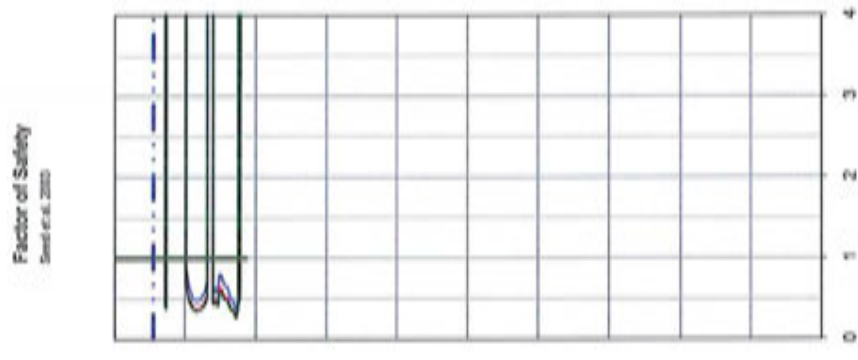
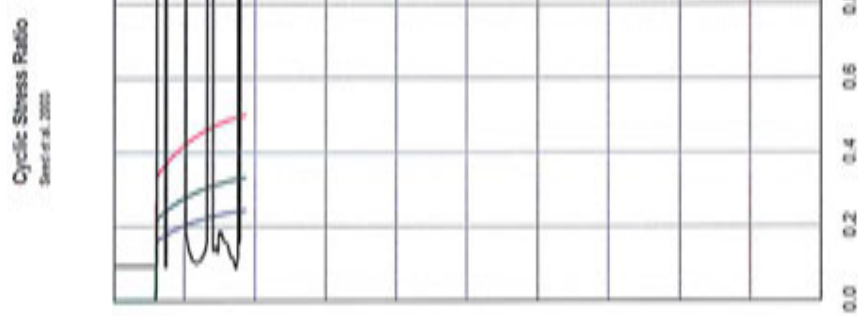
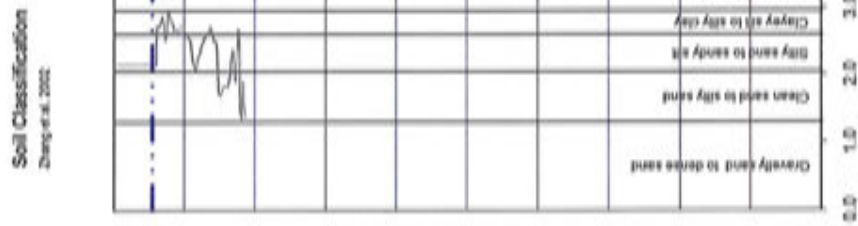
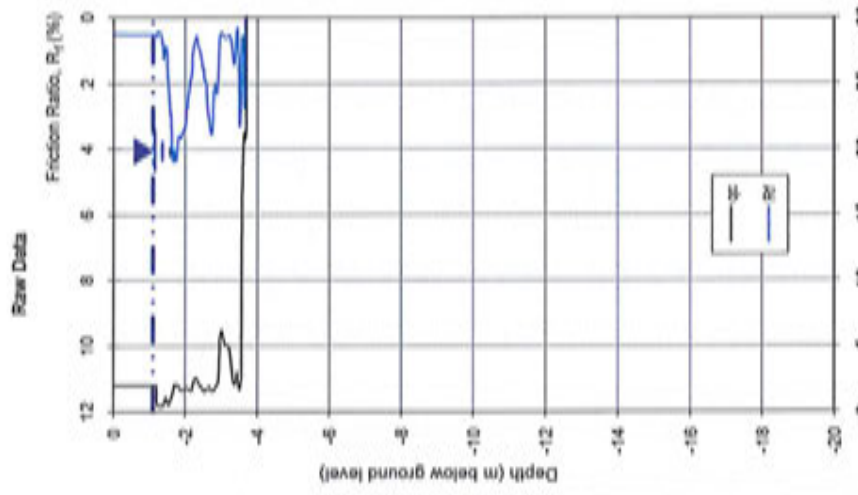
SOILC PROJECT

**CPT-CBD-75P**

JOB NUMBER: 52000\_301

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Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

1.4
1.4
1.4

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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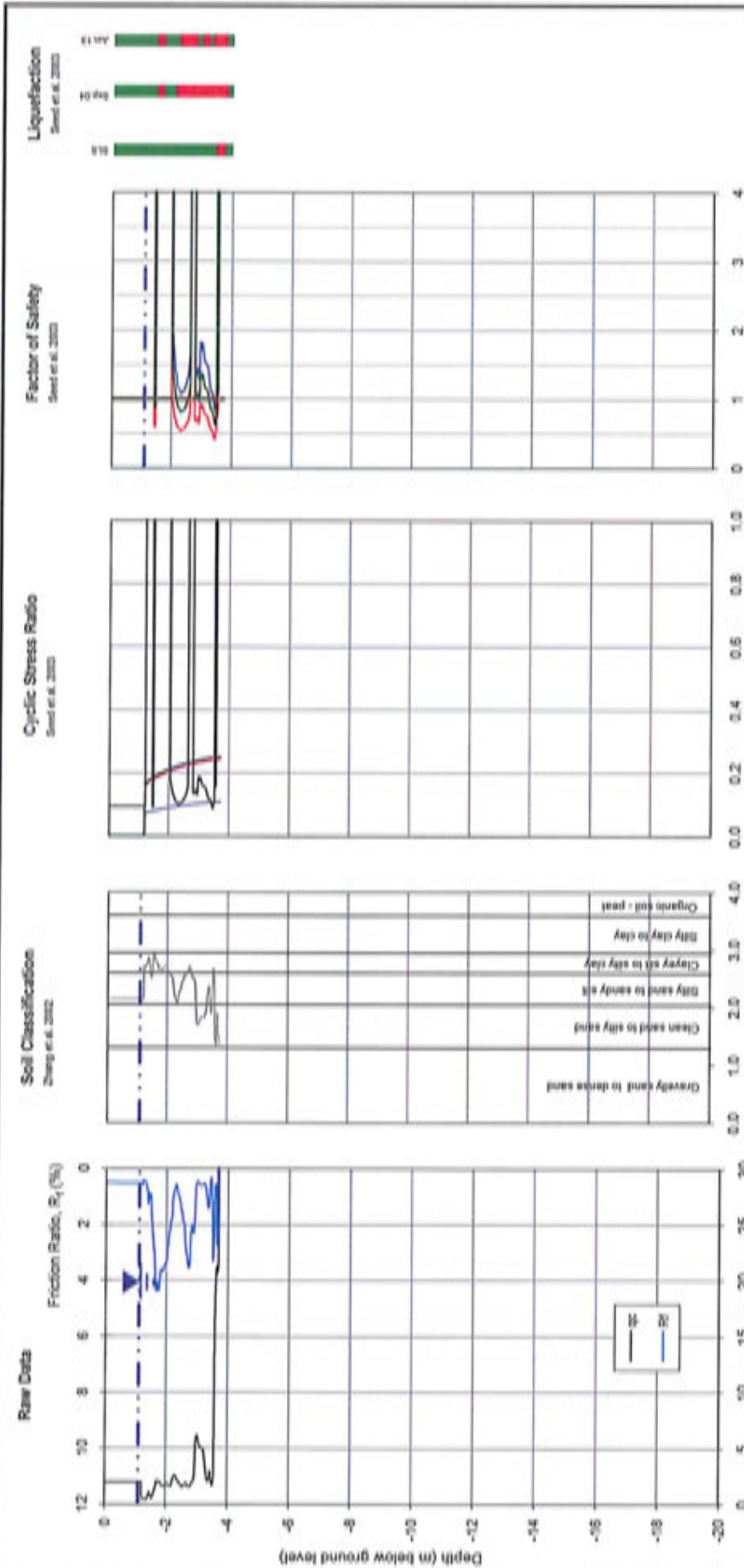
PROJECT

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results

JOB NUMBER: 520000\_301

LOCATION: CPT-CBD-76



**Earthquake scenario**


Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sev. 04	0.25	7.1	-
Jan. 13	0.25	6	-

**Thickness of liquefied layers (m)**  
Seed et al. 2003

0.1
1.4
0.7

**Liquefaction FOS**

FOS $\geq$ 1.0
FOS $<$ 1.0



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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**PROJECT:** Liquefaction Assessment from CPT Results

**CLIENT:** Christchurch City Council

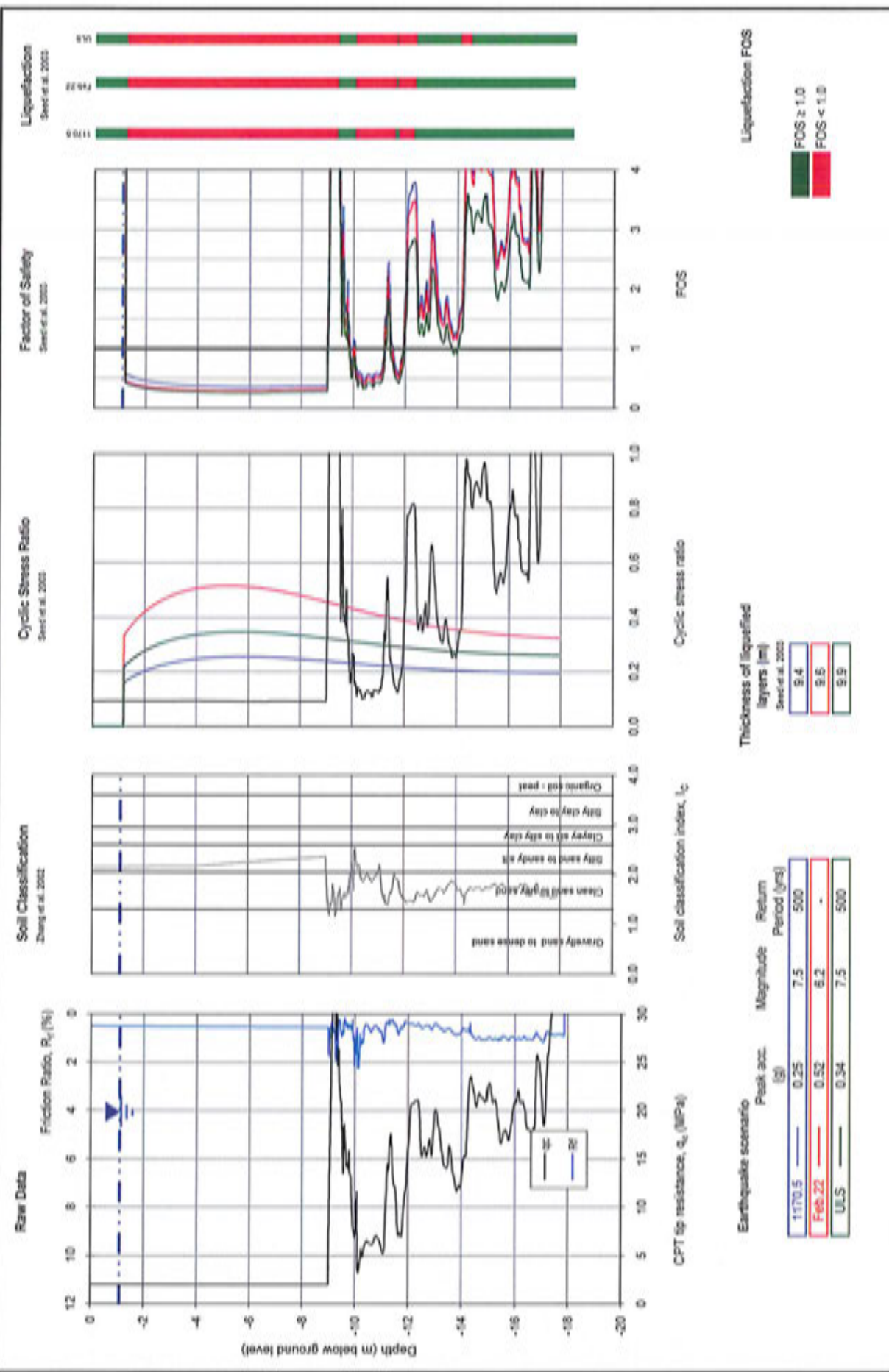
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**DATE ANALYSED:** 7/12/2011

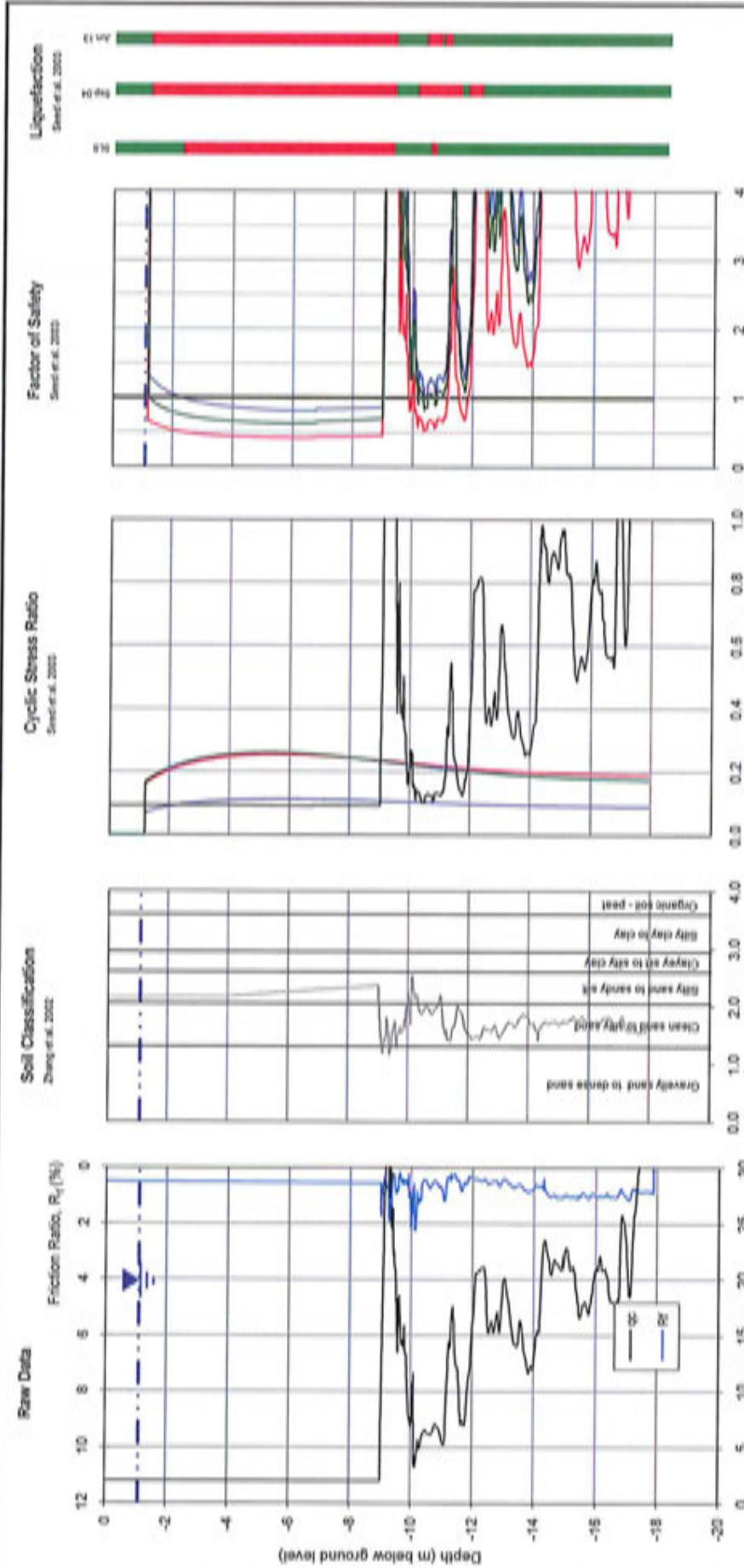
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**RAP:** AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-76P</b>	DATE 6/12/2011
	FILE Liquefaction Assessment from CPT Results	JOB NUMBER 52000.301	ANALYSED RAP
			CHECKED AFF



**Earthquake scenario**

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.25	6	-

**Thickness of liquefied layers (m)**

Scenario	Thickness (m)
SLS	6.7
Sep 04	9.3
Jun 13	8.1


**CPT tip resistance,  $q_c$  (MPa)**

**Soil classification index,  $I_c$**

**Cyclic stress ratio**

**Factor of Safety (FOS)**

**Liquefaction FOS**



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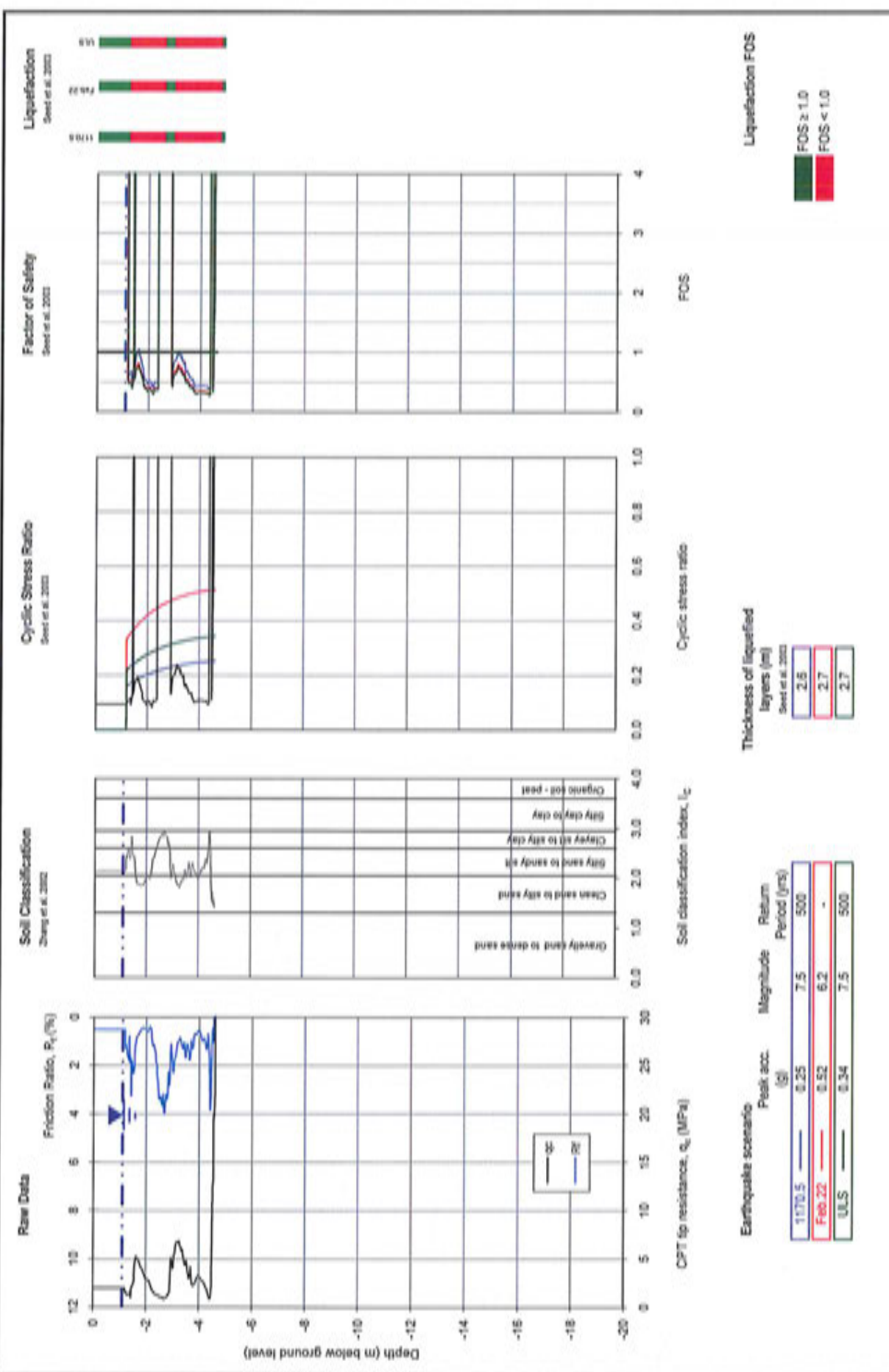
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**CPT-CBD-76P**

DATE: 11/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
AFF

JOB NUMBER: 52000\_301

Liquefaction Assessment from CPT Results



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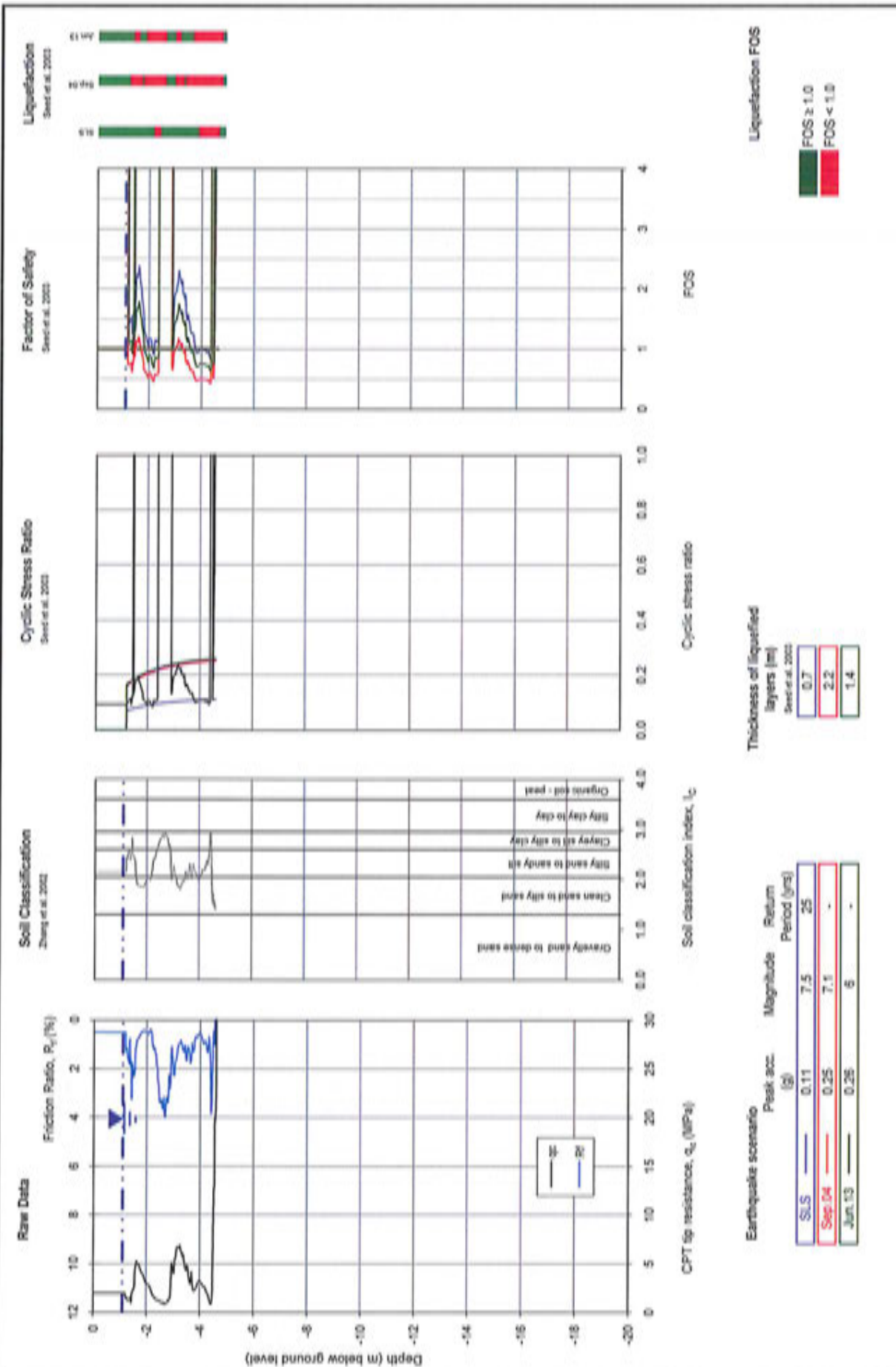
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

Liquefaction Assessment from CPT Results

**CPT-CBD-77**

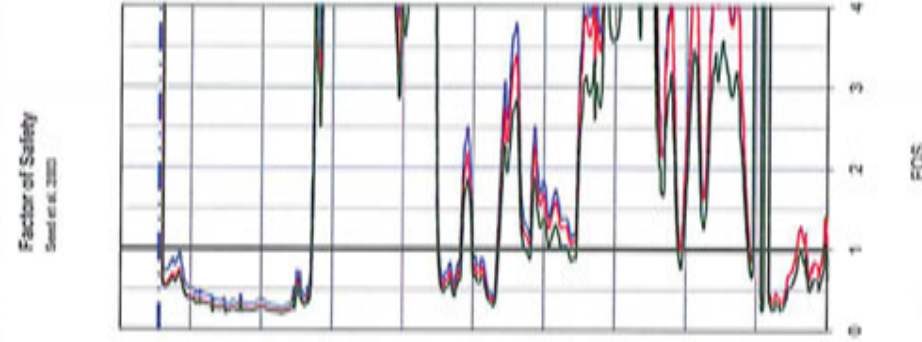
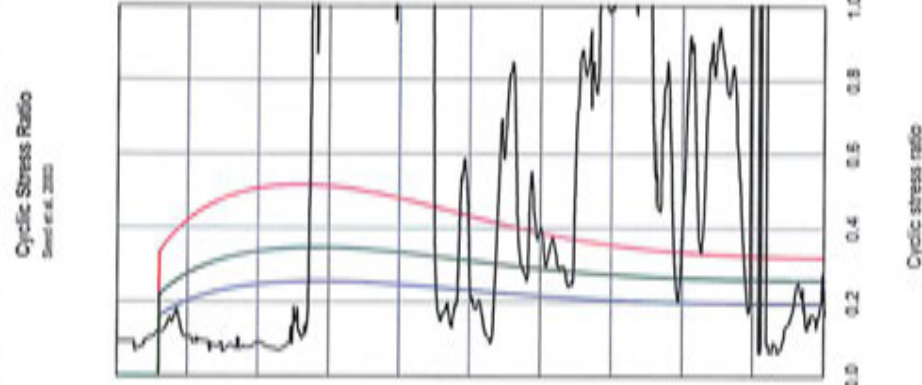
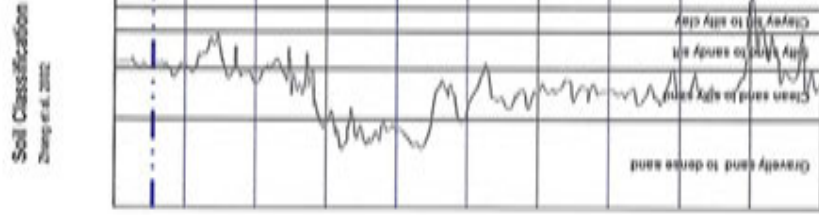
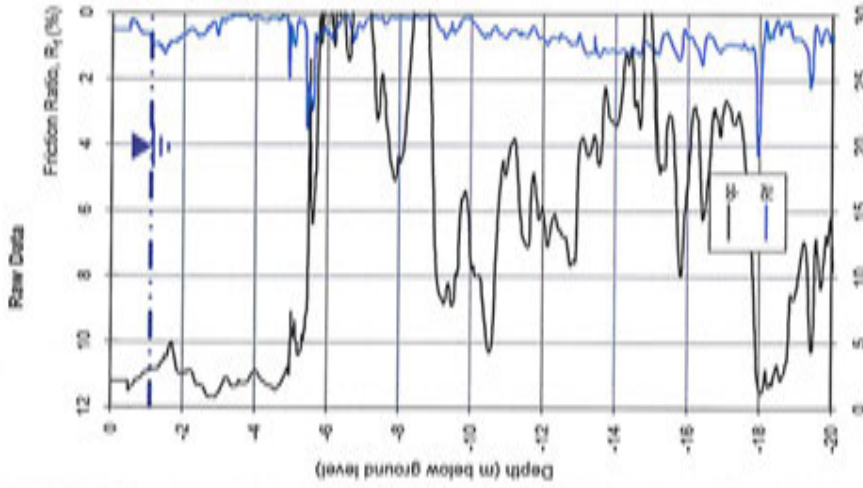
JOB NUMBER: 52000\_301

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	SECTION <b>CPT-C80-77</b>	DATE 7/12/2011
	FILE Liquefaction Assessment from CPT Results	JOB NUMBER 52000.301	ANALYSED RAP





CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
11/70.5	0.25	7.5	500
Feb.22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
8.5
8.6
9.5

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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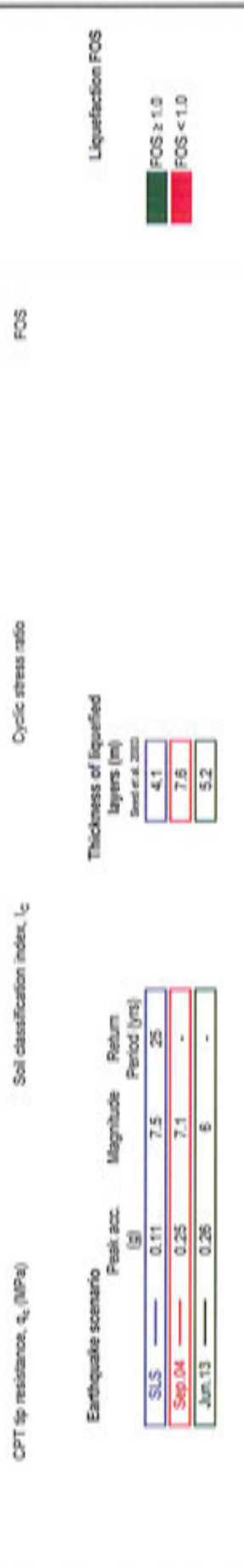
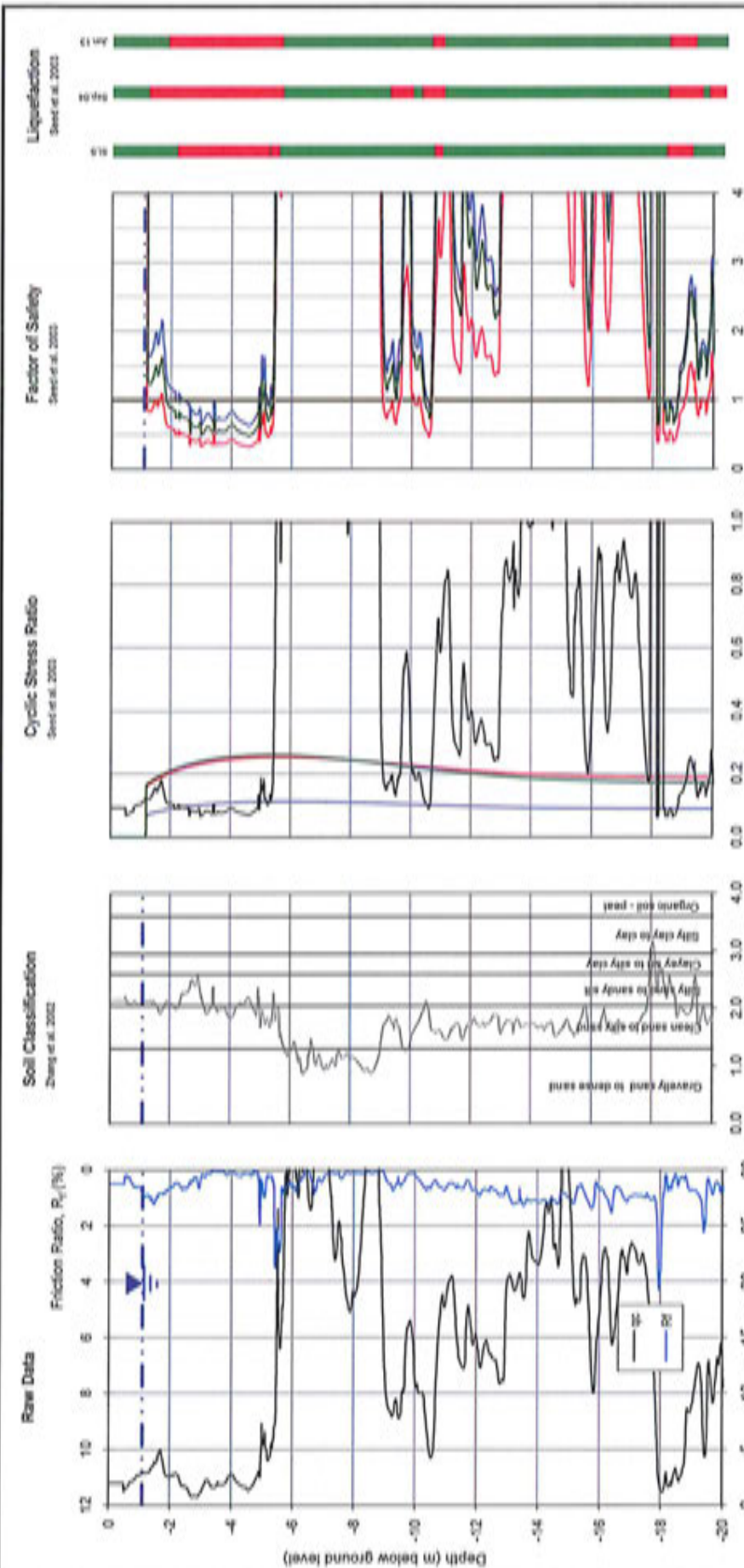
Christchurch City Council  
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PROJECT  
CPT-CBD-77P

DATE 6/12/2011  
ANALYSED RAP  
CHECKED AFF

LOT NUMBER  
53000.351

Liquefaction Assessment from CPT Results





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Geotechnical Assessment for Christchurch Central City

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**PROJECT**

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

**LOCATION**

CPT-CBD-77P

**FILE**

Liquefaction Assessment from CPT Results

**JOB NUMBER**

52000\_301

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**DATE**

7/12/2011

**RAP**

AFF

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**ANALYSED**

CHECKED

**DATE**

7/12/2011

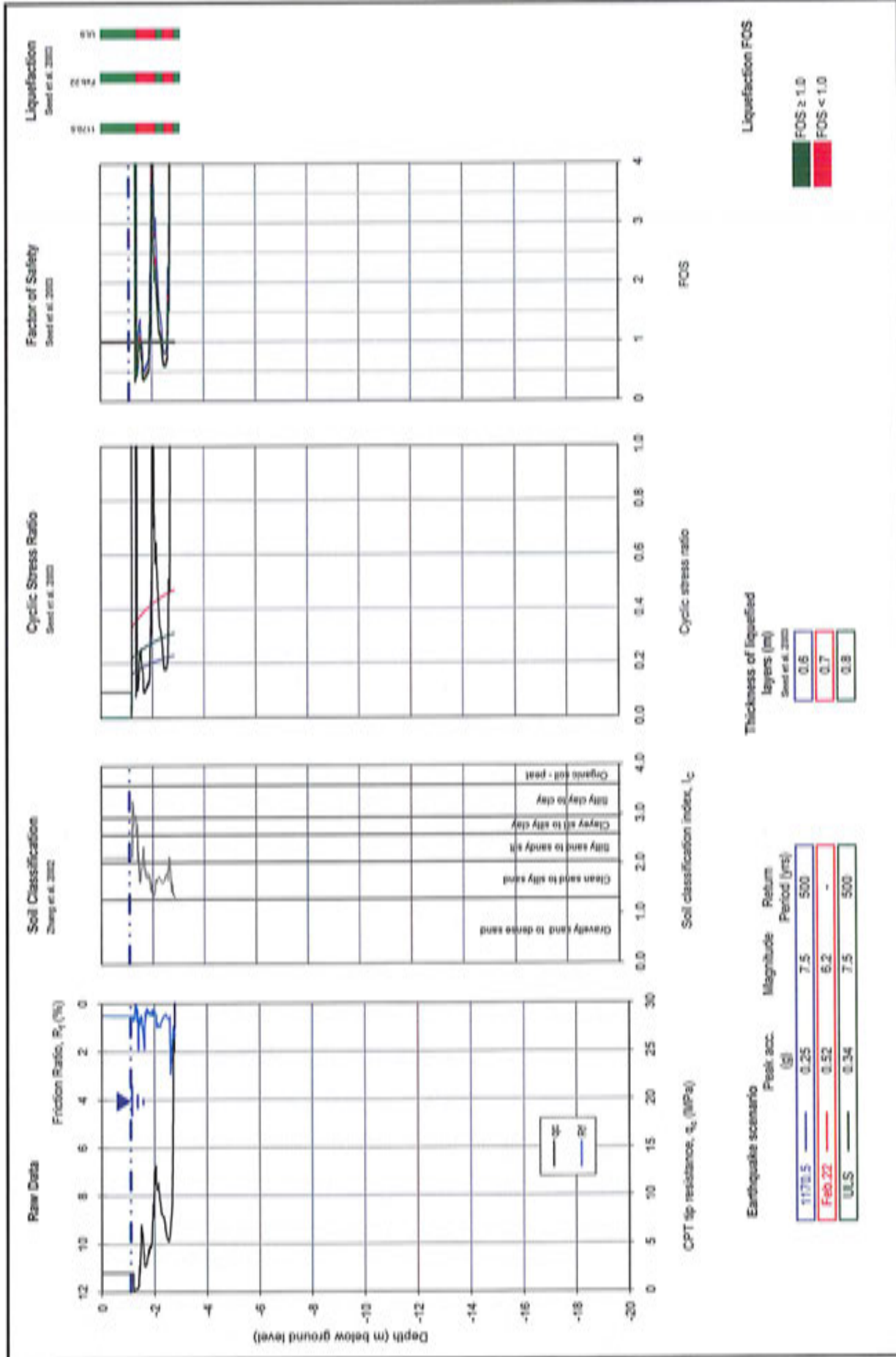
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**APPROVED**

AFF

**DATE**

7/12/2011



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE: 6/12/2011 ANALYSED: RAP CHECKED: AFF
	SUBJECT PROJECT <b>CPT-C8D-78</b>		JOB NUMBER: S2006.301
Liquefaction Assessment from CPT Results			

Earthquake scenario

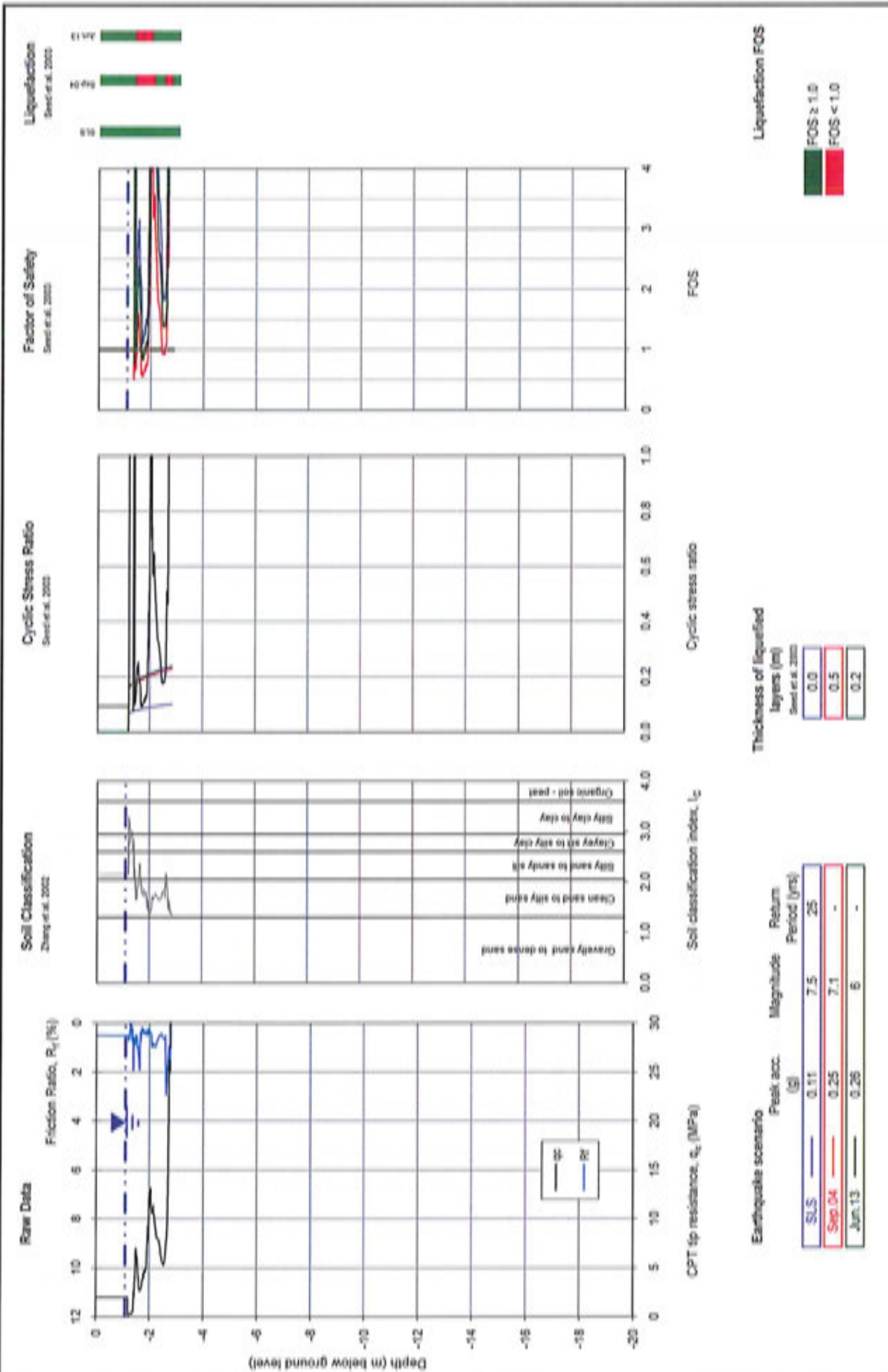
Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
U.S.	7.5	500

Thickness of liquefied layers (m)

0.6
0.7
0.8

Liquefaction FOS

FOS ≥ 1.0
FOS < 1.0



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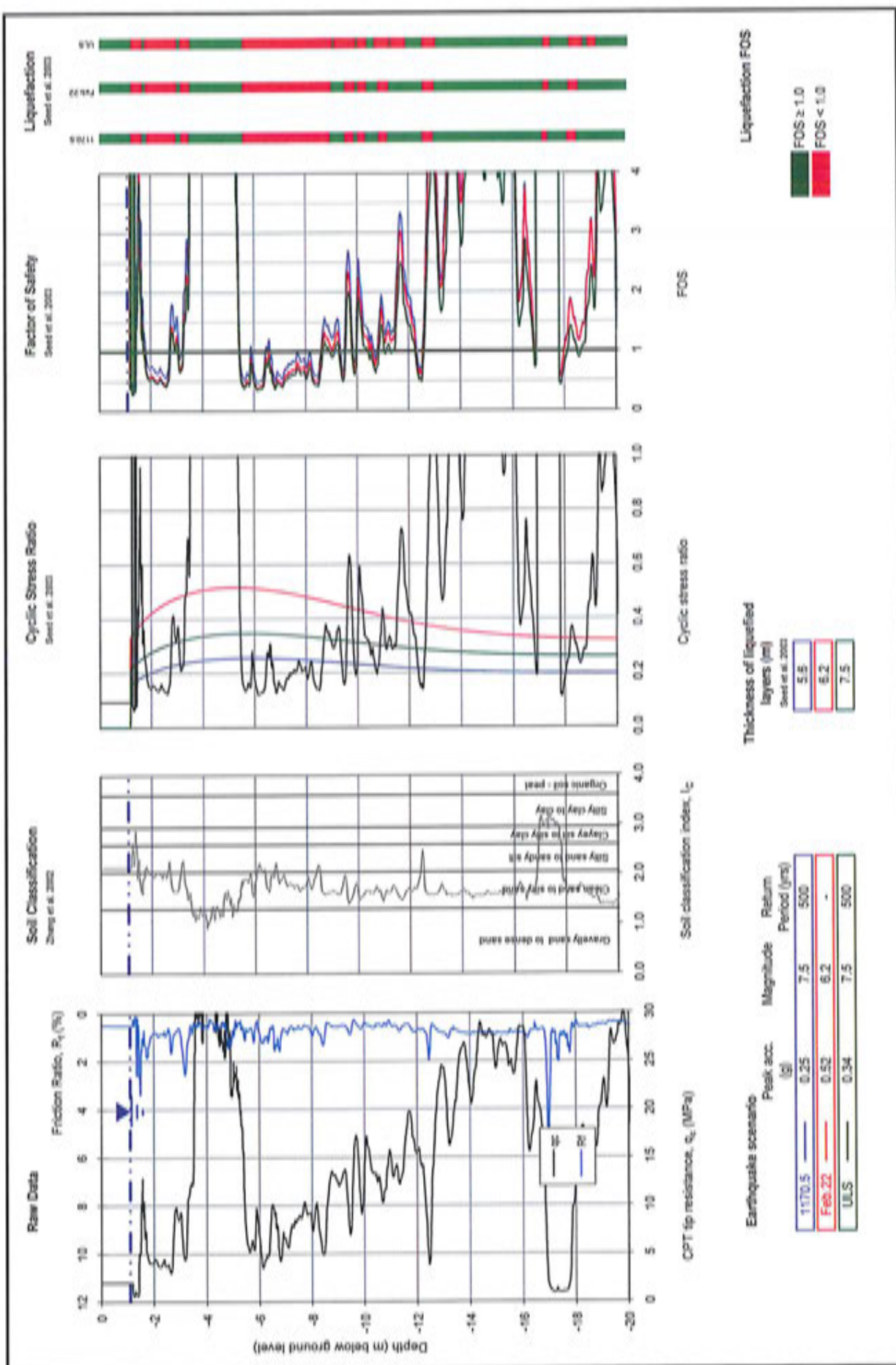
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**LOCATION**  
CPT-CBD-78

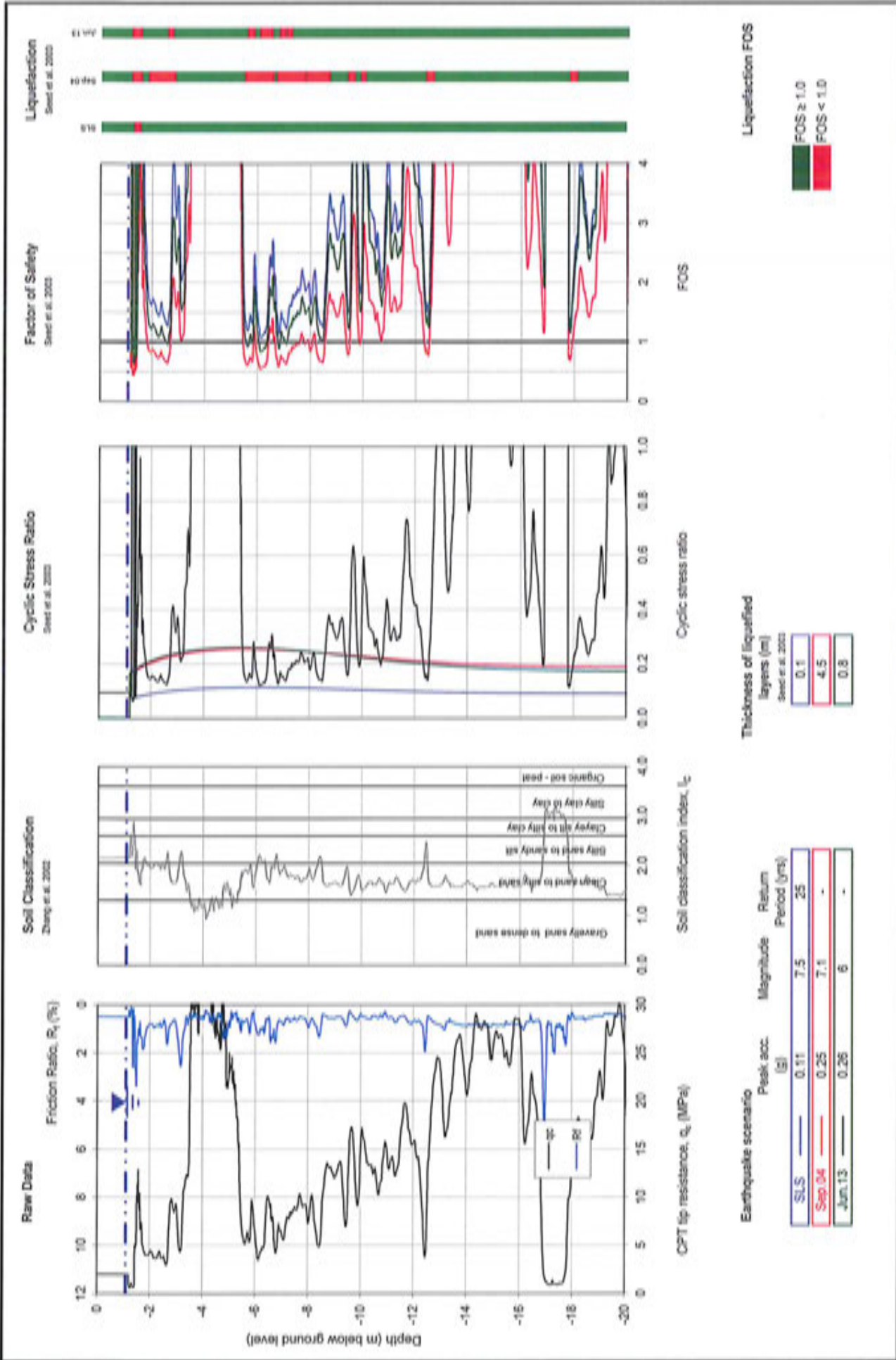
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**DATE** 27/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
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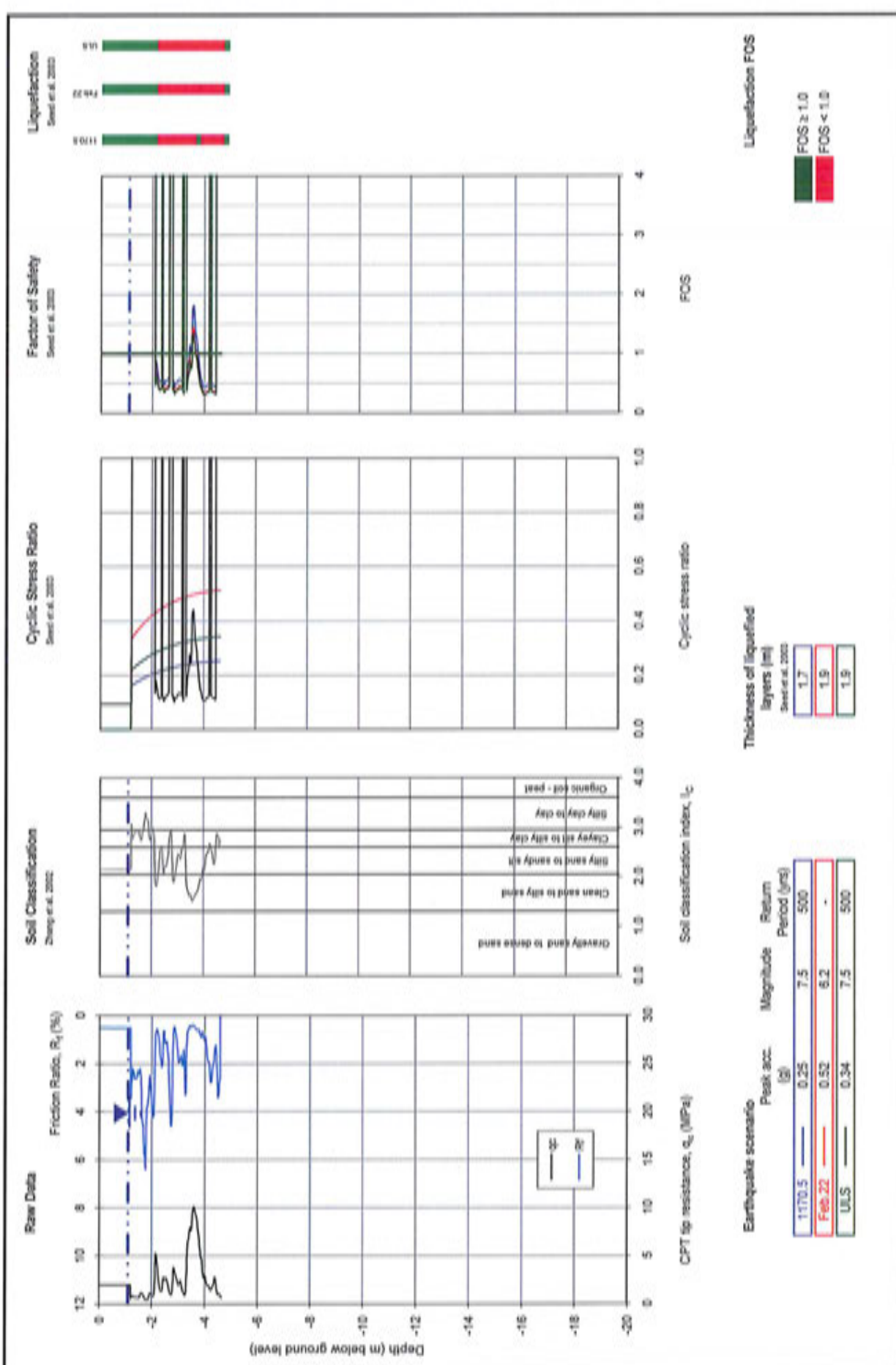
Liquefaction Assessment from CPT Results



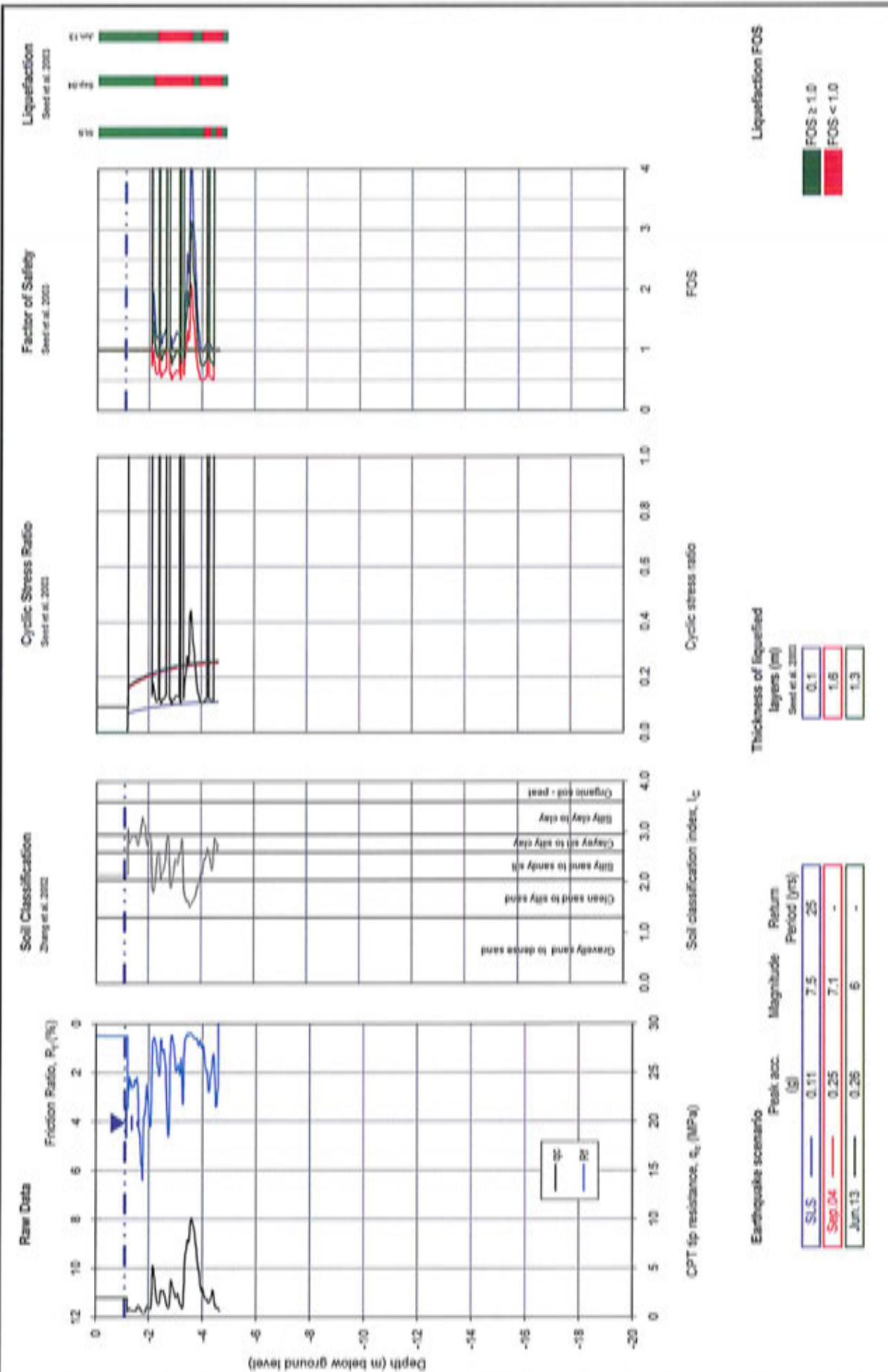
 Tonkin & Taylor Ltd Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		LOCATION <b>CPT-CBD-79</b>	DATE 5/12/2011
	TITLE Liquefaction Assessment from CPT Results		JOB NUMBER 52000.301	ANALYSED RRP
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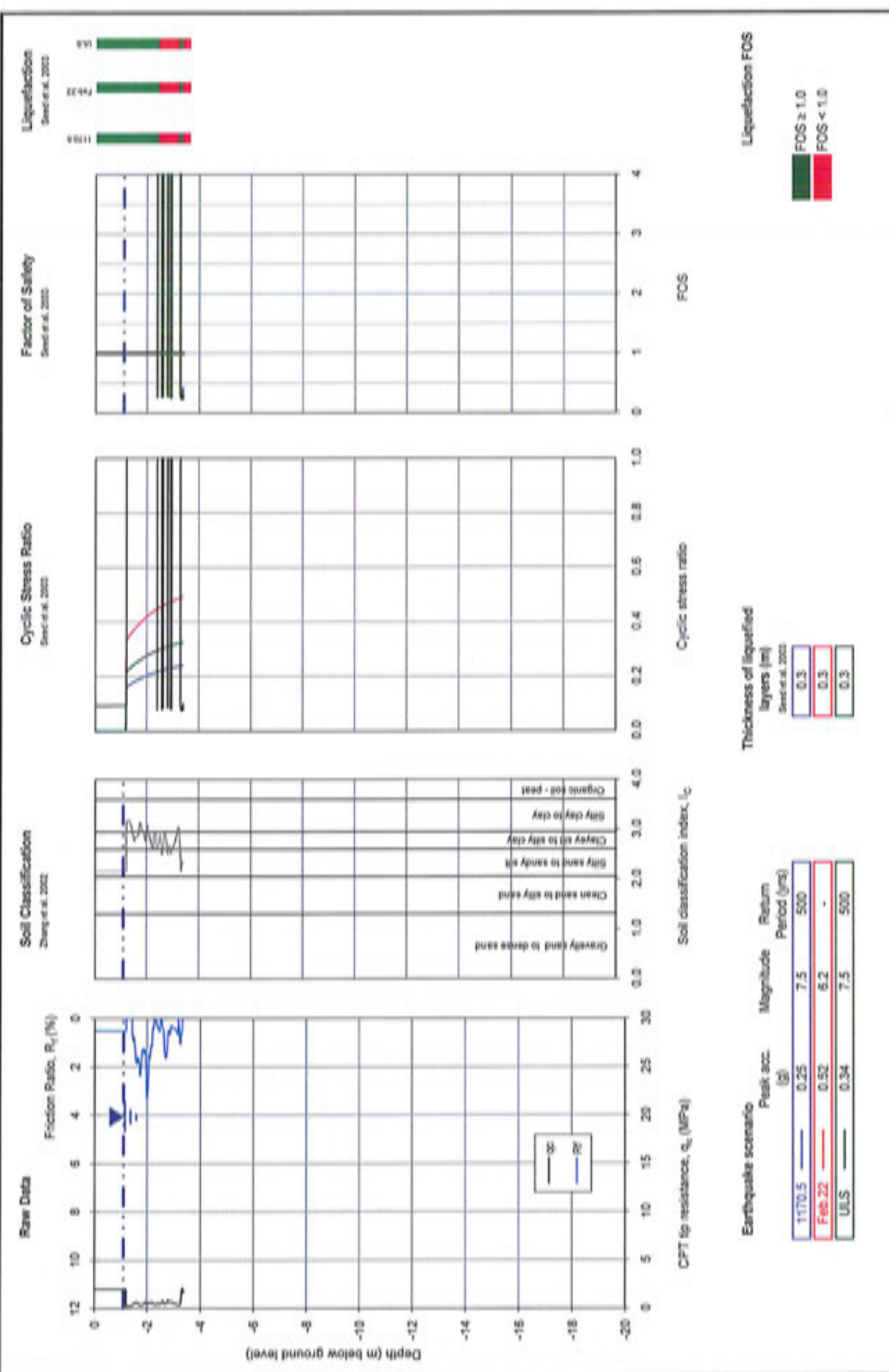
 <b>Troakin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-79</b>	DATE 7/12/2011
	FILE Liquefaction Assessment from CPT Results	JOB NUMBER 52000.301	ANALYSED RAP



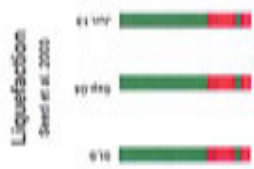
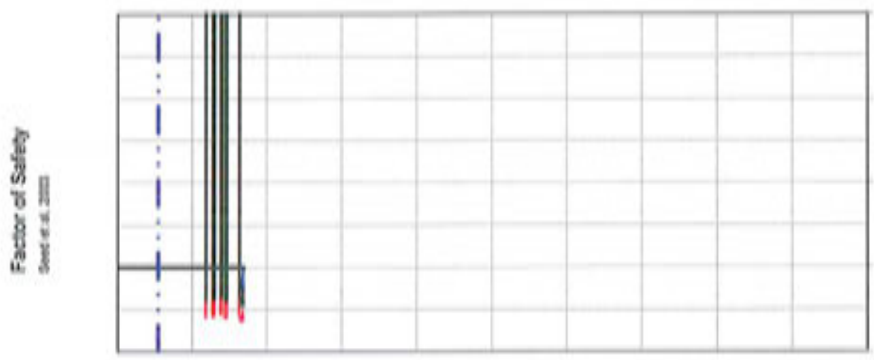
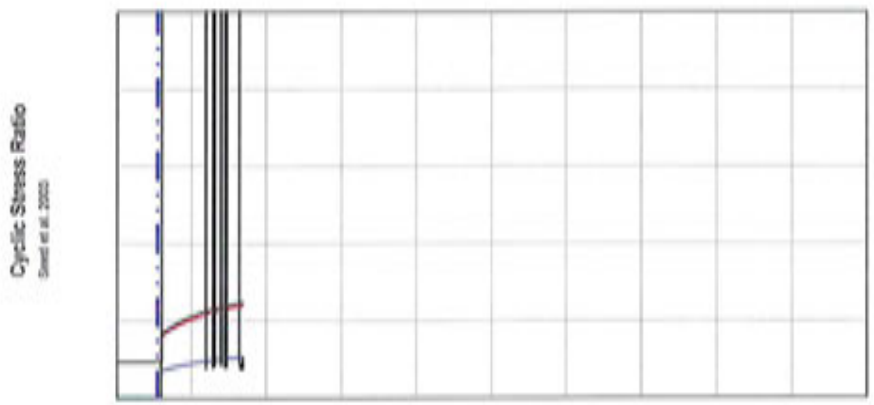
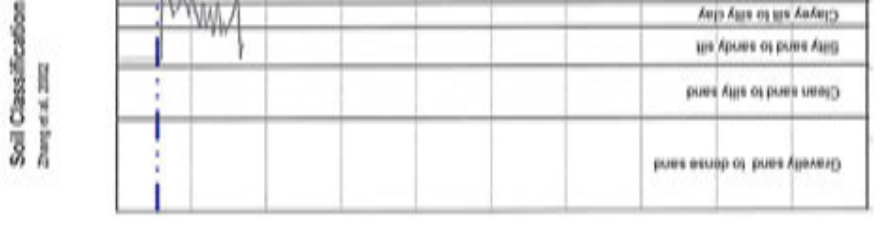
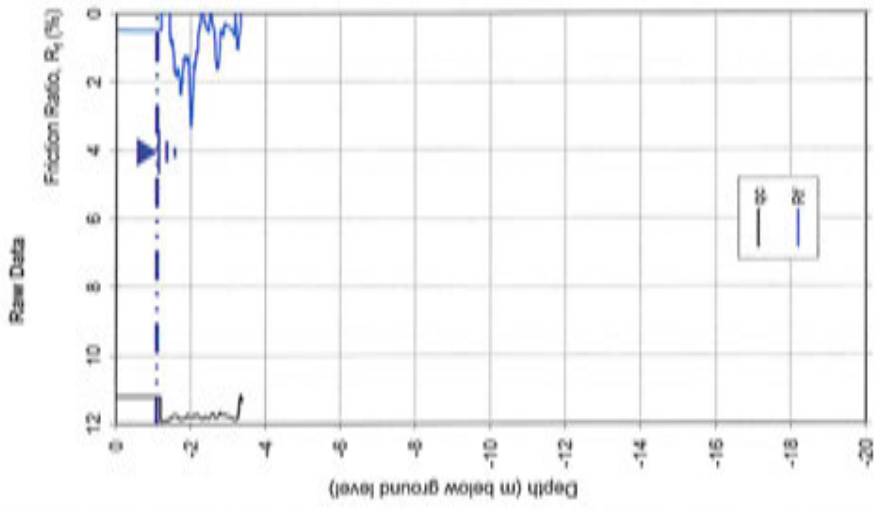
 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT/PROJECT <b>Christchurch City Council</b> <b>Geotechnical Assessment for Christchurch Central City</b>	DATE 6/12/2011	ANALYSED RAP
		CHECKED AFF	DATE 6/12/2011
FILE <b>Liquefaction Assessment from CPT Results</b>		JOB NUMBER 52000.301	PROJECT <b>CPT-CBD-80</b>







 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	DATE 6/12/2011
		ANALYSED RAP
Liquefaction Assessment from CPT Results		CHECKED AFF
Liquefaction Assessment from CPT Results		LIAISON NUMBER 52006.101
Liquefaction Assessment from CPT Results		LIAISON NUMBER 52006.101



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5
0.25	7.1	25
0.25	7.1	-
0.25	6	-

Thickness of liquefied layers (m)

0.3
0.3
0.3

Liquefaction FOS



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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-80a

ANALYSED  
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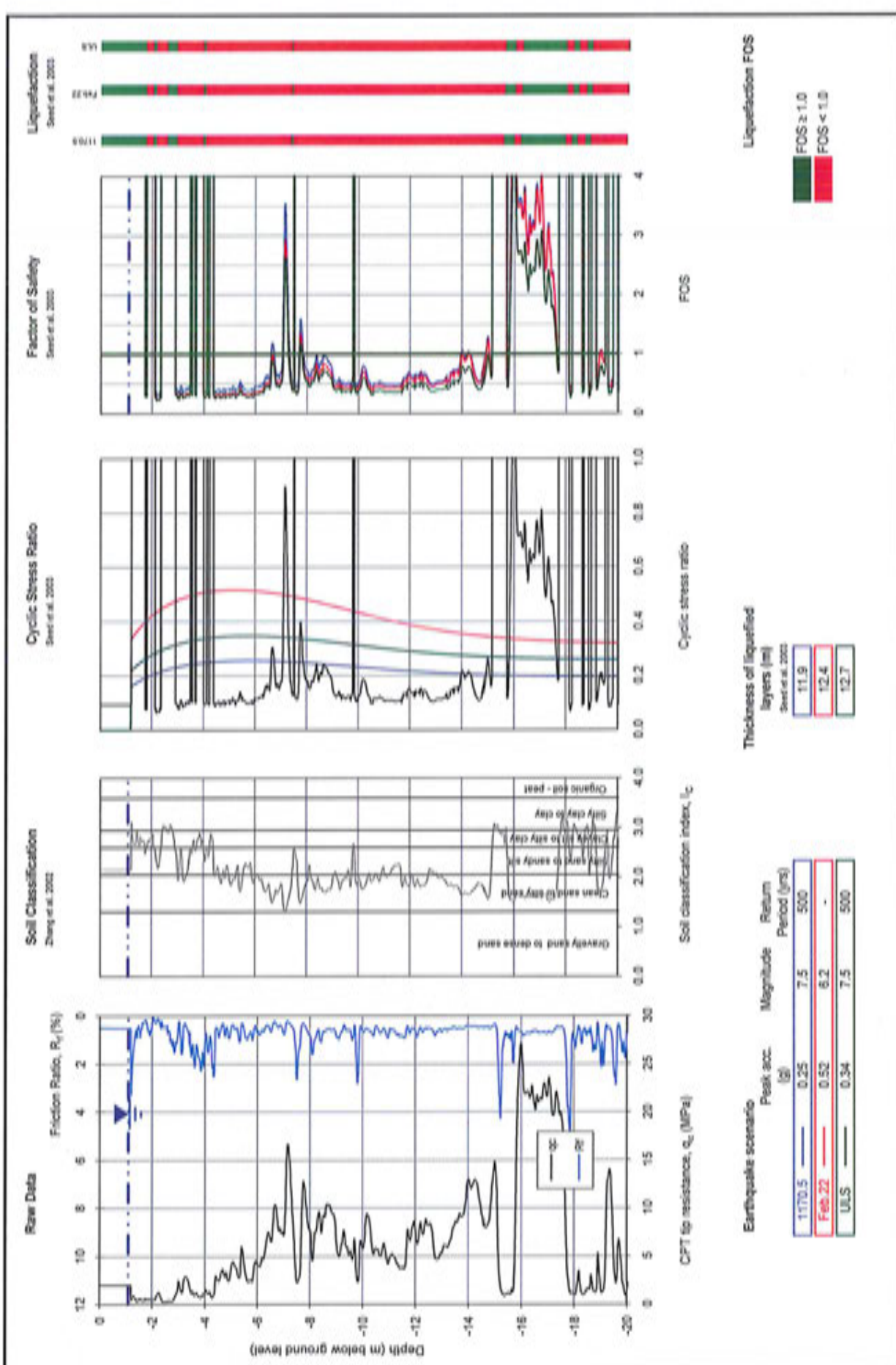
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J11/2/2011

RAP

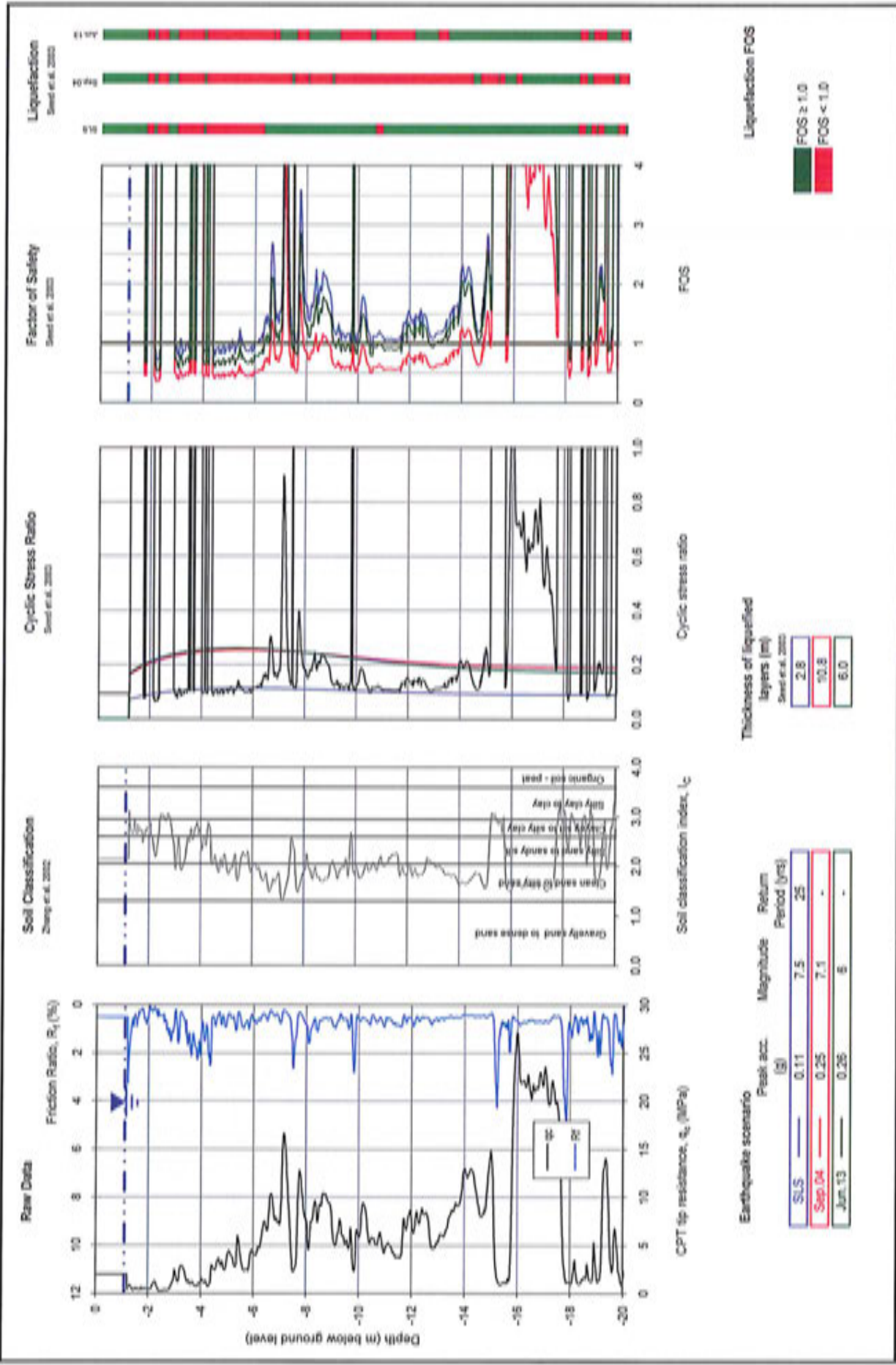
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JOB NUMBER  
52000.30/1

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT/PROJECT <b>Christchurch City Council          Geotechnical Assessment for Christchurch Central City</b>	LOCATION <b>CPT-CBD-81</b>	DATE 6/12/2011
	TITLE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 52000.301	ANALYSED RAP
			CHECKED AFF



Raw Data

Soil Classification  
Zhang et al. 2002

Cyclic Stress Ratio  
Seed et al. 2003

Factor of Safety  
Seed et al. 2003

Liquefaction  
Seed et al. 2003

CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5
Op 04	0.25	7.1
Jun 13	0.26	6

Thickness of liquefied layers (m)

Thickness (m)
2.8
10.8
6.0

Liquefaction FOS

FOS $\geq 1.0$
FOS $< 1.0$



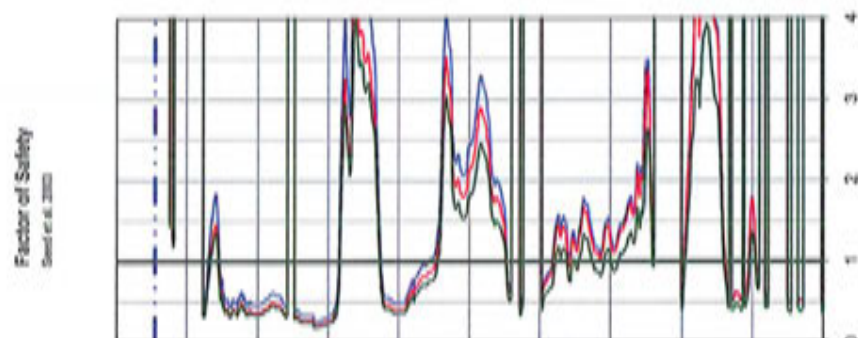
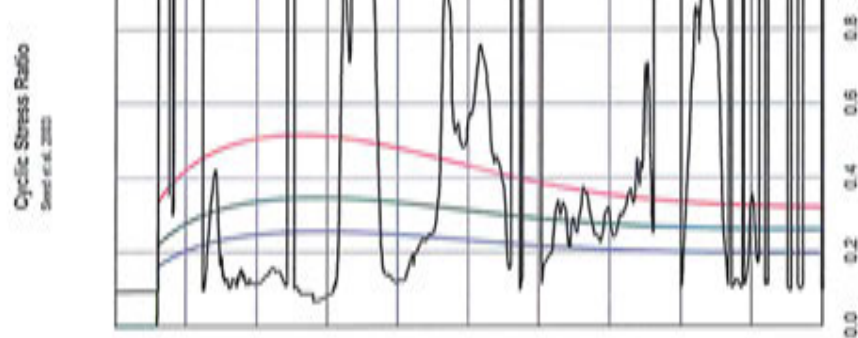
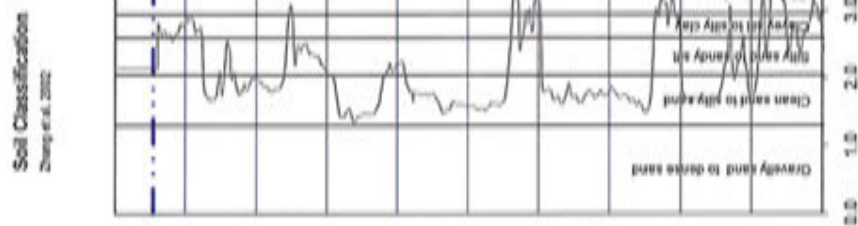
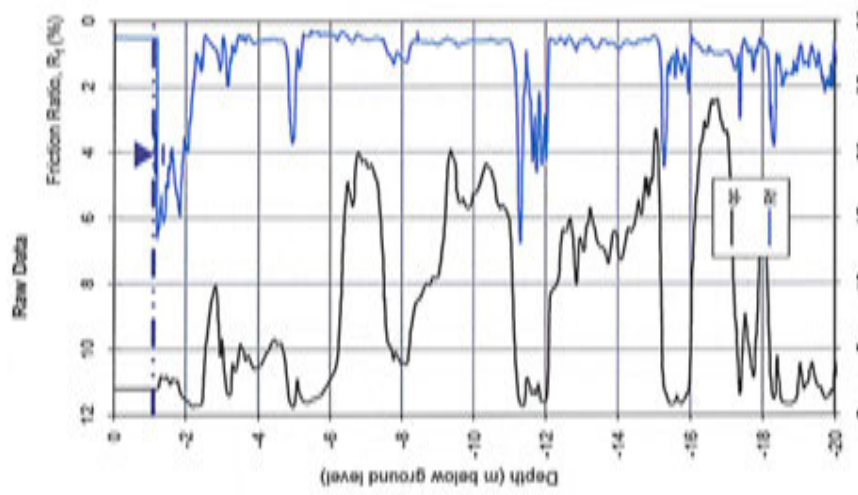
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Environmental & Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT LOCATION  
**CPT-CBD-81**  
JOB NUMBER  
52000.301

DATE  
7/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF  
FILE

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

6.8
7.2
8.3

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

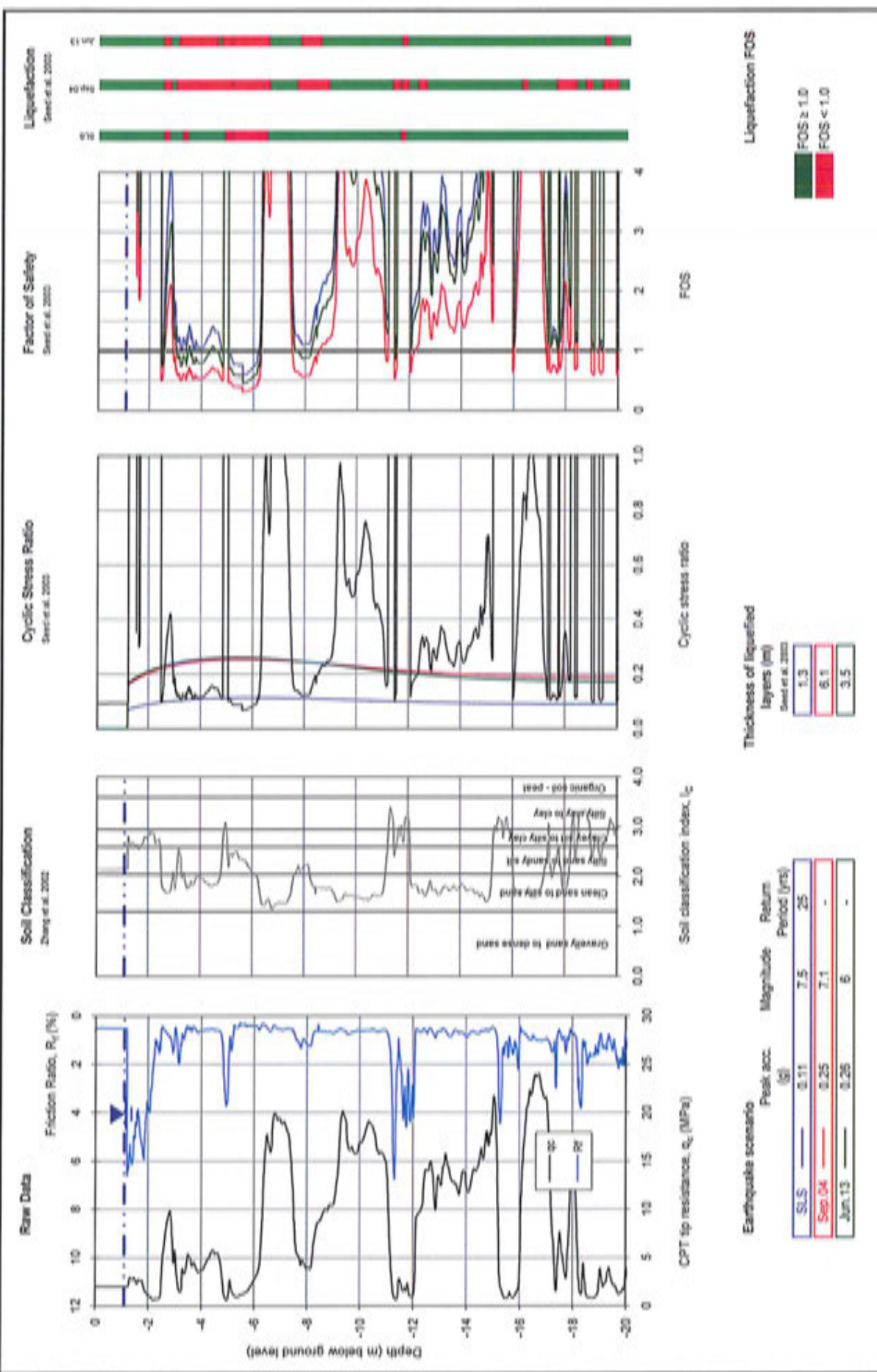
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JOB NUMBER

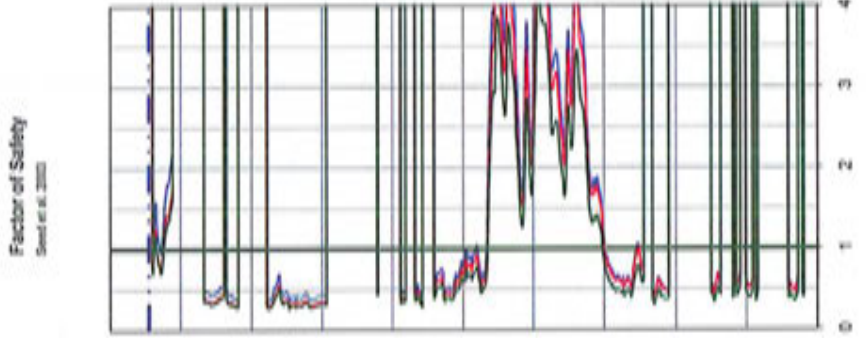
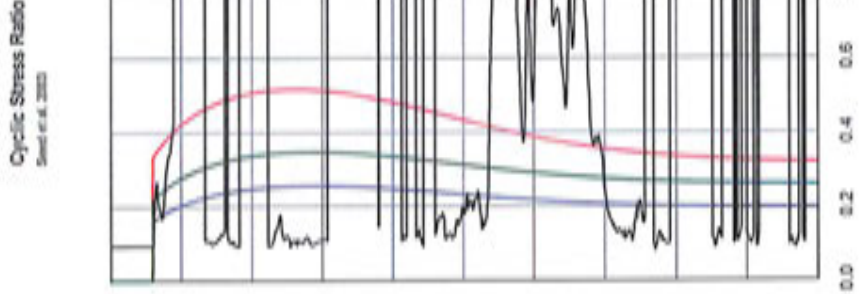
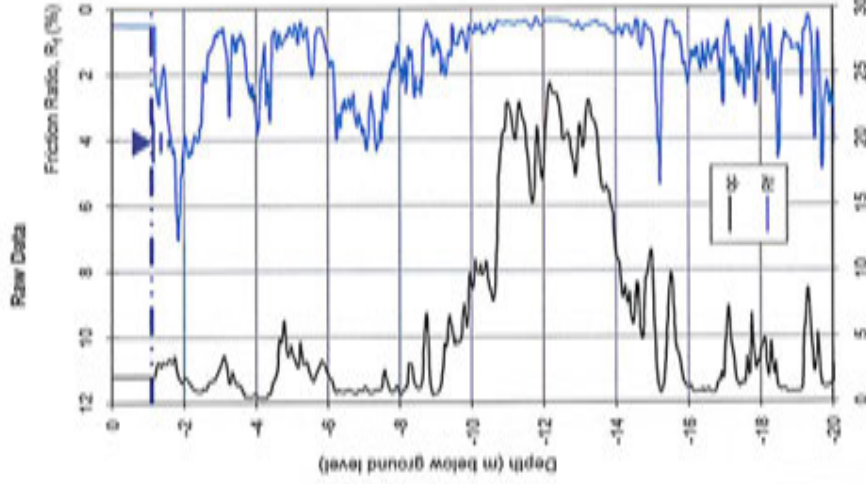
52000\_301

DATE 5/12/2011  
ANALYSED RAP  
CHECKED AFF

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE: 7/12/2011 ANALYSED: RAB CHECKED: AFF
	CLIENT PROJECT: <b>CPT-CBD-82</b>		LOCATION: S2000_301
Liquefaction Assessment from CPT Results			



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

7.1
7.5
7.5

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-83

DATE

6/12/2011

ANALYSED

RAP

CHECKED

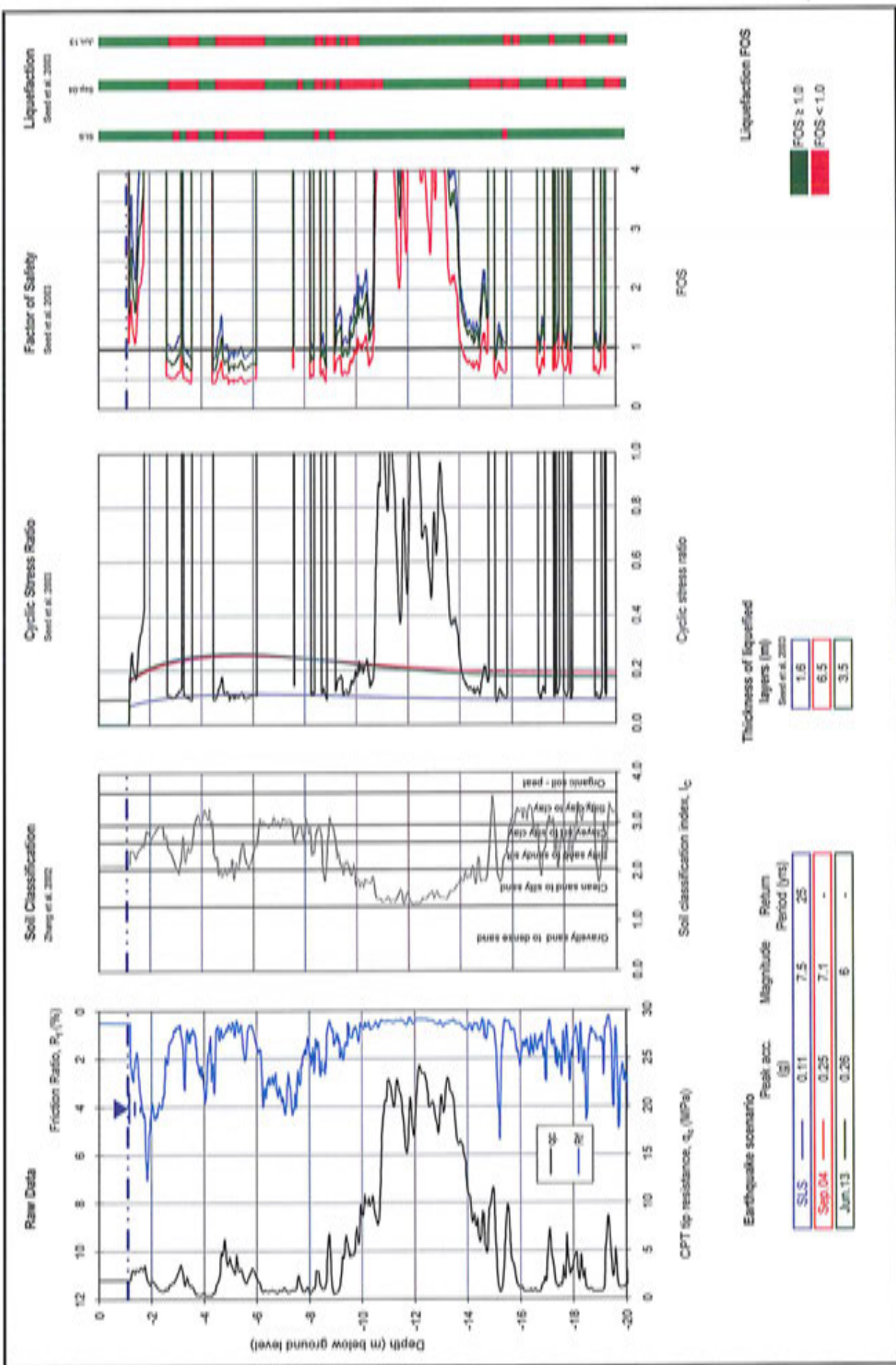
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JOB NUMBER

52000\_301

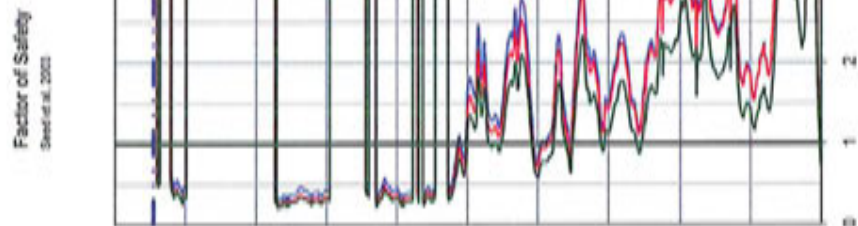
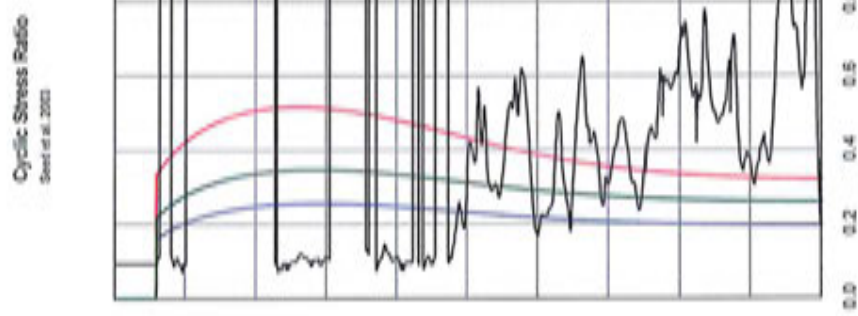
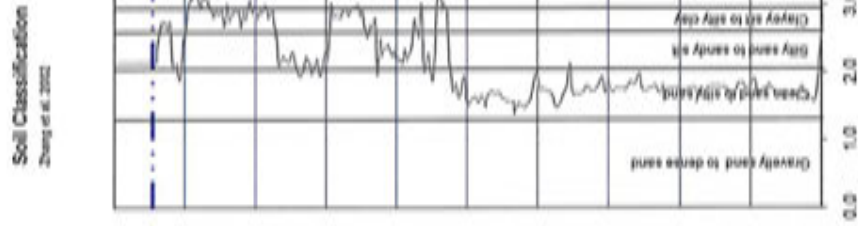
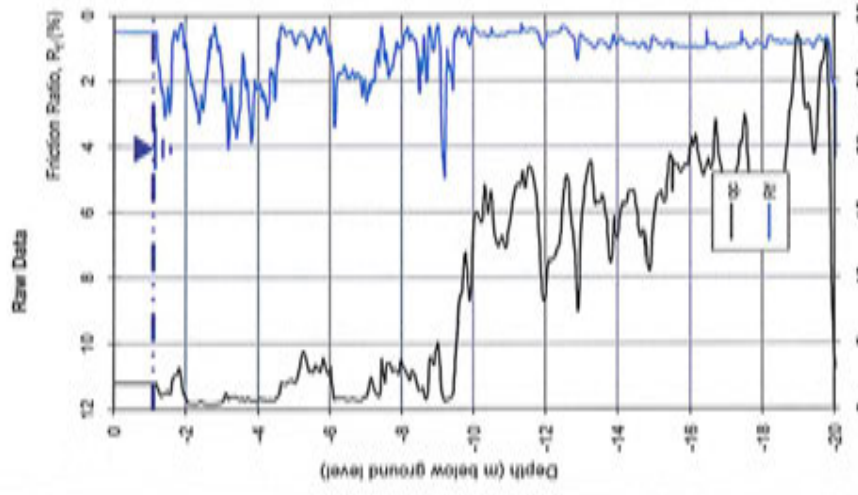
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Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE: 7/12/2011 ANNULSED: RRP CHECKED: AFF
	Liquefaction Assessment from CPT Results		LOCATION: <b>CPT-CBD-83</b> JOB NUMBER: 52000_301





CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
4.3
4.5
5.5

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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Geotechnical Assessment for Christchurch Central City

PROJECT NUMBER  
CPT-CBD-84

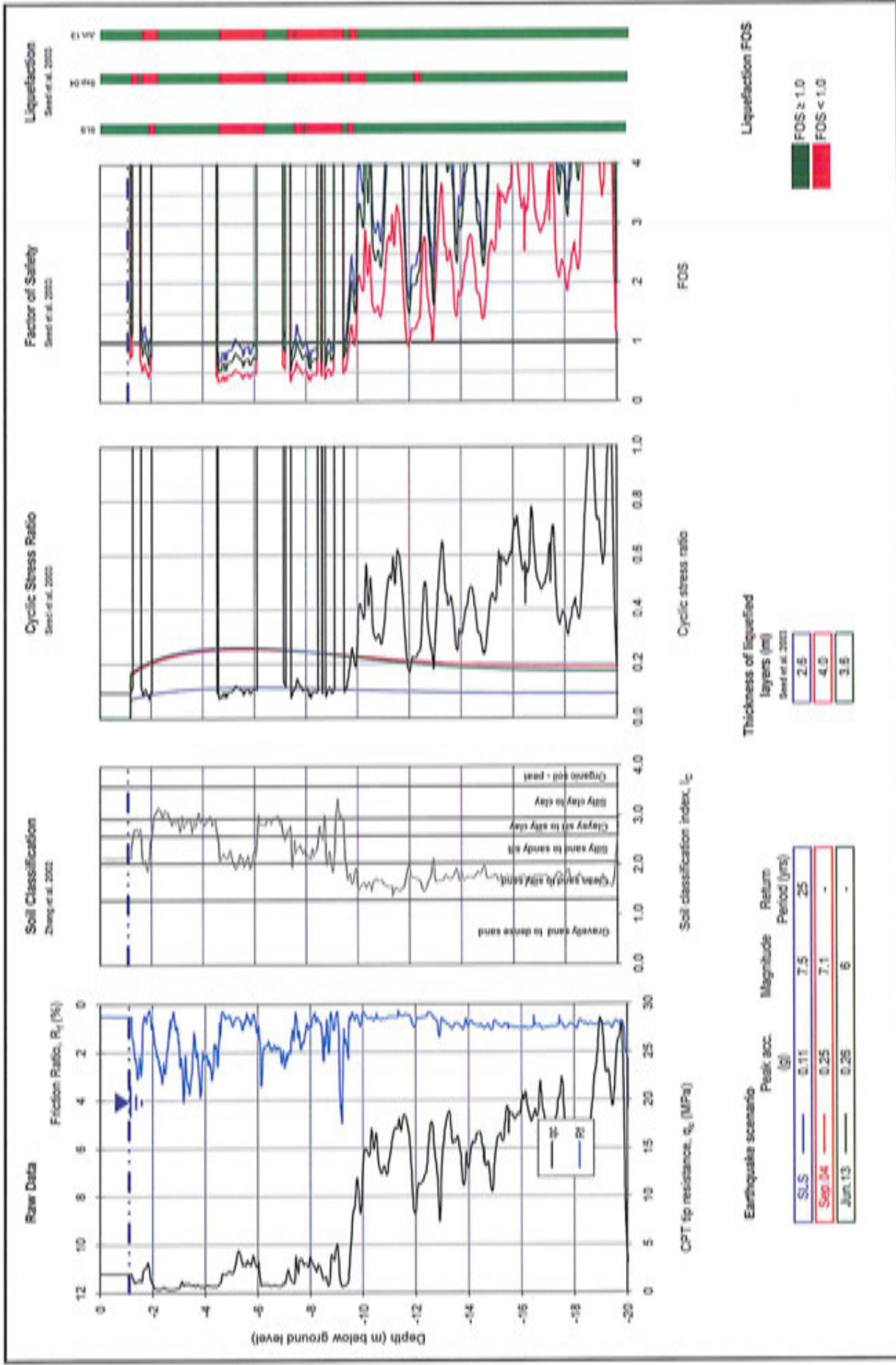
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Liquefaction Assessment from CPT Results

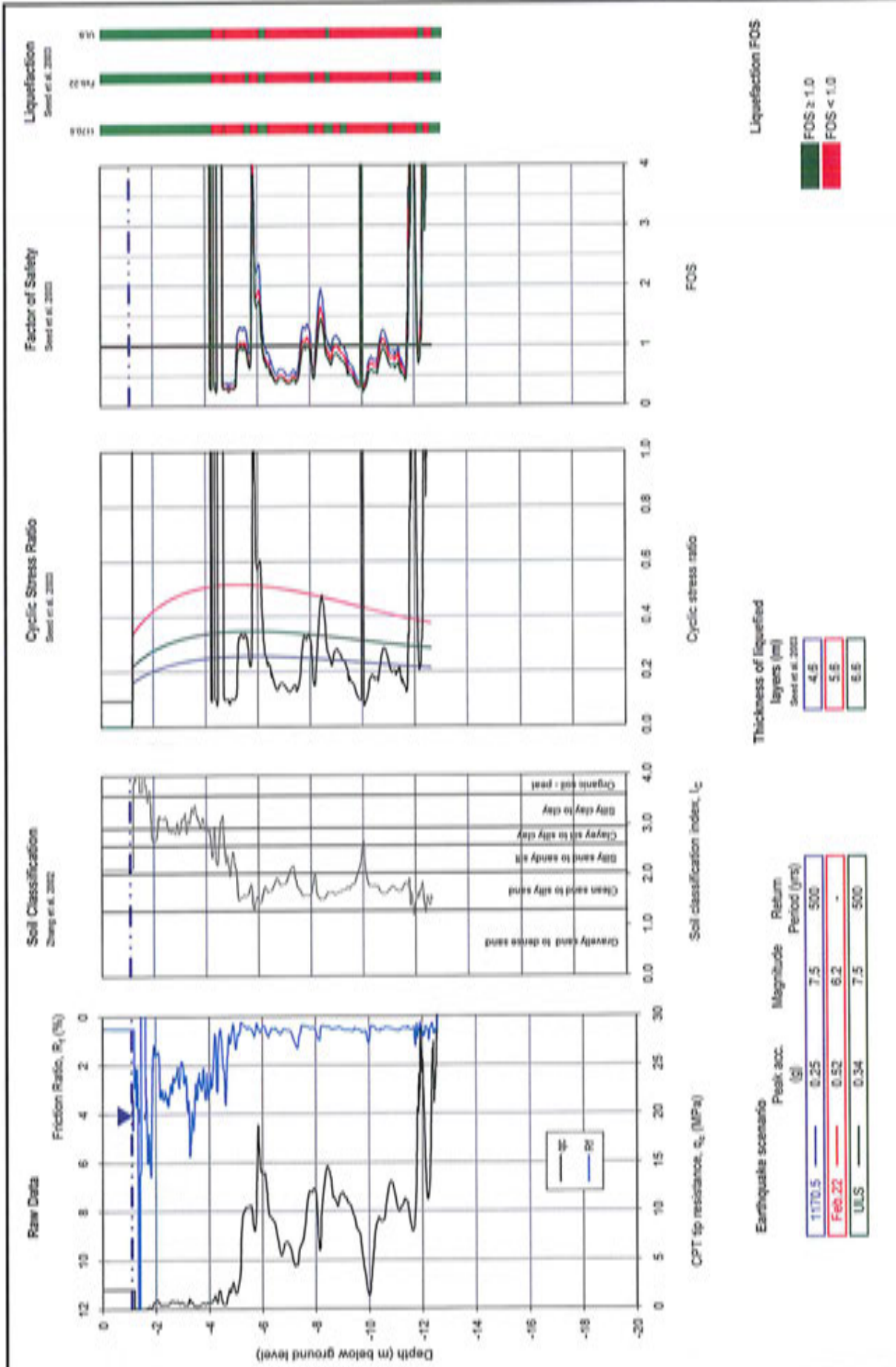
DATE  
6/12/2011

ANALYSED  
RAP

CHECKED  
AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT PROJECT:</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City	<b>LOCATION:</b> CPT-CBD-84	<b>DATE:</b> 7/12/2011 <b>ANALYSED:</b> RAP <b>CHECKED:</b> AFF
	<b>TITLE:</b> Liquefaction Assessment from CPT Results	<b>JOB NUMBER:</b> 52000_301	



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	SUBJECT/PROJECT <b>Christchurch City Council          Geotechnical Assessment for Christchurch Central City</b>	LOCATION <b>CPT-CBD-85</b>	DATE 6/12/2011
	TITLE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 52000_36/1	ANALYSED RAP
			CHECKED AFF

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb. 22	6.2	-
U.S.	7.5	500

Thickness of liquefied layers (m)

4.5
5.5
6.5

FOS

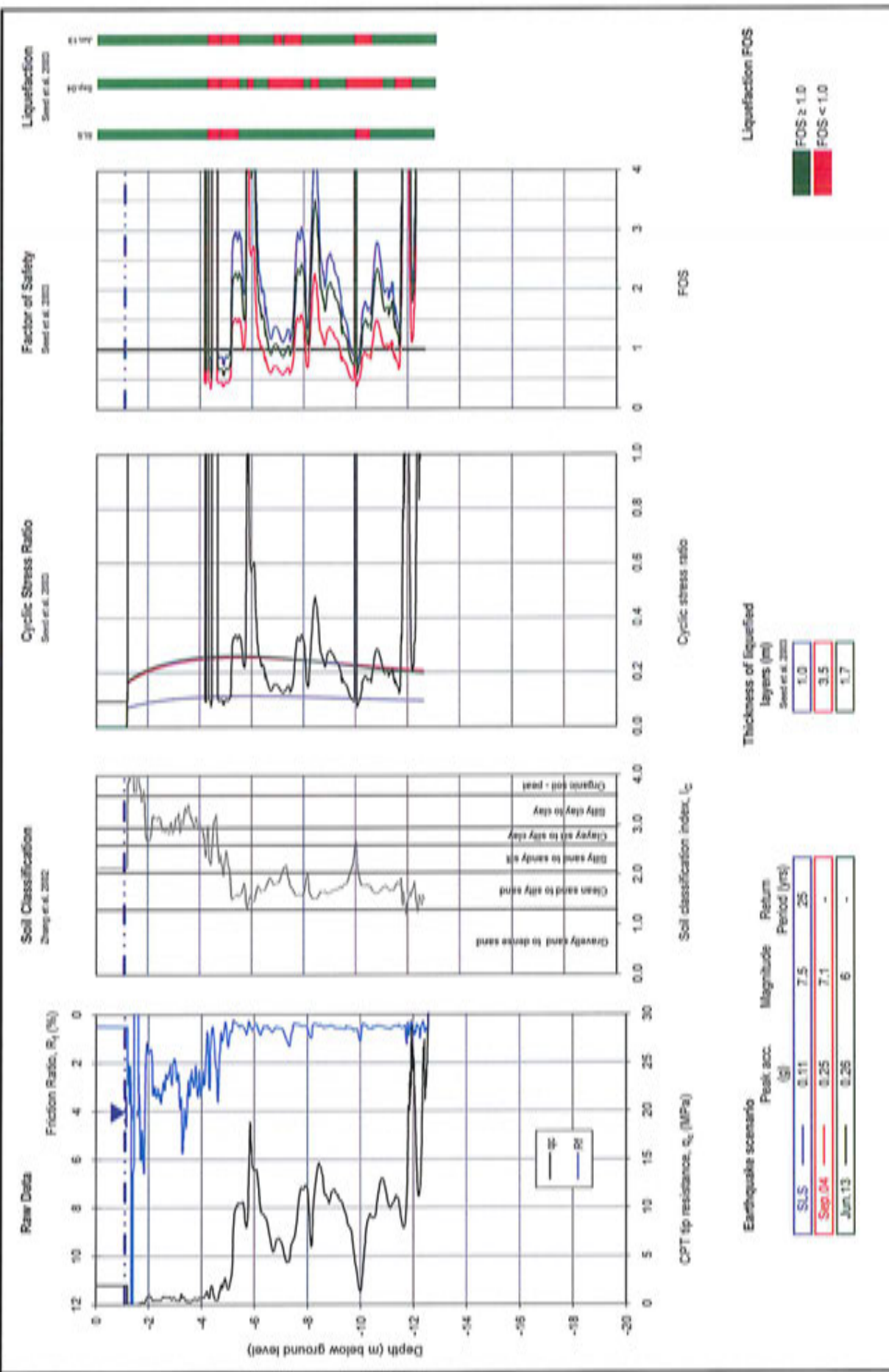
Cyclic stress ratio

Soil classification index,  $I_c$

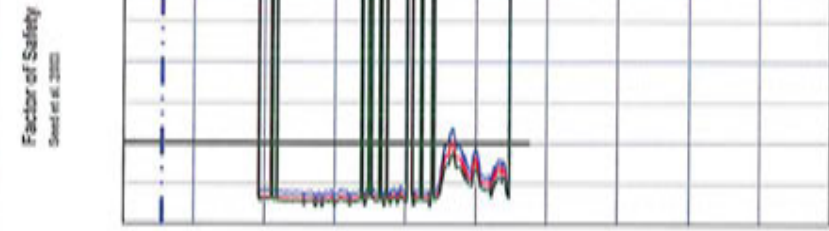
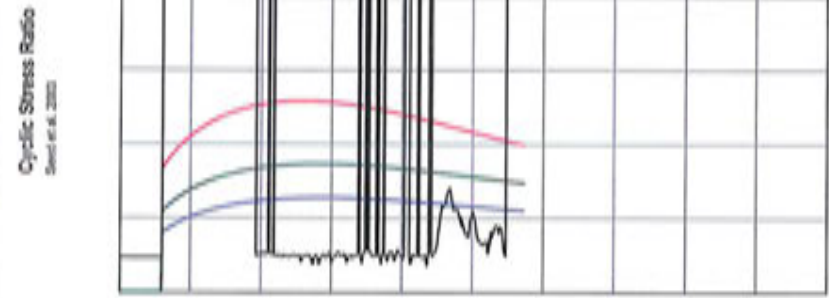
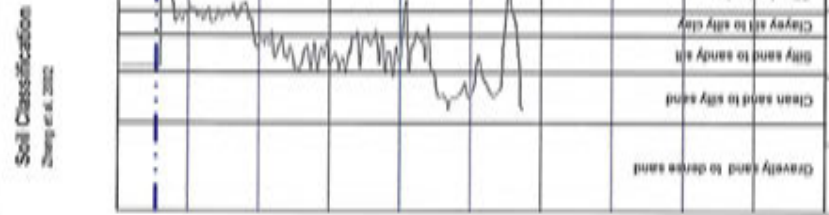
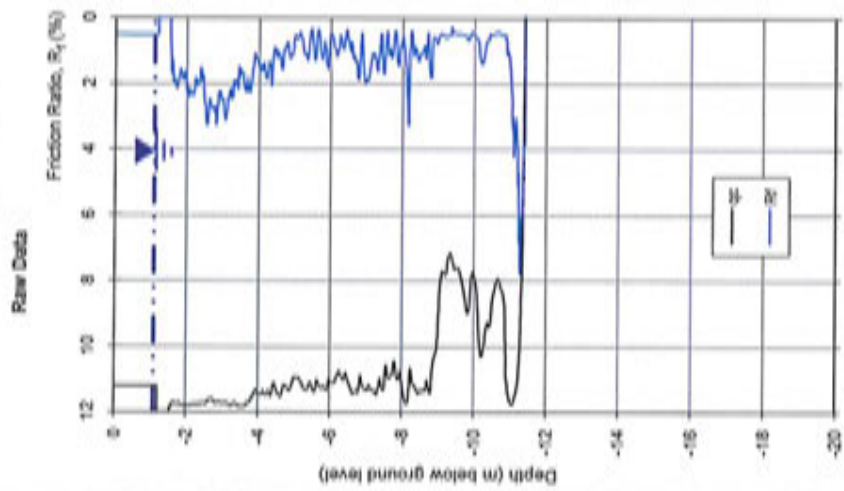
CPT tip resistance,  $q_t$  (MPa)

Liquefaction FOS

FOS  $\geq 1.0$   
FOS  $< 1.0$



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CHRISTCHURCH PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City Liquefaction Assessment from CPT Results	LOCATION <b>CPT-CBD-85</b>	DATE 7/12/2011
		TITLE	ANALYSED RAP
		JOB NUMBER 520000_301	CHECKED AFF



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb 22	0.52	6.2	-
U.L.S.	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
6.5
6.6
6.7

Liquefaction FOS

Liquefaction FOS
FOS > 1.0
FOS < 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-86

LOT NUMBER

52000.351

DATE

6/12/2011

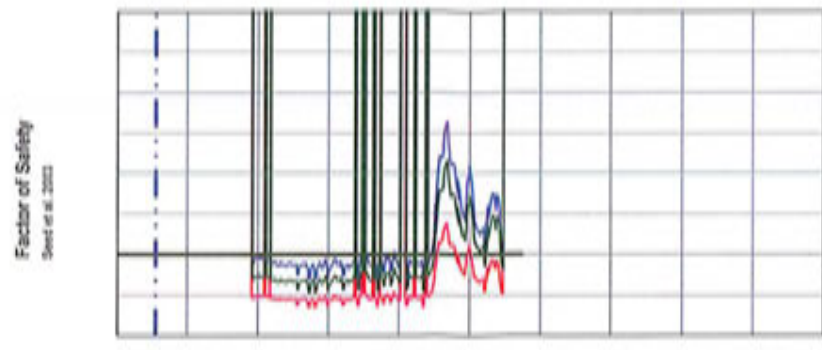
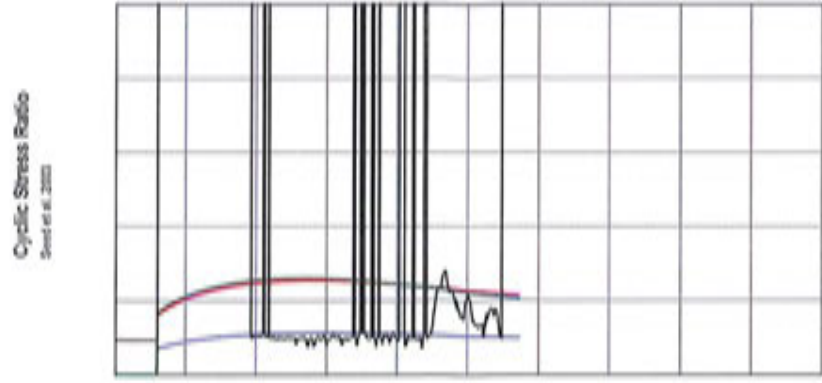
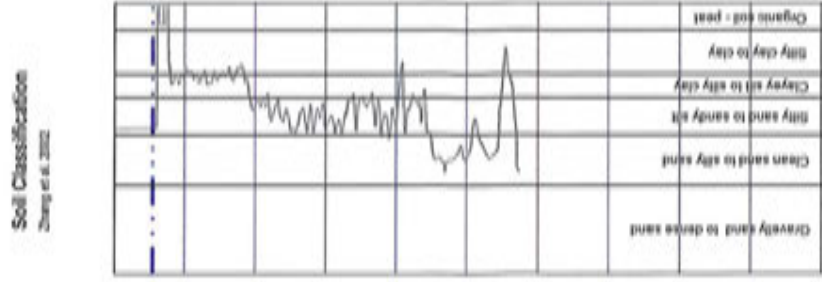
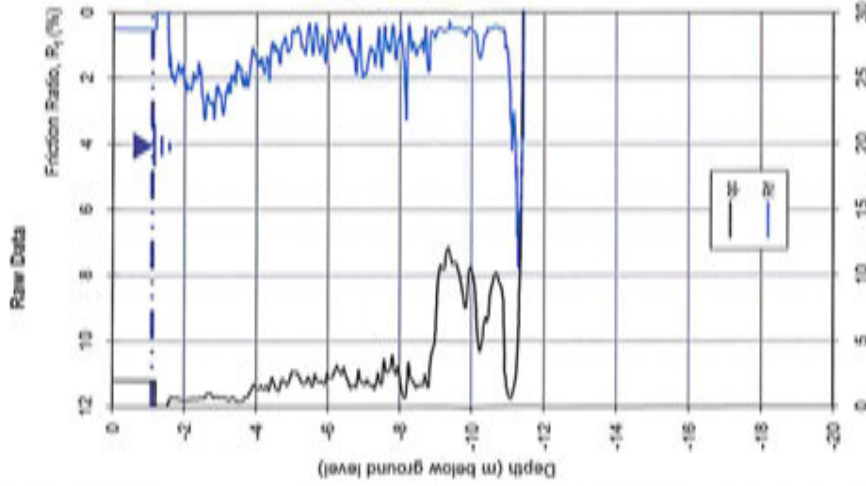
ANALYSED

RAP

CHECKED

AFF

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
0.11	7.5	25
0.25	7.1	-
0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
4.6
6.0
4.8

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-86

FILE

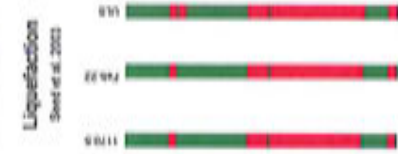
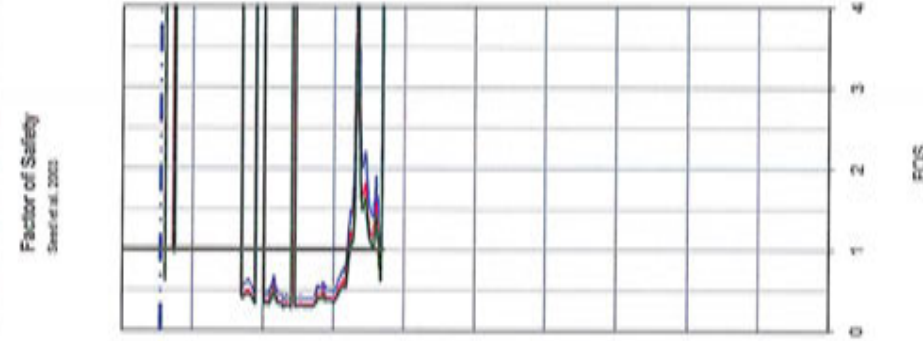
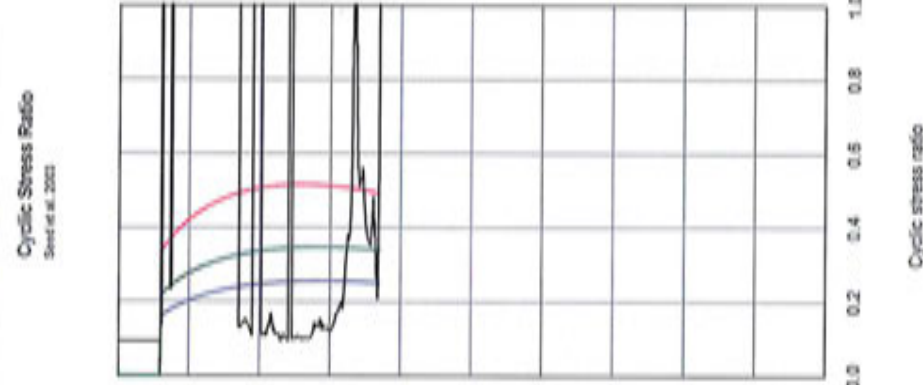
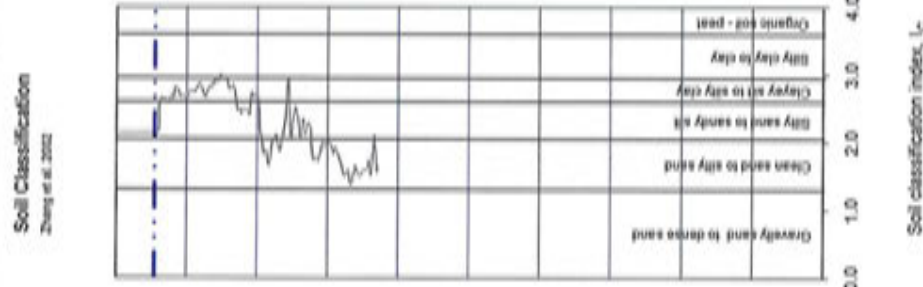
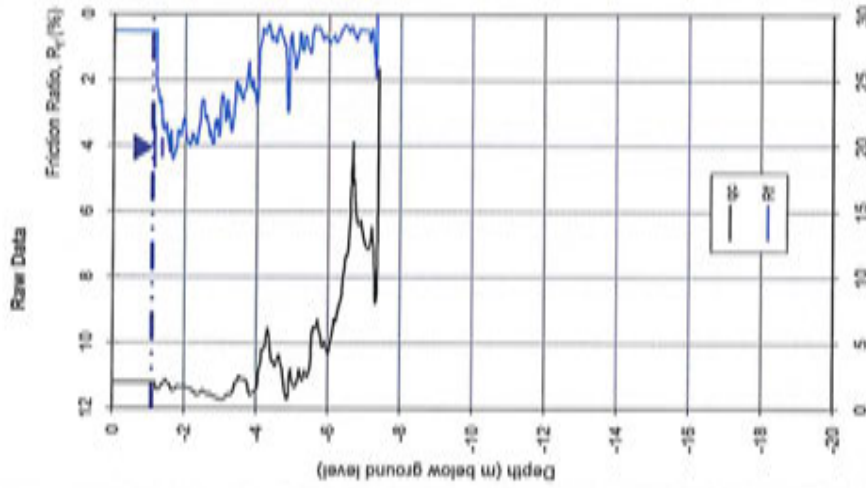
Liquefaction Assessment from CPT Results

LOT NUMBER

52000\_301

DATE  
ANALYSED  
CHECKED  
RAP  
AFF

DATE  
7/12/2011



CPT  $f_p$  resistance,  $q_p$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5
Feb.22	0.52	6.2
ULS	0.34	7.5

Thickness of liquefied layers (m)

2.7
2.8
2.9



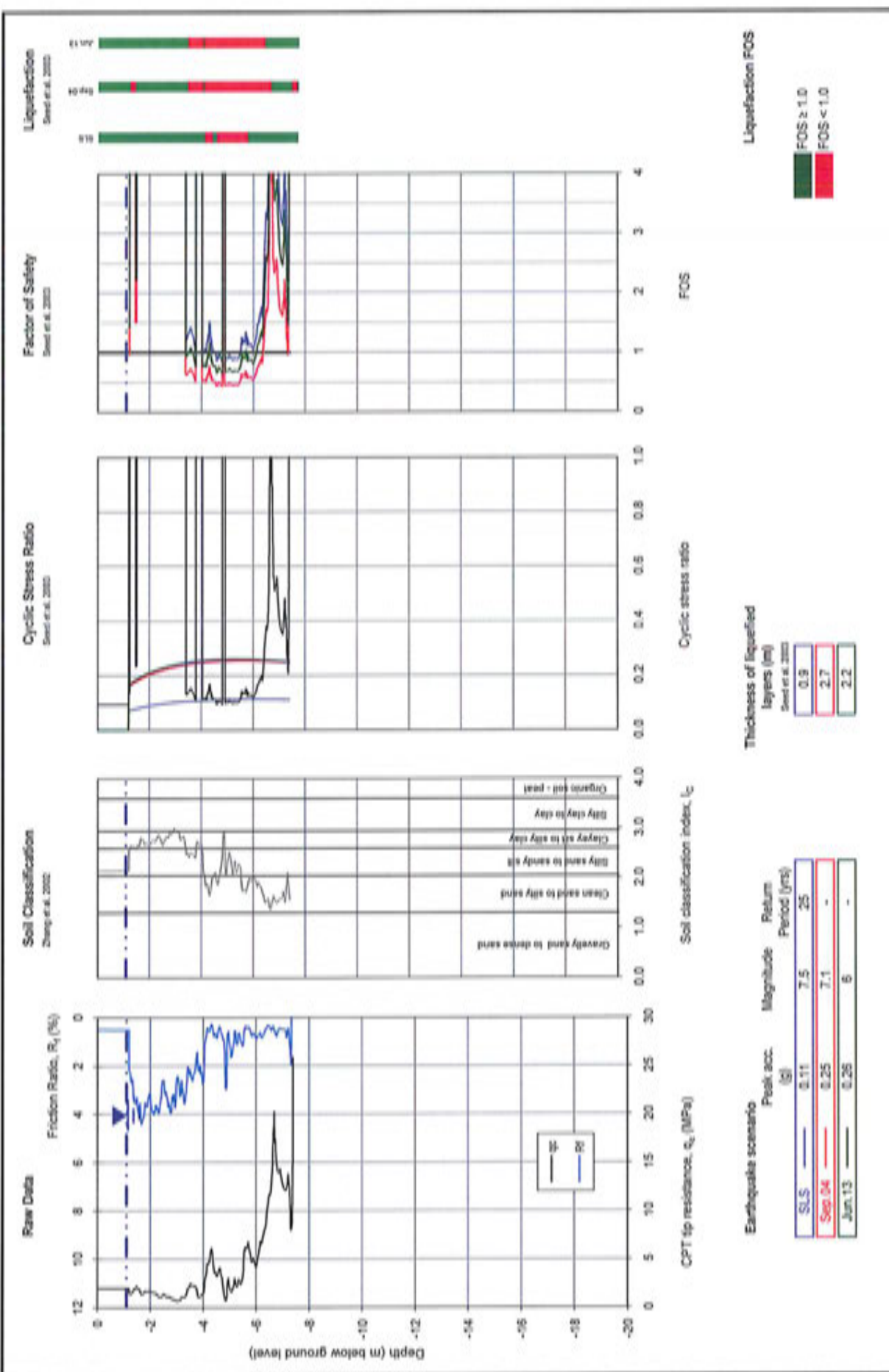
Tonkin & Taylor Ltd  
Environmental & Engineering Consultants

CLIENT PROJECT  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

SECTION  
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JOB NUMBER  
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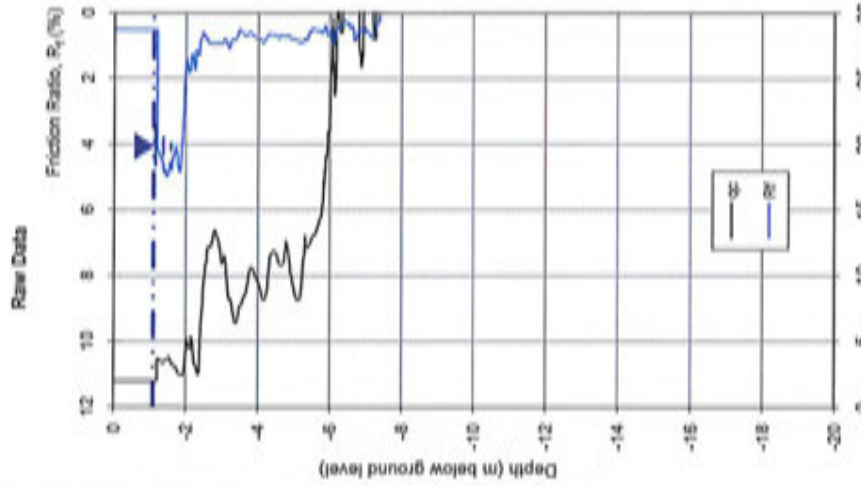
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6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results

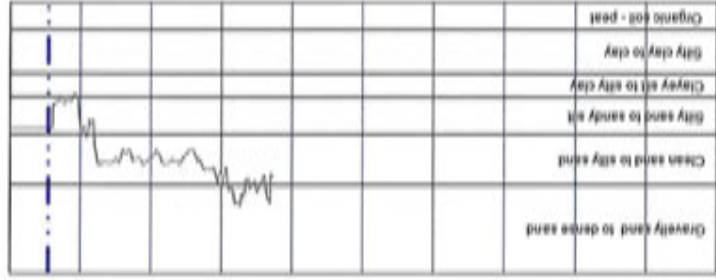


 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE: 7/12/2011 ANALYSED: R4P CHECKED: AFF
	SUBJECT PROJECT: <b>CPT-CBD-87</b>	LOCATION: S2000_301	TITLE: Liquefaction Assessment from CPT Results

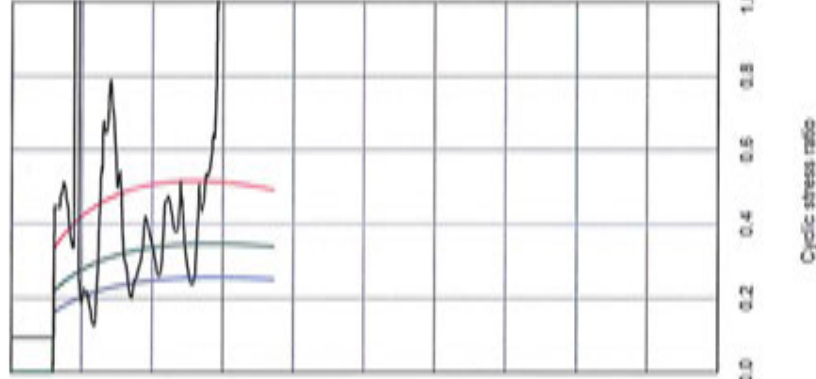




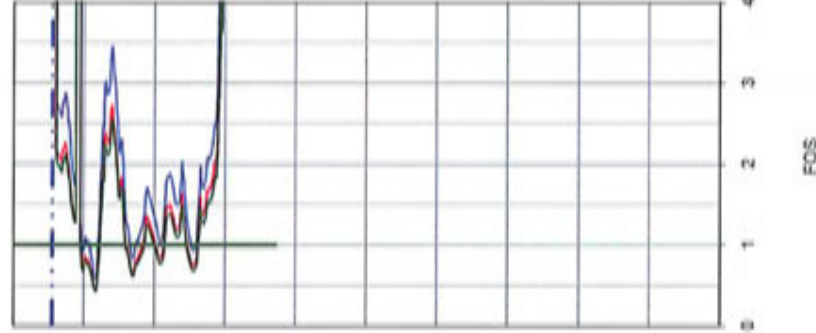
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
<b>F60.22</b>	<b>0.52</b>	<b>6.2</b>	-
ULLS	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.8
1.5
1.7

Liquefaction FOS



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-88

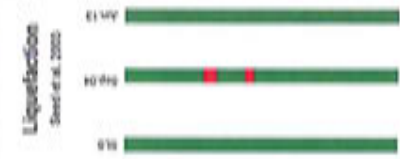
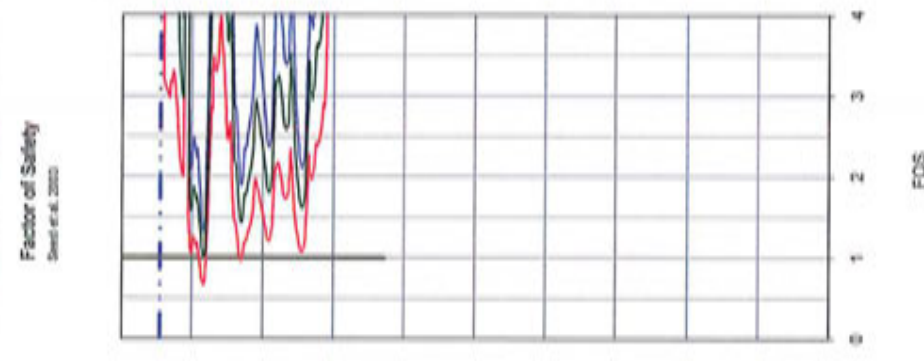
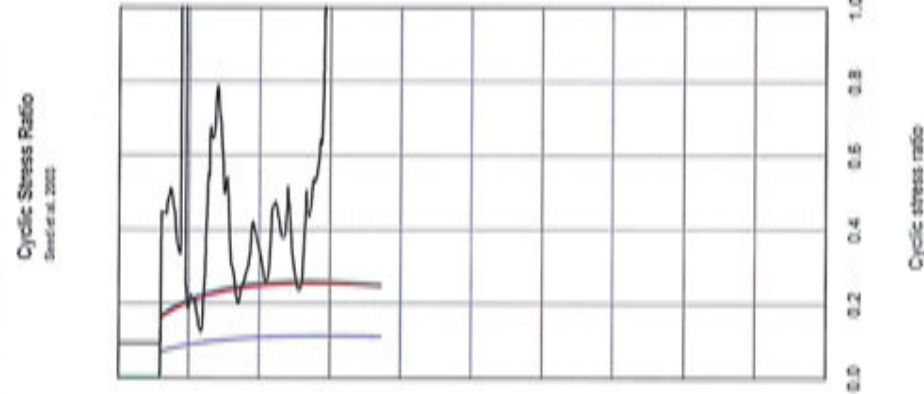
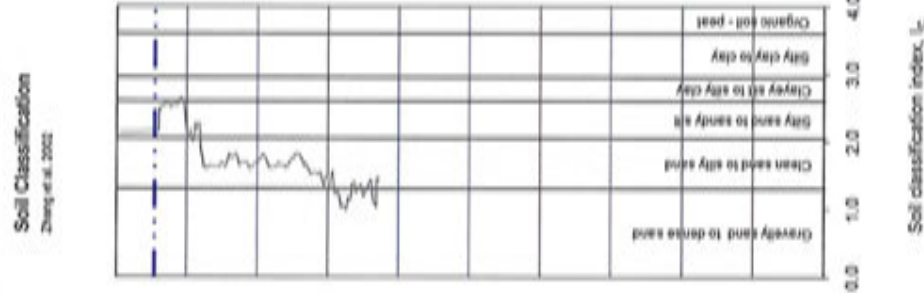
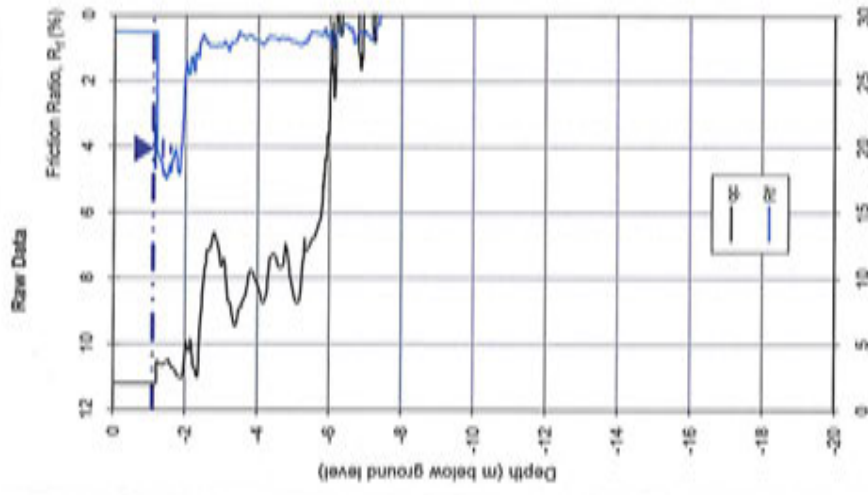
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Liquefaction Assessment from CPT Results

JOB NUMBER

52000\_301

DATE 5/12/2011  
ANALYSED RAP  
CHECKED AFF



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. ( $g$ )	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.04	0.25	7.1	-
Jun.13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.0
0.3
0.0

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

WORK

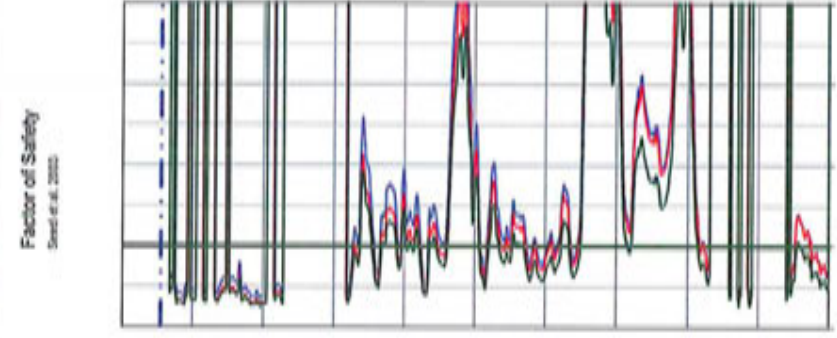
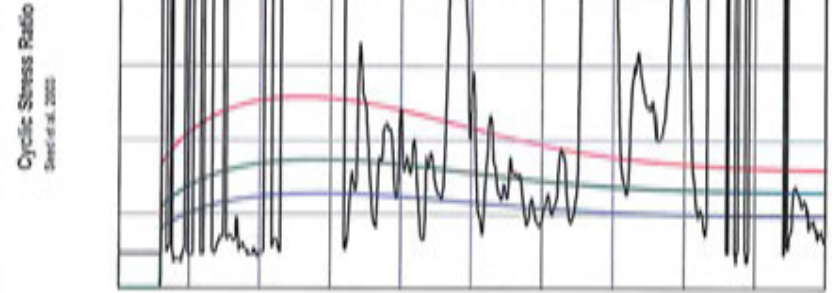
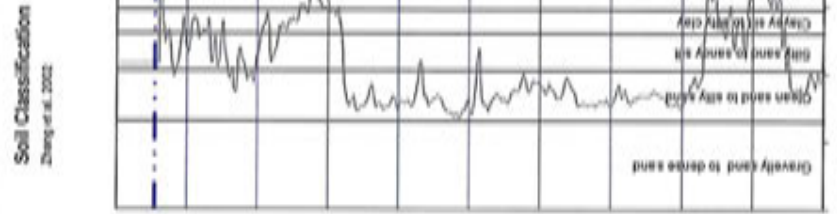
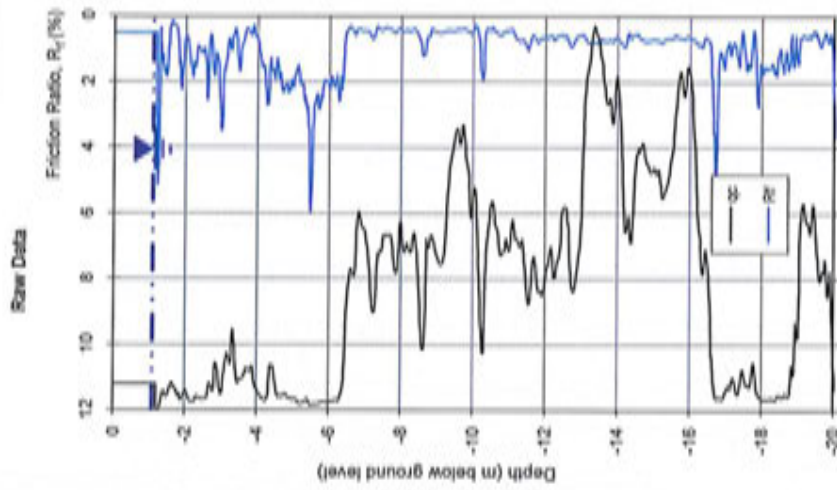
**CPT-CBD-88**

JOB NUMBER

52000.301

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5
Feb.22	0.52	6.2
ULS	0.34	7.5

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
5.1
6.2
7.7

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0

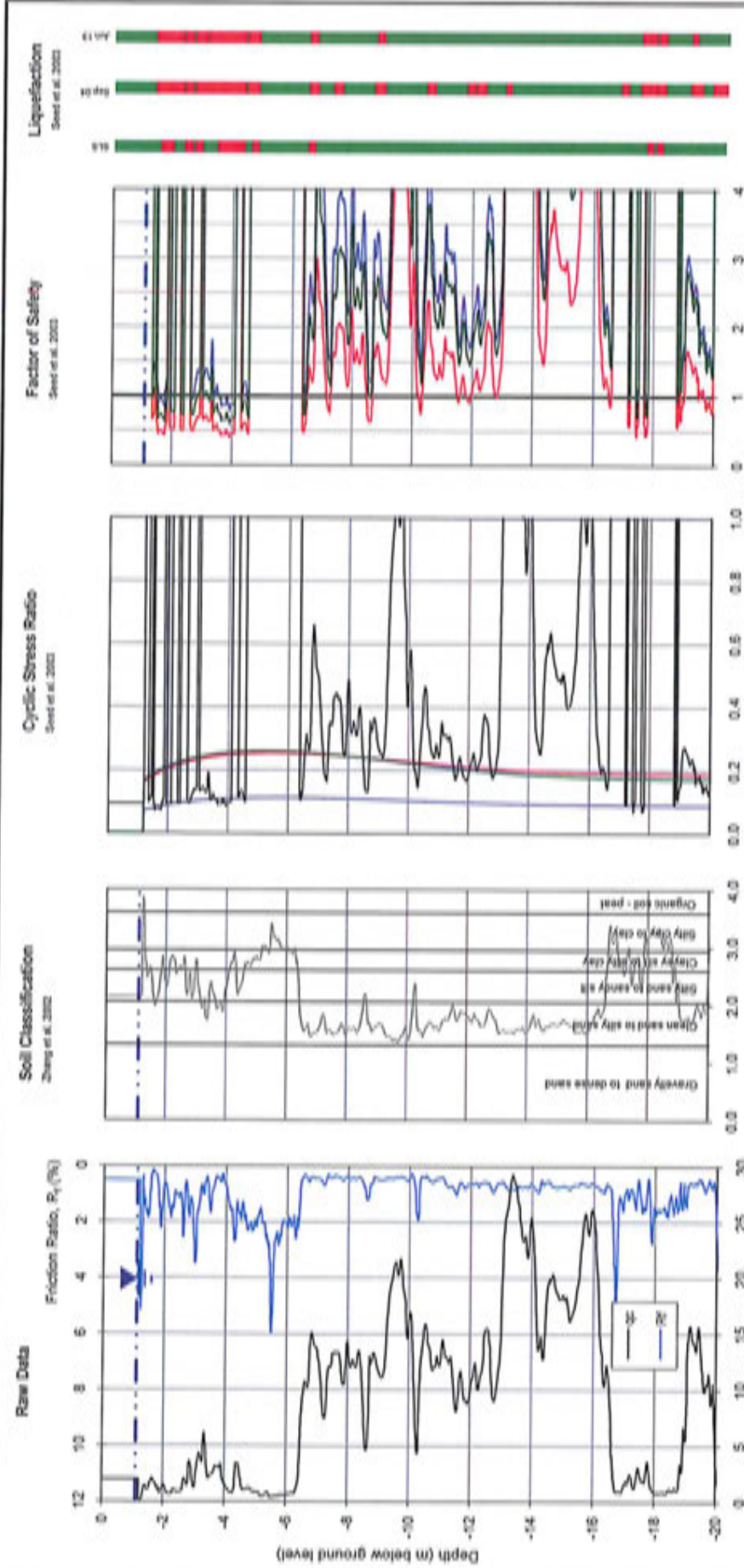


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CLIENT PROJECT  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

LOCATION  
CPT-CBD-89  
JOB NUMBER  
S2000.301

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF



**Earthquake scenario**


Peak acc. (g)	Magnitude	Return Period (yrs)
0.11	7.5	25
0.25	7.1	-
0.26	6	-

**Thickness of liquefied layers (m)**

1.2
4.1
2.4

**Liquefaction FOS**

- FOS  $\geq 1.0$  (Green)
- FOS  $< 1.0$  (Red)



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**CLIENT/PROJECT**  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

**LOCATION**  
CPT-CBD-89

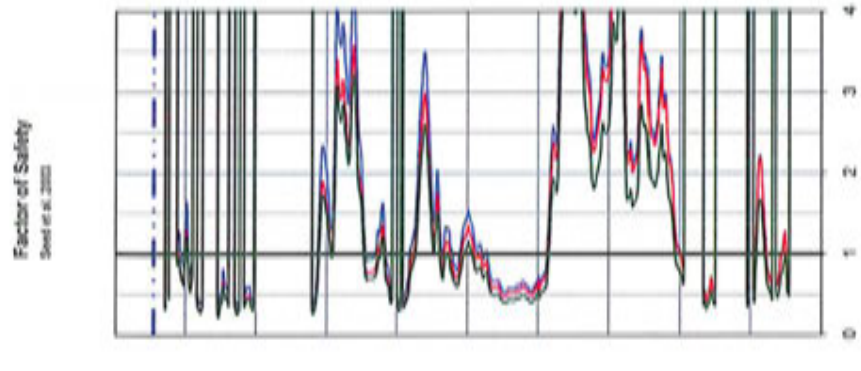
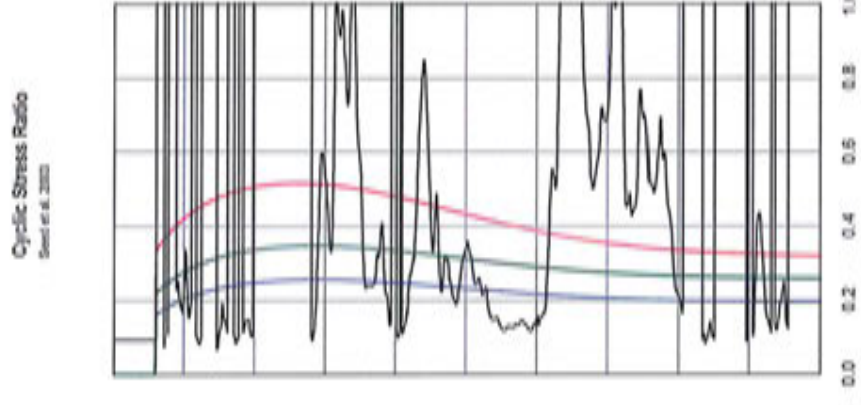
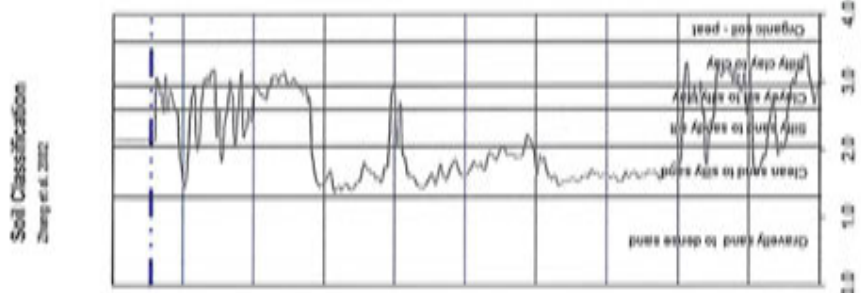
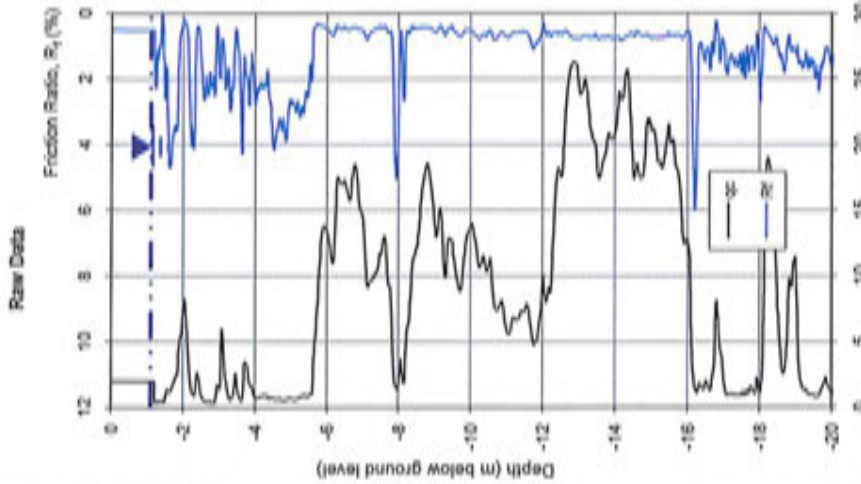
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7/12/2011

**CHECKED**  
RAP

**JOB NUMBER**  
52000.301

**AFF**  
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**Liquefaction Assessment from CPT Results**



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
11/70.5	0.25	7.5	500
Feb 22	0.52	6.2	-
U.L.S.	0.34	7.5	500

Thickness of liquefied layers (m)

5.1
5.9
5.9

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



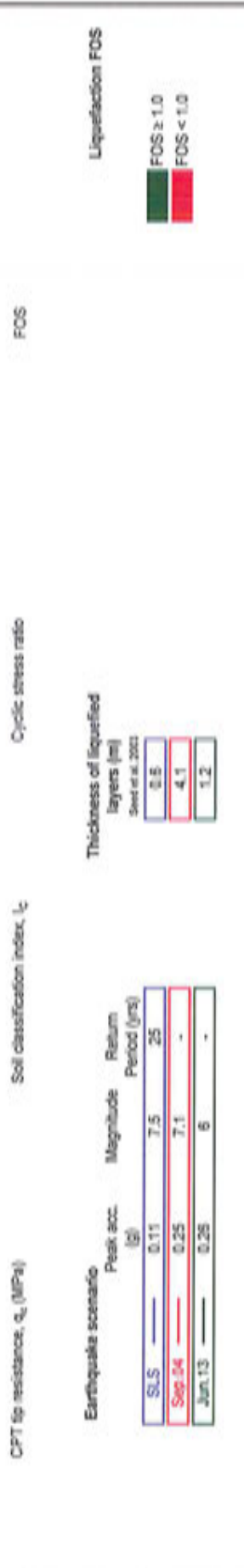
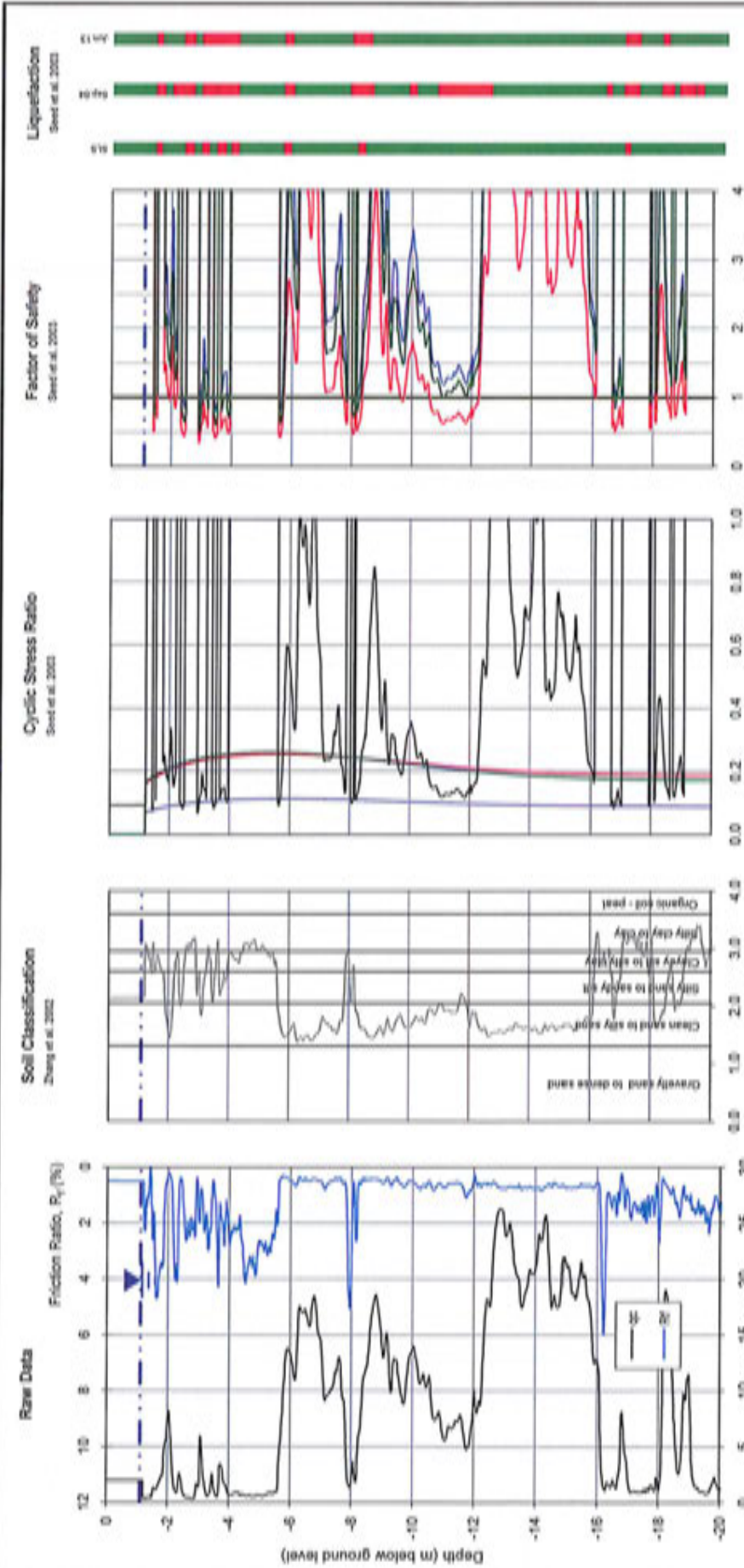
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Environmental & Engineering Consultants

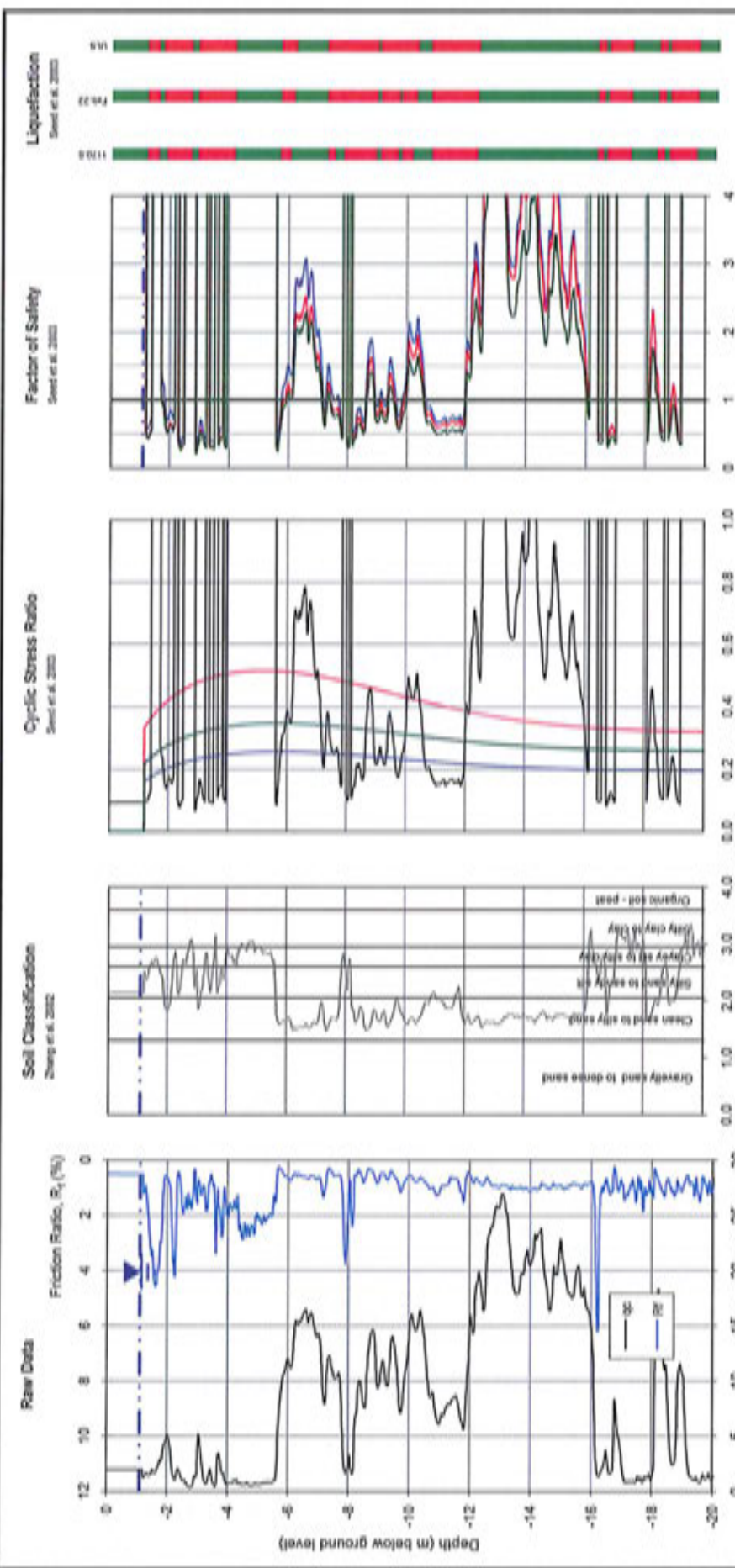
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-80  
JOB NUMBER  
52006.301

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results





**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

**Thickness of liquefied layers (m)**

5.3
6.3
6.8

**Liquefaction FOS**

FOS > 1.0
FOS < 1.0



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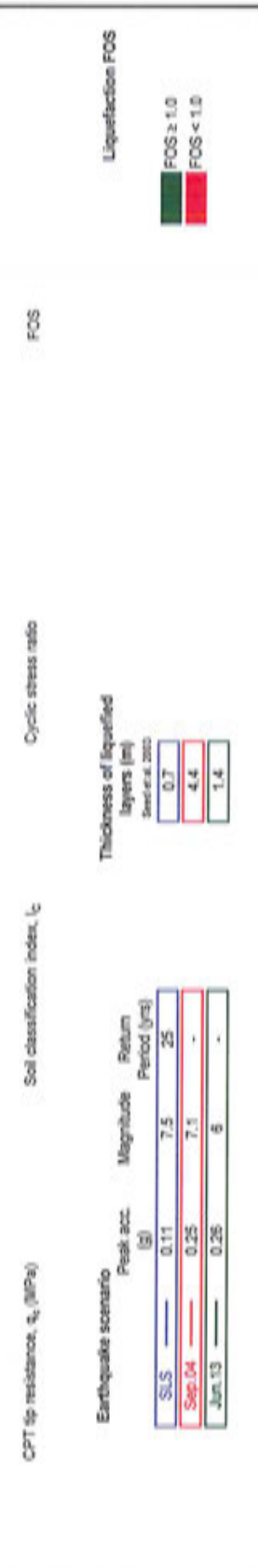
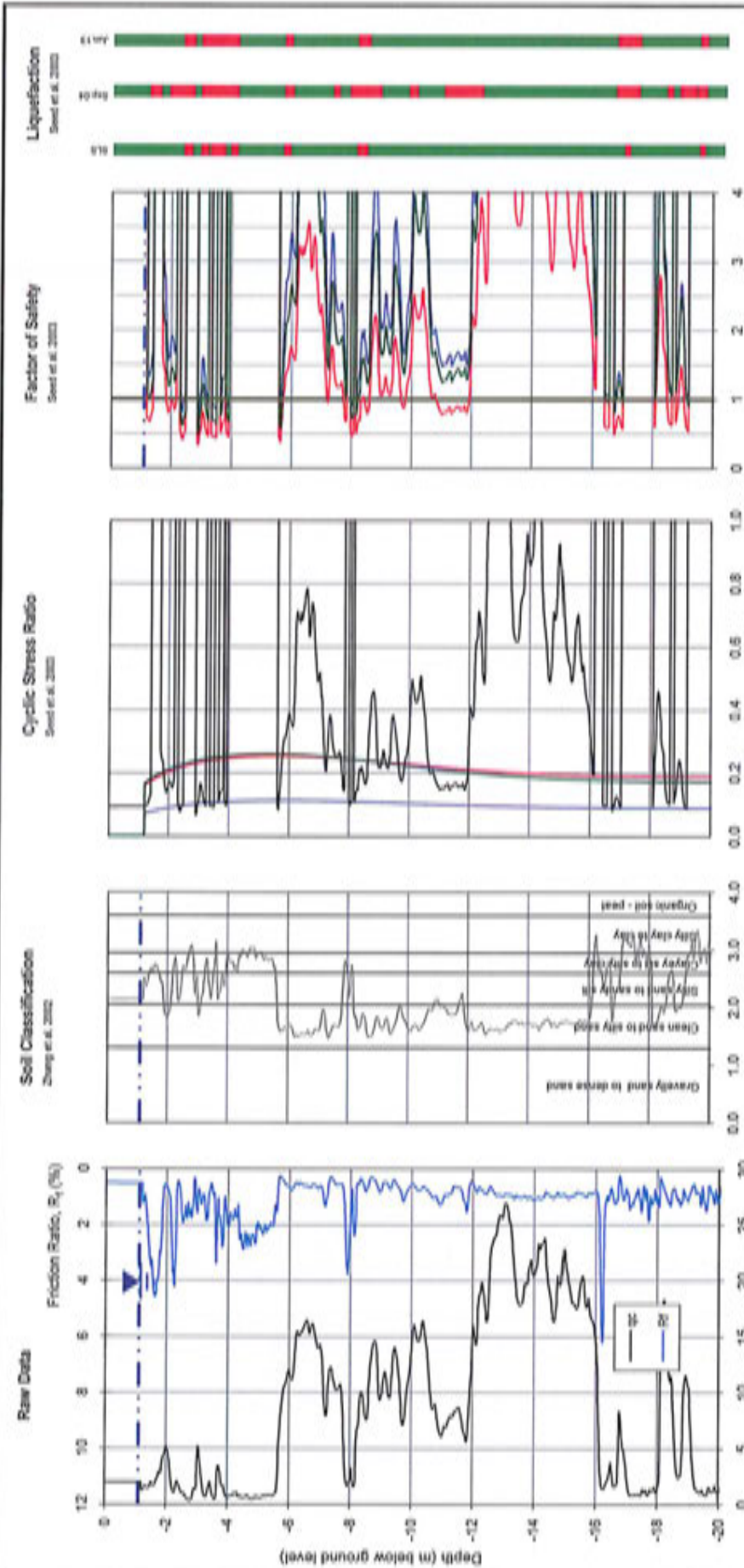
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City


**CLIENT PROJECT**  
CPT-CBD-90a

**FILE**  
JOB NUMBER: S2000\_301

**DATE** 6/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
**AFF**

**Liquefaction Assessment from CPT Results**





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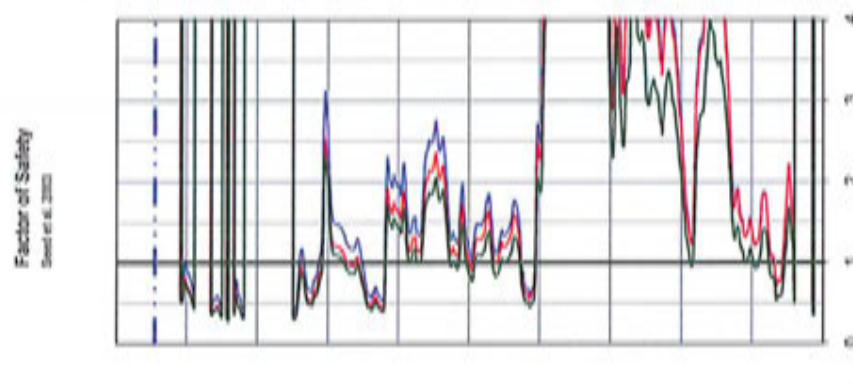
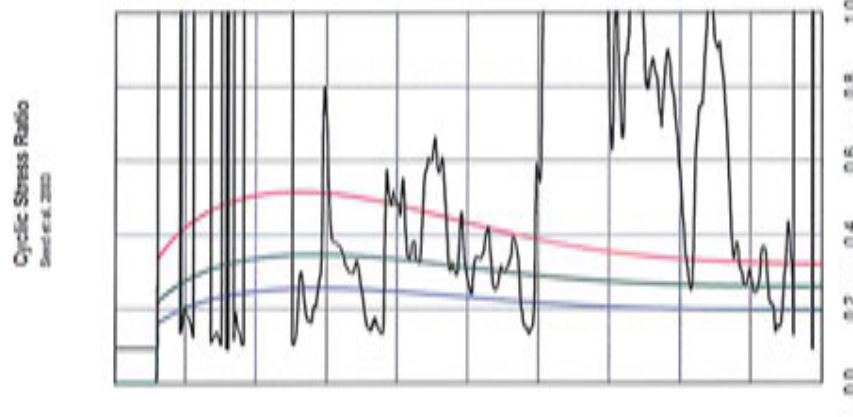
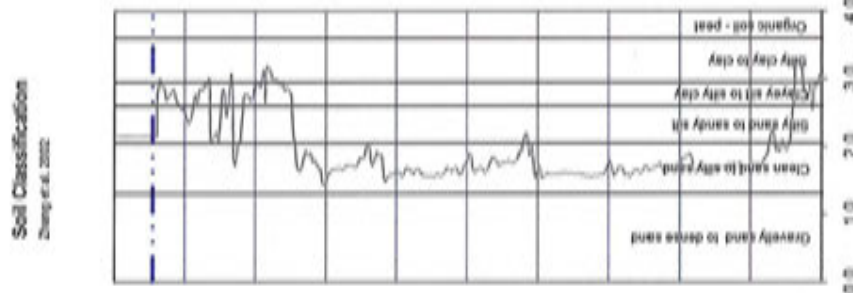
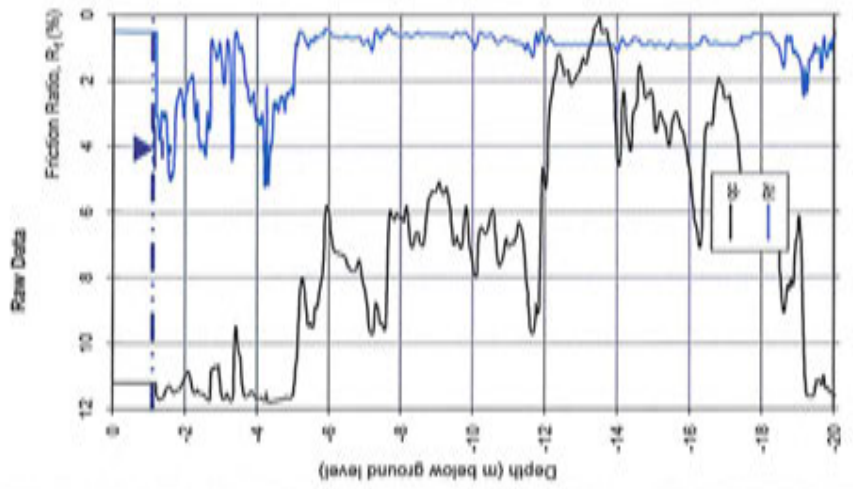
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

PROJECT NUMBER: **CPT-CBD-90a**  
JOB NUMBER: 52000.301

LIQUEFACTION ASSESSMENT FROM CPT RESULTS

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
AFF





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

3.0
3.7
5.1

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-91

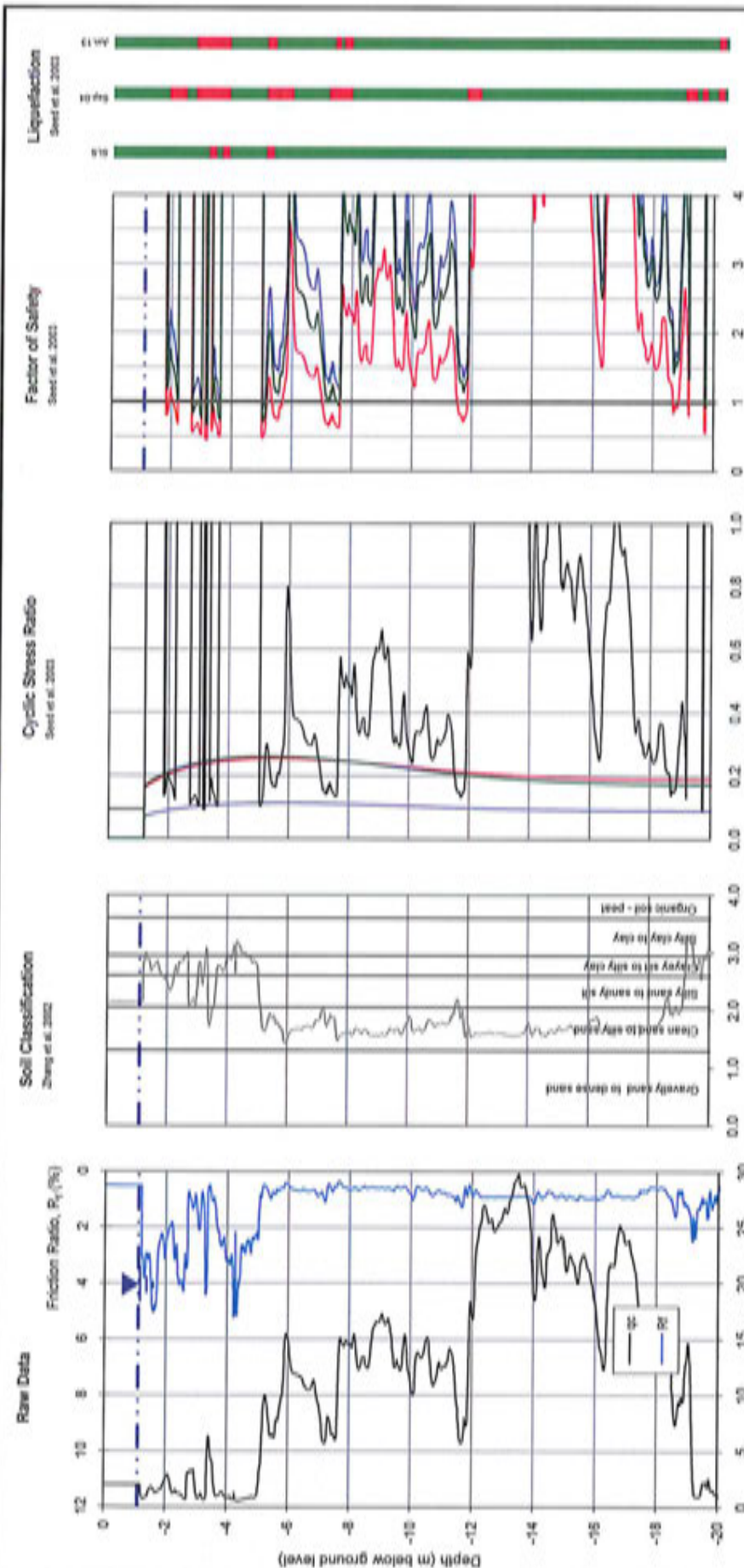
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Liquefaction Assessment from CPT Results

JOB NUMBER

52008.301

DATE 6/12/2011  
ANALYSED RAP  
CHECKED AFF



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Liquefaction FOS

Thickness of liquefied layers (m)

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sept 04	0.25	7.1	-
Jun 13	0.25	6	-

FOS  $\geq 1.0$  (Green)  
 FOS  $< 1.0$  (Red)



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Geotechnical Assessment for Christchurch Central City

Liquefaction Assessment from CPT Results

CLIENT PROJECT: **CPT-CBD-91**

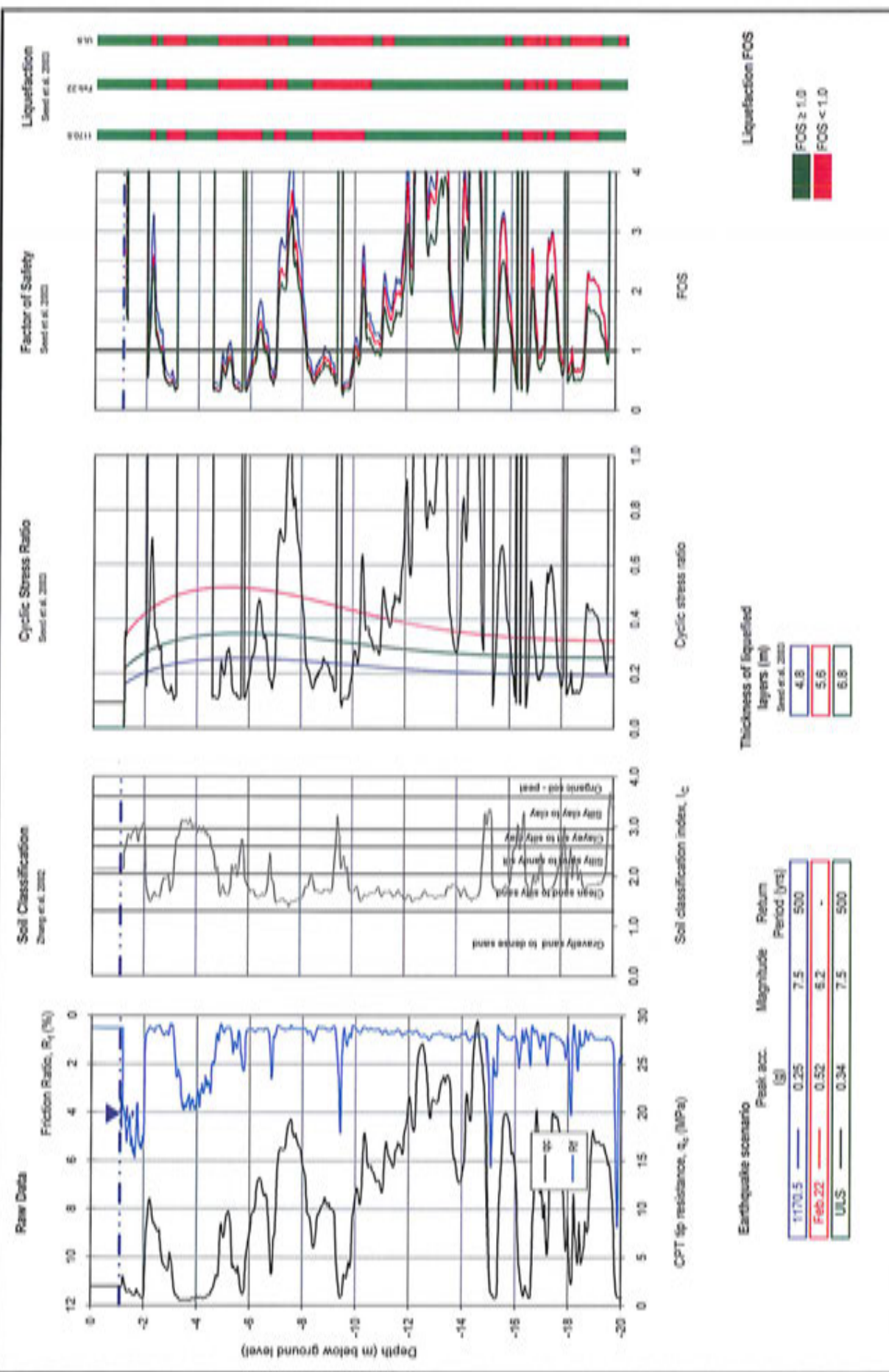
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FILE: **52000\_301**

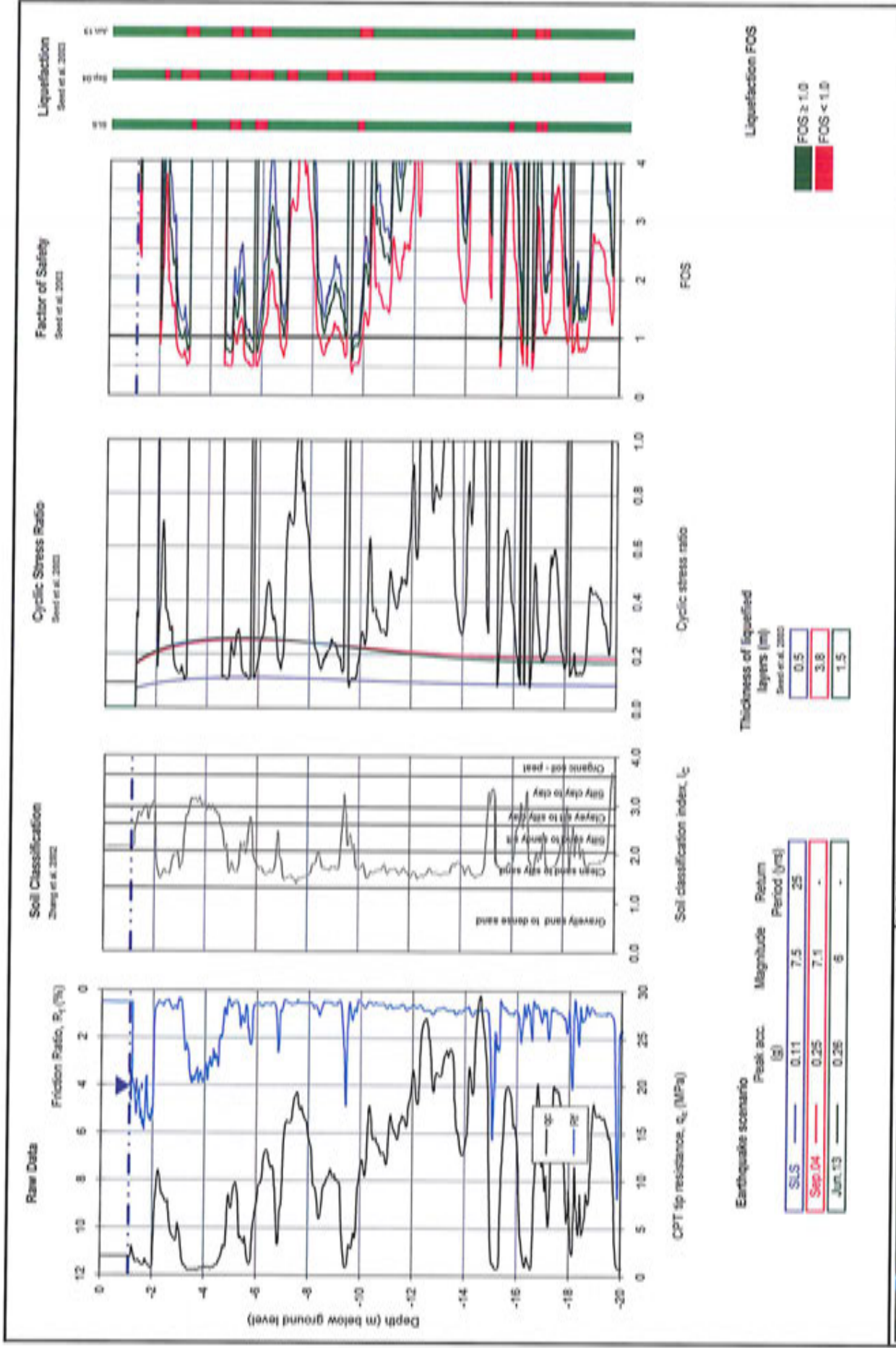
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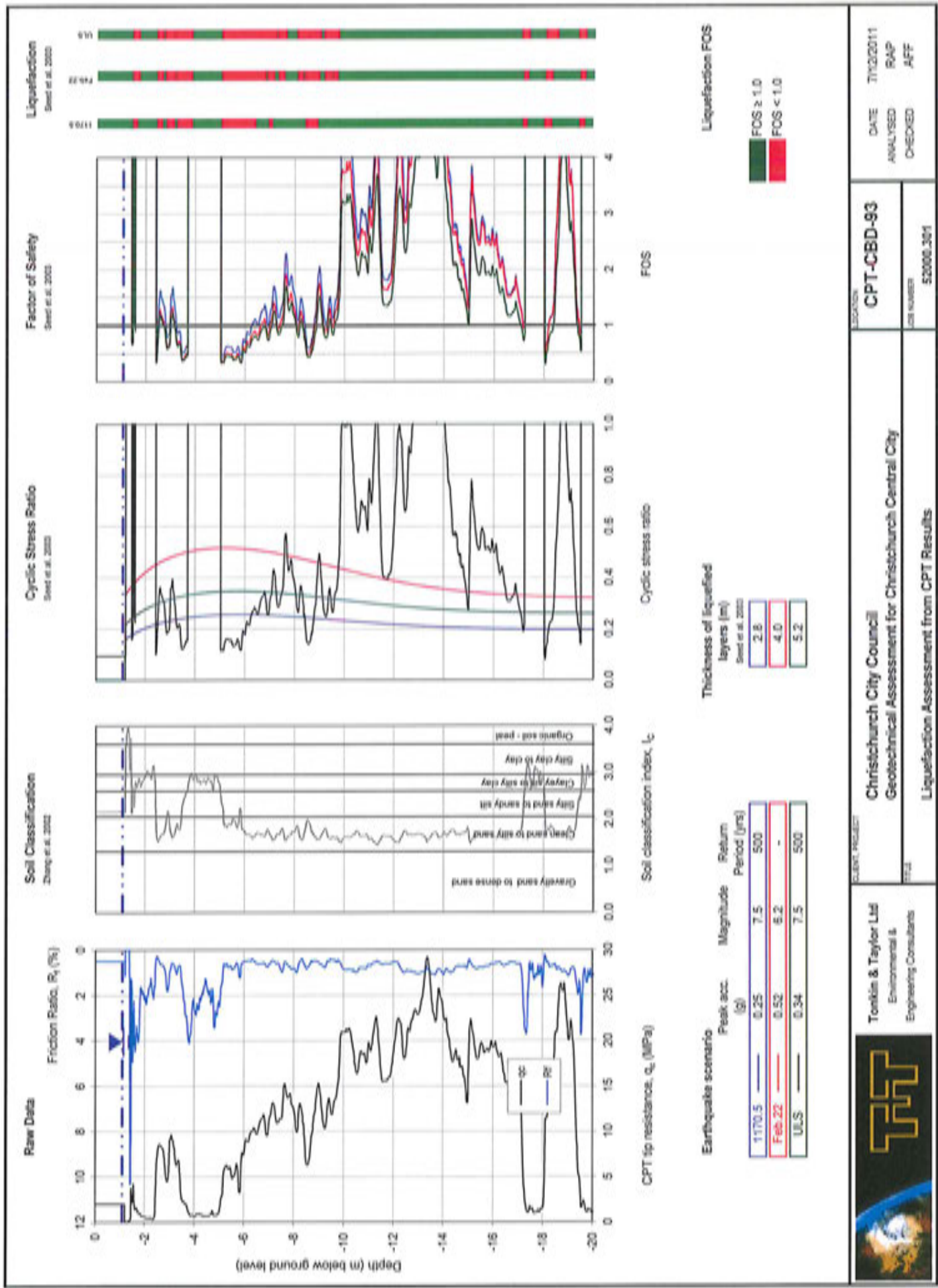
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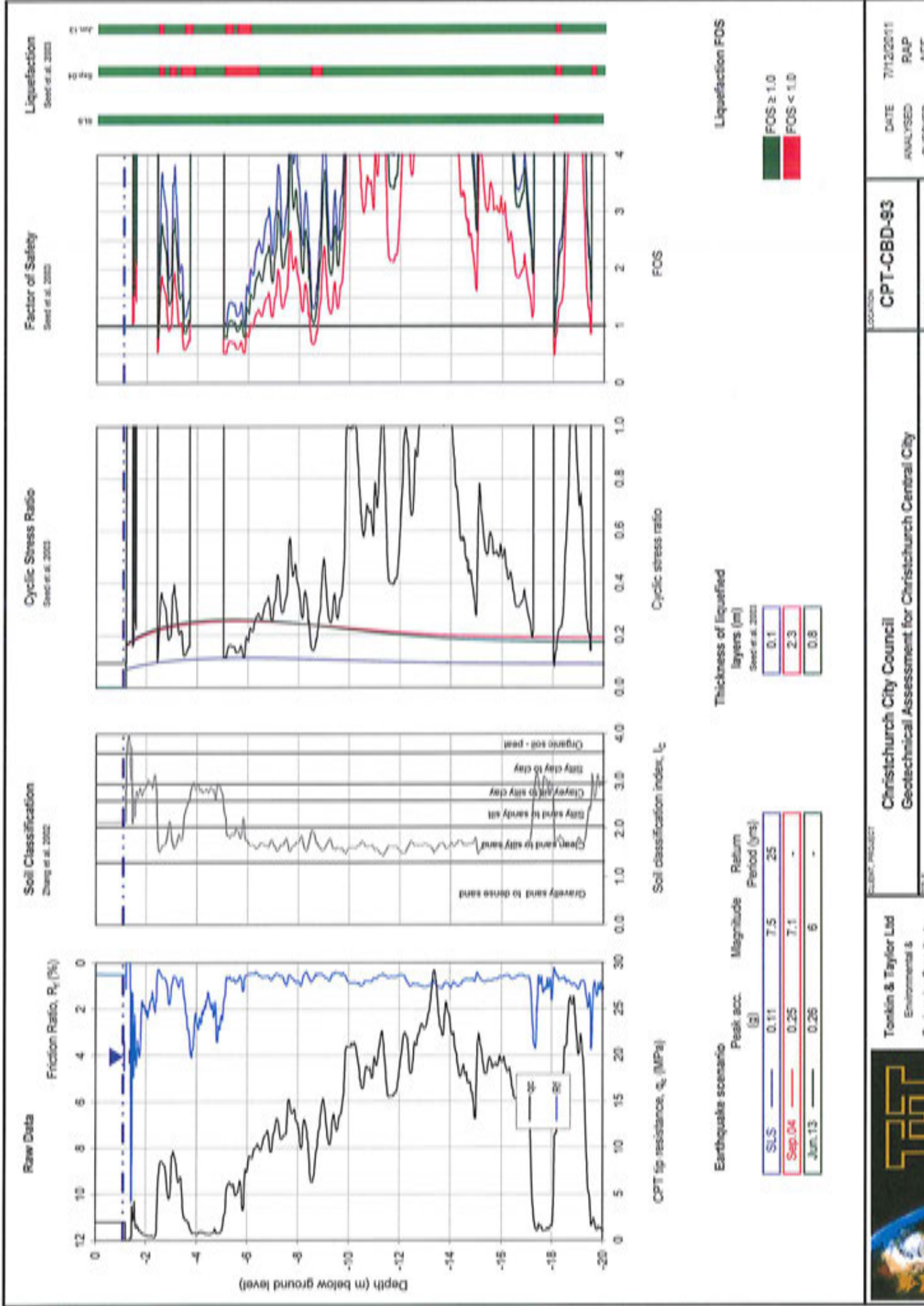
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	PROJECT PROJECT Liquefaction Assessment from CPT Results		JOB NUMBER 52000.101	ANALYSED RAP
				CHECKED AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> <b>Geotechnical Assessment for Christchurch Central City</b>	SECTION <b>CPT-CBD-92</b>	DATE 11/12/2011
	TITLE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER S2008.301	ANALYSED RAP
			CHECKED AFF



 <b>Tomlin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT	Christchurch City Council Geotechnical Assessment for Christchurch Central City	DATE	JT12/2011
	REPORT		ANALYSED	RAP
			CHECKED	AFF
			JOB NUMBER	52000.301
			ISSUES	CPT-CBD-93
				Liquefaction Assessment from CPT Results



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 Geotechnical Assessment for Christchurch Central City

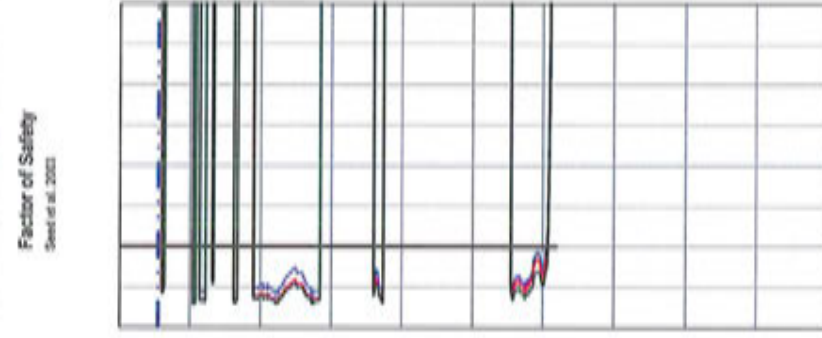
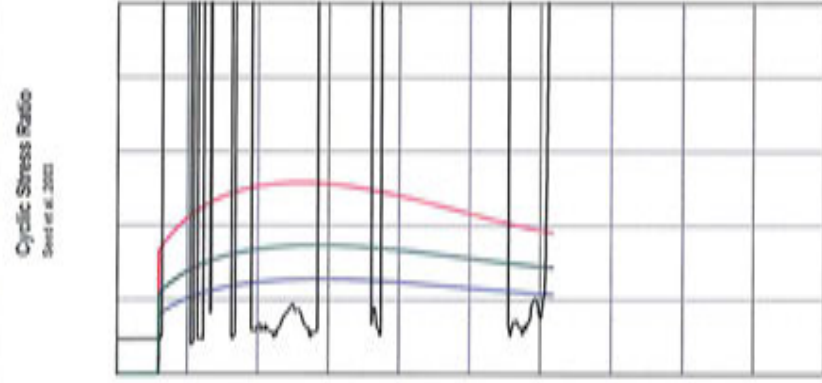
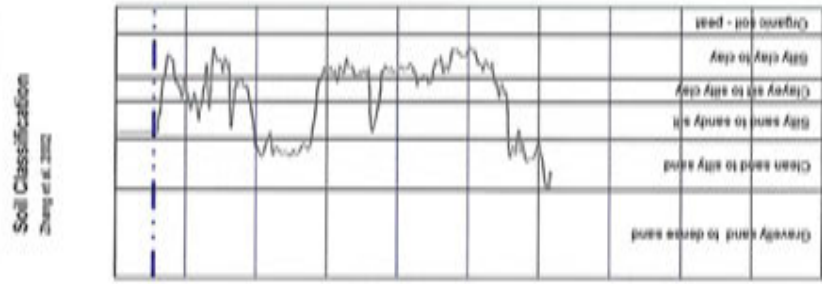
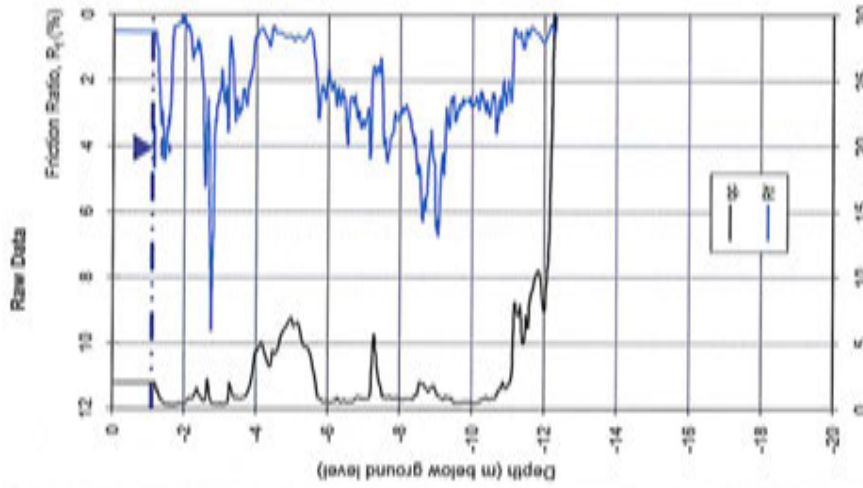
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**CPT-CBD-93**

**DATE** 7/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

**JOB NUMBER** 530000.301

**FILE**

**Liquefaction Assessment from: CPT Results**



CPT tip resistance,  $q_p$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5
Feb.22	0.52	6.2
ULS	0.34	7.5

Thickness of liquefied layers (m)

3.7
3.7
3.7

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0

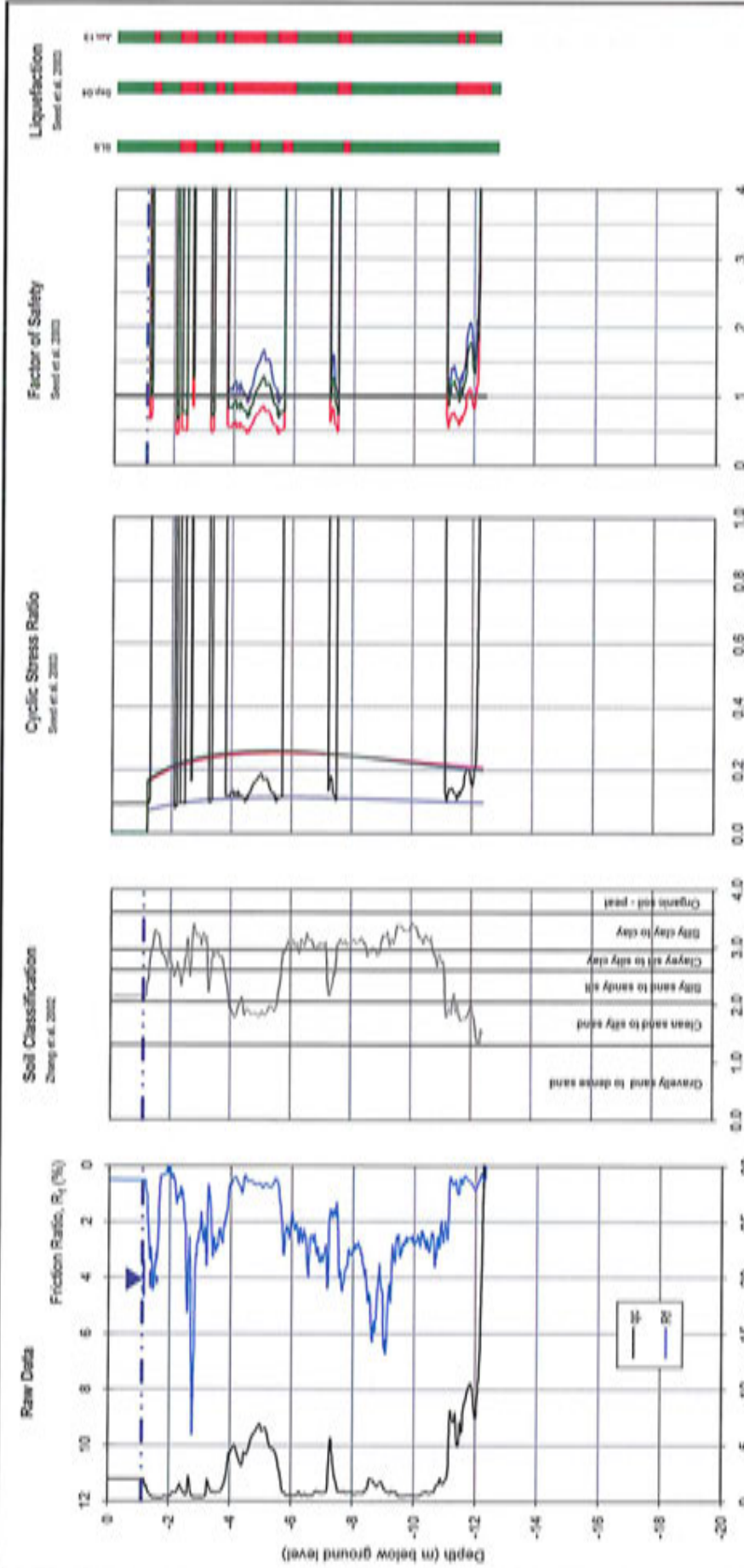


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Environmental & Engineering Consultants

CLIENT PROJECT	DATE	ANALYSED	CHECKED
Christchurch City Council Geotechnical Assessment for Christchurch Central City	6/12/2011	RAP	AFF
PROJECT NUMBER	52000.301		

CPT-CBD-94

Liquefaction Assessment from CPT Results



Soil classification index, $I_c$	Soil description
0.0 - 1.0	Gravelly sand to dense sand
1.0 - 2.0	Clean sand to silty sand
2.0 - 3.0	Clayey sand to silty clay
3.0 - 4.0	Silty clay to clay
4.0 - 5.0	Organic silty clay to peat

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sev. 04	0.25	7.1	-
Jun. 13	0.25	6	-

Thickness of liquefied layers (m)	Soil description
0.5	Gravelly sand to dense sand
3.5	Clean sand to silty sand
1.9	Clayey sand to silty clay

Liquefaction FOS	Color
FOS $\geq$ 1.0	Green
FOS $<$ 1.0	Red



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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**PROJECT REQUEST**

FILE

LOCATION: **CPT-C8D-94**

JOB NUMBER: **52000\_301**

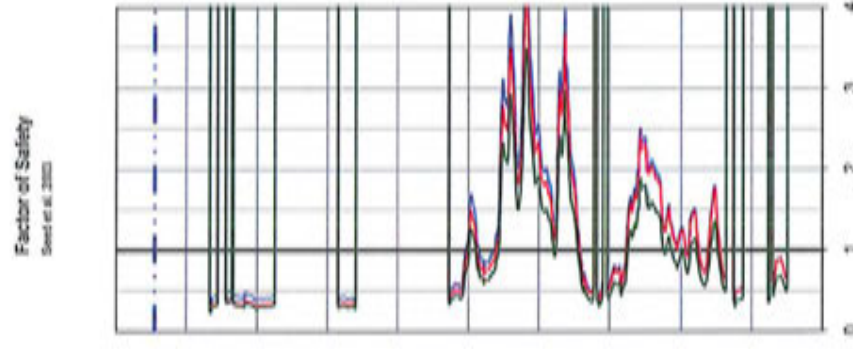
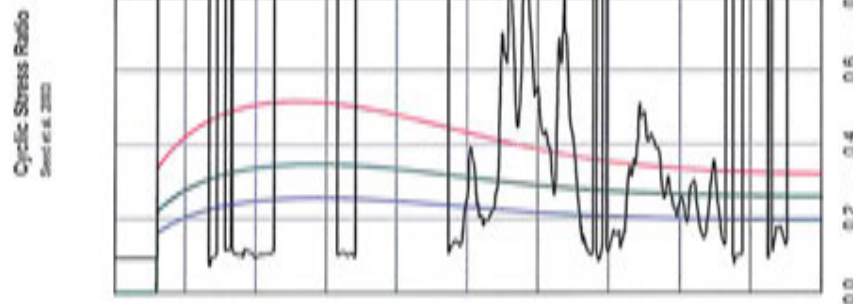
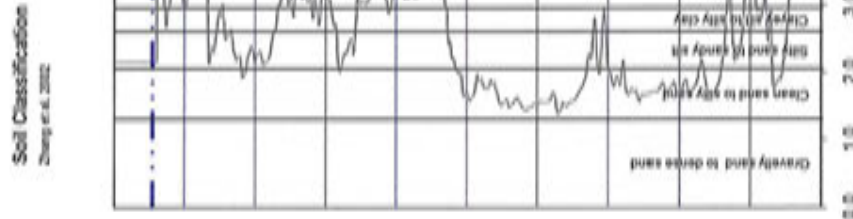
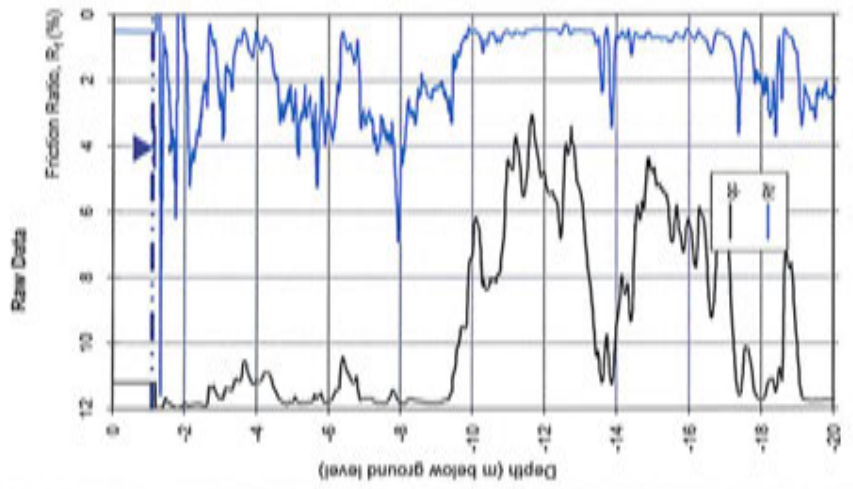
DATE: **31/12/2011**

ANALYSED: **RAP**

CHECKED: **AFF**

Liquefaction Assessment from CPT Results





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

5.5
5.7
6.7



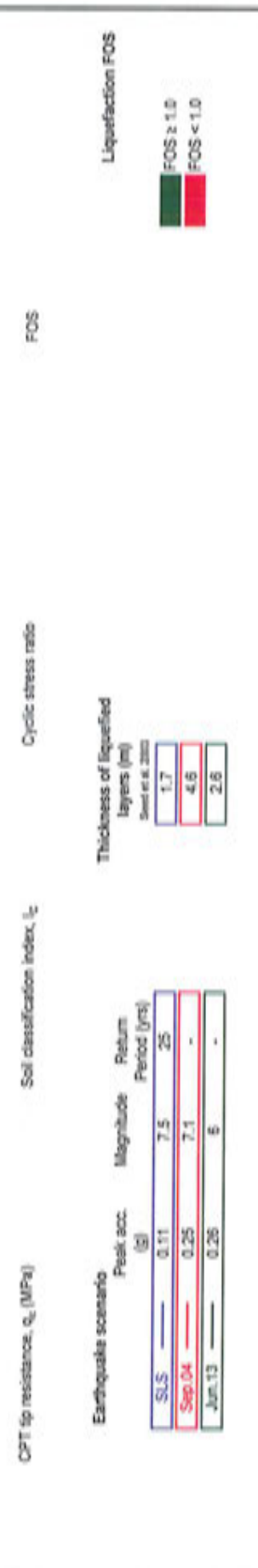
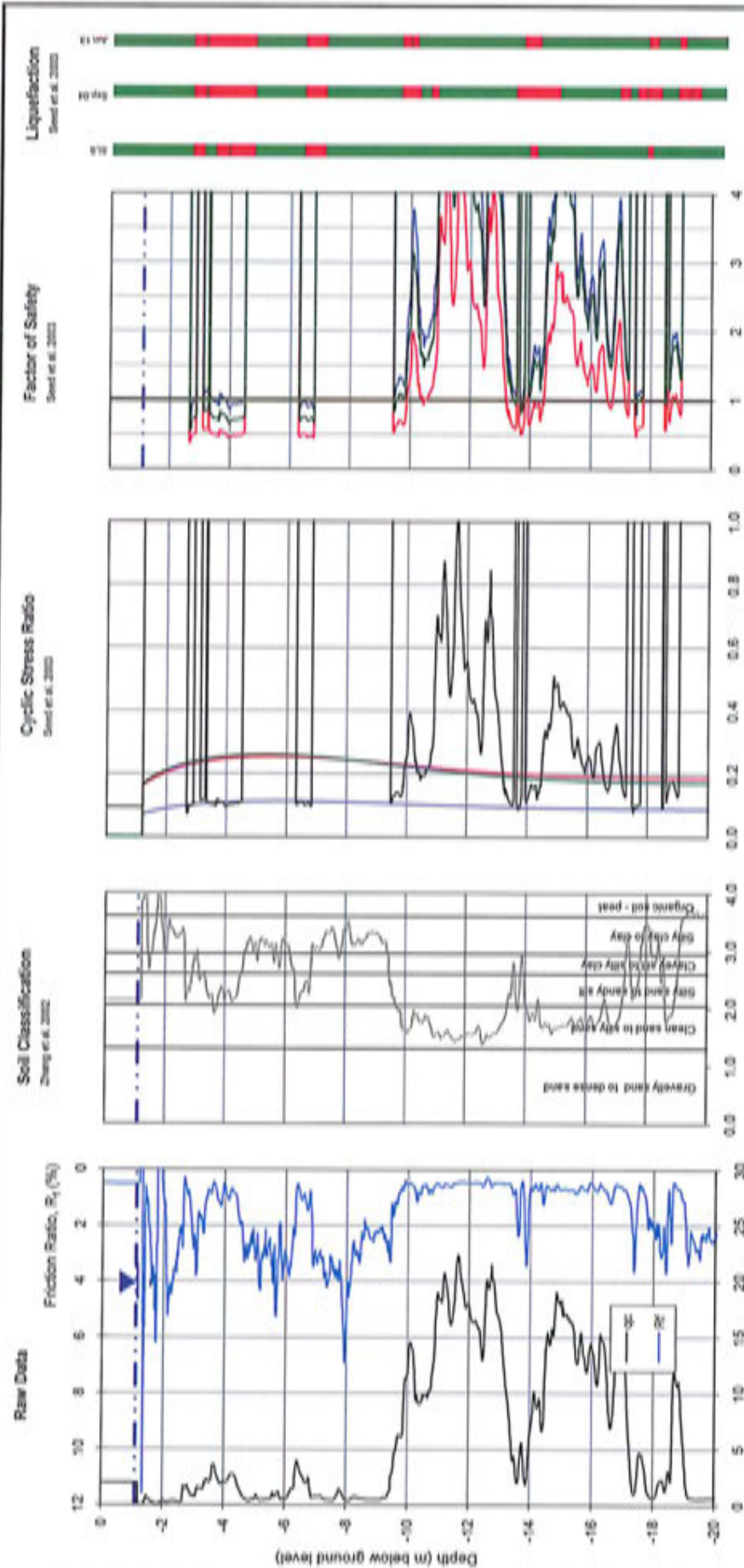
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Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-95  
JOB NUMBER  
52000.301

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results





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Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF

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CLIENT PROJECT

**CPT-CBD-95**

LOCATION

Christchurch Central City

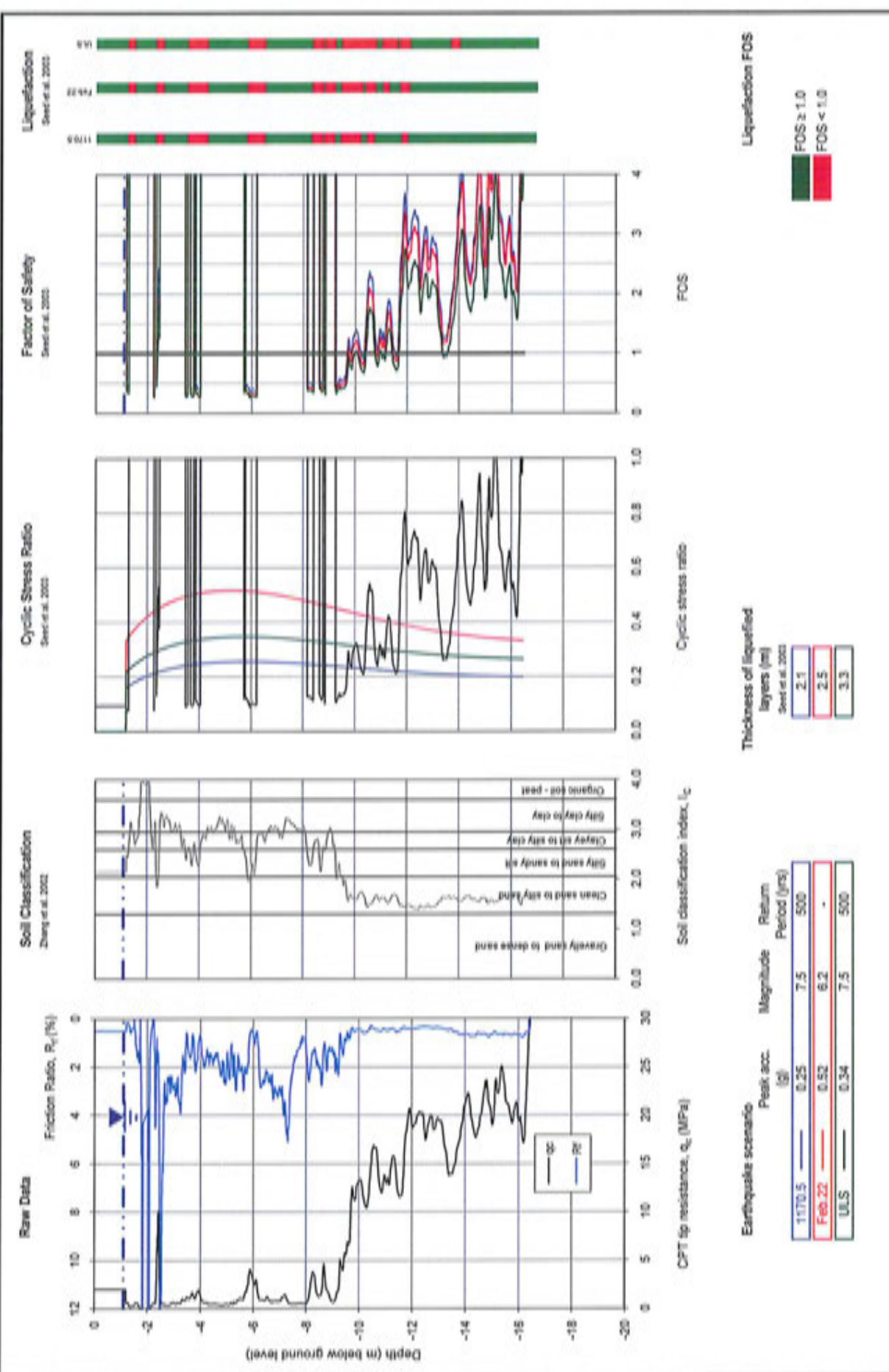
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ANALYSED: RAP  
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JOB NUMBER

52000.301

LIQUEFACTION ASSESSMENT FROM CPT RESULTS





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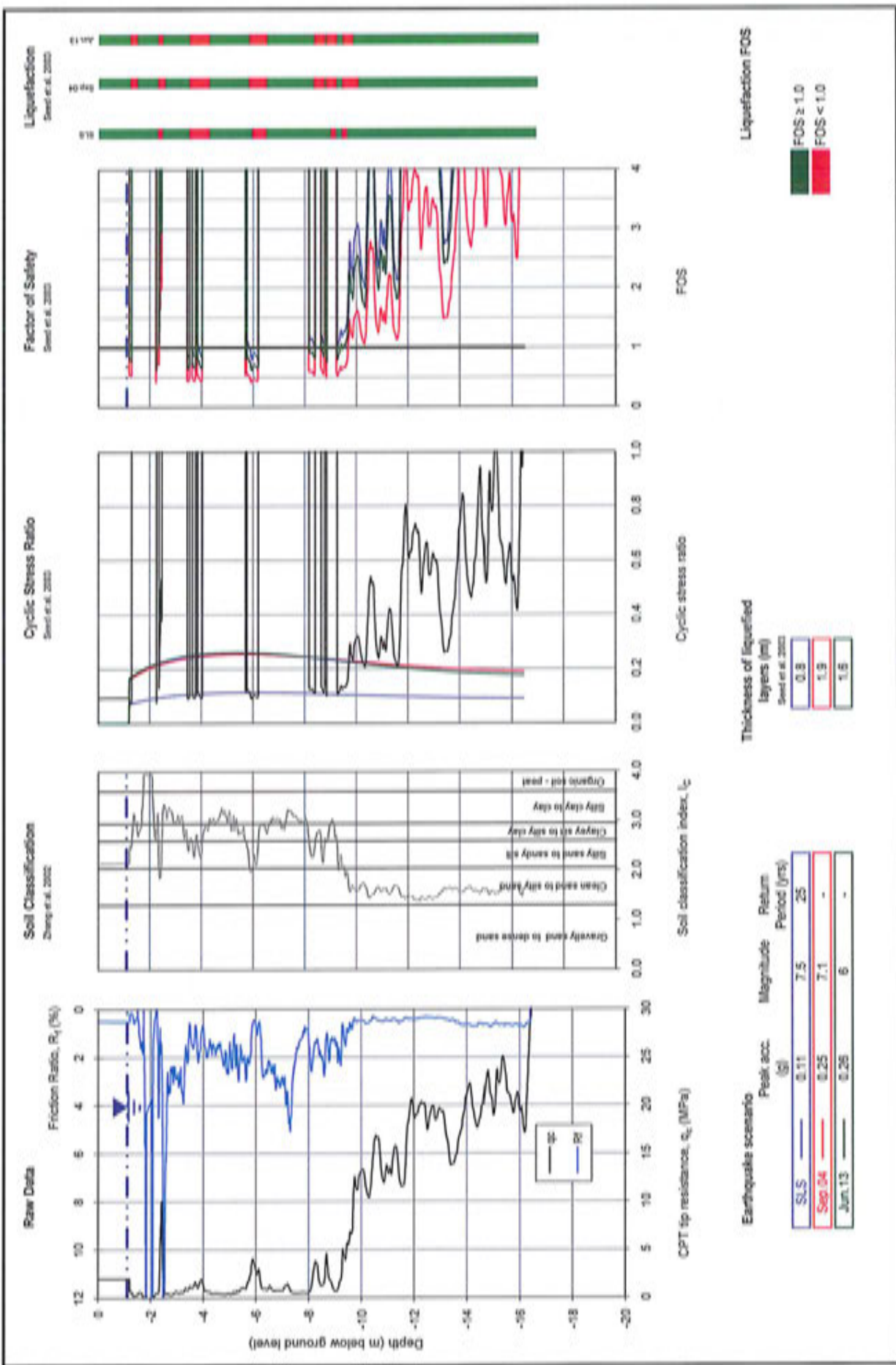
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

Liquefaction Assessment from CPT Results

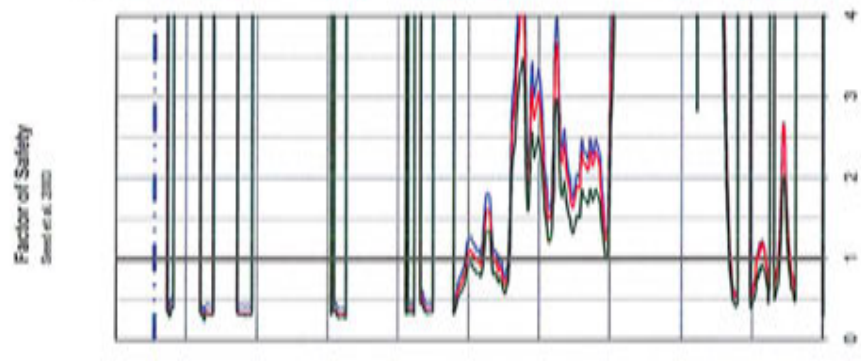
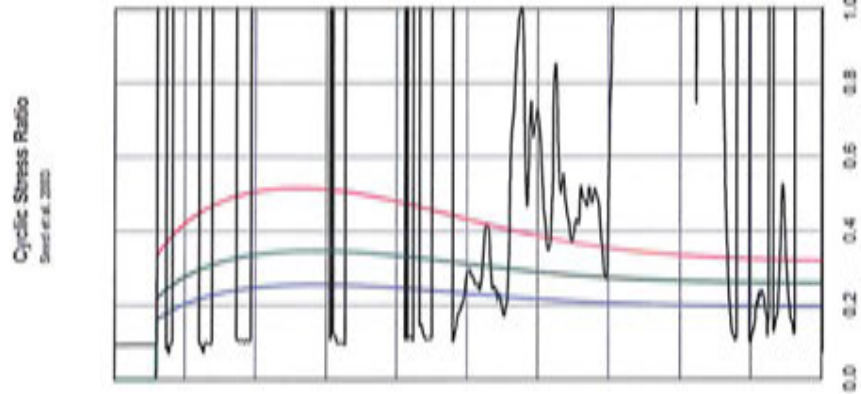
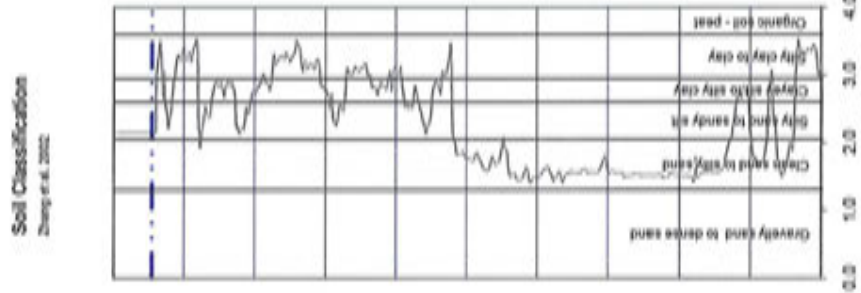
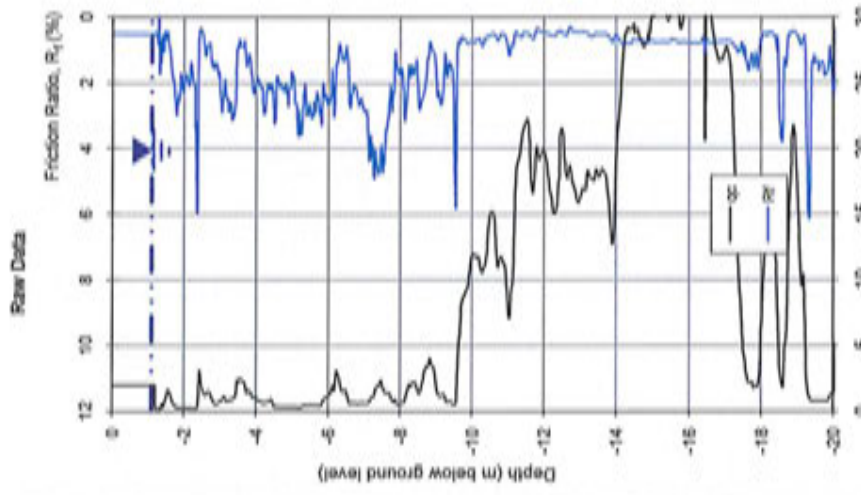
CLIENT PROJECT  
**CPT-CBD-96**

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
AFF

JOB NUMBER: 52006\_301



 Tomlin & Taylor Ltd Environmental & Engineering Consultants	CHRISTCHURCH <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE 7/12/2011
	PROJECT <b>CPT-C8D-96</b>		ANALYSED RAP
FILE Liquefaction Assessment from CPT Results		JOB NUMBER S2000.301	CHECKED AFF



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5
Feb 22	0.52	6.2
U.L.S.	0.34	7.5

Thickness of liquefied layers (m)

Thickness (m)
3.8
4.2
5.0

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



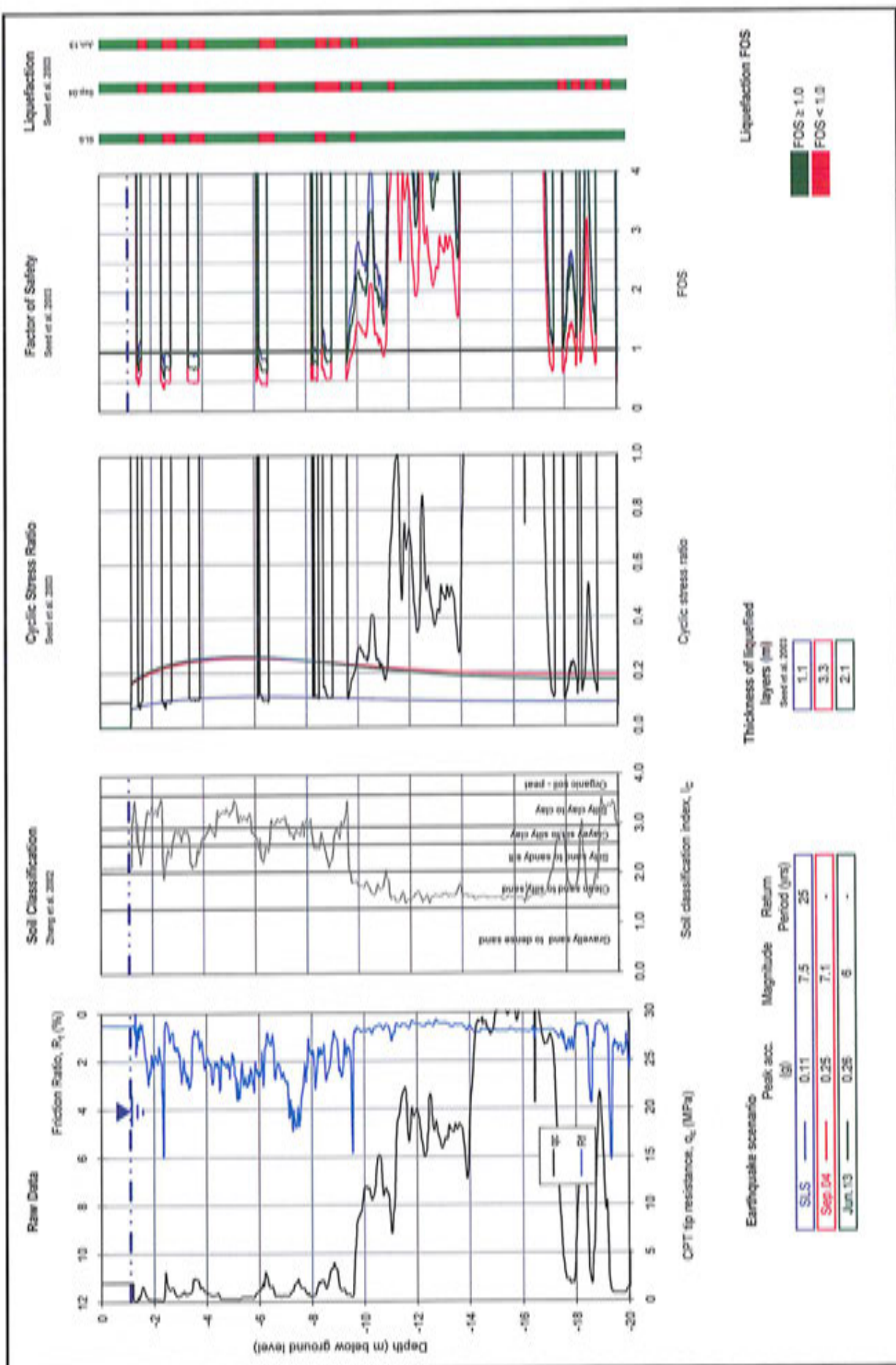
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Environmental & Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

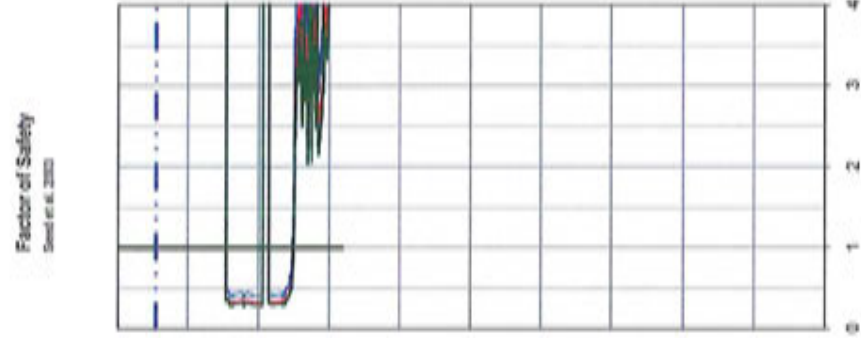
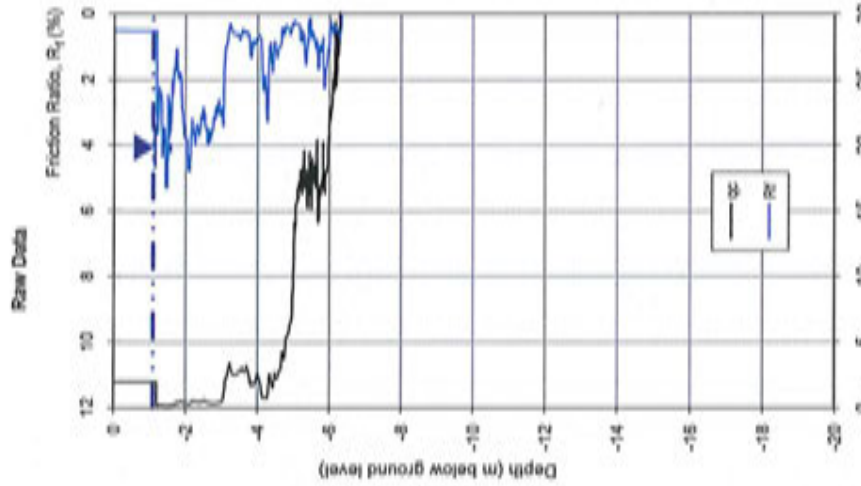
PROJECT CPT-CBD-97  
JOB NUMBER 52000.301

DATE 6/12/2011  
ANALYSED RAP  
CHECKED AFF

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-97</b>	DATE 7/12/2011
	ANALYSED RAP	CHECKED AFF	JOB NUMBER 52000.301
LIQUEFACTION ASSESSMENT FROM CPT RESULTS			



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
F60.22	0.52	6.2	-
ULLS	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
1.7
1.7
1.7

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



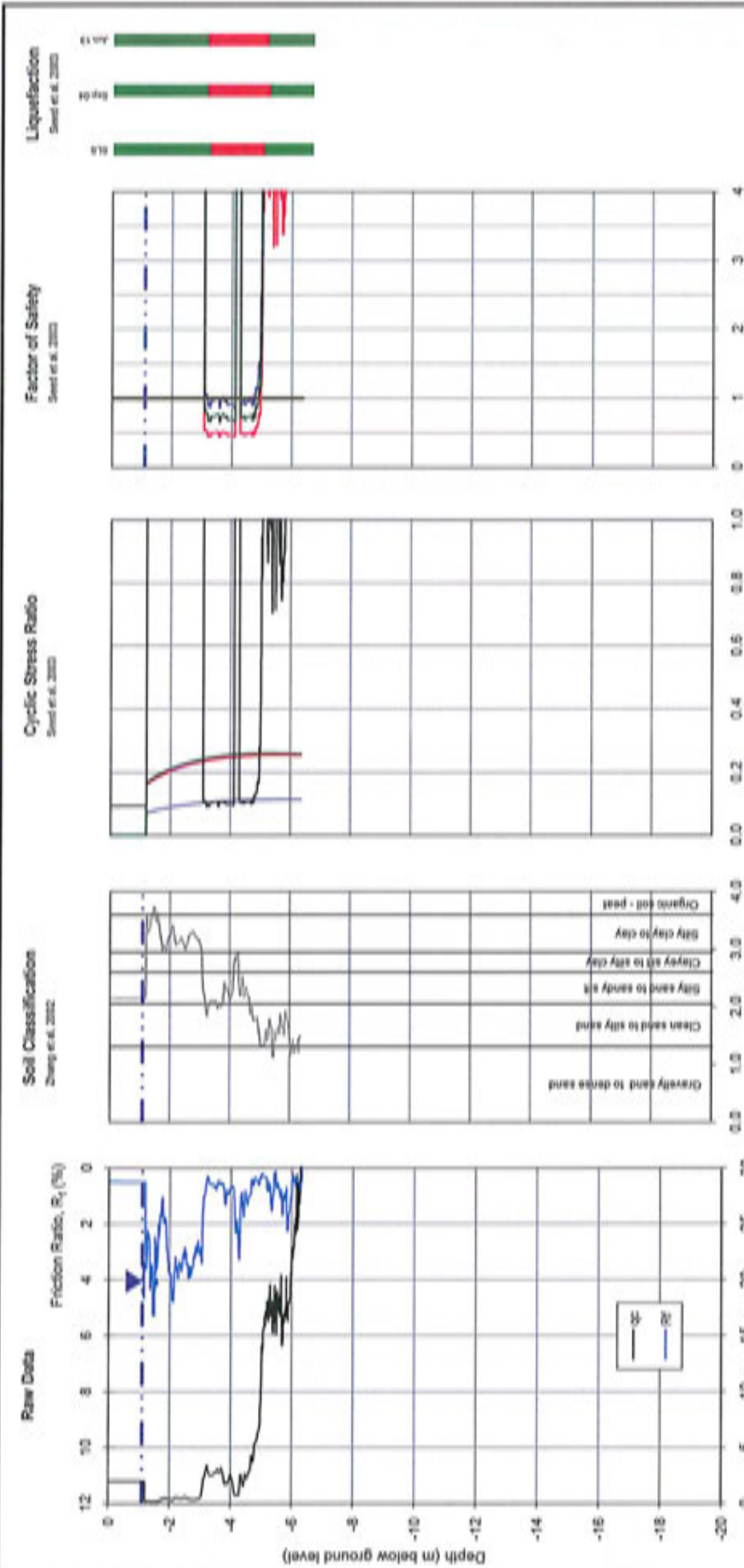
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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-98

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
JOB NUMBER: 52000\_301

Liquefaction Assessment from CPT Results



**CPT tip resistance,  $q_t$  (MPa)**

**Earthquake scenario**


Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jan. 13	0.25	6	-

**Thickness of liquefied layers (m)**  
Seed et al. 2002

1.3
1.7
1.6

**Liquefaction FOS**

$FOS \geq 1.0$
$FOS < 1.0$



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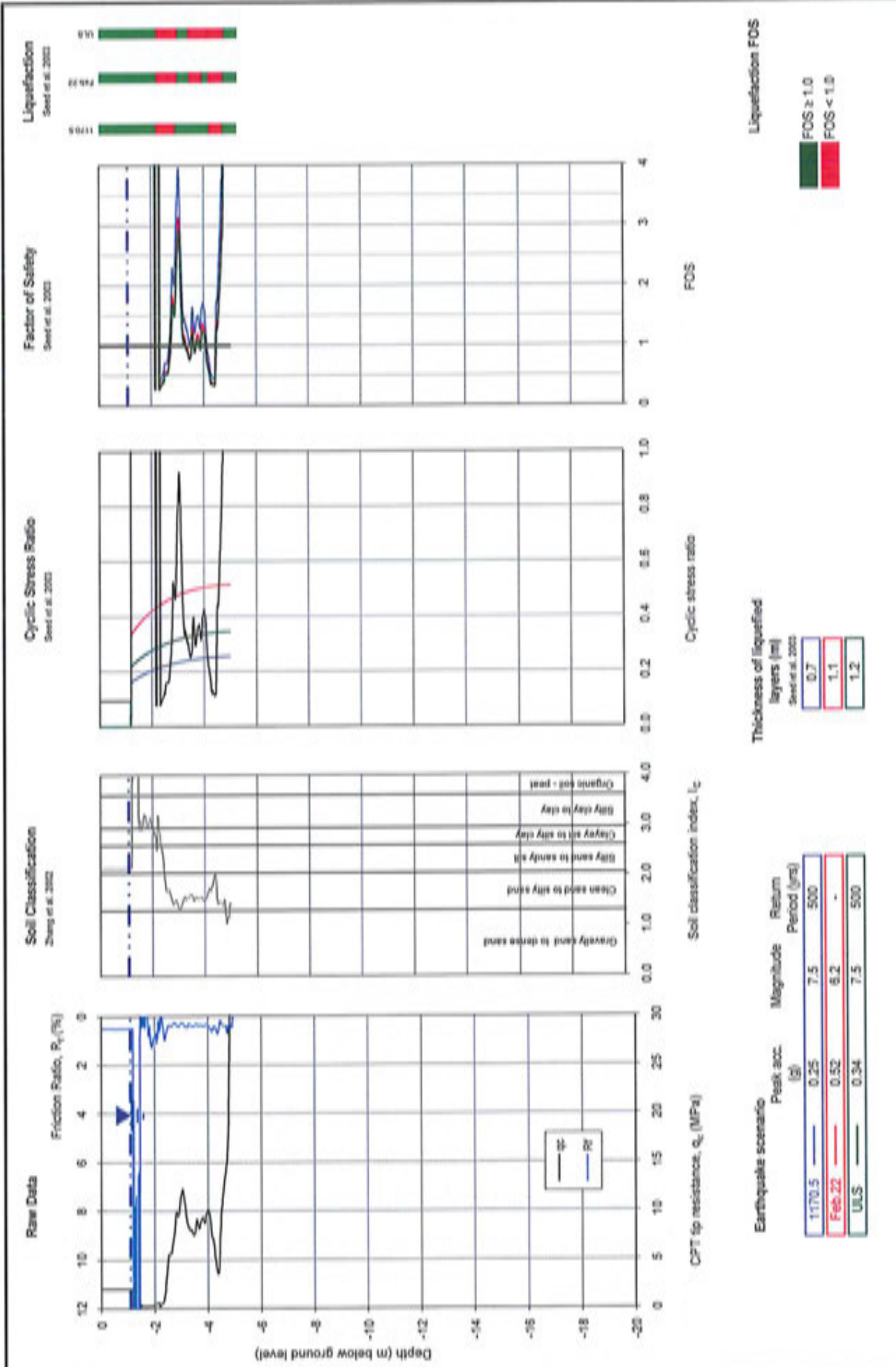
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**PROJECT**  
Liquefaction Assessment from CPT Results

**LOCATION**  
CPT-CBD-98

**DATE** 31/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
**JOB NUMBER** 52000\_301





 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT/PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-99</b>	DATE 6/12/2011
	TITLE Liquefaction Assessment from CPT Results	JOB NUMBER 52000_301	ANALYSED RAP
			CHECKED AFF

Earthquake scenario

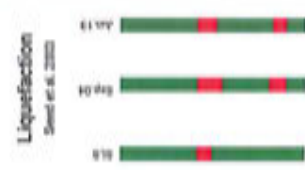
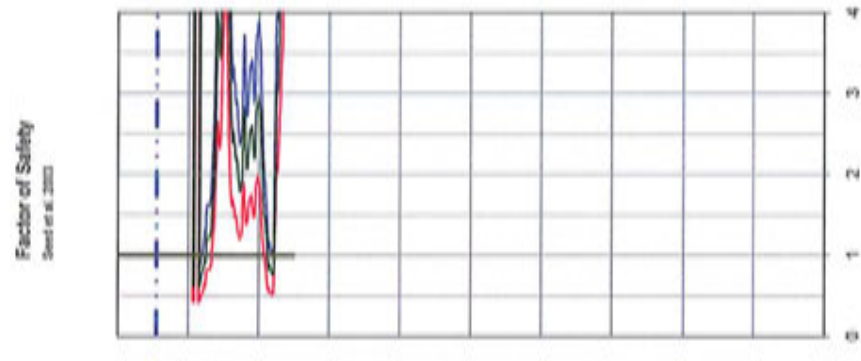
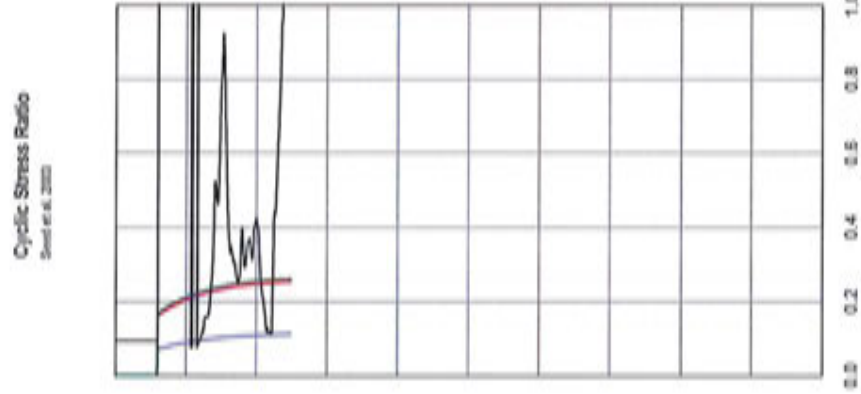
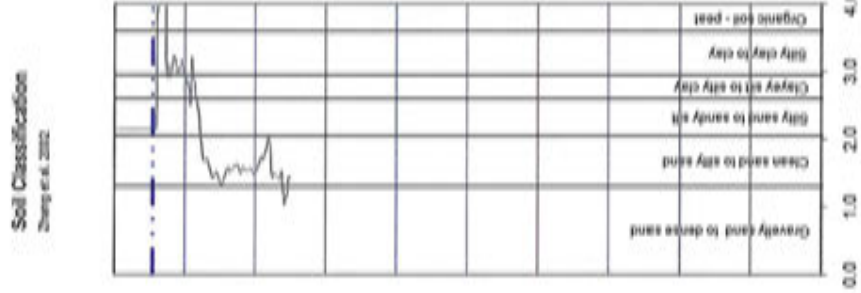
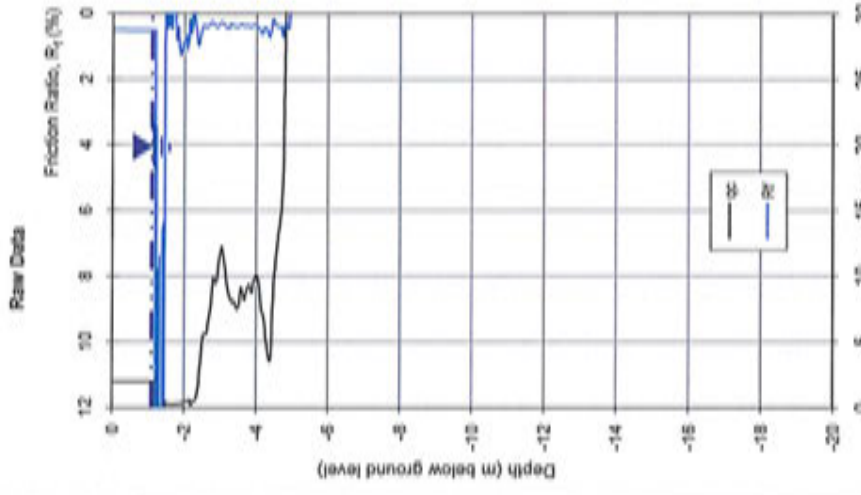
Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb. 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

0.7
1.1
1.2

Liquefaction FOS

FOS $\geq 1.0$
FOS $< 1.0$



CPT tip resistances,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5
Sep 04	0.25	7.1
Jun 13	0.26	6

Thickness of liquefied layers (m)

0.1
0.7
0.4

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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LOCATION

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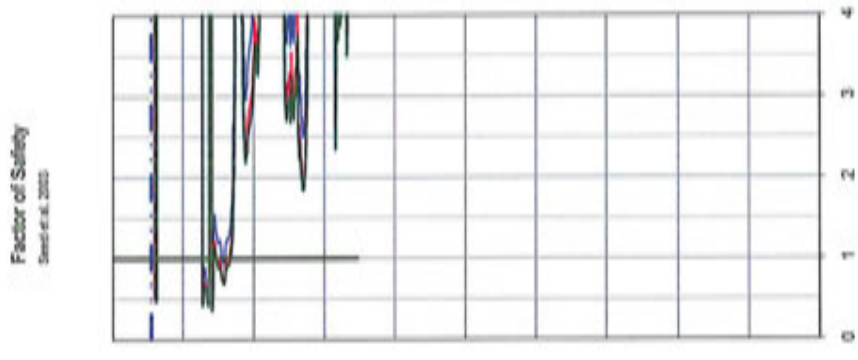
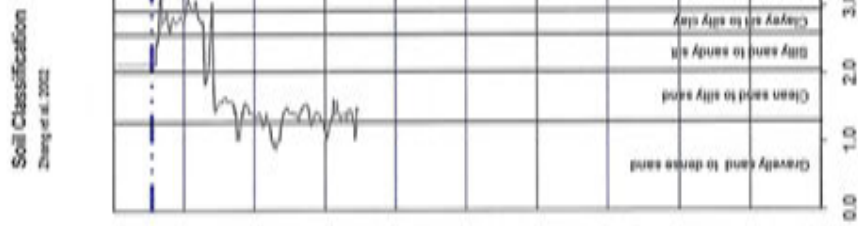
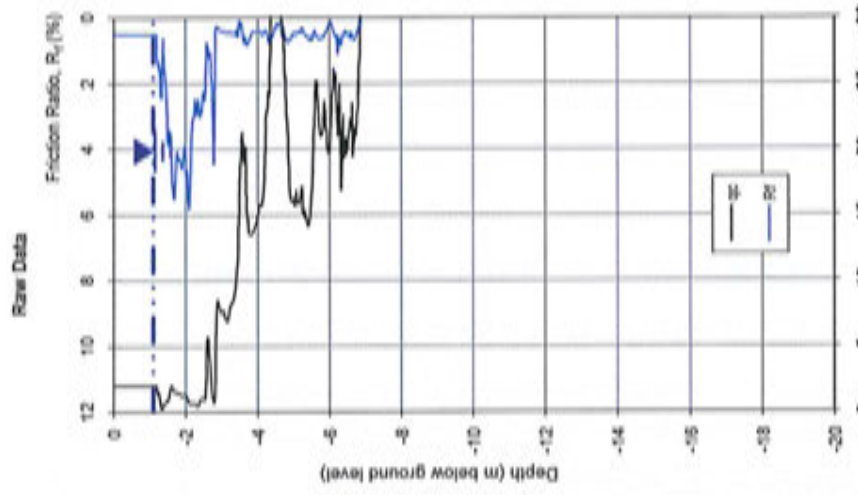
FILE

Liquefaction Assessment from CPT Results

JOB NUMBER

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CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness (m)
0.4
0.5
0.7

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0

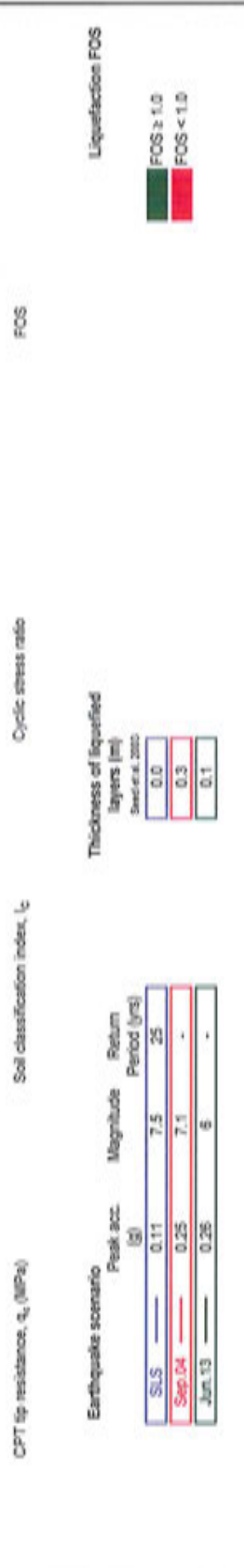
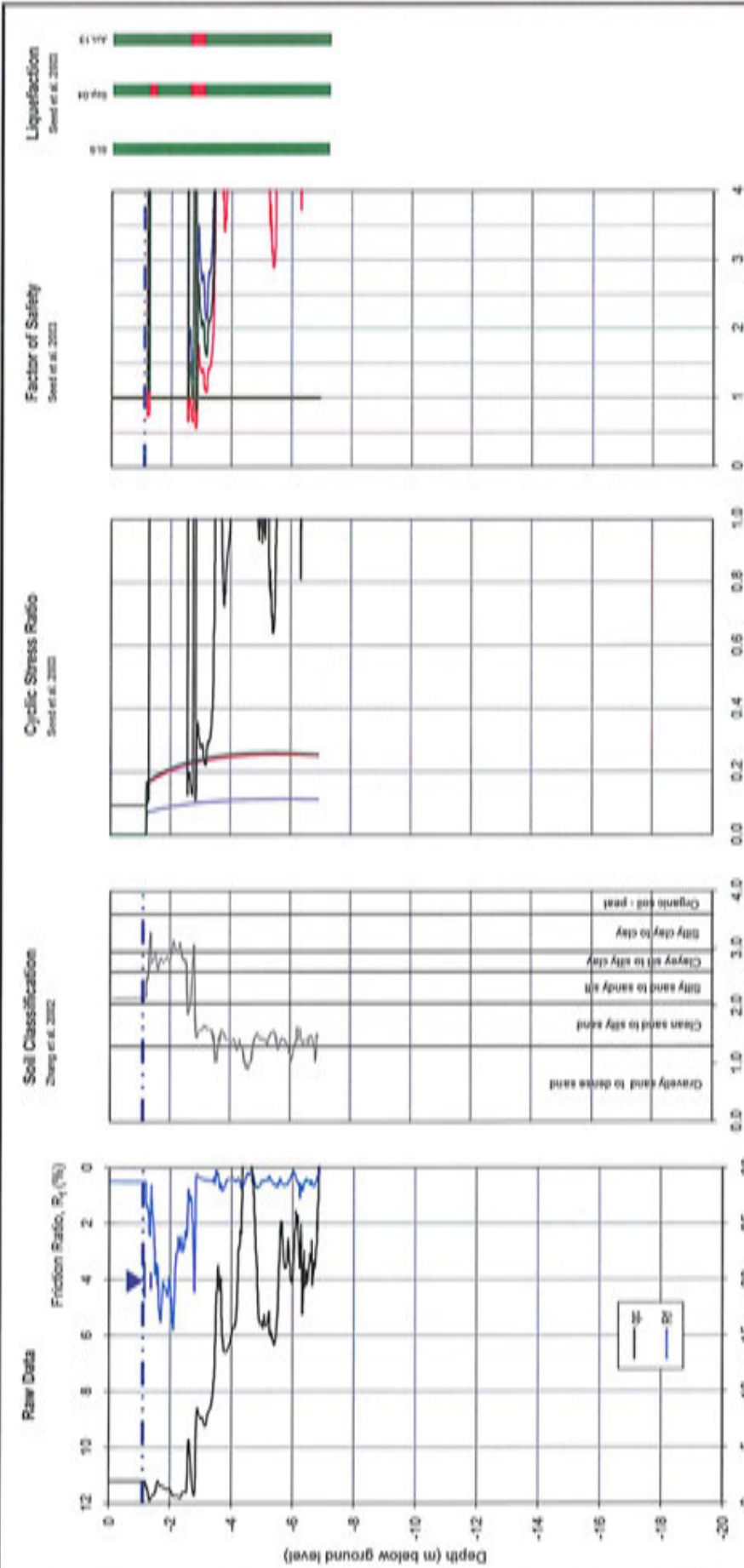



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Christchurch City Council  
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Liquefaction Assessment from CPT Results

SECTION  
CPT-CBD-100  
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52000\_301

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CLIENT PROJECT  
**CPT-CBD-100**

LOCATION  
Christchurch Central City

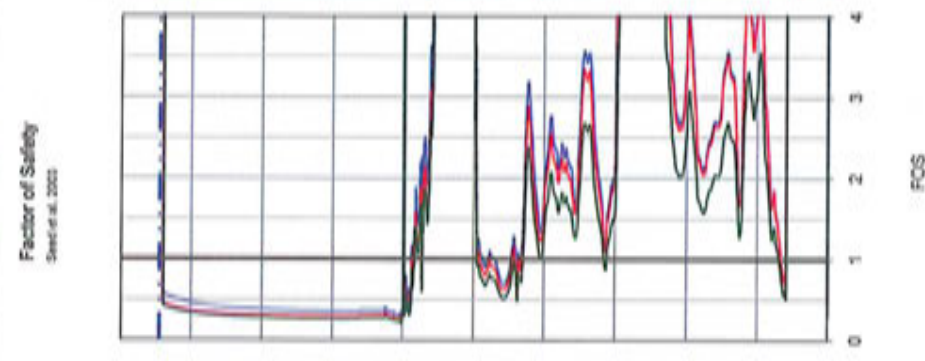
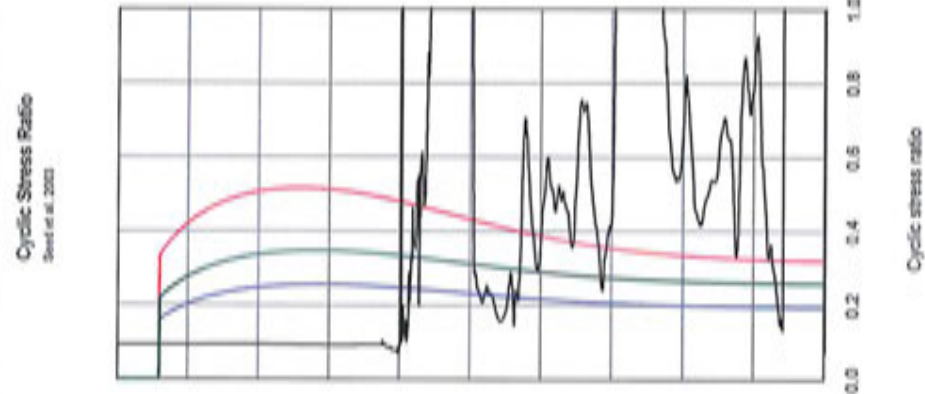
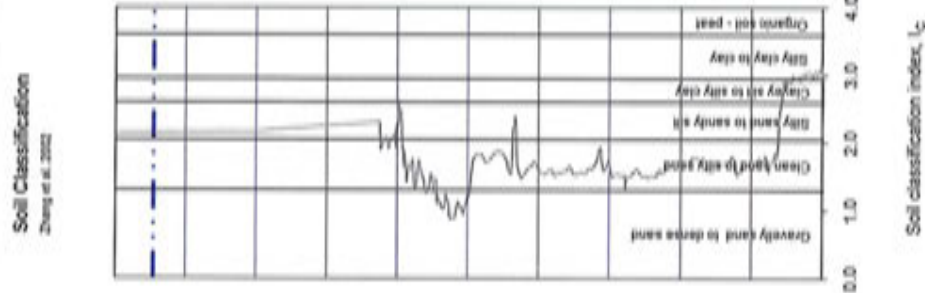
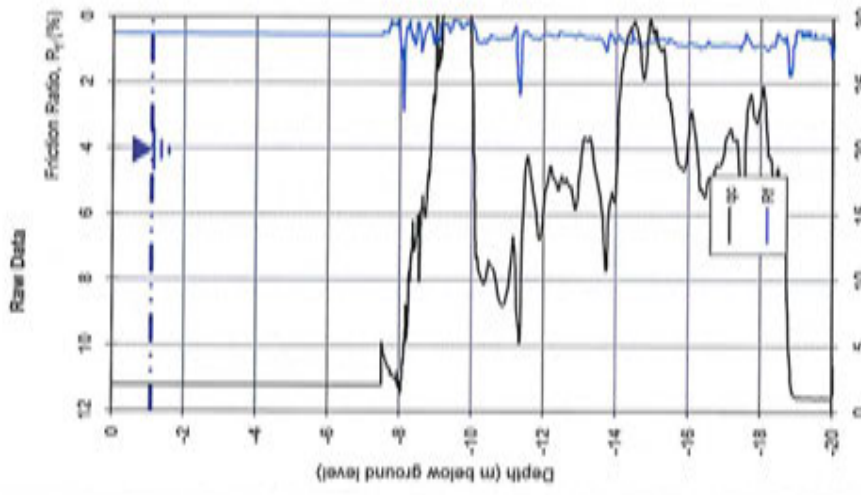
DATE  
7/12/2011

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RAP

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FILE  
Liquefaction Assessment from CPT Results

JOB NUMBER  
52000\_301



CPT tip resistance,  $q_c$  (MPa)

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
0.25	7.5	500
0.52	6.2	-
0.34	7.5	500

Thickness of liquefied layers (m)

Seed et al. 2003

8.5
8.9
9.3



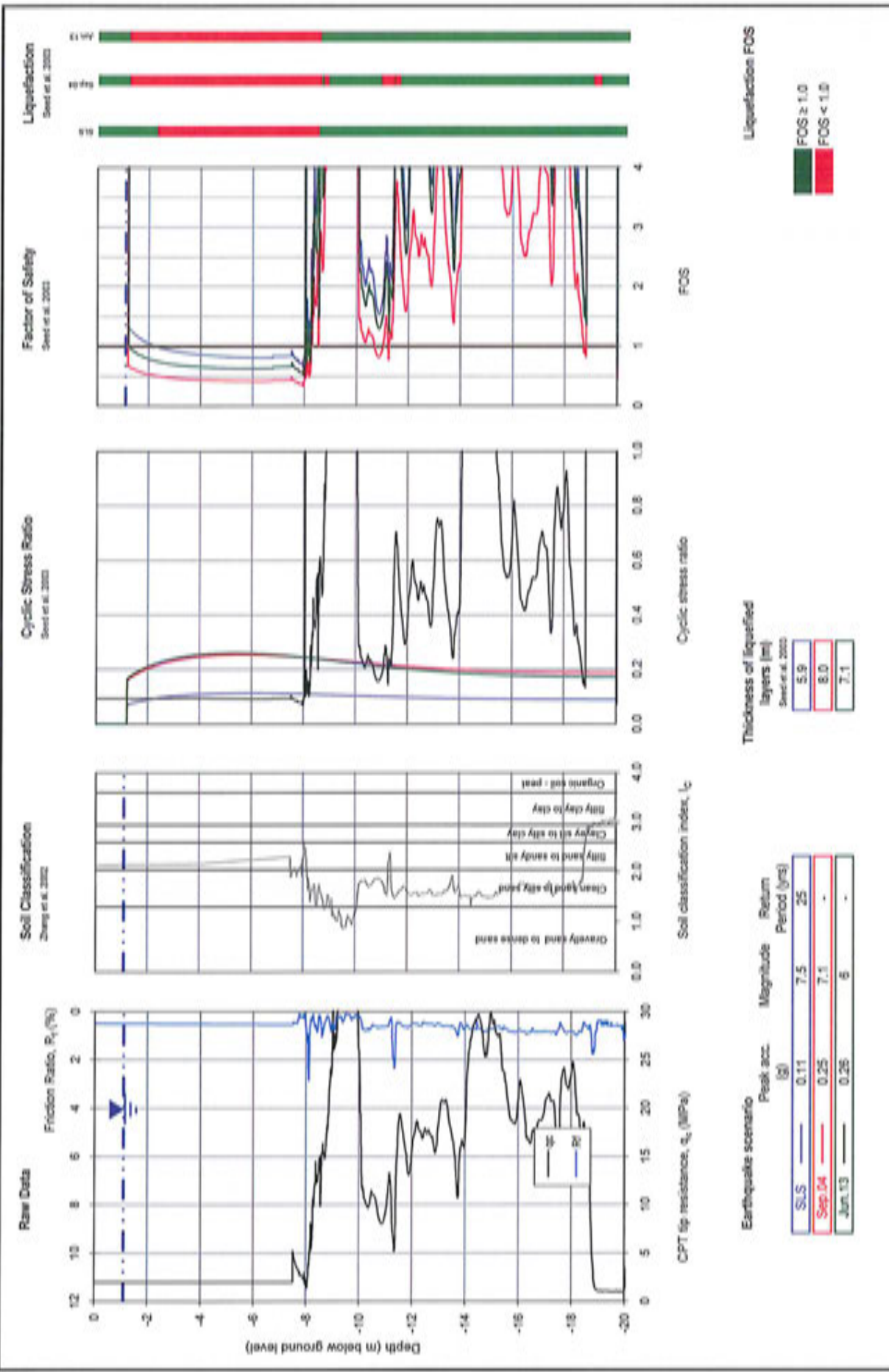
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CLIENT PROJECT  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

SECTION  
CPT-CBD-100P  
JOB NUMBER  
52000.301

DATE  
6/12/2011  
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TITLE  
Liquefaction Assessment from CPT Results





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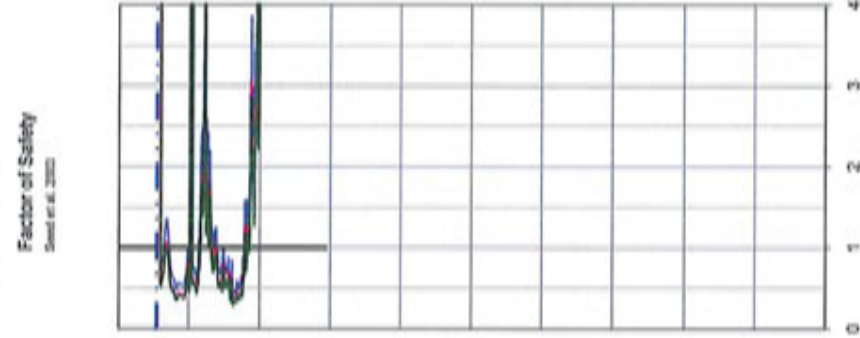
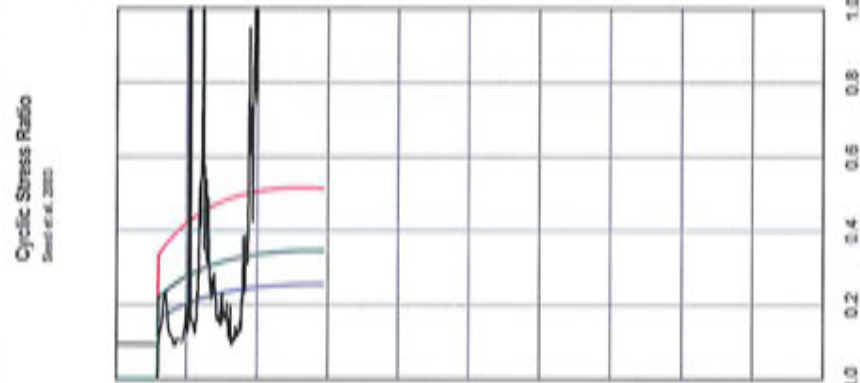
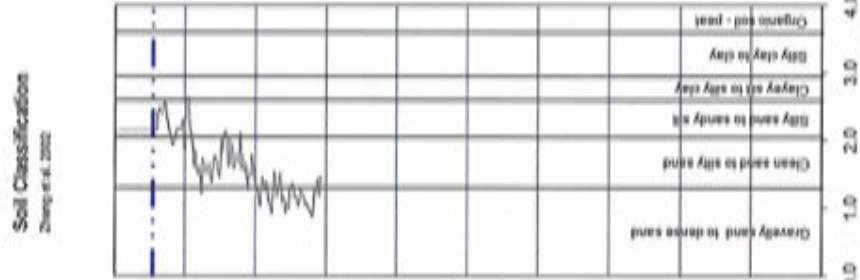
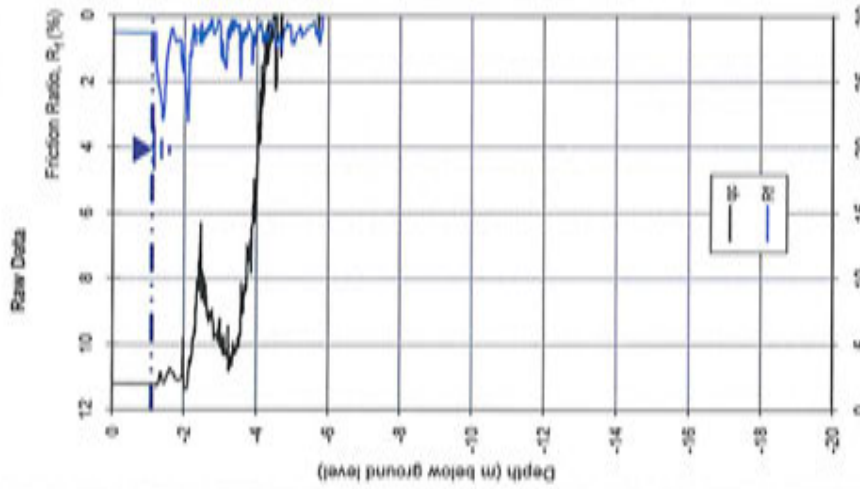
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PROJECT/REQUEST

**CPT-CBD-100P**

JOB NUMBER: 52000\_301

LOCATION



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. ( $g$ )	Magnitude	Return Period (yrs)
0.25	7.5	500
0.52	8.2	-
0.34	7.5	500

Thickness of liquefied layers (m)

1.7
2.0
2.1

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



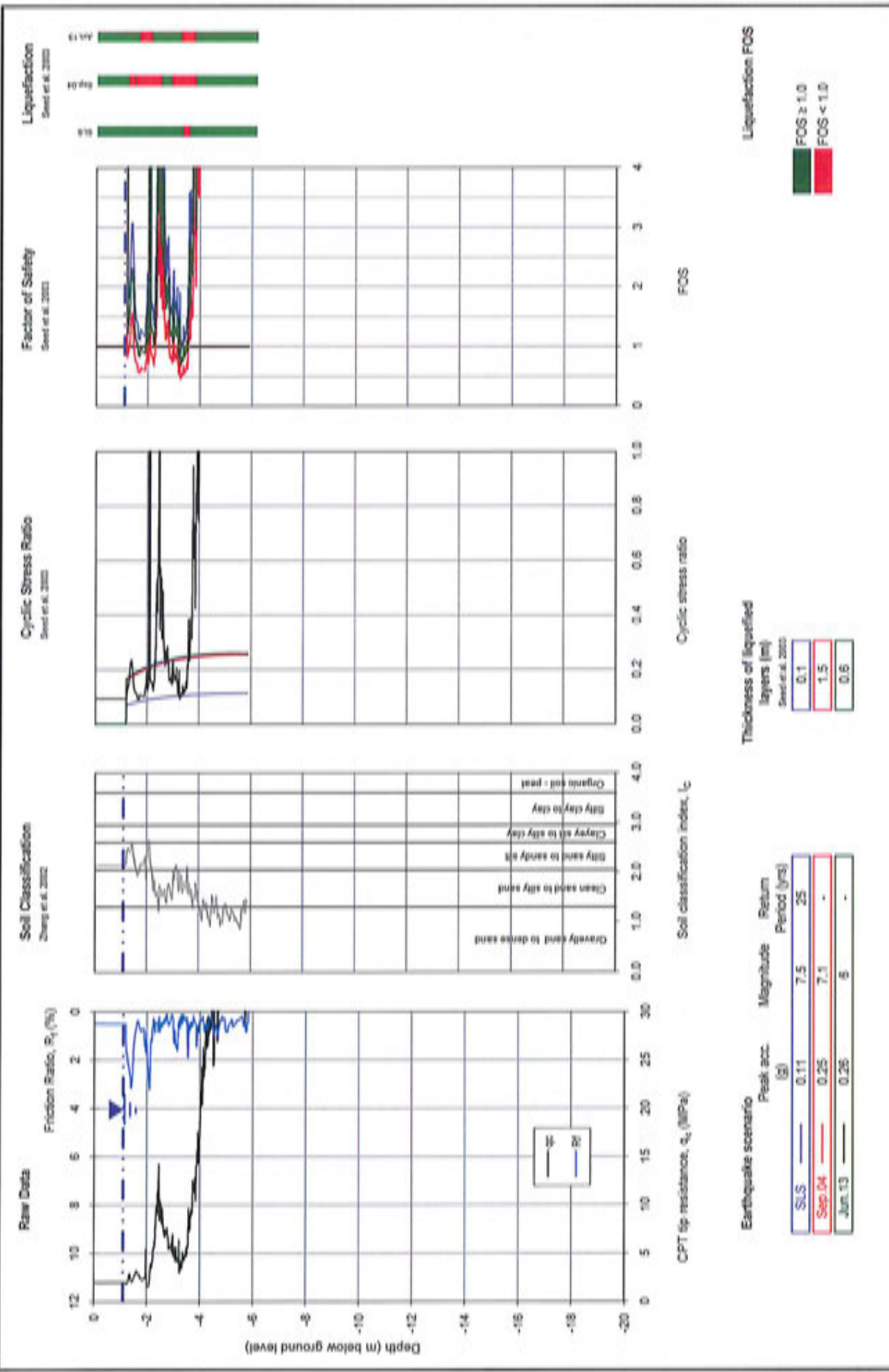
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Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-101  
JOB NUMBER  
52000.301

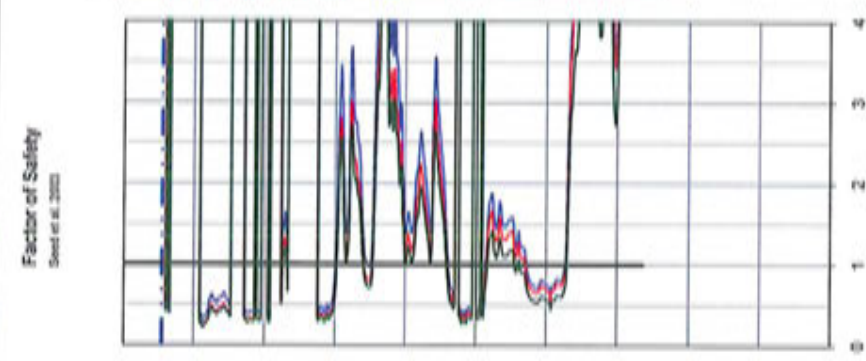
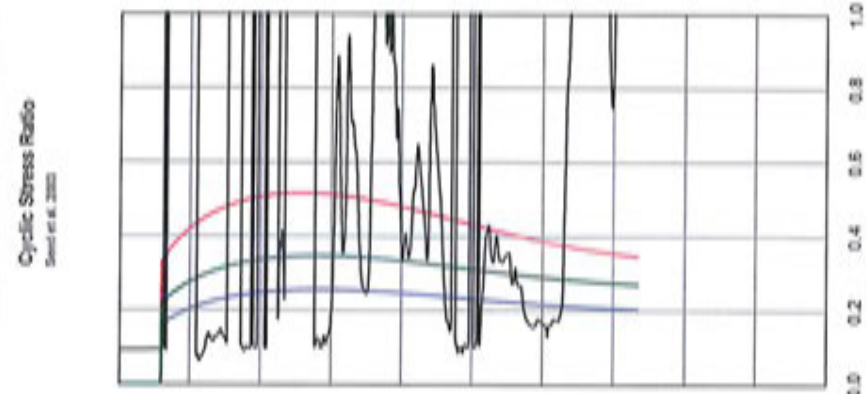
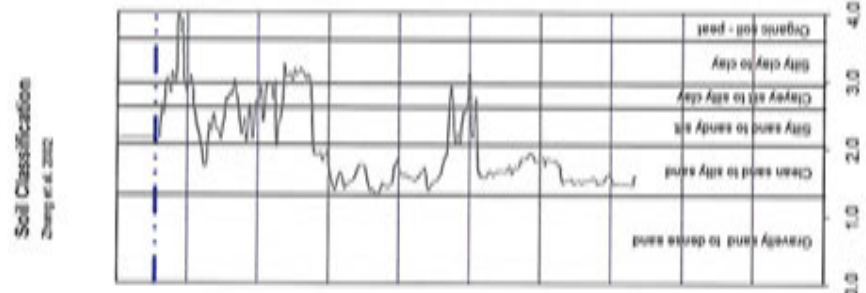
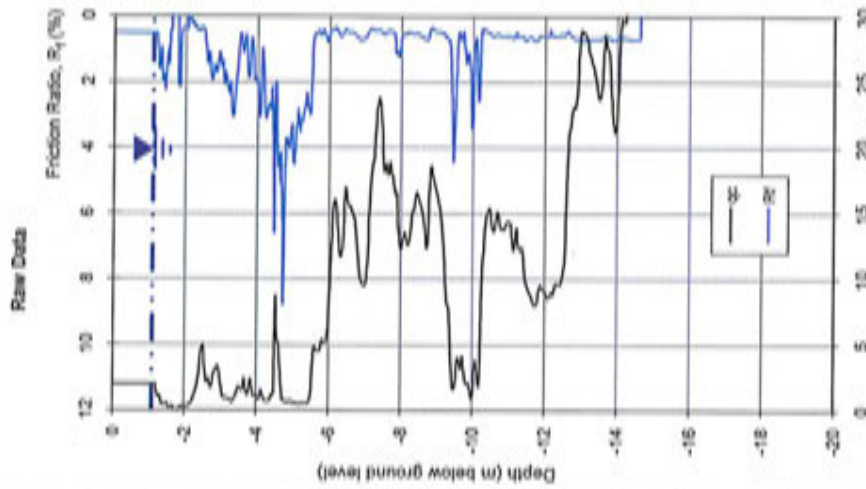
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Liquefaction Assessment from CPT Results



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			<b>ANALYSED</b> RAP
		<b>CHECKED</b> AFF	<b>RAP</b> AFF





CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
4.0
4.3
4.7

Liquefaction FOS



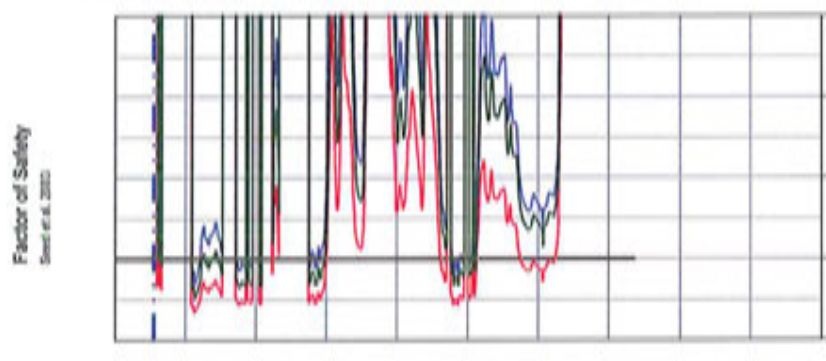
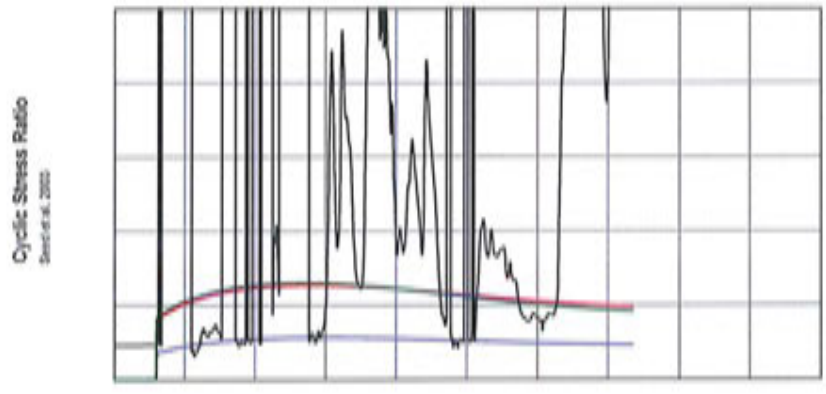
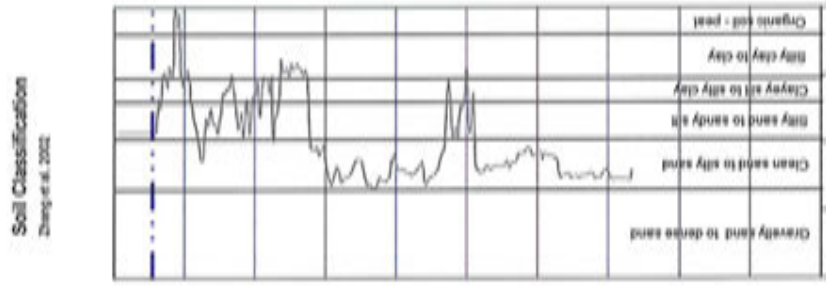
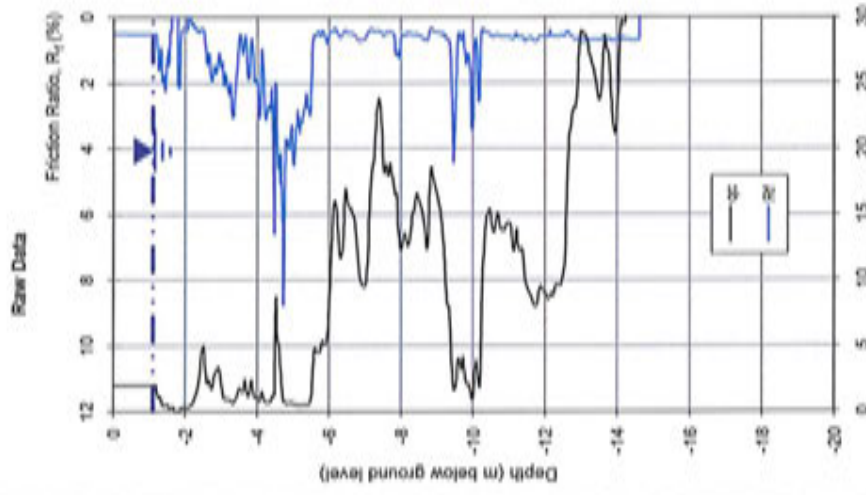
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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT: CPT-CBD-102  
JOB NUMBER: S2000.301

DATE: 6/12/2011  
ANALYSED: RAP  
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Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.26	6	-

Thickness of liquefied layers (m)

SLS	1.2
Sep 04	3.7
Jun 13	2.2

Liquefaction FOS

FOS $\geq 1.0$	Green
FOS $< 1.0$	Red

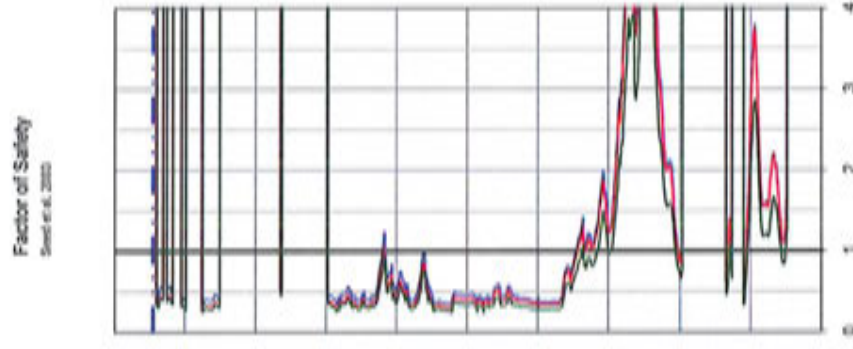
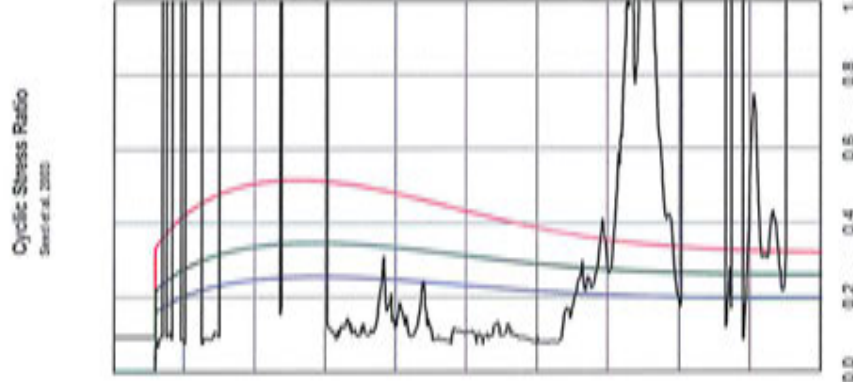
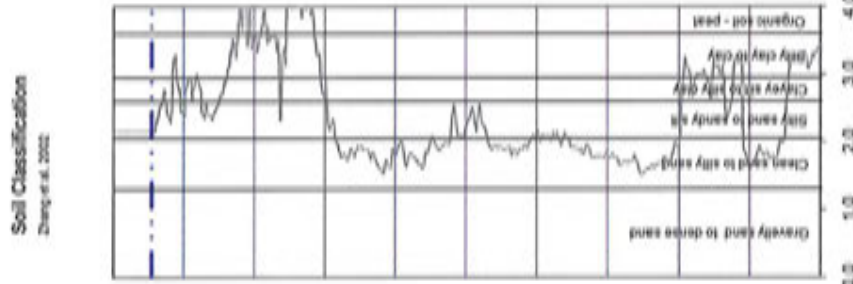
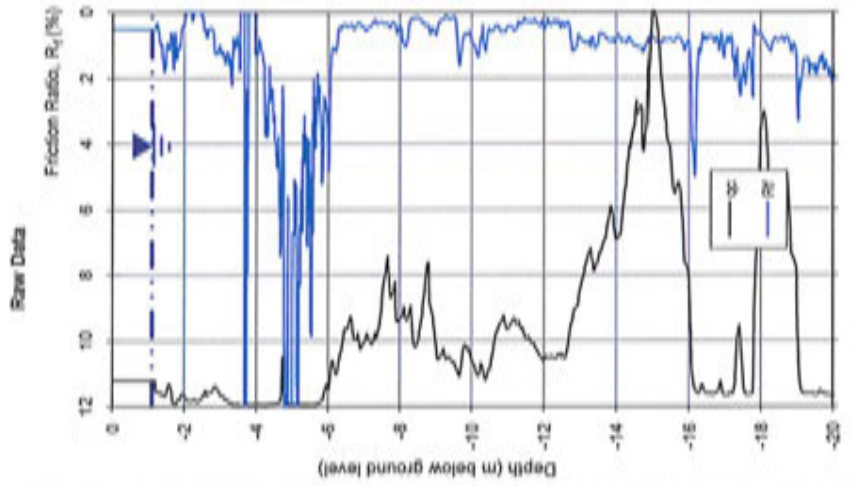


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Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

PROJECT/REQUEST  
**CPT-CBD-102**

DATE: 7/12/2011  
ANALYSED: RAP  
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JOB NUMBER: 52000\_301



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
86.22	6.2	-
0.34	7.5	500

Thickness of liquefied layers (m)

Thickness (m)
8.3
8.5
9.3

Liquefaction FOS

FOS $\geq 1.0$	FOS $< 1.0$
Green	Red



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FILE  
Liquefaction Assessment from CPT Results

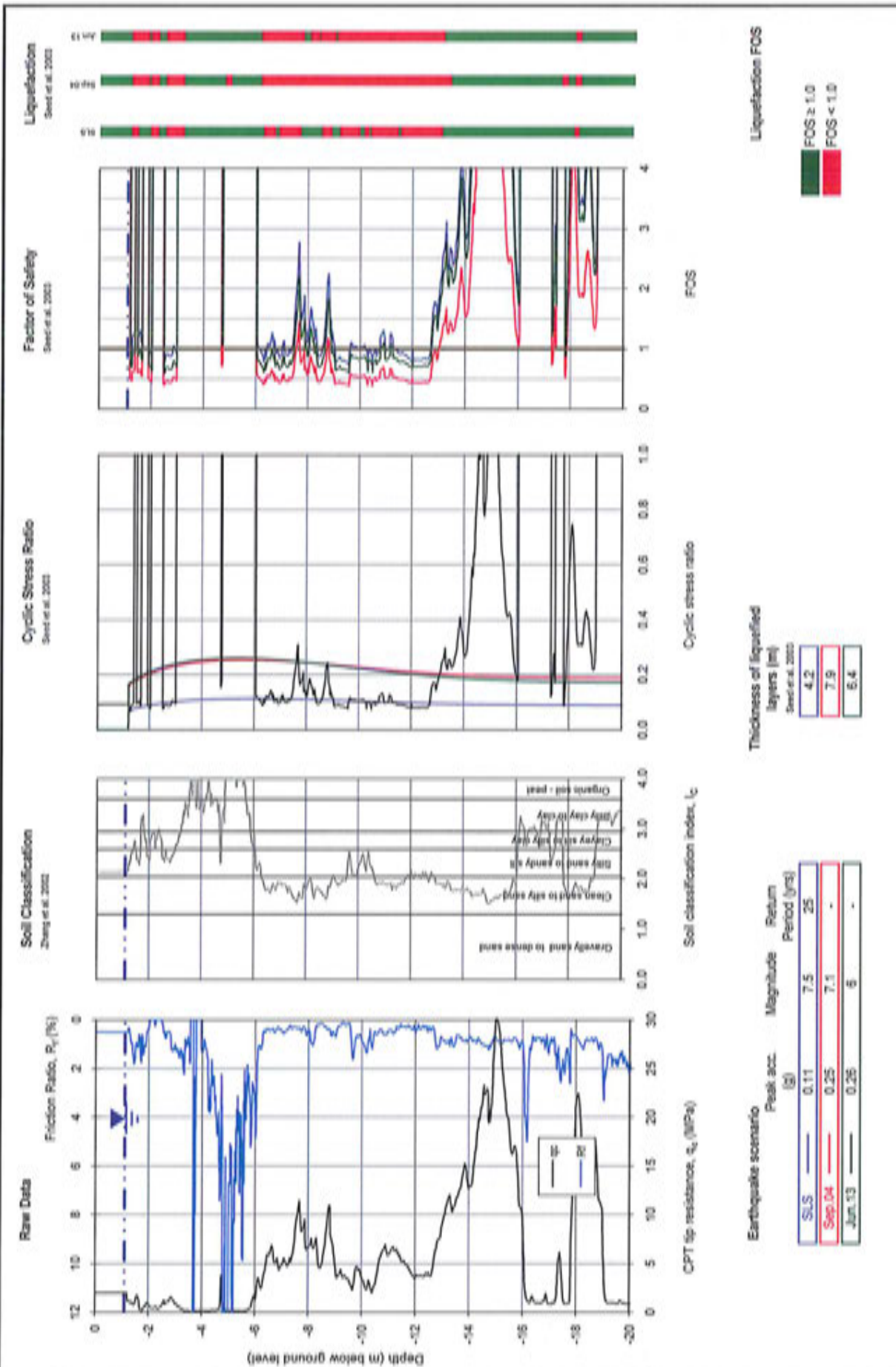
LOCATION  
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JOB NUMBER  
52000.301

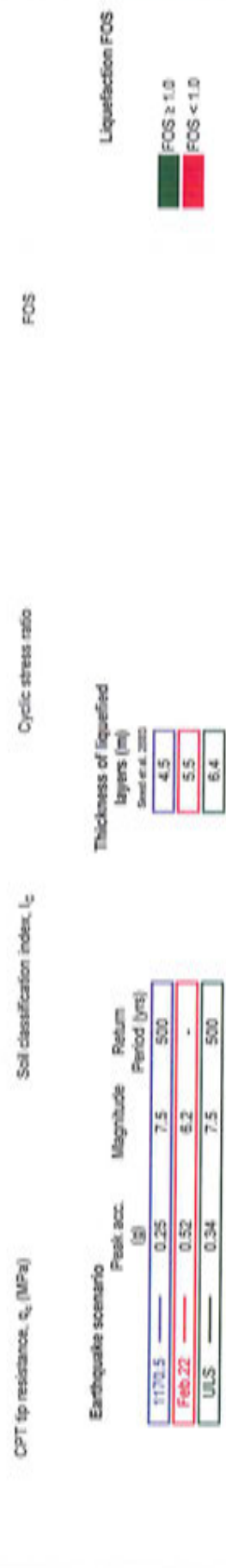
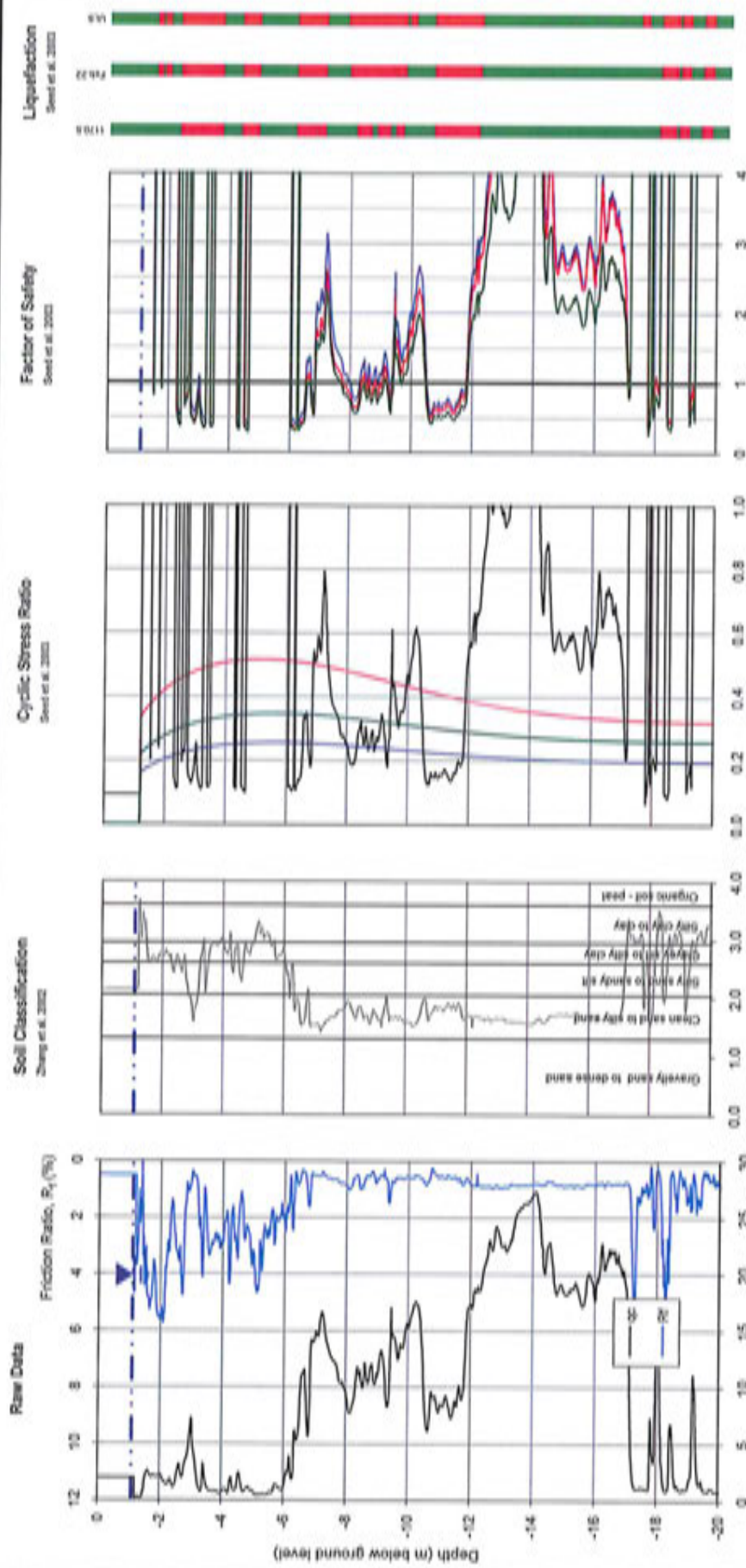
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6/10/2011

ANALYSED  
RAP

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Thickness of liquefied layers (m)

4.5
5.5
6.4

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
<b>Feb.22</b>	<b>6.2</b>	-
ULS	7.5	500



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**Christchurch City Council**  
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CLIENT PROJECT

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Geotechnical Assessment for Christchurch Central City

LOCATION

**CPT-CBD-103**

DATE: 6/12/2011  
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LOCATION

**CPT-CBD-103**

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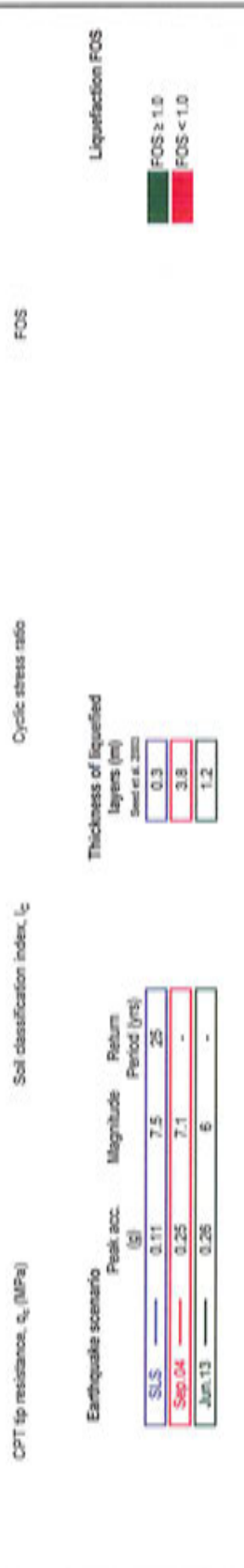
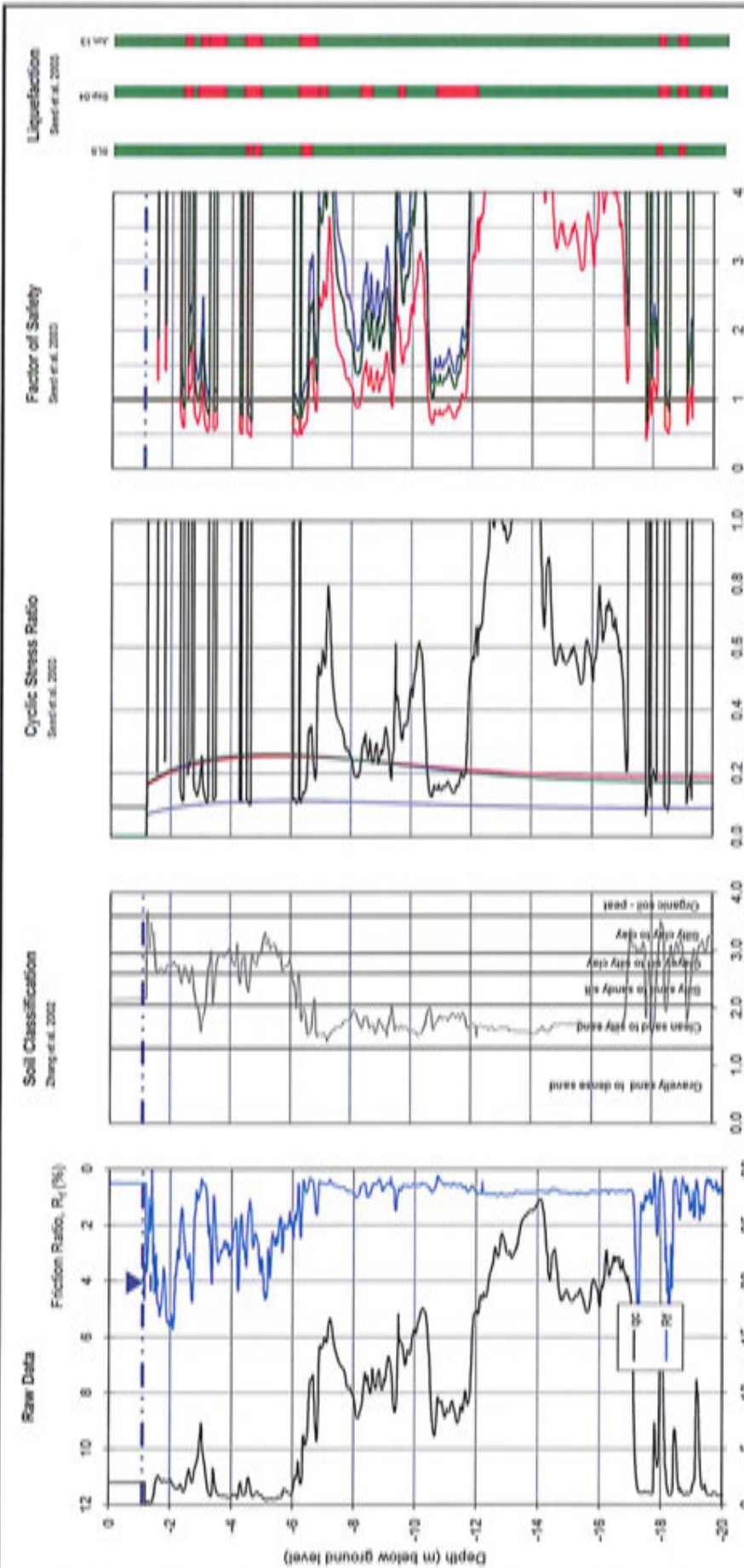
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LOCATION

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Geotechnical Assessment for Christchurch Central City

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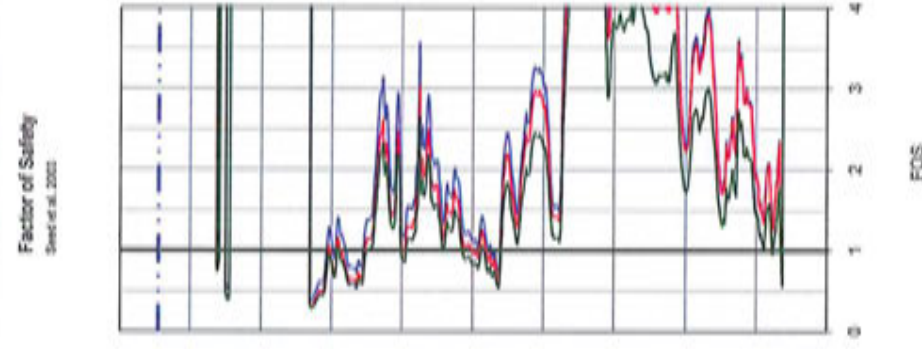
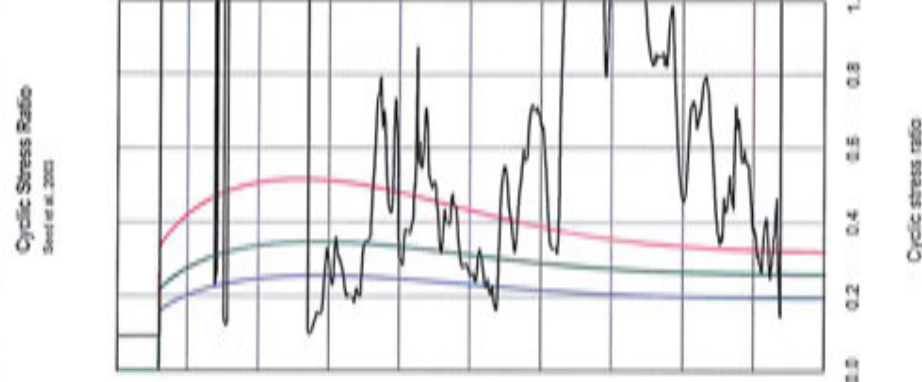
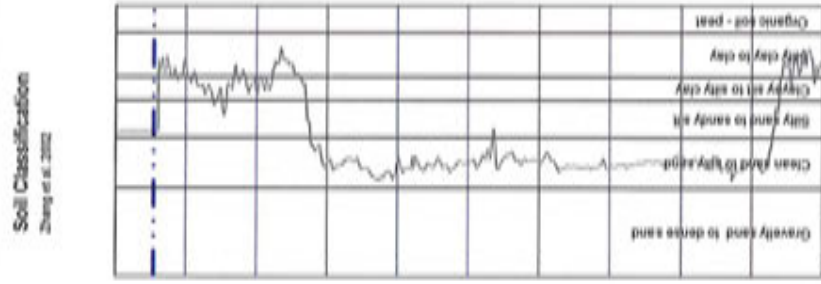
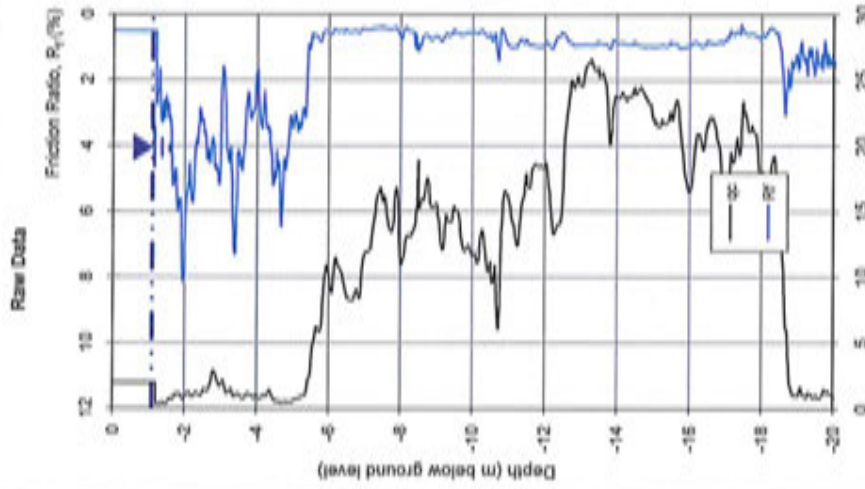
PROJECT NUMBER: 52000\_301

**CPT-CBD-103**

JOB NUMBER: 52000\_301

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Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. ( $g$ )	Magnitude	Return Period (yrs)
0.25	7.5	500
0.52	6.2	-
0.34	7.5	500

Thickness of liquefied layers (m)

1.5
2.4
3.0

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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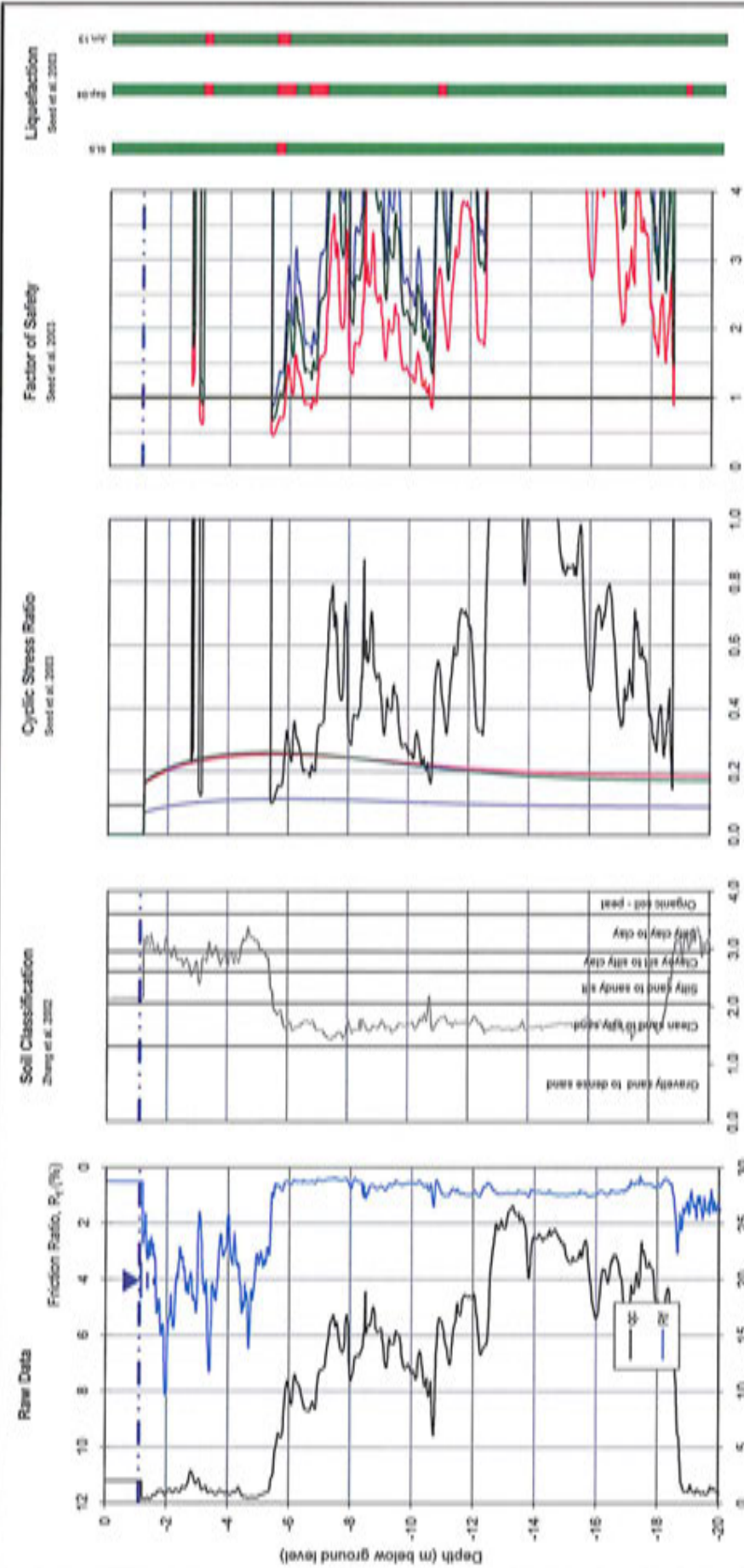
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DATE  
6/12/2011

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RAP

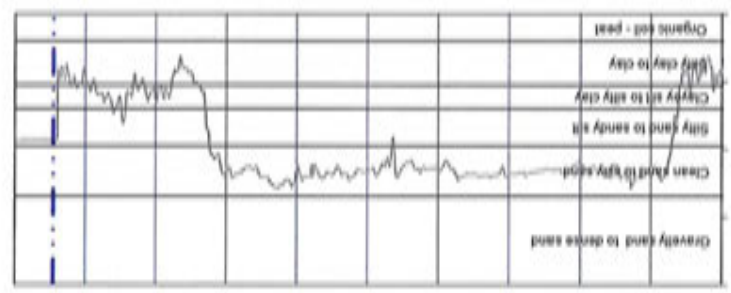
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Liquefaction Assessment from CPT Results

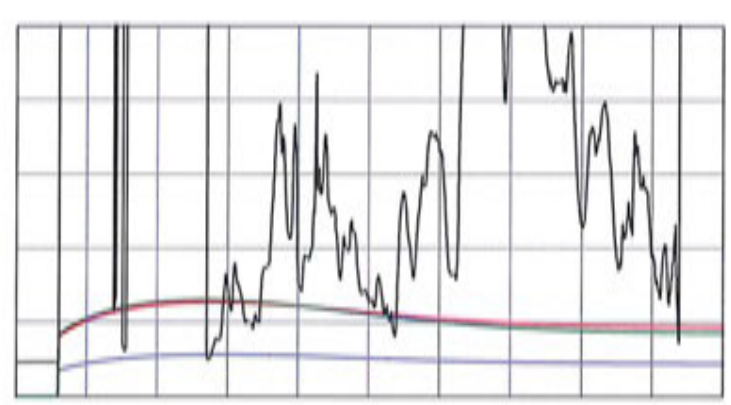


Raw Data  
Friction Ratio,  $R_f$  (%)

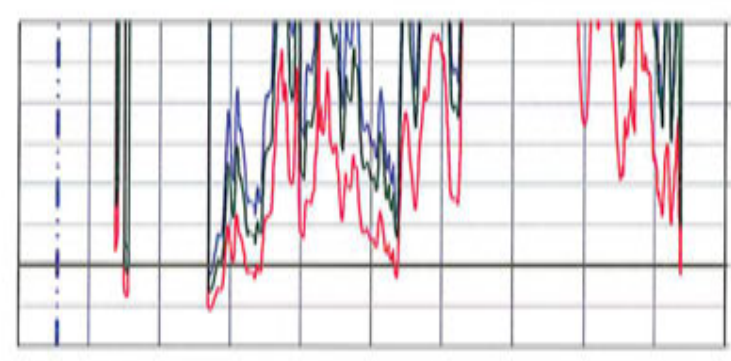
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2003



Factor of Safety  
Seed et al. 2003



Liquefaction  
Seed et al. 2003



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sev. 04	0.25	7.1	-
Jun. 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.1
1.1
0.4

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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LOCATION

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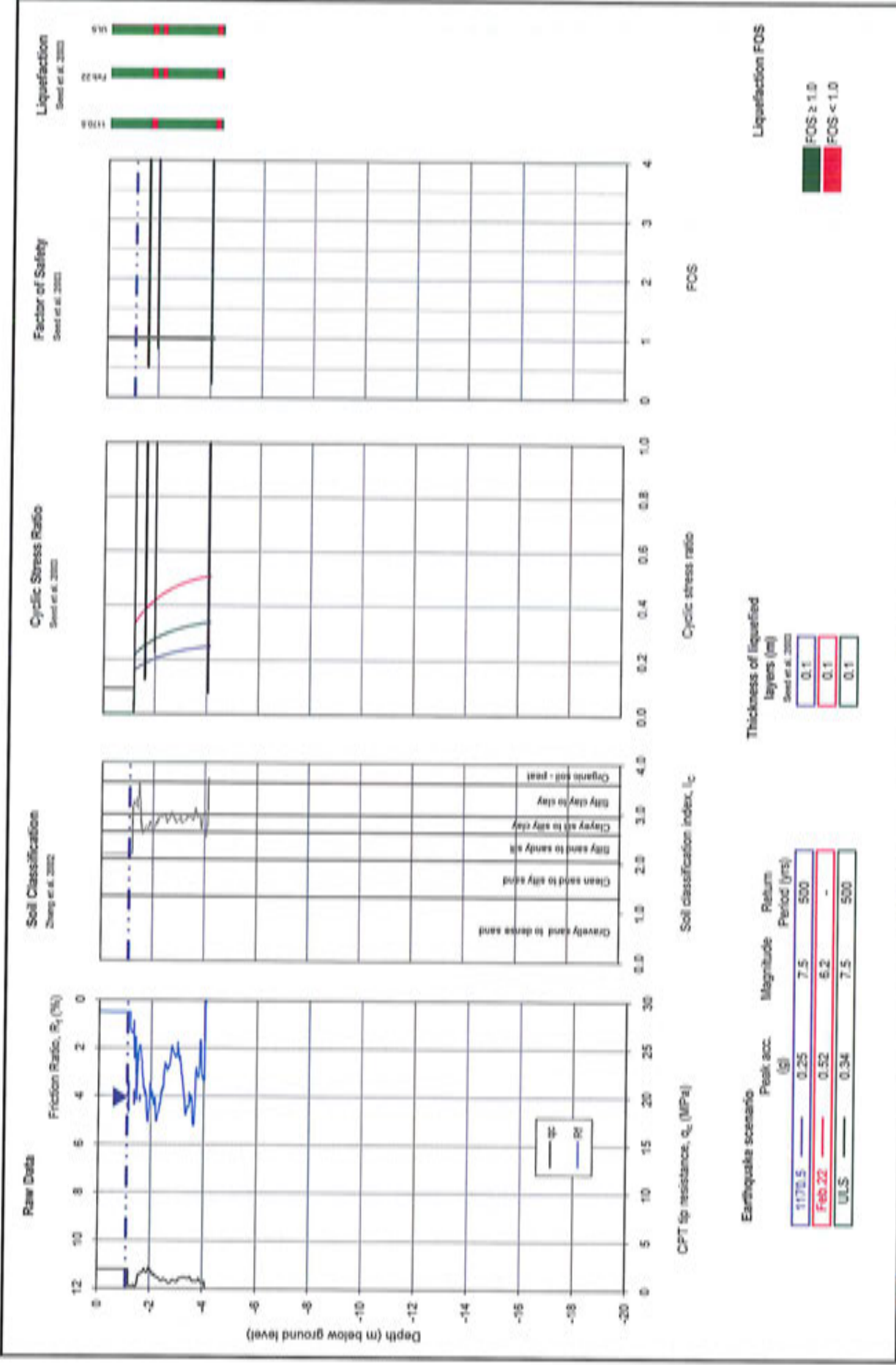
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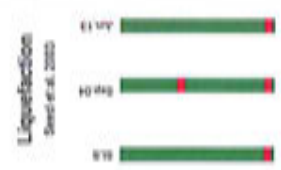
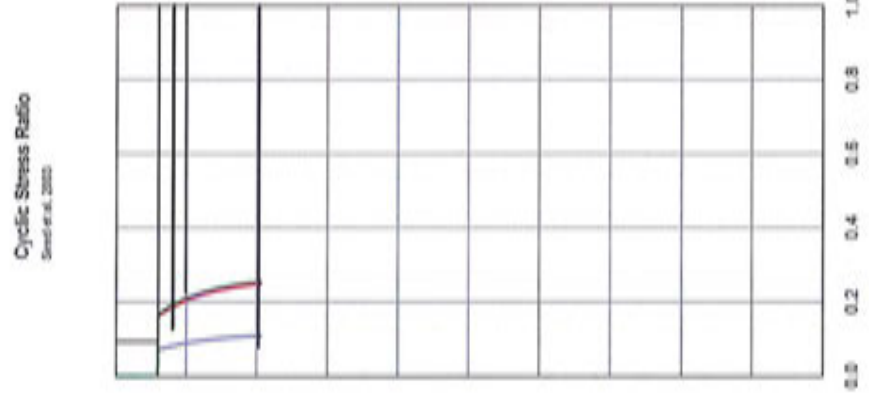
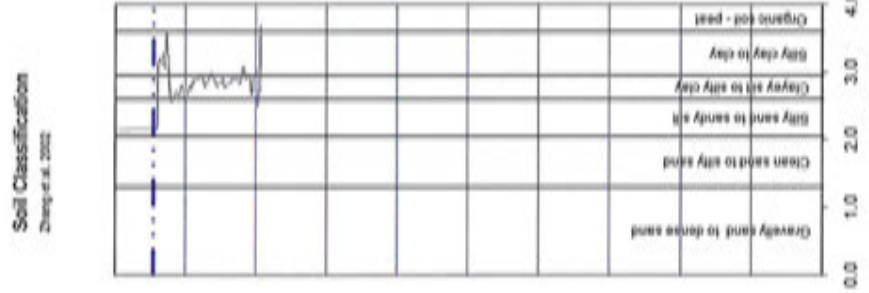
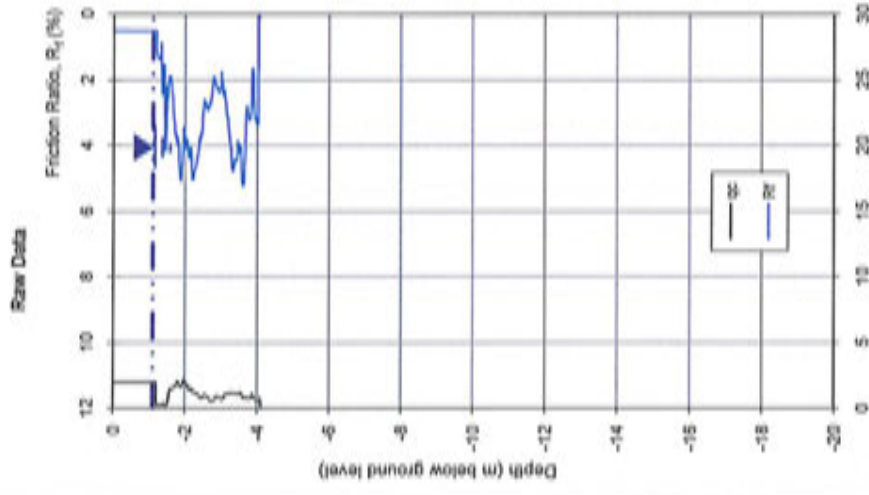
31/12/2011

Liquefaction Assessment from CPT Results





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	SOIL NO. <b>CPT-CBD-105</b>	SET NUMBER 52006.301
FILE Liquefaction Assessment from CPT Results		



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5
Sep-04	0.25	7.1
Jun-13	0.25	6

Thickness of liquefied layers (m)

0.0
0.1
0.0

Liquefaction FOS

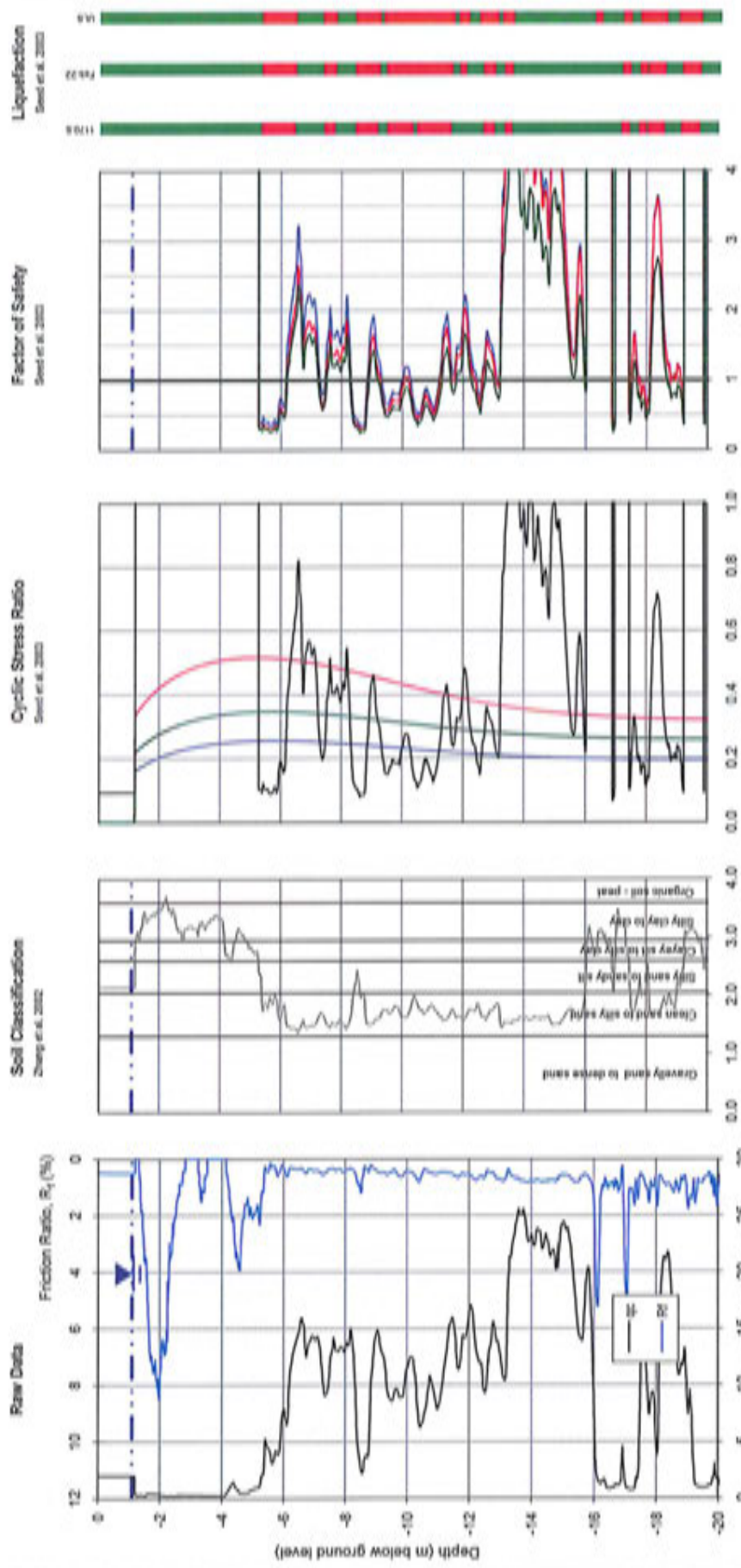
FOS $\geq$ 1.0
FOS $<$ 1.0



Tonkin & Taylor Ltd  
Environmental & Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

PROJECT NUMBER: CPT-CBD-105  
JOB NUMBER: 52000\_301  
DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

Location: CPT-CBD-105a

Job Number: 52000.301

Client Project: TTT

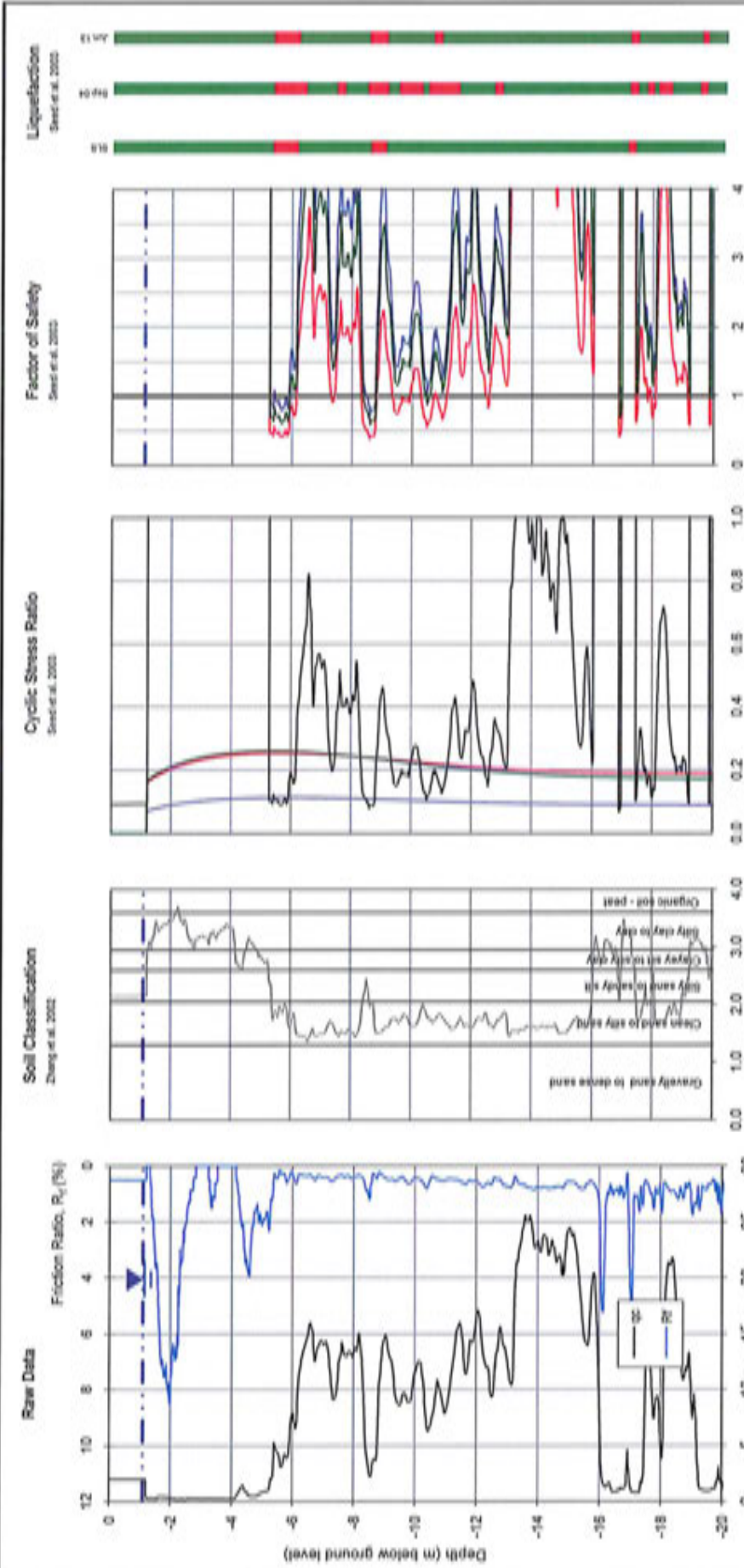
Analysed: RAP

Checked: AFF

Date: 6/12/2011

Engineer: Toekle & Taylor Ltd  
Environmental & Engineering Consultants

Liquefaction Assessment from CPT Results



**CPT tip resistance,  $q_t$  (MPa)**

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep. 04	0.25	7.1	-
Jun. 13	0.25	6	-

**Thickness of liquefied layers (m)**

1.0
3.4
1.3

**Liquefaction FOS**

FOS $\geq$ 1.0
FOS $<$ 1.0



**Troikin & Taylor Ltd**  
Environmental & Engineering Consultants

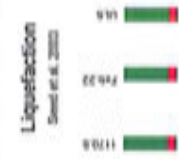
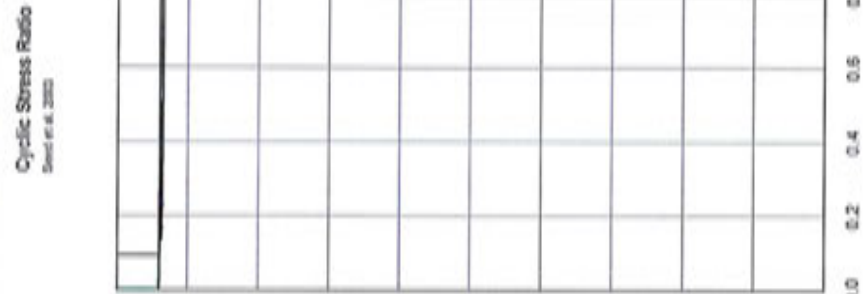
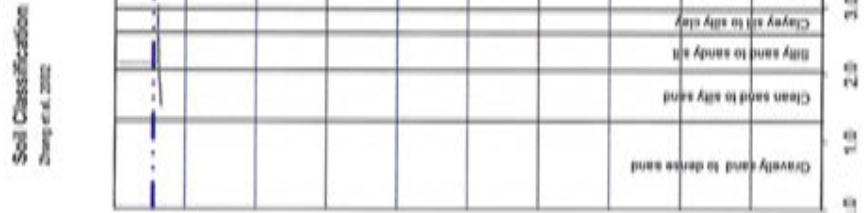
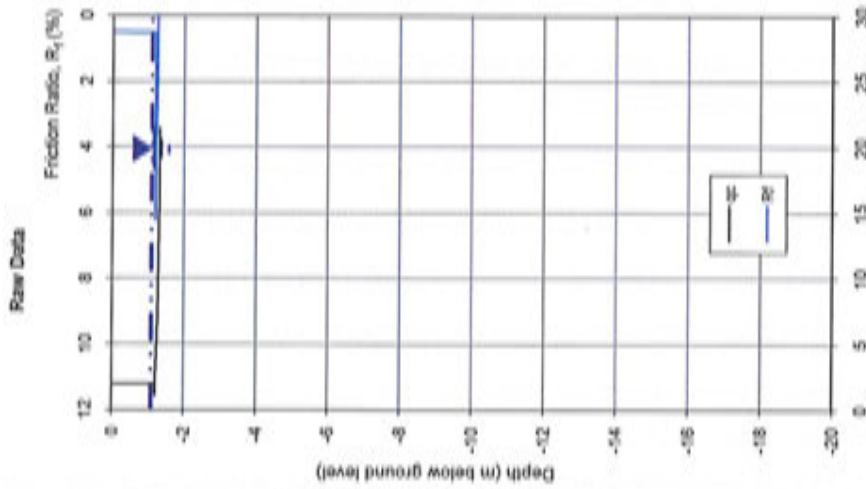
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**PROJECT**  
Liquefaction Assessment from CPT Results

**LOCATION**  
CPT-CBD-105a

**DATE** 7/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF  
**FILE**

**LOT NUMBER** 52000\_301



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1:170.5	0.25	7.5	500
Feb. 22	0.52	6.2	-
ULLS	0.34	7.5	500

Thickness of liquefied layers (m)

Seed et al. 2002

0.0
0.5
0.0

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



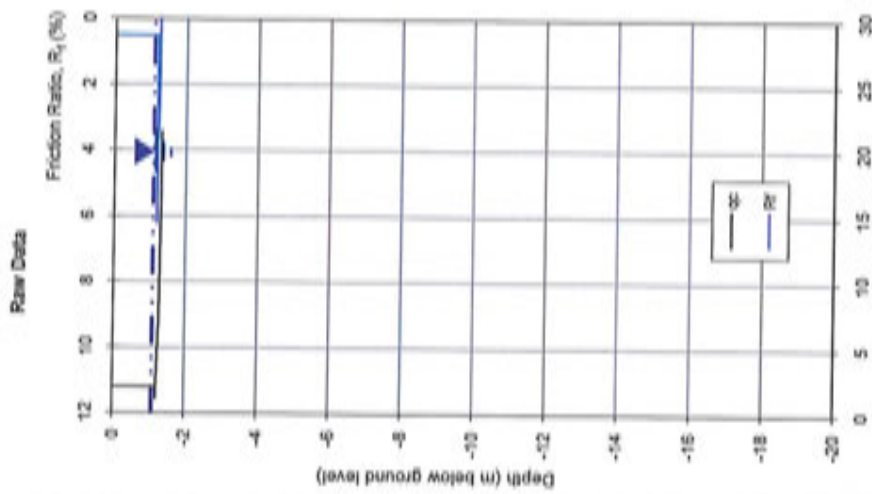
**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

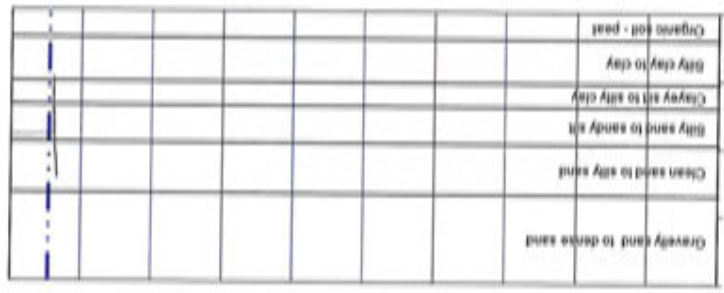
**CPT-CBD-106**  
JOB NUMBER: 52000.301

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

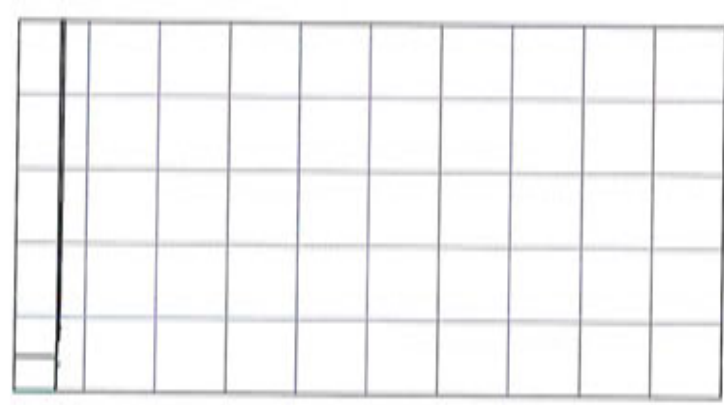
Liquefaction Assessment from CPT Results



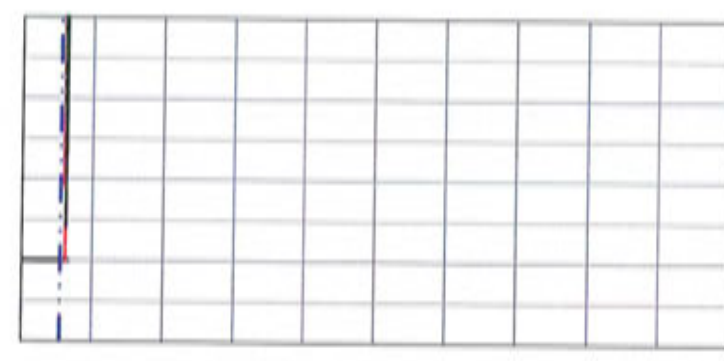
**Soil Classification**  
Zheng et al. 2002



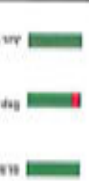
**Cyclic Stress Ratio**  
Seed et al. 2003



**Factor of Safety**  
Seed et al. 2003



**Liquefaction**  
Seed et al. 2003



**CPT tip resistance,  $q_t$  (MPa)**

**Soil classification index,  $I_c$**

**Cyclic stress ratio**

**Earthquake scenario**

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.25	6	-

**Thickness of liquefied layers (m)**

Thickness of liquefied layers (m)
0.0
0.0
0.0

**Liquefaction FOS**



**Taylor & Taylor Ltd**  
Environmental & Engineering Consultants

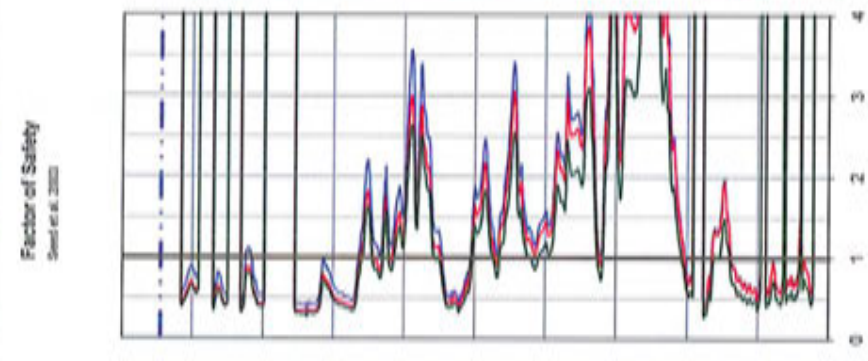
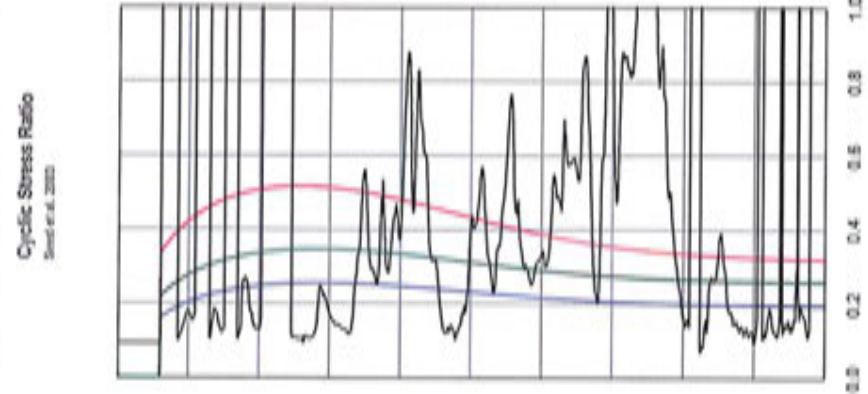
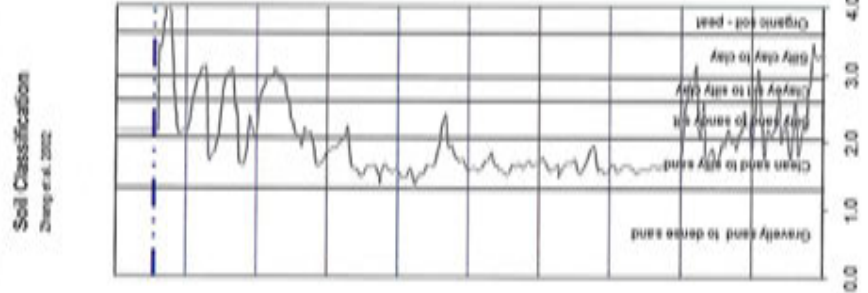
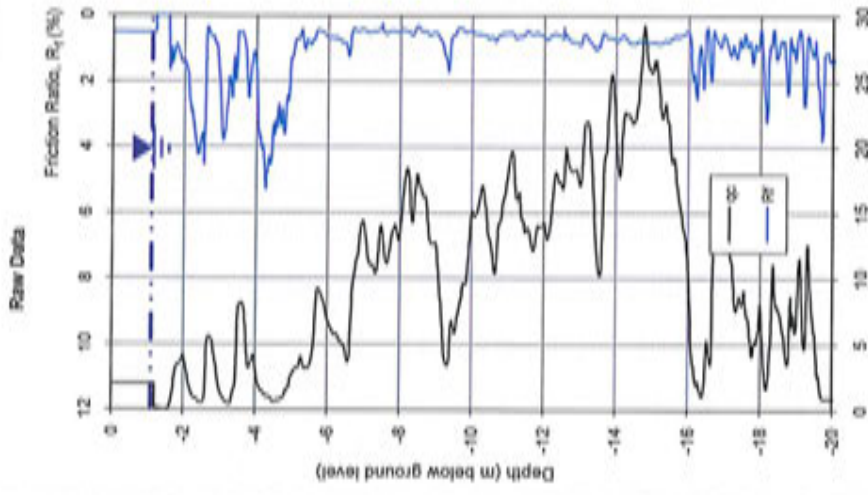
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**PROJECT**  
CPT-CBD-106

**FILE**  
Job number: 52000.301

**DATE** 7/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_p$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
0.25	7.5	500
0.52	6.2	-
0.34	7.5	500

Thickness of liquefied layers (m)

6.7
7.4
8.5

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



Tonkin & Taylor Ltd  
Environmental & Engineering Consultants

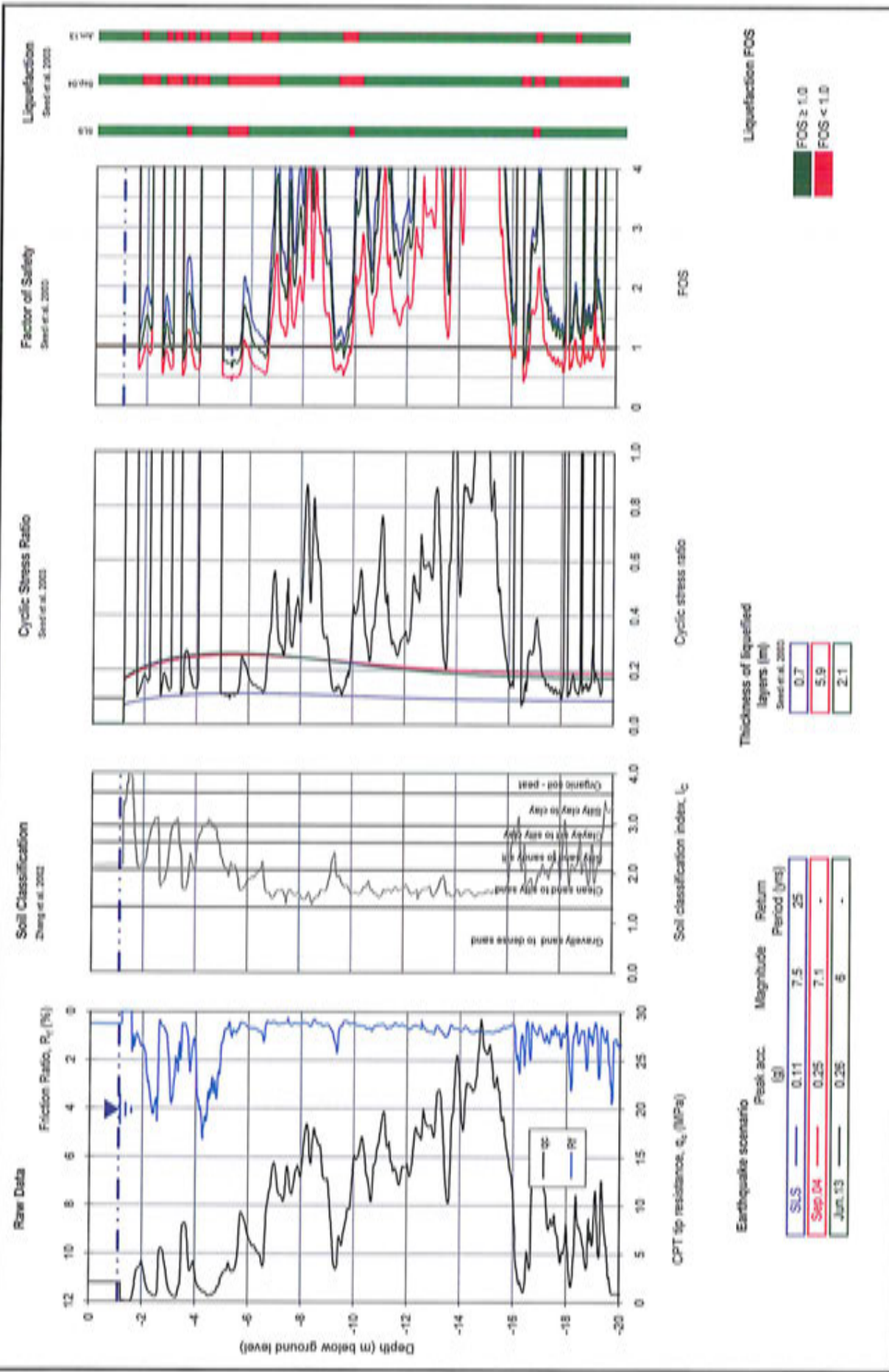
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-106a

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

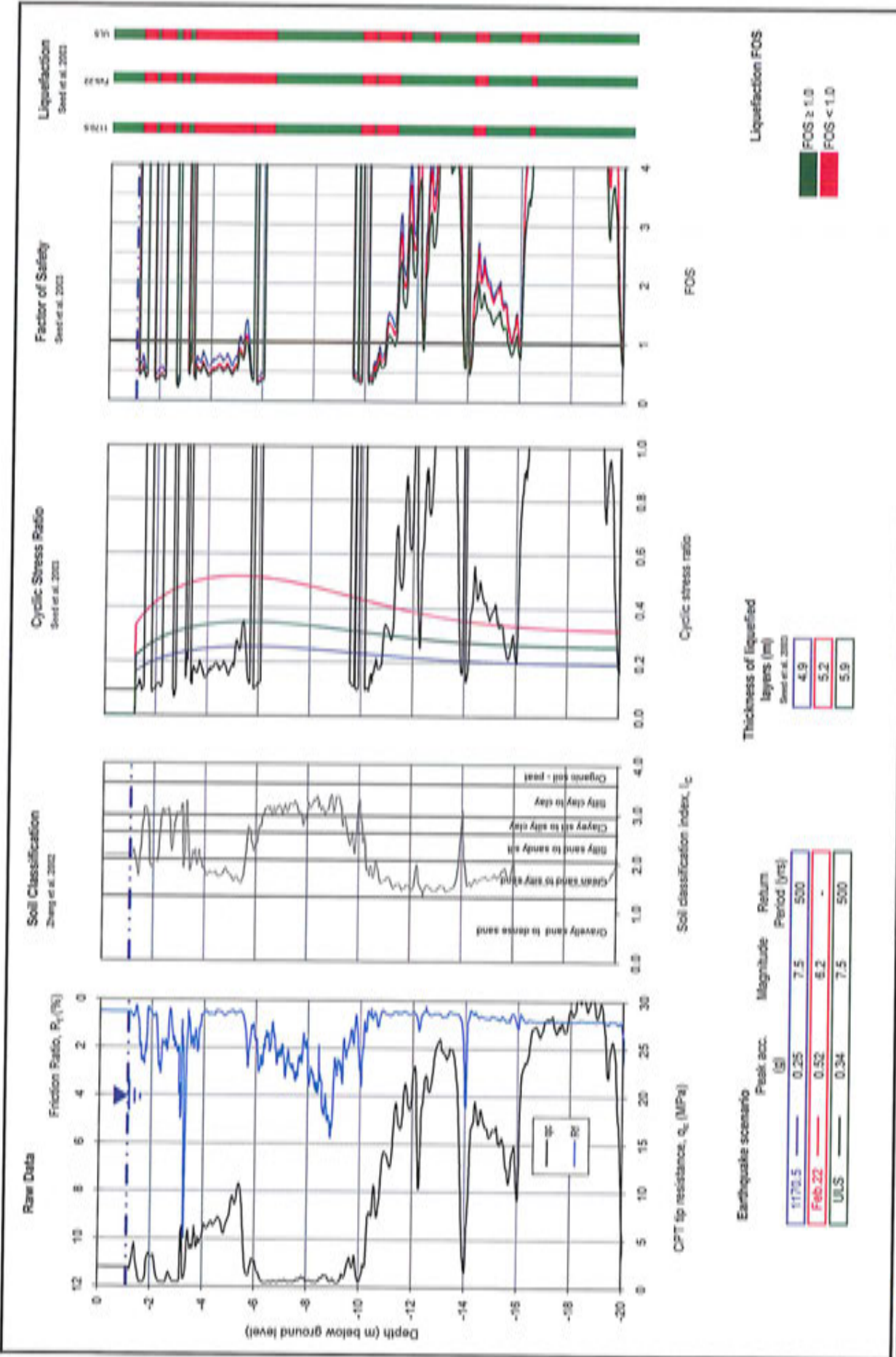
FILE  
Liquefaction Assessment from CPT Results

JOB NUMBER  
52000.301

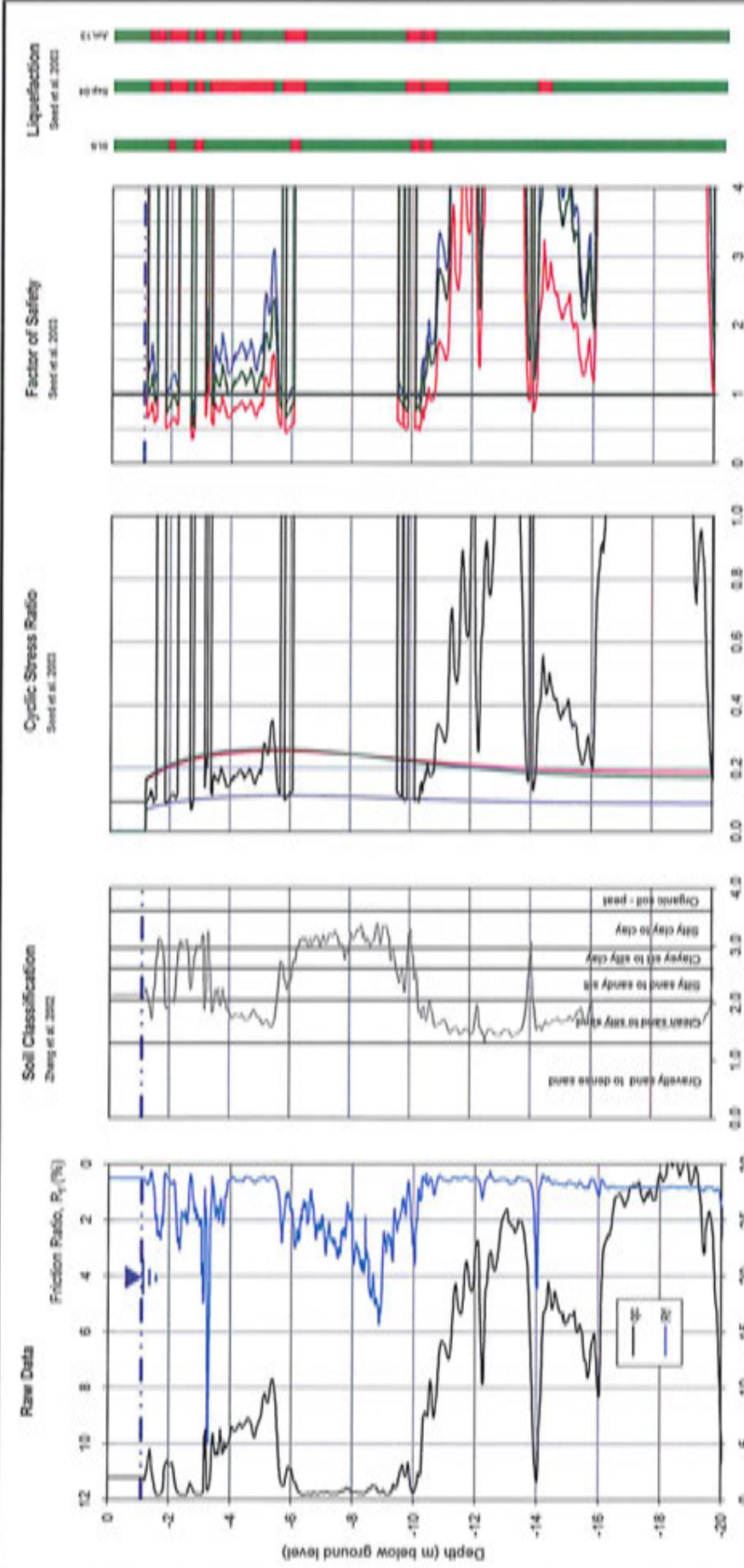


 <p><b>Tonkin &amp; Taylor Ltd</b> Environmental &amp; Engineering Consultants</p>	<p>CLIENT PROJECT: <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City</p>	<p>DATE: 7/12/2011</p>
		<p>ANALYSED: RAP</p>
<p>FILE: <b>CPT-CBD-106a</b></p>		<p>CHECKED: AFF</p>
<p>LIQUEFACTION ASSESSMENT FROM CPT RESULTS</p>		<p>JOB NUMBER: 52000.301</p>





 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT/PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-108</b>	DATE 6/12/2011
	TITLE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 520000_301	ANALYSED RAP
			CHECKED AFF



**Earthquake scenario**


Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 14	0.25	7.1	-
Jun 13	0.25	6	-

**Thickness of liquefied layers (m)**

Scenario	Thickness (m)
SLS	0.5
Sep 14	4.5
Jun 13	1.8

**Liquefaction FOS**

Scenario	FOS $\geq$ 1.0 (m)	FOS $<$ 1.0 (m)
SLS	~10	~10
Sep 14	~10	~10
Jun 13	~10	~10



**TTF**  
Tooklin & Taylor Ltd  
Environmental & Engineering Consultants

**CLIENT PROJECT**

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

**FILE**

Liquefaction Assessment from CPT Results

**LOCATION**

CPT-CBD-108

**JOB NUMBER**

52000\_301

**DATE**

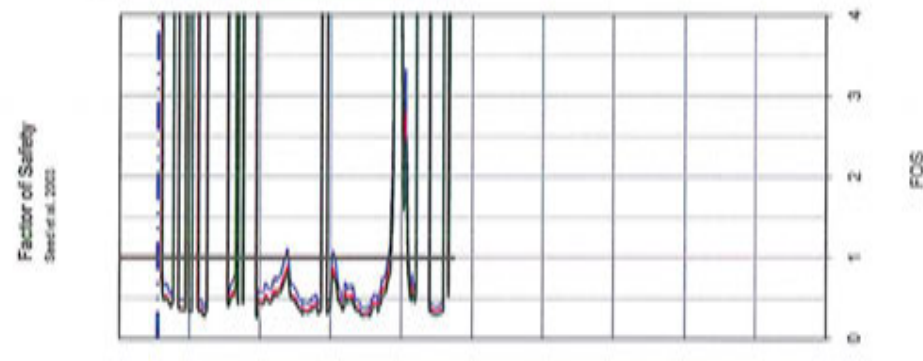
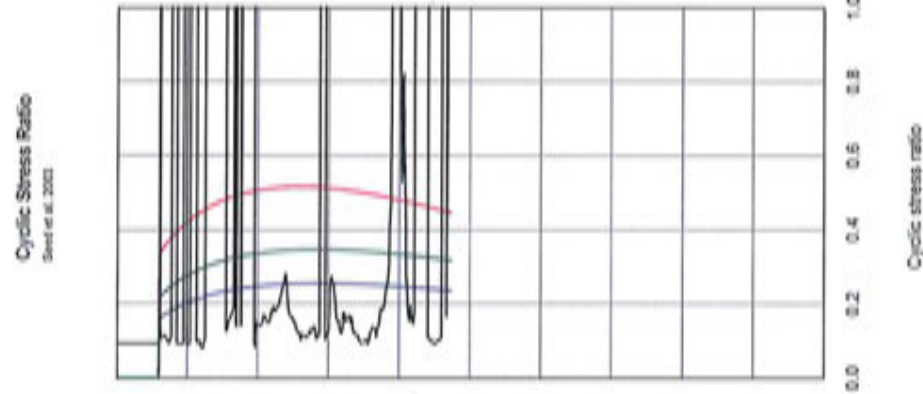
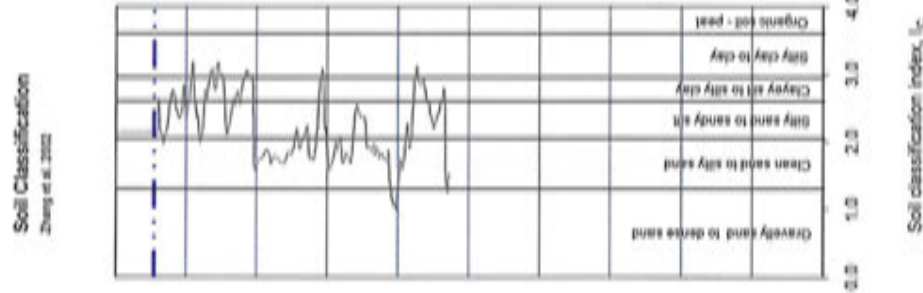
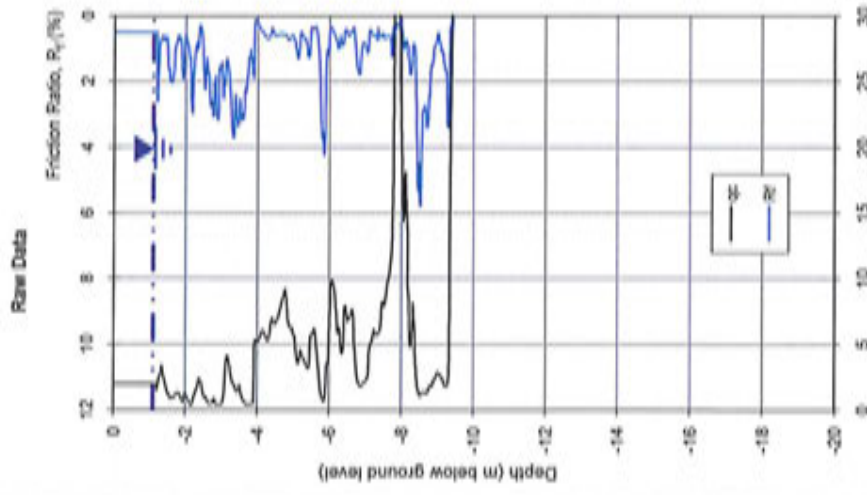
7/12/2011

**ANALYSED**

RAP

**CHECKED**

AFF



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb.22	0.52	6.2	-
U.L.S.	0.34	7.5	500

Thickness of liquefied layers (m)

Scenario	Thickness (m)
1170.5	5.3
Feb.22	5.5
U.L.S.	5.5



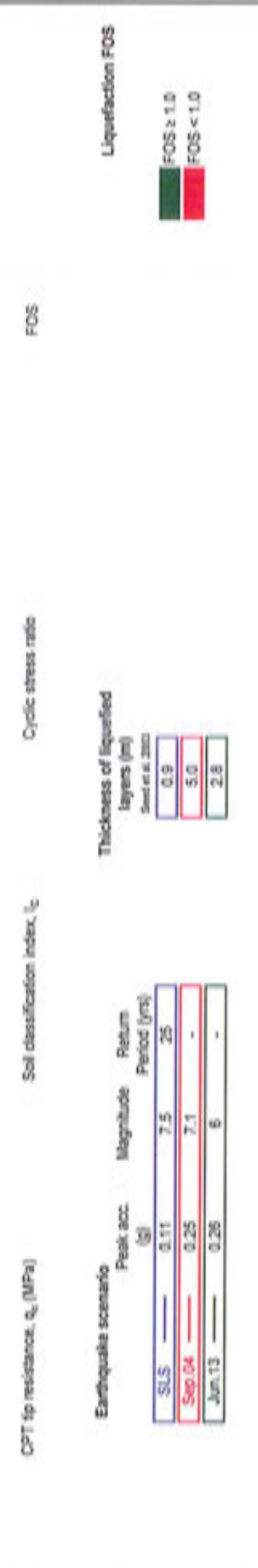
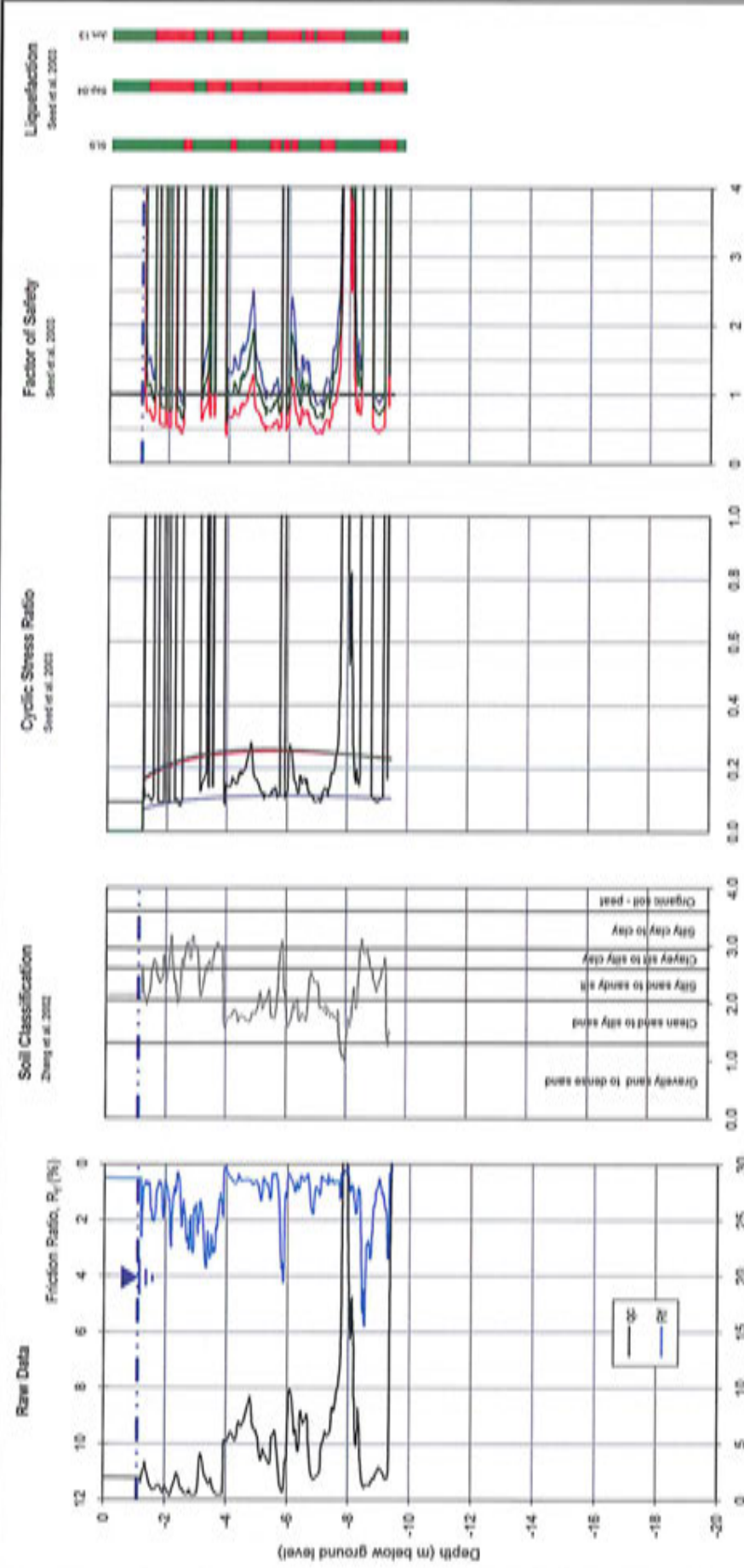
Tonkin & Taylor Ltd  
Environmental &  
Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

SECTION  
**CPT-CBD-109**  
JOB NUMBER  
52000.301

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

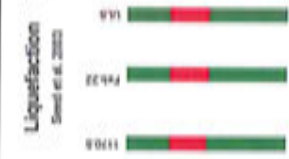
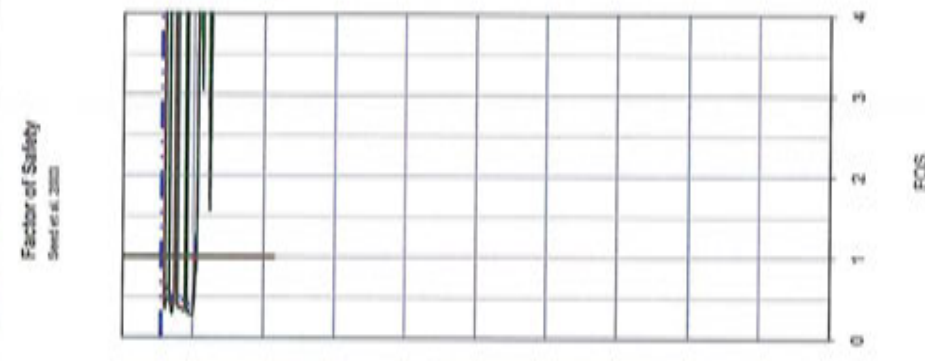
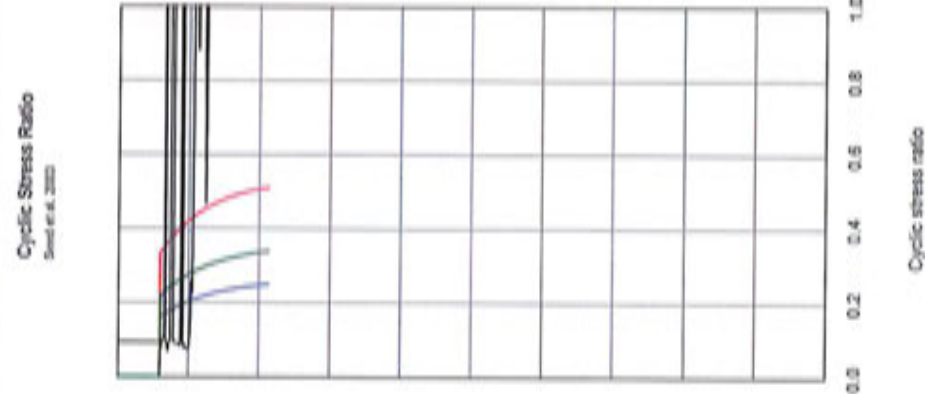
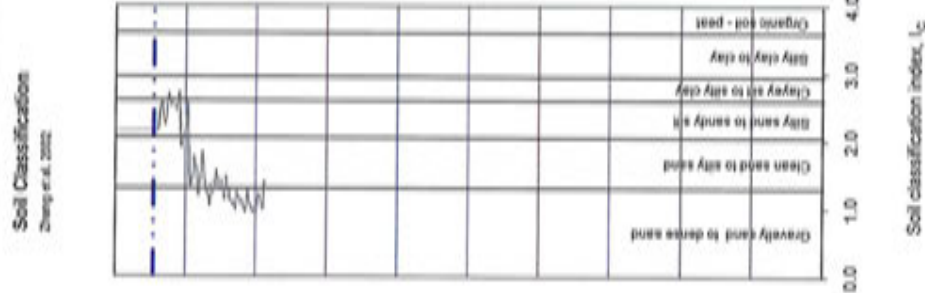
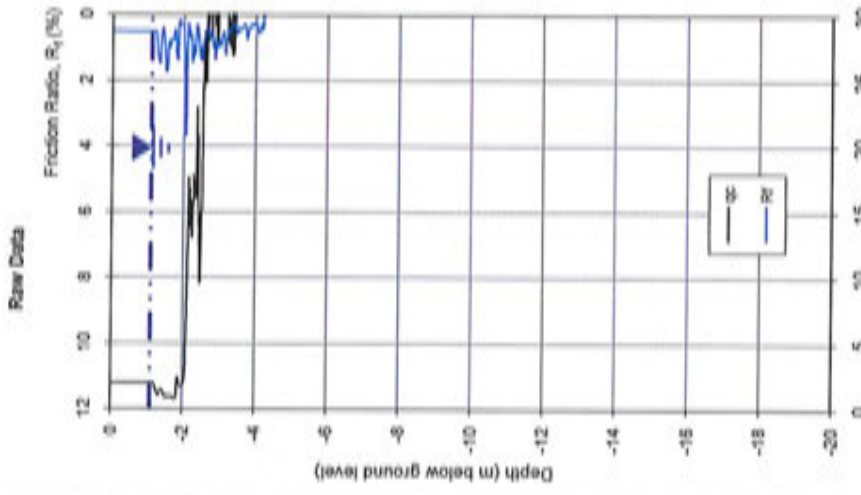
Liquefaction Assessment from CPT Results



Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.04	0.25	7.1	-
Jun.13	0.25	6	-

Soil classification	Thickness of liquefied layers (m)
Cravely sand to dense sand	0.9
Clean sand to silty sand	5.0
City sand to sandy sil	2.8
Clayey sil to silty clay	-
City clay to clay	-
Craysil soil - peat	-

	<b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-109</b>	DATE 7/12/2011
	FILE Liquefaction Assessment from CPT Results	LOT NUMBER 520000_301	ANALYSED RAP	CHECKED AFF



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb 22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.7
0.8
0.8

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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Environmental & Engineering Consultants

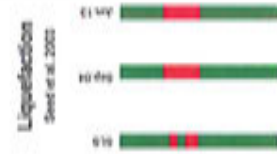
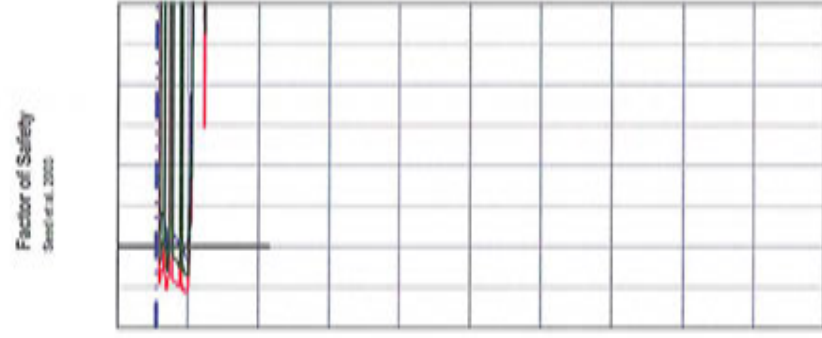
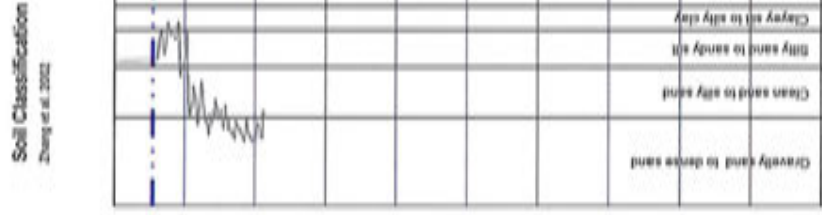
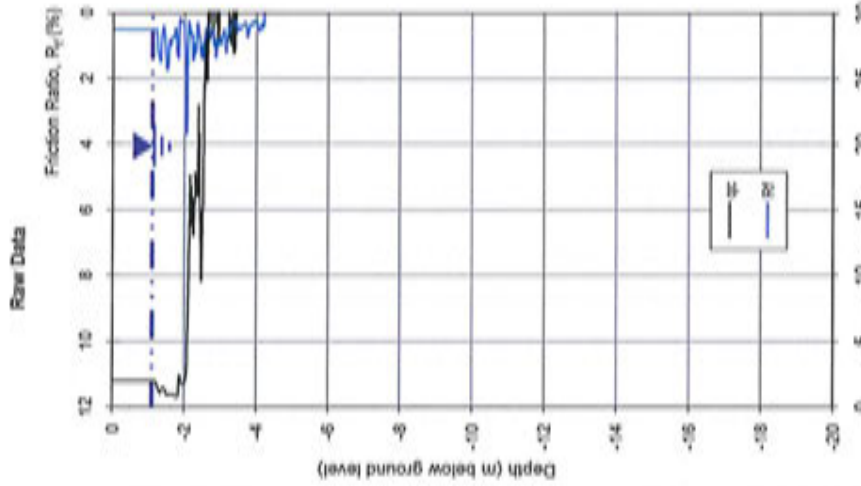
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

SECTION  
CPT-CBD-110

JOB NUMBER  
52000.301

Liquefaction Assessment from CPT Results

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5
Sep 04	0.25	7.1
Jun 13	0.25	6

Thickness of liquefied layers (m)

0.2
0.7
0.5

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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CUSTOMER PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-110

FILE

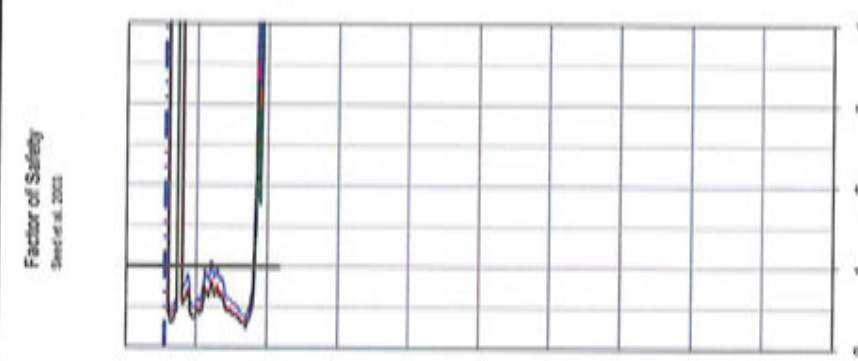
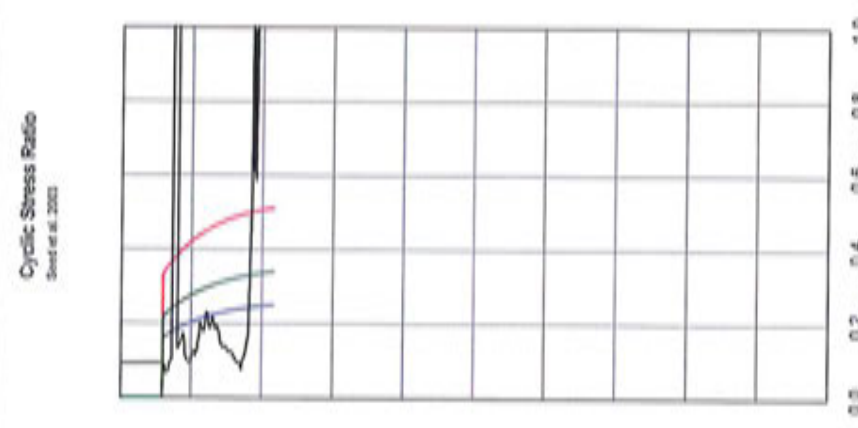
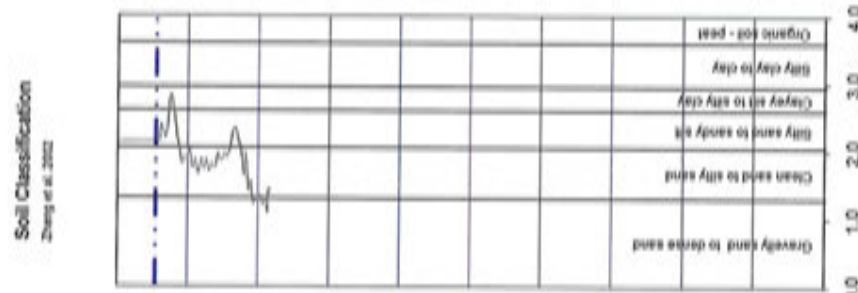
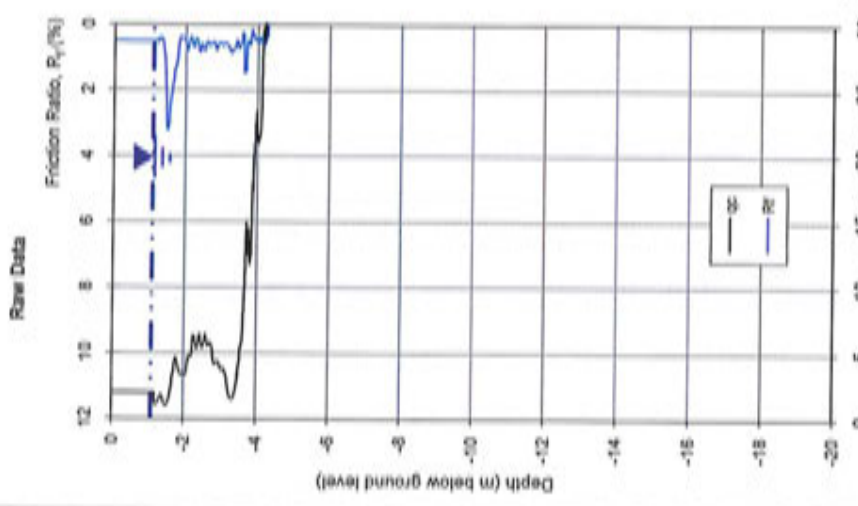
Liquefaction Assessment from CPT Results

Lot NUMBER  
52000\_301

DATE  
7/12/2011

ANALYSED  
RAP

CHECKED  
AFF



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5
Feb 22	0.52	6.2
ULS	0.34	7.5

Thickness of liquefied layers (m)

2.2
2.3
2.3

Liquefaction FOS



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Engineering Consultants

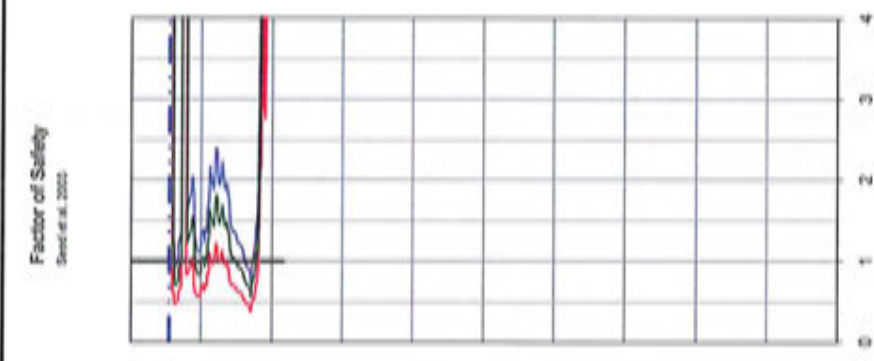
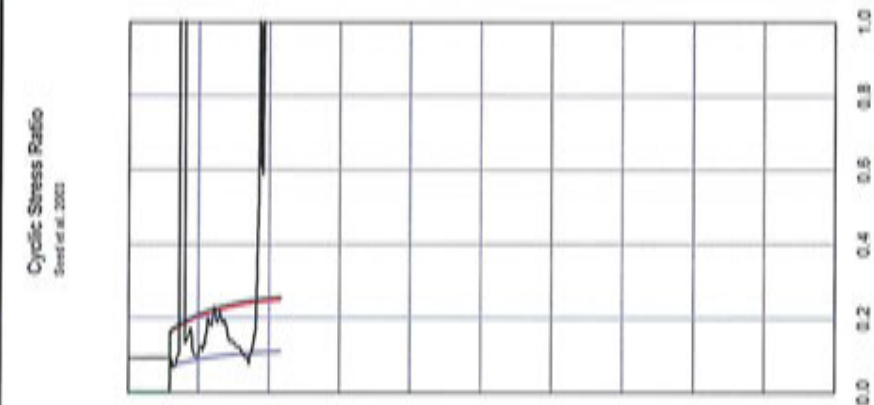
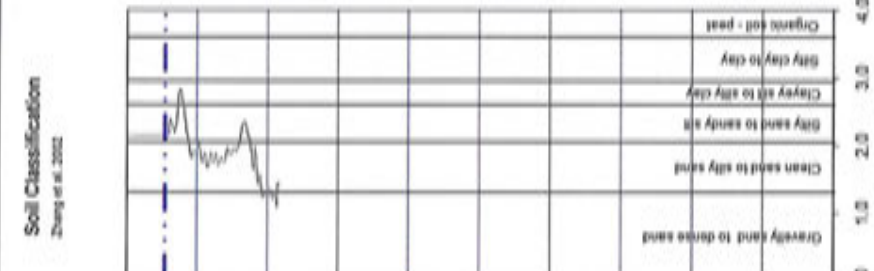
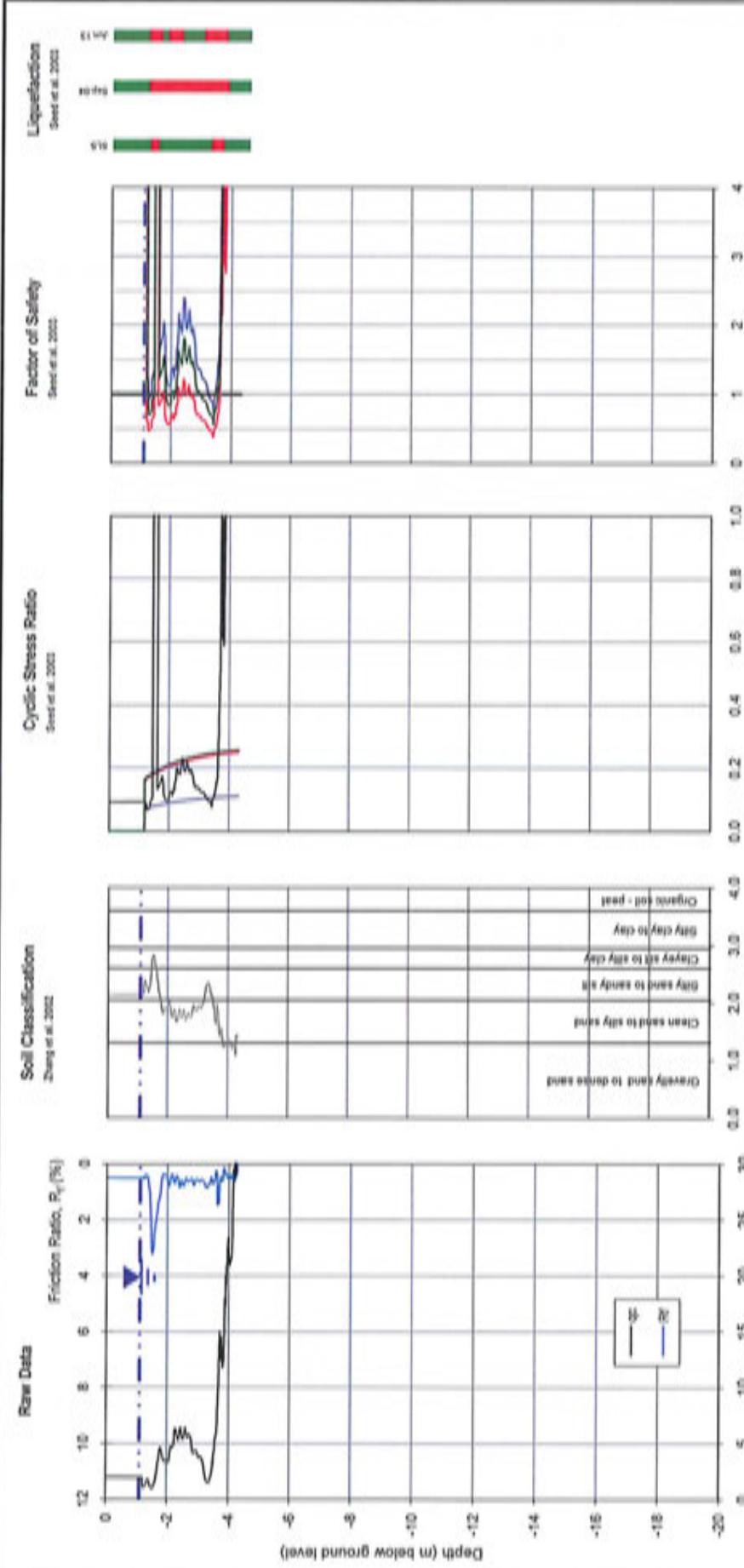
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-111

FILE  
JOB NUMBER  
52000.301

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep. 04	0.25	7.1	-
Jun. 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.3
1.9
1.0

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0

Raw Data

Friction Ratio,  $R_f$  (%)

Depth (m below ground level)

Soil Classification

Zheng et al. 2002

Cyclic Stress Ratio

Seed et al. 2002

Factor of Safety

Seed et al. 2002

Liquefaction

Seed et al. 2002

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

Christchurch City Council  
Geotechnical Assessment from CPT Results

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF

PROJECT NUMBER: 52000\_301

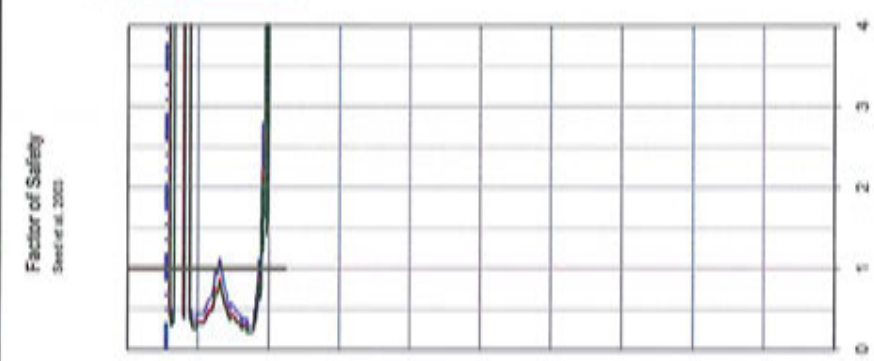
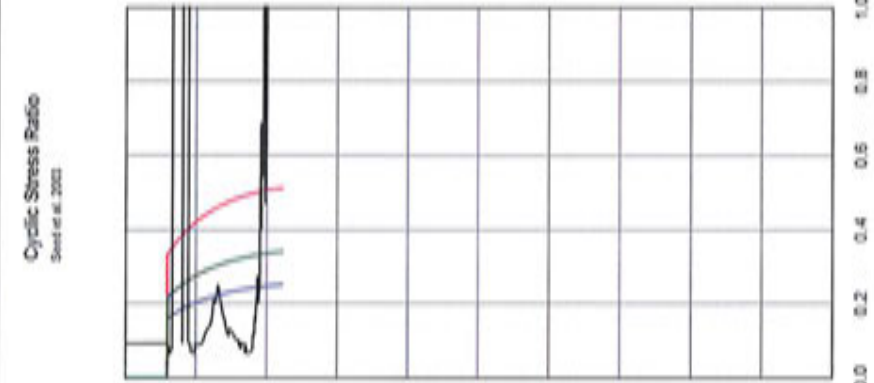
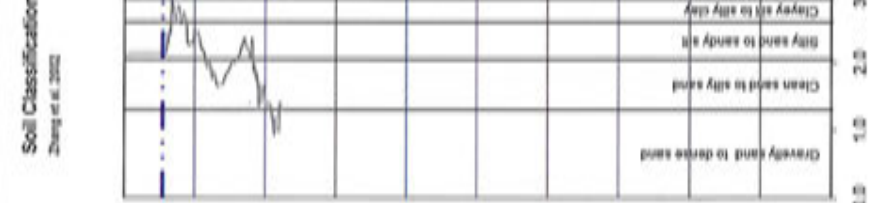
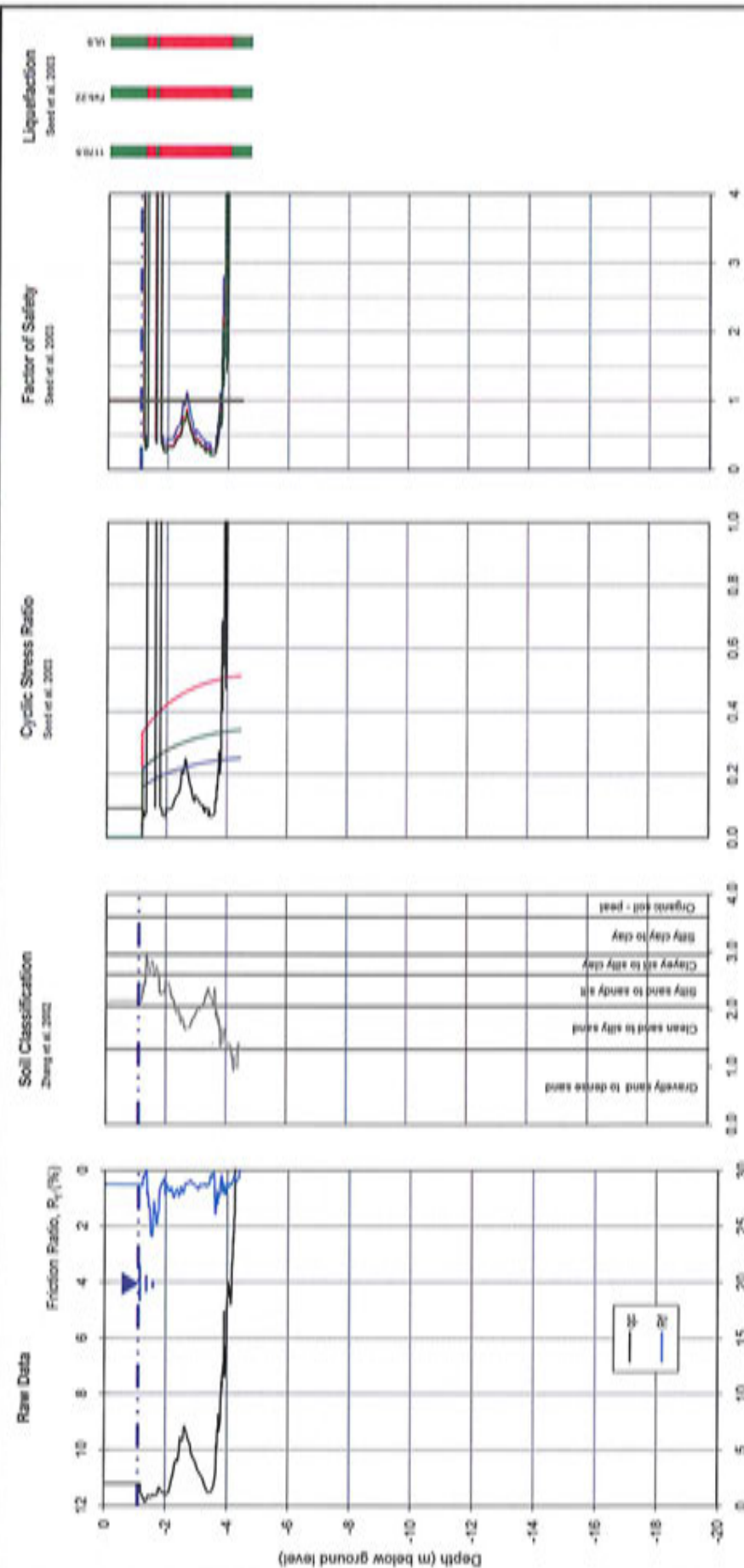
Client: Christchurch City Council

Project: Geotechnical Assessment for Christchurch Central City

File: Liquefaction Assessment from CPT Results

Tonkin & Taylor Ltd  
Environmental & Engineering Consultants





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

Factor of Safety

Liquefaction

Earthquake scenario

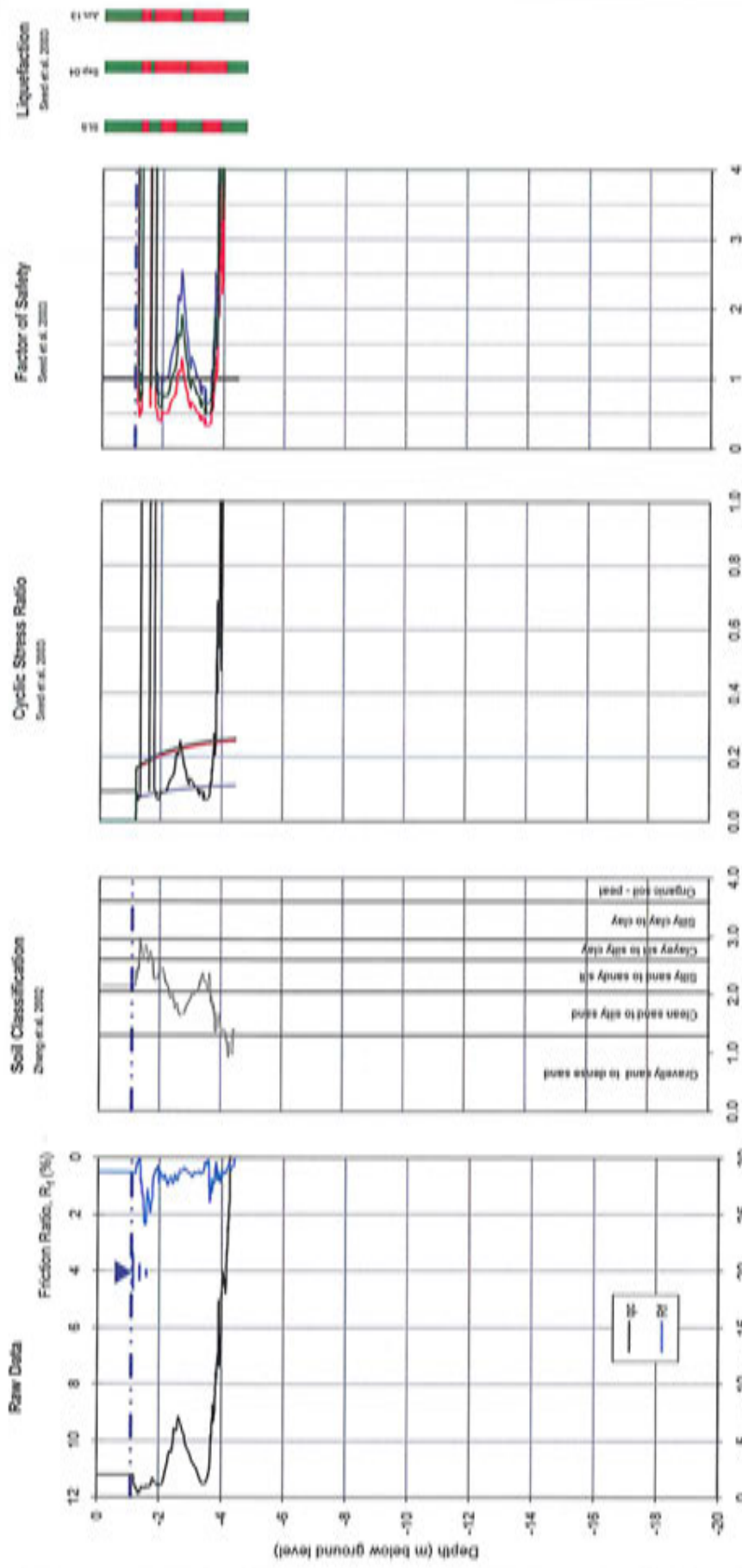
Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb.22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

1170.5	2.1
Feb.22	2.2
ULS	2.2

Liquefaction FOS

FOS $\geq$ 1.0	Green
FOS < 1.0	Red



CPT tip resistance,  $t_p$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

Factor of Safety (FOS)

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

Client/Project: Christchurch City Council

Location: CPT-CBD-111a

Role: [Blank]

Job Number: 52000\_301

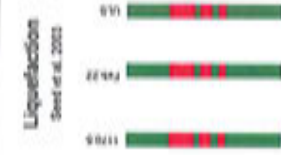
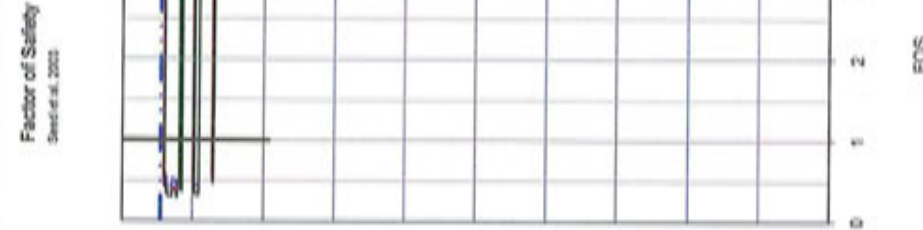
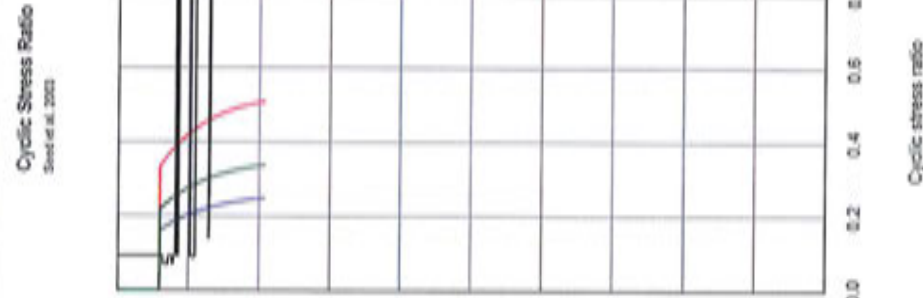
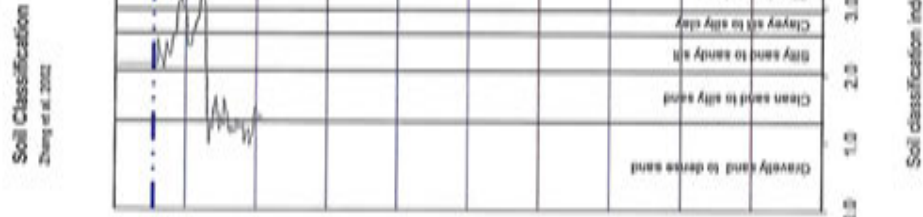
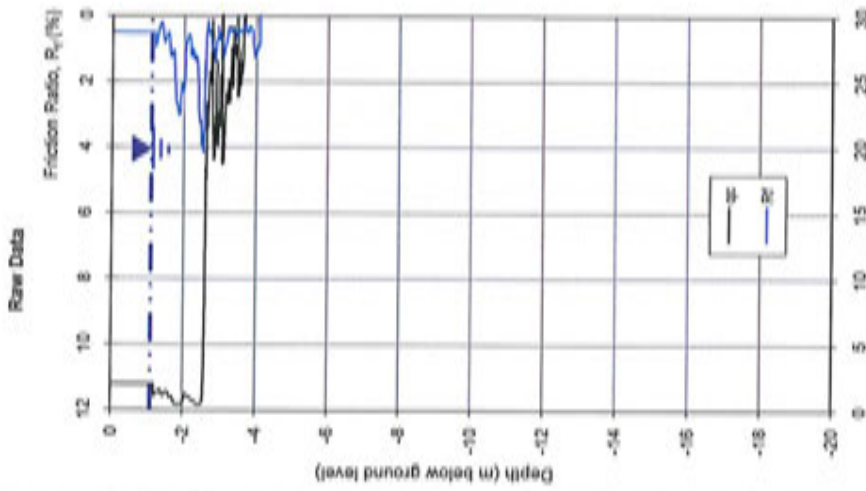
Date Analyzed: 7/12/2011

Date Checked: RMP

Date Affected: AFF

Liquefaction Assessment from CPT Results

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CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
1175.5	7.5	500
0.25	7.5	500
0.52	6.2	-
0.34	7.5	500

**Thickness of liquefied layers (m)**  
Seed et al. 2002

0.8
0.5
0.6

**Liquefaction FOS**

FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

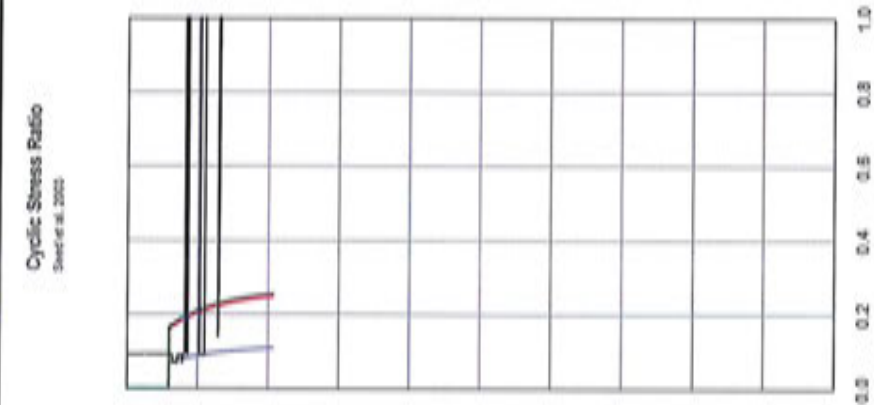
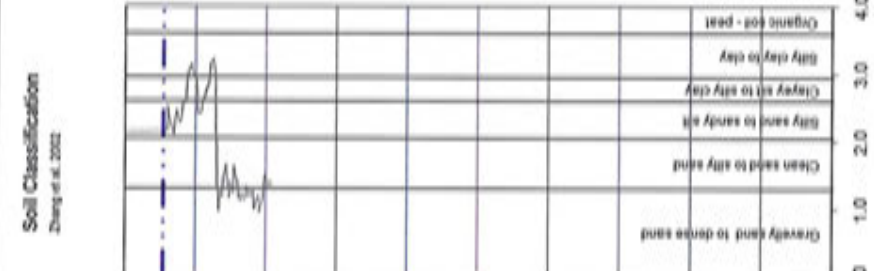
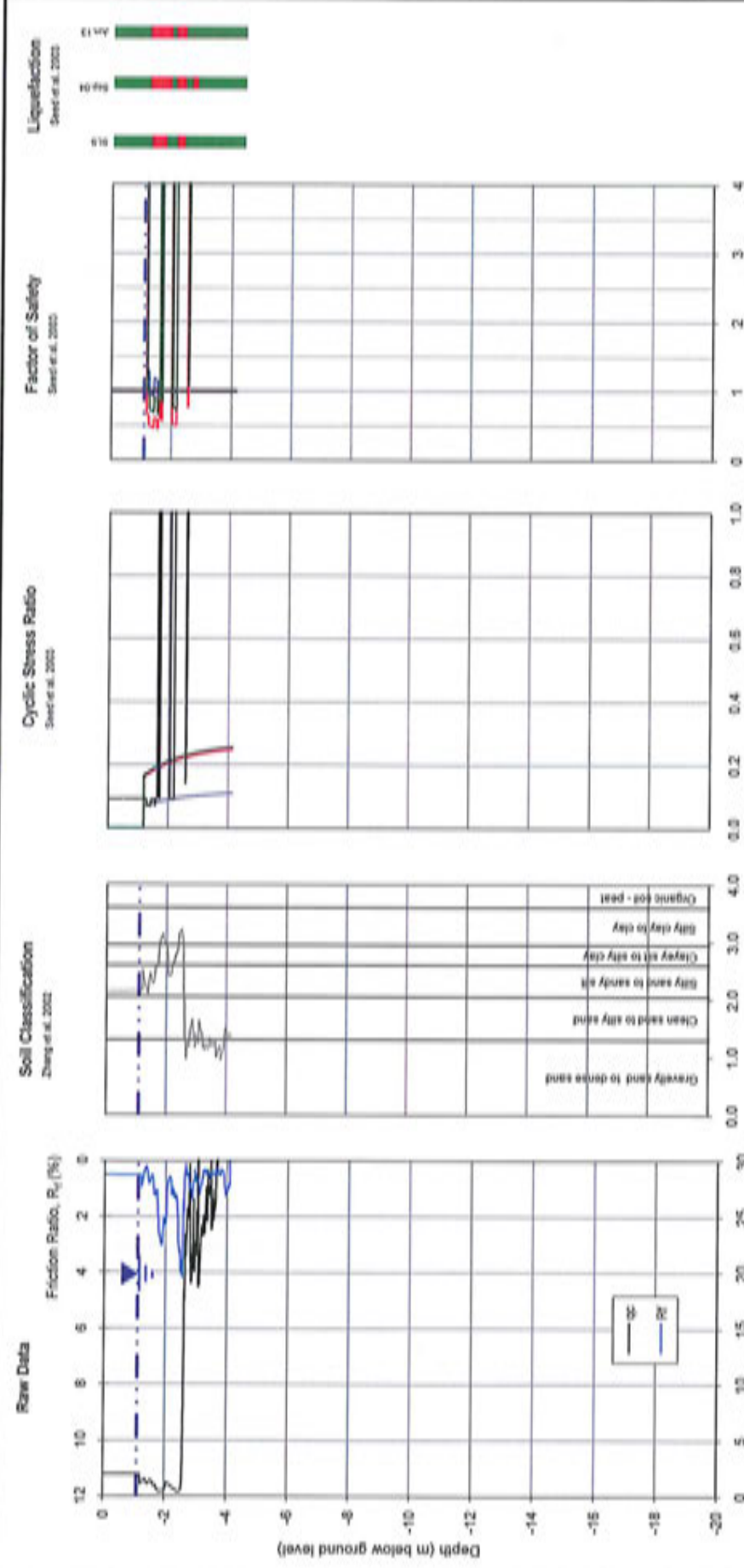
**CPT-CBD-112**

LOT NUMBER

52000.301

DATE 6/12/2011  
ANALYSED RAP  
CHECKED AFF

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Thickness of liquefied layers (m)

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Exp. 04	0.25	7.1	-
Jun. 13	0.25	6	-

Liquefaction FOS

FOS	Color
FOS > 1.0	Green
FOS < 1.0	Red



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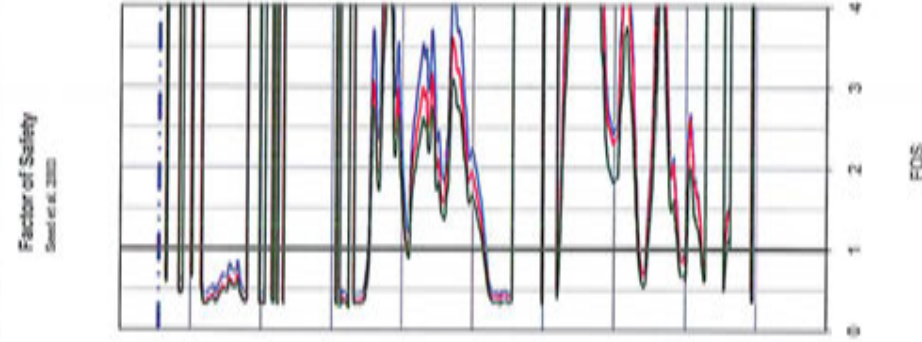
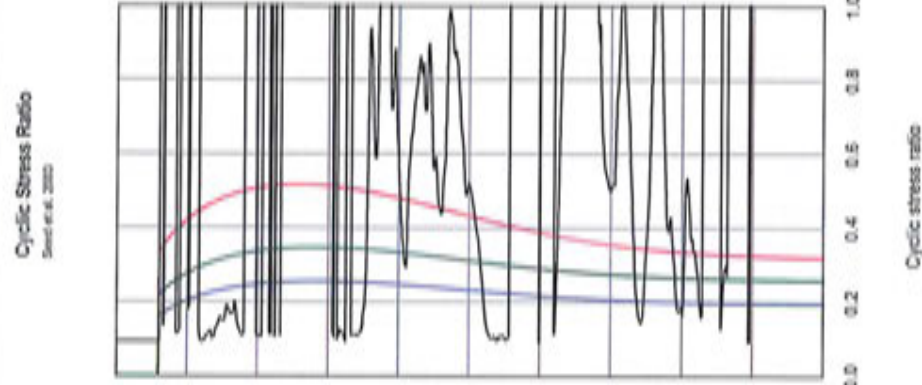
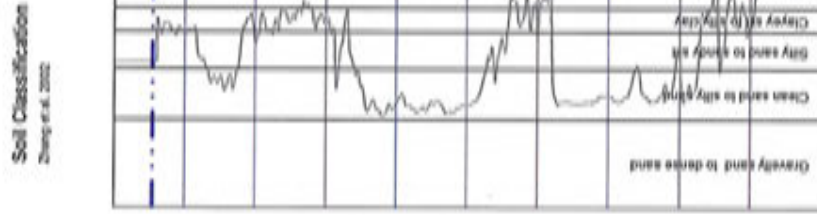
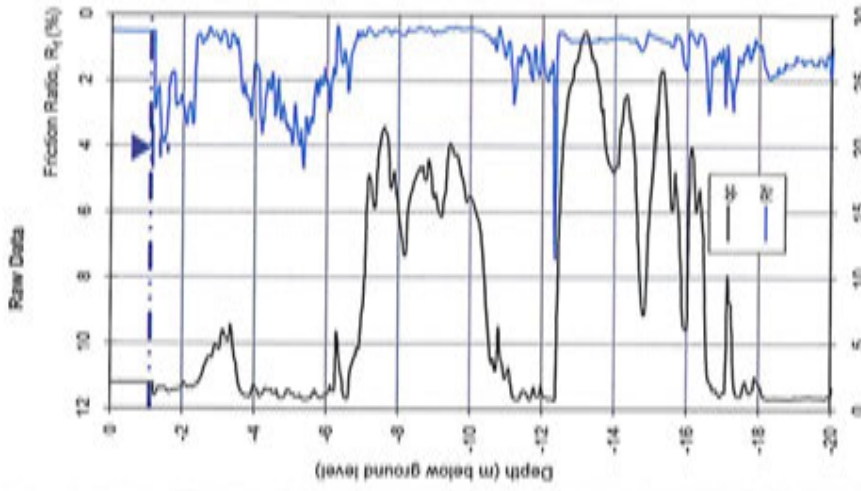
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

CLIENT PROJECT: **Christchurch City Council**  
PROJECT: **Geotechnical Assessment for Christchurch Central City**

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
AFF

LOCATION: **CPT-CBD-112**  
JOB NUMBER: **52000\_301**

Liquefaction Assessment from CPT Results



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
0.25	7.5	500
0.52	6.2	-
0.34	7.5	500

Thickness of liquefied layers (m)

4.1
4.1
4.5

Liquefaction FOS

Legend: FOS  $\geq 1.0$  (green), FOS  $< 1.0$  (red)



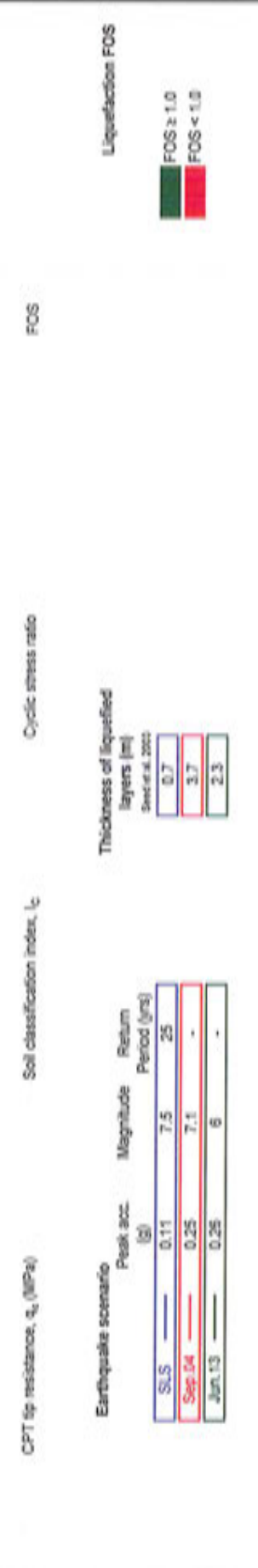
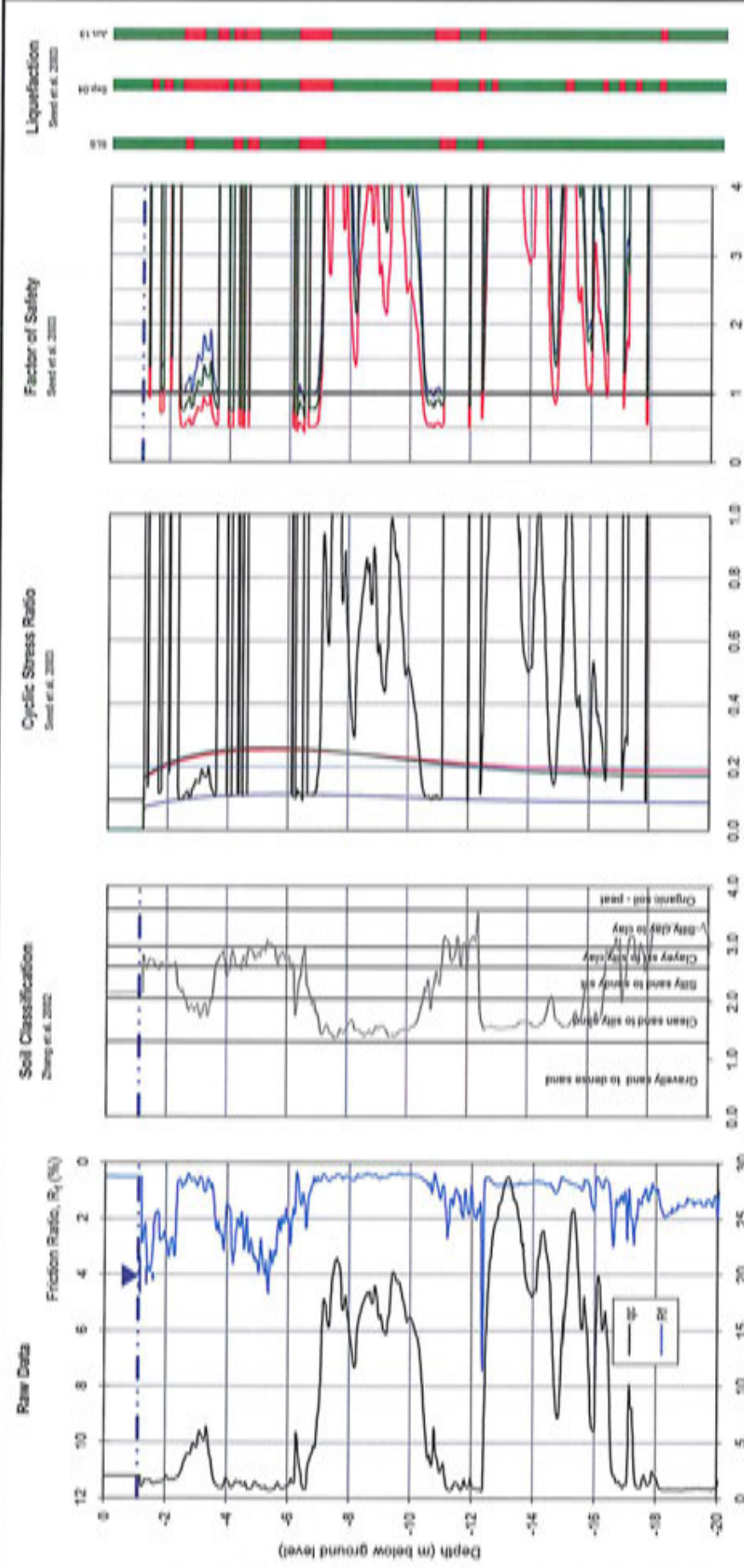
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Geotechnical Assessment for Christchurch Central City

PROJECT: CPT-CBD-113  
JOB NUMBER: 52000.301

DATE: 5/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results





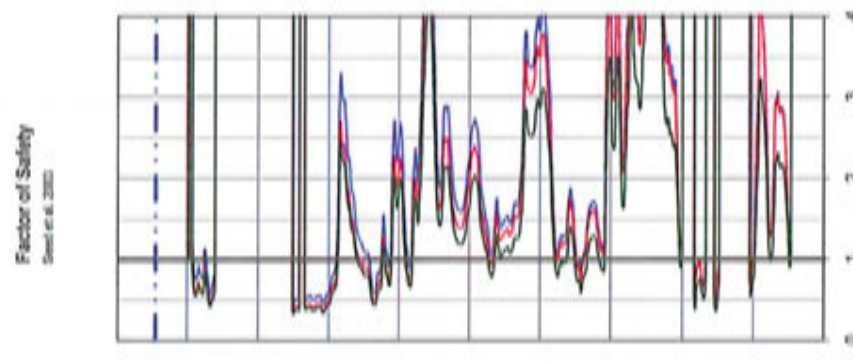
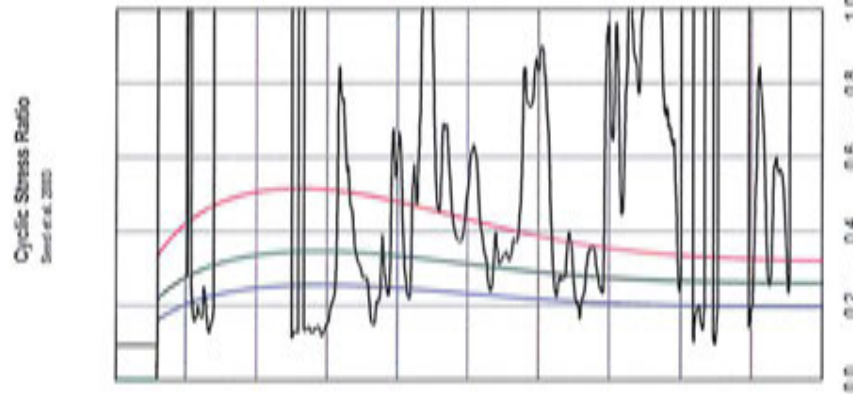
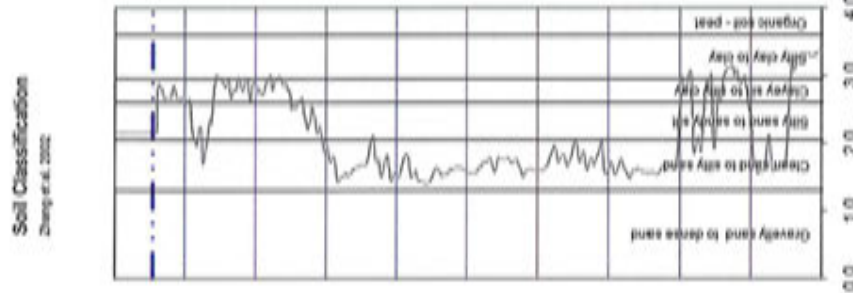
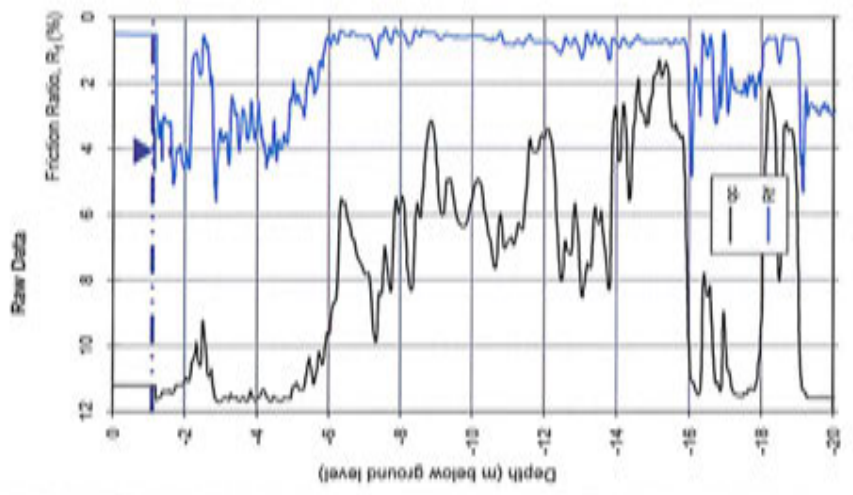
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Geotechnical Assessment for Christchurch Central City

CLIENT PROJECT  
**CPT-CBD-113**

DATE ANALYSED: 17/12/2011  
CHECKED: RAP  
AFF: AFF

FILE NUMBER: 52000\_301



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5
Feb 22	0.52	6.2
U.L.S.	0.34	7.5

Thickness of liquefied layers (m)

2.9
3.7
4.7

Liquefaction FOS



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Geotechnical Assessment for Christchurch Central City

SECTION

CPT-CBD-114

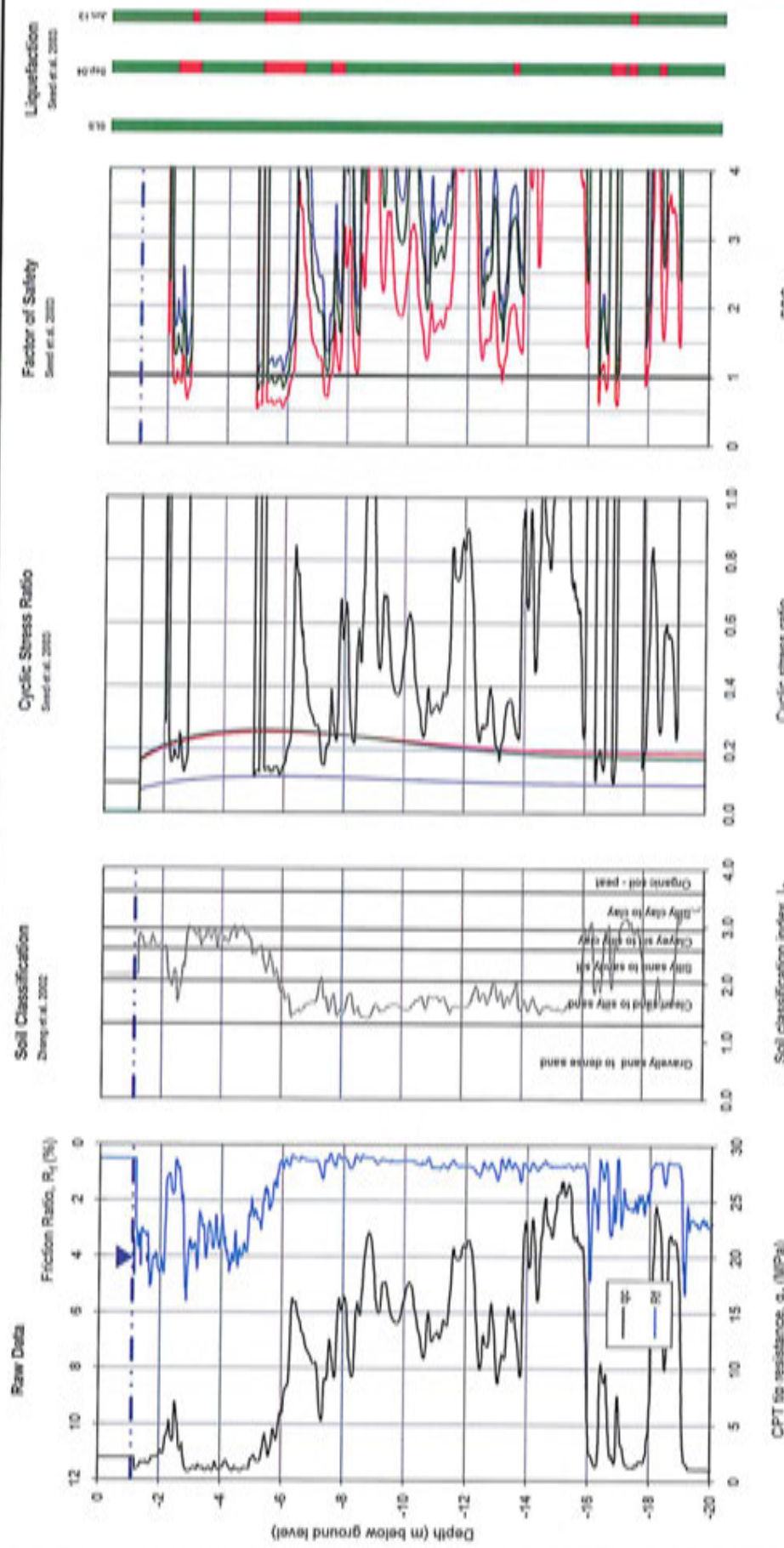
TITLE

Liquefaction Assessment from CPT Results

DATE 6/12/2011  
ANALYSED RAP  
CHECKED AFF

JOB NUMBER

520000.301



Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Seo 04	0.25	7.1	-
Jun.13	0.26	6	-

Thickness of liquefied layers (m)

Thickness (m)	Color
0.0	Blue
2.1	Red
0.5	Green

Liquefaction FOS

FOS	Color
$\geq$ 1.0	Green
$<$ 1.0	Red



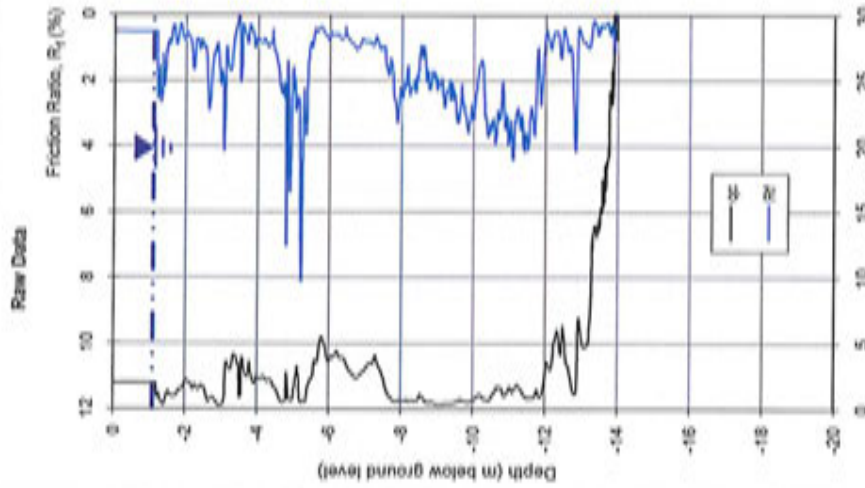
**Tonkin & Taylor Ltd**  
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CLIENT PROJECT  
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

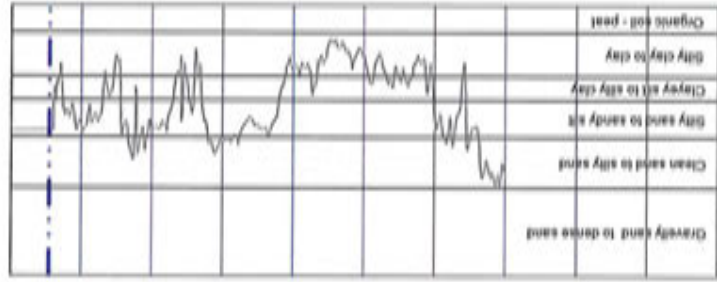
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LOT NUMBER  
52000.301

DATE  
7/12/2011  
ANALYSED  
RAP  
CHECKED  
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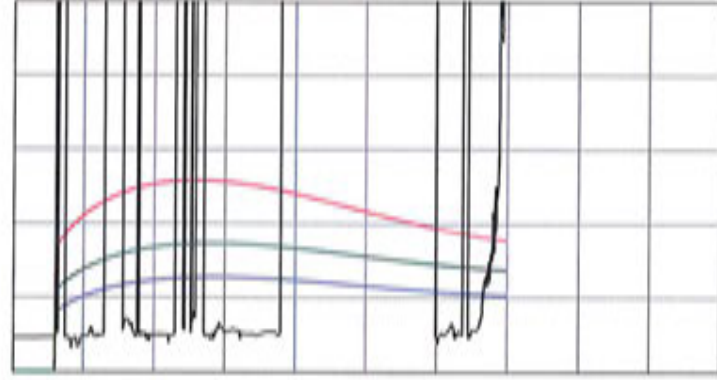




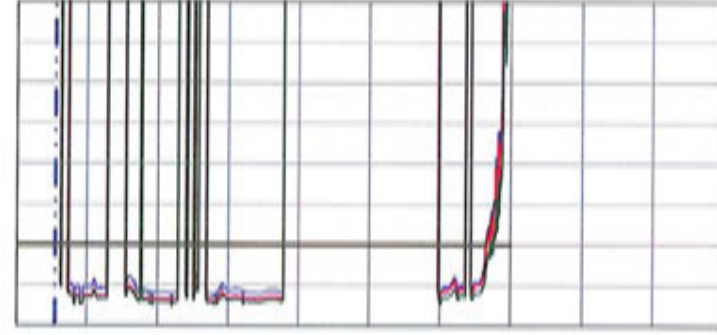
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1175.5	0.25	7.5	500
Feb.22	0.52	6.2	-
U.L.S.	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
6.1
6.2
6.3

Liquefaction FOS

■	FOS $\geq$ 1.0
■	FOS $<$ 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-115

ANALYSED

CHECKED

DATE

6/12/2011

FILE

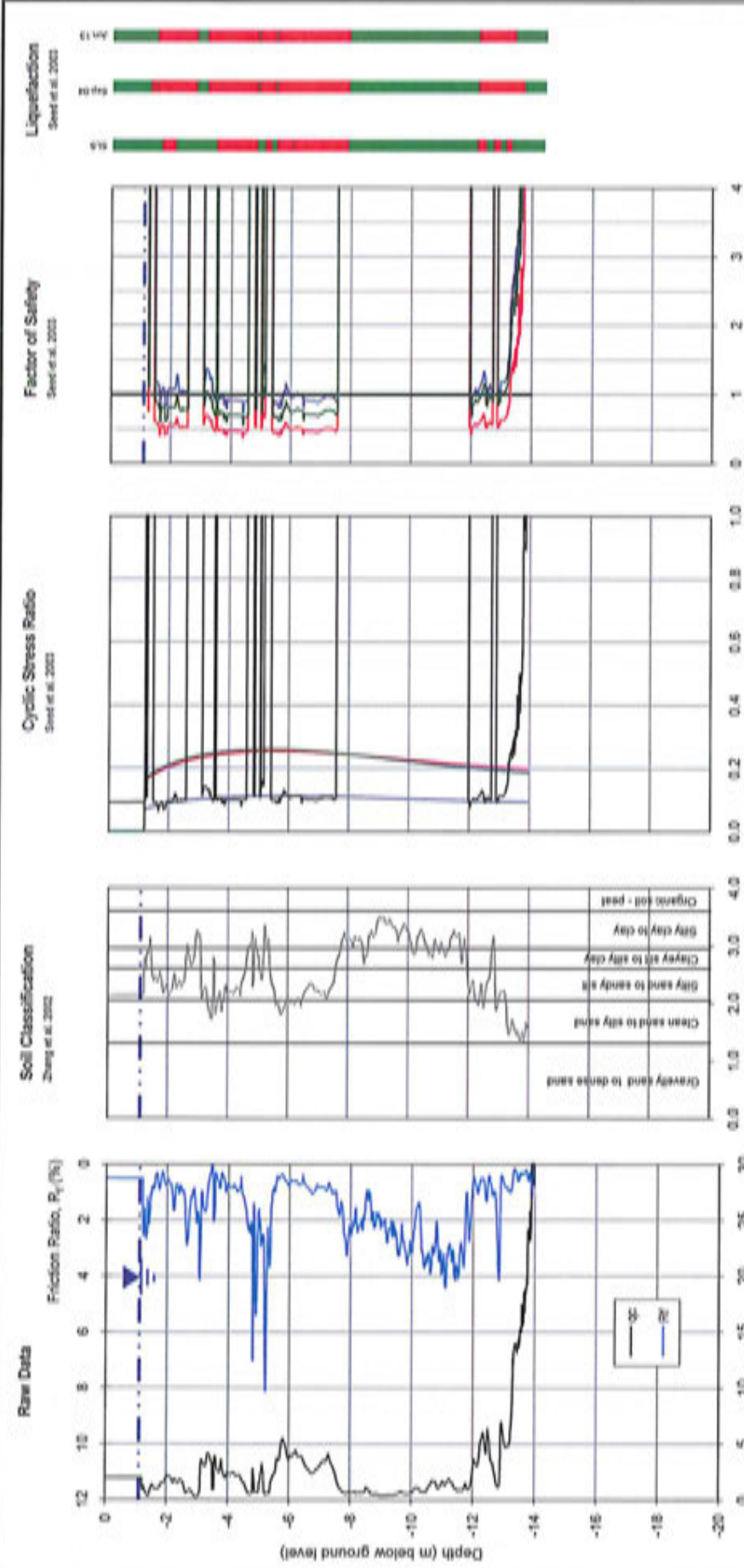
Liquefaction Assessment from CPT Results

JOB NUMBER

52000.301

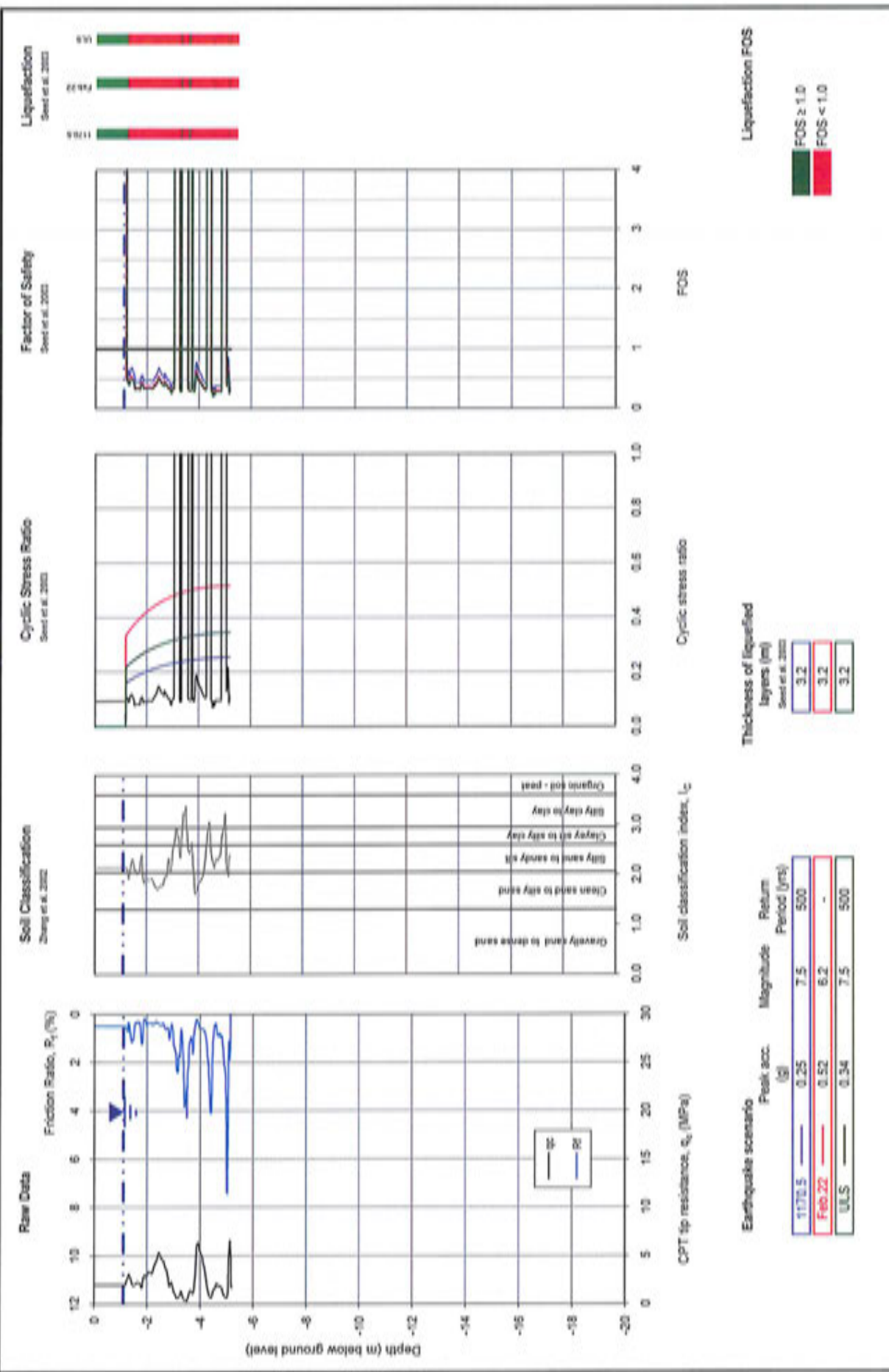
RAP

AFF



<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		LOCATION <b>CPT-CBD-115</b>	DATE 27/12/2011
Liquefaction Assessment from CPT Results		JOB NUMBER 52000_301	ANALYSED RAP
<b>Torkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants		CHECKED AFF	





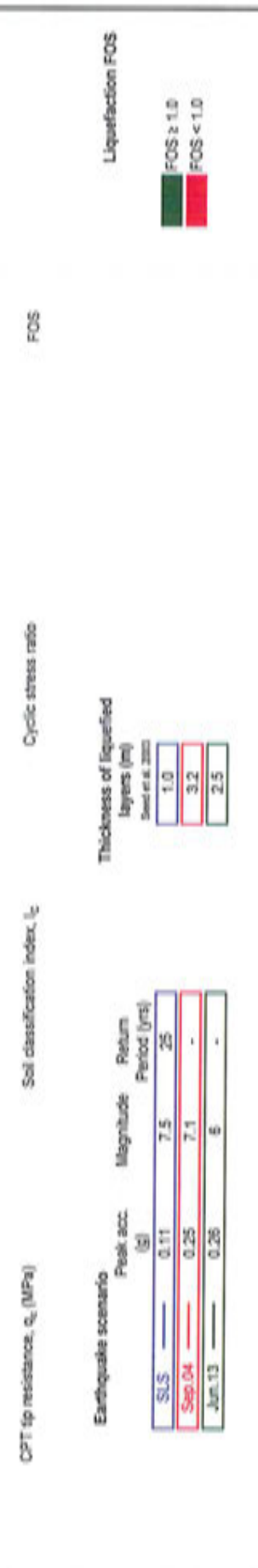
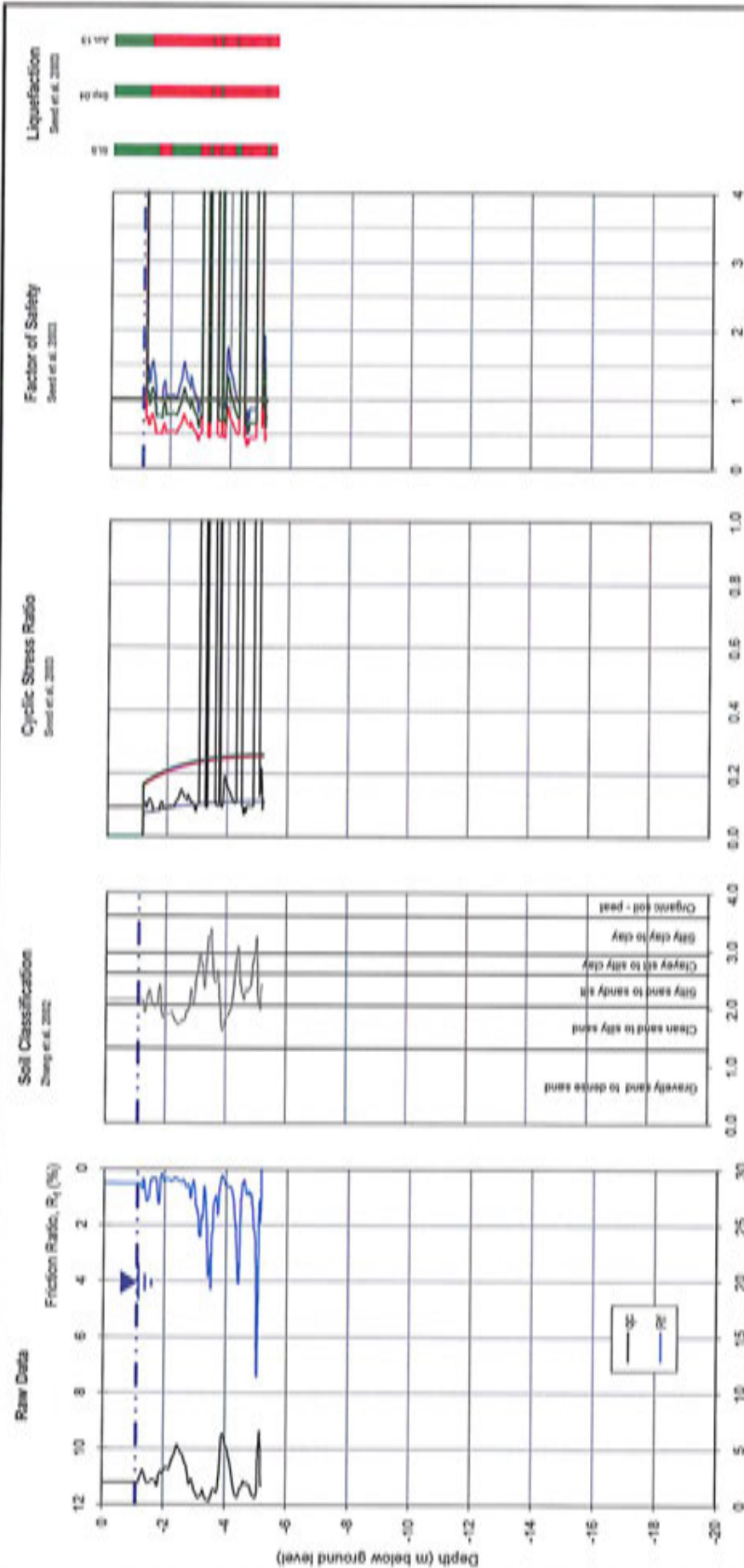
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 Geotechnical Assessment for Christchurch Central City

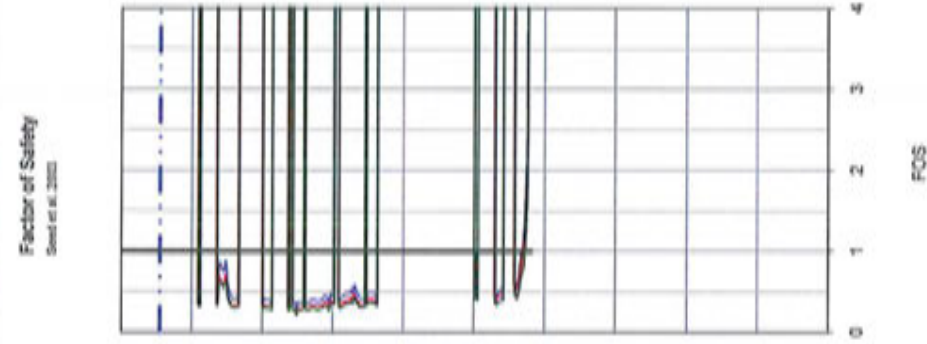
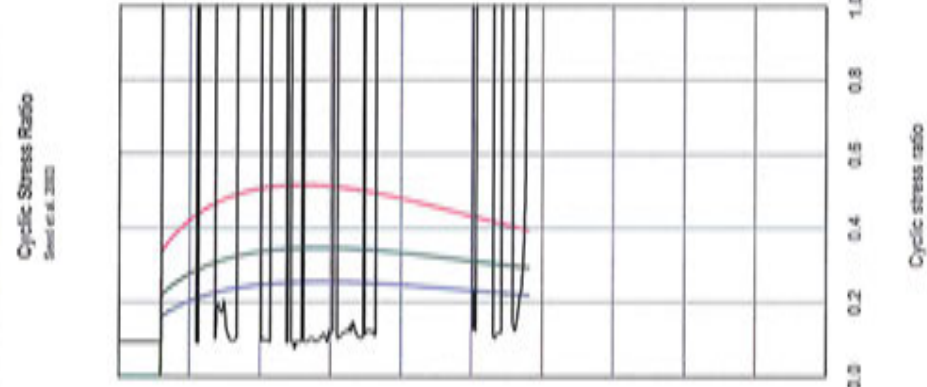
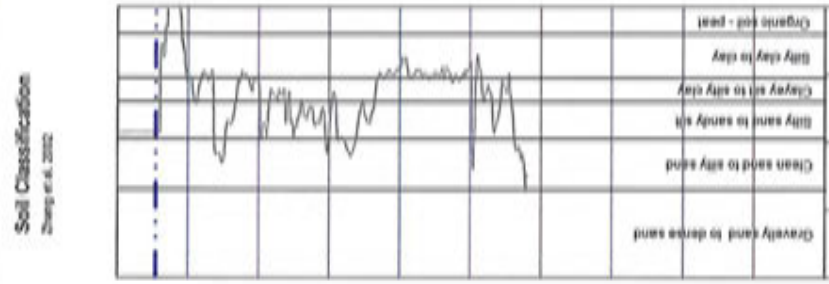
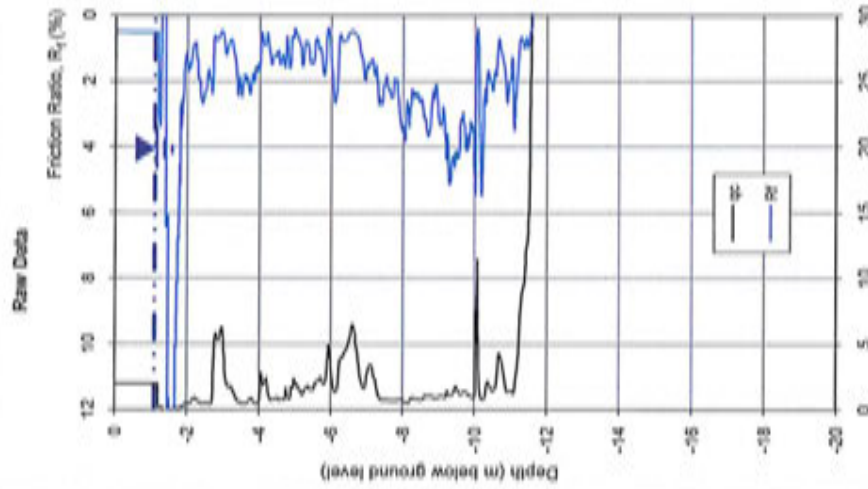
**CPT-CBD-116**  
 JOB NUMBER: 520000\_301

**DATE:** 6/12/2011  
**ANALYSED:** RAP  
**CHECKED:** AFF

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-116</b>	DATE 7/12/2011
		TITLE Liquefaction Assessment from CPT Results	ANALYSED RAP
		JOB NUMBER 52000_301	CHECKED AFF



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
3.8
3.9
3.9

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

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DATE

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ANALYSED

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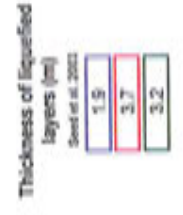
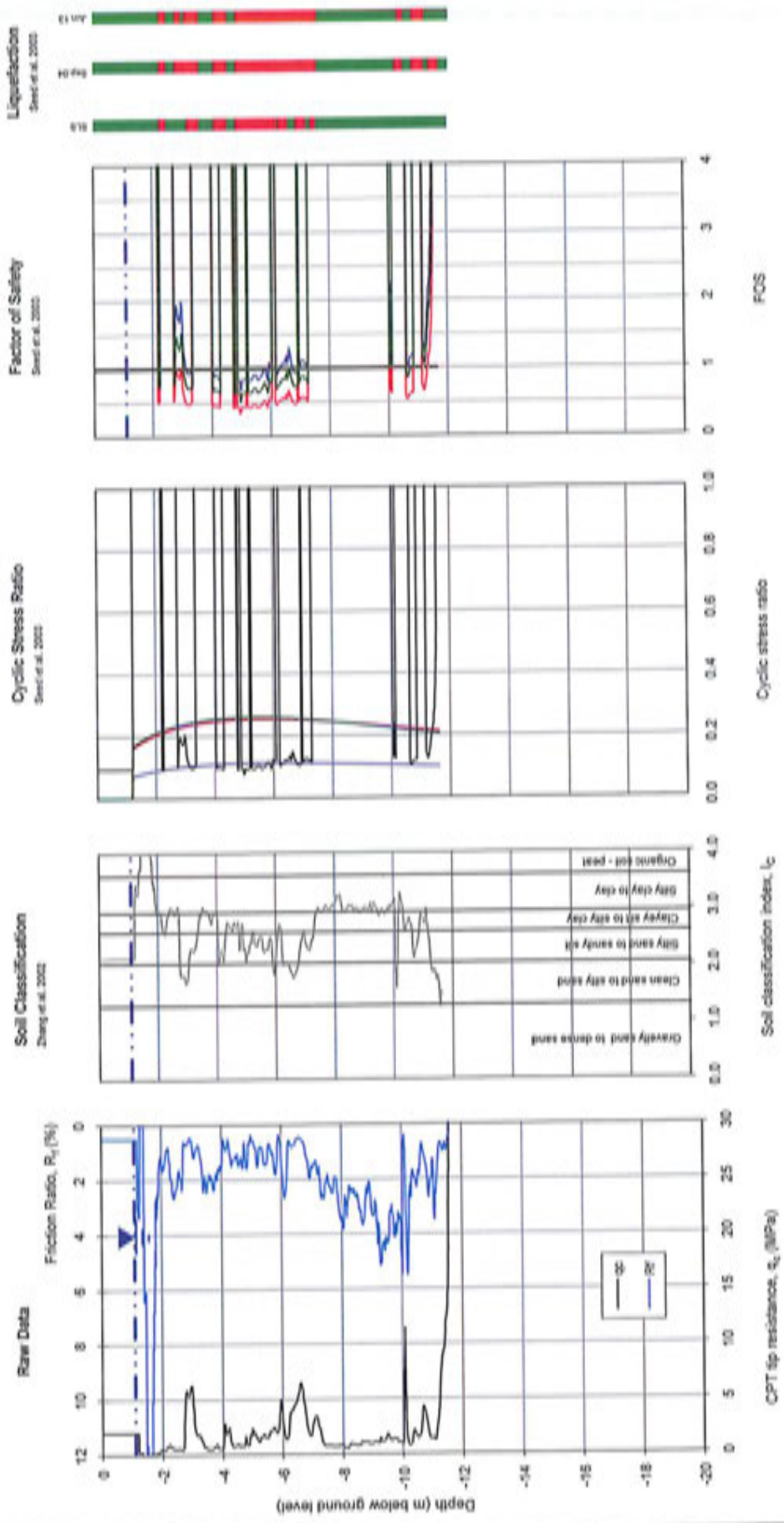
CHECKED

AFF

JOB NUMBER

52000.301

Liquefaction Assessment from CPT Results



Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep. 14	0.25	7.1	-
Jun. 13	0.25	6	-

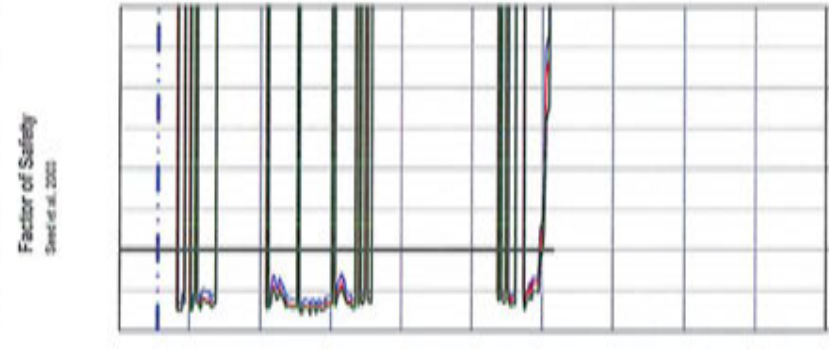
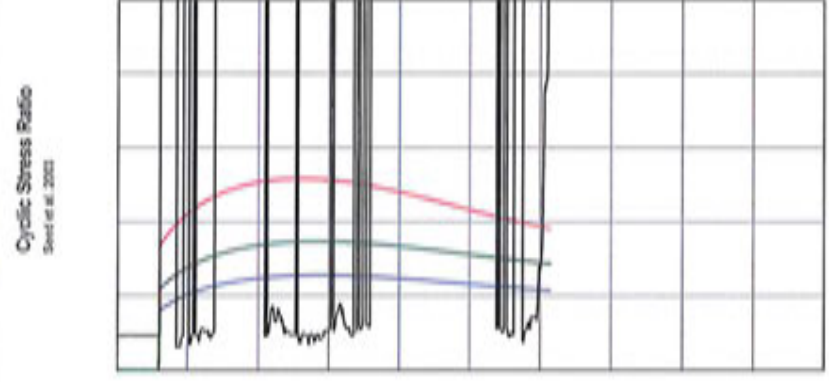
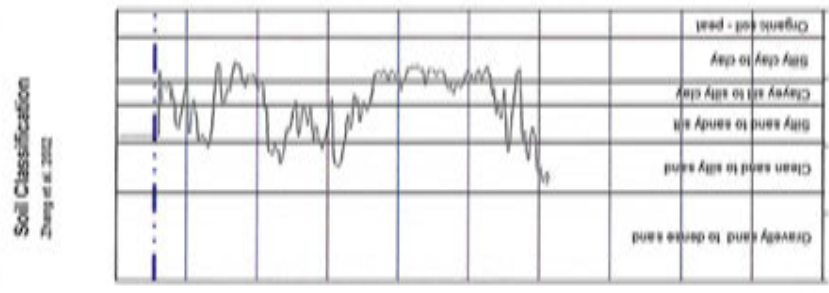
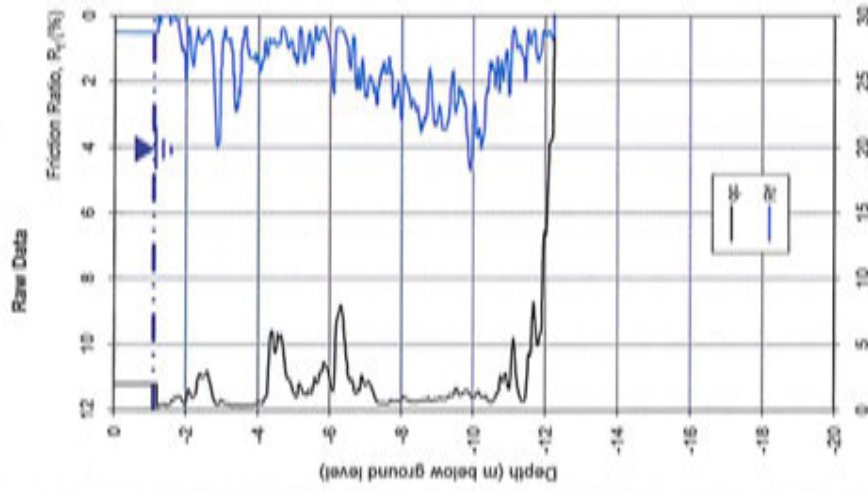


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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

LOCATION: **CPT-CBD-117**  
JOB NUMBER: S2000\_301

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb.22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
4.3
4.4
4.4

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



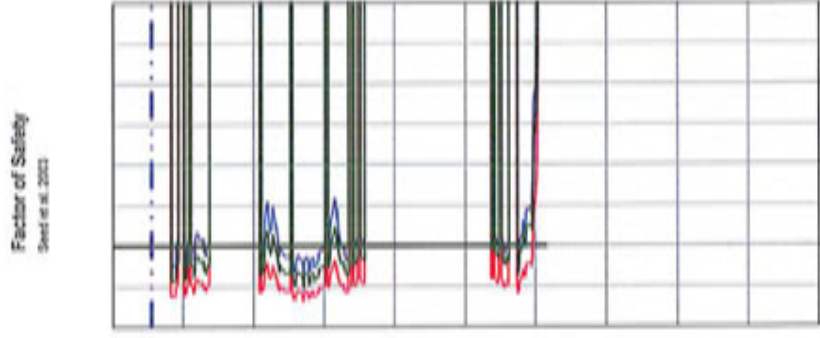
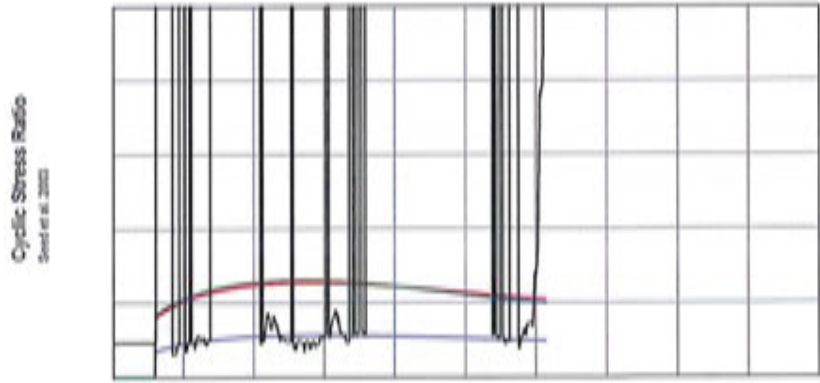
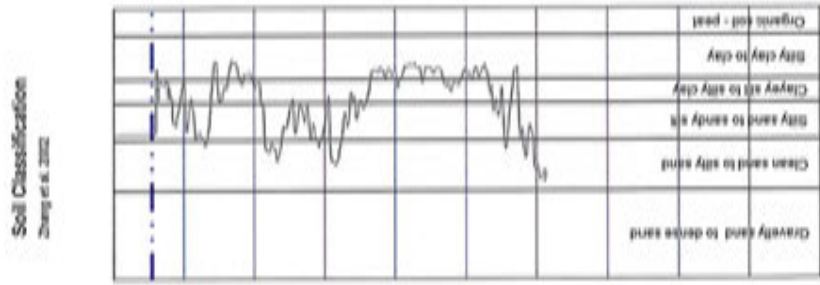
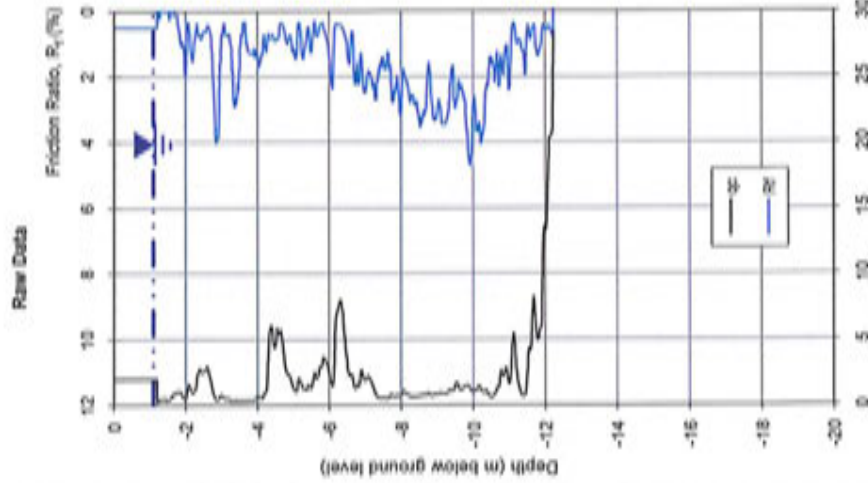
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CLIENT PROJECT	DATE
Christchurch City Council Geotechnical Assessment for Christchurch Central City	6/12/2011
FILE	ANALYSED
	CHECKED
	RAP
	AFF

LOGNO	DATE
CPT-CBD-118	6/12/2011
LOT NUMBER	RAP
	CHECKED
	AFF

Liquefaction Assessment from CPT Results

52000.301



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
0.11	7.5	25
0.25	7.1	-
0.26	6	-

Thickness of liquefied layers (m)

2.2
4.3
3.5

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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Geotechnical Assessment for Christchurch Central City

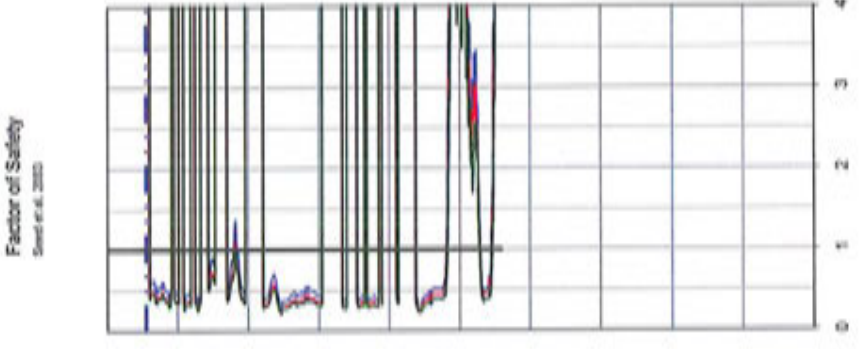
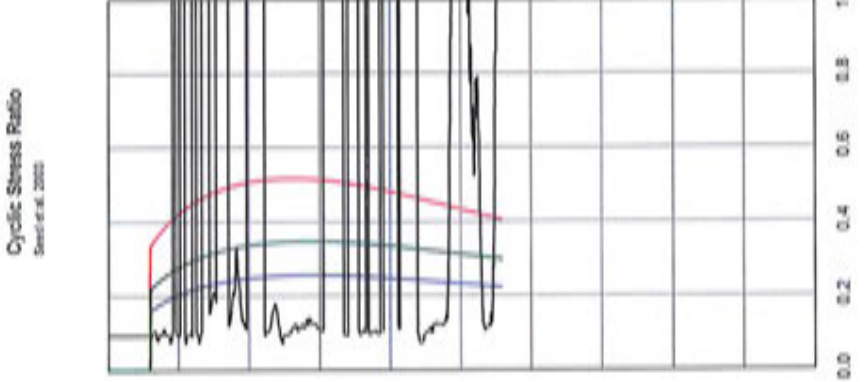
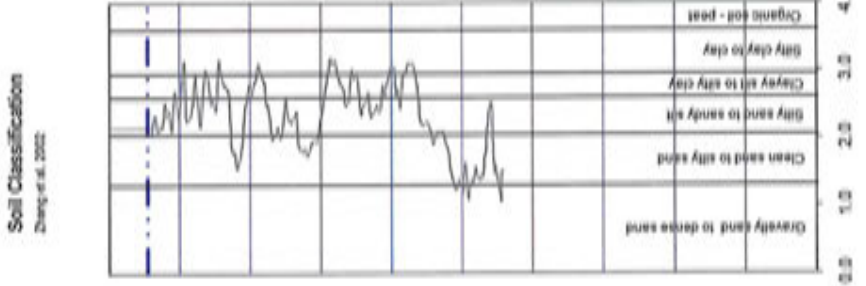
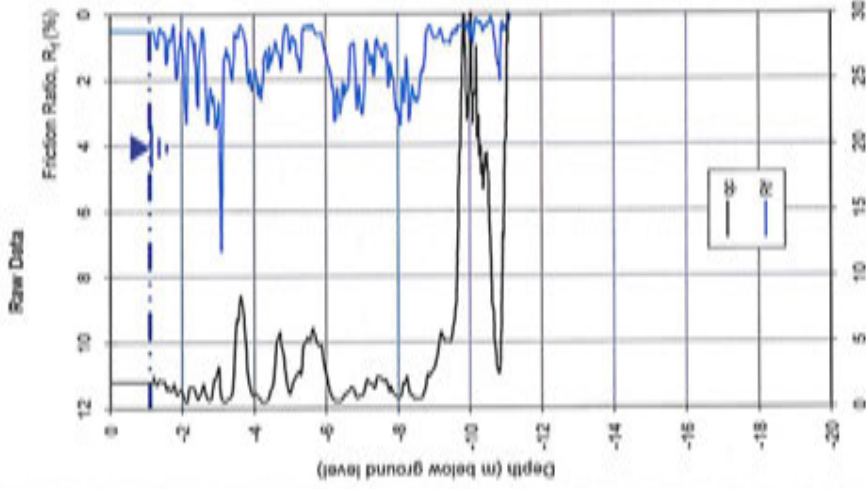
PROJECT NUMBER  
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JOB NUMBER  
S20000\_301

DATE  
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ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results





CPT tip resistance,  $q_c$  (MPa)

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
11/20.5	0.25	7.5	500
Feb.22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

5.4
5.5
5.5

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



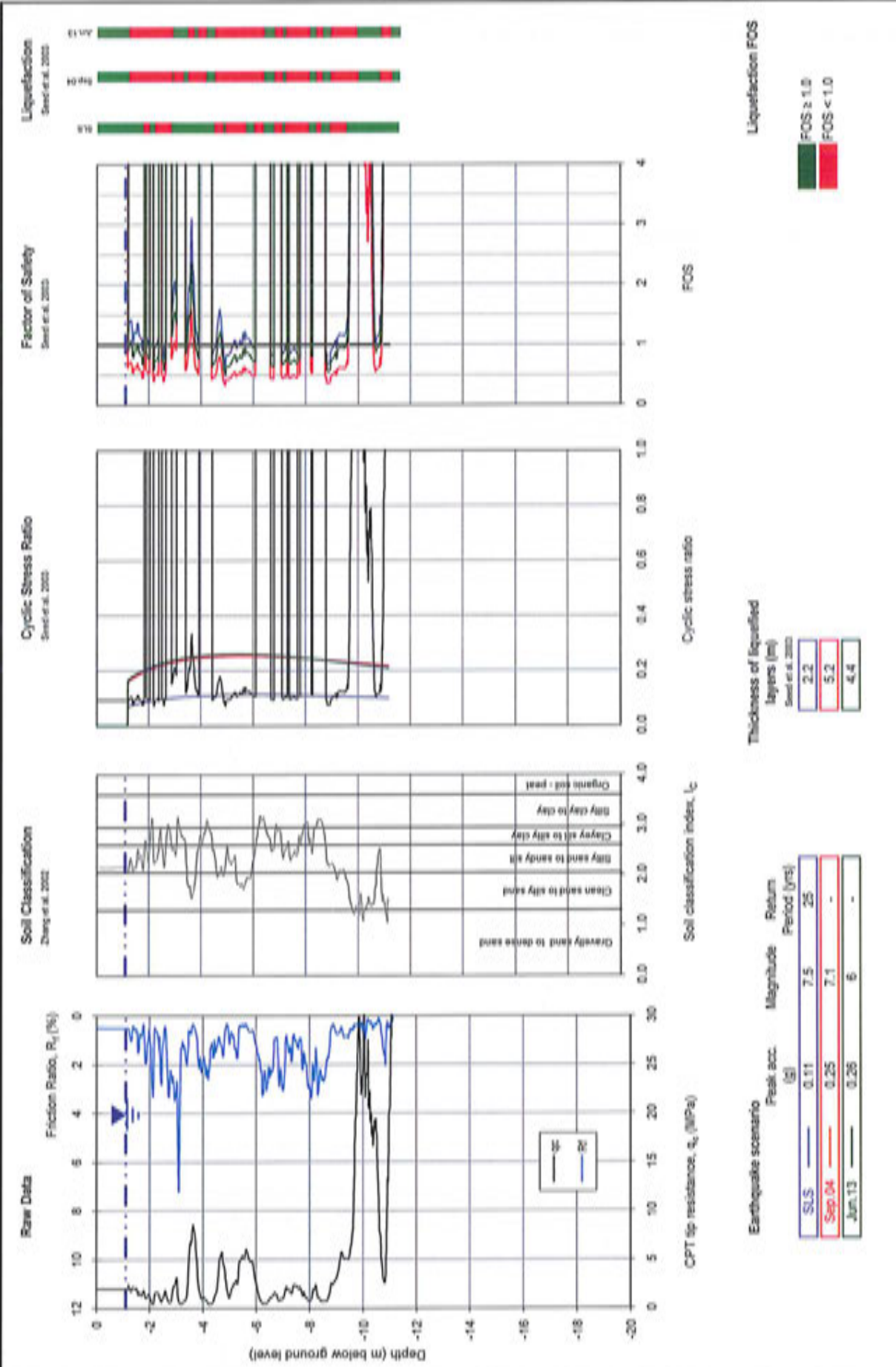
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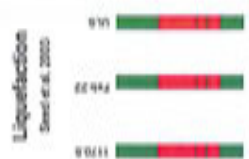
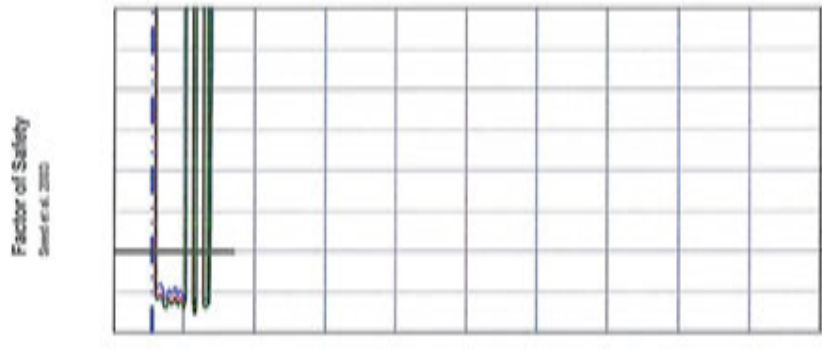
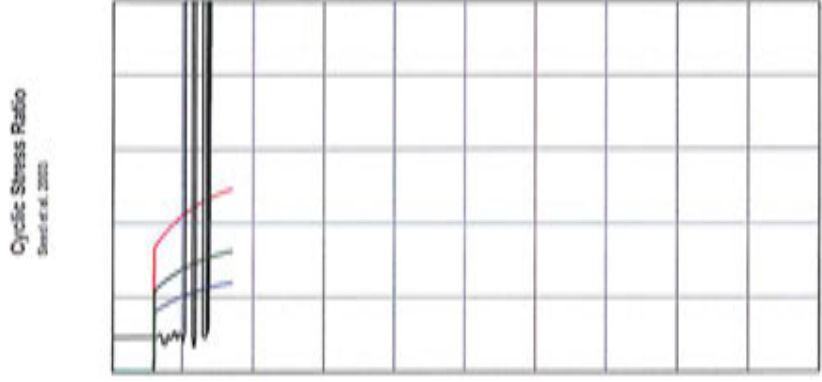
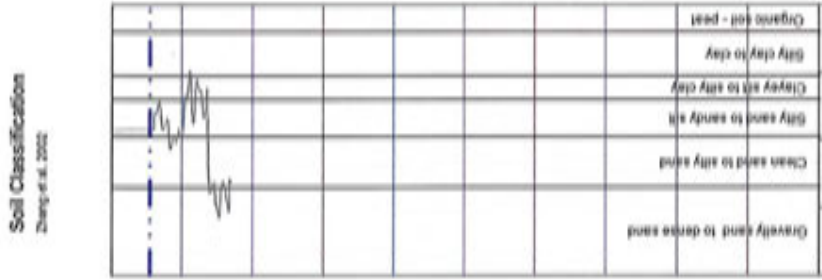
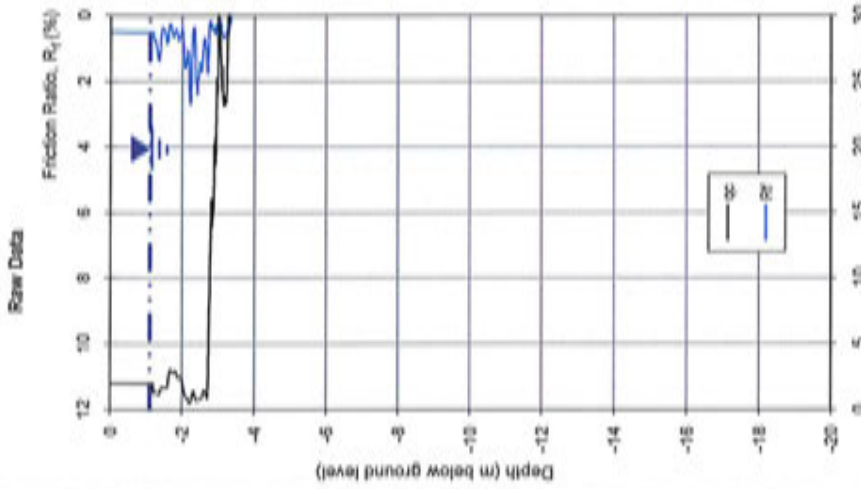
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Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-119  
JOB NUMBER  
52000.301

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb 22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
1.1
1.1
1.1

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

SECTION

CPT-CBD-120

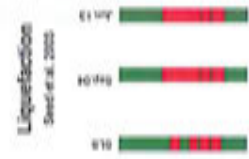
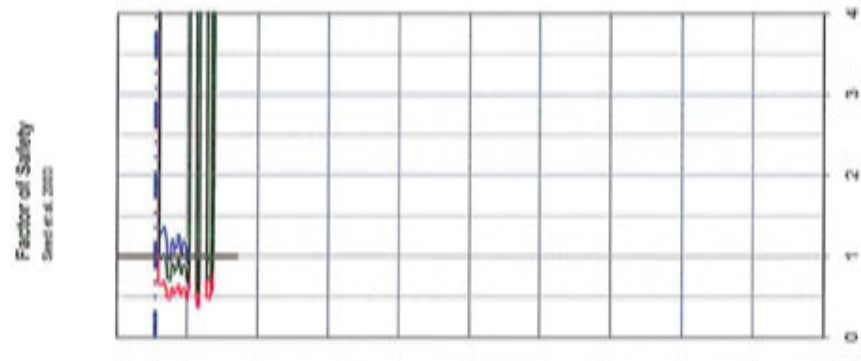
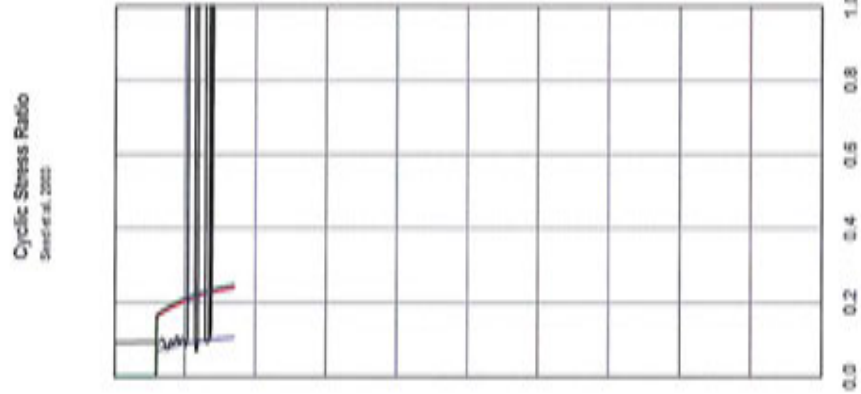
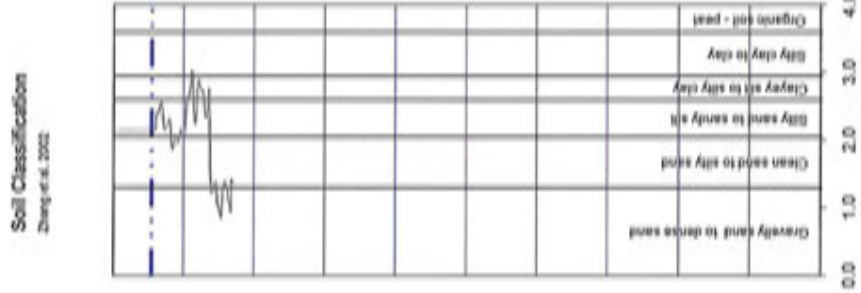
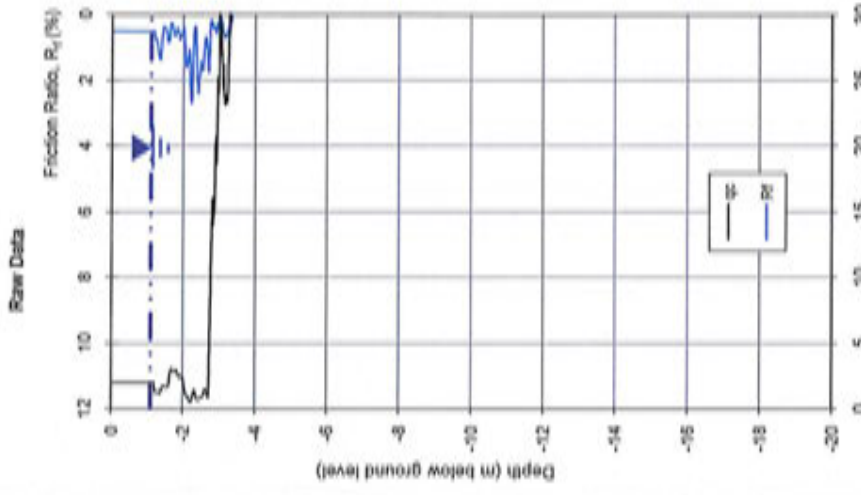
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Liquefaction Assessment from CPT Results

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52000.301

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CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

**Earthquake scenario**

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.04	0.25	7.1	-
Jan.13	0.25	6	-

**Thickness of liquefied layers (m)**  
Seed et al. 2002

0.4
1.1
1.0

**Liquefaction FOS**

FOS $\geq$ 1.0
FOS $<$ 1.0



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Geotechnical Assessment for Christchurch Central City

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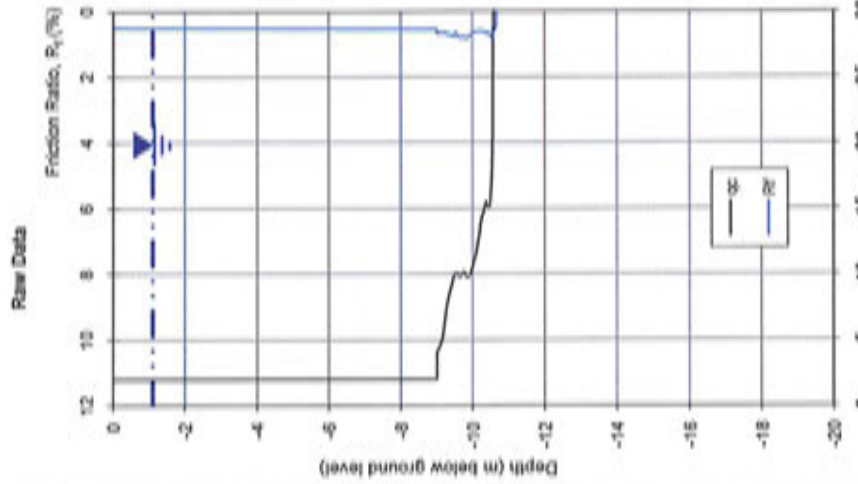
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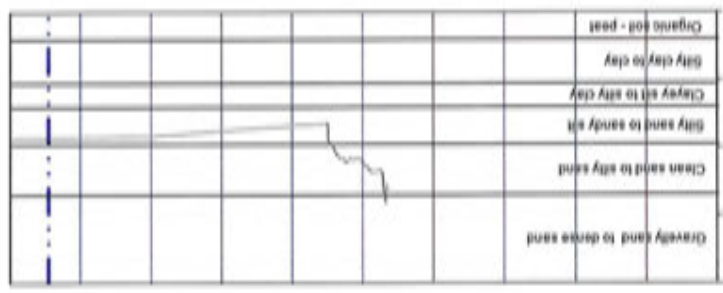
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ANALYSED: RAP  
CHECKED: AFF

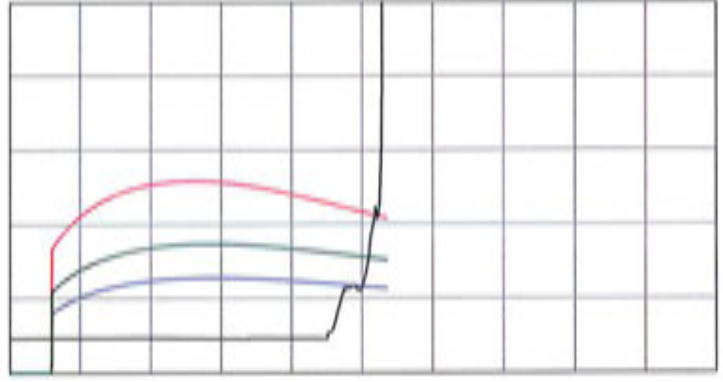
Liquefaction Assessment from CPT Results



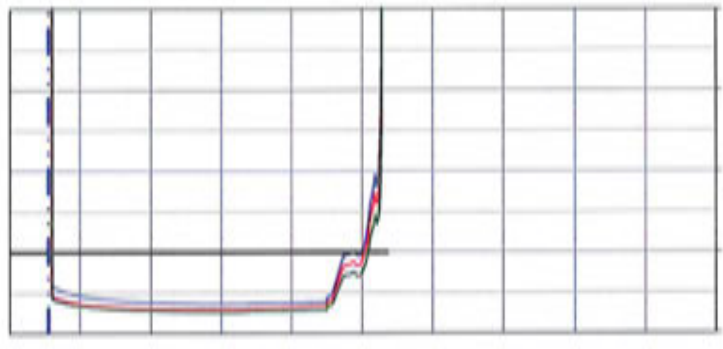
Soil Classification  
Zheng et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

8.7
8.9
9.0



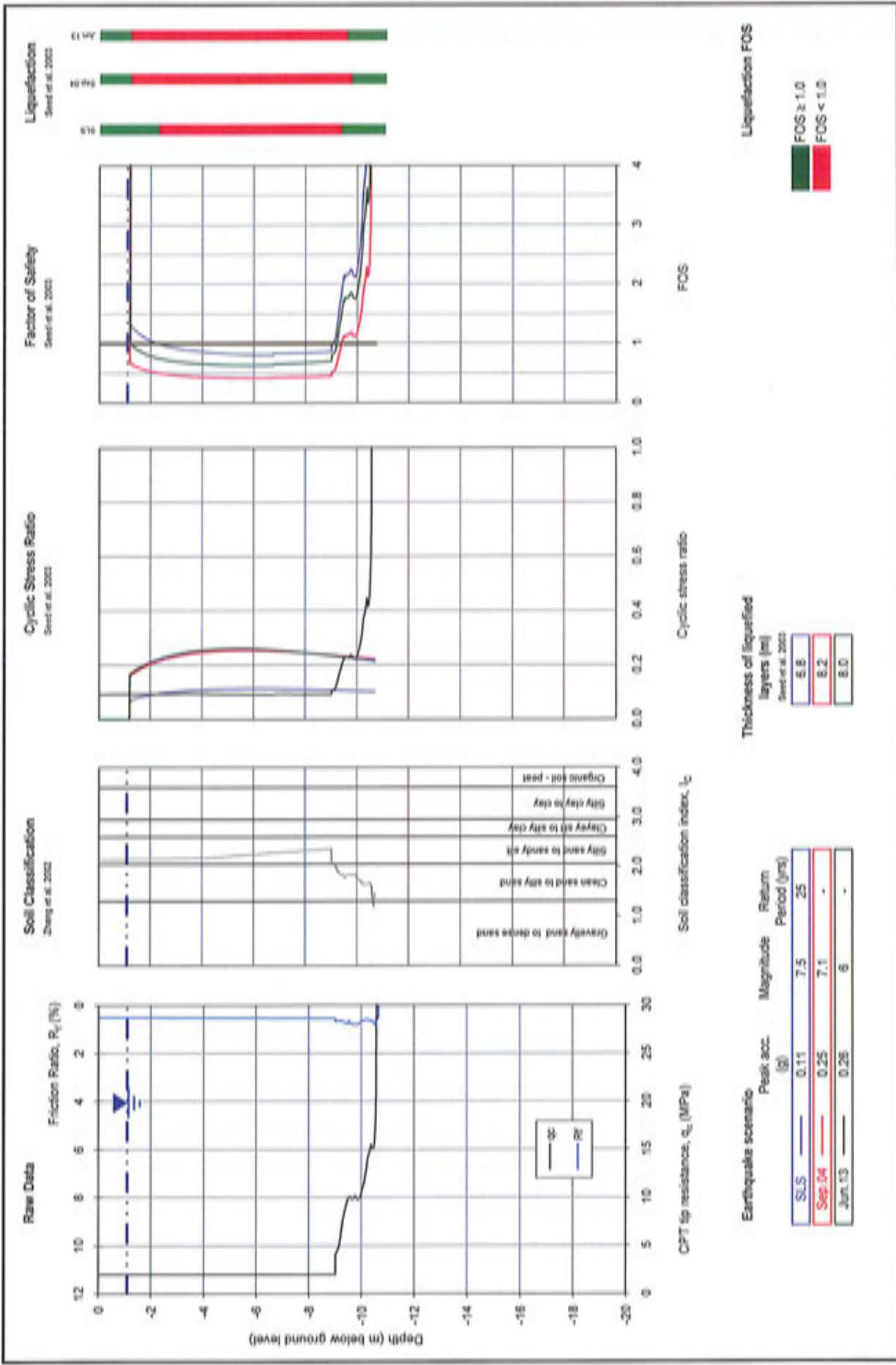
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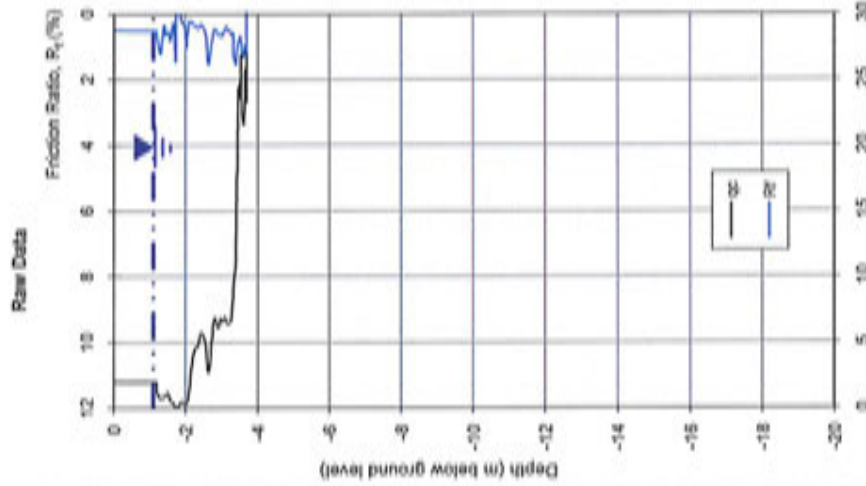
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JOB NUMBER  
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DATE  
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RAP  
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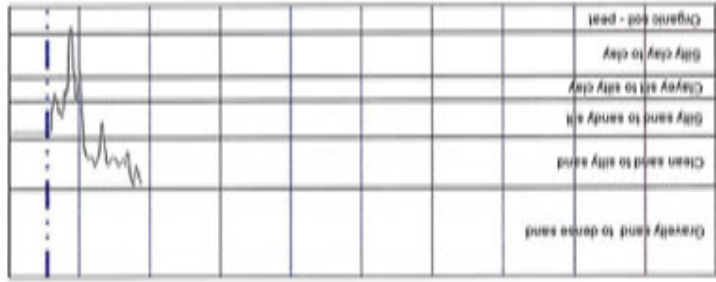
Liquefaction Assessment from CPT Results



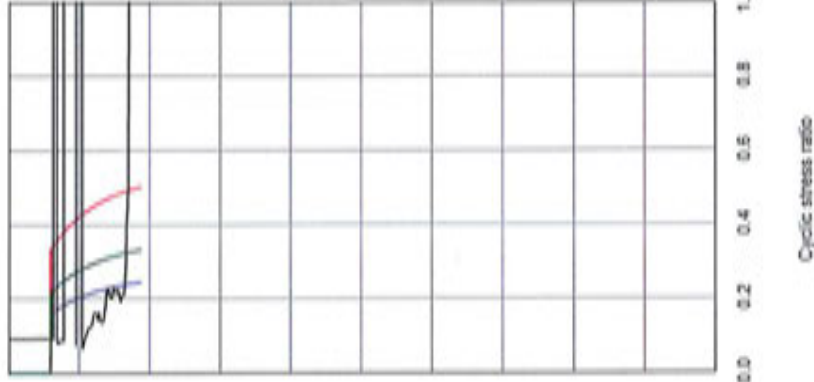
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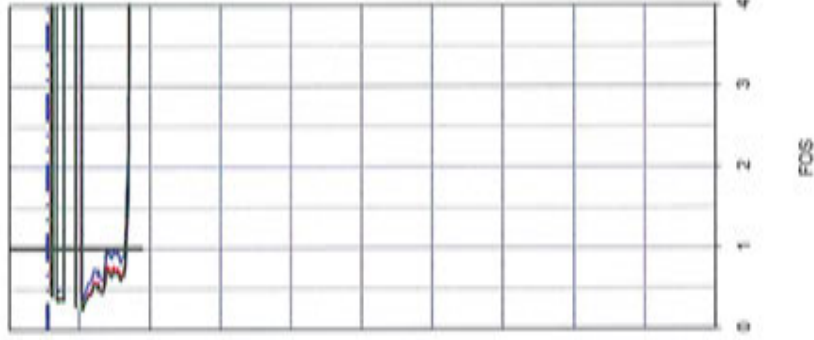
Soil Classification  
Zheng et al. 2002



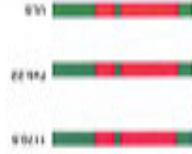
Cyclic Stress Ratio  
Seed et al. 2003



Factor of Safety  
Seed et al. 2003



Liquefaction  
Seed et al. 2003



CPT sp resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc.	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
1.5
1.5
1.5

Liquefaction FOS



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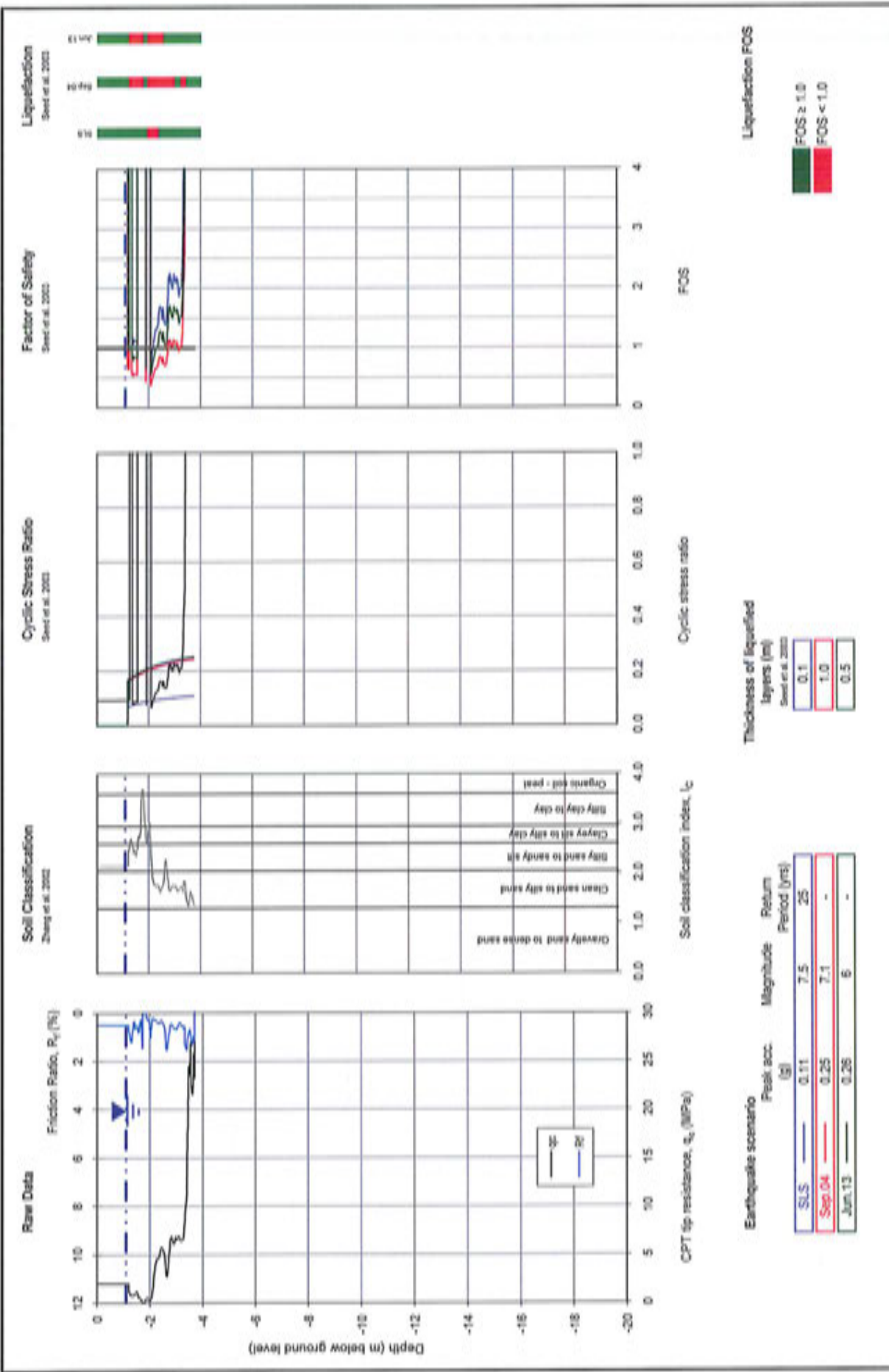
CPT-CBD-121

FILE

52000.301

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Liquefaction Assessment from CPT Results



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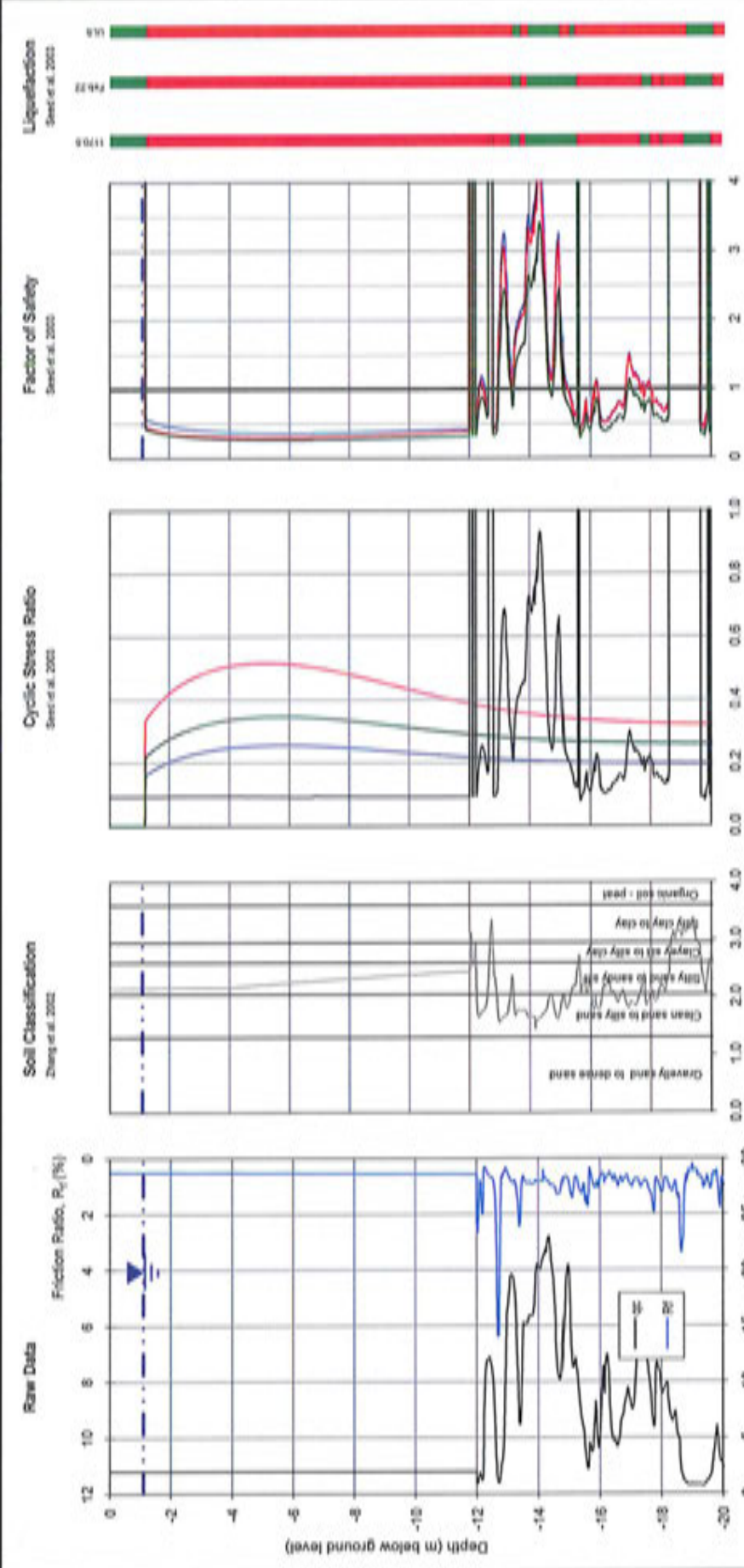
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**LOCATION**  
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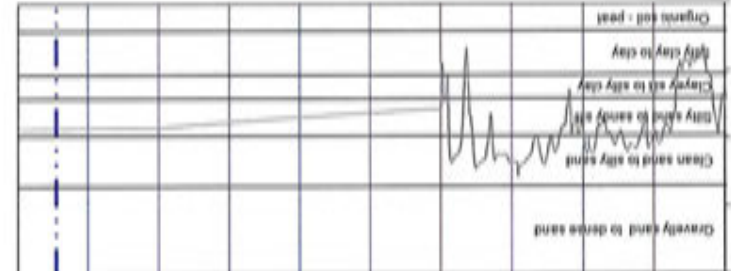
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 52000\_301

**DATE** 31/12/2011  
**ANALYSED** RAP  
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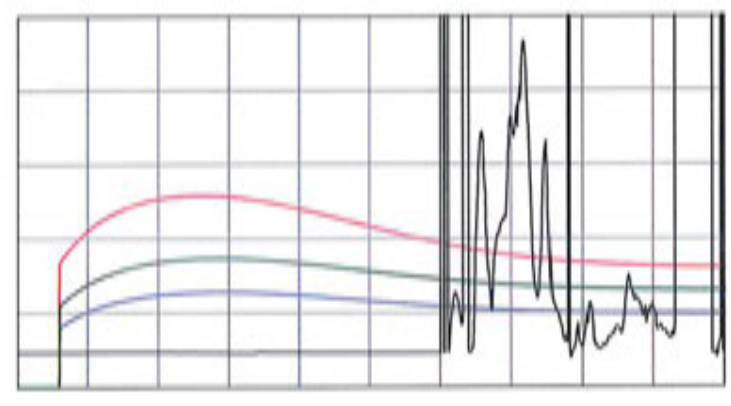




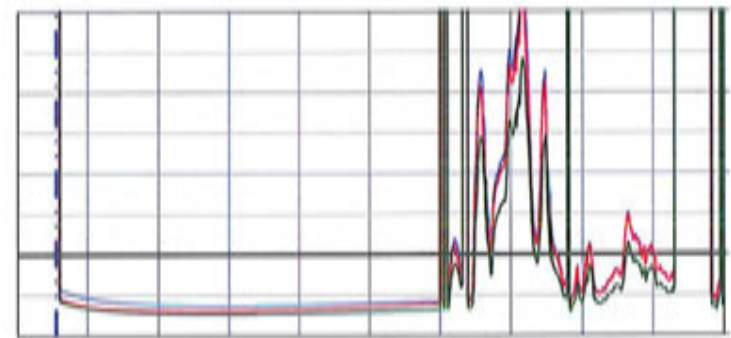
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



Soil classification index,  $I_c$

FOS

CPT tip resistance,  $q_t$  (MPa)

Earthquake scenario

Peak acc.	Magnitude	Return Period (yrs)
1170.5	0.25	7.5
Feb. 22	0.52	6.2
ULS	0.34	7.5

Thickness of liquefied layers (m)

14.4
14.5
15.7

Liquefaction FOS

FOS $\geq 1.0$
FOS $< 1.0$

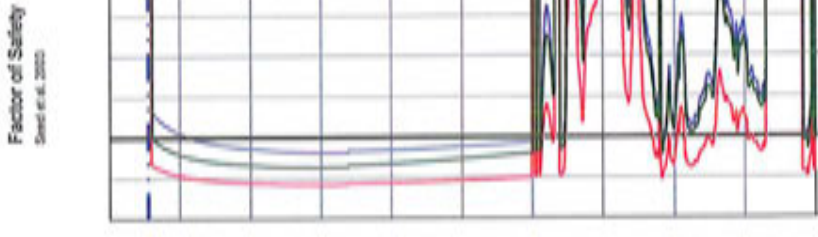
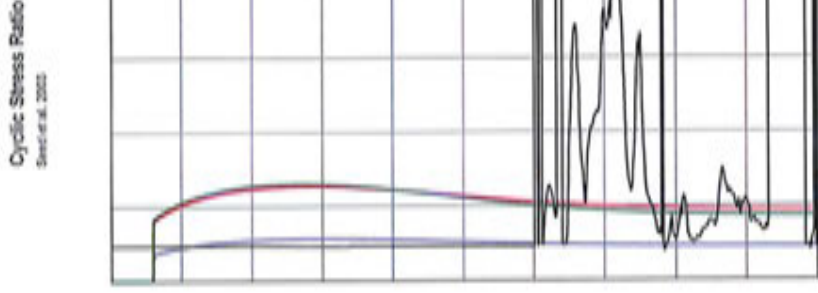
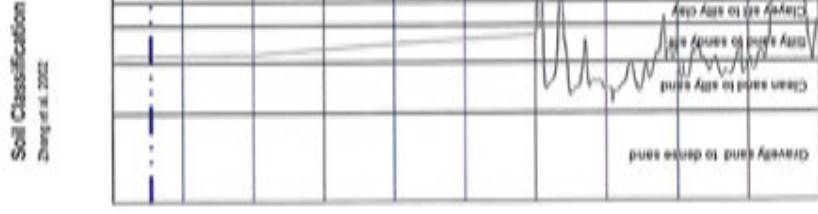
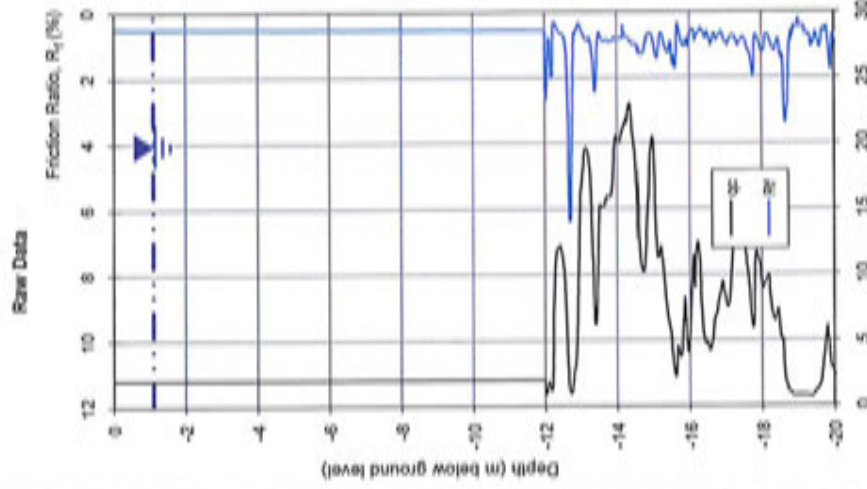


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CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	7.5	25
Sep 04	7.1	-
Jun 13	6	-

Thickness of liquefied layers (m)

SLS	10.0
Sep 04	13.6
Jun 13	11.5

Liquefaction FOS



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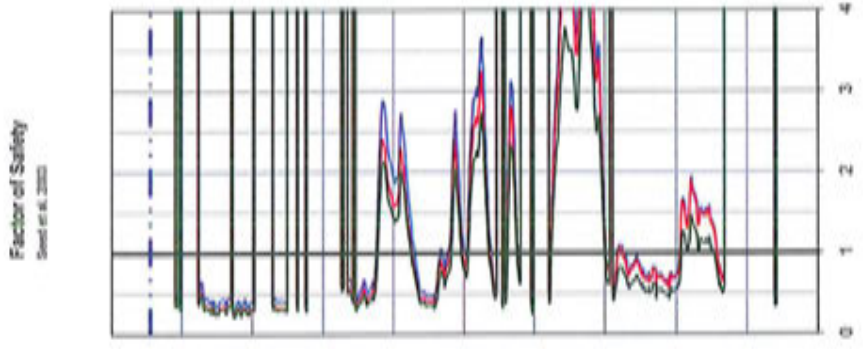
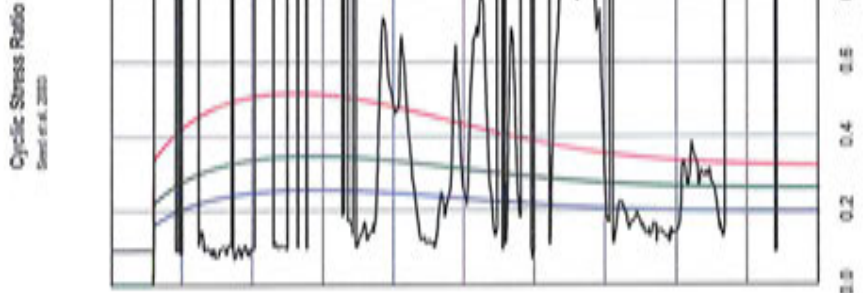
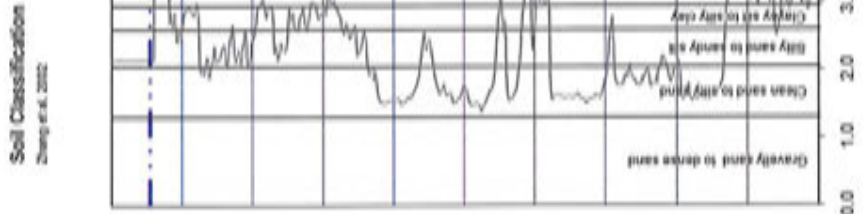
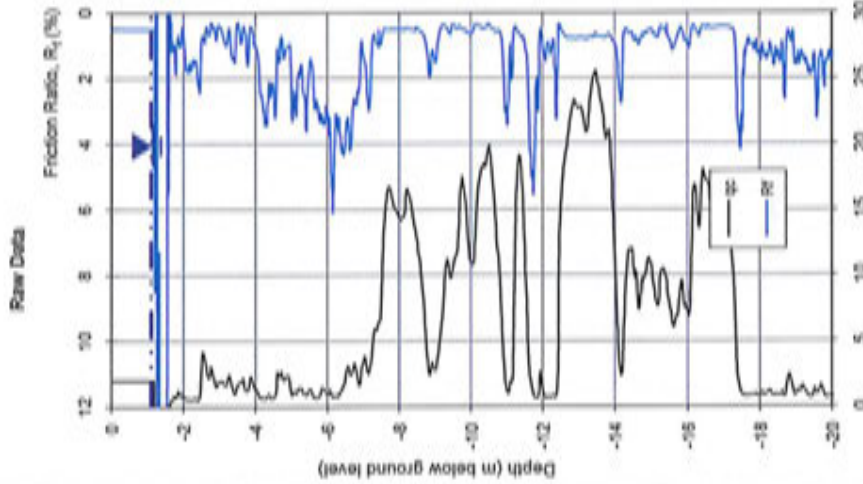
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CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

6.5
7.1
7.5

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



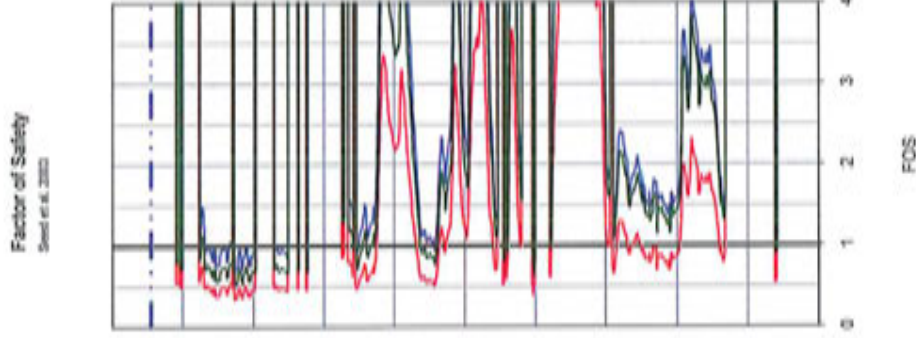
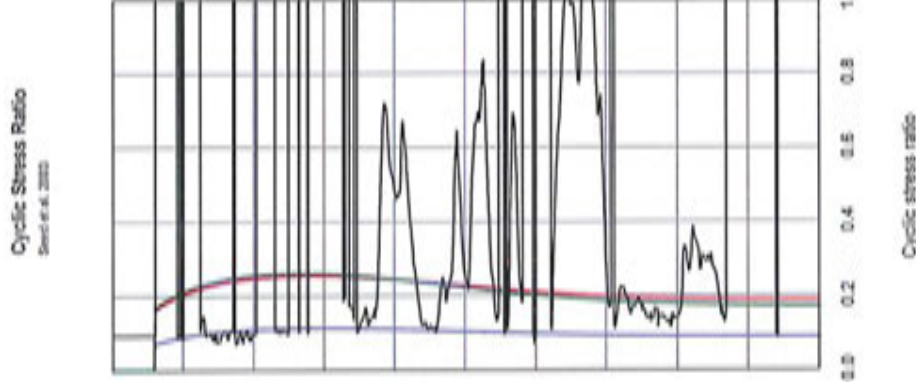
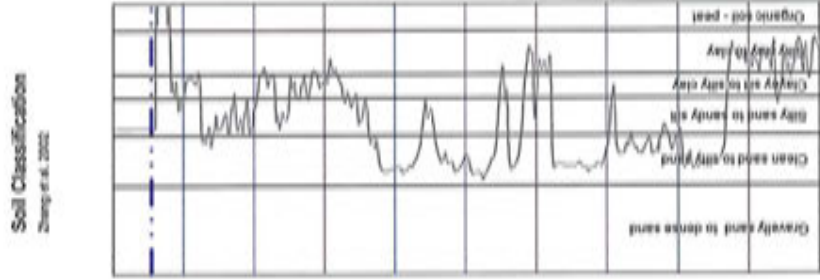
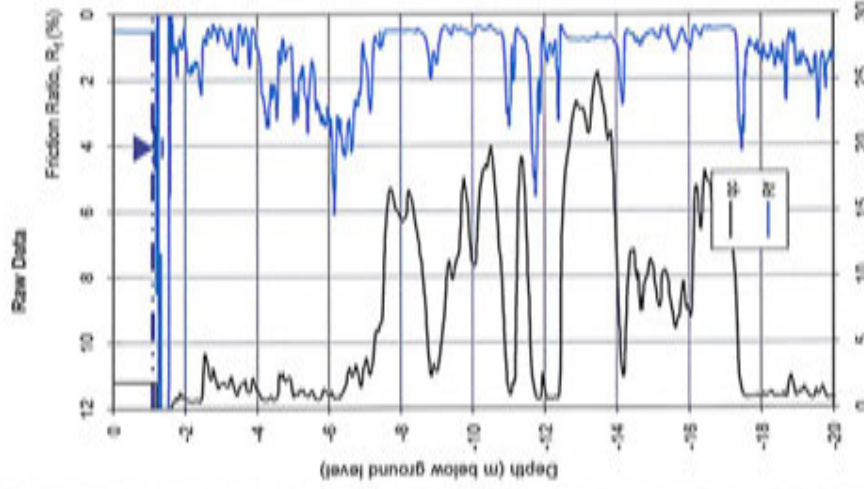
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CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_s$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sev 04	0.25	7.1	-
Jan 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
1.9
5.7
3.1

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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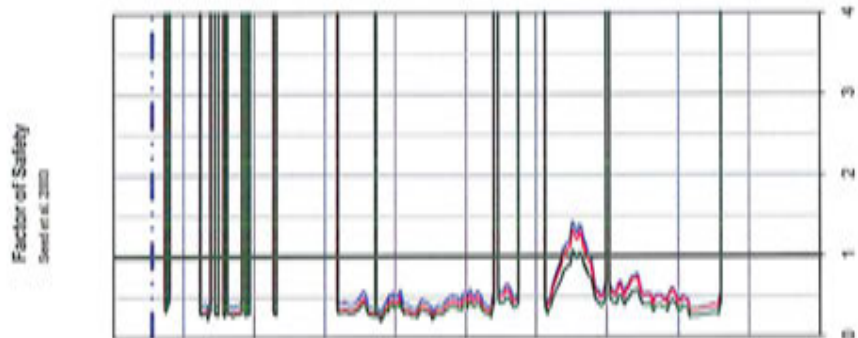
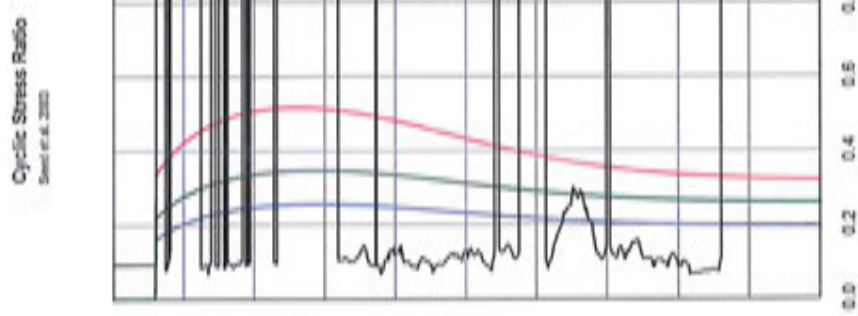
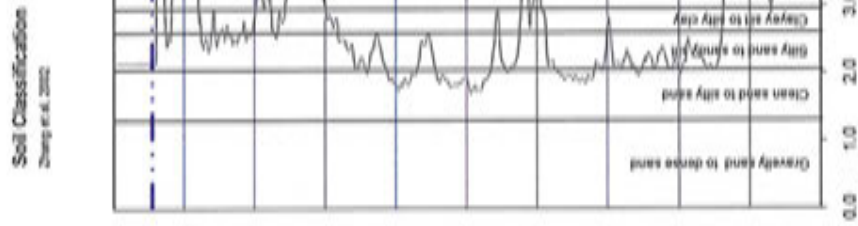
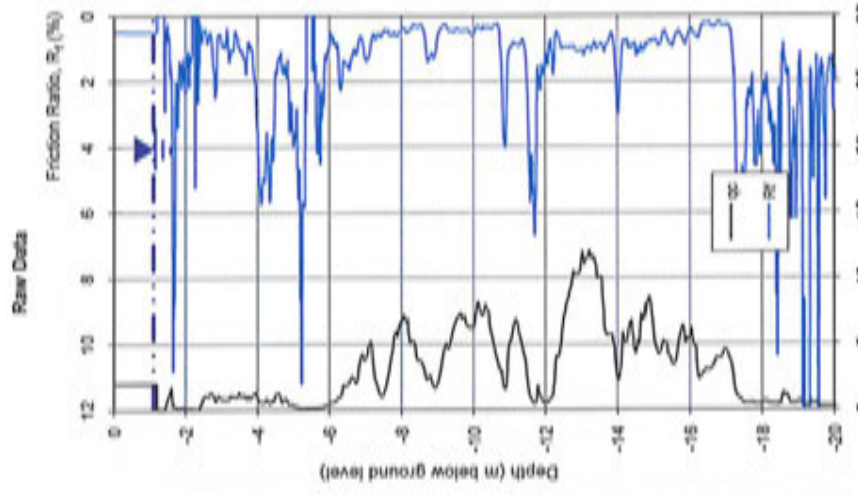
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CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb. 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

10.6
10.7
11.1

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0

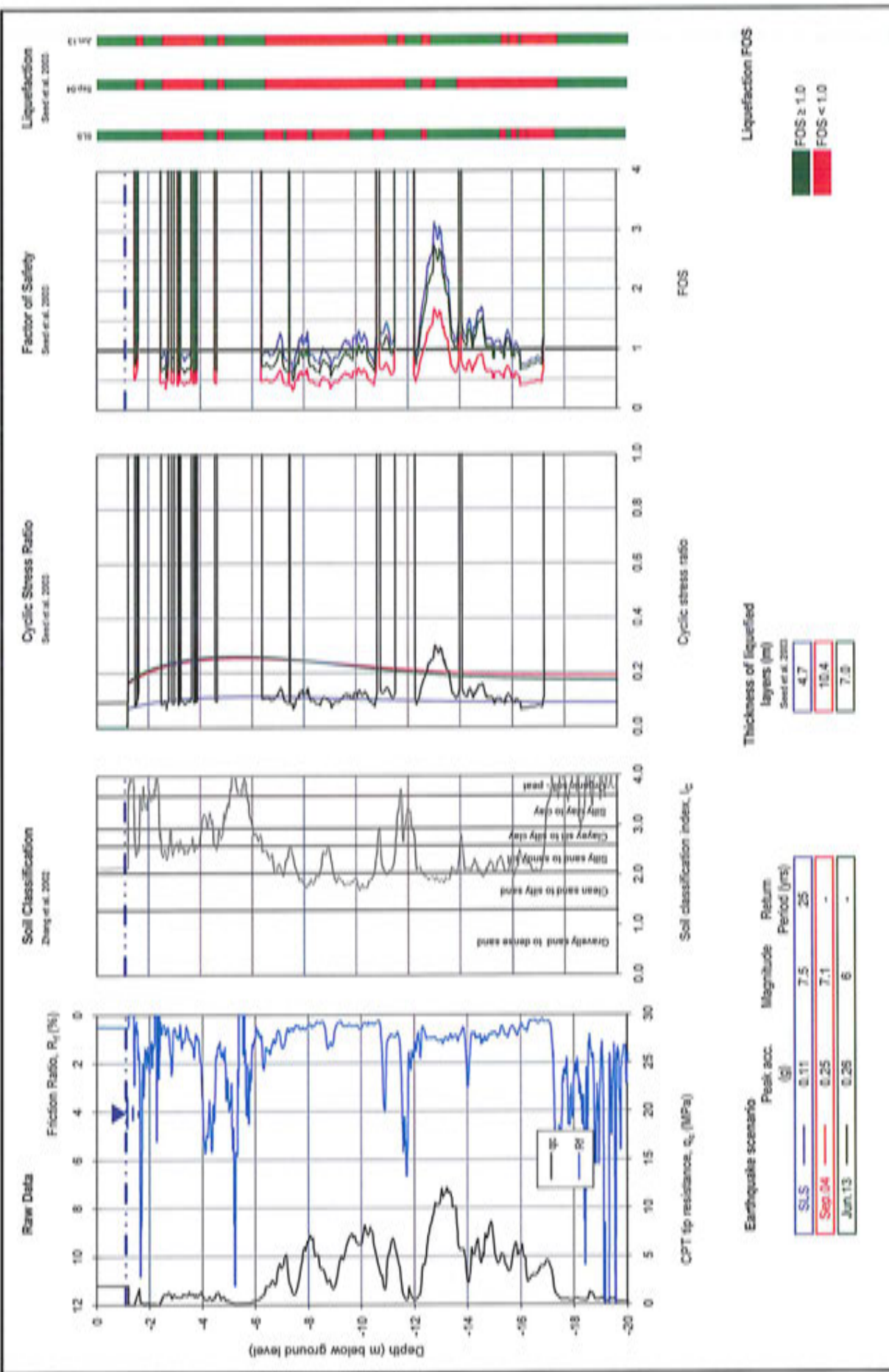


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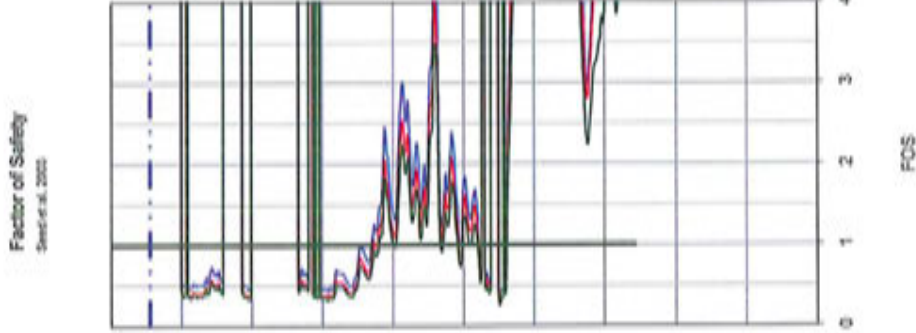
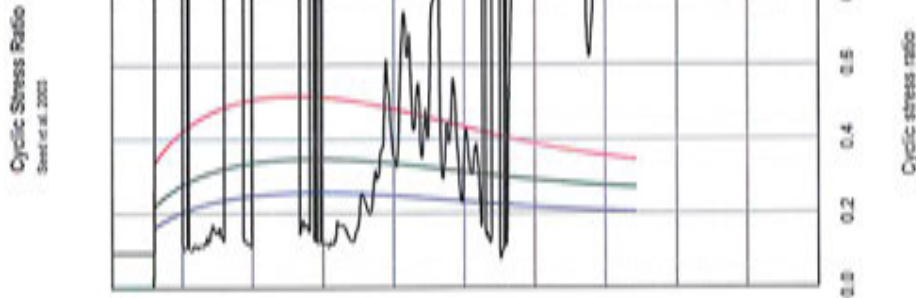
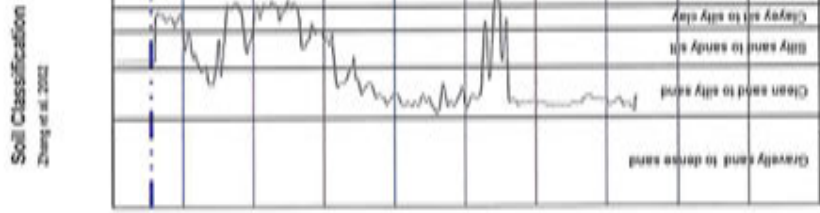
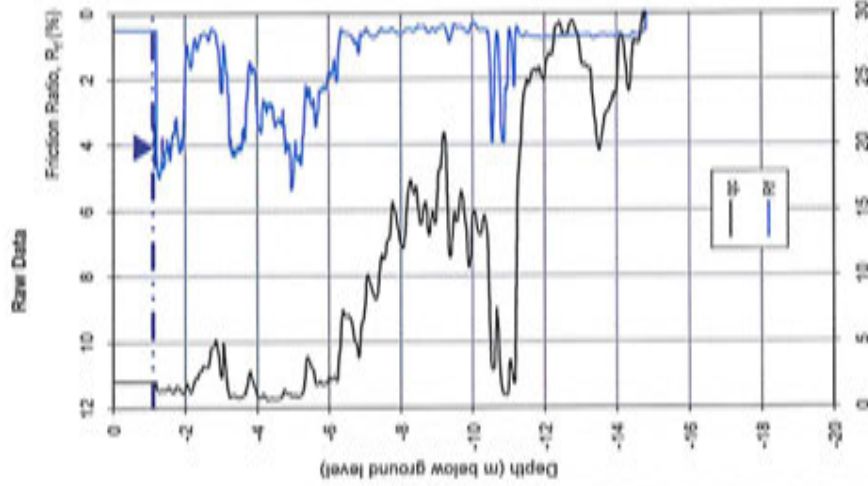
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

LOCATION  
CPT-CBD-122a  
JOB NUMBER  
52000.301

DATE  
5/12/2011  
ANALYSED  
RAP  
CHECKED  
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			ANALYSED RAP
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CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1:170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness (m)
3.7
3.9
4.3

Liquefaction FOS

FOS $\geq 1.0$	FOS $< 1.0$



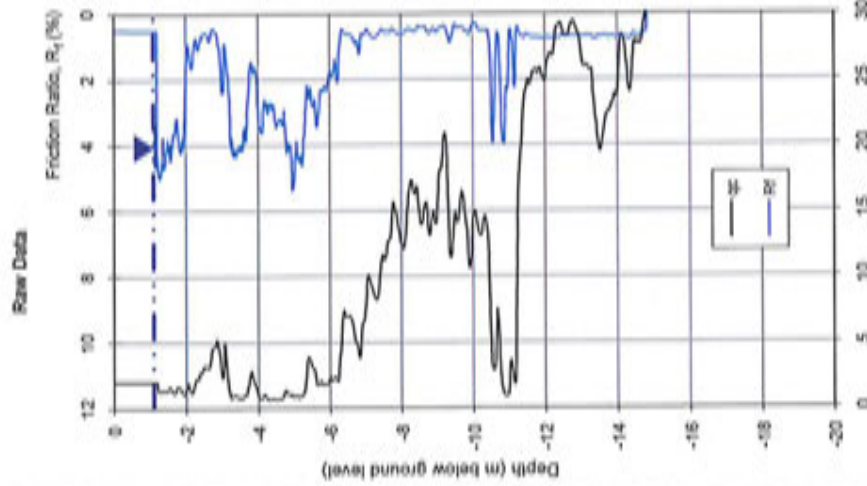
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Geotechnical Assessment for Christchurch Central City

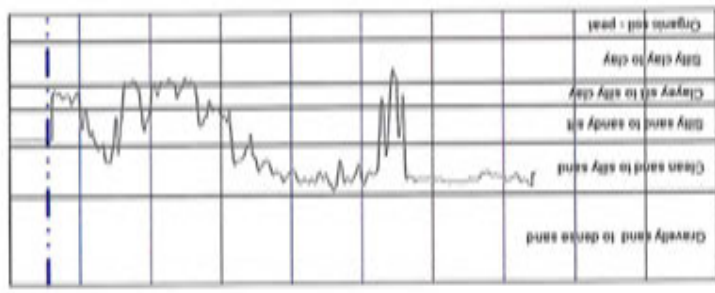
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6/12/2011  
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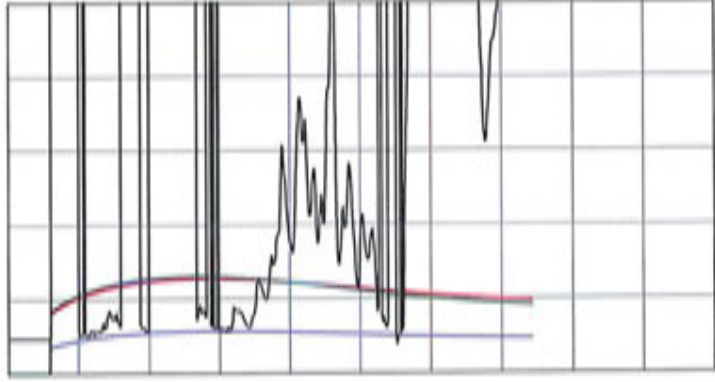
Liquefaction Assessment from CPT Results



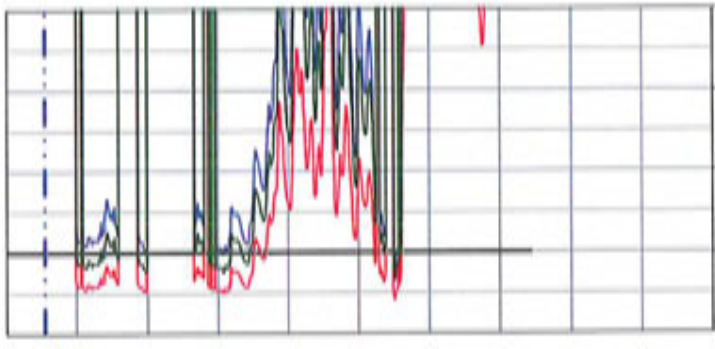
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Santol et al. 2003



Factor of Safety  
Santol et al. 2003



Liquefaction  
Santol et al. 2003



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sup 34	0.25	7.1	-
Jun 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.1
3.5
2.0

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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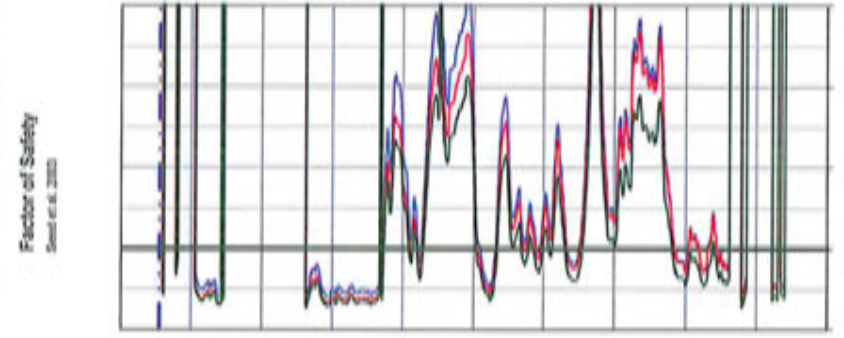
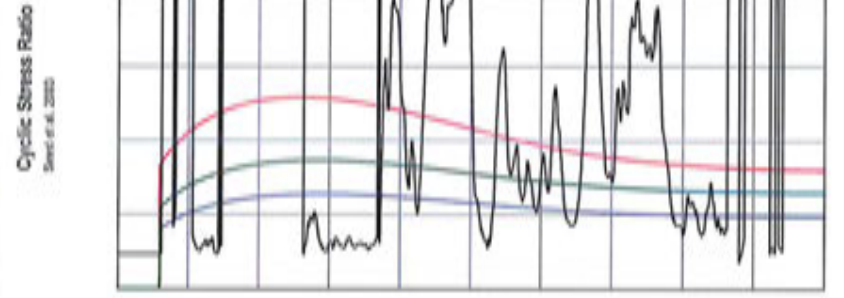
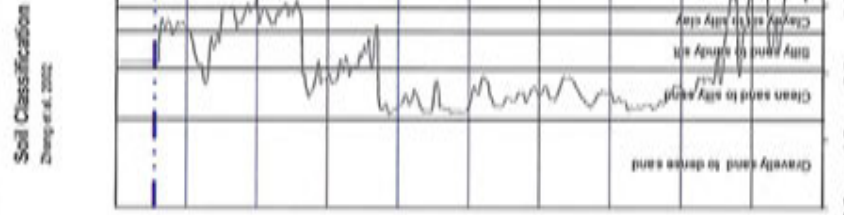
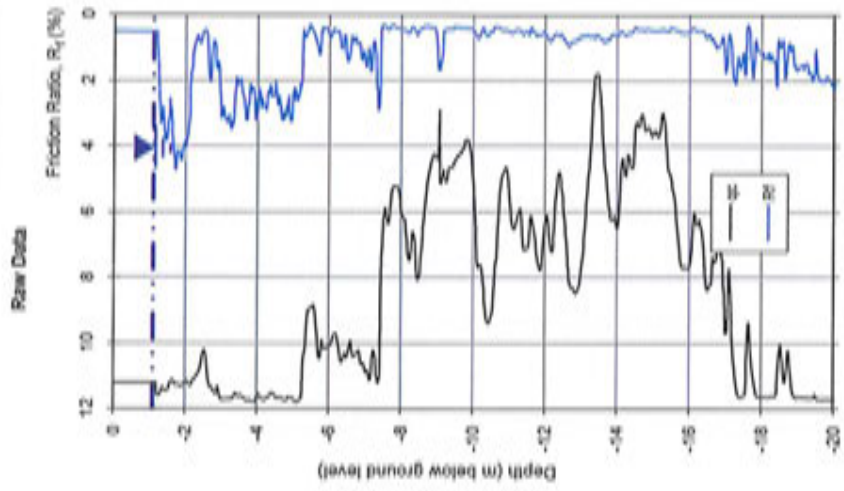
PROJECT LOCATION  
CPT-CBD-123

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
AFF

Liquefaction Assessment from CPT Results

JOB NUMBER: 52000\_301





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
U.I.S.	7.5	500

Thickness of liquefied layers (m)

Thickness (m)
5.4
5.8
7.5

Liquefaction FOS

FOS $\geq 1.0$	FOS $< 1.0$



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CLIENT PROJECT

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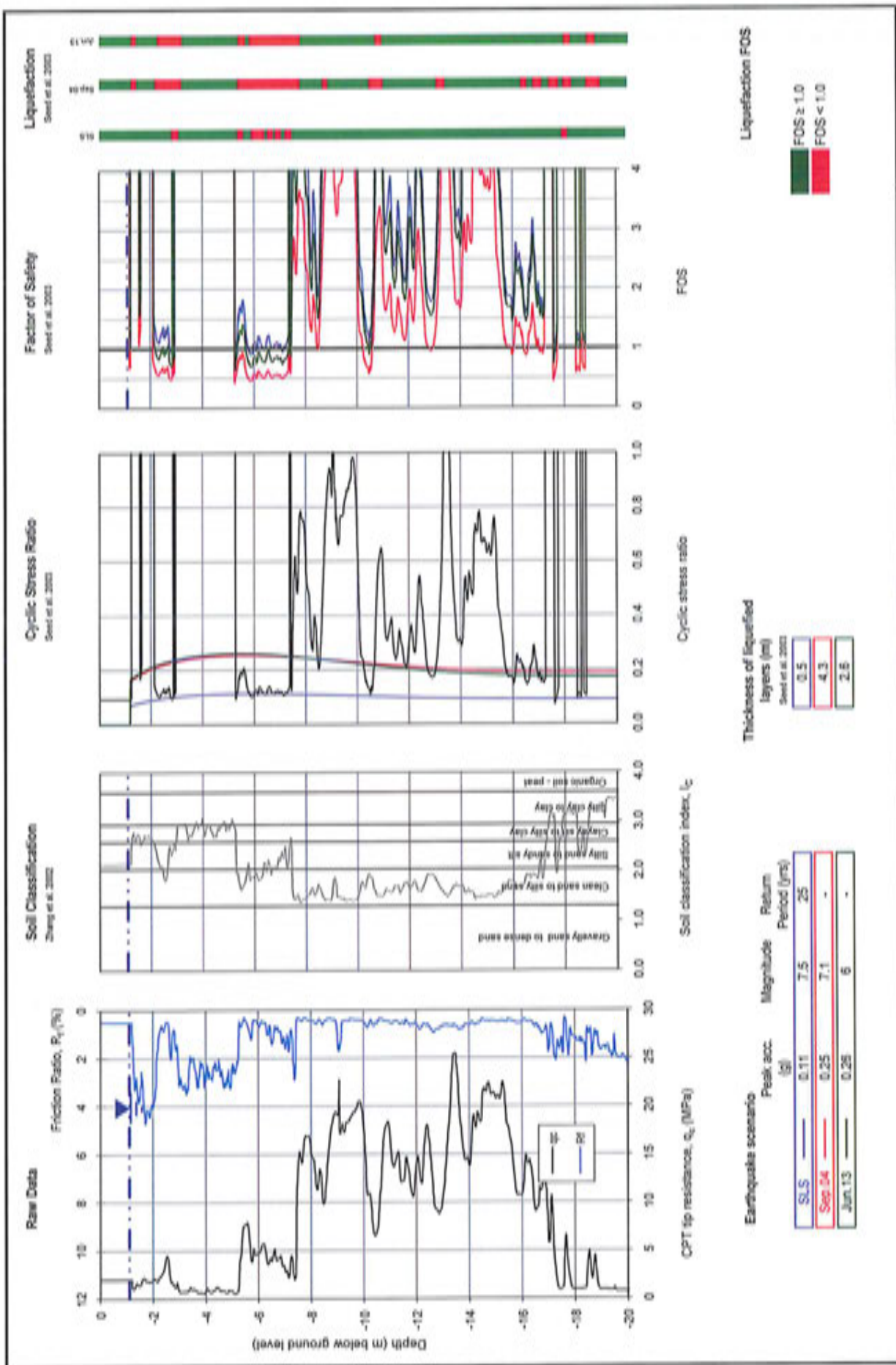
CPT-CBD-124

JOB NUMBER

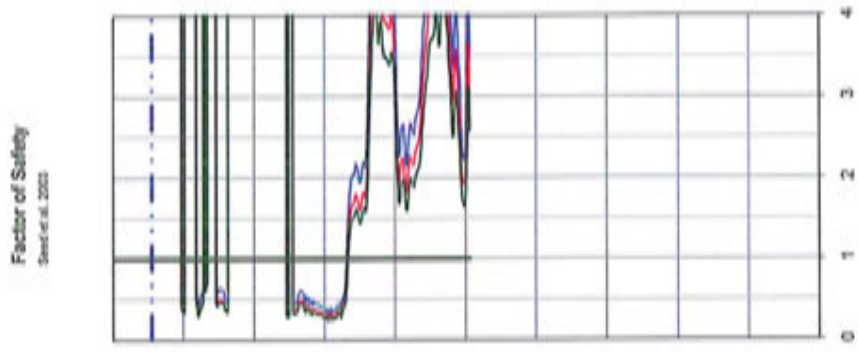
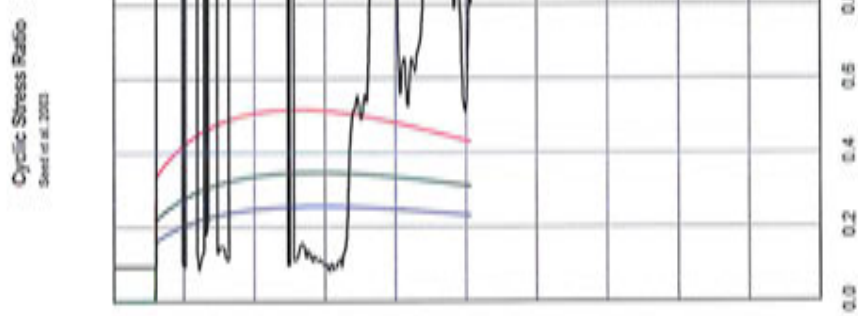
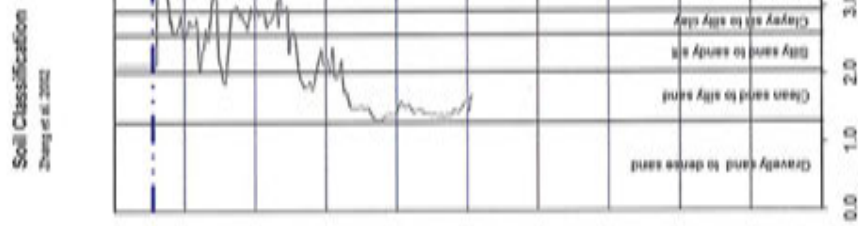
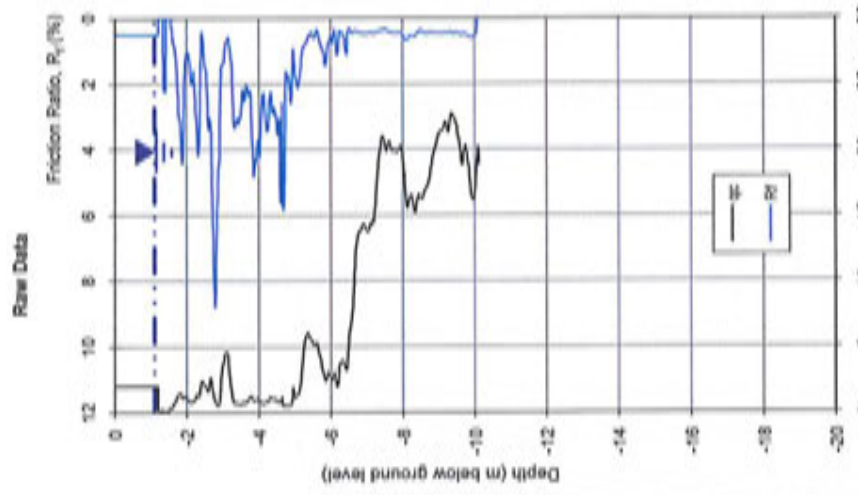
S2000.301

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results



 Tonkin & Taylor Ltd Environmental & Engineering Consultants	CLIENT PROJECT Christchurch City Council Geotechnical Assessment for Christchurch Central City		LOCATION <b>CPT-CBD-124</b>	DATE 7/12/2011
	TITLE Liquefaction Assessment from CPT Results		JOB NUMBER 52000.301	ANALYSED RAP
				CHECKED AFF



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1:170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

2.3
2.3
2.3

Liquefaction FOS



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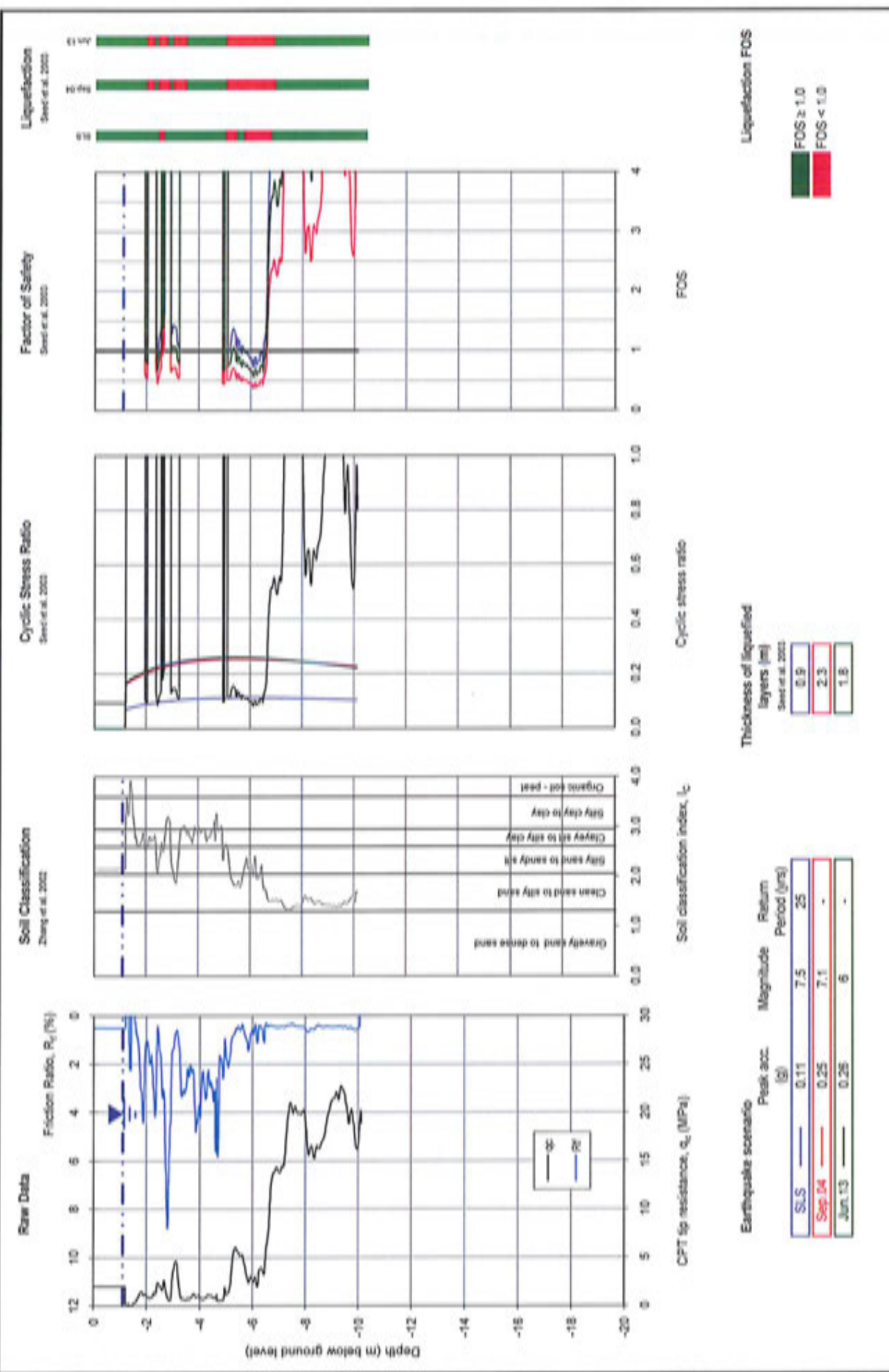
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

CLIENT PROJECT

**CPT-CBD-125**

JOB NUMBER: 52006.301

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-125</b>	DATE	T11/2011
			ANALYSED	RAP
TITLE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 52000.301	CHECKED AFF	CHECKED	
			ANALYSED	

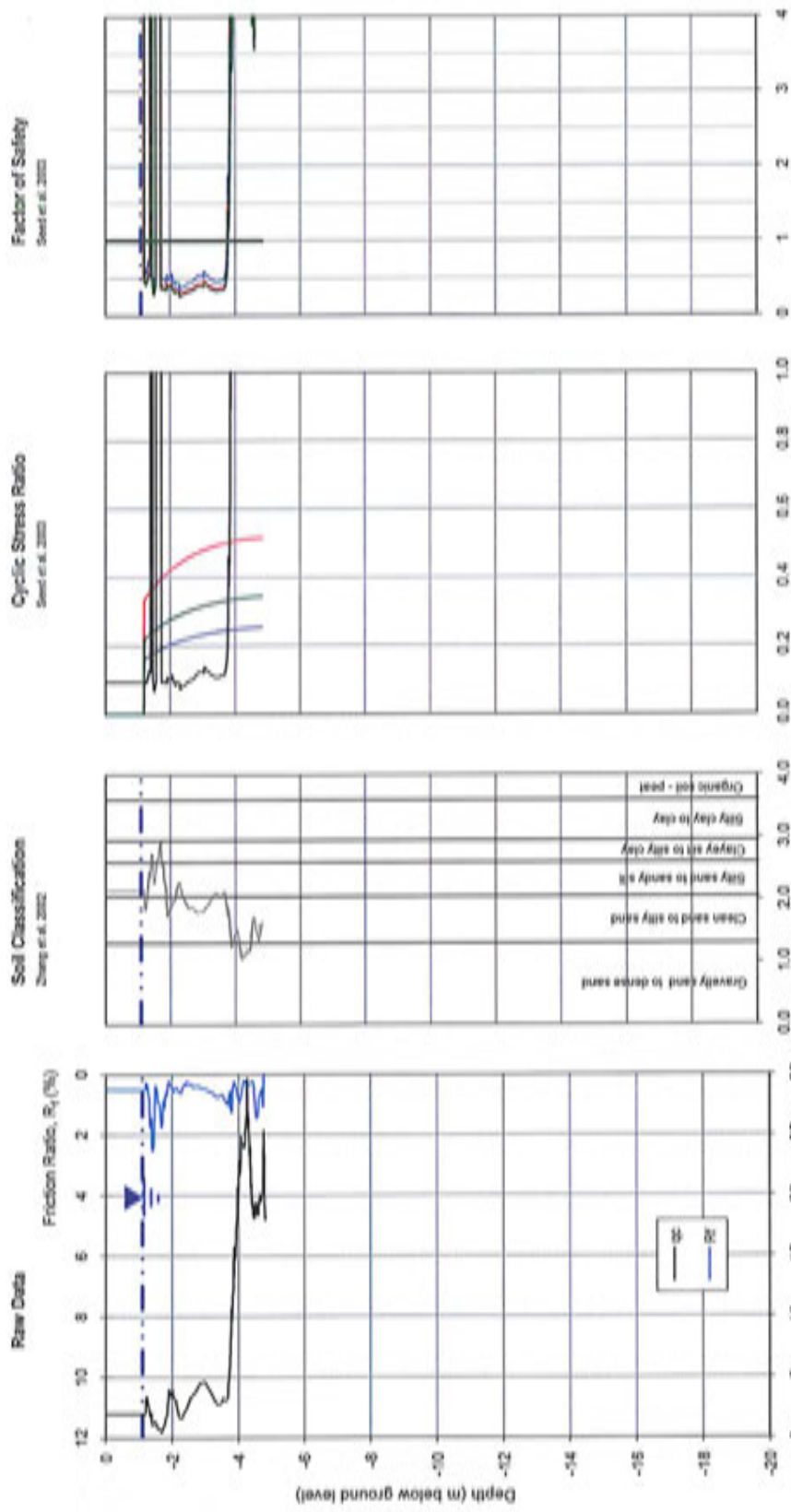
**Raw Data**  
Friction Ratio,  $R_f$  (%)

Factor of Safety  
Seed et al. 2002

Cyclic Stress Ratio  
Seed et al. 2002

Soil Classification  
Zhang et al. 2002

Liquefaction  
Seed et al. 2002



Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

CPT sp resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Liquefaction FOS

FOS  $\geq 1.0$   
FOS  $< 1.0$

**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

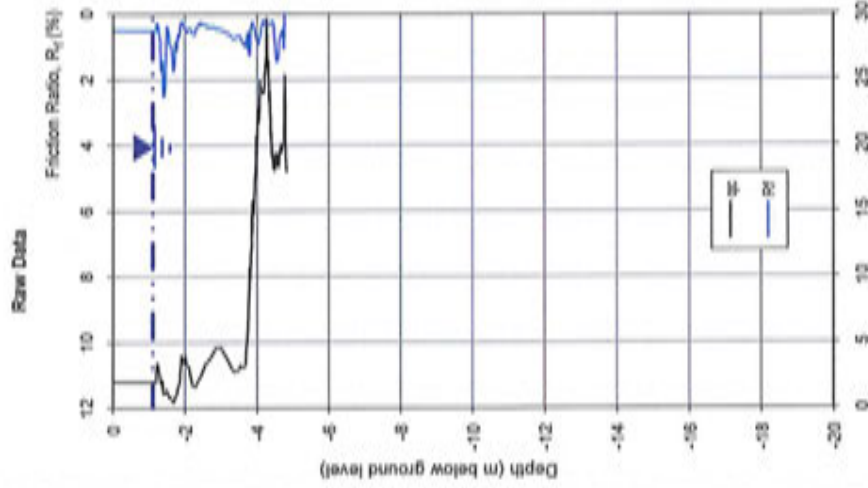
CLIENT PROJECT: **Christchurch City Council**  
**Geotechnical Assessment for Christchurch Central City**

LOCATION: **CPT-CBD-126**

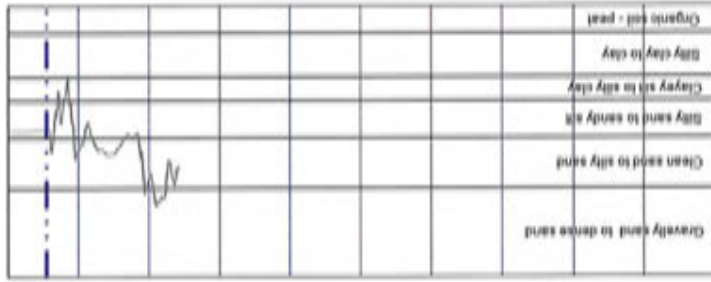
DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
AFF

TITLE: **Liquefaction Assessment from CPT Results**

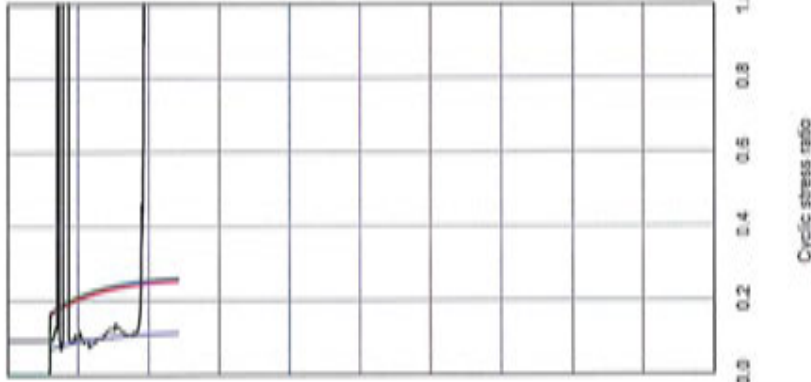
JOB NUMBER: 52000\_301



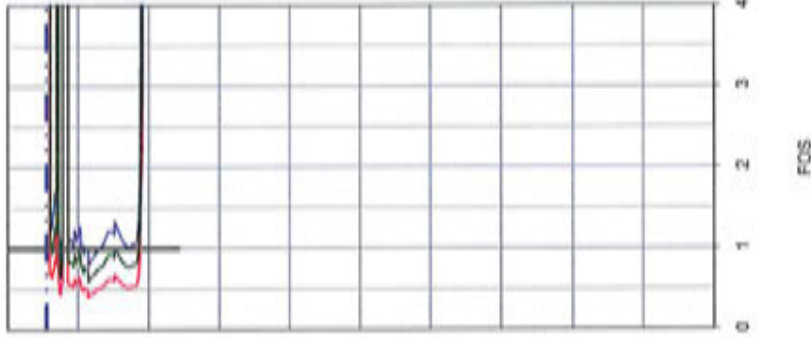
Soil Classification  
Zhang et al. 2002



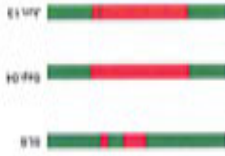
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.26	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.4
2.4
2.1

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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Engineering Consultants

CUSTOMER PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

SECTION

CPT-CBD-126

TITLE

Liquefaction Assessment from CPT Results

JOB NUMBER

52000.301

DATE

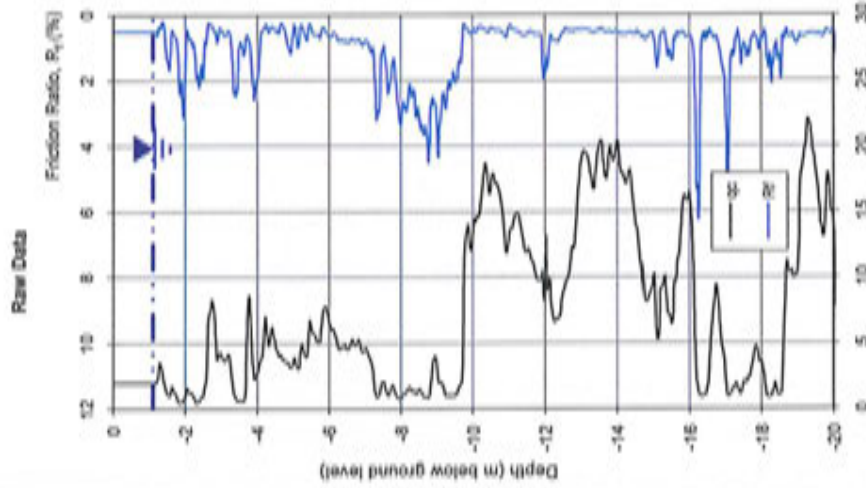
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ANALYSED

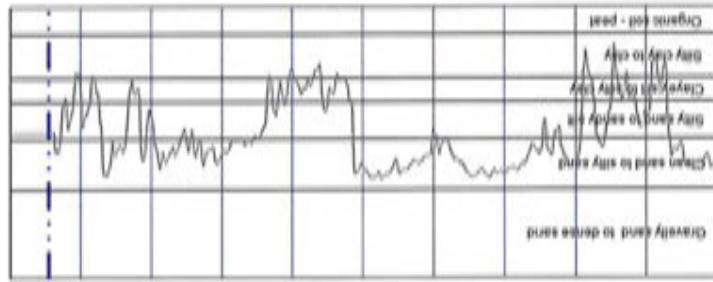
RAP

CHECKED

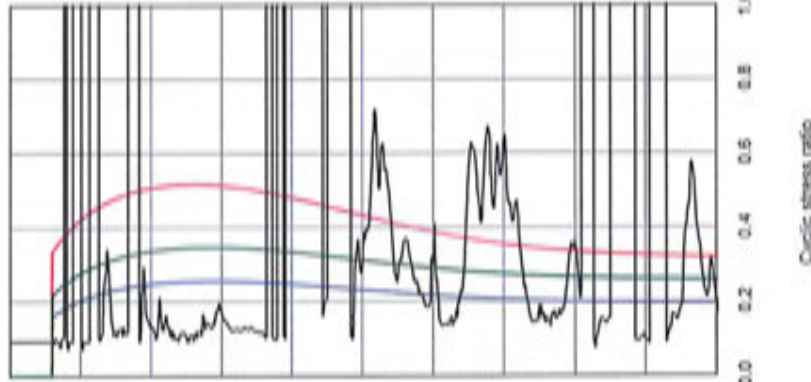
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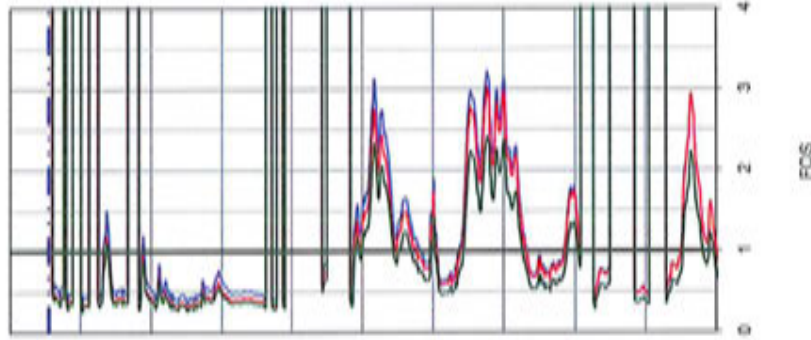
Soil Classification  
Zheng et al. 2002



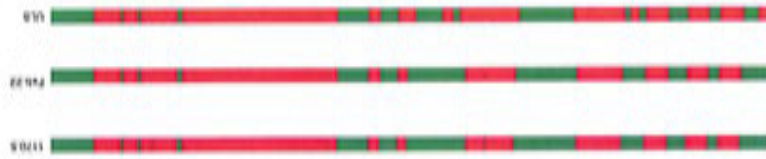
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc.	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
9.0
9.4
10.6

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



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Environmental &  
Engineering Consultants

CLIENT PROJECT

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION

CPT-CBD-127

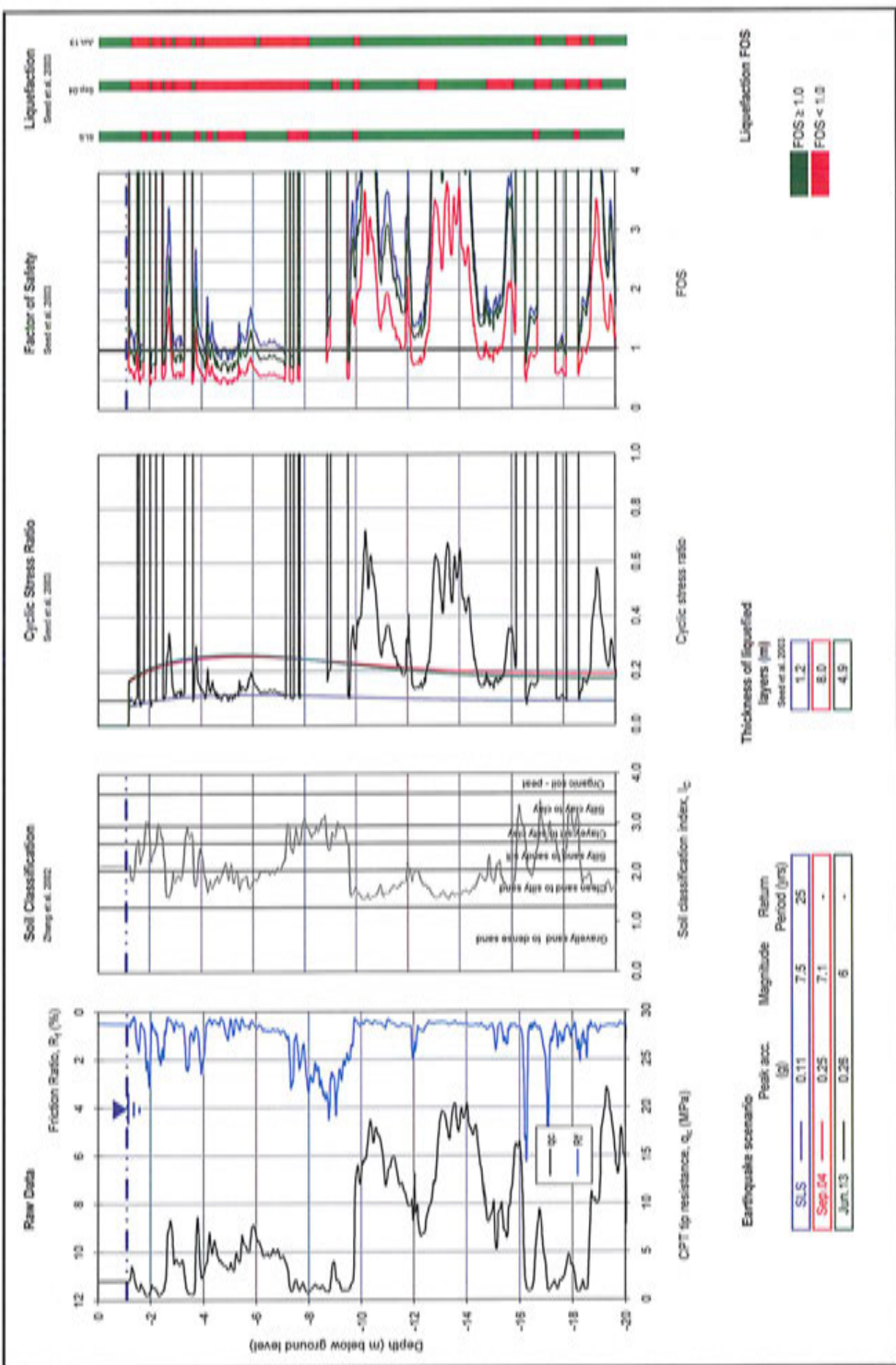
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Liquefaction Assessment from CPT Results

JOB NUMBER

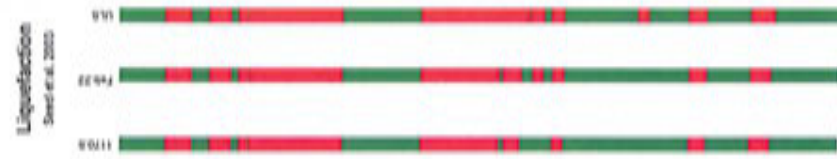
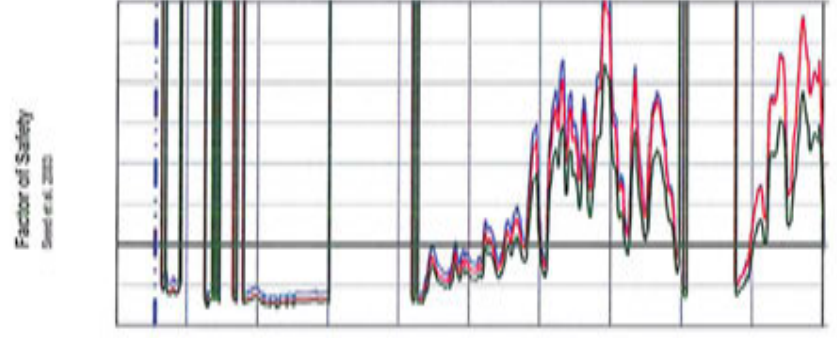
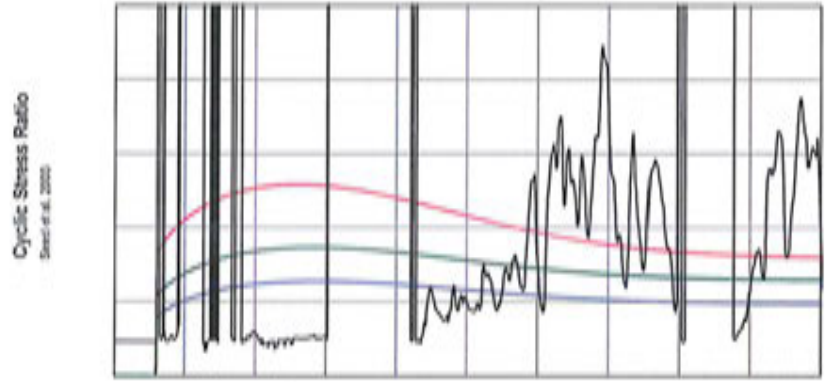
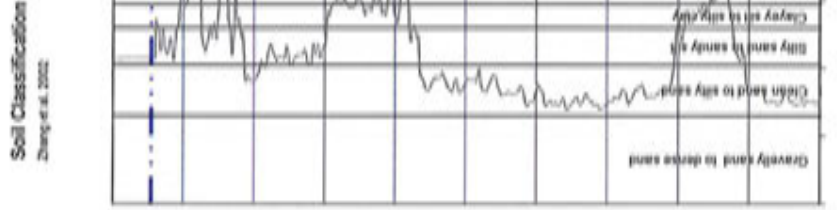
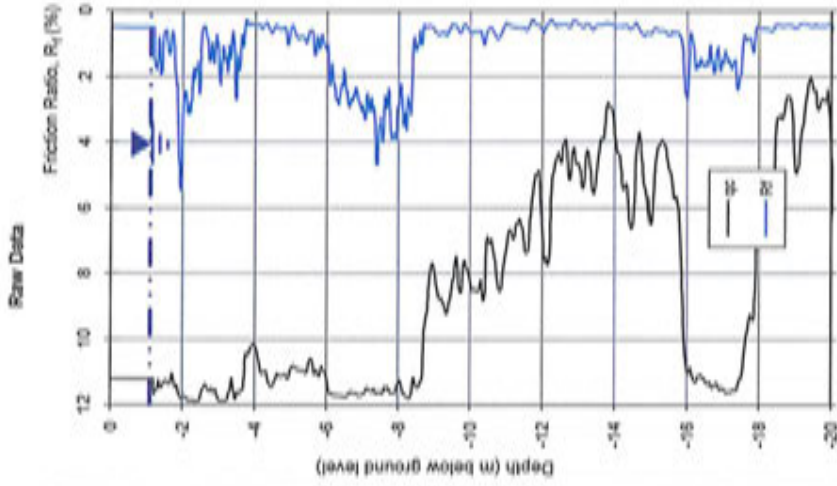
S2000.301

DATE 6/12/2011  
ANALYSED RAP  
CHECKED AFF



 Tonkin & Taylor Ltd Environmental & Engineering Consultants	LOCATION <b>CPT-CBD-127</b>	DATE 7/12/2011
	PROJECT <b>Christchurch City Council Geotechnical Assessment for Christchurch Central City</b>	ANALYSED RAP
RESULT <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 52000.301	CHECKED AFF





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
U.S.	7.5	500

Thickness of liquefied layers (m)

Seed et al. 2002

6.9
7.2
8.2

Liquefaction FOS

Legend: FOS  $\geq 1.0$  (green), FOS  $< 1.0$  (red)



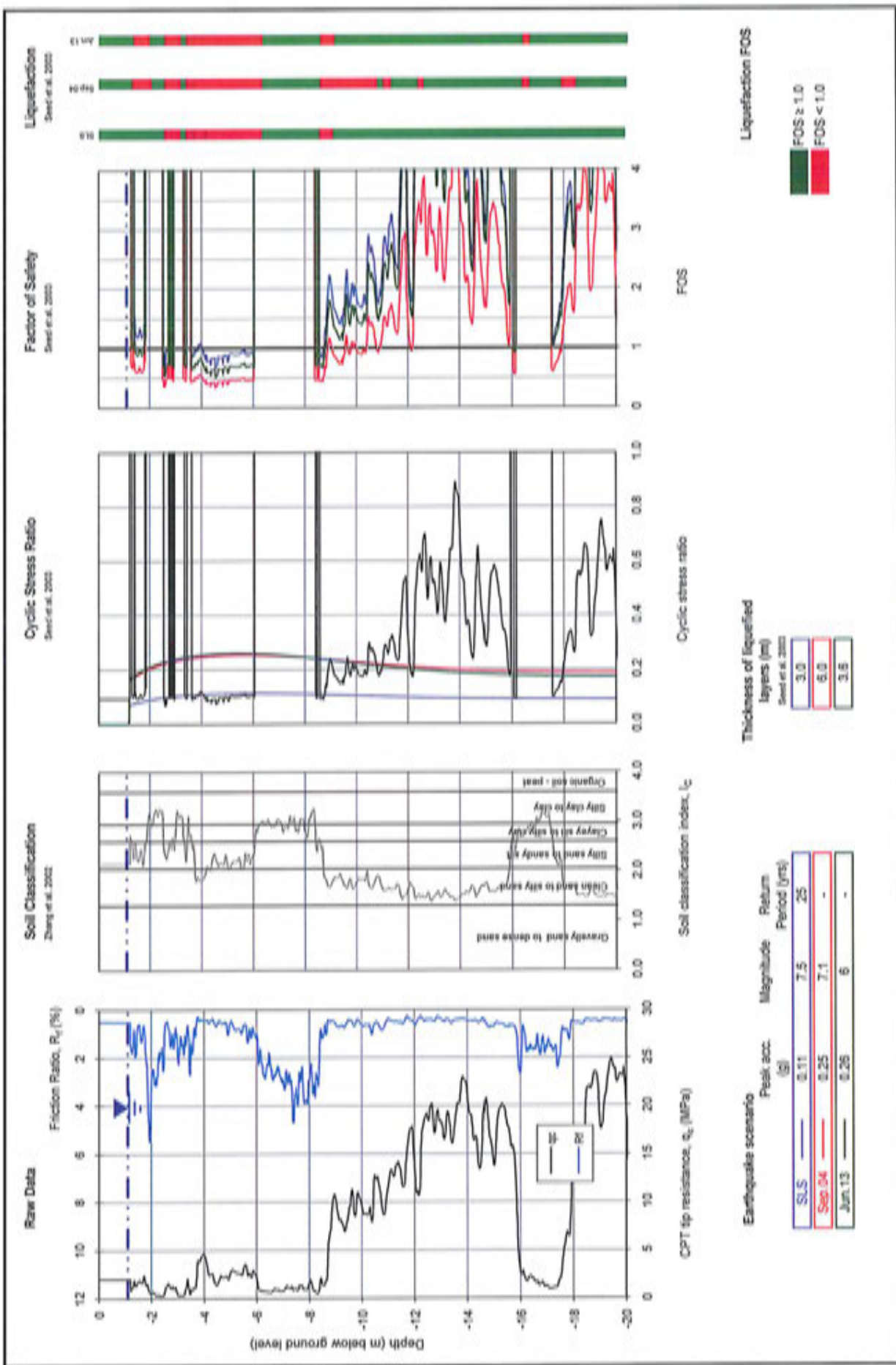
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Environmental & Engineering Consultants

CLIENT PROJECT  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

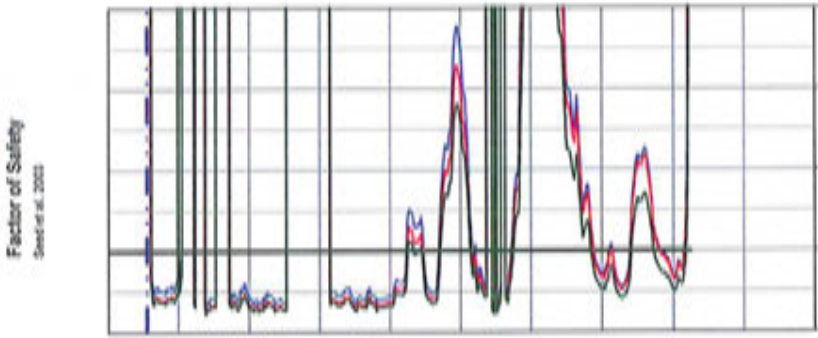
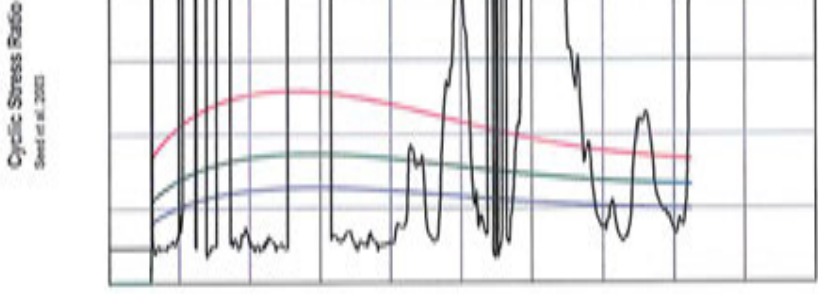
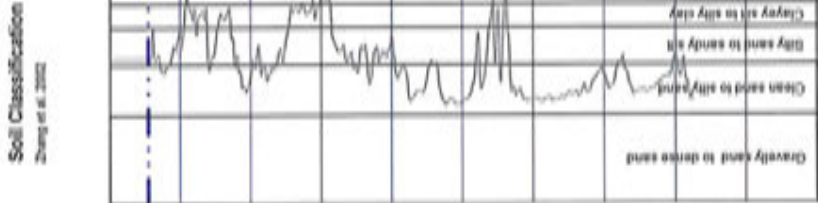
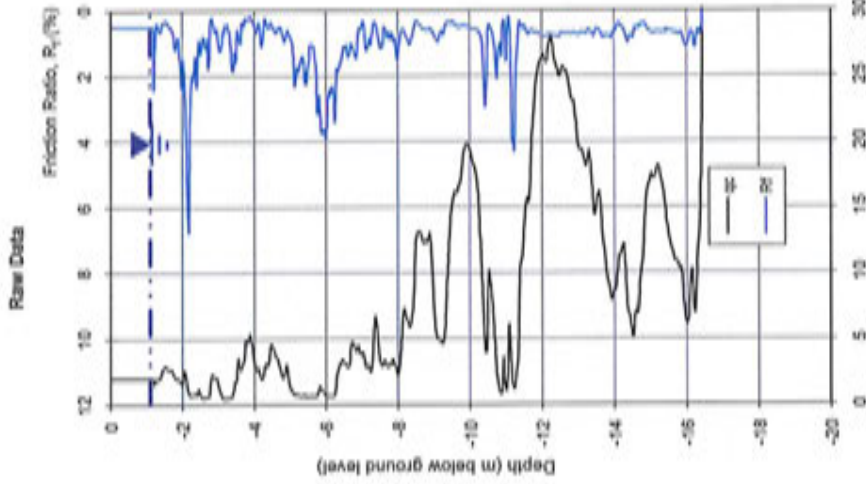
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CPT-CBD-128  
LOT NUMBER  
52000.301

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City		<b>DATE</b> 7/12/2011 <b>ANALYSED</b> RAP <b>CHECKED</b> AFF
	<b>LOCATION</b> CPT-CBD-128		<b>JOB NUMBER</b> S2000.301
<b>Liquefaction Assessment from CPT Results</b>			



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

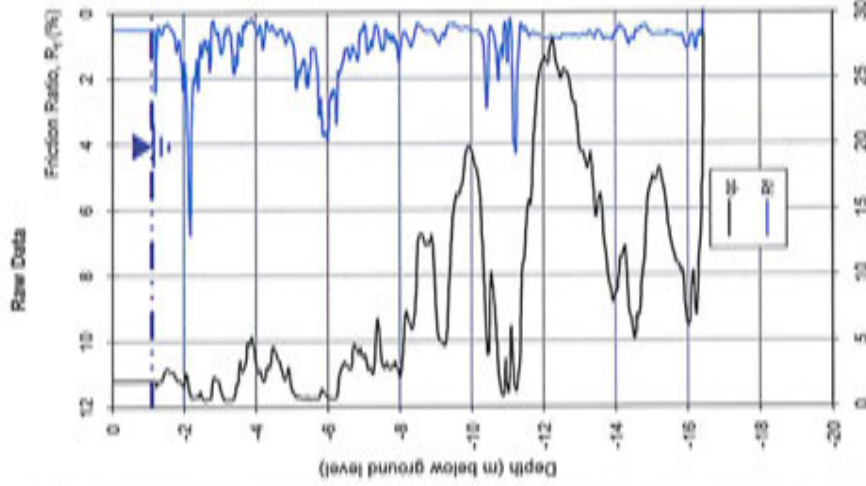
7.5
8.0
8.7



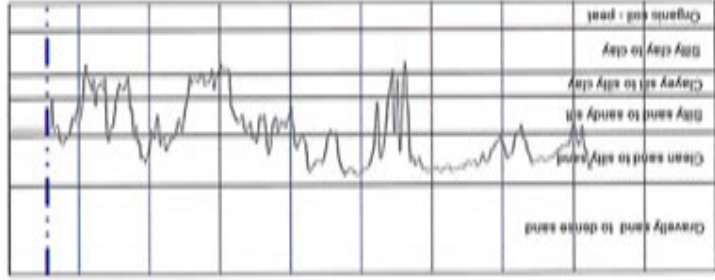
Tonkin & Taylor Ltd  
Environmental & Engineering Consultants

CLIENT PROJECT	LOCATION
Christchurch City Council Geotechnical Assessment for Christchurch Central City	CPT-CBD-129
FILE	JOB NUMBER
	52000_301

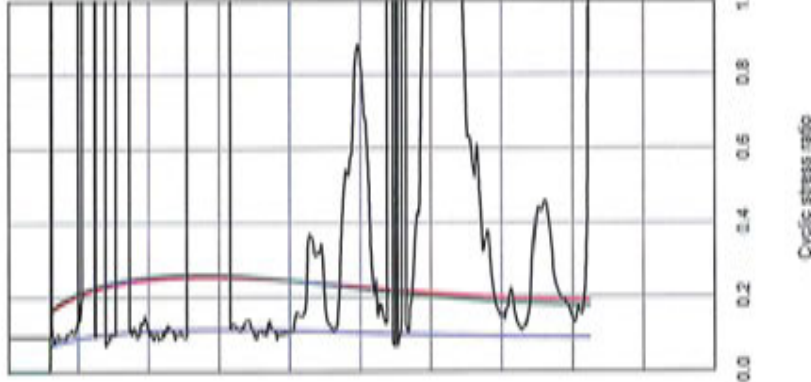
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ANALYSED	6/12/2011
CHECKED	RAP
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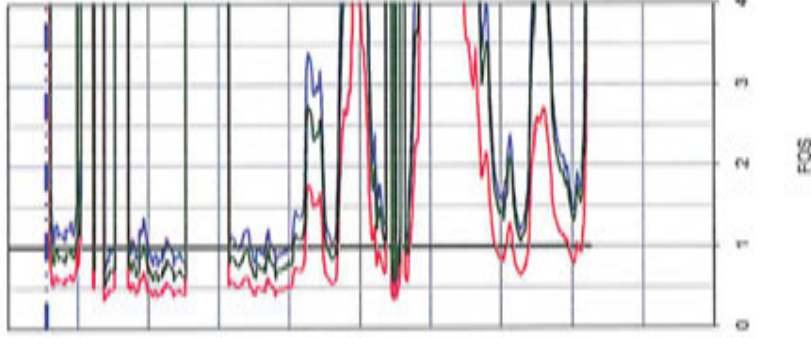
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_c$  (kPa)

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jan.13	0.25	6	-

Thickness of liquefied layers (m)

SLS	2.6
Sep 04	7.1
Jan.13	5.0

Liquefaction FOS

FOS  $\geq$  1.0  
FOS  $<$  1.0



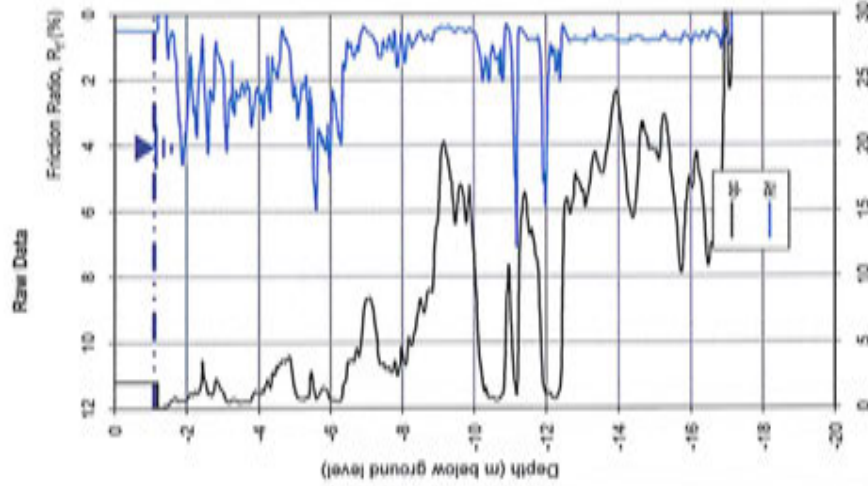
Tonkin & Taylor Ltd  
Environmental & Engineering Consultants

CLIENT PROJECT: Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

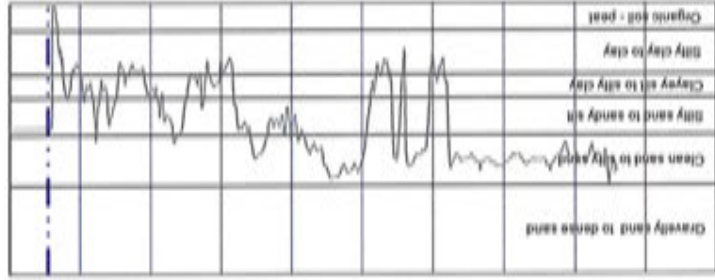
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JOB NUMBER: 52000\_301

DATE: 7/12/2011  
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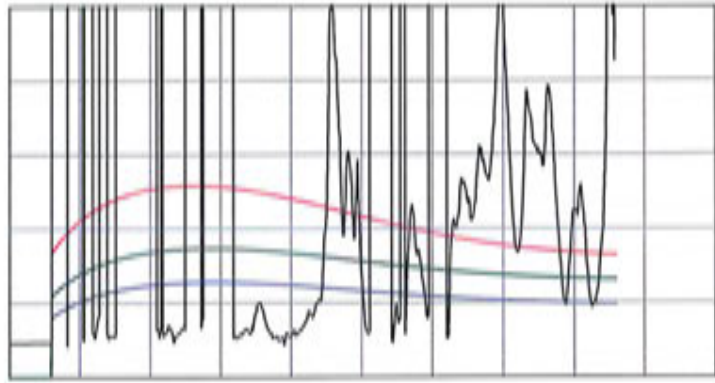
FILE: Liquefaction Assessment from CPT Results



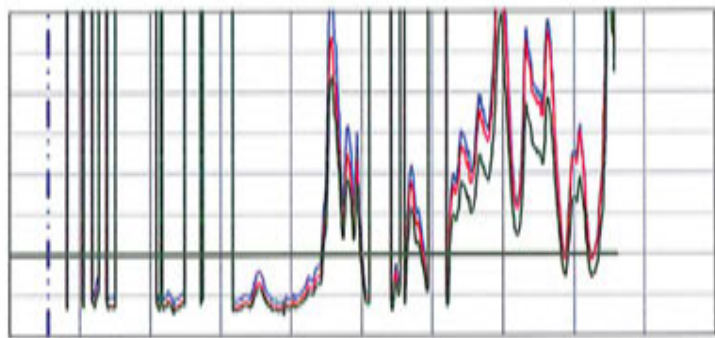
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc.	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

4.7
4.8
5.3

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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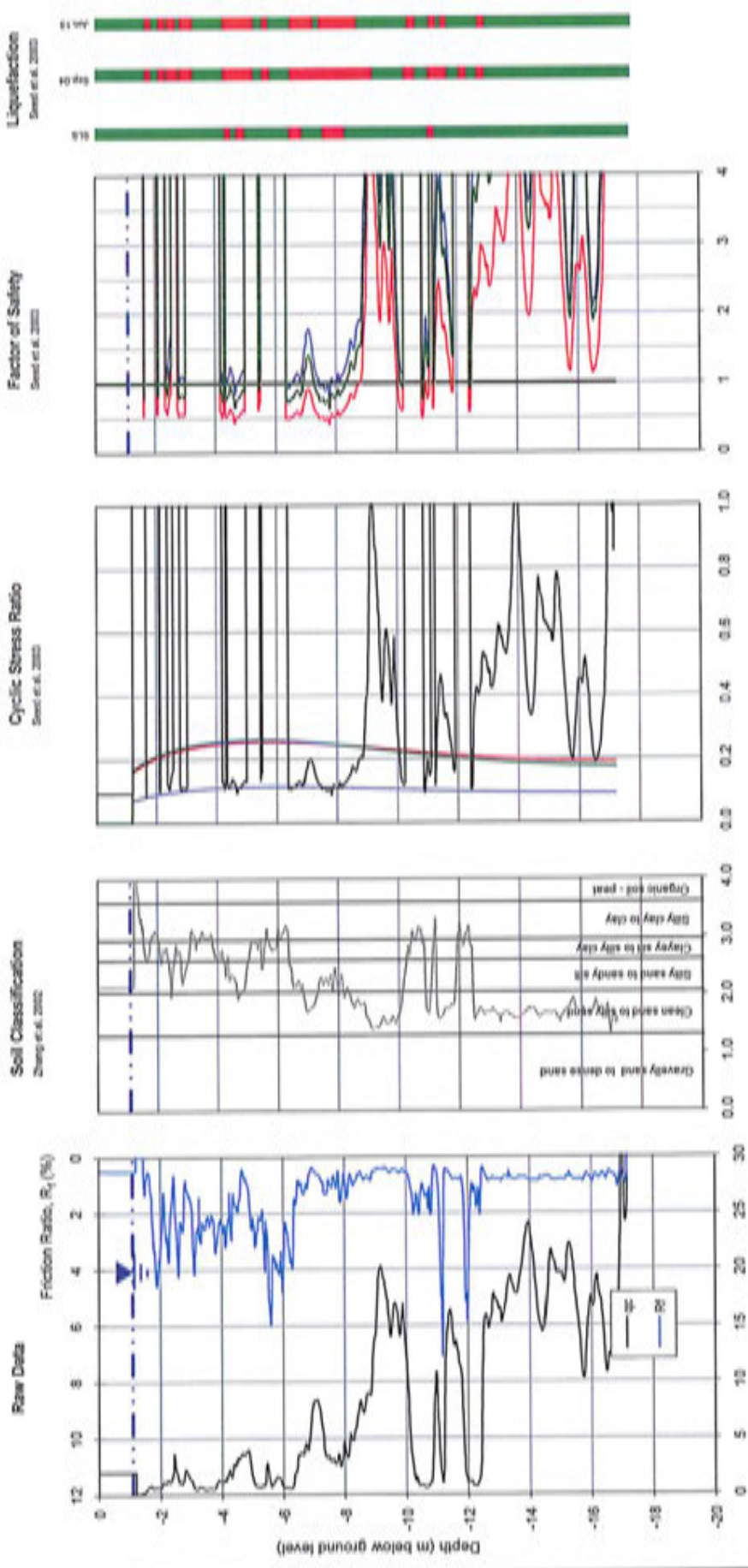
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

CPT-CBD-130

Liquefaction Assessment from CPT Results

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

JOB NUMBER: S2000\_301



Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.25	6	-

Soil classification index, $I_c$	Thickness of liquefied layers (m)
Gravelly sand to dense sand	0.8
Clean sand to silty sand	4.4
Silty sand to sandy silty clay	3.0
Silty clay to clay	-
(Organic) silt - peat	-

Soil Classification	Cyclic Stress Ratio	Factor of Safety	Liquefaction
Gravelly sand to dense sand	~0.2	~1.5	Green
Clean sand to silty sand	~0.3	~1.2	Red
Silty sand to sandy silty clay	~0.4	~1.0	Red
Silty clay to clay	~0.5	~1.0	Red
(Organic) silt - peat	~0.6	~1.0	Red

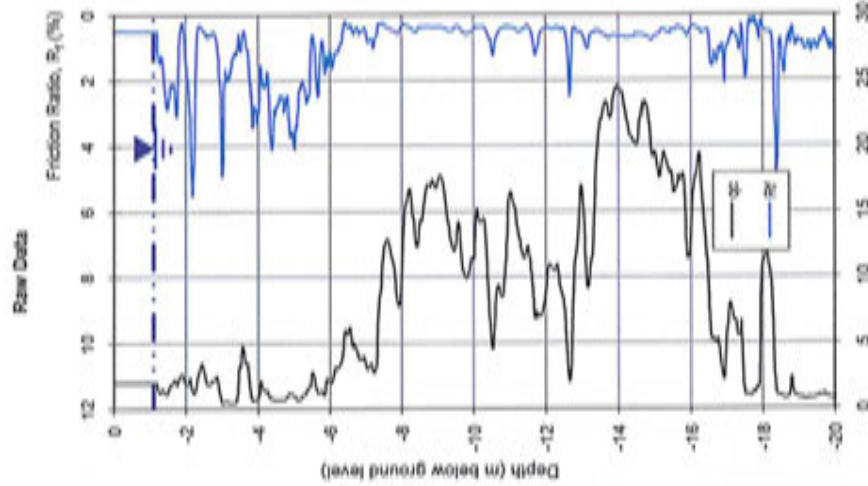
**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

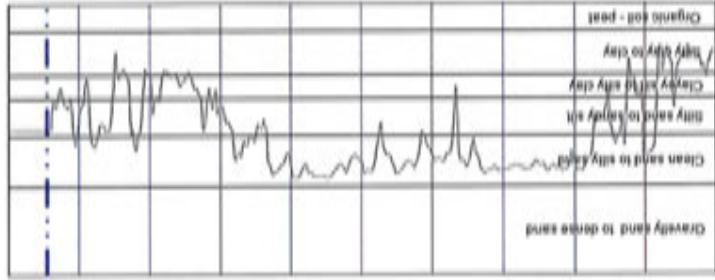
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DATE	7/12/2011
APPROVED	RAP
CHECKED	AFF

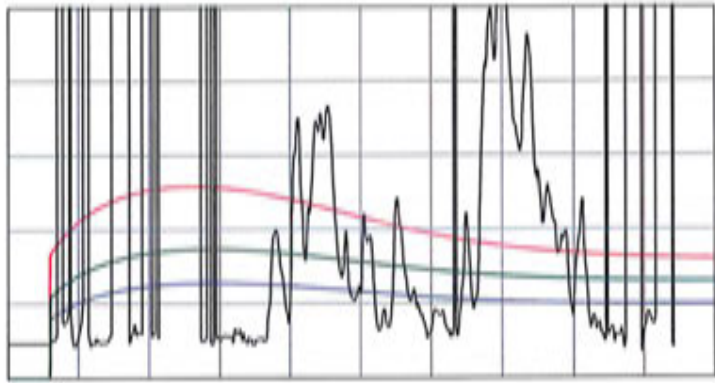
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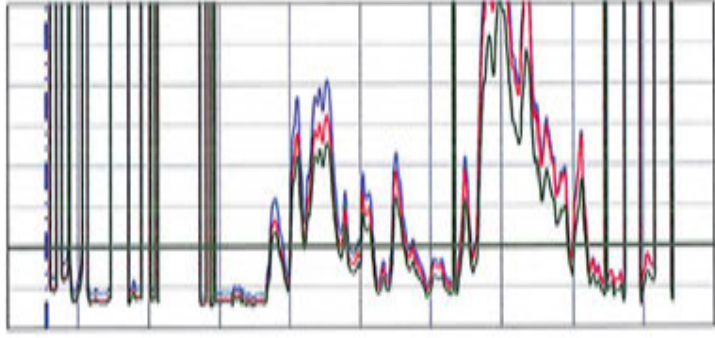
Soil Classification  
Zheng et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (kPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness (m)
8.1
8.6
9.3

Liquefaction FOS



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Engineering Consultants

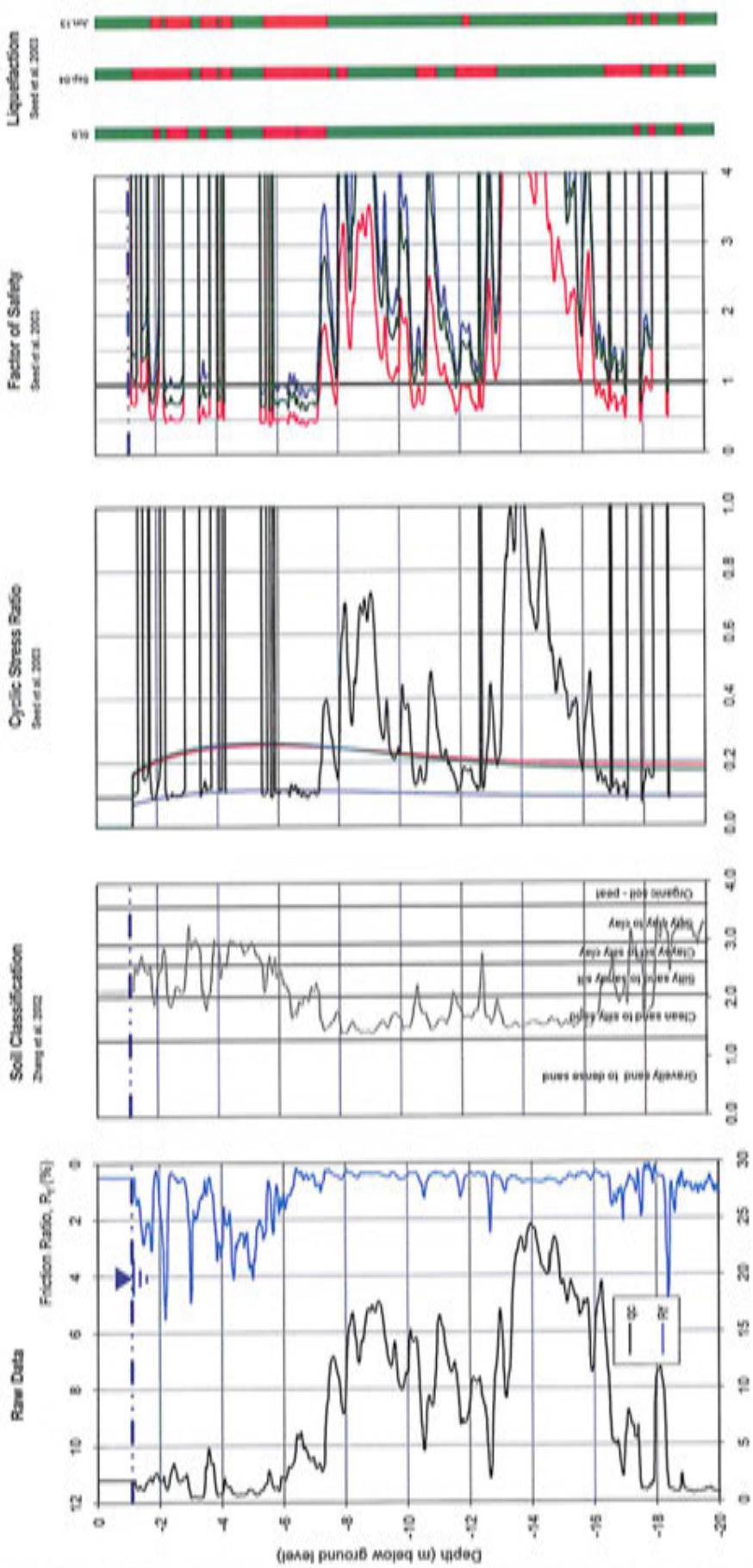
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

CPT-CBD-131

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

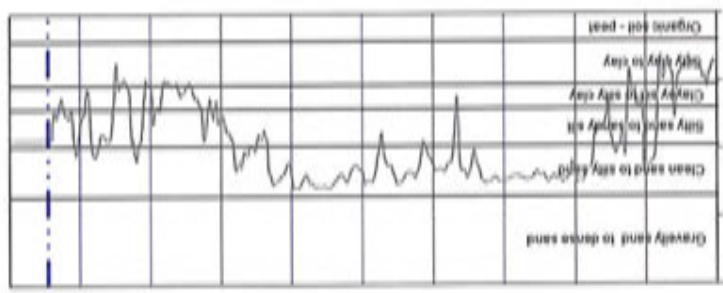
Liquefaction Assessment from CPT Results

JOB NUMBER: 52000\_301

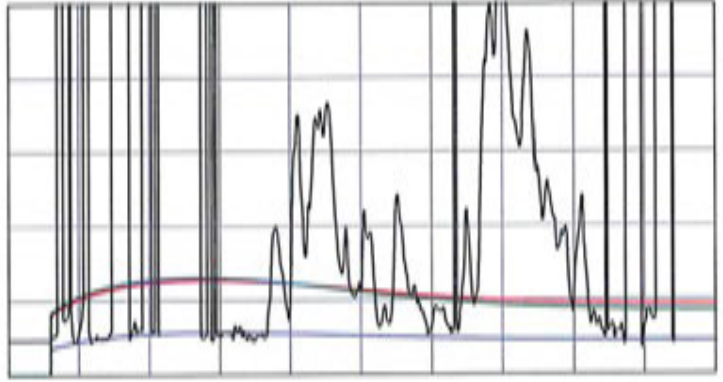


Raw Data  
Friction Ratio,  $R_f$  (%)

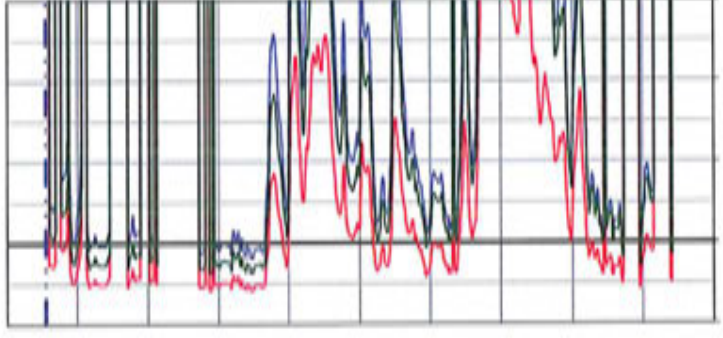
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. ( $g$ )	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.04	0.25	7.1	-
Jan.13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
2.0
7.1
3.3

Liquefaction FOS



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Environmental & Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

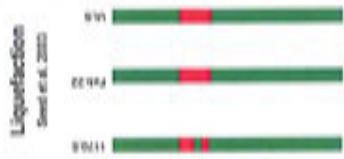
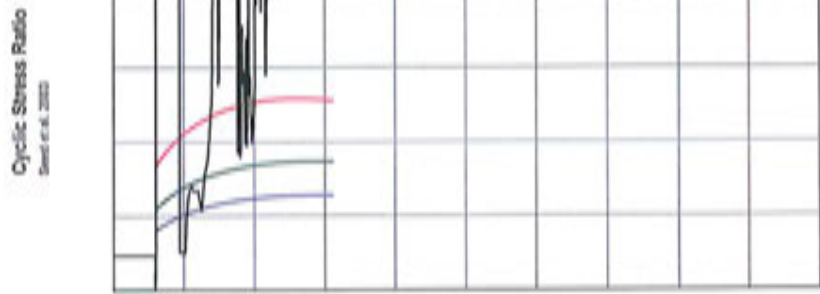
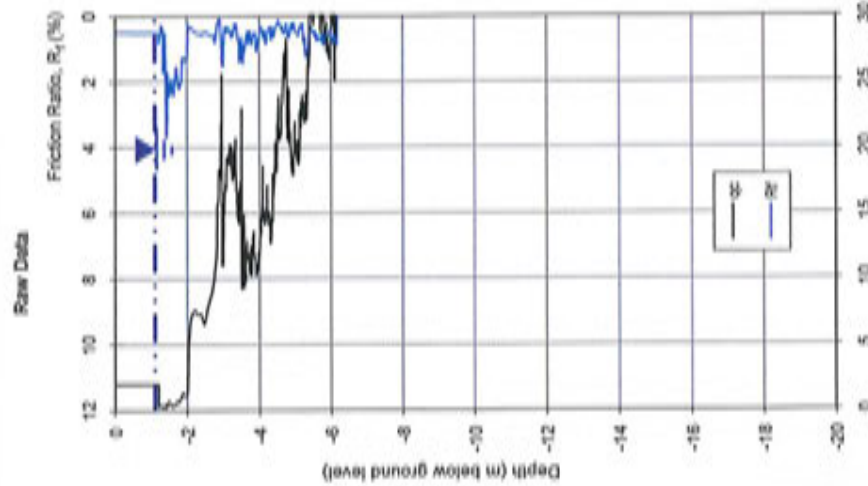
PROJECT  
CPT-CBD-131

DATE 7/12/2011  
ANALYSED RAP  
CHECKED AFF

FILE  
Liquefaction Assessment from CPT Results

JOB NUMBER  
S2000\_301





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

0.2
0.6
0.7

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



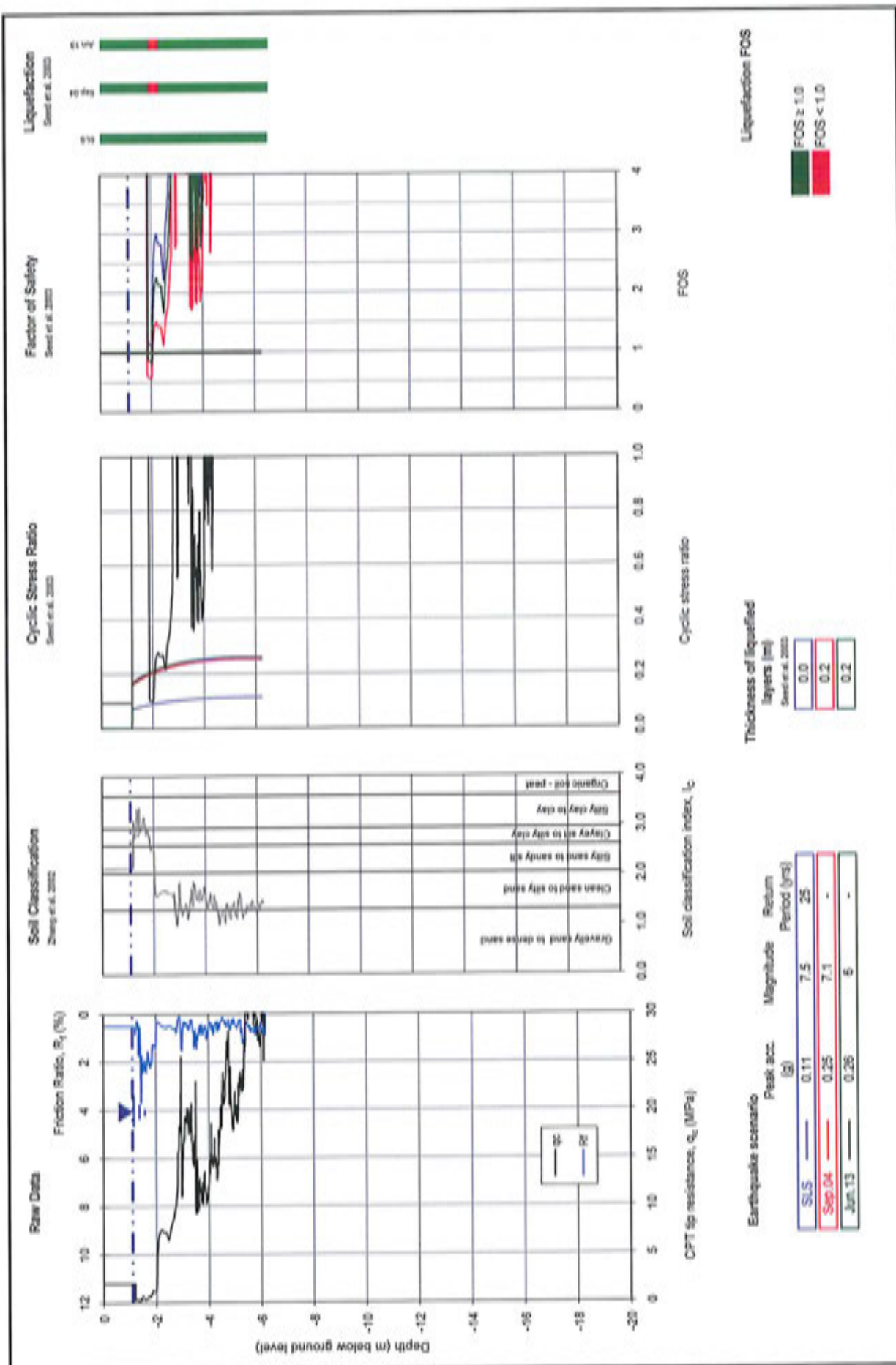
Tonkin & Taylor Ltd  
Environmental & Engineering Consultants


Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

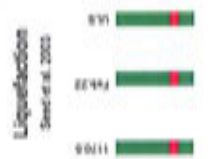
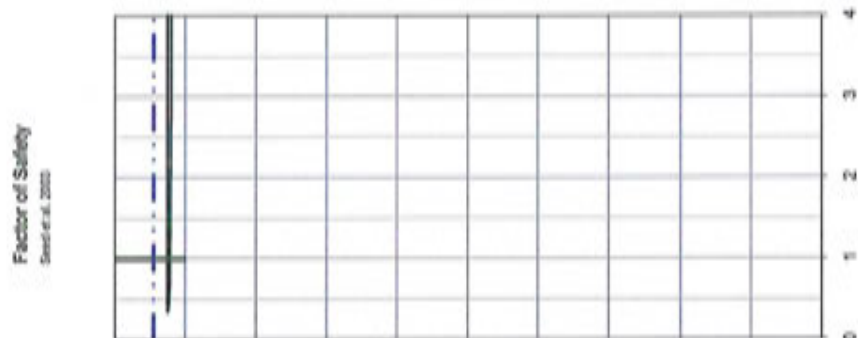
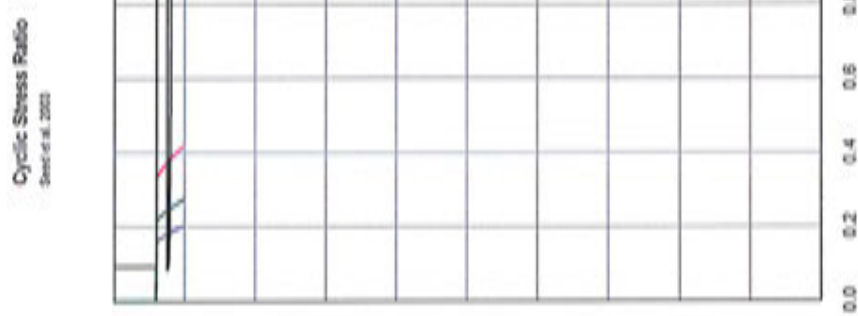
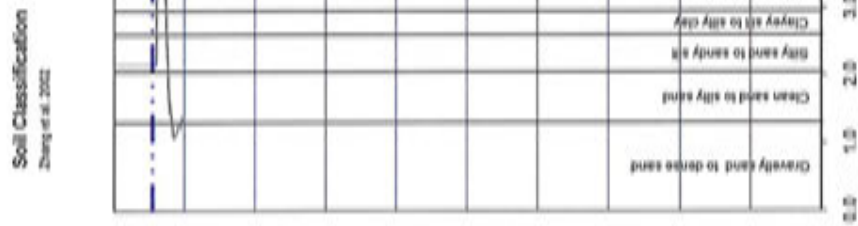
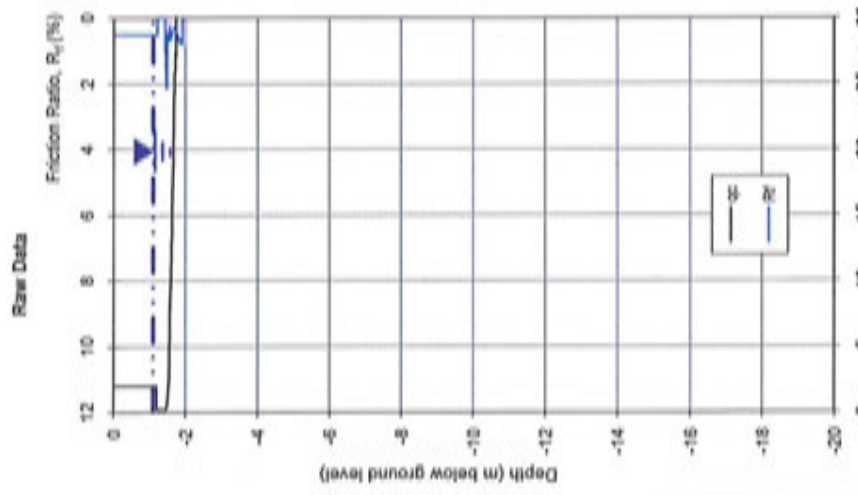
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CPT-CBD-132  
JOB NUMBER  
52000\_301

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results



 Torkin & Taylor Ltd Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		LOCATION <b>CPT-CBD-132</b>	DATE 7/12/2011
	FILE Liquefaction Assessment from CPT Results		JOB NUMBER S2000_301	ANALYSED RAP
				CHECKED AFF



CPT tip resistance,  $q_c$  (MPa)

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
Feb.22	0.52	6.2	-
ULS	0.34	7.5	500

Thickness of liquefied layers (m)

0.1
0.1
0.1

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0

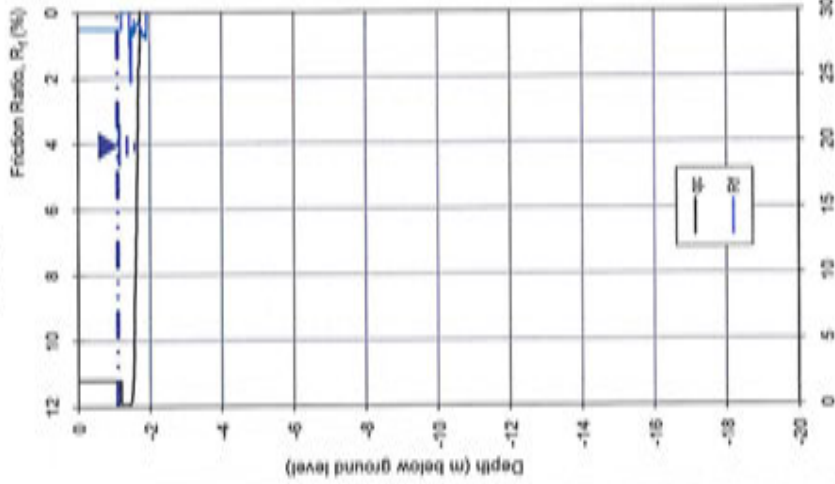


Tonkin & Taylor Ltd  
Environmental & Engineering Consultants

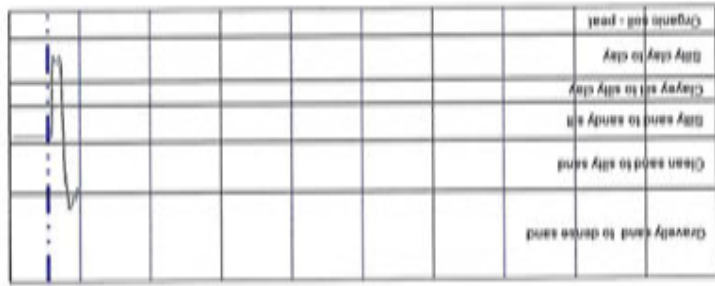
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
JOB NUMBER: 52000\_301

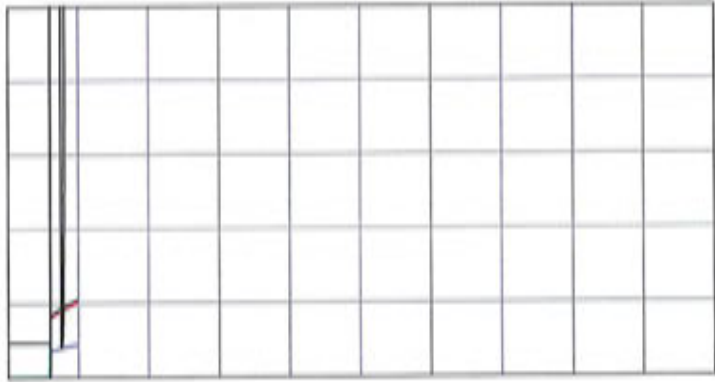
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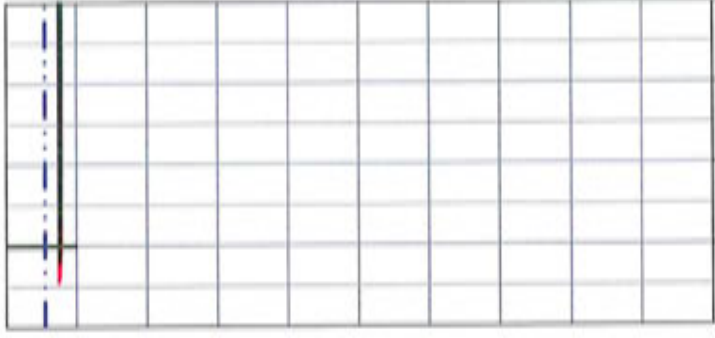
**Soil Classification**  
Zheng et al. 2002



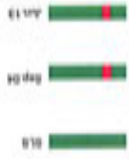
**Cyclic Stress Ratio**  
Seed et al. 2002



**Factor of Safety**  
Seed et al. 2002



**Liquefaction**  
Seed et al. 2002



**CPT tip resistance,  $q_c$  (MPa)**

**Soil classification index,  $I_c$**

**Cyclic stress ratio**

**FOS**

**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	7.5	25
Sep 04	7.1	-
Jun 13	6	-

**Thickness of liquefied layers (m)**  
Seed et al. 2002

0.0
0.1
0.1

**Liquefaction FOS**



**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

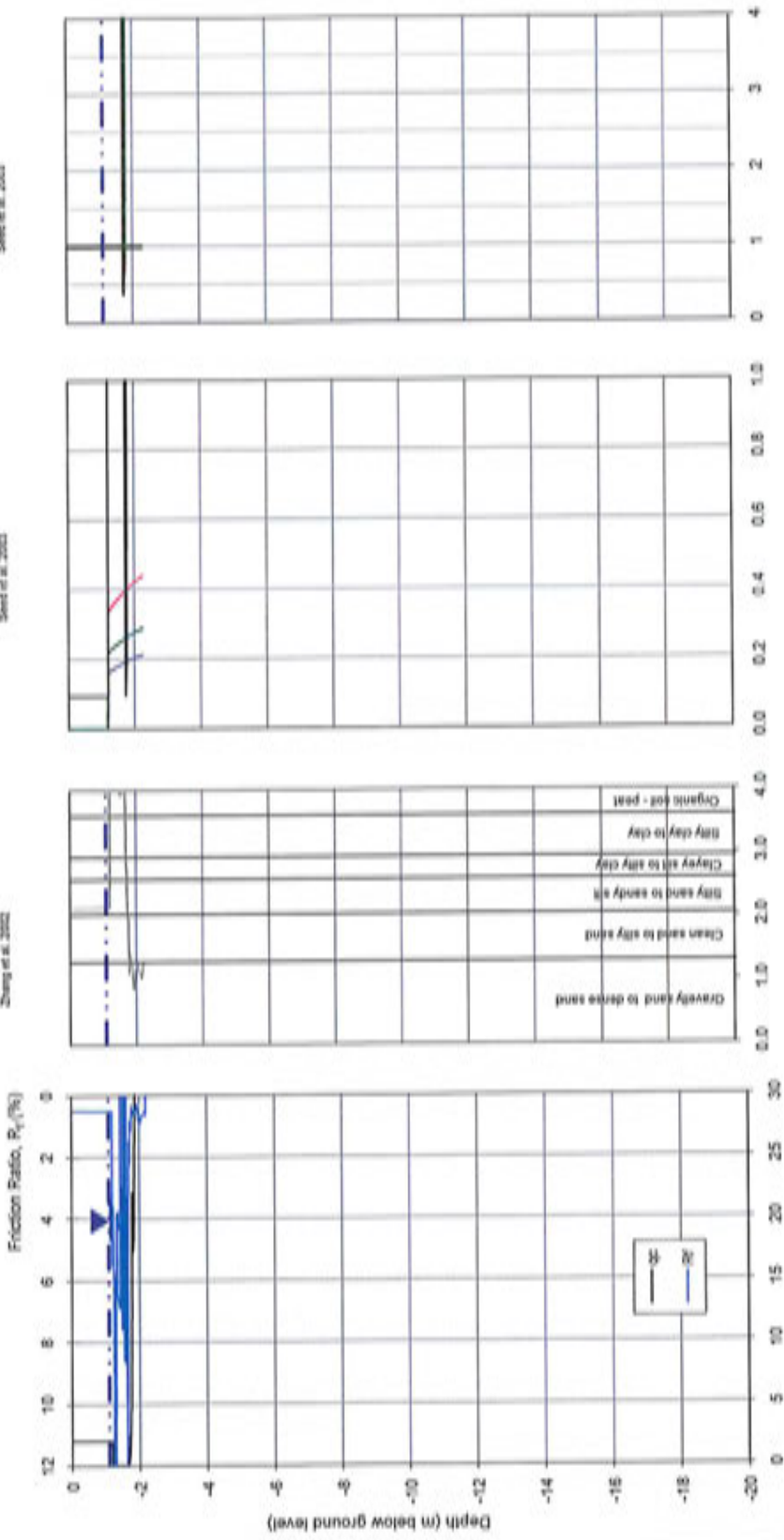
**LOCATION**  
CPT-CBD-133

**DATE** 7/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

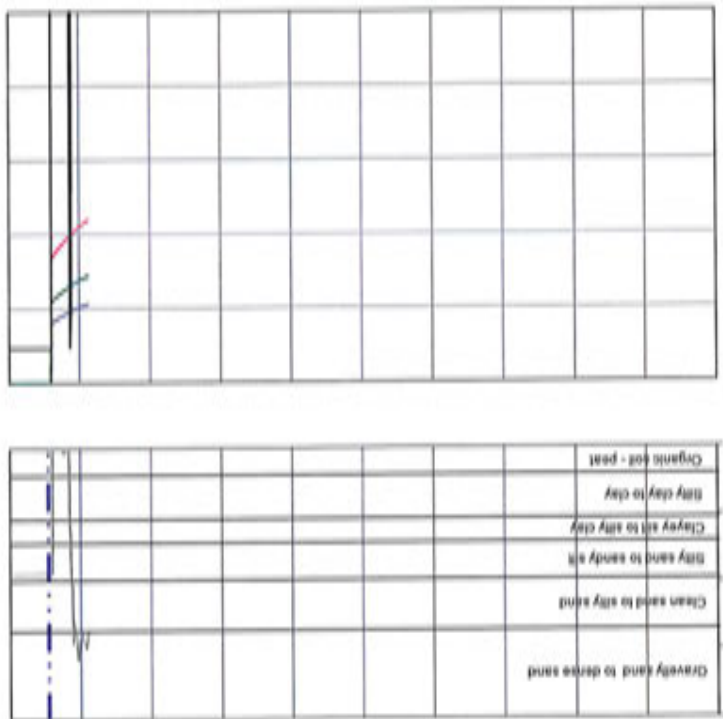
**JOB NUMBER** S2000.301

**Liquefaction Assessment from CPT Results**

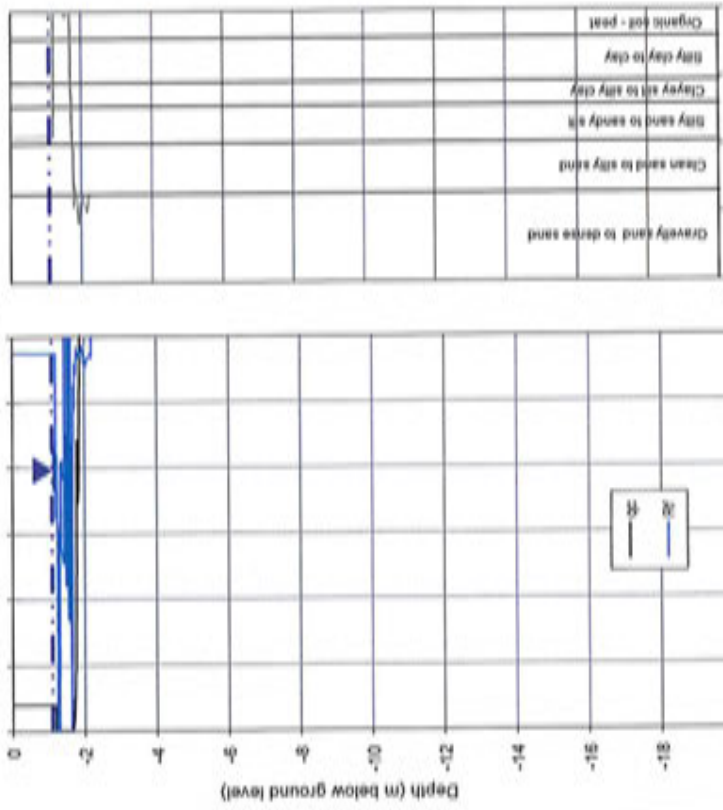
**Raw Data**  
Friction Ratio,  $R_f$  (%)



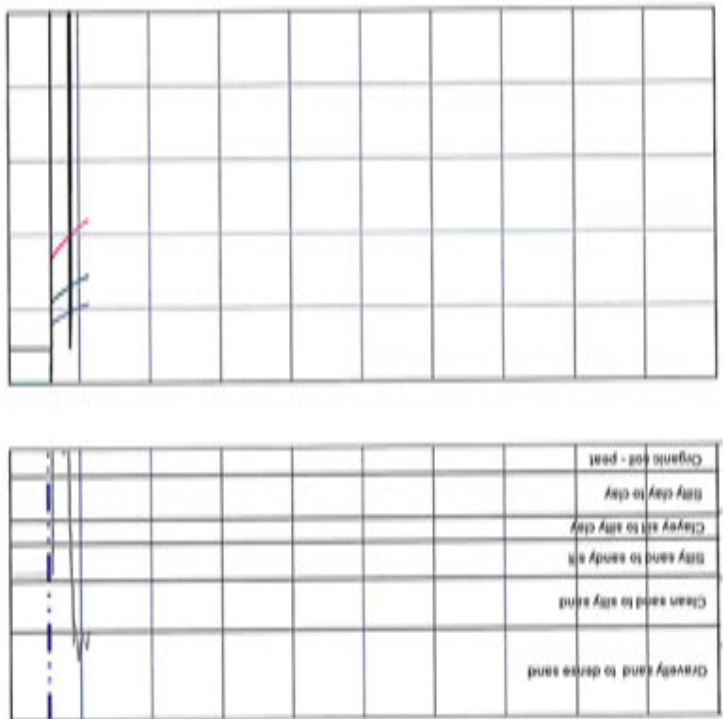
**Soil Classification**  
Zheng et al. 2002



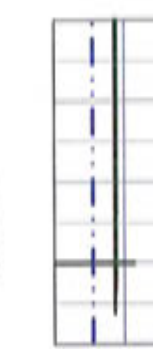
**Cyclic Stress Ratio**  
Seed et al. 2002



**Factor of Safety**  
Seed et al. 2002



**Liquefaction**  
Seed et al. 2002



**CPT tip resistance,  $q_t$  (MPa)**

**Soil classification index,  $I_c$**

**Cyclic stress ratio**

**Factor of Safety (FOS)**



**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
1:170.5	7.5	500
Feb. 22	6.2	-
U.S.	7.5	500

**Thickness of liquefied layers (m)**

0.1
0.1
0.1

**Liquefaction FOS**

FOS >= 1.0
FOS < 1.0



**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

**CLIENT PROJECT**  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

**LOCATION**  
CPT-CBD-133a

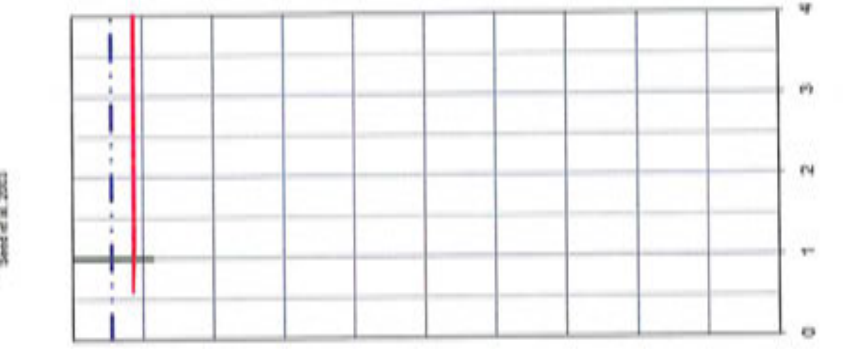
**DATE** 6/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

**JOB NUMBER**  
S2000.301

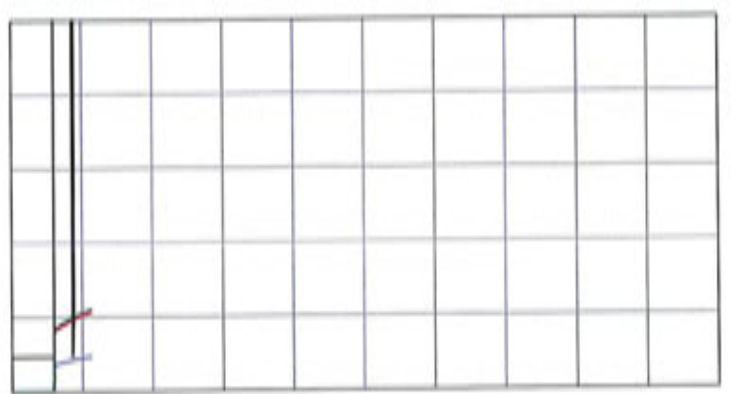
**REPORT TITLE**  
Liquefaction Assessment from CPT Results

**Raw Data**  
Friction Ratio,  $R_f$  (%)

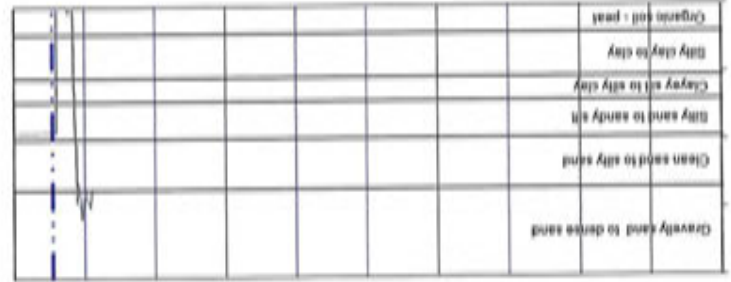
Depth (m below ground level)



**Soil Classification**  
Zheng et al. 2002



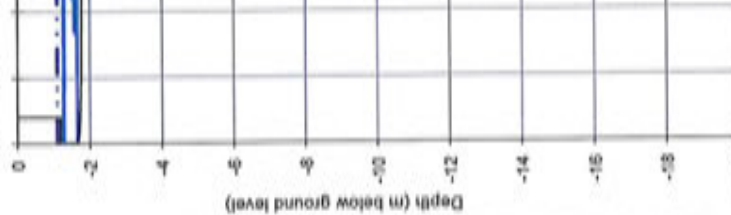
**Cyclic Stress Ratio**  
Seed et al. 2003



**Factor of Safety**  
Seed et al. 2003



**Liquefaction**  
Seed et al. 2003



**Soil classification index,  $I_c$**

**Cyclic stress ratio**

**Factor of Safety**

**Liquefaction FOS**

**Thickness of liquefied layers (m)**  
Seed et al. 2002

SLS	0.0
Sep 04	0.0
Jun 13	0.0

**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5
Sep 04	0.25	7.1
Jun 13	0.25	6

**CPT tip resistance,  $q_t$  (MPa)**

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**TONKIN & TAYLOR LTD**  
Environmental & Engineering Consultants

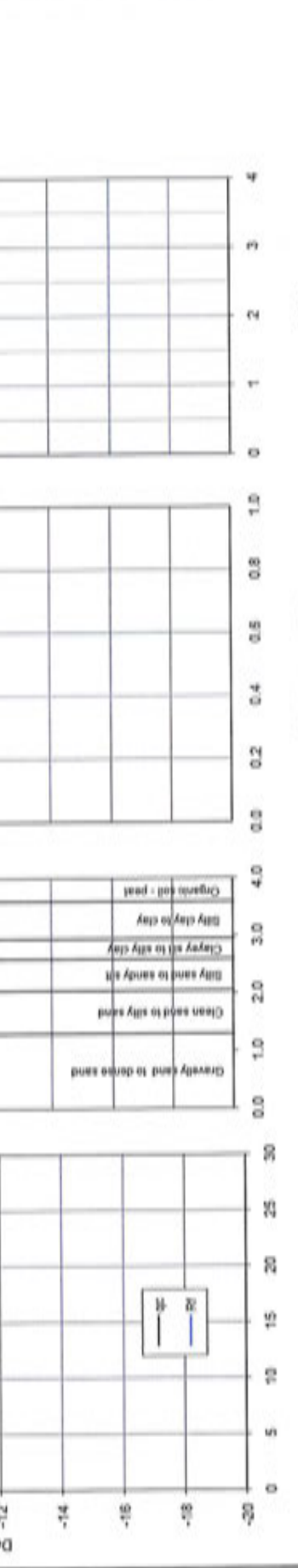
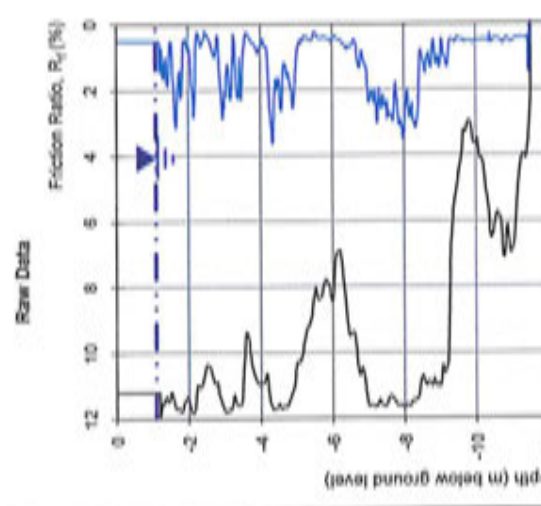
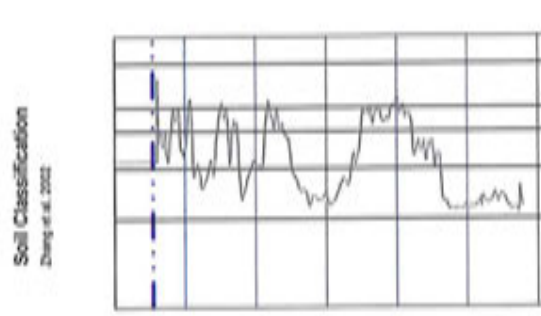
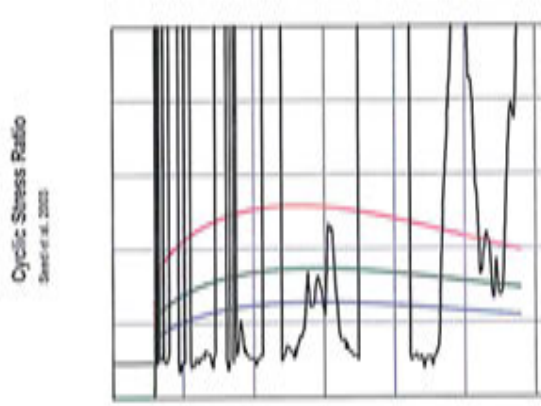
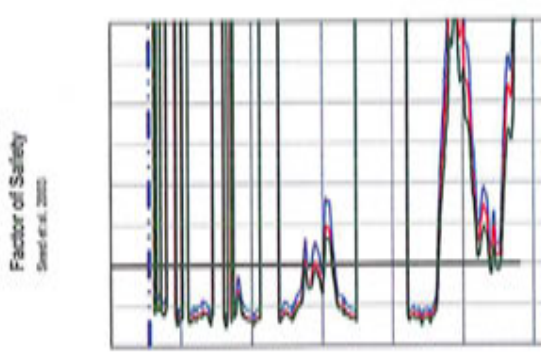
**CLIENT PROJECT**  
CPT-CBD-133a

**DATE** 7/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

**JOB NUMBER** 52000\_301

**FILE** Liquefaction Assessment from CPT Results

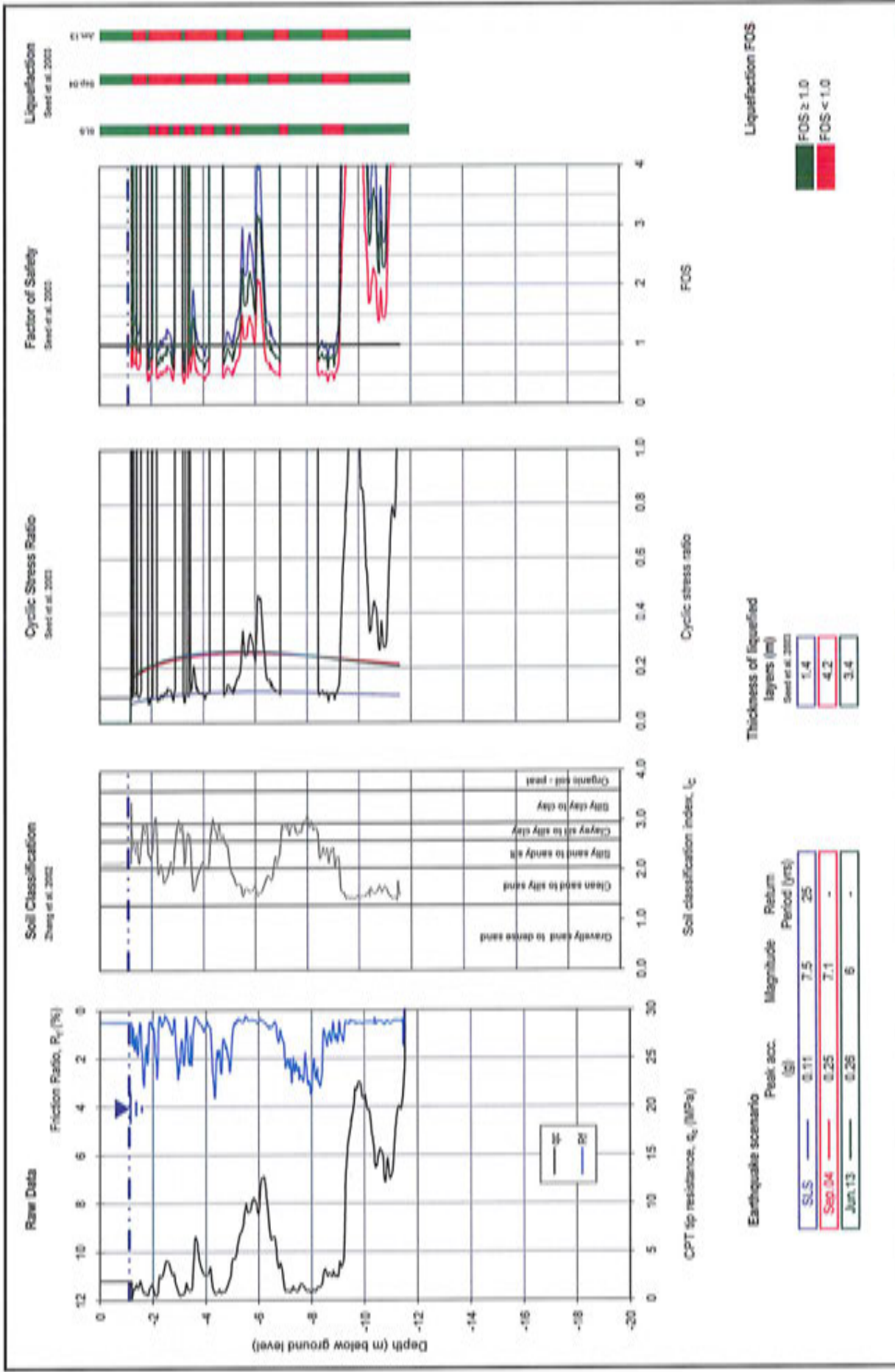




Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	0.25	7.5	500
<b>Feb 22</b>	<b>0.52</b>	<b>6.2</b>	-
U.S.	0.34	7.5	500

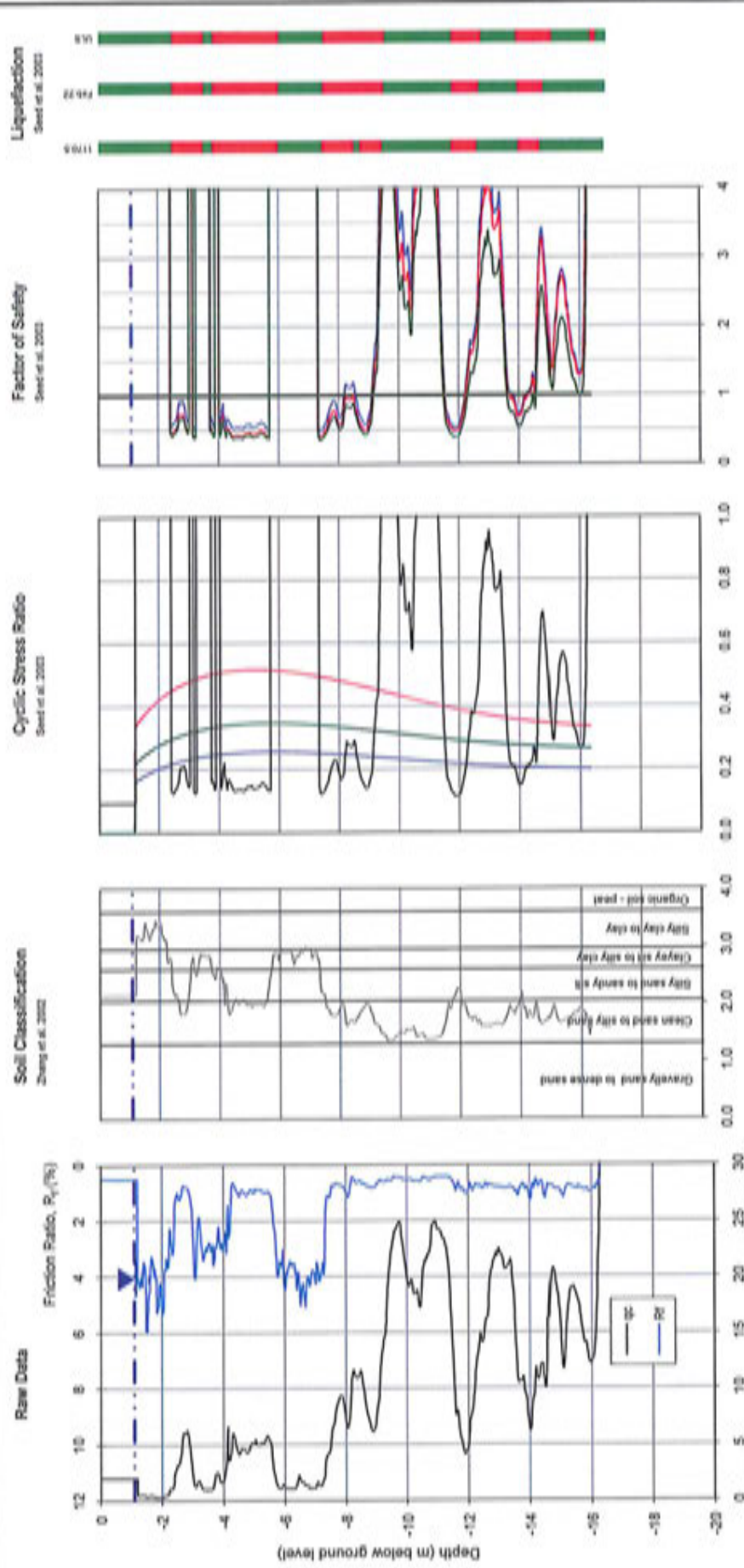
  

Thickness of liquefied layers (m)
4.5
4.8
5.2

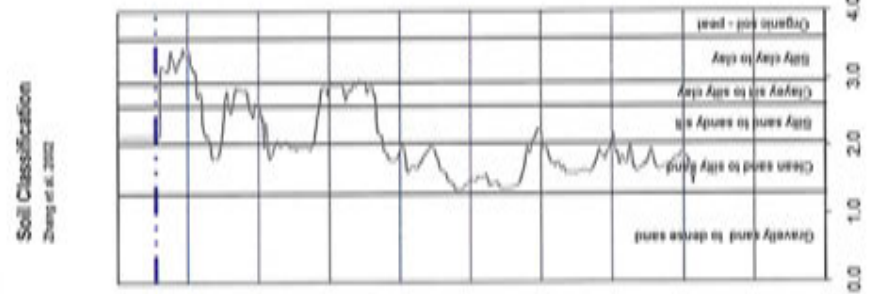


 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City	<b>LOCATION</b> CPT-CBD-134	<b>DATE</b> 7/12/2011 <b>ANALYSED</b> RAP <b>CHECKED</b> AFF
	<b>FILE</b> Liquefaction Assessment from CPT Results	<b>JOB NUMBER</b> S2000.301	

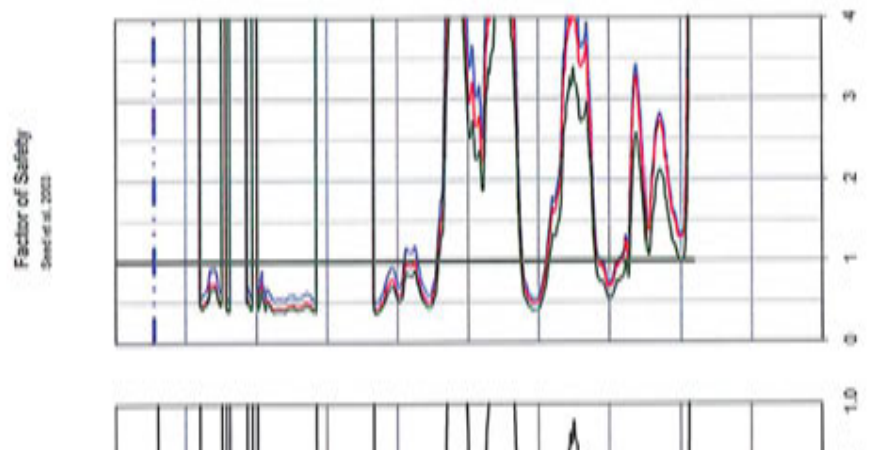




Raw Data  
Friction Ratio,  $R_f$  (%)  
Depth (m below ground level)



Soil Classification  
Soil Classification Index,  $I_c$   
Depth (m below ground level)



Cyclic Stress Ratio  
Cyclic Stress Ratio  
Depth (m below ground level)



Factor of Safety  
Factor of Safety  
Depth (m below ground level)



Liquefaction  
Liquefaction  
Depth (m below ground level)

CPT tip resistance,  $q_c$  (MPa) | Soil classification index,  $I_c$  | Cyclic stress ratio | FOS

Earthquake scenario

Peak acc. ( $g$ )	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Soil type	Thickness (m)
Cravely sand to dense sand	5.1
Clean sand to silty sand	5.7
Silty sand to silty clay	6.2
Organic soil - peat	-

Liquefaction FOS

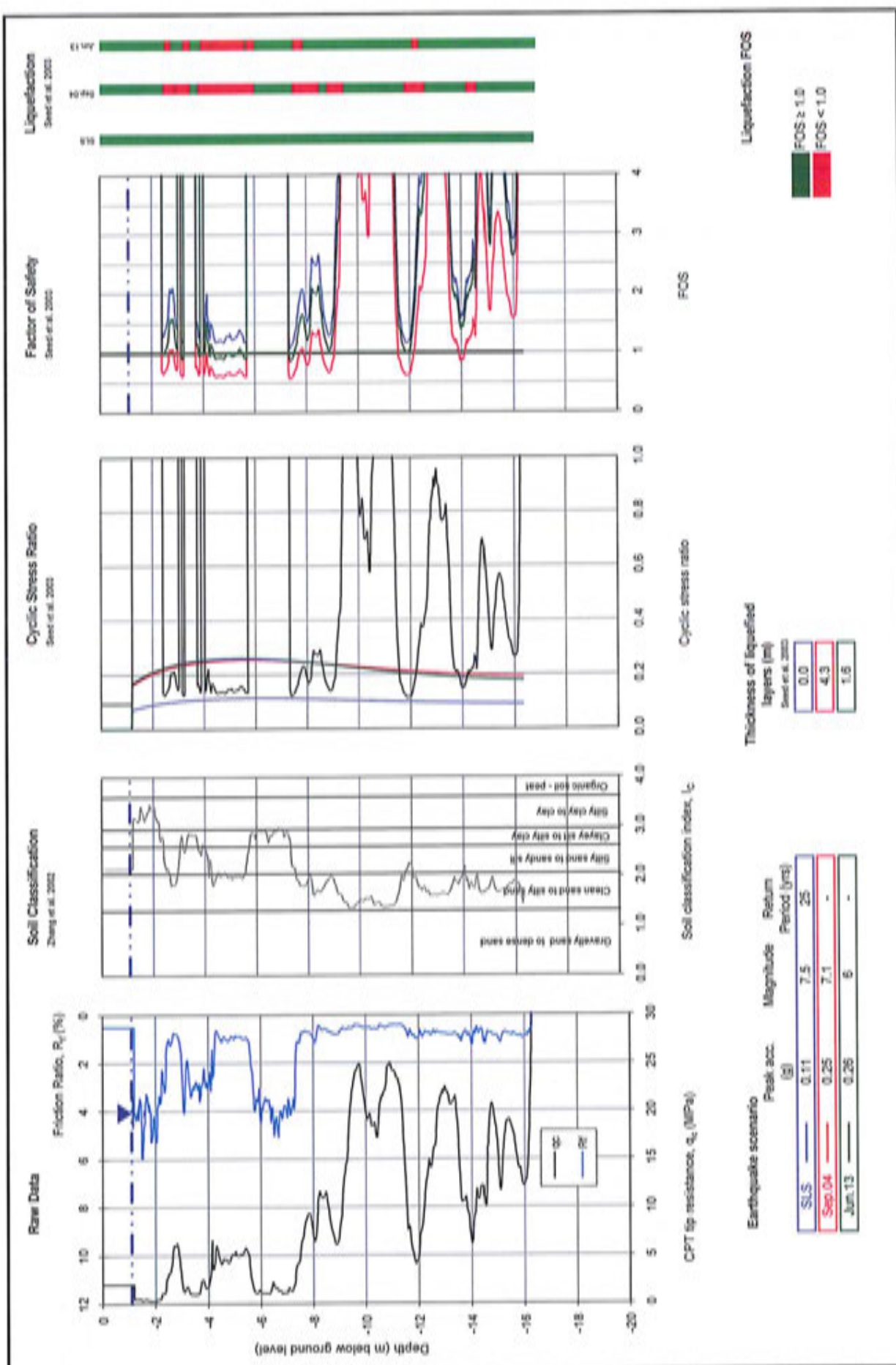
FOS	Color
$\geq 1.0$	Green
$< 1.0$	Red


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Environmental & Engineering Consultants

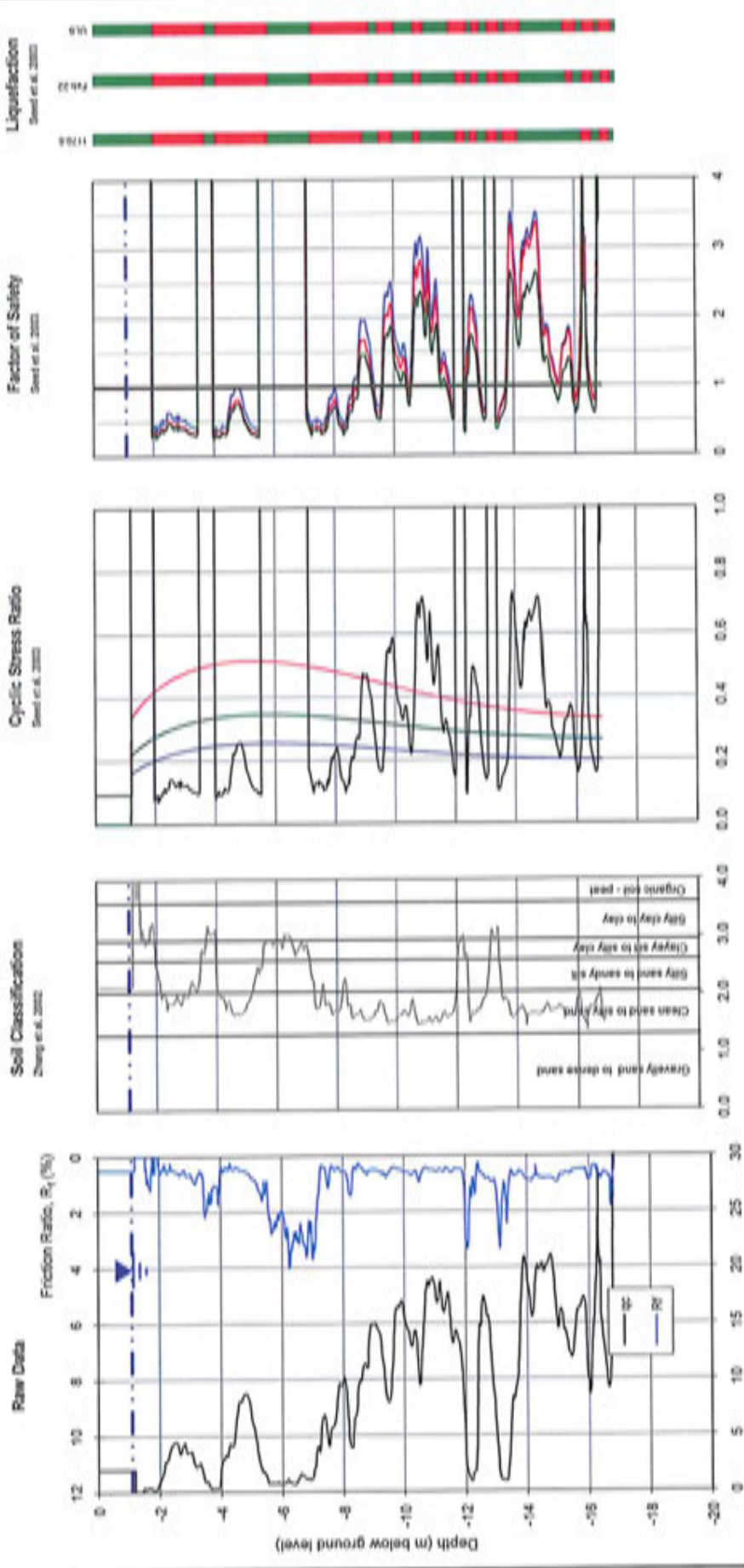
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

PROJECT: CPT-CBD-135  
JOB NUMBER: 52000\_301

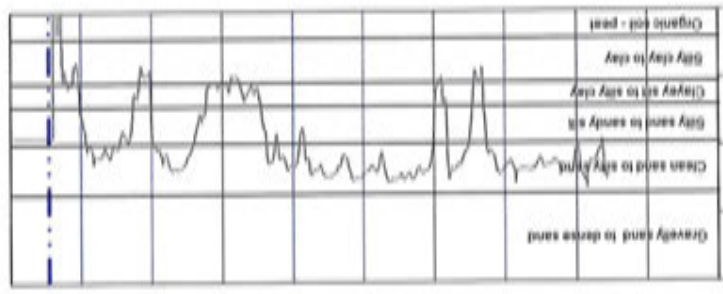
DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
FILE: Liquefaction Assessment from CPT Results



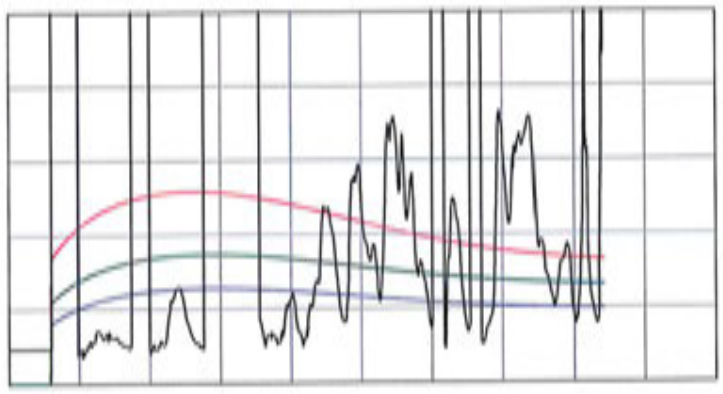
 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-135</b>	DATE 7/12/2011
	FILE Liquefaction Assessment from CPT Results	JOB NUMBER 52000_301	ANALYSED RAP



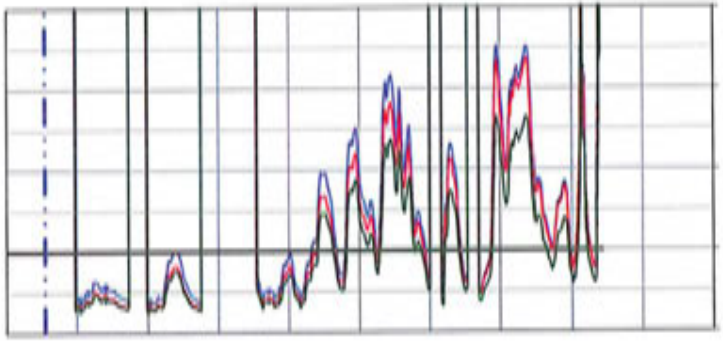
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb. 22	6.2	-
U.S.	7.5	500

Thickness of liquefied layers (m)

Thickness (m)
5.8
6.3
7.1

Liquefaction FOS



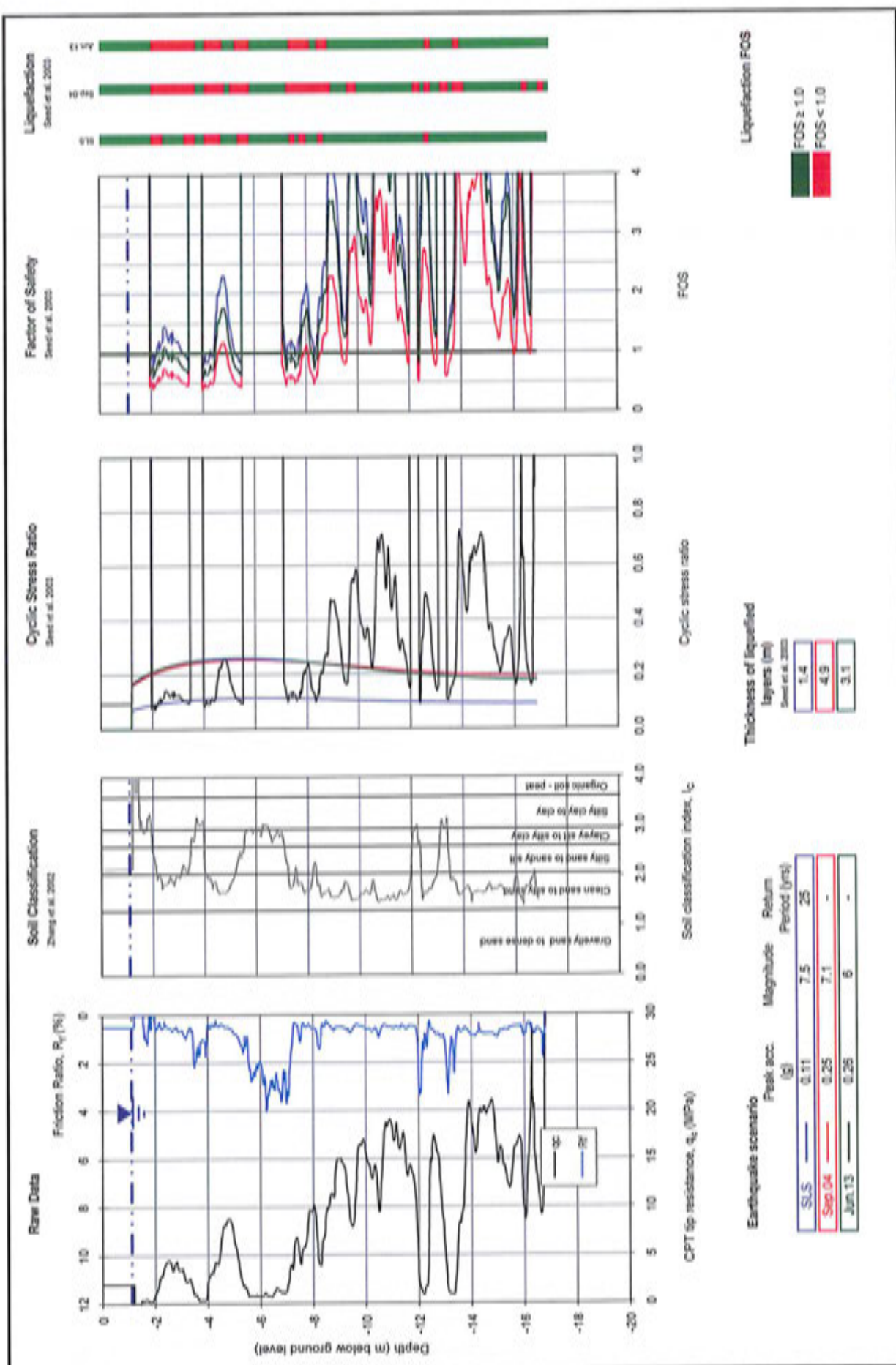
Tonkin & Taylor Ltd  
Environmental & Engineering Consultants

Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

PROJECT  
CPT-CBD-136  
JOB NUMBER  
52000\_301

DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council          Geotechnical Assessment for Christchurch Central City</b>	LOCATION <b>CPT-CBD-136</b>	DATE 7/12/2011
	TITLE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 52000.301	ANALYSED RAP
			CHECKED AFF

Earthquake scenario

Scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.25	6	-

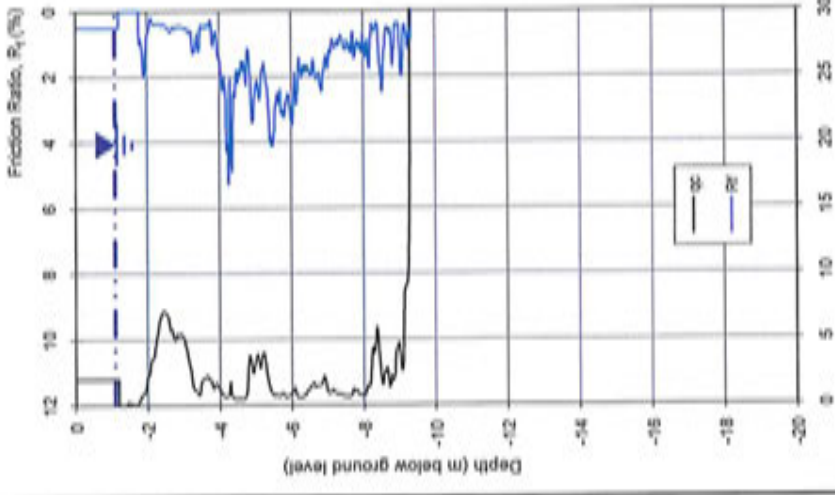
Thickness of liquefied layers (m)

SLS	1.4
Sep 04	4.9
Jun 13	3.1

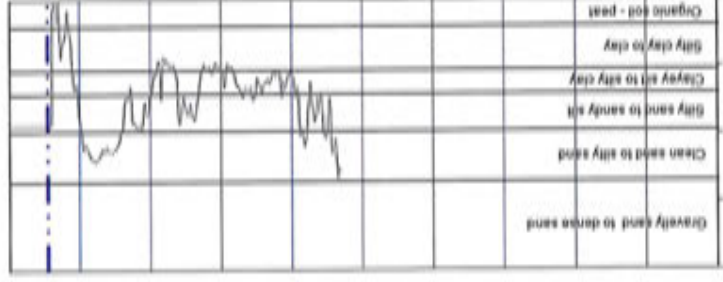
Liquefaction FOS

FOS > 1.0	Green
FOS < 1.0	Red

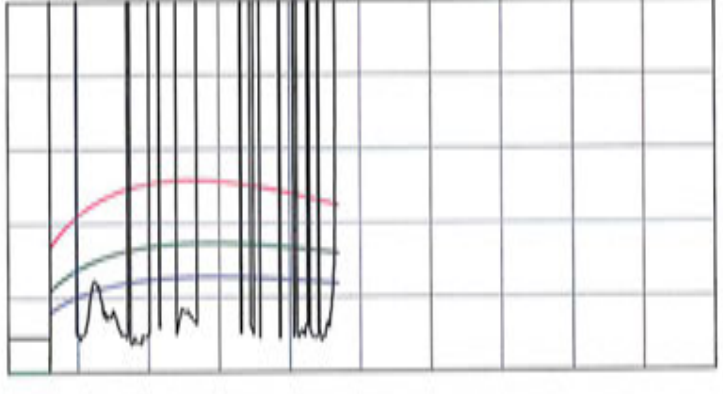
**Raw Data**



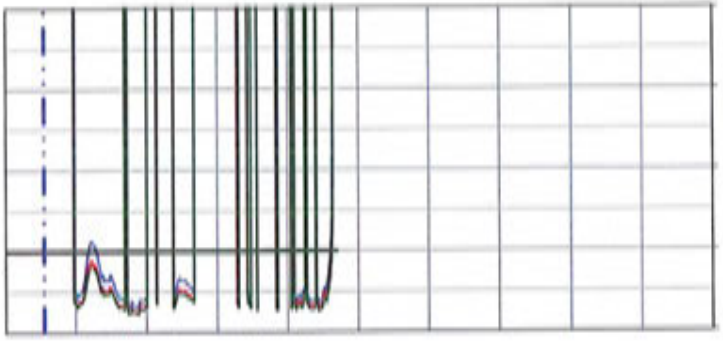
**Soil Classification**  
Zheng et al. 2002



**Cyclic Stress Ratio**  
Seed et al. 2003



**Factor of Safety**  
Seed et al. 2003



**Liquefaction**  
Seed et al. 2003



**CPT tip resistance,  $q_t$  (MPa)**

**Soil classification index,  $I_c$**

**Cyclic stress ratio**

**FOS**

**Earthquake scenario**

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
U.L.S.	7.5	500

**Thickness of liquefied layers (m)**  
Seed et al. 2003

3.6
3.8
3.9

**Liquefaction FOS**



**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

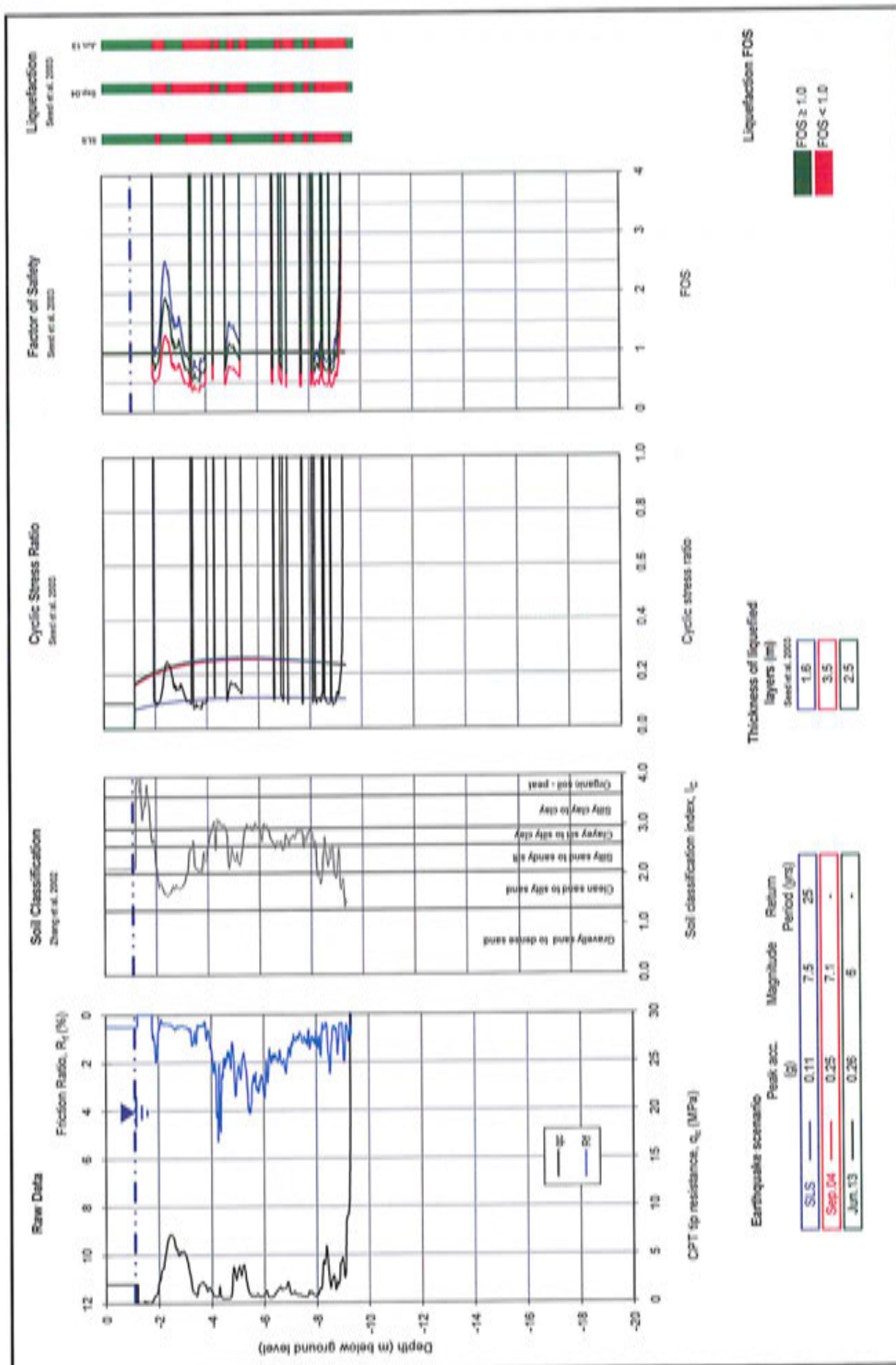
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**CPT-CBD-137**

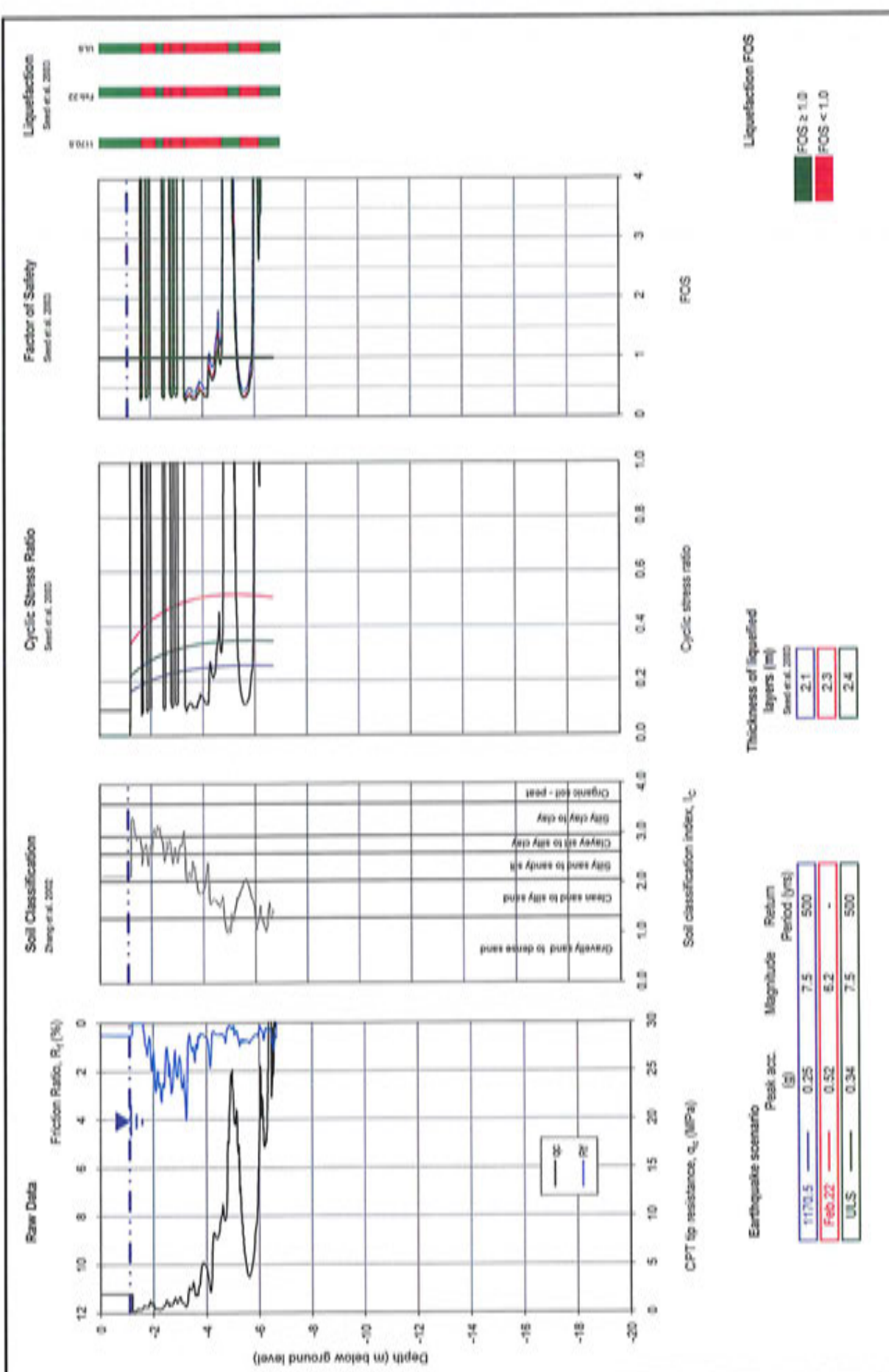
DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results

LOT NUMBER: 52000\_301



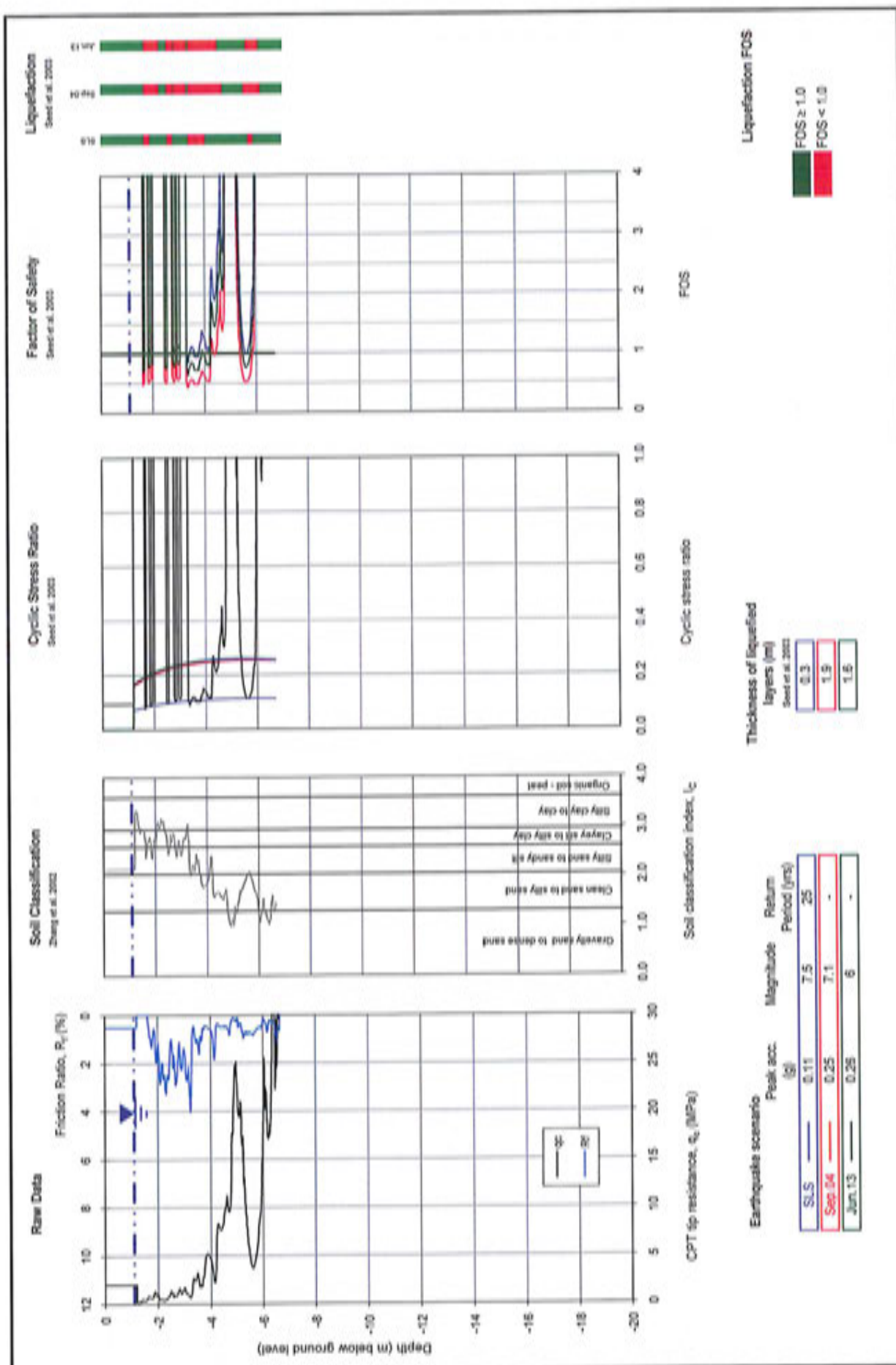
 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE: 7/12/2011 ANALYSED: RAP CHECKED: AFF
	PROJECT: CPT-CBD-137 JOB NUMBER: 52000.301	Liquefaction Assessment from CPT Results	



**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

CLIENT PROJECT: **Christchurch City Council**  
**Geotechnical Assessment for Christchurch Central City**  
Liquefaction Assessment from CPT Results

LOCATION: **CPT-CBD-138**  
DATE: 6/12/2011  
ANALYSED: R&P  
CHECKED: AFF  
JOB NUMBER: 52000\_301

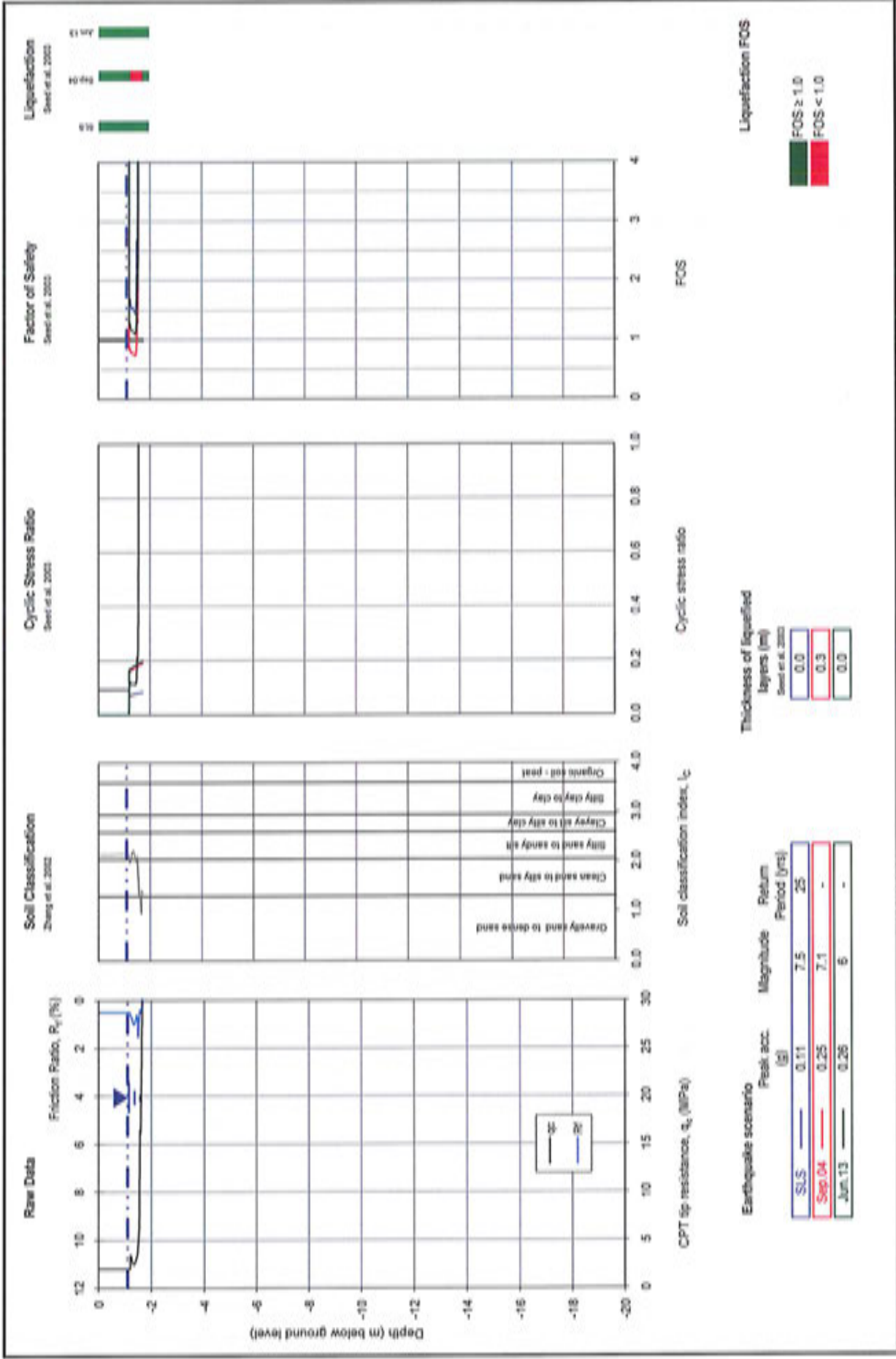


 <b>Tomlin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-138</b>	DATE 7/12/2011
	TITLE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 52000.301	ANALYSED RANP
			CHECKED AFF





 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-140</b>	DATE 5/10/2015
		PROJECT Liquefaction Assessment from CPT Results	ANALYSED RAP
		JOB NUMBER S2000.301	CHECKED AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City Liquefaction Assessment from CPT Results	<b>LOGNO</b> CPT-CBD-140	<b>DATE</b> 7/12/2011 <b>ANALYSED</b> RAP <b>CHECKED</b> AFF
		<b>FILE</b>	<b>JOB NUMBER</b> S2000.301

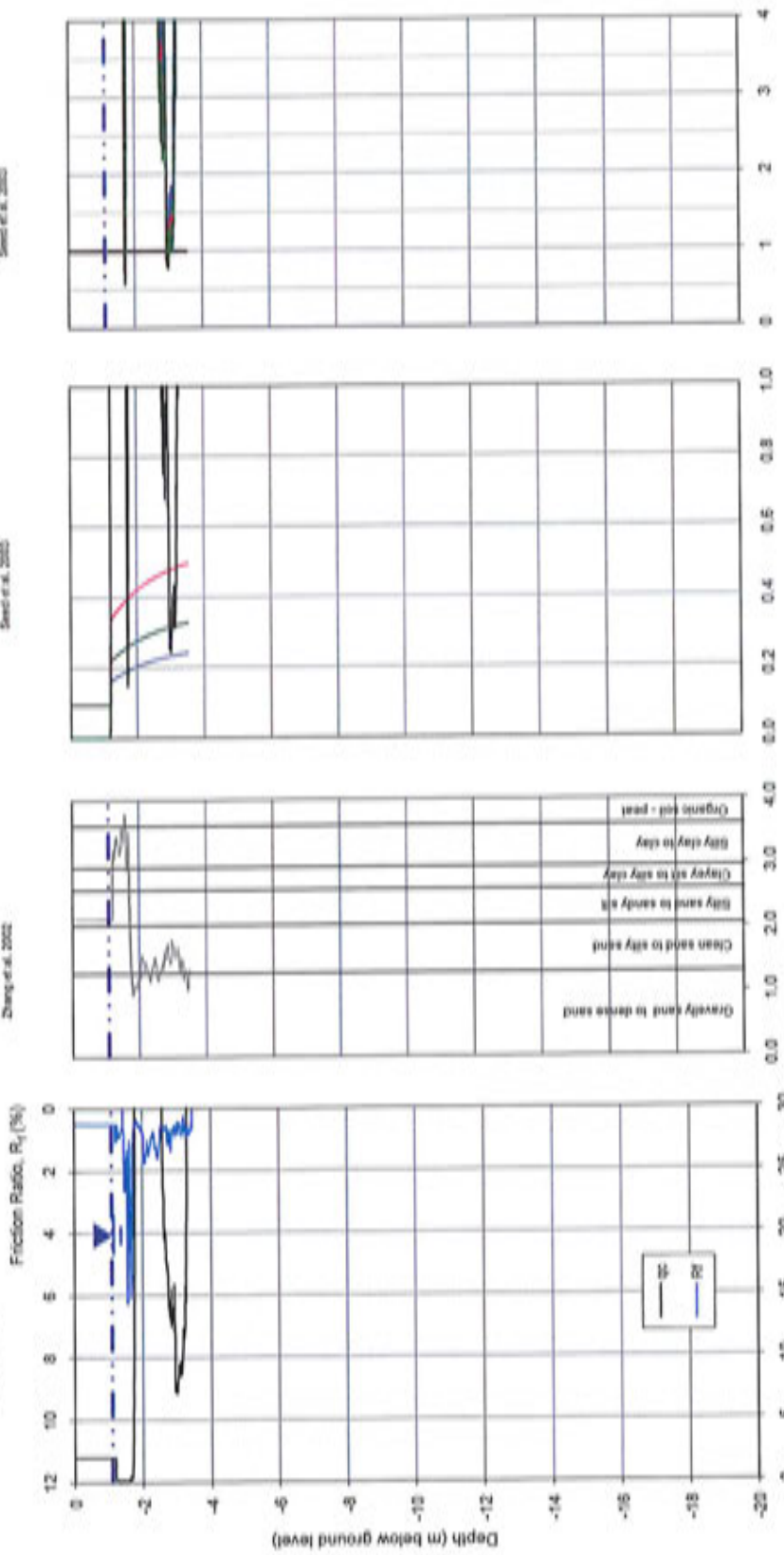
Raw Data  
Friction Ratio,  $R_f$  (%)

Soil Classification  
Zhang et al. 2002

Cyclic Stress Ratio  
Seed et al. 2002

Factor of Safety  
Seed et al. 2002

Liquefaction  
Seed et al. 2002



FOS

Cyclic stress ratio

Soil classification index,  $I_c$

CPT tip resistance,  $q_t$  (MPa)

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb. 22	6.2	-
U.L.S.	7.5	500

Thickness of liquefied layers (m)

Thickness (m)
0.0
0.1
0.1

Liquefaction FOS

FOS
$\geq 1.0$
$< 1.0$



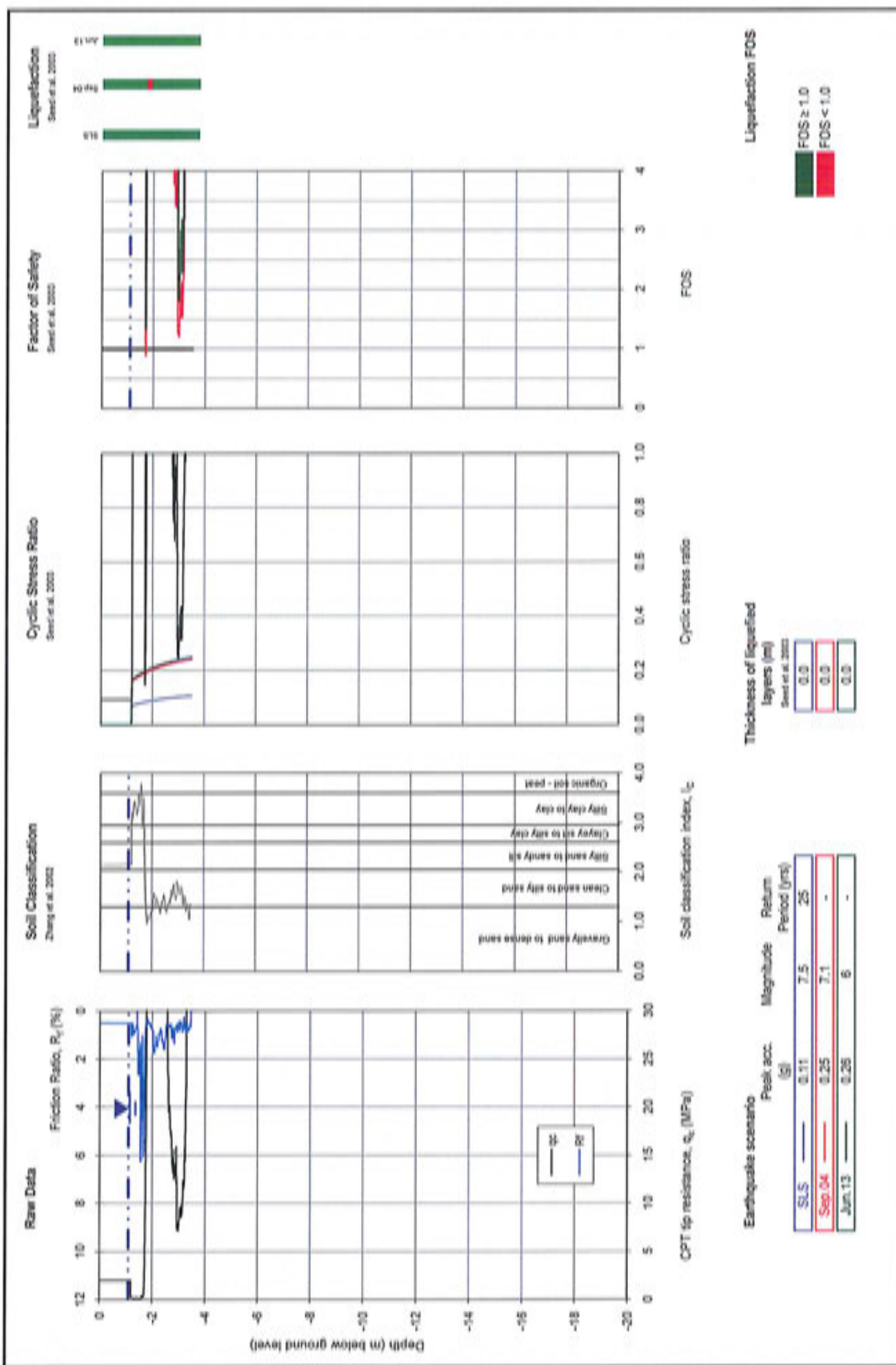
**Tonkin & Taylor Ltd**  
Environmental & Engineering Consultants

**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

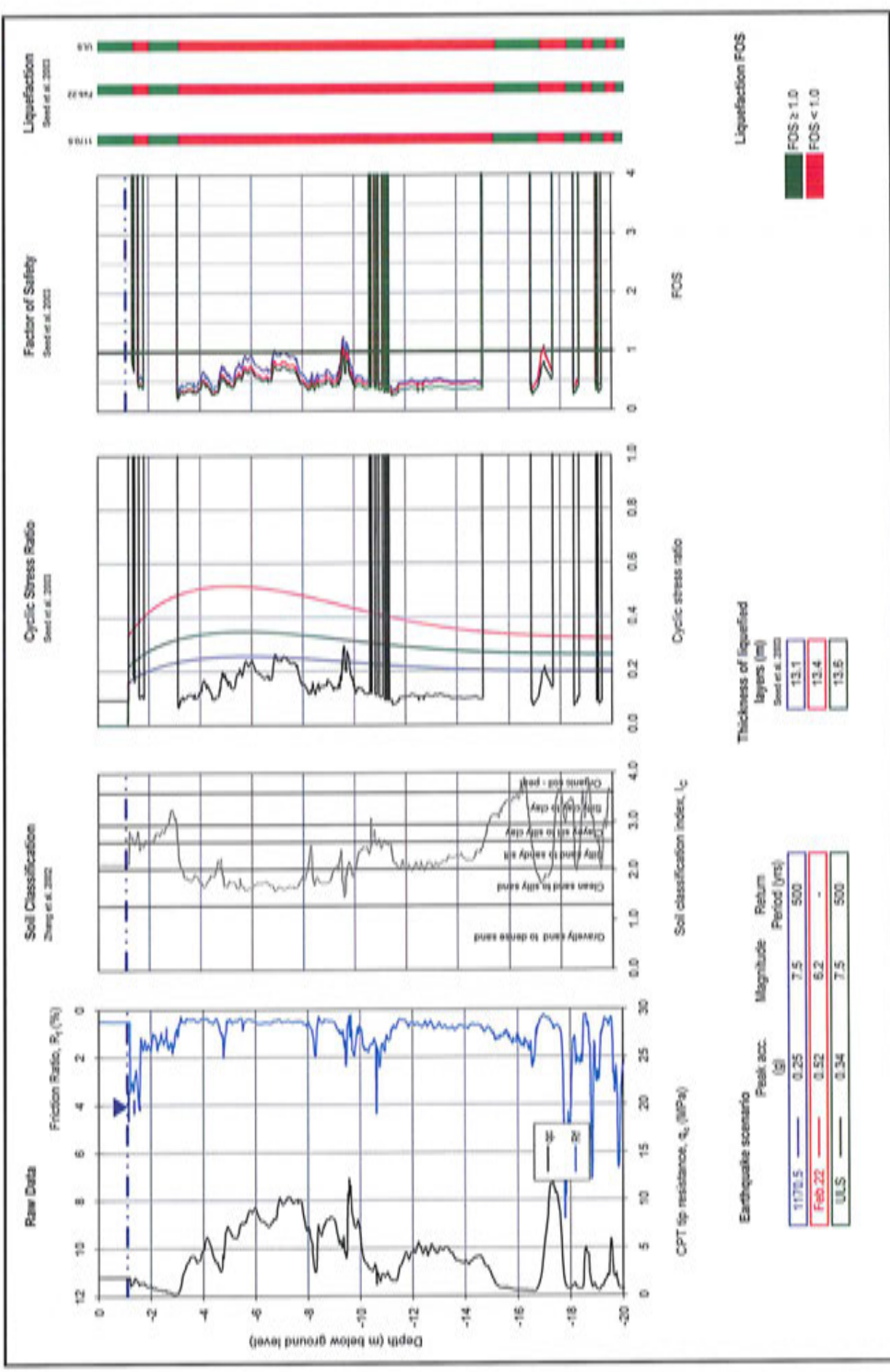
LOCATION: **CPT-CBD-140a**  
JOB NUMBER: S2006\_301


DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results



 <b>TTF</b> Tookin & Taylor Ltd Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City Liquefaction Assessment from CPT Results	LOCATION <b>CPT-CBD-140a</b>	DATE 7/12/2011
		JOB NUMBER S2000.301	ANALYSED RAP CHECKED AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		SOURCE <b>CPT-CBD-141</b>	DATE 6/12/2011
	Liquefaction Assessment from CPT Results		JOB NUMBER S2006_301	ANALYSED RRP
				CHECKED AFF

Earthquake scenario

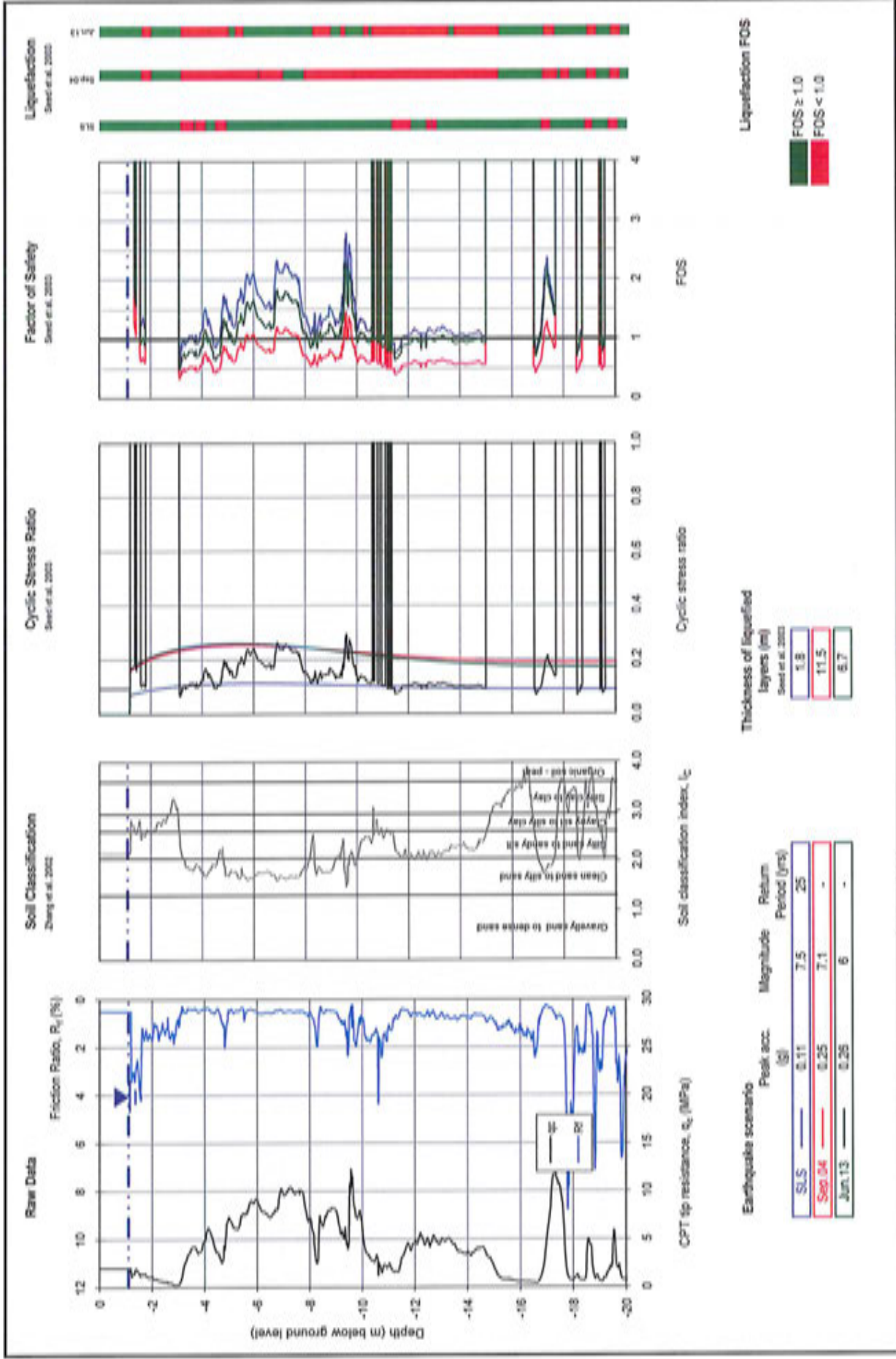
Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULLS	7.5	500

Thickness of liquefied layers (m)

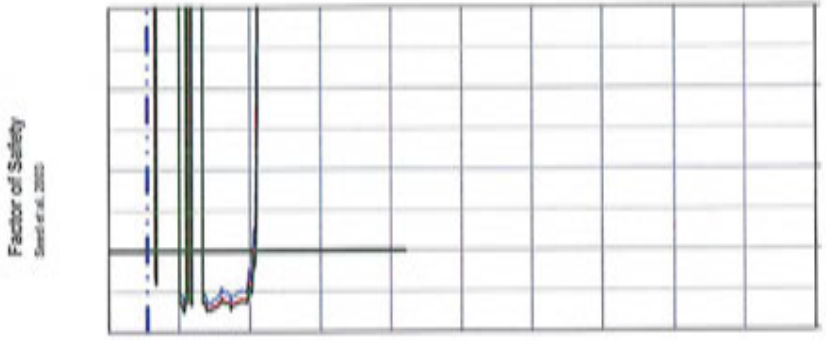
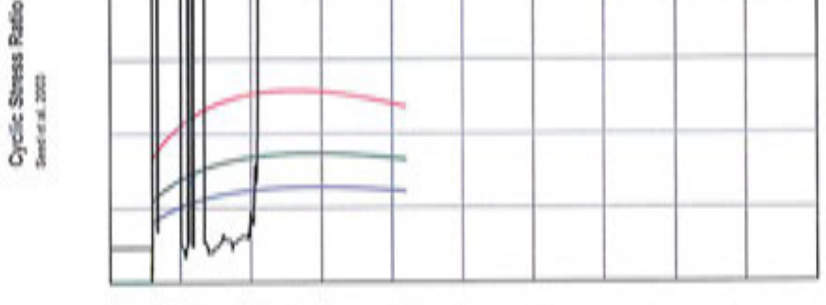
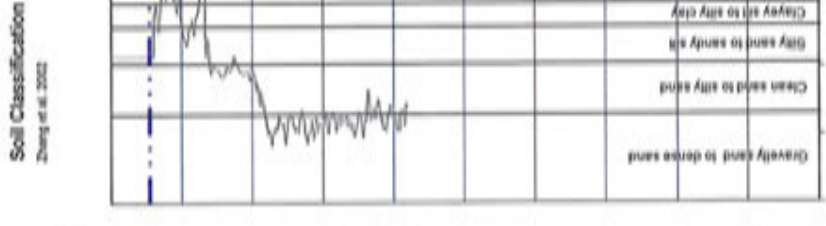
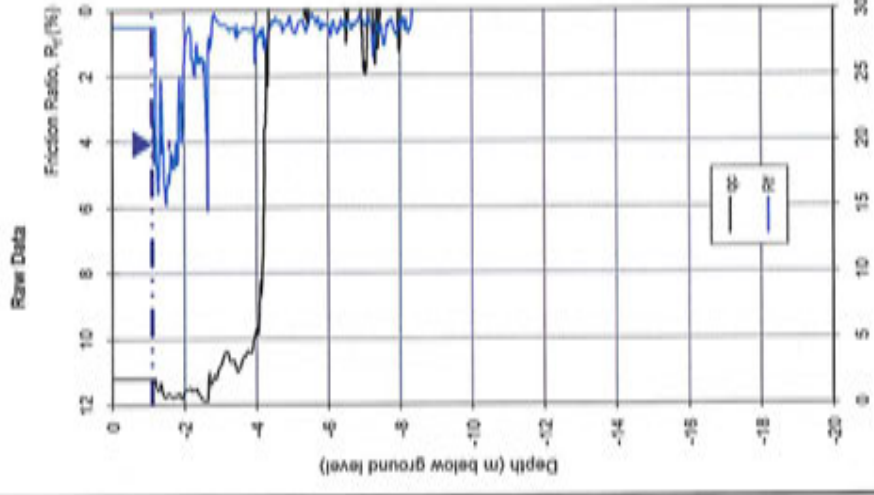
13.1
13.4
13.6

Liquefaction FOS

FOS > 1.0
FOS < 1.0



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City		<b>DATE</b> 17/12/2011 <b>ANALYSED</b> RAP <b>CHECKED</b> AFF
	<b>FILE</b> Liquefaction Assessment from CPT Results		<b>SECTION</b> <b>CPT-CBD-141</b> <b>JOB NUMBER</b> 52000.301



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

1.7
1.8
1.8

Liquefaction FOS



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Engineering Consultants

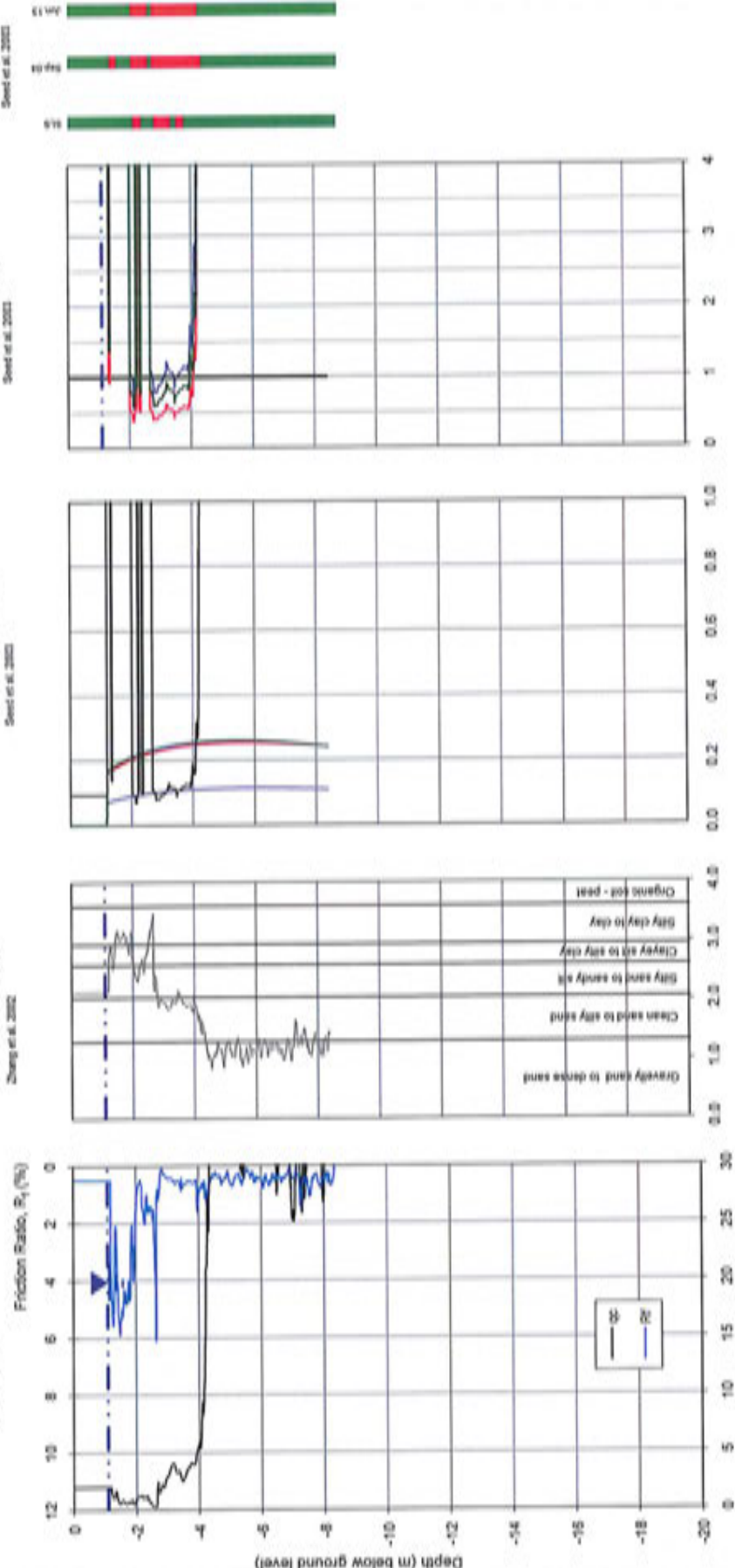
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION  
CPT-CBD-142  
JOB NUMBER  
52000\_301

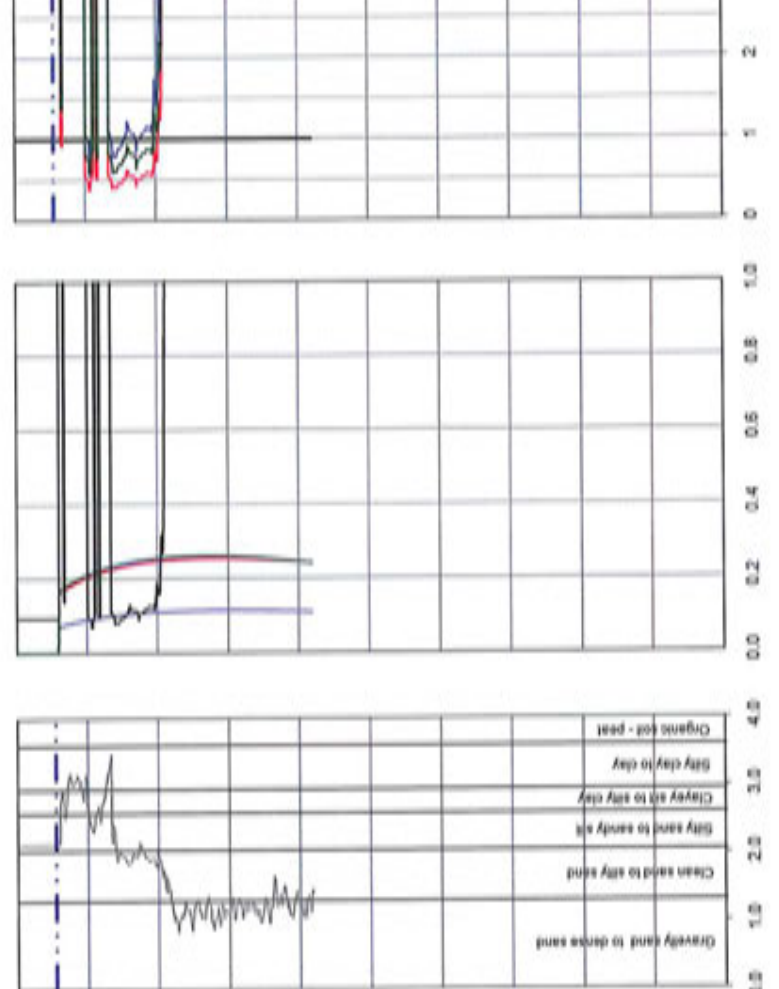
DATE  
6/12/2011  
ANALYSED  
RAP  
CHECKED  
AFF

Liquefaction Assessment from CPT Results

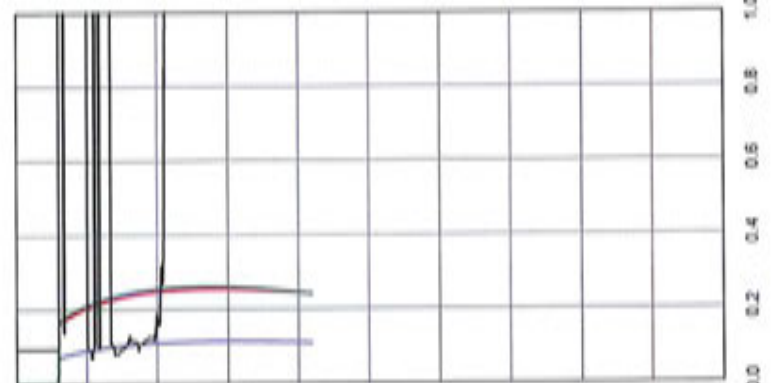
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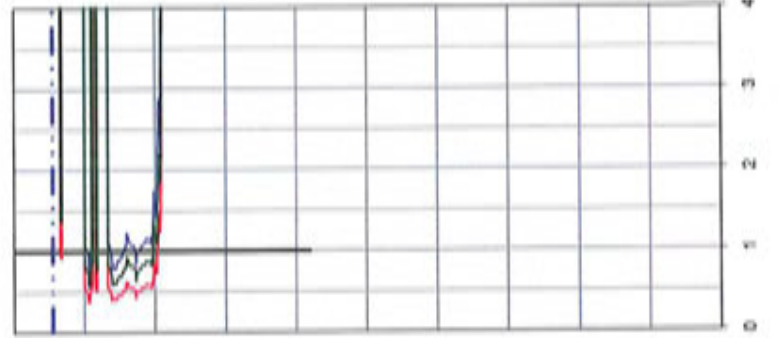
**Soil Classification**  
Zheng et al. 2002



**Cyclic Stress Ratio**  
Seed et al. 2002



**Factor of Safety**  
Seed et al. 2002



**Liquefaction**  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep 04	0.25	7.1	-
Jun 13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.5
1.7
1.5

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



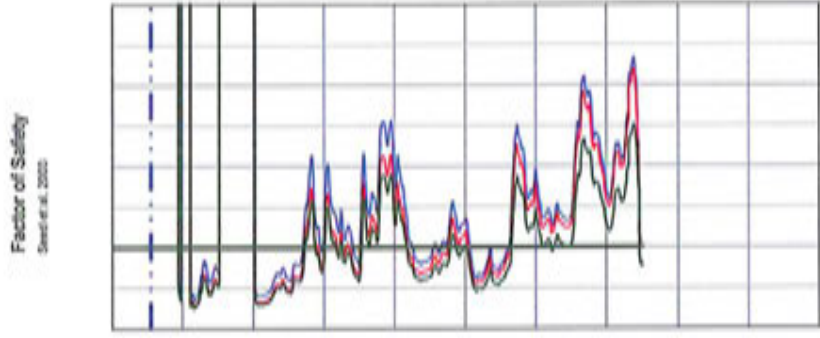
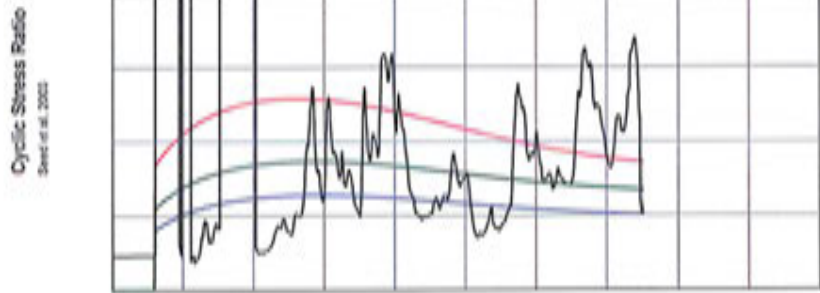
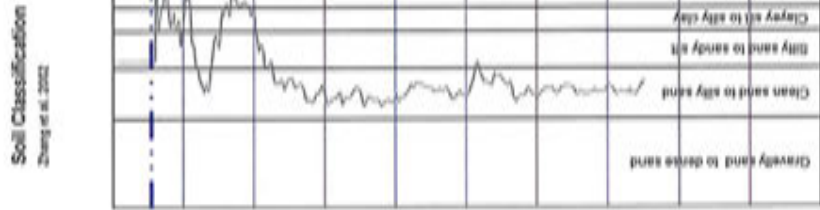
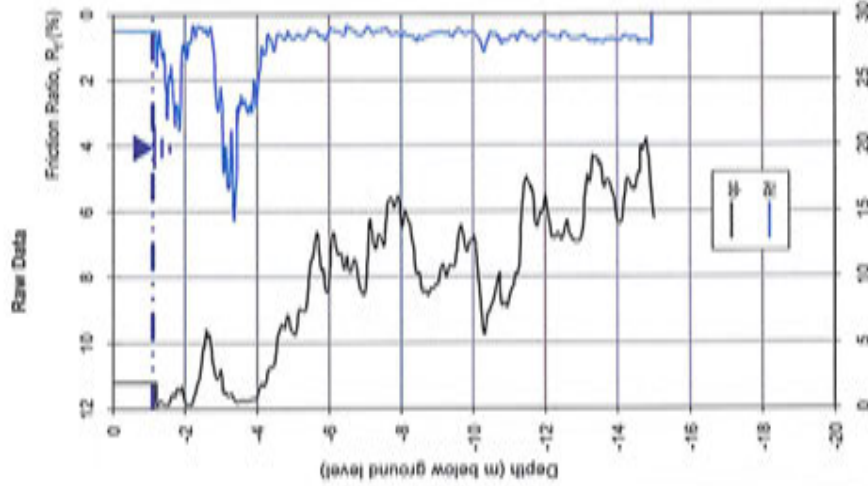
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Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

PROJECT: CPT-CBD-142  
JOB NUMBER: 53000.301

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF





CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc.	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

4.4
5.4
6.2

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



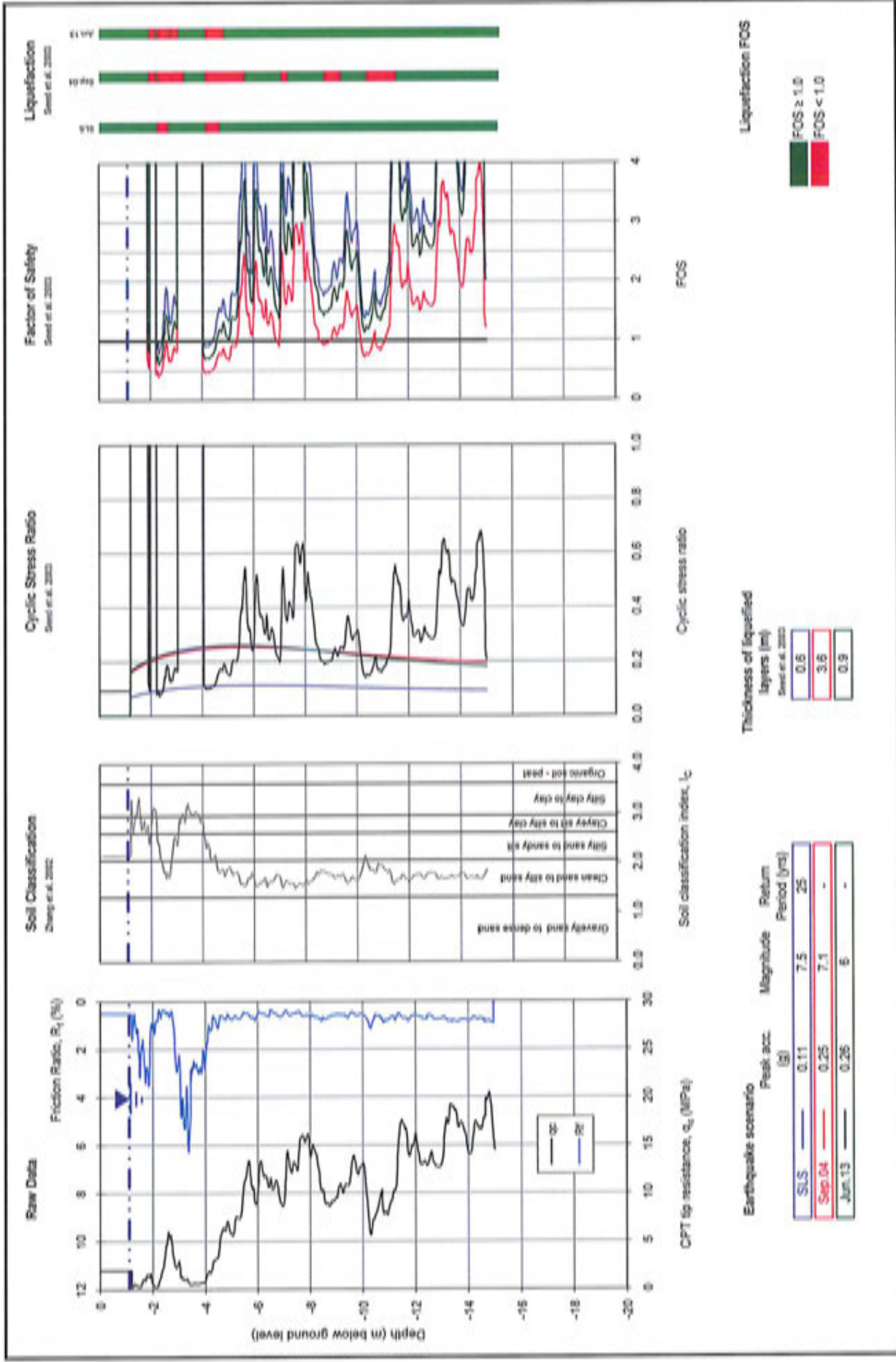
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Geotechnical Assessment for Christchurch Central City

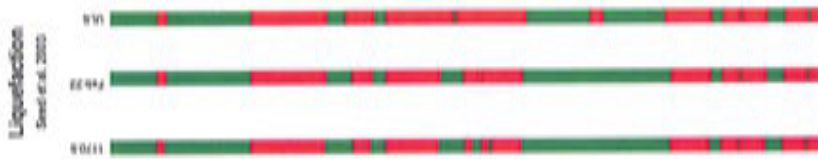
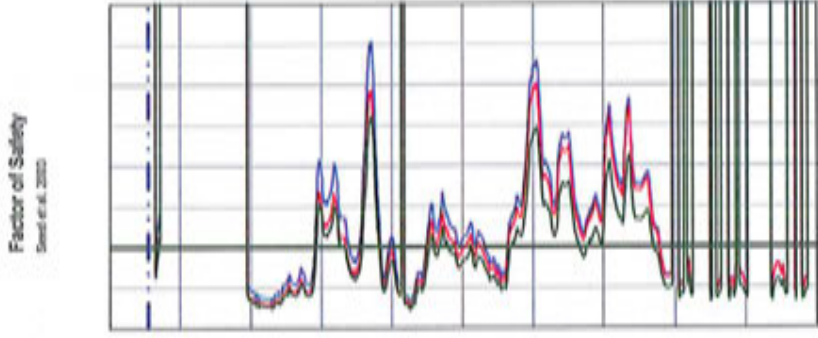
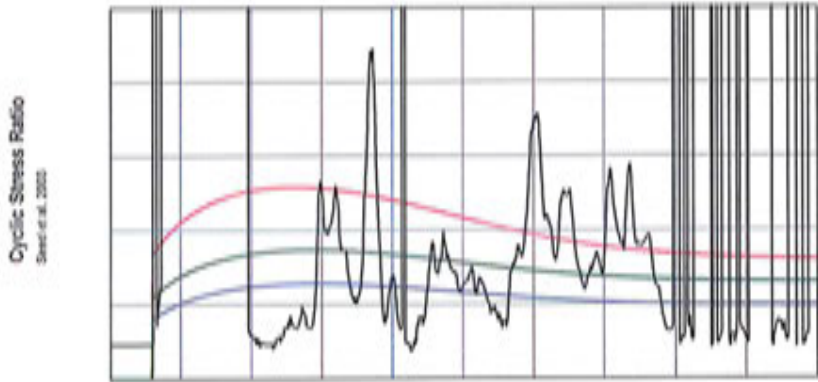
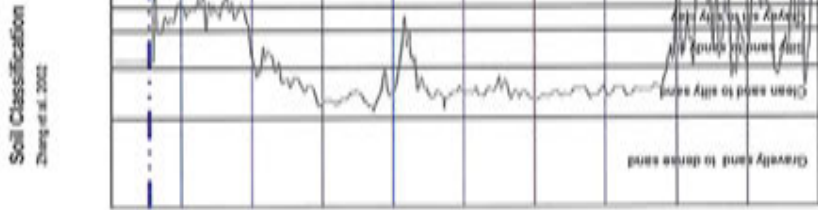
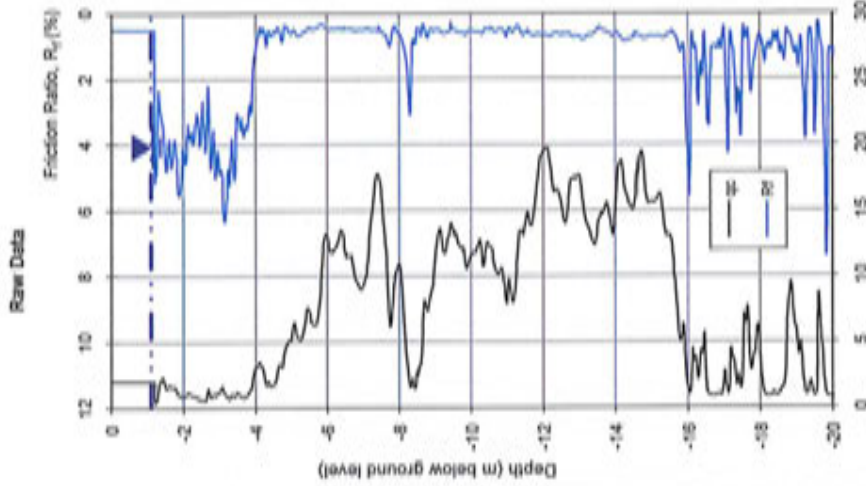
CPT-CBD-143

DATE: 6/12/2011  
ANALYSED: RAP  
CHECKED: AFF  
AFF

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City Liquefaction Assessment from CPT Results	<b>DATE</b> 31/12/2011 <b>ANALYSED</b> RAP <b>CHECKED</b> AFF
		<b>SOILS</b> <b>CPT-CBD-143</b> <b>JOB NUMBER</b> 52000.301



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. ( $g$ )	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

6.4
7.3
8.5

Liquefaction FOS

FOS $\geq$ 1.0
FOS $<$ 1.0



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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

PROJECT NUMBER  
**CPT-CBD-144**

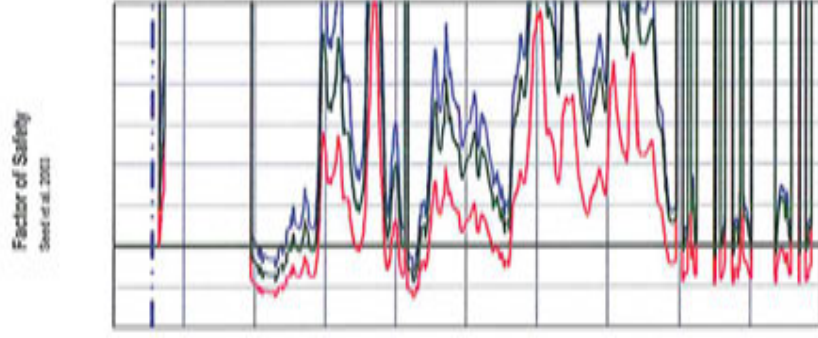
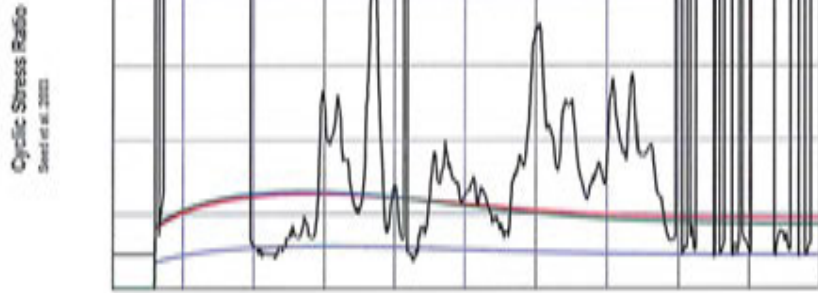
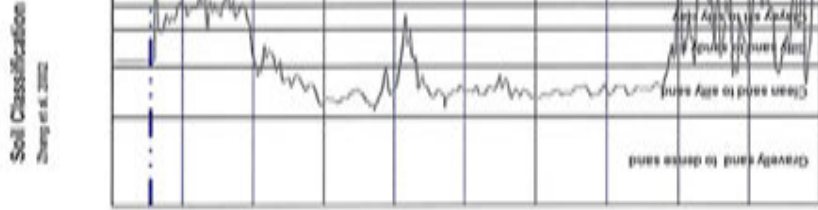
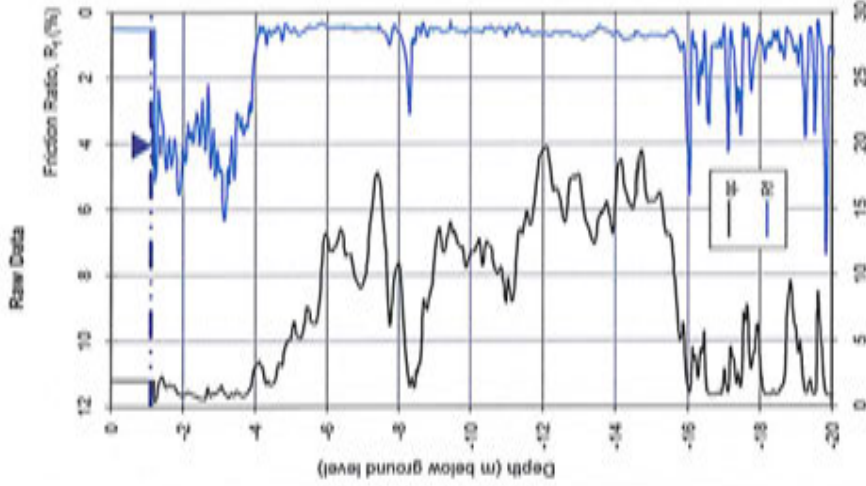
FILE NUMBER  
52000.301

Liquefaction Assessment from CPT Results

DATE  
5/10/2011

ANALYSED  
RAP

CHECKED  
AFF



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.04	0.25	7.1	-
Jun.13	0.25	6	-

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
1.1
5.7
2.2

Liquefaction FOS

■	FOS $\geq$ 1.0
■	FOS $<$ 1.0



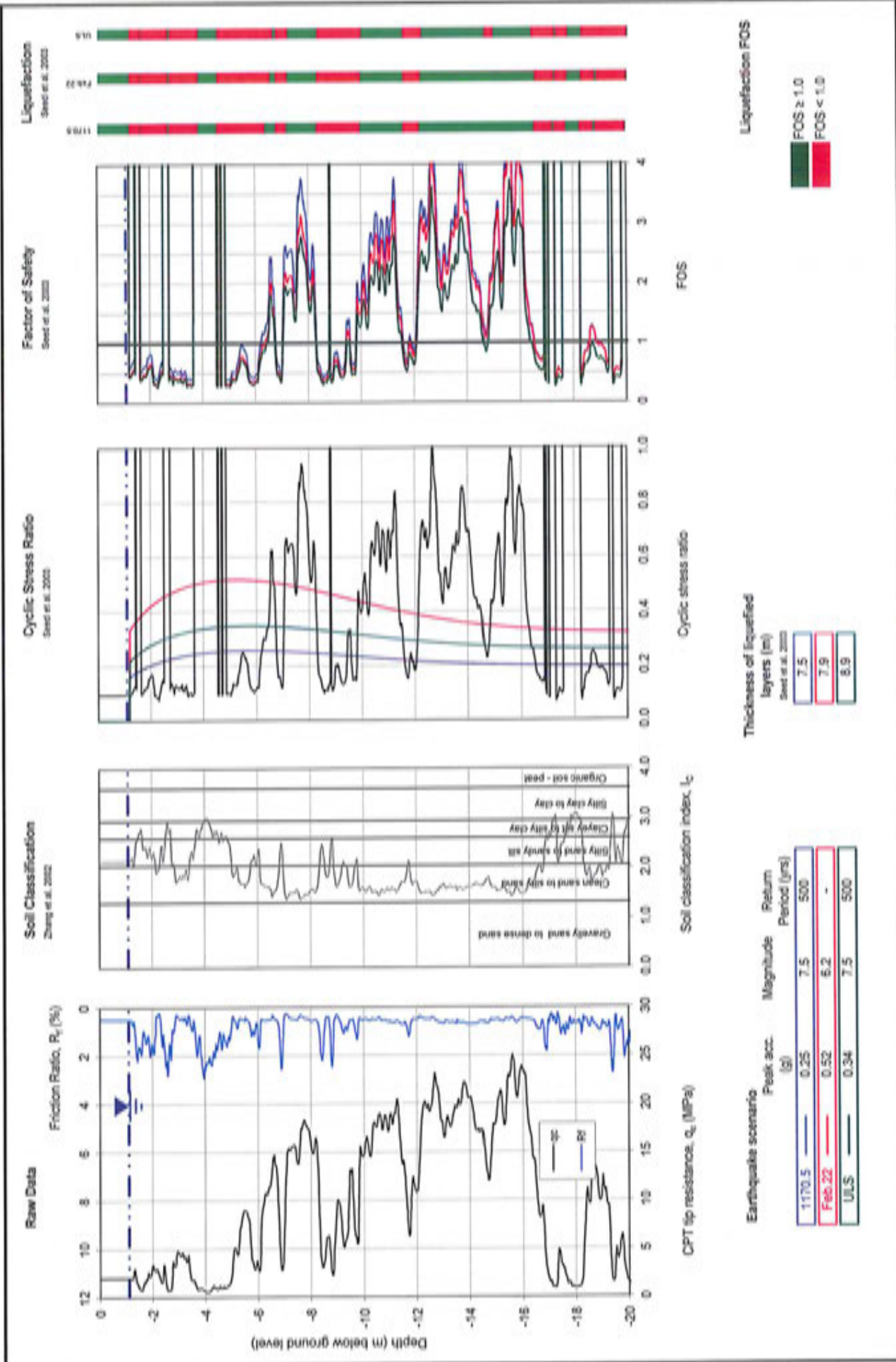
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Geotechnical Assessment for Christchurch Central City

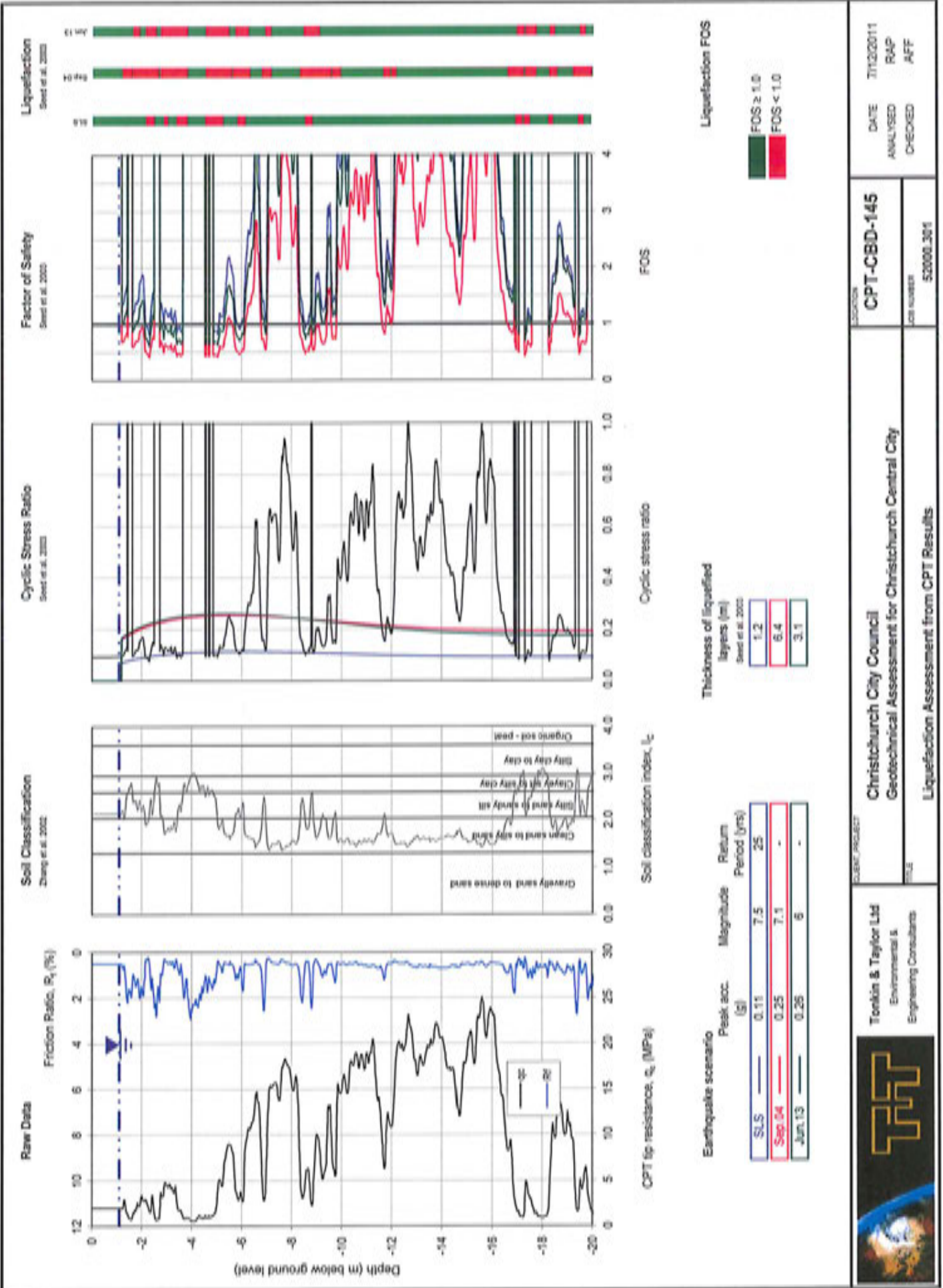
PROJECT: CPT-CBD-144  
JOB NUMBER: 52000\_301

DATE: 27/12/2011  
ANALYSED: RAP  
CHECKED: AFF

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City		DATE: 7/12/2011 ANALYSED: RAP CHECKED: AFF
	PROJECT:	<b>CPT-CBD-145</b>	JOB NUMBER: 52000_301
Liquefaction Assessment from CPT Results			



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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

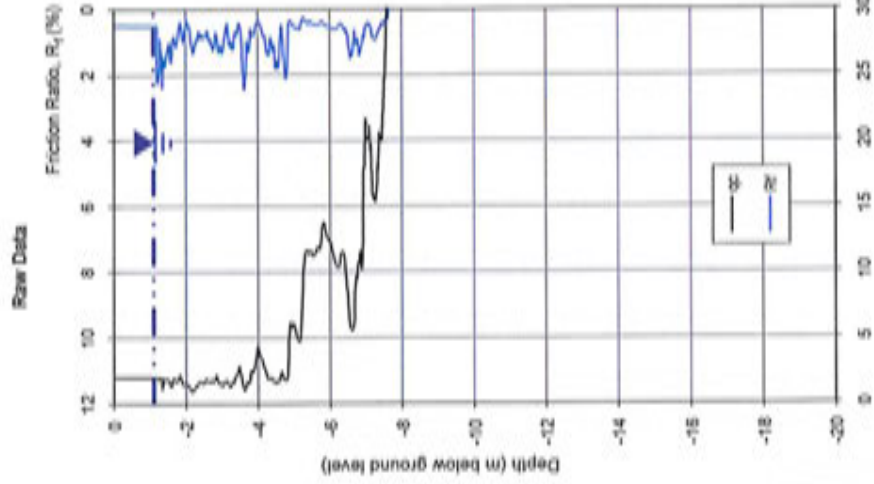
**CLIENT PROJECT**

**CPT-CBD-145**

**SECTION**

**JOB NUMBER** 52000\_301

**DATE** 11/12/2011  
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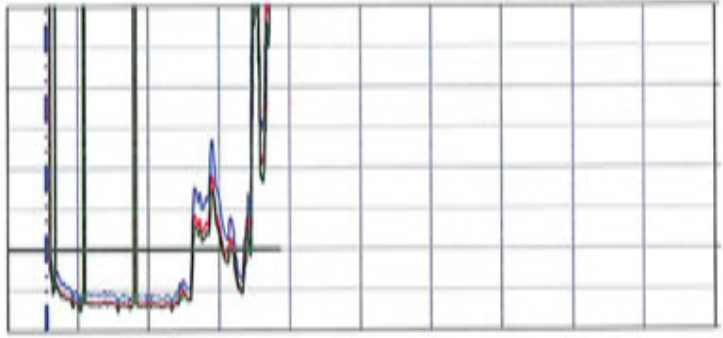
Soil Classification  
Zhang et al. 2002



Cyclic Stress Ratio  
Seed et al. 2003



Factor of Safety  
Seed et al. 2003



Liquefaction  
Seed et al. 2003



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1172.5	7.5	500
Feb 22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
4.2
4.4
4.5

Liquefaction FOS

Liquefaction FOS
FOS $\geq$ 1.0
FOS $<$ 1.0



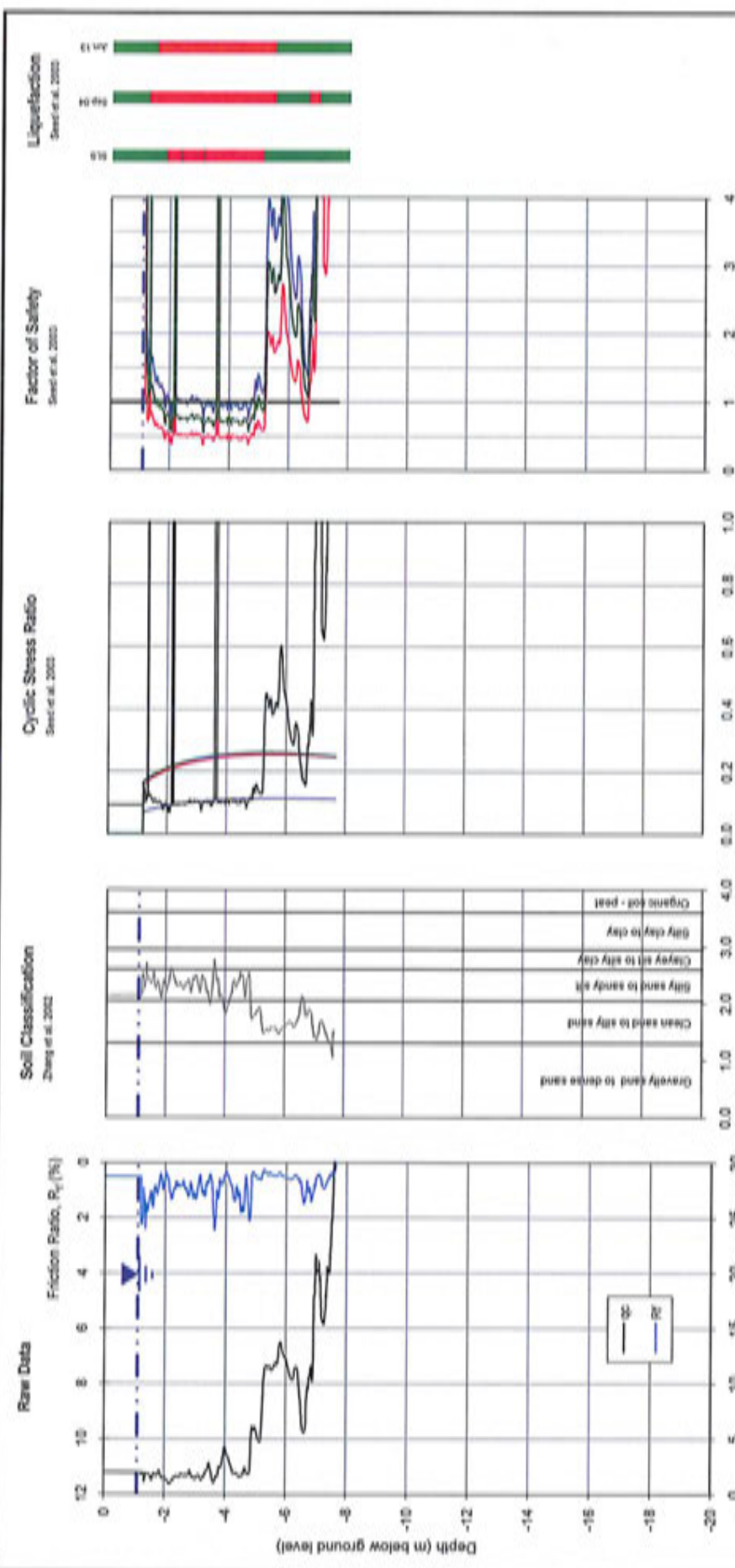
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Environmental & Engineering Consultants

CLIENT PROJECT  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

LOCATION  
CPT-CBD-146  
JOB NUMBER  
S2006\_301

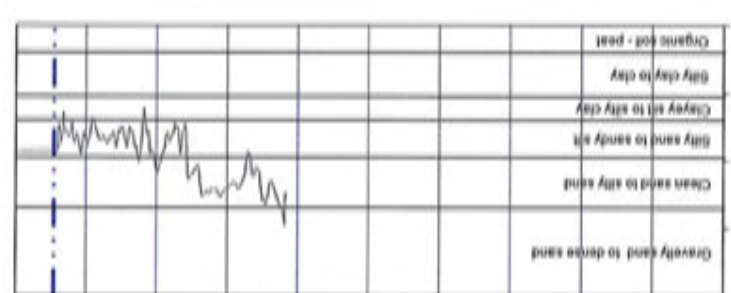
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ANALYSED RMP  
CHECKED AFF

Liquefaction Assessment from CPT Results



**Raw Data**  
Friction Ratio,  $R_f$  (%)

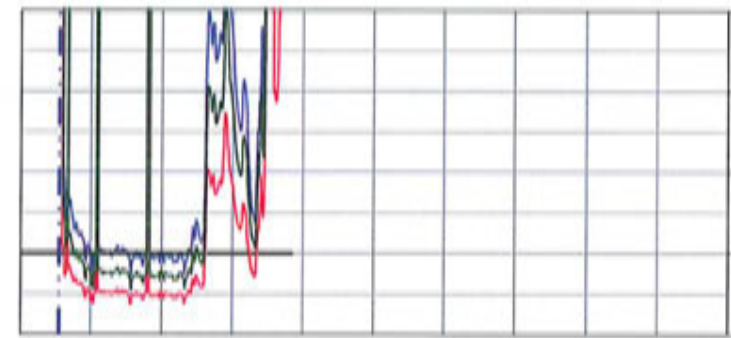
**Soil Classification**  
Zheng et al. 2002



**Cyclic Stress Ratio**  
Seed et al. 2002



**Factor of Safety**  
Seed et al. 2002



**Liquefaction**  
Seed et al. 2002



CPT tip resistance,  $q_c$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

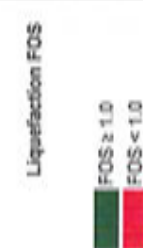
FOS

**Earthquake scenario**

Earthquake scenario	Peak acc. (g)	Magnitude	Return Period (yrs)
SLS	0.11	7.5	25
Sep.04	0.25	7.1	-
Jun.13	0.25	6	-

**Thickness of liquefied layers (m)**  
Seed et al. 2002

1.8
4.1
3.5



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CURT PROJECT

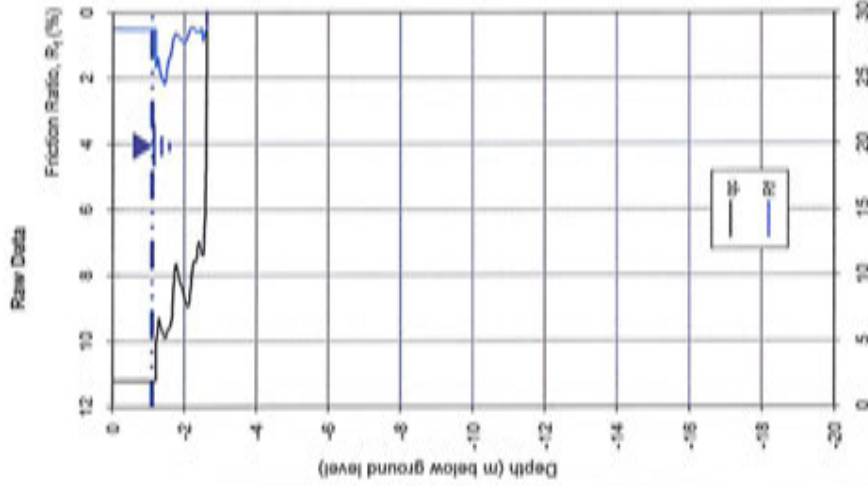
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

LOCATION  
**CPT-CBD-146**

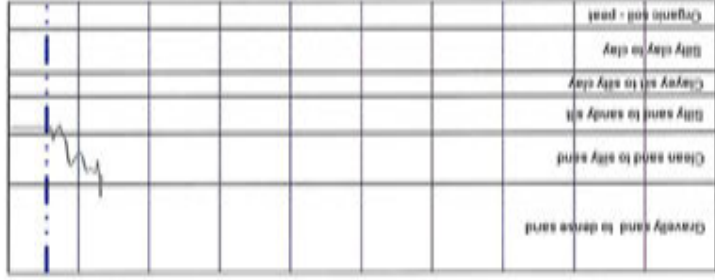
DATE 7/12/2011  
ANALYSED RAP  
CHECKED AFF  
JOB NUMBER 52000\_301

Liquefaction Assessment from CPT Results

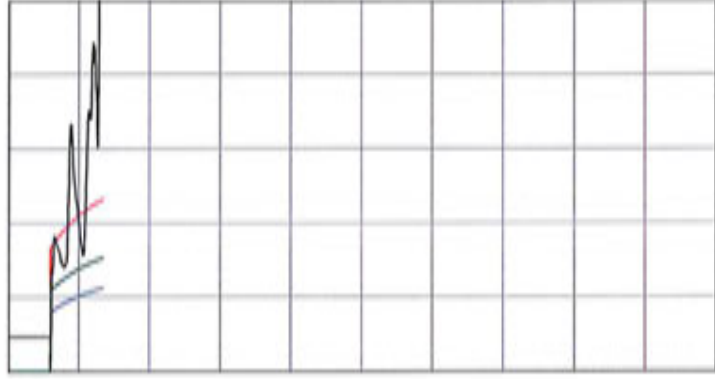




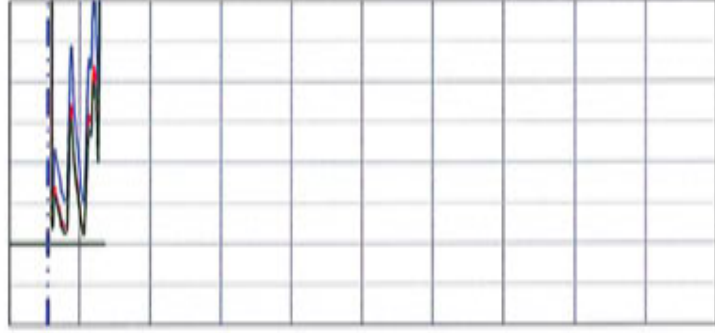
Soil Classification  
Zheng et al. 2002



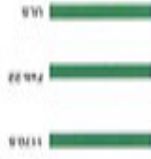
Cyclic Stress Ratio  
Seed et al. 2002



Factor of Safety  
Seed et al. 2002



Liquefaction  
Seed et al. 2002



CPT tip resistance,  $q_t$  (MPa)

Soil classification index,  $I_c$

Cyclic stress ratio

FOS

Earthquake scenario

Peak acc. (g)	Magnitude	Return Period (yrs)
1170.5	7.5	500
Feb.22	6.2	-
ULS	7.5	500

Thickness of liquefied layers (m)

Thickness of liquefied layers (m)
0.0
0.0
0.0

Liquefaction FOS

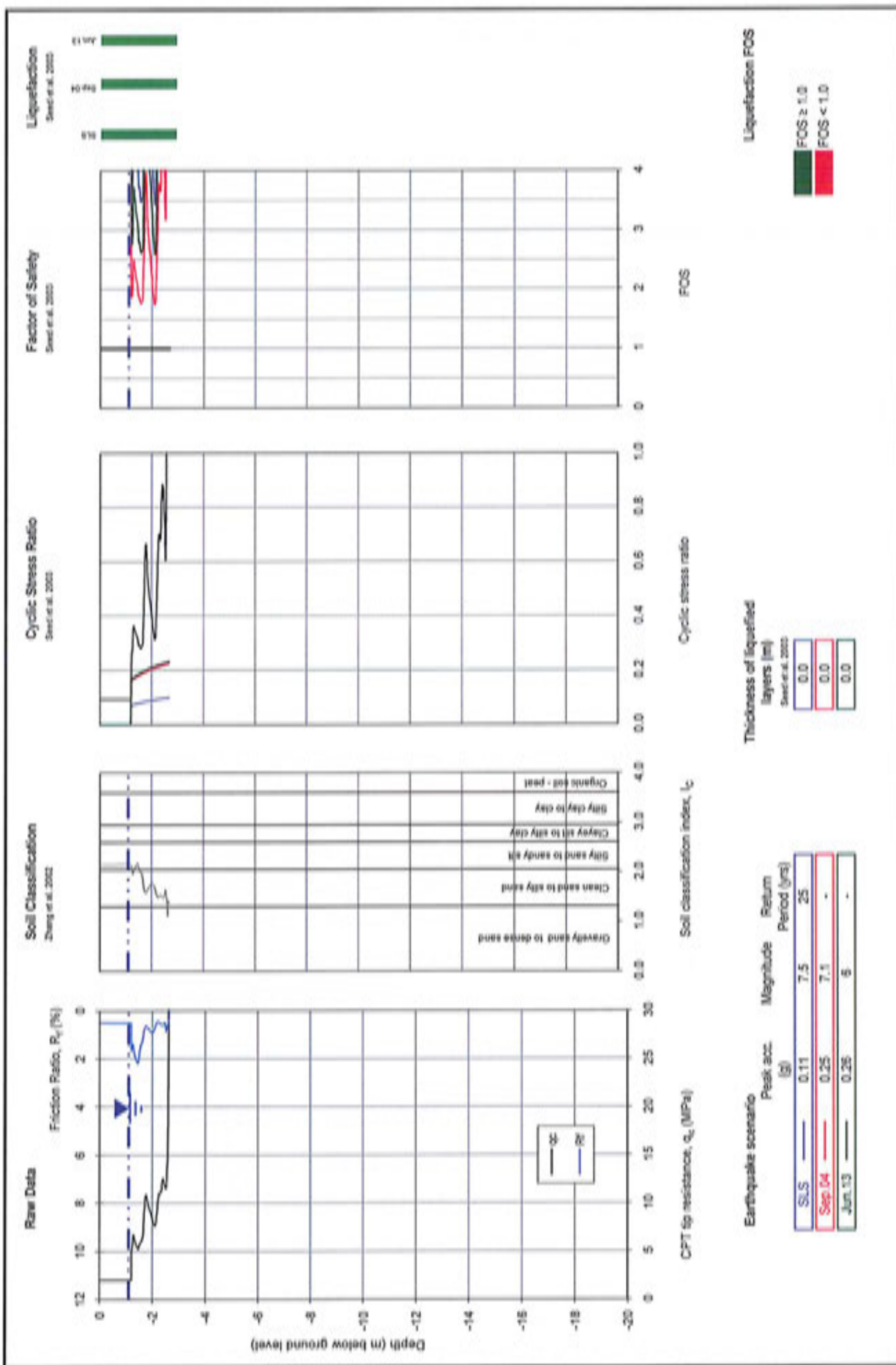


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Engineering Consultants

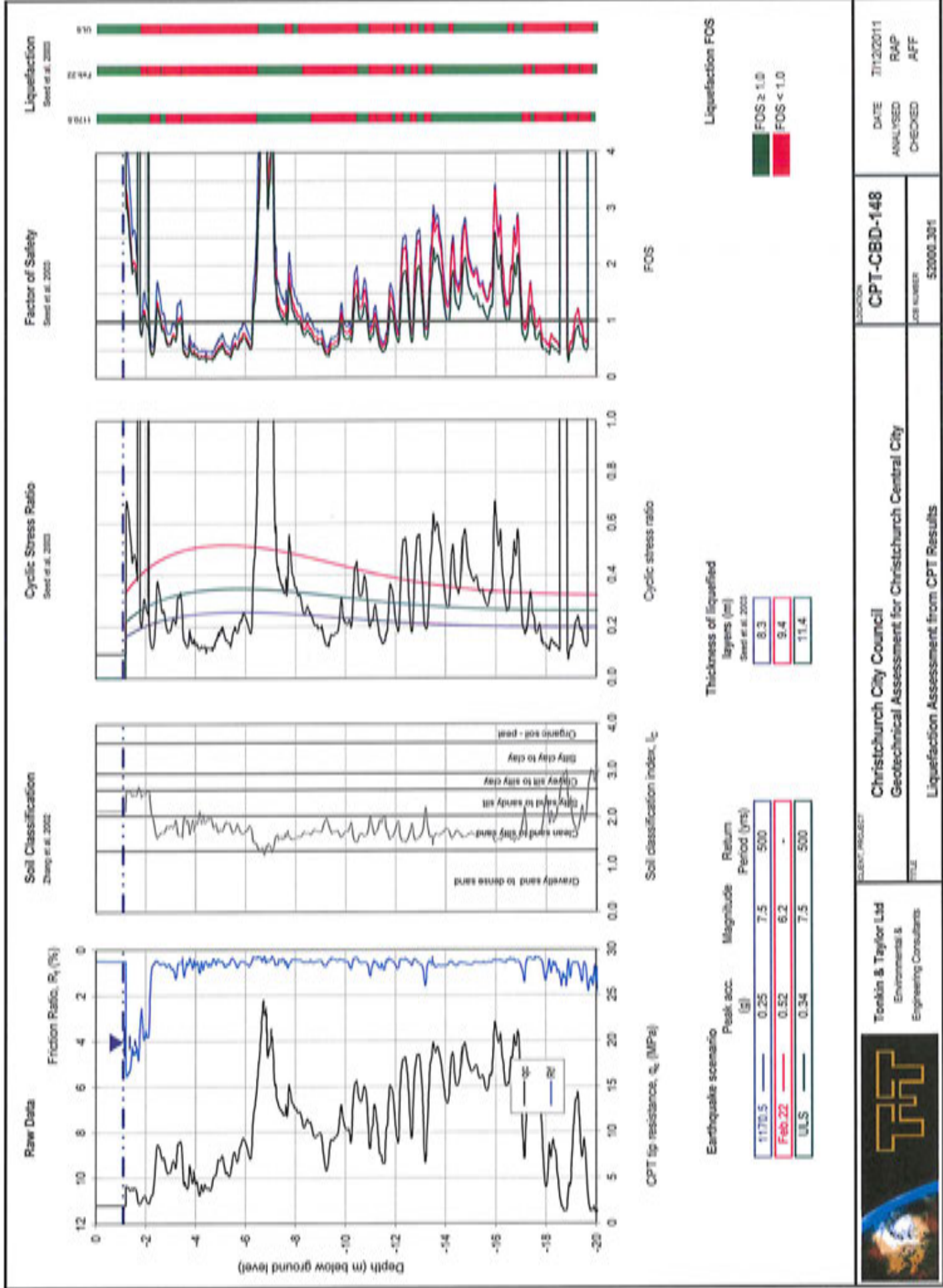
CLIENT PROJECT	LOCATION
Christchurch City Council Geotechnical Assessment for Christchurch Central City	CPT-CBD-147
FILE	JOB NUMBER
	52000_301

DATE	DATE
ANALYSED	6/12/2011
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	AFF

Liquefaction Assessment from CPT Results



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council          Geotechnical Assessment for Christchurch Central City</b>	LOCATION <b>CPT-CBD-147</b>	DATE 7/12/2011
	TITLE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 52000.301	ANALYSED RAMP
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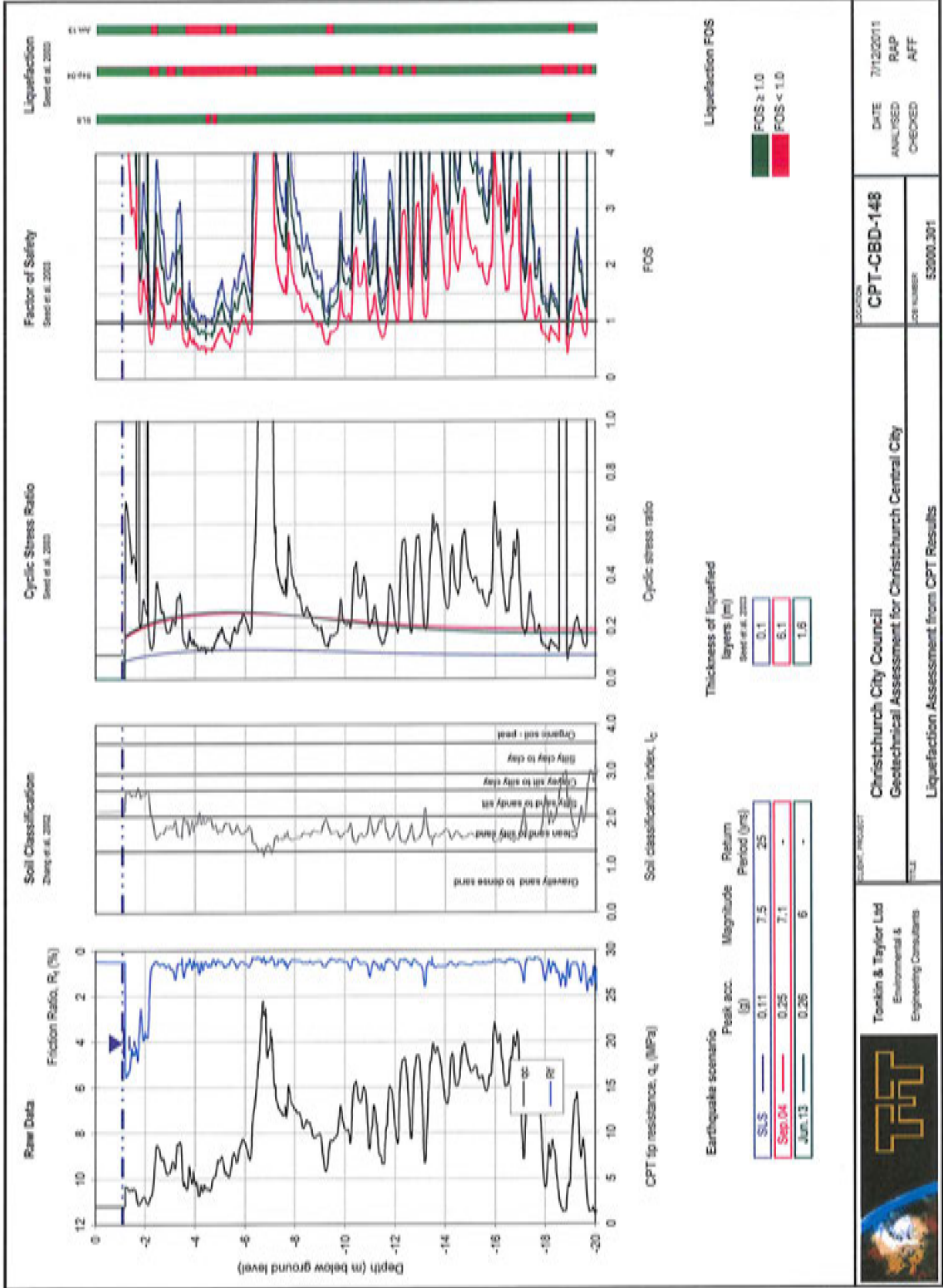


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**CLIENT REQUEST**  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

**SECTION**  
CPT-CBD-148  
**JOB NUMBER**  
52000\_301

**DATE** 31/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF



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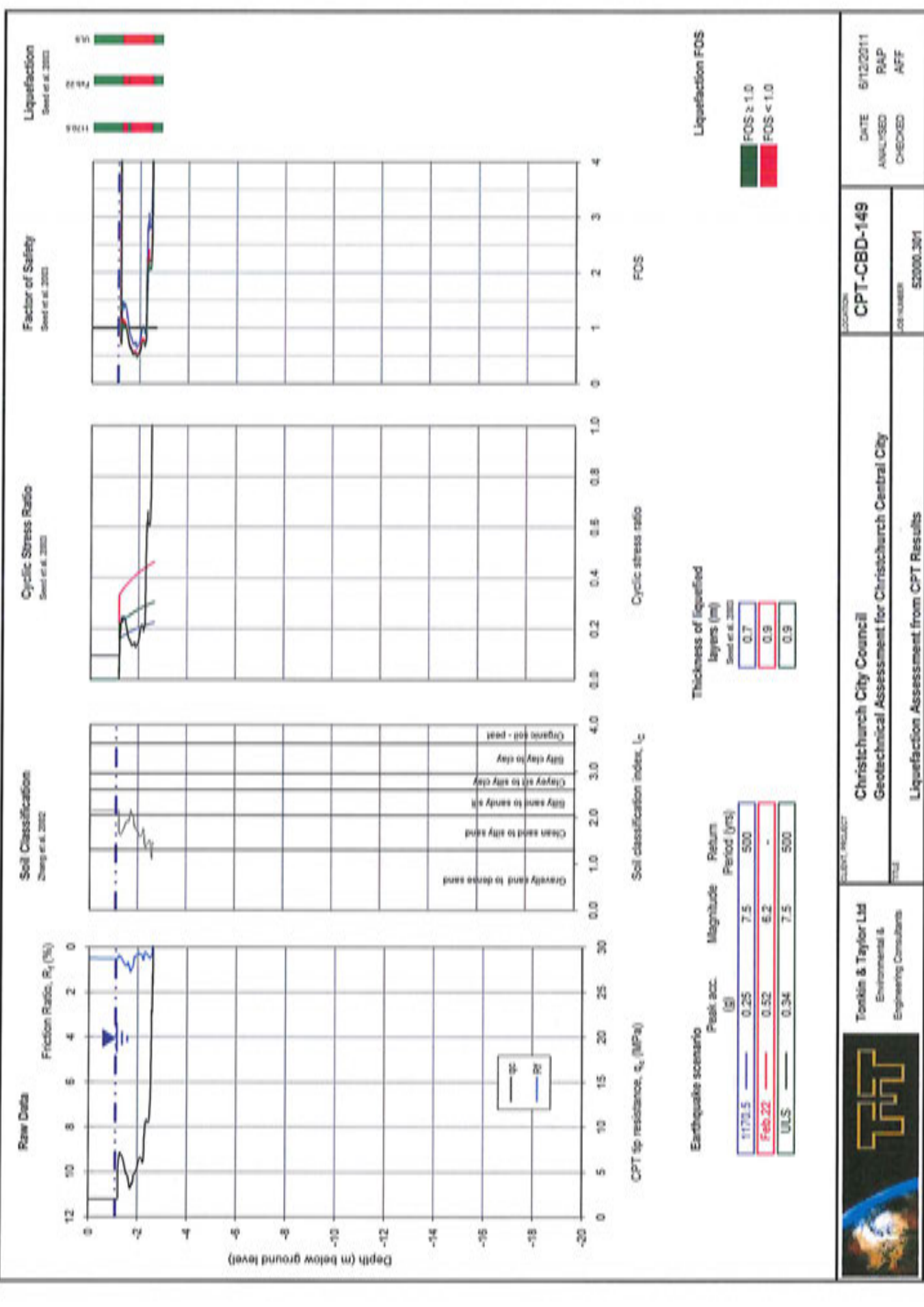
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

PROJECT NUMBER: 52000\_301

LIQUEFACTION ASSESSMENT FROM CPT RESULTS

**CPT-CBD-148**

DATE: 7/12/2011  
ANALYSED: RAP  
CHECKED: AFF



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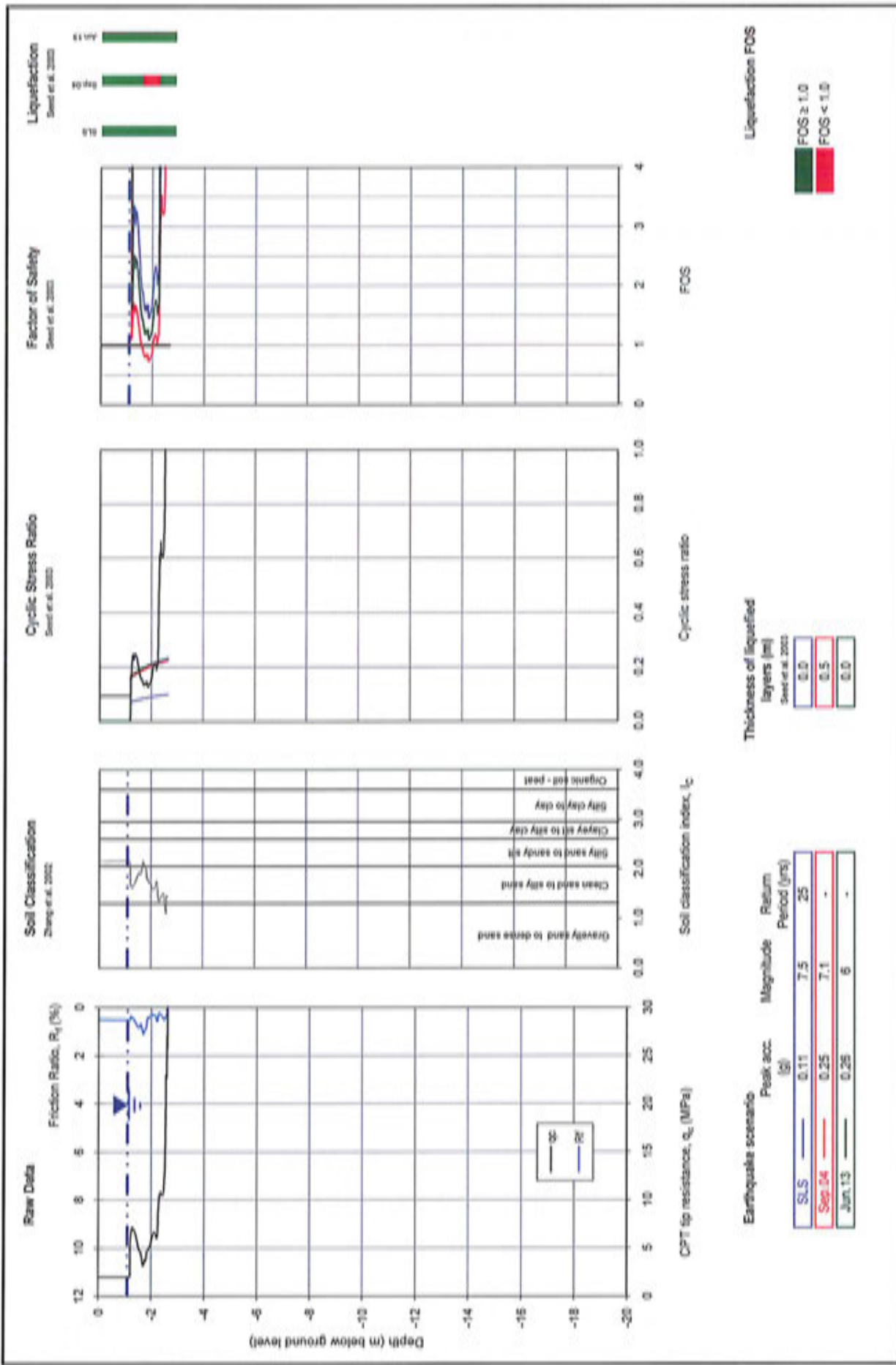
**CLIENT PROJECT**  
Christchurch City Council  
Geotechnical Assessment for Christchurch Central City

**FILE**  
Liquefaction Assessment from CPT Results

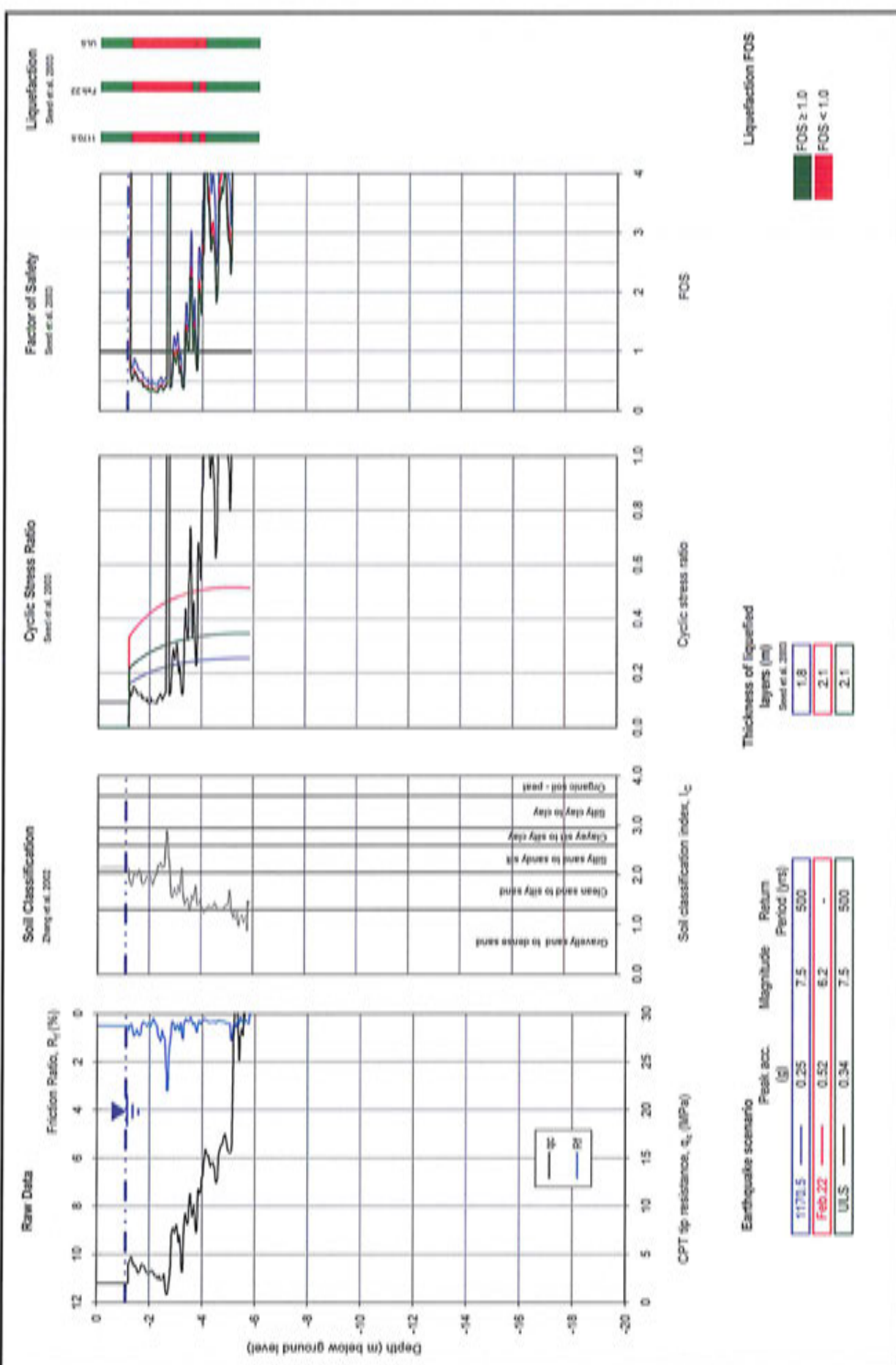
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CPT-CBD-149

**DATE** 6/12/2011  
**ANALYSED** RAP  
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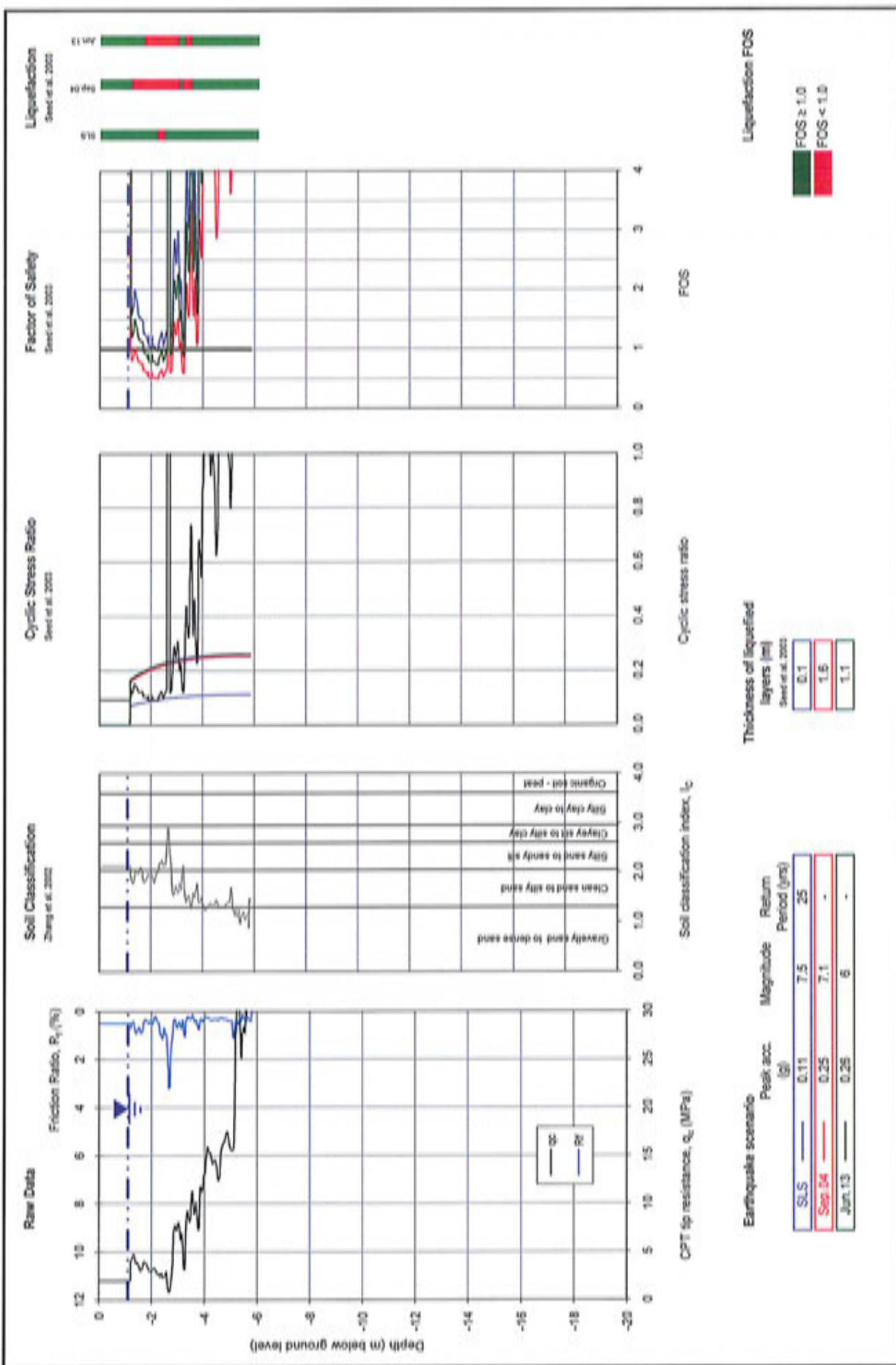
**JOB NUMBER** 52000\_301



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City Liquefaction Assessment from CPT Results	SOURCE <b>CPT-CBD-149</b>	DATE 7/12/2011
		FILE 52000.301	ANALYSED RAP
		CHECKED AFF	

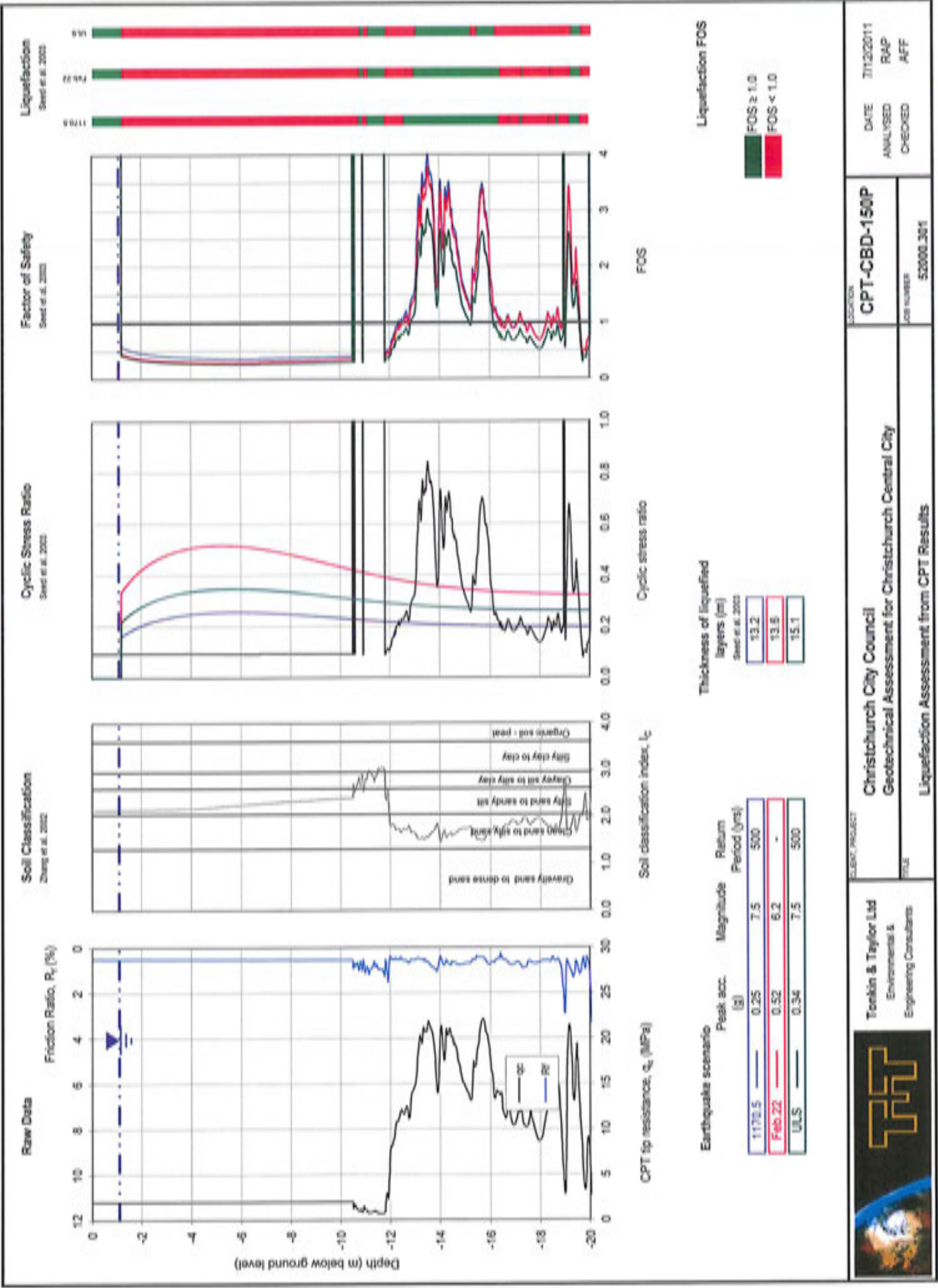


 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT PROJECT <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	LOCATION <b>CPT-CBD-150</b>	DATE 6/12/2011
	TITLE <b>Liquefaction Assessment from CPT Results</b>	JOB NUMBER 52000.301	ANALYSED RAP
			CHECKED AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	<b>CLIENT PROJECT</b> Christchurch City Council Geotechnical Assessment for Christchurch Central City	<b>LOCATION</b> CPT-CBD-150	<b>DATE</b> 7/12/2011 <b>ANALYSED</b> RAB <b>CHECKED</b> AFF
	<b>LIQUEFACTION ASSESSMENT FROM CPT RESULTS</b>		<b>JOB NUMBER</b> 52000.301





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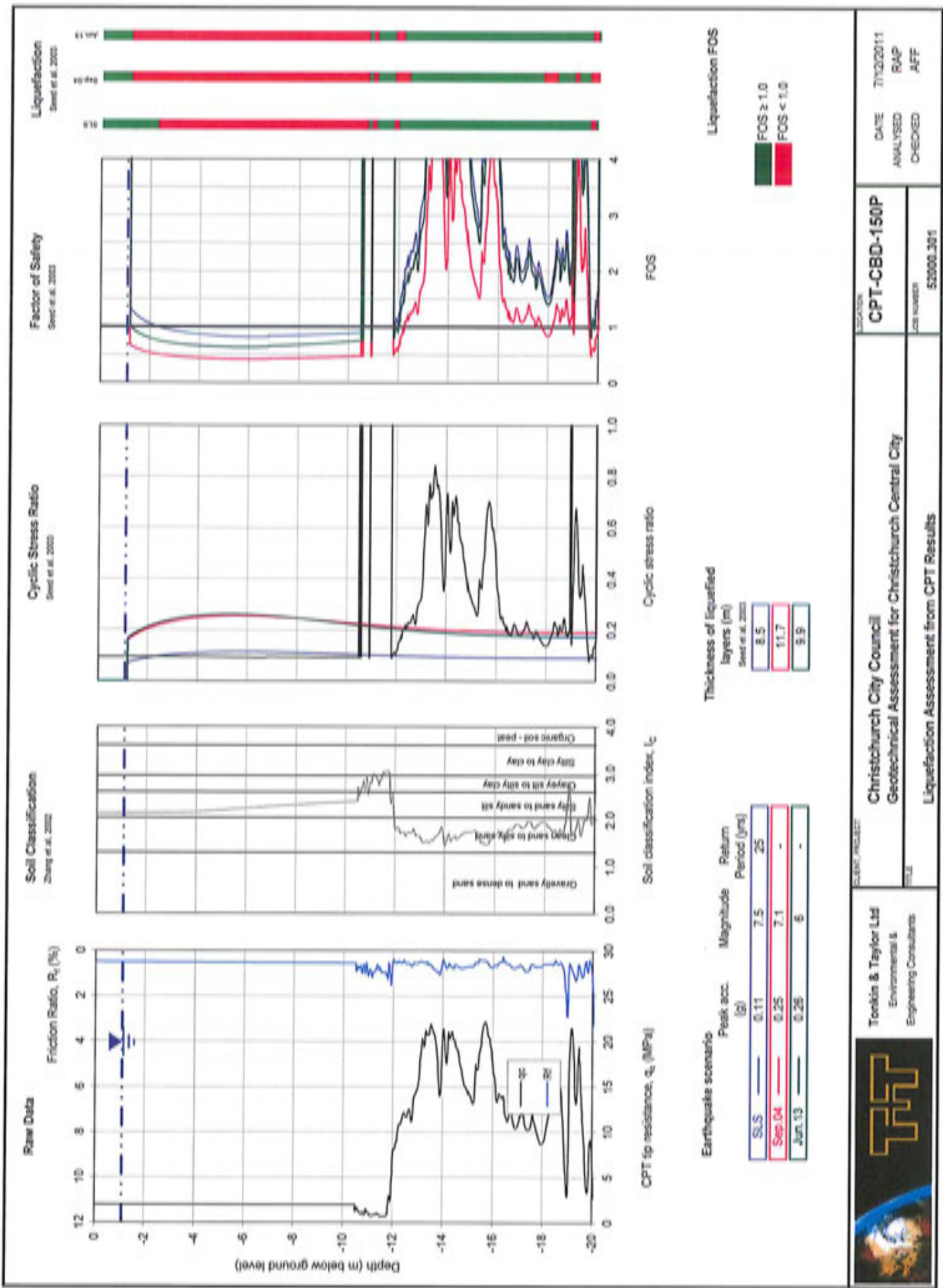
**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City

**LOCATION**  
CPT-CBD-150P

**JOB NUMBER**  
52000\_301

**DATE** 31/12/2011  
**ANALYSED** RAP  
**CHECKED** AFF

Liquefaction Assessment from CPT Results

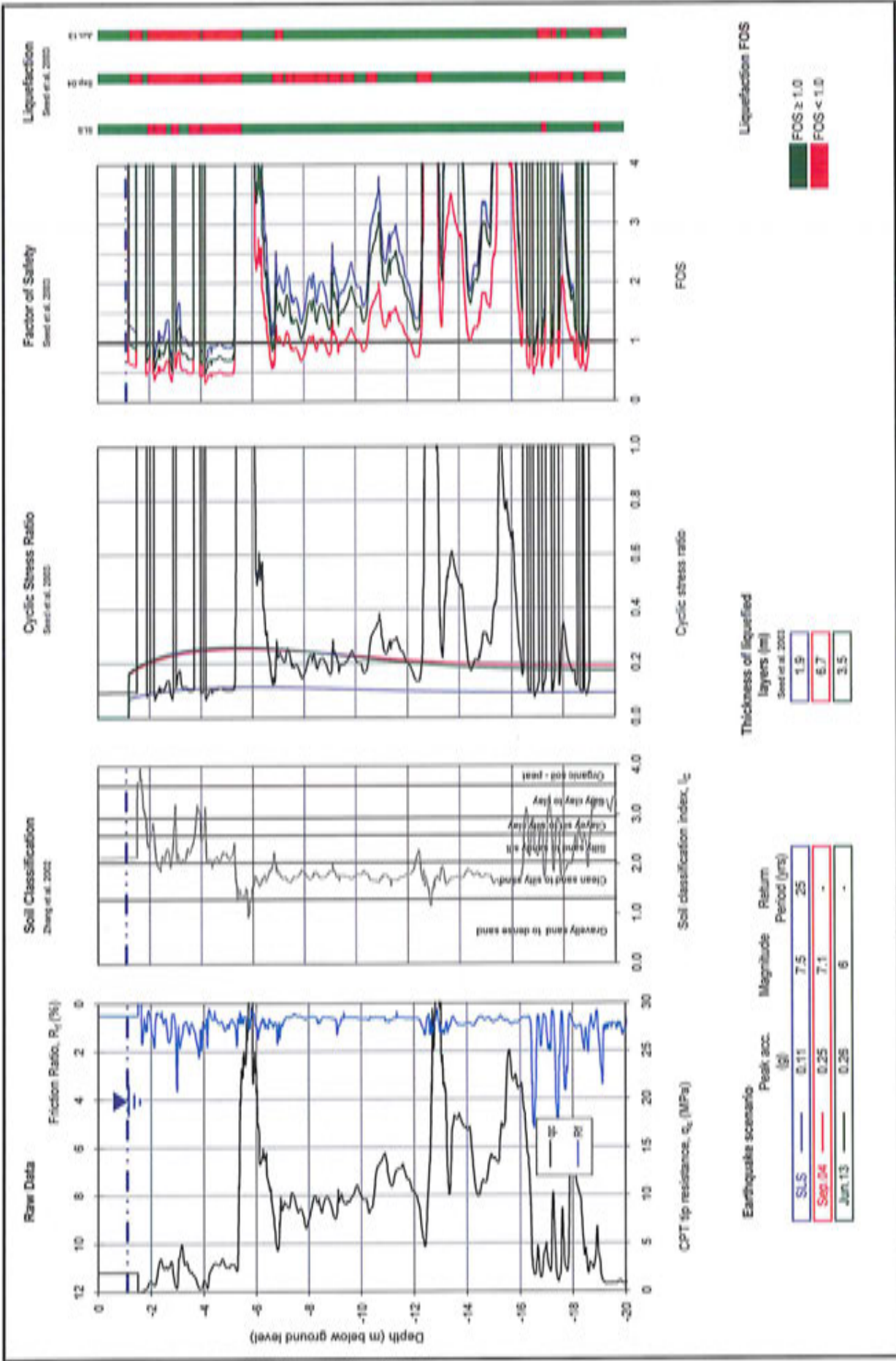


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**Christchurch City Council**  
Geotechnical Assessment for Christchurch Central City  
Liquefaction Assessment from CPT Results

**CPT-CBD-150P**  
JOB NUMBER: 53000\_301

DATE: 17/02/2011  
ANALYSED: RAP  
CHECKED: AFF



 <b>Tonkin &amp; Taylor Ltd</b> Environmental & Engineering Consultants	CLIENT / PROJECT: <b>Christchurch City Council</b> Geotechnical Assessment for Christchurch Central City	BOOKER: <b>CPT-CBD-151</b>	DATE: 7/12/2011
	TITLE: Liquefaction Assessment from CPT Results	JOB NUMBER: 52000.301	ANALYSED: RAP