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Tasmanian Magnesite NL

Report for Arthur River ML Scoping Study

Hydrogeological Investigation

July 2011

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1. Introduction

GHD was commissioned by Stuart Capp, of Derwent Geosciences, to provide Geotechnical and Hydrogeological services to Tasmania Magnesite NL. This document presents the report covering these services at Tasmania Magnesite's Arthur River mining lease, in northwestern Tasmania as proposed in the document 53342 Rev. No. 2

This work included:

- Advice on the preferred design of pumping and monitoring bores (Document 53560)
- Supervision and a scope of works document (Document 54409) for a pumping test
- Sampling and data logger installation and analysis of results;
- Pumping test interpretation;
- Construct groundwater model consistent with previous works;
- Groundwater model calibrated to the new pumping test data (including consideration of boundary/internal model conditions such as ground and surface water connectivity);
- Model dewatering scenarios;
- Conceptual dewatering infrastructure design; and
- Recommendations for further work

2. Aquifer Monitoring

2.1 Existing data

Existing data were provided to GHD by Tasmanian Magnesite/Derwent Geosciences. This included a previous report by Golder Associates (Golder, 1999). The key data (in a coarse graphical format) pertained to a 6-day pumping test and displayed drawdowns in the pumping bore and monitoring bores. Of note, MB005 displayed little or no drawdown. The report (*ibid.*) also describes a groundwater modelling exercise undertaken using the result from this test. Golder (1999) applied the hydrogeological units of a magnesite barrier and partial barrier to deal with boundary conditions observed on site and recognised that these may be associated to the dolerite bodies.

In addition, GHD were provided a previous report undertaken by Coffey Mining for Tasmanian Magnesite N.L. (Coffey, 2010) which summarises the hydrogeological aspects of the proposed mining options at the time.

2.2 Proposed works

Previous works undertook no significant temporal monitoring other than that undertaken during the pumping test, hence how the system responds in its natural state was not well understood. GHD proposed obtaining a temporal data set to examine the dynamics of the groundwater system.

In addition to the temporal monitoring, GHD proposed that an additional pumping tests be undertaken and the monitoring network be expanded to monitor both the pumping tests and any temporal variations in groundwater levels. The modelling exercise GHD proposed could then utilise the three key data sets as observation targets:

- the Golders (1999) pumping test
- the temporal data set (BOM, GHD and Derwent Geosciences, 2011); and
- the GHD and Derwent Geosciences (2011) pumping test

The combination of the three data sets provides significantly more confidence in understanding the limitations of the modelling output.

2.3 Temporal Monitoring

Monitoring locations are presented in Figure 1 in the body of this report. Monitoring over time is presented in the Appendices of this report.

2.3.1 Barometric pressure

A single barometric pressure logging device (In-situ Rugged BaroTROLL) was deployed by GHD on 9 February 2011 in the collar of MB004, at an elevation of approximately 161 mAHD. The device was set to measure barometric pressure in 5 minute intervals and was required to correct water level logger data. A summary of the site barometric data is provided in Appendix A, Figure 1.

2.3.2 Precipitation

Precipitation was recorded on site from 21 April 2011 by Derwent Geosciences (Appendix E). The nearest weather station is Luncheon Hill (BOM, 2011). The site precipitation data were compared to Luncheon Hill and although they show a broad correlation to the frequency of precipitation at the site, they do not reflect the intensity of precipitation. In lieu of data for the entire study period, the Luncheon Hill data were used as a proxy, and scaled up by a factor of 0.75:1. A summary of the Luncheon Hill precipitation data is provided in Appendix A, Figure 2.

2.3.3 Groundwater levels

Initially, 3 groundwater level monitoring devices (in-situ Rugged TROLL 100) were deployed by GHD on 9 February 2011, in MB003, and MB004, PB002. The placement concept was to provide temporal groundwater level data for the upper, middle and lower (respectively in those bores mentioned above) sections of the magnesite aquifer associated with the proposed pit area.

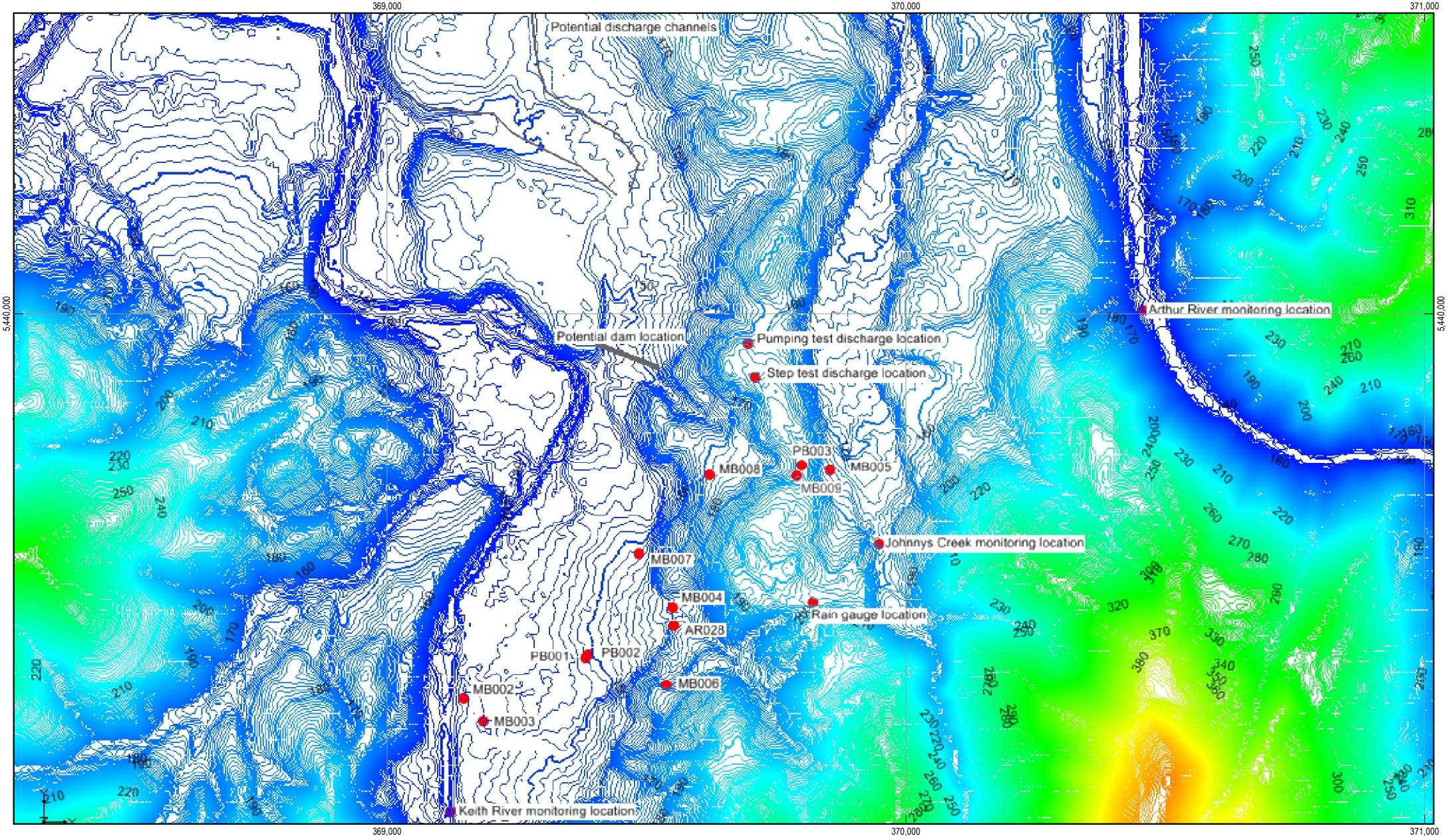
The temporal data for MB003, MB004 and PB002 are presented in Appendix A in Figures 3, 4 and 5 respectively.

During the period in which the loggers were installed, a drilling program was being undertaken, so the system was not in a completely natural state. Numerous drilling related activities are therefore observable in the groundwater level record. These provide valuable data on connectivity and confirm the general hypotheses presented in the Golder (1999) report. Derwent Geosciences provided a timeline of events, of which the notable events apparent in the groundwater level temporal dataset are:

- the airlifting of PB002 on 7 March 2011 observable in MB004, MB003
- nearby diamond drilling (AR028 drilling in dolerite) on 2 May 2011
- the airlifting of MB006, MB007 and MB008 on 11 June 2011 observable in MB004

2.4 Step Test

A stepped-rate pumping test (step test) was undertaken on PB003 to determine the maximum pumping capacity of the aquifer, bore and installed pump. Four pumping rates were tested and analysed. The full capacity of the installed pump of approximately 5L/s was deemed sustainable for the planned period of five days. Data from the step test is provided in Appendix D.



Paper Size A4

0 62.5 125 250

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Tasmania Magnesite
Hydrogeological Investigation

Job Number	32-15824
Revision	A
Date	04 Nov 2011

Monitoring locations

Figure 1

G:\32\15824\GIS\Maps\Figure1.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 62100601 E hbamail@ghd.com W www.ghd.com

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Data source: Topography data LIDAR (Tasmania Magnesite, 2011) Created by:Irevans

2.5 Pumping Test

A constant-rate pumping test was undertaken over a five day period from 10:00 AM 16 June 2011. Pumping rates were measured over time to consistently be 5 L/s. Groundwater levels were monitored in all available monitoring and pumping bores. Short-term temporal data were also gathered associated with the 2011 pumping test, using both manual readings in all monitoring bores (MB002, MB003, MB004, MB005, MB006, MB007, MB008, MB009, PB001, PB002 and PB003) and groundwater level monitoring devices (in-situ Rugged TROLL 100) in all bores excluding (MB002 PB003 and PB003) for this period. For the period that the test pump was installed in PB003, a groundwater level monitoring devices (In-situ LevelTROLL 500) was installed in PB003.

The barometric pressure readings for the period of the pumping test are displayed in Appendix B Figure 1. The short-term temporal automatic data (including the pumping test period) for the bores MB003, MB004, MB005, MB006, MB007, MB008, MB009, and PB002 are displayed in Appendix B in Figures 2, 3, 4, 5, 6, 7, 8, and 9 respectively. The short term temporal manual readings for the pumping test period in both log time (drawdowns over the pumping test period) and water table elevation over time are provided in Appendix C for:

- PB003 and MB005 in Figures 1 and 2;
- PB003 pumping in Figure 3 and 4;
- PB003 recovery in Figure 5 and 6;
- PB001 in Figure 7 and 8;
- PB002 in Figure 9 and 10;
- MB002 in Figure 11 and 12;
- MB003 in Figure 13 and 14;
- MB004 in Figure 15 and 16;
- MB005 in Figure 17 and 18;
- MB006 in Figure 19 and 20;
- MB007 in Figure 21 and 22;
- MB008 in Figure 23 and 24;
- MB009 in Figure 25 and 26;
- Arthur River in Figure 27 and 28;
- Keith River in Figure 29 and 30;
- Johnnys Creek in Figure 31 and 32; and
- Cumulative rainfall on site over the pumping period in Figure 33.

2.5.1 Pumping Test Groundwater Chemistry

Water samples were obtained from the pumped bore PB003 during the pumping test. Field parameters

were measured with a laboratory-calibrated (Thermo Fisher Scientific, 2011) TPS 90FL-MV and the samples were included in with the ongoing surface water sample set dispatch to act as a comparative set of samples. To maintain consistency with the surface water samples undertaken by Derwent Geosciences, the groundwater samples were tested for the same suite in the same manner (i.e. totals not dissolved). The groundwater sample results and surface water sample results are understood to be maintained in a database for Tasmania Magnesite by Pitt and Sherry. Field parameters are presented in Table 1. During the step test, groundwater was discharged to a drainage line, which drained towards the Keith River, 200m from the pumping boree (Figure 1). This was considered too close to MB008 by GHD and the discharge line was extended to the next drainage line, off the access road, to avoid interference between draw downs and infiltration associated to discharge of pumped water. Groundwater was discharged to a second surface water drainage line 260m from the pumped bore, that flows towards the Keith River (Figure 1). Groundwater from the pumping test was not visibly observed to be flowing into the Keith River during or after the test. The distance down the drainage line is approximately 420m and it is likely that the significant quantity leaf litter and alluvium observed in the drainage line would result in the infiltration of much or all of the discharge prior to it reaching the river over the pumping period.

Table 1 Field parameters (NR refers to not recorded).

Date Time	Location	Dissolved Oxygen "DO" (ppm)	Electrical Conductivity "EC" (uS/cm)	pH	Oxidation Reduction Potential "ORP" (mV Ag/AgCl)	Temperature "T" (^{o}C)	Comment
15/06/2011 11:26	PB003	2.87	NR	4.66	24	10.6	Water milky, no visible grains, very slight odour
15/06/2011 11:55	PB003	3	225	4.59	40	10.5	Water still yellow milky, no visible grains, very slight odour
15/06/2011 13:35	PB003	1.71	237	4.46	NR	11	Water less milky, no visible grains
15/06/2011 15:03	PB003	4.6	240	4.42	75	11	Still yellow, less milky, no visible grains
16/06/2011 10:05	PB003	6.24	160.4	4.19	70	10.7	Almost clear, slight yellow tinge
17/06/2011 08:40	PB003	5.75	275	4.38	83	11.7	Very slight yellow tinge-clear, slight mineral odour
17/06/2011 18:25	PB003	5.7	271	4.51	74	11.2	Clear
18/06/2011 10:15	PB003	5.7	279	4.88	74	11.4	Clear
19/06/2011 10:00	PB003	6.9	278	5.25	67	11.3	Clear
20/06/2011 08:41	PB003	6.29	293	5.51	75	11.7	Clear

Date Time	Location	Dissolved Oxygen "DO" (ppm)	Electrical Conductivity "EC" (uS/cm)	pH	Oxidation Reduction Potential "ORP" (mV Ag/AgCl)	Temperature "T" (^{o}C)	Comment
20/06/2011 14:05	PB003	6	273	5.96	92	11.6	Clear
16/06/2011 13:02	Keith River	15.07	43.4	4.07	132	4.9	Low flow
16/06/2011 13:50	Johnnys Creek	13.6	52.6	3.99	164	6.4	Low flow
20/06/2011 14:00	Rainwater	11.37	33.6	5.97	157	11.5	Heavy rain
20/06/2011 16:12	Drainage line	1.76	58.2	5.81	182	7.4	Stagnant, but flowing out from other side of road
20/06/2011 16:18	Arthur River	13.95	38.4	5.81	153	7.8	Raging torrent
20/06/2011 16:24	Keith River	13:54	30.9	5.75	182	8	Mid flow
20/06/2011 16:34	Johnnys Creek	14.05	49.2	5.65	228	8.4	Mid flow

3. Modelling

3.1 Steady State Model

A steady-state model was created using the following inputs:

- Geological geometry based on the digital surfaces and solids provided by Derwent Geosciences in September and October 2011;
- Initial model hydraulic conductivity values based on the Golder (1999) model input values;
- Gridded digital topographic surface data at 1 m spacing from an interpreted LIDAR survey provided by Tasmanian Magnesite;
- Starting heads based on the topographic surface at 10 m spacing;
- Initial recharge values based on the Golder (1999) model input values;
- Calibration targets based on the static water levels observed before the pumping test performed on 16 June 2011.

3.1.1 Model Development

The model development involved the generation of groundwater flow model using the finite-difference package MODFLOW and the graphical user interface GMS 8.0.

3.1.2 Model Boundaries

The boundaries of the model extended to beyond the rivers to the north, east and west of the magnesite deposit in the mining lease. To the south, the model was extended up the catchment to an area sufficiently distant from the deposit within the hanging wall material. The southern boundary is not a drainage divide, however is modelled as a no flow boundary for simplicity with the concept that this boundary is not likely to significantly affect flows within the area of interest. Beyond the rivers, the model boundaries are also modelled as no flow based on the same concept. The rivers themselves are not the true model boundaries so the effects beyond them can be inferred. The model extent is also in part limited by the extent of the LIDAR topographic information.

3.1.3 Model Grid

The model grid was created in GDA94 MGA Zone 55 at 45° to grid north, to broadly correspond to groundwater flow directions and the strike of local geological units. Grid refinement points located in the centre of the pit crests provided by Derwent Geosciences were used to refine the grid from a minimum grid spacing of 10 m, expanding with a bias of 1.1 to maximum grid sizes of 100 m.

3.1.4 Model Geometry

The model geometry is presented in Appendix F (Figure 1 to 6). The model geometry incorporated:

- The topography applied as the top of layer 1;
- The base of alluvium surface (Derwent Geosciences, 2011) applied to the base of layer 1;
- The top of fresh rock (i.e. the weathering profile) surface (Derwent Geosciences, 2011) applied to the base of layer 2;
- The topography minus a nominal 50m, 100m and 200m was applied to the base of layers 3, 4 and 5 respectively;
- A nominal elevation of -200 m AHD was applied to the base of layer 6;
- Layer overlap errors were then corrected by applying a minimum thickness of 10 m, truncated to the to the base of the overlying layer (to aid model stability and functionality).

Material types were then applied to the model grid to represent the hydrogeological units:

- In Layer 1, the material 'Alluvium' was applied to the extent of alluvium based on the surface provided and 'weathered hangingwall', 'weathered footwall' and 'weathered magnesite' were applied elsewhere based on the solids provided;
- In Layer 2, the weathered materials were applied based on the solid models provided;
- In Layer 3 to 6, the materials 'magnesite', 'footwall' and 'hangingwall' were applied based on the solid models provided;
- The four geology solids provided for dolerite were then applied manually to layers 3-5 based on its inferred spatial extent at the resolution of the model grid (in cross section 32 sections).

Based on later discussions with Derwent Geosciences, GHD requested that the magnesite solid model be extended to beyond the Keith River, to better represent field observation and to reflect initial calibration results. This geometry alteration was adjusted manually by GHD. The resultant model geometry is presented in Appendix F. It should be noted that, due to the finite-difference grid of the hydrogeological model, the geology in the solids and surfaces are not able to be represented exactly, and the model geometry presented is a representation designed to allow a 'best-fit' to the geology provided, whilst also conforming to the hydrogeological model grid constraints.

3.1.5 Model Hydraulic Conductivity

The Golder (1999) provided a base case for model hydraulic conductivity values, however, due to the changes in geometry, increase in understanding of the deposit and differing approach, the materials required further alteration through calibration.

Table 2 Hydraulic conductivity values assigned to the model

Hydrogeological unit	Kh (m/day)	Kv/Kh
Alluvium	0.2	3
Magnesite	7	3
Dolerite	0.07	3
Footwall	0.07	3
Hangingwall	0.07	3
Weathered magnesite	0.7	3
Weathered footwall	0.5	3
Weathered hangingwall	0.1	3

3.1.6 Model Recharge

The model recharge was maintained at the same rates as those applied in the Golder (1999) model, however the distribution of the differing rates varied based on the new geology geometry. It is estimated that the recharge is in the order of 15 to 20% of the precipitation. Table 3 displays the recharge values applied to the steady state model.

Table 3 Recharge values applied to the model

	Alluvium	Magnesite	Footwall	Hangingwall
(mm/year)	400	300	120	60
(m/day)	0.001095	0.000821	0.000329	0.000164

3.1.7 Model Observation Calibration Targets

The calibration of the steady state model was based on the final set of observations (a complete set on all monitoring and pumping bores) prior to the pumping test on 16 June 2011. The observations used as calibration targets are provided in Table 4. Groundwater elevations displayed a general trend decreasing from east to west. MB009 did not follow this trend and due to: (i) lack of response in the pumping test; (ii) the borehole geometry (i.e. no screen and only an open base and top) MB009 was not considered a reliable monitoring bore. Also of note, MB008 did not follow the general is trend and despite not responding to the 2011 pumping test, it is considered a reliable monitoring bore. This is due to the response to airlifting in June 2011 and the boreholes installation record (Derwent Geosciences, pers. comm., 2011), although it is recognised that this record noted the bore was left overnight and collapsed prior to confirmation of the depth of filter pack.

Table 4 Static groundwater levels 16 June 2011

Bore	Easting (GDA94 Zone 55)	Northing (GD94 Zone 55)	Water table Elevation (mAHD)
MB002	369148.04	5439259.66	143.5
MB003	369186.24	5439215.46	143.21
MB004	369551.04	5439434.45	147.16
MB005	369853.64	5439698.35	160.31
MB006	369538.44	5439284.45	144.5
MB007	369485.641	5439537.784	148.69
MB008	369621.935	5439689.18	165.99
MB009	369789.375	5439687.419	174.92
PB001	369382.94	5439336.75	145.95
PB002	369389.04	5439343.35	145.25
PB003	369799.281	5439707.941	159.63

3.1.8 Model Package Parameters

To represent the groundwater system the following MODFLOW packages have been utilised in the steady-state model:

- The rivers package has been used to represent the Keith River and Johnnys Creek (in separate zones to allow differentiation between the two);
- The general head boundary package has been used to represent the Arthur River;
- The barrier package has been used to represent the observed compartmentalisation of the magnesite aquifer that could not be explained by the provided geology alone; and
- The recharge package as discussed above.

Calibrated model parameters are presented in Table 5.

Table 5 MODFLOW package parameters

Item	Conductance (m^2/day)/m	Stage Elevation	Bed Elevation	Layer
Keith River	2	Topography-1m	Topography-2m	1 and 2
Arthur River	1	Topography-1m		1
Johnnys Creek	1	Topography-1m	Topography-2m	1

Item	Conductance (m^2/day)/m	Stage Elevation	Bed Elevation	Layer
Barriers	0.0001 to 0.00001			2-6

3.1.9 Steady State Model Outputs

The steady state model produces output in the form of:

- visual representations of calculated heads in the GUI (Appendix F Figure 7 to 12)
- calculated values for groundwater heads;
- graphical representation of the observed groundwater heads versus the calculated heads in the GUI;
- statistical analysis of the observed groundwater heads versus the calculated heads in the GUI; and
- numerical groundwater flow budget output for each of the model packages in the GUI.

The calculated values for groundwater heads from the steady state model (188TasMag.gpr) are presented in Table 6.

Table 6 Observed versus calculated groundwater elevations (188TasMag.gpr)

Borehole	Groundwater elevation observed value (mAHD)	Groundwater elevation calculated value (mAHD)
MB002	143.5	144.292
MB003	143.21	144.649
MB004	147.16	146.55
MB005	160.31	159.955
MB006	144.5	145.442
MB007	148.69	148.682
MB008	165.99	154.342
PB001	145.95	145.238
PB002	145.25	145.24
PB003	159.63	159.919

The graphical representation of these values demonstrates an acceptable calibration for all monitoring bores apart from MB008 (Table 7 and Figure 2).

Table 7 Steady-state model residuals

Model measure of error	All bores	All bores (excluding MB008)
Mean Residual (m Head)	0.99	-0.20
Mean Absolute Residual (m Head)	1.68	0.57
Root Mean Squared (RMS) Residual (m Head)	3.75	0.72
Scaled RMS (%)	16%	4%

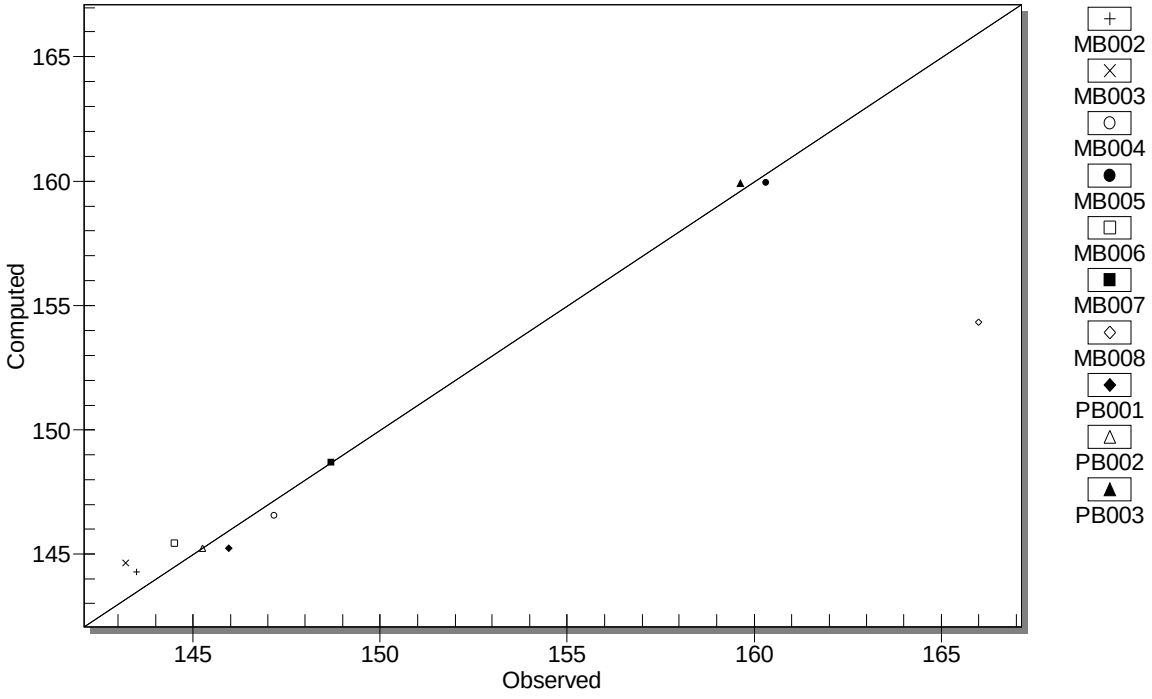


Figure 2 Steady state calibration observed versus computed values (mAHD)

Critical aspects for the flow budget within the model are provided in Table 8.

Table 8 Steady state flow budget

	Johnnys Creek	Keith River	Arthur River	Total model area
Recharge (m^3/day)				3071
Rivers in (m^3/day)	996	2115		

	Johnnys Creek	Keith River	Arthur River	Total model area
Rivers out (m^3/day)	498	3768		
General head in (m^3/day)			396	
General head out (m^3/day)			1881	

3.1.10 Steady State Model Discussion

The steady-state model was able to produce calculated heads that represented the groundwater observations. That the model was unable to represent the elevated groundwater level observed in MB008 demonstrates that there is not a high degree of confidence in the model in this area. Calibration could be improved by increasing the recharge locally around MB008 and such an increase may be justified by the presence of coarse grained alluvium observed in the area or the geometry of drainage lines which may result in a localised increased recharge. Increased recharge coupled by a better understanding of the geometry and properties of barriers in the area are likely to improve the calibration further, however, without additional data or analysis, this was not undertaken as part of this study.

3.2 PB002 Pumping Test 1999 Transient Model

3.2.1 PB002 Pumping Test 1999 Transient Model Inputs

The pumping test conducted in 1999 was the first calibration target for the transient model. The pumping test outlined in (Golder, 1999). The flow rates of 10L/s from 10:45 AM 8 April 1999 to 10:45 AM 11 April 1999 and then at 14L/s until 10:00 AM 14 April 1999 were applied to the wells package. The transient model was designed to run from 12:00 AM 8 April 1999 to 12:00 AM 19 April 1999 with hourly stress periods with a single time step in each stress period.

The calibrated steady state flow model provided the following input for the transient models:

- starting heads;
- hydraulic conductivity parameters;
- recharge parameters;
- model grid;
- model geometry;
- model package parameters.

The remaining parameters requiring calibration for a transient model included specific yield and specific storage.

Table 9 Hydraulic parameter values assigned to the transient models

Hydrogeological unit	Specific storage (1/m)	Specific yield
Alluvium	0.00001	0.0001
Magnesite	0.00001	0.0001
Dolerite	0.00001	0.0001
Footwall	0.00001	0.0001
Hangingwall	0.00001	0.0001
Weathered magnesite	0.00001	0.0001
Weathered footwall	0.00001	0.0001
Weathered hangingwall	0.00001	0.0001

3.2.2 PB002 Pumping Test 1999 Transient Model Outputs

Transient model (306TasMag.gpr) outputs include:

- visual representations of calculated heads in the GUI
- calculated values for groundwater heads over time (to be compared to the 1999 observations);
- graphical representation of the calculated heads over time in the GUI; and
- numerical groundwater flow budget output for each of the model packages over time in the GUI.

In the case of the pumping test in PB002 the most relevant output are the graphical representation of the calculated heads over time in the GUI compared with the output from the Golders (1999) observations (e.g. Figure 3).

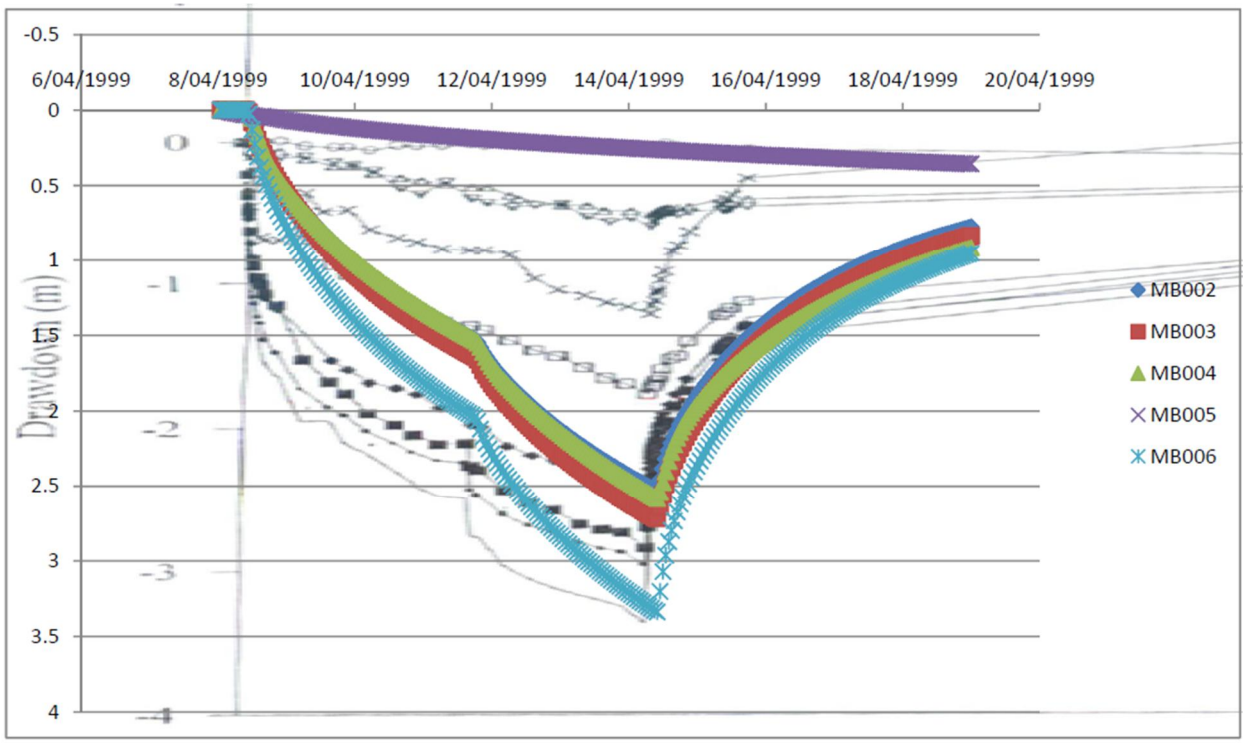


Figure 3 Example of observations from monitoring bores (Golders, 1999) versus modelled values (example is from 306TasMag.gpr)

3.2.3 PB002 Pumping Test 1999 Transient Model Discussion

The calibrated transient model calculated heads demonstrated a reasonable match to the observation displayed in the Golders (1999). Such a calibration demonstrates confidence in the model to provide valid prediction for the dewatering scenario.

3.3 PB003 Pumping Test 2011 Transient Model

3.3.1 PB003 Pumping Test 2011 Transient Model Inputs

The PB003 pumping test 2011 clearly displayed observable drawdowns in only MB005 (and the pumped bore PB003). This further supported the compartmental hypothesis for the magnesite aquifer. The monitoring in the additional bores did not demonstrate any drawdown associated to the pumping test and recharge associated to significant precipitation part way through the pumping test resulted in increases in groundwater elevations.

The transient model was designed to run from 12:00 AM 16 June 2011 to 12:00 AM 1 July 2011 with hourly stress periods with a single time step in each stress period.

Building on the transient model for the 1999 pumping test, the 2011 pumping test was represented in the model 404TasMag.gpr. The rate of 5L/s was applied in the model to PB003 using the wells package.

The notable difference between the two models was that calibration of the PB003 model required a calibrated value of 0.00005 for specific storage (1/m) to better represent the observed values locally.

Unlike the PB002 pumping test 1999 which applied the steady state recharge rate, an attempt was made to apply local rainfall to recharge to the PB003 pumping test 2011. Recharge was based on a similar ratio to the steady state model assuming an annual rainfall of 2500 mm but scaled to the actual rainfall that was measured during the pumping test. For example, as the steady state model applied 400 mm per year to the alluvium, if 5 mm was recorded in a set period, 5mm times 400/2500 was applied for that period.

3.3.2 PB003 Pumping Test 2011 Transient Model Outputs

Unlike the PB002 pumping pest 1999, the PB003 pumping test 2011 had a considerable digital dataset, which enabled the presentation of observed groundwater heads over time versus the calibrated groundwater heads over time (Appendix F Figure 14 to 15). This aided the additional calibration of the model in the area and gave greater confidence in the model parameters. There is scope for additional calibration to focus on these outputs to provide a greater confidence in the recharge and aquifer parameters, however, this was not undertaken as part of this study.

3.3.3 PB003 Pumping Test 2011 Transient Model Discussion

The model demonstrated that it could adequately represent the pumping test and recovery. That the model required additional calibration and changes in parameters suggest that either the aquifer has different storage properties in the PB003 area or that the assumptions around the barrier locations are not fully representative of the natural system. That a representative drawdown and recovery was able to modelled provides confidence that a dewatering scenario can be applied to model in its current form.

3.4 2011 Temporal Transient Model

3.4.1 2011 Temporal Transient Model Inputs

In addition to the pumping tests having the ability to ‘stress’ (change the conditions) an aquifer, the natural changes in the environment also ‘stress’ the aquifer and the response from this can be observed. Using a similar approach adopted for the recharge in the PB003 Pumping Test 2011, an attempt was made to provide recharge input to the 2011 temporal model (501TasMag.gpr). In lieu of site-based precipitation recording over the period, data from Luncheon Hill as described in section 2.3.2 was used as recharge input. The wells package was utilised to represent an airlift in PB002 that was undertaken during the model period. The transient model was designed to run from 12:00 AM 1 January 2011 to 12:00 AM 17 June 2011 with daily stress periods with a single time step in each stress period.

3.4.2 2011 Temporal Transient Model Outputs

Like the previous transient models, the key output were the observed groundwater levels versus the modelled groundwater levels over time (Appendix F Figure 16 to 18) for 501TasMag.gpr.

3.4.3 2011 Temporal Transient Model Discussion

The outputs demonstrated that the recharge applied to the model gave less pronounced responses in the aquifer than those calculated by the model (501TasMag.gpr). The demonstrates that recharge is a key factor that may require further attention if a more definitive groundwater model is required to provide greater confidence in the predict dewatering scenarios. It may also reflect underestimation of storage coefficients, especially unconfined storage in the upper layers. Additional calibration indicated that an unconfined storage (specific yield) value of 0.1 may be more appropriate (503TasMag.gpr). It should be noted that changes in specific yield did not greatly affect the mine dewatering scenario output presented below.

3.5 Mine Dewatering Scenario Transient Model

3.5.1 Mine Dewatering Scenario Transient Model Inputs

A nominal mine dewatering scenario was developed using a nominal mine schedule to form the base case for dewatering. The transient model was designed to run from 12:00 AM 1 January 2013 to 12:00 AM 1 January 2024 with monthly stress periods, with a single time step in each stress period. The pit crests provided by Derwent Geosciences were used to create a very simplified pit shell based on a series of 10m benches, with an overall angle of 45°. The MODFLOW Drains package was utilised, based on the schedule outlined in Table 10 and Table 11. Recharge was applied as in the steady state model. The model was purely operational (i.e. pumps on) and does not take into consideration any closure scenario. A model 700TasMag.gpr was run with the exact scenario (minus the drains package) to provide a validation tool that the without the dewatering imposed on the system to ensure there was no drift in the transient model.

Table 10 Western pit drain elevations for bench polygons over time

Bench Elevation	150	140	130	120	110	100	90	80	70	60	50
Drain Elevation											
1/01/2013	150	150	150	150	150	150	150	150	150	150	150
1/01/2014	150	140	140	140	140	140	140	140	140	140	140
1/01/2015	150	140	130	130	130	130	130	130	130	130	130
1/01/2016	150	140	130	120	120	120	120	120	120	120	120
31/12/2016	150	140	130	120	110	110	110	110	110	110	110
31/12/2017	150	140	130	120	110	100	100	100	100	100	100
31/12/2018	150	140	130	120	110	100	90	90	90	90	90

Bench Elevation	150	140	130	120	110	100	90	80	70	60	50
Drain Elevation											
31/12/2019	150	140	130	120	110	100	90	80	80	80	80
30/12/2020	150	140	130	120	110	100	90	80	70	70	70
30/12/2021	150	140	130	120	110	100	90	80	70	60	60
30/12/2022	150	140	130	120	110	100	90	80	70	60	50
30/12/2023	150	140	130	120	110	100	90	80	70	60	50

Table 11 Eastern pit drain elevations for bench polygons over time

Bench Elevation	180	170	160	150	140	130	120	110
Drain Elevation								
1/01/2013	180	180	180	180	180	180	180	180
1/01/2014	180	170	170	170	170	170	170	170
1/01/2015	180	170	160	160	160	160	160	160
1/01/2016	180	170	160	150	150	150	150	150
31/12/2016	180	170	160	150	140	140	140	140
31/12/2017	180	170	160	150	140	130	130	130
31/12/2018	180	170	160	150	140	130	120	120
31/12/2019	180	170	160	150	140	130	120	110
30/12/2020	180	170	160	150	140	130	120	110
30/12/2021	180	170	160	150	140	130	120	110
30/12/2022	180	170	160	150	140	130	120	110
30/12/2023	180	170	160	150	140	130	120	110

3.5.2 Mine Dewatering Scenario Transient Model Outputs

The mine dewatering scenario transient model outputs were the visual representations of groundwater elevations and drawdowns in the model over time. An example of the outputs for the final stress period is provided in Appendix F, Figure 19 to 20). In addition to this, the flow budget outputs are also of

significance. The important flows are the predicted dewatering rates required to meet the mine schedule (Figure 4 and Figure 5). Whilst the current model is designed to be used as a predictive model to understand mine dewatering, it may also be used to estimate the influence on the surrounding environment. It must be stressed that the flow volumes produced in this modelling exercise require significantly more confidence before they could be considered definitive and referring to these flows relative to environmental consequences requires consideration of this qualification.

Important flows from an environmental context include changes in flows in and out of the model at Johnnys Creek, the Keith River and the Arthur River (Figure 6, Figure 7, and Figure 8 respectively) relative to the steady state model (Table 8). Drawdown in groundwater levels may also be important from an environmental context. Determining the environmental consequences of mine dewatering is considered beyond the scope of this study.

Figure 4 Western pit dewatering rate (m^3/day)

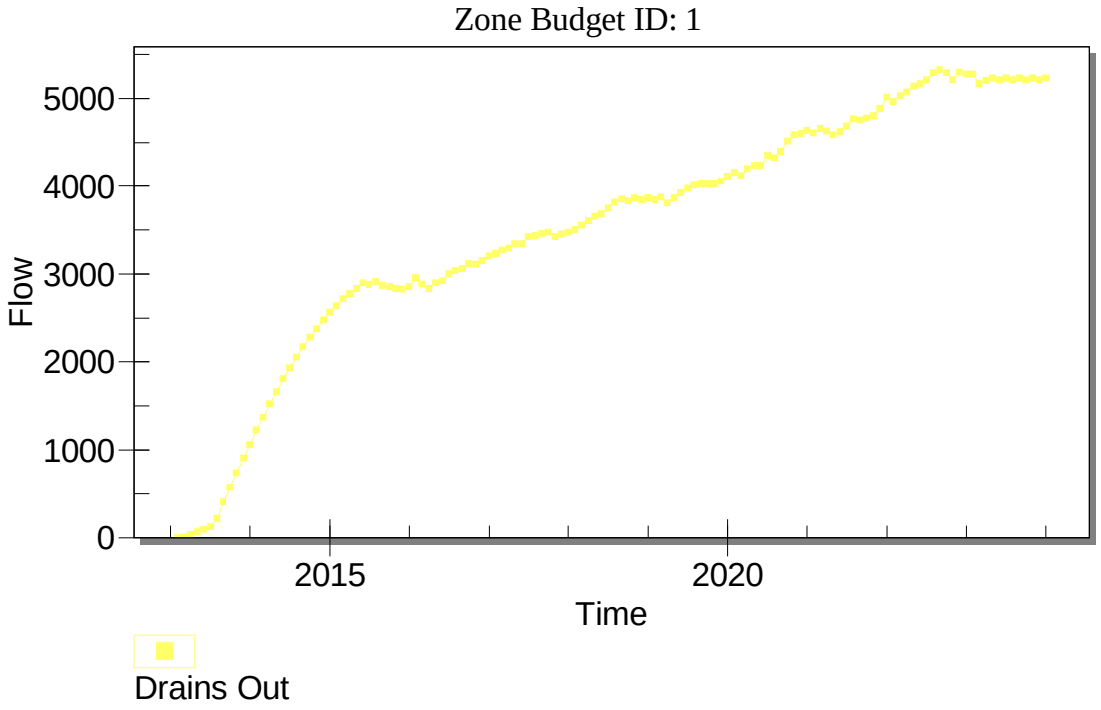


Figure 5 Eastern pit dewatering rate (m^3/day)

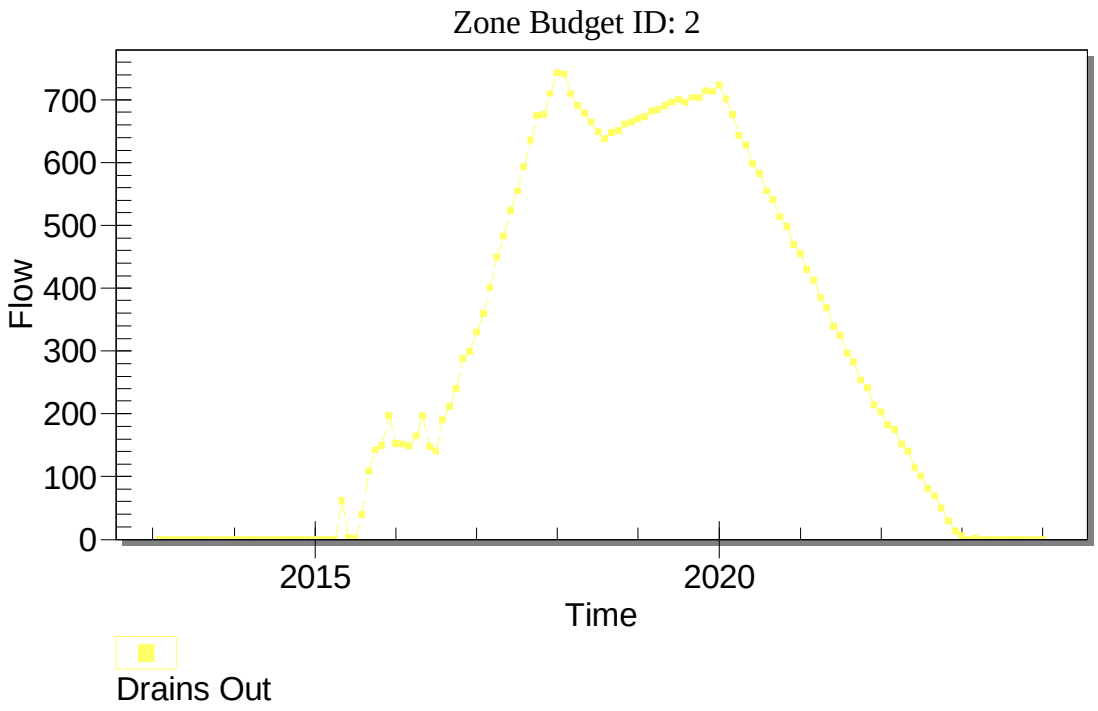


Figure 6 Johnnys Creek model groundwater exchange rate (m^3/day) over time

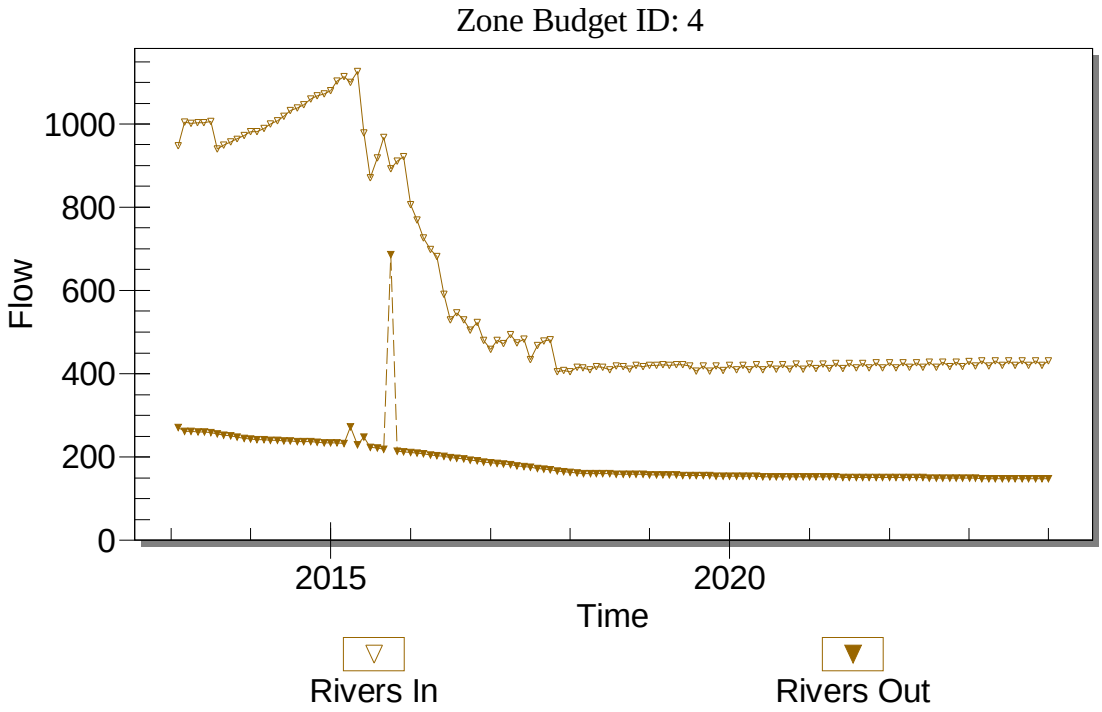


Figure 7 Keith River model groundwater exchange rate (m^3/day) over time

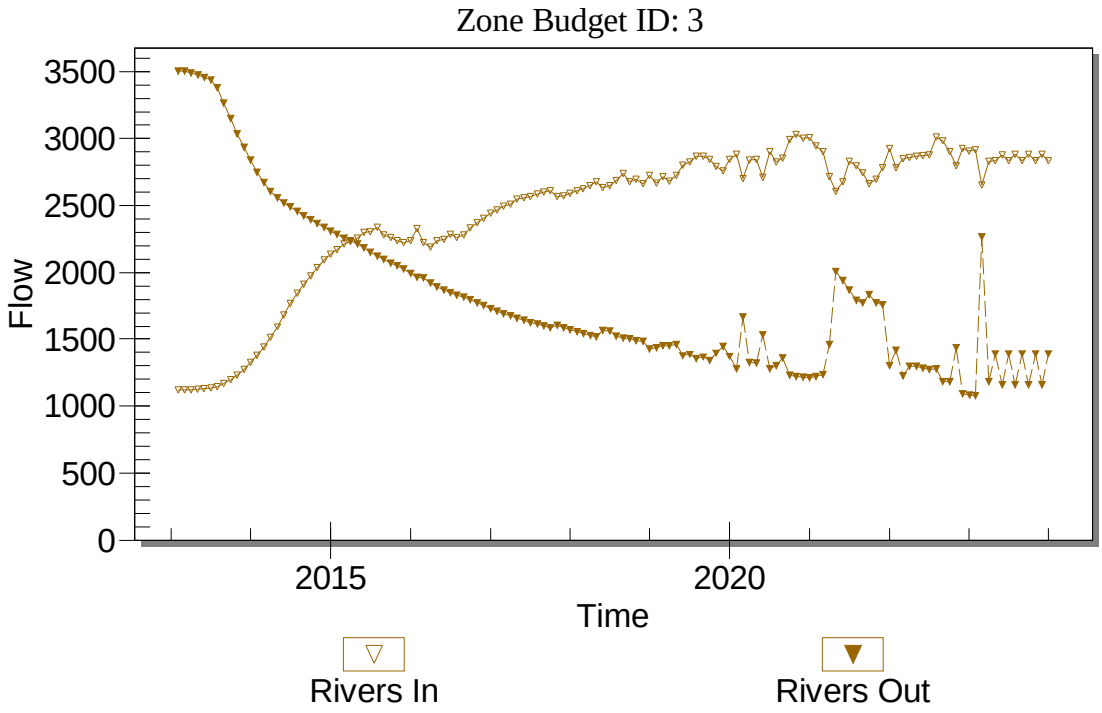
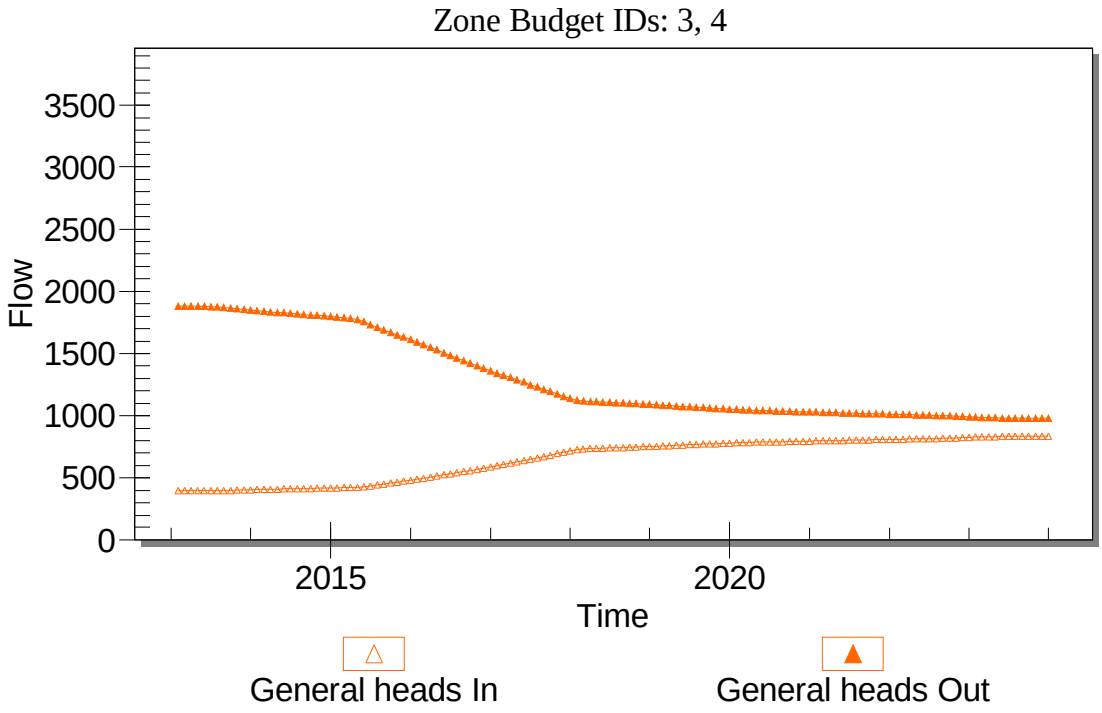


Figure 8 Arthur River model groundwater exchange rate (m^3/day) over time



3.5.3 Mine Dewatering Scenario Temporal Transient Model Discussion

Modelled dewatering in the pits peaked in the order of 62 L/s and 9L/s for the western and eastern pits respectively (Figure 4 and Figure 5). The key difference between these pits is the likely depth of the pits. Starting at 190mAHD, the maximum depth bench elevation of the east pit was assigned at 110mAHD based on an overall angle of 45°. The west starting at 160mAHD was a pit assigned a maximum depth bench elevation of 50mAHD based on overall angle of 45°.

The mine dewatering scenario indicated that the amount of modelled water that Johnnys Creek contributes to the aquifer (denoted as Rivers In in Figure 6) decreased over time as did the amount of modelled groundwater that discharges into Johnnys Creek (denoted as Rivers Out in Figure 6). The mine dewatering scenario indicated that the amount of modelled groundwater that discharges into the Keith River (denoted as Rivers Out in Figure 7) decreases over time and the amount of modelled water that the Keith River contributes to the aquifer (denoted as Rivers In in Figure 7) increases over time as mining progresses. The mine dewatering scenario indicated that the Arthur River (denoted as Rivers Out in Figure 8) decreases over time and the amount of modelled water that the Arthur River contributes to the aquifer (denoted as Rivers In in Figure 8) increases over time as mining progresses. Expressed as a precent the decrease in baseflow in the Keith River based on the Golders (1999) estimate of 870L/s is 3%.

A detailed sensitivity analysis of the model parameters has not been undertaken and is recommended as an action for further work.

4. Mine Dewatering

Given the wet temperate climatic condition at the Arthur River and the year-round precipitation, it is likely that precipitation and runoff will require active pumping from the lowest pit bench. As a result, GHD considers it likely that sump pumping will be an appropriate means to control pit dewatering. Should advanced, out-of-pit dewatering be necessary (i.e. for geotechnical reasons) a dewatering and interception bore system may be appropriate. It is likely that the placement of such bores would be along strike both up gradient and down gradient.

4.1 Compartmentalisation and dewatering

It should be noted that the inferred barrier boundary observed in the pumping tests and water levels is likely to be straddled by the east pit. The compartmental nature (the presence of inferred barriers) of the magnesite aquifer presents both possible benefits and difficulties for the proposed mining operation. Potential benefits associated to the compartmental nature of the aquifer are:

- That the hydraulic barriers control the flow of groundwater along-strike, limiting the extent of draw down associated to mining;
- That mining (if only associated to the east pit) potentially may only a limited effect on water levels in the Johnnys Creek catchment.
- That mining (if only associated to the west pit) potentially may only a limited effect on water levels in the Keith River catchment.

Potential difficulties associated to the compartmental nature of the aquifer are:

- Potentially steep hydraulic gradients adjacent to pit walls;
- Potential alteration of the hydraulic barriers properties as dewatering, blasting and mining progresses.

Understanding the geometry, nature and extent of the barriers is a key goal for future work at the site. A better understanding could be obtained from further analysis of the existing dataset; more detailed drilling focussing on these barriers, further geophysical investigation and additional site based hydraulic characterisation for example small scale pumping tests on individual monitoring bores.

4.2 Pumping Infrastructure

Given the calculated flow rates of approximately 60L/s, a nominal 100L/s rate was considered appropriate for the sizing of a sump pump to allow for groundwater inflow and manage incidental rainfall. Incident rainfall averages about 2L/s, however, the 100L/s is a nominal figure applied in order to be able to manage periods of higher flow and maintain a working bench. Depending on the actual inflows, actual rainfall, mining schedule requirements and sump capacities this will need to be revisited. A single base case cost estimate for the pumping infrastructure was obtained using a series of assumptions:

- Pipeline Inlet RL of 50m AHD. High point RL of 160m AHD. IE Static Head of 110m;

- High point occurs at outlet (although it is recognised this may not be the case);
- Flow rate of 100 L/s;
- DN 250 PE Pipe;
- Submersible Pump;
- Pipeline Length 2000m;
- Dynamic Head (developed utilising material roughness Max 0.6mm, minor losses k=10) of 45m. IE Total Head 155m;
- Pump power (developed using Specific Gravity of 1.0 and Total Efficiency (Motor & Pump) of 0.6) equal to 253 kW; and
- Power supply has not been considered.

Appendix G provides 2 methods of calculating a cost estimate which was calculated to be $1.2M. The cost estimate is a preliminary estimate only and should not be used for any other purpose. Actual prices, costs and other variables may be different to those used to prepare the cost estimate and may change. GHD does not represent, warrant or guarantee that the dewatering can or will be undertaken at a cost which is the same or less than the cost estimate.

The costing assumes the operation of one pit with a contingency pump. An in-pit generator or power supply to the pump has not been costed, nor has the ongoing operating cost. Depending on the mining approach/scheduling, a pontoon or skid mounted unit or set of units may be more practical, however, such units have not been considered in the above costing. The assumption of an annual maintenance (OPEX) at 5% of CAPEX (not including power consumption) covers parts and labour but does not include on site dewatering personnel. Appendix H has been added as an addendum upon specific request from S. Capp of Derwent Geosciences (2011), this addendum provides an example power usage based upon an example set of pit designs provided by S. Capp.

4.3 Water Management Infrastructure

Without a detailed water management plan, and an understanding of the requirements for discharge the design and costing of water management infrastructure cannot be determined. Golder (1999) proposed a water retaining structure to assist in the settlement of suspended solids prior to discharge. Coffey Mining (2010) proposed the potential use of existing drainage features for the location of such a feature. Whilst the feasibility and appropriateness of such a structure has not assessed the details are provided below:

Approximate potential water retaining structure height 10 m

Approximate potential water retaining structure height 170 m

Approximate potential water retaining location (Figure 1)

Approximate length of potential drainage outflow channel to Arthur River 815 m

Seepage from such a structure has not been considered in the modelling scenarios presented herein.

5. Conclusions and Recommendations

The dewatering scenarios presented herein assume dewatering is undertaken using in-pit sump pumping (or bores). The preliminary dewatering estimates indicated that peak flows of in the order of 60L/s could be expected based on the assumptions presented herein. Local drawdowns in the magnesite aquifer are likely to be significant but controlled to an extent by compartmentalisation in the aquifer, the footwall and hangingwall material and inflows from (or decreased outflows to) the Keith River and Arthur River.

The site now has two short-term, 5-6 day, pumping tests that provide a sound background for testing a 'stressed' aquifer. In addition, the temporal monitoring over the first half of the year (2011) provides a significant dataset for potential calibration of a recharge factor relative to nearby weather stations. Additional monitoring would benefit significantly from routine or automatic monitoring of rainfall on site. Over the period where rainfall was obtained in 2011, additional calibration may be able to better refine the recharge (and associated aquifer properties) component of these existing models. At present there does appear to be adequate coverage of monitoring bores in the magnesite deposit, however, if mining proceeds additional bores are likely to be required.

The calibration of the model could benefit from further work to:

- establish convergence at a lower convergence criterion;
- better define the location/likely properties of the of the barriers; and hence
- provide greater confidence in the model results and prediction estimates.

In addition to additional calibration a number of items are proposed for further works at future:

- reinvestigate the existing core with a focus on defining and delineating the barrier materials
- additional bores in the footwall and hanging would allow better calibration beyond the magnesite deposit;
- additional bores targeting isolated flow zones or barrier zones;

Changes in pit geometry, location and mining schedule may require rerunning of the model. The environmental consequences of drawdowns associated to mine dewatering have not yet been considered and may require a separate assessment before mining proceeds.

A detailed sensitivity analysis of the model parameters has not been undertaken and is recommended as an action for further work to determine the level of confidence in the scenarios provided herein.

6. References

Coffey Mining Pty Ltd (Coffey), 2010, Arthur River Deposit Hydrogeological Review Beacon Hill Resources MINEHOBA00297AA_RE01

Golder Associates Pty Ltd (Golder), 1999, Preliminary Groundwater Study Crest – Multiplex Magnesite Project West Takone Tasmania, Submitted to Pitt & Sherry, July, 1999

Appendix A

2011 Temporal Data

Figure 1 Arthur River ML barometric pressure (hPa at 161 m AHD) 2
Figure 2 Luncheon Hill daily rainfall (BOM, 2011) 3
Figure 3 MB003 water level (m AHD) 4
Figure 4 MB004 water level (m AHD) 5
Figure 5 PB002 water level (m AHD) 6

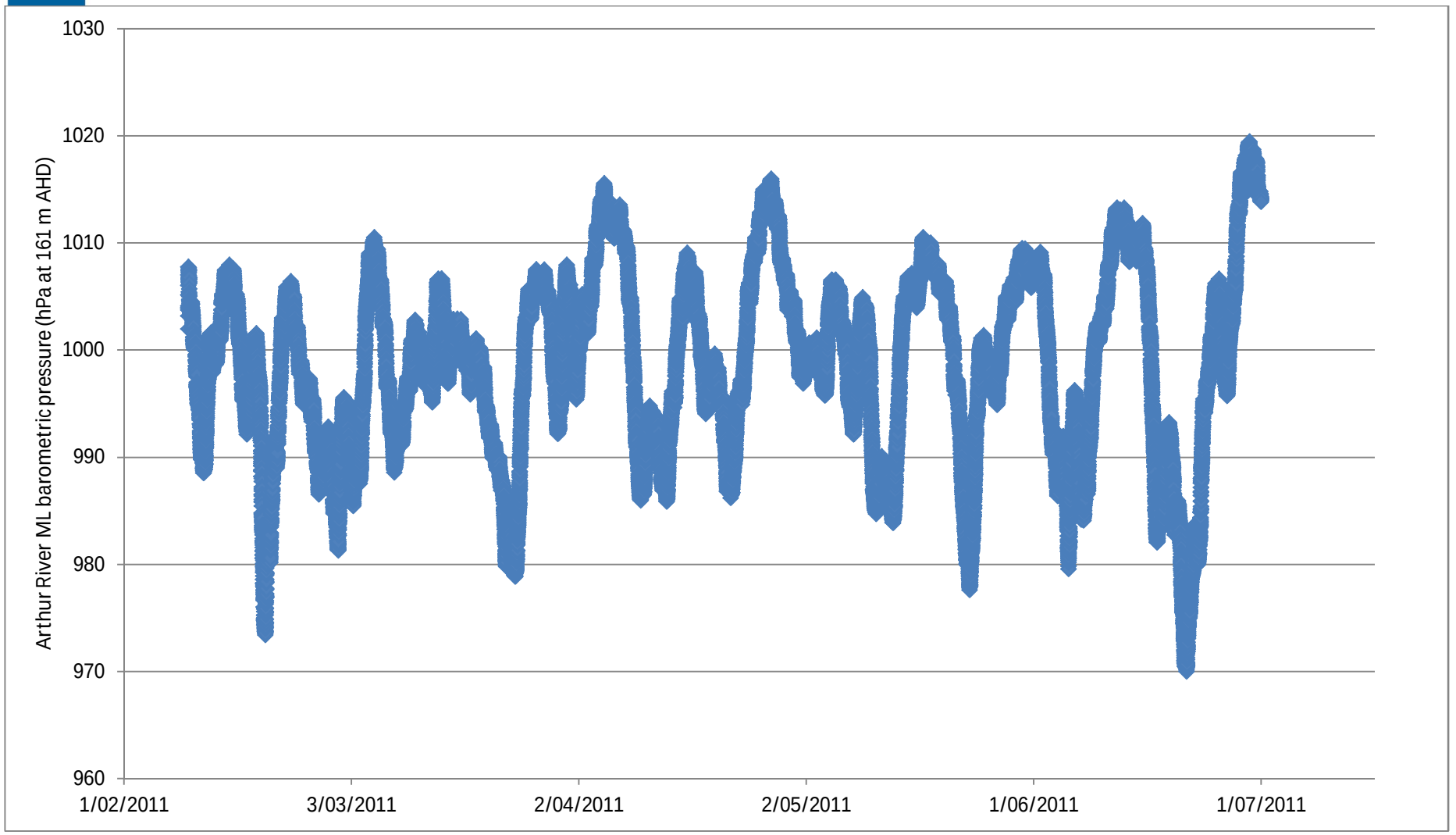


Figure 1 Arthur River ML barometric pressure (hPa at 161 m AHD)

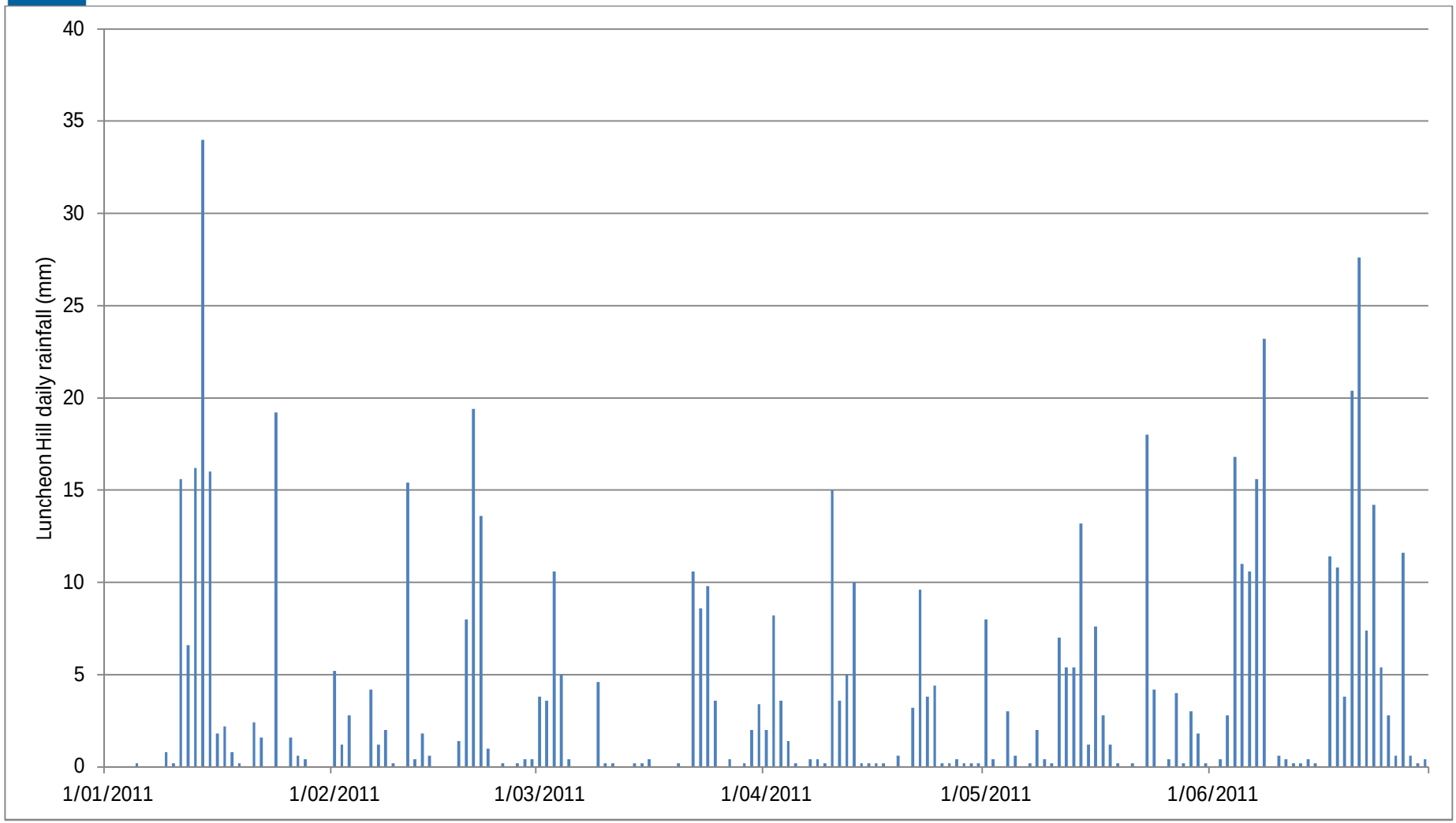


Figure 2 Luncheon Hill daily rainfall (BOM, 2011)

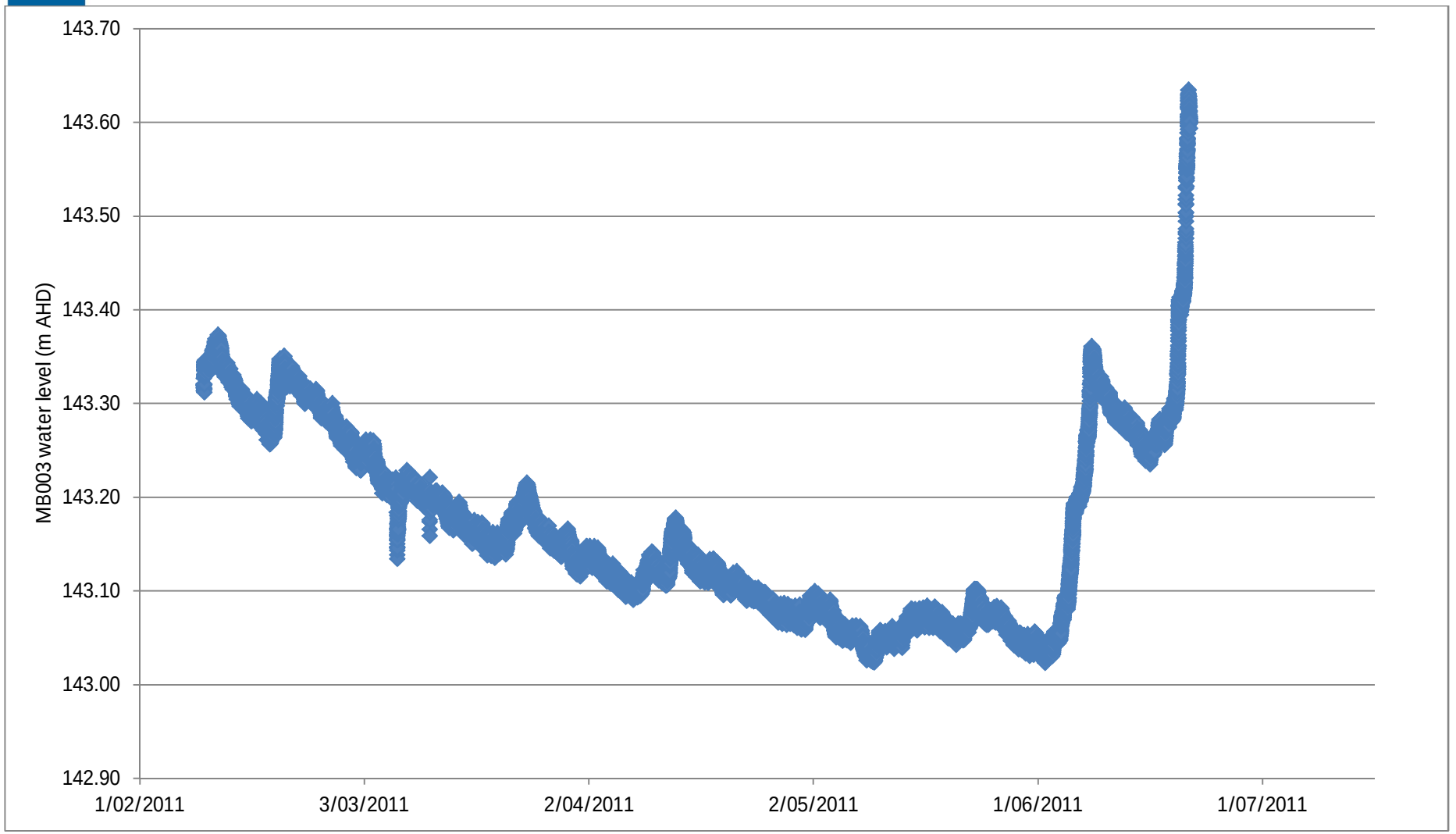


Figure 3 MB003 water level (m AHD)

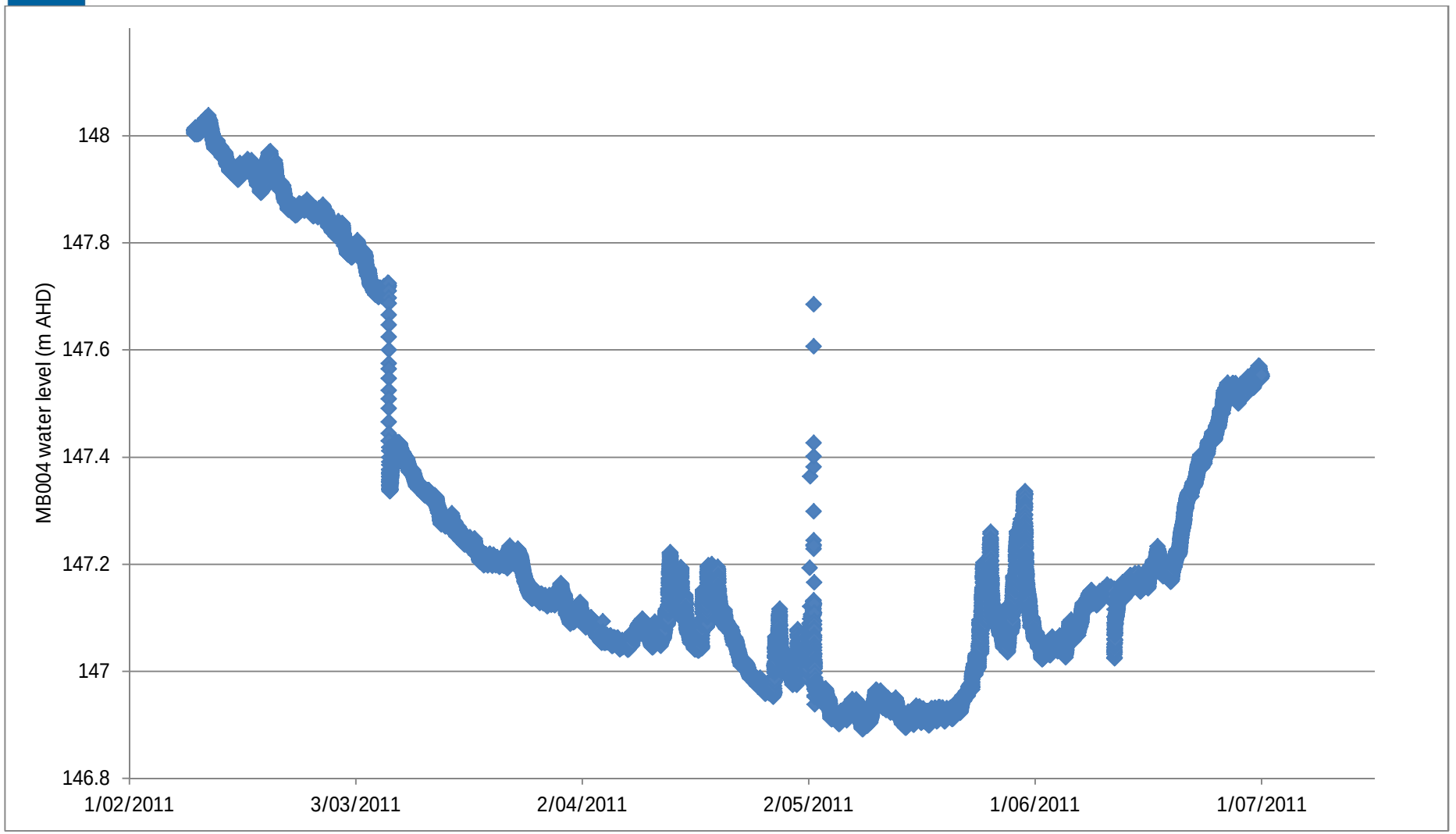


Figure 4 MB004 water level (m AHD)

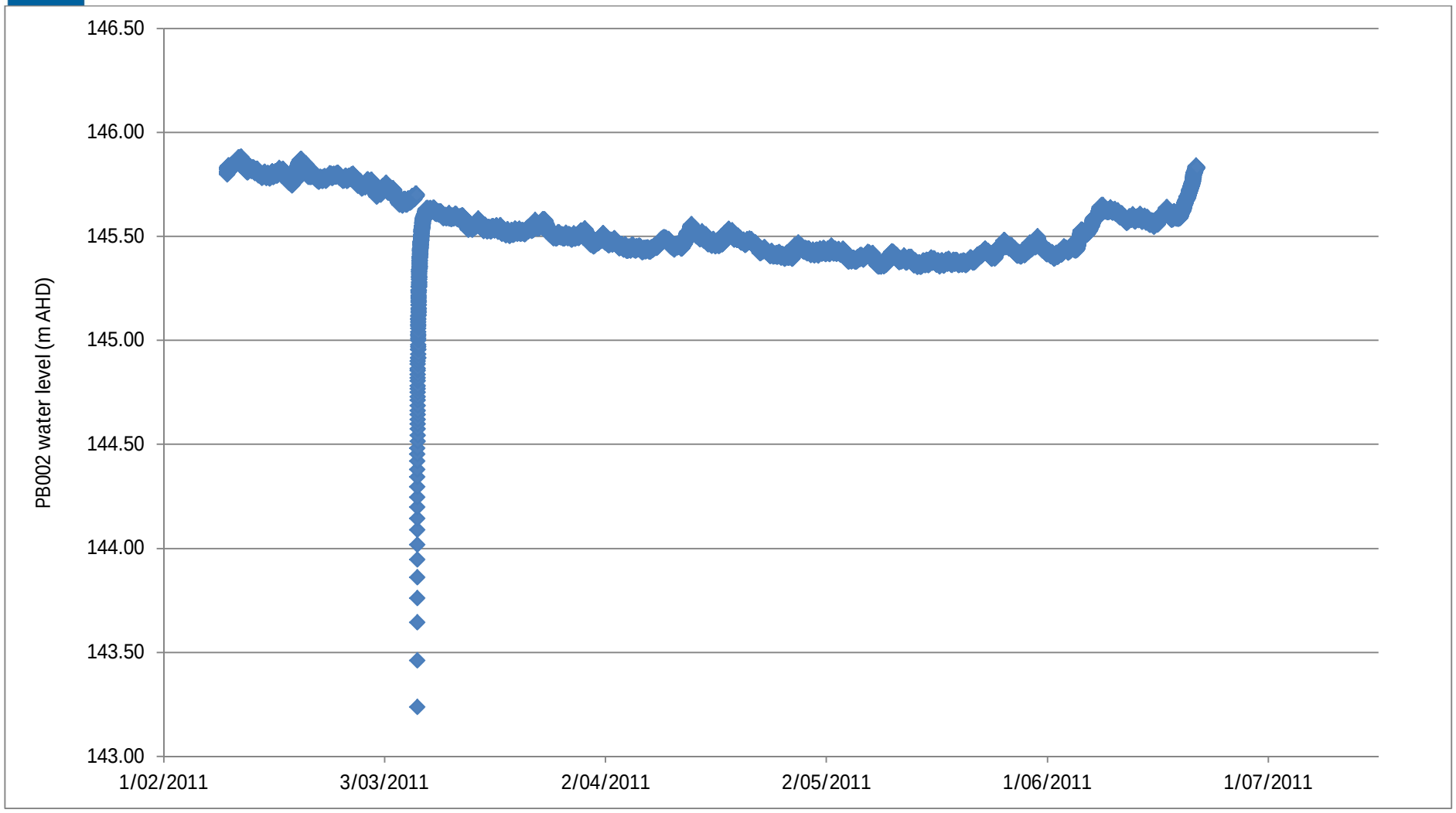


Figure 5 PB002 water level (m AHD)

Appendix B

PB003 Pumping Test 2011 Automatic Readings

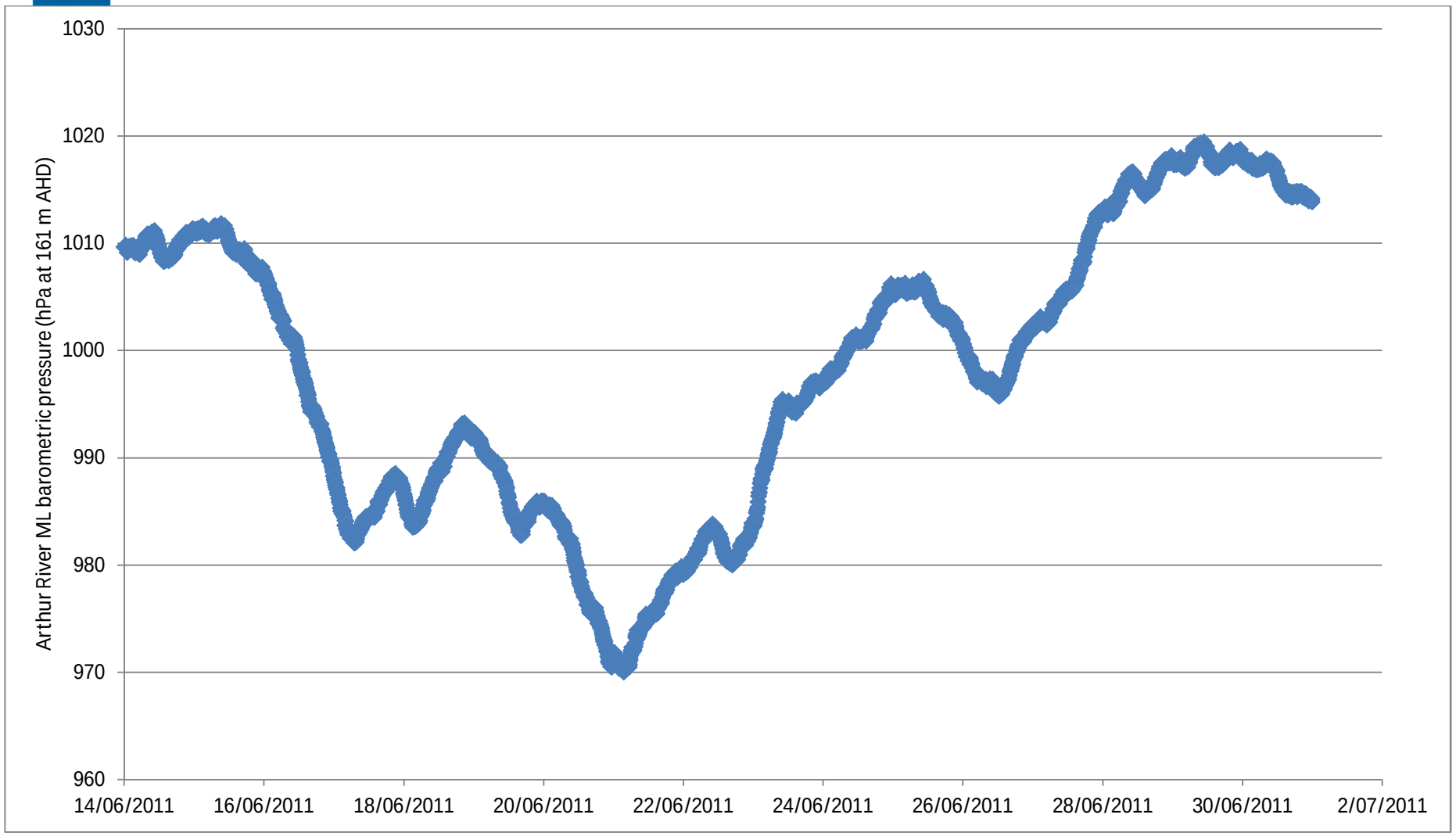


Figure 1 Arthur River ML barometric pressure (hPa at 161 m AHD)

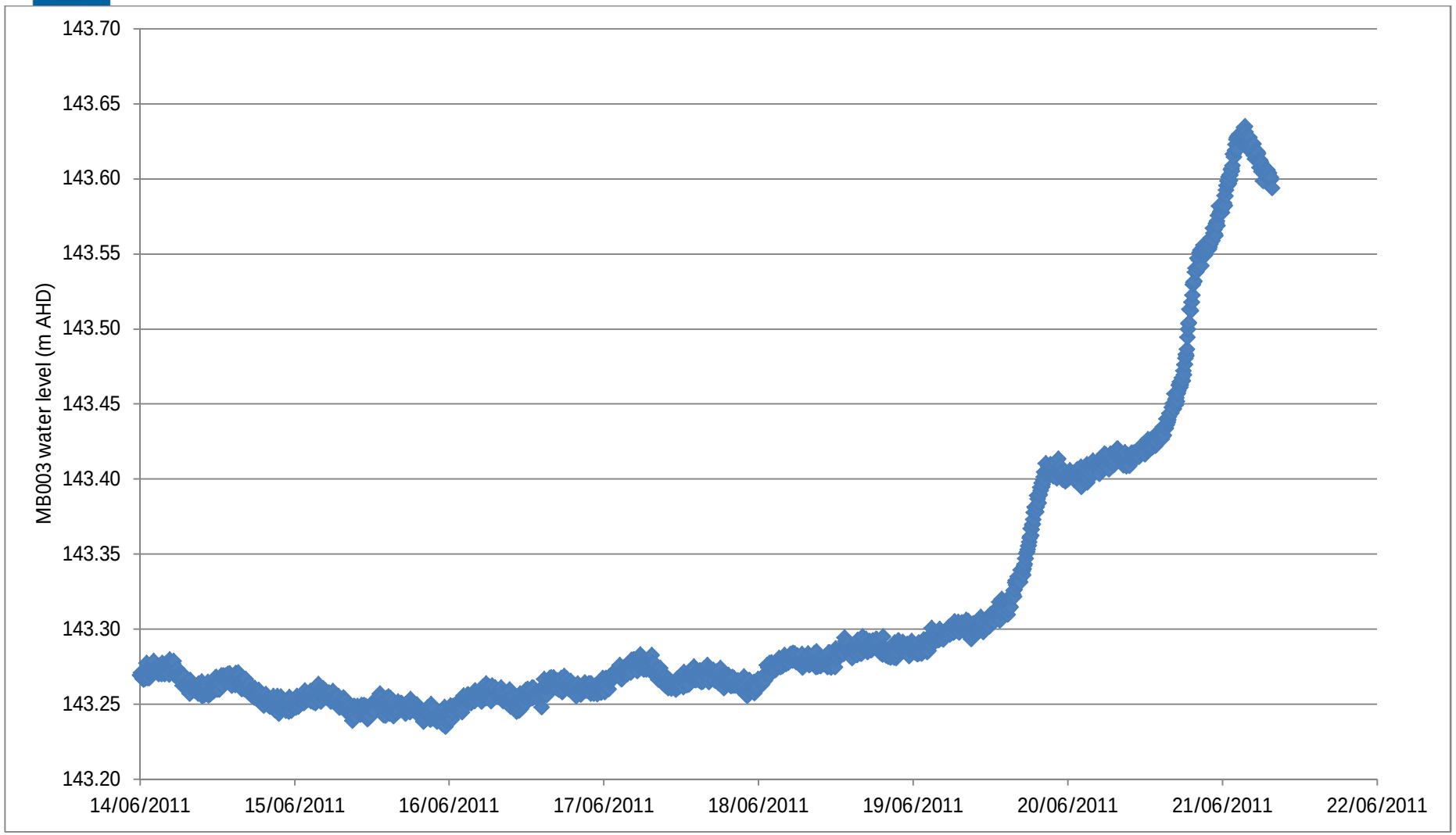


Figure 2 MB003 water level (m)

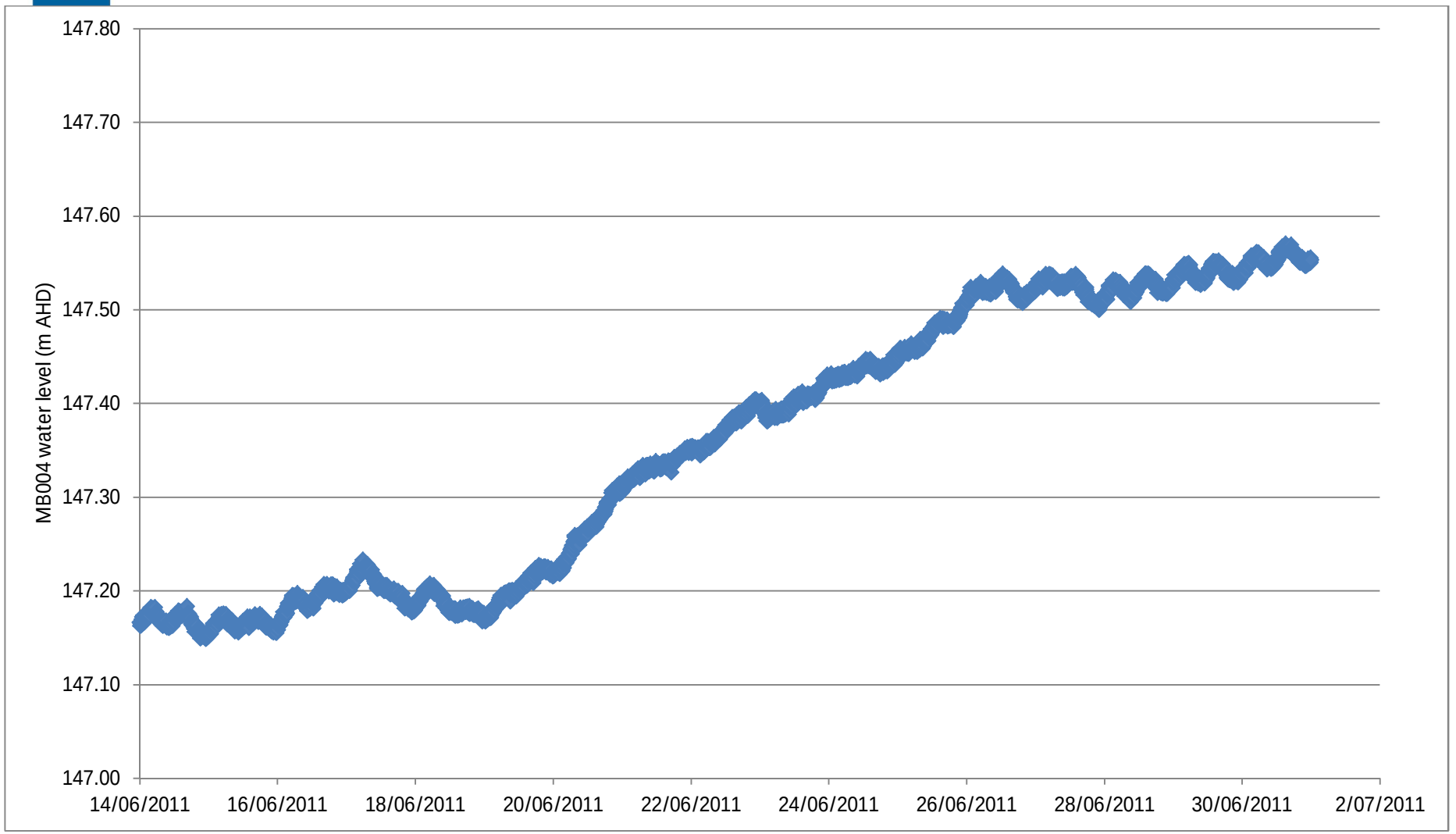


Figure 3 MB004 water level (m AHD)

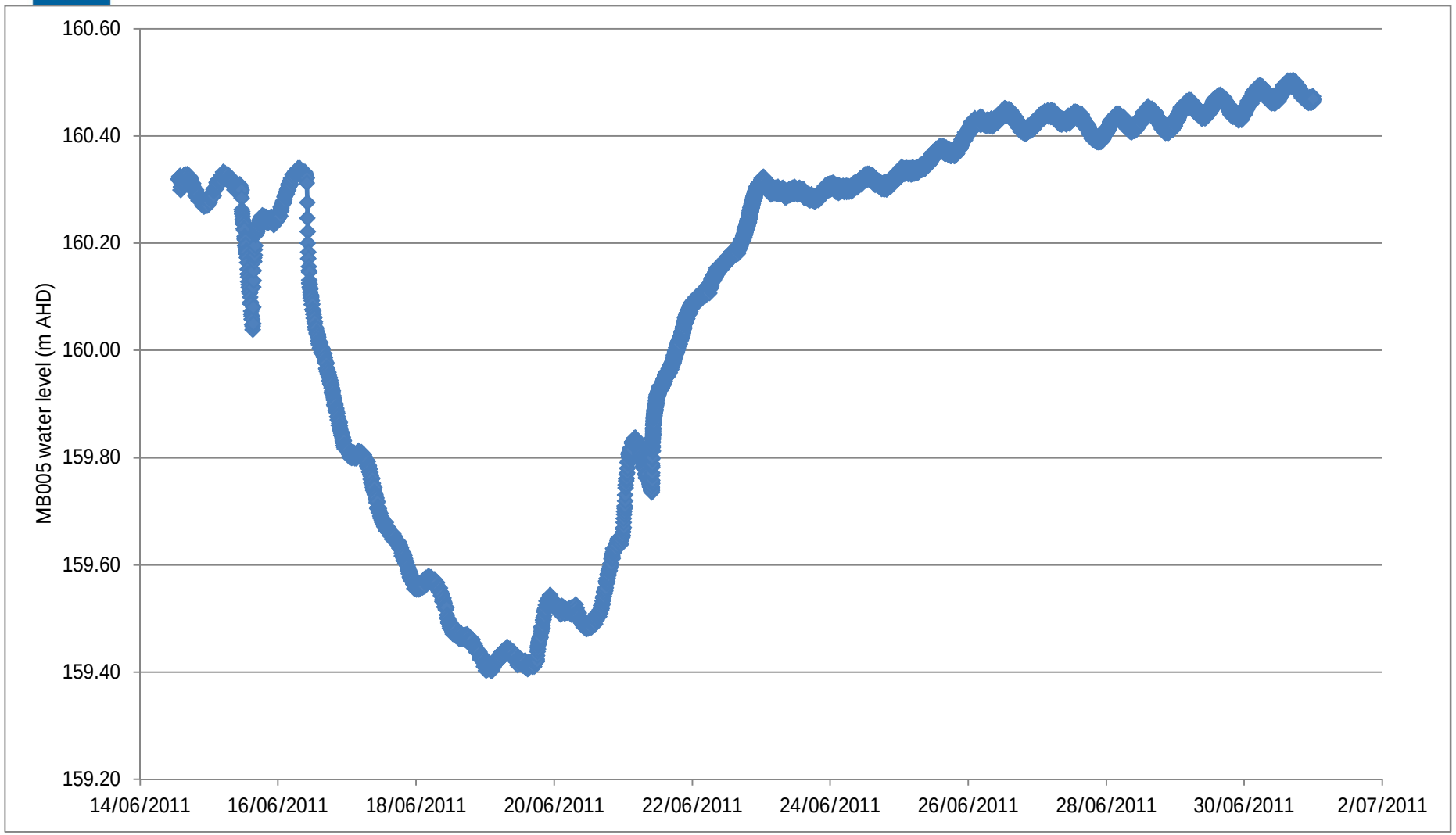


Figure 4 MB005 water level (m AHD)

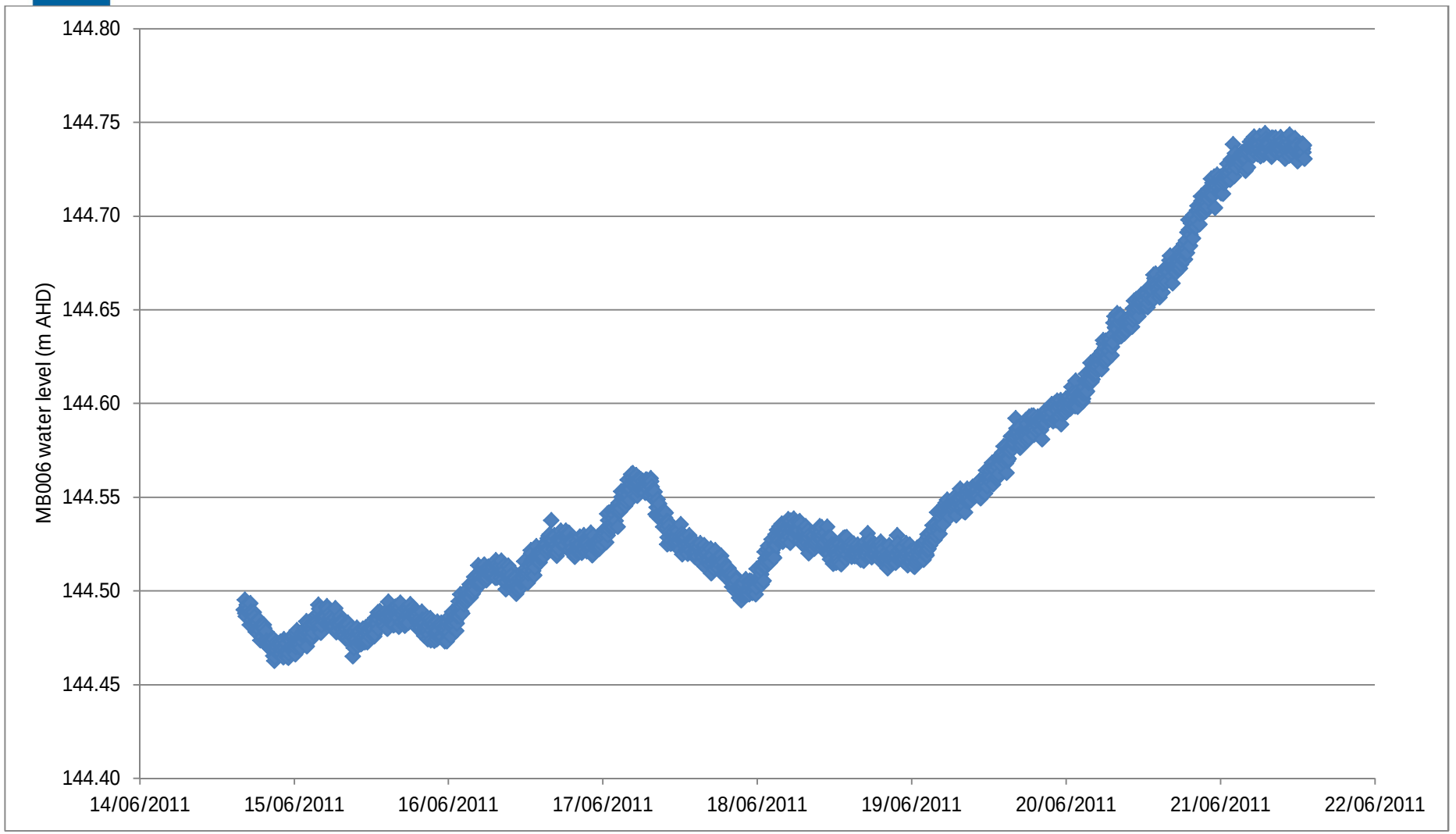


Figure 5 MB006 water level (m AHD)

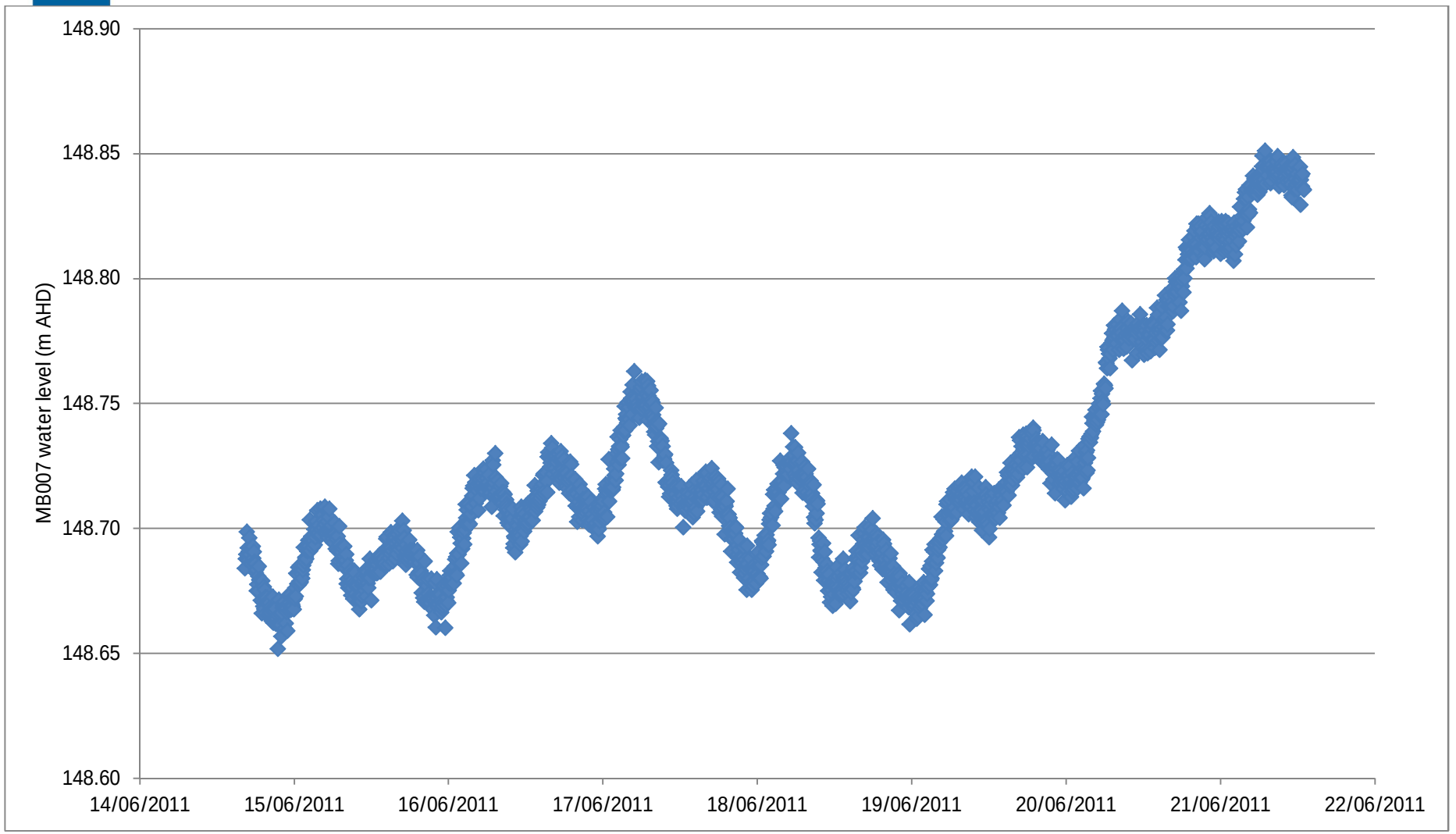


Figure 6 MB007 water level (m AHD)

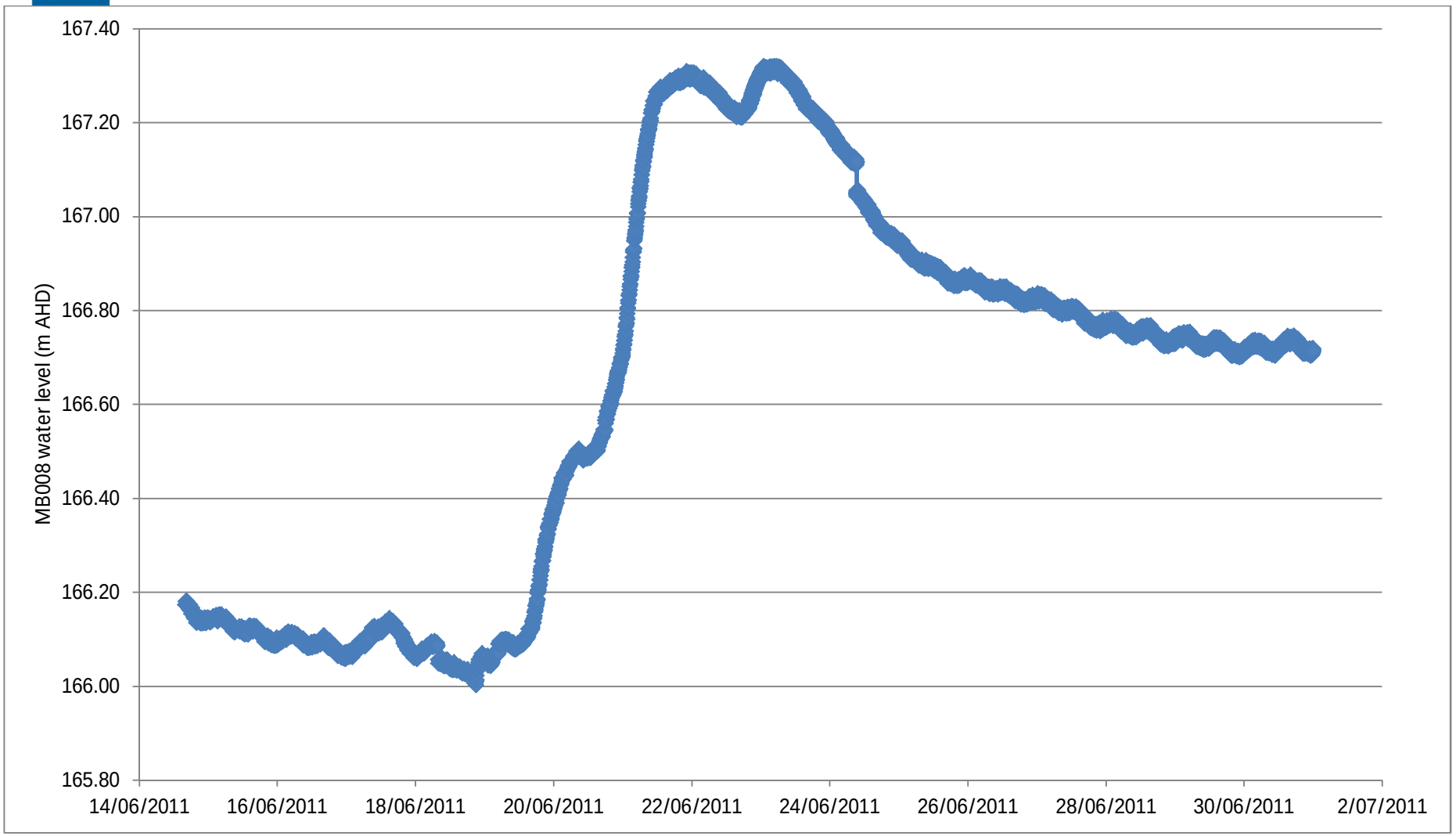


Figure 7 MB008 water level (m AHD)

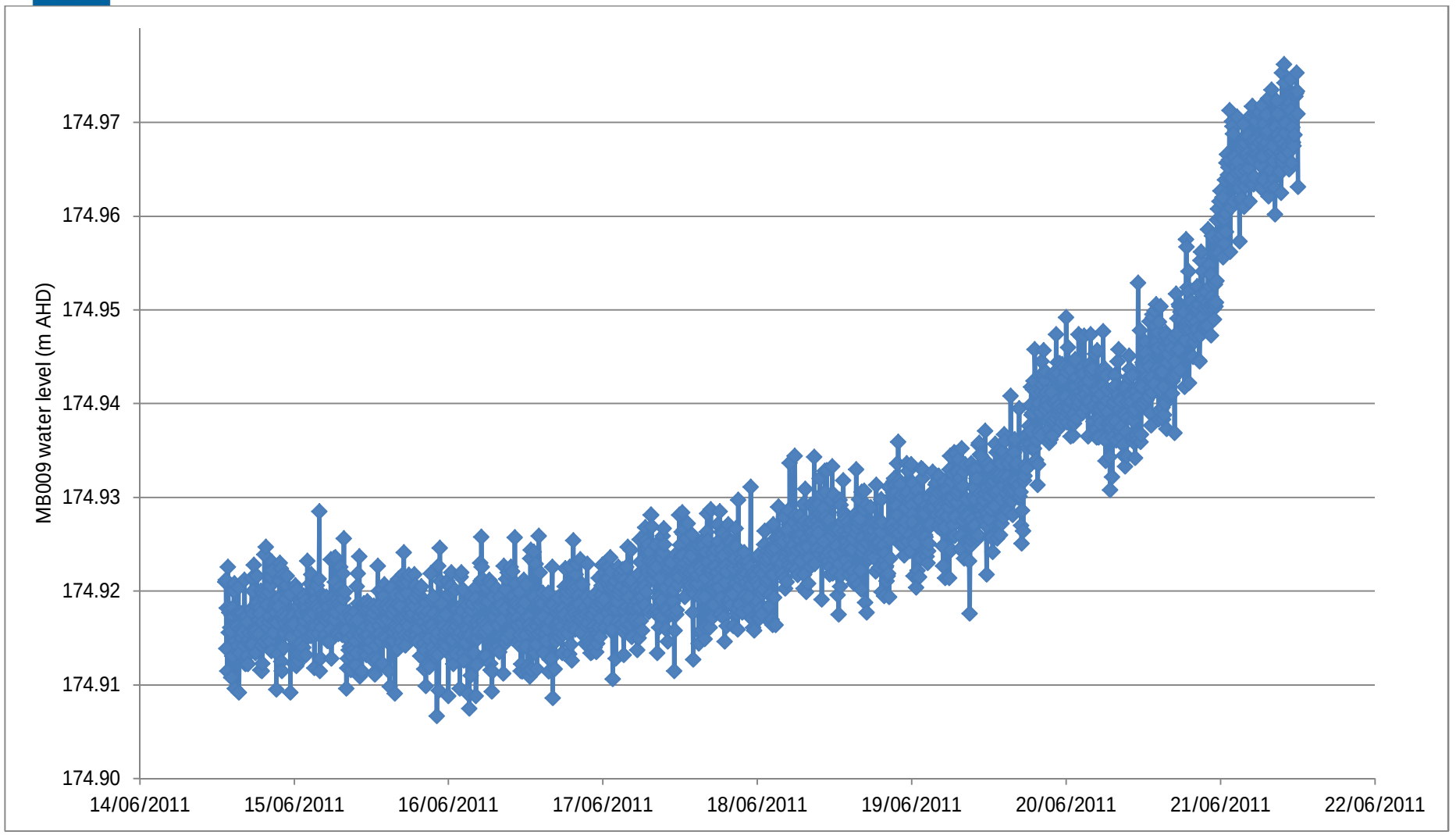


Figure 8 MB009 water level (m AHD)

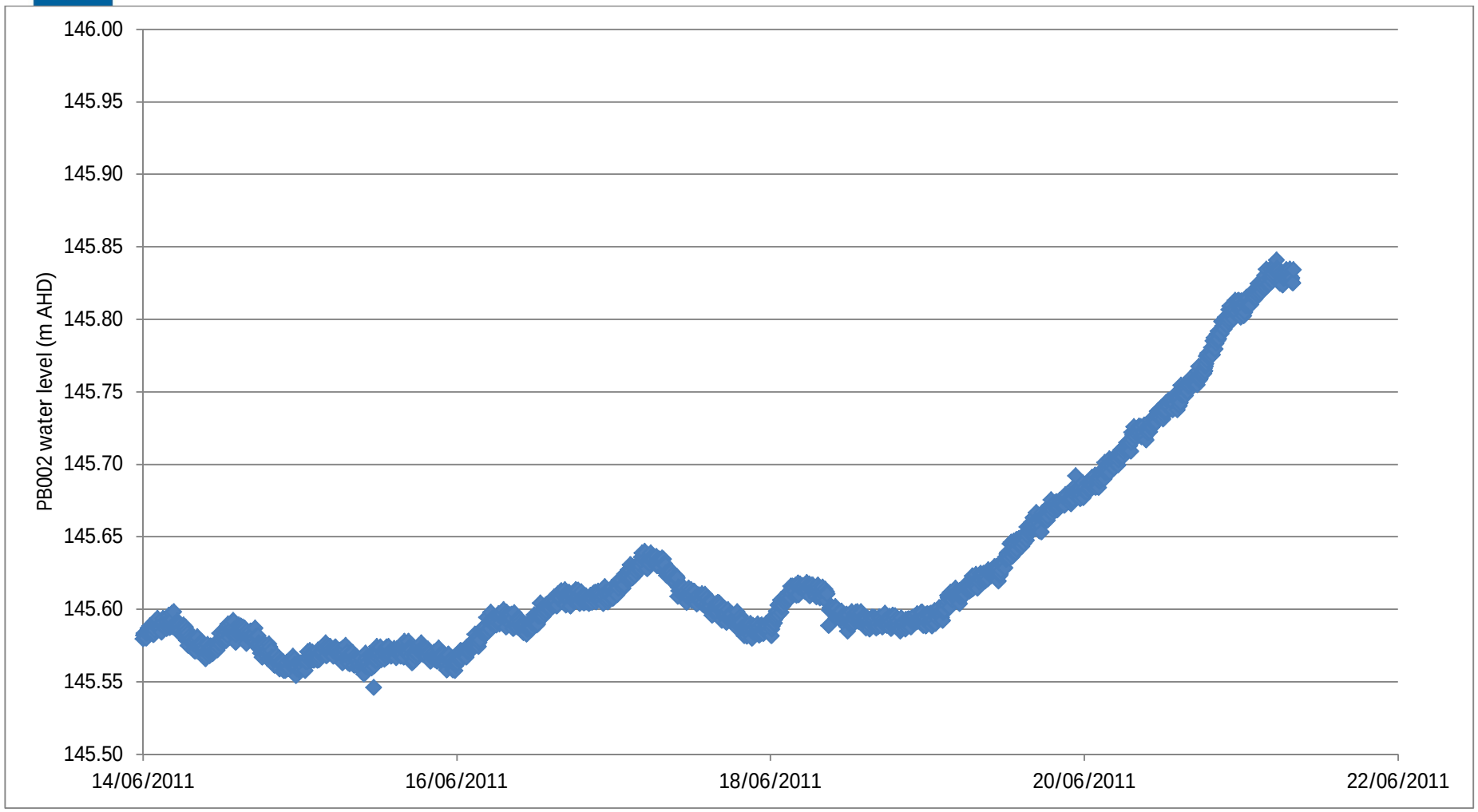


Figure 9 PB002 water level (m AHD)

Appendix C

PB003 Pumping test 2011 Manual Readings

Figure 1 PB003 Pumping Test 2011 PB003 and MB005 drawdowns (m) log time 3
Figure 2 PB003 Pumping Test 2011 PB003 and MB005 drawdowns (m) 4
Figure 3 PB003 Pumping Test 2011 PB003 drawdown (m) log time 5
Figure 4 PB003 Pumping Test 2011 PB003 drawdown (m) 6
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Figure 7 PB003 Pumping Test 2011 PB001 drawdown (m) 9
Figure 8 PB003 Pumping Test 2011 PB001 measured water table elevation (m AHD) 10
Figure 9 PB003 Pumping Test 2011 PB002 drawdown (m) 11
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Figure 13 PB003 Pumping Test 2011 MB3 drawdown (m) 15
Figure 14 PB003 Pumping Test 2011 MB003 measured water table elevation (m AHD) 16
Figure 15 PB003 Pumping Test 2011 MB4 drawdown (m) 17
Figure 16 PB003 Pumping Test 2011 MB005 measured water table elevation (m AHD) 18
Figure 17 PB003 Pumping Test 2011 MB005 drawdown (m) 19
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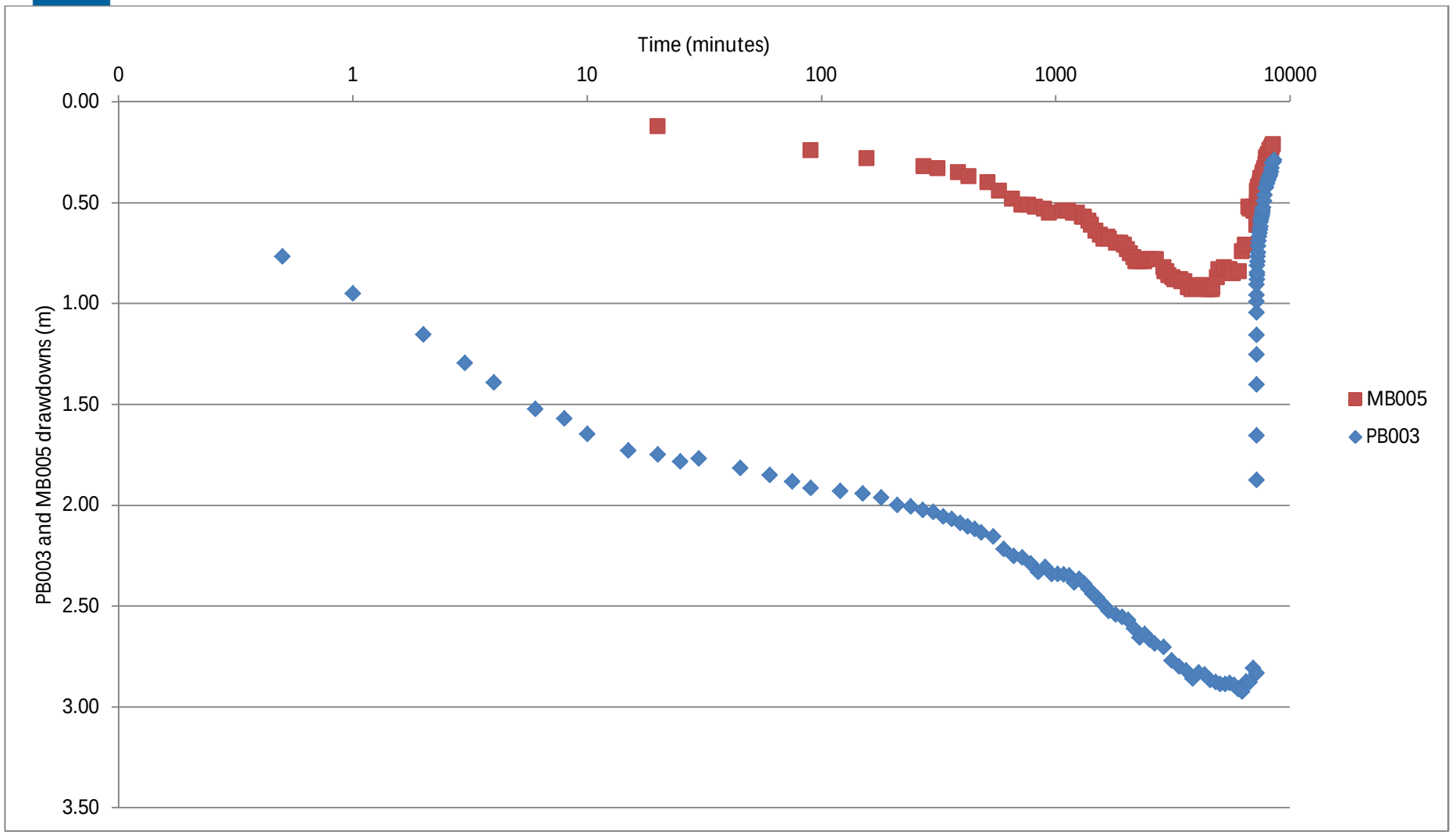

Figure 1 PB003 Pumping Test 2011 PB003 and MB005 drawdowns (m) log time

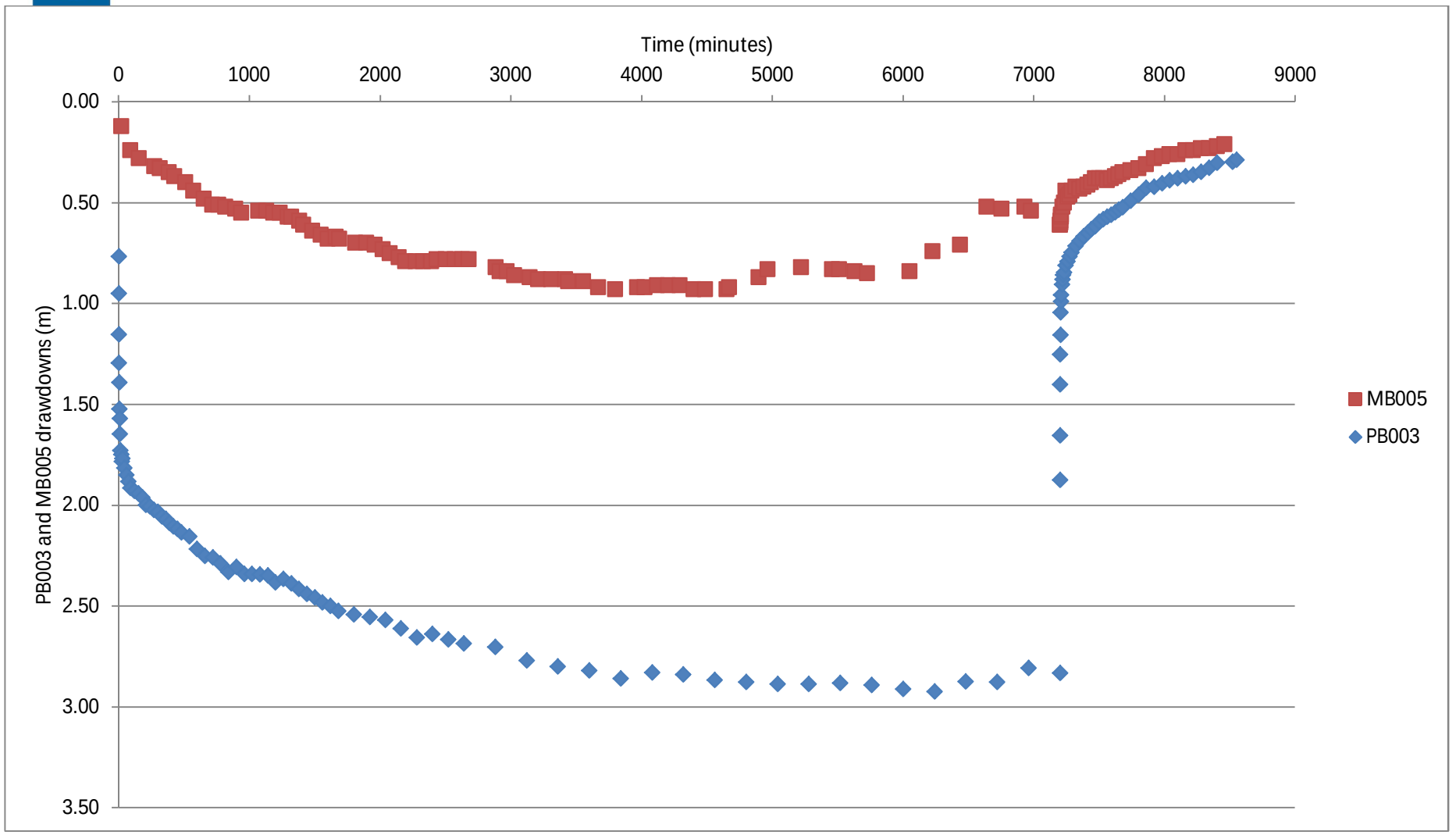

Figure 2 PB003 Pumping Test 2011 PB003 and MB005 drawdowns (m)

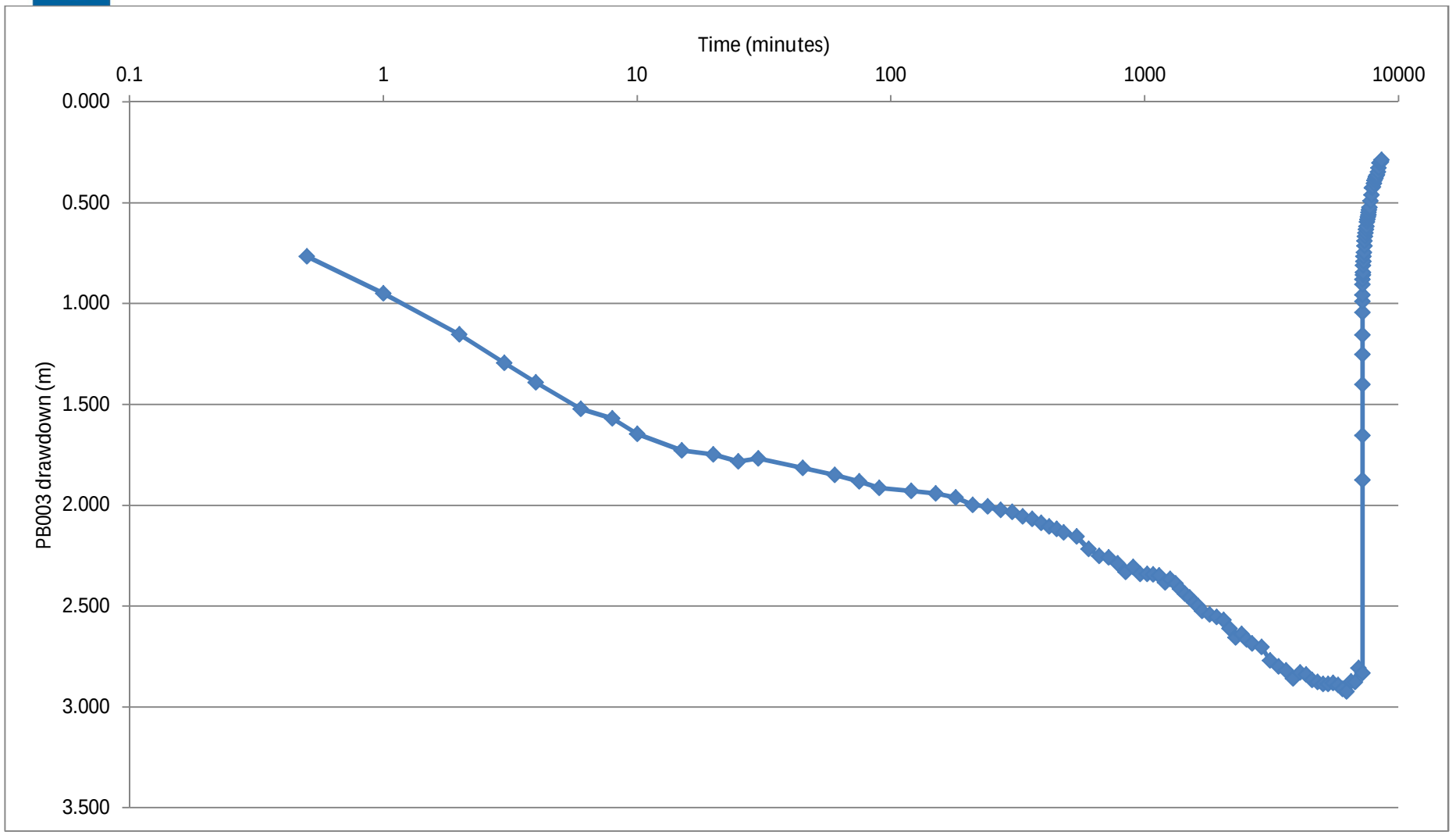

Figure 3 PB003 Pumping Test 2011 PB003 drawdown (m) log time

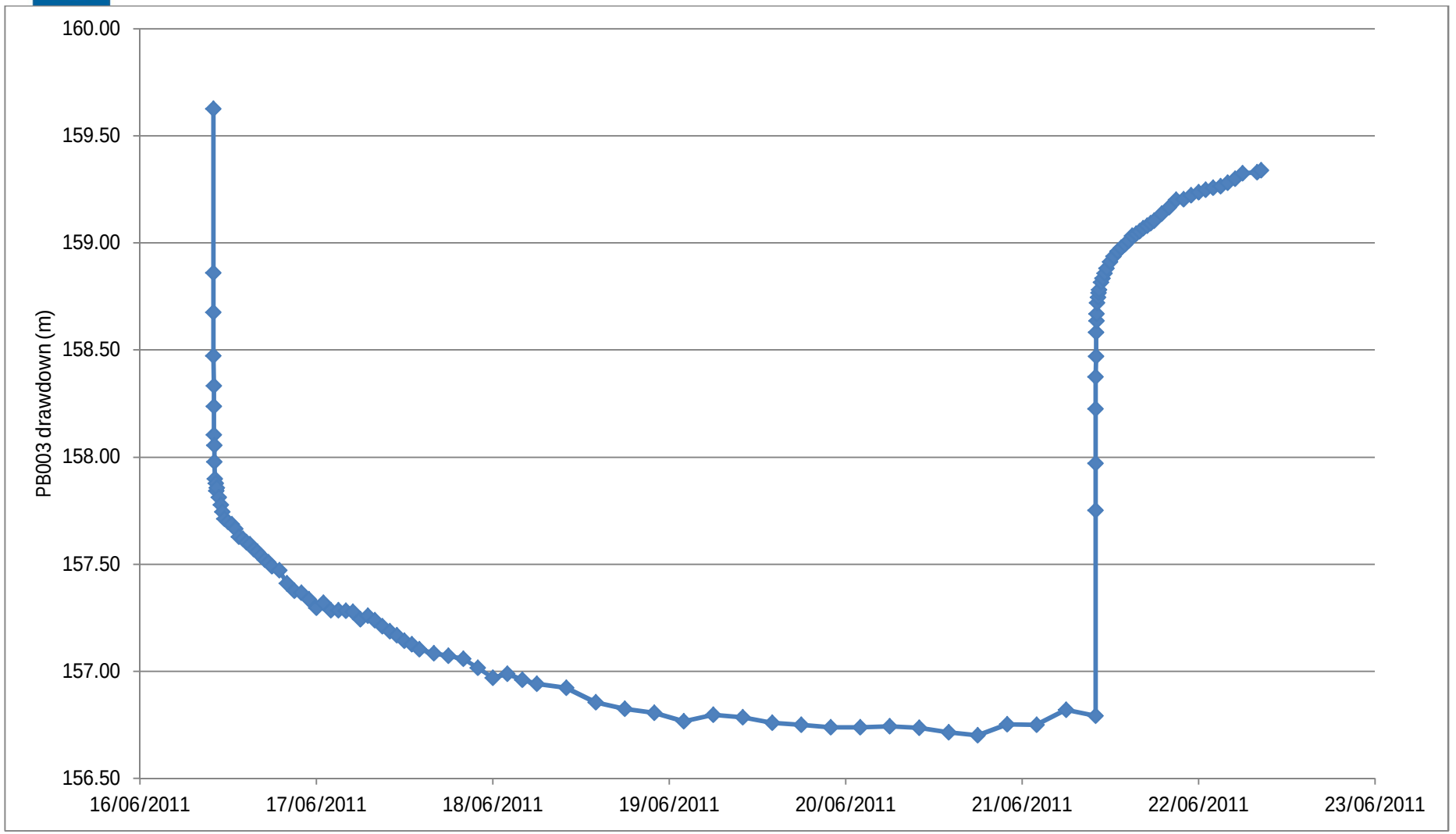

Figure 4 PB003 Pumping Test 2011 PB003 drawdown (m)

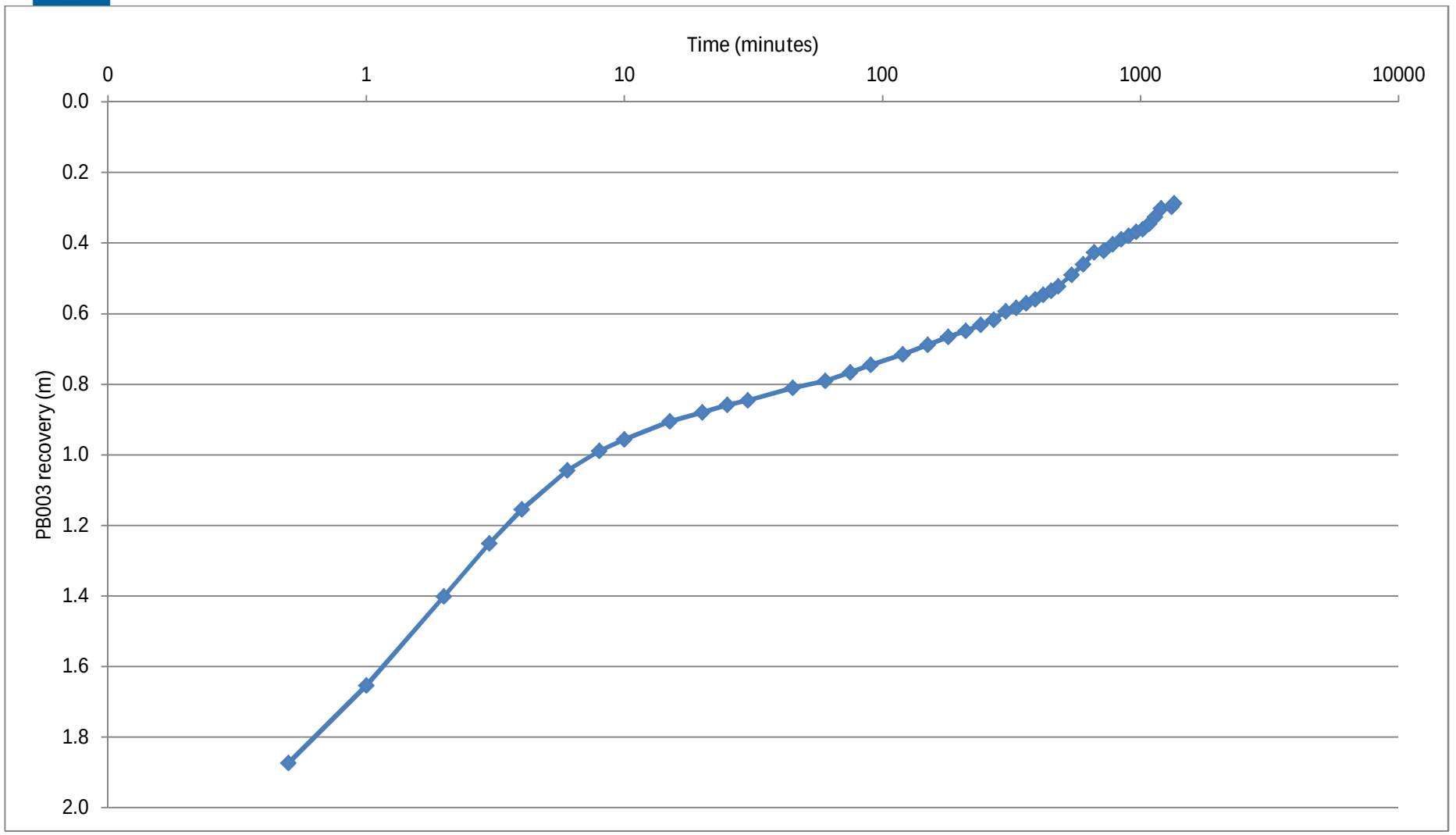

Figure 5 PB003 Pumping Test 2011 PB003 recovery (m) log time

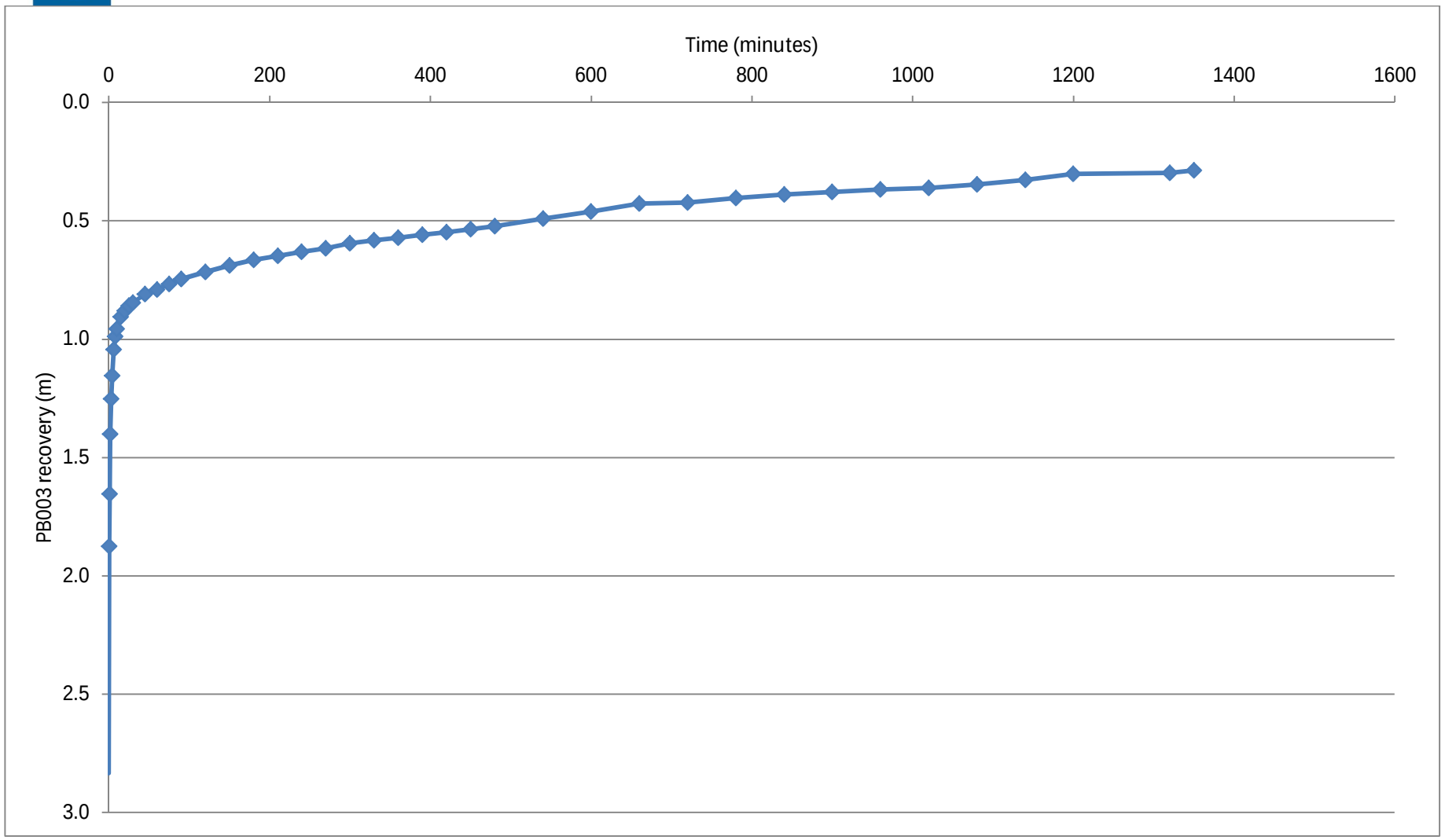

Figure 6 PB003 Pumping Test 2011 PB003 recovery (m)

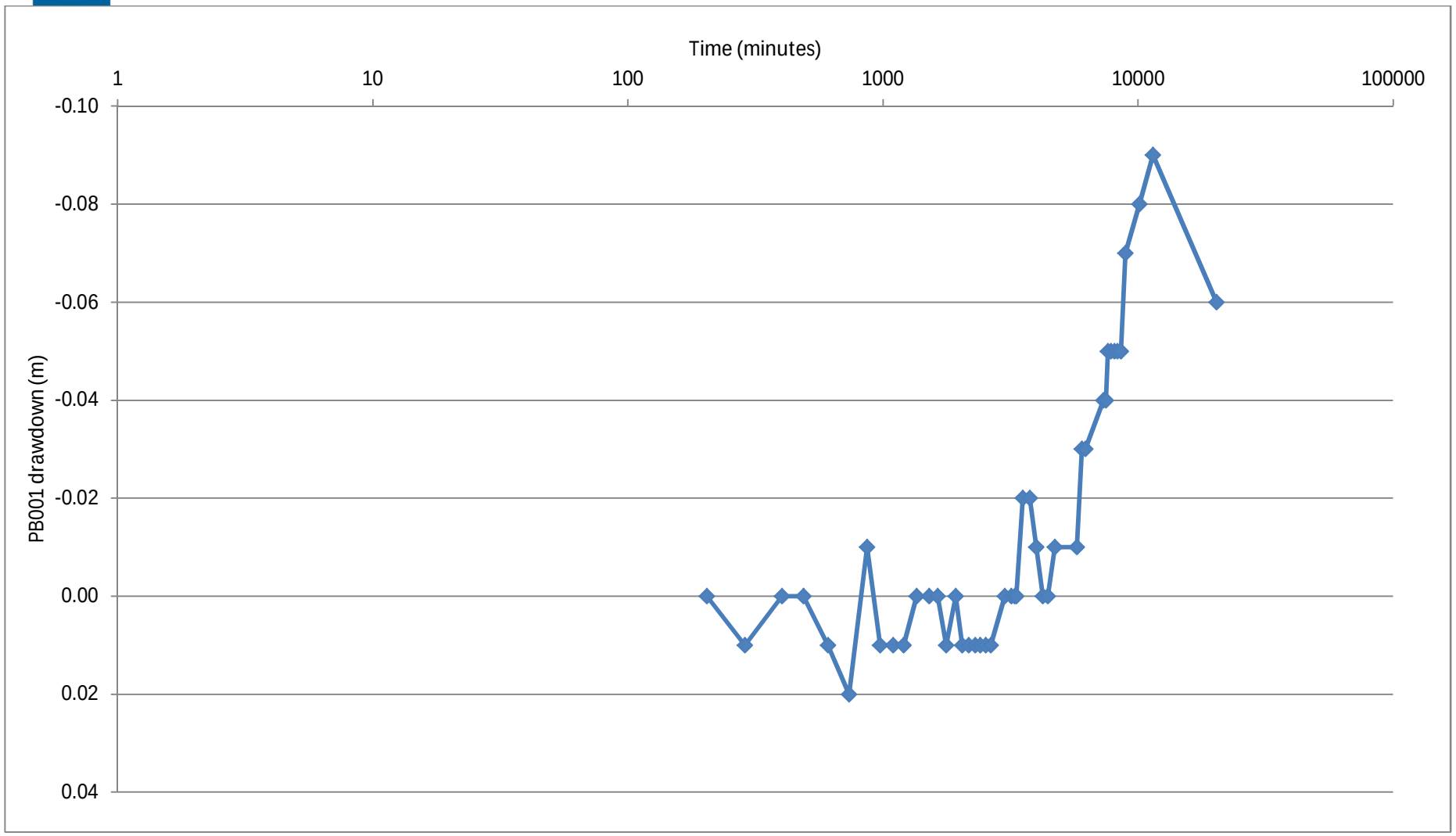

Figure 7 PB003 Pumping Test 2011 PB001 drawdown (m)

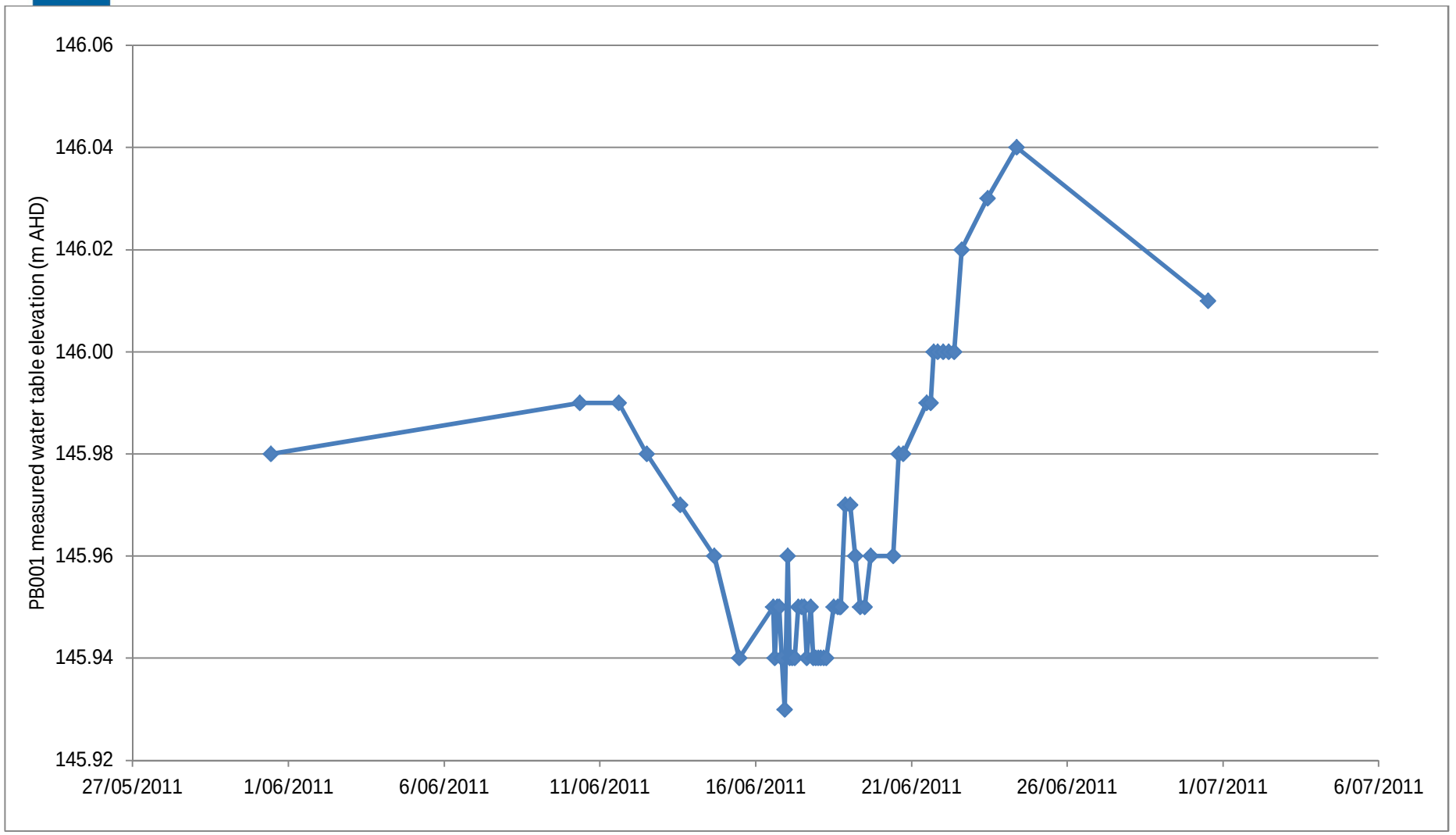

Figure 8 PB003 Pumping Test 2011 PB001 measured water table elevation (m AHD)

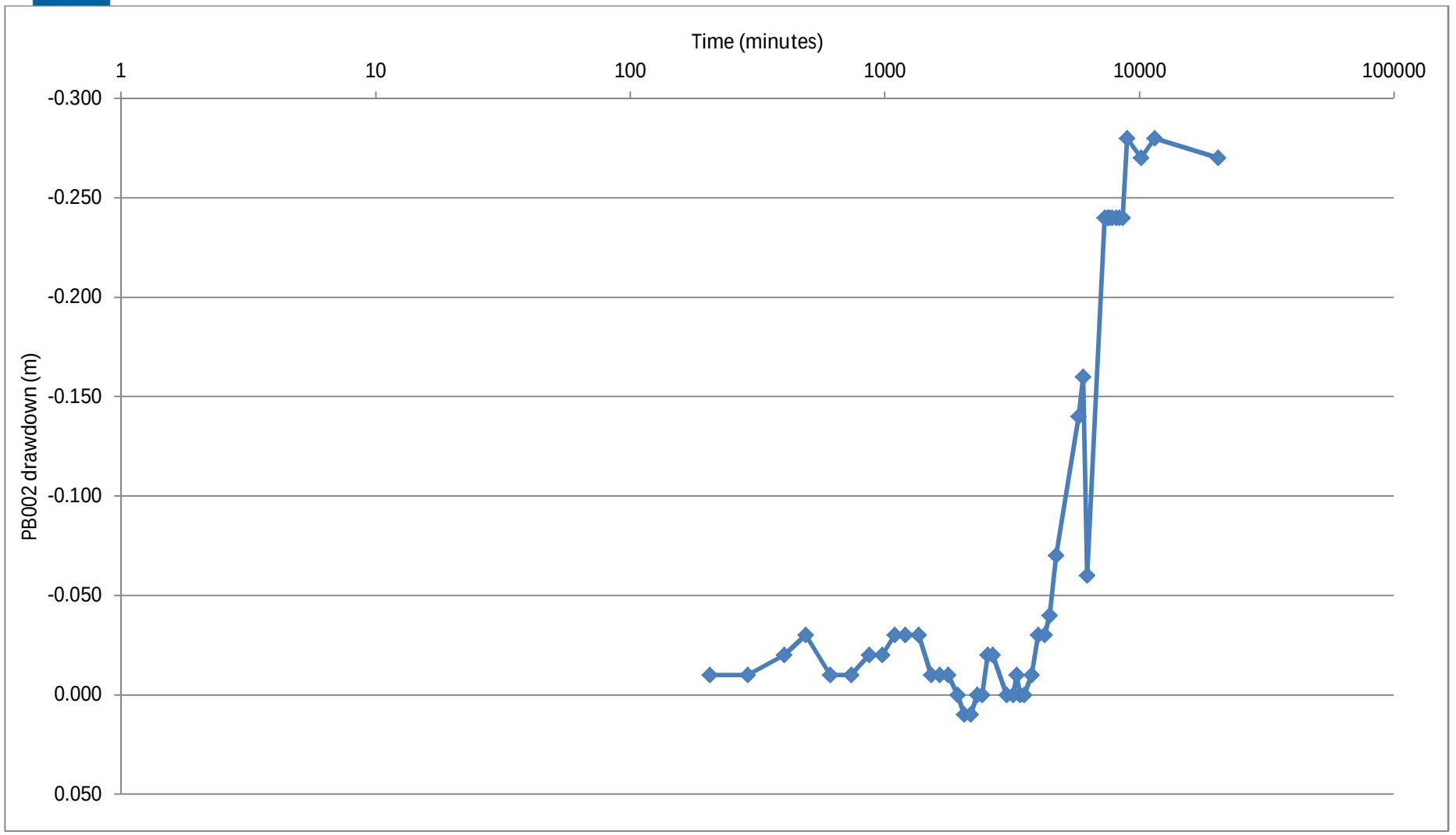

Figure 9 PB003 Pumping Test 2011 PB002 drawdown (m)

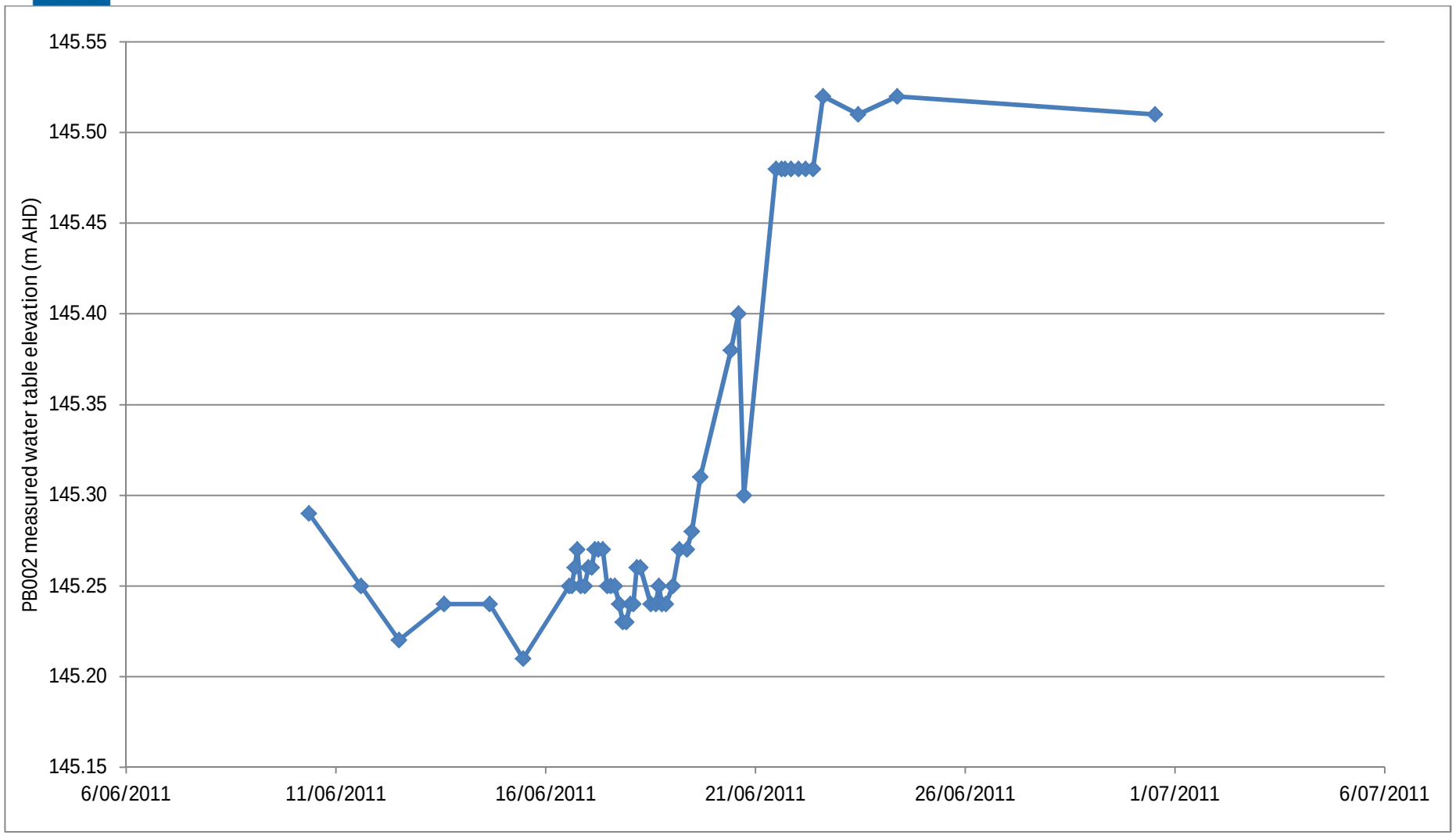

Figure 10 PB003 Pumping Test 2011 PB002 measured water table elevation (m AHD)

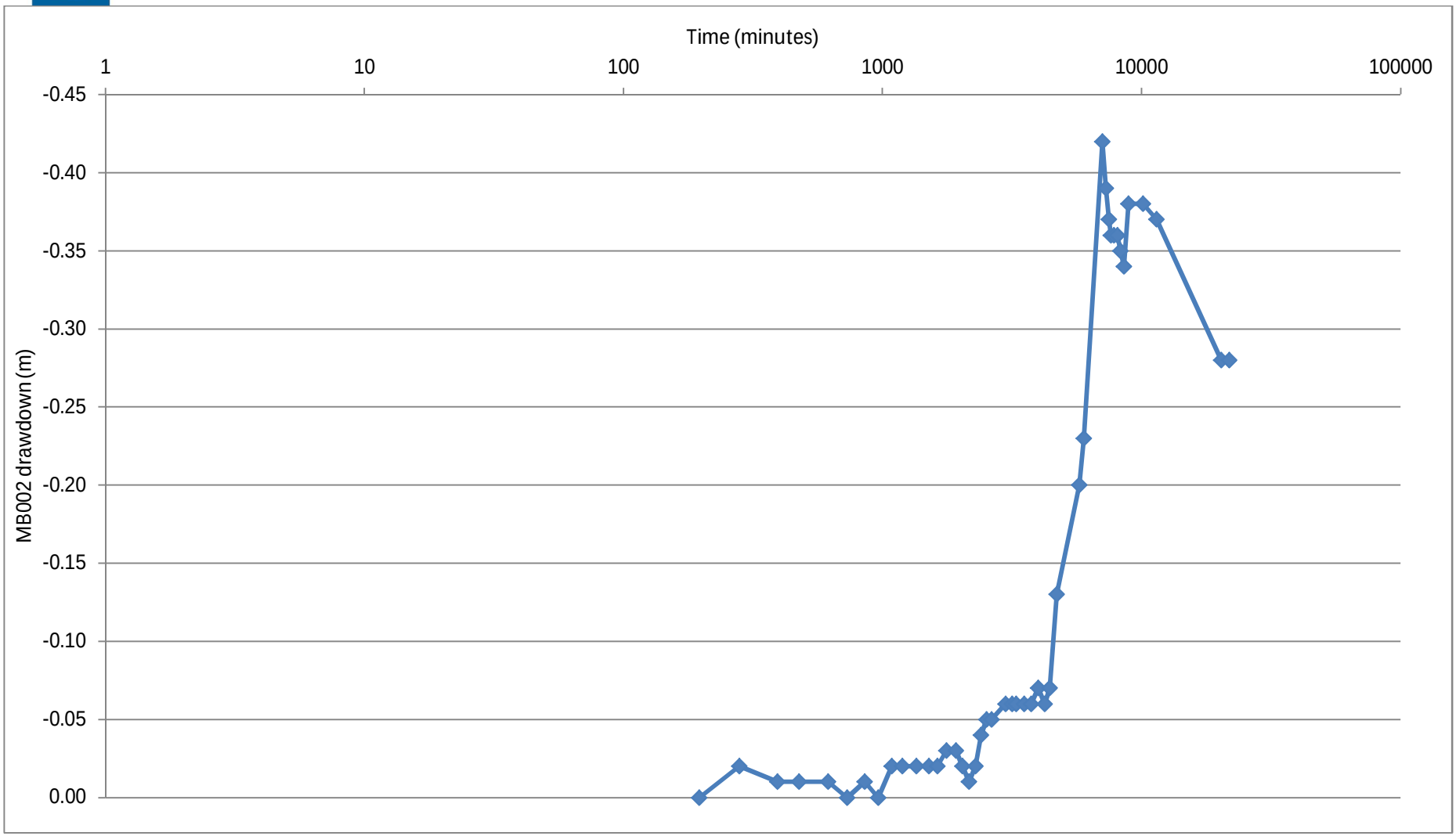

Figure 11 PB003 Pumping Test 2011 MB002 drawdown (m)

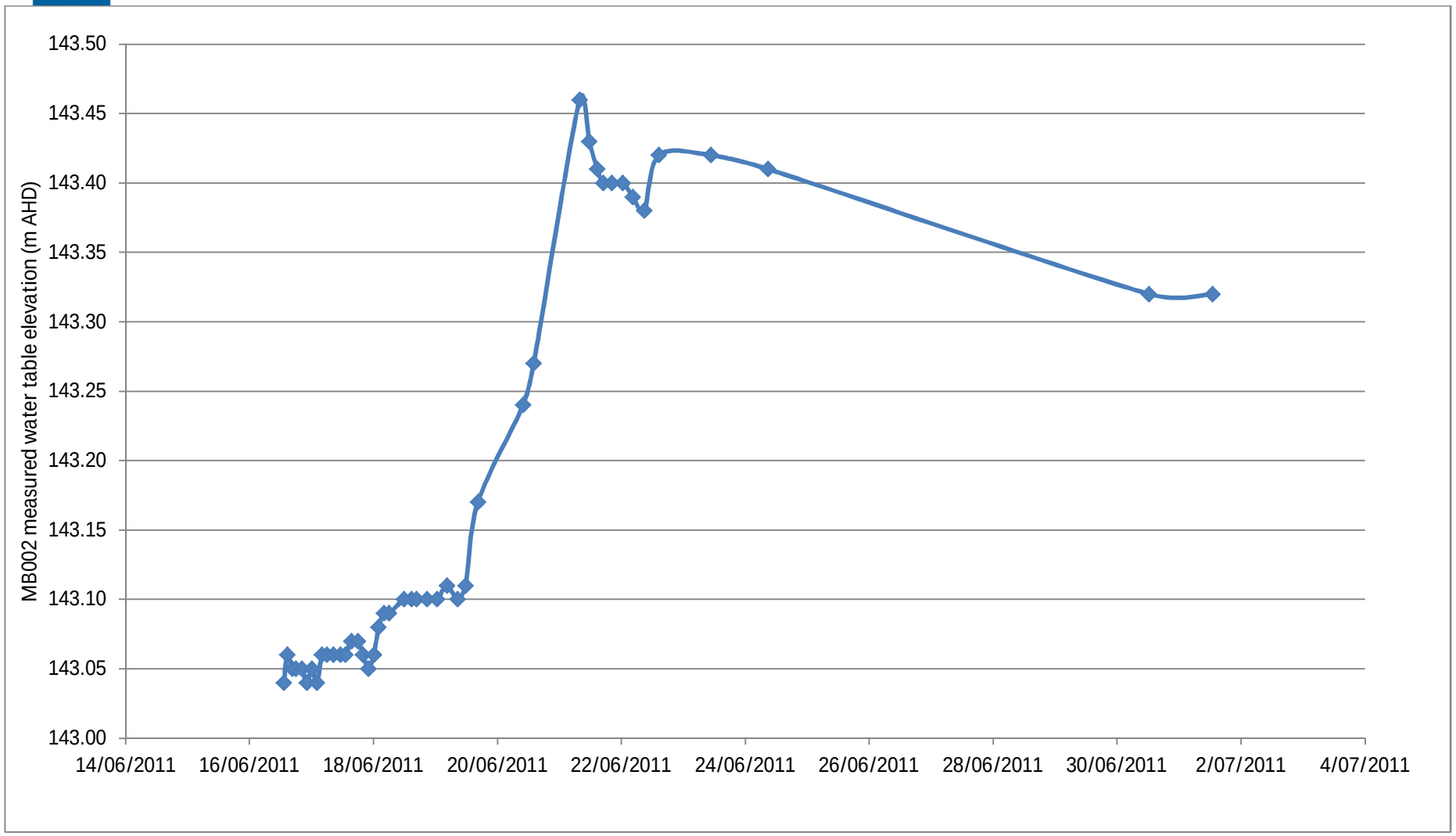

Figure 12 PB003 Pumping Test 2011 MB002 measured water table elevation (m AHD)

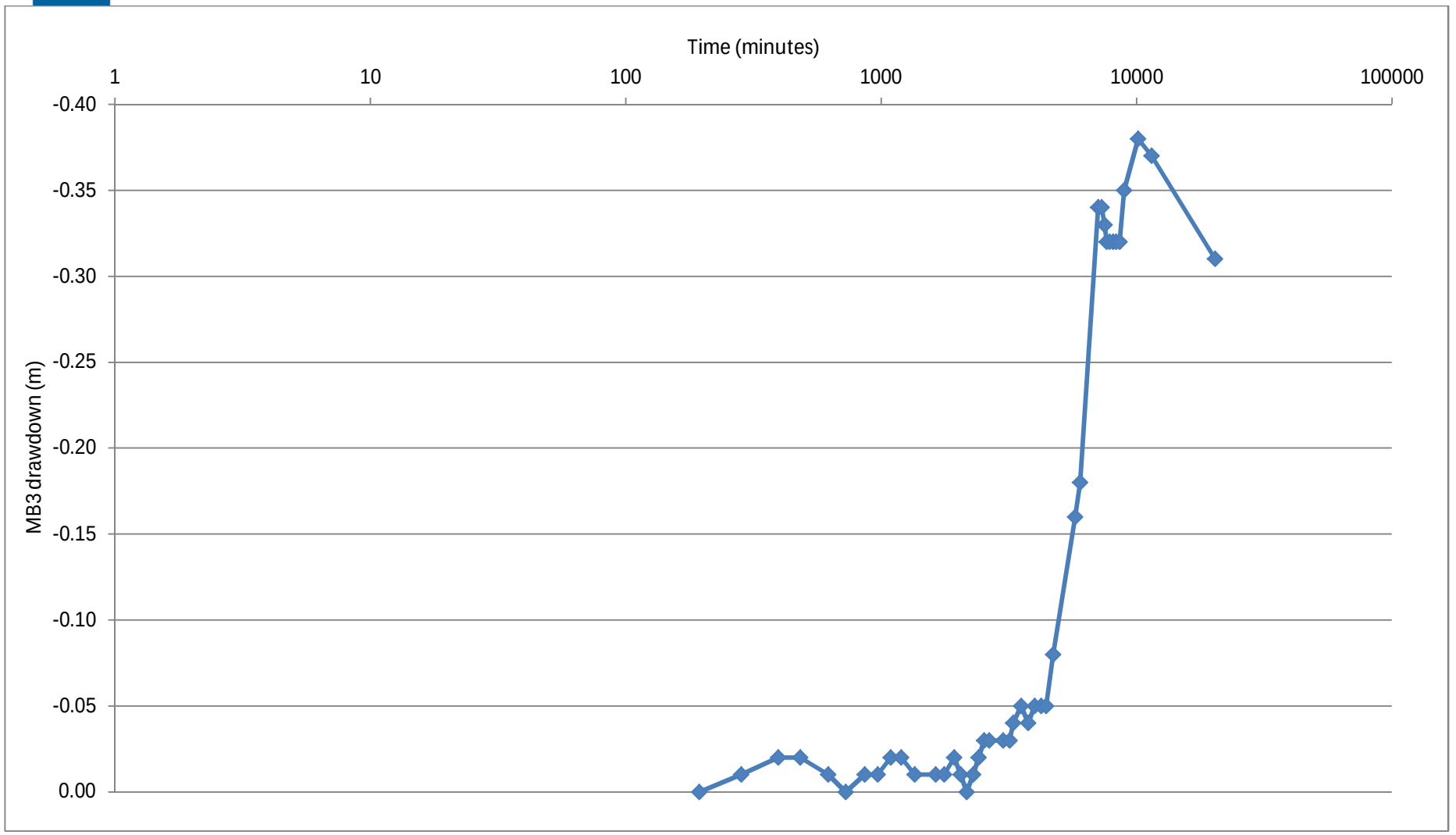

Figure 13 PB003 Pumping Test 2011 MB3 drawdown (m)

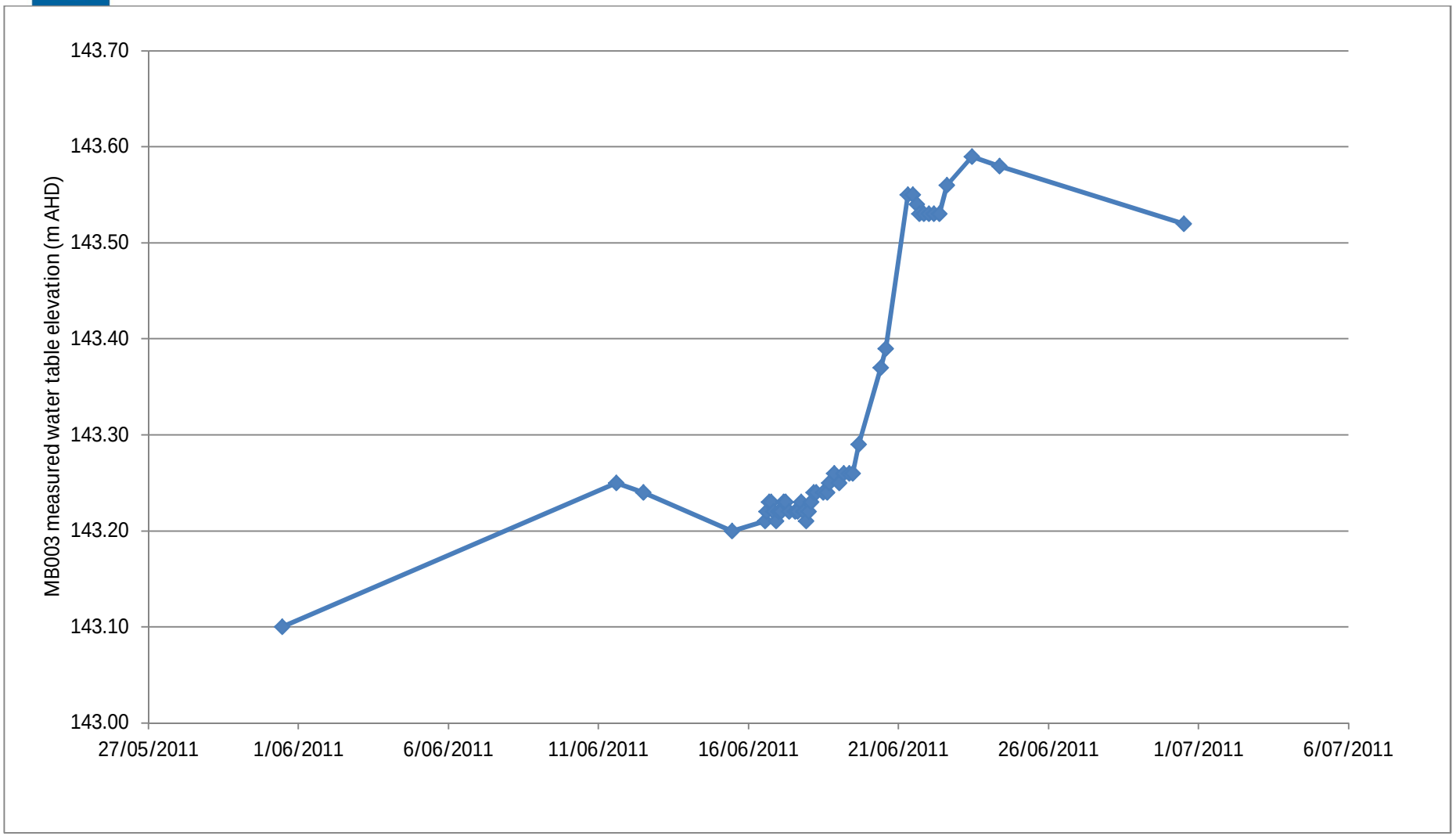

Figure 14 PB003 Pumping Test 2011 MB003 measured water table elevation (m AHD)

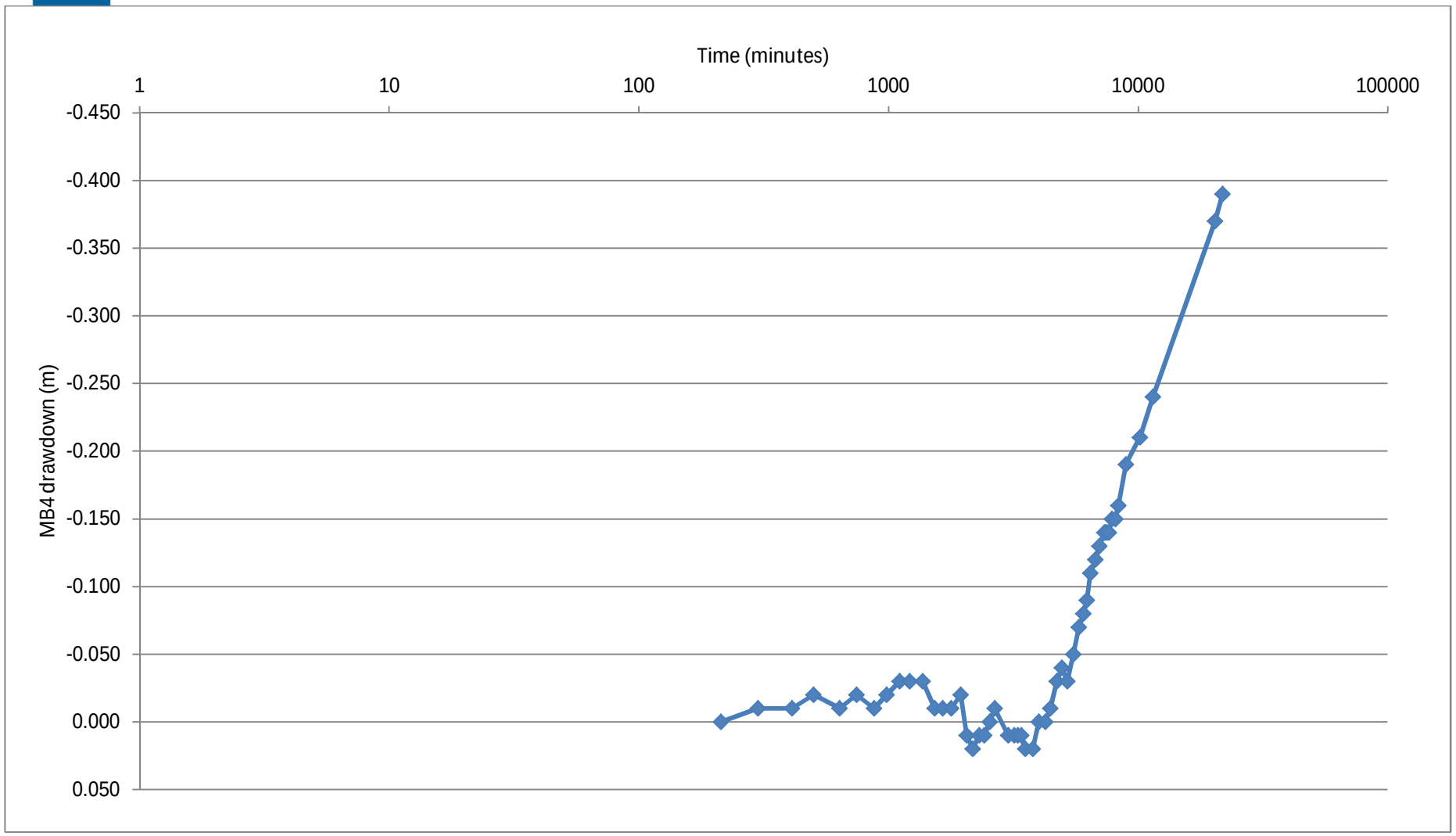

Figure 15 PB003 Pumping Test 2011 MB4 drawdown (m)

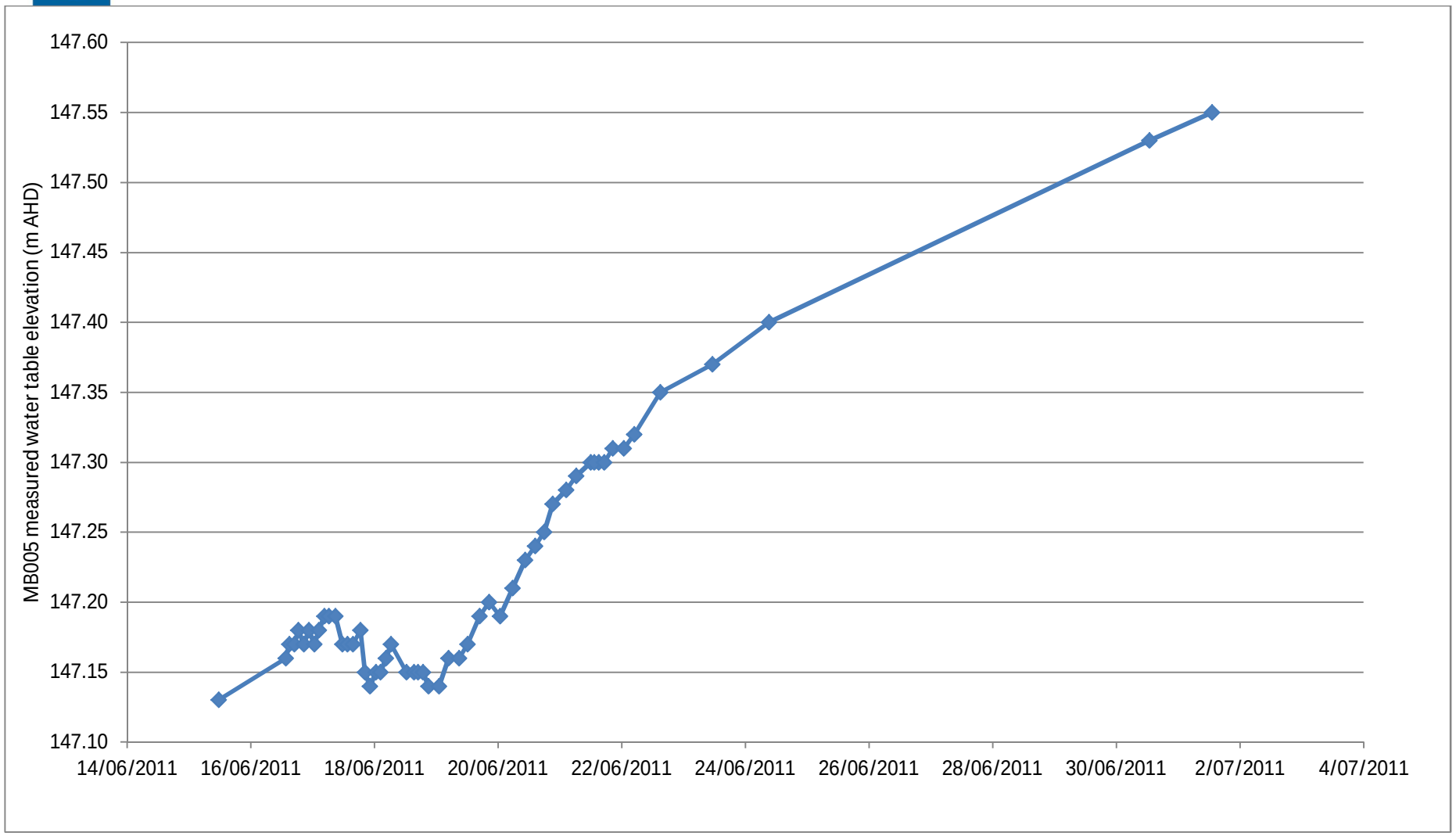

Figure 16 PB003 Pumping Test 2011 MB005 measured water table elevation (m AHD)

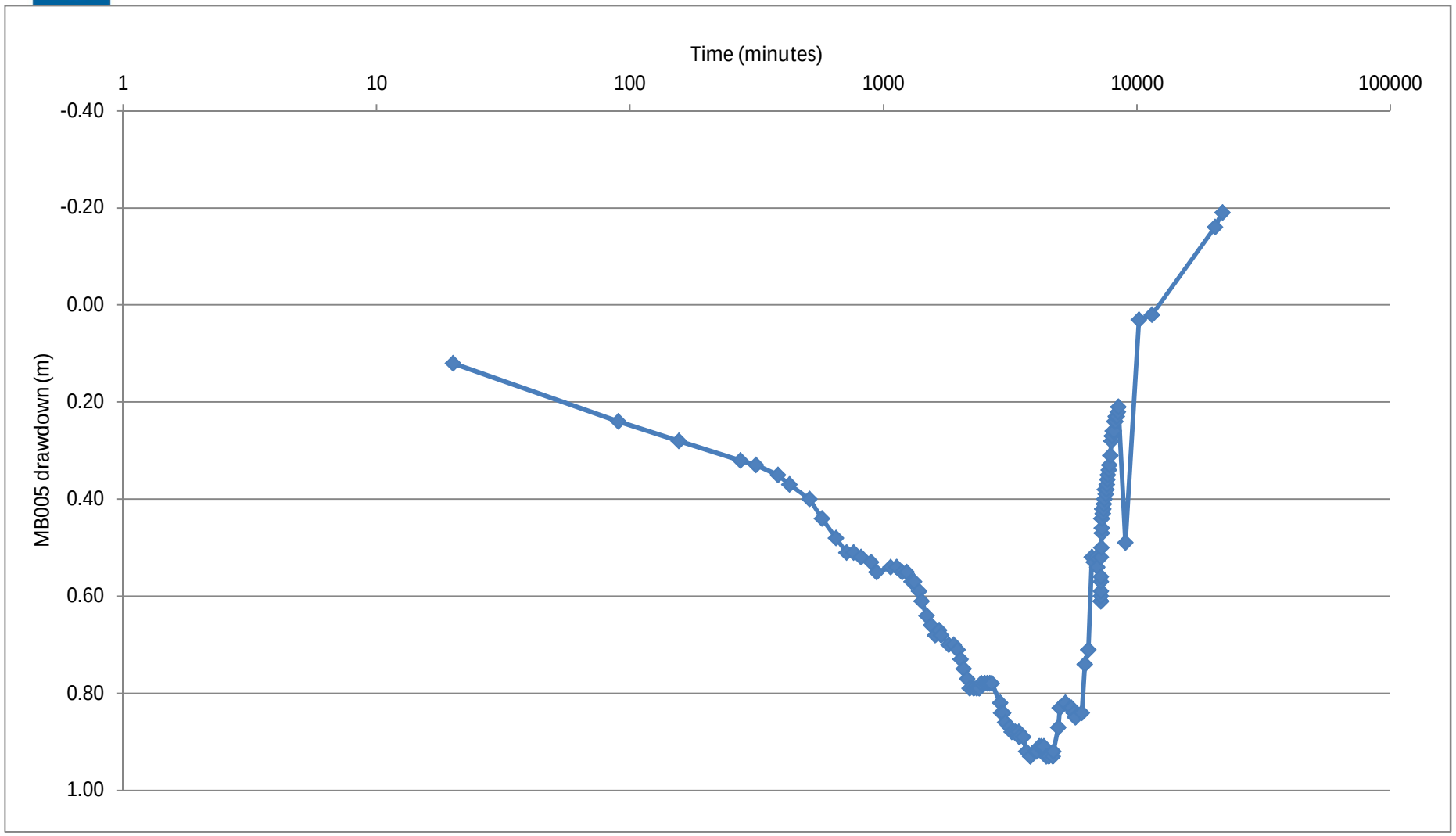

Figure 17 PB003 Pumping Test 2011 MB005 drawdown (m)

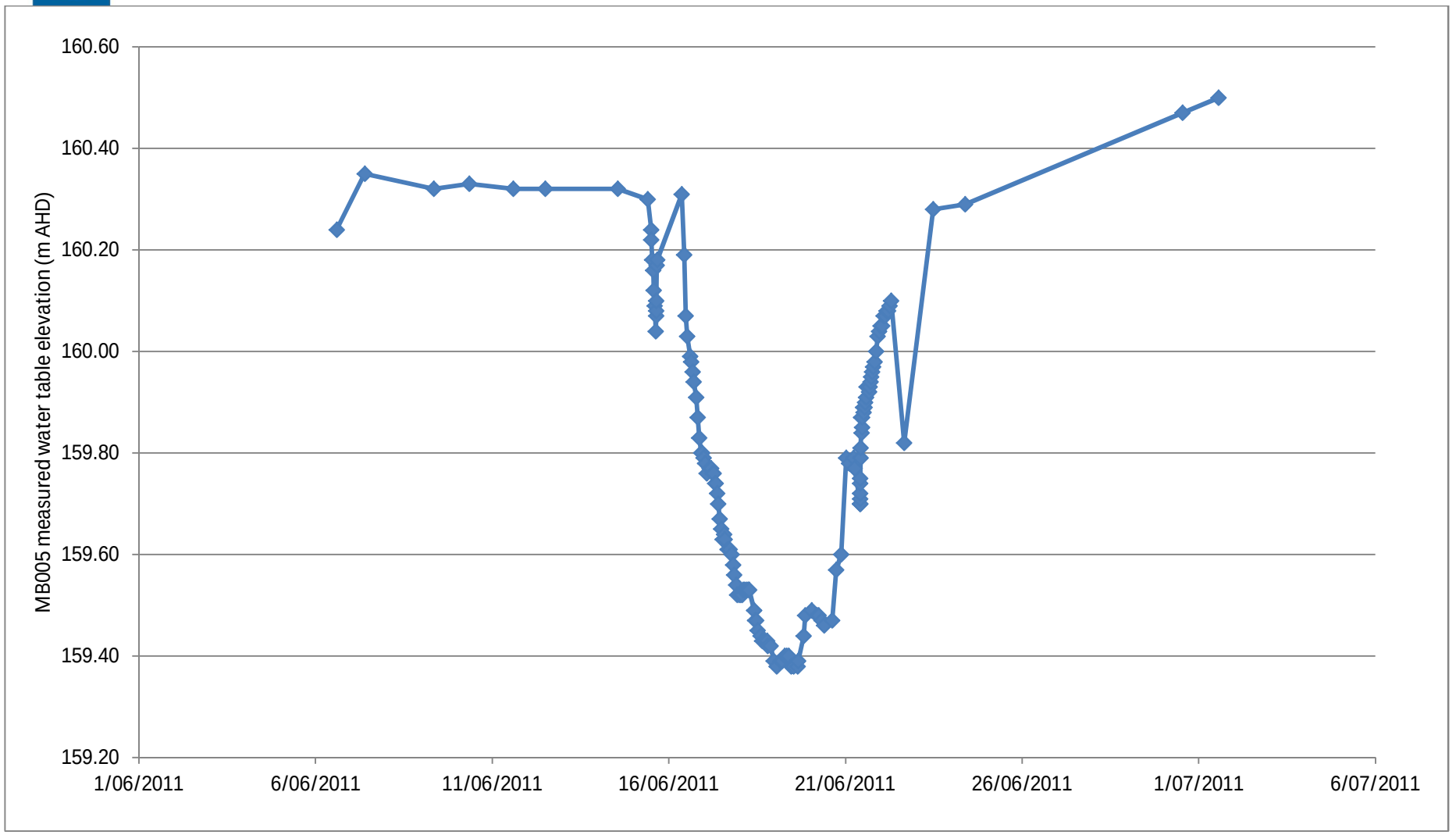

Figure 18 PB003 Pumping Test 2011 MB005 measured water table elevation (m AHD)

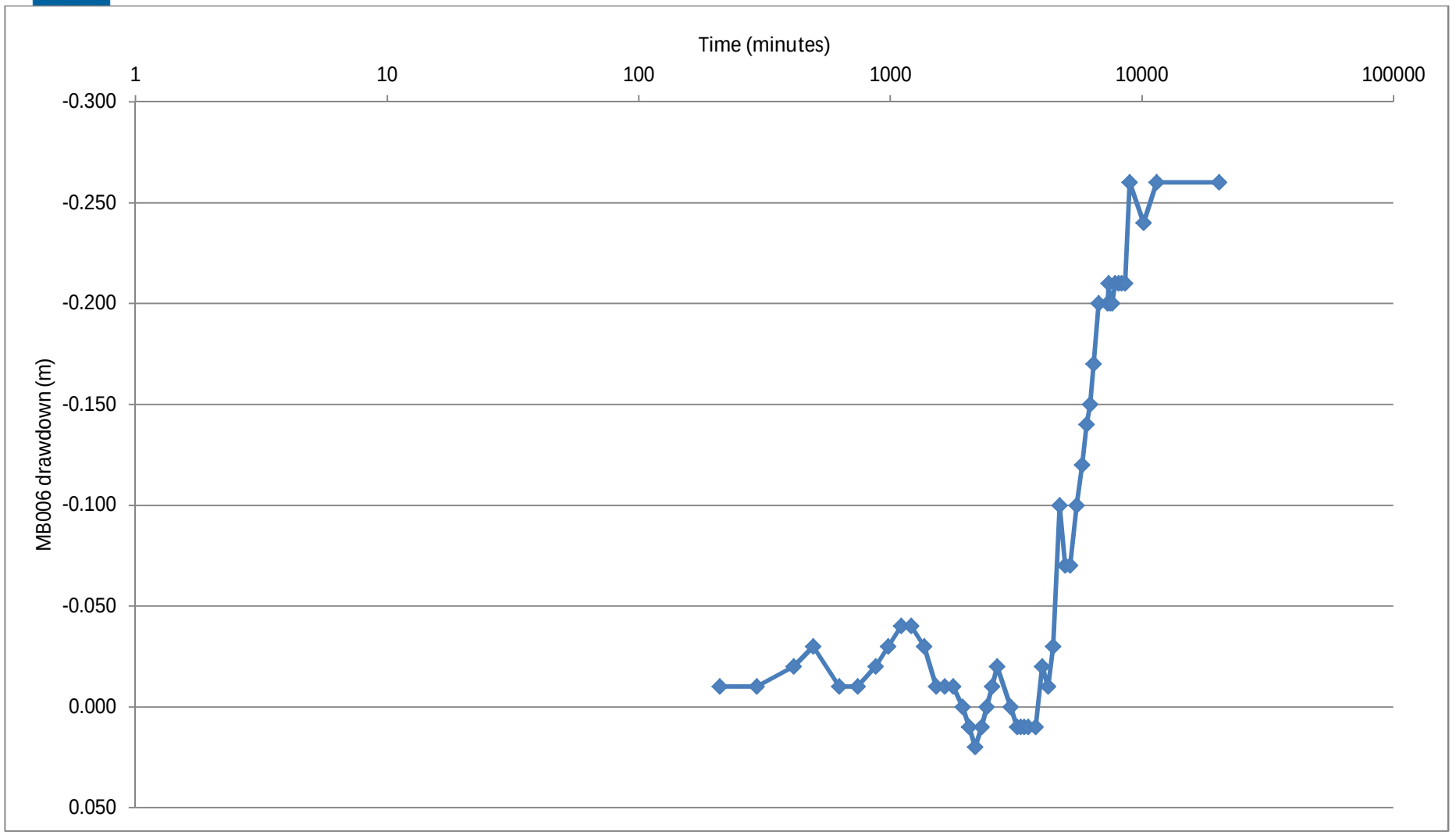

Figure 19 PB003 Pumping Test 2011 MB006 drawdown (m)

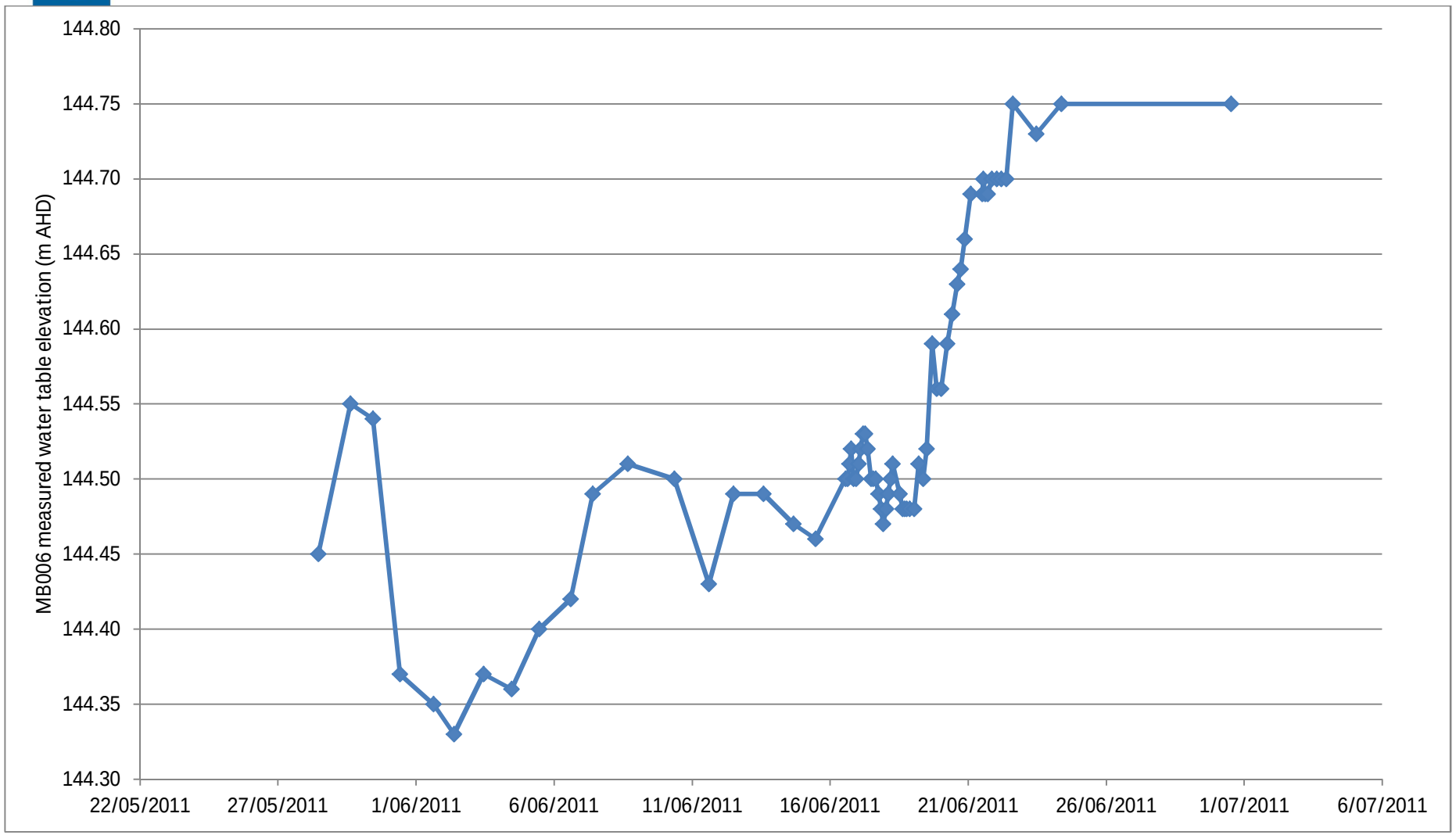

Figure 20 PB003 Pumping Test 2011 MB006 measured water table elevation (m AHD)

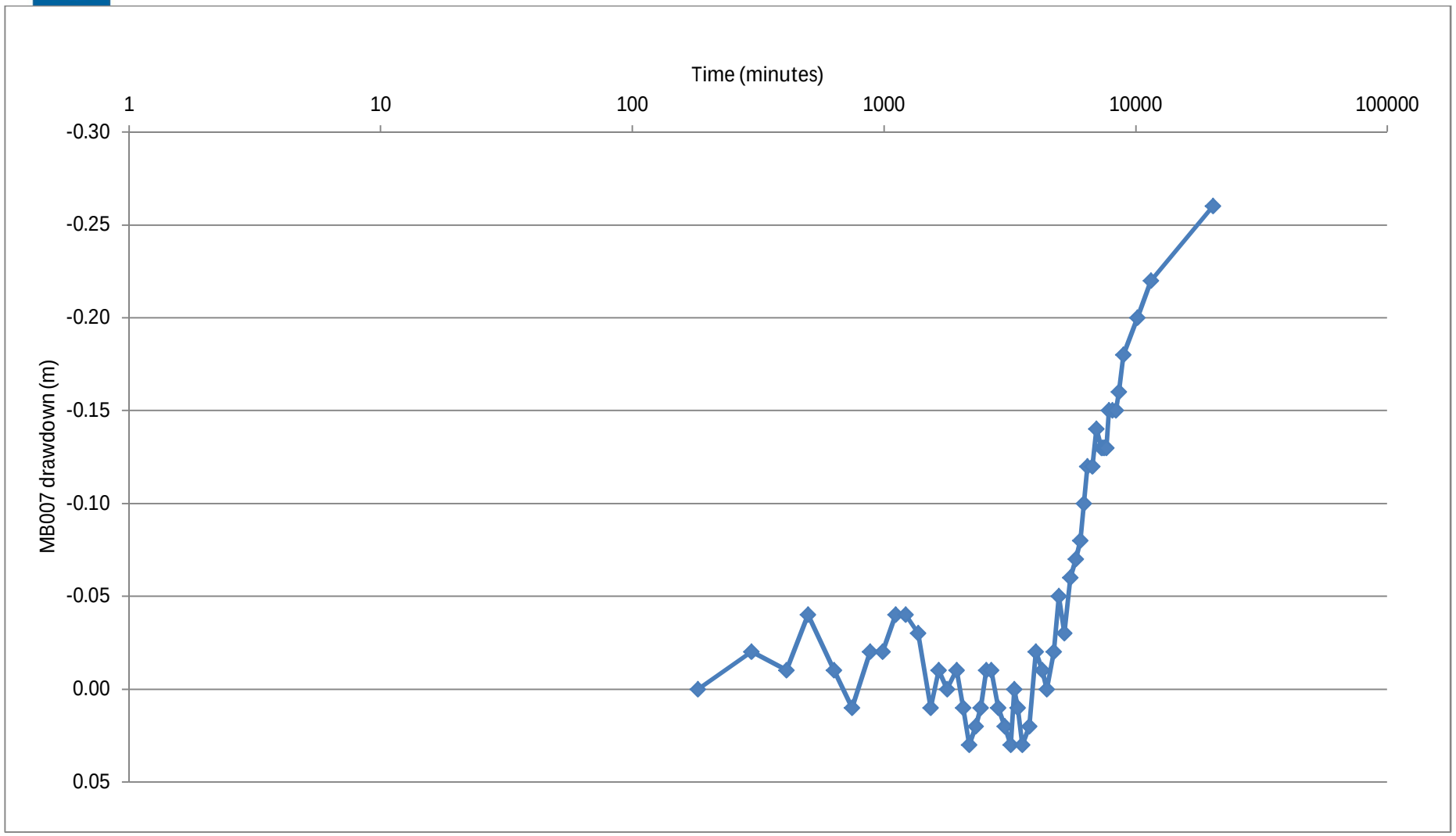

Figure 21 PB003 Pumping Test 2011 MB007 drawdown (m)

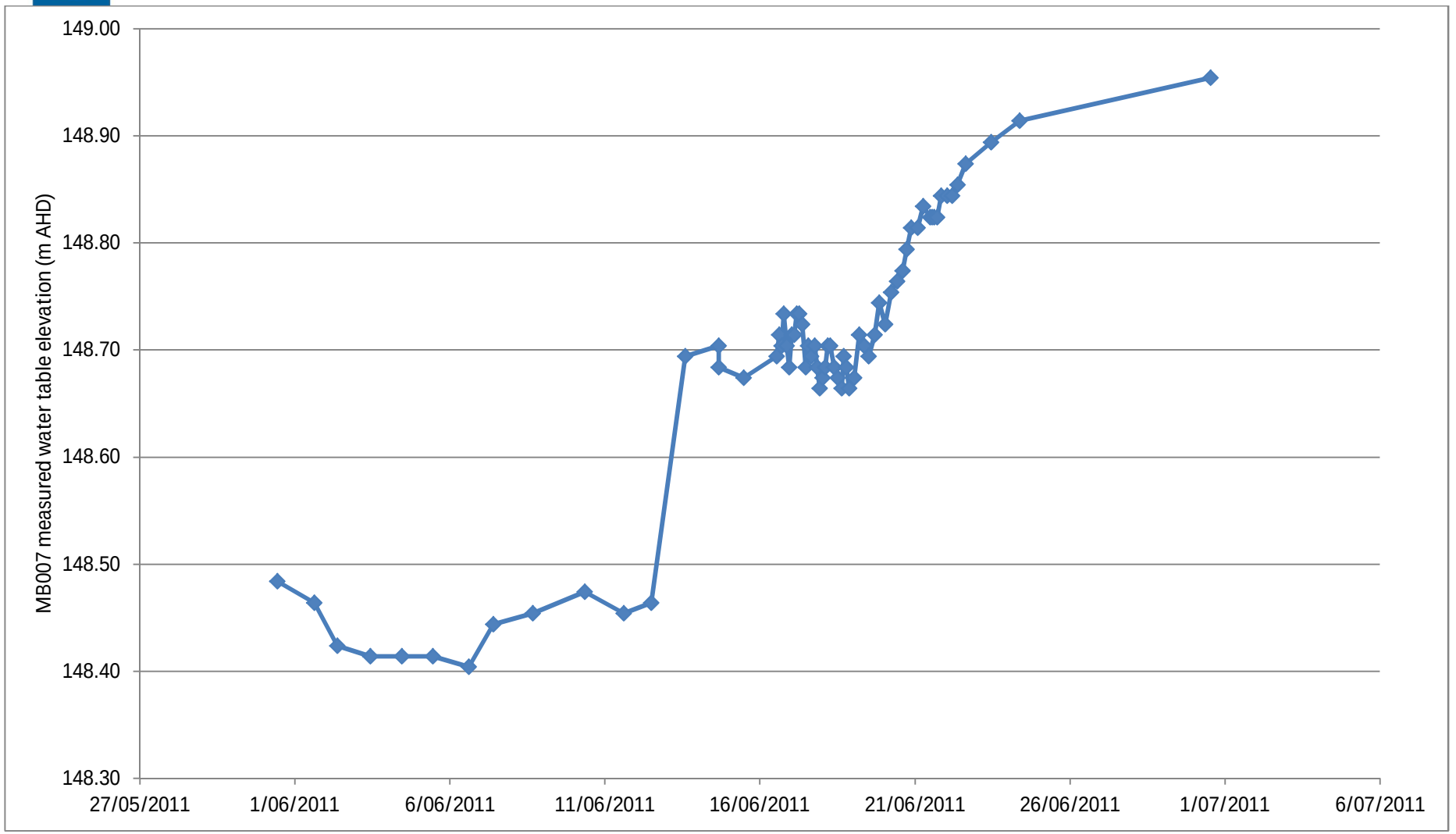

Figure 22 PB003 Pumping Test 2011 MB007 measured water table elevation (m AHD)

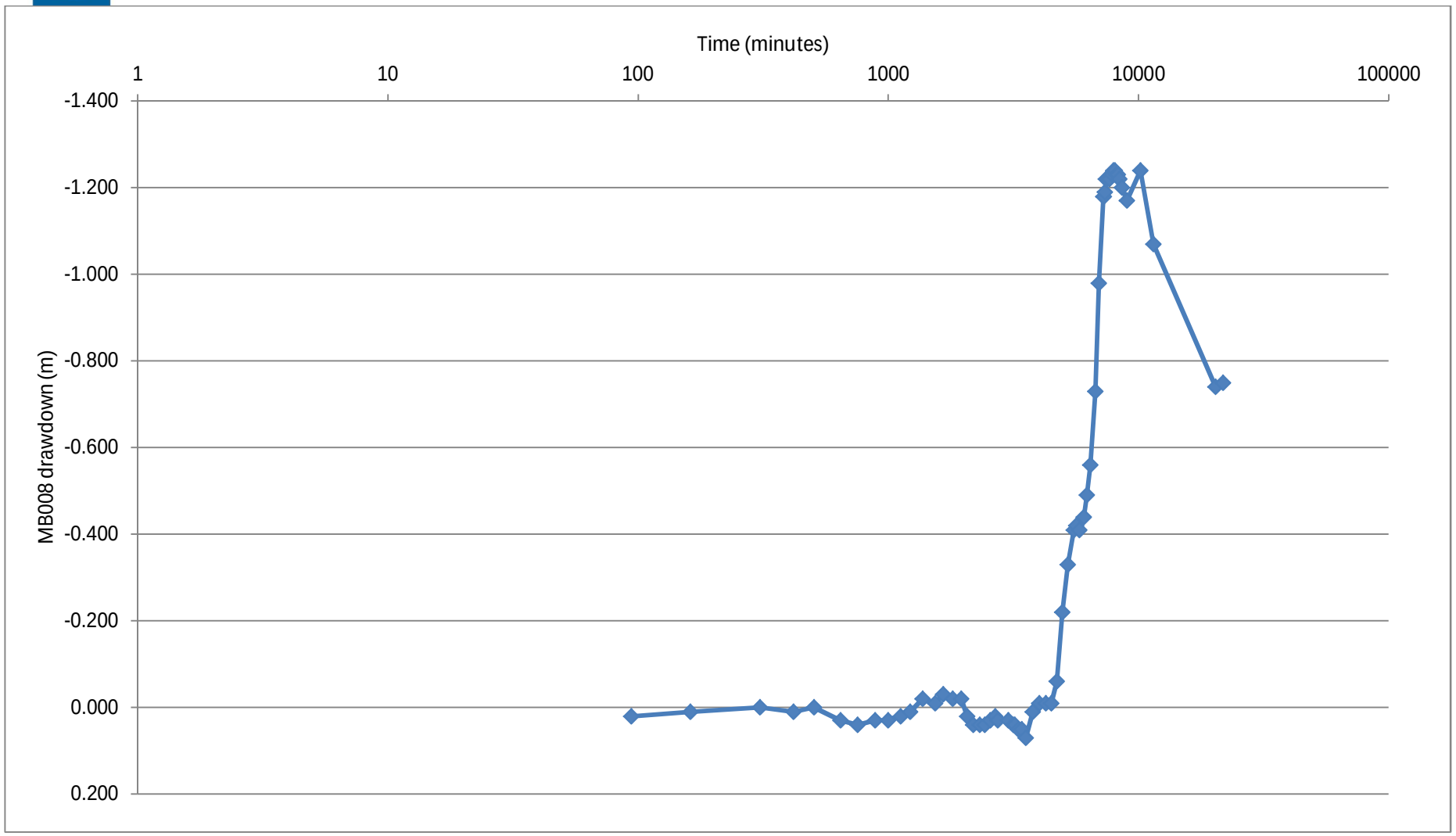

Figure 23 PB003 Pumping Test 2011 MB008 drawdown (m)

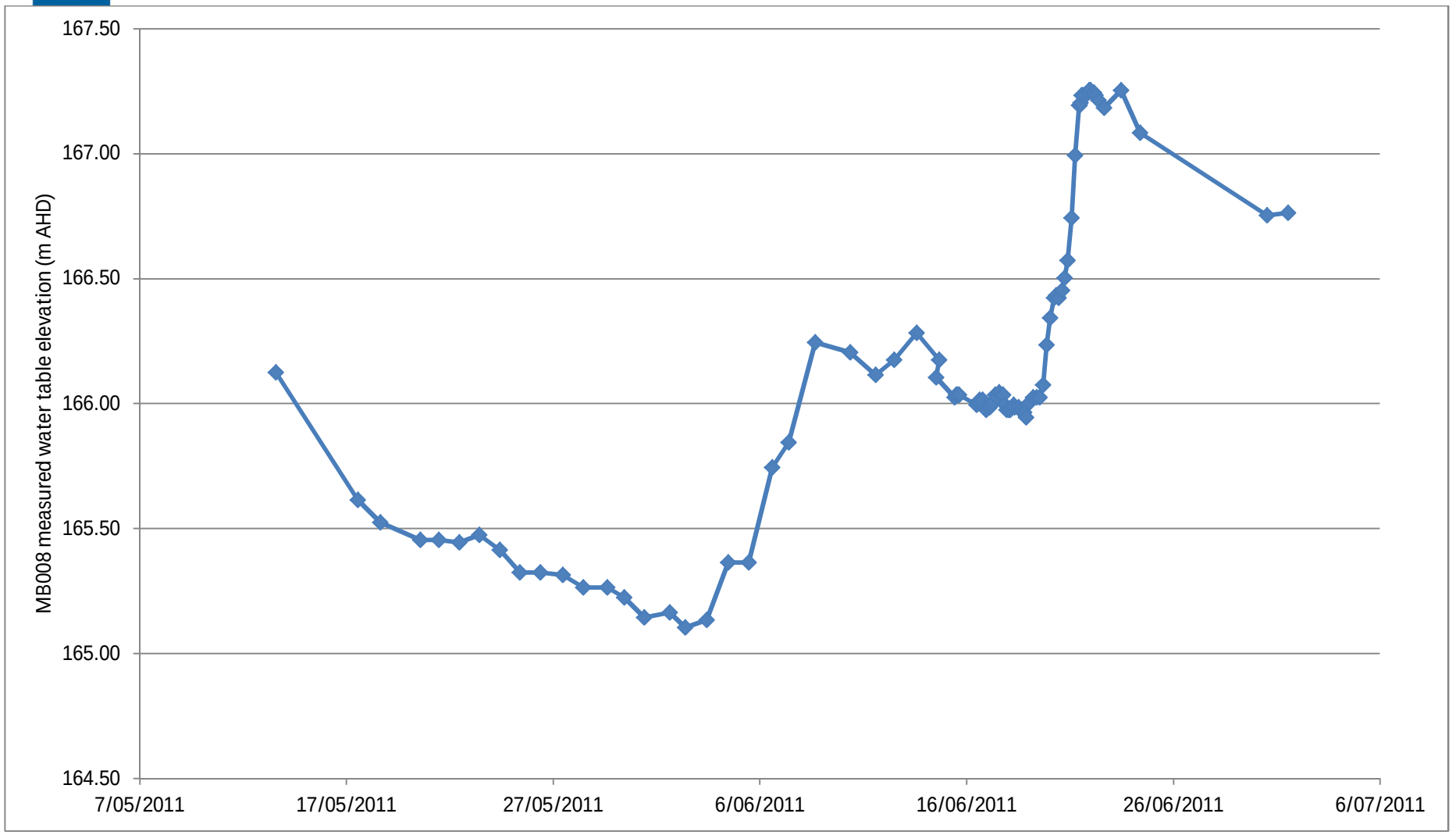

Figure 24 PB003 Pumping Test 2011 MB008 measured water table elevation (m AHD)

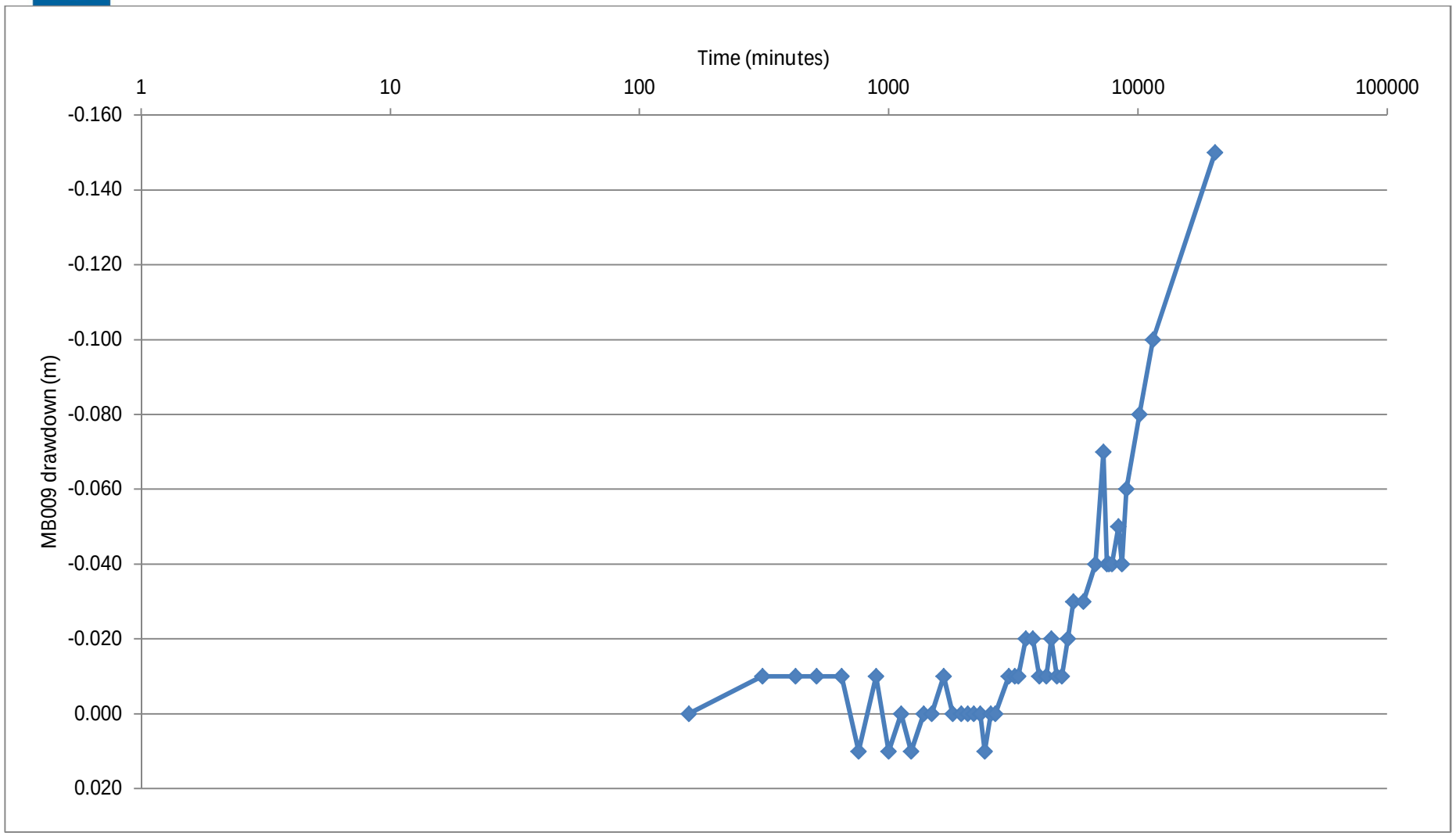

Figure 25 PB003 Pumping Test 2011 MB009 drawdown (m)

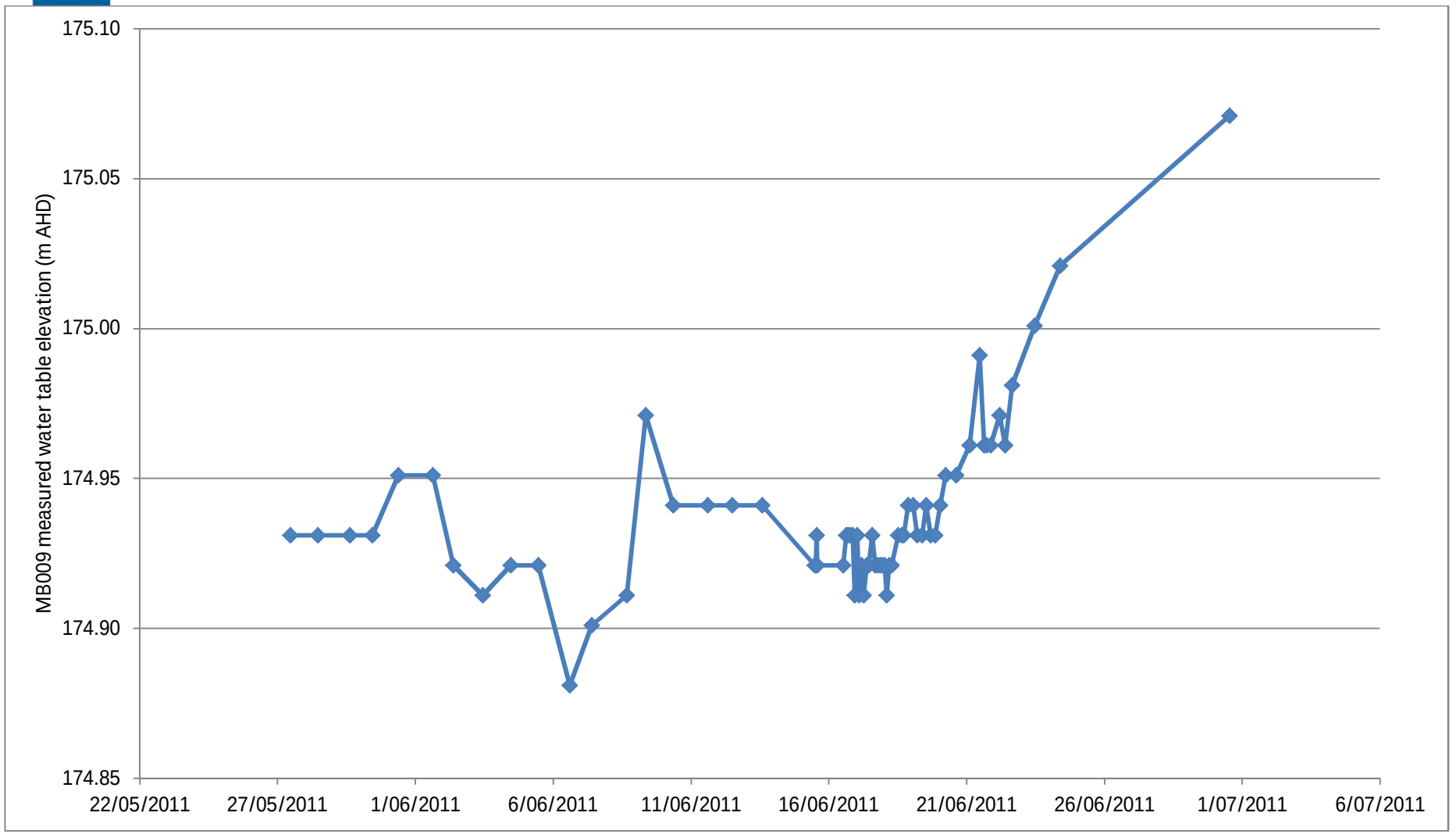

Figure 26 PB003 Pumping Test 2011 MB009 measured water table elevation (m AHD)

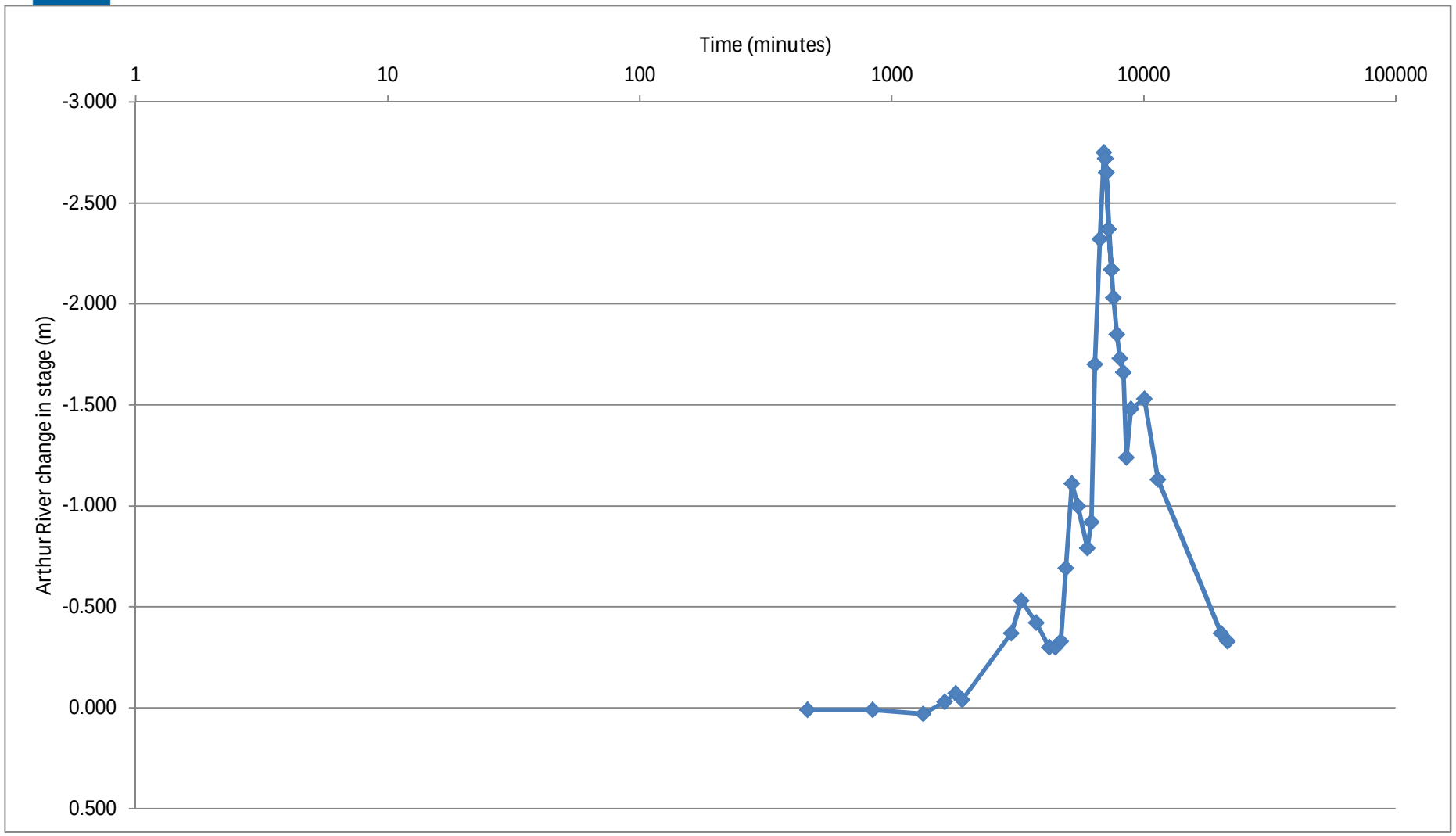

Figure 27 PB003 Pumping Test 2011 Arthur River change in stage (m)

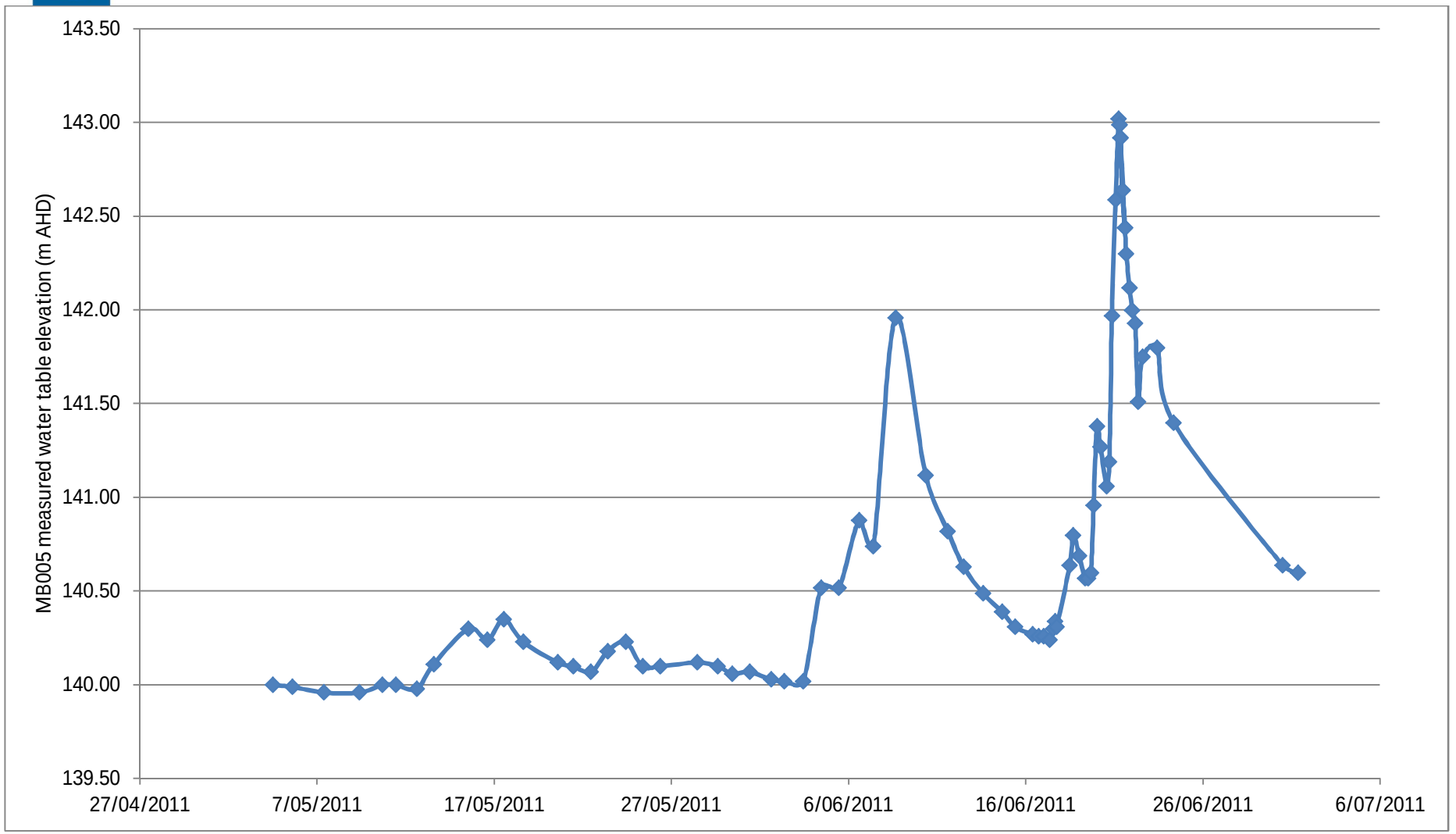

Figure 28 PB003 Pumping Test 2011 MB005 measured water table elevation (m AHD)

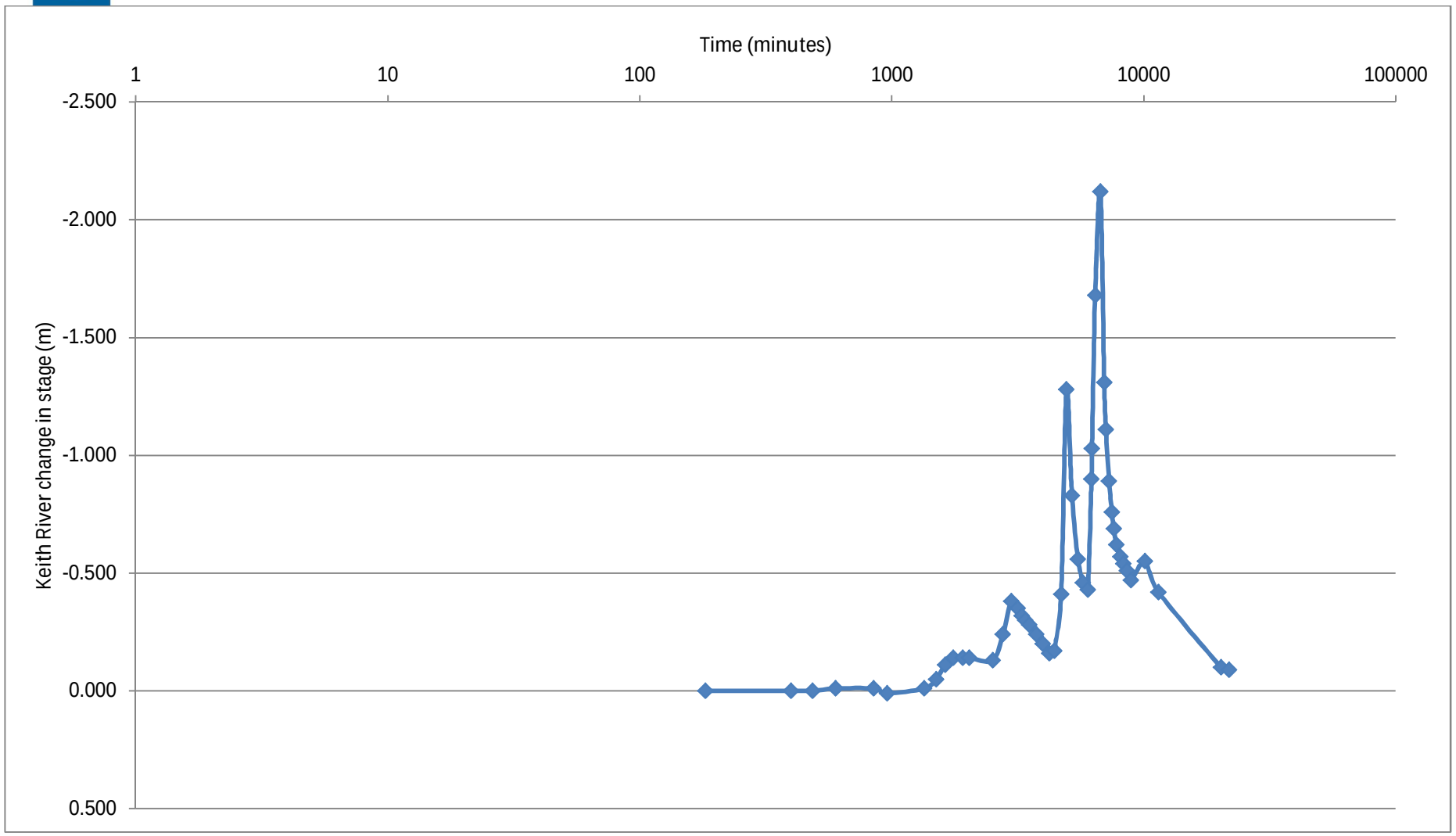

Figure 29 PB003 Pumping Test 2011 Keith River change in stage (m)

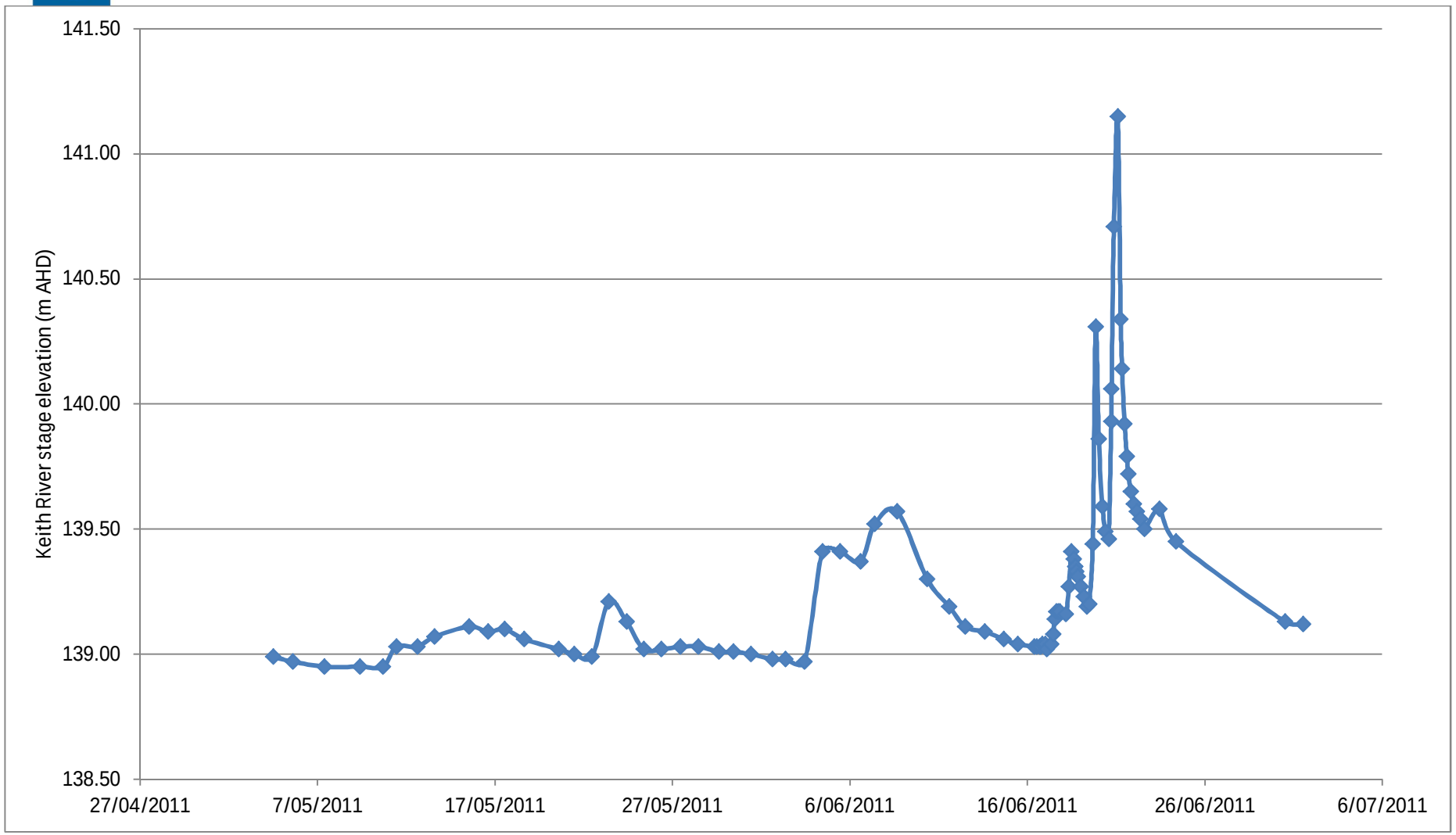

Figure 30 PB003 Pumping Test 2011 Keith River stage elevation (m AHD)

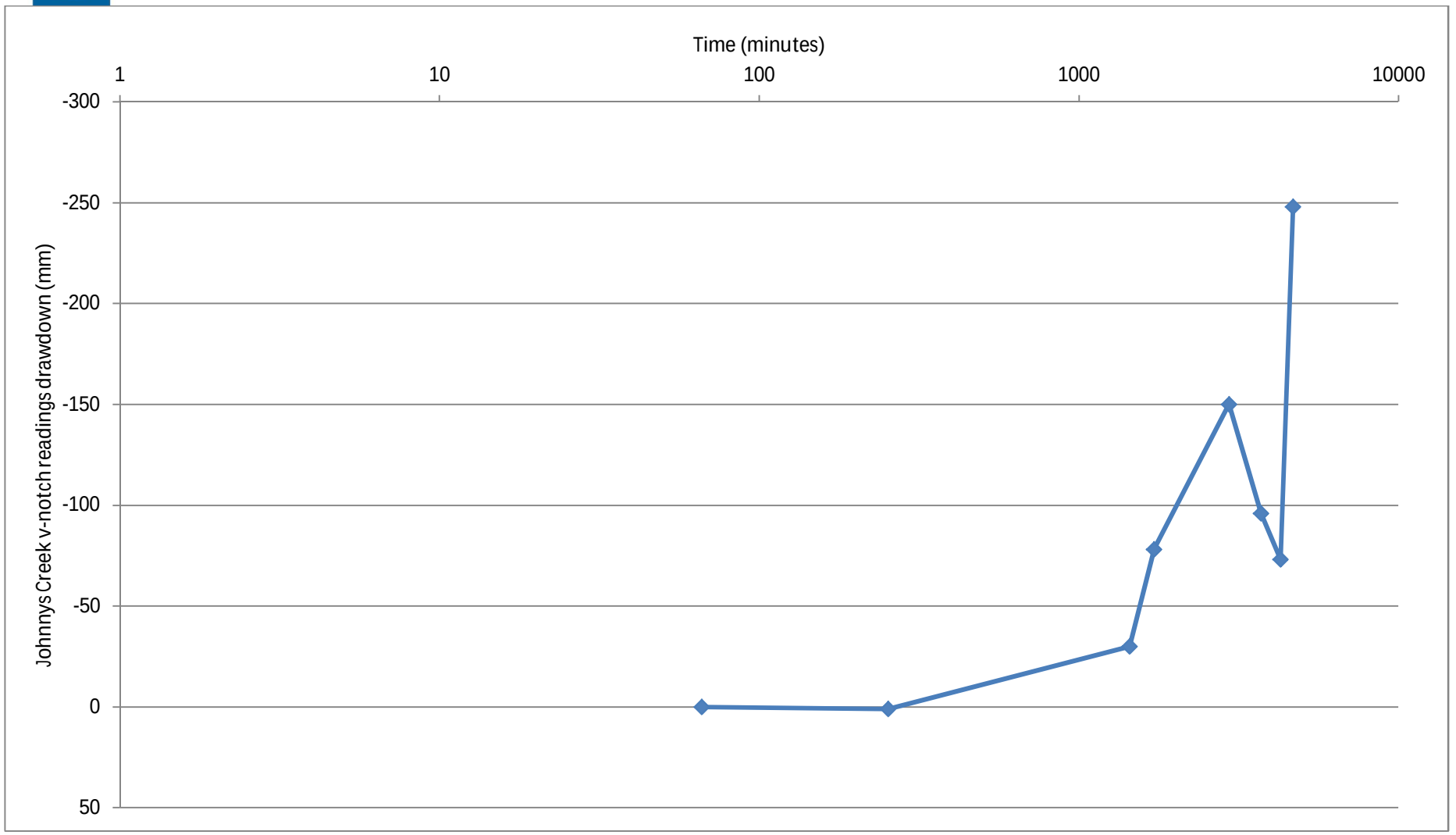

Figure 31 31 Johnnys Creek v-notch readings drawdown (mm)

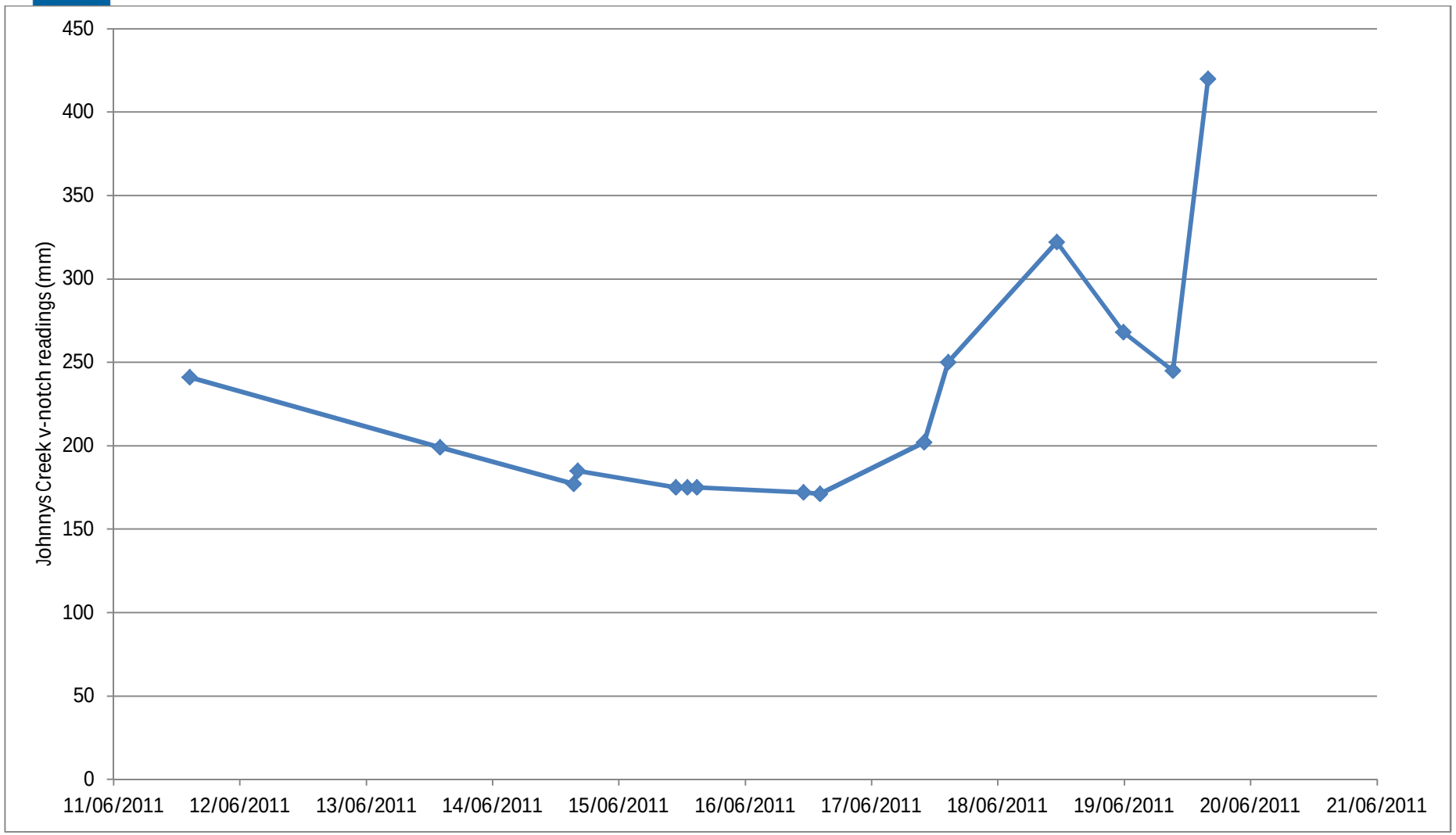

Figure 32 Johnnys Creek v-notch readings (mm)

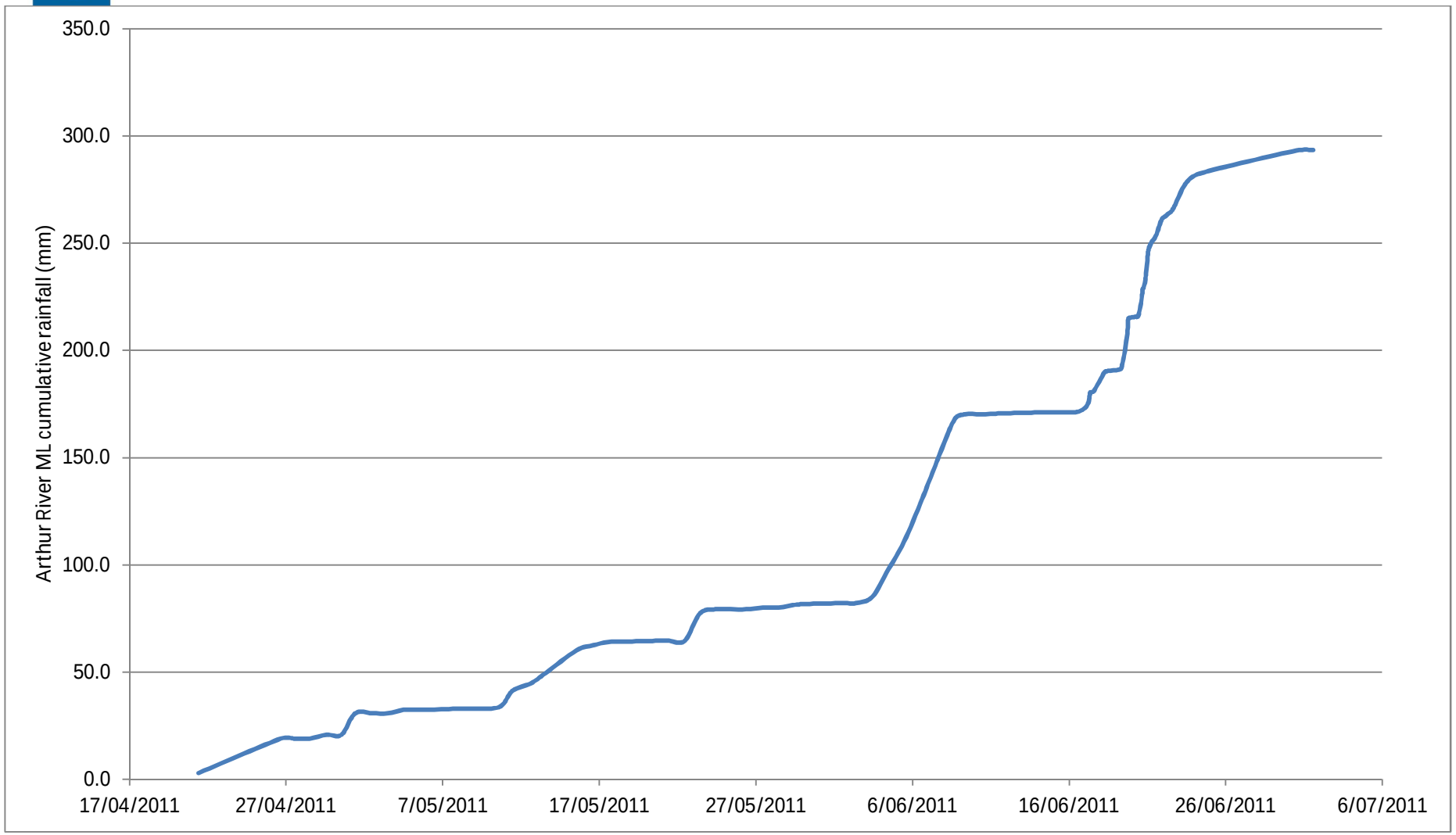

Figure 33 Arthur River ML cumulative rainfall (mm)

Appendix D

PB003 Step Test 2011

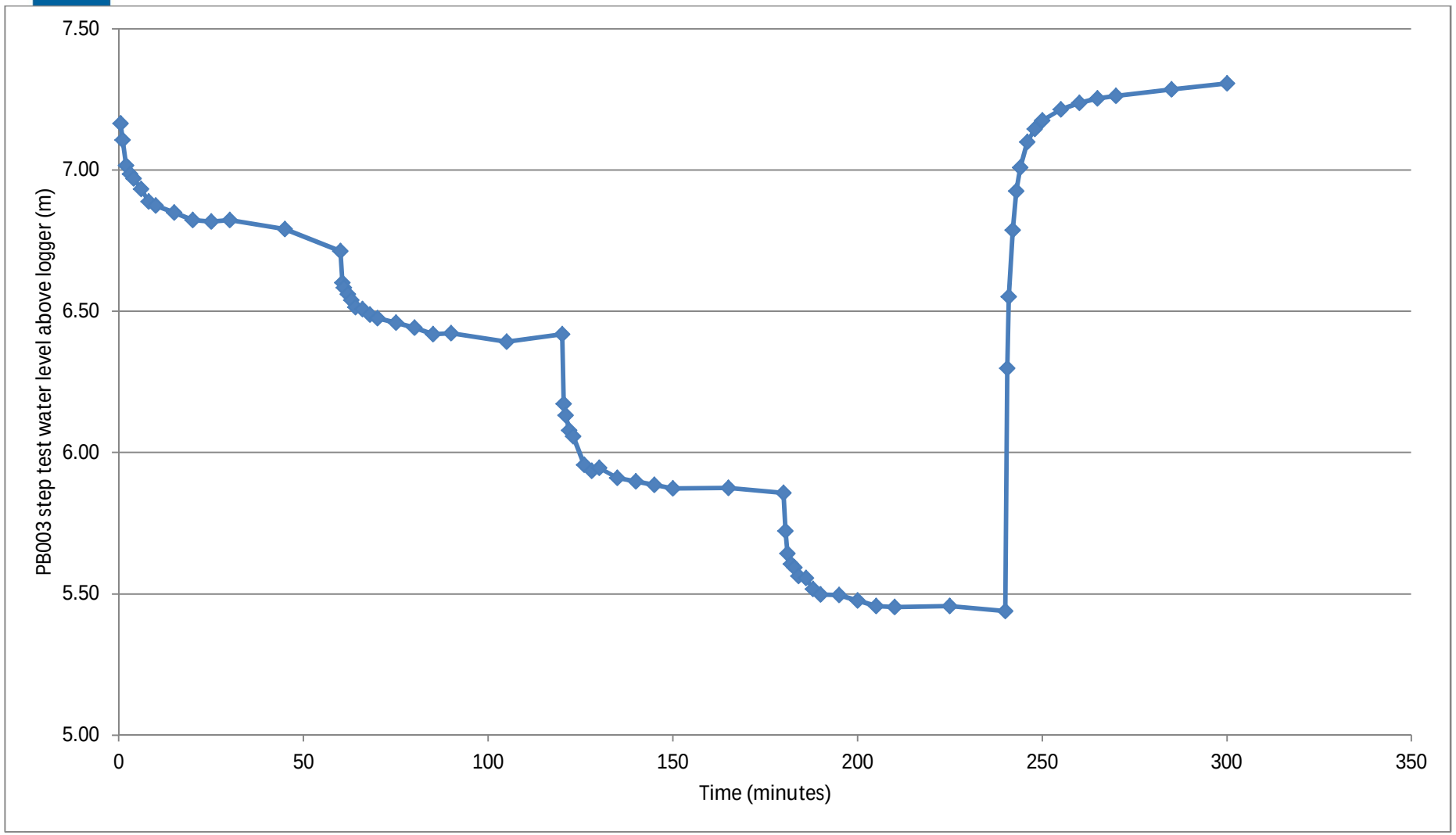

Figure 1 PB003 step test 2011 observed water level above logger (m)

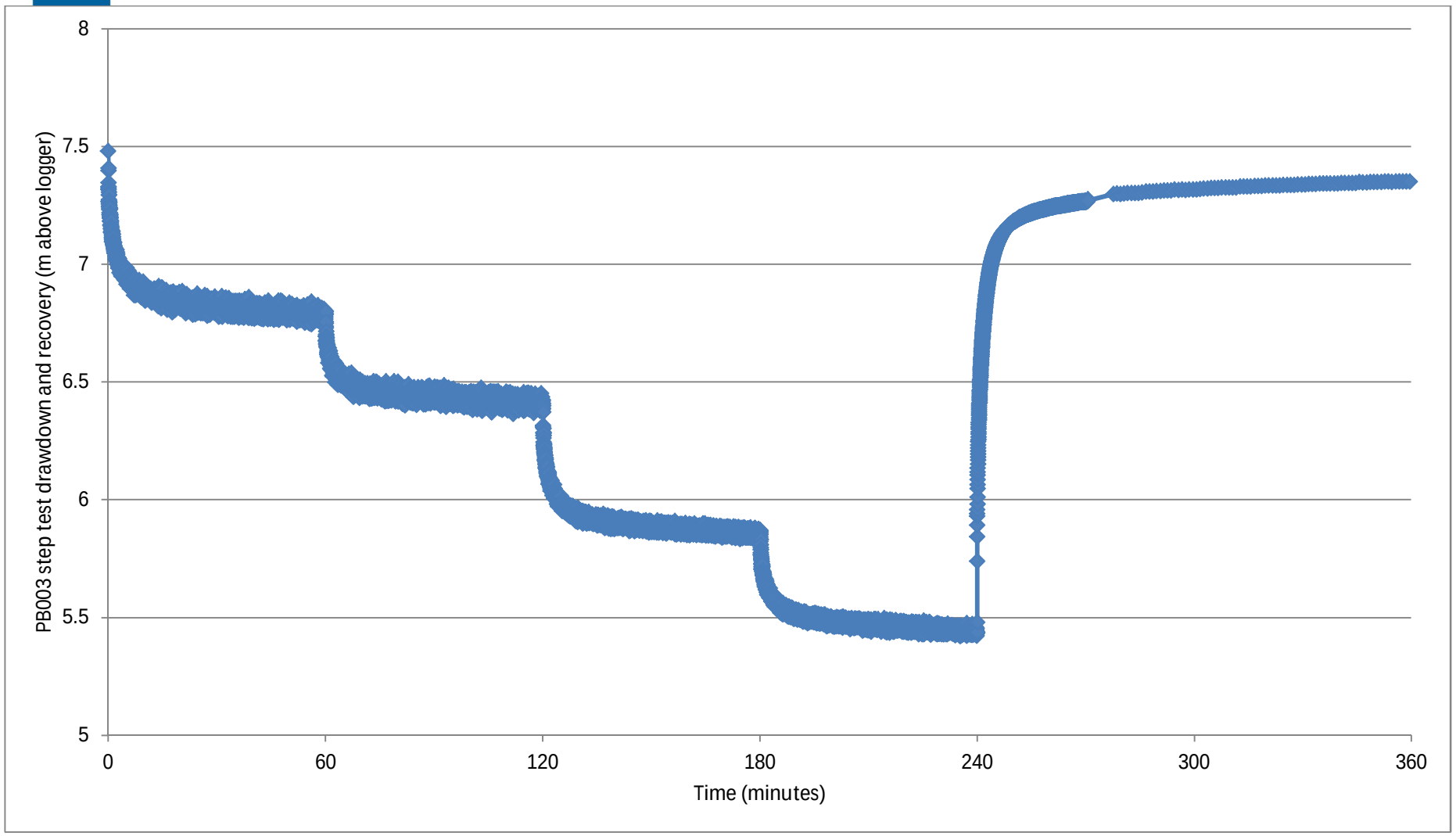

Figure 2 PB003 step test 2011 drawdown and recovery over 6 hours (m above logger)

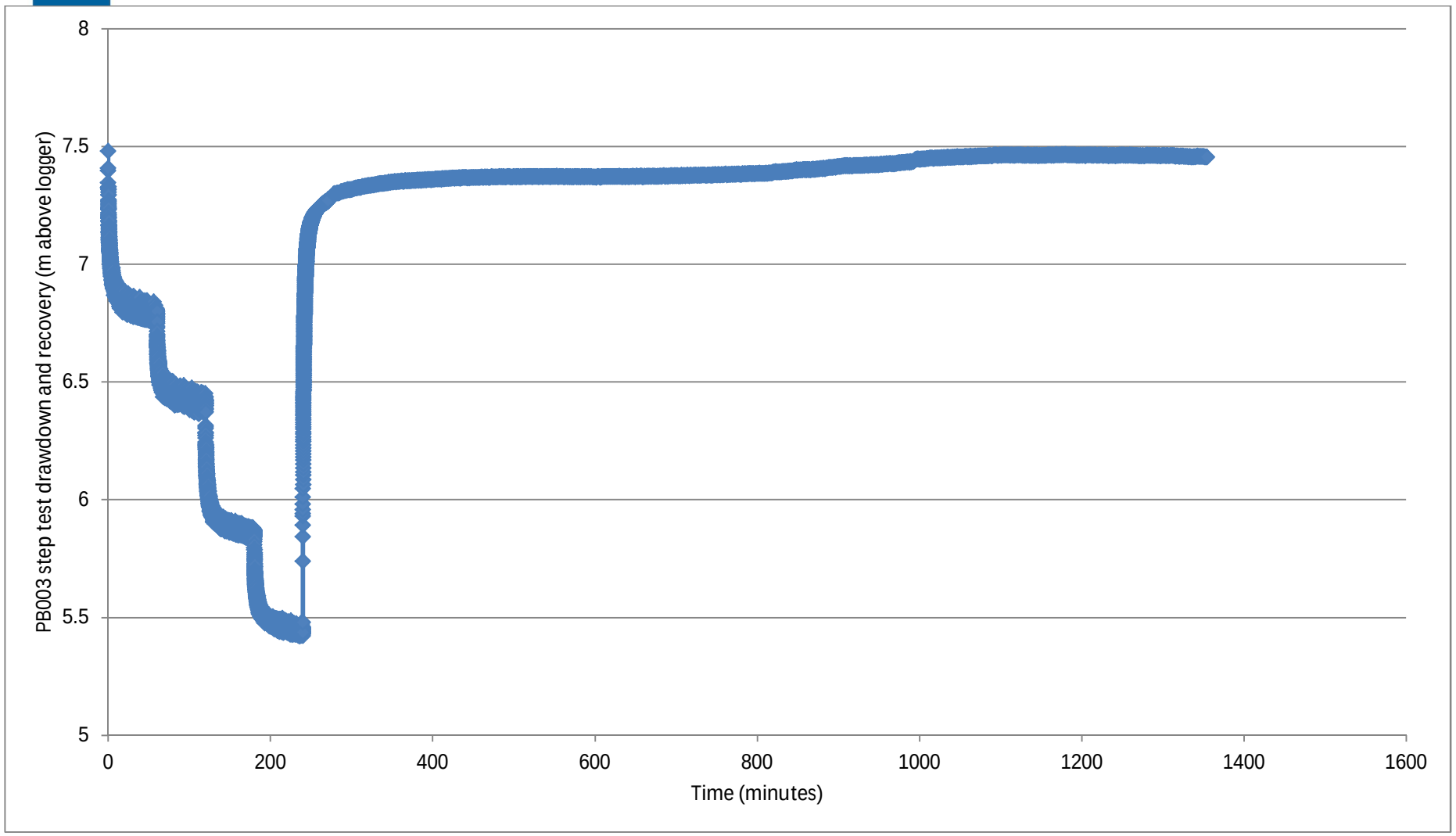

Figure 3 PB003 step test 2011 drawdown and recovery over 24 hours (m above logger)

Appendix E

Site Precipitation (Derwent Geosciences, 2011)

Date	Precipitation (mm) at Arthur River ML
21/04/2011 10:00	3
26/04/2011 16:00	16
27/04/2011 12:00	0
28/04/2011 12:00	0
29/04/2011 14:00	1.8
30/04/2011 13:00	0
1/05/2011 10:00	10
2/05/2011 12:00	0
3/05/2011 12:00	0
4/05/2011 12:00	1.6
5/05/2011 15:00	0
7/05/2011 9:30	0.4
9/05/2011 9:30	0.2
10/05/2011 16:30	1
11/05/2011 11:00	7.3
12/05/2011 15:00	3.5
13/05/2011 14:00	4.8
15/05/2011 13:00	10.5
16/05/2011 15:00	2.4
17/05/2011 13:00	1.5
18/05/2011 15:30	0.2
20/05/2011 14:00	0.4
21/05/2011 11:00	0
22/05/2011 11:00	0
23/05/2011 10:00	12.7
24/05/2011 10:00	2
25/05/2011 9:00	0
26/05/2011 9:00	0
27/05/2011 11:00	0.8
28/05/2011 11:00	0
29/05/2011 15:00	1.4
30/05/2011 10:30	0.3
31/05/2011 11:40	0.2
1/06/2011 15:00	0.2
2/06/2011 9:00	0
3/06/2011 10:30	2.9
4/06/2011 11:00	12.8
5/06/2011 11:00	12.8
6/06/2011 14:30	19.8
7/06/2011 9:30	14.7
8/06/2011 16:00	22.5
9/06/2011 8:30	2.5
10/06/2011 8:30	0
11/06/2011 14:30	0.4

Date	Precipitation (mm) at Arthur River ML
12/06/2011 12:00	0.2
13/06/2011 14:00	0.2
15/06/2011 11:39	0.2
16/06/2011 15:00	0.3
17/06/2011 4:35	3.5
17/06/2011 8:22	5.4
17/06/2011 13:30	0.5
18/06/2011 5:55	8.8
18/06/2011 11:40	0.7
19/06/2011 4:10	0.6
19/06/2011 8:21	1
19/06/2011 16:10	12.9
19/06/2011 18:45	10
19/06/2011 20:04	0.3
20/06/2011 0:09	0.2
20/06/2011 5:19	0.3
20/06/2011 9:34	0.2
20/06/2011 14:29	6.7
20/06/2011 16:38	6
20/06/2011 17:48	0.4
20/06/2011 20:50	4
21/06/2011 1:13	13.5
21/06/2011 2:26	1.3
21/06/2011 5:49	2.4
21/06/2011 13:06	3.3
21/06/2011 20:48	6.9
22/06/2011 0:21	1.5
22/06/2011 4:22	0.8
22/06/2011 7:41	1.1

Appendix F

Graphical Model Output

Figure 1 Model grid layer 1 2
Figure 2 Model grid layer 2 3
Figure 3 Model grid layer 3 4
Figure 4 Model grid layer 4 5
Figure 5 Model grid layer 5 6
Figure 6 Model grid layer 6 7
Figure 7 Model heads steady state model layer 1 heads 8
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Figure 9 Model heads steady state model layer 3 heads 10
Figure 10 Model heads steady state model layer 4 heads 11
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Figure 12 Model heads steady state model layer 6 heads 13
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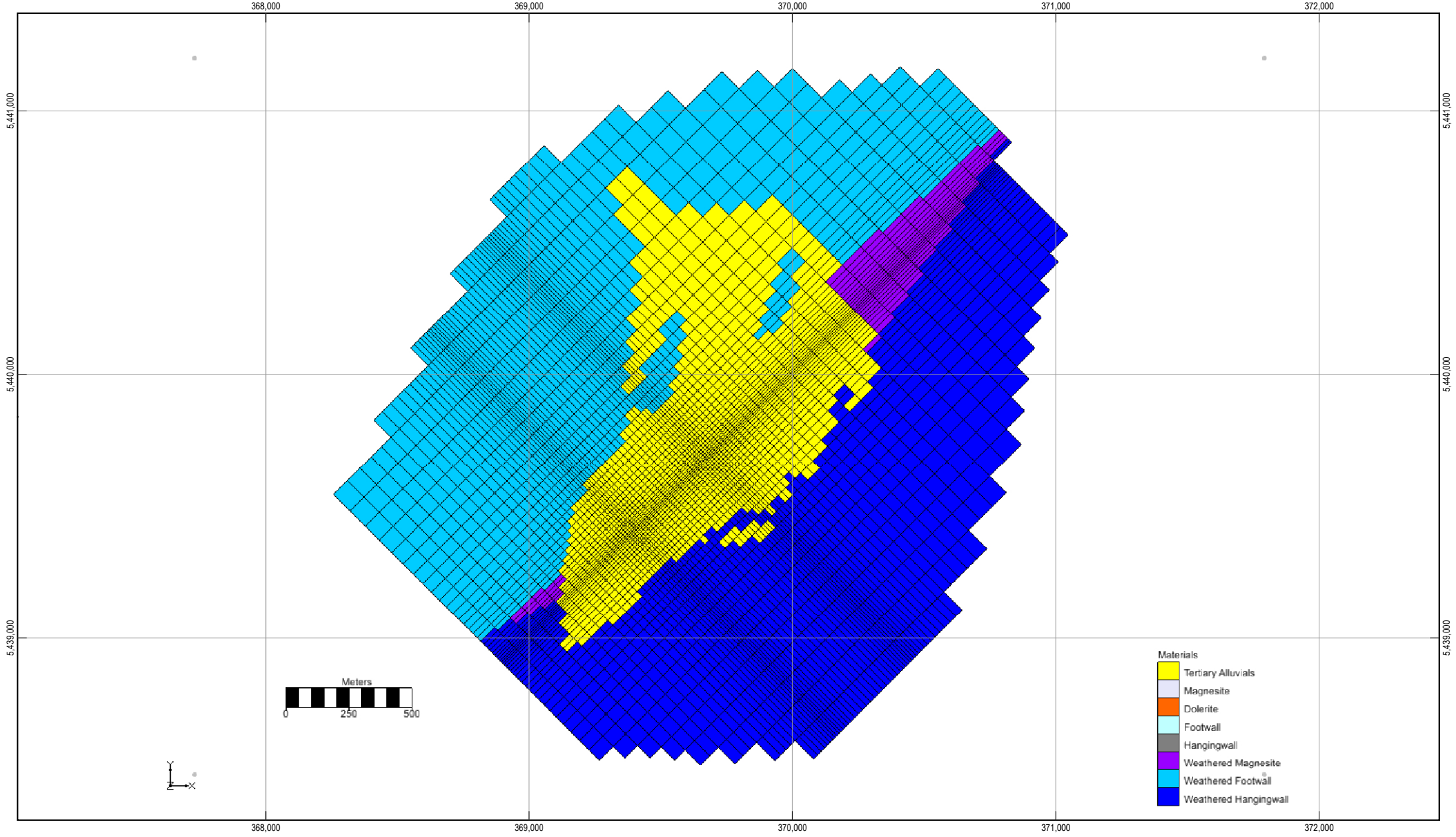
Figure 14 PB003 2011 transient model; PB003 heads (mAHD) triangles = observations, diamonds = modelled 15
Figure 15 PB003 2011 transient model; MB005 heads (mAHD) triangles = observations, diamonds = modelled 16
Figure 16 2011 temporal model; MB003 heads (mAHD) triangles = observations, diamonds = modelled 17
Figure 17 2011 temporal model; MB004 heads (mAHD) squares = observations, diamonds = modelled 18
Figure 18 2011 temporal model; PB002 heads (mAHD) triangles = observations, diamonds = modelled 19
Figure 19 Dewatering scenario heads example 2018 layer 6 20
Figure 20 Dewatering scenario heads example 2024 layer 6 21



Paper Size A4

0 125 250 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

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Job Number | 32-15824
Revision | A
Date | 03 Nov 2011

Appendix F
Model Grid Layer 1

Figure 1

G:\32\15824\GIS\Maps\AppFFigure1.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 62100601 E hbamail@ghd.com W www.ghd.com

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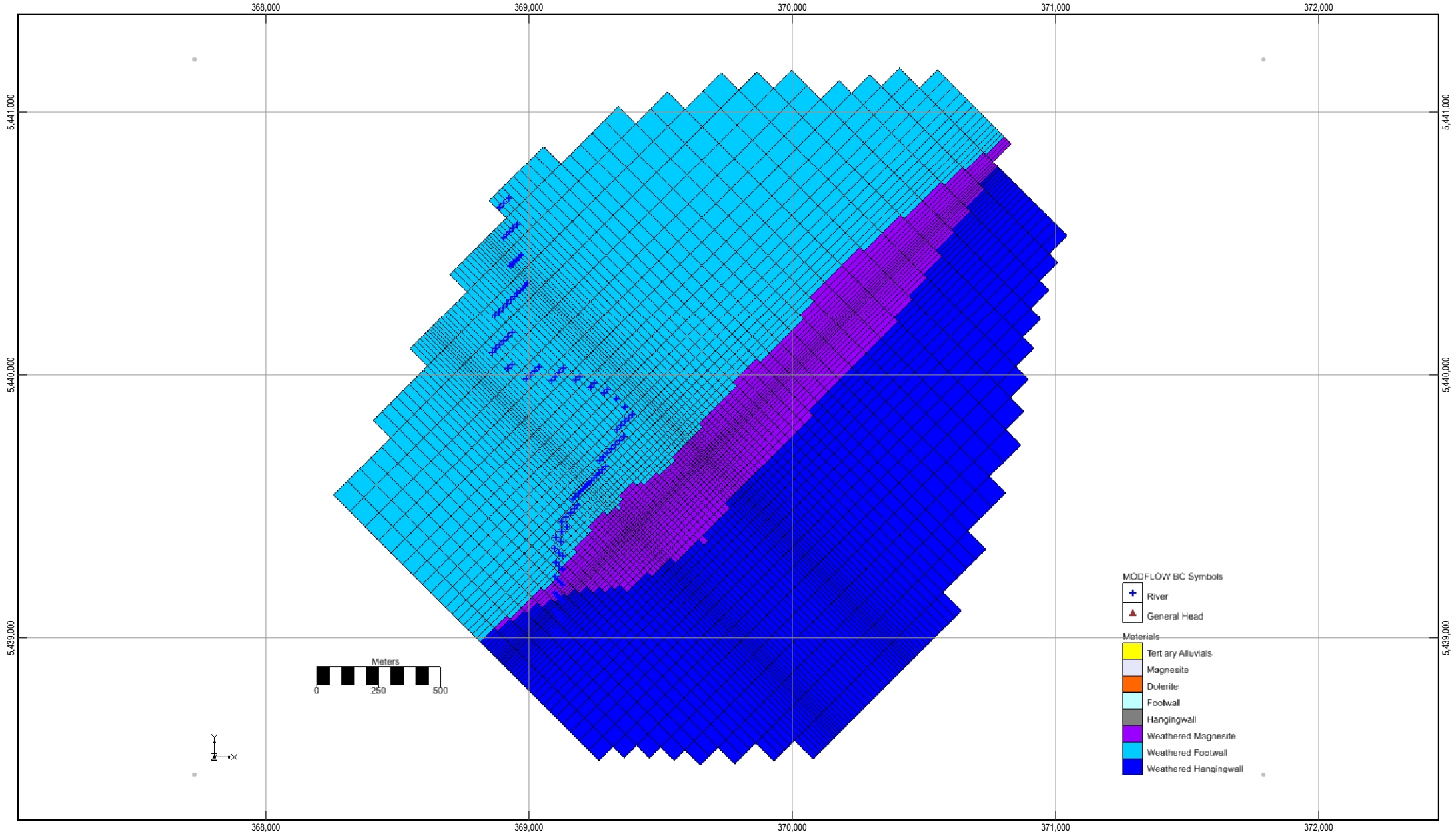
Data source: Created by:Irevans



Paper Size A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

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Revision A
Date 03 Nov 2011

Appendix F
Model Grid Layer 2

Figure 2

G:\32\15824\GIS\Maps\AppFFigure2.mxd

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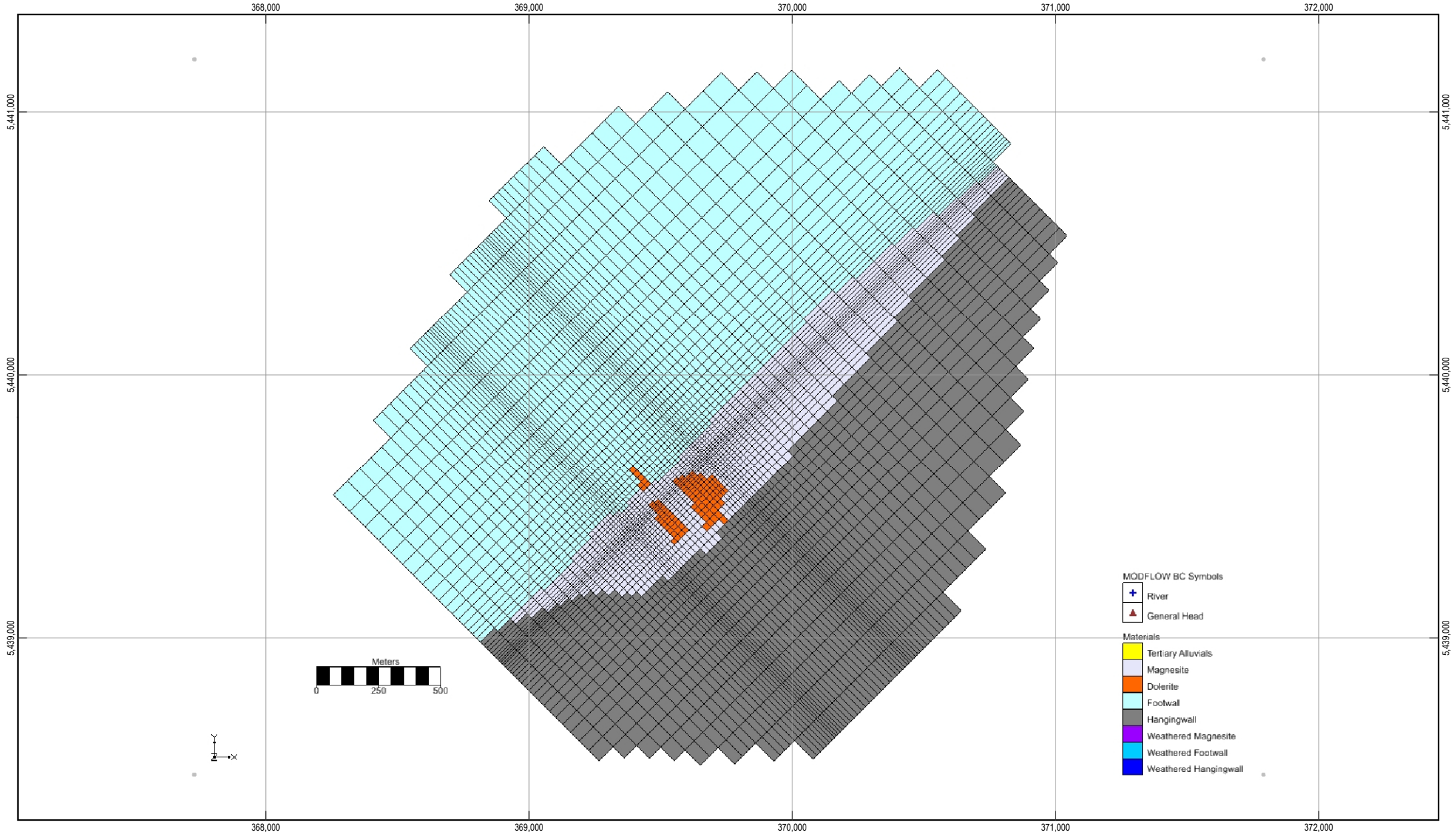

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Metres

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Appendix F
Model Grid Layer 3

Figure 3

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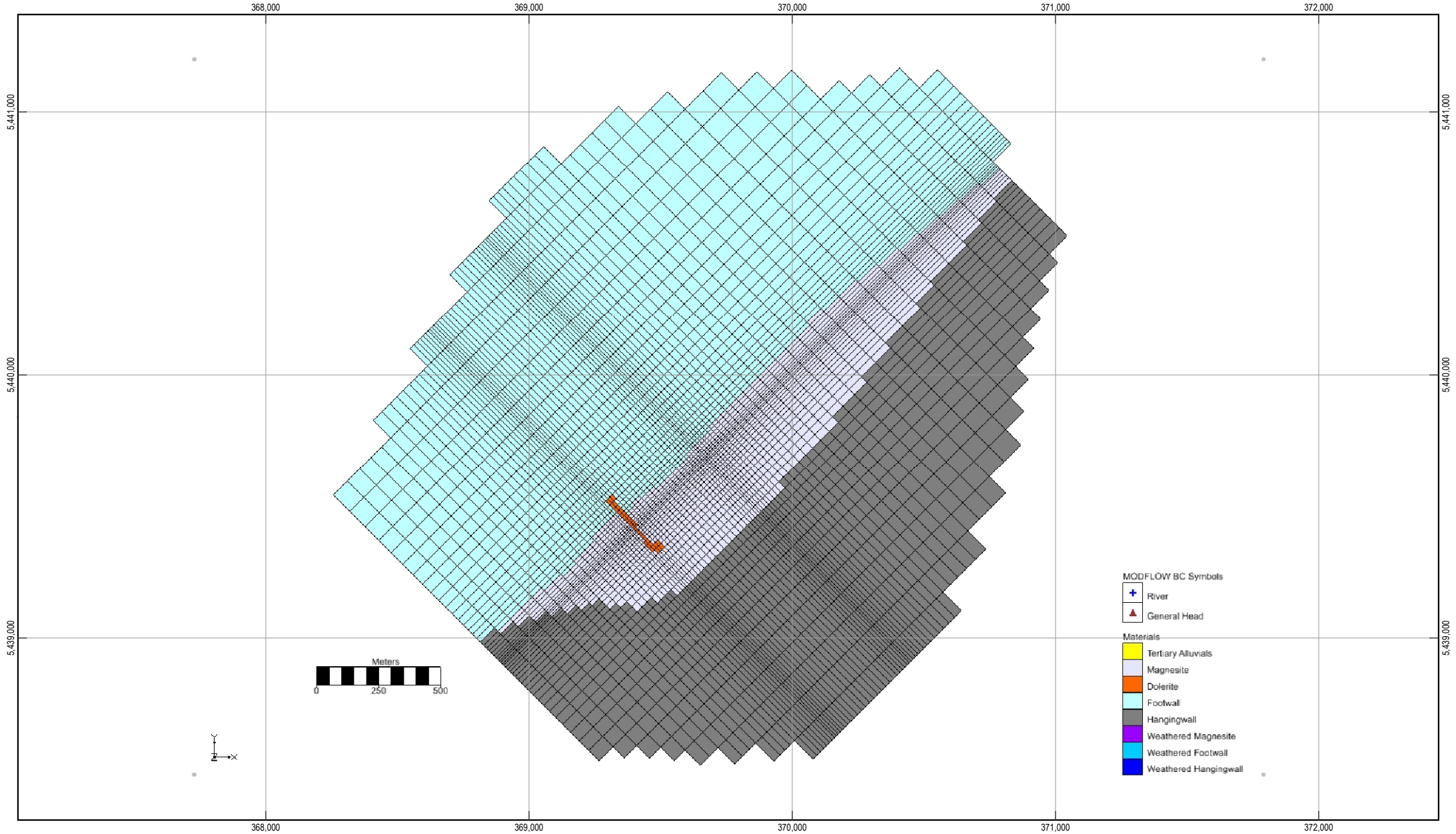

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Appendix F
Model Grid Layer 4

Figure 4

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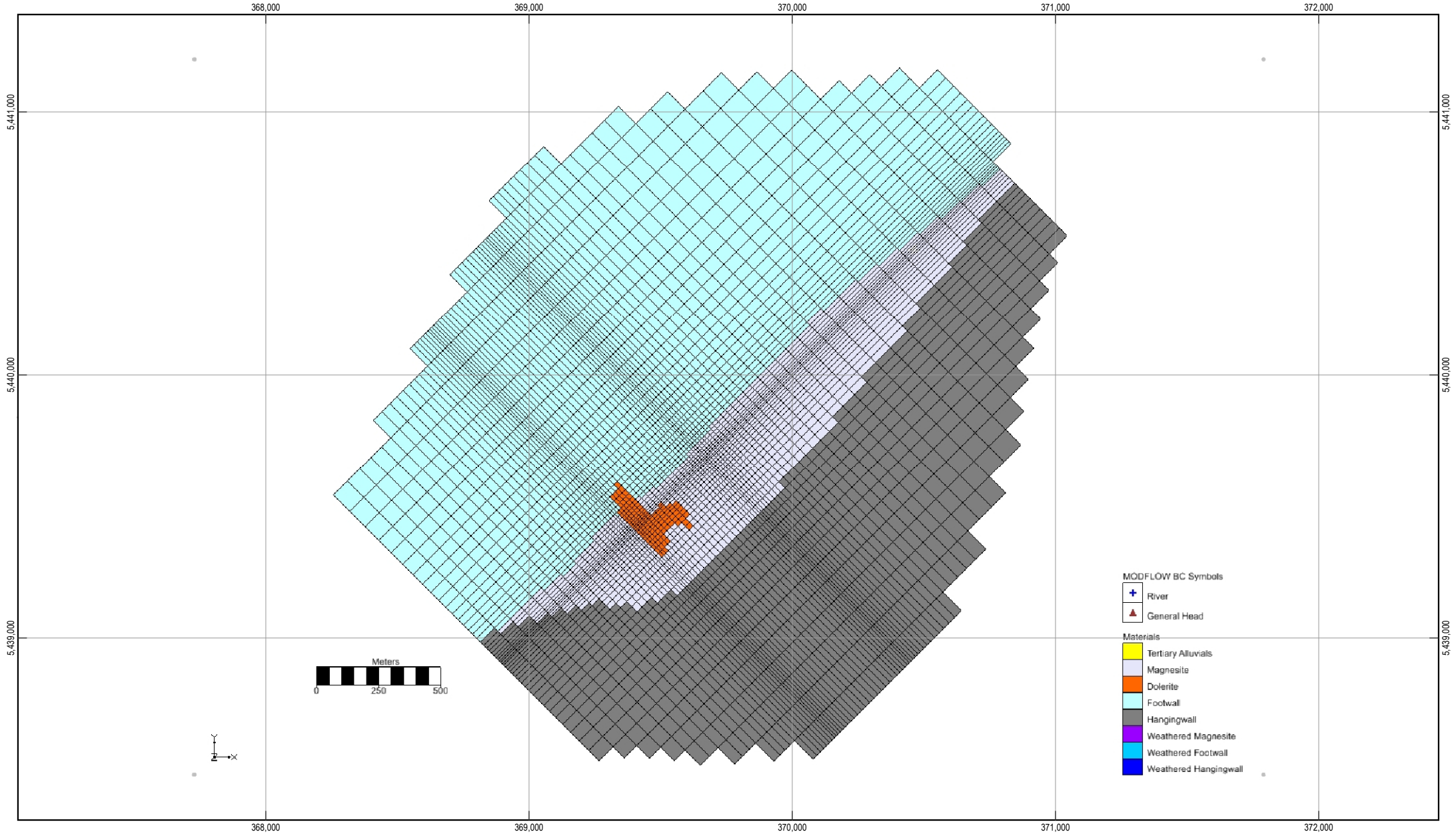

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Appendix F
Model Grid Layer 5

Figure 5

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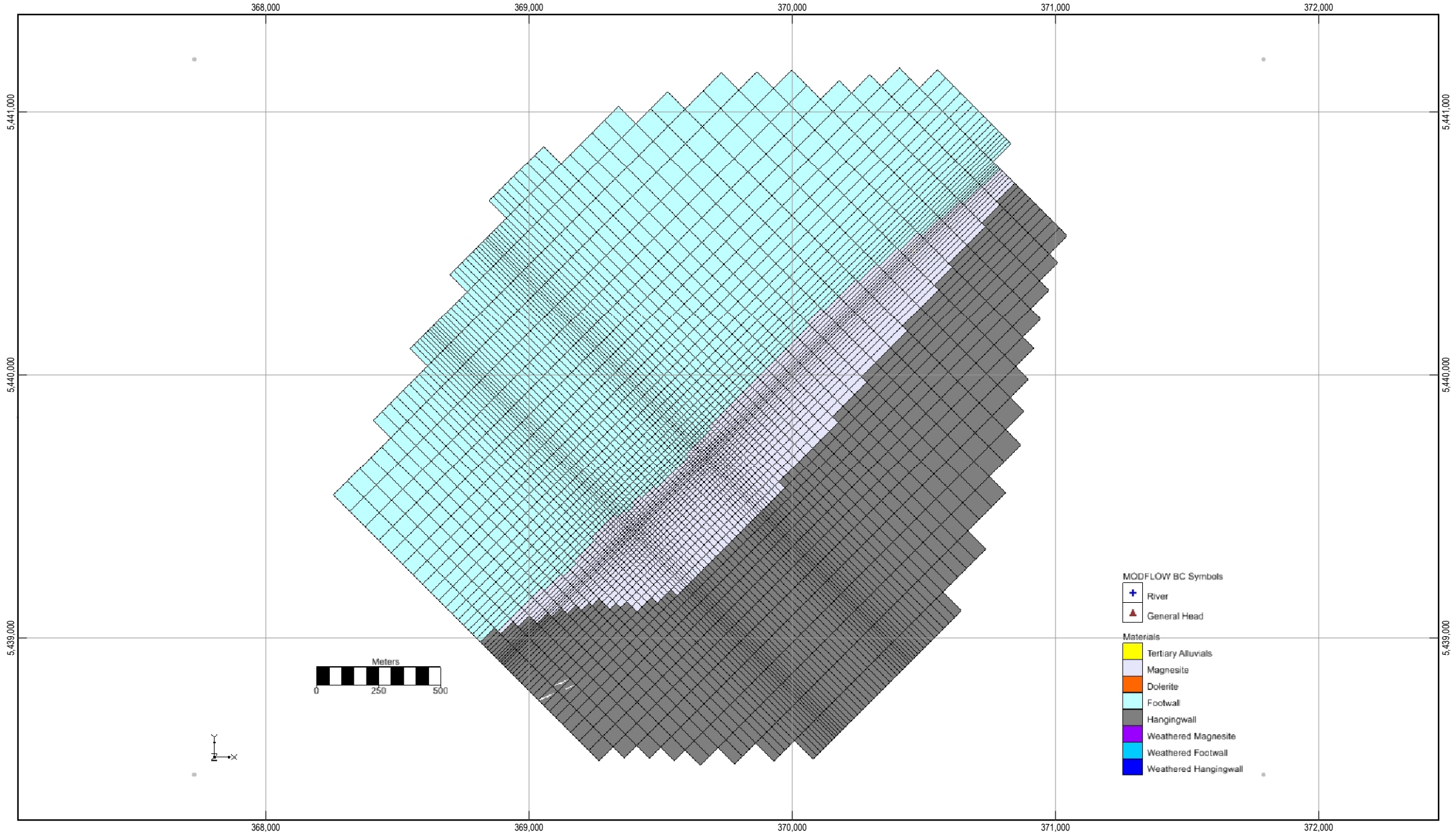

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Metres

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Appendix F
Model Grid Layer 6

Figure 6

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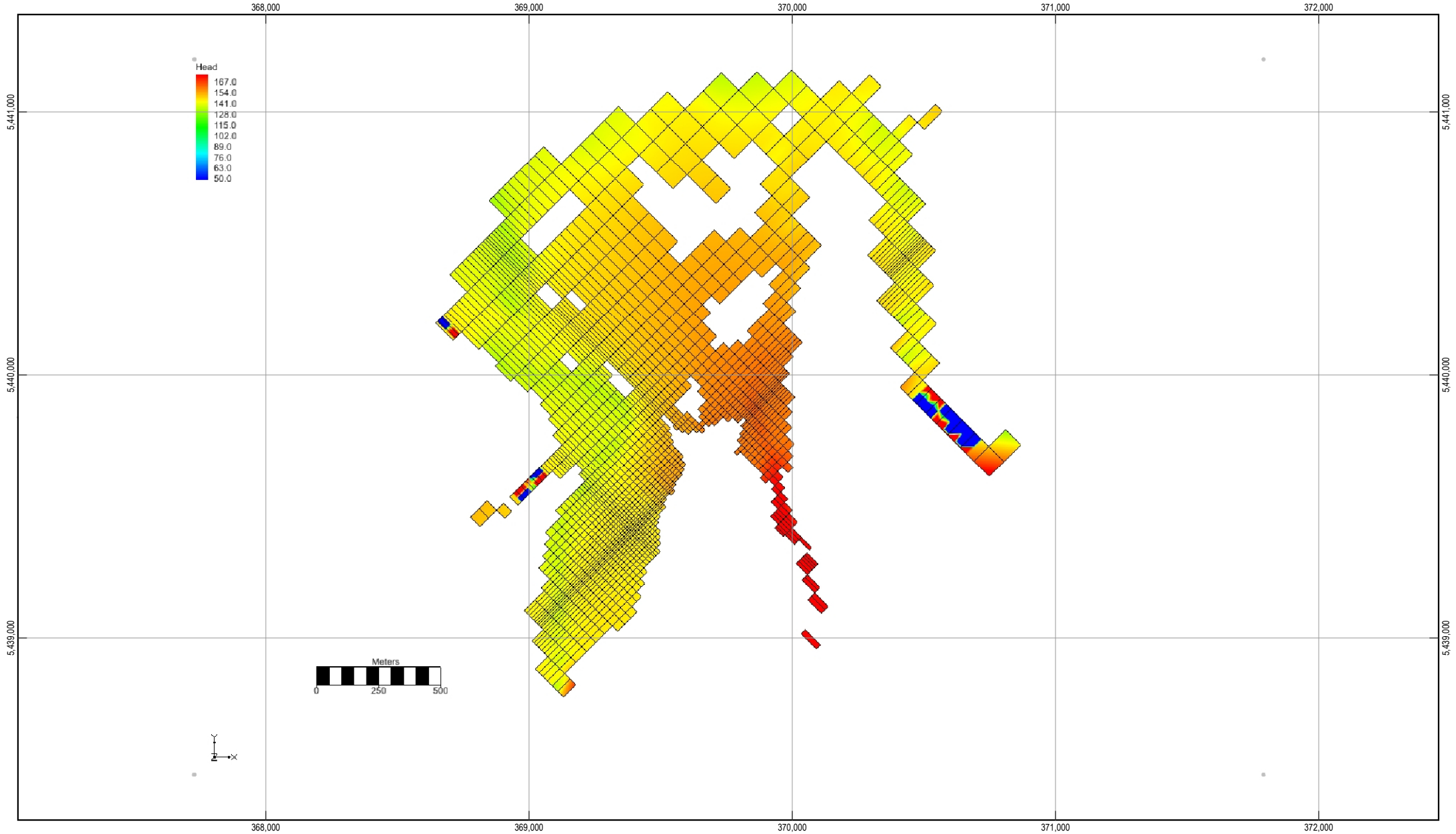

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Metres

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Appendix F
Steady State Model Layer 1 Heads Figure 7

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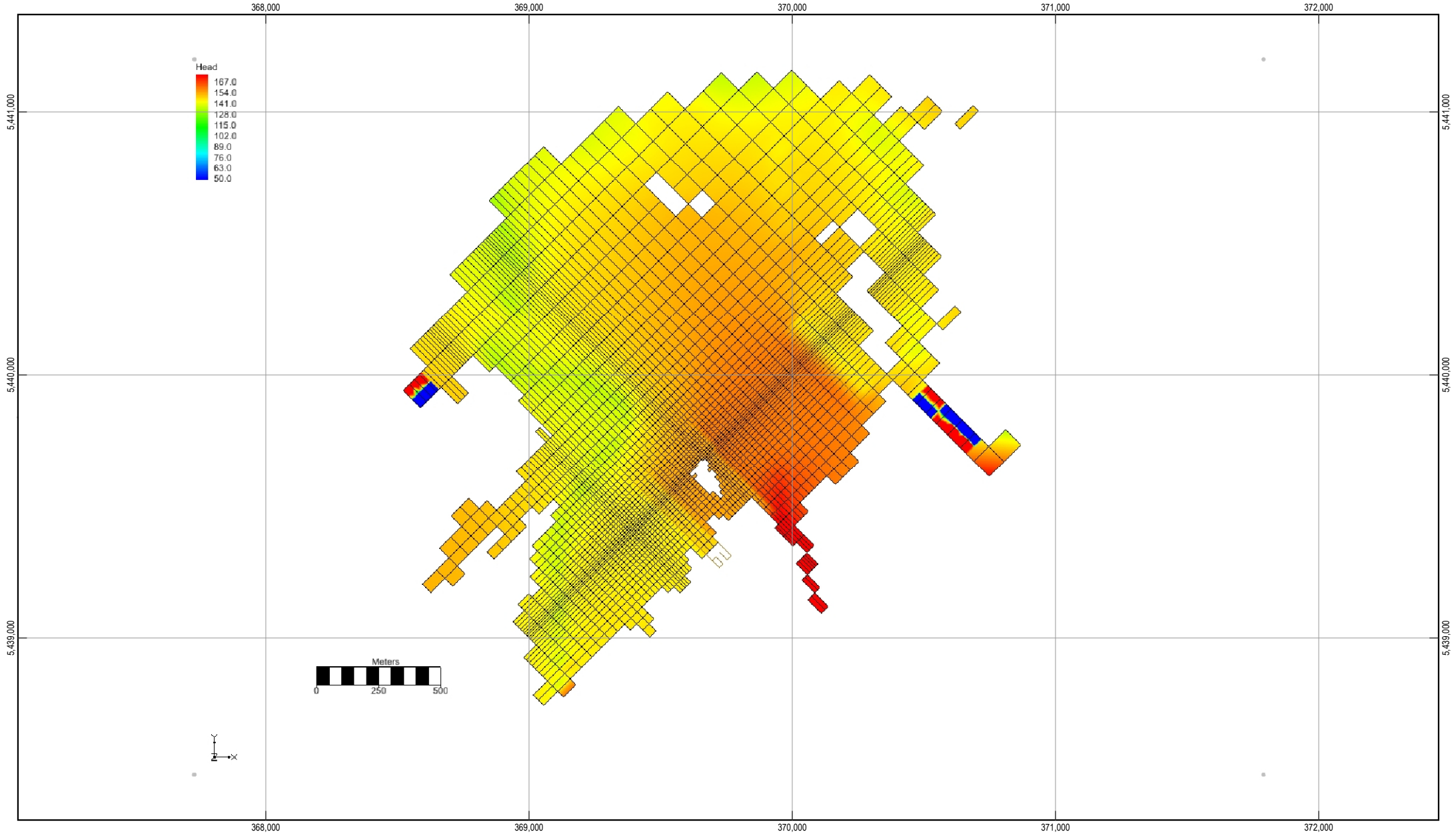

Paper Size A4

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Metres

Map Projection: Transverse Mercator
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Appendix F
Steady State Model Layer 2 Heads

Figure 8

G:\32\15824\GIS\Maps\AppFFigure8.mxd

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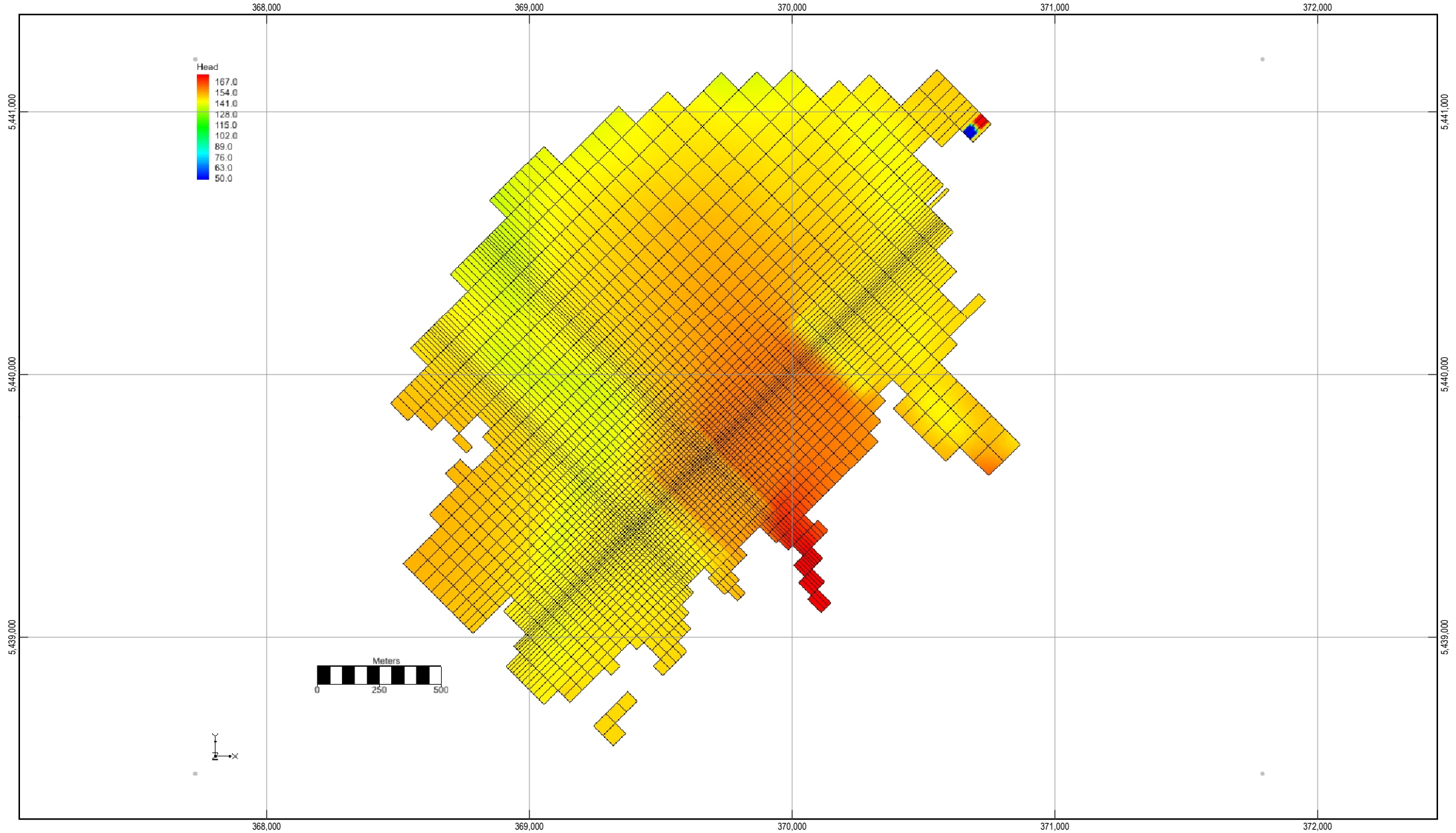

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Appendix F
Steady State Model Layer 3 Heads

Figure 9

G:\32\15824\GIS\Maps\AppFFigure9.mxd

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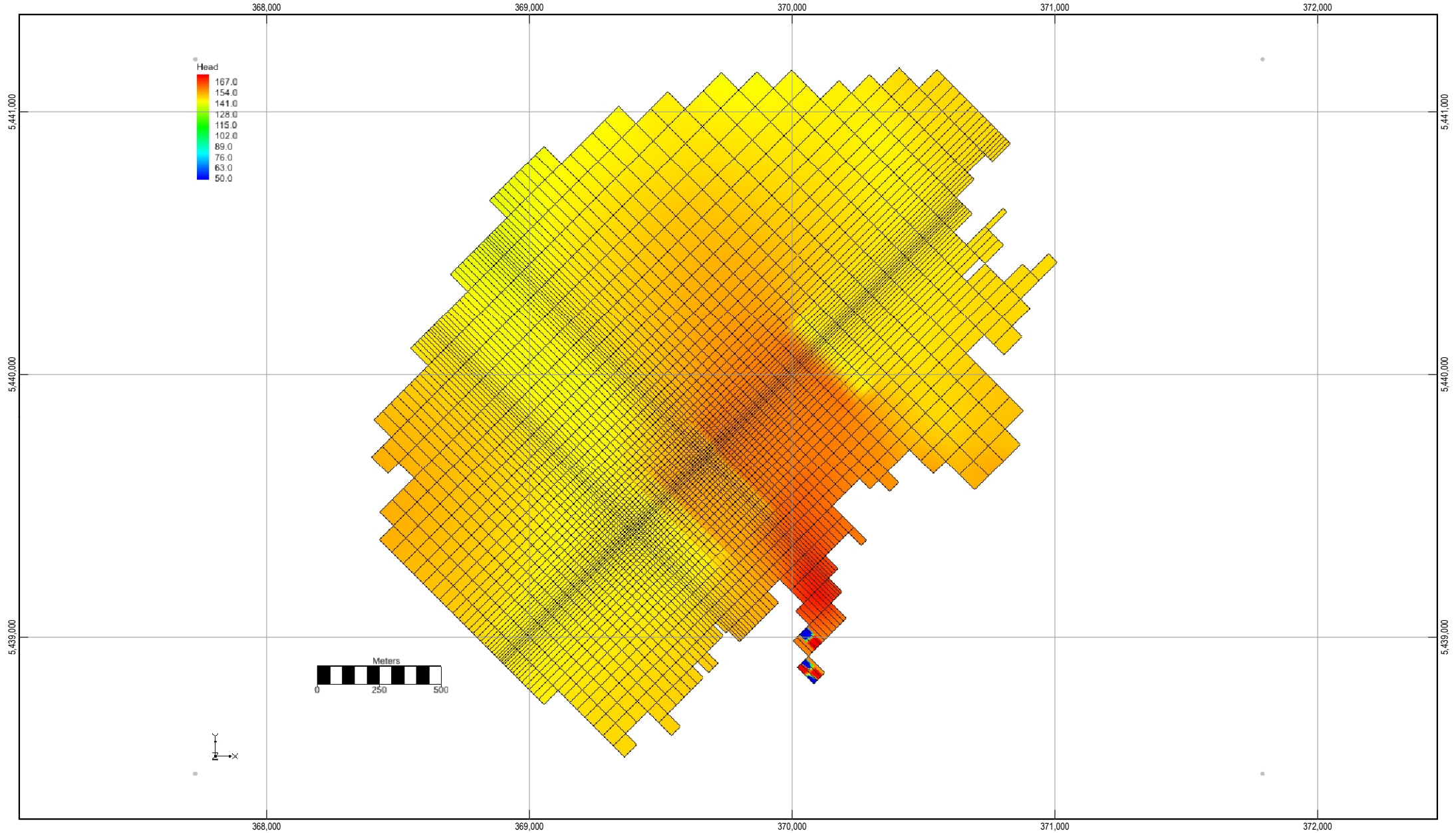

Paper Size A4

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Metres

Map Projection: Transverse Mercator
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Appendix F
Steady State Model Layer 4 Heads Figure 10

G:\32\15824\GIS\Maps\AppFFigure10.mxd

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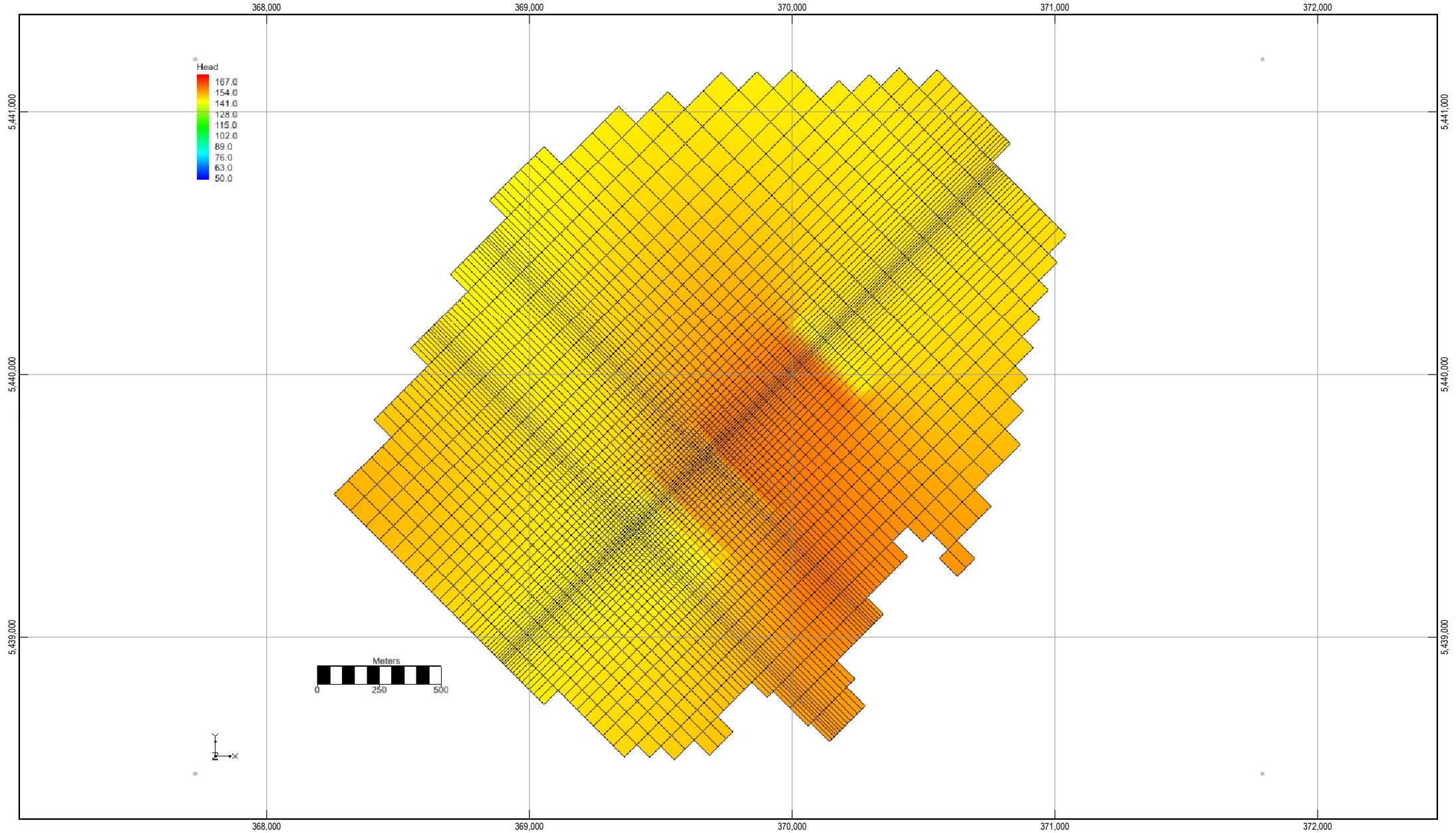

Paper Size A4

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Metres

Map Projection: Transverse Mercator
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Appendix F
Steady State Model Layer 5 Heads Figure 11

G:\32\15824\GIS\Maps\AppFFigure11.mxd

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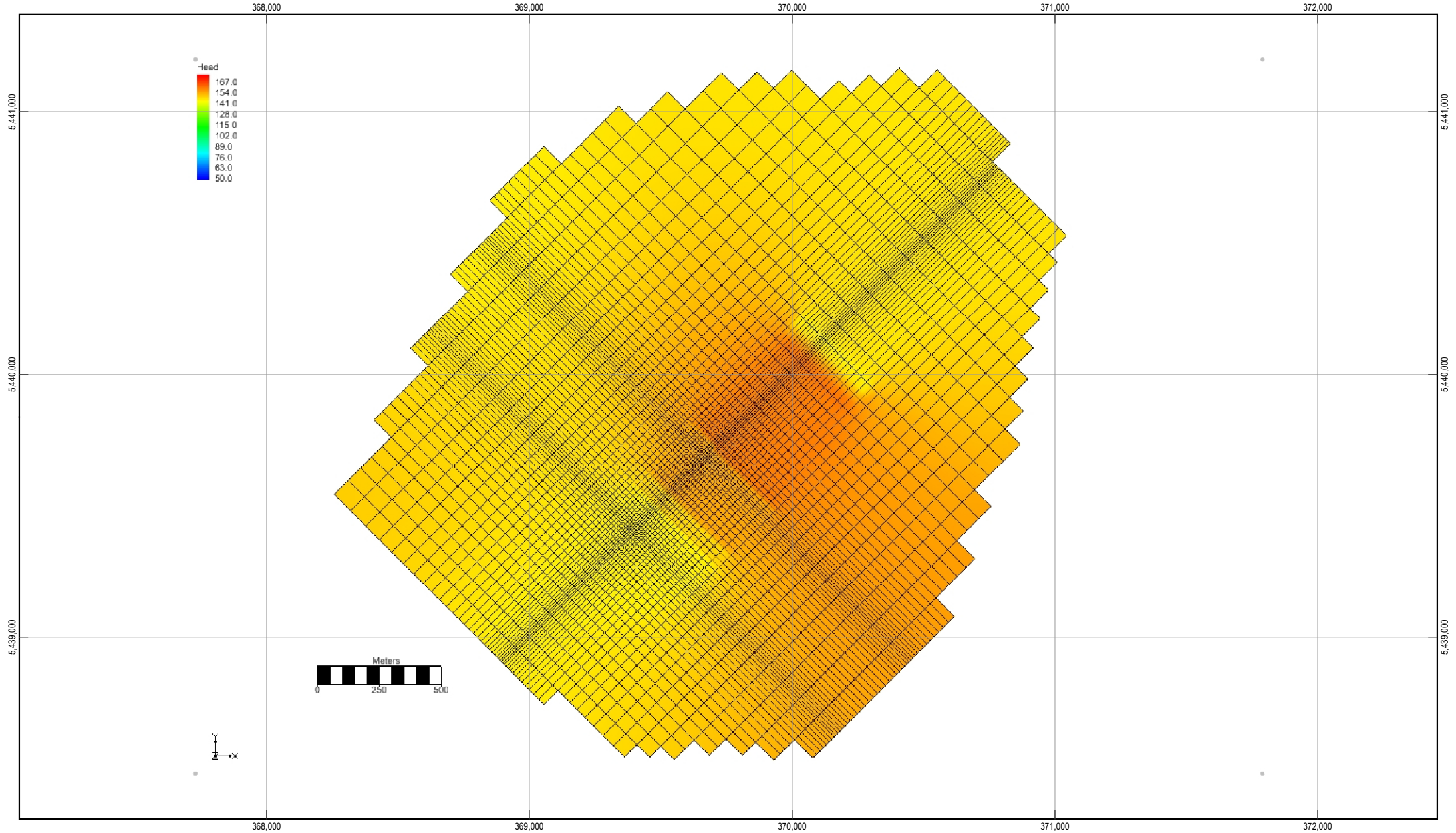

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Appendix F
Steady State Model Layer 6 Heads Figure 12

G:\32\15824\GIS\Maps\AppFFigure12.mxd

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Figure 13 PB002 1999 transient model; MB002, MB003, MB004, MB006 and PB001 heads (mAHD)

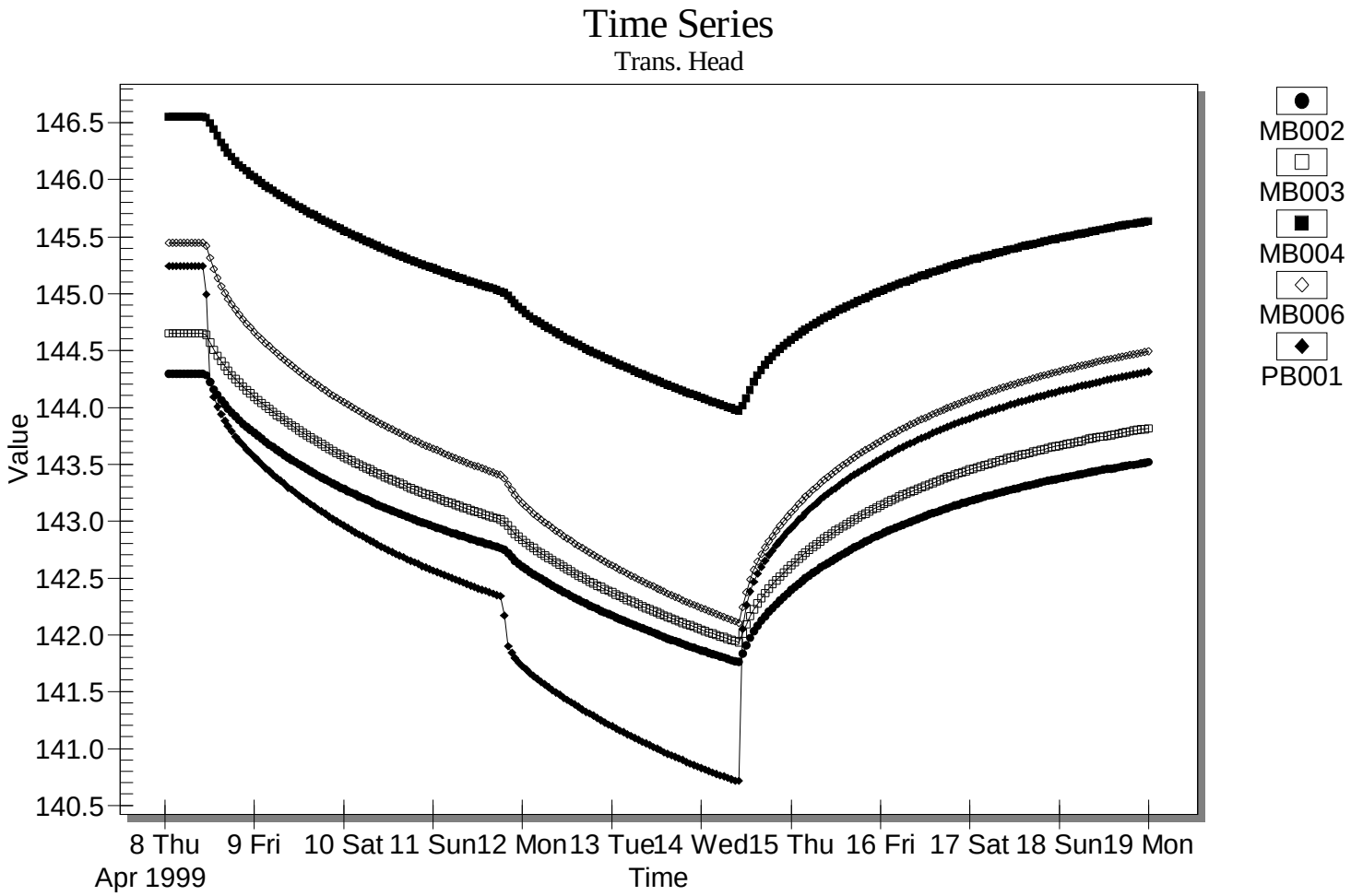


Figure 14 PB003 2011 transient model; PB003 heads (mAHD) triangles = observations, diamonds = modelled

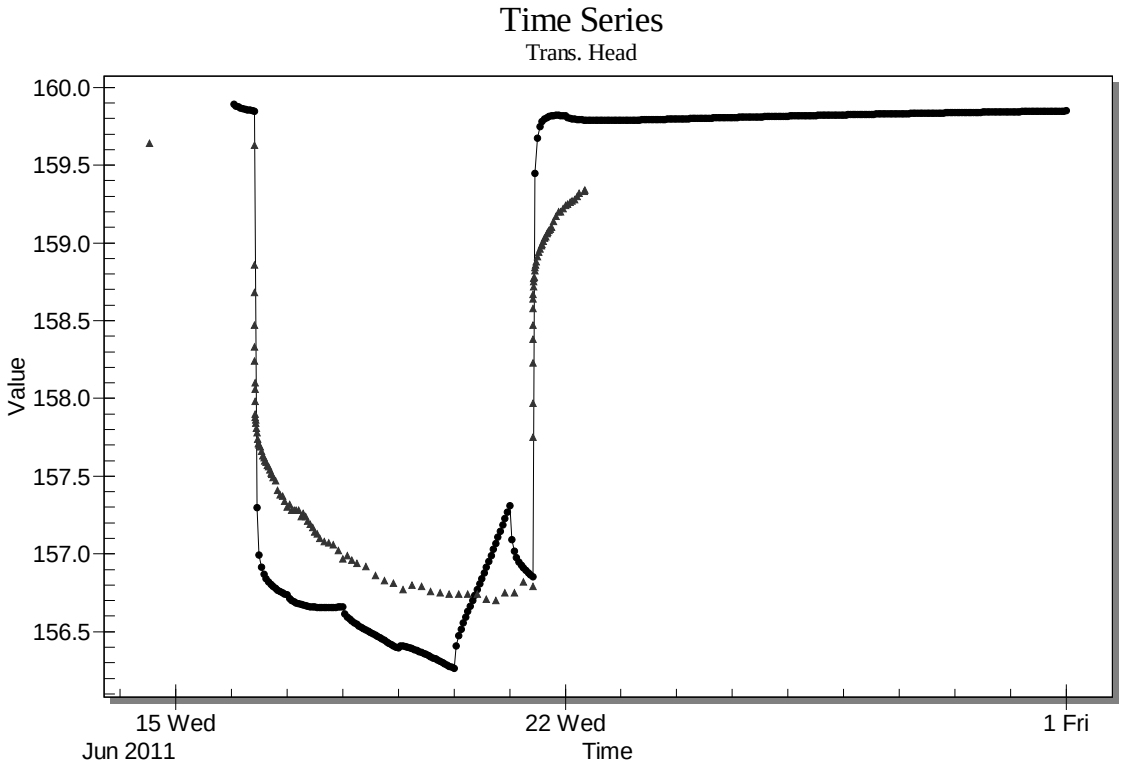


Figure 15 PB003 2011 transient model; MB005 heads (mAHD) triangles = observations, diamonds = modelled

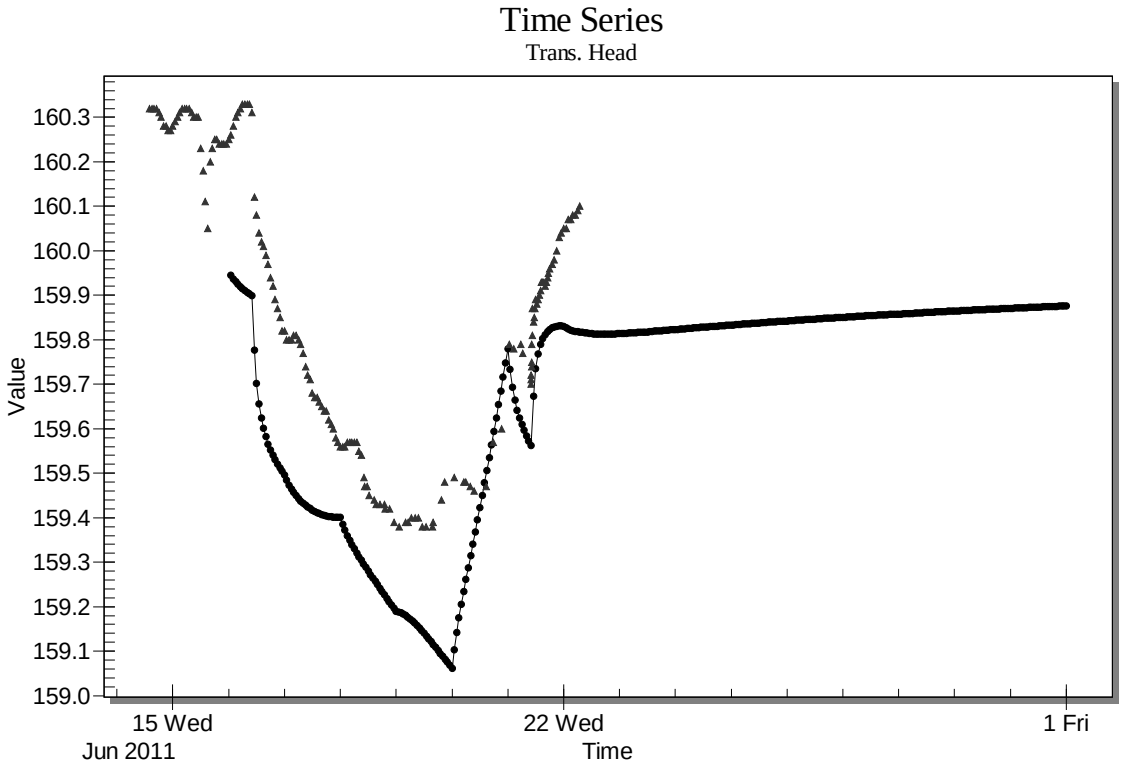


Figure 16 2011 temporal model; MB003 heads (mAHD) triangles = observations, diamonds = modelled

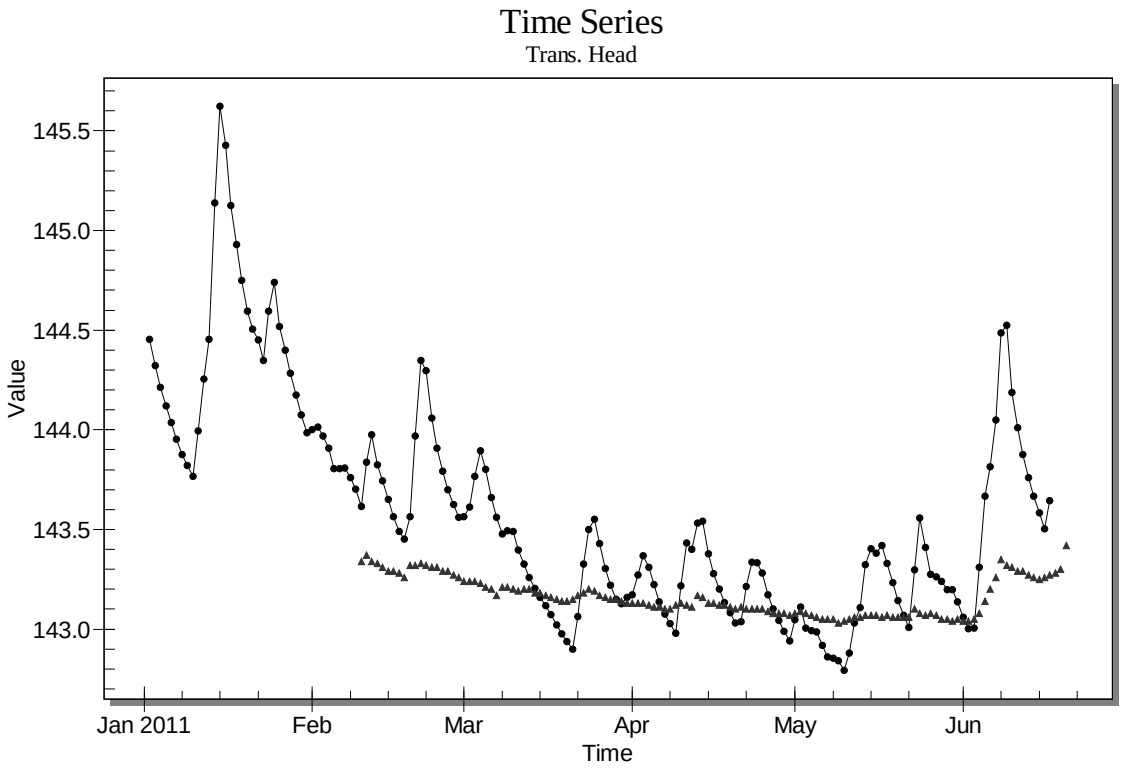


Figure 17 2011 temporal model; MB004 heads (mAHD) squares = observations, diamonds = modelled

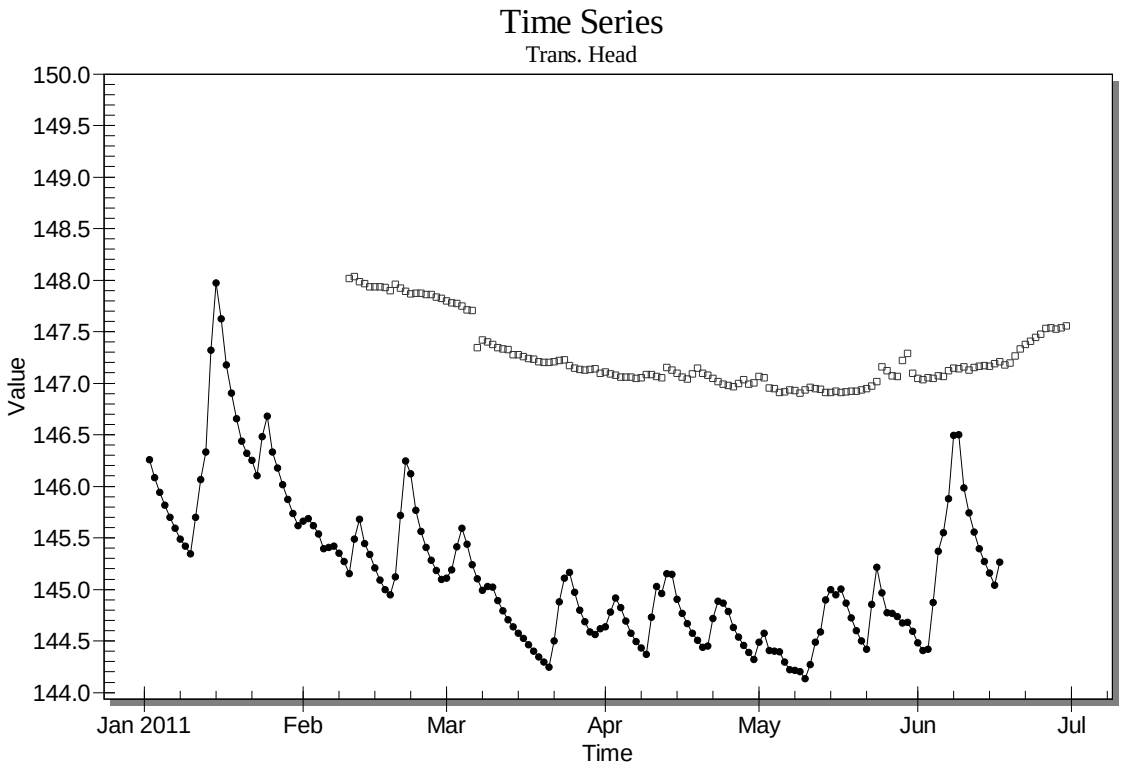
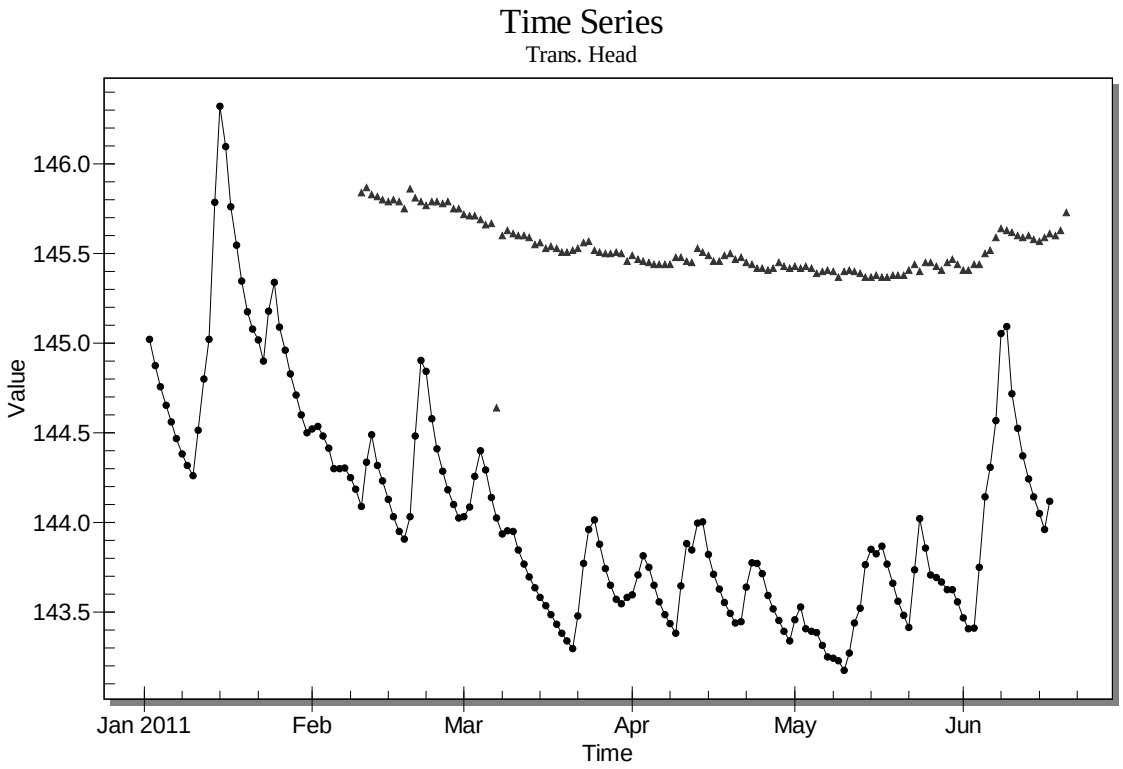
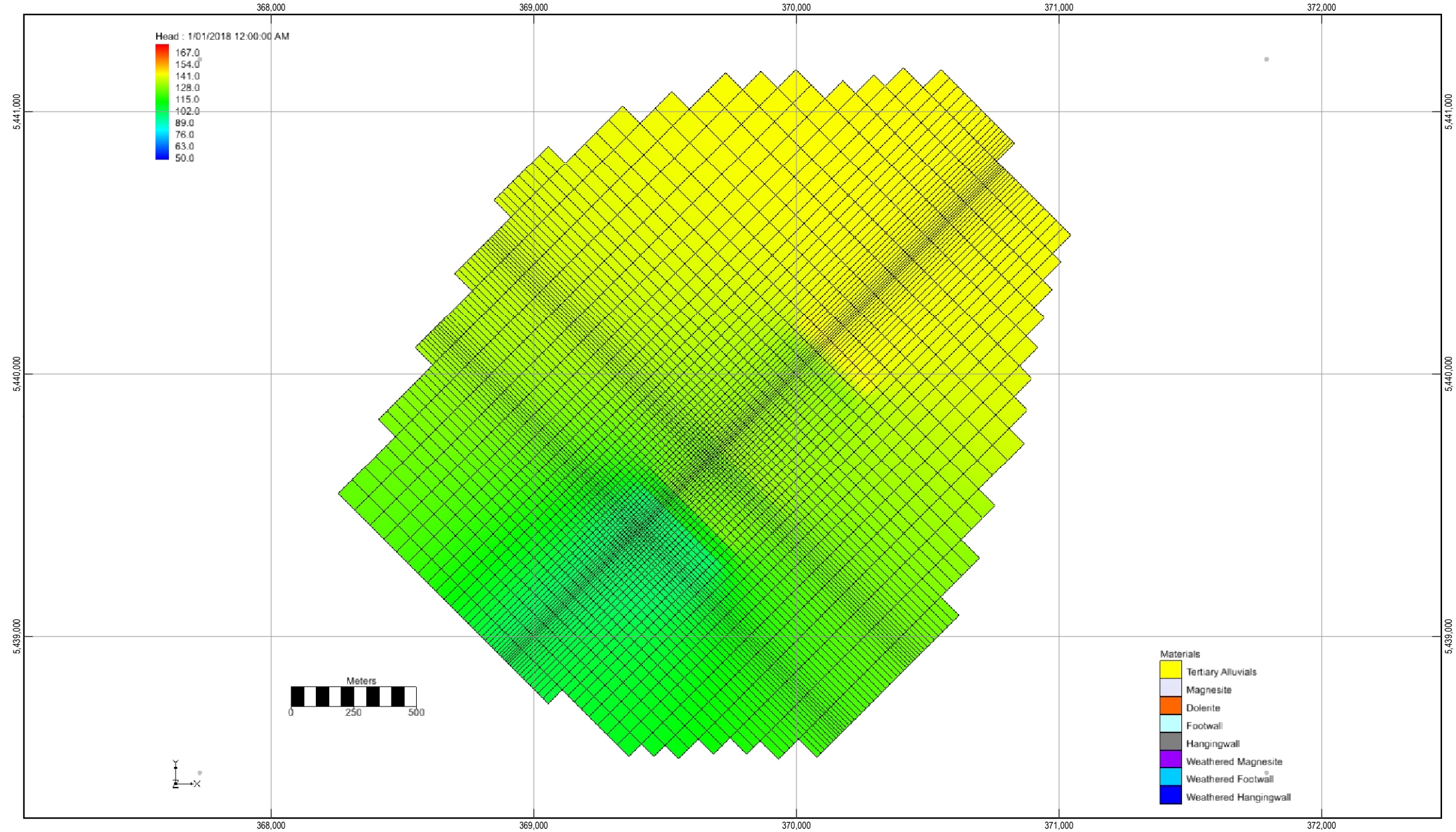


Figure 18 2011 temporal model; PB002 heads (mAHD) triangles = observations, diamonds = modelled





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Appendix F
Dewatering 2018 Layer 6 Heads

Figure 19

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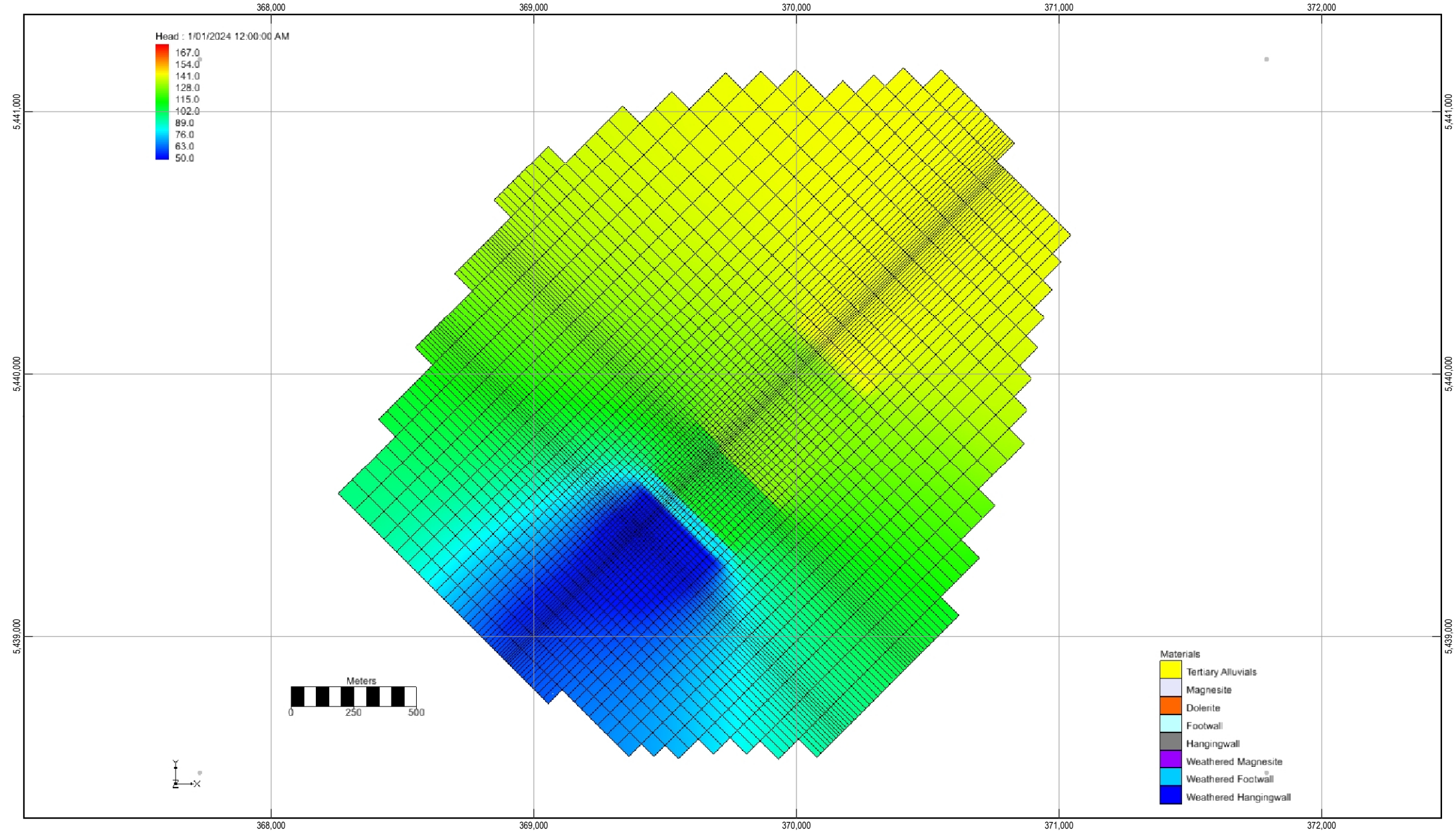

Paper Size A4

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Metres

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Appendix F
Dewatering 2024 Layer 6 Heads

Figure 20

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Appendix G

Pump & Pipe Cost Estimate

Item	Quantity	Unit	Rate	Total	Comment
261 kW Submersible Pump	2	Item	$ 70,000.00	$ 140,000.00	From Cost Databases, assumed duty/standby
DN250 PE Pipe	2000	m	223	$ 445,000.00	See Sheet 2
Structure	1	Item	$ 25,000.00	$ 25,000.00	From SW Asset Valuation - Slab & Colorbond Shed (6m x 3m)
Pump Station Pipework & Valving	1	Item	$ 50,000.00	$ 50,000.00	From SW Asset Valuation - (Interpolate between DN200 & DN300)
Electrics/Controls/Telemetry	1	Item	$ 150,000.00	$ 150,000.00	From SW Asset Valuation - 100 to 250 kW
Sub Total				$ 810,000.00	
Contingency		30%		$ 243,000.00	
Design		5%		$ 40,500.00	
			TOTAL	$ 1,094,000.00	
			GRAND TOTAL	$ 1,126,820.00	Multiplied by 3% to cater for CPI as SW Supplement 2010

261 kW Submersible Pump and Pipework	253	$/KW	$ 1,190.00	$ 301,268.33	From Cost Databases, assumed duty/standby
DN250 PE Pipe	2000	m	223	$ 445,000.00	See Sheet 2
Structure	1	Item	$ 25,000.00	$ 25,000.00	From SW Asset Valuation - Slab & Colorbond Shed (6m x 3m)
Electrics/Controls/Telemetry	253	$/KW	$ 412.46	$ 104,421.55	From SW Asset Valuation - 100 to 250 kW
Sub Total				$ 875,689.88	
Contingency		30%		$ 262,706.97	
Design		5%		$ 43,784.49	
			TOTAL	$ 1,182,000.00	
			GRAND TOTAL	$ 1,217,460.00	Multiplied by 3% to cater for CPI as SW Supplement 2010

Appendix H

Addendum of an Example Power Usage

Upon request from S. Capp (2011) this addendum provides an example power usage based upon an example set of pit designs provided by S. Capp of Derwent Geosciences.

Western Pit RL m AHD	Av pumping rate L/s	Efficencey (*assumed off curve)	Power by RL mAHD kW
150	24	0.4*	105
140	50	0.5*	175
130	57	0.67	151
120	66	0.73	161
110	78	0.77	170
100	84	0.79	174
90	89	0.82	172
80	93	0.83	176
70	96	0.83	178
60	97	0.83	177
50	96	0.83	176

This estimate is based on the pump characteristics of an example single pump and its published curves. This estimate has numerous assumptions including (but not limited to):

- This estimate represents the total dewatering amount (i.e. both pits are combined as requested by S. Capp, however, realistically we cannot consider the pits as a single entity due to the different RL. As requested, RLs are presented for the Western Pit);
- A 50% contingency on groundwater inflows (additional scenarios should definitely be considered);
- Average rainfall conditions (i.e. no contingency to quickly handle rainfall events); and
- Artificial heads are added to the system (i.e. via a value) to ensure the pump operates on its curve

The original calculation utilised figures of ~60L/s groundwater inflow and a maximum dewatering rate of 100L/s at full depth (to handle contingency and rainfall incidents relatively quickly) giving a power consumption of 253kW. The major discrepancy is due to a single efficiency value of 0.6 being applied to the original calculations.

Greater efficiencies could be achieved using a modular, multi-stage pump and adding stages as mining progresses, however, this scenario has not yet been considered.

GHD

2 Salamanca Square Hobart 7000
GPO Box 667 Hobart 7001
T: 03 6210 0600 F: 03 6210 0601 E: hbamail@ghd.com

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