

**Median water table elevation in
Christchurch and surrounding area
after the 4 September 2010 Darfield Earthquake
Version 2**

S. van Ballegooy, S. C. Cox, C. Thurlow,
H. K. Rutter, T. Reynolds, G. Harrington,
J. Fraser, T. Smith

GNS Science Report 2014/18

May 2014

**Median water table elevation in
Christchurch and surrounding area
after the 4 September 2010 Darfield Earthquake
Version 2**

S. van Ballegooy, S. C. Cox, C. Thurlow, H. K. Rutter,
T. Reynolds, G. Harrington, J. Fraser, T. Smith

GNS Science Report 2014/18 May 2014

The following report is an update of the median water table elevation report for Christchurch and surrounding areas released in March 2013 (GNS Report 2013/01). The revision encompasses an extension of the period of groundwater monitoring (4 September 2010 to 30 November 2013) and new surfaces for improved definition of water table fluctuation.

BIBLIOGRAPHIC REFERENCE

S. van Ballegooy, S. C. Cox, C. Thurlow, H. K. Rutter, T. Reynolds, G. Harrington, J. Fraser, T. Smith, 2014. Median water table elevation in Christchurch and surrounding area after the 4 September 2010 Darfield Earthquake: Version 2. GNS Science Report 2014/18, 79 pages plus 8 appendices.

Sjoerd van Ballegooy, Chris Thurlow, Tony Reynolds
Tonkin and Taylor Limited, P O Box 5271, Auckland

Simon Cox
GNS Science, Private Bag 1930, Dunedin

Helen Rutter
Aqualinc Research Ltd, PO Box 20-462, Christchurch

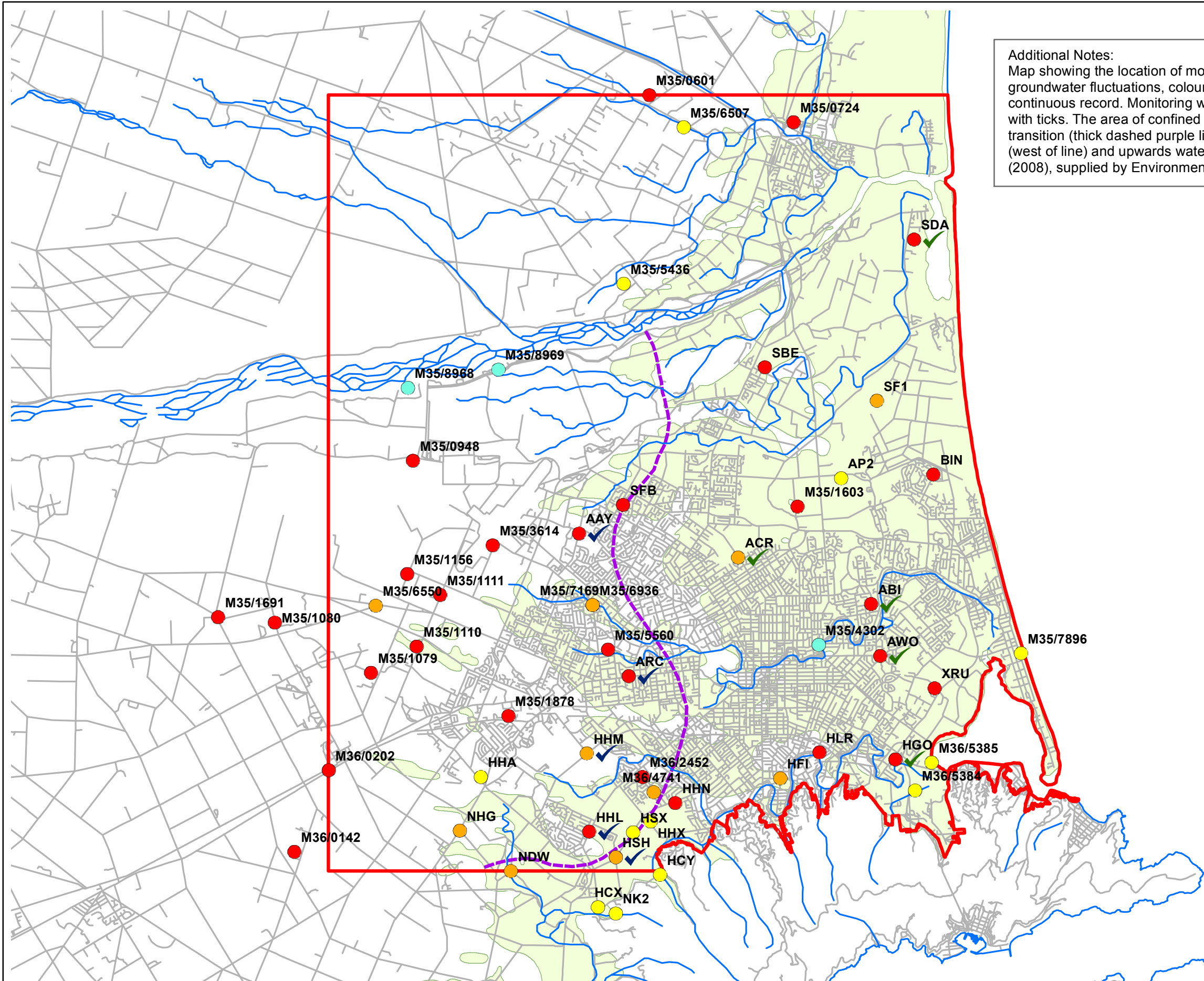
Graham Harrington
Christchurch City Council, PO Box 73014, Christchurch

Jeff Fraser
Golder Associates (NZ) Limited, PO Box 2281, Christchurch

Titus Smith
Riley Consultants Ltd, PO Box 4355, Christchurch

APPENDIX H: WATER LEVEL FLUCTUATION

Figure H.1	Location of monitoring wells used in the assessment of pre-earthquake fluctuations
Figure H.2	Range of groundwater elevation in metres, for the period 1990-2010
Figure H.3	Groundwater elevation in selected monitoring wells, 1990-2010, plotted by Julian Day of the year
Figure H.4	Groundwater elevation in selected monitoring wells, rainfall and groundwater recharge, 1990-2010 time series
Figure H.5	Comparison of shallow groundwater elevation in monitoring wells including 2010-2011 Canterbury earthquake sequence
Figure H.6	Comparison of shallow groundwater elevation in monitoring wells including 2010-2011 Canterbury earthquake sequence
Figure H.7	Ground and shallow groundwater elevation changes in selected monitoring wells during 2010-2011 Canterbury earthquake sequence
Figure H.8	Difference between groundwater levels: post-Darfield Earthquake (2010-2013) median values minus pre-Darfield Earthquake (1990-2010) median values
Figure H.9	Difference between the 85th percentile and median groundwater elevations, 1990 -2010
Figure H.10	Difference between the median and 15th percentile groundwater elevations, 1990 -2010
Figure H.11	Median water table elevation for the period 1990 - 2010



Additional Notes:
Map showing the location of monitoring wells used in the assessment of shallow groundwater fluctuations, coloured according to the length of available continuous record. Monitoring wells selected for extended analysis are annotated with ticks. The area of confined aquifers (green polygons) and the approximate transition (thick dashed purple line) between downwards water pressure gradients (west of line) and upwards water pressure gradients (east of line) follows Weeber (2008), supplied by Environment Canterbury.

Variation 1990-2010

Length of data record

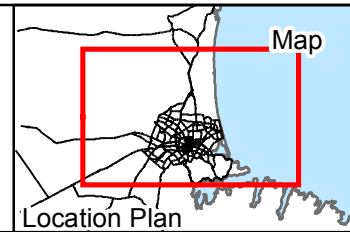
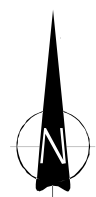
- 20 year
- 15-19 years
- 10-14 years
- <10 year

Selected monitoring wells

- ✓ Eastern/Coastal Zone
- ✓ Inland Zone
- River
- Coastline
- Upwards P gradient to east
- Road
- ▭ Study Area
- ▭ Confined aquifers

Notes: Roads, rivers, lagoons and coastline licensed under Creative Commons Attribution 3.0 New Zealand and sourced from LINZ.
Crown Copyright Reserved

A3 SCALE 1:125,000



DRAWN	CXP	Feb.14
CHECKED		
APPROVED		
ARCFILE	52020-0200-CPT035	
SCALE (AT A3 SIZE)	1:125,000	
Prepared By	Tonkin & Taylor Ltd.	
Ref.	52020.0200	

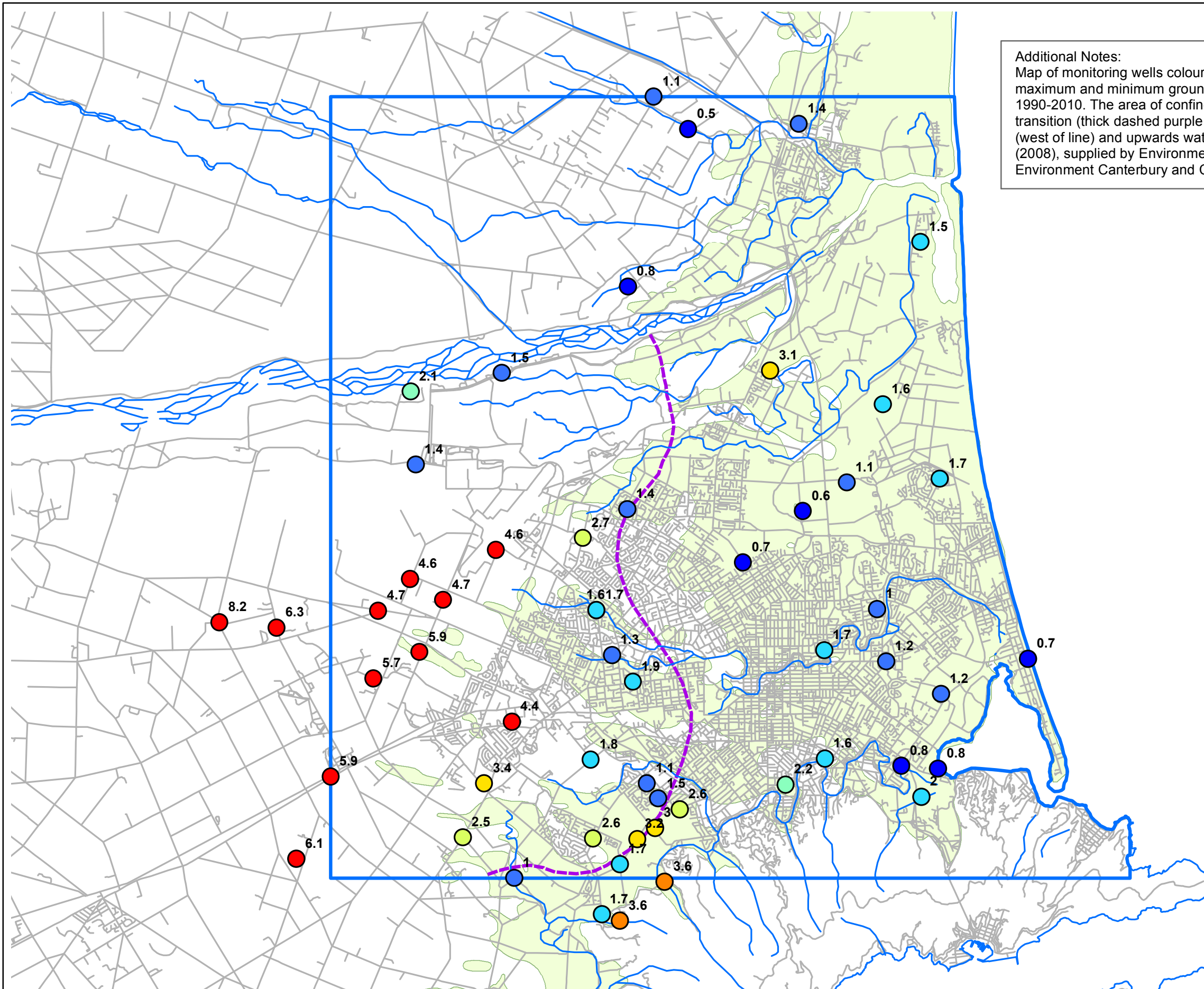
CHRISTCHURCH MEDIAN WATER TABLE ELEVATION REPORT

Location of monitoring wells used in the assessment of pre-earthquake fluctuations

FIGURE No. Figure H.1

Rev. 0

Date: 19/02/2014 Time: 3:42:55 p.m.



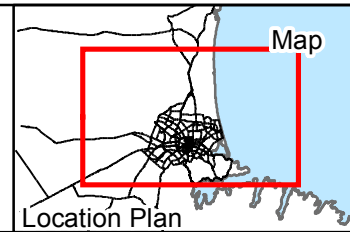
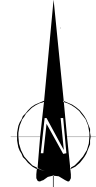
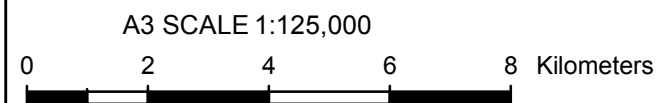
Additional Notes:
 Map of monitoring wells coloured according to the range (in metres) between maximum and minimum groundwater elevations recorded during the period 1990-2010. The area of confined aquifers (green polygons) and the approximate transition (thick dashed purple line) between downwards water pressure gradients (west of line) and upwards water pressure gradients (east of line) follows Weeber (2008), supplied by Environment Canterbury. Monitoring data supplied by Environment Canterbury and Christchurch City Council.

Variation 1990-2010
Range = Max-Min (m)

- >4
- 3.5 - 4.0
- 3.0 - 3.5
- 2.5 - 3.0
- 2.0 - 2.5
- 1.5 - 2.0
- 1.0 - 1.5
- <1.0

- River
- Coastline
- - - Upwards P gradient to east
- Road
- Study Area
- Confined aquifers

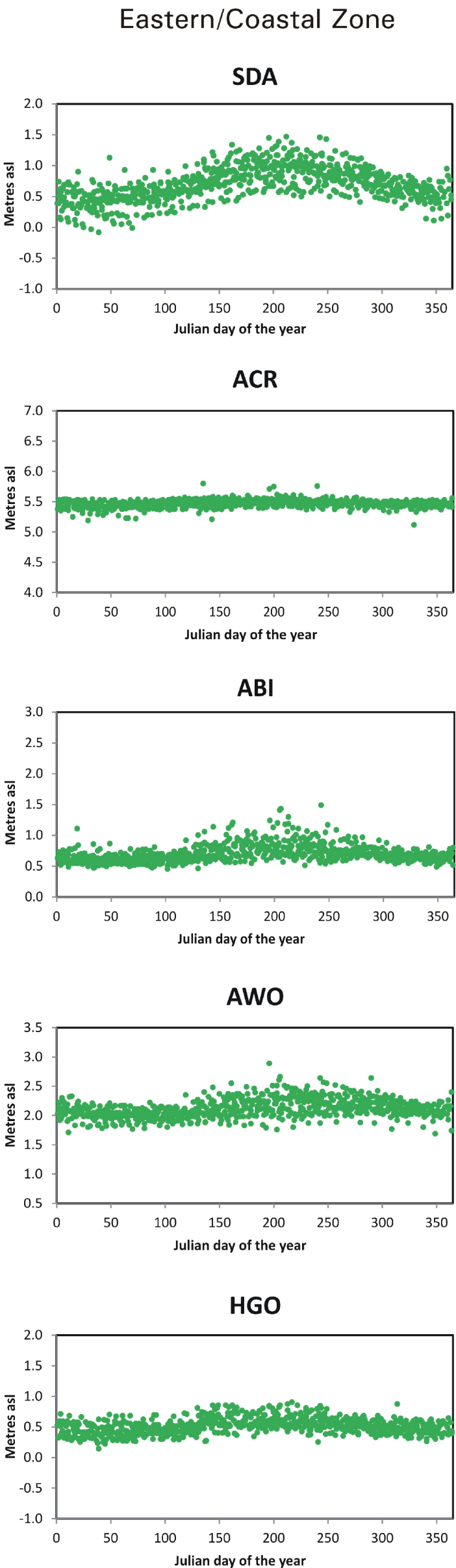
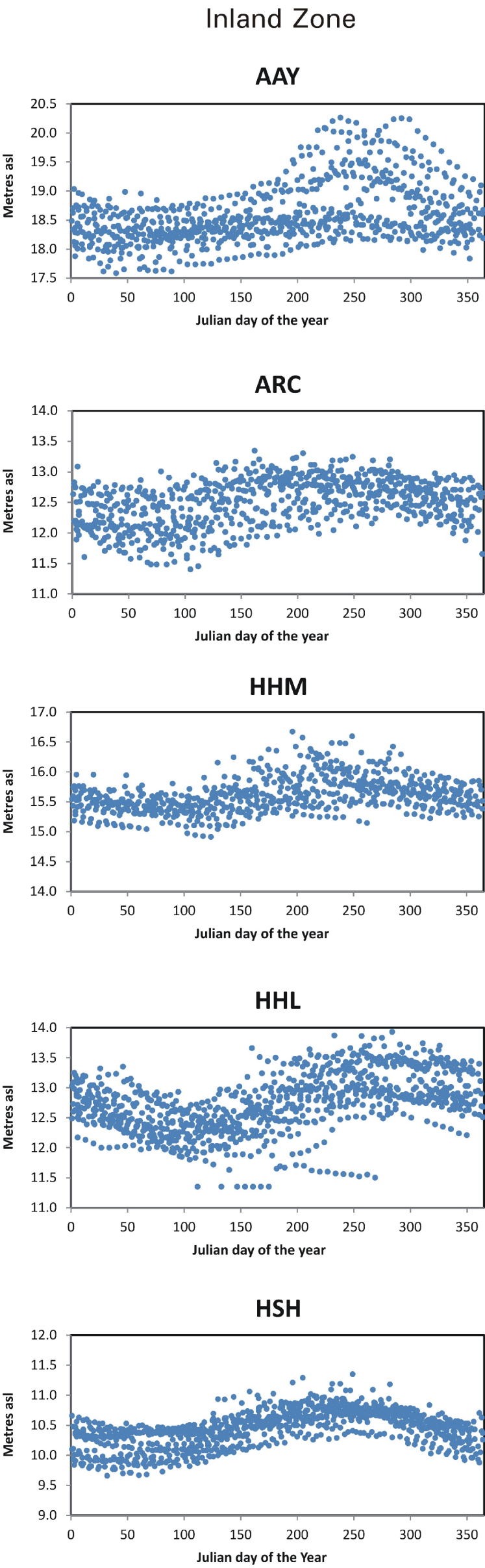
Notes: Road, Rivers, lagoons and coastline licensed under Creative Commons Attribution 3.0 New Zealand and sourced from LINZ.
 Crown Copyright Reserved



DRAWN	CXP	Feb.13
CHECKED		
APPROVED		
ARCFILE 52020-0200-CPT036		
SCALE (AT A3 SIZE) 1:125,000		
Prepared By Tonkin & Taylor Ltd. Ref. 52020.0200		

CHRISTCHURCH MEDIAN WATER TABLE ELEVATION REPORT Range of groundwater elevation in metres, for the period 1990-2010

Date: 25/02/2013 Time: 11:27:04 a.m.

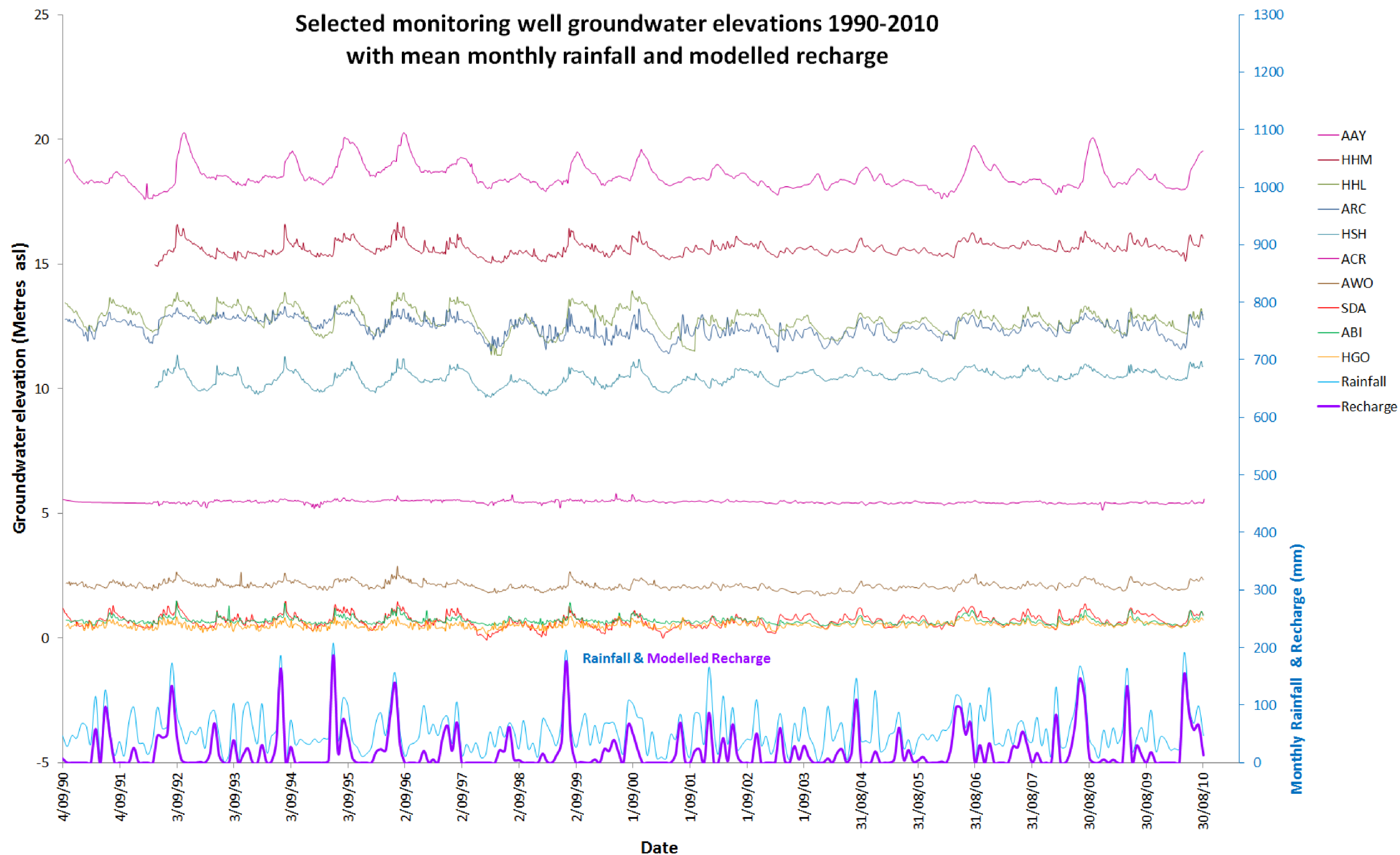


Notes:
Groundwater elevations (in mRL above sea level) in selected monitoring wells for the period 1990-2010, plotted according to the numerical (Julian) day of the year (0-365). Monitoring wells from the inland zone (blue) are distinguished from the eastern coastal zone (green). The scale ranges of the water elevations (vertical axes) are all the same (3 m), although absolute values differ between graphs, for ease of comparison between graphs. Monitoring data collected by NIWA and supplied by Christchurch City Council.



DRAWN	CXP	Apr.14
CHECKED		
APPROVED		
ARCFILE 52020-0200-CPT040		
SCALE (AT A3 SIZE)		
Prepared by Tonkin & Taylor Ltd		
Ref.	52020.0200	

CHRISTCHURCH MEDIAN WATER		
TABLE ELEVATION REPORT		
Groundwater elevation in selected monitoring well water levels, 1990-2010, plotted by numerical (Julian) day of the year		
FIGURE No.	Figure H.3	Rev. 0



Notes: Time series plot of water level fluctuations in selected monitoring wells during the period 1990-2010. Data collected by NIWA and supplied by Christchurch City Council. The mean monthly rainfall and modelled groundwater recharge (in mm – right axis) at Christchurch airport is shown at the base of the graph for reference. Monitoring data collected by NIWA and supplied by Christchurch City Council. Rainfall data sourced from NIWA through the Cliflo database.



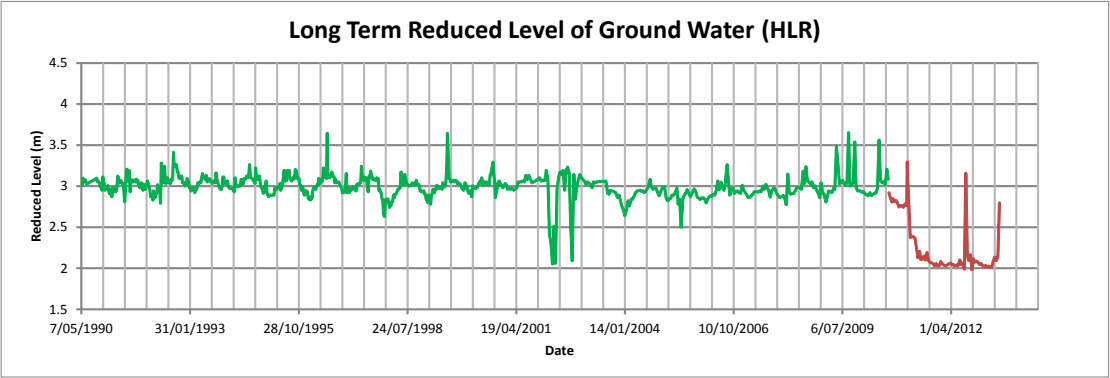
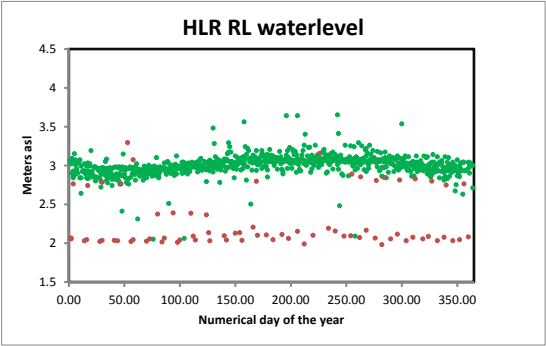
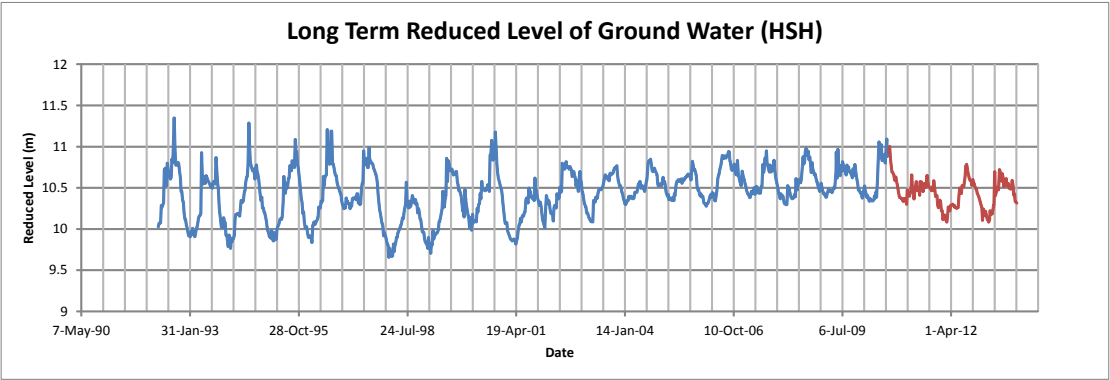
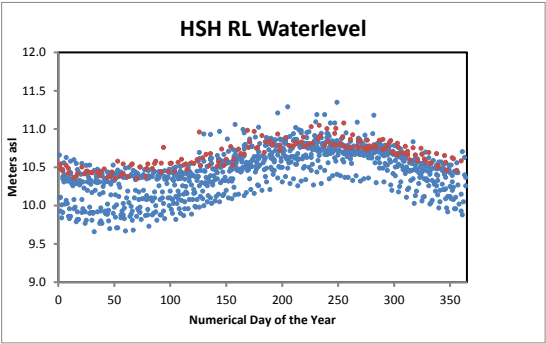
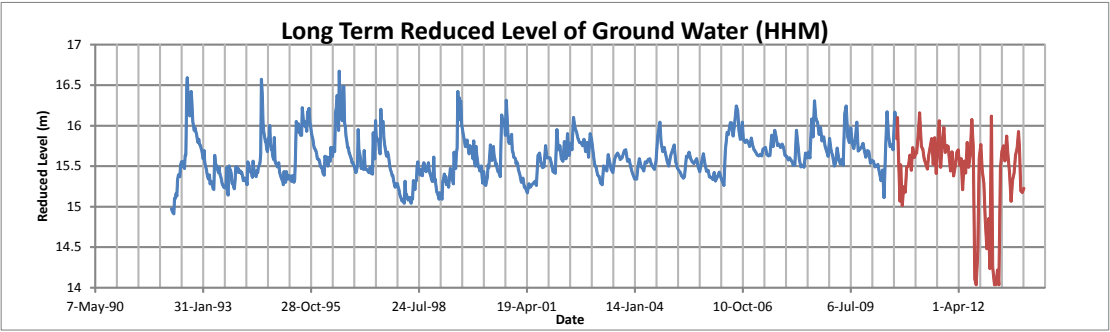
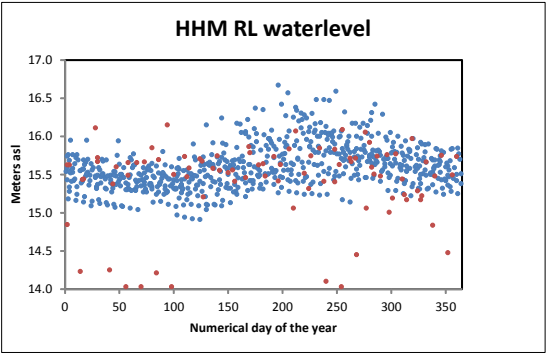
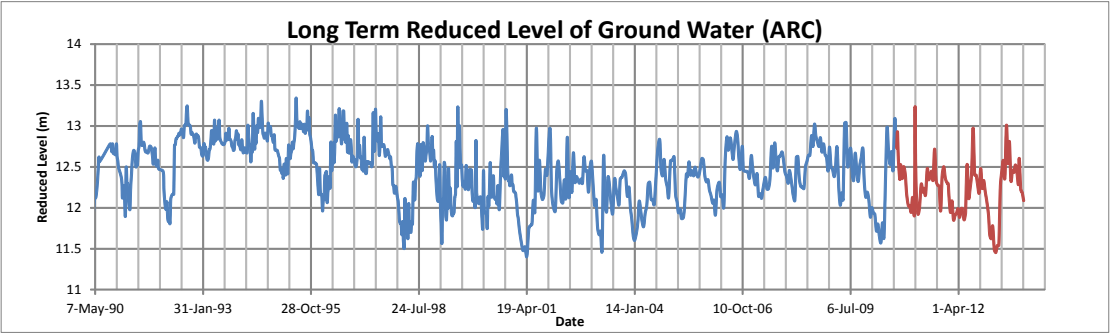
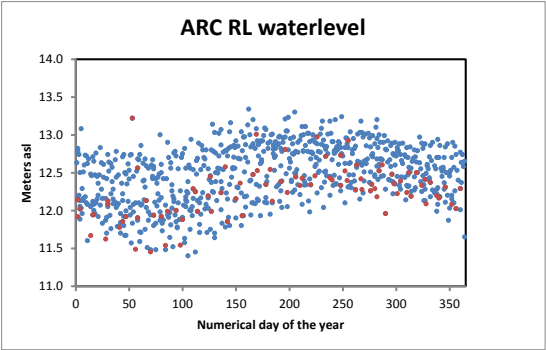
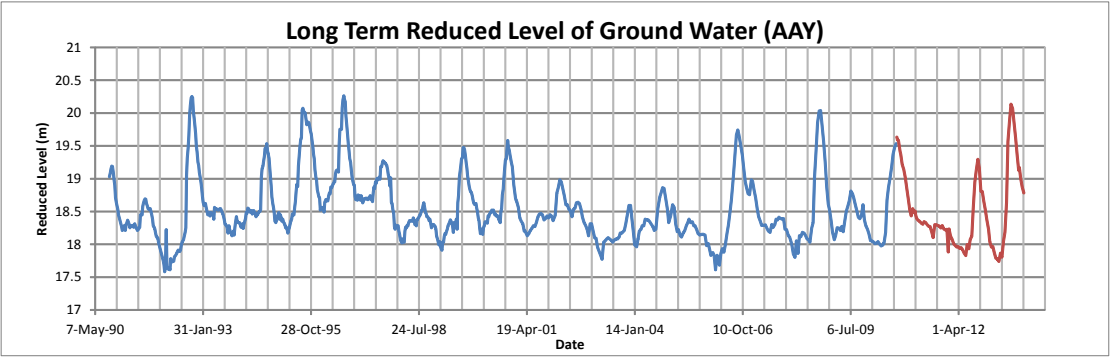
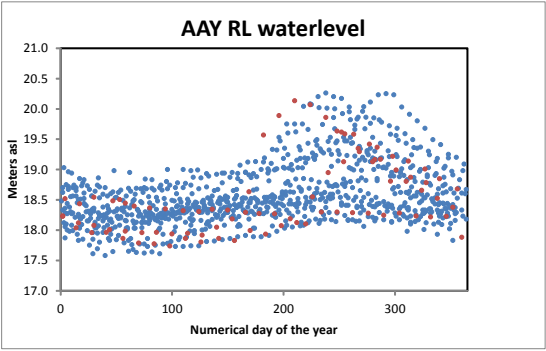
Tonkin & Taylor

DRAWN	CXP	Apr.14
CHECKED		
APPROVED		
ARCFILE 52020-0200-CPT039 SCALE (AT A3 SIZE)		
Prepared By Tonkin & Taylor Ltd. Ref. 52020.0200		

**CHRISTCHURCH MEDIAN WATER
TABLE ELEVATION REPORT**
Groundwater elevation in selected monitoring wells, rainfall
& groundwater recharge, 1990-2010 time series

FIGURE No. Figure H.4

Rev. 0



Inland Zone Eastern/Coastal Zone

● — pre Darfield Earthquake ● — pre Darfield Earthquake

● — post Darfield Earthquake ● — post Darfield Earthquake

Notes:



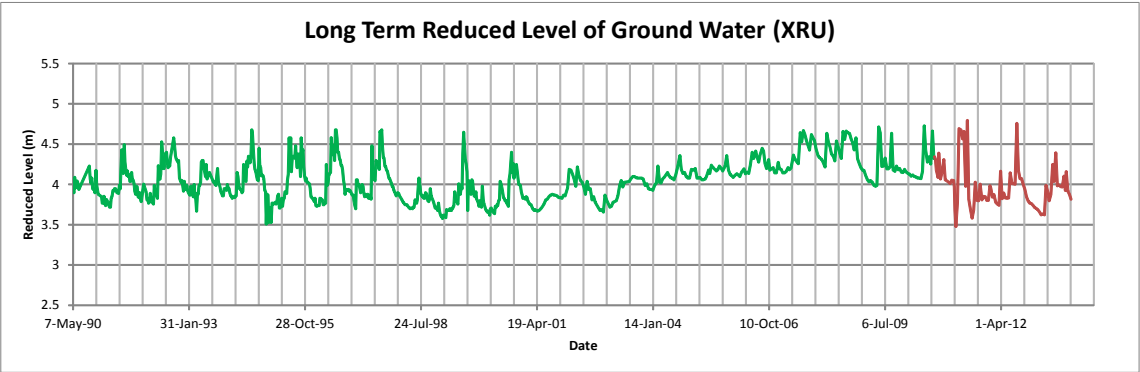
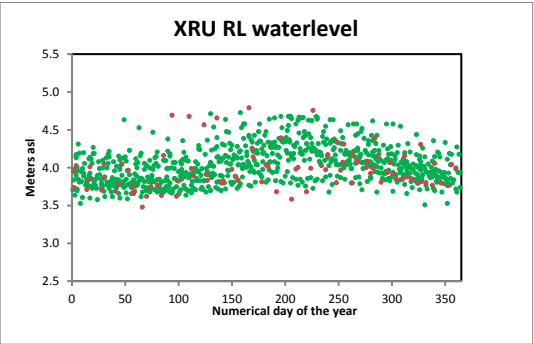
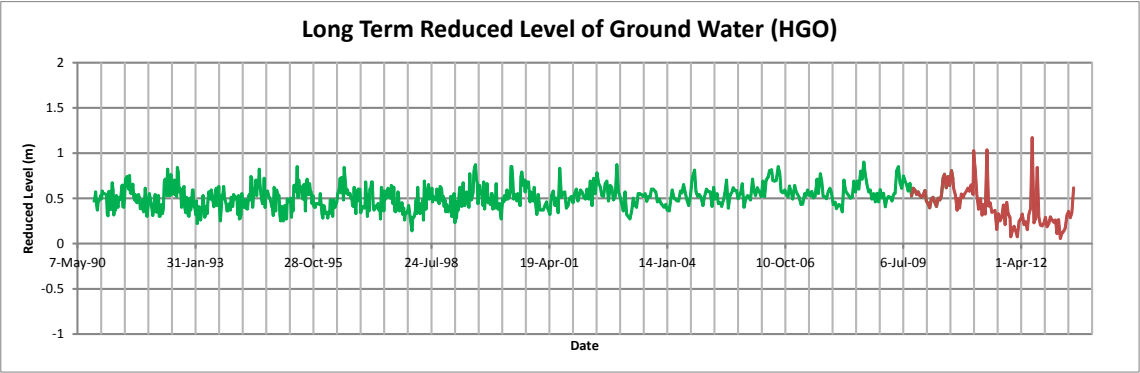
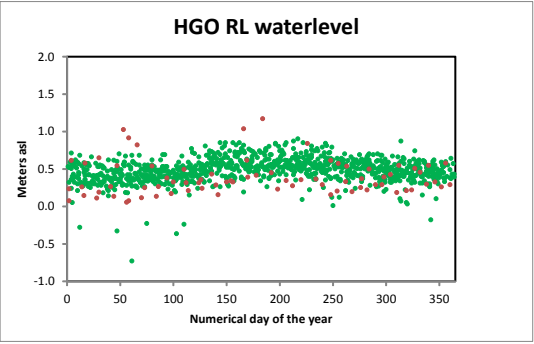
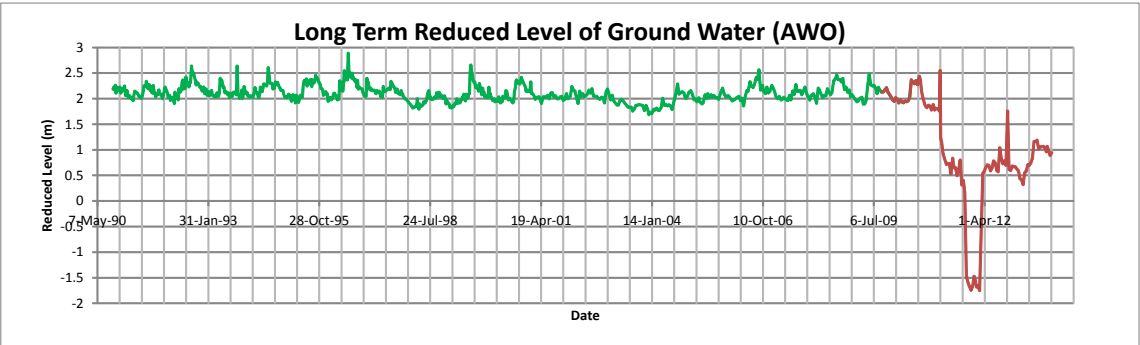
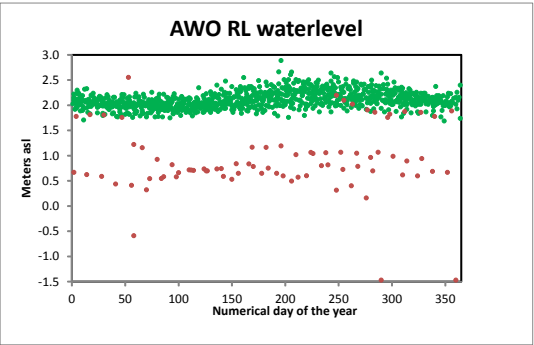
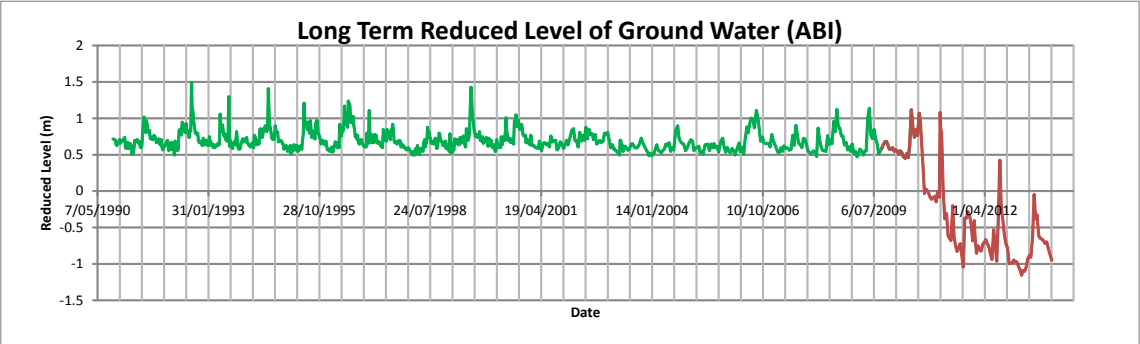
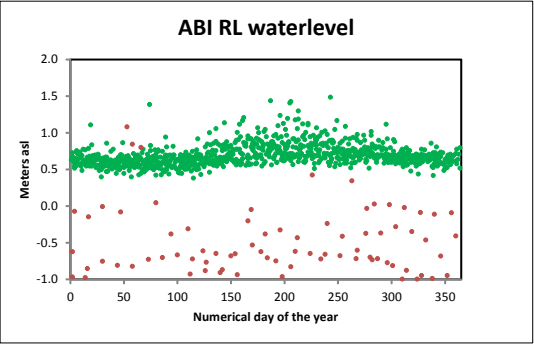
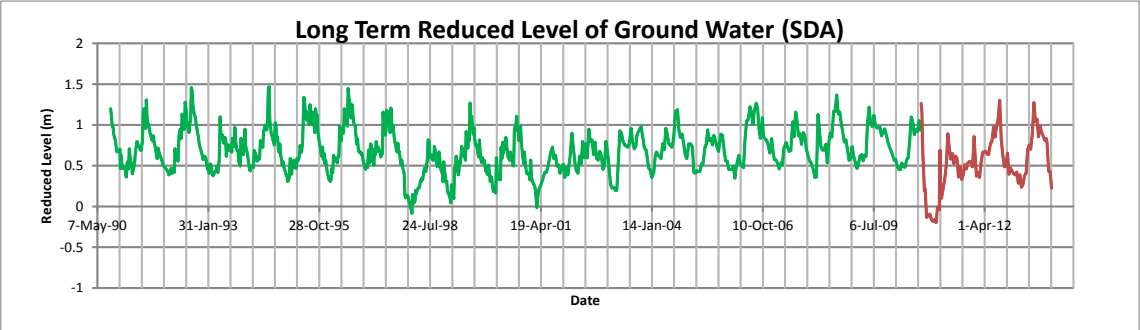
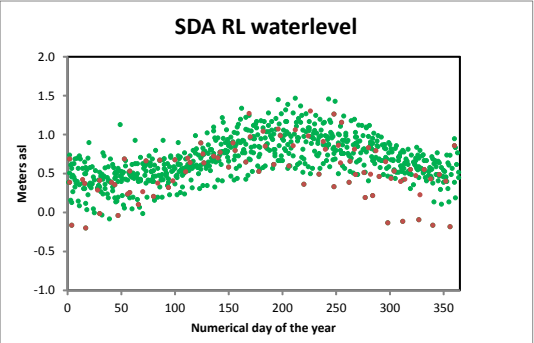
DRAWN	CXP	May.14
CHECKED		
APPROVED		
ARCFILE 52020-0200-CPT054 SCALE (AT A3 SIZE)		
Prepared by Tonkin & Taylor Ltd Ref. 52020.0200		

CHRISTCHURCH MEDIAN WATER
TABLE ELEVATION REPORT

Comparison of shallow groundwater elevation in monitoring wells including 2010–2011 Canterbury earthquake sequence

FIGURE No.
Figure H.5

Rev.
0



Eastern/Coastal Zone

● — pre Darfield Earthquake

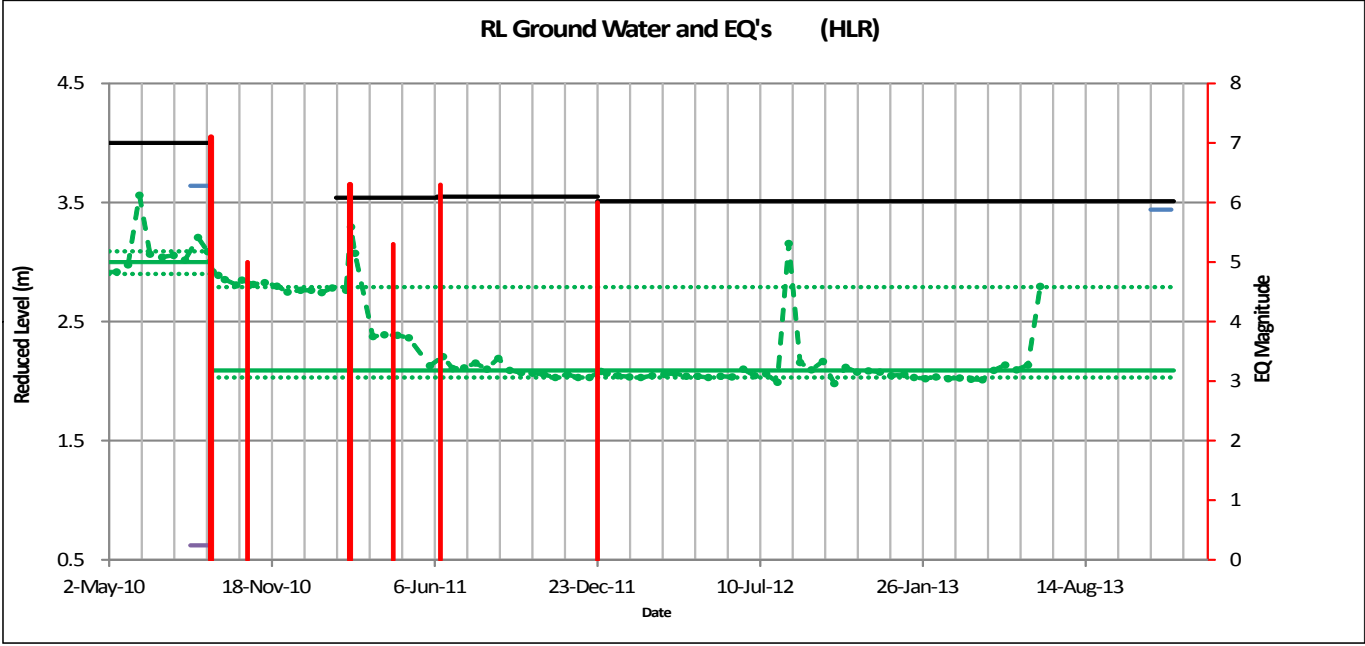
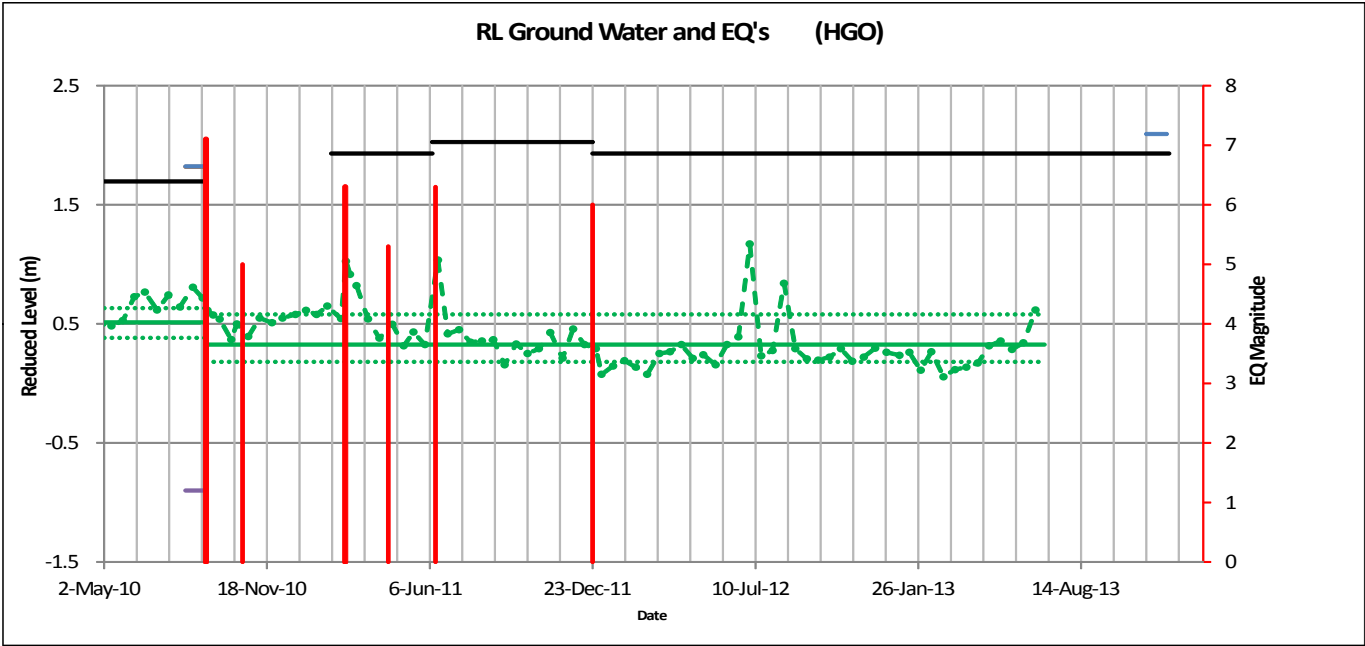
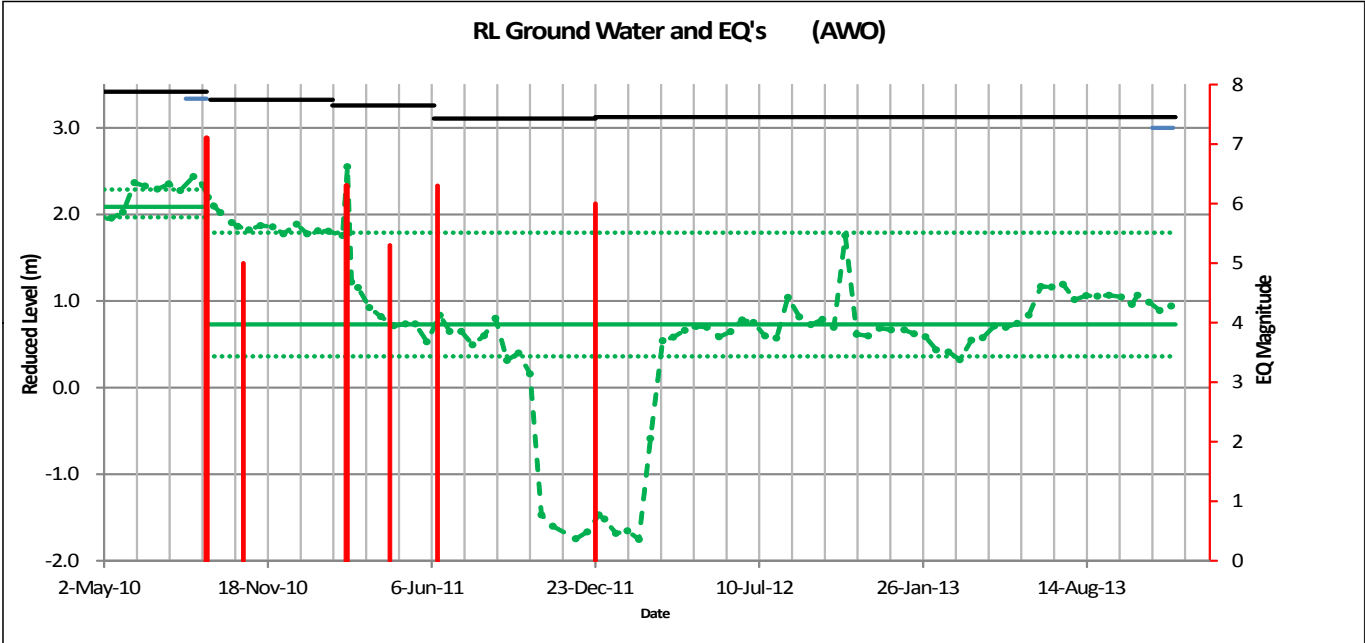
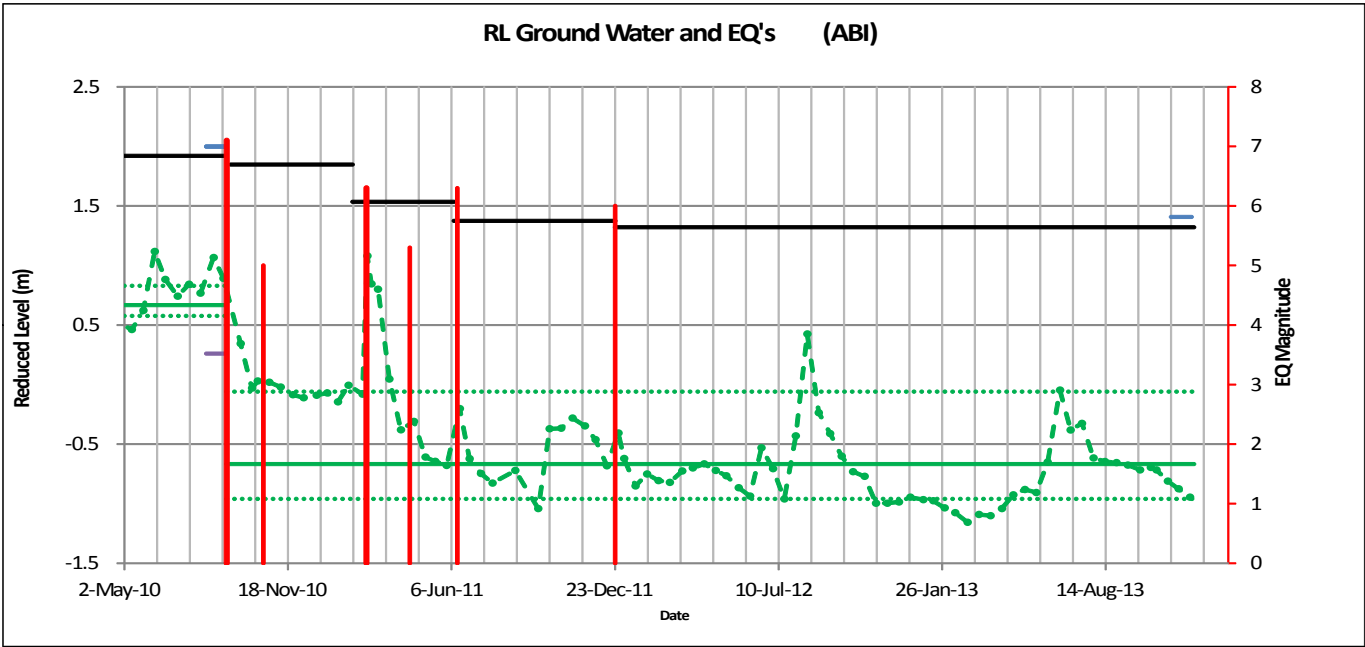
● — post DarField Earthquake

Notes:



DRAWN	JEL	May.14
CHECKED		
APPROVED		
ARCFILE 52020-0200-CPT055		
SCALE (AT A3 SIZE)		
Prepared by Tonkin & Taylor Ltd		
Ref. 52020.0200		

CHRISTCHURCH MEDIAN WATER	
TABLE ELEVATION REPORT	
Comparison of shallow groundwater elevation in monitoring wells including 2010–2011 Canterbury earthquake sequence	
FIGURE No.	Figure H.6
Rev.	



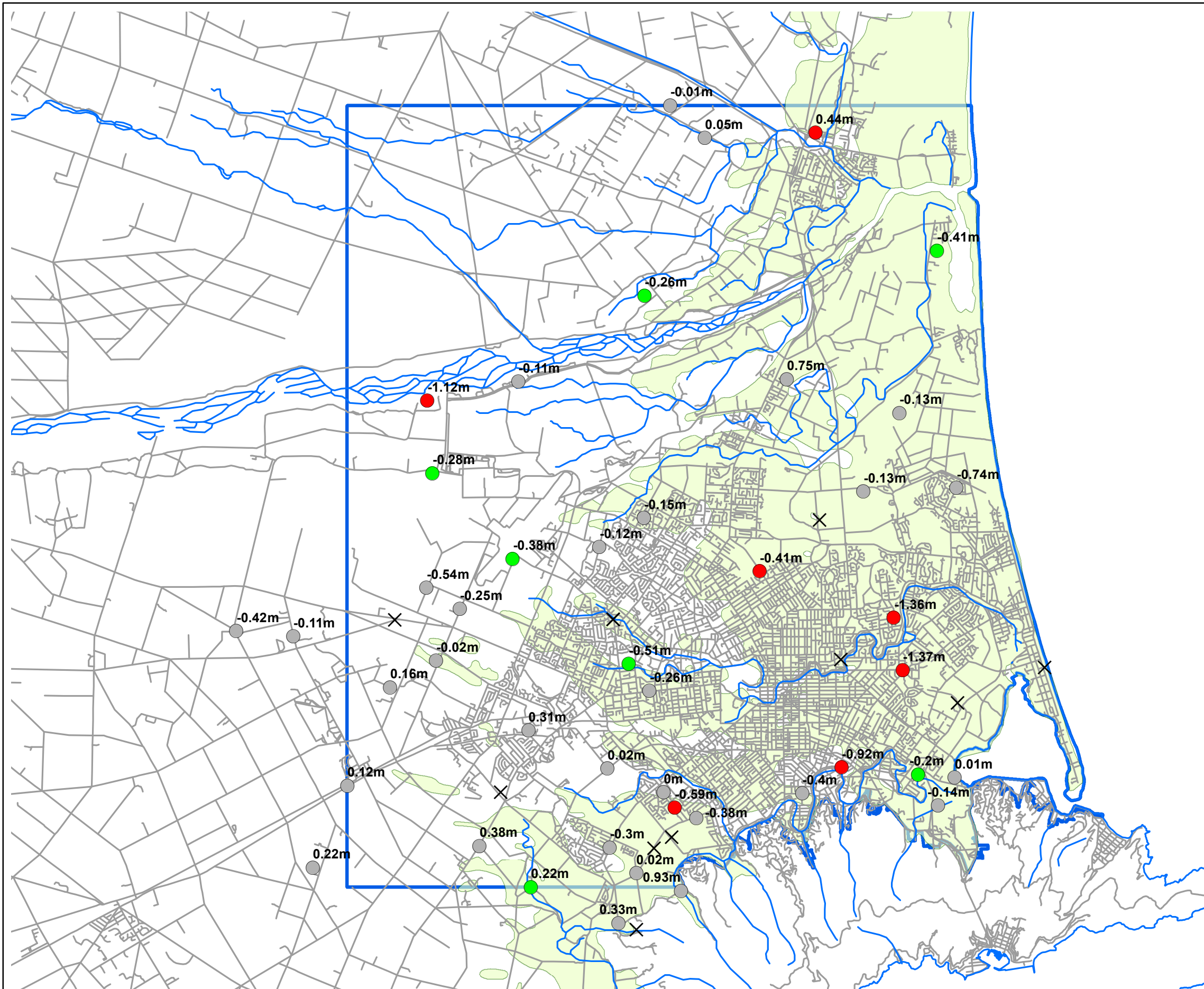
- 1990/2010 Median
- Post EQ Median
- Water level
- MP pre EQ
- Lidar ground level
- 85th & 15th percentiles
- Seismicity
- Surveyed MP elevation
- Bottom of Borehole

Notes:



DRAWN	JEL	May.14
CHECKED		
APPROVED		
ARCFILE		
52020-0200-CPT056		
SCALE (AT A3 SIZE)		
Prepared by Tonkin & Taylor Ltd		
Ref.	52020.0200	

CHRISTCHURCH MEDIAN WATER TABLE ELEVATION REPORT	
Ground & shallow groundwater elevation changes in selected monitoring wells during 2010-2011 Canterbury earthquake sequence	
FIGURE No.	Figure H.7
Rev.	0



LEGEND

**Median groundwater elevation difference
(2010-2013 minus 1990-2010)**

clearly significant

potentially significant

not significant

X

discontinuous data

River

Coastline

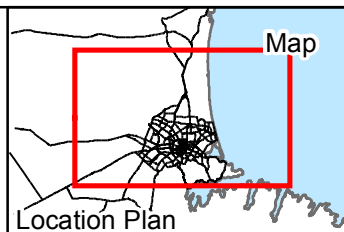
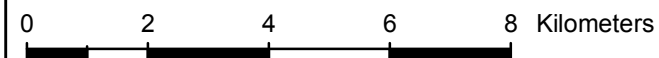
Road

Study Area

Confined aquifers

Notes: Road Database and Coastline licensed under Creative Commons Attribution 3.0 New Zealand and sourced from LINZ.
Crown Copyright Reserved

A3 SCALE 1:125,000



DRAWN	DAP	Apr.14
CHECKED		
APPROVED		
ARCFILE 52020-0200-GWM96		
SCALE (AT A3 SIZE) 1:125,000		
Prepared By Tonkin & Taylor Ltd. Ref. 52020.0200		

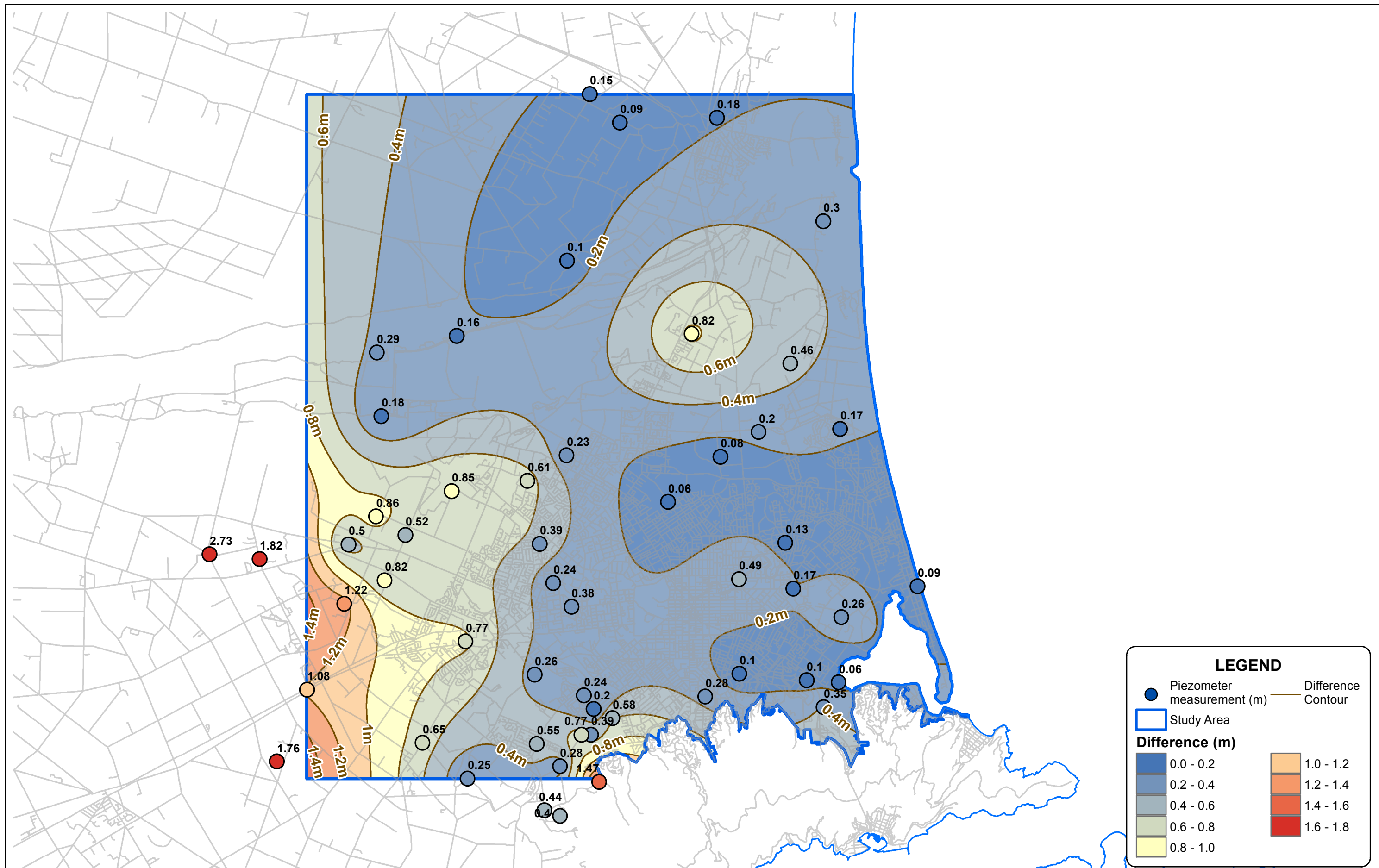
CHRISTCHURCH MEDIAN GROUNDWATER REPORT

Difference between Pre- and Post-Darfield
Earthquake median groundwater elevation

FIGURE No. Figure H.8

Rev. 0

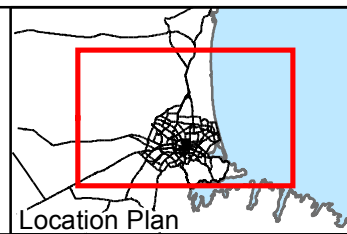
Date: 22/04/2014 Time: 5:24:35 p.m.



Notes: Road Database and Coastline licensed under Creative Commons Attribution 3.0 New Zealand and sourced from LINZ.
Crown Copyright Reserved

A3 SCALE 1:125,000

0 2 4 6 8 Kilometers



Tonkin & Taylor

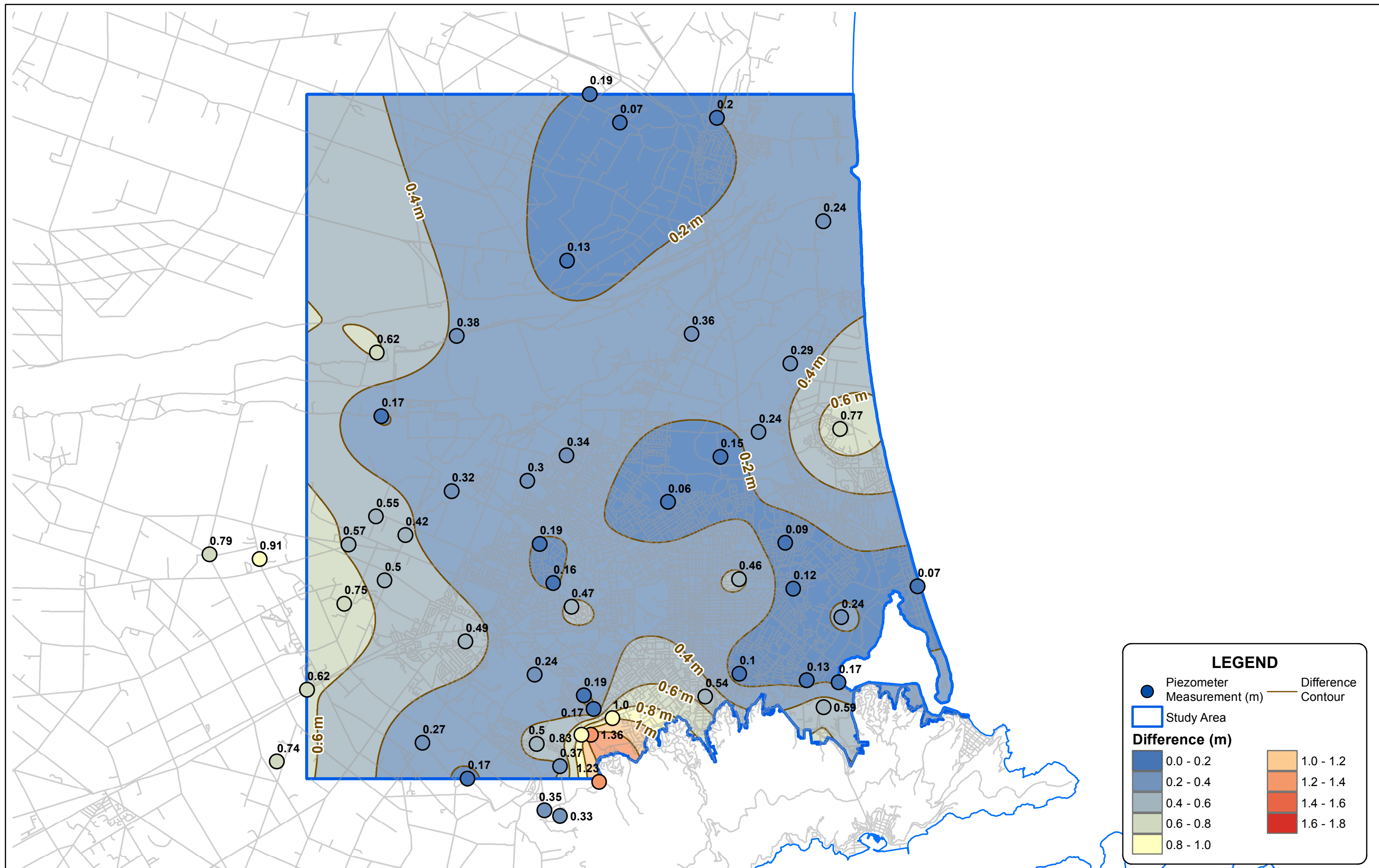
DRAWN	DAP	Apr.14
CHECKED		
APPROVED		
ARCFIELD 52020-0200-GWM93		
SCALE (AT A3 SIZE) 1:125,000		
Prepared By Tonkin & Taylor Ltd. Ref. 52020.0200		

**CHRISTCHURCH MEDIAN WATER
TABLE ELEVATION REPORT**
Difference between the 85th percentile and
median groundwater elevation 1990-2010

FIGURE No. Figure H.9

Rev. 0

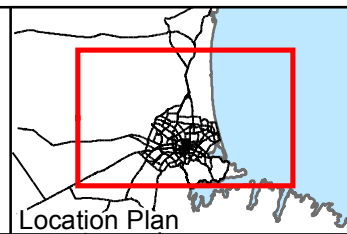
Date: 22/04/2014 Time: 5:24:36 p.m.



Notes: Road Database and Coastline licensed under Creative Commons Attribution 3.0 New Zealand and sourced from LINZ.
Crown Copyright Reserved

A3 SCALE 1:125,000

0 2 4 6 8 Kilometers



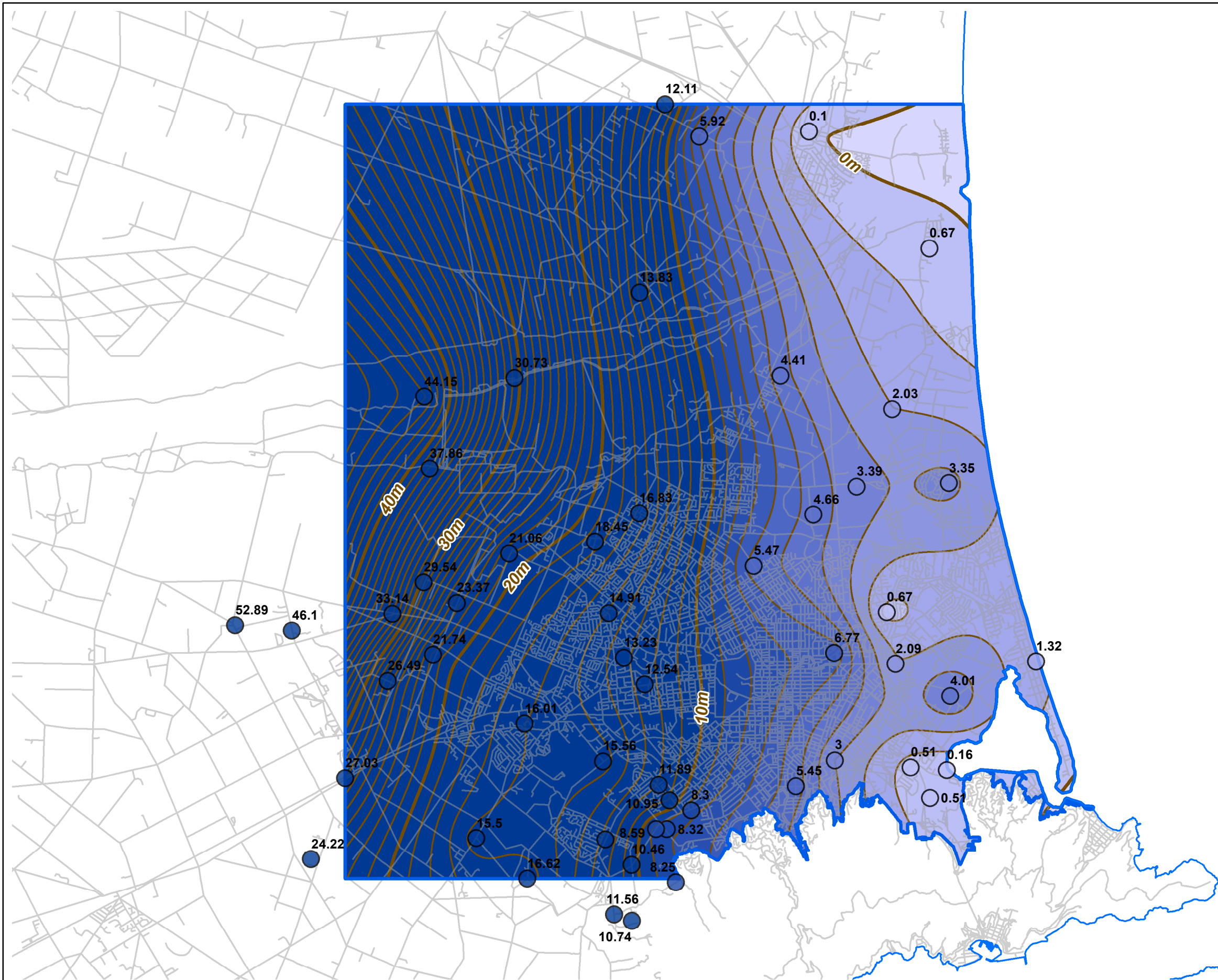
Tonkin & Taylor

DRAWN	DAP	Apr.14
CHECKED		
APPROVED		
ARCFILE 52020-0200-GWM94		
SCALE (AT A3 SIZE) 1:125,000		
Prepared By Tonkin & Taylor Ltd. Ref. 52020.0200		

**CHRISTCHURCH MEDIAN WATER
TABLE ELEVATION REPORT**
Difference between median and the 15th
percentile groundwater elevation 1990-2010

FIGURE No. Figure H.10

Rev. 0



LEGEND

● Piezometer measurement (m)

□ Study Area

— Level Contour

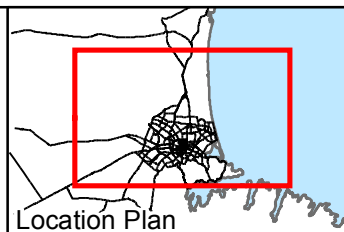
Median GW Level (m)

< 0	5 - 6
0 - 1	6 - 7
1 - 2	7 - 8
2 - 3	8 - 9
3 - 4	9 - 10
4 - 5	> 10

Notes: Road Database and Coastline licensed under Creative Commons Attribution 3.0 New Zealand and sourced from LINZ.
Crown Copyright Reserved

A3 SCALE 1:125,000

0 2 4 6 8 Kilometers



DRAWN	DAP	Apr.14
CHECKED		
APPROVED		
ARCFILE 52020-0200-GWM92		
SCALE (AT A3 SIZE) 1:125,000		
Prepared By Tonkin & Taylor Ltd. Ref. 52020.0200		

CHRISTCHURCH MEDIAN WATER TABLE ELEVATION REPORT Median groundwater elevation 1990-2010

FIGURE No. Figure H.11

Rev. 0



www.gns.cri.nz

Principal Location

1 Fairway Drive
Avalon
PO Box 30368
Lower Hutt
New Zealand
T +64-4-570 1444
F +64-4-570 4600

Other Locations

Dunedin Research Centre
764 Cumberland Street
Private Bag 1930
Dunedin
New Zealand
T +64-3-477 4050
F +64-3-477 5232

Wairakei Research Centre
114 Karetoto Road
Wairakei
Private Bag 2000, Taupo
New Zealand
T +64-7-374 8211
F +64-7-374 8199

National Isotope Centre
30 Gracefield Road
PO Box 31312
Lower Hutt
New Zealand
T +64-4-570 1444
F +64-4-570 4657