Tonkin & Taylor

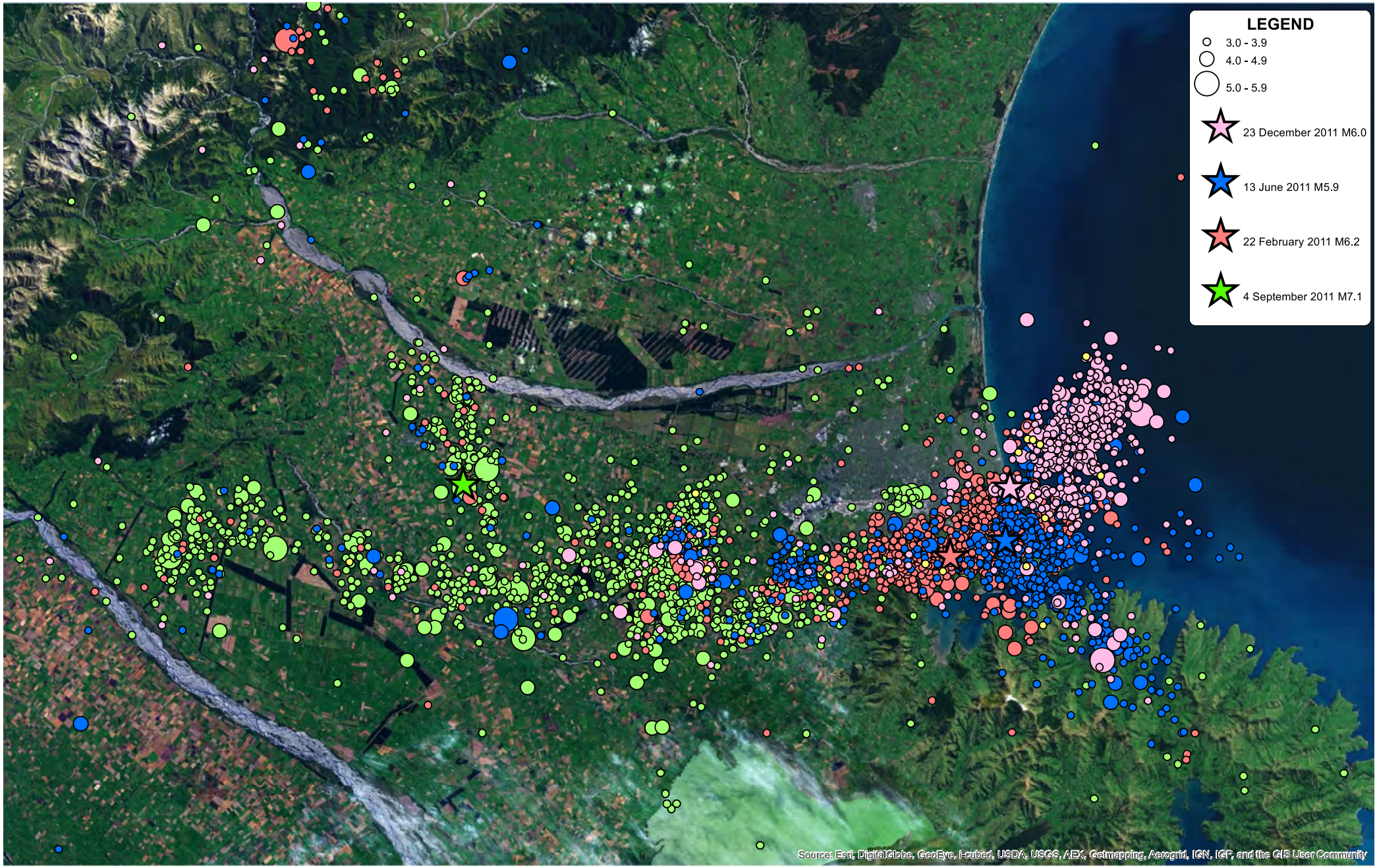
Appendix A: Figures

ENVIRONMENTAL AND ENGINEERING CONSULTANTS



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Notes:
We acknowledge the New Zealand geonet project and its sponsors EQC, GNS Science and LINZ for providing data

A3 SCALE 1:300,000

0 5 10 15 20 (km)

Location Plan

EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	HKB	Feb.13
CHECKED		
APPROVED		
ARCFILE	52000.2000-EQC_AllQuakes	
SCALE (AT A3 SIZE)	1:300,000	
PROJECT No.		

Earthquake Commission
Earthquake Epicentres
4 September 2010 - 18 September 2012

FIGURE No. Figure A1

Rev. 0

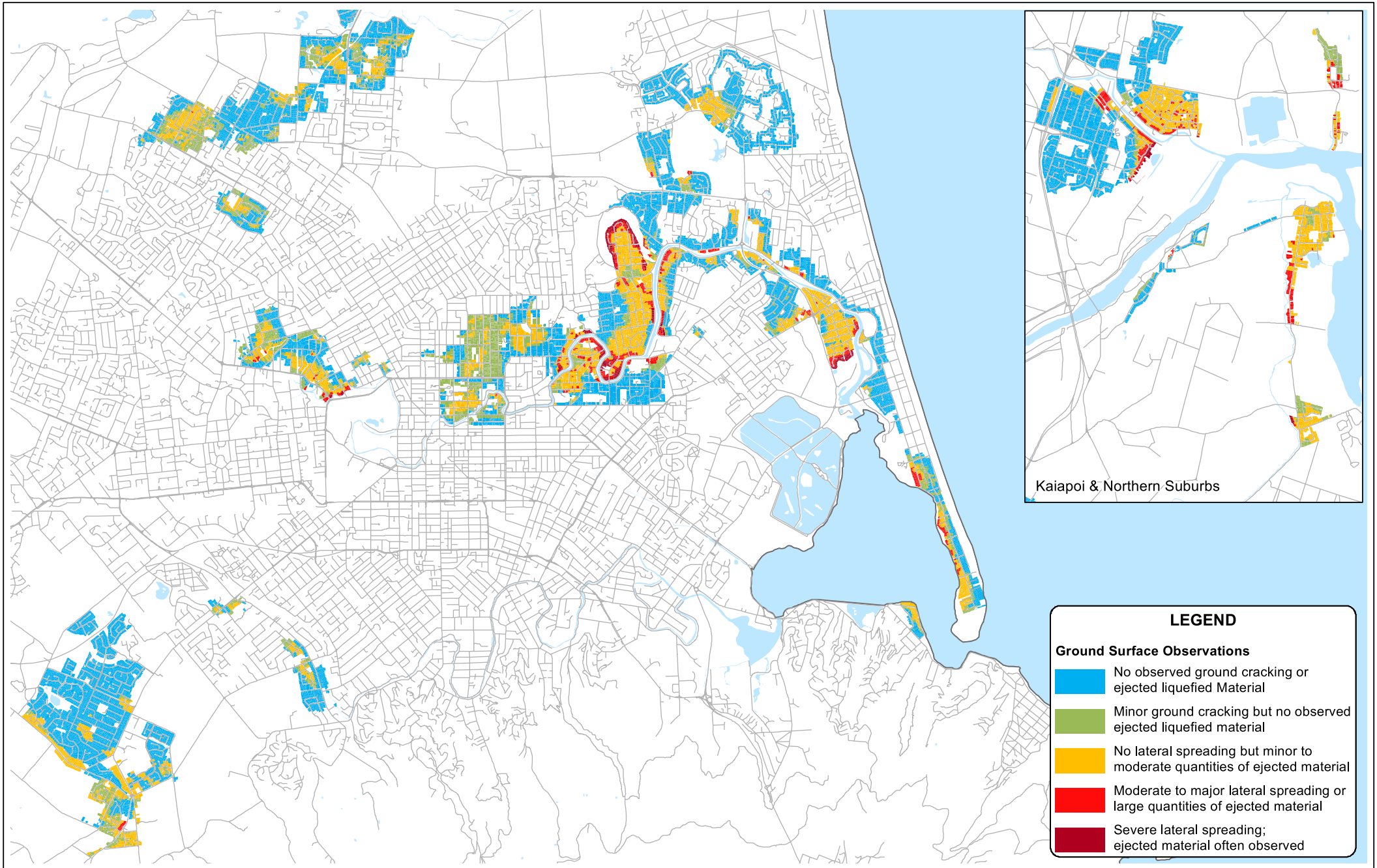
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Land Observation Categories (September 2010)	
Land Observation Category	Criteria / Description
Blue	• No observed cracks, undulations / deformations at the ground surface, and, • No signs of ejected liquefied material at the ground surface, and, • No apparent lateral movement.
Green	• Shaking-induced damage resulting from cyclic deformation and surface-waves causing ground surface damage. Ground surface damage likely limited to minor cracking (tension) and buckling (compression) and/or minor undulations at the ground surface, and, • No signs of ejected liquefied material at the ground surface, and, • No apparent lateral movement.
Light Orange	• Minor to moderate quantities of ejected liquefied material on ground surface (generally <25% of site covered with ejected material), and/or, • Small cracks from ground oscillations (<50 mm) may be present, but little to no vertical displacement across cracks, and, • No apparent lateral movement.
Red	Either • Large quantities of ejected liquefied material on ground surface (generally >25% of the site covered with ejected material), and/or, • Severe observed ground surface subsidence, and/or; • Small cracks from ground oscillations (<50 mm) may be present, but little to no vertical displacement across cracks, and, • Limited evidence of lateral movement. or • Moderate to major lateral spreading (<1 m cumulative), and/or, • Large cracks extending across the ground surface, with horizontal and/or vertical displacement (>50 mm, but generally <200 mm). • Ejection of liquefied material at the ground surface may also be observed
Dark Red	• Extensive lateral spreading (≥1 m cumulative), and/or, • Large open cracks extending through the ground surface, with very severe horizontal and/or vertical displacements (≥200 mm), and, • Ejection of liquefied material at the ground surface may also be observed.

Figure A.2A

Land Observation Categories (February 2011 and June 2011)	
Land Observation Category	Criteria / Description
Blue	• No observed cracks, undulations / deformations at the ground surface, and, • No signs of ejected liquefied material at the ground surface, and, • No apparent lateral movement.
Green	• Shaking-induced damage resulting from cyclic deformation and surface-waves causing ground surface damage. Ground surface damage likely limited to minor cracking (tension) and buckling (compression) and/or minor undulations at the ground surface, and, • No signs of ejected liquefied material at the ground surface, and, • No apparent lateral movement.
Light Orange	• Minor to moderate quantities of ejected liquefied material on ground surface (generally <25% of site covered with ejected material), and/or, • Small cracks from ground oscillations (<50 mm) may be present, but little to no vertical displacement across cracks, and, • No apparent lateral movement.
Dark Orange	• Large quantities of ejected liquefied material on ground surface (generally >25% of the site covered with ejected material), and/or, • Severe observed ground surface subsidence, and/or; • Small cracks from ground oscillations (<50 mm) may be present, but little to no vertical displacement across cracks, and, • Limited evidence of lateral movement.
Red	• Moderate to major lateral spreading (<1 m cumulative), and/or, • Large cracks extending across the ground surface, with horizontal and/or vertical displacement (>50 mm, but generally <200 mm). • Ejection of liquefied material at the ground surface may also be observed
Dark Red	• Extensive lateral spreading (≥1 m cumulative), and/or, • Large open cracks extending through the ground surface, with very severe horizontal and/or vertical displacements (≥200 mm), and, • Ejection of liquefied material at the ground surface may also be observed.

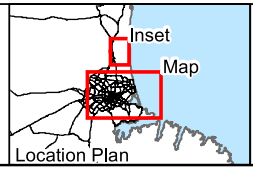
Figure A.2B



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



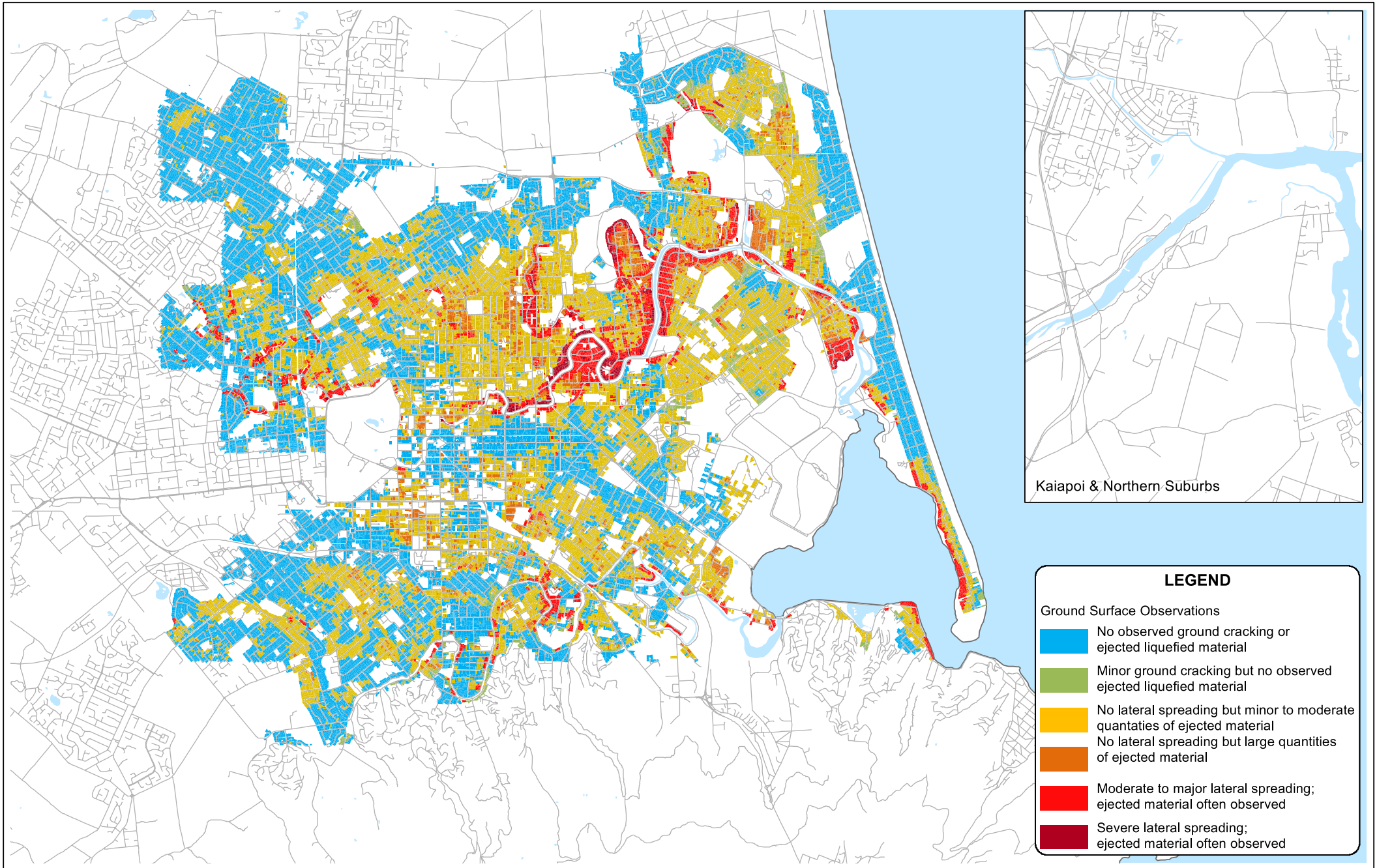
EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	HKB	Mar.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LFF01	
SCALE (AT A3 SIZE)	1:60,000	
	52000.200	

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
Liquefaction and Lateral Spreading Observations Post September 2010

FIGURE No. Figure A3 Rev. 0

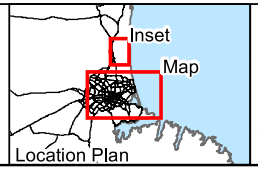
Date: 4/03/2013 Time: 11:00:10 a.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Mar,13
CHECKED		
APPROVED		

ARCFILE 52020-0200-LFF02

SCALE (AT A3 SIZE) 1:60,000

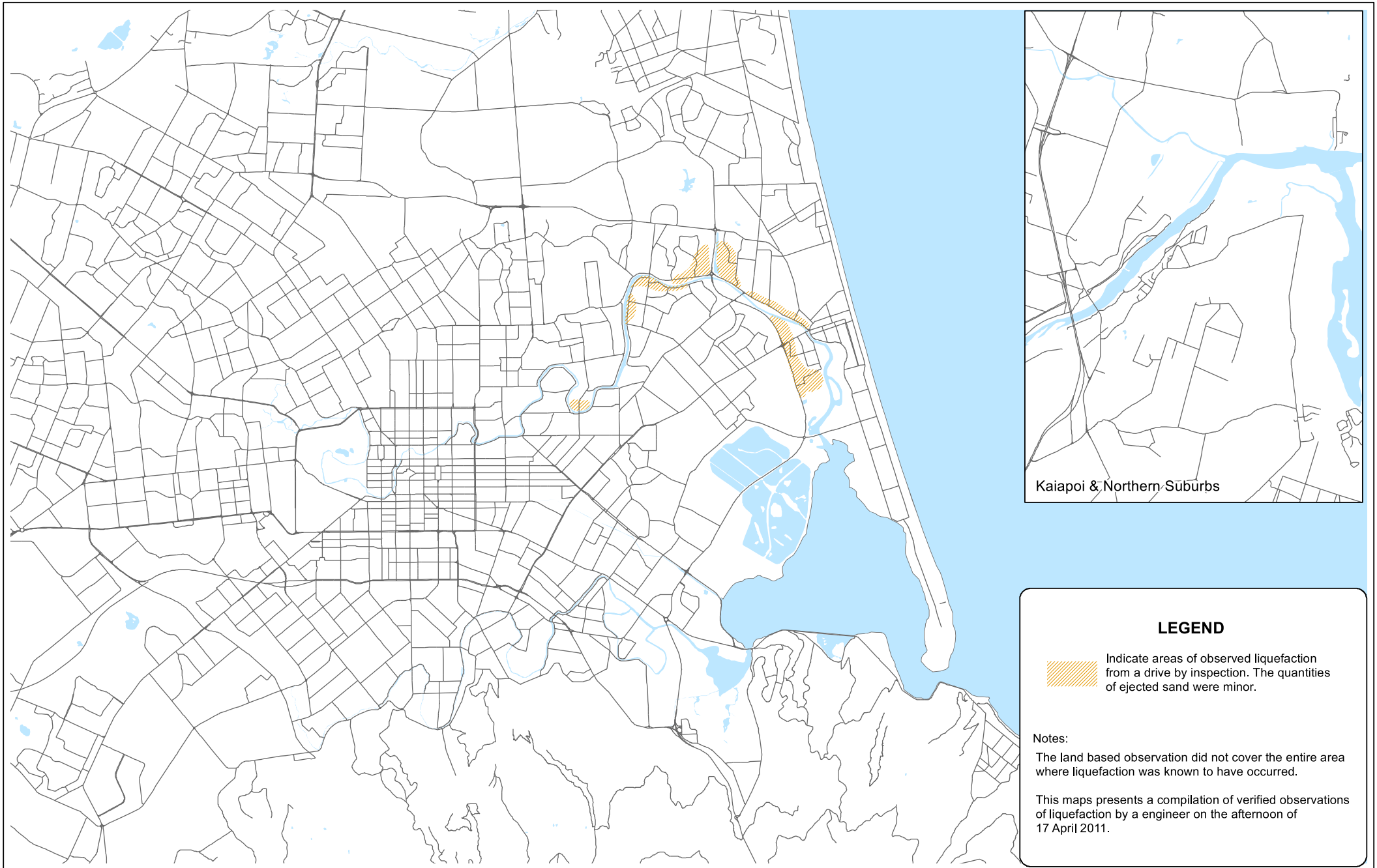
Prepared By Tonkin & Taylor Ltd. Ref. 52000.200

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
Liquefaction and Lateral Spreading Observations Post February 2011

FIGURE No. Figure A4

Rev. 0

Date: 4/03/2013 Time: 10:59:06 a.m.



LEGEND

Indicate areas of observed liquefaction from a drive by inspection. The quantities of ejected sand were minor.

Notes:

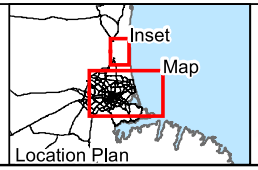
The land based observation did not cover the entire area where liquefaction was known to have occurred.

This maps presents a compilation of verified observations of liquefaction by a engineer on the afternoon of 17 April 2011.

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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	JEL	Mar,13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LDF27	
SCALE (AT A3 SIZE)	1:60,000	
Prepared by Tonkin & Taylor Ltd Ref:	52020.0200	

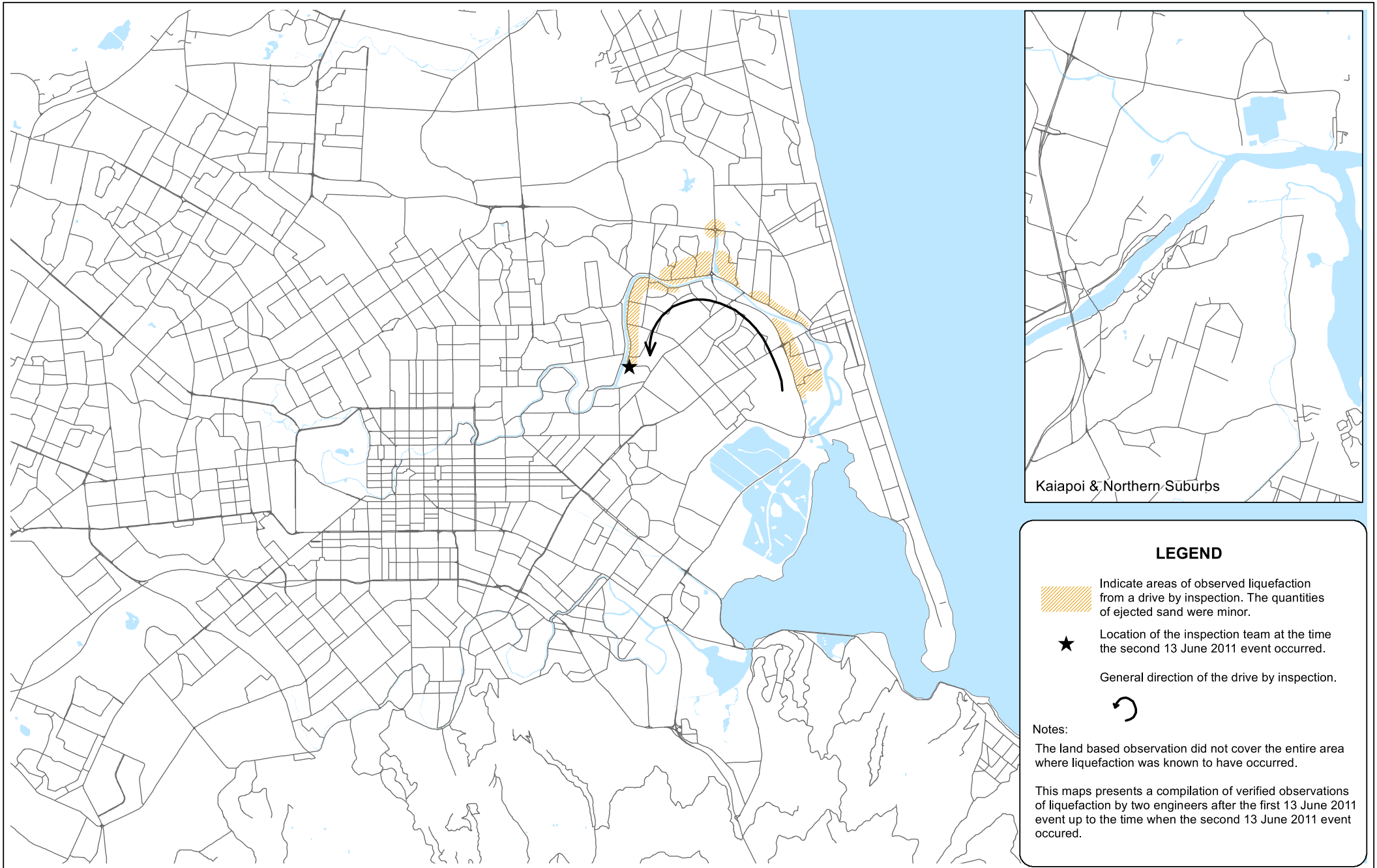
EARTHQUAKE COMMISSION

CHRISTCHURCH CITY & KAIAPOI

Liquefaction and Lateral Spreading Observations Post 16 April 2011

FIGURE No. Figure A5 Rev. 0

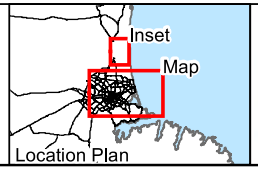
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A3 SCALE 1:60,000

0 1 2 3 4 (km)



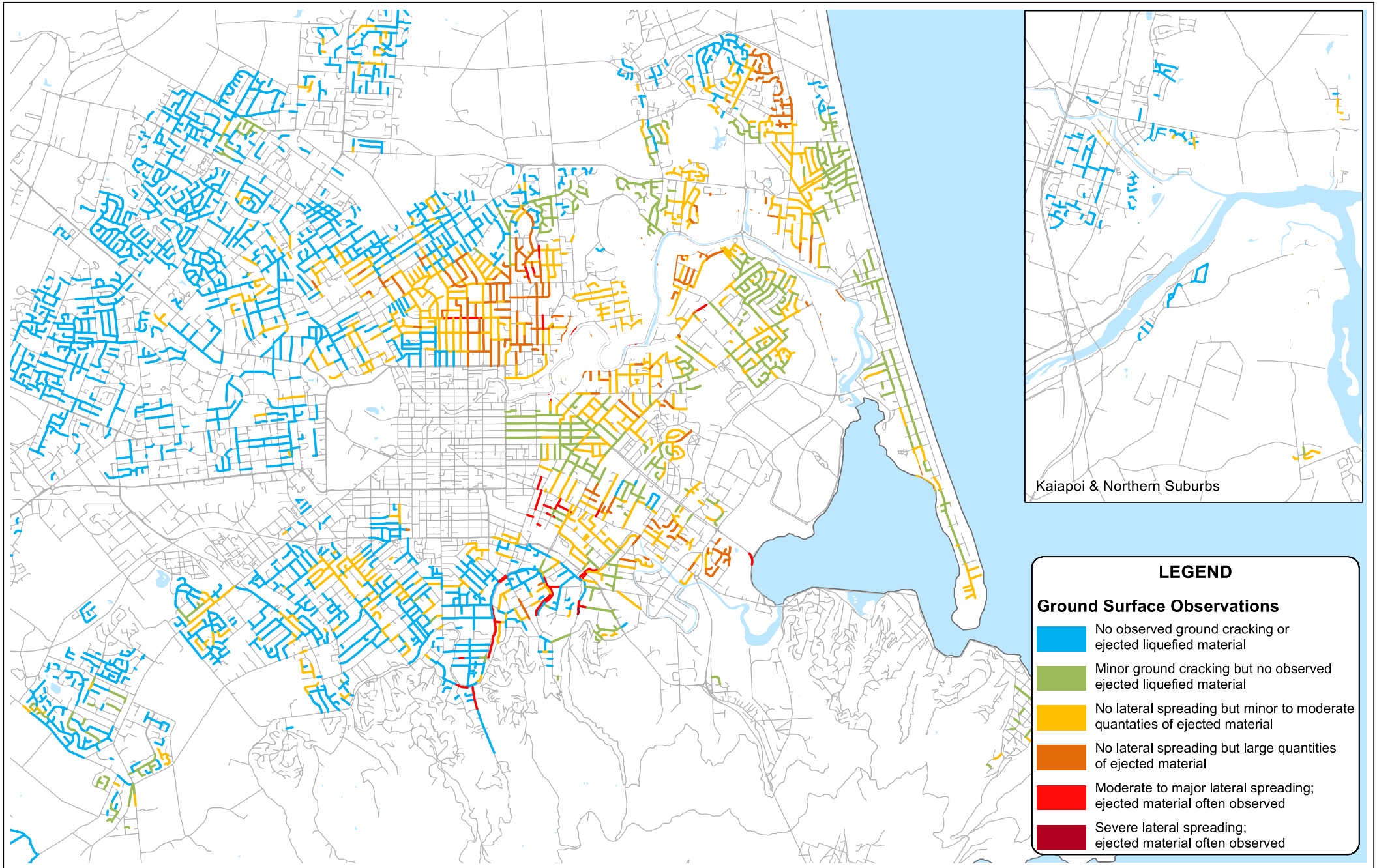
EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	JEL	Mar,13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LDF26	
SCALE (AT A3 SIZE)	1:60,000	
Prepared by Tonkin & Taylor Ltd Ref:	52020.0200	

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
Liquefaction and Lateral Spreading Observations Post 13 June 2011 (Event A)

FIGURE No. Figure A6 Rev. 0

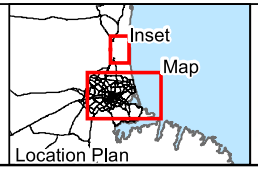
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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	HKB	Mar.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-RLF02	
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PROJECT No.	52000.200	

EARTHQUAKE COMMISSION

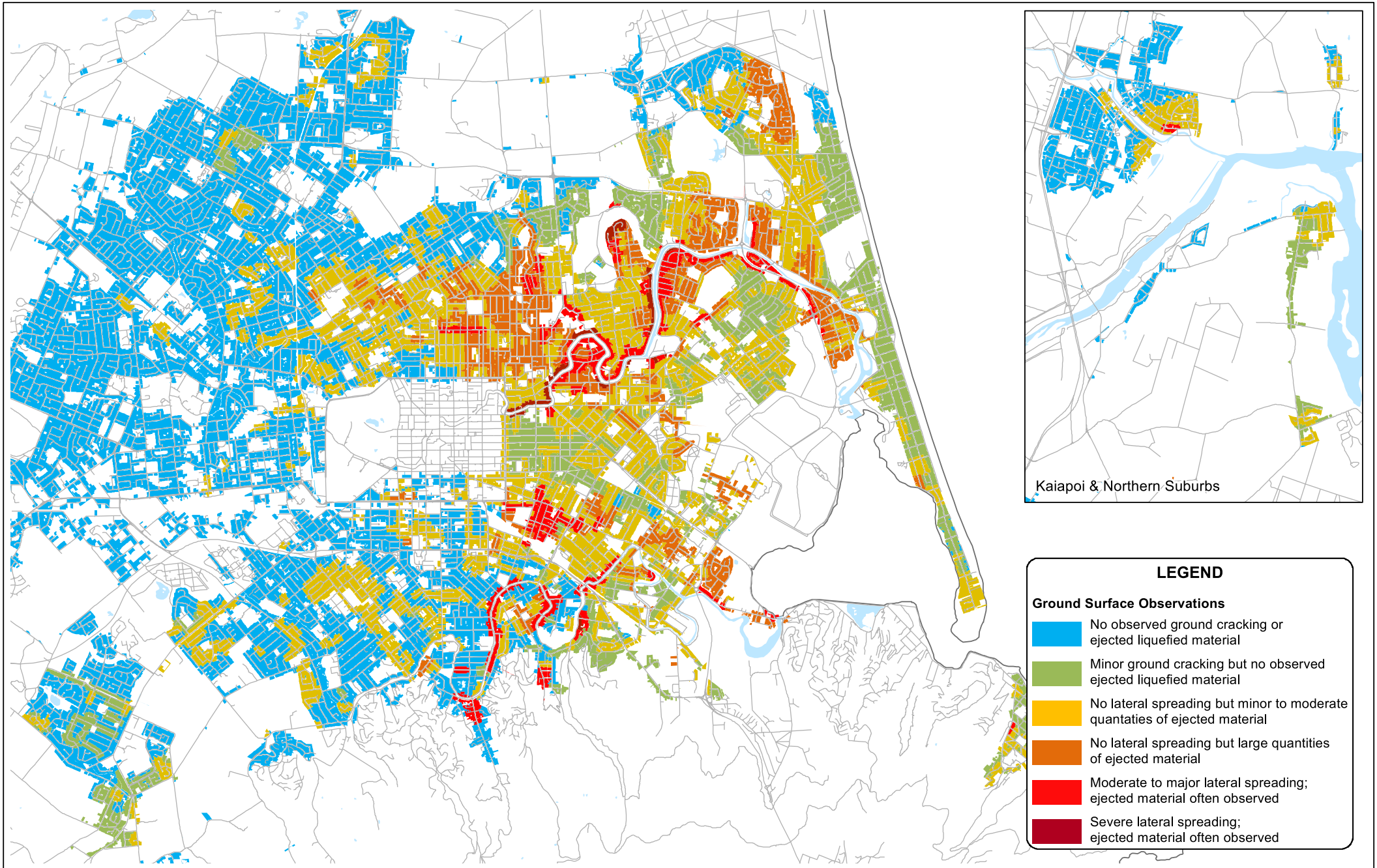
CHRISTCHURCH CITY & KAIAPOI

Liquefaction and Lateral Spreading Observations Post June 2011 (Event B)

FIGURE No. Figure A7.A

Rev. 0

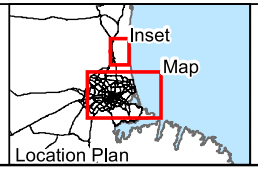
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A3 SCALE 1:60,000

0 1 2 3 4 (km)



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DRAWN	CXP	Feb.13	
CHECKED			
APPROVED			
ARCFILE	52020-0200-LFF03		
SCALE (AT A3 SIZE)	1:60,000		
Prepared By Tonkin & Taylor Ltd, Ref.	52020.0200		

EARTHQUAKE COMMISSION

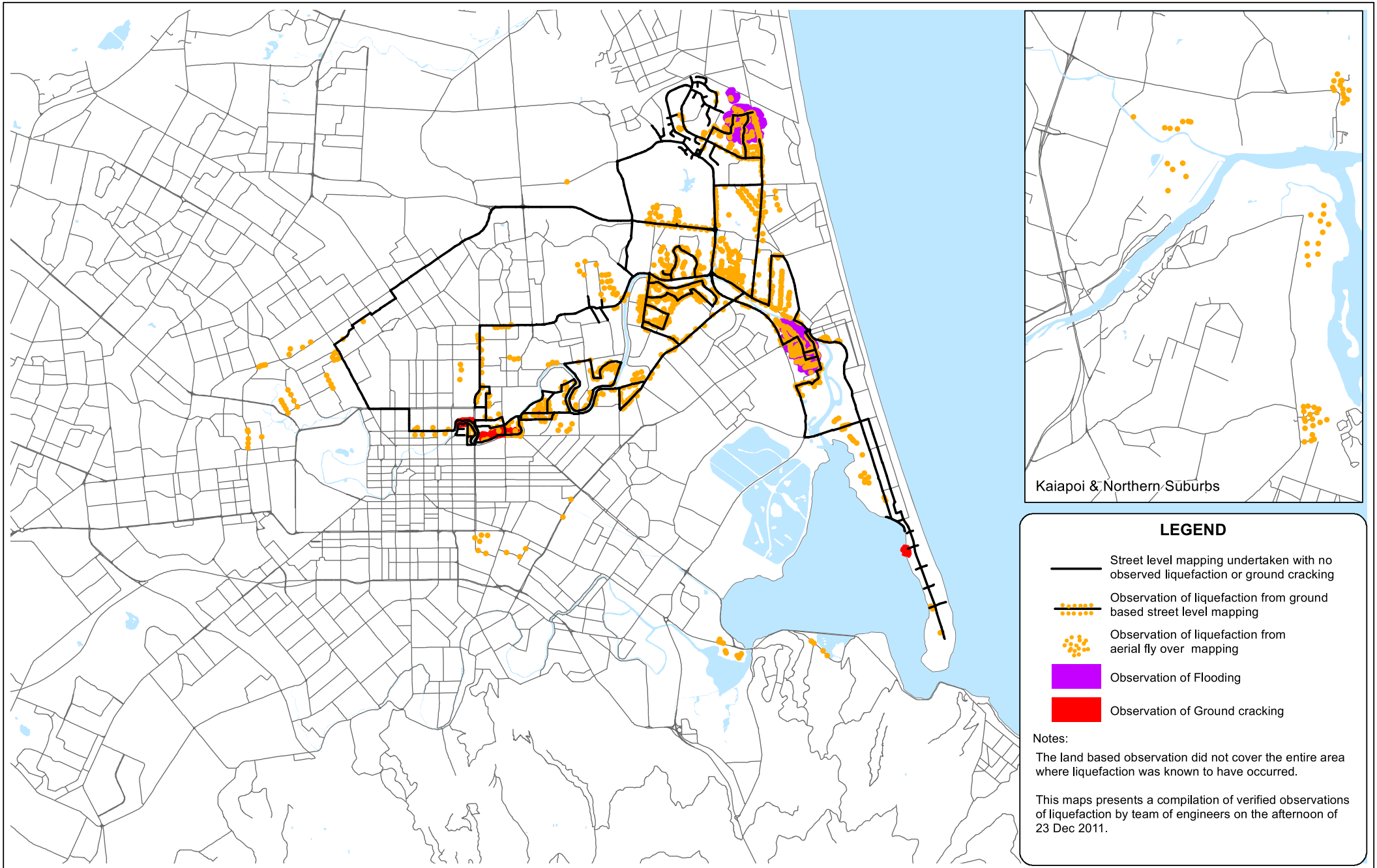
CHRISTCHURCH CITY & KAIAPOI

Liquefaction and Lateral Spreading from Road Observations Post June 2011 (Event B)

FIGURE No. Figure A7.B

Rev. 0

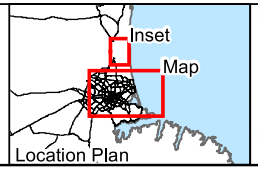
Date: 25/02/2013 Time: 1:31:25 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



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DRAWN	JSD	Mar,13
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APPROVED		
ARCFILE	52020-0200-LDF28	
SCALE (AT A3 SIZE)	1:60,000	
Prepared by Tonkin & Taylor Ltd Ref:	52020.0200	

EARTHQUAKE COMMISSION

CHRISTCHURCH CITY & KAIAPOI

Liquefaction and Lateral Spreading Observations Post 23 December 2011 (Event B)

FIGURE No. Figure A8 Rev. 0

Date: 4/03/2013 Time: 11:06:51 a.m.

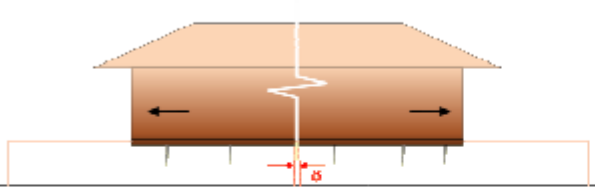
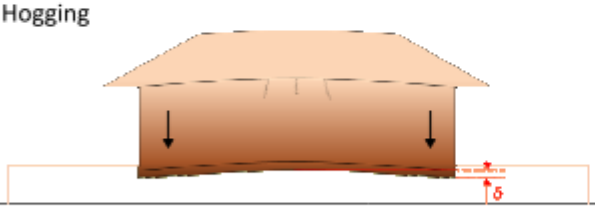
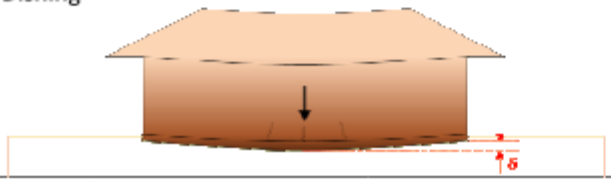
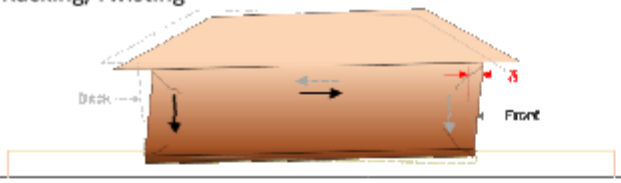
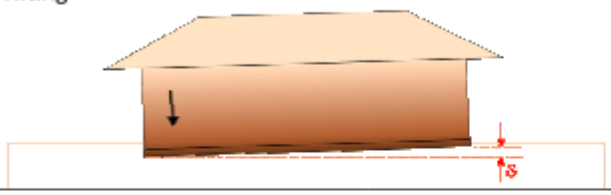
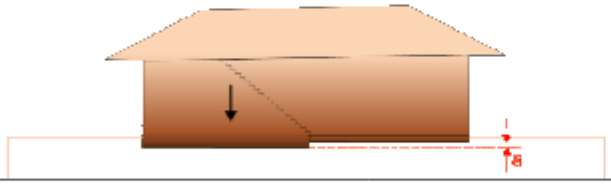
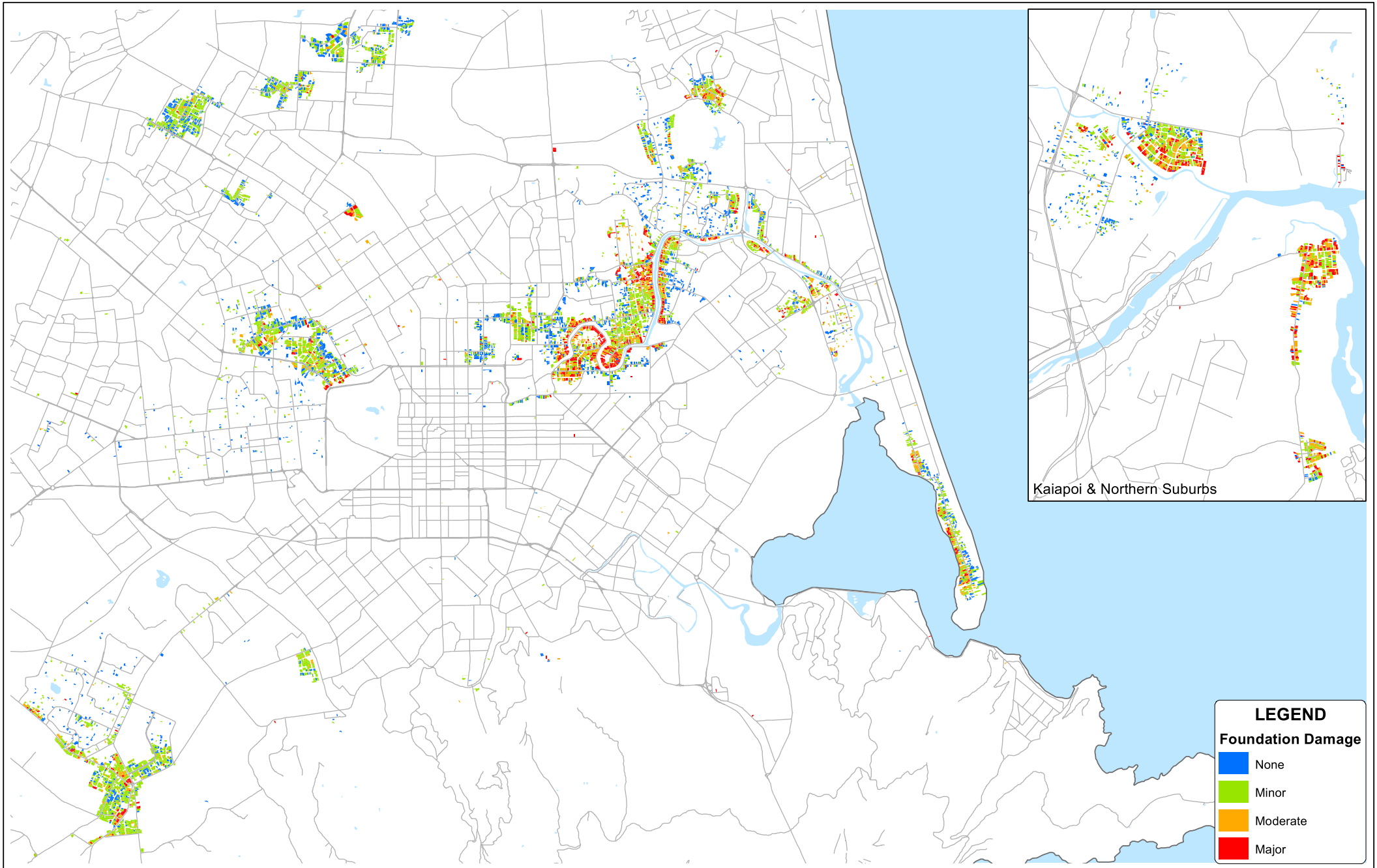
Damage to Dwelling predominantly from:	Shaking		Land damage
Type of Damage	Severity		
	Minor	Moderate	Major
Stretching 	0 to 5mm	5 to 30mm	>30mm
Hogging 	0 to 20mm	20 to 50mm	>50mm
Dishing 	0 to 20mm	20 to 50mm	>50mm
Racking/Twisting 	0 to 10mm	10 to 30mm	>30mm
Tilting 	0 to 20mm	20 to 50mm	>50mm
Discontinuous Foundation 	0 to 10mm	10 to 20mm	>20mm
Global Settlement 	0 to 50mm	50 to 100mm	>100mm

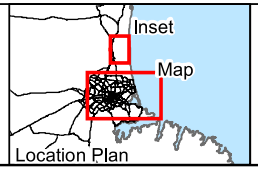
Figure A9



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	JSD	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-BDF01	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION

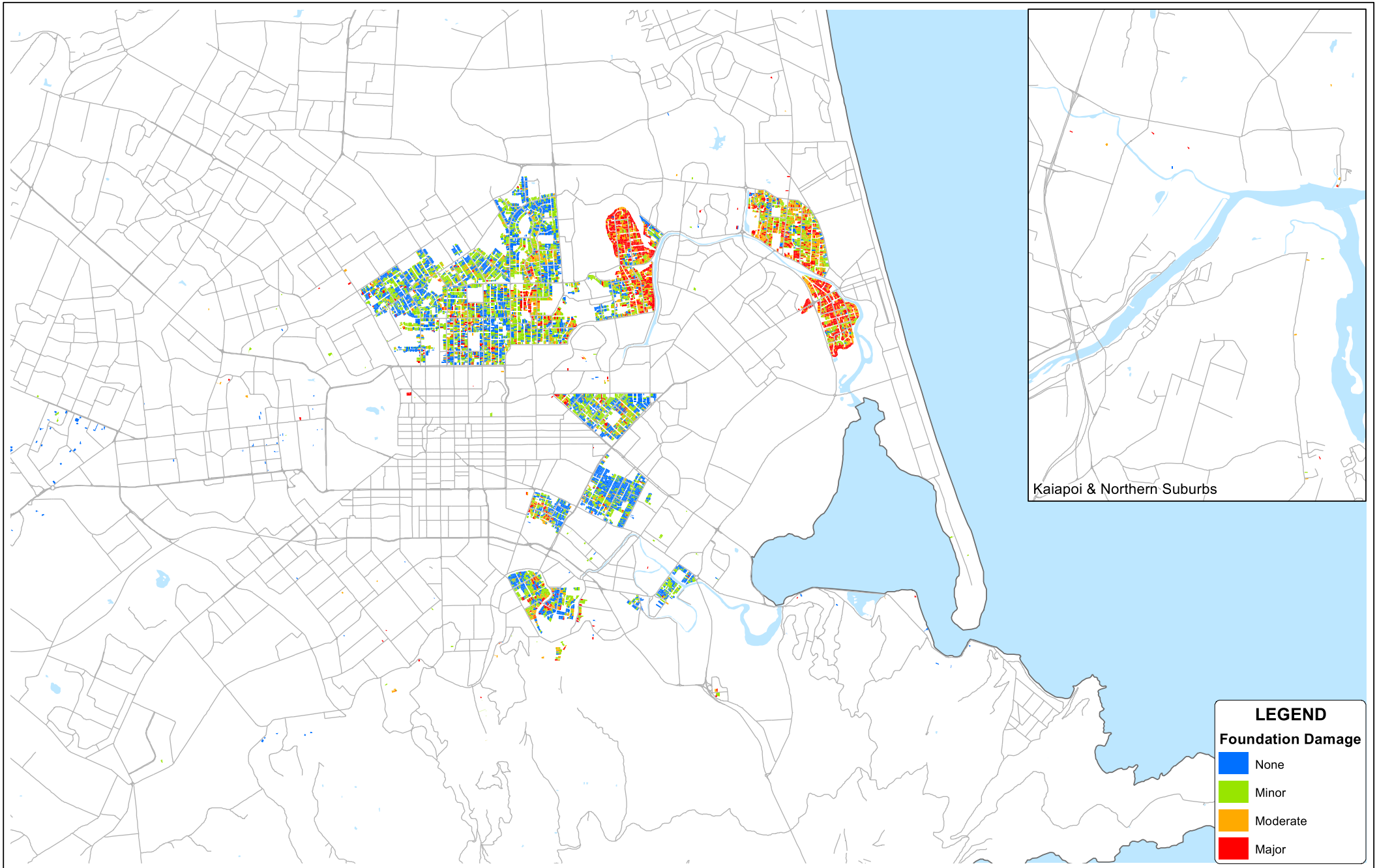
CHRISTCHURCH CITY & KAIAPOI

Observed Foundation Damage Based on Inspections Undertaken Between Sept 2010 and Feb 2011

FIGURE No. Figure A10

Rev. 0

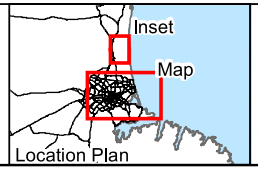
Date: 22/02/2013 Time: 11:56:57 a.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

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CHECKED		
APPROVED		
ARCFILE	52020-0200-BDF02	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION

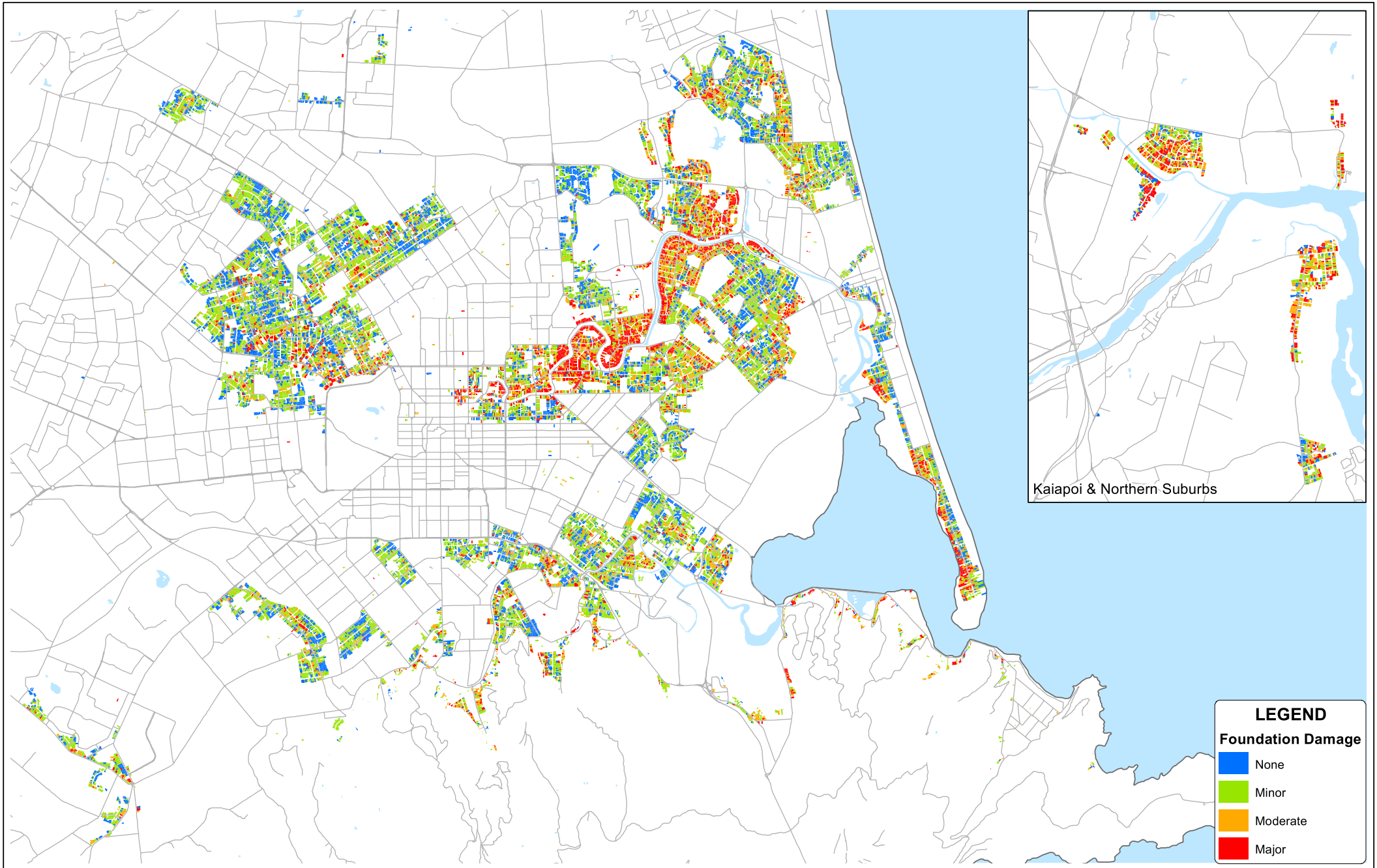
CHRISTCHURCH CITY & KAIAPOI

Observed Foundation Damage Based on Inspections Undertaken Between Feb 2011 and June 2011

FIGURE No. Figure A11

Rev. 0

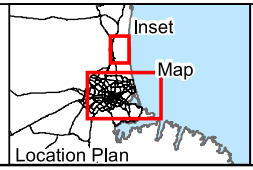
Date: 25/02/2013 Time: 12:36:41 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC
EARTHQUAKE COMMISSION
Kōmihana Rūwhenua

DRAWN	JSD	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-BDF03	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION

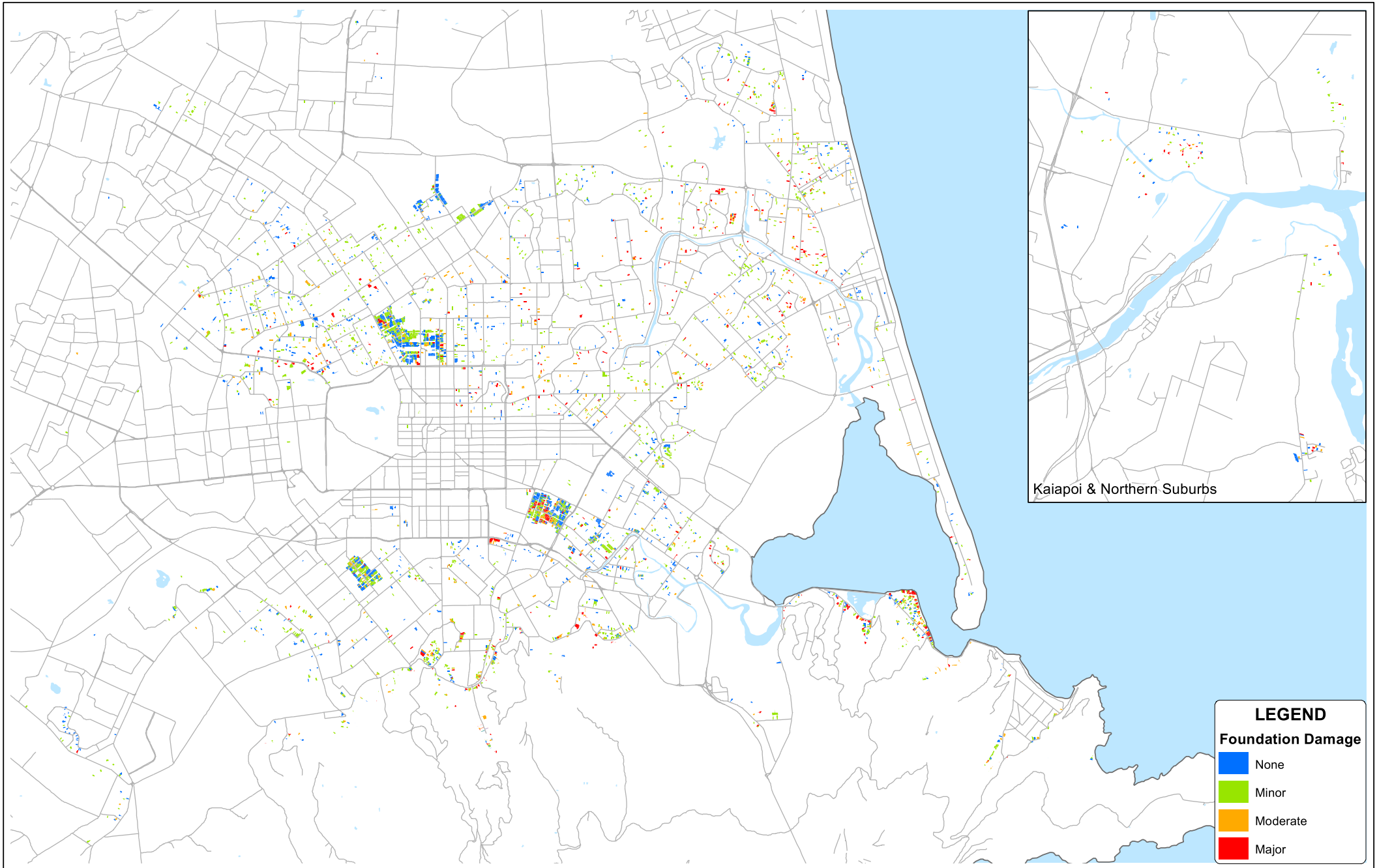
CHRISTCHURCH CITY & KAIAPOI

Observed Foundation Damage Based on Inspections Undertaken Between June 2011 and Dec 2011

FIGURE No. Figure A12

Rev. 0

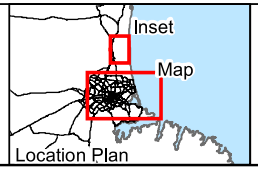
Date: 25/02/2013 Time: 12:47:50 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	JSD	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-BDF05	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION

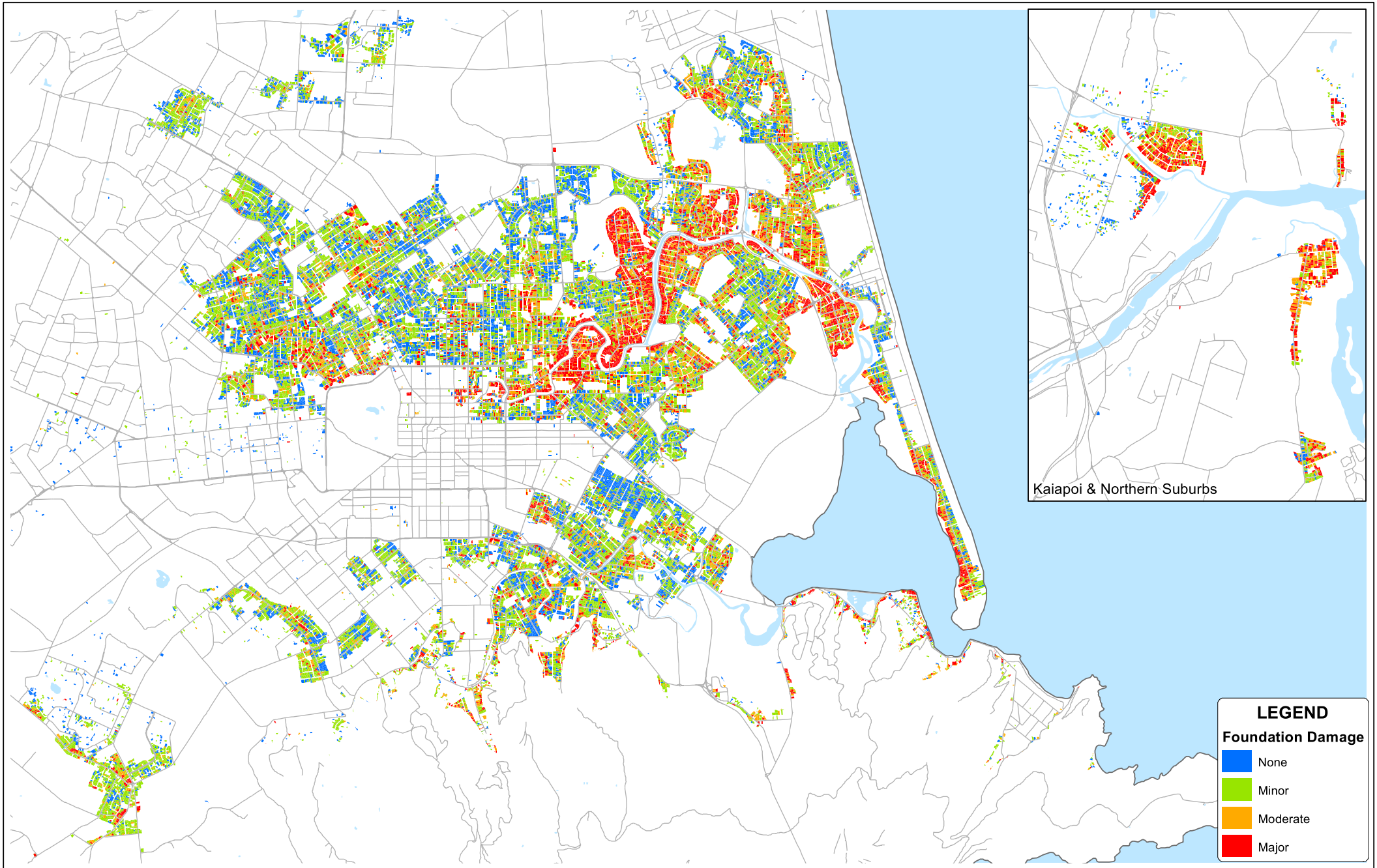
CHRISTCHURCH CITY & KAIAPOI

Observed Foundation Damage Based on Inspections Undertaken Between Dec 2011 to Present

FIGURE No. Figure A13

Rev. 0

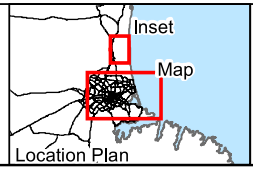
Date: 22/02/2013 Time: 12:14:28 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC
EARTHQUAKE COMMISSION
Kōmihana Rūwhenua

DRAWN	JSD	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-BDF04	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION

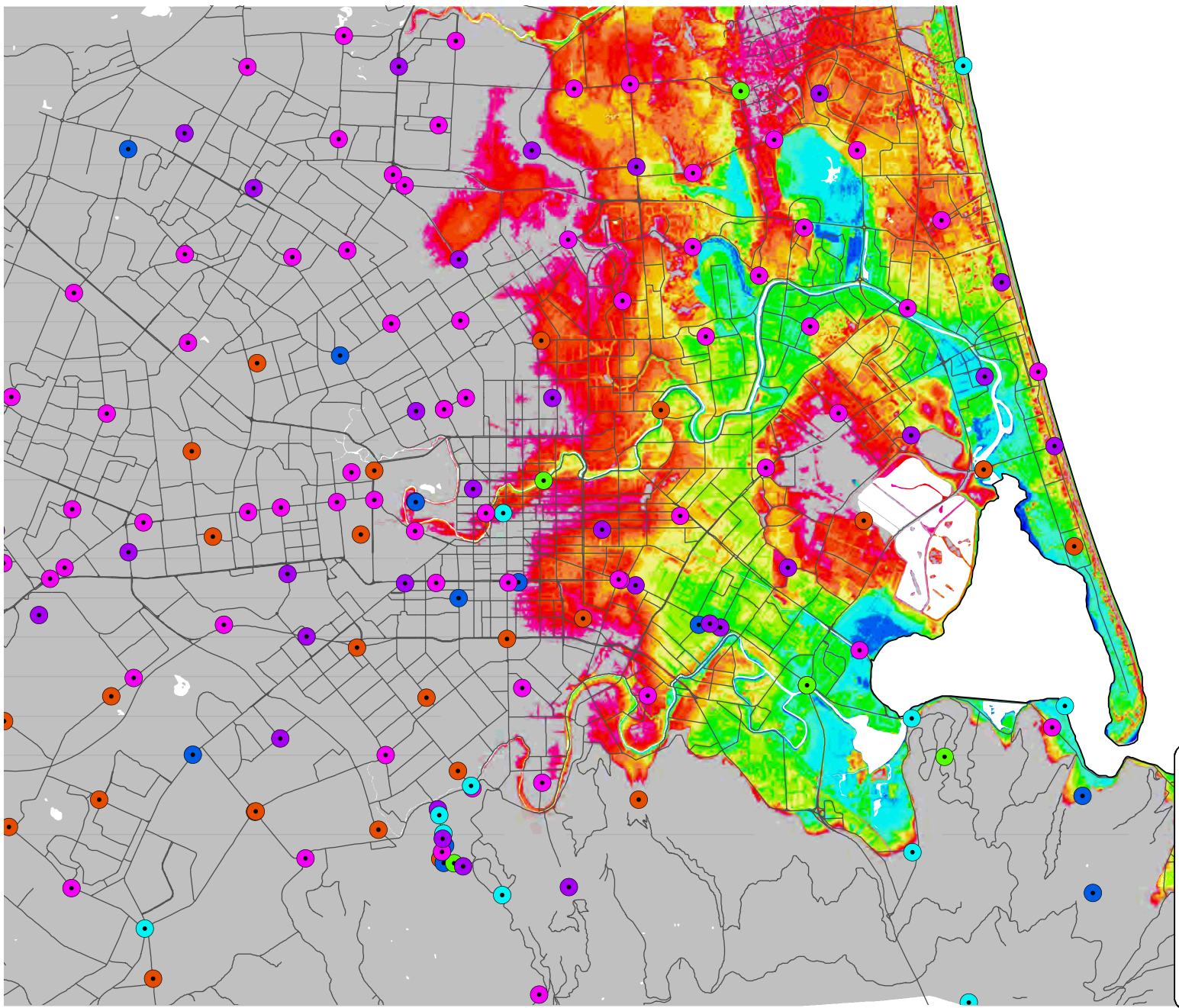
CHRISTCHURCH CITY & KAIAPOI

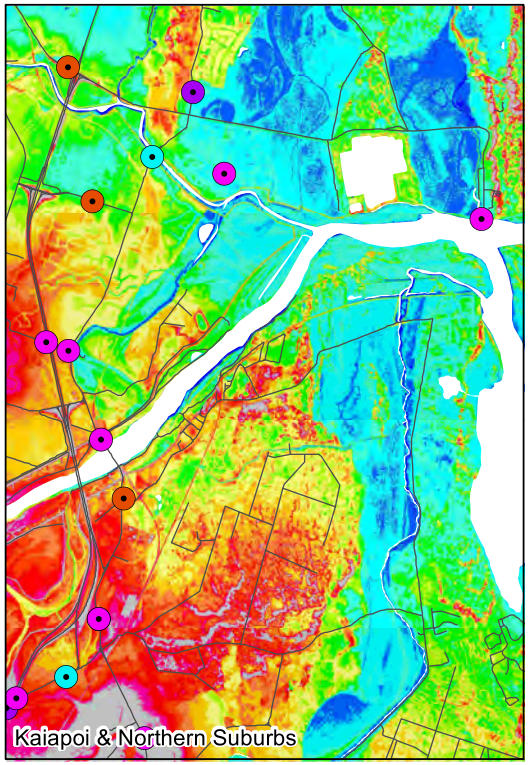
Observed Foundation Damage (Worst Recorded Damage Between September 2010 to Present)

FIGURE No. Figure A14

Rev. 0

Date: 27/02/2013 Time: 5:12:02 p.m.





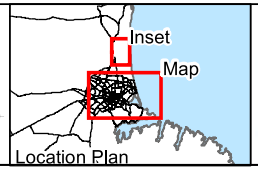
LEGEND

Offset	Elevation (m)		
LIDAR > 0.2 m LOWER	0 - 0.5	3.5 - 4.0	
LIDAR 0.1 - 0.2 m LOWER	0.5 - 1.0	4.0 - 4.5	
LIDAR 0.0 - 0.1 m LOWER	1.0 - 1.5	4.5 - 5.0	
LIDAR 0.0 - 0.1 m HIGHER	1.5 - 2.0	5.0 - 5.5	
LIDAR 0.1 - 0.2 m HIGHER	2.0 - 2.5	5.5 - 6.0	
LIDAR > 0.2 m HIGHER	2.5 - 3.0	>6.0	
	3.0 - 3.5		

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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

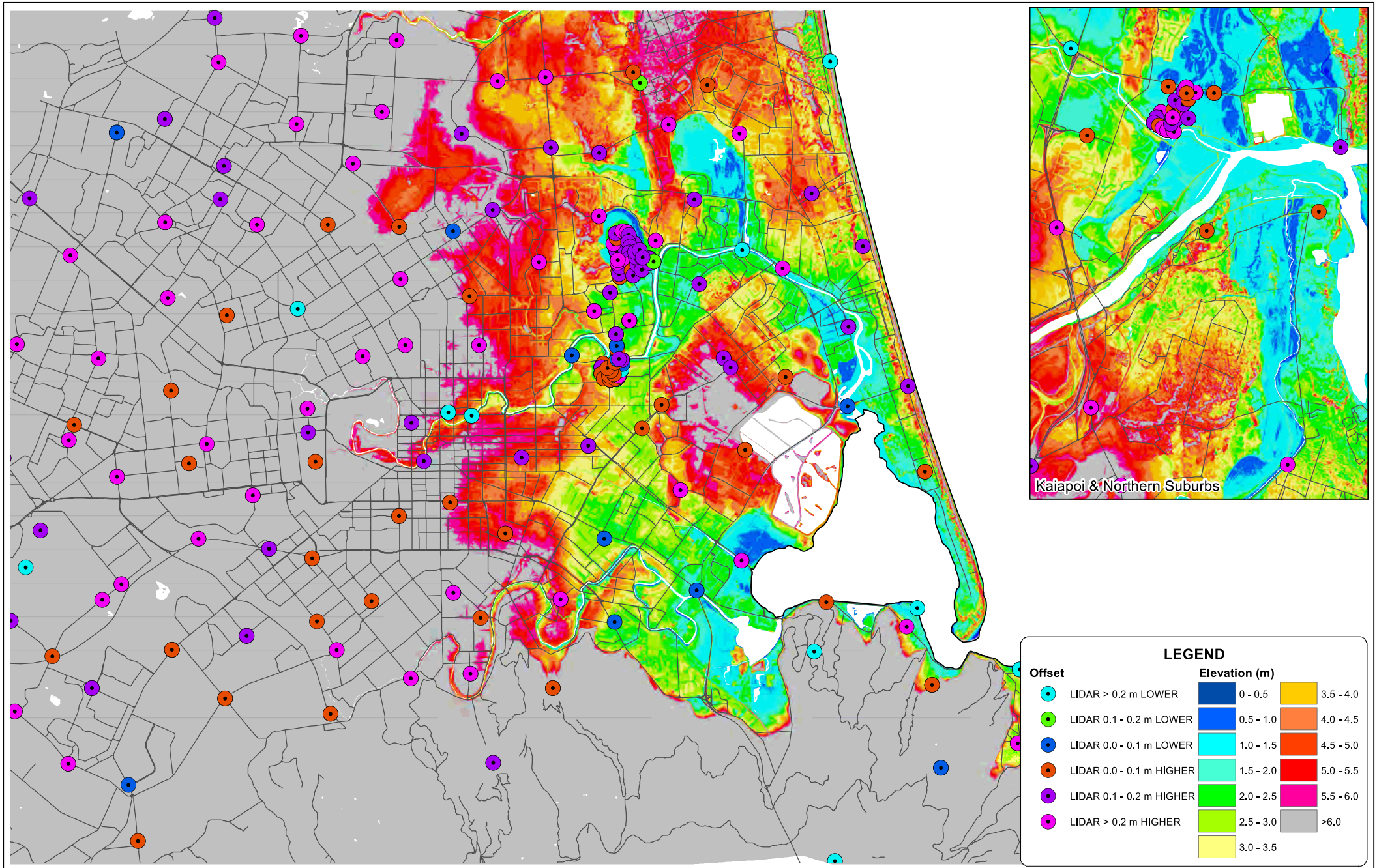
DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LSE02	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
LiDAR Elevation and Verification (Pre September 2010)

FIGURE No. Figure A15

Rev. 0

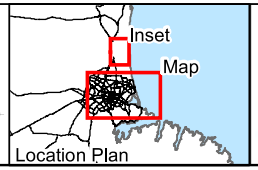
Path: T:\Christchurch\EQC\Cad\52000\WorkingMaterials\GIS\MapDocuments\LIDAR\52020-0200-LSE02.mxd Date: 22/02/2013 Time: 12:27:34 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

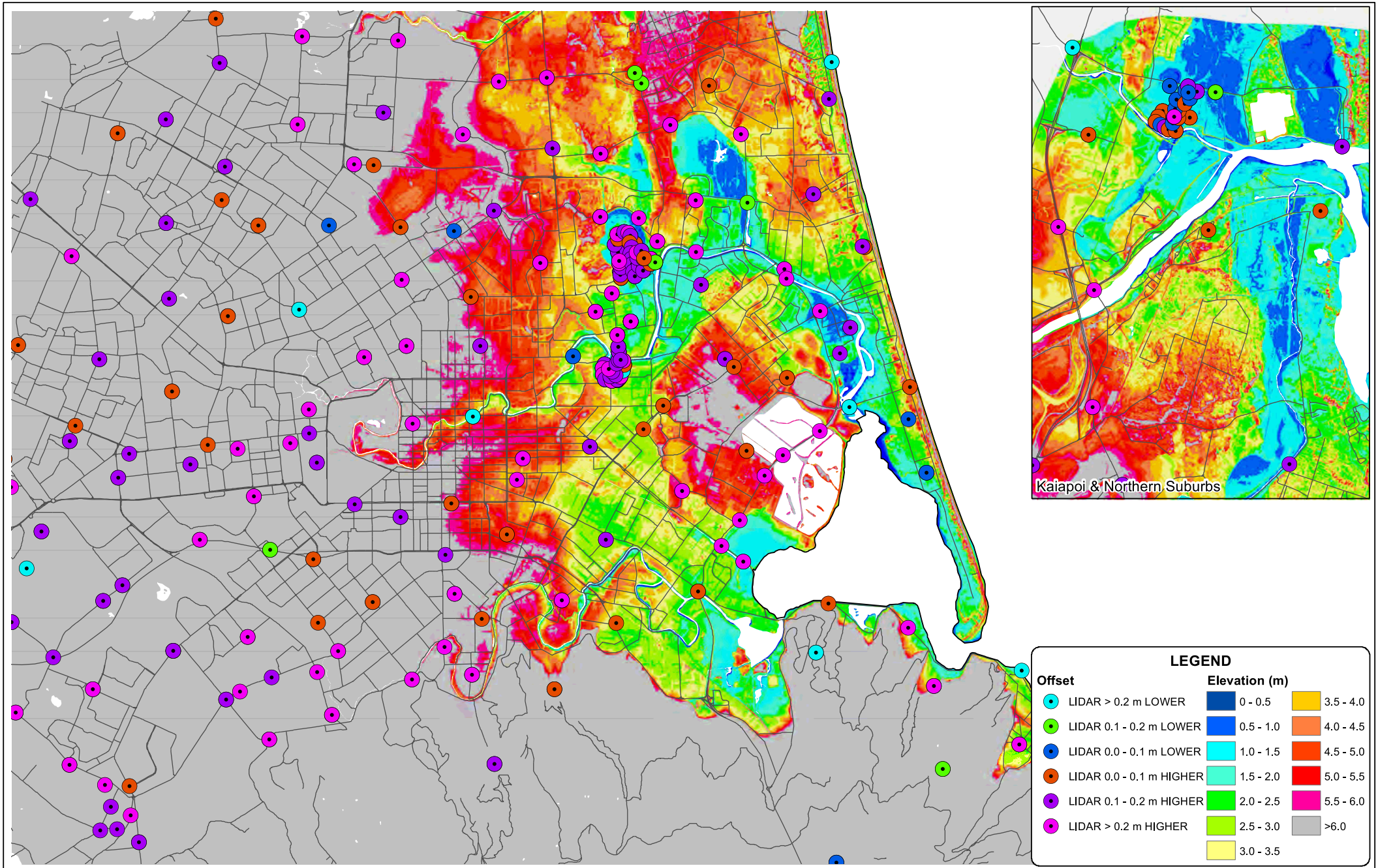
DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LSE03	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
LiDAR Elevation and Verification (Post September 2010)

FIGURE No. Figure A16

Rev. 0

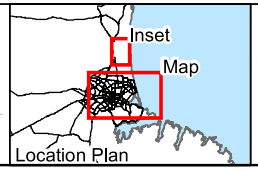
Path: T:\Christchurch\EQC\Cad\52000\WorkingMaterials\GIS\MapDocuments\LIDAR\52020-0200-LSE03.mxd Date: 22/02/2013 Time: 12:31:21 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



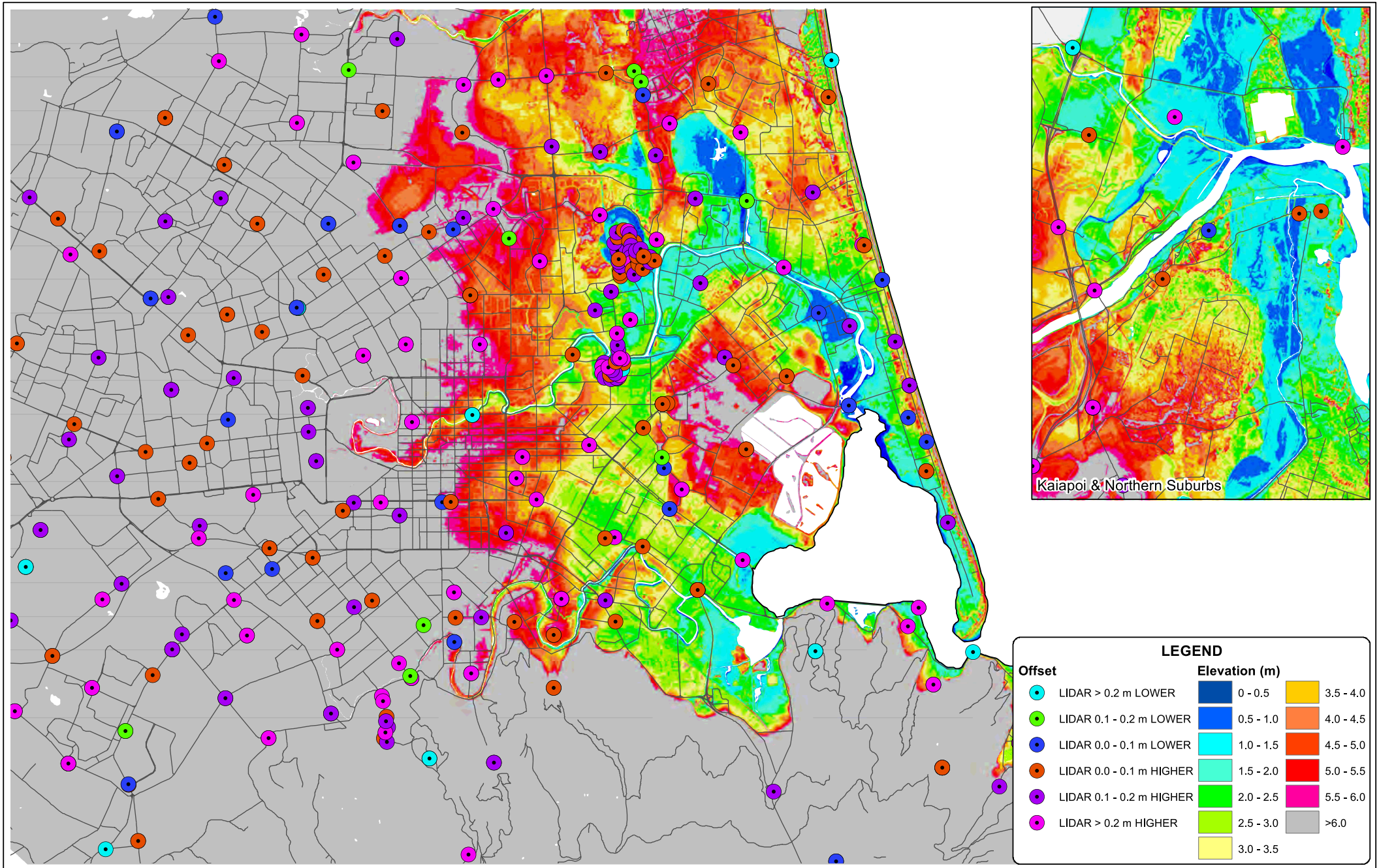
EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LSE04	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
LiDAR Elevation and Verification (Post February 2011)

FIGURE No. Figure A17 | Rev. 0

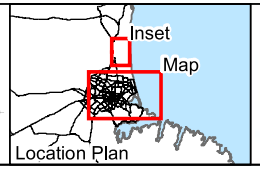
Path: T:\Christchurch\EQC\Cad\52000\WorkingMaterials\GIS\MapDocuments\LiDAR\52020-0200-LSE04.mxd Date: 22/02/2013 Time: 12:27:42 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



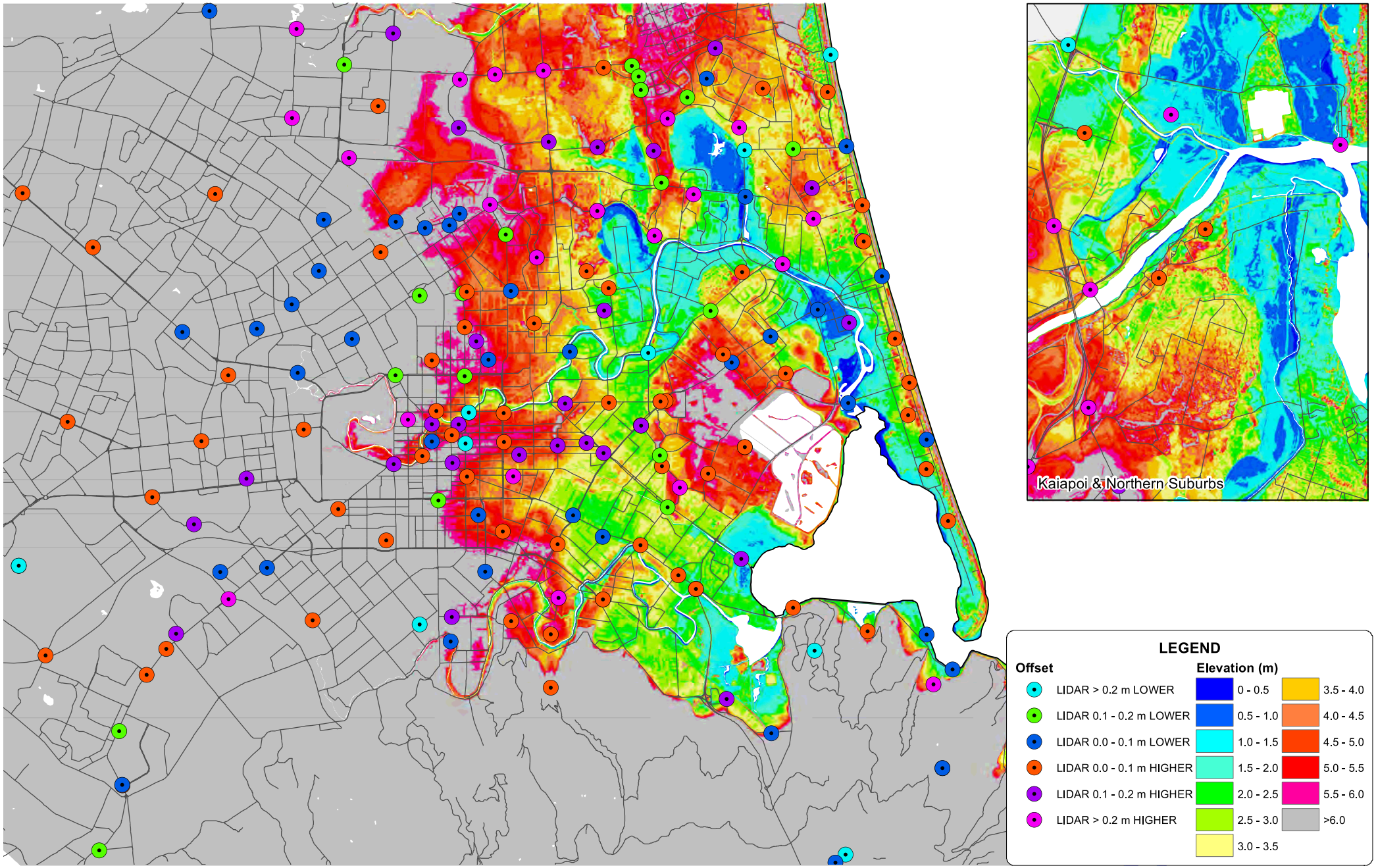
EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LSE05	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
LiDAR Elevation and Verification (Post June 2011)

FIGURE No. Figure A18 Rev. 0

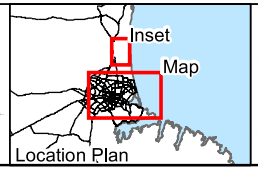
Path: T:\Christchurch\EQC\Cad\52000\WorkingMaterials\GIS\MapDocuments\LIDAR\52020-0200-LSE05.mxd Date: 22/02/2013 Time: 12:27:37 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



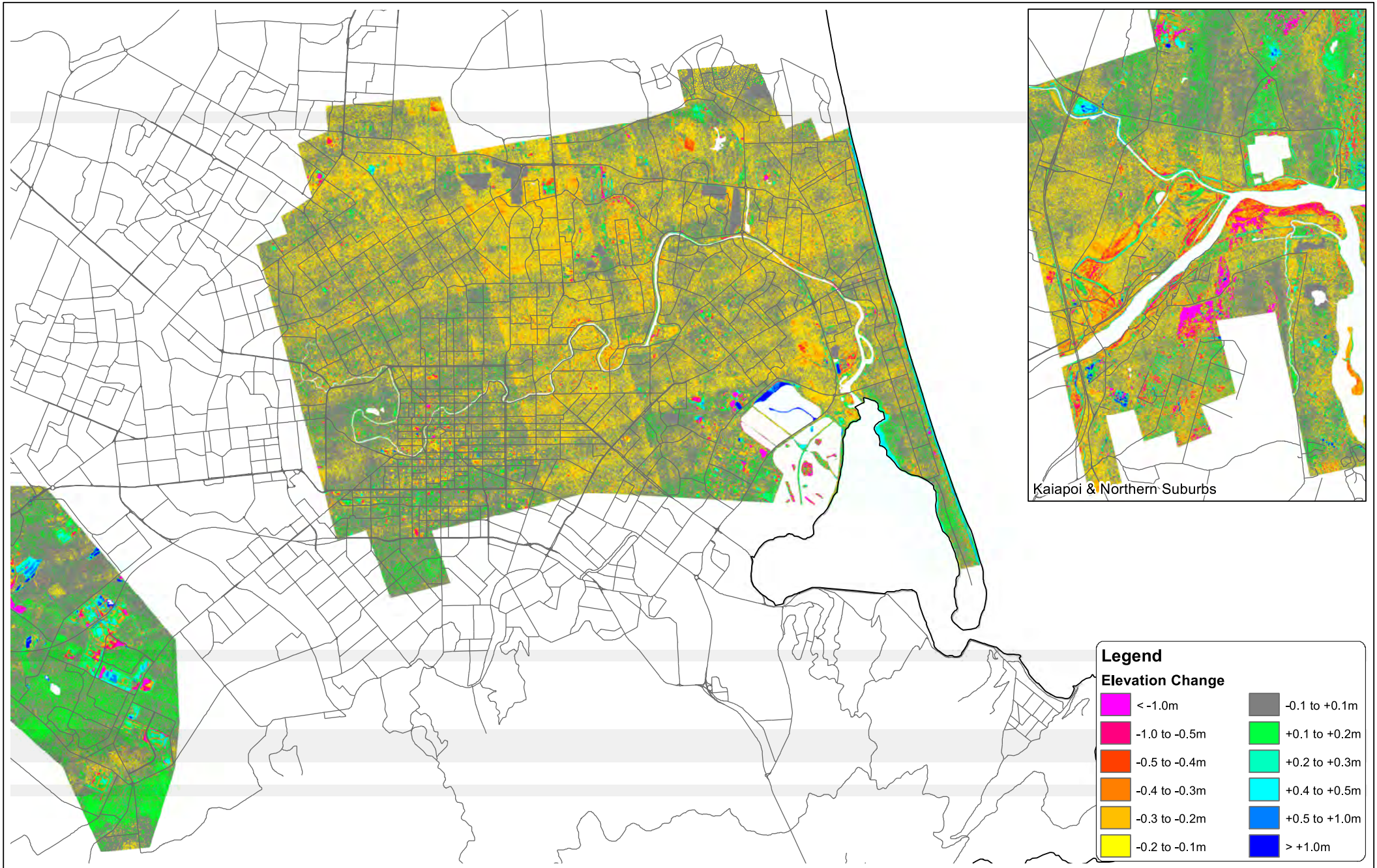
EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LSE15	
SCALE (AT A3 SIZE)	1:60,000	
Prepared by Tonkin & Taylor Ltd. Ref:	52020.0200	

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
LiDAR Elevation and Verification (Post December 2011)

FIGURE No. Figure A19 | Rev. 0

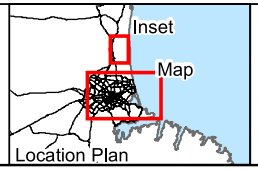
Date: 22/02/2013 Time: 12:40:13 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	JEL	Dec.12
CHECKED		
APPROVED		
ARCFILE	52020-0200-LEC32	
SCALE (AT A3 SIZE)	1:60,000	
Prepared By Tonkin & Taylor Ltd. Ref.	52020-0200	

EARTHQUAKE COMMISSION

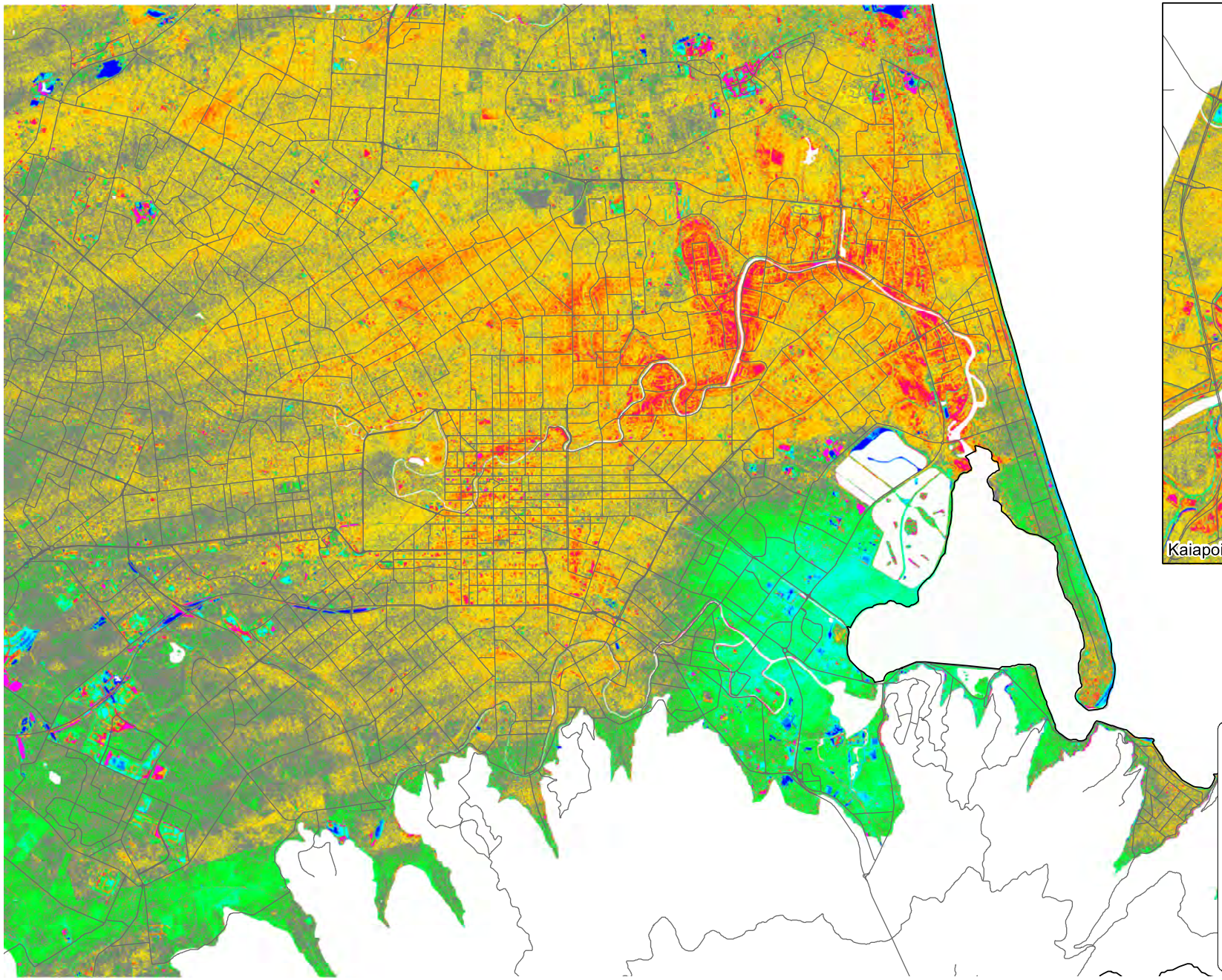
CHRISTCHURCH CITY & KAIAPOI

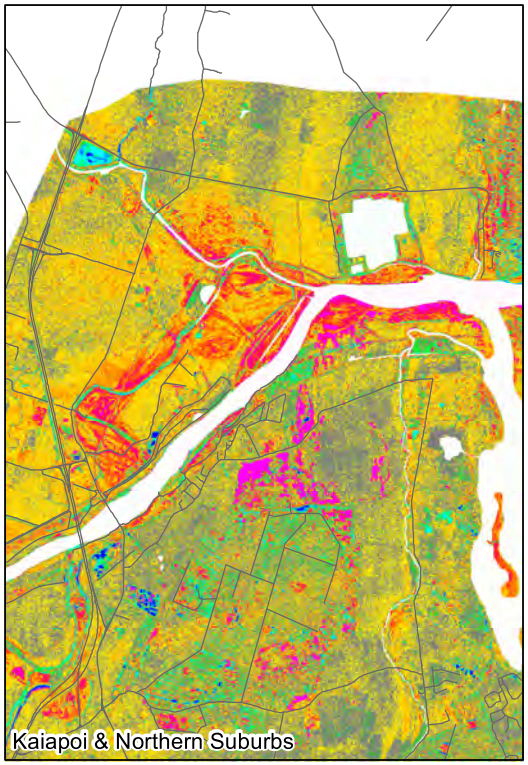
Earthquake Related Elevation Change

(Pre September 2010 to Post September 2010)

FIGURE No. Figure A20 | Rev. 0

Date: 4/12/2012 Time: 2:01:23 p.m.





Legend

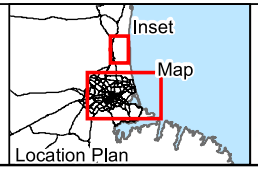
Elevation Difference

-1.5m to -1.0m	-0.1 to +0.1m
-1.0 to -0.5m	+0.1 to +0.2m
-0.5 to -0.4m	+0.2 to +0.3m
-0.4 to -0.3m	+0.4 to +0.5m
-0.3 to -0.2m	+0.5 to +1.0m
-0.2 to -0.1m	> +1.0m

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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	JEL	Dec.12
CHECKED		
APPROVED		
ARCFILE	52020-0200-LEC33	
SCALE (AT A3 SIZE)	1:60,000	
Prepared By Tonkin & Taylor Ltd. Ref.	52020-0200	

EARTHQUAKE COMMISSION

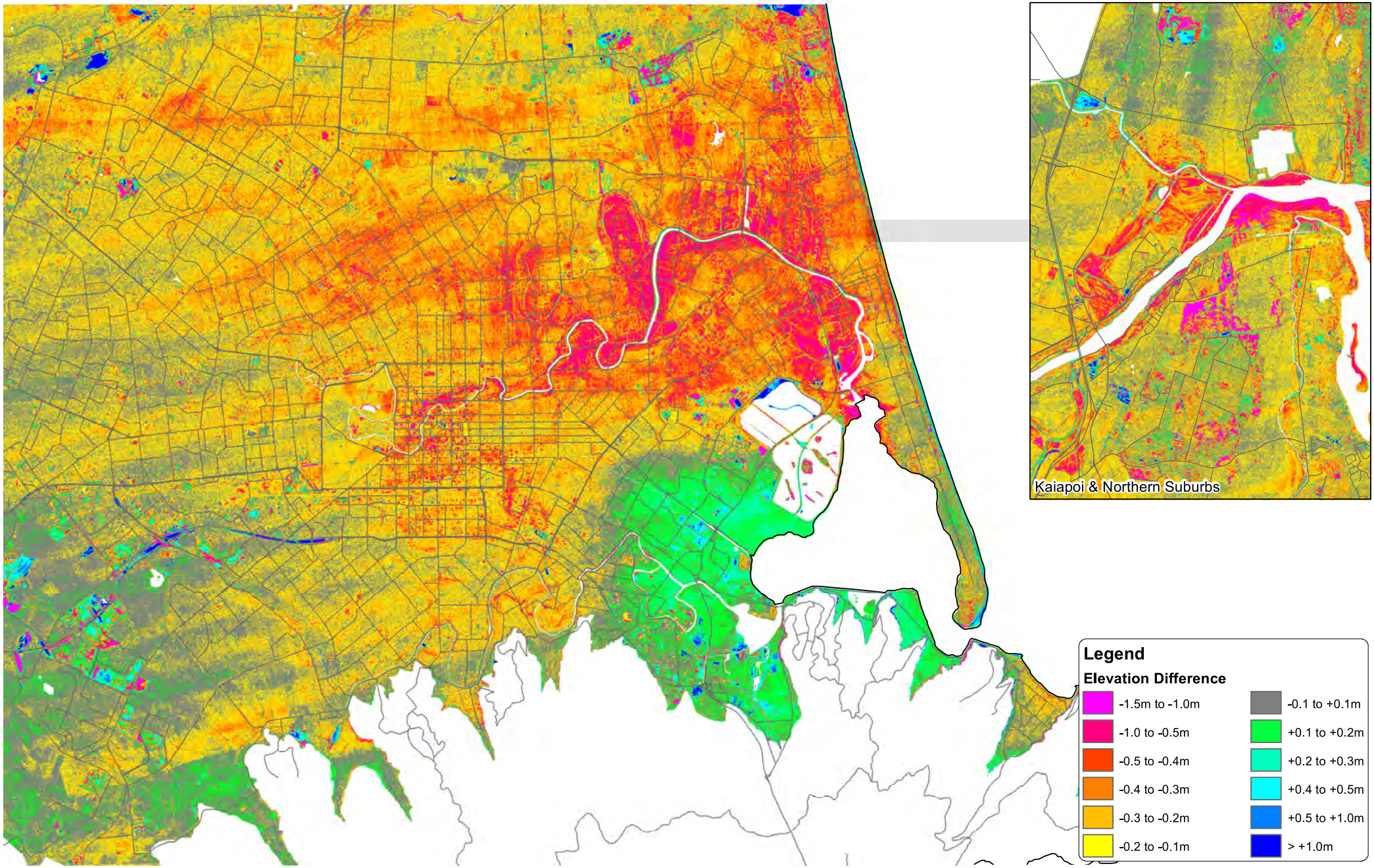
CHRISTCHURCH CITY & KAIAPOI

Earthquake Related Elevation Change

(Pre September 2010 to Post February 2011)

FIGURE No. Figure A21 Rev. 0

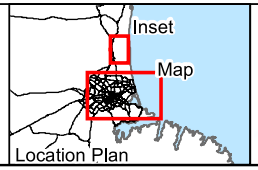
Date: 4/12/2012 Time: 2:11:21 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC
EARTHQUAKE COMMISSION
Kōmihana Rūwhenua

DRAWN	JEL	Dec.12
CHECKED		
APPROVED		
ARCFILE	52020-0200-LEC34	
SCALE (AT A3 SIZE)	1:60,000	
Prepared By Tonkin & Taylor Ltd. Ref.	52020-0200	

EARTHQUAKE COMMISSION

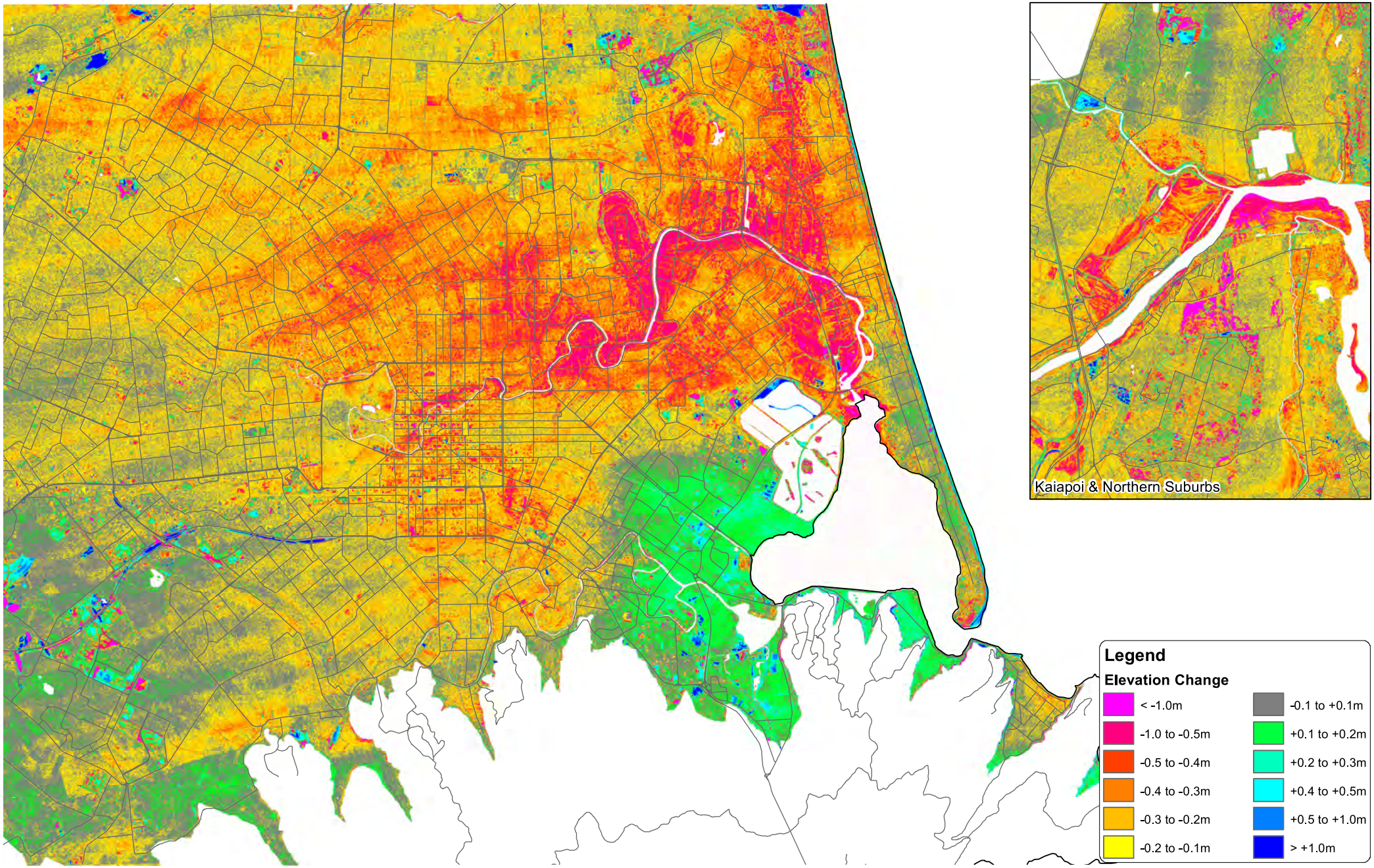
CHRISTCHURCH CITY & KAIAPOI

Earthquake Related Elevation Change
(Pre September 2010 to Post June 2011)

FIGURE No. Figure A22

Rev. 0

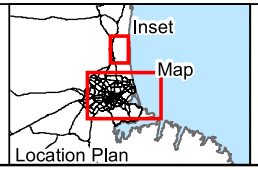
Date: 4/12/2012 Time: 2:11:24 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	JEL	Dec.12
CHECKED		
APPROVED		
ARCFILE	52020-0200-LEC35	
SCALE (AT A3 SIZE)	1:60,000	
Prepared By Tonkin & Taylor Ltd. Ref.	52020.0200	

EARTHQUAKE COMMISSION

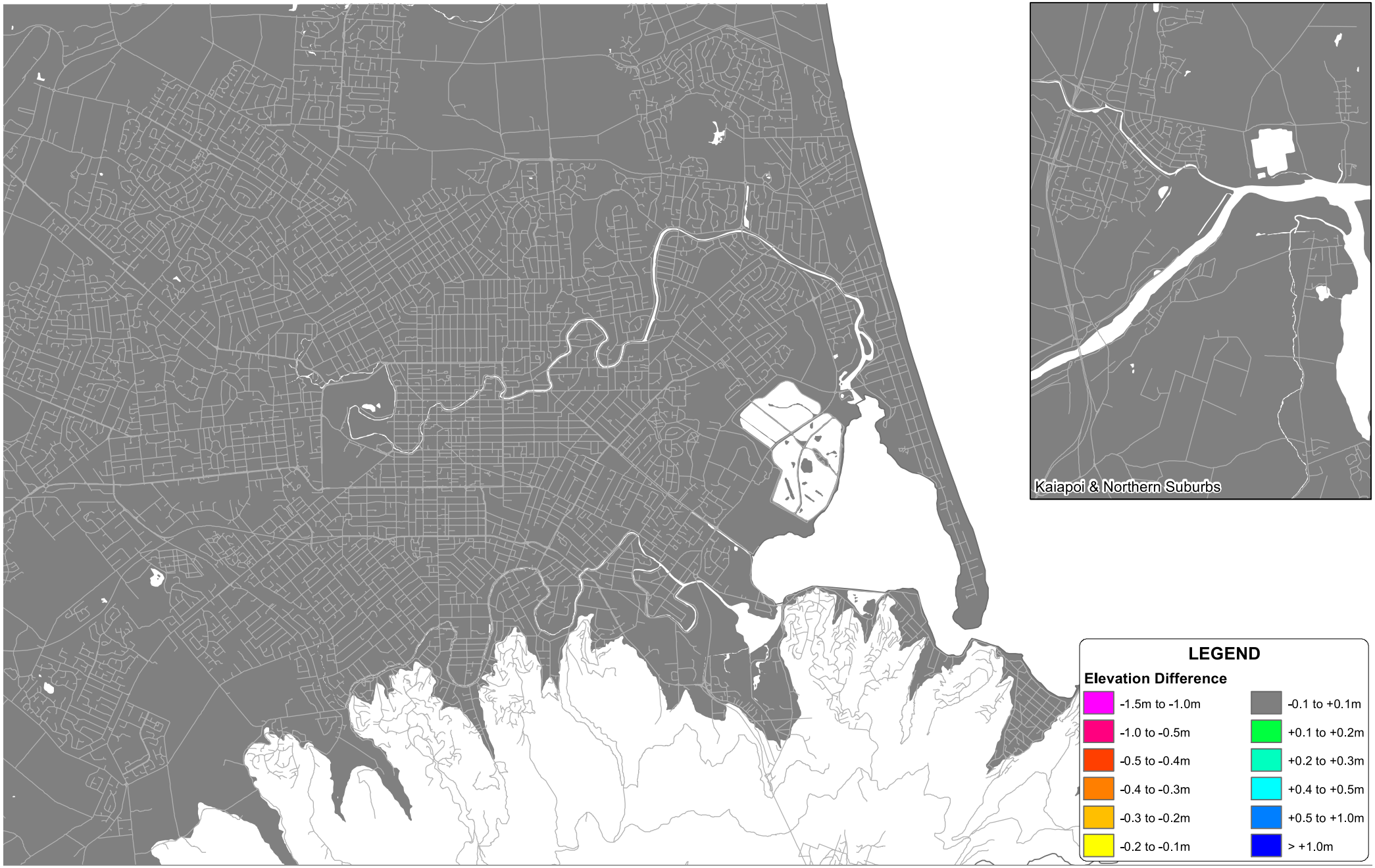
CHRISTCHURCH CITY & KAIAPOI

Earthquake Related Elevation Change

(Pre September 2010 to Post June/December 2011)

FIGURE No. Figure A23 Rev. 0

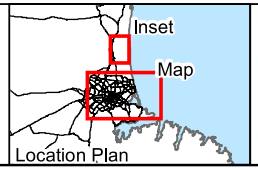
Date: 4/12/2012 Time: 2:00:17 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LEC04	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION

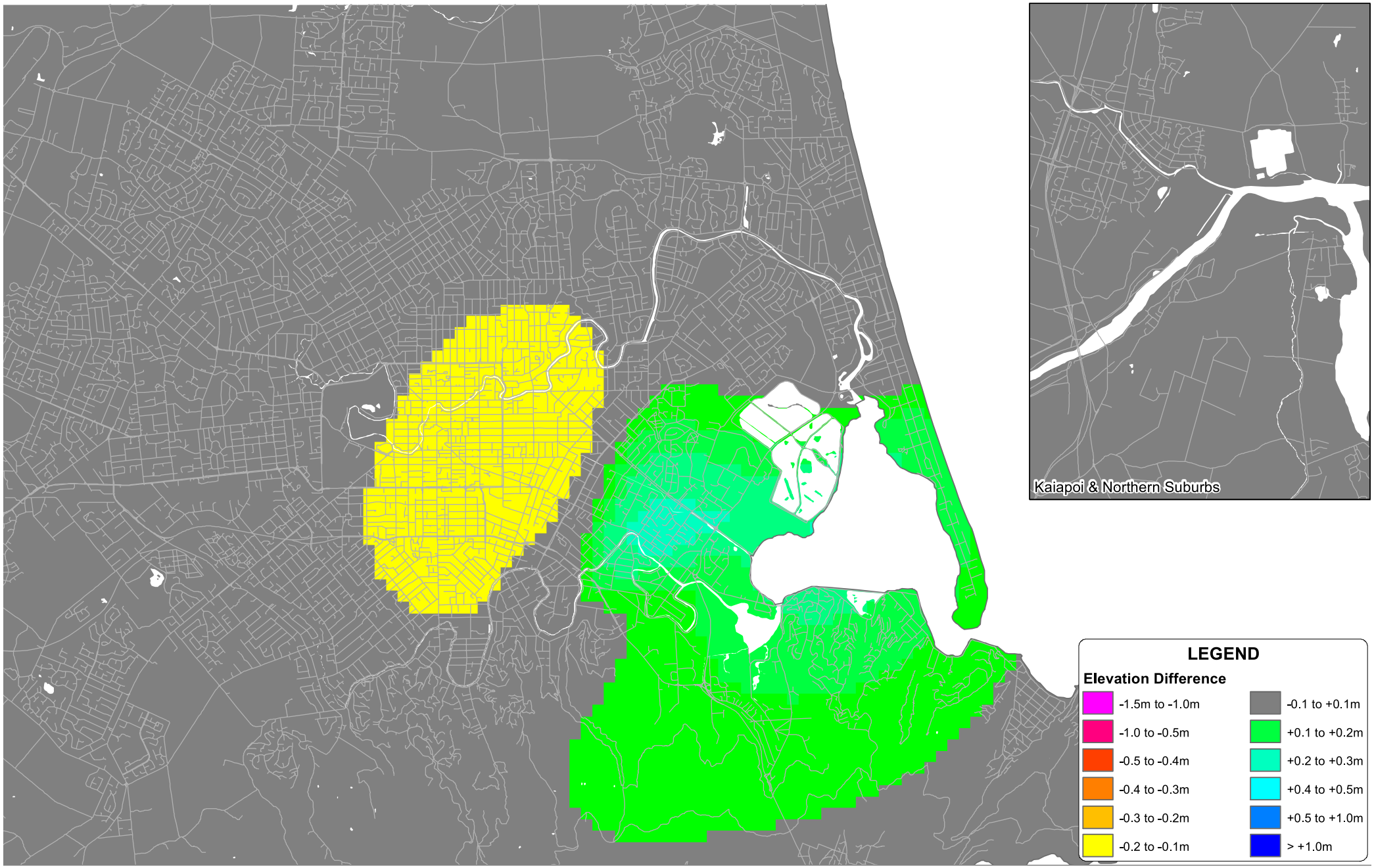
CHRISTCHURCH CITY

Tectonic Related Elevation Change
(Pre September 2010 to Post September 2010)

FIGURE No. Figure A24

Rev. 0

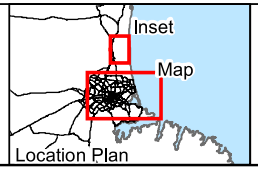
Path: T:\Christchurch\EQC\Cad\52000\WorkingMaterials\GIS\MapDocuments\LiDAR Elevation Change\52020-0200-LEC04.mxd Date: 22/02/2013 Time: 1:11:35 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LEC05	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION

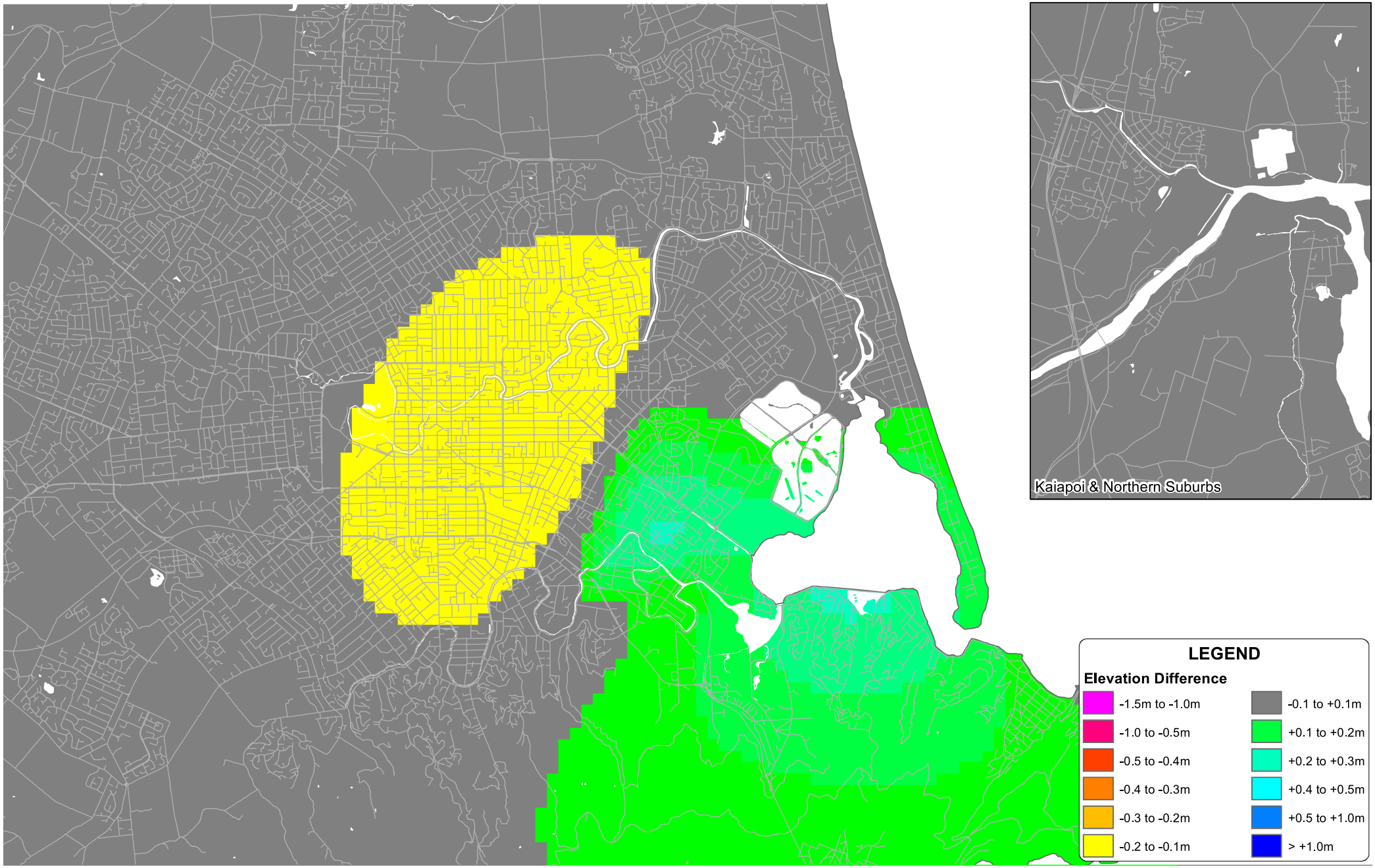
CHRISTCHURCH CITY

Tectonic Related Elevation Change
(Pre September 2010 to Post February 2011)

FIGURE No. Figure A25

Rev. 0

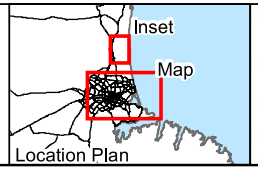
Path: T:\Christchurch\EQC\Cad\52000\WorkingMaterials\GIS\MapDocuments\LiDAR Elevation Change\52020-0200-LEC05.mxd Date: 22/02/2013 Time: 1:05:52 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LEC06	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52020.0200	

EARTHQUAKE COMMISSION

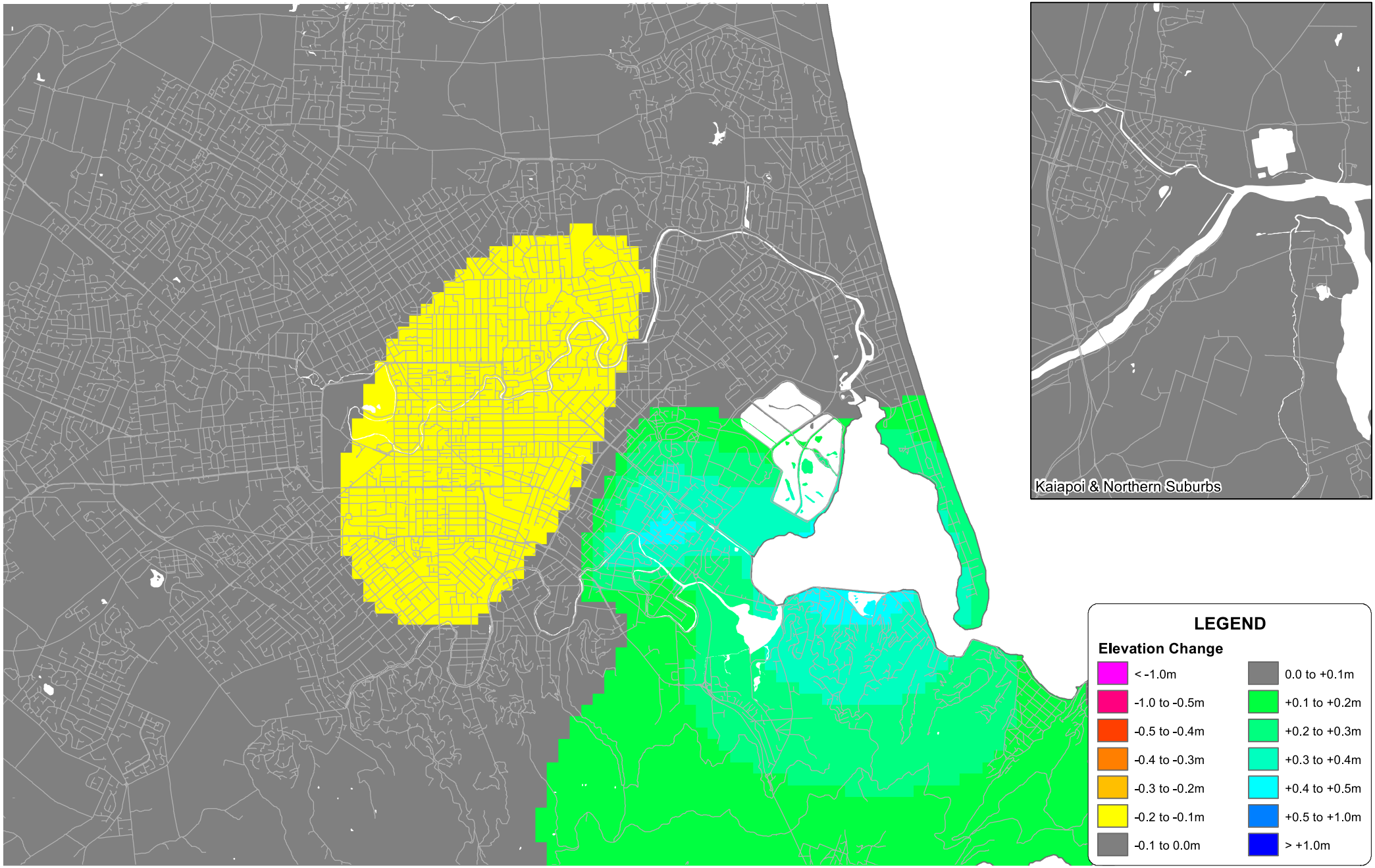
CHRISTCHURCH CITY

Tectonic Related Elevation Change
(Pre September 2010 to Post June 2011)

FIGURE No. Figure A26

Rev. 0

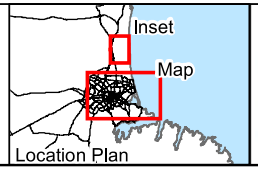
Path: T:\Christchurch\EQC\Cad\52000\WorkingMaterials\GIS\MapDocuments\LiDAR Elevation Change\52020-0200-LEC06.mxd Date: 25/02/2013 Time: 1:09:48 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)

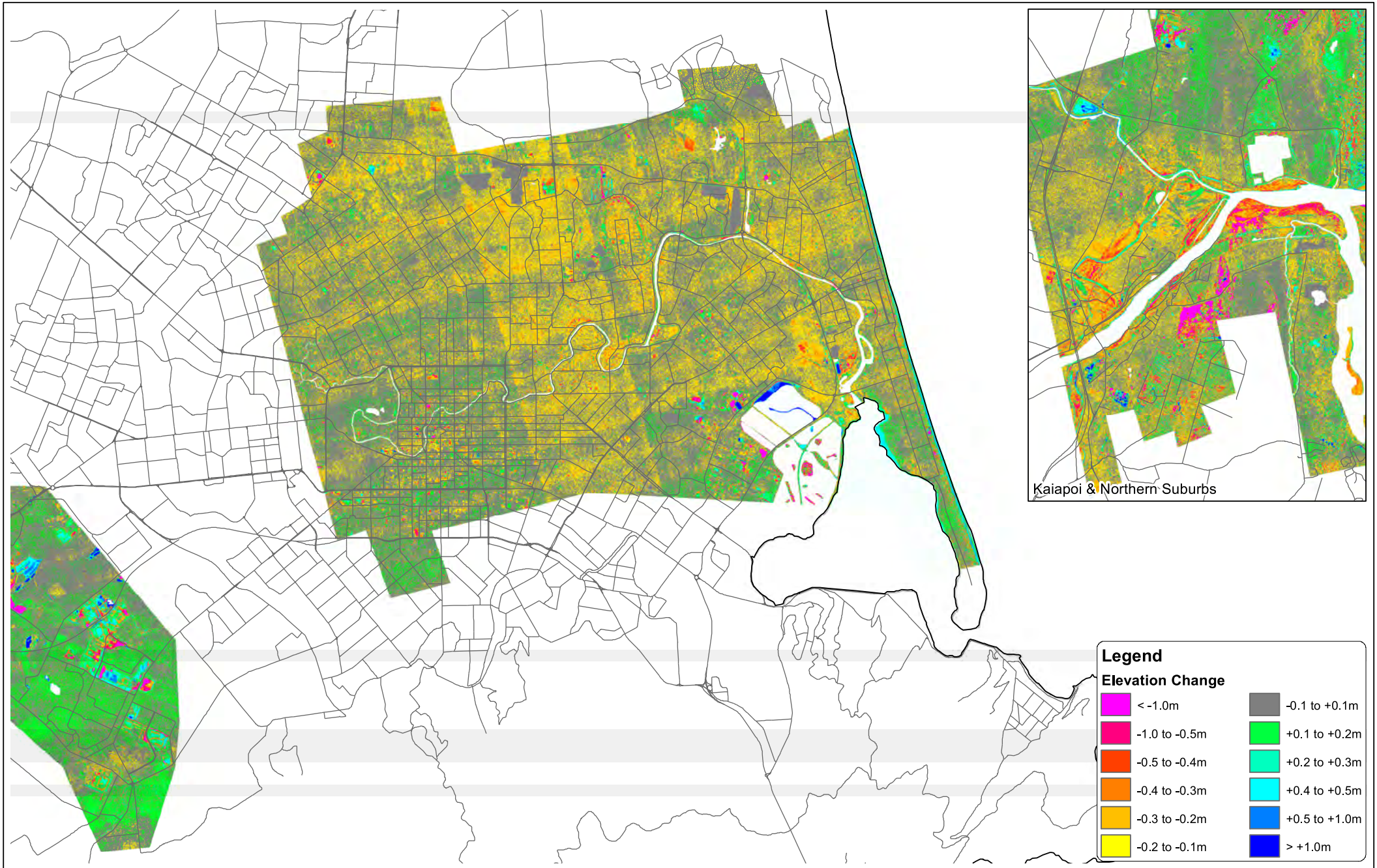


EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Feb.13	
CHECKED			
APPROVED			
ARCFILE	52020-0200-LEC29		
SCALE (AT A3 SIZE)	1:60,000		
PROJECT No.	52020.0200	FIGURE No.	Figure A27
		Rev.	0

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY
Tectonic Related Elevation Change
(Pre September 2010 to Post December 2011)

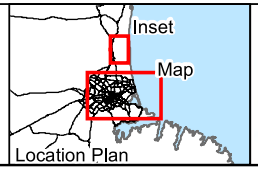
Path: T:\Christchurch\EQC\Cad\52000\WorkingMaterials\GIS\MapDocuments\LiDAR Elevation Change\52020-0200-LEC29.mxd Date: 22/02/2013 Time: 1:07:07 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	JEL	Dec.12
CHECKED		
APPROVED		
ARCFILE	52020-0200-LEC36	
SCALE (AT A3 SIZE)	1:60,000	
Prepared By Tonkin & Taylor Ltd. Ref.	52020-0200	

EARTHQUAKE COMMISSION

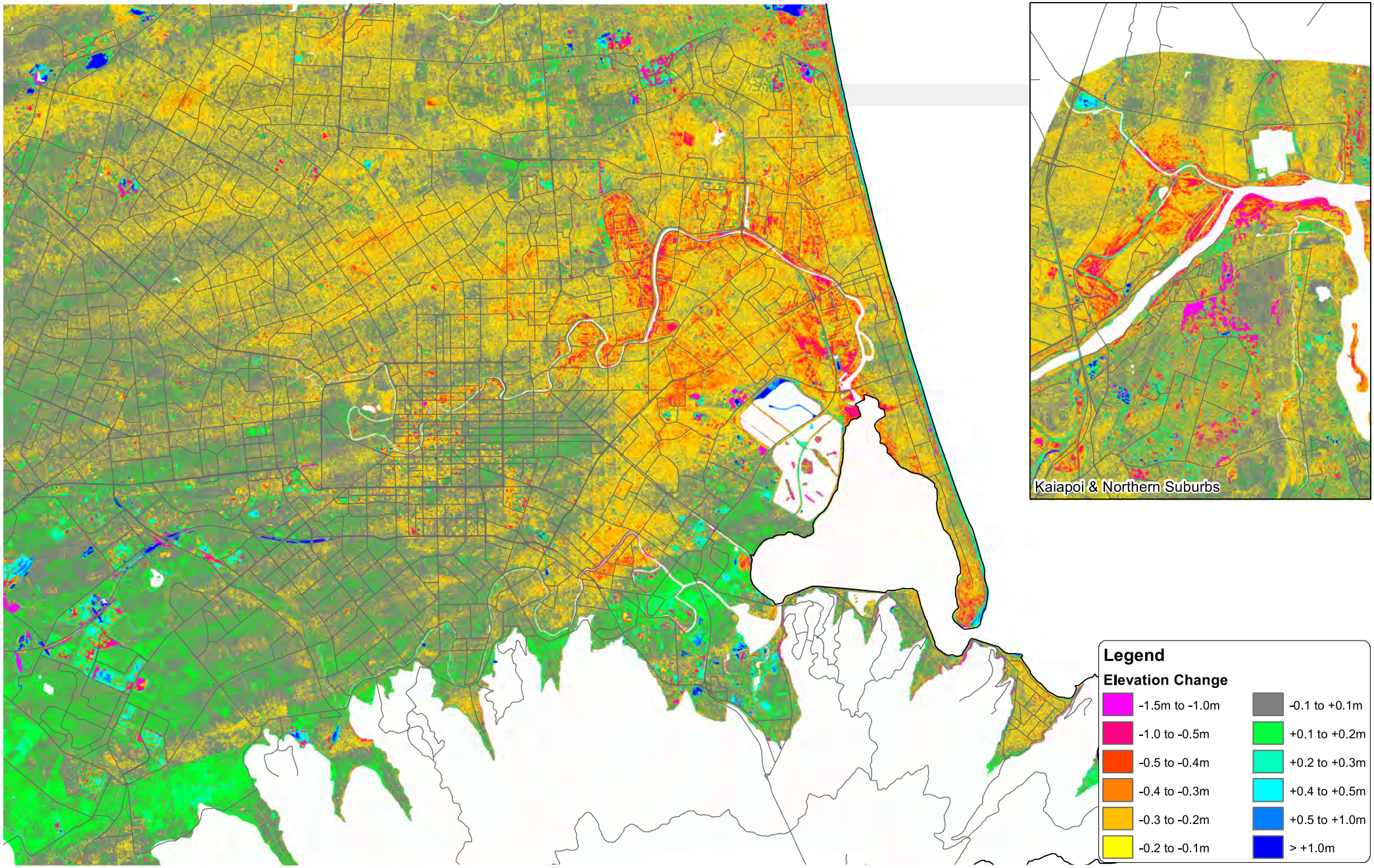
CHRISTCHURCH CITY & KAIAPOI

Liquefaction Related Elevation Change

(Pre September 2010 to Post September 2010)

FIGURE No. Figure A28 Rev. 0

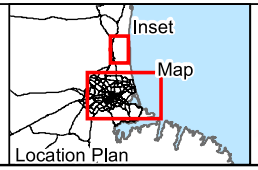
Date: 4/12/2012 Time: 2:36:06 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	JEL	Dec.12
CHECKED		
APPROVED		
ARCFILE	52020-0200-LEC37	
SCALE (AT A3 SIZE)	1:60,000	
Prepared By Tonkin & Taylor Ltd. Ref.	52020-0200	

EARTHQUAKE COMMISSION

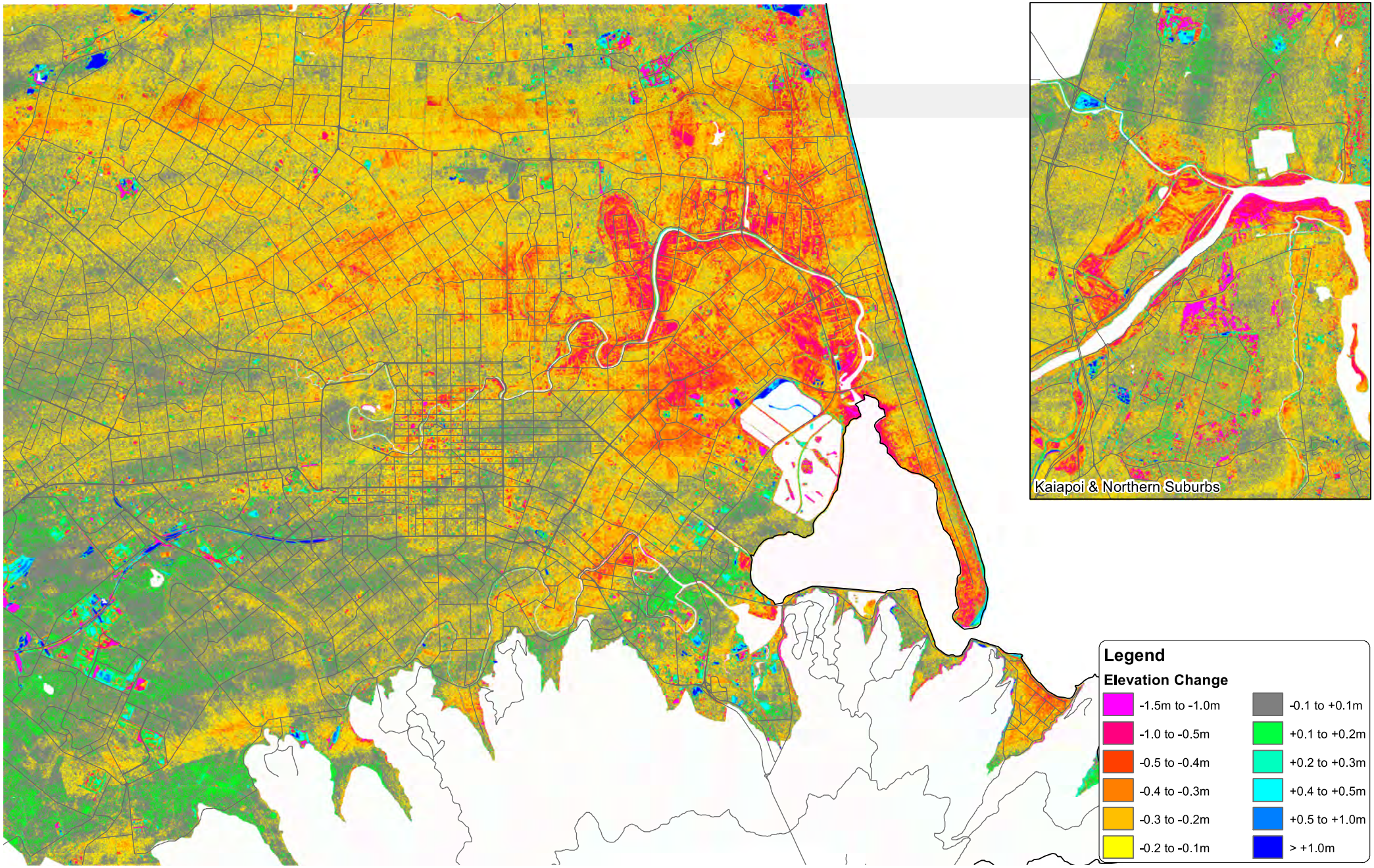
CHRISTCHURCH CITY & KAIAPOI

Liquefaction Related Elevation Change

(Pre September 2010 to Post February 2011)

FIGURE No. Figure A29 Rev. 0

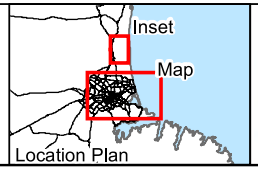
Date: 4/12/2012 Time: 2:43:40 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	JEL	Dec.12
CHECKED		
APPROVED		
ARCFILE	52020-0200-LEC38	
SCALE (AT A3 SIZE)	1:60,000	
Prepared By Tonkin & Taylor Ltd. Ref.	52020.0200	

EARTHQUAKE COMMISSION

CHRISTCHURCH CITY & KAIAPOI

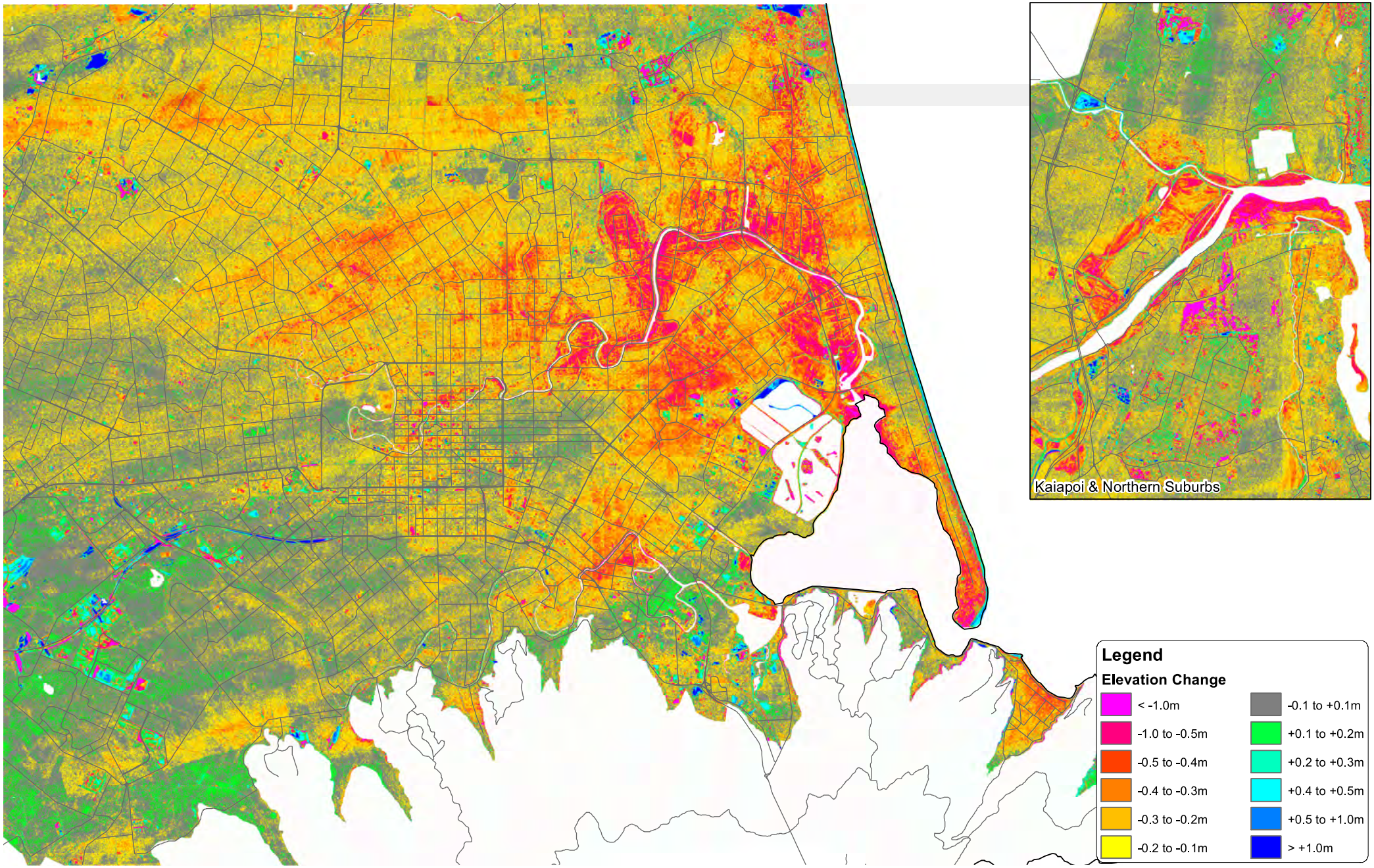
Liquefaction Related Elevation Change

(Pre September 2010 to Post June 2011)

FIGURE No. Figure A30

Rev. 0

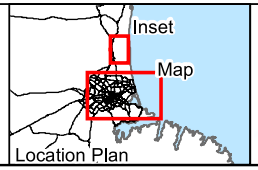
Date: 4/12/2012 Time: 3:09:47 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC
EARTHQUAKE COMMISSION
Kōmihana Rūwhenua

DRAWN	CXP	Dec.12
CHECKED		
APPROVED		
ARCFILE	52020-0200-LEC39	
SCALE (AT A3 SIZE)	1:60,000	
Prepared By Tonkin & Taylor Ltd. Ref.	52020.0200	

EARTHQUAKE COMMISSION

CHRISTCHURCH CITY & KAIAPOI

Liquefaction Related Elevation Change
(Pre September 2010 to Post June/December 2011)

FIGURE No. Figure A31 | Rev. 0

Date: 4/12/2012 Time: 3:11:50 p.m.



Notes: Aerial Imagery Supplied by New Zealand Aerial Mapping ltd.

A3 SCALE 1:7,500

0 0.1 0.2 0.3 0.4 0.5 (km)

Vector Movement Scale at 1:7,500

0.5m
1.0m
2.0m

EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LCV13	
SCALE (AT A3 SIZE)	1:7,500	
Prepared By Tonkin & Taylor Ltd Ref:	52020.0200	

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
Horizontal Movement Vectors
(Pre September 2010 - Post December 2011)

FIGURE No. Figure A32

Rev. 0

Date: 25/02/2013 Time: 4:10:06 p.m.



Notes: Aerial Imagery Supplied by New Zealand Aerial Mapping ltd.

A3 SCALE 1:7,500

0 0.1 0.2 0.3 0.4 0.5 (km)

Vector Movement Scale at 1:7,500

0.5m
1.0m
2.0m

EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LCV14	
SCALE (AT A3 SIZE)	1:7,500	
Prepared By Tonkin & Taylor Ltd Ref:	52020.0200	

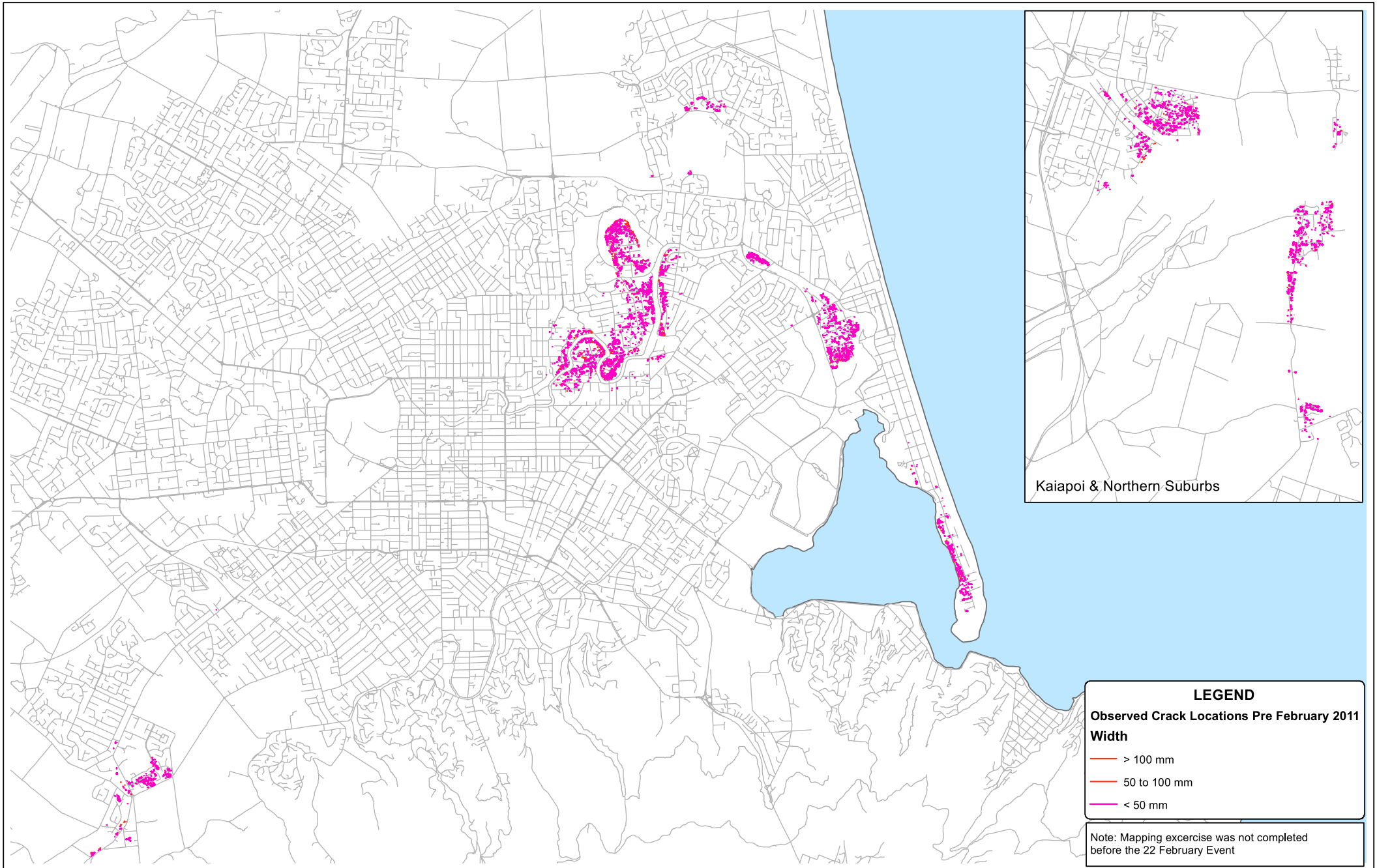
EARTHQUAKE COMMISSION

CHRISTCHURCH CITY & KAIAPOI

Horizontal Movement Vectors and Crack Locations
(Pre September 2010 - Post December 2011)

FIGURE No. Figure A33 | Rev. 0

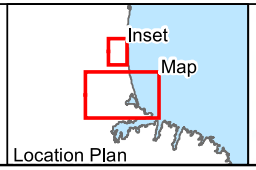
Date: 25/02/2013 Time: 4:10:50 p.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



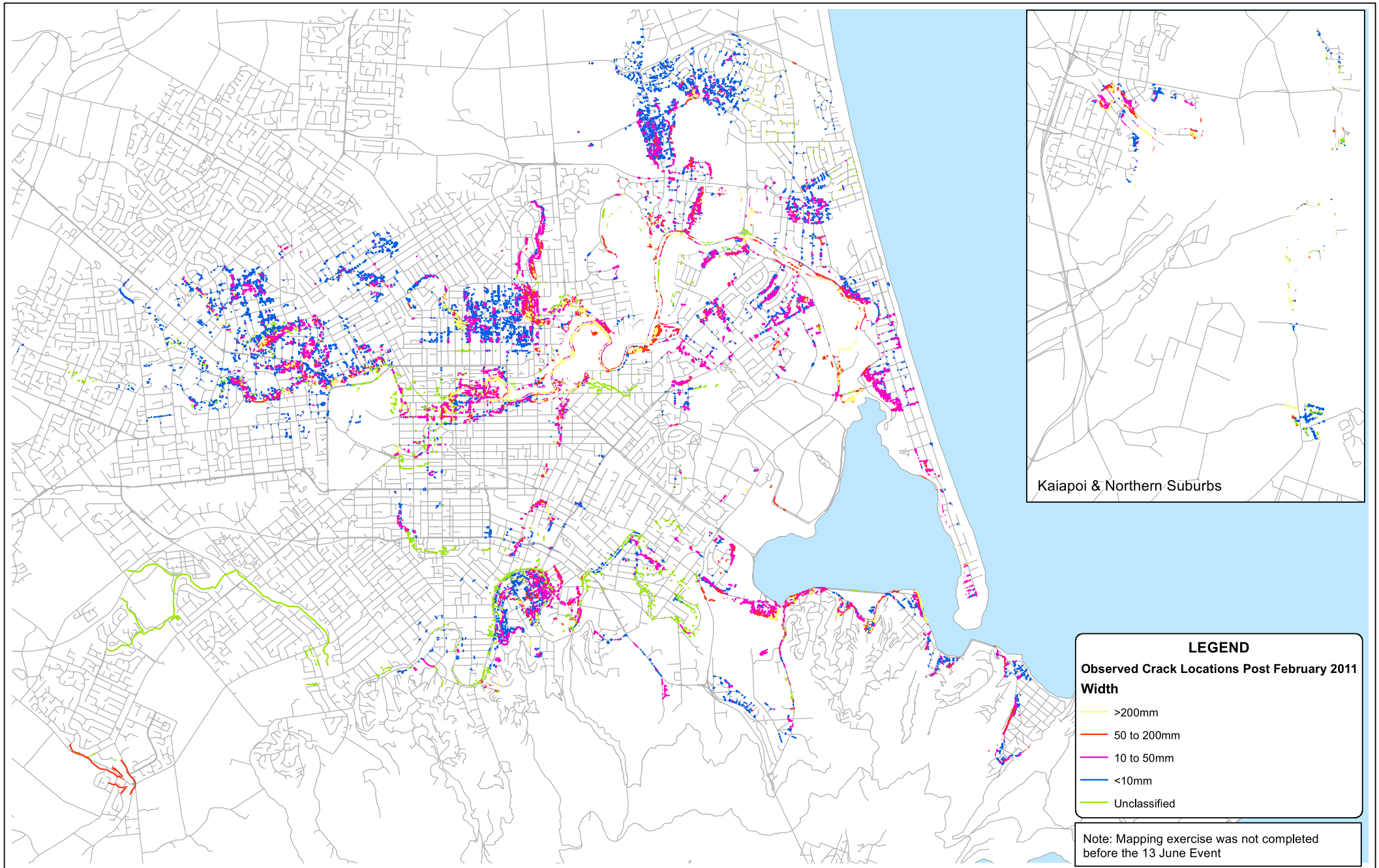
EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	HKB	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020.0200_LSF01	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52000.200	

EARTHQUAKE COMMISSION
DISTRIBUTION OF LAND DAMAGE
Observations of Ground Crack Locations Post September 2010

FIGURE No. Figure A34 Rev. 0

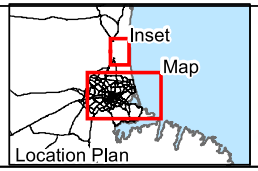
Date: 26/02/2013 Time: 10:46:35 a.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



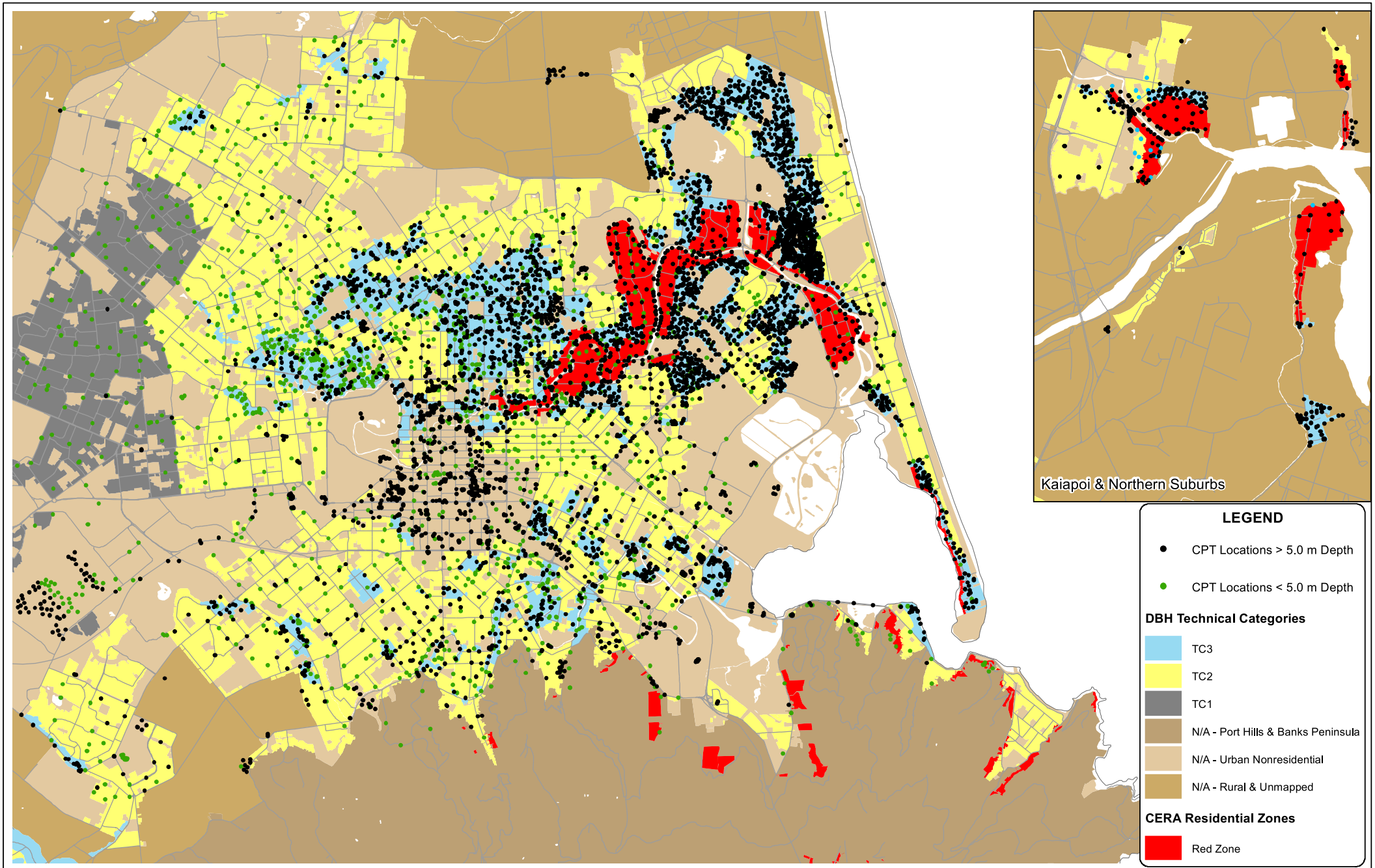
EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020.0200_LSF02	
SCALE (AT A3 SIZE)	1:60,000	
PROJECT No.	52000.200	

EARTHQUAKE COMMISSION
DISTRIBUTION OF LAND DAMAGE
Observations of Ground Crack Locations Post February 2011

FIGURE No. Figure A35 Rev. 0

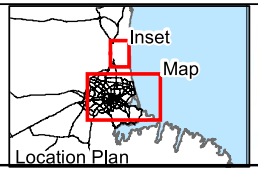
Date: 26/02/2013 Time: 10:46:32 a.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	CXP	Feb.13
CHECKED		
APPROVED		

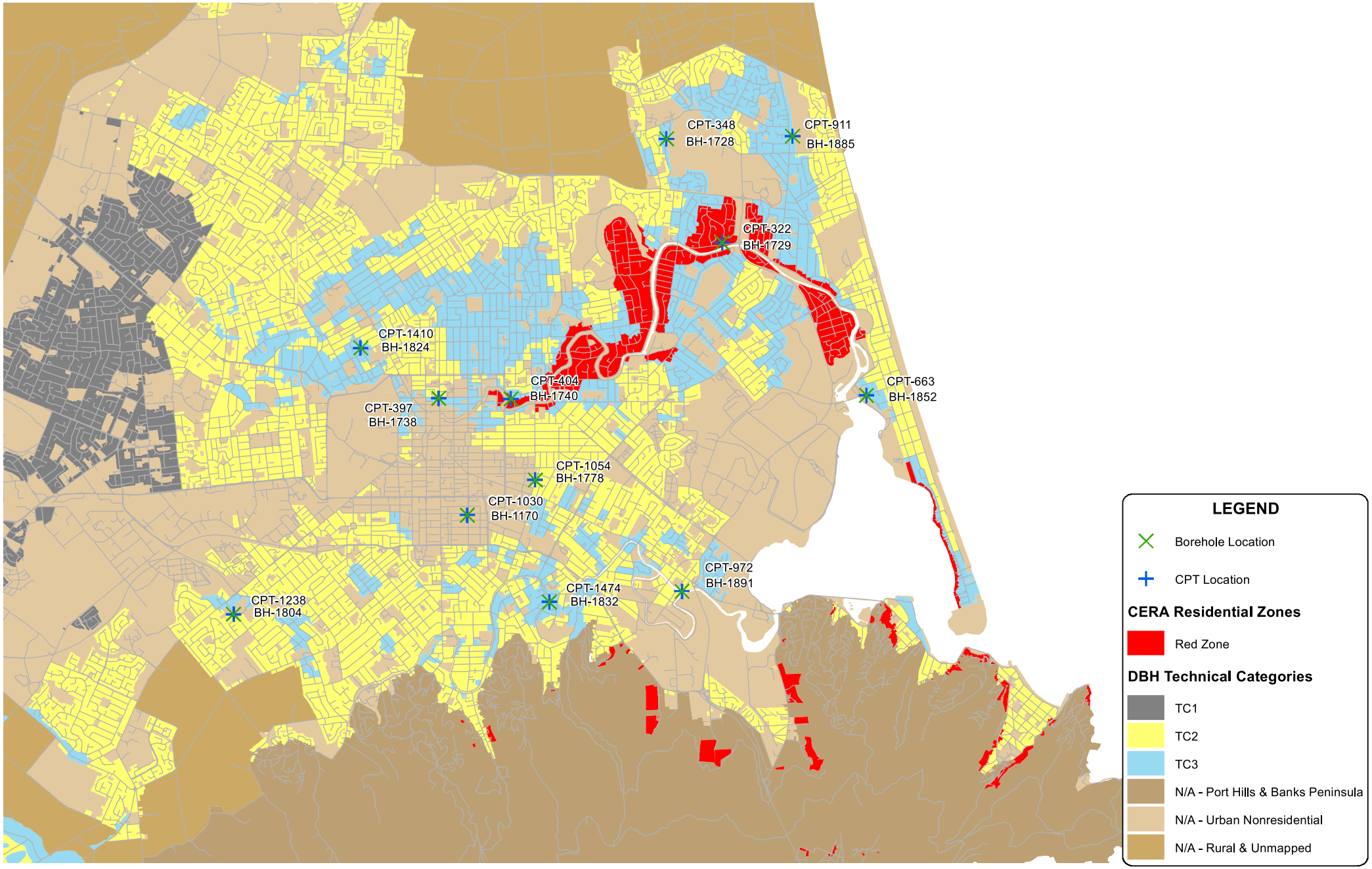
ARCFILE 52020-0200-CPT008
SCALE (AT A3 SIZE) 1:60,000
PROJECT No. 52020-0200

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
Spatial Distribution of CPT used for the Liquifaction Vulnurability Study

FIGURE No. Figure A36

Rev. 0

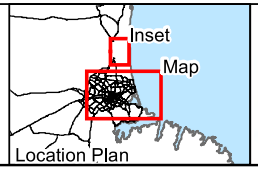
Date: 26/02/2013 Time: 11:00:07 a.m.



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A3 SCALE 1:60,987

0 1 2 3 4 (km)



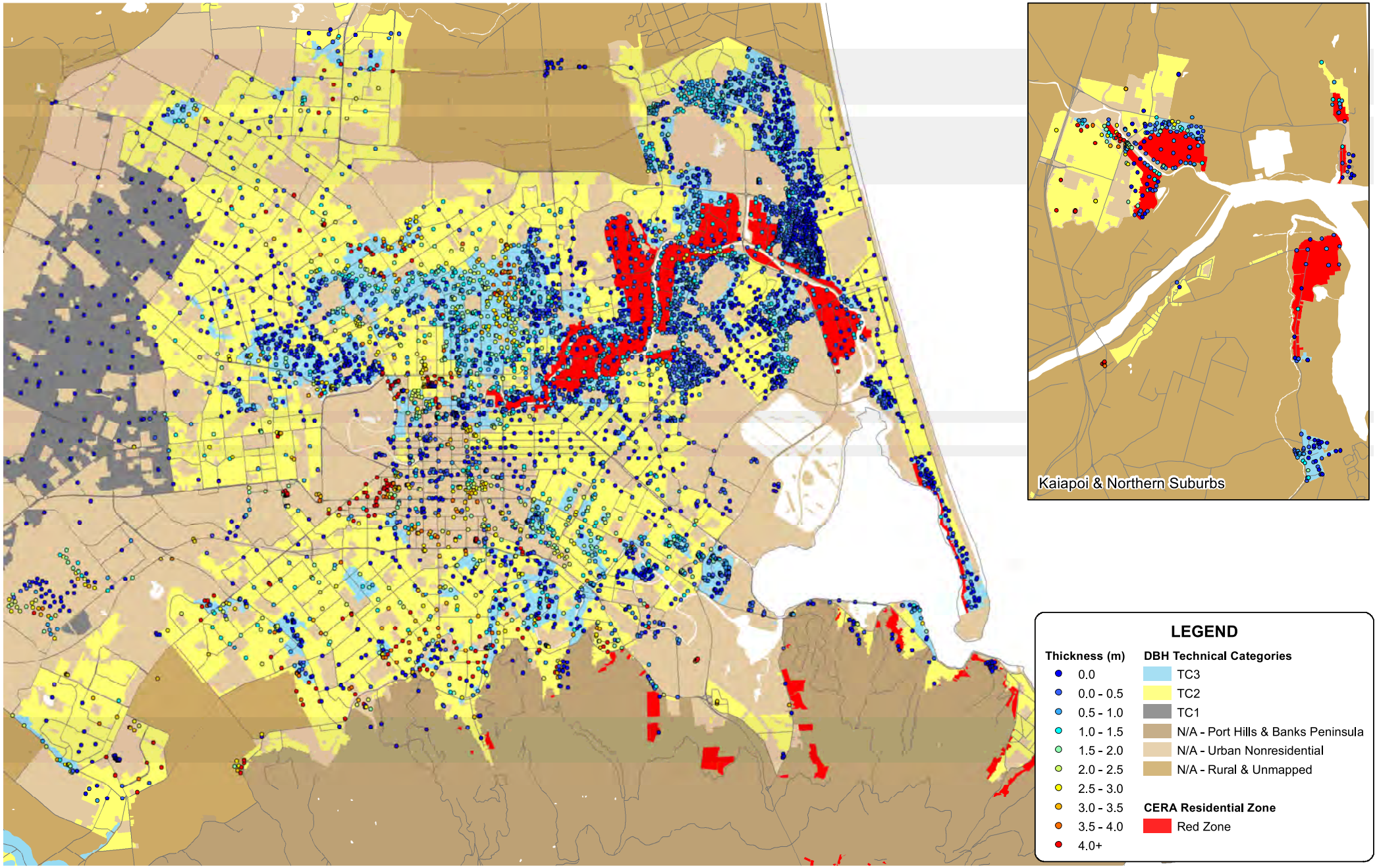
EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

DRAWN	JEL	Feb.13
CHECKED		
APPROVED		
ARCFILE	52000.2000-BHCP01	
SCALE (AT A3 SIZE)	1:60,987	
PROJECT No.	52000.2000	

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
Selected CPT & Borehole Pairs

FIGURE No. Figure A37 Rev. 0

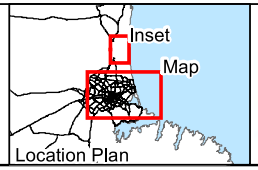
Date: 26/02/2013 Time: 10:19:12 a.m.



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

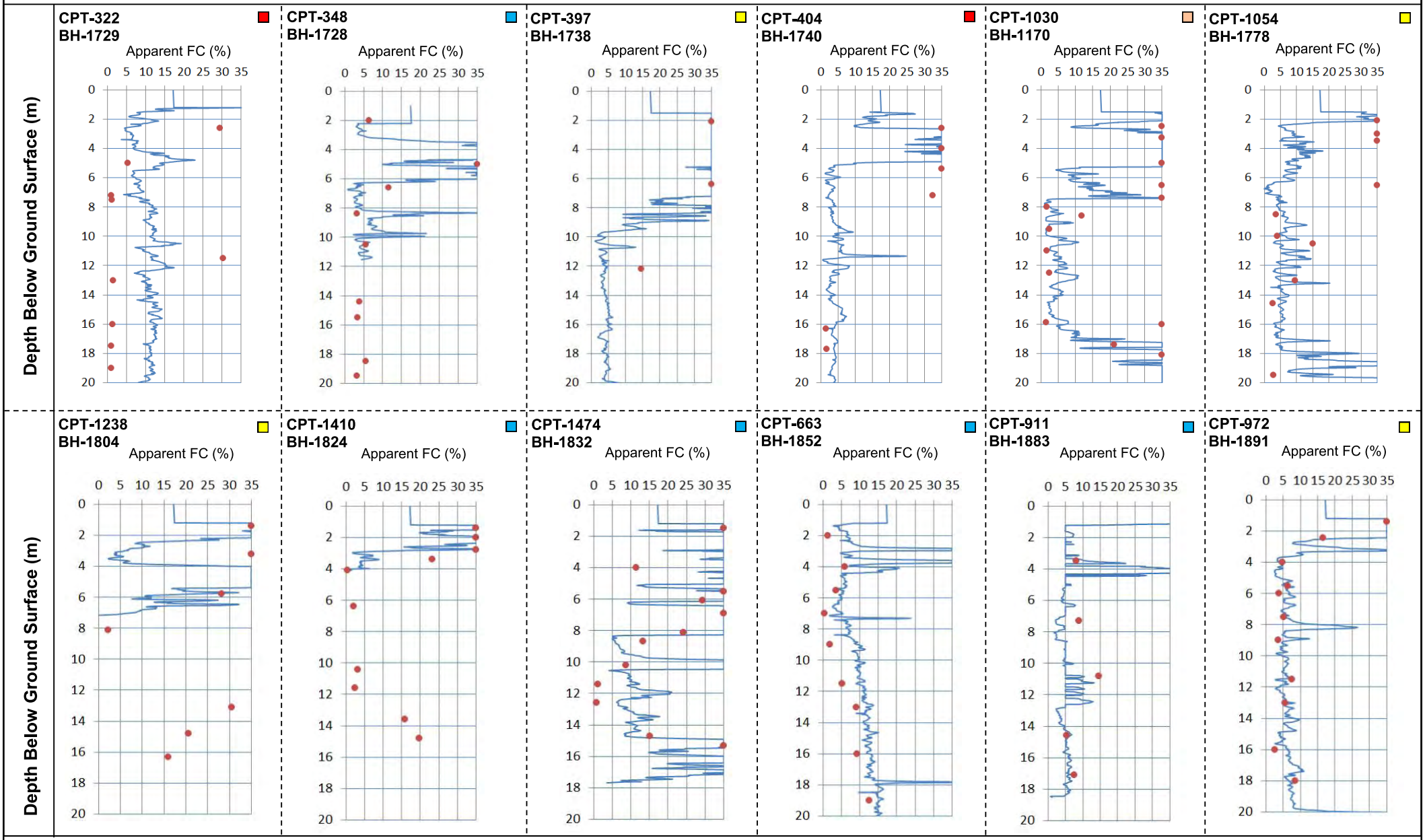
DRAWN	JEL	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LSN218	
SCALE (AT A3 SIZE)	1:60,000	
Prepared By Tonkin & Taylor Ltd Ref:	52020-0200	

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
Cumulative Thickness of Material with Ic > 2.6 (in the Top 10m)

FIGURE No. Figure A39 Rev. 0

Date: 26/02/2013 Time: 4:15:20 p.m.

Apparent Fines Content, FC(%) with Depth as Calculated From Ic for Twelve CPT Soundings



LEGEND:

Apparent Fines Content as Calculated From Ic for CPT Soundings:

Measured Fines Contents From Adjacent Boreholes:

TC2:

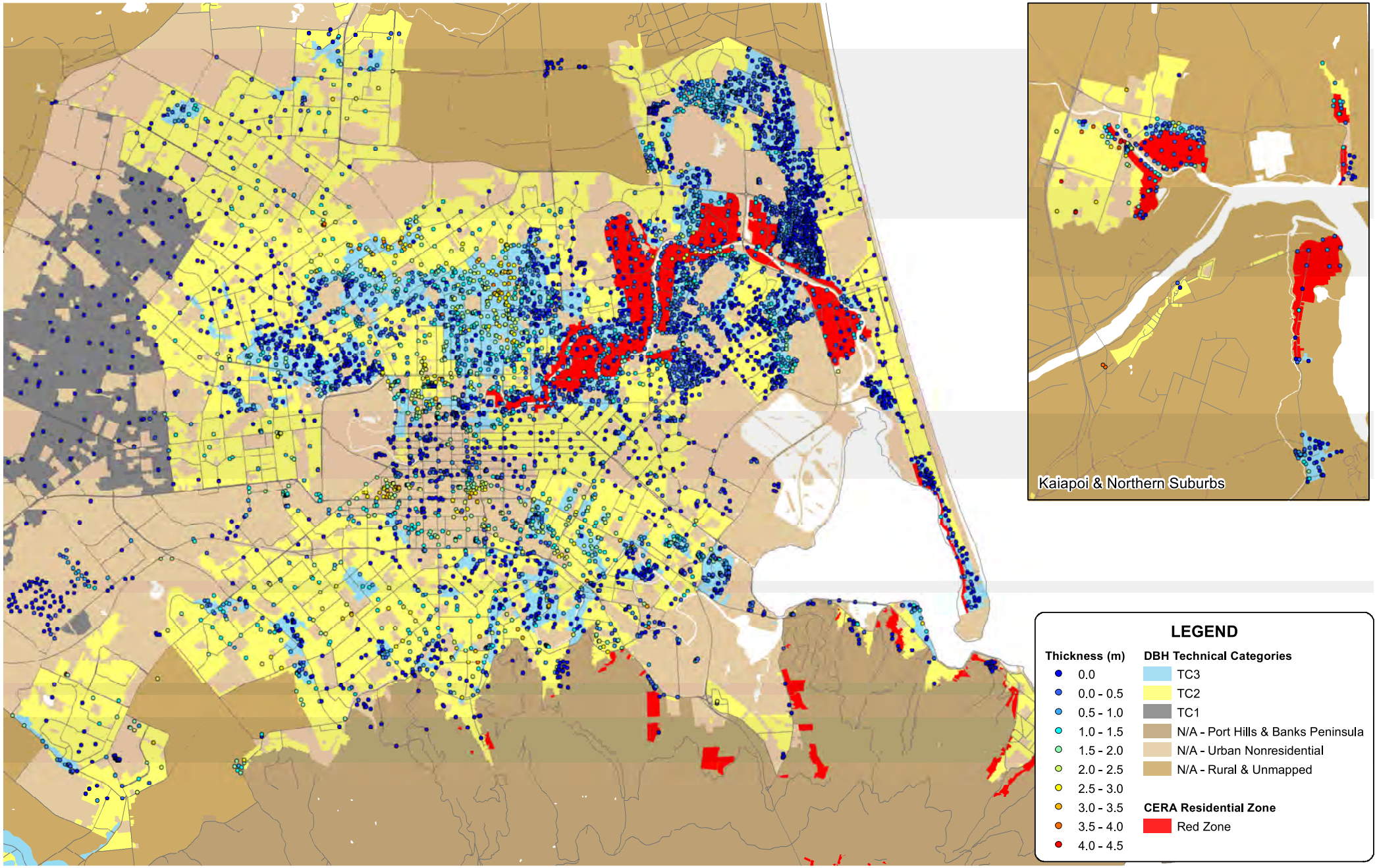
Red Zone:

TC3:

Urban/non residential:

Note: Measured and apparent fines contents have been capped at 35%

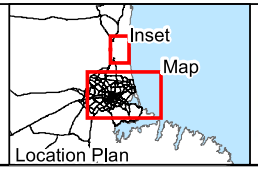
Figure A38



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A3 SCALE 1:60,000

0 1 2 3 4 (km)



EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua

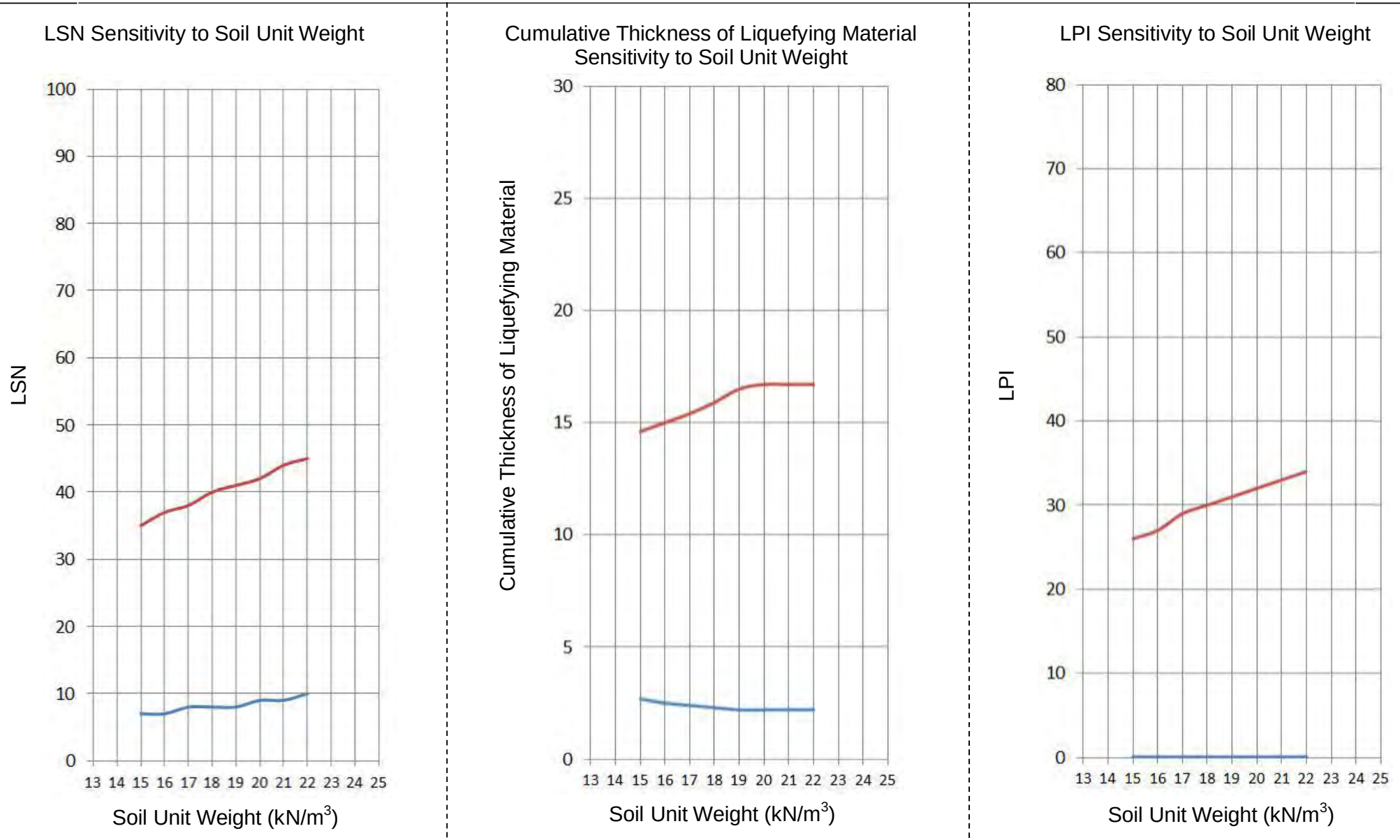
DRAWN	JEL	Feb.13
CHECKED		
APPROVED		
ARCFILE	52020-0200-LSN219	
SCALE (AT A3 SIZE)	1:60,000	
Prepared By Tonkin & Taylor Ltd Ref:	52020-0200	

EARTHQUAKE COMMISSION
CHRISTCHURCH CITY & KAIAPOI
Cumulative Thickness of Material with Ic > 2.6 (in the Top 5m)

FIGURE No. Figure A40 Rev. 0

Date: 26/02/2013 Time: 4:15:26 p.m.

Effects of Changing Soil Unit Weight on LSN, Cumulative Thickness of Liquefying Material and LPI for CPT 1054
Using the Post December Median Groundwater Depth



LEGEND: PGA = 0.13g (SLS) PGA = 0.35g (ULS)

Figure A41

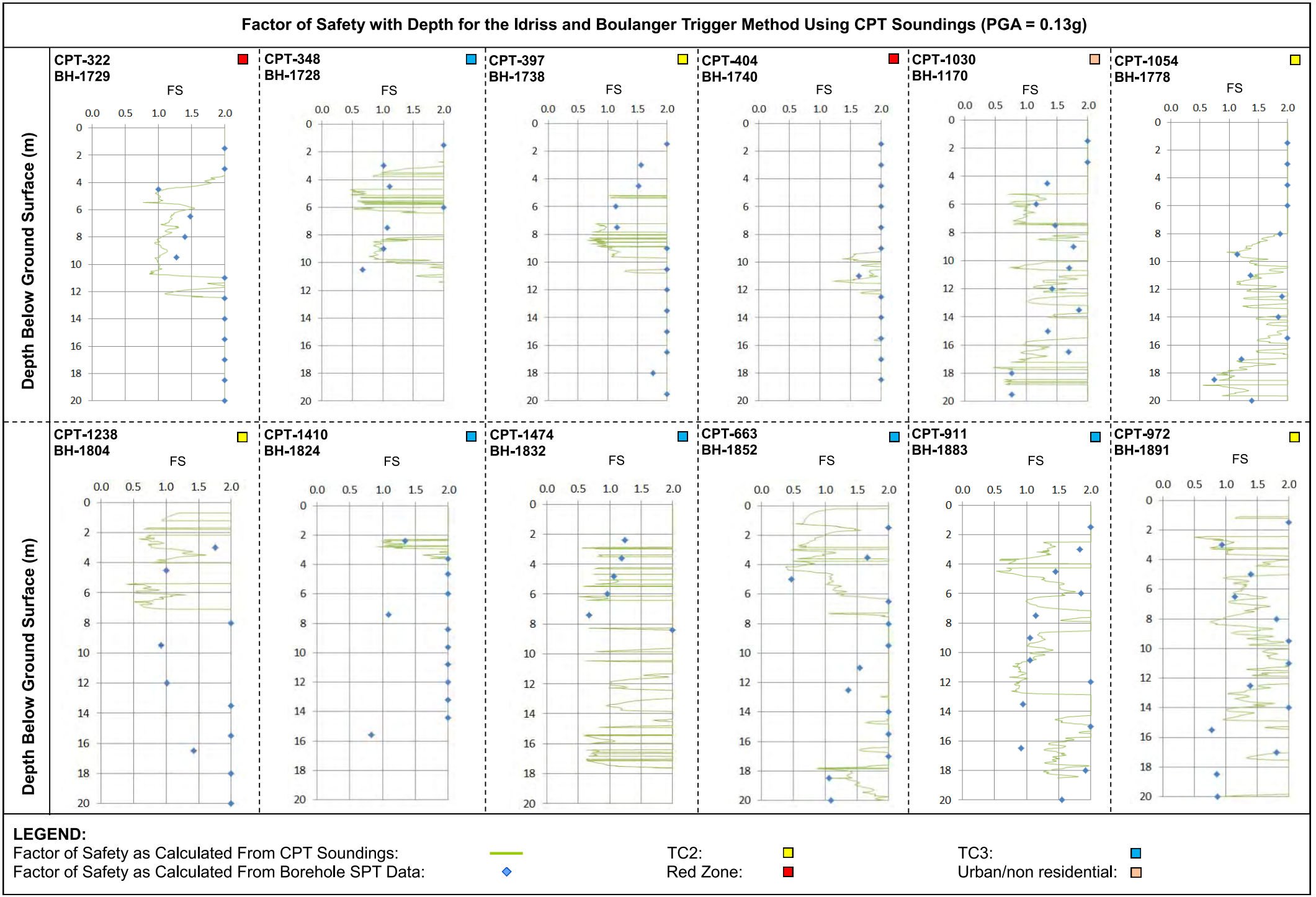

Factor of Safety with Depth for the Idriss and Boulanger Trigger Method Using CPT Soundings (PGA = 0.13g)
Depth Below Ground Surface (m)
CPT-322
BH-1729
CPT-348
BH-1728
CPT-397
BH-1738
CPT-404
BH-1740
CPT-1030
BH-1170
CPT-1054
BH-1778
CPT-1238
BH-1804
CPT-1410
BH-1824
CPT-1474
BH-1832
CPT-663
BH-1852
CPT-911
BH-1883
CPT-972
BH-1891
FS
0.0 0.5 1.0 1.5 2.0
0 2 4 6 8 10 12 14 16 18 20
LEGEND:
Factor of Safety as Calculated From CPT Soundings:
Factor of Safety as Calculated From Borehole SPT Data:
TC2:
Red Zone:
TC3:
Urban/non residential:

Figure A42

Factor of Safety with Depth for the Idriss and Boulanger Trigger Method Using CPT Soundings (PGA = 0.35g)

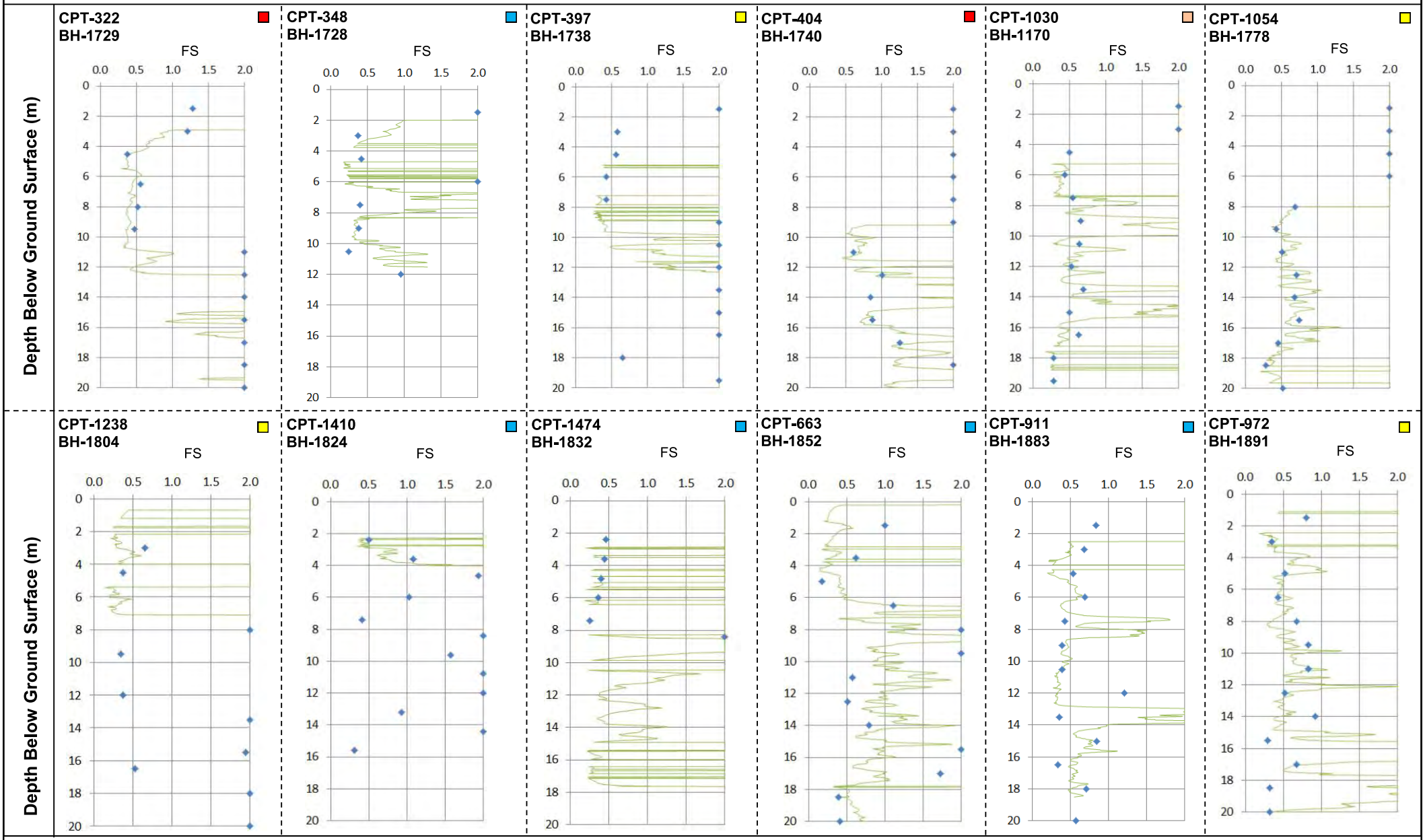
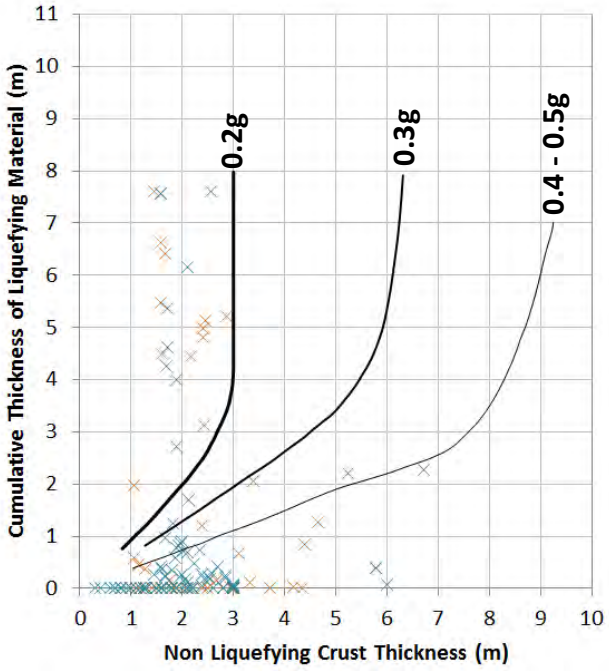


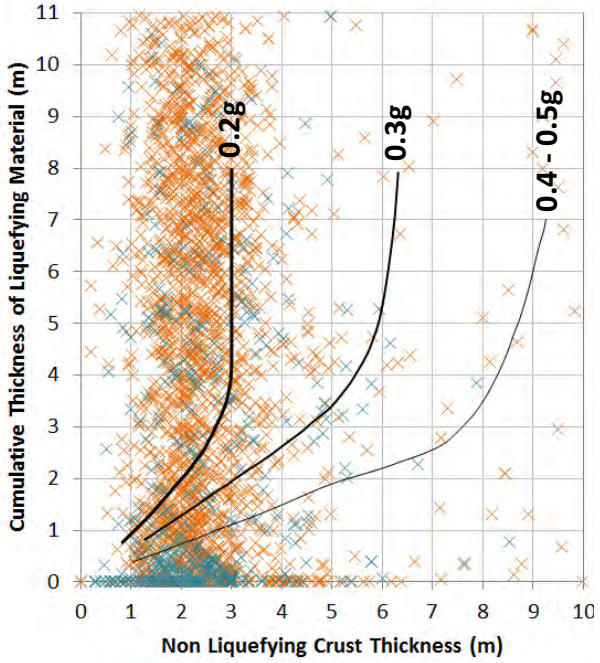
Figure A43

Cumulative Thickness of Liquefying Material Plotted Against the Corresponding Non Liquefying Crust Thickness (Data overlaying within Ishihara,1985)

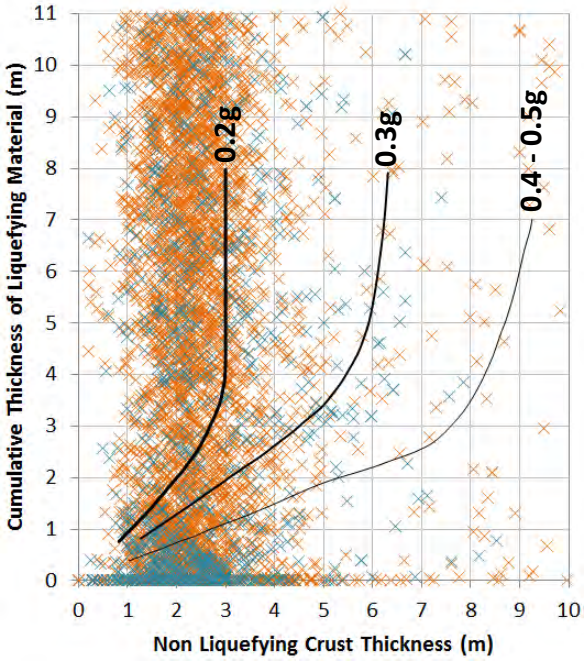
Sites Which Experienced a Magnitude Weighted PGA Between 0 and 0.2g



Sites Which Experienced a Magnitude Weighted PGA Between 0 and 0.3g



Sites Which Experienced a Magnitude Weighted PGA Between 0 and 0.5g



LEGEND:

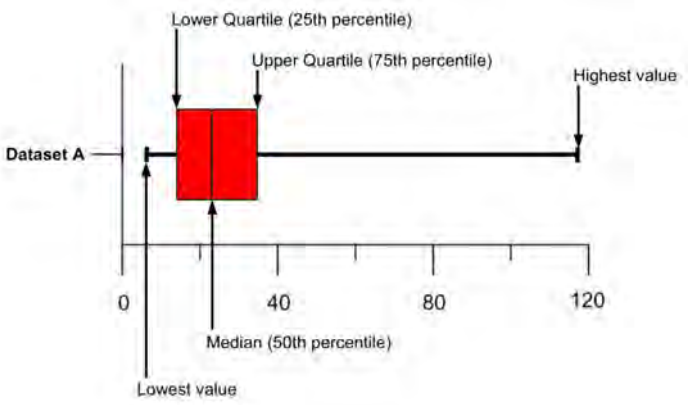
× No Observable Liquefaction at the Ground Surface

× Observed Liquefaction at the Ground Surface

Figure A44

KEY

Box and Whisker Plots



LEGEND

Liquefaction and Lateral Spreading Observation Category

	1	No observed ground cracking or ejected liquefied material
	2	Minor ground cracking but no observed ejected liquefied material
	3	No lateral spreading but minor to moderate quantities of ejected material
	4	No lateral spreading but large quantities of ejected material
	5	Moderate to major lateral spreading; ejected material often observed
	6	Severe lateral spreading; ejected material often observed

Dwelling Damage Category

	None
	Minor
	Moderate
	Major

Refer to Figure A9 for diagrams and a full description.

To avoid plotting seven sets of results for the different mechanisms of foundation damage, the worst foundation damage severity is taken for each LDAT inspection and is referred to as a 'Dwelling Damage Category'.

Figure A45

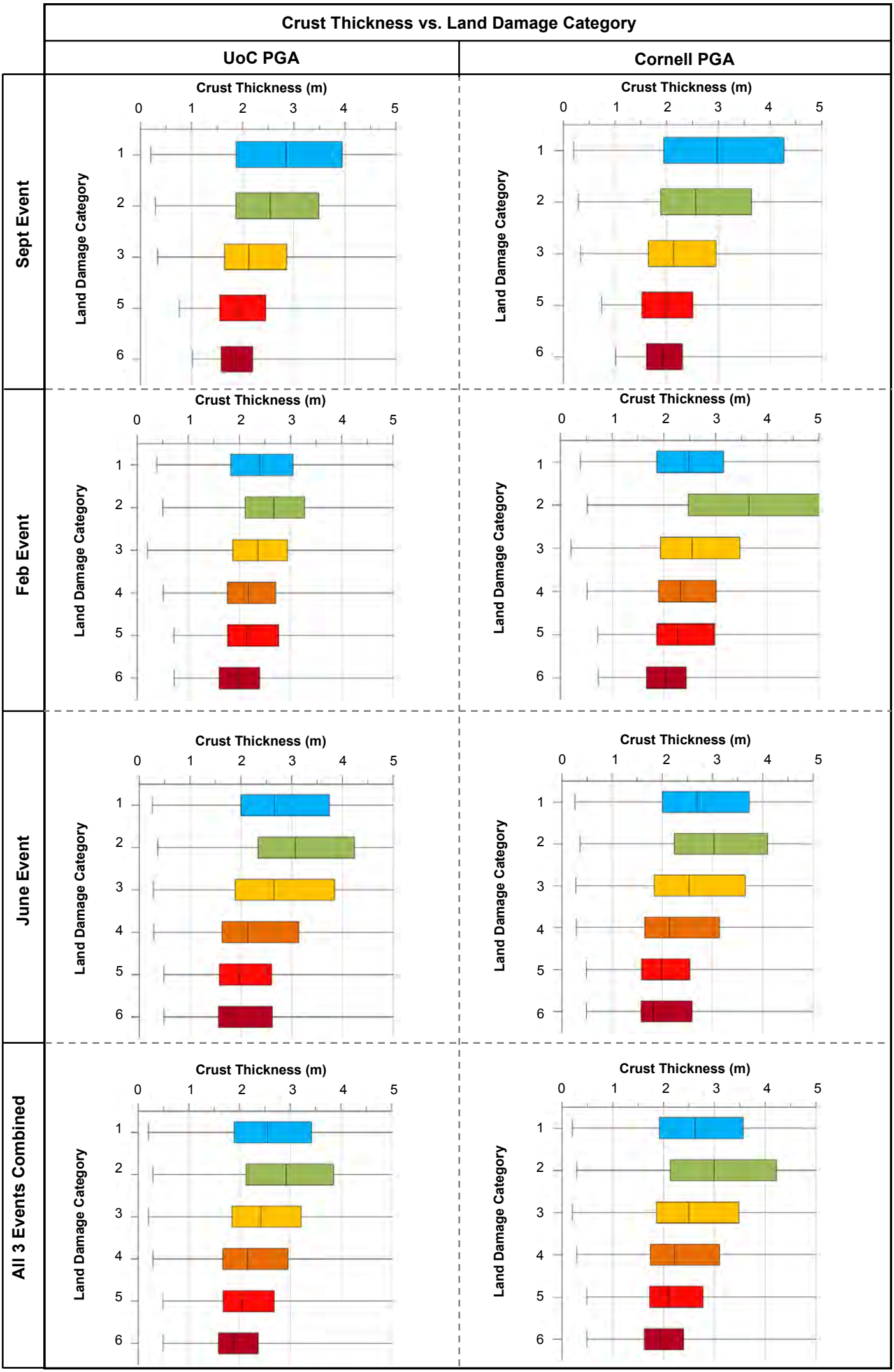

Crust Thickness vs. Land Damage Category
UoC PGA
Cornell PGA
Sept Event
Feb Event
June Event
All 3 Events Combined
Crust Thickness (m)
Land Damage Category
0
1
2
3
4
5
1
2
3
4
5
6

Figure A46

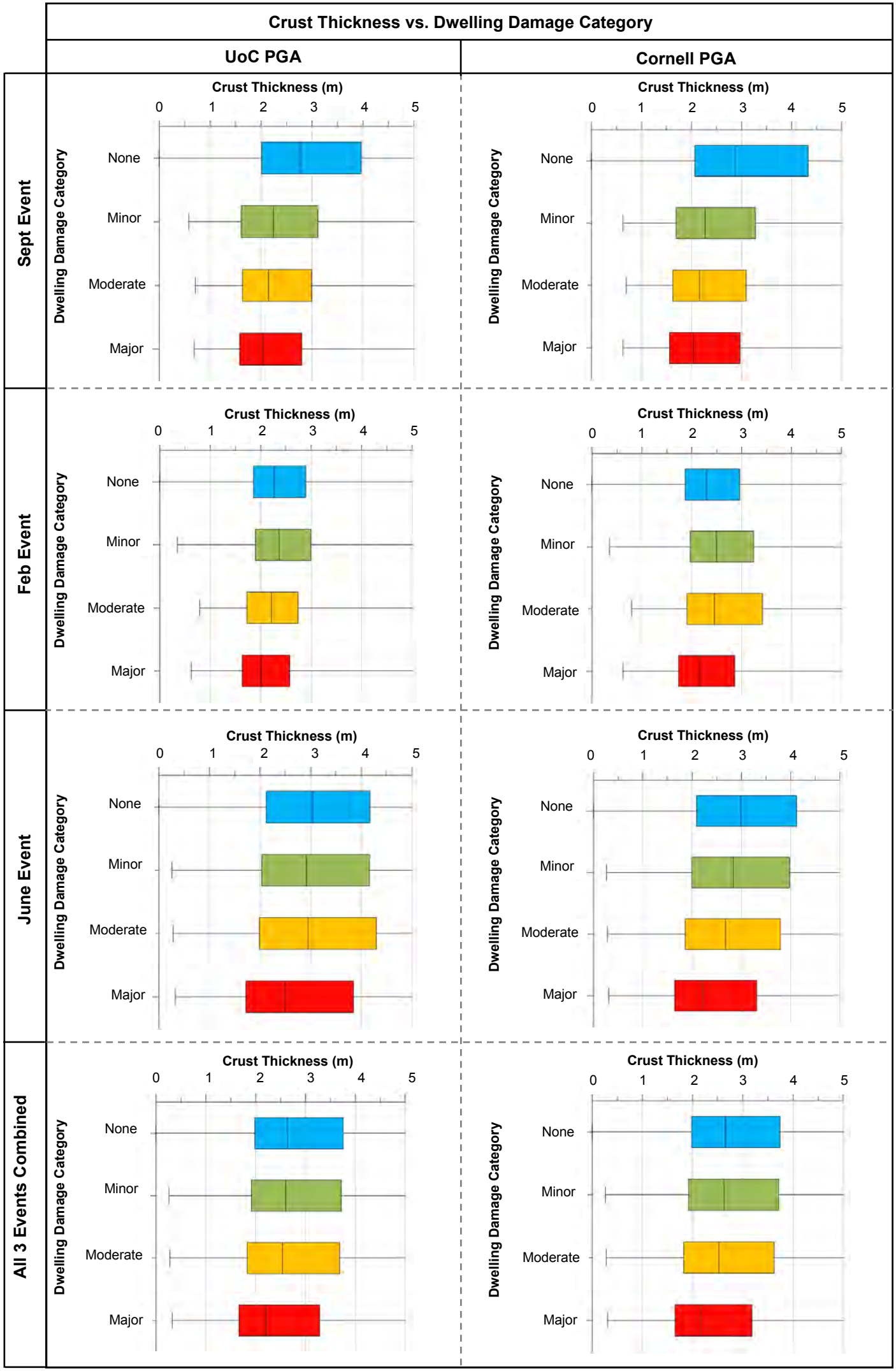
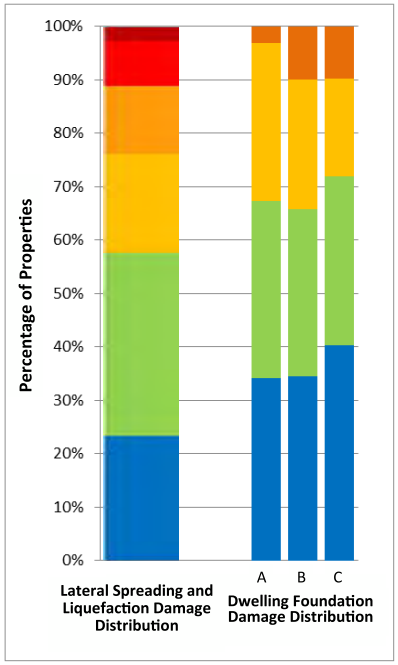

Crust Thickness vs. Dwelling Damage Category
UoC PGA
Cornell PGA
Sept Event
Feb Event
June Event
All 3 Events Combined
Crust Thickness (m)
0
1
2
3
4
5
Dwelling Damage Category
None
Minor
Moderate
Major

Figure A47

Photos of Typical Damage for LSN Ranges (Based on UoC PGA Distribution)

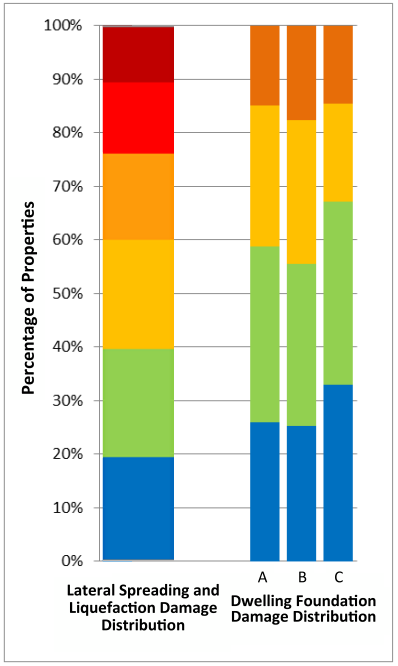
LSN Band 0-10



Photos of Typical Observed Land Damage



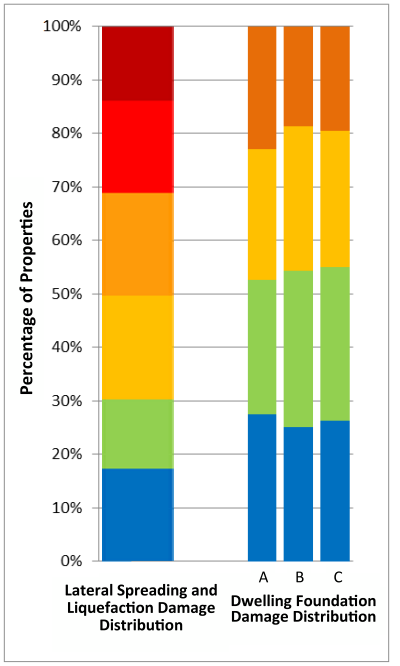
LSN Band 10-20



Photos of Typical Observed Land Damage



LSN Band 20-30



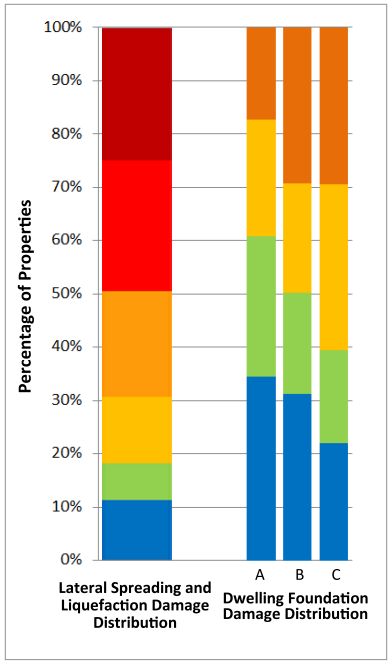
Photos of Typical Observed Land Damage



Figure A48

Photos of Typical Damage for LSN Ranges
(Based on UoC PGA Distribution)

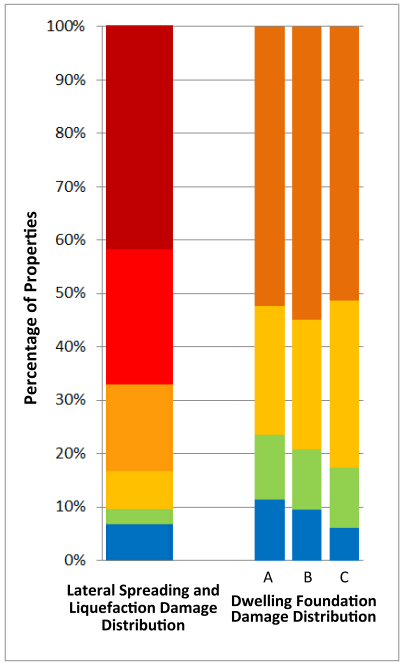
LSN Band 30-40



Photos of Typical Observed Land Damage



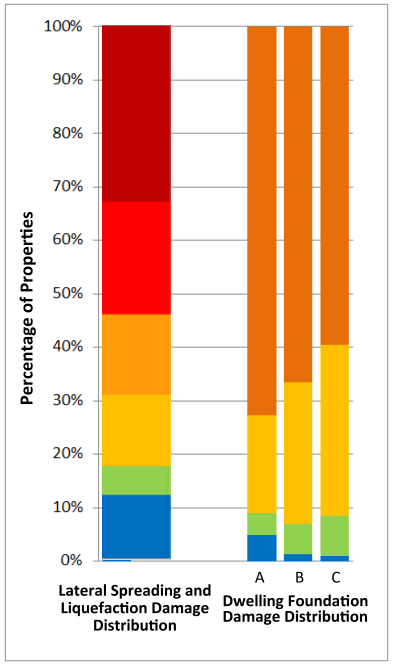
LSN Band 40-50



Photos of Typical Observed Land Damage



LSN Band 50+



Photos of Typical Observed Land Damage



Figure A49