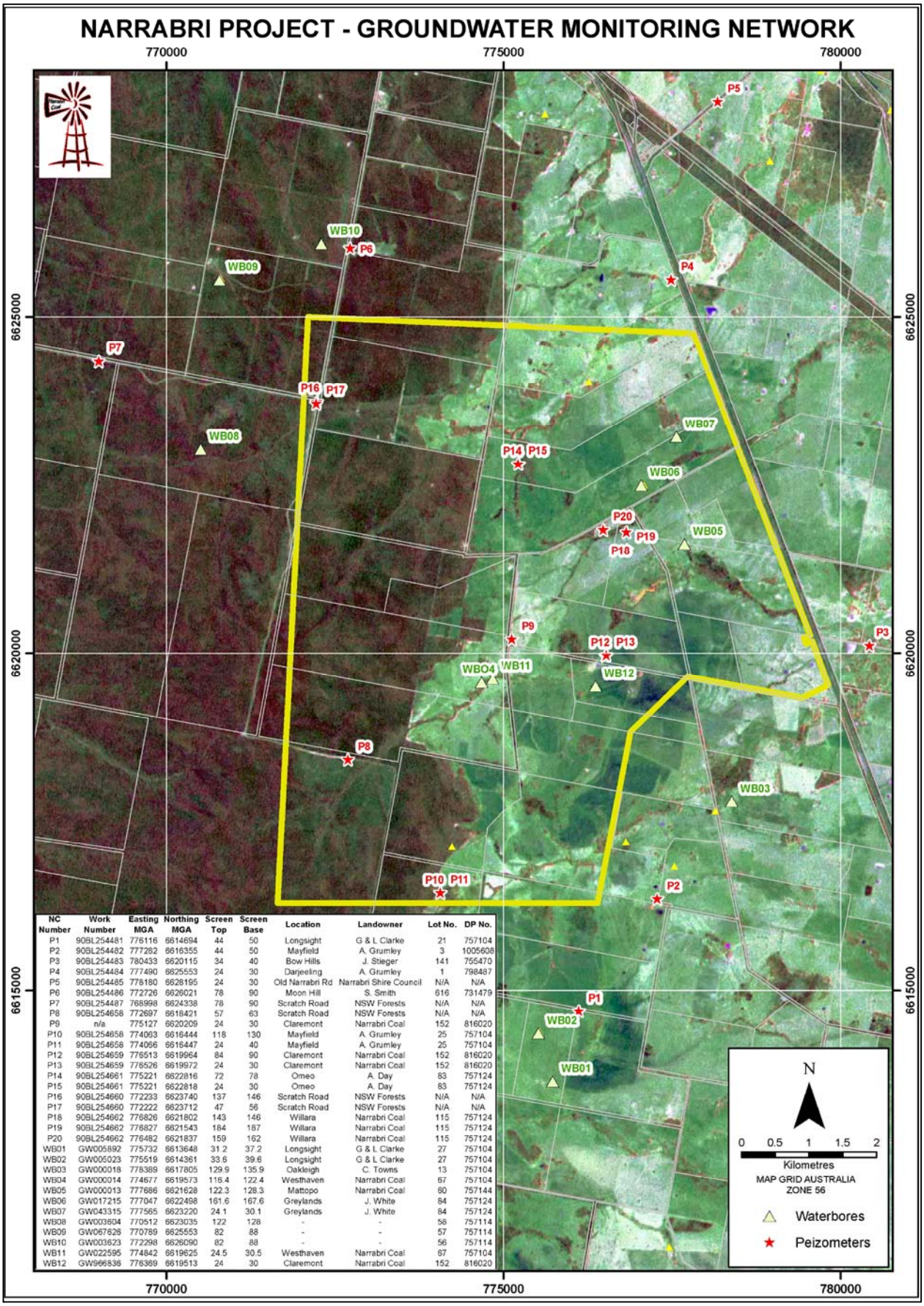
APPENDIX A

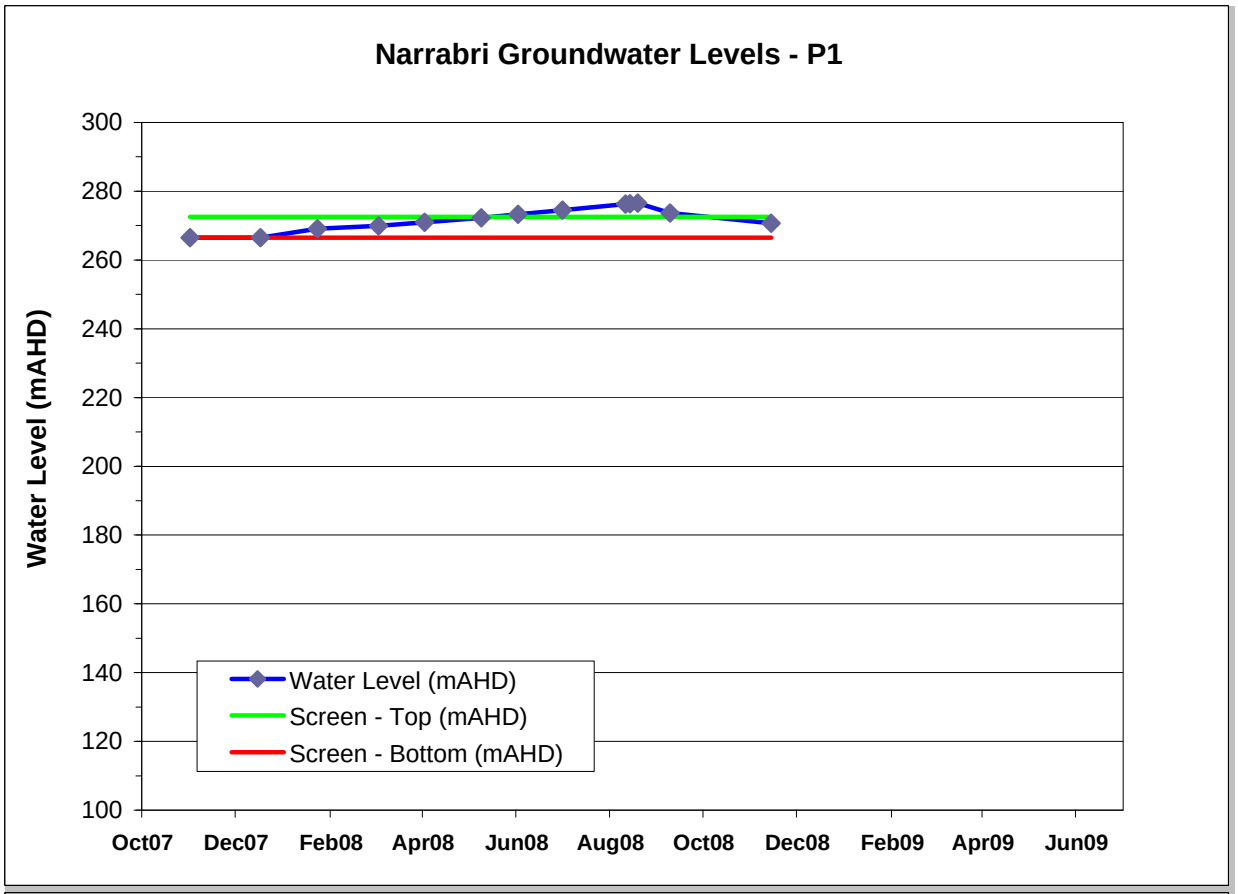
NARRABRI WATER LEVEL HYDROGRAPHS

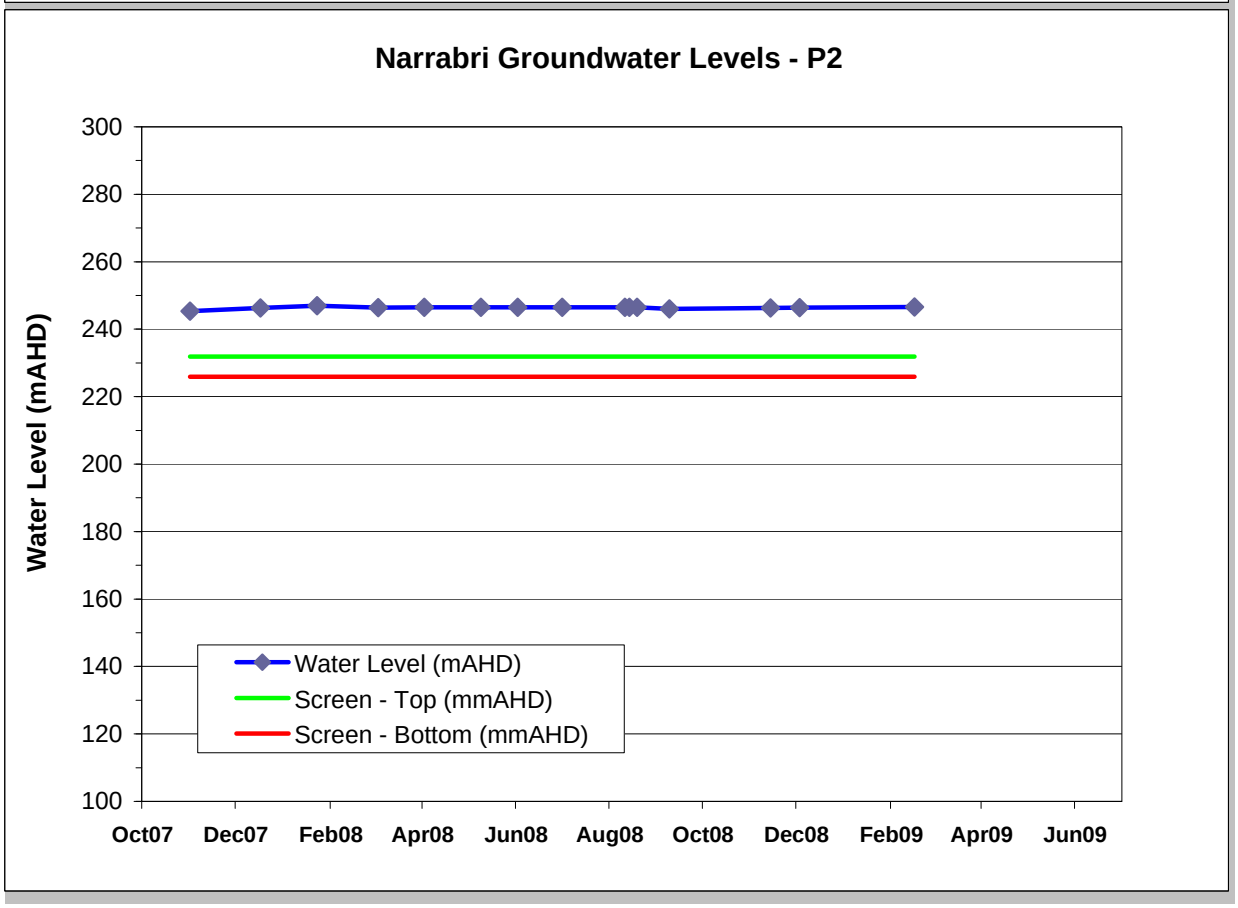
NARRABRI PROJECT - GROUNDWATER MONITORING NETWORK

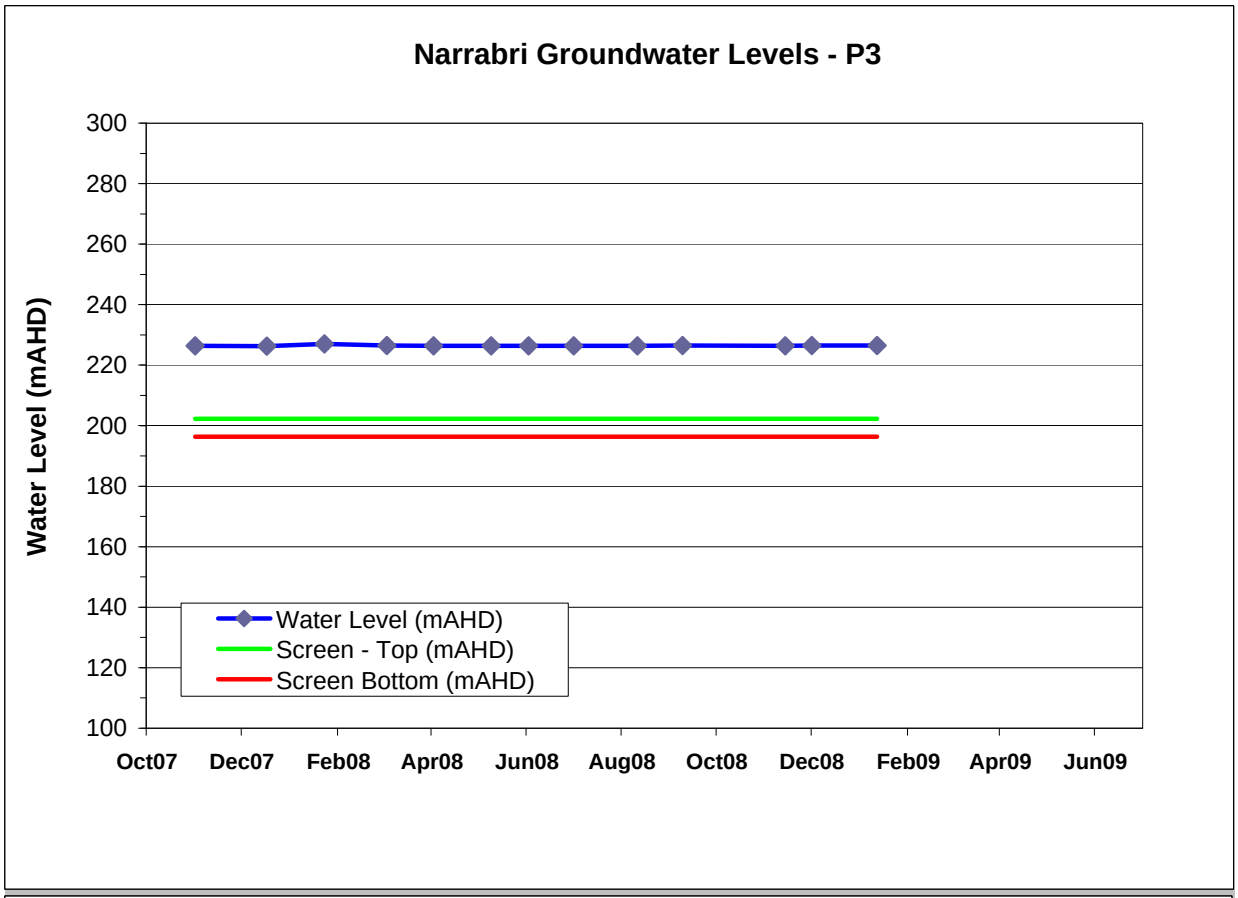


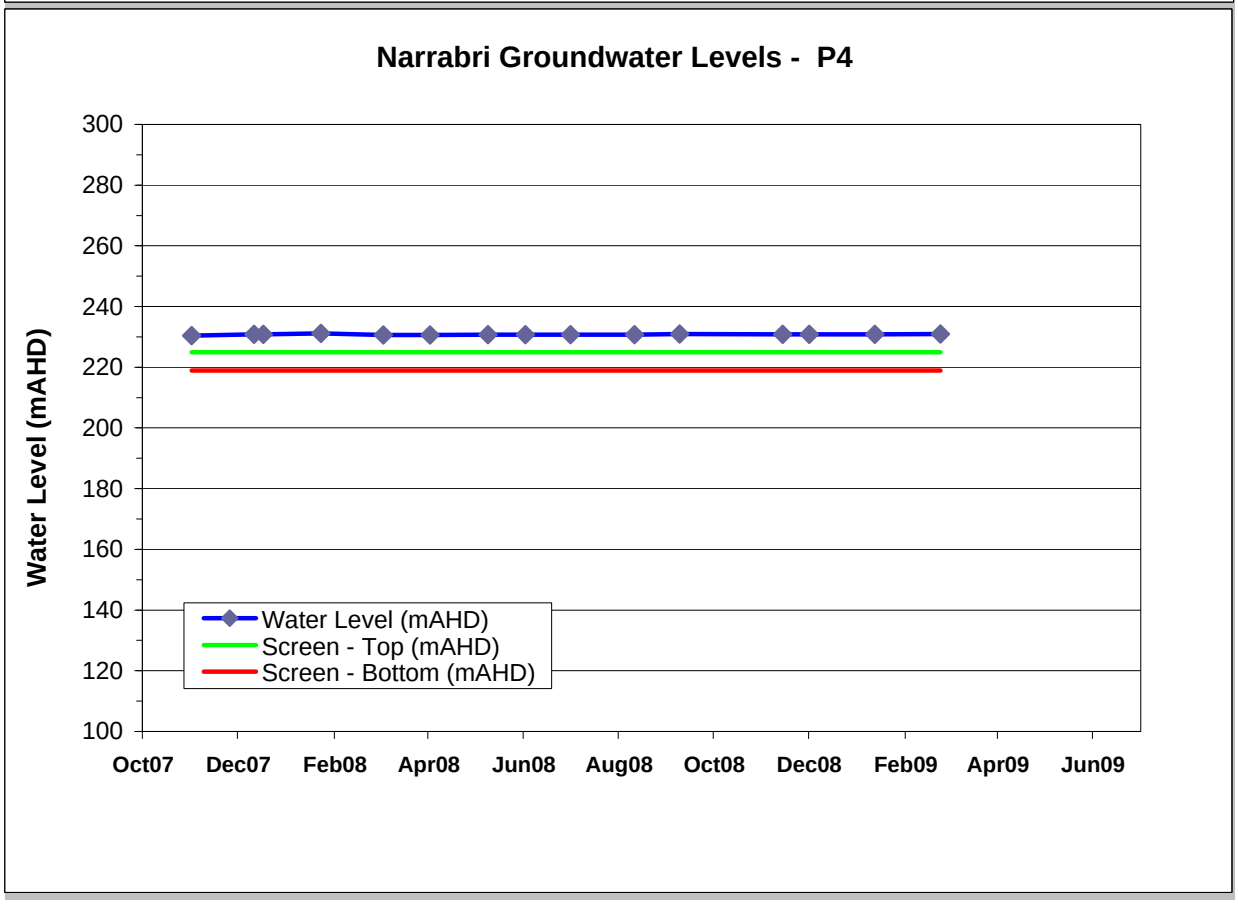
NC Number	Work Number	Easting MGA	Northing MGA	Screen Top	Screen Base	Location	Landowner	Lot No.	DP No.
P1	90BL254481	776116	6614694	44	50	Longsight	G & L Clarke	21	757104
P2	90BL254482	777262	6616355	44	50	Mayfield	A. Grumley	3	1005608
P3	90BL254483	780433	6620115	34	40	Bow Hills	J. Stieger	141	755470
P4	90BL254484	777490	6625553	24	30	Darjeeling	A. Grumley	1	798487
P5	90BL254485	778180	6628195	24	30	Old Narrabri Rd	Narrabri Shire Council	N/A	N/A
P6	90BL254486	772726	6626021	78	90	Moon Hill	S. Smith	616	731479
P7	90BL254487	768998	6624338	78	90	Scratch Road	NSW Forests	N/A	N/A
P8	90BL254658	772697	6618421	57	63	Scratch Road	NSW Forests	N/A	N/A
P9	n/a	775127	6620209	24	30	Claremont	Narrabri Coal	152	816020
P10	90BL254658	774063	6616444	118	130	Mayfield	A. Grumley	25	757104
P11	90BL254658	774066	6616447	24	40	Mayfield	A. Grumley	25	757104
P12	90BL254659	776513	6619964	84	90	Claremont	Narrabri Coal	152	816020
P13	90BL254659	776526	6619972	24	30	Claremont	Narrabri Coal	152	816020
P14	90BL254661	775221	6622816	72	78	Omeo	A. Day	83	757124
P15	90BL254661	775221	6622818	24	30	Omeo	A. Day	83	757124
P16	90BL254660	772233	6623740	137	146	Scratch Road	NSW Forests	N/A	N/A
P17	90BL254660	772222	6623712	47	56	Scratch Road	NSW Forests	N/A	N/A
P18	90BL254662	776826	6621802	143	146	Willara	Narrabri Coal	115	757124
P19	90BL254662	776827	6621543	184	187	Willara	Narrabri Coal	115	757124
P20	90BL254662	776482	6621837	159	162	Willara	Narrabri Coal	115	757124
WB01	GW005892	775732	6613648	31.2	37.2	Longsight	G & L Clarke	27	757104
WB02	GW005023	775519	6614361	33.6	39.6	Longsight	G & L Clarke	27	757104
WB03	GW000018	778389	6617805	129.9	135.9	Oakleigh	C. Towns	13	757104
WB04	GW000014	774677	6619573	116.4	122.4	Westhaven	Narrabri Coal	67	757104
WB05	GW000013	777686	6621628	122.3	128.3	Mattopo	Narrabri Coal	60	757144
WB06	GW017215	777047	6622498	161.6	167.6	Greylands	J. White	84	757124
WB07	GW043315	777565	6623220	24.1	30.1	Greylands	J. White	84	757124
WB08	GW003604	770512	6623035	122	128	-	-	58	757114
WB09	GW067626	770789	6625553	82	88	-	-	57	757114
WB10	GW003623	772298	6626090	82	88	-	-	56	757114
WB11	GW022595	774842	6619625	24.5	30.5	Westhaven	Narrabri Coal	67	757104
WB12	GW966836	776369	6619513	24	30	Claremont	Narrabri Coal	152	816020

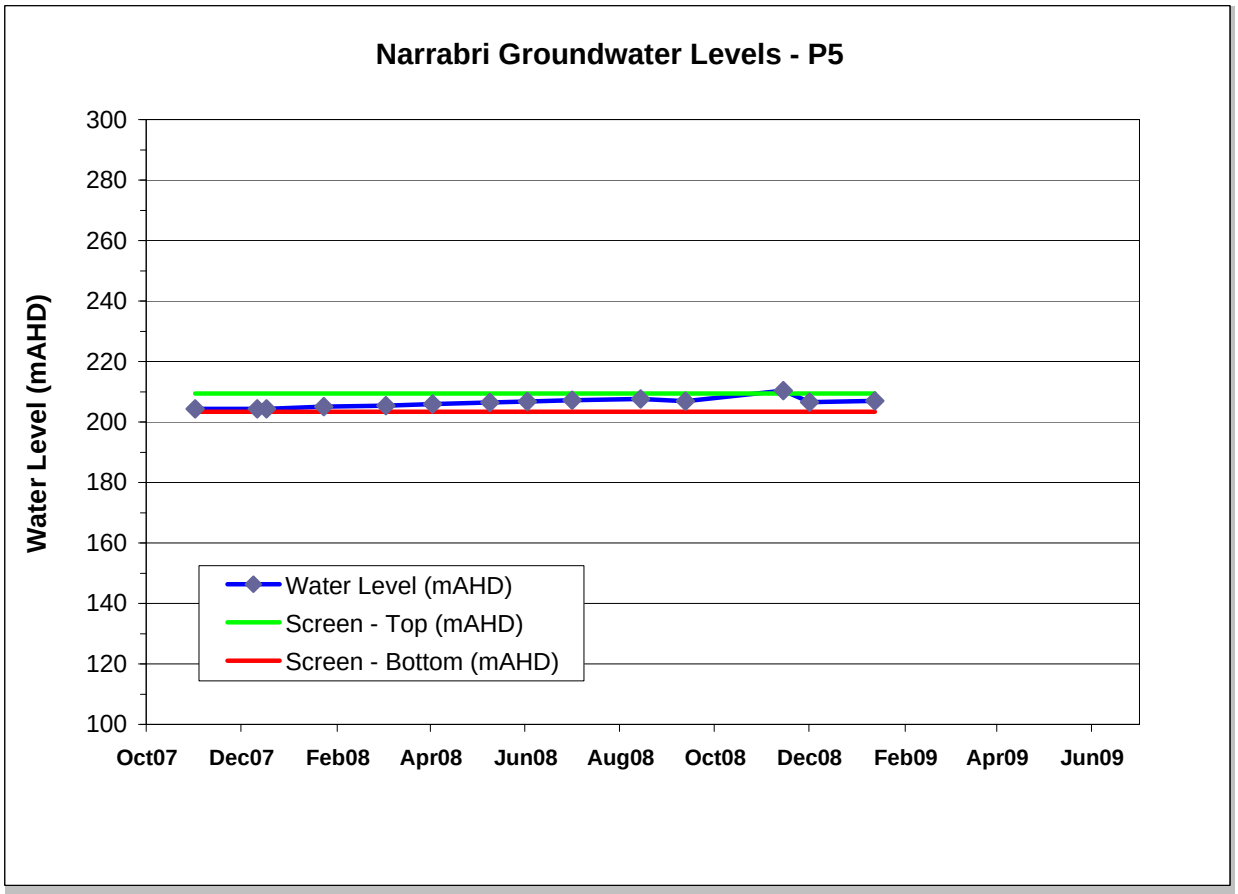
Date: 24 April 2009	Scale: As Shown	**Narrabri Coal Pty Ltd**	
Initials: TL	Job No: S28	**Groundwater Monitoring Location**	
Drawing No: S28-051a	Rev: A		
aquaterra			**Appendix A**

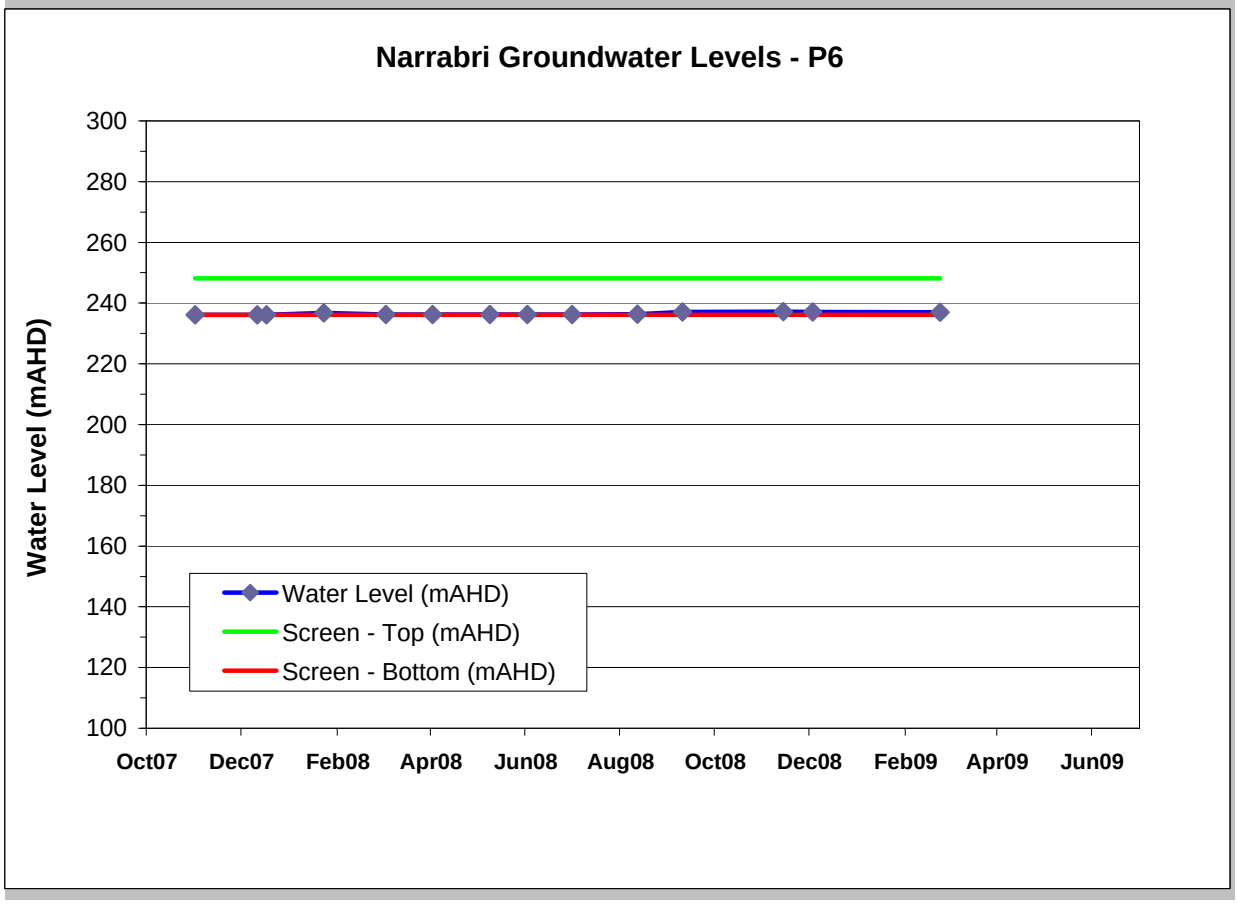

Narrabri Groundwater Levels - P1
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

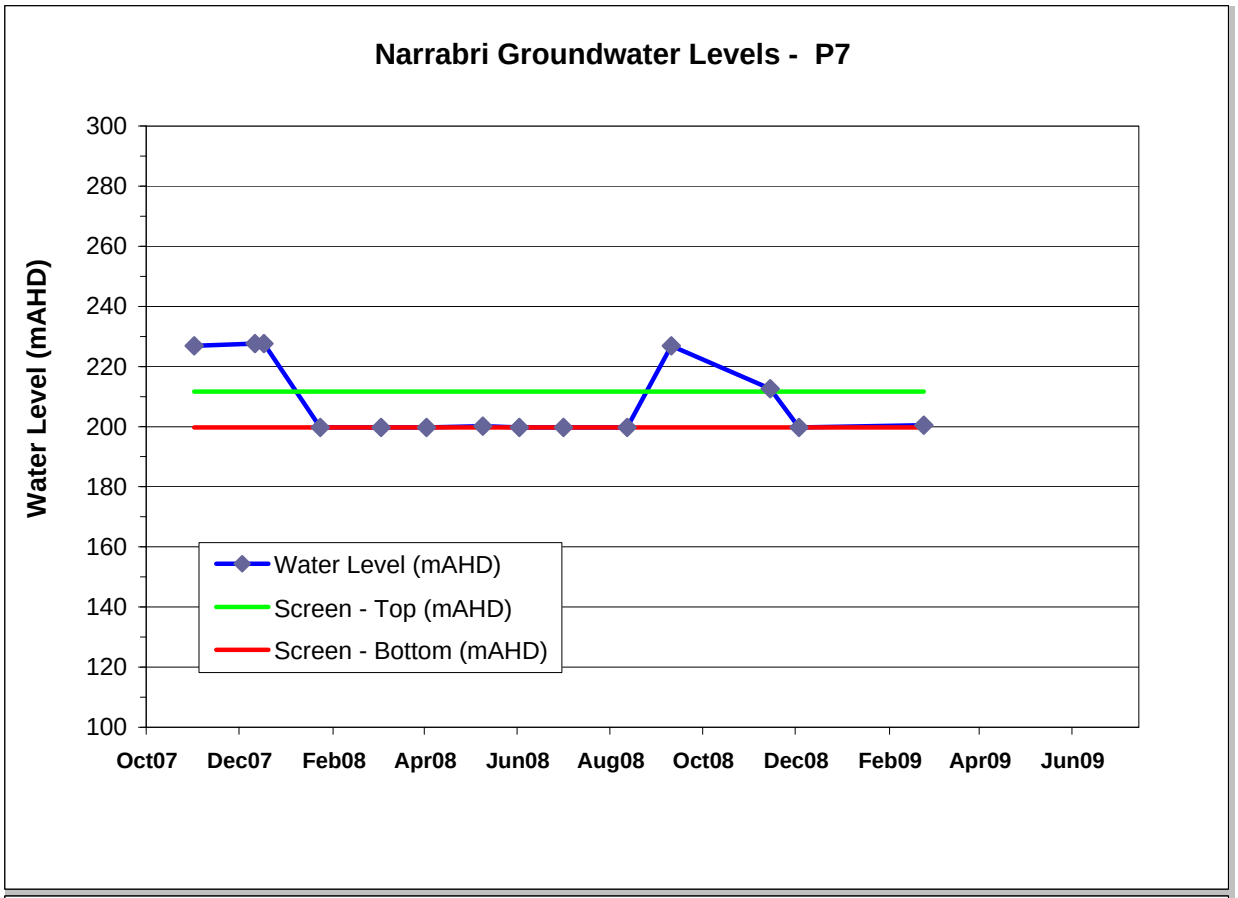

Narrabri Groundwater Levels - P2
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mmAHD)
Screen - Bottom (mmAHD)

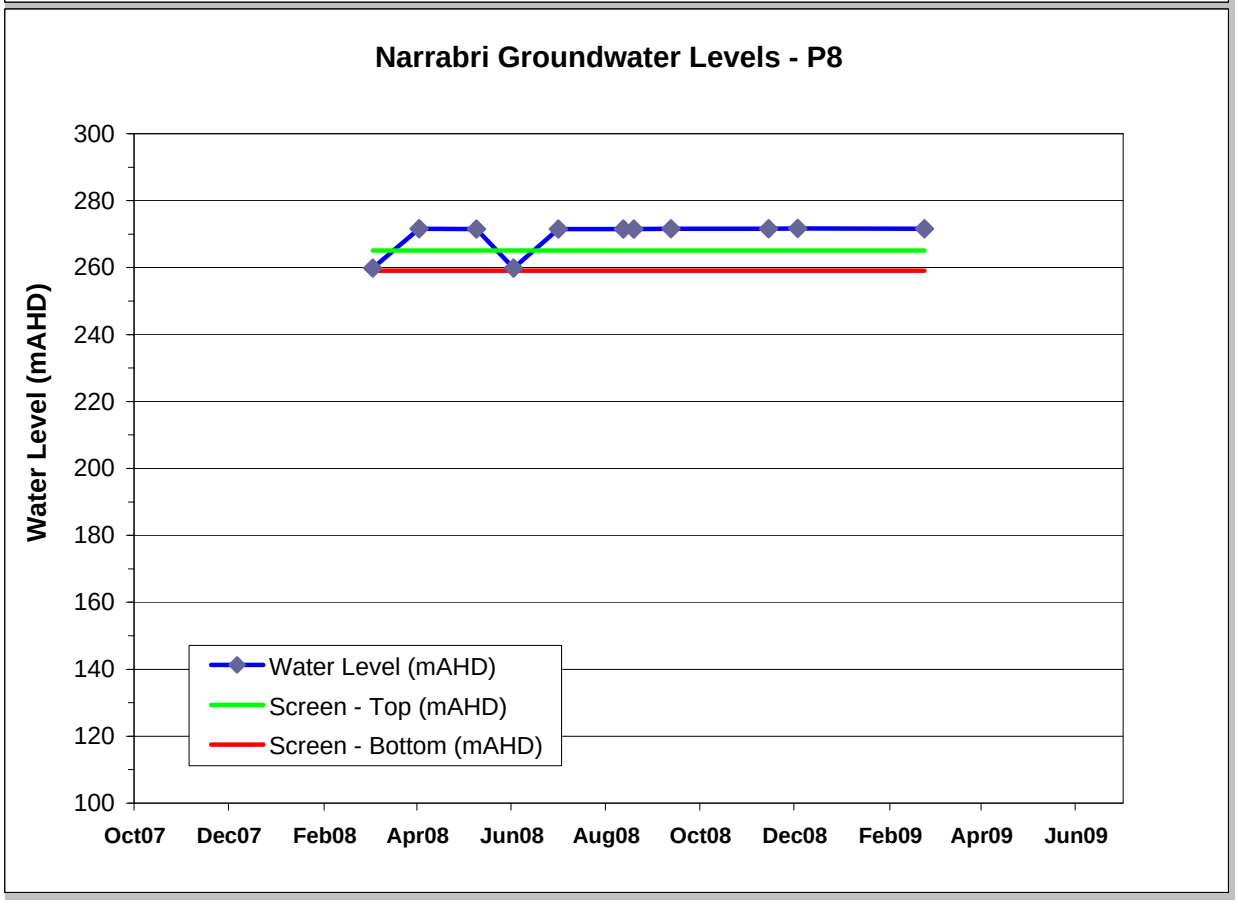

Narrabri Groundwater Levels - P3
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen Bottom (mAHD)

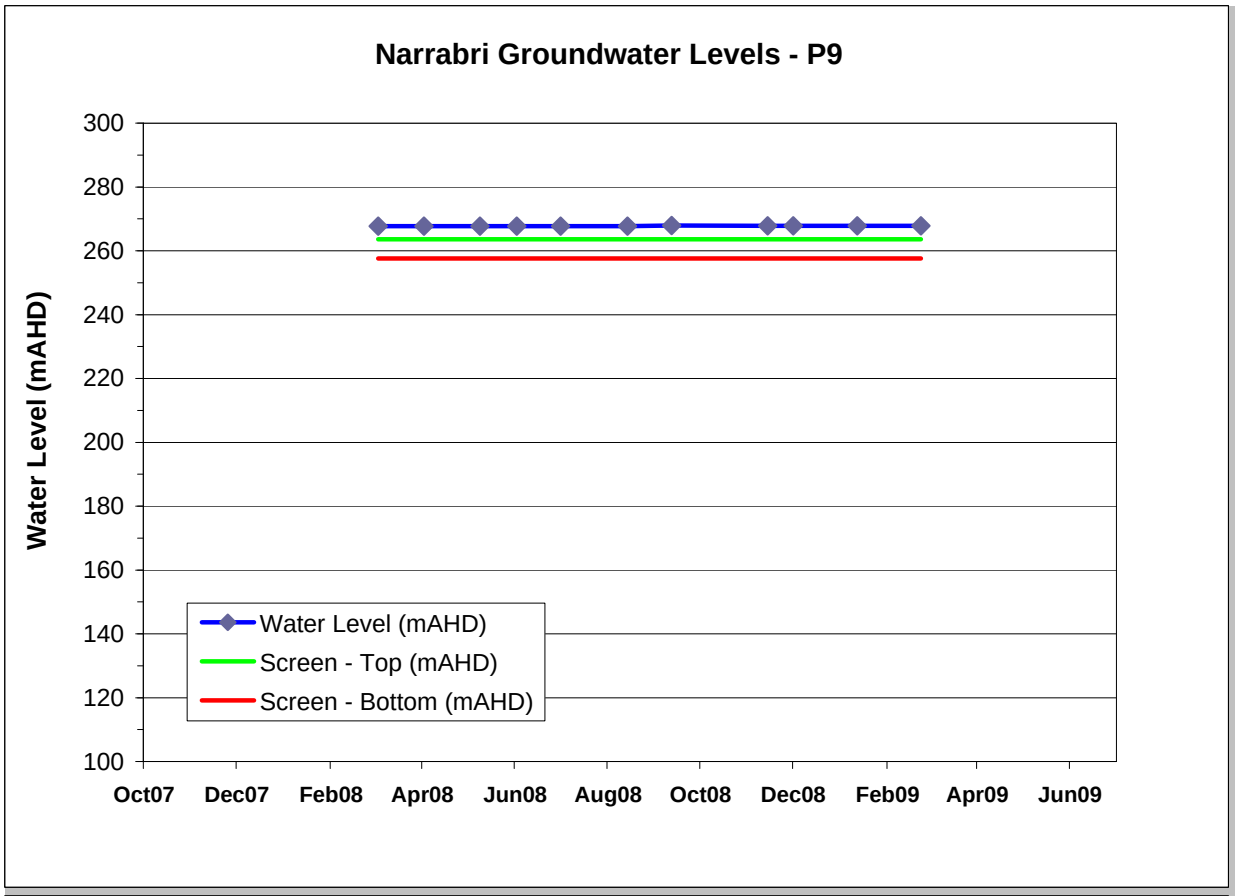

Narrabri Groundwater Levels - P4
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

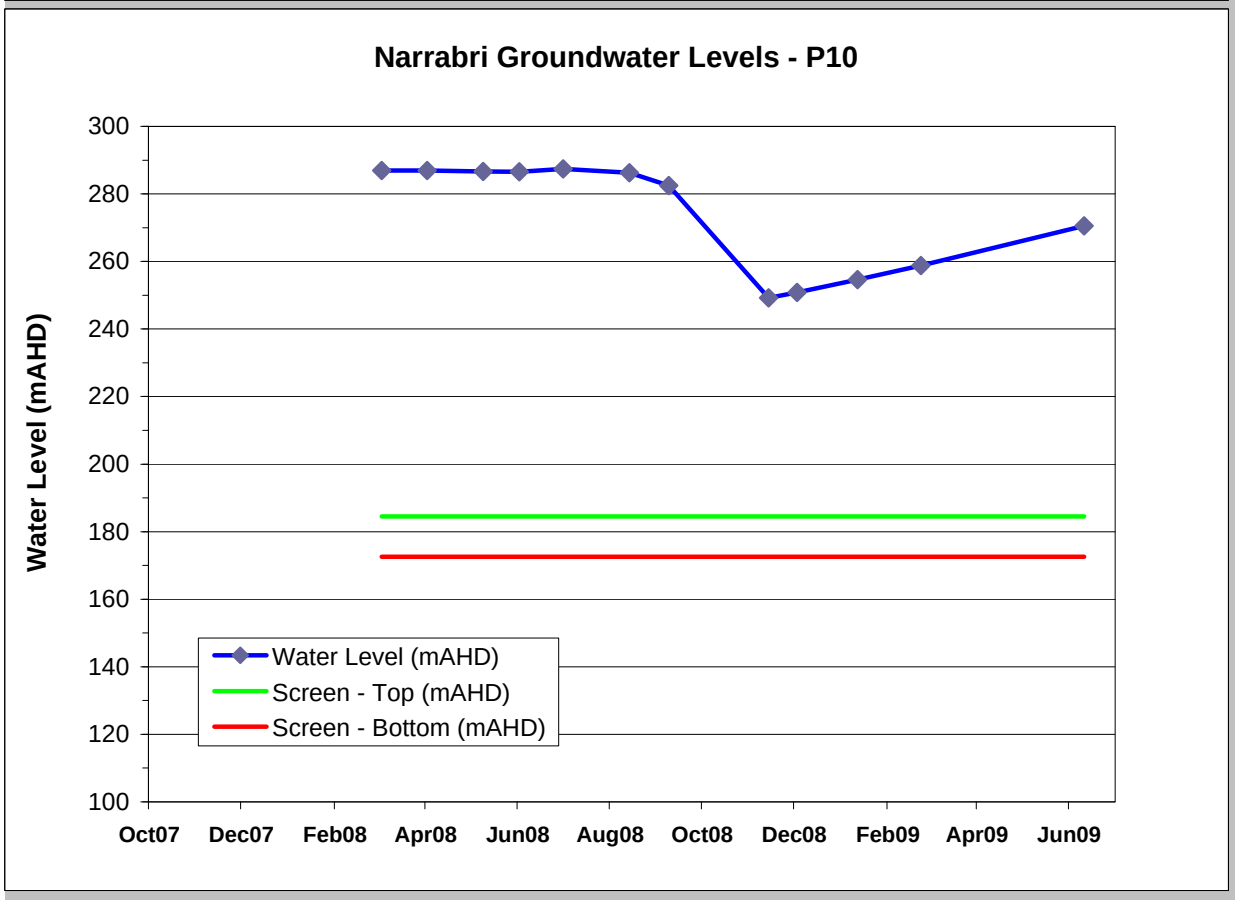

Narrabri Groundwater Levels - P5
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

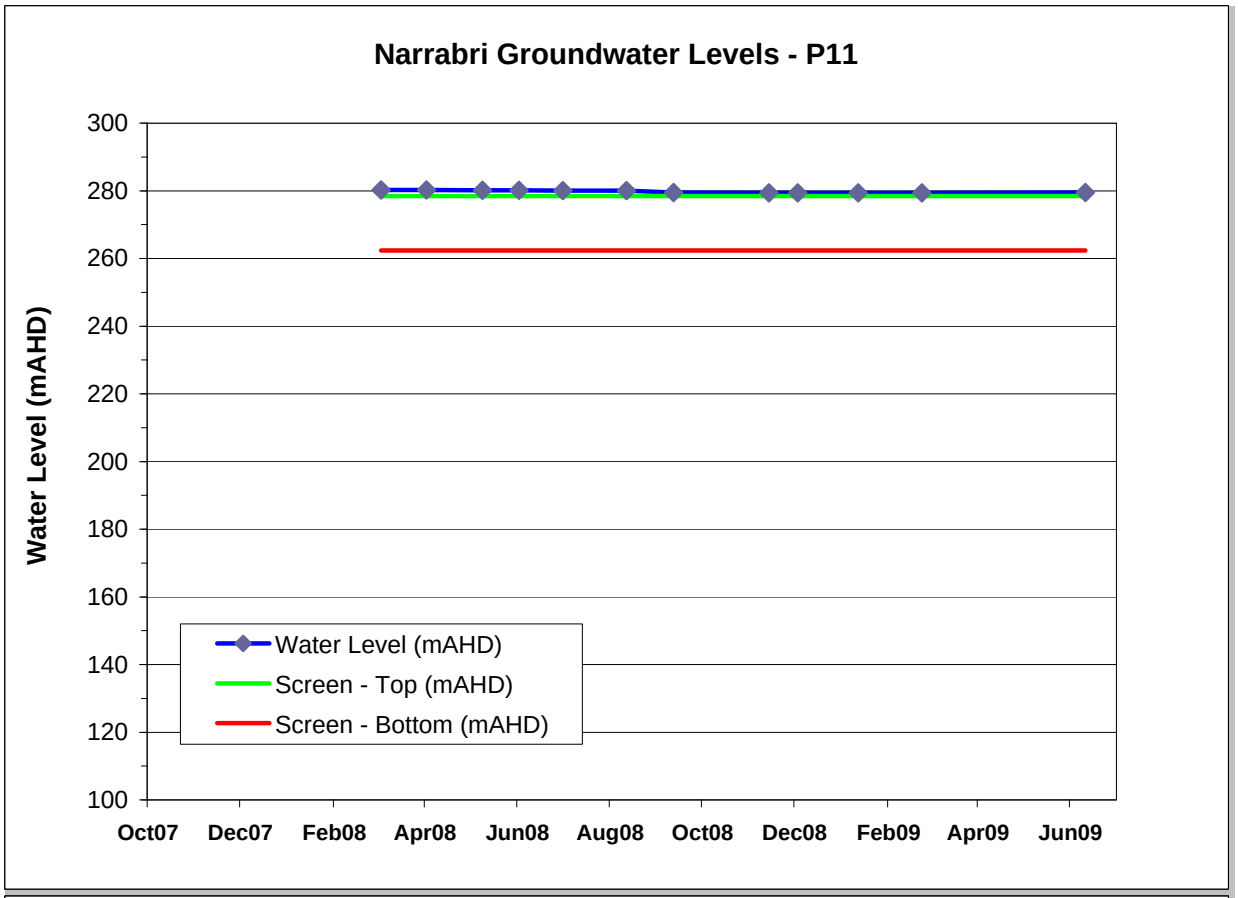

Narrabri Groundwater Levels - P6
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

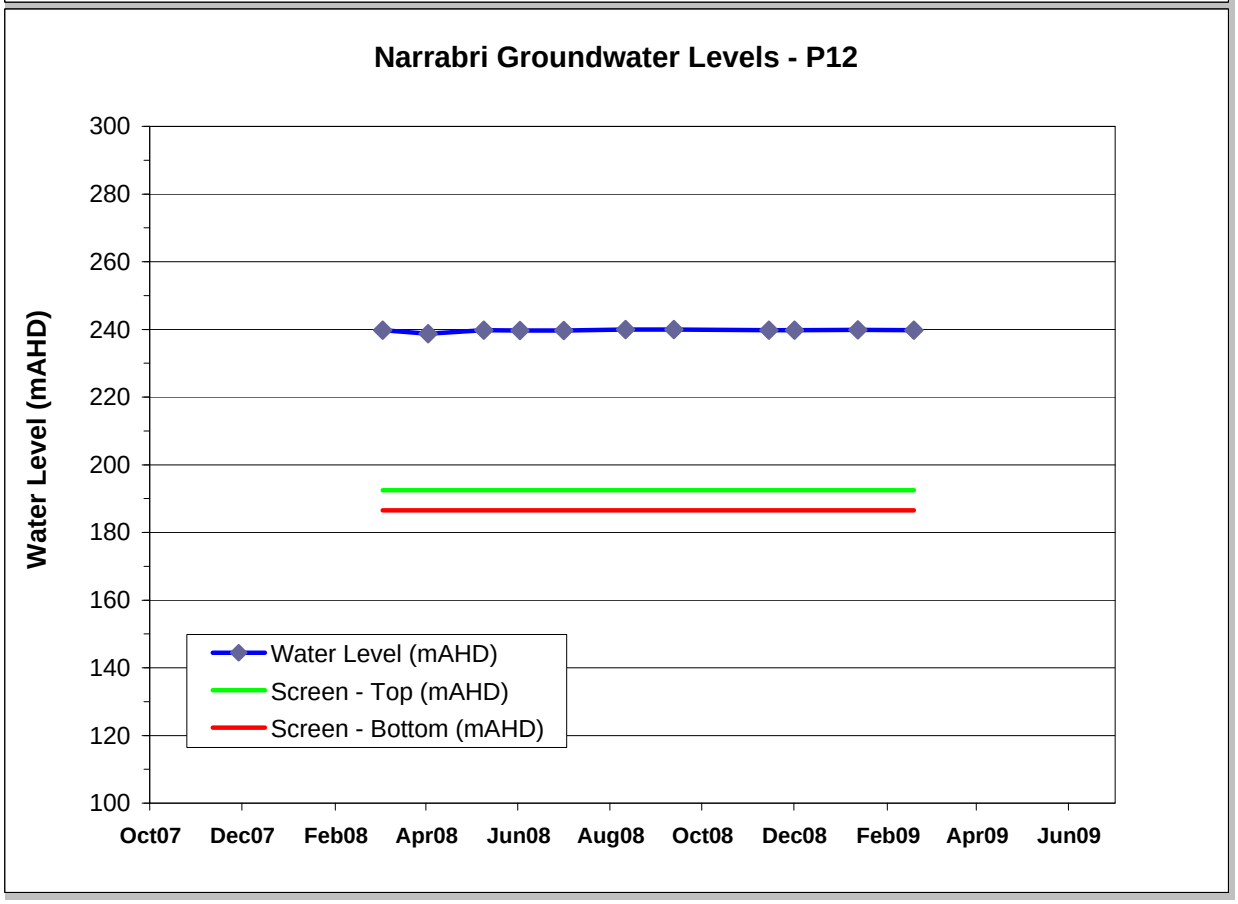

Narrabri Groundwater Levels - P7
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

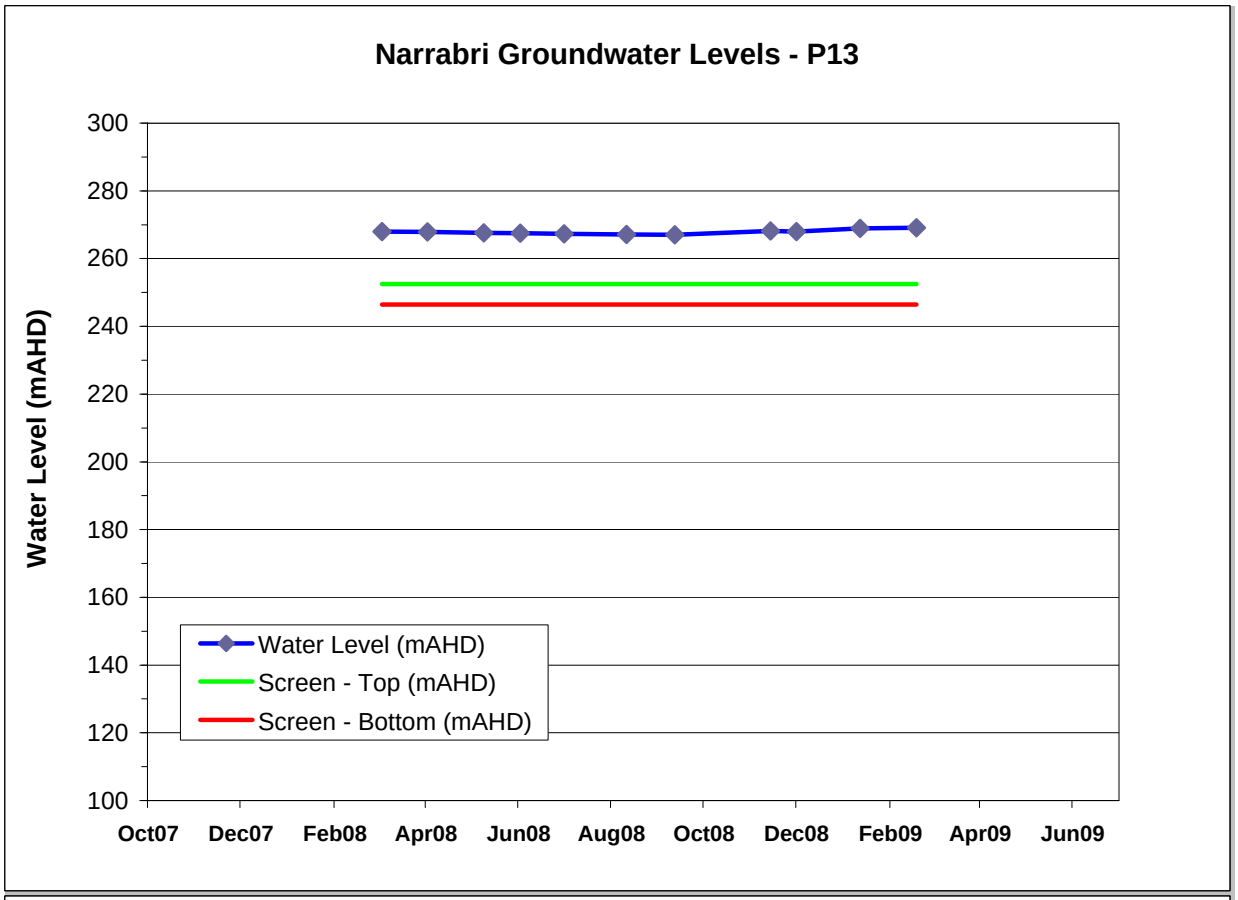

Narrabri Groundwater Levels - P8
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

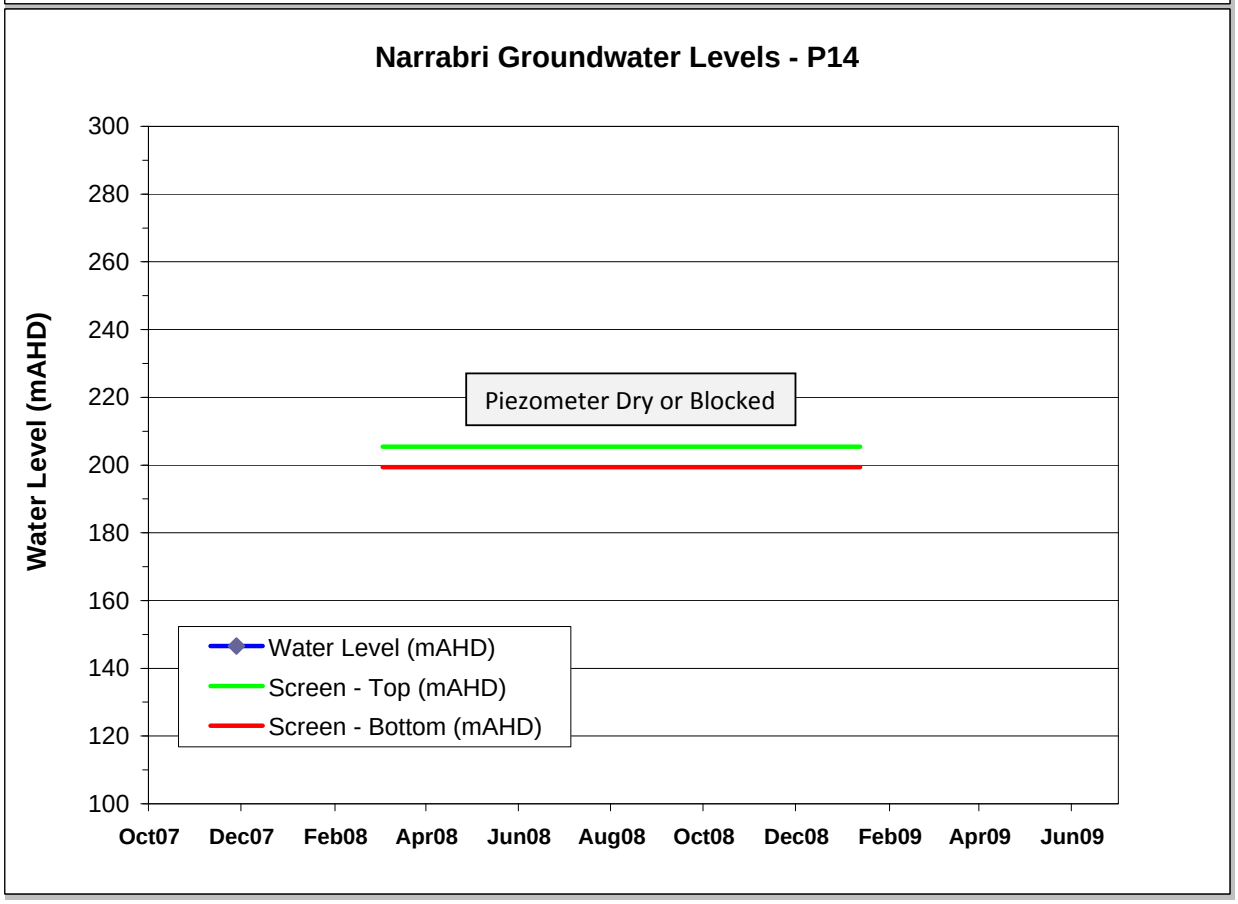

Narrabri Groundwater Levels - P9
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

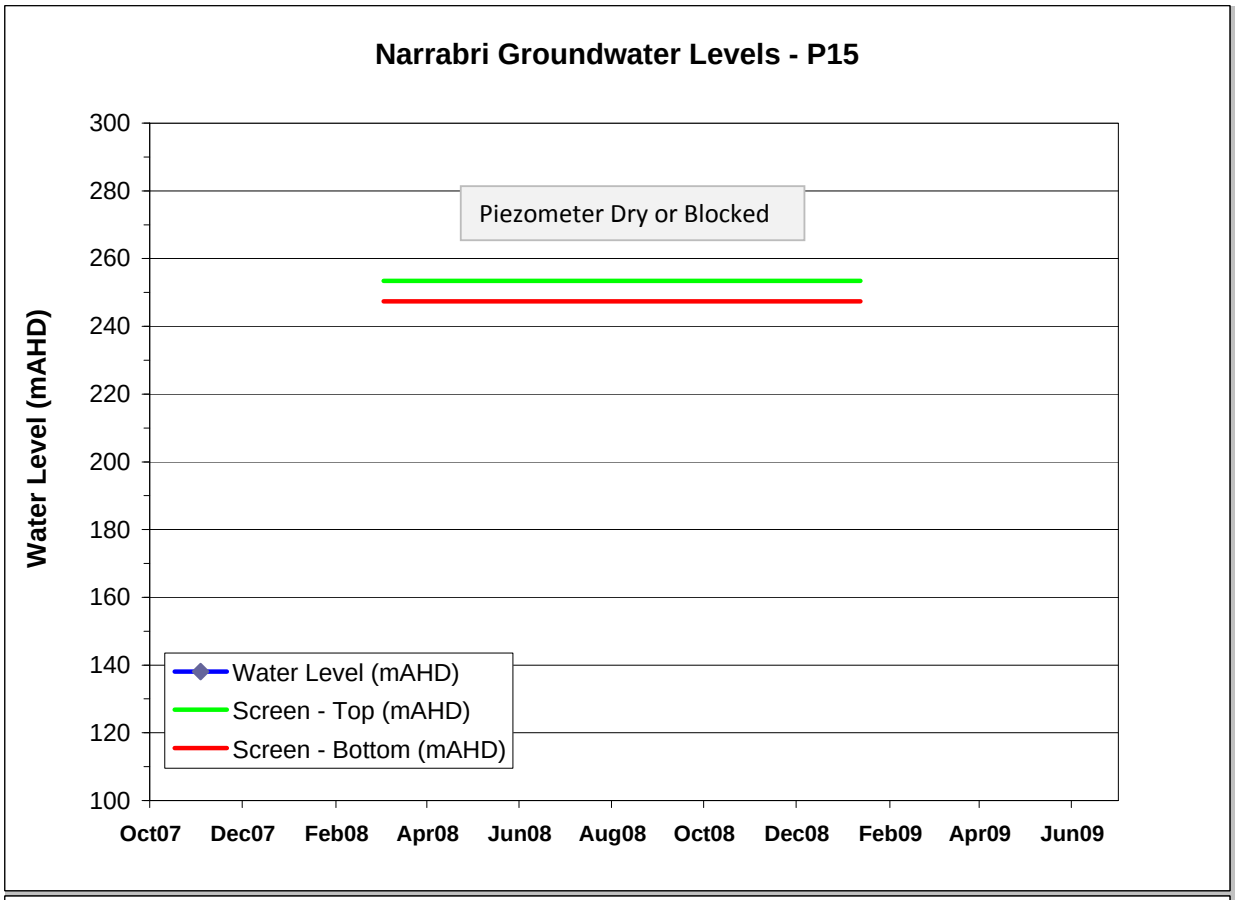

Narrabri Groundwater Levels - P10
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

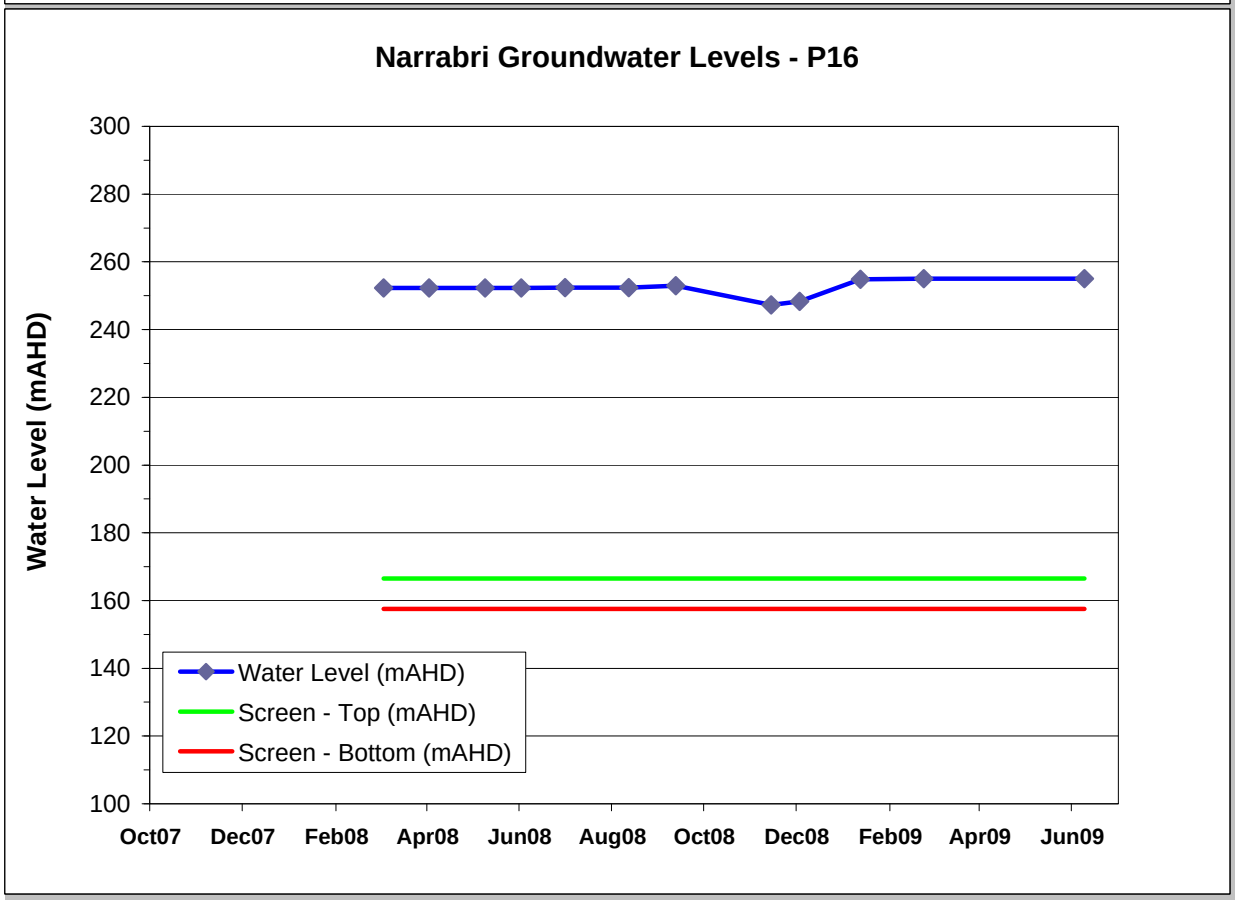

Narrabri Groundwater Levels - P11
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

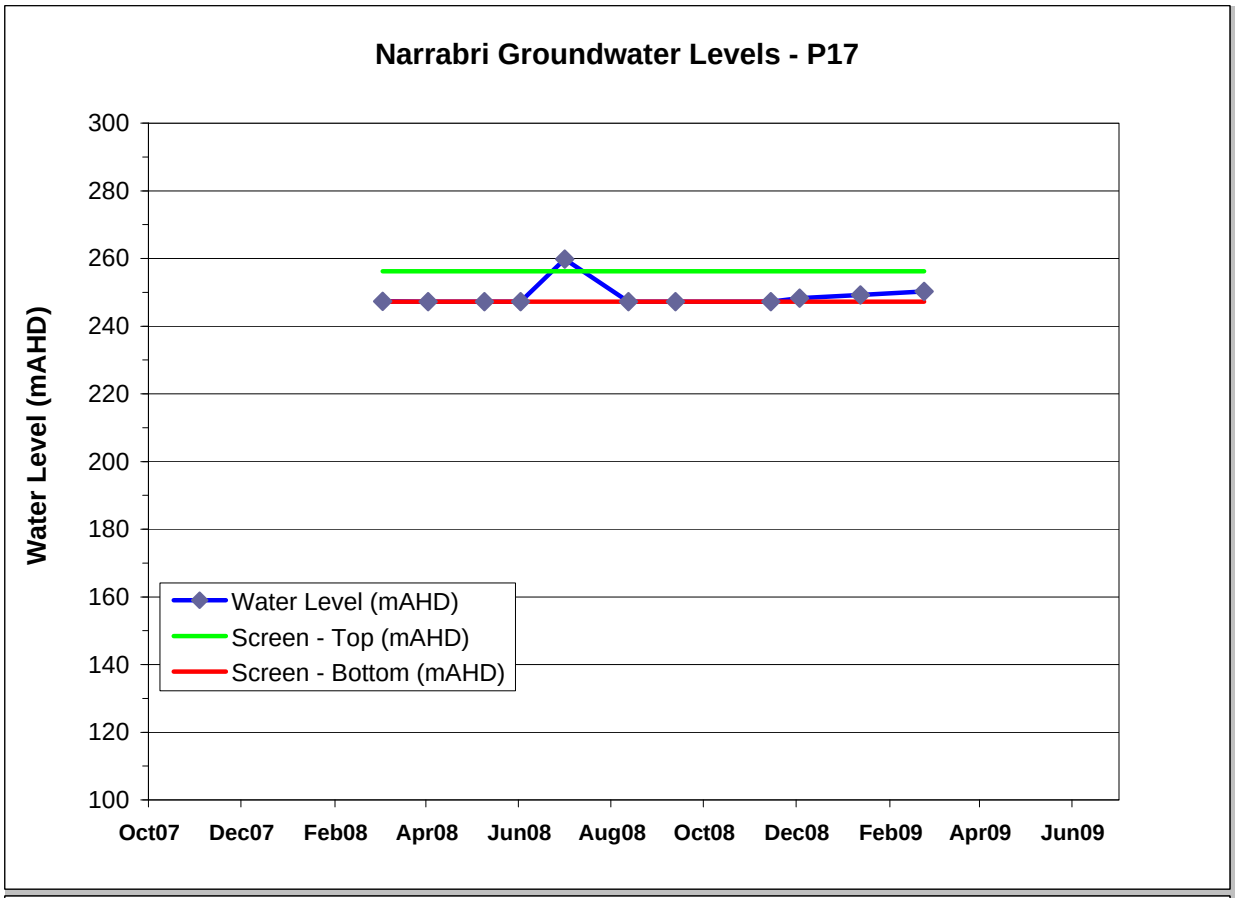

Narrabri Groundwater Levels - P12
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

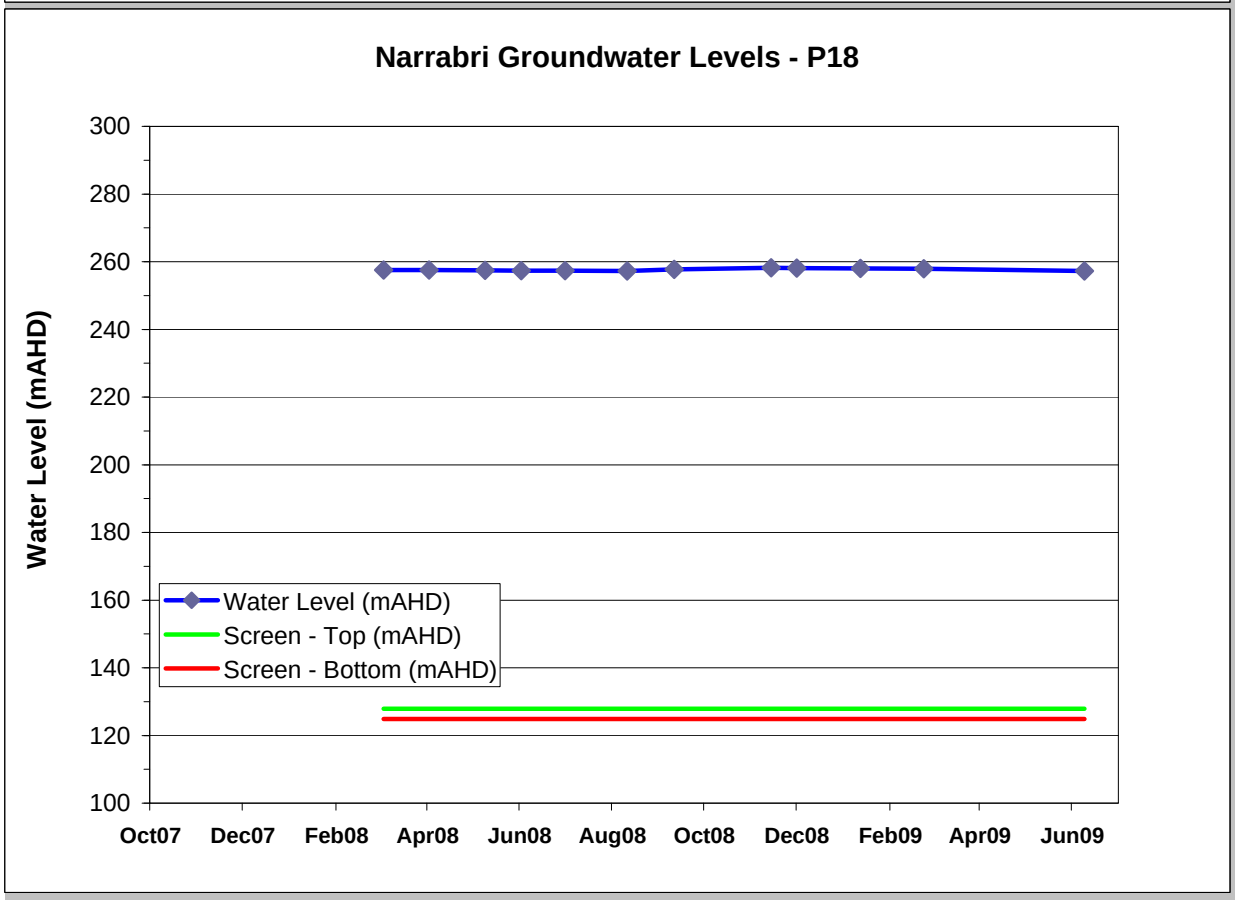

Narrabri Groundwater Levels - P13
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

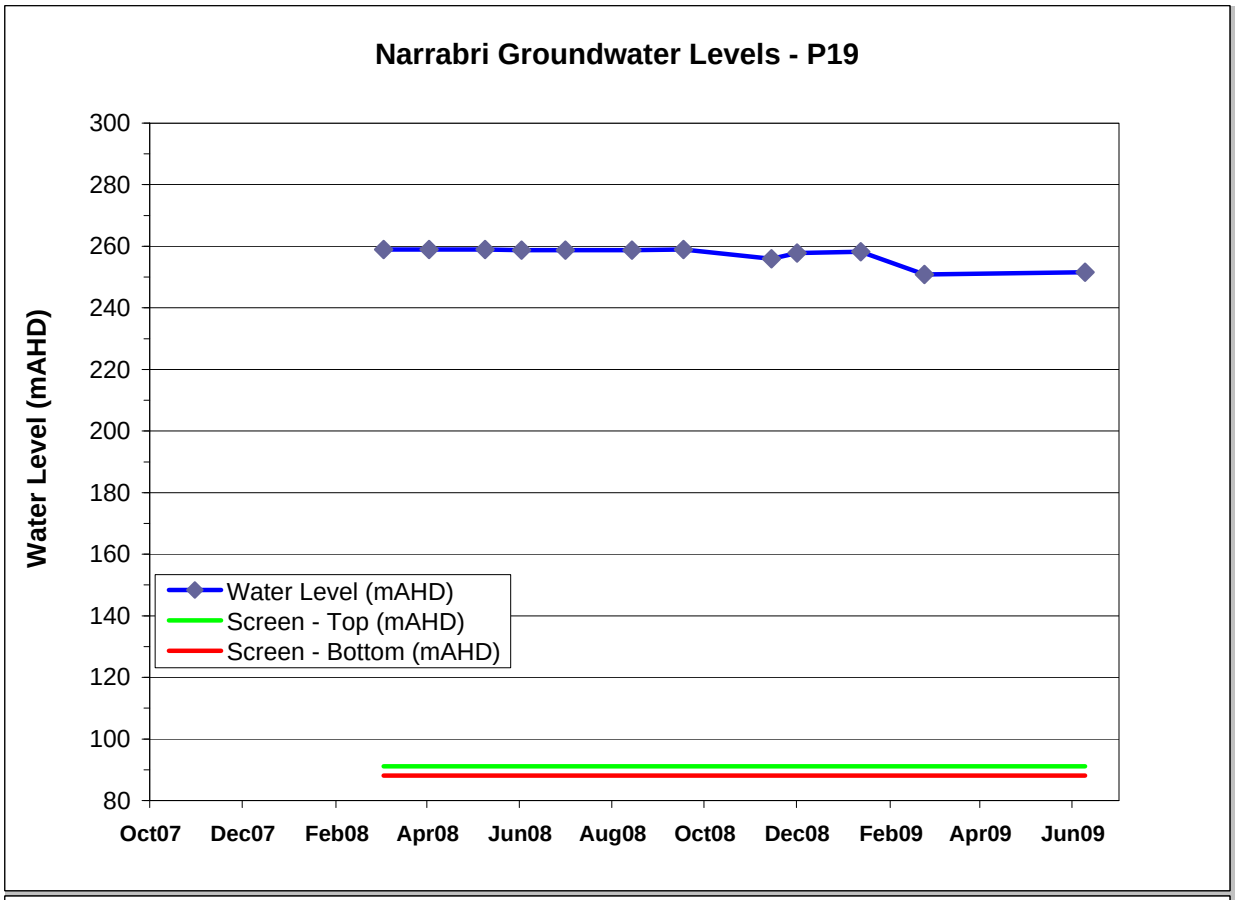

Narrabri Groundwater Levels - P14
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Piezometer Dry or Blocked
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

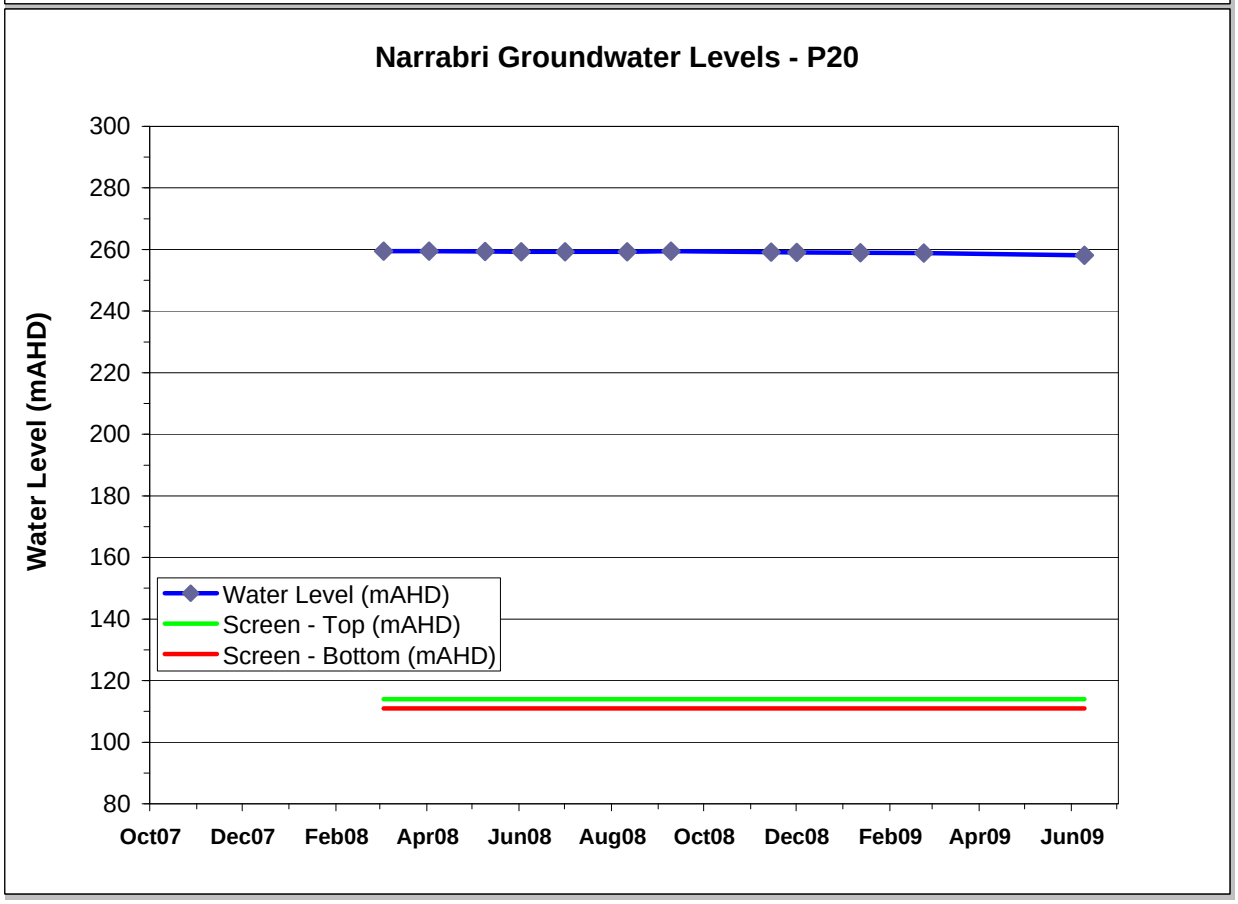

Narrabri Groundwater Levels - P15
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Piezometer Dry or Blocked
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09


Narrabri Groundwater Levels - P16
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09


Narrabri Groundwater Levels - P17
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

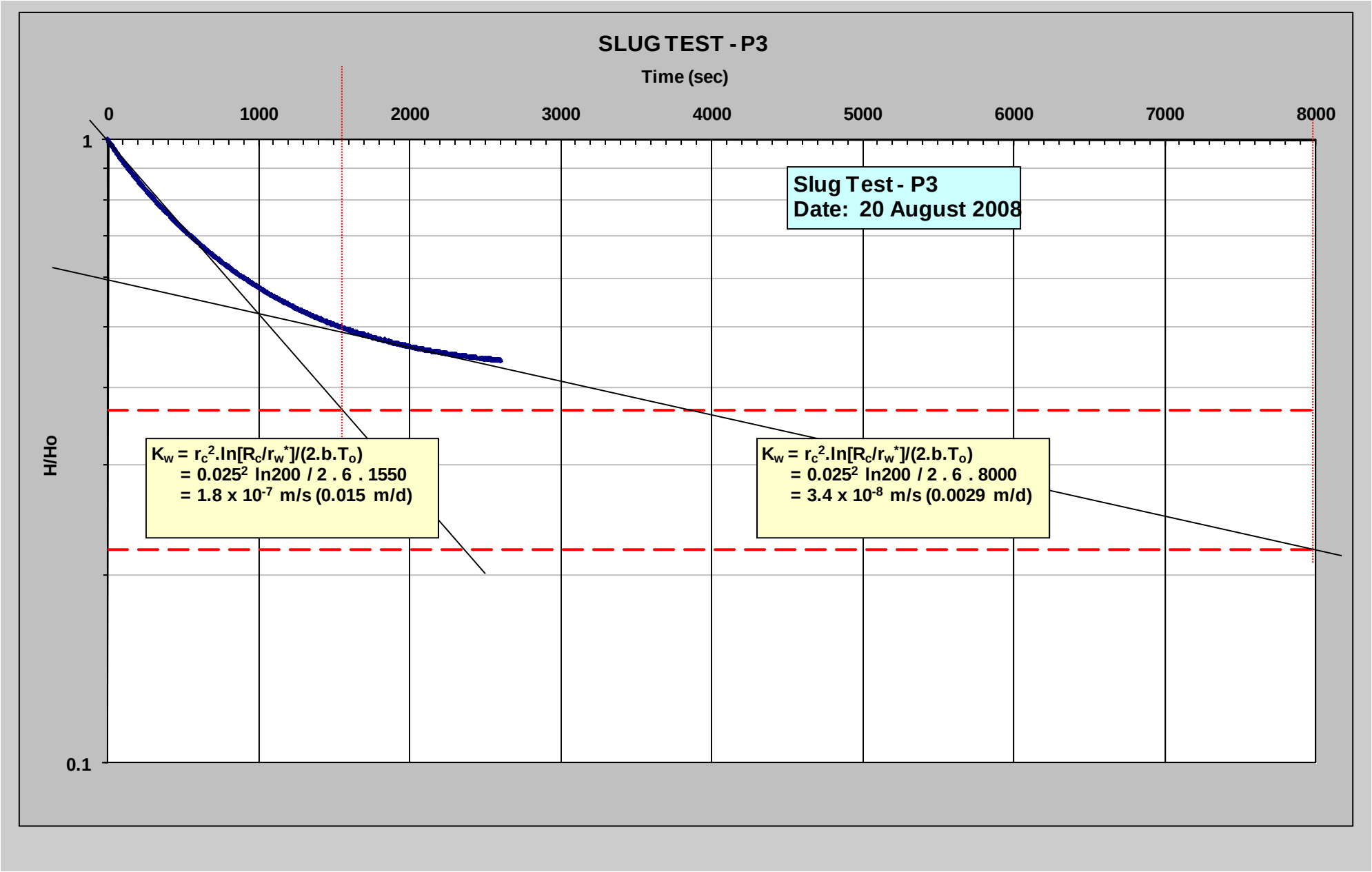

Narrabri Groundwater Levels - P18
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

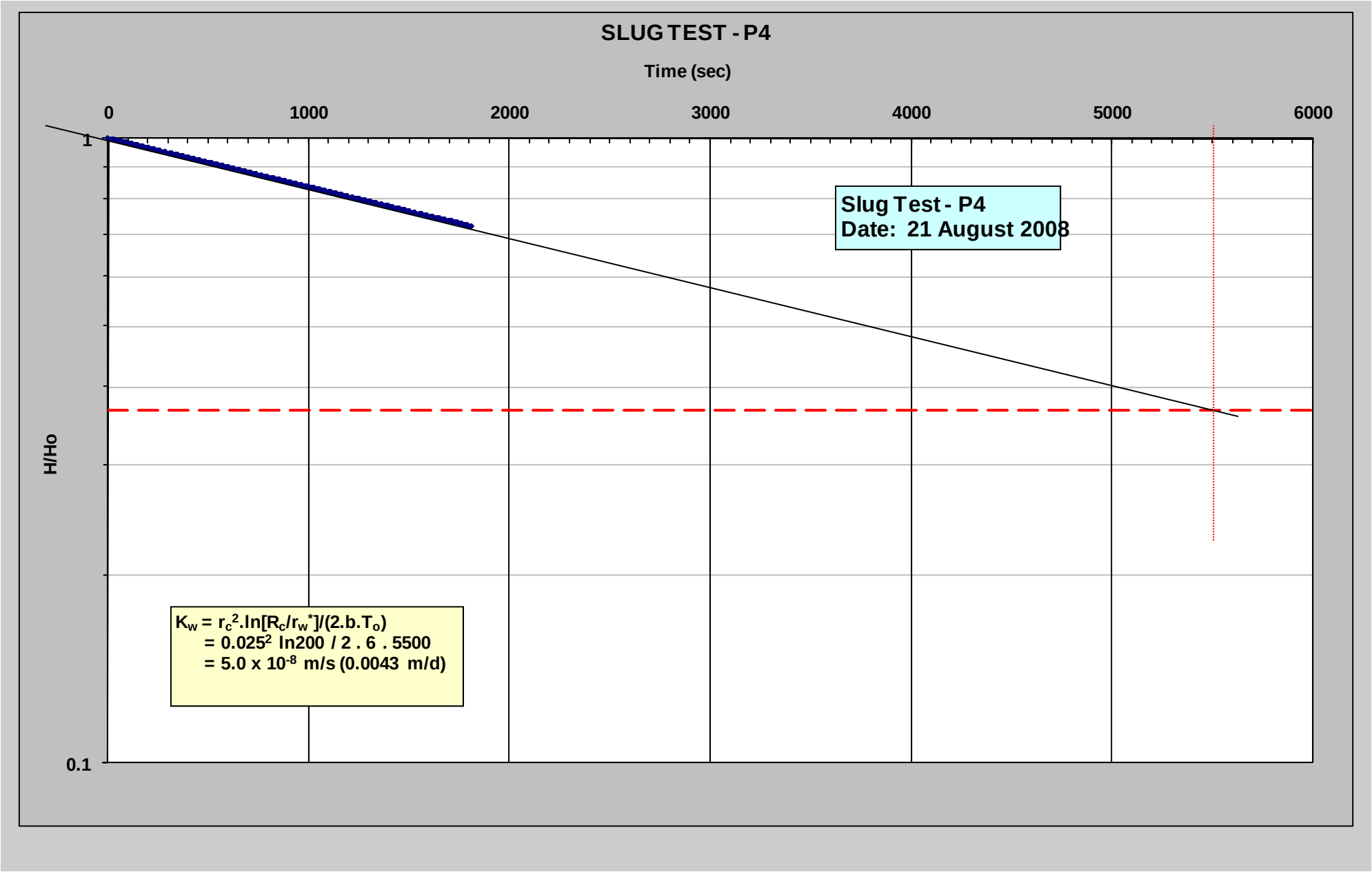

Narrabri Groundwater Levels - P19
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
80
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

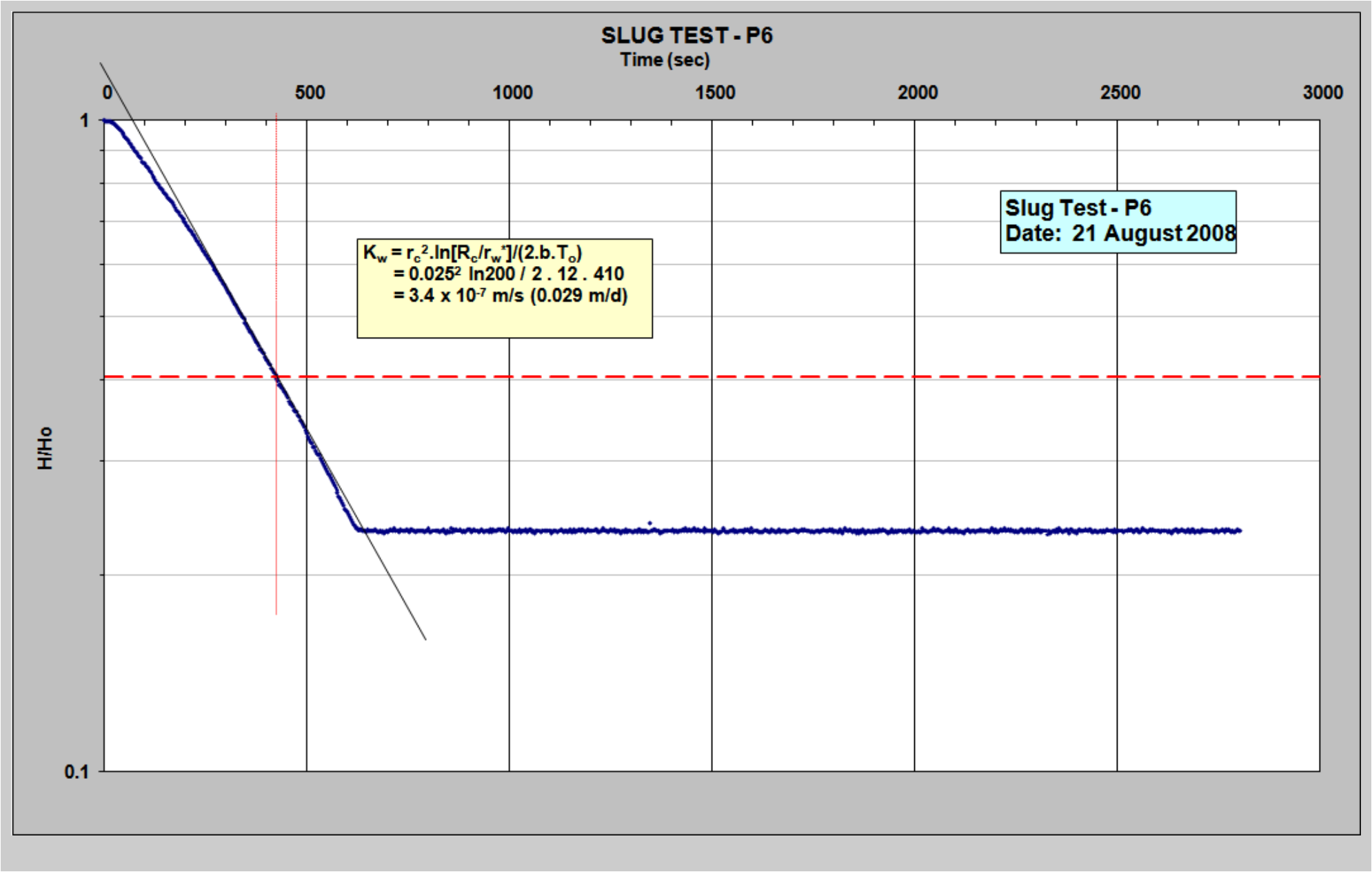

Narrabri Groundwater Levels - P20
Water Level (mAHD)
300
280
260
240
220
200
180
160
140
120
100
80
Oct07
Dec07
Feb08
Apr08
Jun08
Aug08
Oct08
Dec08
Feb09
Apr09
Jun09
Water Level (mAHD)
Screen - Top (mAHD)
Screen - Bottom (mAHD)

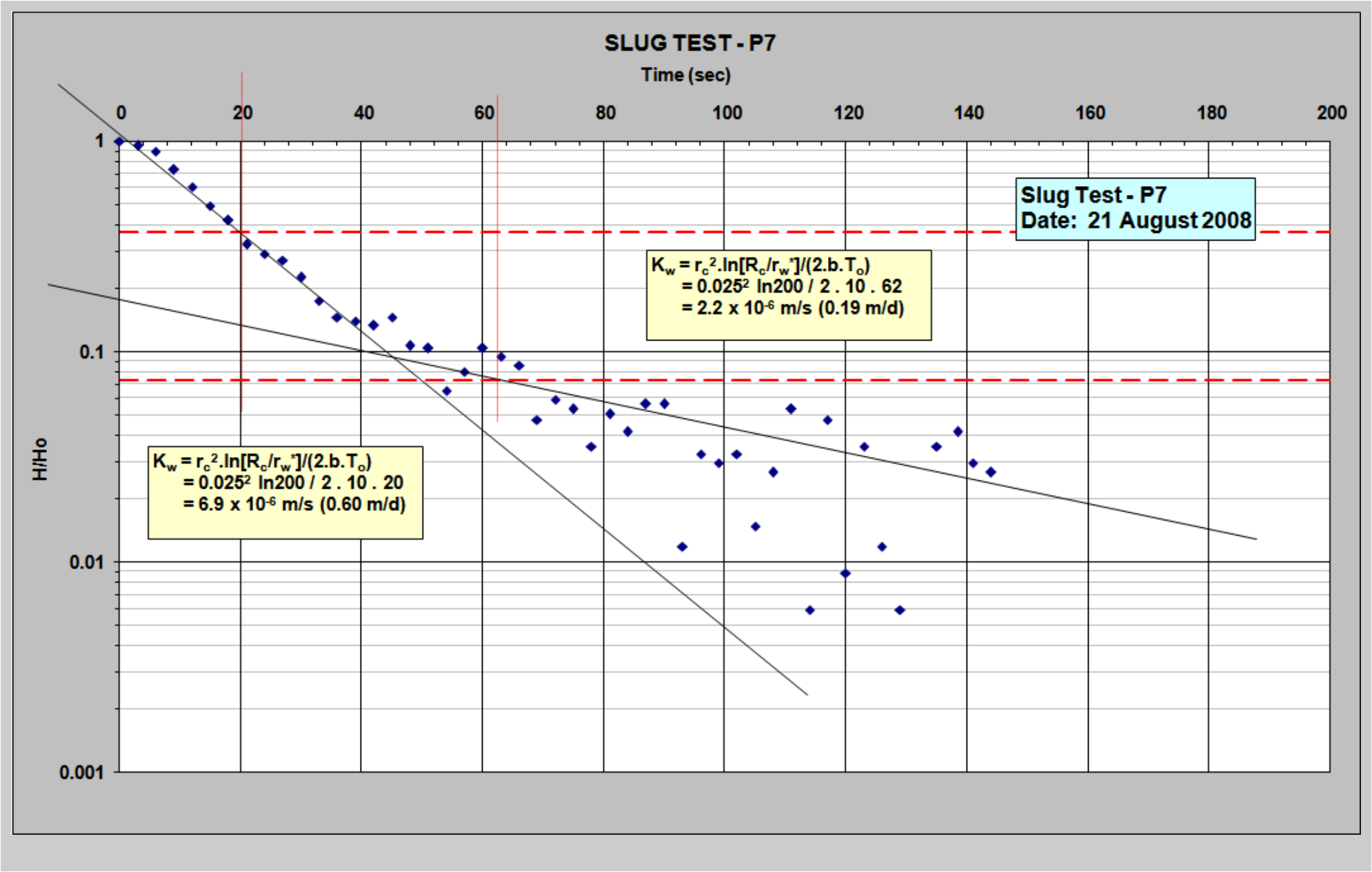
APPENDIX B

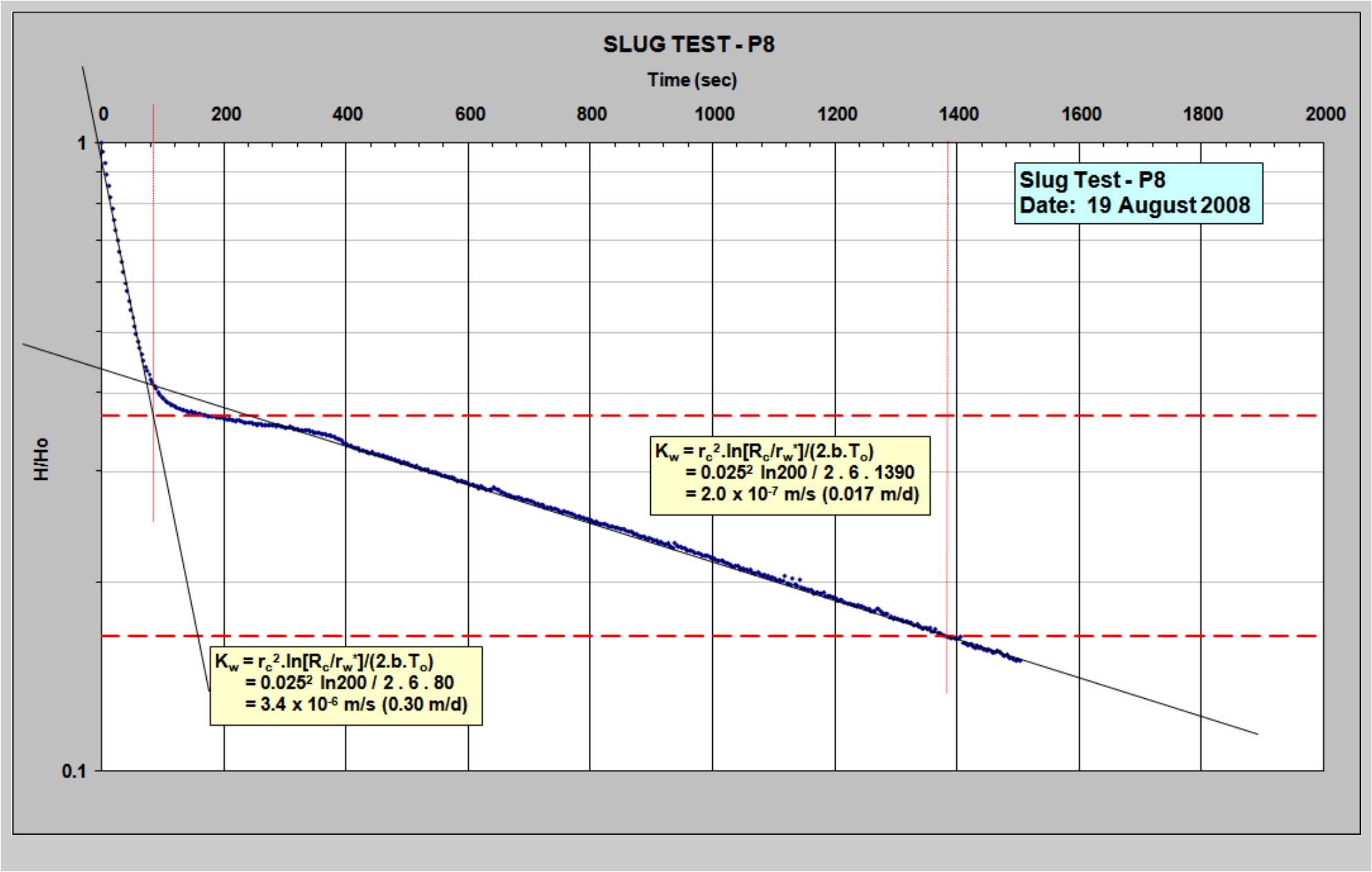
NARRABRI HYDRAULIC TEST DATA

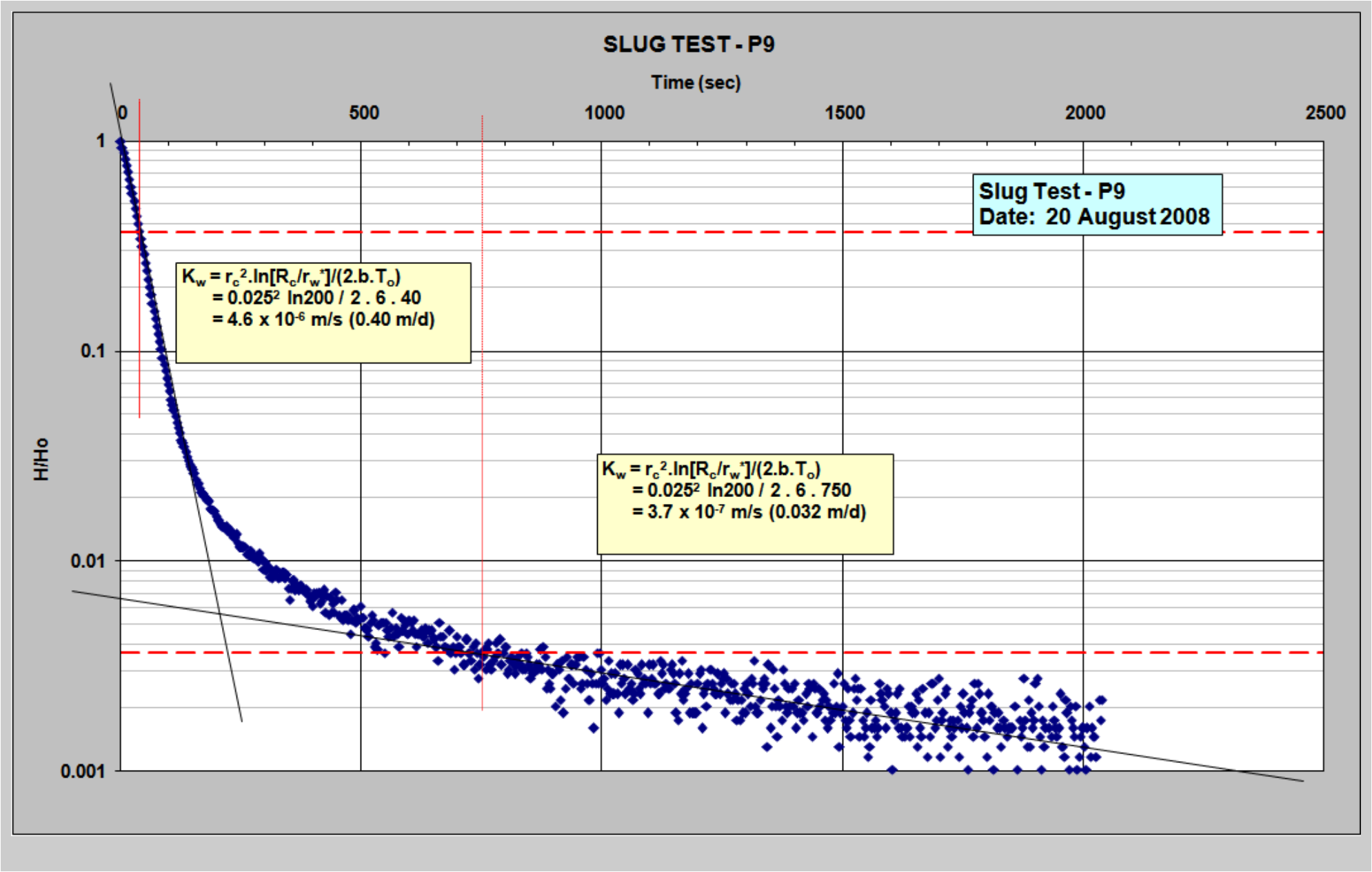

SLUG TEST - P3
Time (sec)
0
1000
2000
3000
4000
5000
6000
7000
8000
1
0.1
H/Ho
Slug Test - P3
Date: 20 August 2008
Kw = rc2.ln[Rc/rw*]/(2.b.To)
= 0.0252 ln200 / 2 . 6 . 1550
= 1.8 x 10-7 m/s (0.015 m/d)
Kw = rc2.ln[Rc/rw*]/(2.b.To)
= 0.0252 ln200 / 2 . 6 . 8000
= 3.4 x 10-8 m/s (0.0029 m/d)

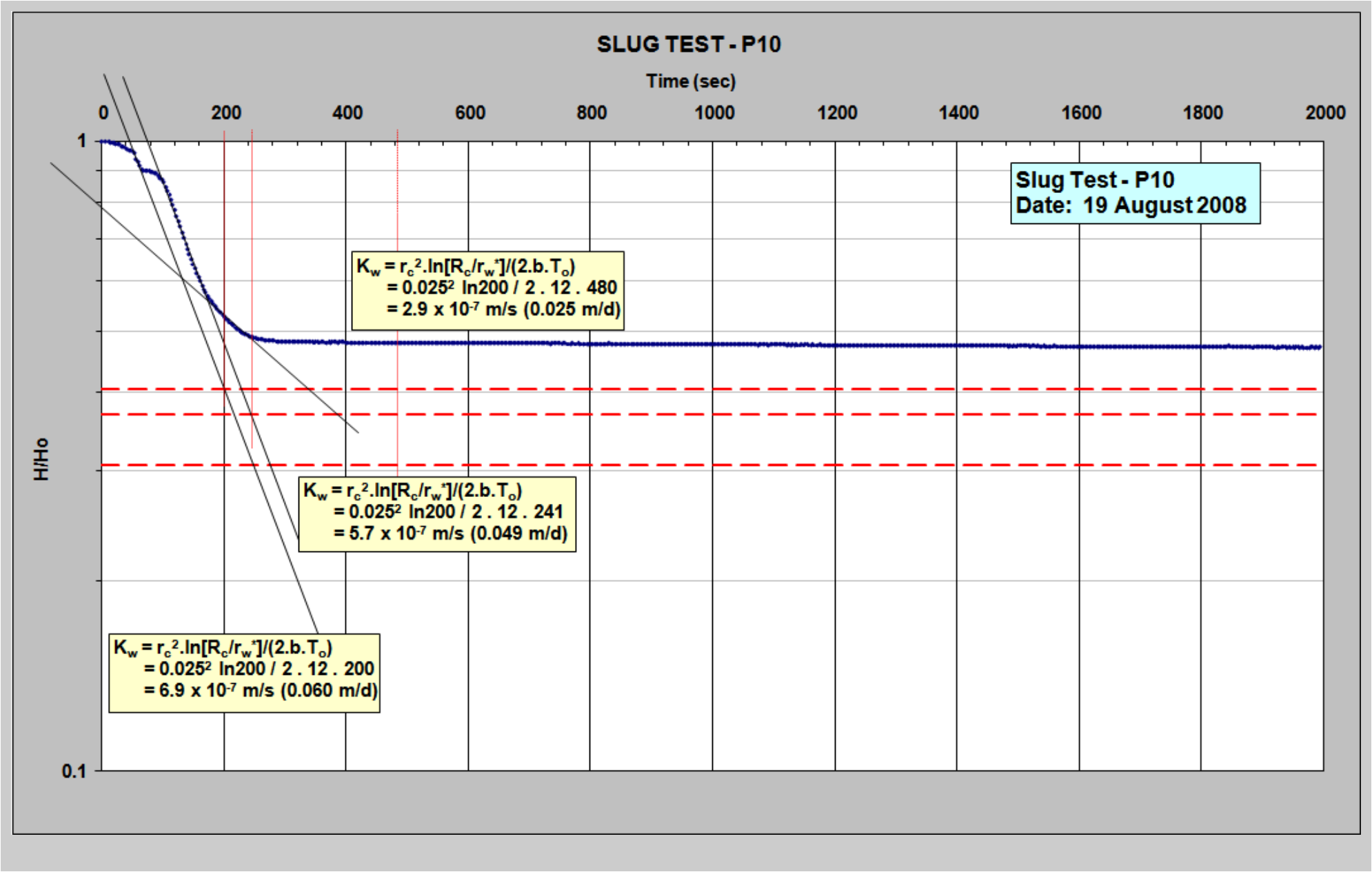

SLUG TEST - P4
Time (sec)
0
1000
2000
3000
4000
5000
6000
1
0.1
H/Ho
Slug Test - P4
Date: 21 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 6 . 5500
$= 5.0 \times 10^{-8}$ m/s (0.0043 m/d)

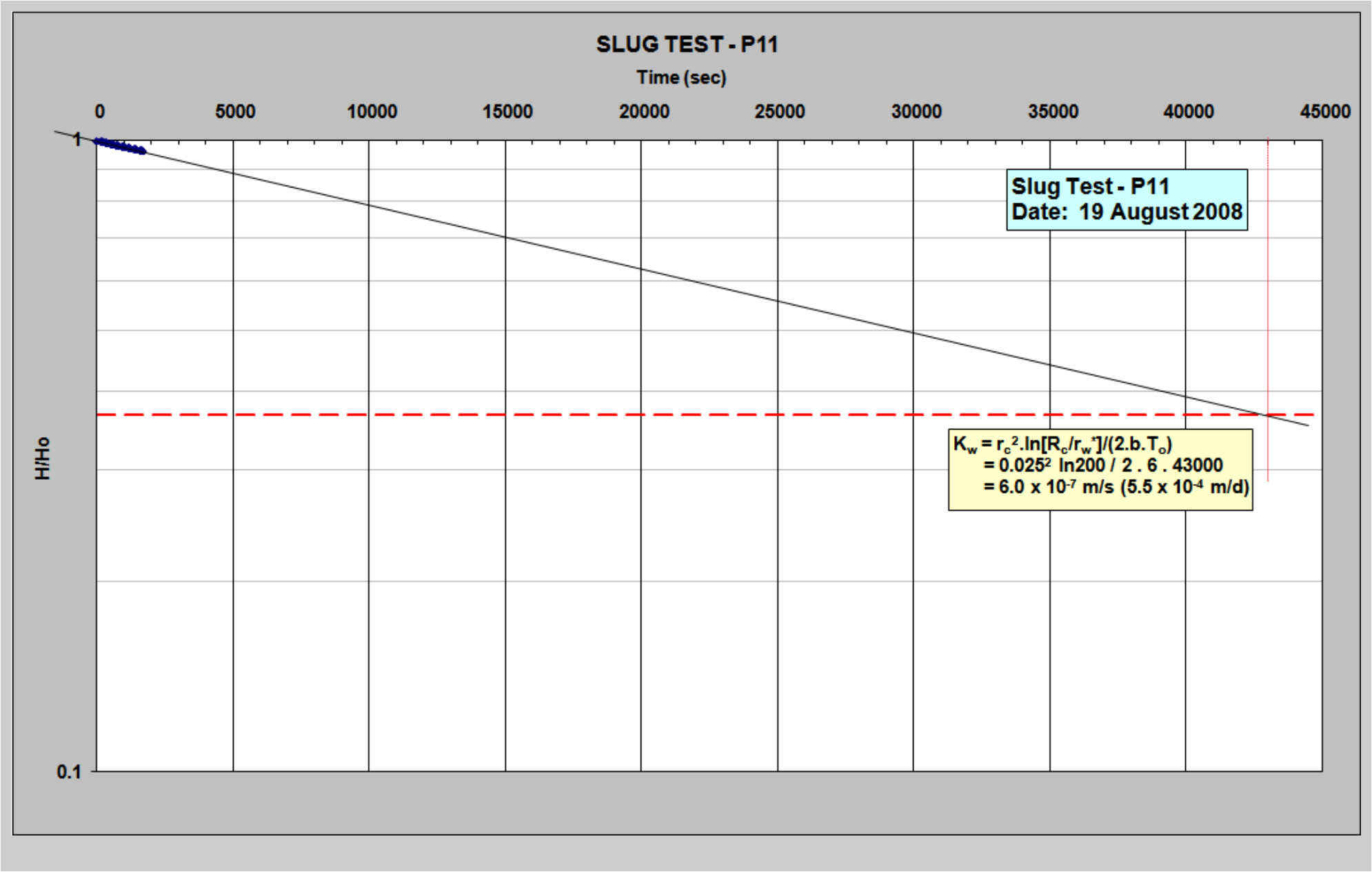

SLUG TEST - P6
Time (sec)
0
500
1000
1500
2000
2500
3000
1
0.1
H/Ho
Slug Test - P6
Date: 21 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 12 . 410
$= 3.4 \times 10^{-7}$ m/s (0.029 m/d)

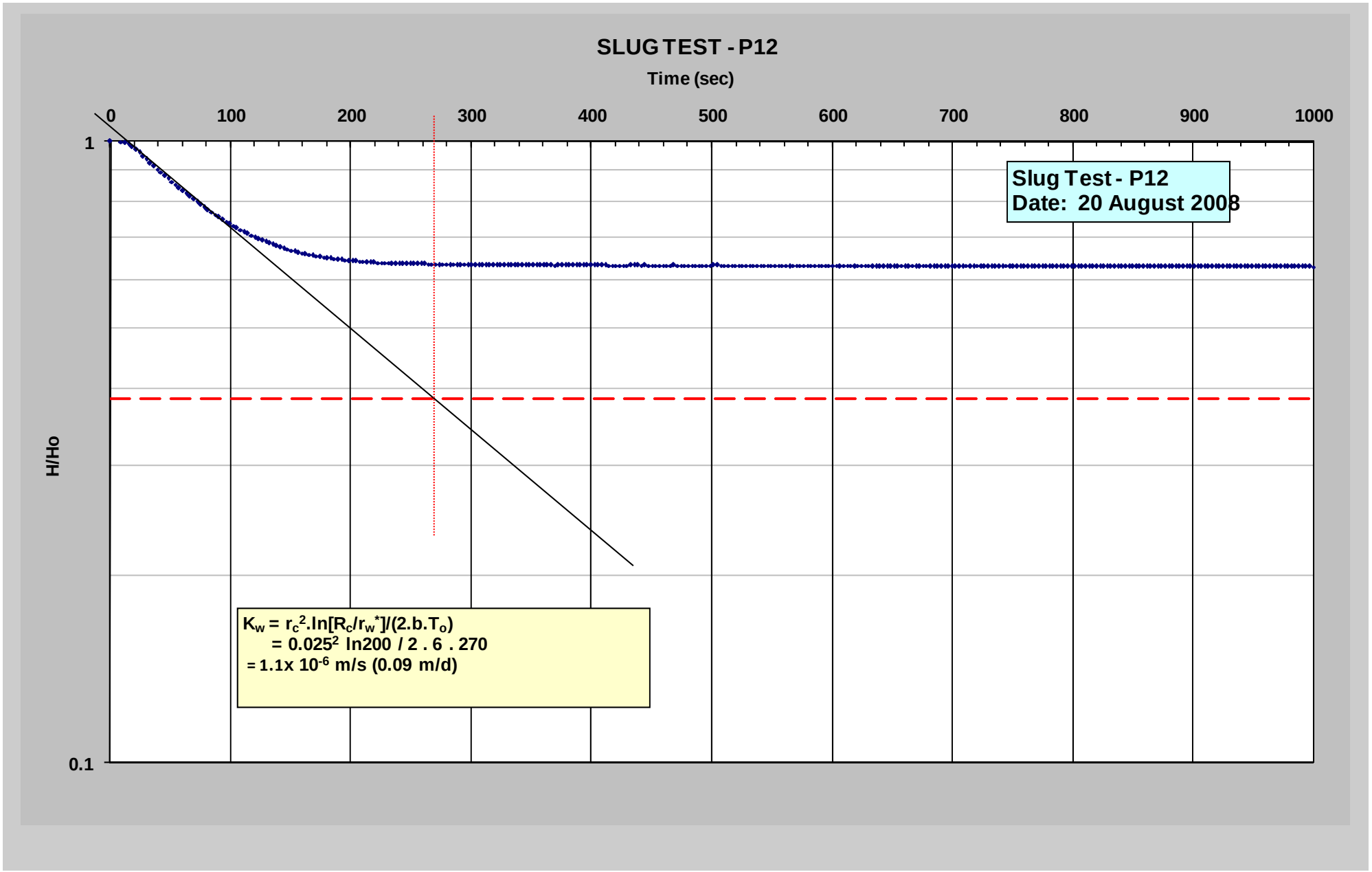

SLUG TEST - P7
Time (sec)
0
20
40
60
80
100
120
140
160
180
200
1
0.1
0.01
0.001
H/Ho
Slug Test - P7
Date: 21 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 10 . 62
$= 2.2 \times 10^{-6}$ m/s (0.19 m/d)
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 10 . 20
$= 6.9 \times 10^{-6}$ m/s (0.60 m/d)

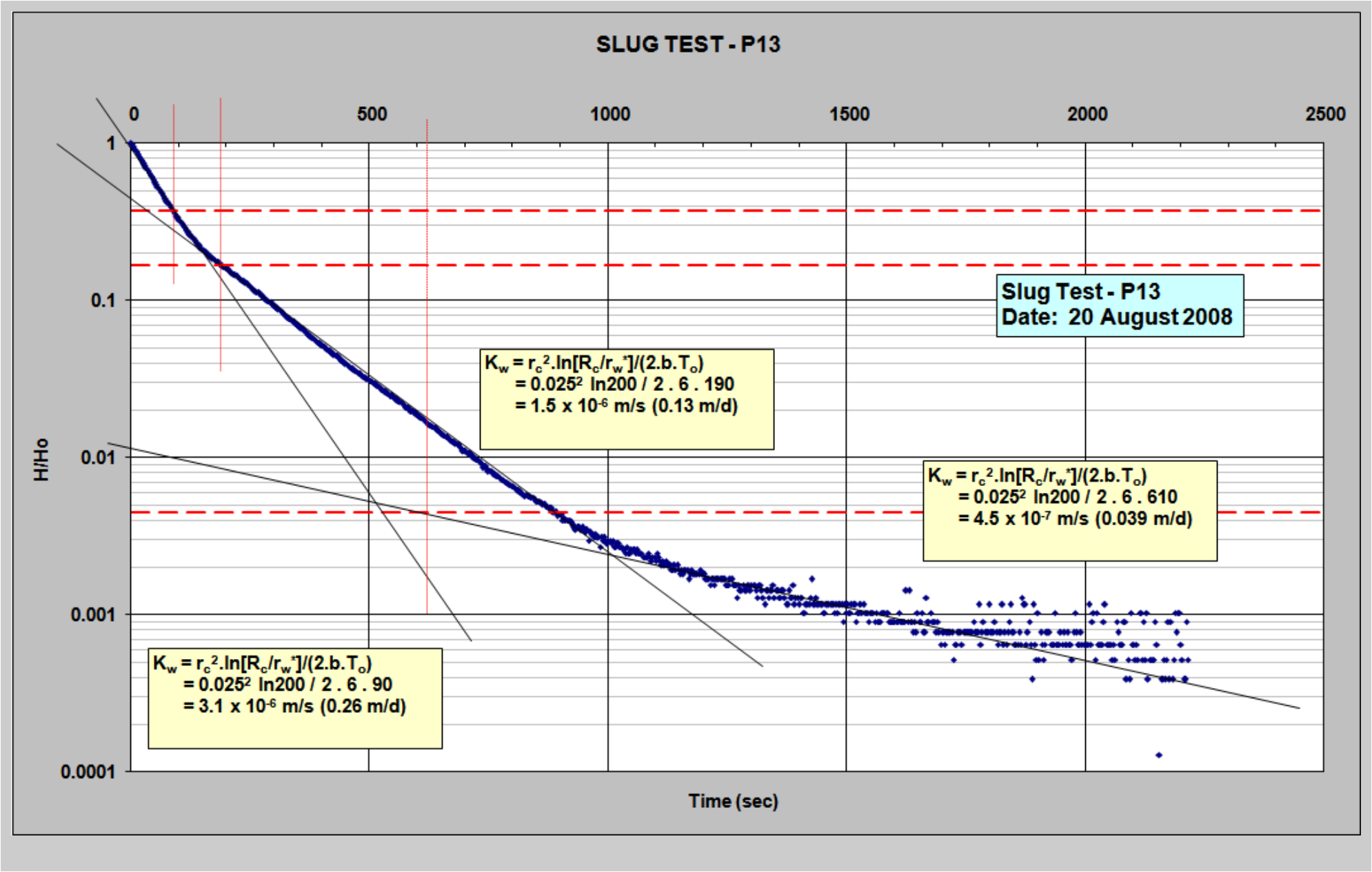

SLUG TEST - P8
Time (sec)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
1
0.1
H/Ho
Slug Test - P8
Date: 19 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 6 . 1390
$= 2.0 \times 10^{-7}$ m/s (0.017 m/d)
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 6 . 80
$= 3.4 \times 10^{-6}$ m/s (0.30 m/d)

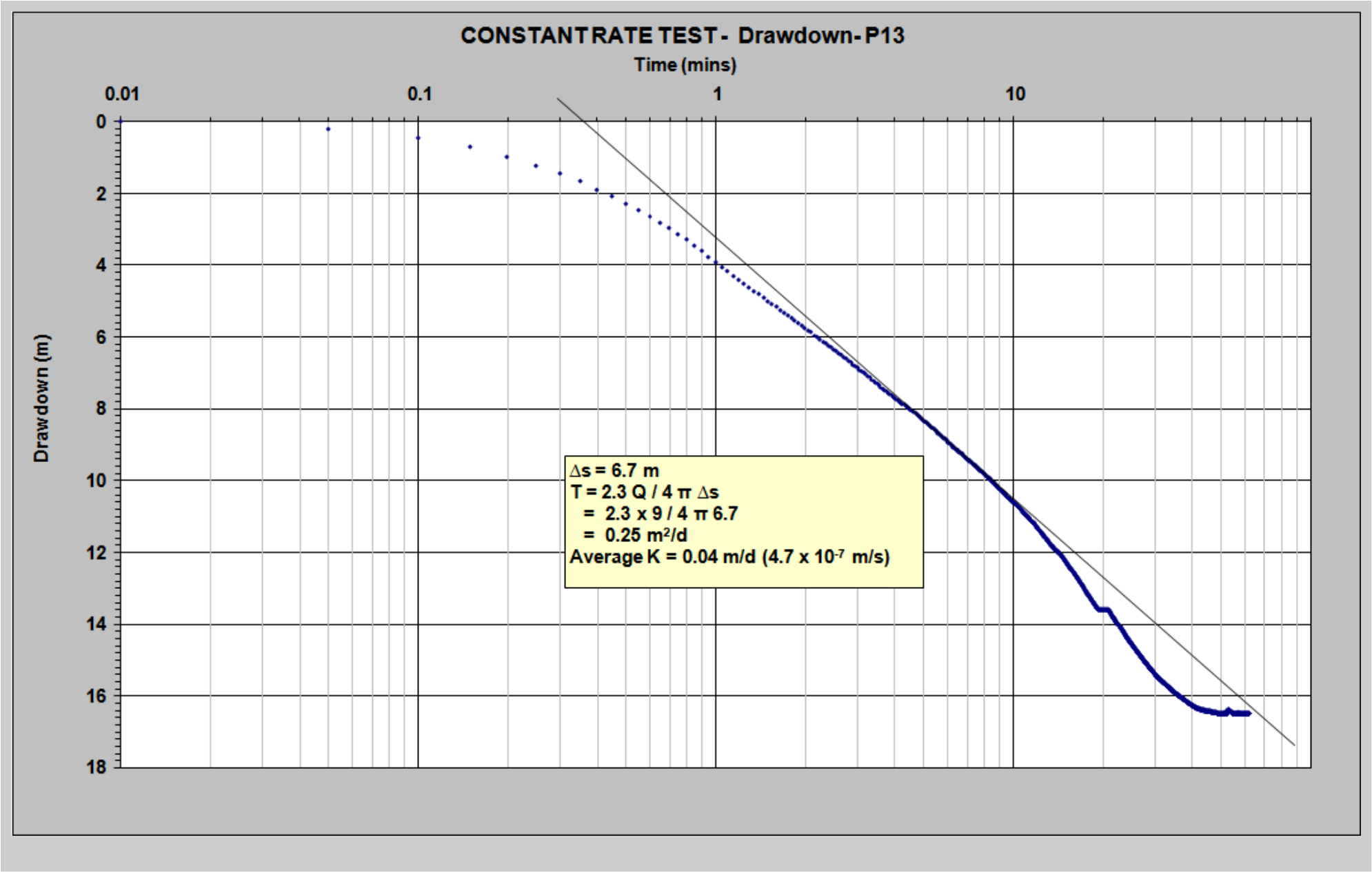

SLUG TEST - P9
Time (sec)
0
500
1000
1500
2000
2500
1
0.1
0.01
0.001
H/Ho
Slug Test - P9
Date: 20 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 6 . 40
$= 4.6 \times 10^{-6}$ m/s (0.40 m/d)
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 6 . 750
$= 3.7 \times 10^{-7}$ m/s (0.032 m/d)

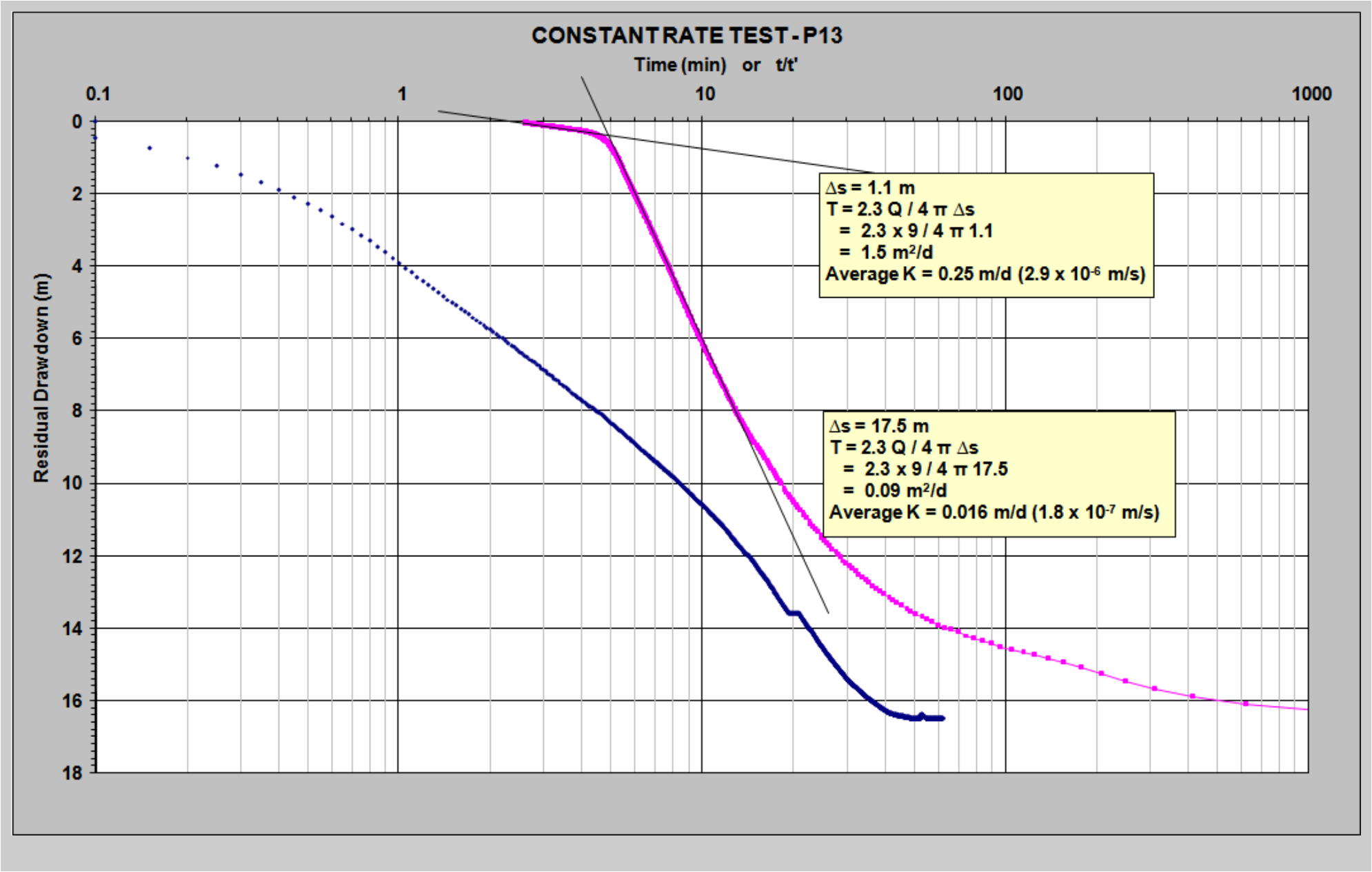

SLUG TEST - P10
Time (sec)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
1
0.1
H/Ho
Slug Test - P10
Date: 19 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 12 . 480
$= 2.9 \times 10^{-7}$ m/s (0.025 m/d)
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 12 . 241
$= 5.7 \times 10^{-7}$ m/s (0.049 m/d)
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 12 . 200
$= 6.9 \times 10^{-7}$ m/s (0.060 m/d)

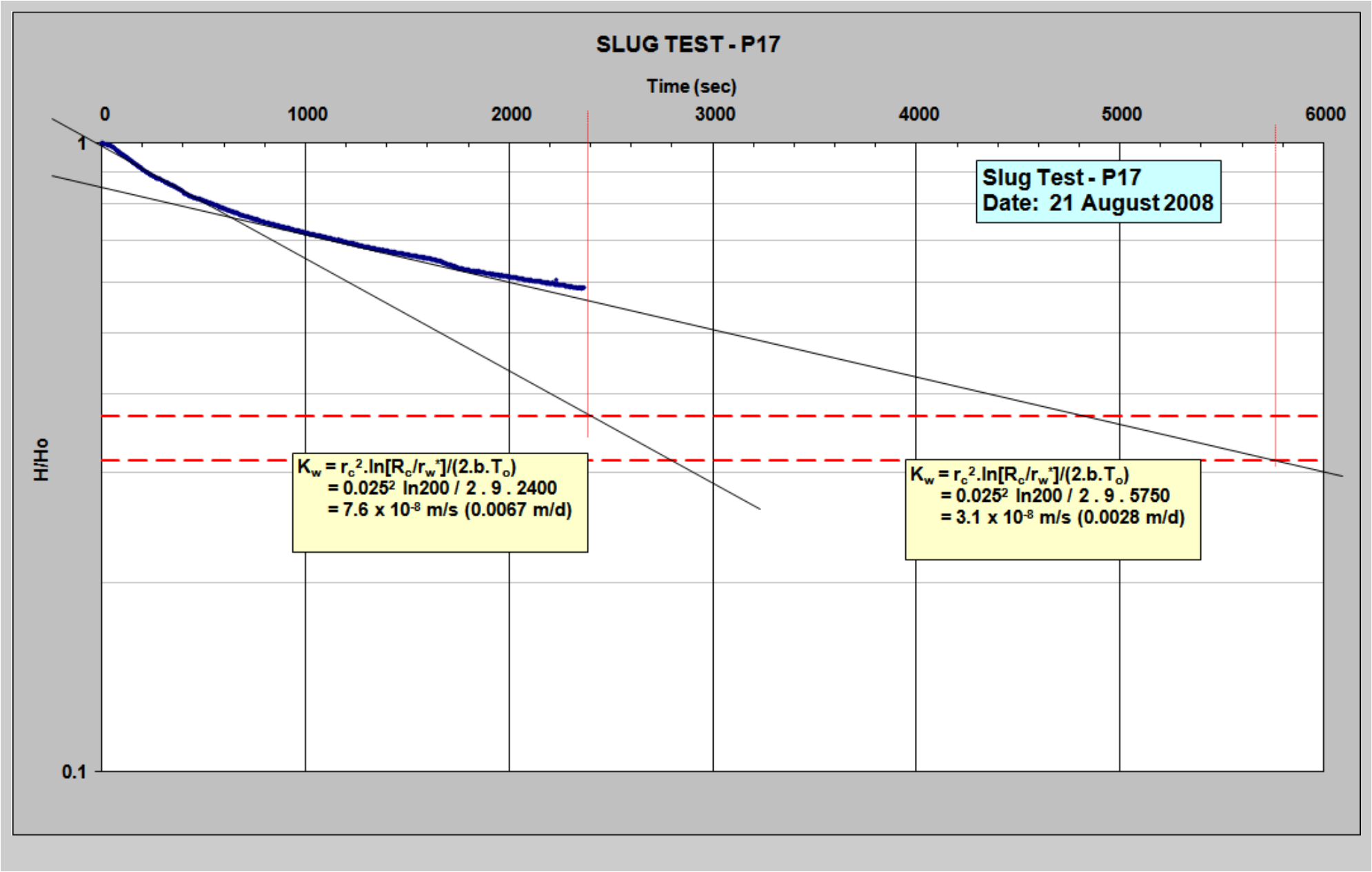

SLUG TEST - P11
Time (sec)
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
1
0.1
H/Ho
Slug Test - P11
Date: 19 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 6 . 43000
$= 6.0 \times 10^{-7}$ m/s (5.5×10^{-4} m/d)

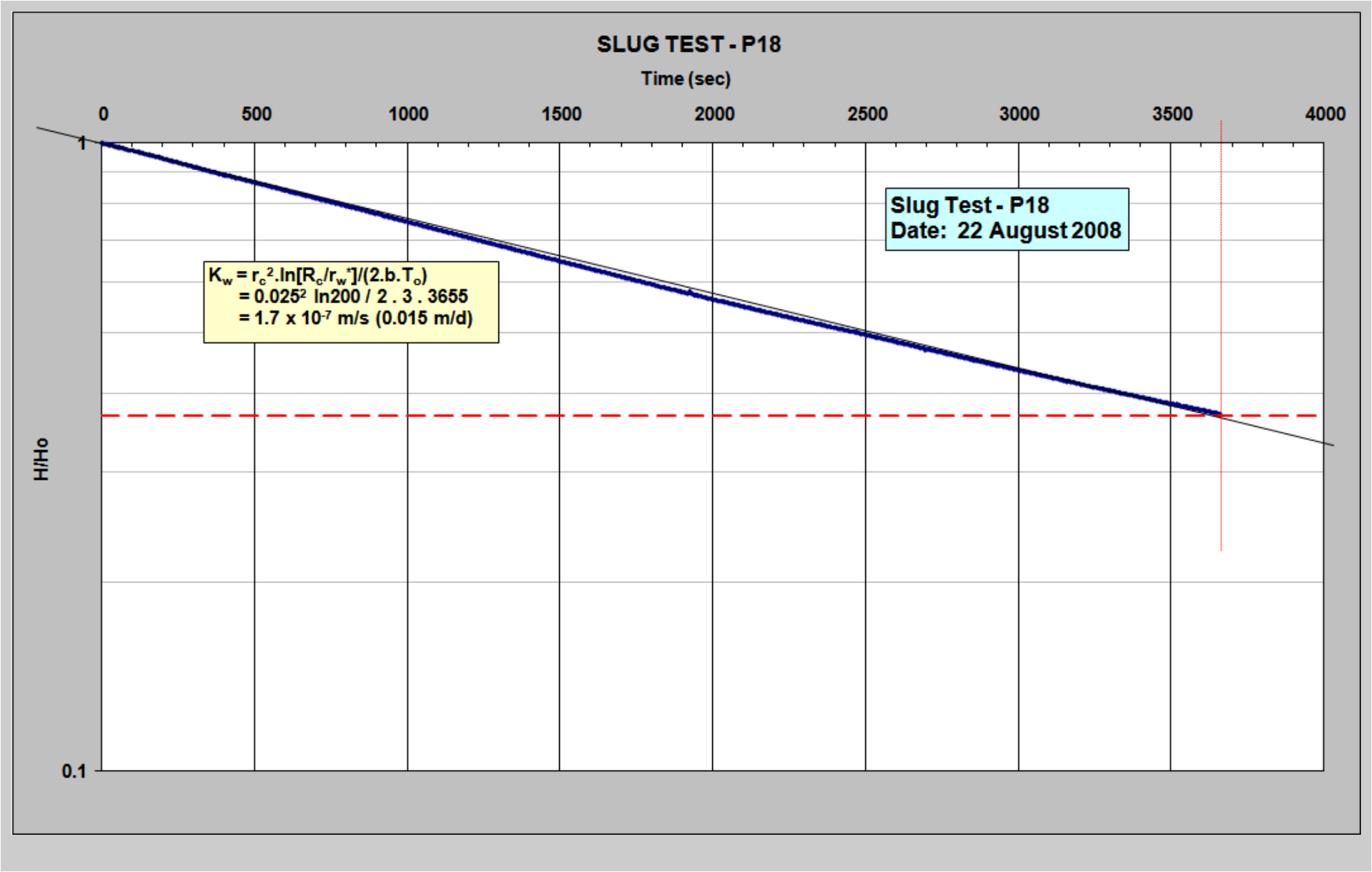

SLUG TEST - P12
Time (sec)
0
100
200
300
400
500
600
700
800
900
1000
1
0.1
H/Ho
Slug Test - P12
Date: 20 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 6 . 270
$= 1.1x\ 10^{-6}$ m/s (0.09 m/d)

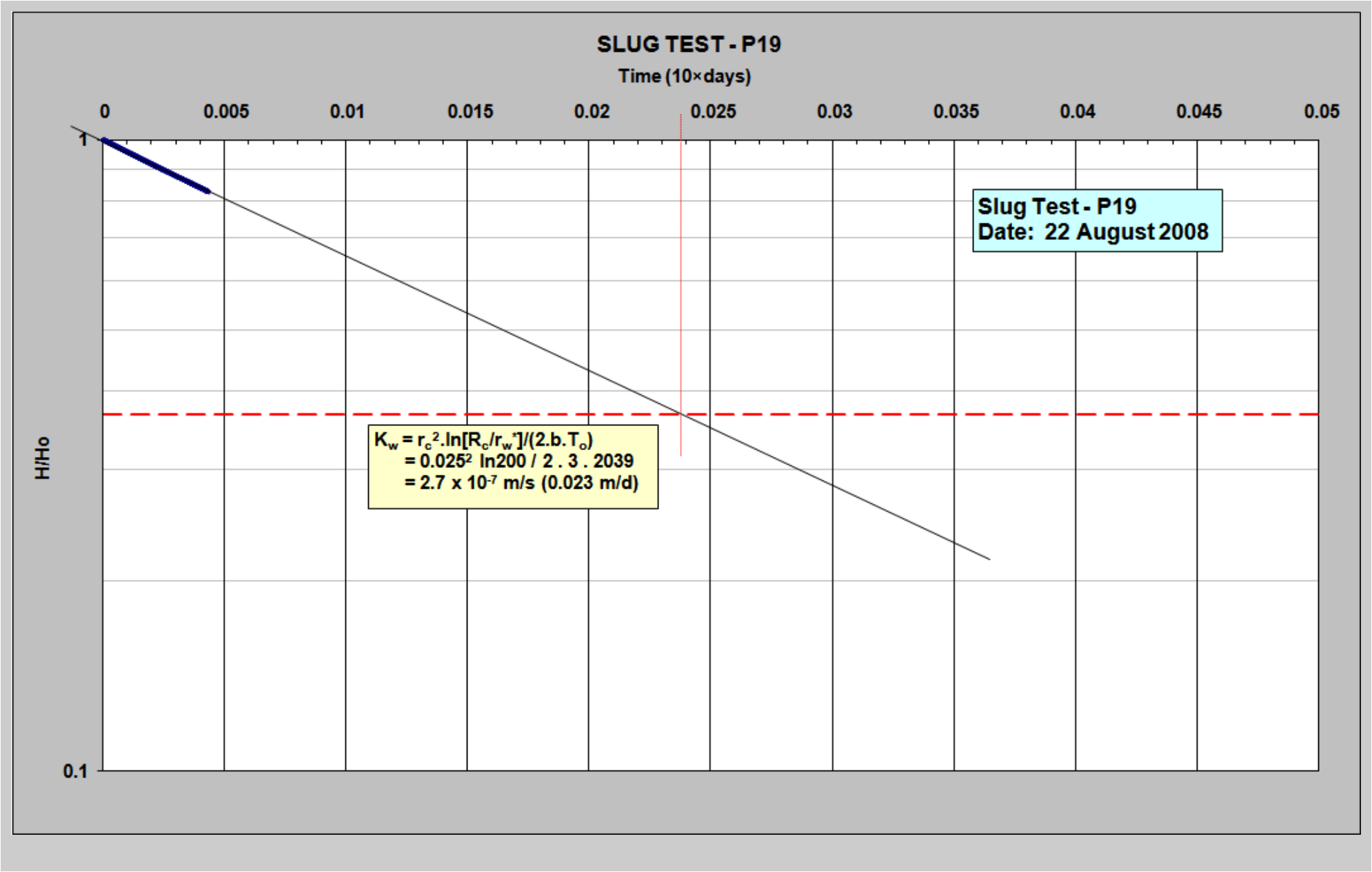

SLUG TEST - P13
0
500
1000
1500
2000
2500
1
0.1
0.01
0.001
0.0001
H/Ho
Time (sec)
Slug Test - P13
Date: 20 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 6 . 190
$= 1.5 \times 10^{-6}$ m/s (0.13 m/d)
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 6 . 610
$= 4.5 \times 10^{-7}$ m/s (0.039 m/d)
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 6 . 90
$= 3.1 \times 10^{-6}$ m/s (0.26 m/d)


CONSTANT RATE TEST - Drawdown - P13
Time (mins)
0.01
0.1
1
10
Drawdown (m)
0
2
4
6
8
10
12
14
16
18
Δs = 6.7 m
T = 2.3 Q / 4 π Δs
= 2.3 x 9 / 4 π 6.7
= 0.25 m²/d
Average K = 0.04 m/d (4.7 x 10⁻⁷ m/s)


CONSTANT RATE TEST - P13
Time (min) or t/t'
0.1
1
10
100
1000
Residual Drawdown (m)
0
2
4
6
8
10
12
14
16
18
Δs = 1.1 m
T = 2.3 Q / 4 π Δs
= 2.3 x 9 / 4 π 1.1
= 1.5 m²/d
Average K = 0.25 m/d (2.9 x 10⁻⁶ m/s)
Δs = 17.5 m
T = 2.3 Q / 4 π Δs
= 2.3 x 9 / 4 π 17.5
= 0.09 m²/d
Average K = 0.016 m/d (1.8 x 10⁻⁷ m/s)


SLUG TEST - P17
Time (sec)
0
1000
2000
3000
4000
5000
6000
1
0.1
H/Ho
Slug Test - P17
Date: 21 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 9 . 2400
$= 7.6 \times 10^{-8}$ m/s (0.0067 m/d)
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 9 . 5750
$= 3.1 \times 10^{-8}$ m/s (0.0028 m/d)


SLUG TEST - P18
Time (sec)
0
500
1000
1500
2000
2500
3000
3500
4000
1
0.1
H/Ho
Slug Test - P18
Date: 22 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 3 . 3655
$= 1.7 \times 10^{-7}$ m/s (0.015 m/d)


SLUG TEST - P19
Time (10×days)
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
0.045
0.05
1
0.1
H/Ho
Slug Test - P19
Date: 22 August 2008
$K_w = r_c^2.\ln[R_c/r_w^*]/(2.b.T_o)$
$= 0.025^2$ ln200 / 2 . 3 . 2039
$= 2.7 \times 10^{-7}$ m/s (0.023 m/d)

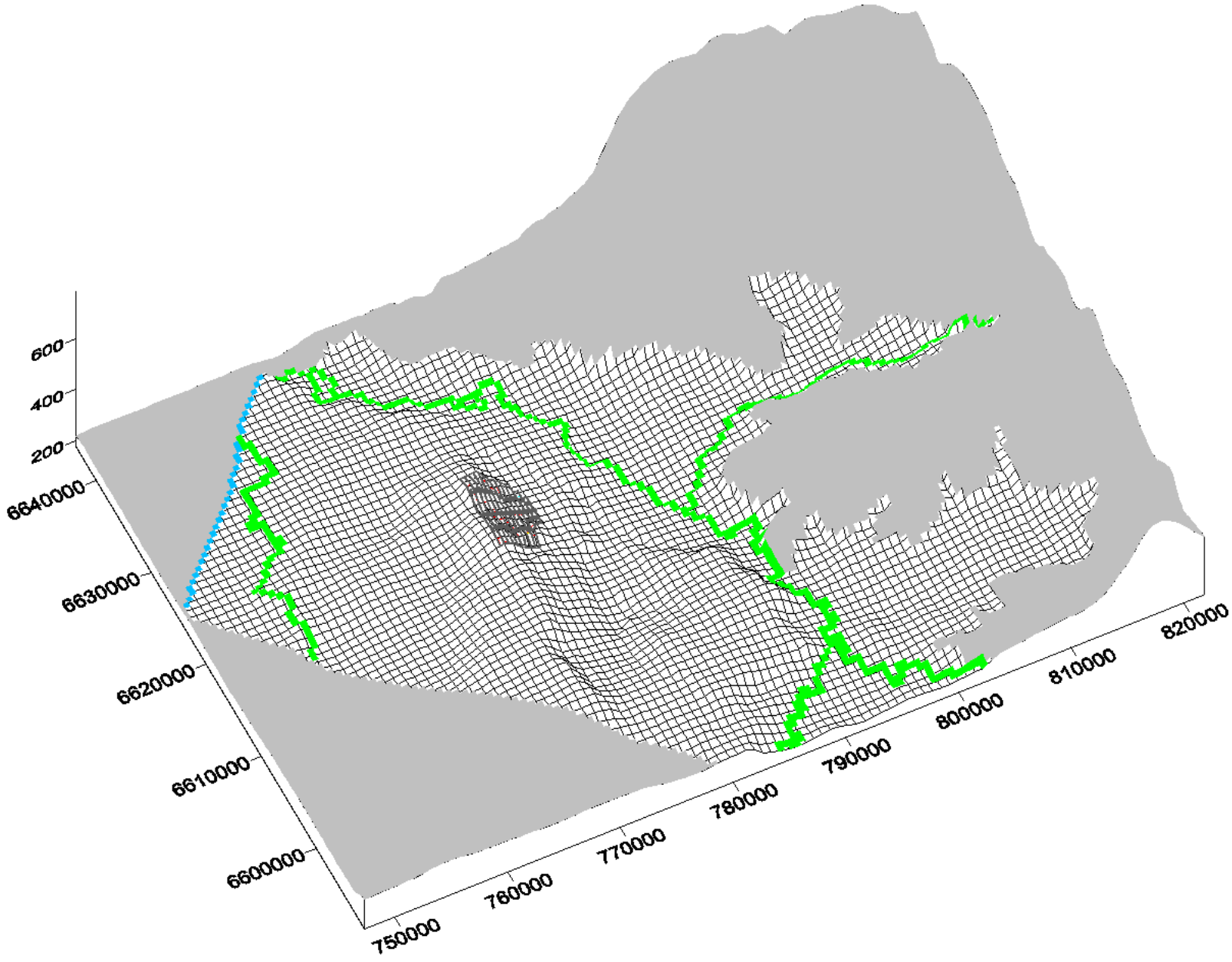
Appendix C: Laboratory Analysis Results – Narrabri Groundwater Monitoring Bores

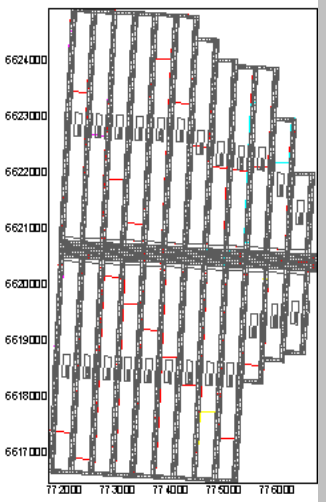
Sample ID	Units	Freshwater Ecosystem Protection Guideline	Drinking Water Guideline	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14
Aquifer				**Garra**	**Napper**	**Pamb**	**Napper**	**Pamb**	**Pilliga**	**Pilliga**	**Purla**	**Purla**	**Napper (no sill)**	**Napper (no sill)**	**Napper (above sill)**	**Garra / Napper**	**Napper (above sill)**
Date of Sampling				**09/9/08**	**09/9/08**	**09/9/08**	**09/9/08**	**12/9/08**	**DRY**	**10/9/08**	**12/9/08**	**12/9/08**	**09/9/08**	**12/9/08**	**12/9/08**	**12/9/08**	**NA**
TDS (dissolved solids)	mg/L		**500**	2380	12900	11700	16800	12700		101	455	295	4170	1330	226	1040	
Field pH				7.6	7.2	7.07	6.7	7		7.95	7.85	6.8	7.92	8.23	6.8	7.1	
Lab pH			6.5 – 8.5														
Field EC	µS/cm			470	15.7	1340	1560	1050		1170	1120	1210	1130	980	1020	1180	
Lab EC	µS/cm			3710	17100	15800	17700	24600		149	805	451	6800	2490	367	2040	
Temperature (°C)				20.8	20.8	20.2	21.2	20.8		20.5	21.2	22.1	20.8	17.6	21.5	20.1	
Total Alkalinity as $CaCO_3$	mg/L			1190	2550	1310	1840	1860		19	276	139	546	248	131	556	
Hydroxide Alk as $CaCO_3$	mg/L			<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<1	
Carbonate Alk as $CaCO_3$	mg/L			<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<1	
MAJOR CATIONS																	
Calcium	mg/L			26	189	331	355	456		1	33	30	155	89	30	50	
Magnesium	mg/L			25	453	504	699	494		1	10	12	80	40	10	89	
Sodium	mg/L		180	933	4060	3190	4550	3960		25	121	43	1490	341	28	253	
Potassium	mg/L			24	126	60	124	71		3	9	5	30	4	5	7	
MAJOR ANIONS																	
Bicarbonate Alkalinity as $CaCO_3$	mg/L			1190	2550	1310	1840	1860		19	276	139	546	248	131	556	
Sulphate as SO_4	mg/L		250	43	366	1230	1700	719		4	20	24	188	16	16	30	
Chloride	mg/L		250	641	5650	5250	7650	7300		26	64	42	2410	581	24	279	
DISSOLVED METALS																	
Copper	mg/L	0.0014	1	0.128	0.057	0.002	0.006	0.007		0.006	0.001	0.014	0.004	0.004	0.002	0.001	
Lead	mg/L	0.0034	0.01	0.516	0.091	0.030	0.027	0.081		0.117	0.004	0.036	0.024	0.006	0.132	0.007	
Nickel	mg/L	0.011	0.02	0.154	0.048	0.014	0.024	0.051		0.005	<0.001	0.012	0.005	0.159	0.002	0.002	
Zinc	mg/L	0.008	3	0.250	0.093	0.014	0.013	0.031		0.033	0.007	0.042	0.023	0.016	0.189	0.023	
Manganese	mg/L		0.1	2.33	2.96	0.496	6.2	1.92		0.095	0.037	0.037	2.13	2.98	0.053	0.134	
Mercury	mg/L	0.0006	0.001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
IONIC BALANCE	%																

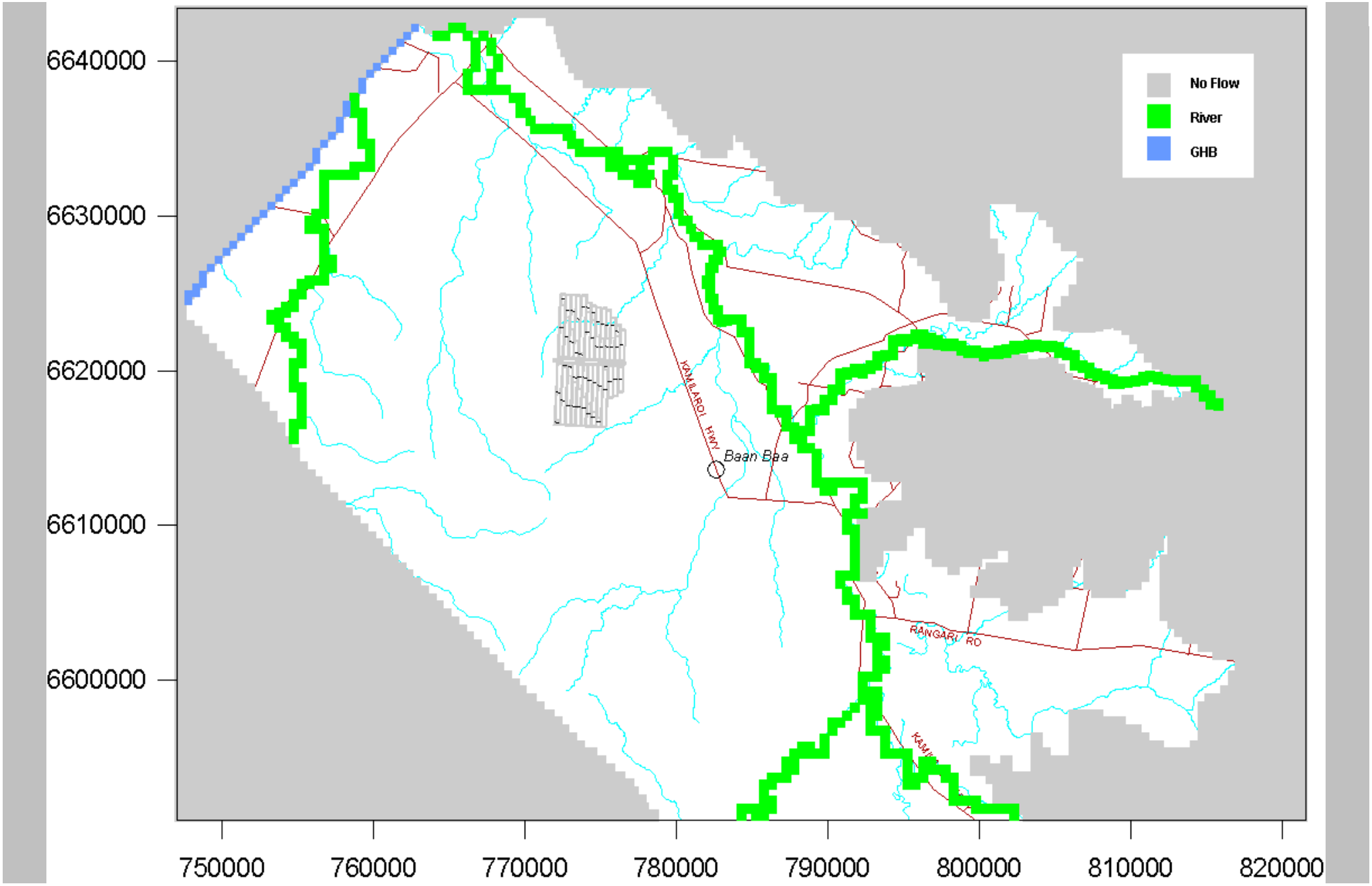
Sample ID	Units	Freshwater Ecosystem Protection Guideline	Drinking Water Guideline	P15	P16	P17	P18	P19	P20	WB1	WB2	WB3	WB3	WB4	WB5	WB5	WB6	WB6	WB6	WB7	VPW1B	VPW1B	Gas Well
Aquifer				Garra	Garra	Purla	Hoskiss CS	Pamb	Arkarula		Garra	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Hoskiss CS	Hoskiss CS	Hoskiss CS
Date of Sampling				NA	**12/09/08**	DRY	11/9/08	17/9/08	09/9/08	**12/9/08**	11/9/08	11/9/08	11/9/08	12/9/08	12/9/08	12/9/08	12/9/08	12/9/08	12/9/08	11/9/08	6/7/09	6/7/09	6/7/09
TDS (dissolved solids)	mg/L		**500**		109		2370	6220	9630	8510	153	431	415	461	281	278	389	389	525	410	9070	8310	8030
Field pH					7.45		6.75	6.7	6.7	7.9	7.2	7.7	7.6	7.3	7.5	7.6	6.8	6.8	7.2	6.9			
Lab pH			6.5 – 8.5																		7.1	7.0	6.66
Field EC	µS/cm				1085		1410	1340	1140	1060	1010	1050	1250	1120	1200	1150	1120	1120	1080	1175			
Lab EC	µS/cm				132		3650	11000	10500	14200	239	703	706	1040	510	505	706	981	781	765	13600	12400	11200
Temperature (°C)					20.5		22.9	23.2	19.6	23.5	20.7	20.1	19.8	19.8	21	21	20.4	20.4	20.7	20.5			
Total Alkalinity as $CaCO_3$	mg/L				25		1870	1880	5970	8700	101	268	268	360	160	166	294	266	305	250			
Hydroxide Alk as $CaCO_3$	mg/L				<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1			
Carbonate Alk as $CaCO_3$	mg/L				<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1			
MAJOR CATIONS																							
Calcium	mg/L				5		30	99	62	102	12	39	38	61	36	35	45	58	45	33	69	66	35
Magnesium	mg/L				1		27	141	68	209	6	20	20	35	18	17	22	36	22	18	90	69	60
Sodium	mg/L		180		14		824	1040	2860	3740	32	78	77	116	32	31	77	74	83	92	4440	3920	2860
Potassium	mg/L				3		38	1400	118	204	1	4	4	1	2	2	3	3	3	2	172	154	108
MAJOR ANIONS																							
Bicarbonate Alkalinity as $CaCO_3$	mg/L				25		1870	1880	5970	8700	101	268	268	360	160	166	294	266	305	250	9300	8600	7180
Sulphate as SO_4	mg/L		250		<1		38	28	<1	3	6	10	10	30	28	28	21	53	21	23	13.2	1.5	21
Chloride	mg/L		250		22		80	1880	425	53	16	54	52	93	29	28	33	89	35	60	215	153	136
DISSOLVED METALS																							
Copper	mg/L	0.0014	1		0.002		0.007	0.005	0.005	0.002	0.001	0.002	0.002	0.002	0.004	0.003	0.008	0.005	0.007	0.013			
Lead	mg/L	0.0034	0.01		0.394		0.046	0.015	0.004	0.002	<0.001	0.002	0.001	<0.001	0.006	0.006	0.029	0.014	0.028	<0.001			
Nickel	mg/L	0.011	0.02		0.036		0.059	0.320	0.014	<0.001	0.002	0.002	0.001	0.002	<0.001	0.001	0.002	0.004	0.006	<0.001			
Zinc	mg/L	0.008	3		0.240		0.022	0.066	0.009	0.091	<0.005	0.009	0.007	0.006	0.008	0.007	0.022	0.017	0.050	0.040			
Manganese	mg/L		0.1		0.070		0.137	0.728	0.035	0.015	0.003	0.259	0.255	0.003	0.033	0.031	0.302	0.419	0.297	<0.001			
Mercury	mg/L	0.0006	0.001																				
IONIC BALANCE	%																						

APPENDIX D

MODEL DOMAIN AND LAYER BOUNDARY CONDITIONS

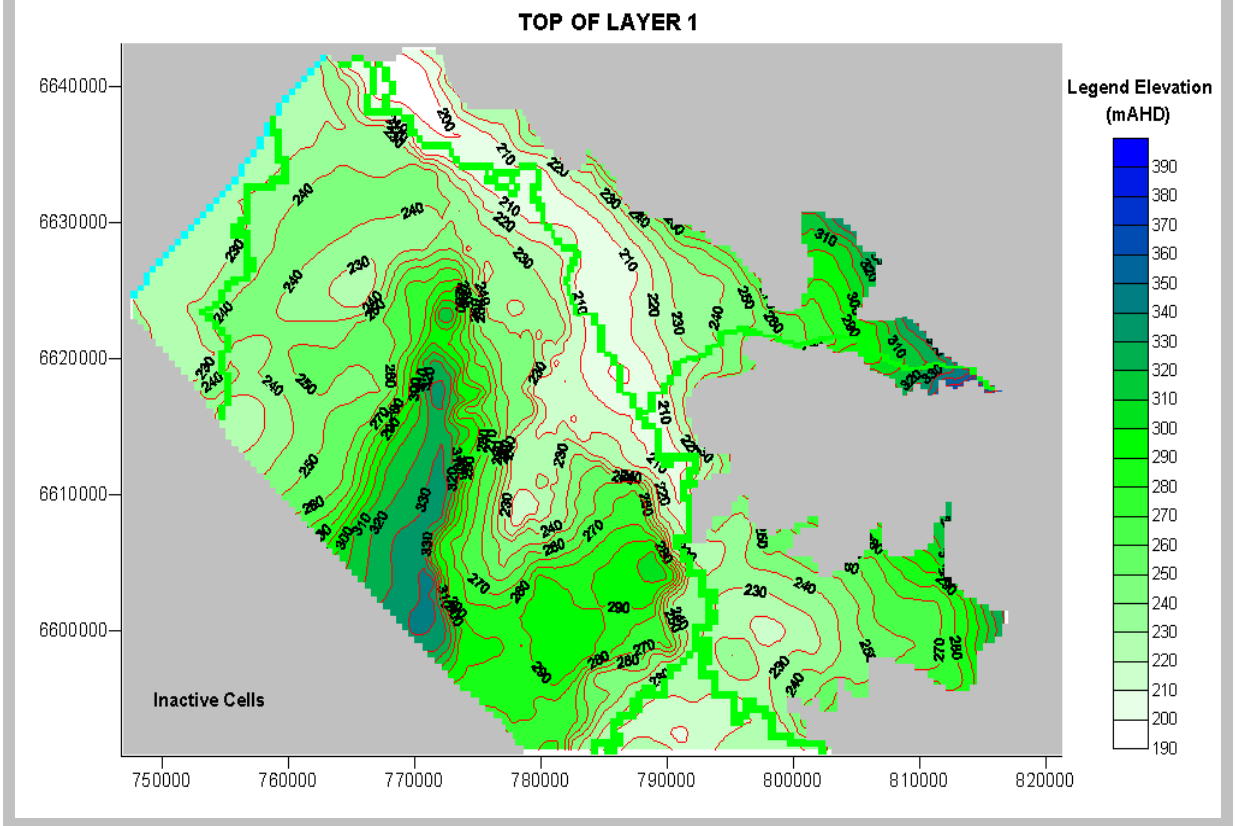

600
400
200
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000

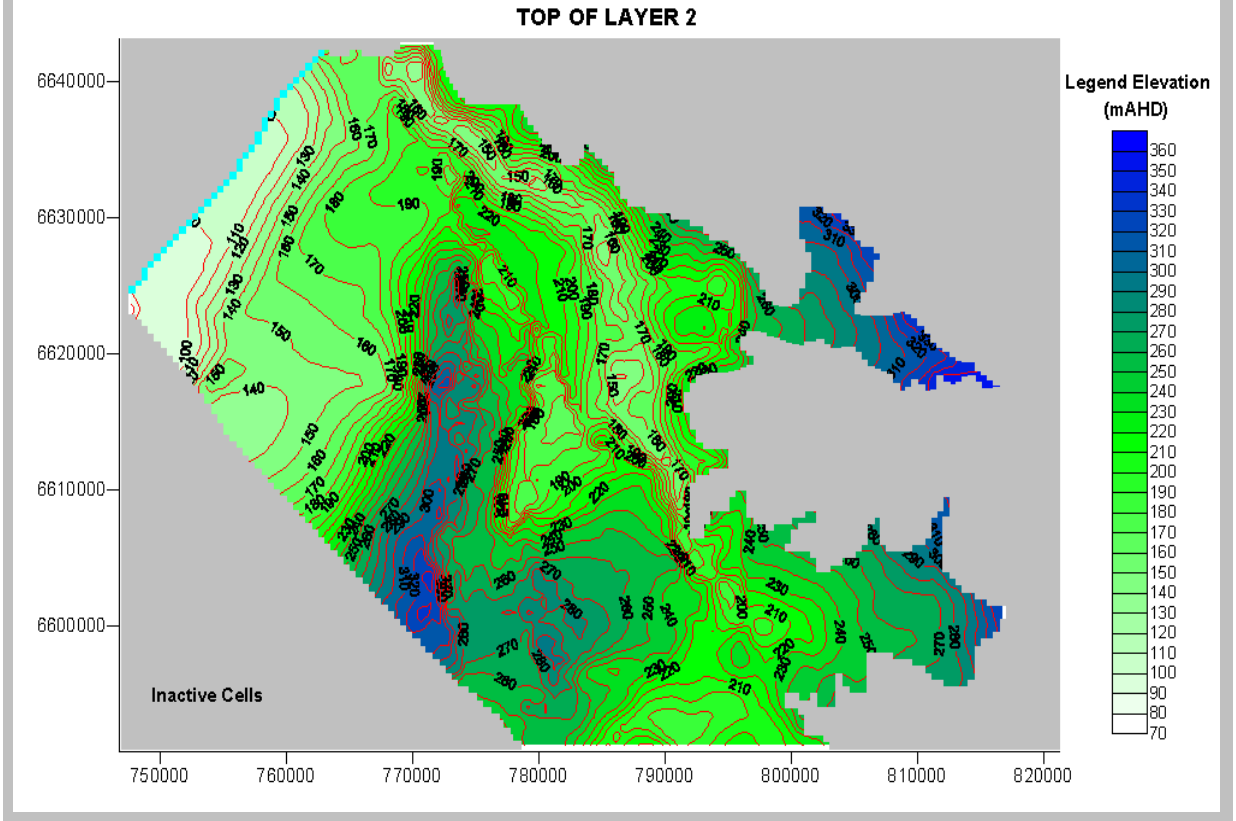

6624000
6623000
6622000
6621000
6620000
6619000
6618000
6617000
77 2000
77 3000
77 4000
77 5000
77 6000

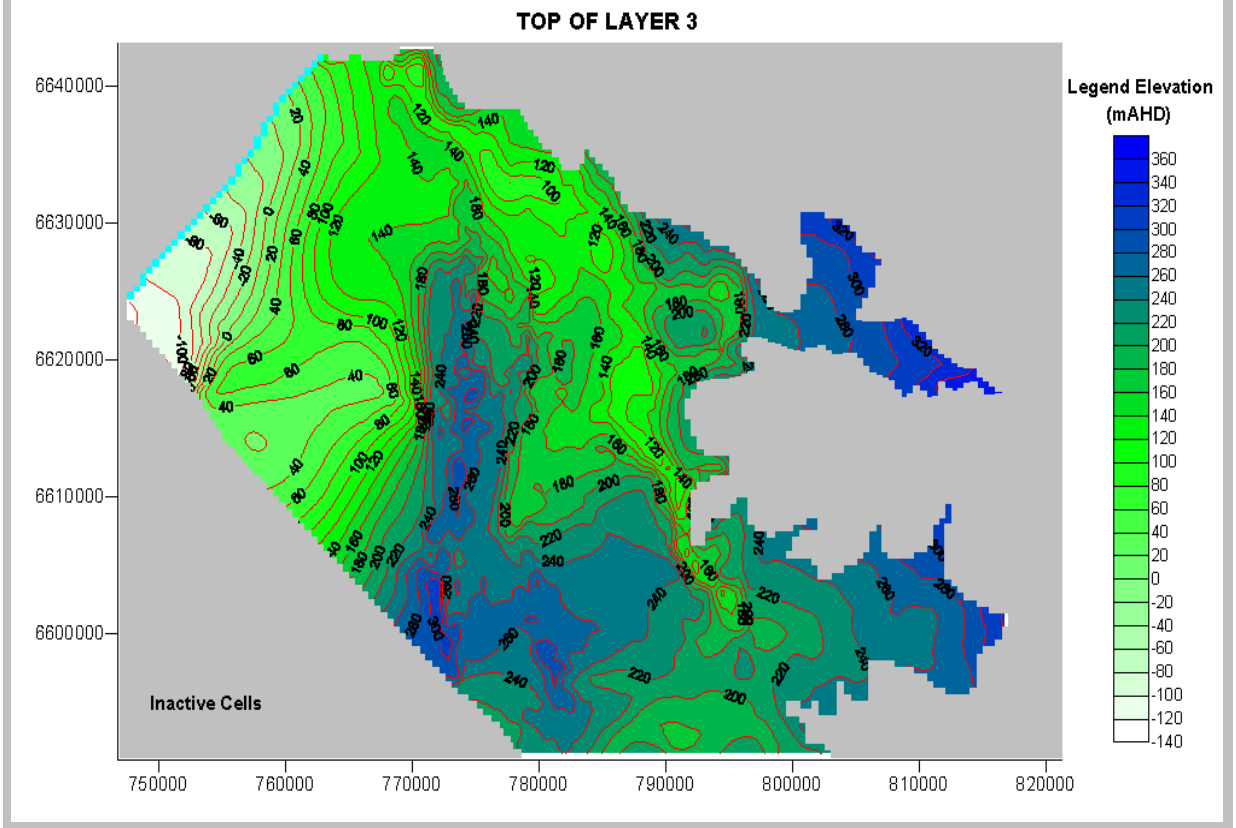

6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000
No Flow
River
GHB
KAMBAROI HWY
Baan Baa
RANGARI RD

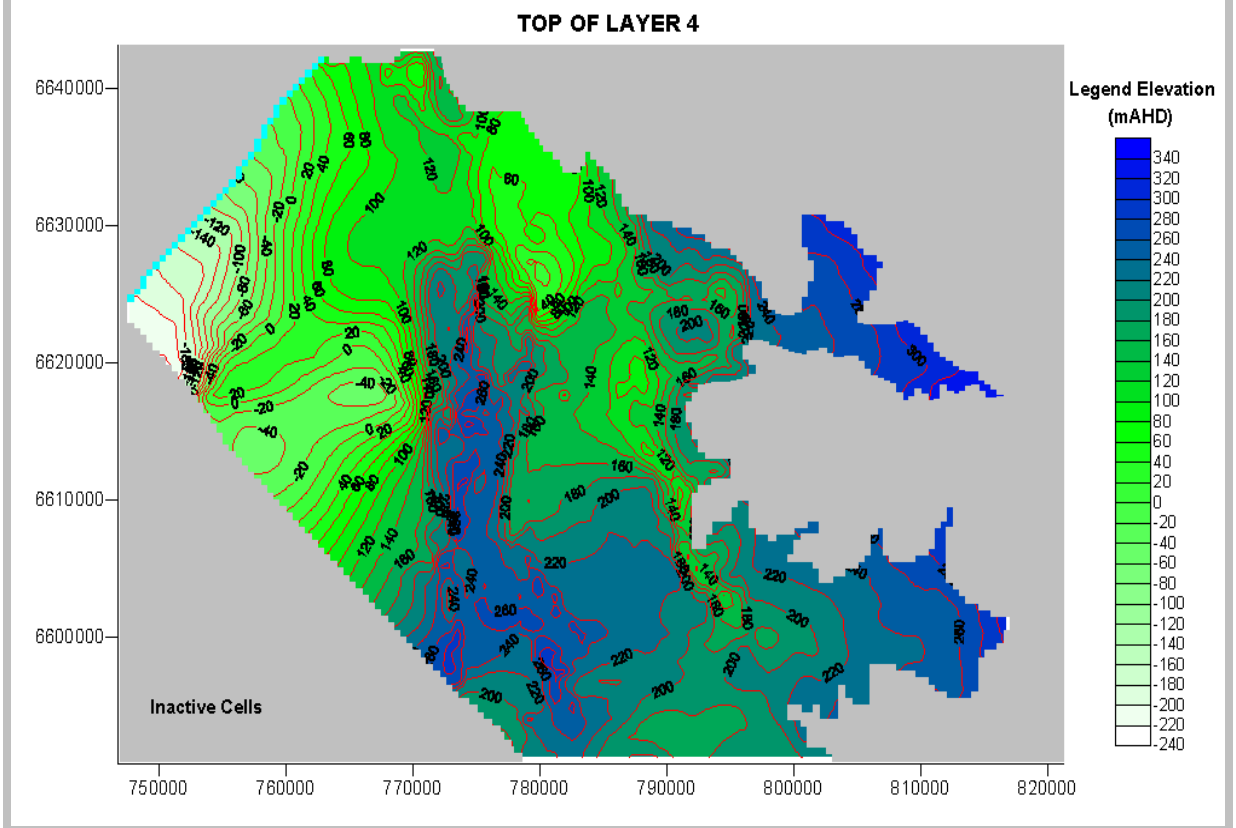
APPENDIX E

NARRABRI MODEL LAYER ELEVATIONS


TOP OF LAYER 1
Legend Elevation (mAHD)
390
380
370
360
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
Inactive Cells
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000


TOP OF LAYER 2
Legend Elevation (mAHD)
360
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
Inactive Cells
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000


TOP OF LAYER 3
Legend Elevation (mAHD)
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
Inactive Cells
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000


TOP OF LAYER 4
Legend Elevation (mAHD)
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
Inactive Cells
6640000
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6620000
6610000
6600000
750000
760000
770000
780000
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800000
810000
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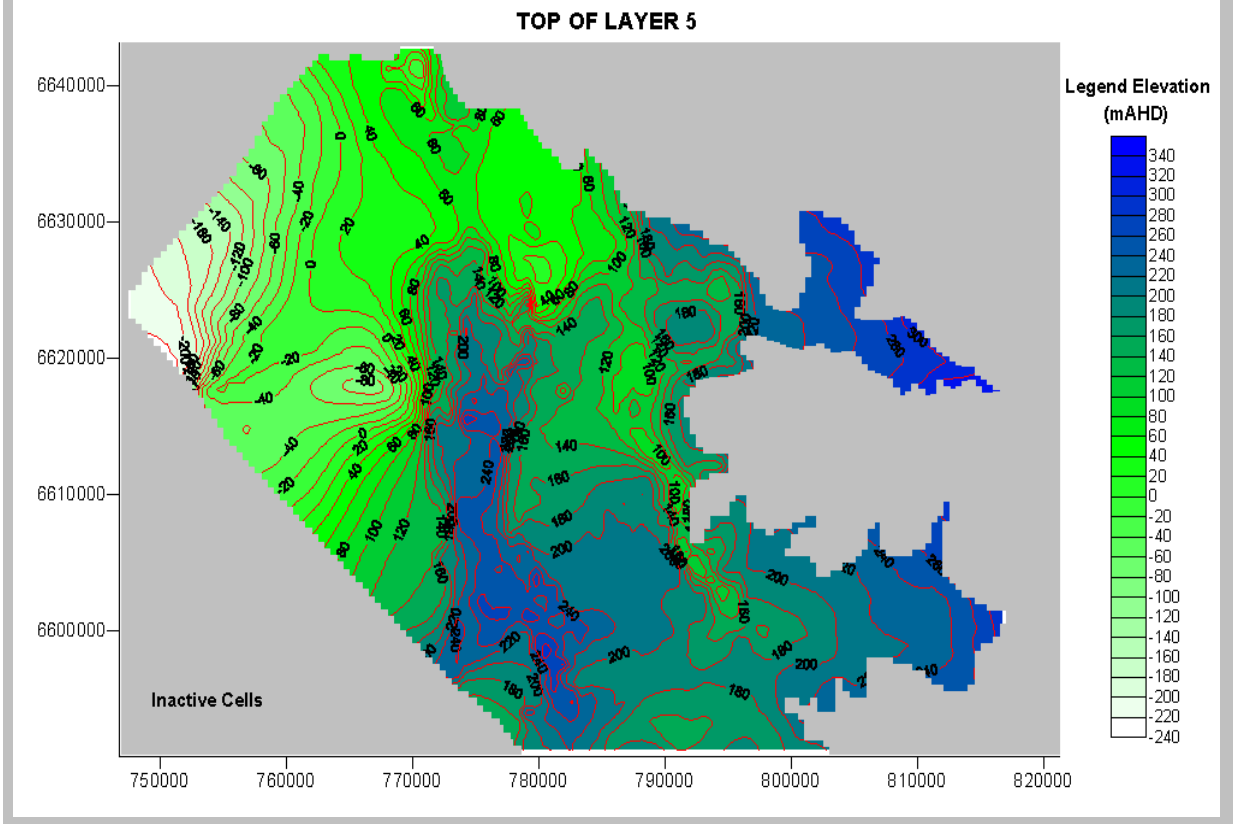
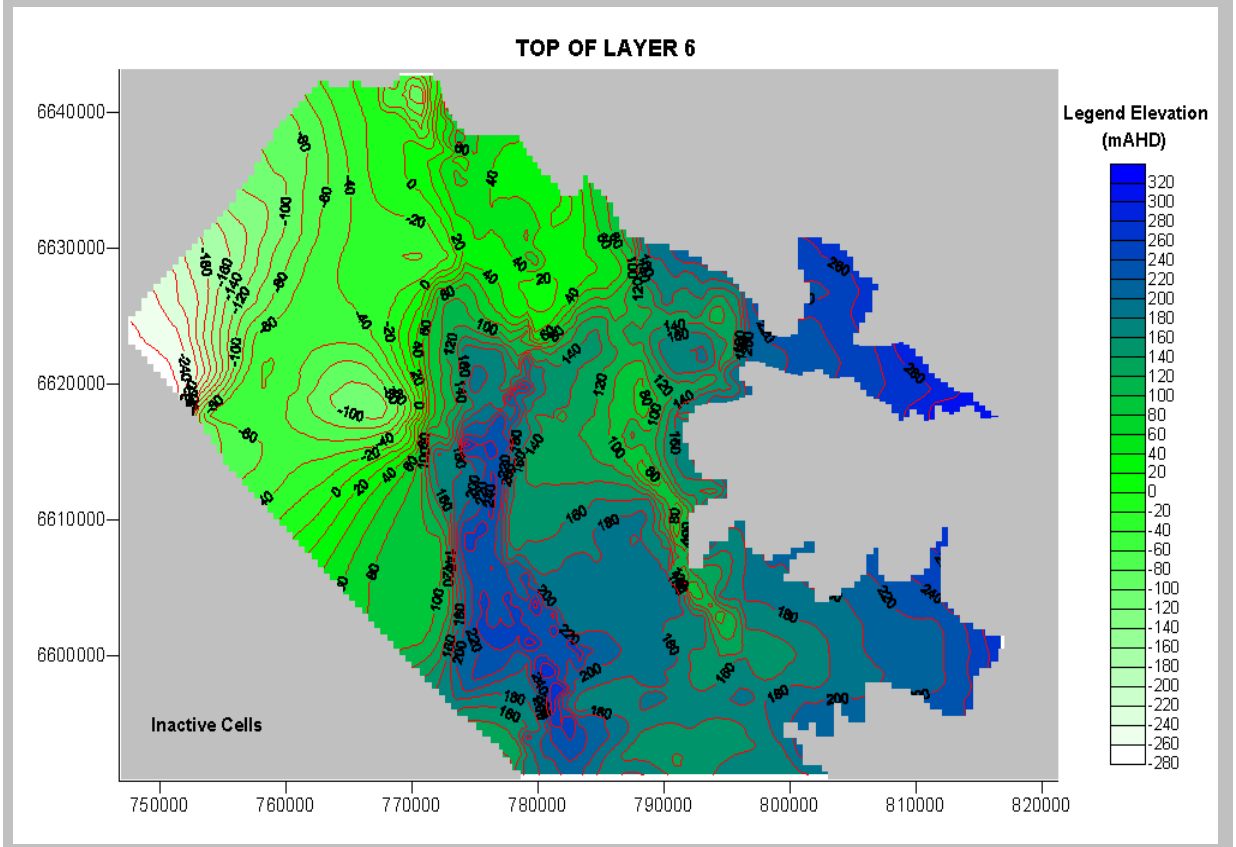
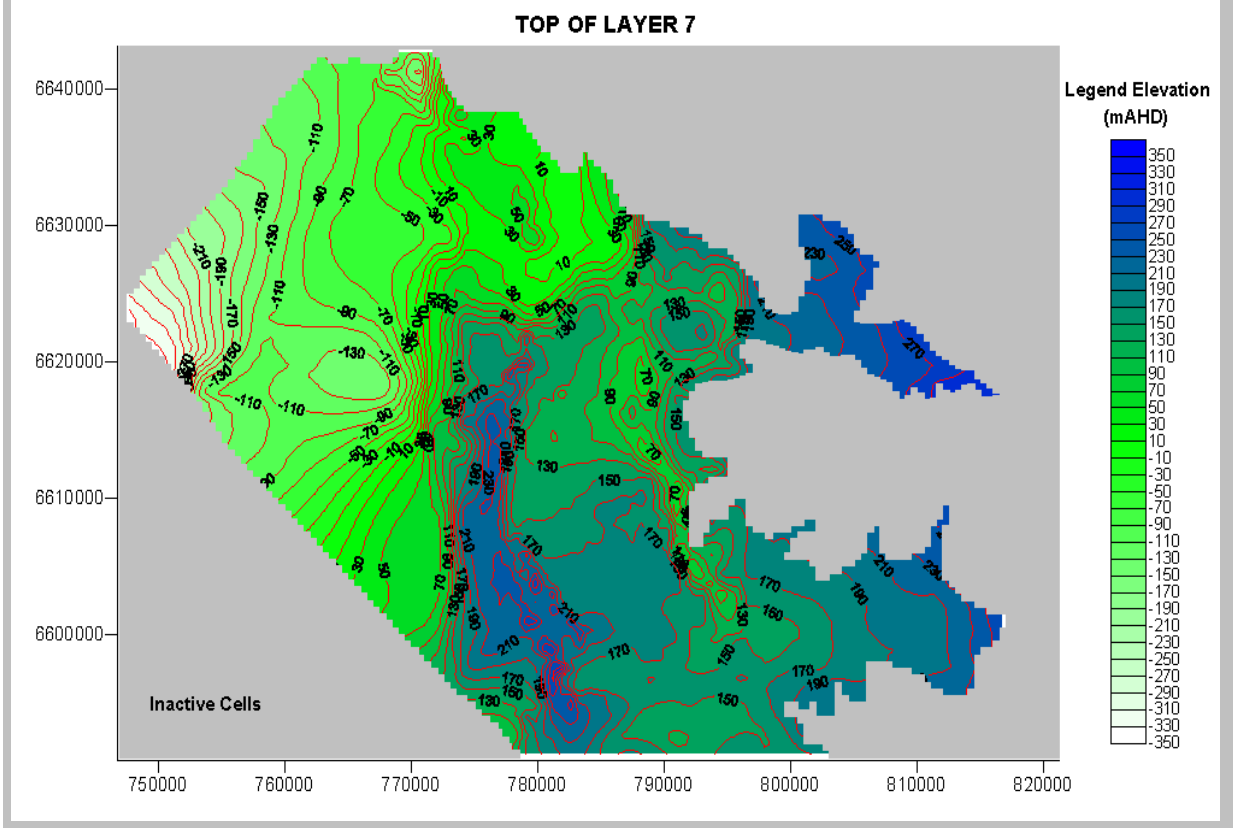
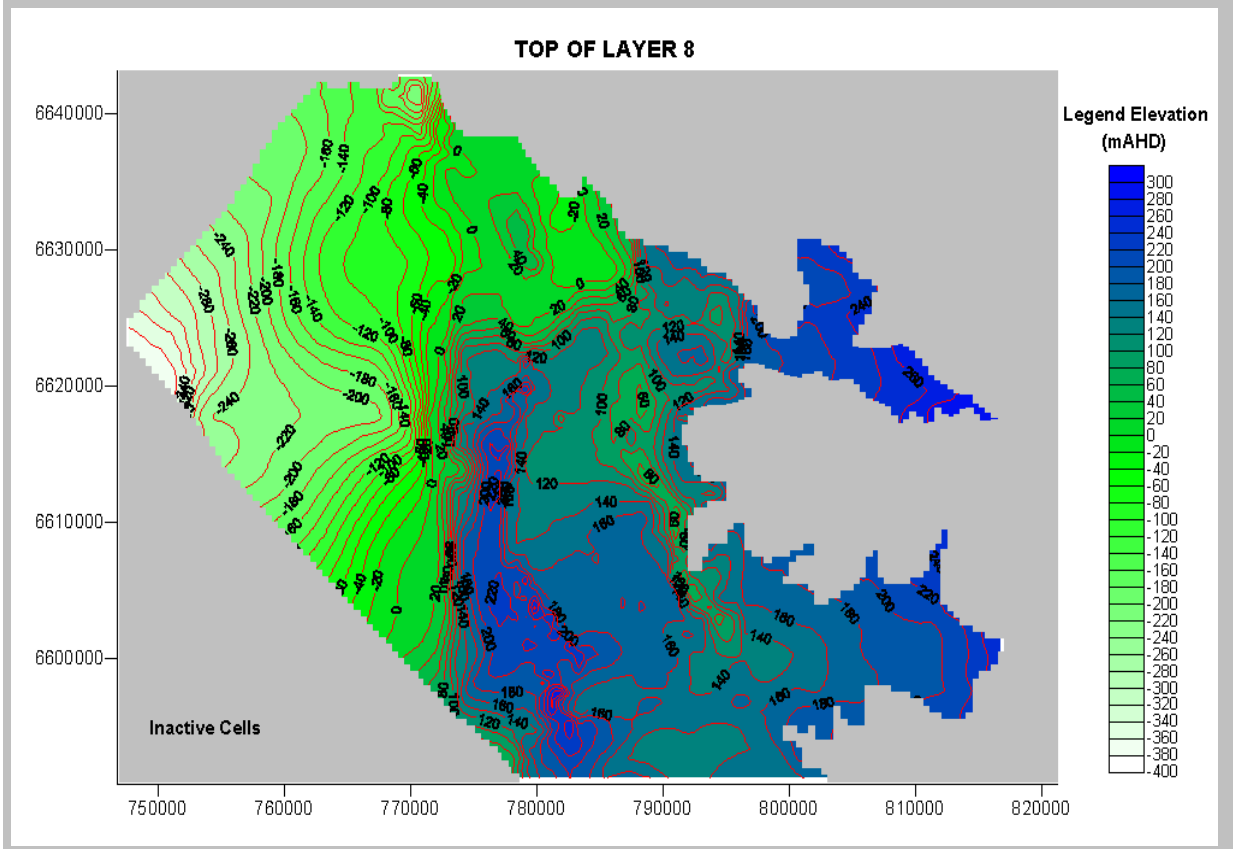
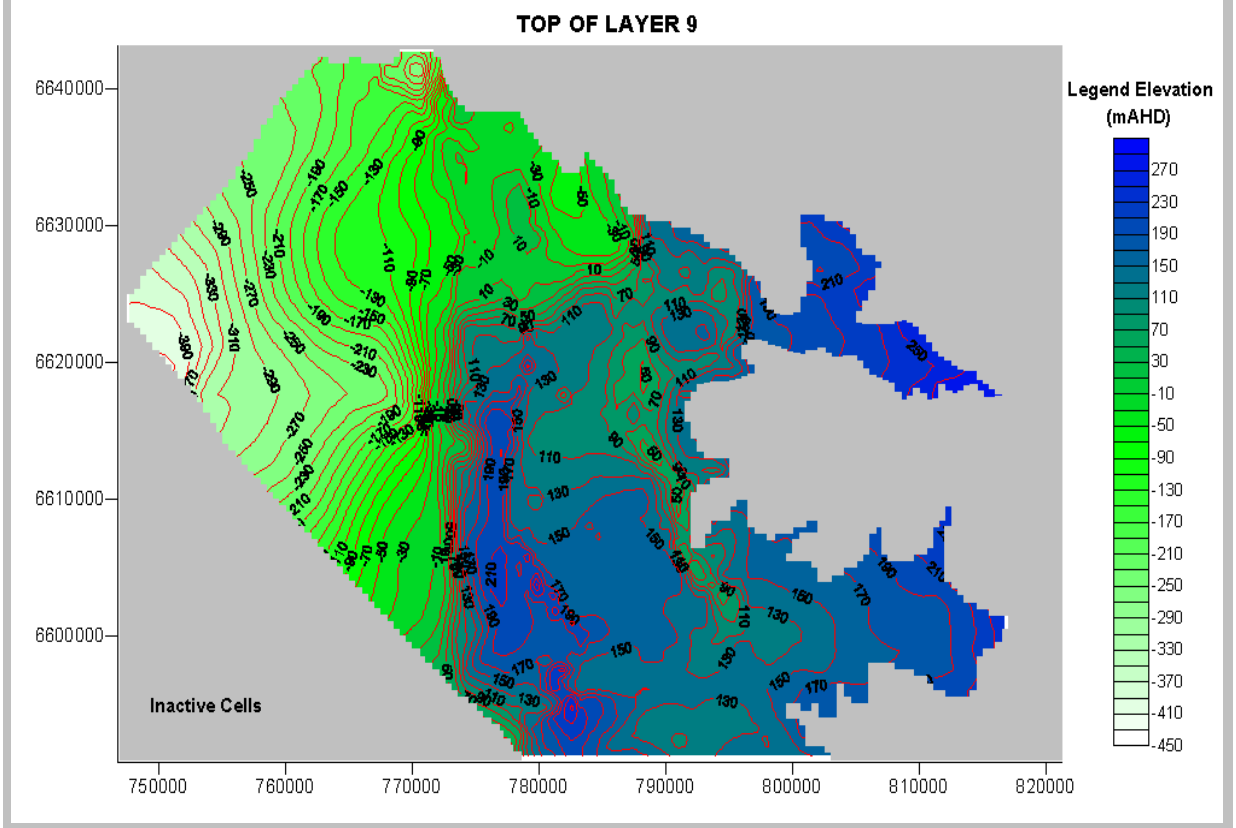
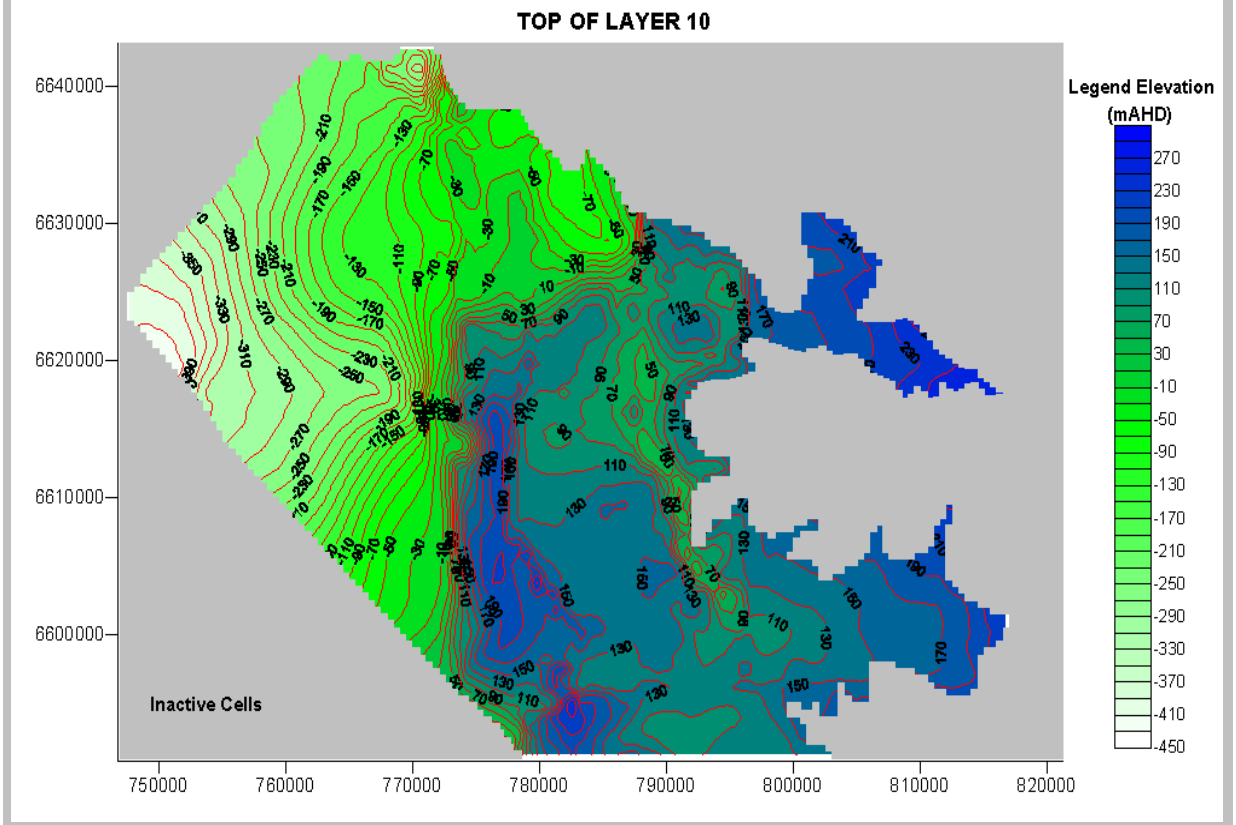

TOP OF LAYER 5
Legend Elevation (mAHD)
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000
Inactive Cells

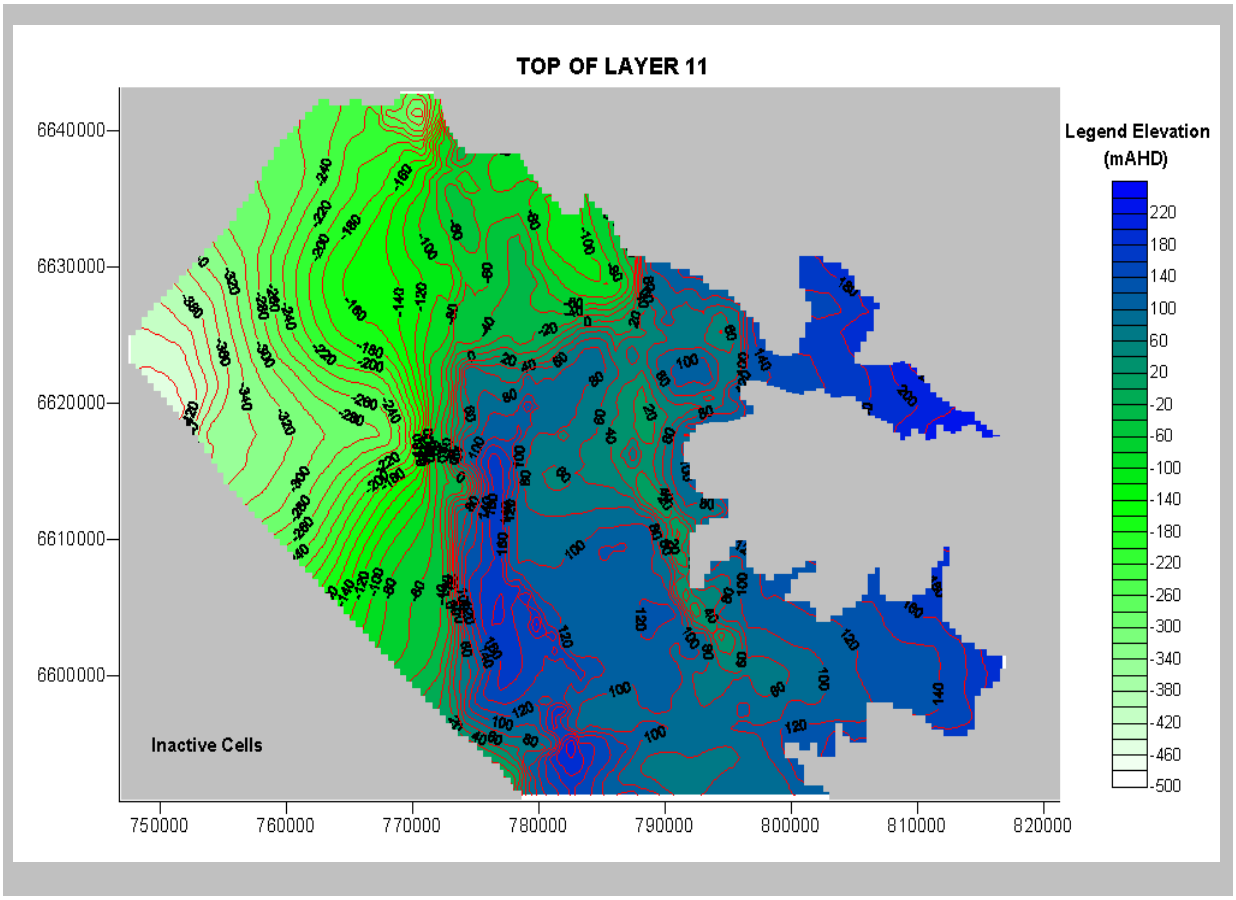

TOP OF LAYER 6
Legend Elevation (mAHD)
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000
Inactive Cells


TOP OF LAYER 7
Legend Elevation (mAHD)
350
330
310
290
270
250
230
210
190
170
150
130
110
90
70
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
-230
-250
-270
-290
-310
-330
-350
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000
Inactive Cells


TOP OF LAYER 8
Legend Elevation (mAHD)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
-300
-320
-340
-360
-380
-400
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000
Inactive Cells

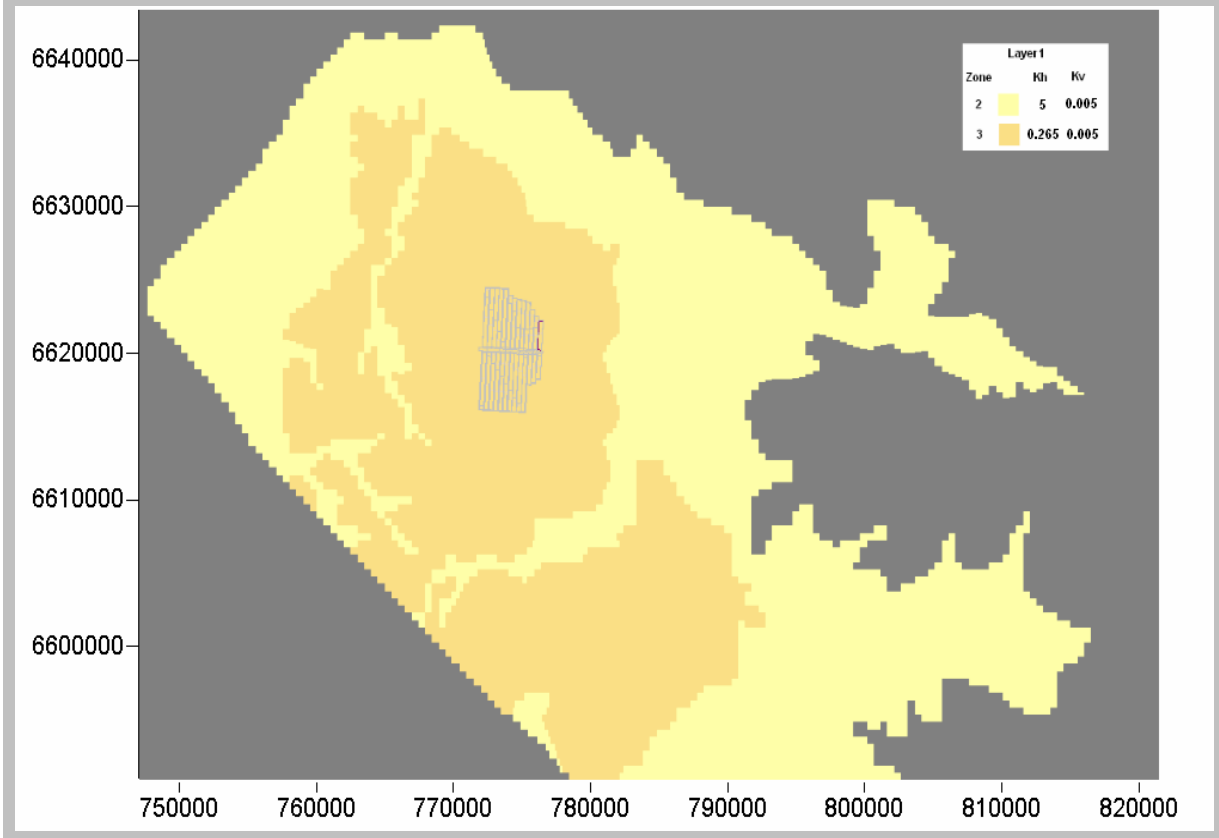

TOP OF LAYER 9
Legend Elevation (mAHD)
270
230
190
150
110
70
30
-10
-50
-90
-130
-170
-210
-250
-290
-330
-370
-410
-450
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000
Inactive Cells

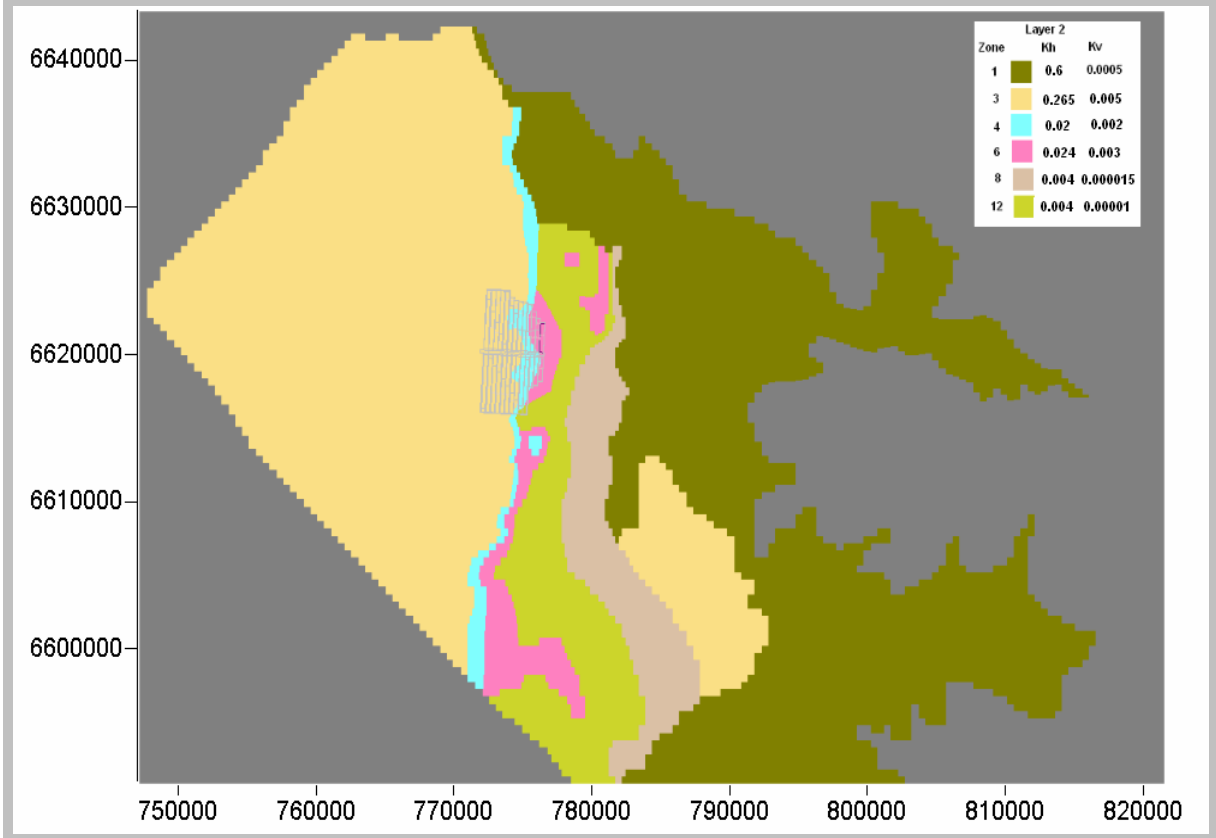

TOP OF LAYER 10
Legend Elevation (mAHD)
270
230
190
150
110
70
30
-10
-50
-90
-130
-170
-210
-250
-290
-330
-370
-410
-450
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000
Inactive Cells

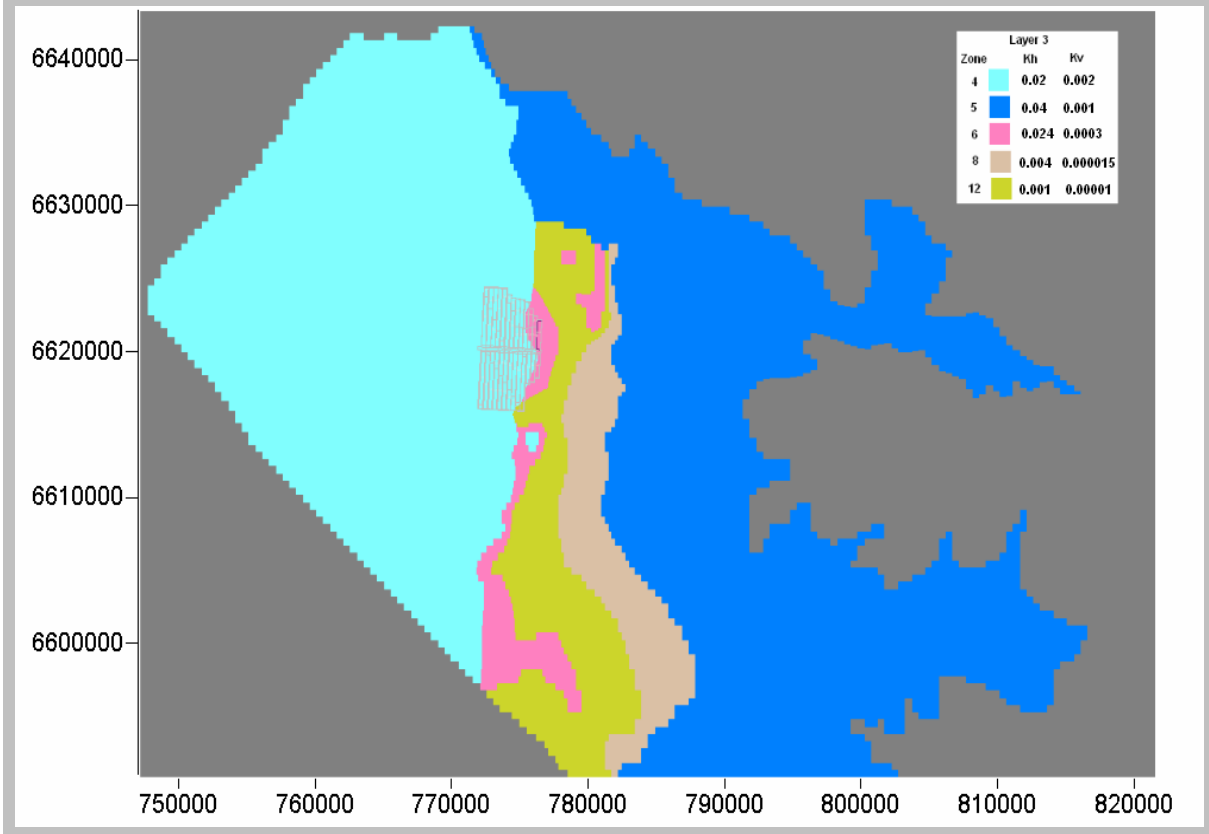

TOP OF LAYER 11
Legend Elevation (mAHD)
220
180
140
100
60
20
-20
-60
-100
-140
-180
-220
-260
-300
-340
-380
-420
-460
-500
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000
Inactive Cells

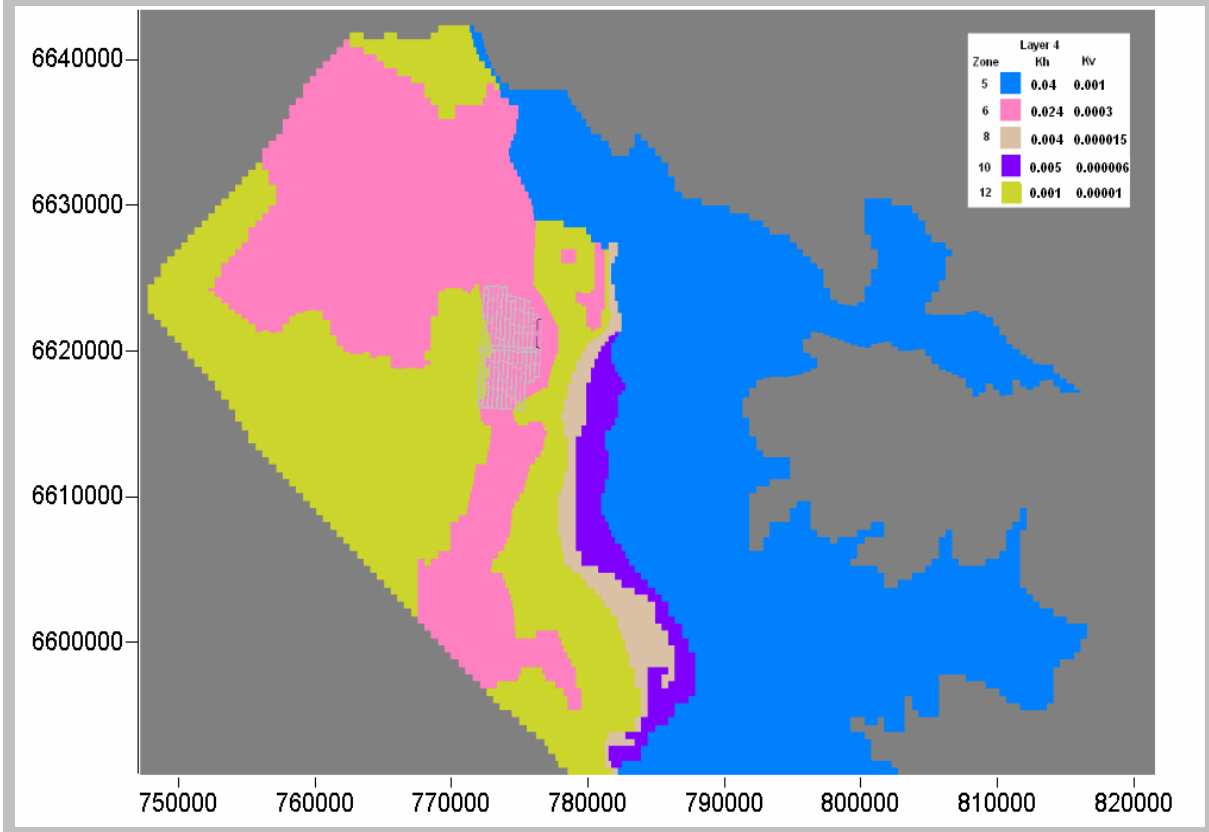
APPENDIX F

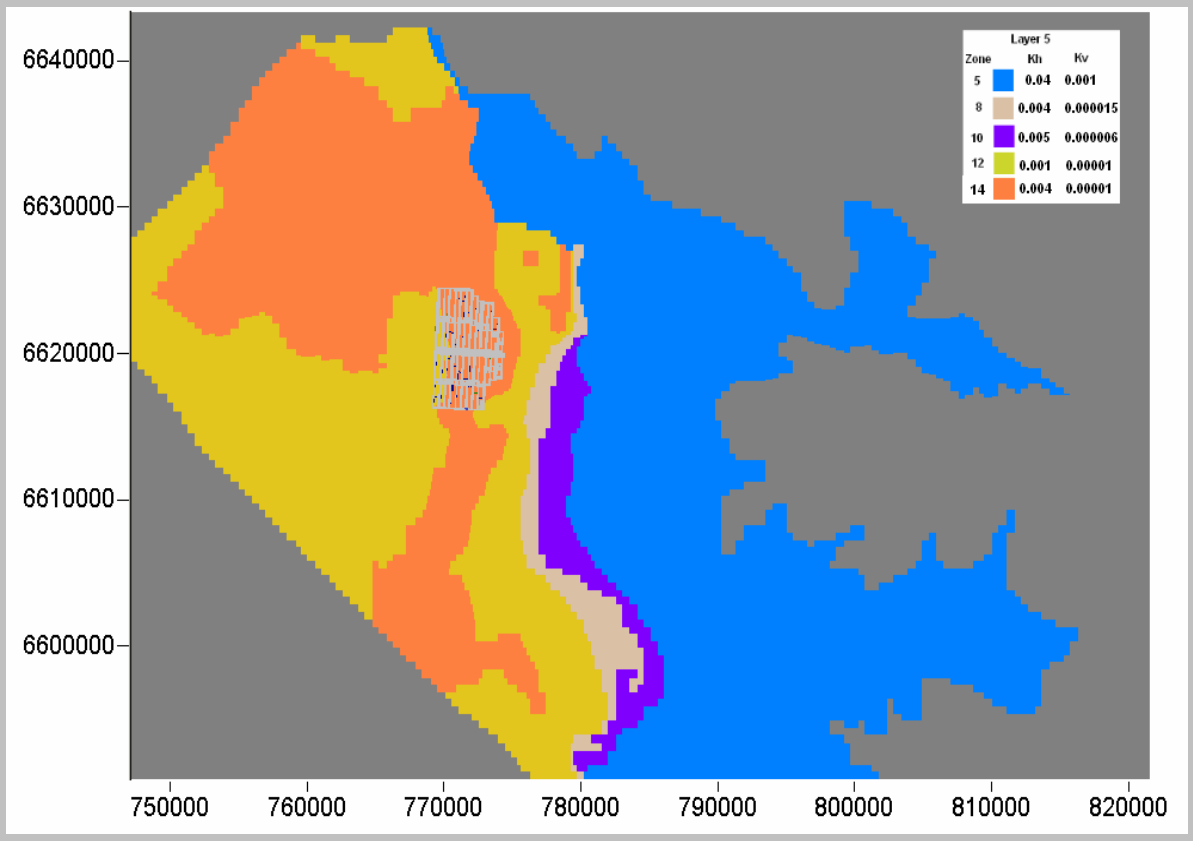
NARRABRI MODEL CALIBRATED PARAMETERS

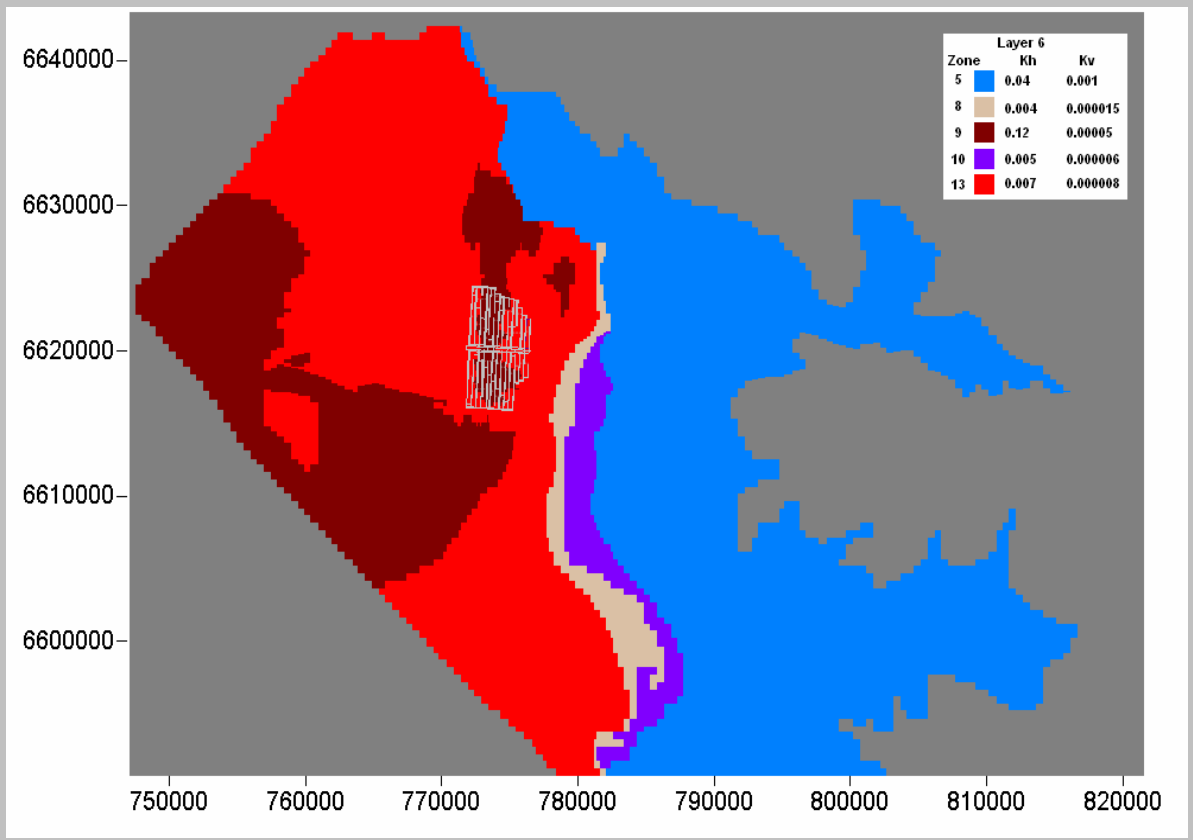

Layer 1
Zone Kh Kv
2 5 0.005
3 0.265 0.005
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000

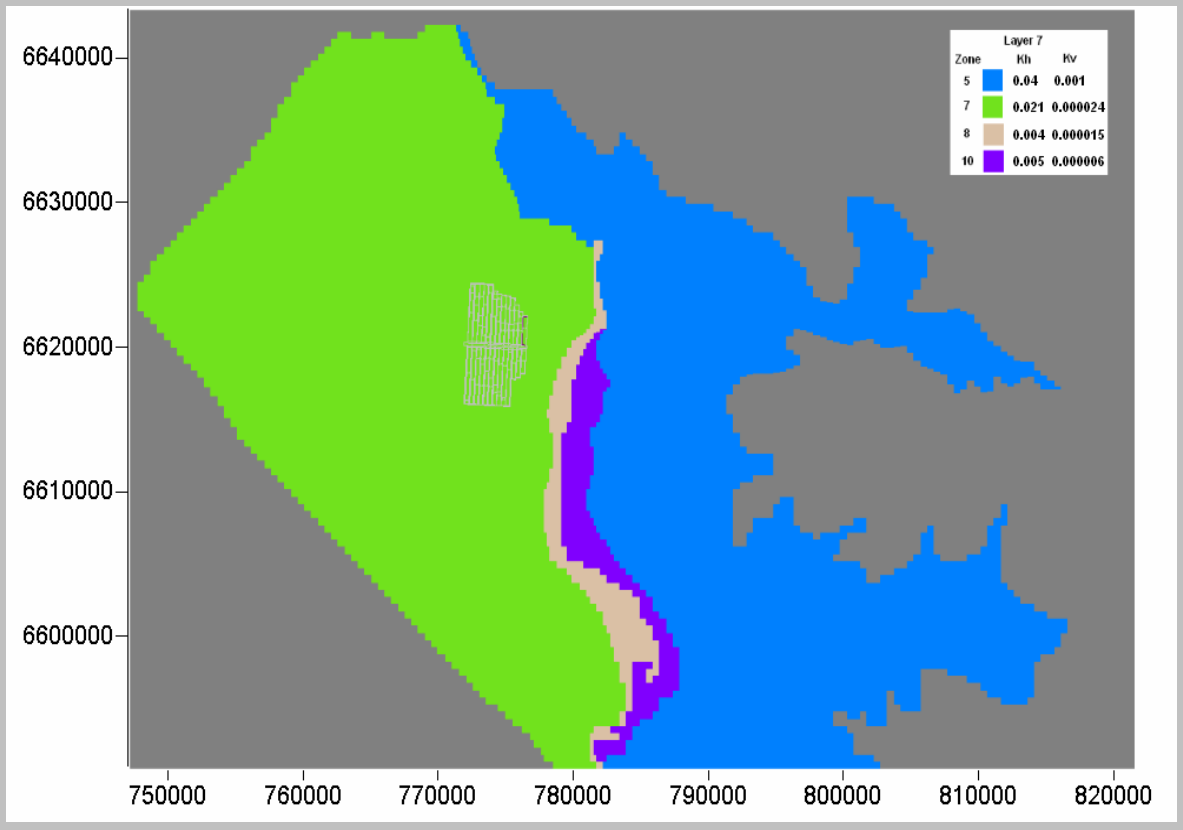

Layer 2
Zone Kh Kv
1 0.6 0.0005
3 0.265 0.005
4 0.02 0.002
6 0.024 0.003
8 0.004 0.000015
12 0.004 0.00001
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000

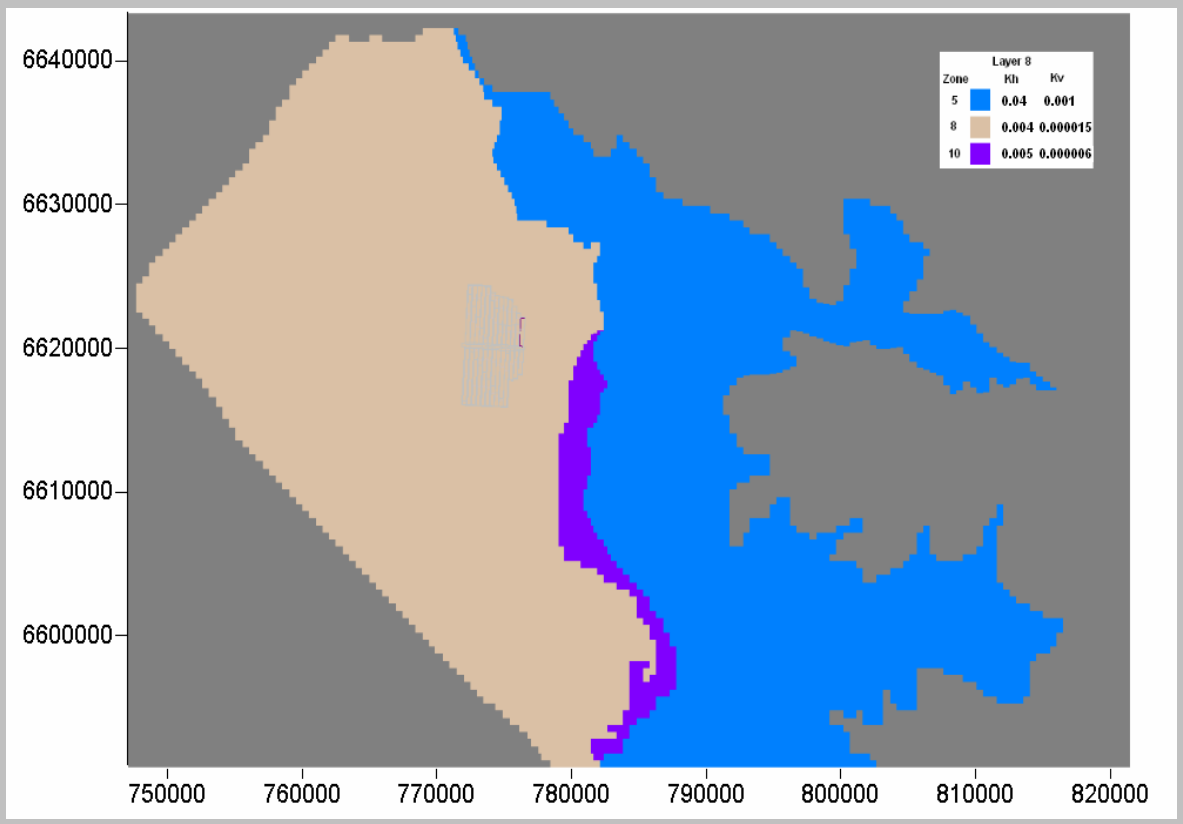

Layer 3
Zone Kh Kv
4 0.02 0.002
5 0.04 0.001
6 0.024 0.0003
8 0.004 0.000015
12 0.001 0.00001
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000

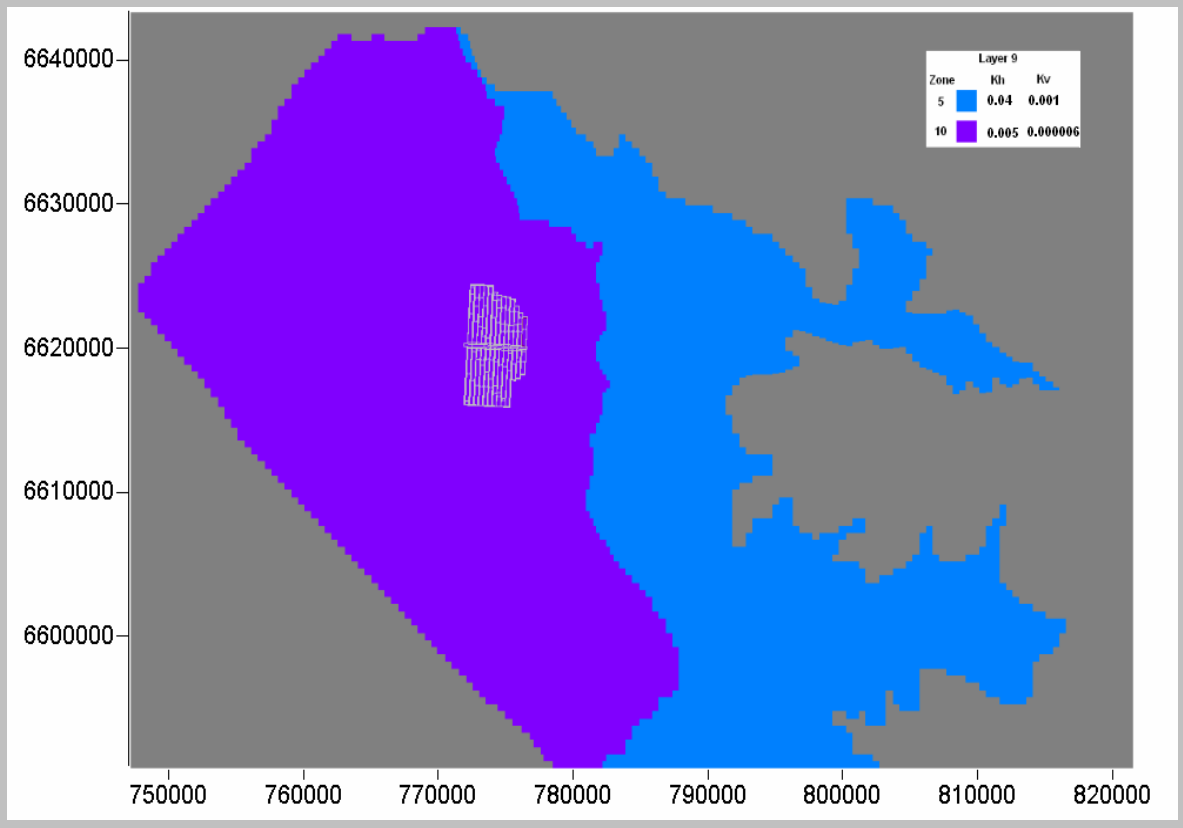

Layer 4
Zone Kh Kv
5 0.04 0.001
6 0.024 0.0003
8 0.004 0.000015
10 0.005 0.000006
12 0.001 0.00001
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000

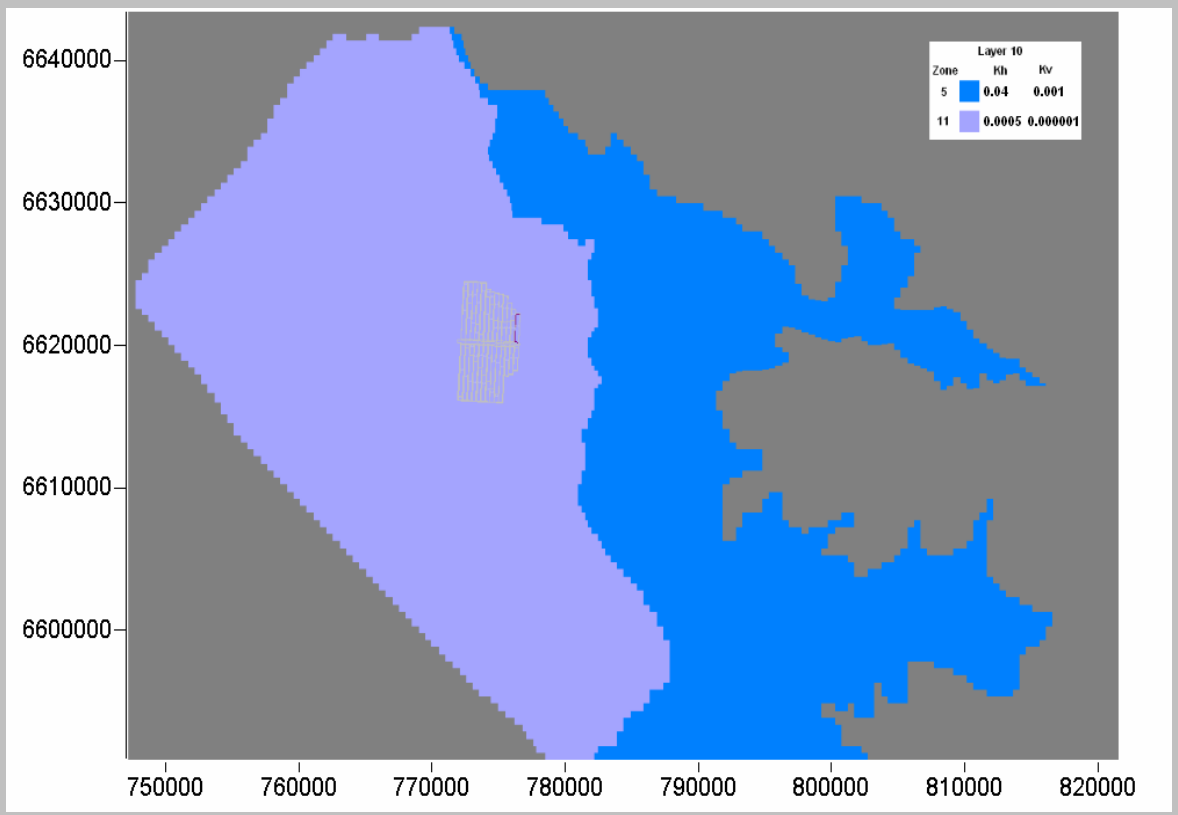

Layer 5
Zone Kh Kv
5 0.04 0.001
8 0.004 0.000015
10 0.005 0.000006
12 0.001 0.00001
14 0.004 0.00001
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000

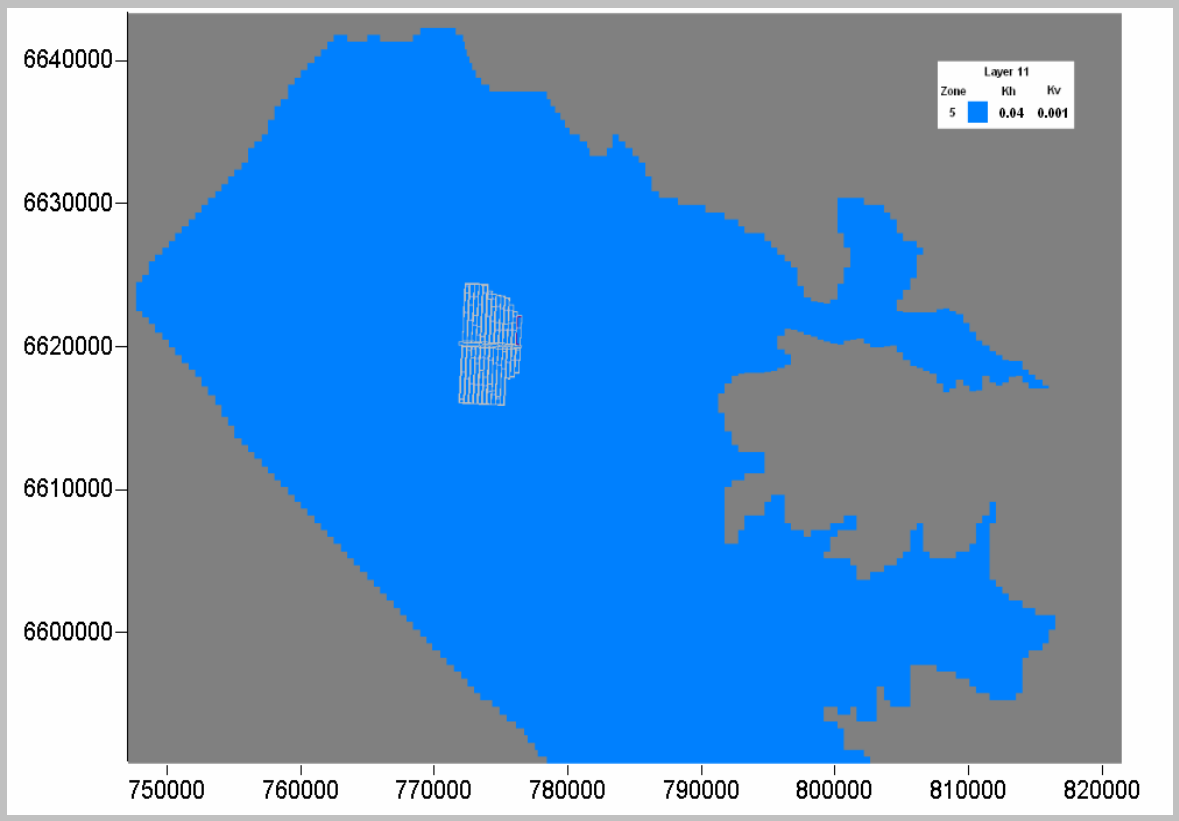

Layer 6
Zone Kh Kv
5 0.04 0.001
8 0.004 0.000015
9 0.12 0.00005
10 0.005 0.000006
13 0.007 0.000008
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000

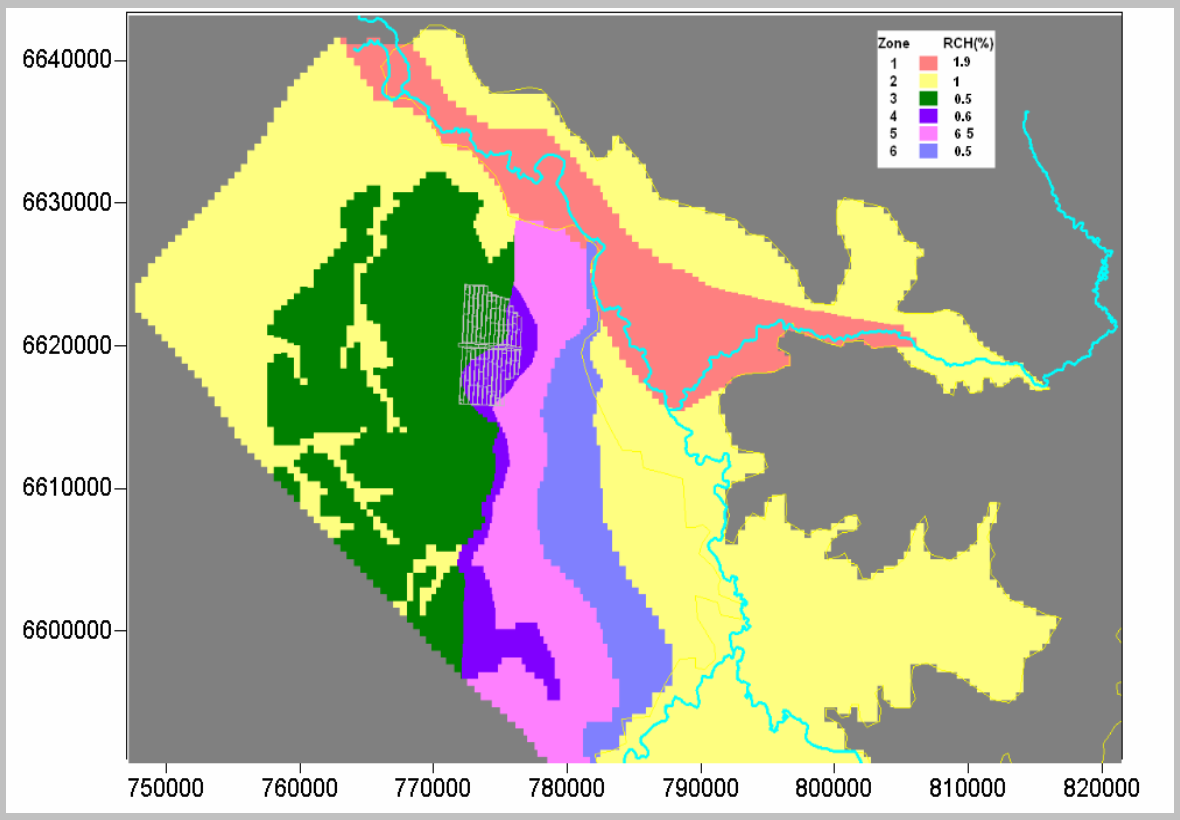

Layer 7
Zone Kh Kv
5 0.04 0.001
7 0.021 0.000024
8 0.004 0.000015
10 0.005 0.000006
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000


Layer 8
Zone Kh Kv
5 0.04 0.001
8 0.004 0.000015
10 0.005 0.000006
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000


Layer 9
Zone Kh Kv
5 0.04 0.001
10 0.005 0.000006
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000

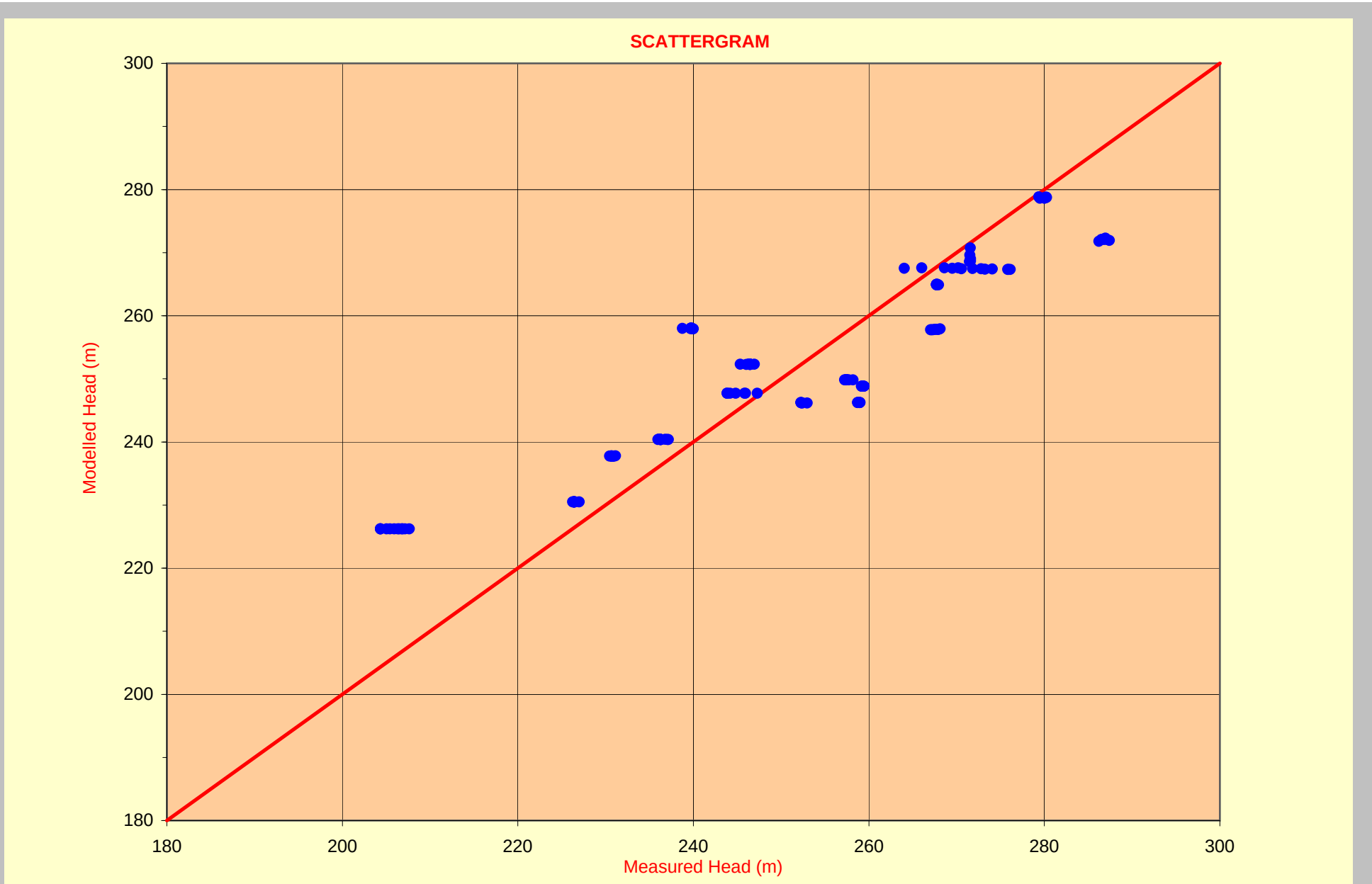

Layer 10
Zone Kh Kv
5 0.04 0.001
11 0.0005 0.000001
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000

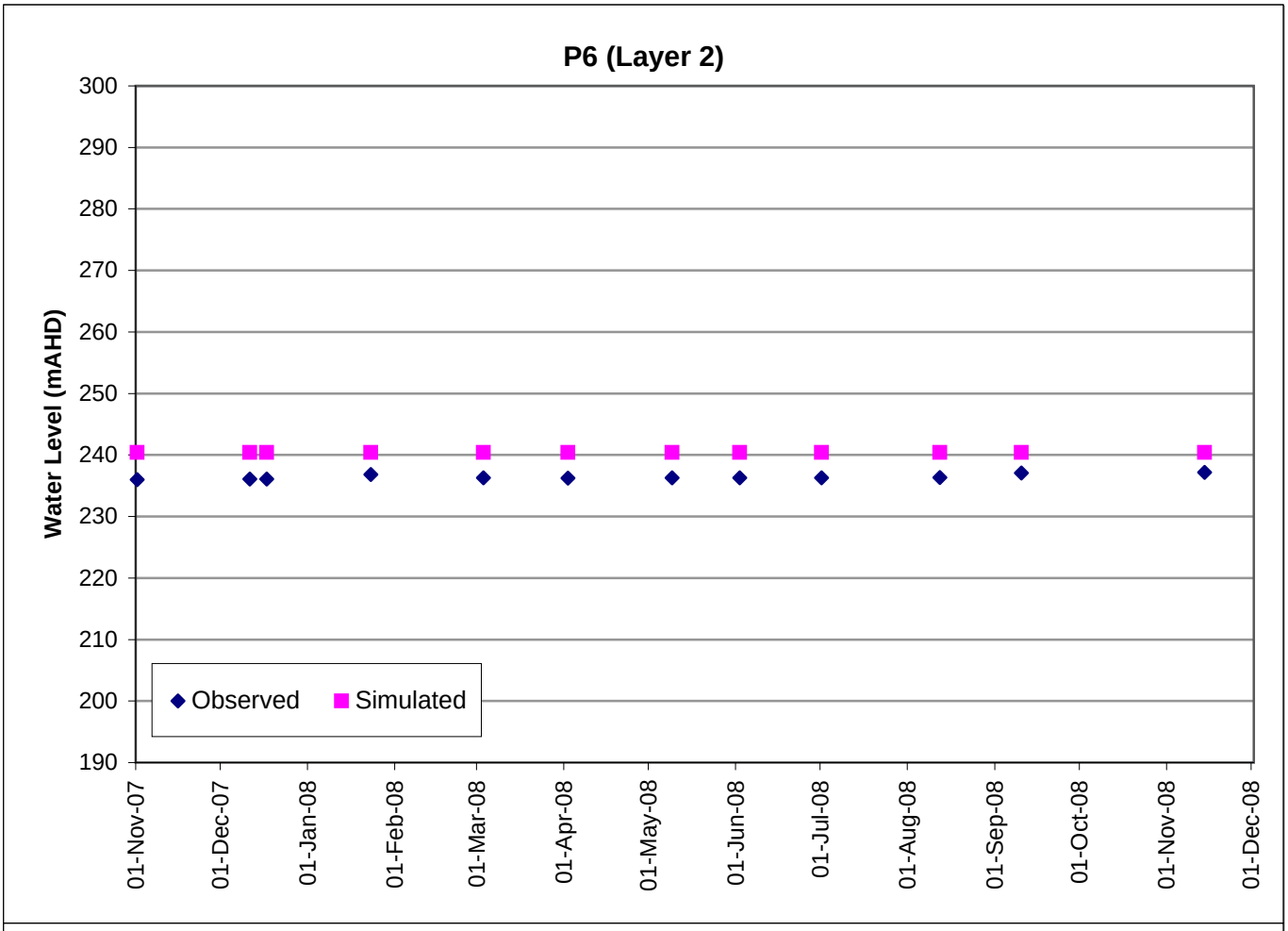

Layer 11
Zone Kh Kv
5 0.04 0.001
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000

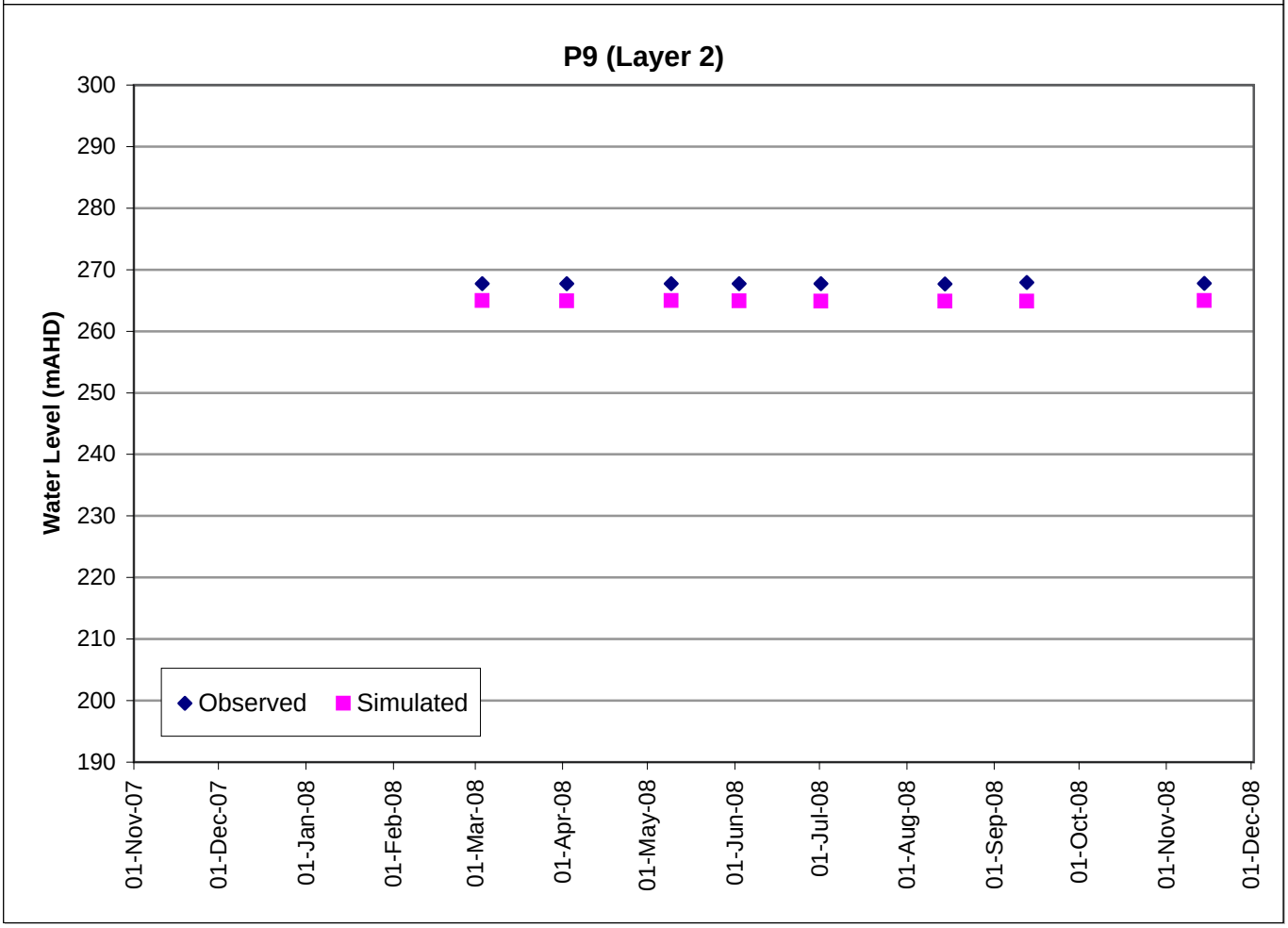

Zone RCH(%)
1 1.9
2 1
3 0.5
4 0.6
5 6 5
6 0.5
6640000
6630000
6620000
6610000
6600000
750000
760000
770000
780000
790000
800000
810000
820000

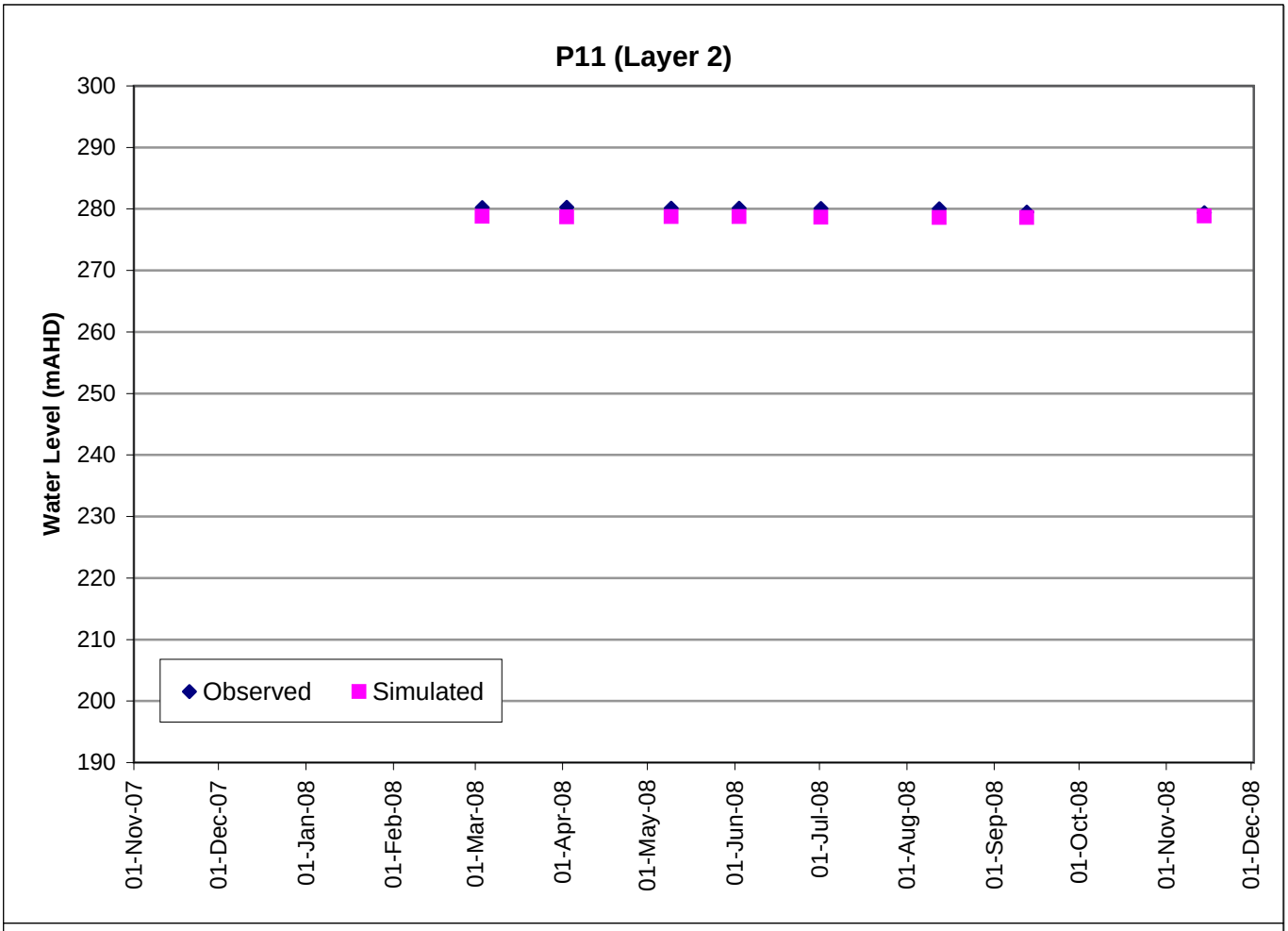
APPENDIX G

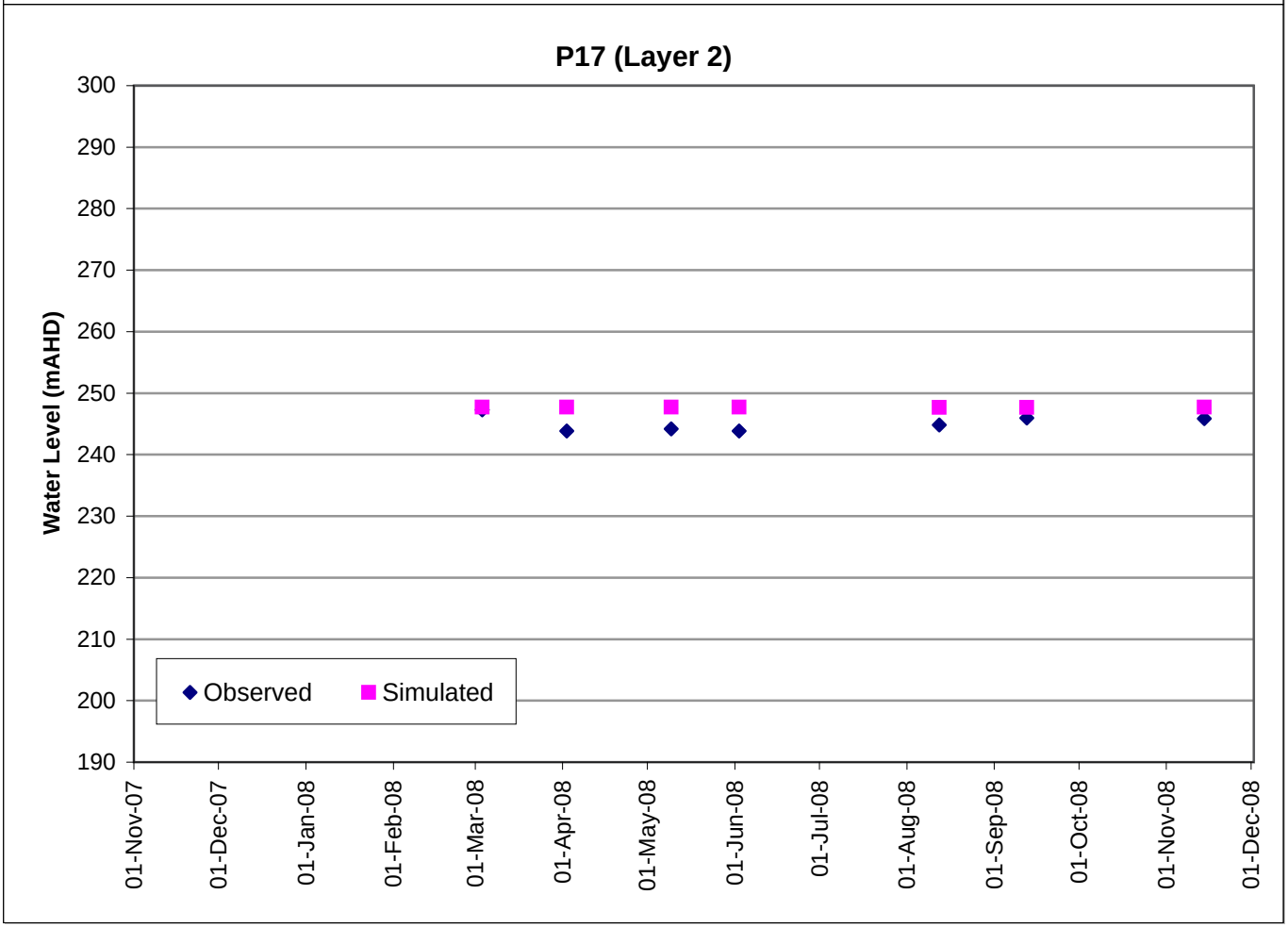
NARRABRI MODEL TRANSIENT CALIBRATION

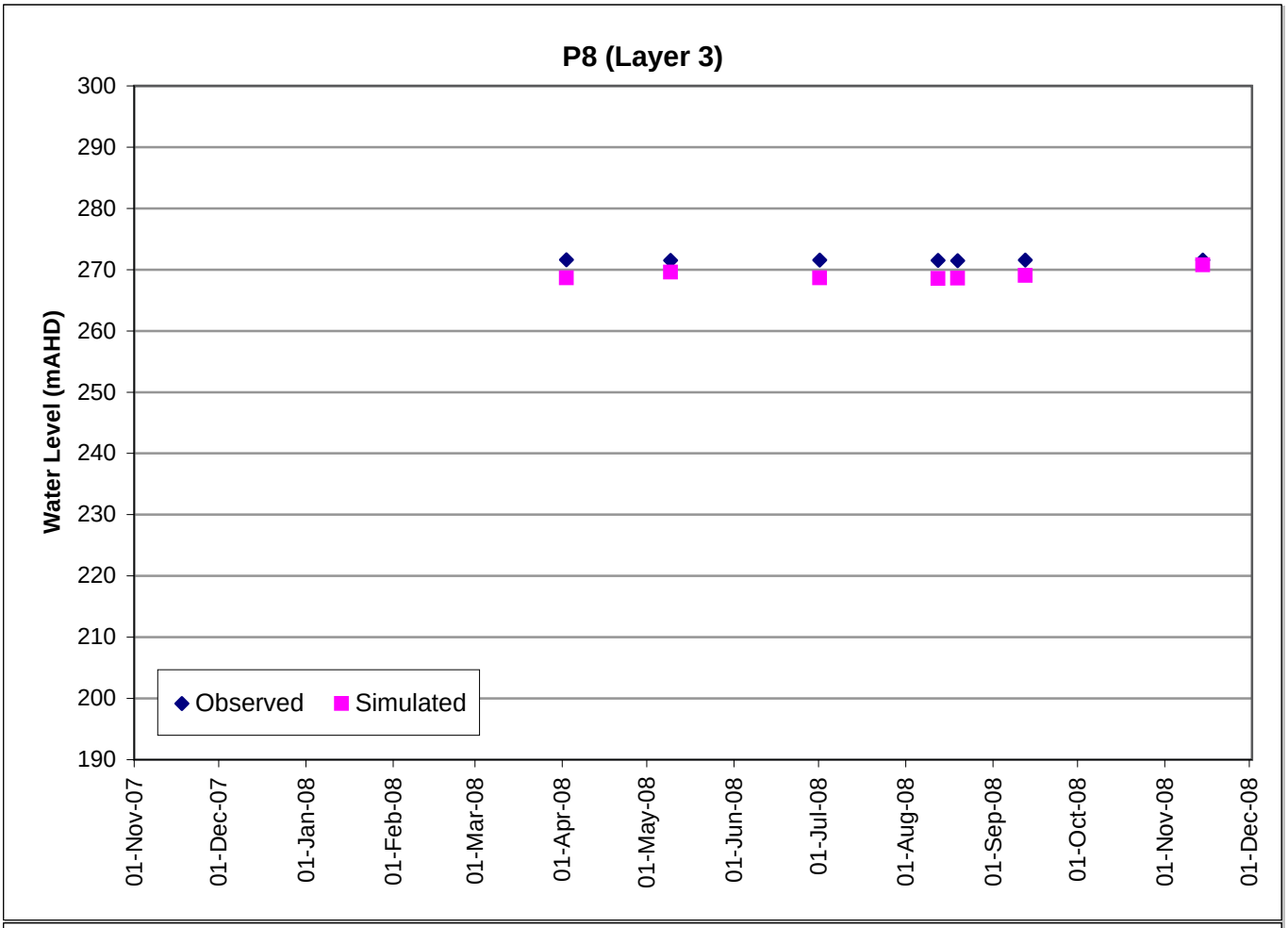

SCATTERGRAM
Modelled Head (m)
Measured Head (m)
300
280
260
240
220
200
180
180
200
220
240
260
280
300

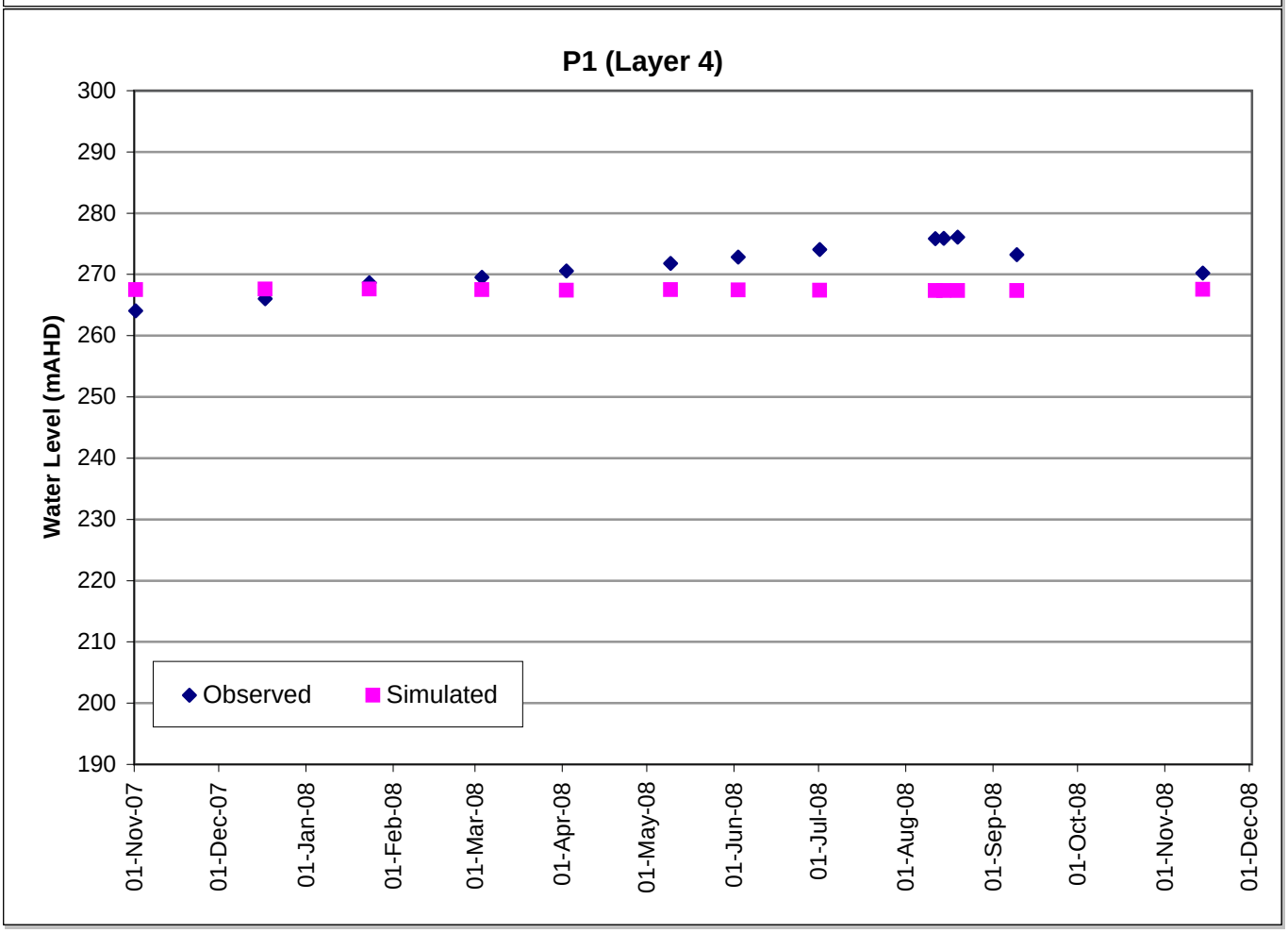

P6 (Layer 2)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08

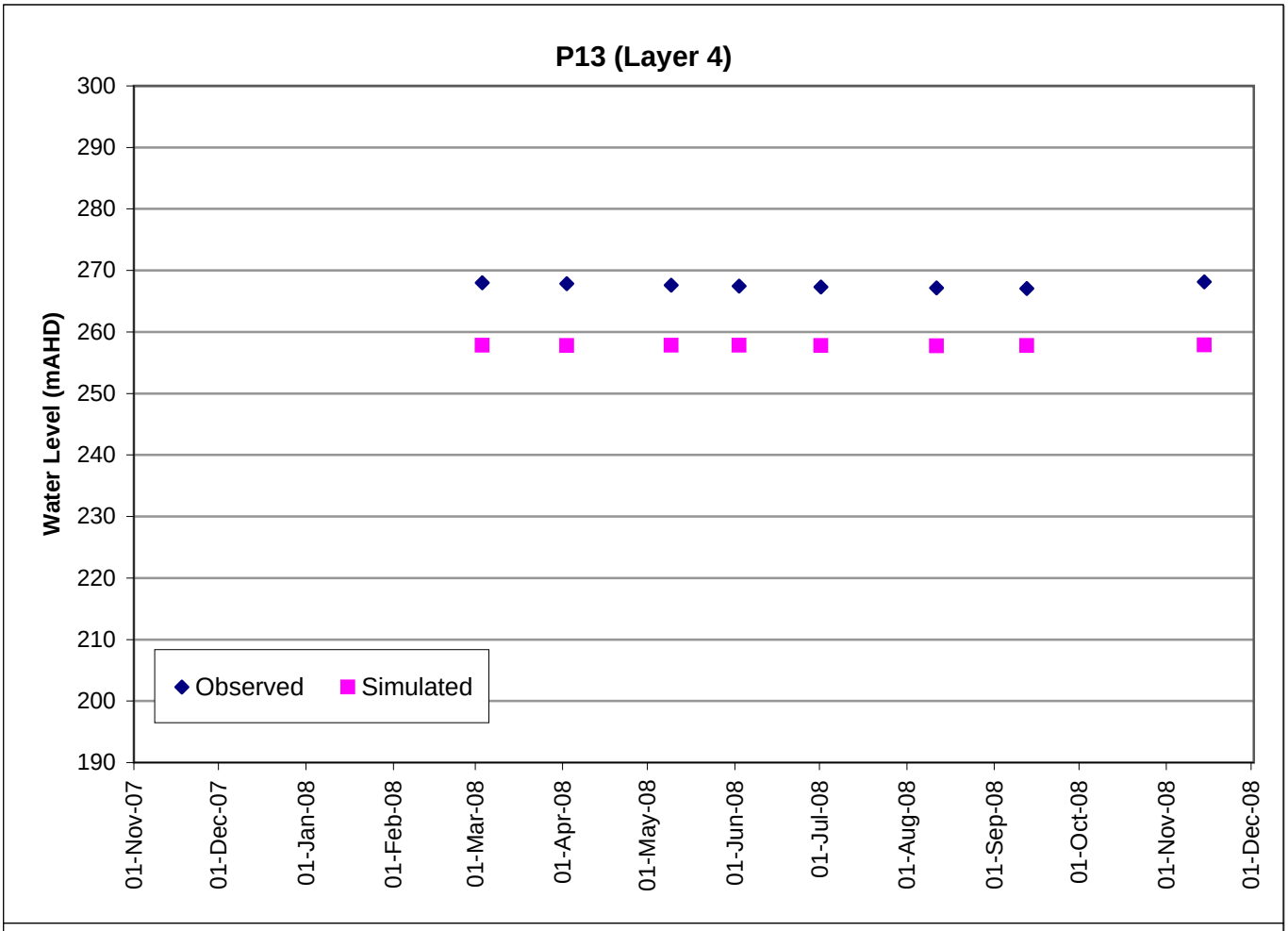

P9 (Layer 2)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08

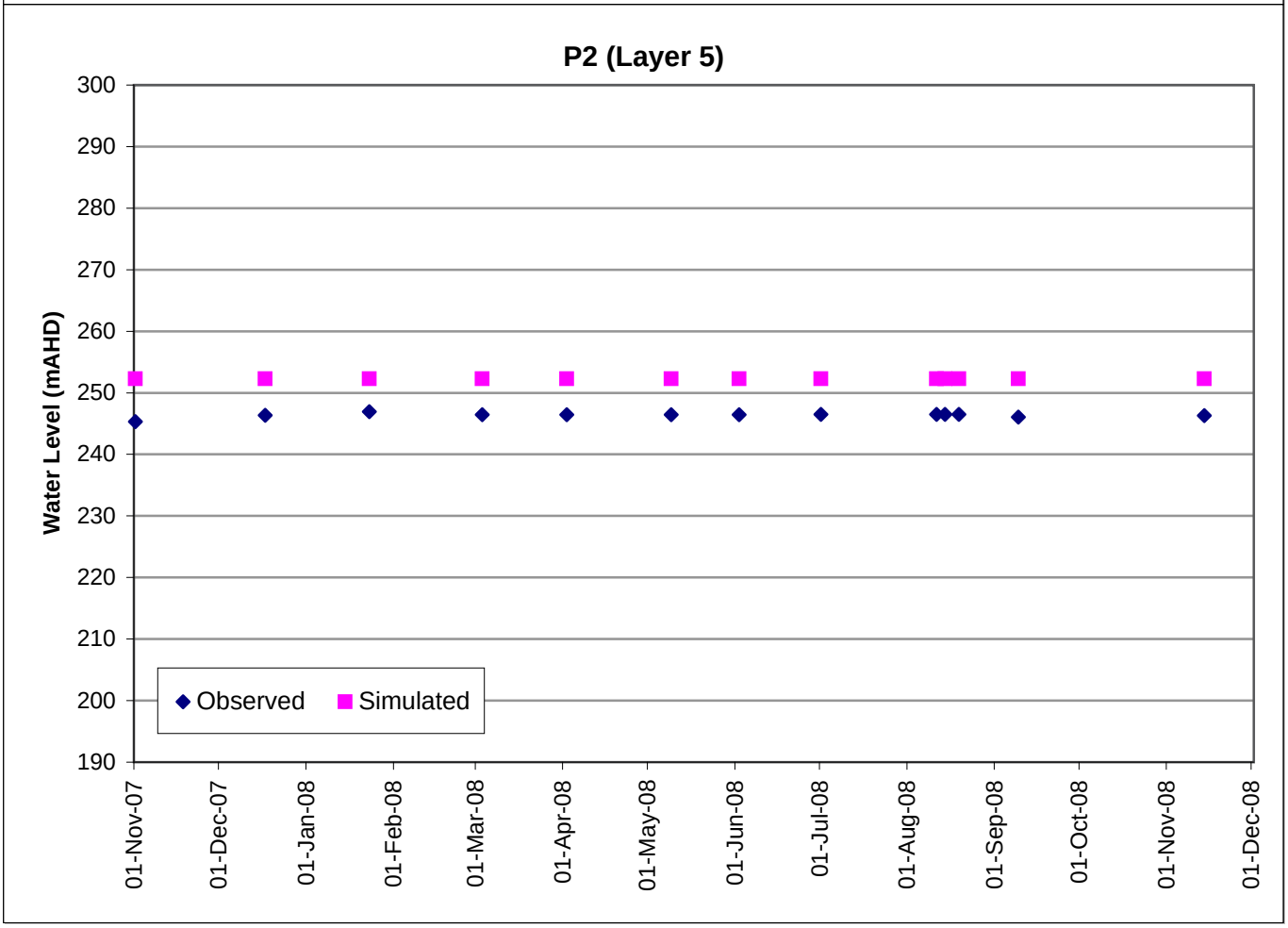

P11 (Layer 2)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08

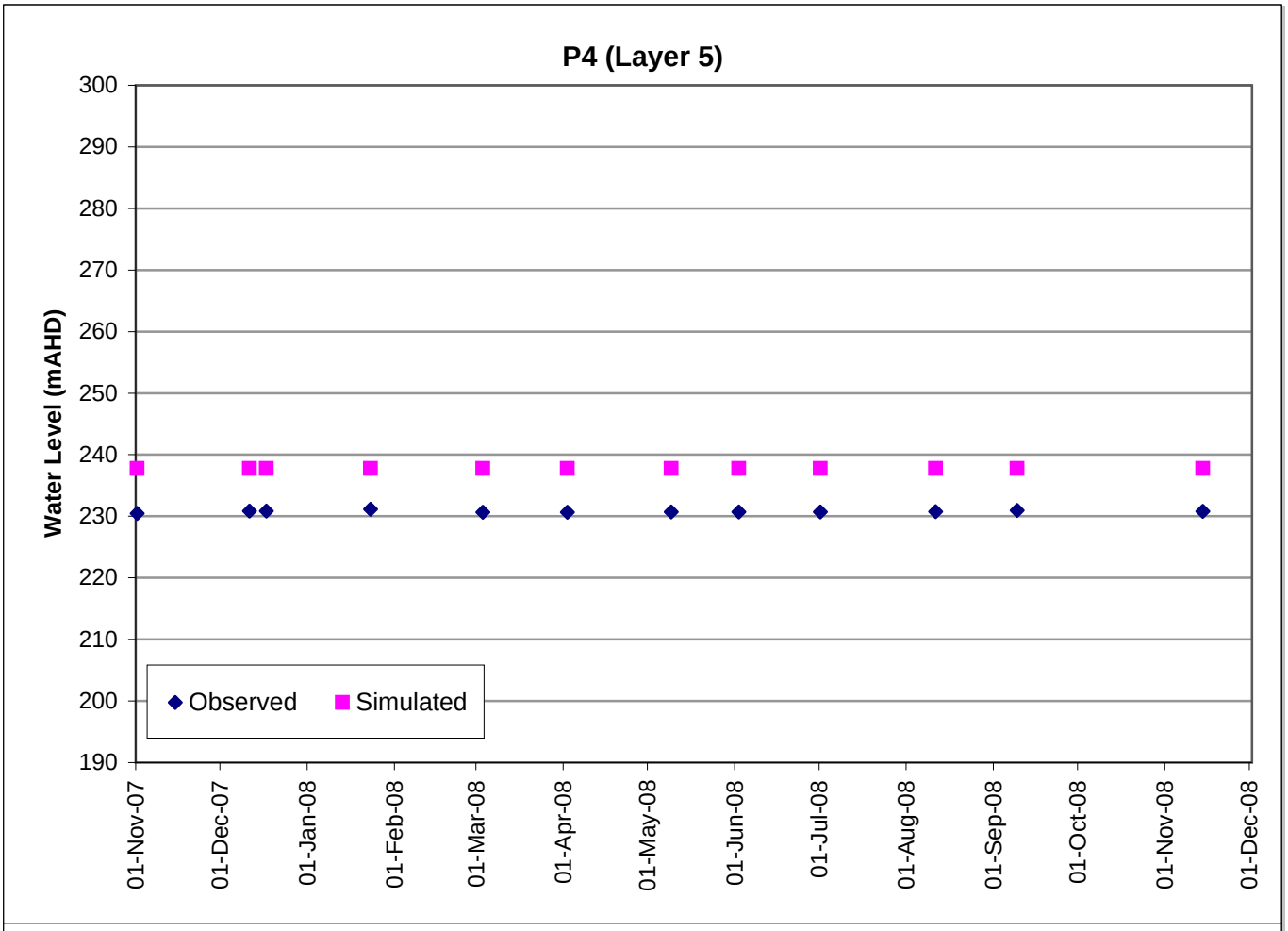

P17 (Layer 2)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08

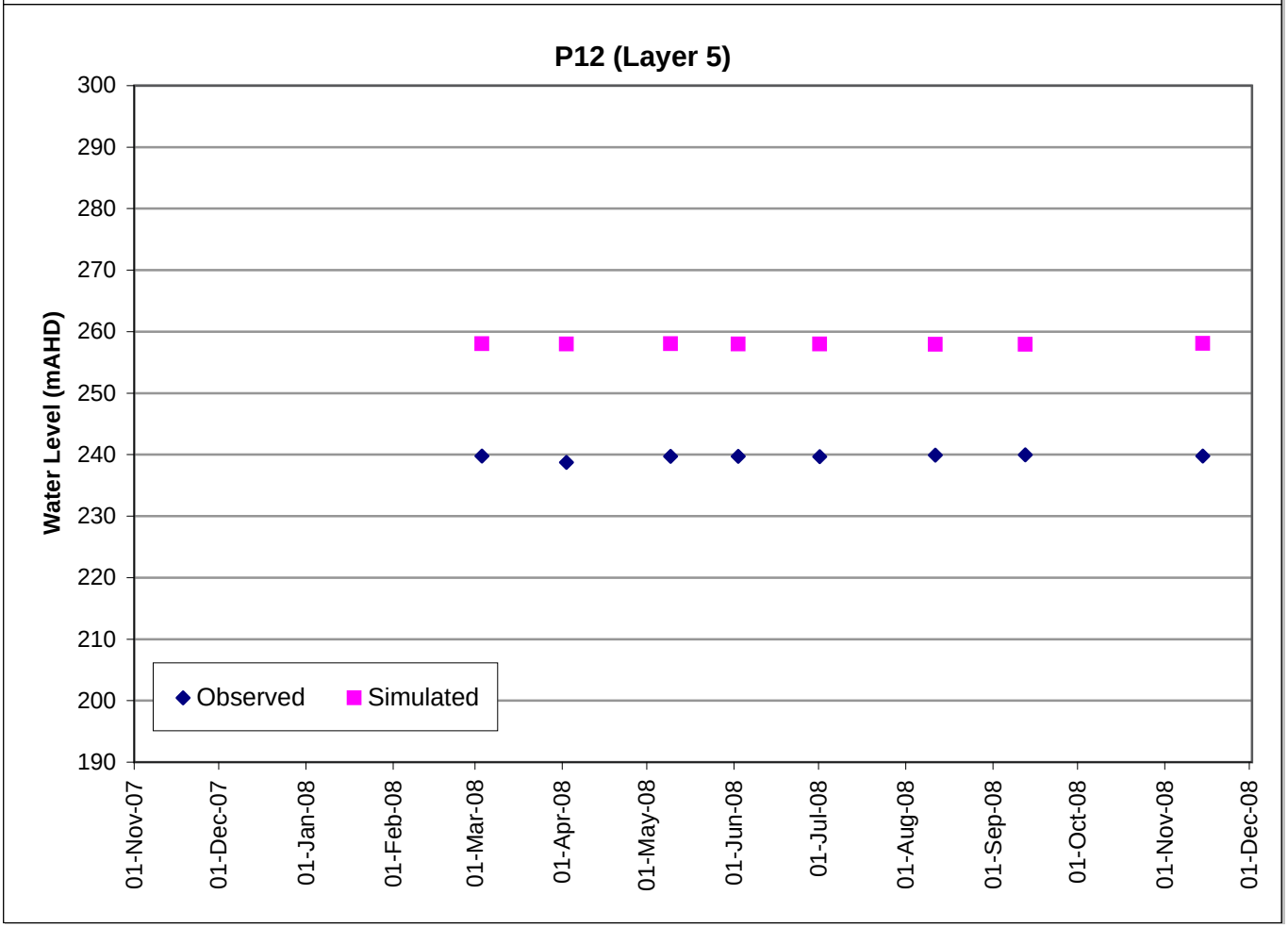

P8 (Layer 3)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08

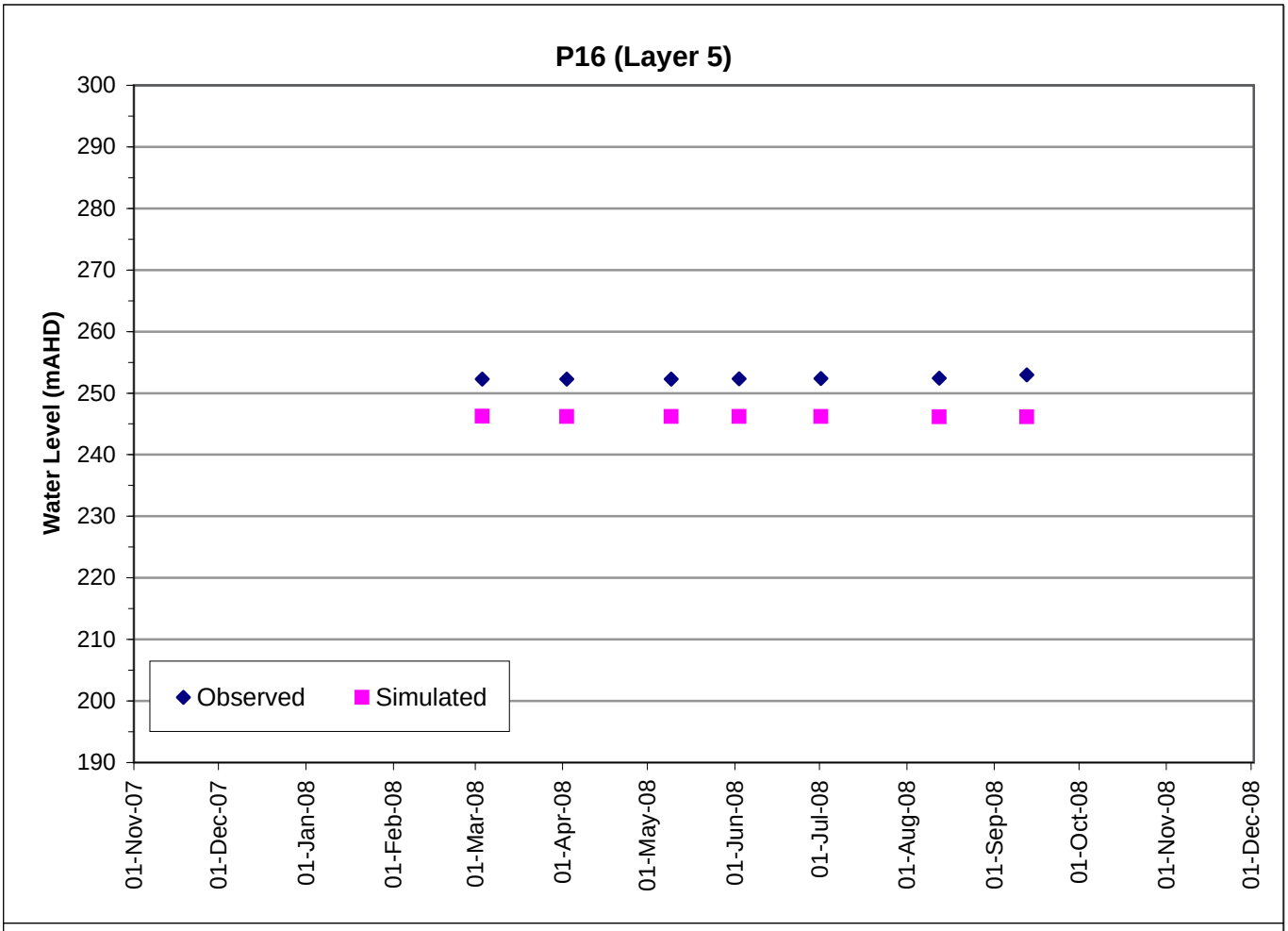

P1 (Layer 4)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08


P13 (Layer 4)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08


P2 (Layer 5)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08


P4 (Layer 5)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08


P12 (Layer 5)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08


P16 (Layer 5)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
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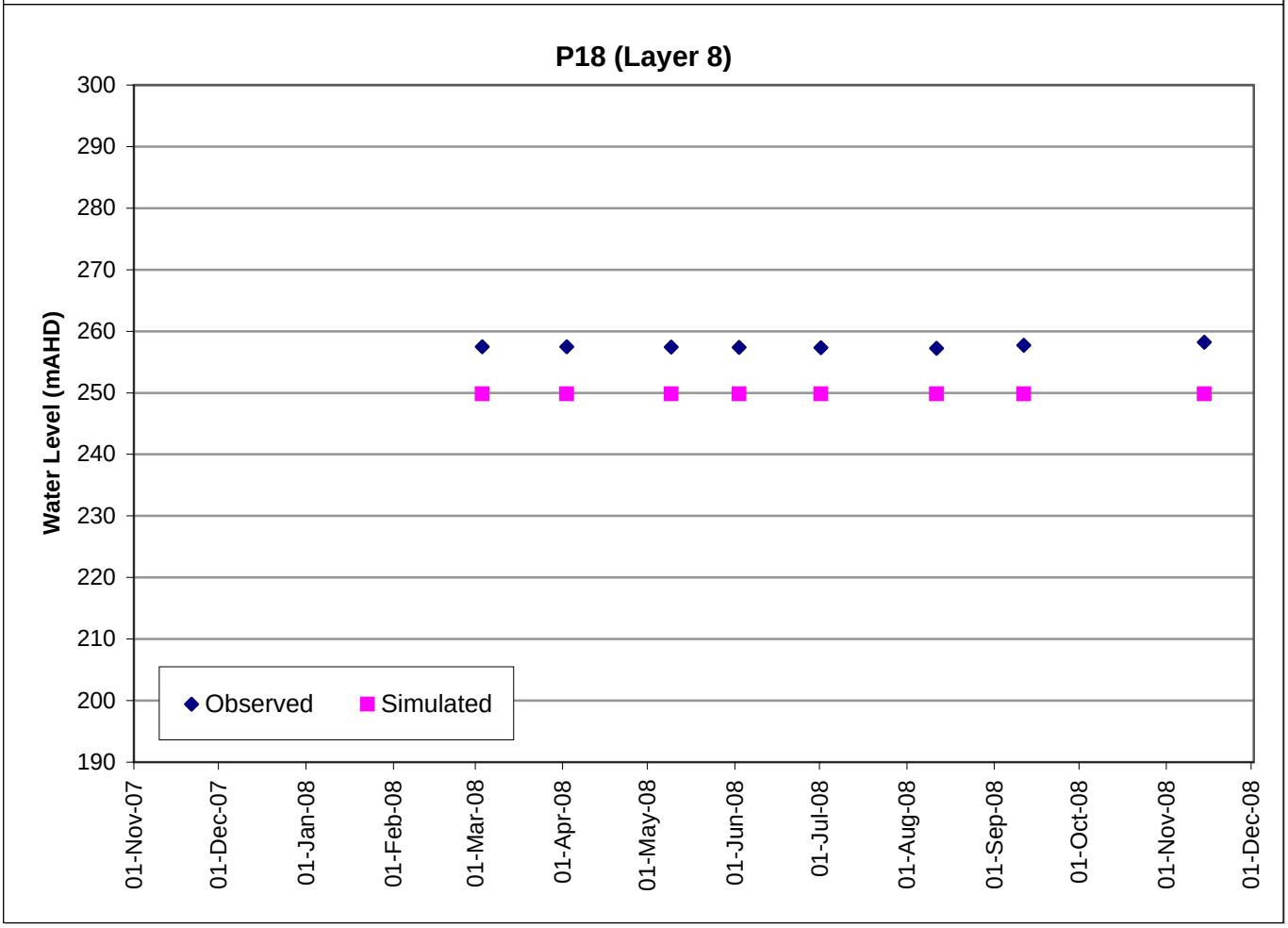
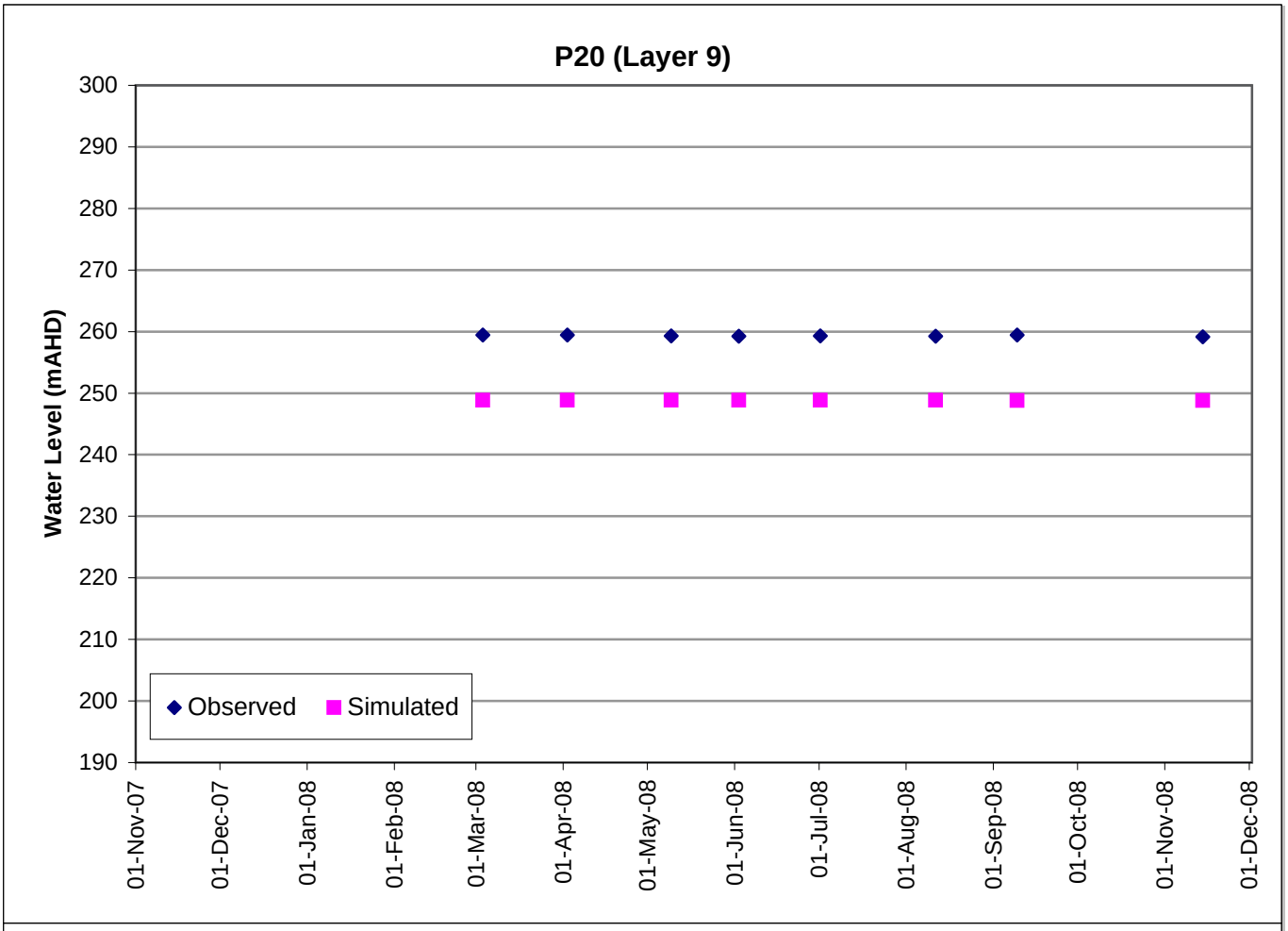
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08


P18 (Layer 8)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08


P20 (Layer 9)
Water Level (mAHD)
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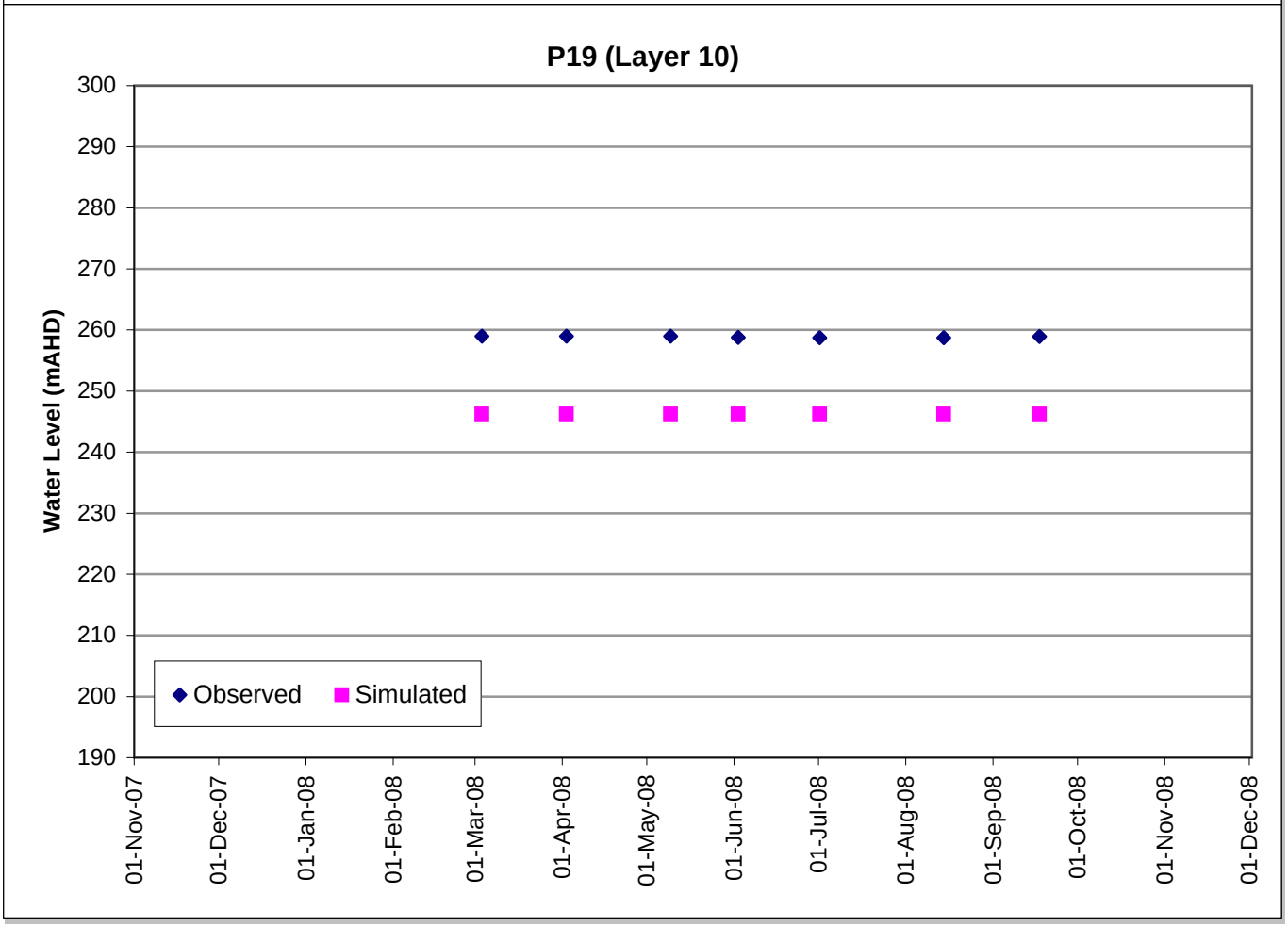
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08


P19 (Layer 10)
Water Level (mAHD)
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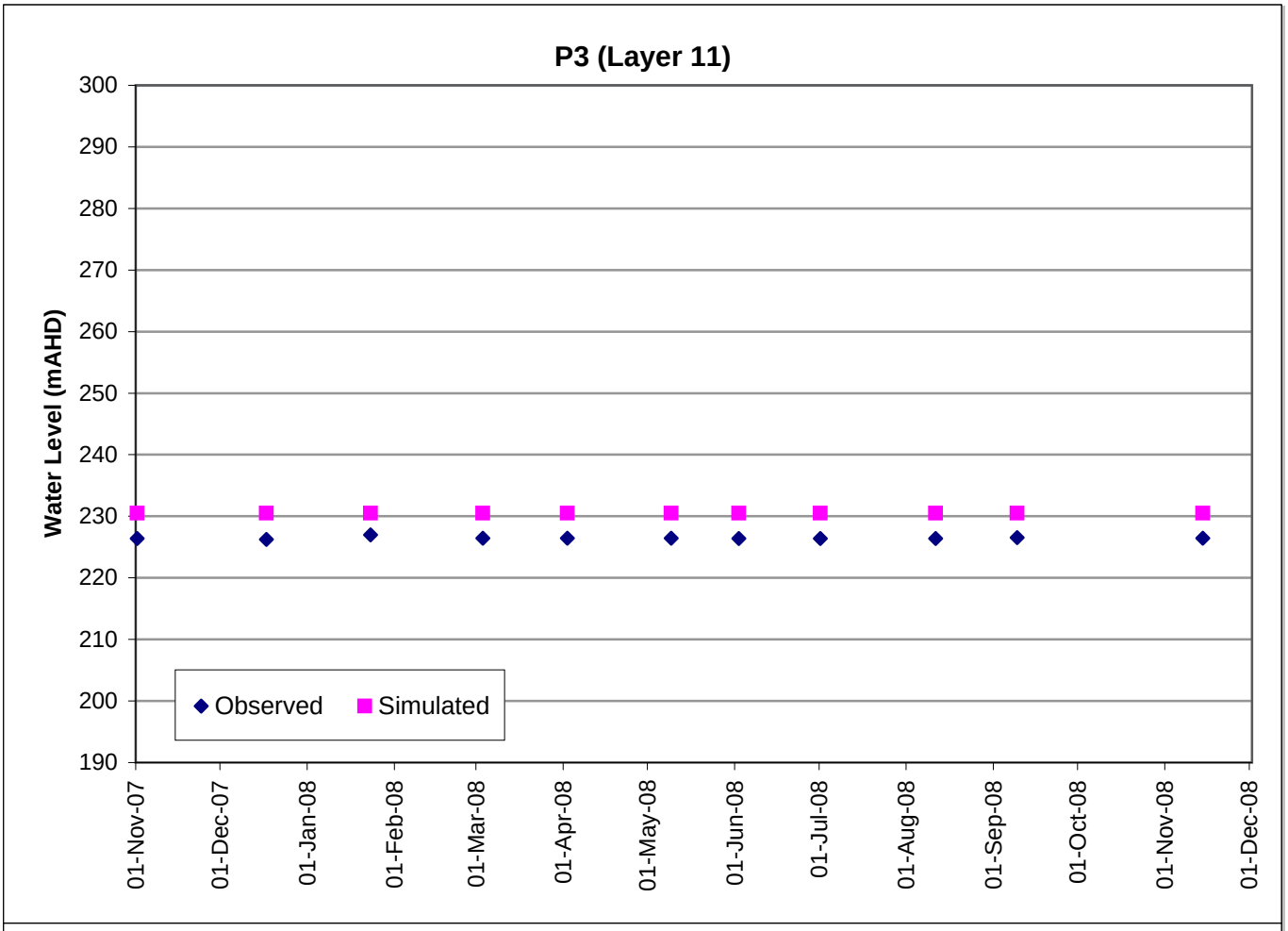
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08


P3 (Layer 11)
Water Level (mAHD)
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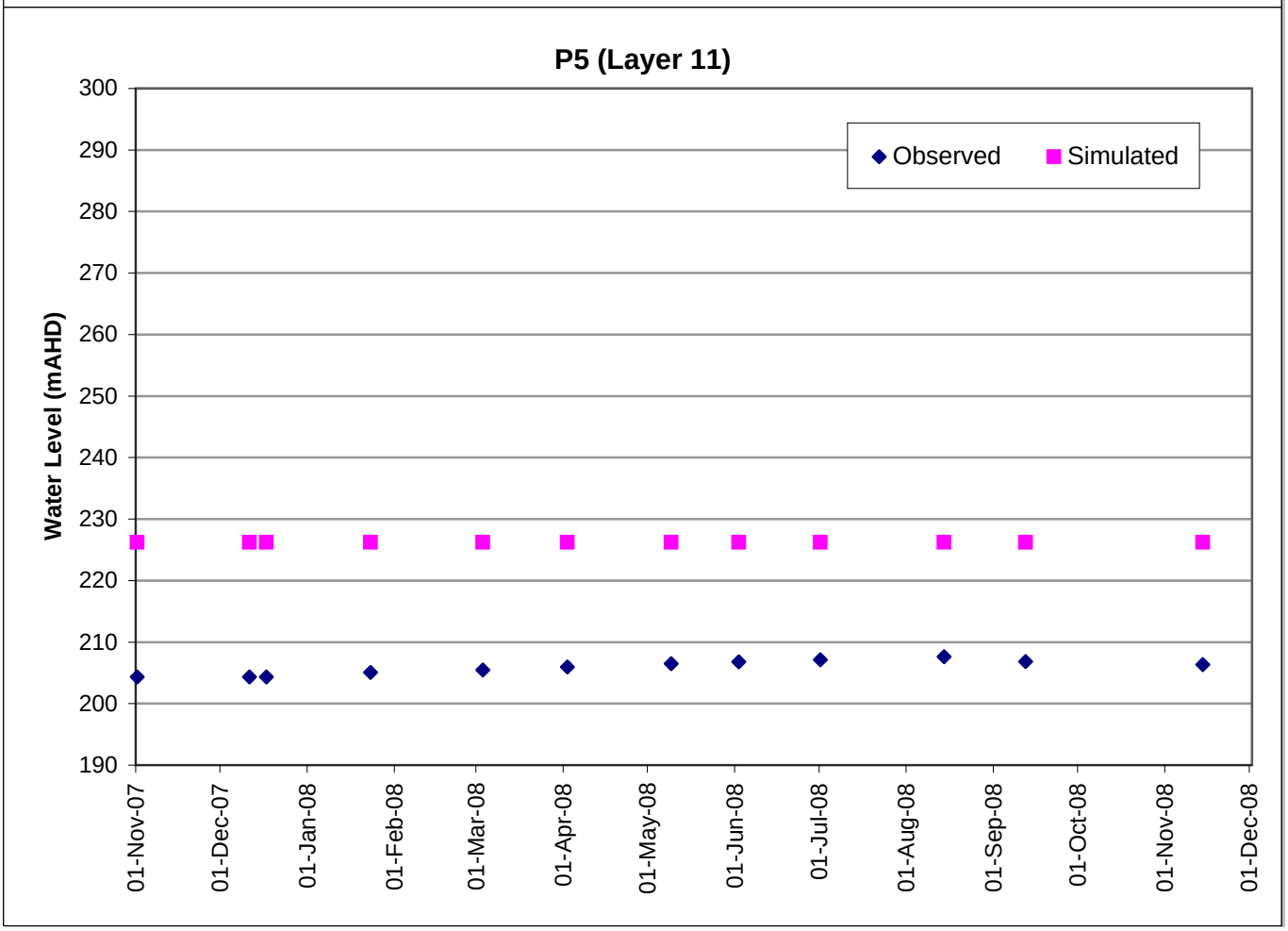
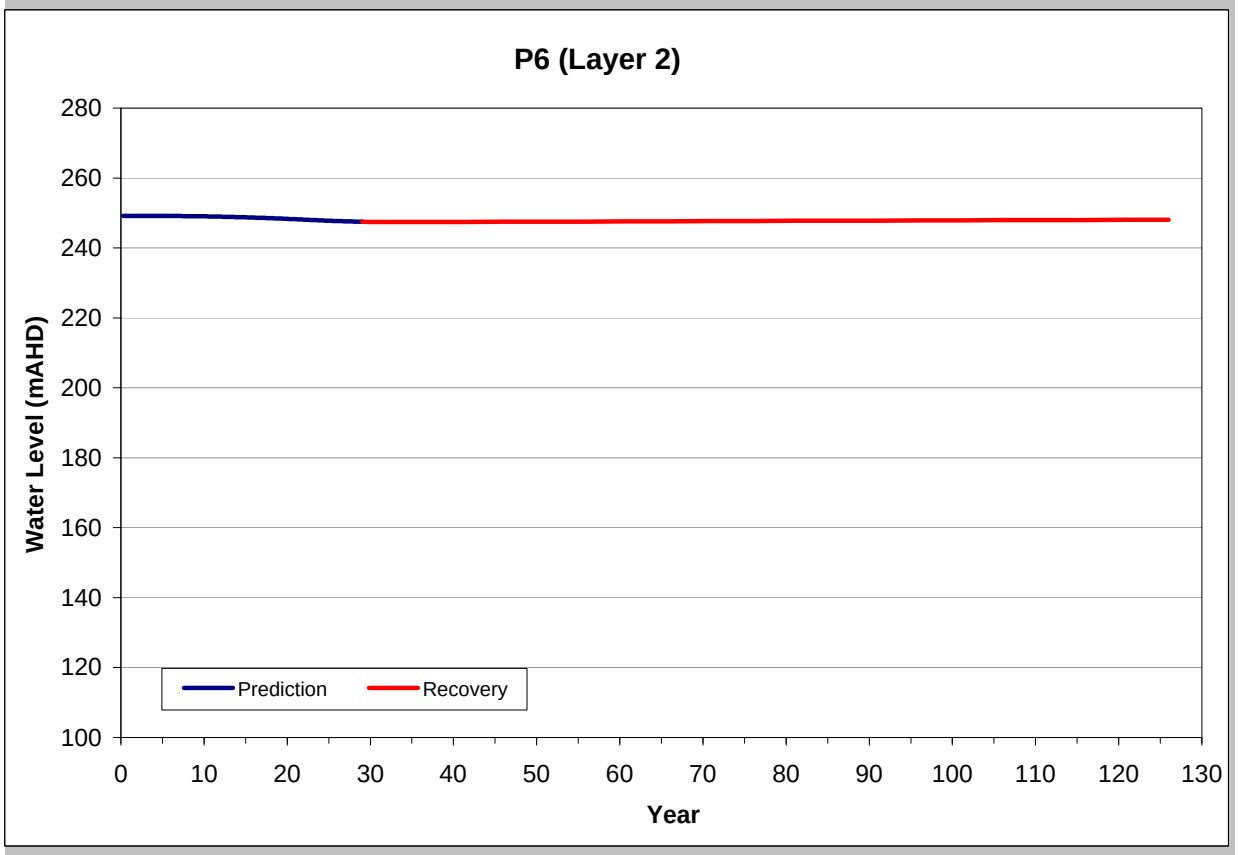
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08


P5 (Layer 11)
Water Level (mAHD)
300
290
280
270
260
250
240
230
220
210
200
190
Observed
Simulated
01-Nov-07
01-Dec-07
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08

APPENDIX H

NARRABRI PREDICTED RECOVERY HYDRAGRAPH


P6 (Layer 2)
Water Level (mAHD)
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260
240
220
200
180
160
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20
30
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60
70
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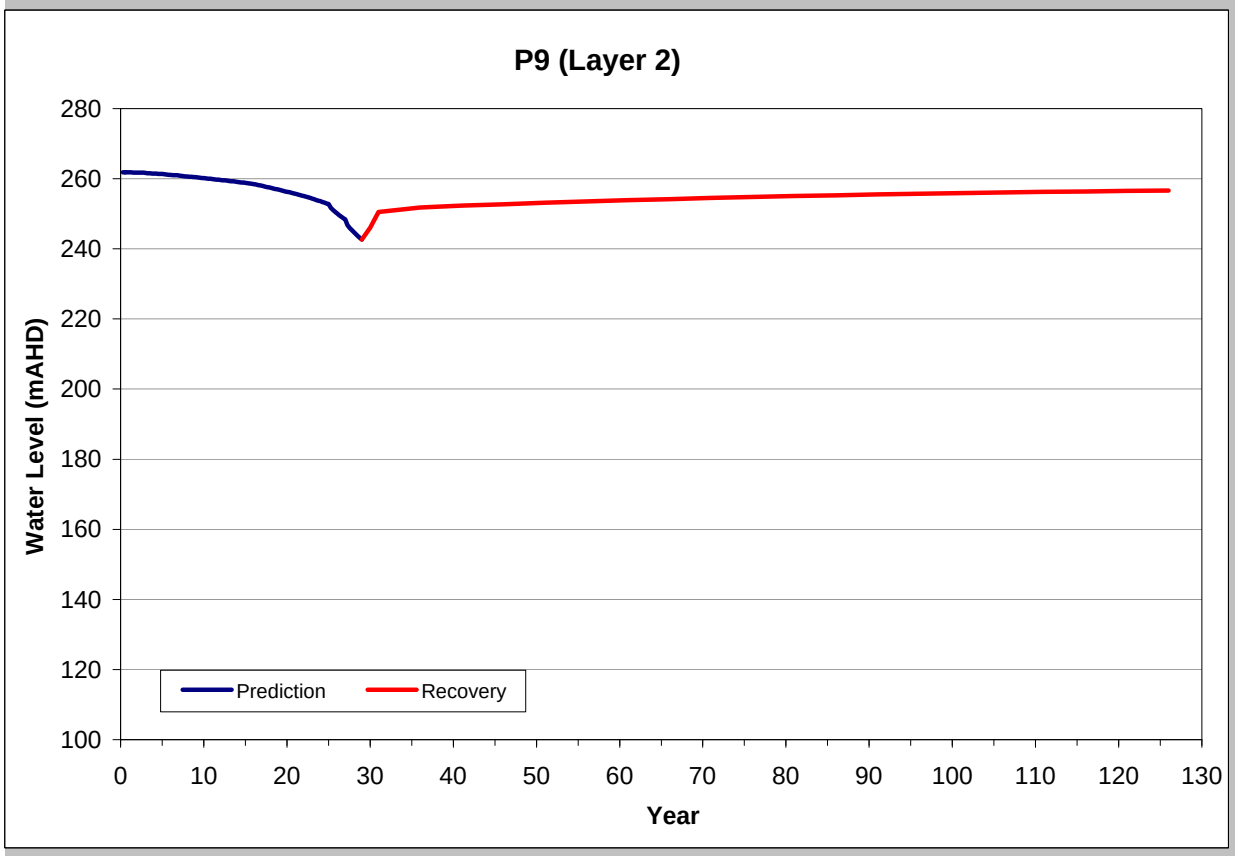
90
100
110
120
130
Year
Prediction
Recovery


P9 (Layer 2)
Water Level (mAHD)
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260
240
220
200
180
160
140
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30
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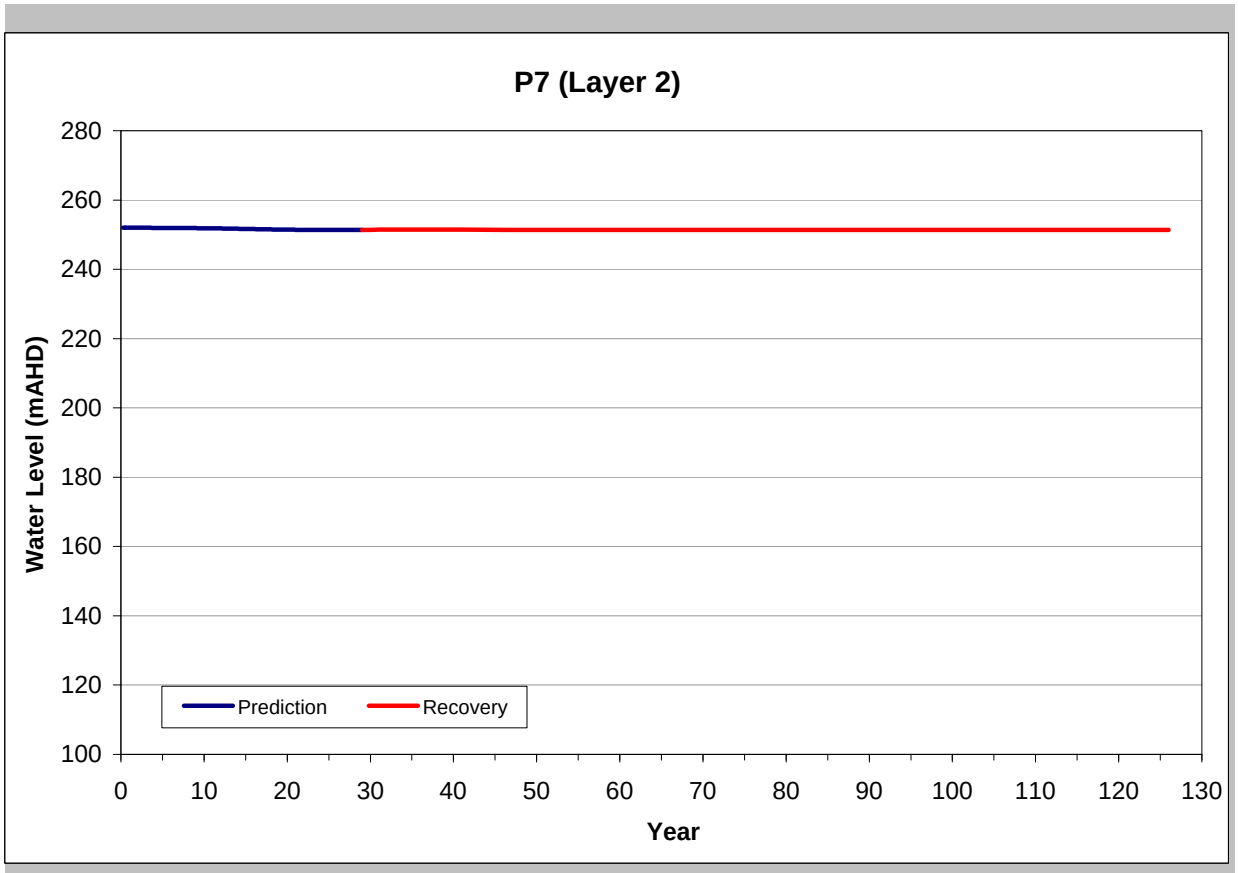
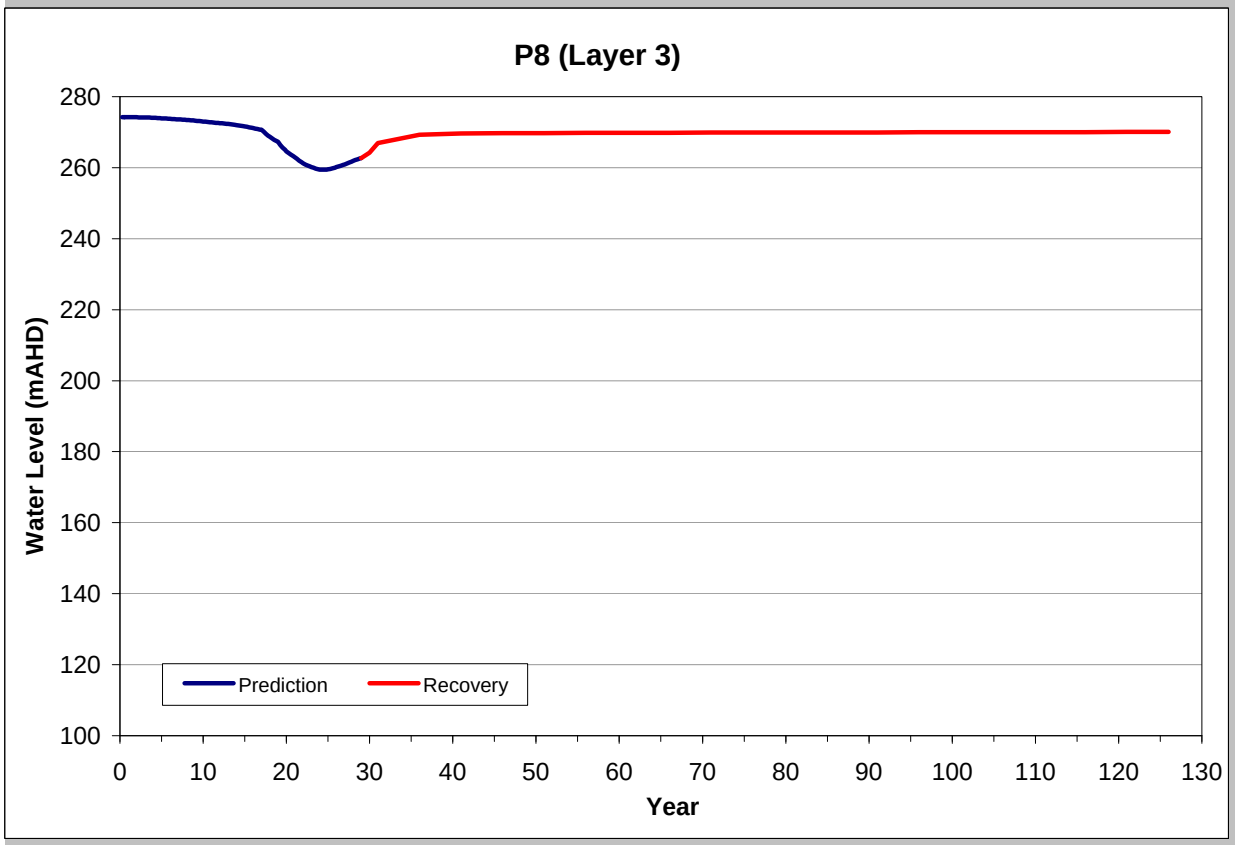
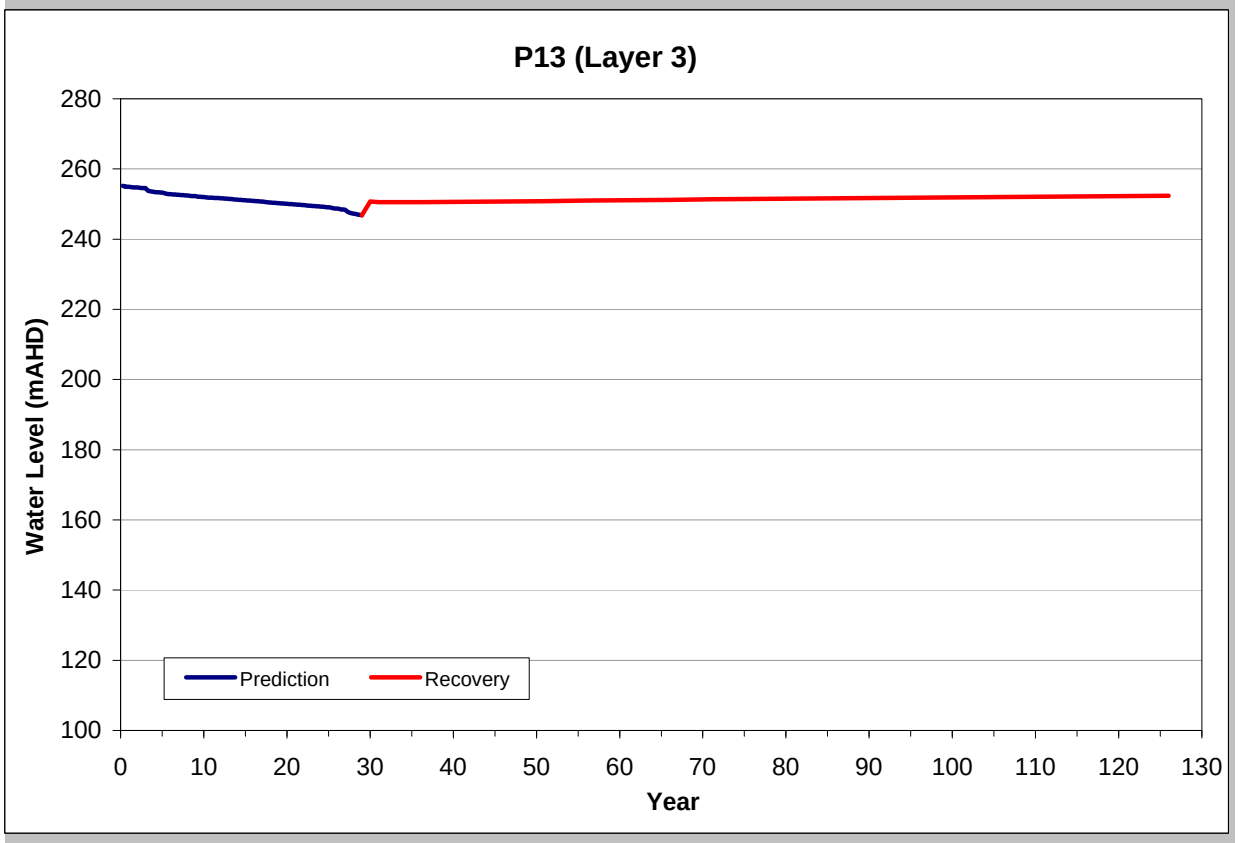
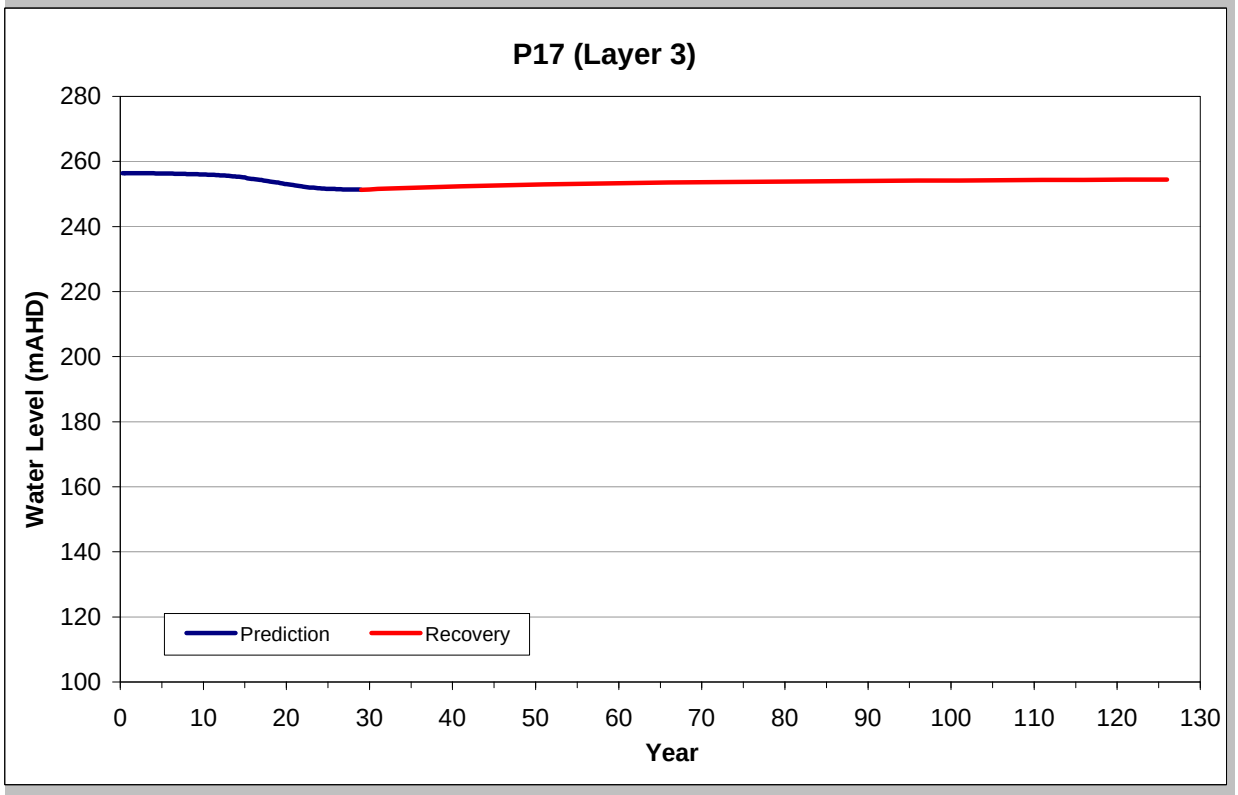
70
80
90
100
110
120
130
Year
Prediction
Recovery


P7 (Layer 2)
Water Level (mAHD)
280
260
240
220
200
180
160
140
120
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Year
Prediction
Recovery


P8 (Layer 3)
Water Level (mAHD)
280
260
240
220
200
180
160
140
120
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Year
Prediction
Recovery


P13 (Layer 3)
Water Level (mAHD)
280
260
240
220
200
180
160
140
120
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Year
Prediction
Recovery


P17 (Layer 3)
Water Level (mAHD)
280
260
240
220
200
180
160
140
120
100
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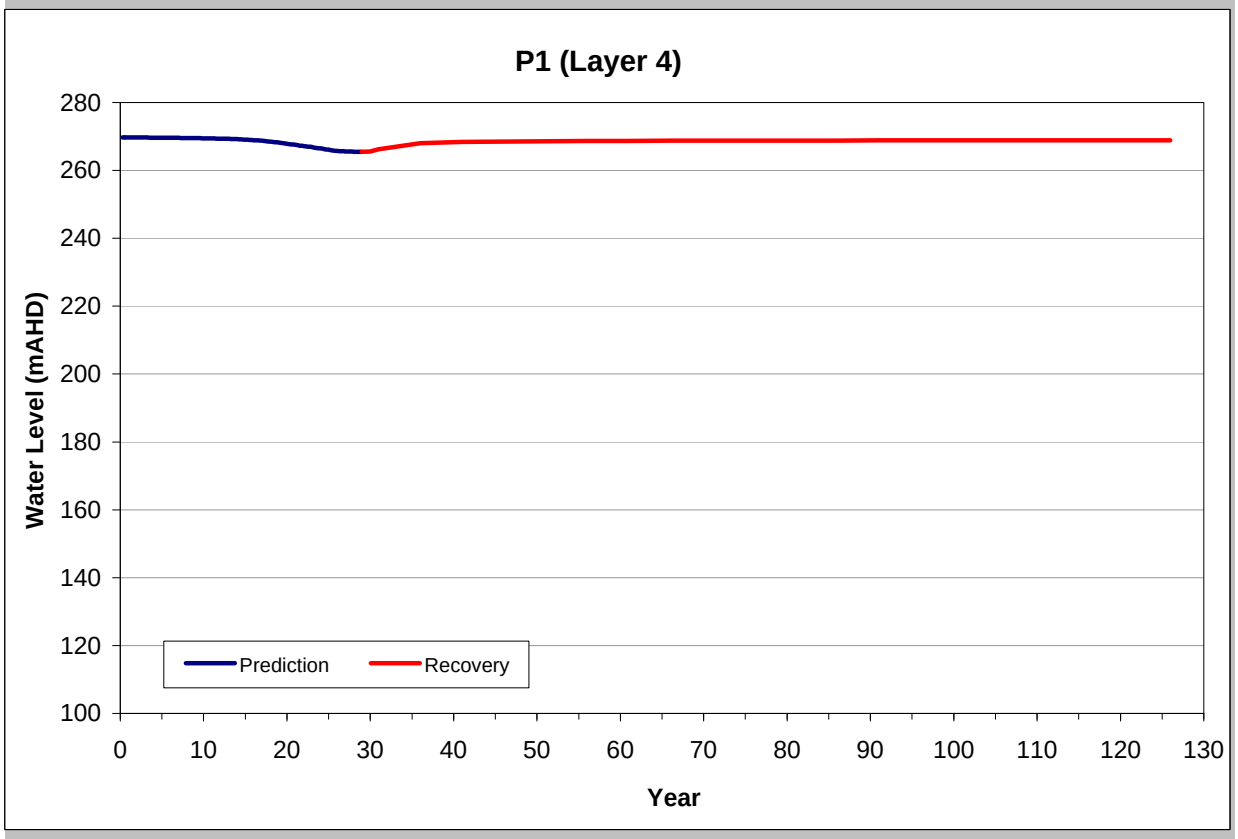
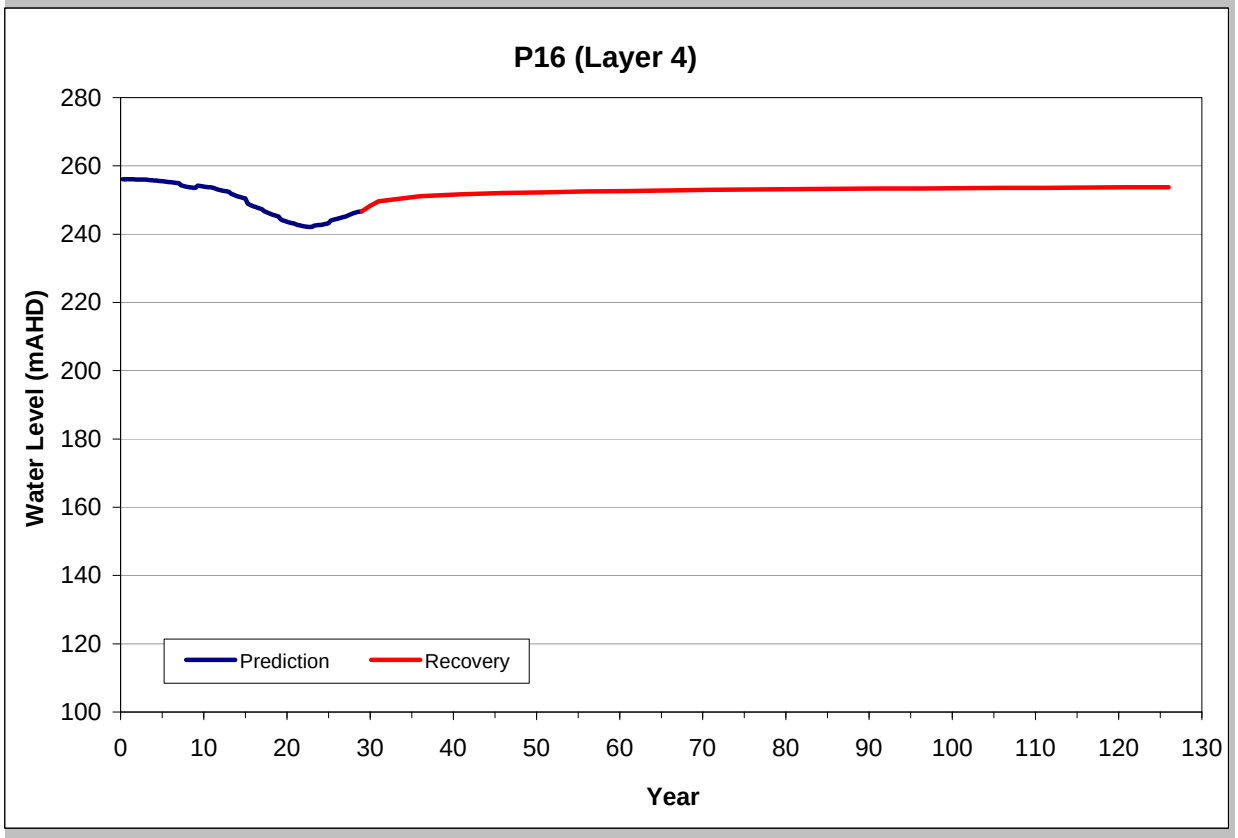
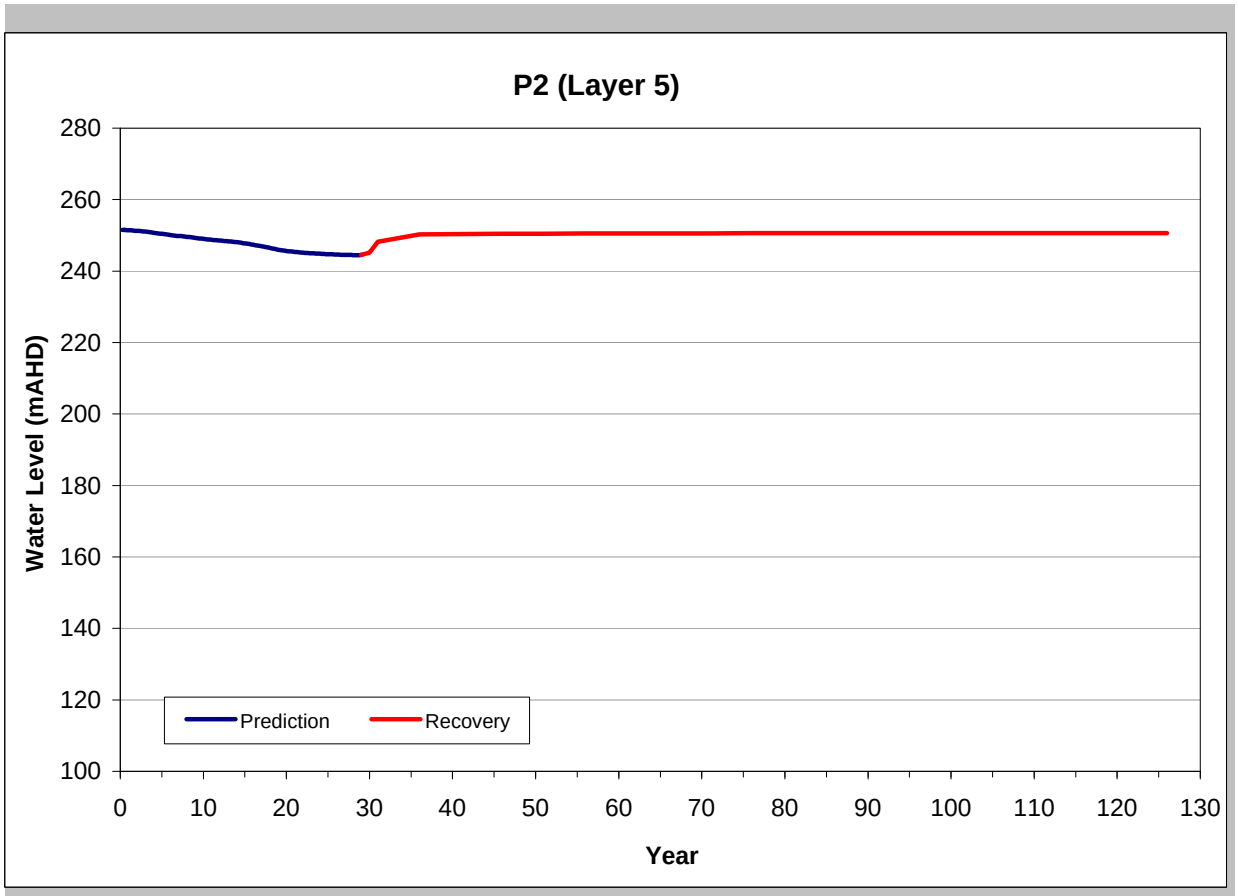
10
20
30
40
50
60
70
80
90
100
110
120
130
Year
Prediction
Recovery


P1 (Layer 4)
Water Level (mAHD)
280
260
240
220
200
180
160
140
120
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Year
Prediction
Recovery


P16 (Layer 4)
Water Level (mAHD)
280
260
240
220
200
180
160
140
120
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Year
Prediction
Recovery


P2 (Layer 5)
Water Level (mAHD)
280
260
240
220
200
180
160
140
120
100
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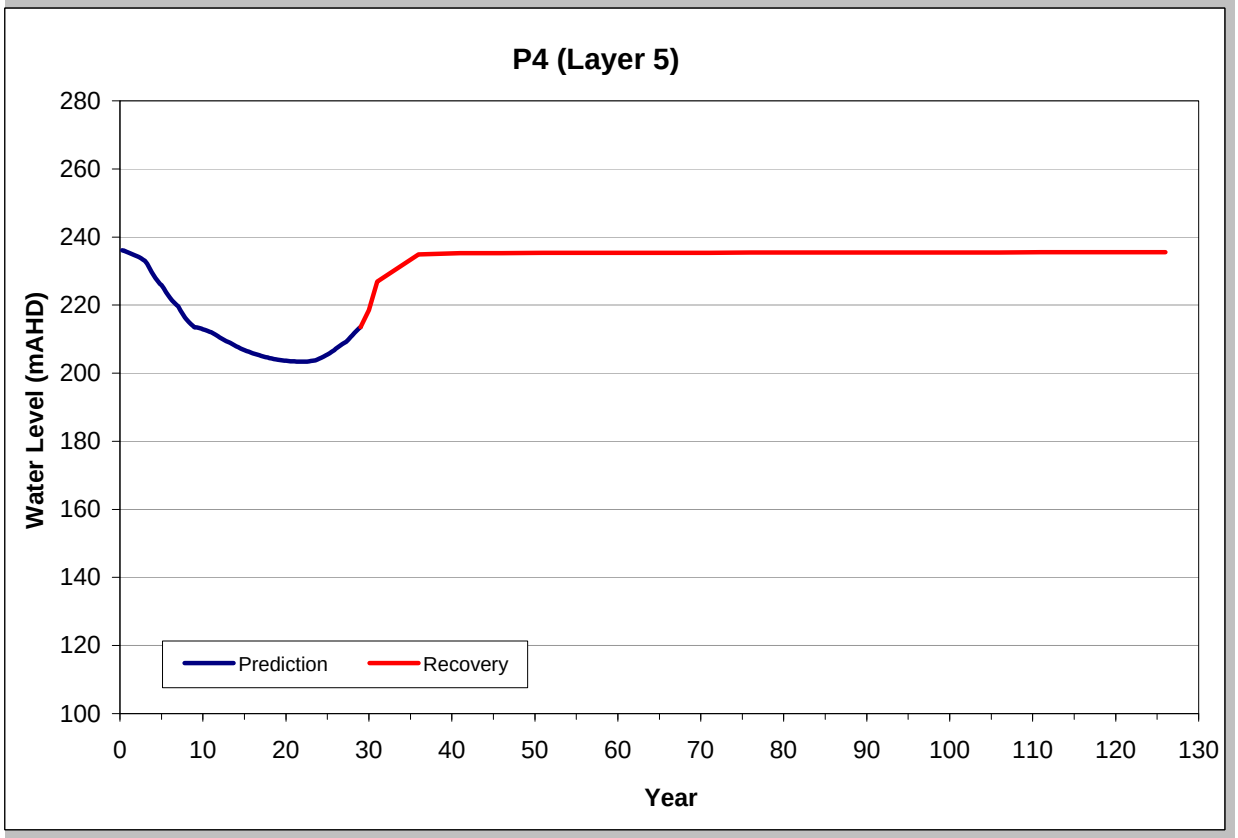
10
20
30
40
50
60
70
80
90
100
110
120
130
Year
Prediction
Recovery


P4 (Layer 5)
Water Level (mAHD)
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260
240
220
200
180
160
140
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100
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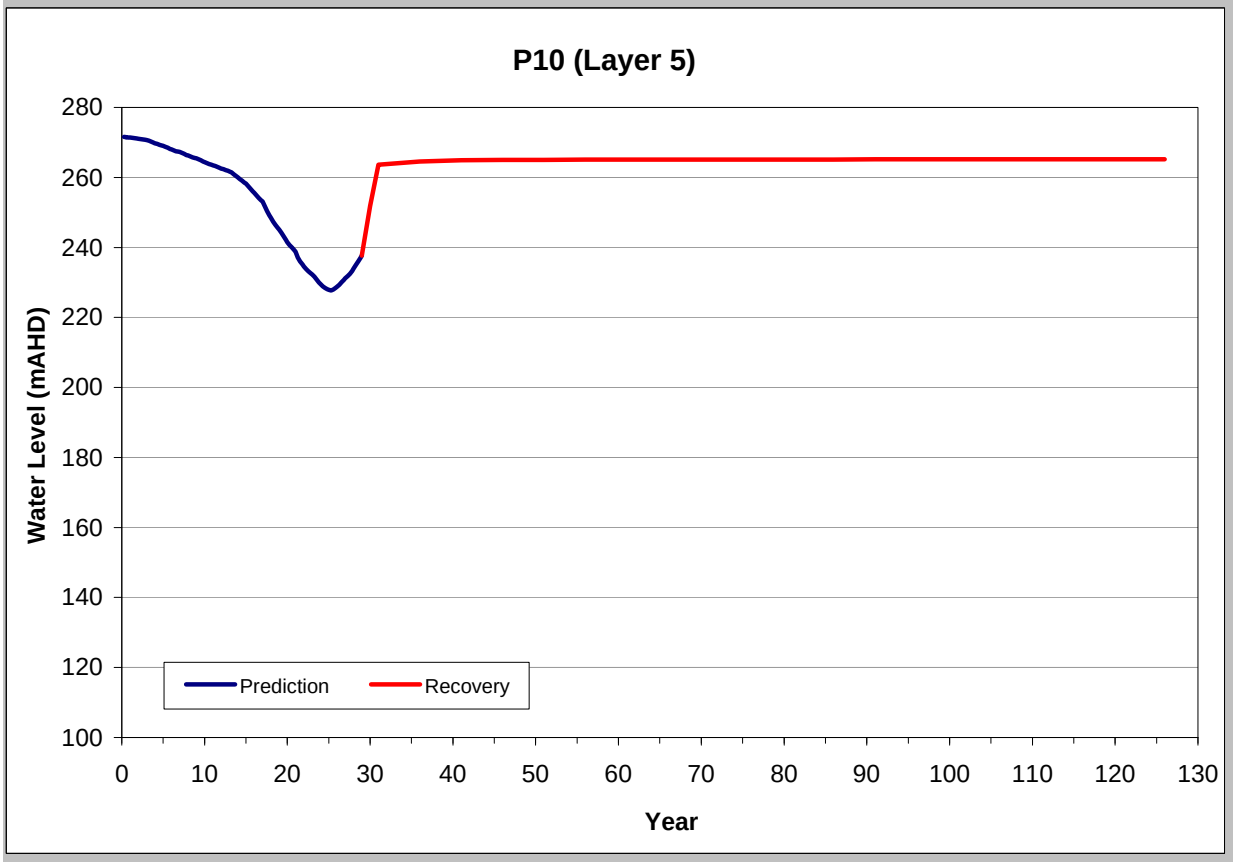
10
20
30
40
50
60
70
80
90
100
110
120
130
Year
Prediction
Recovery


P10 (Layer 5)
Water Level (mAHD)
280
260
240
220
200
180
160
140
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20
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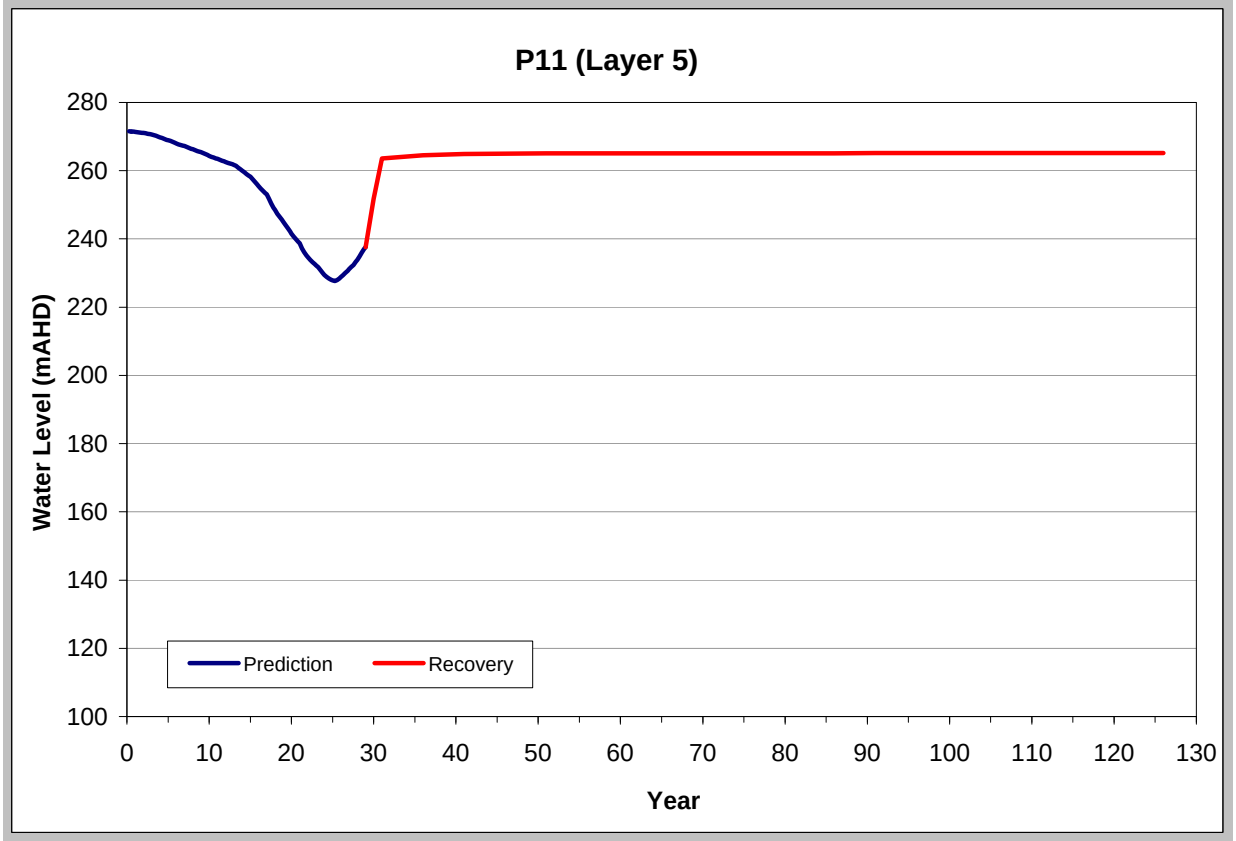
60
70
80
90
100
110
120
130
Year
Prediction
Recovery


P11 (Layer 5)
Water Level (mAHD)
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260
240
220
200
180
160
140
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20
30
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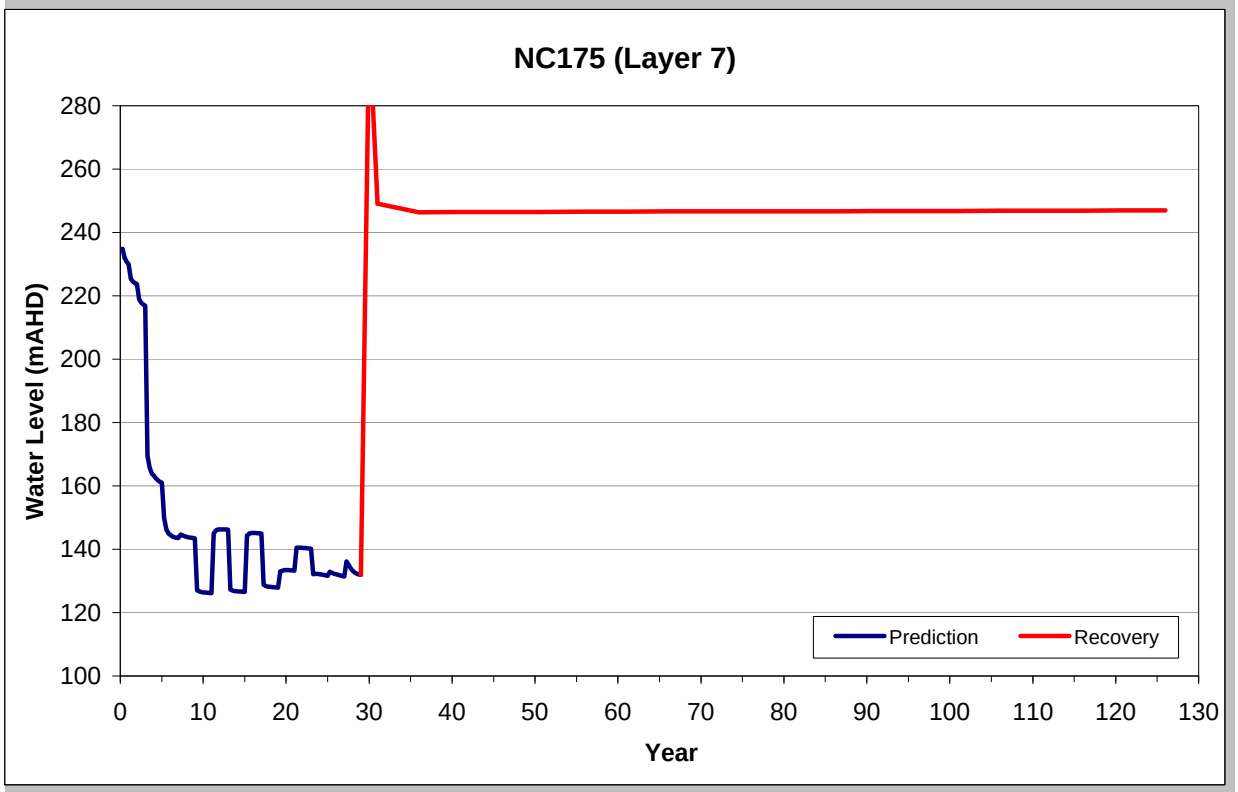
120
130
Year
Prediction
Recovery


NC175 (Layer 7)
Water Level (mAHD)
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260
240
220
200
180
160
140
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100
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20
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40
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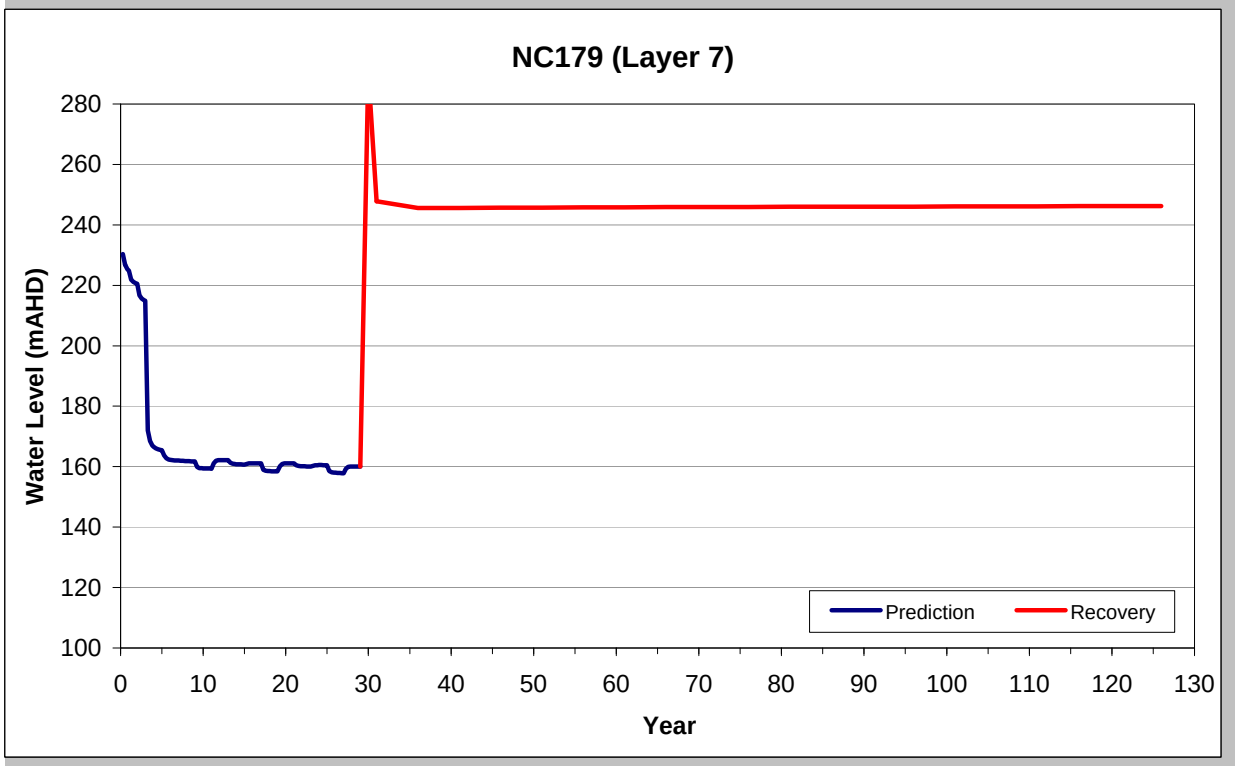
90
100
110
120
130
Year
Prediction
Recovery


NC179 (Layer 7)
Water Level (mAHD)
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220
200
180
160
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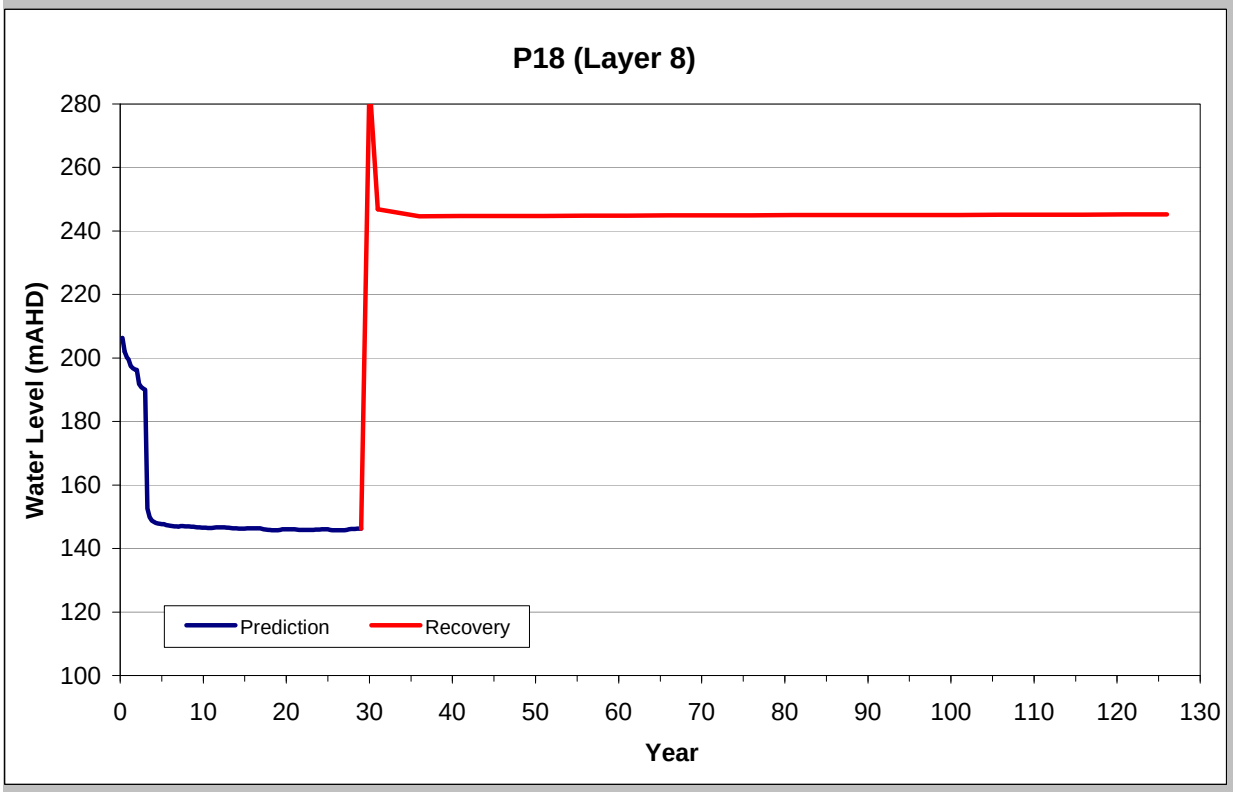
130
Year
Prediction
Recovery


P18 (Layer 8)
Water Level (mAHD)
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260
240
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200
180
160
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10
20
30
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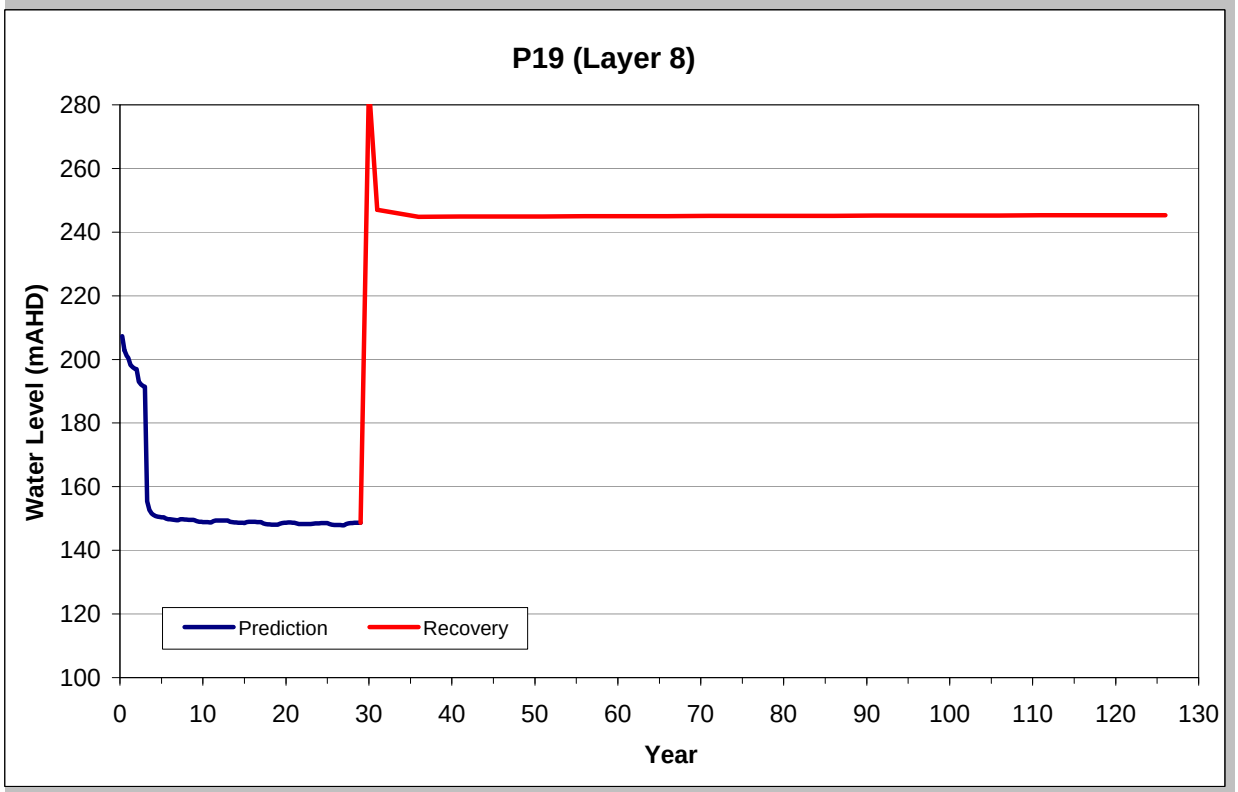
130
Year
Prediction
Recovery


P19 (Layer 8)
Water Level (mAHD)
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260
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220
200
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160
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20
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100
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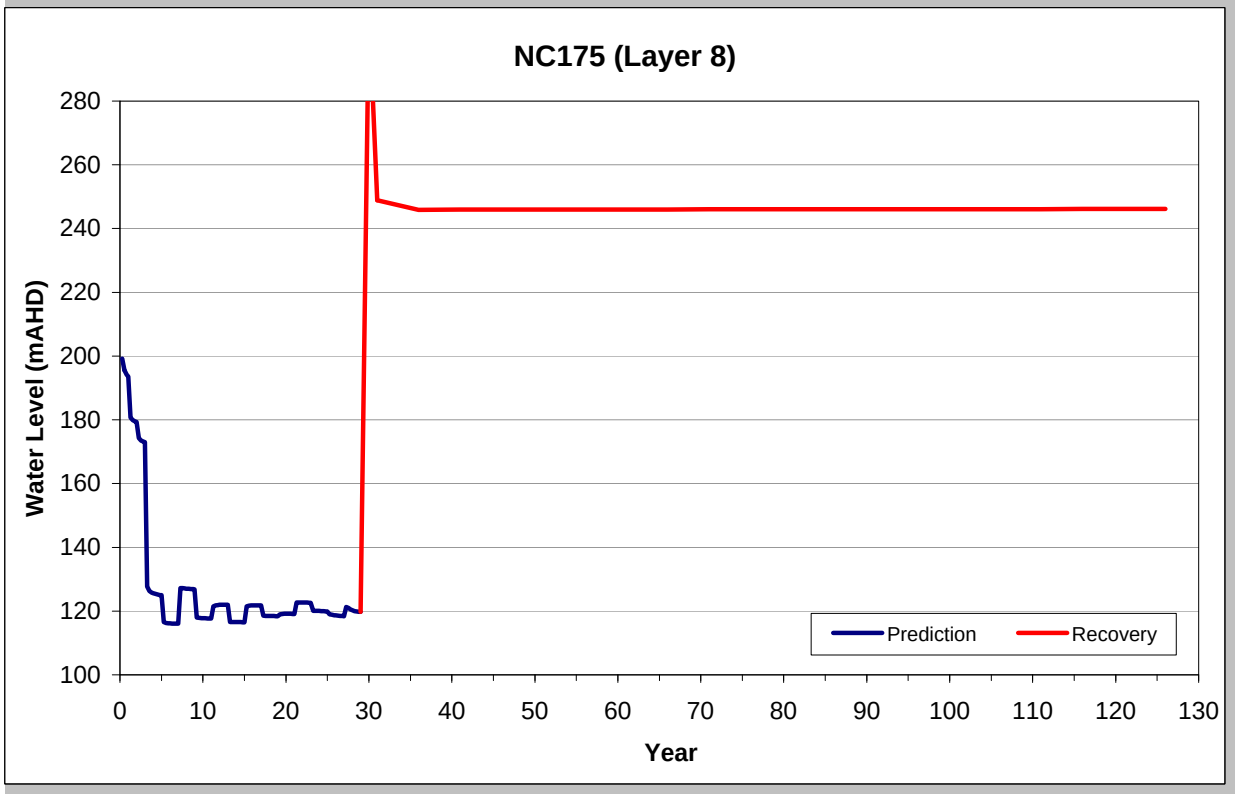
130
Year
Prediction
Recovery


NC175 (Layer 8)
Water Level (mAHD)
280
260
240
220
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180
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100
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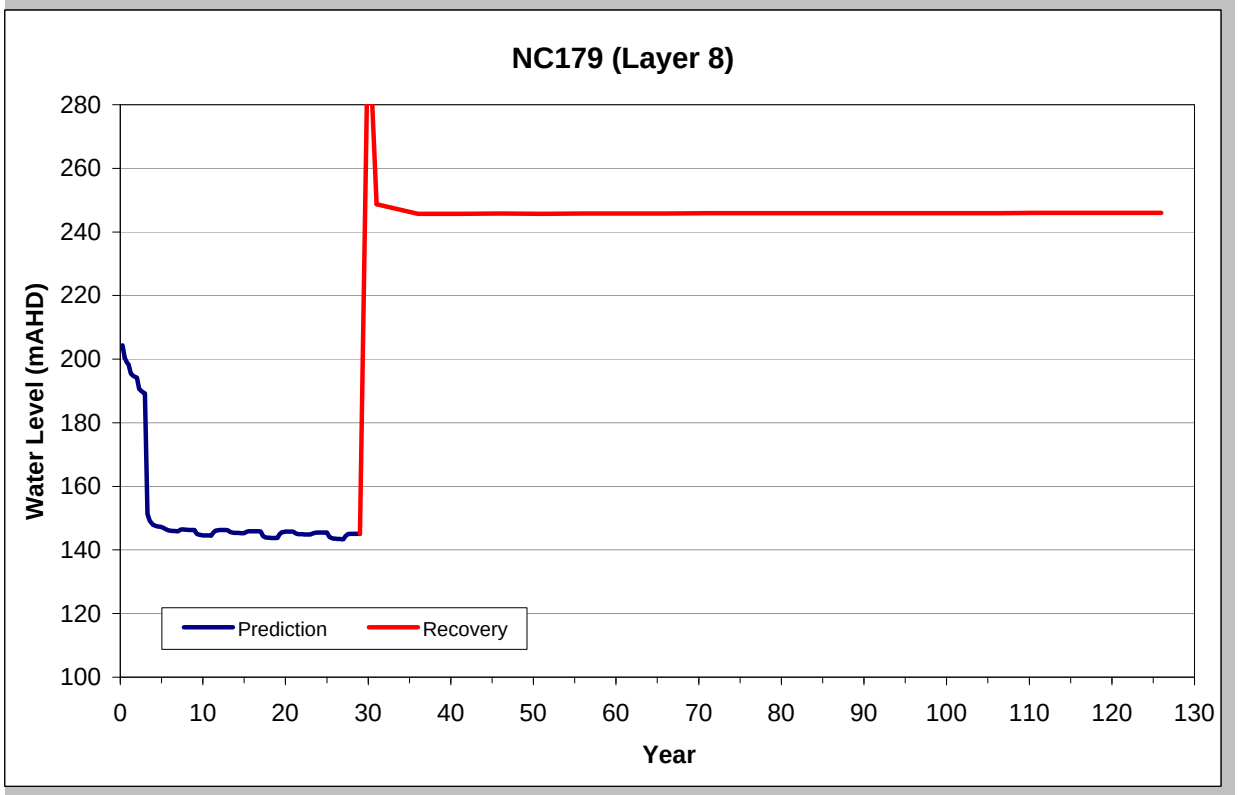
130
Year
Prediction
Recovery


NC179 (Layer 8)
Water Level (mAHD)
280
260
240
220
200
180
160
140
120
100
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20
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40
50
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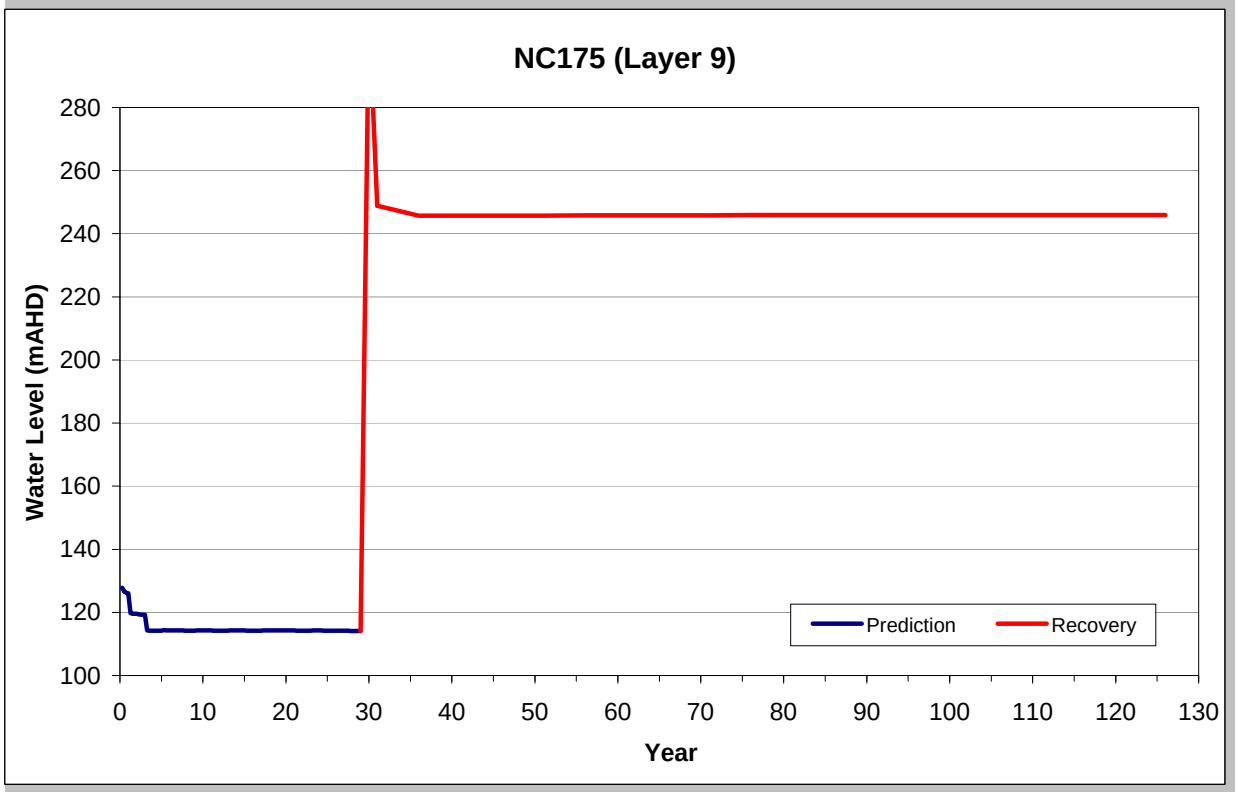
100
110
120
130
Year
Prediction
Recovery


NC175 (Layer 9)
Water Level (mAHD)
280
260
240
220
200
180
160
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100
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30
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60
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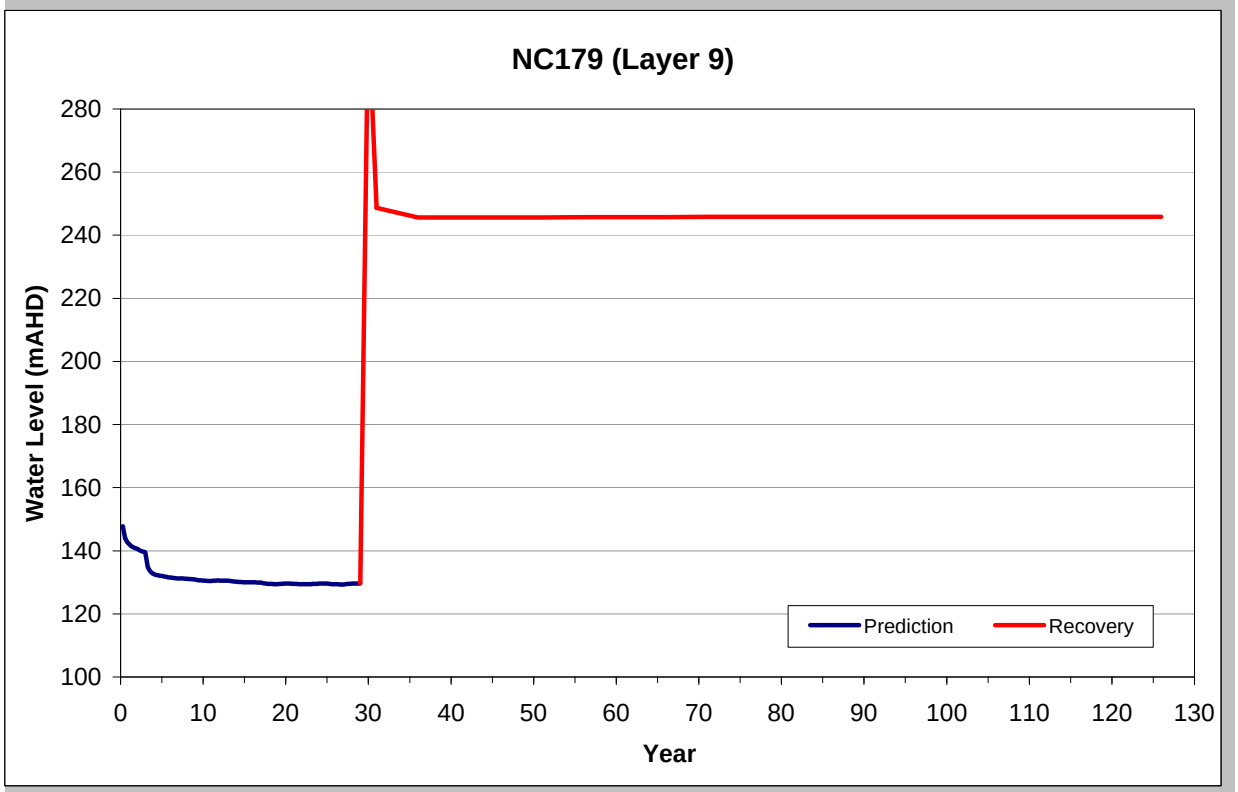
100
110
120
130
Year
Prediction
Recovery


NC179 (Layer 9)
Water Level (mAHD)
280
260
240
220
200
180
160
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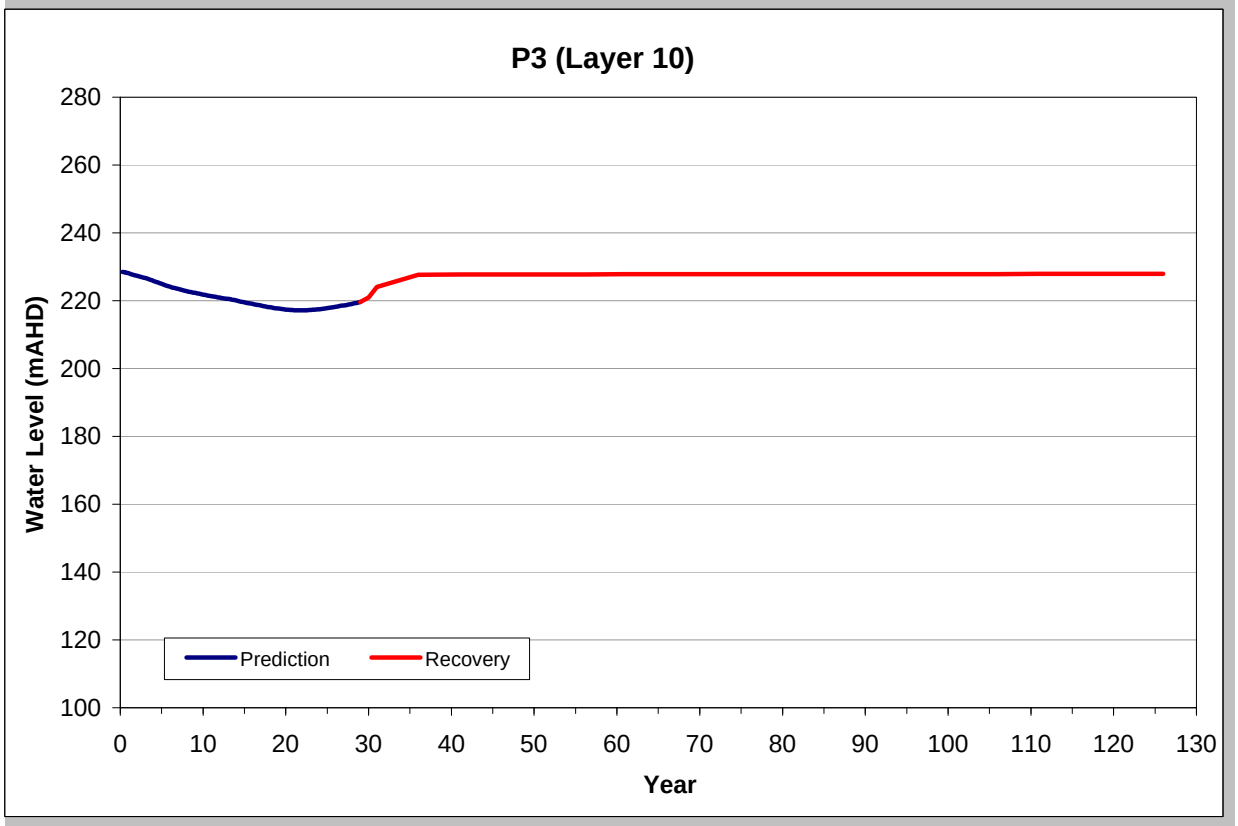
Year
Prediction
Recovery


P3 (Layer 10)
Water Level (mAHD)
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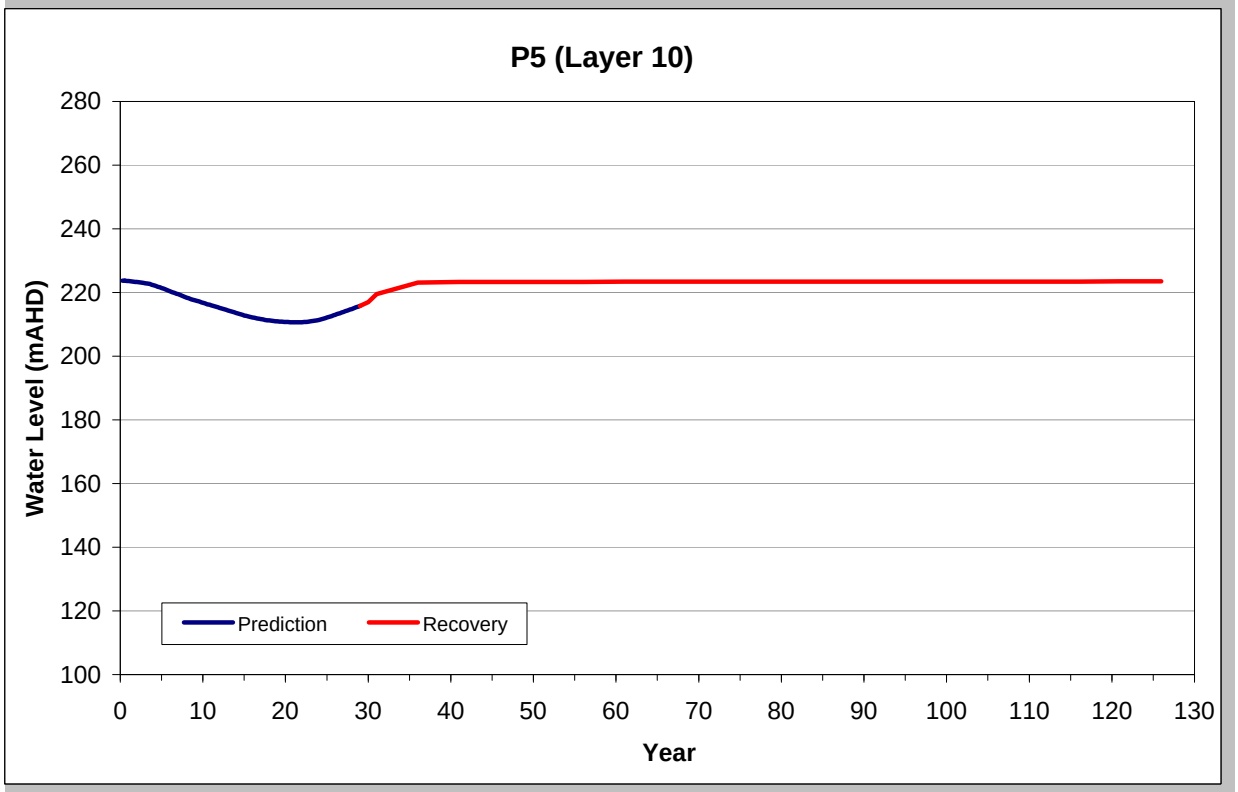
Year
Prediction
Recovery


P5 (Layer 10)
Water Level (mAHD)
280
260
240
220
200
180
160
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30
40
50
60
70
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90
100
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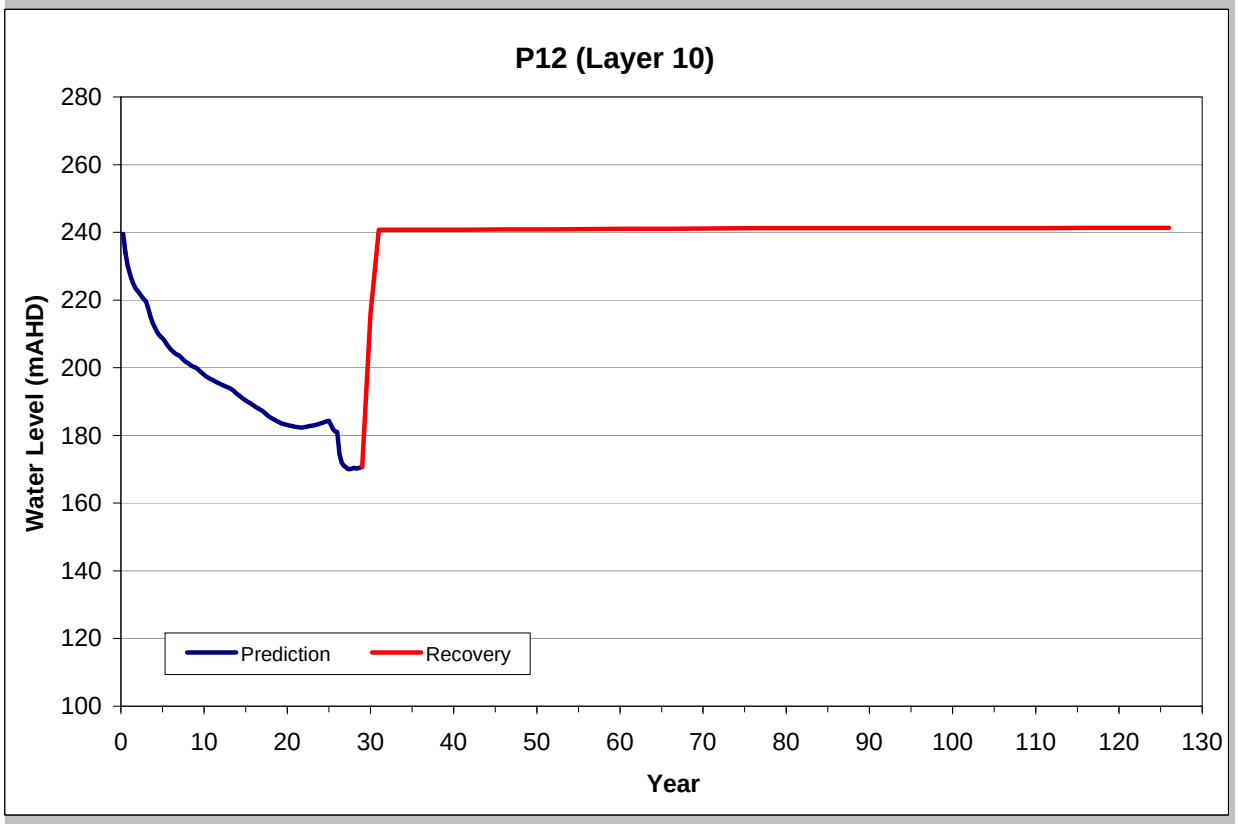
130
Year
Prediction
Recovery


P12 (Layer 10)
Water Level (mAHD)
280
260
240
220
200
180
160
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40
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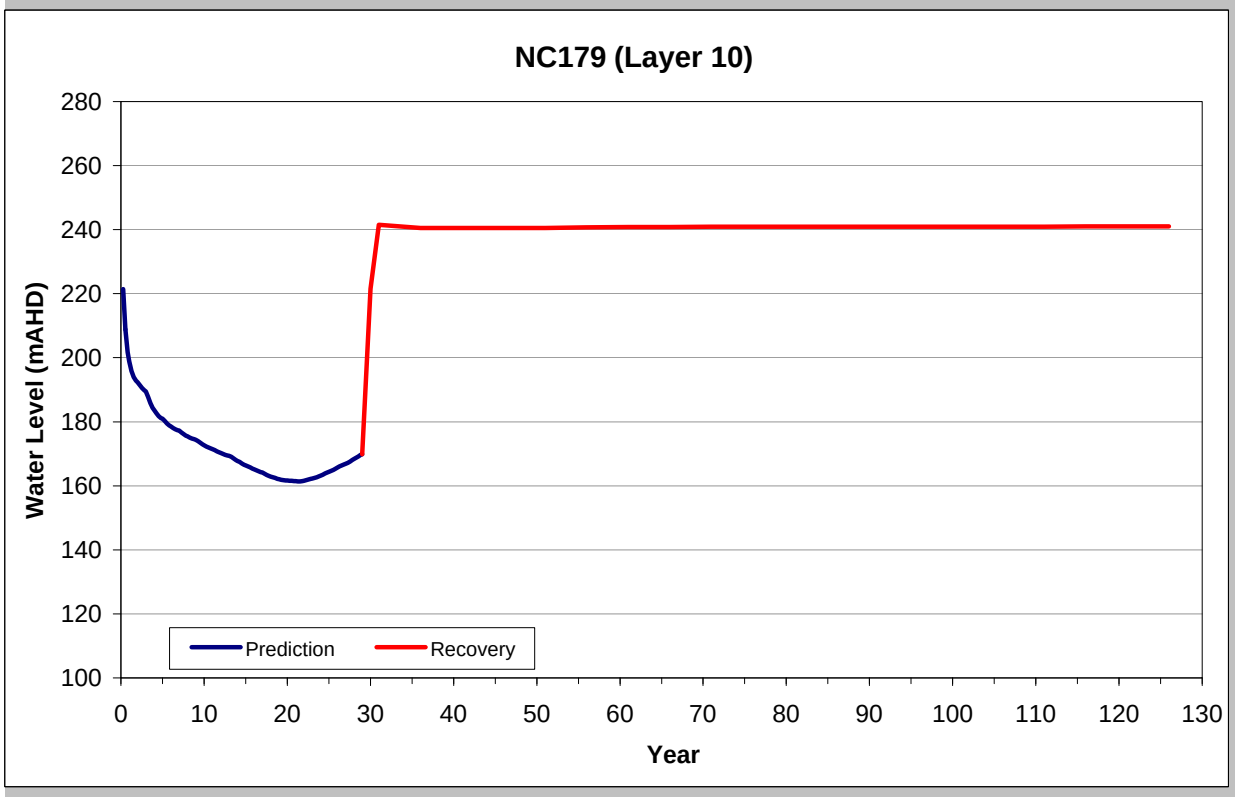
70
80
90
100
110
120
130
Year
Prediction
Recovery


NC179 (Layer 10)
Water Level (mAHD)
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260
240
220
200
180
160
140
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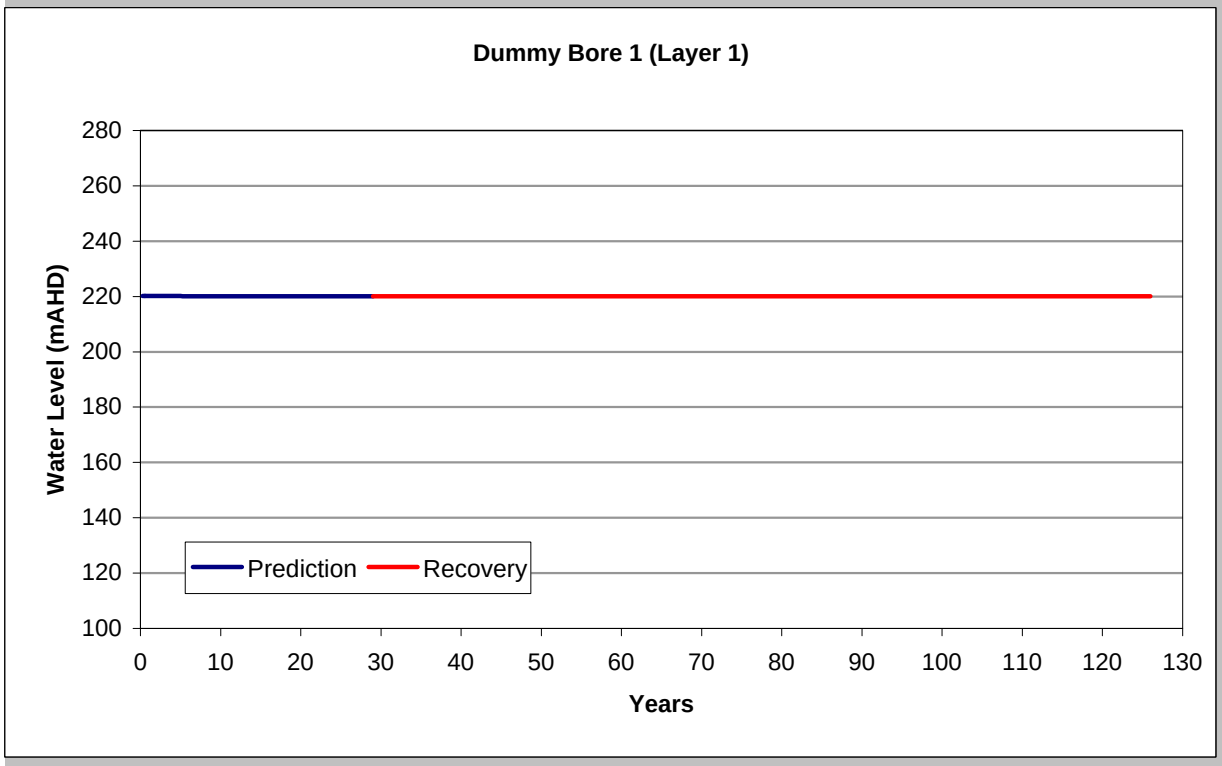
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Year
Prediction
Recovery


Dummy Bore 1 (Layer 1)
Water Level (mAHD)
280
260
240
220
200
180
160
140
120
100
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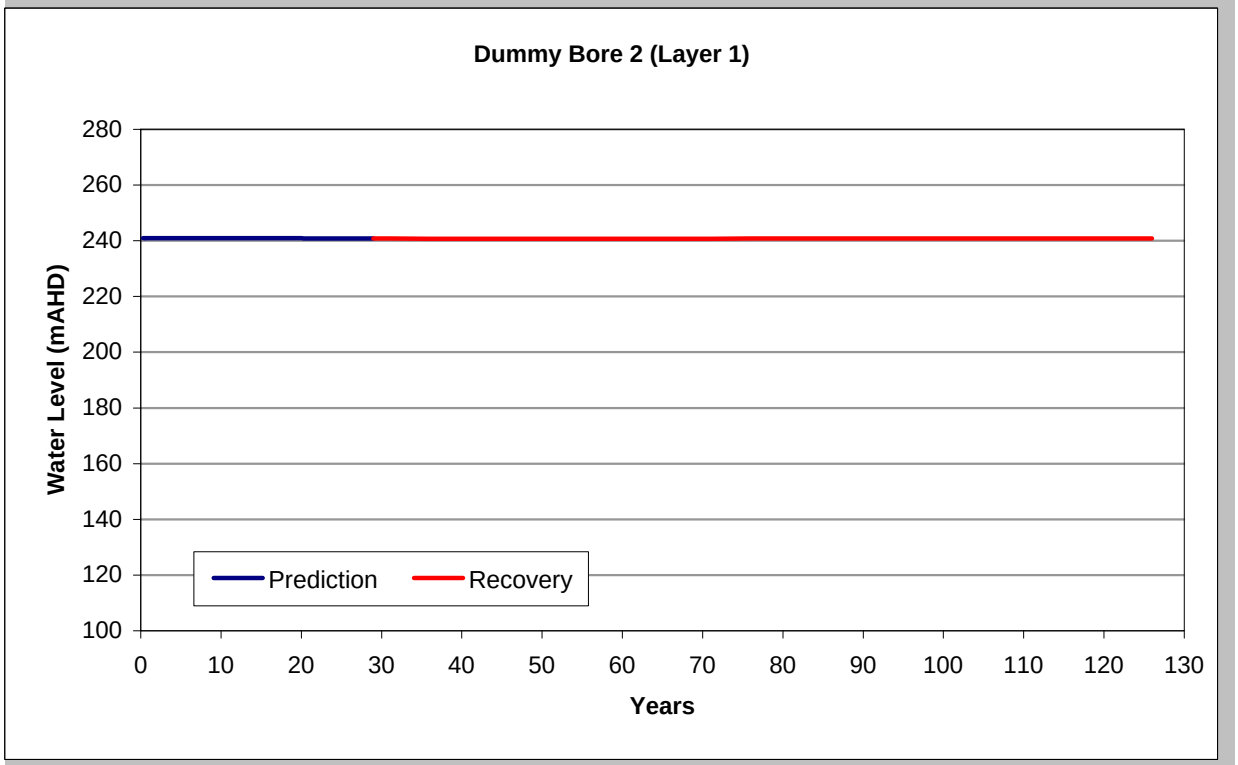
10
20
30
40
50
60
70
80
90
100
110
120
130
Years
Prediction
Recovery


Dummy Bore 2 (Layer 1)
Water Level (mAHD)
280
260
240
220
200
180
160
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120
100
0
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30
40
50
60
70
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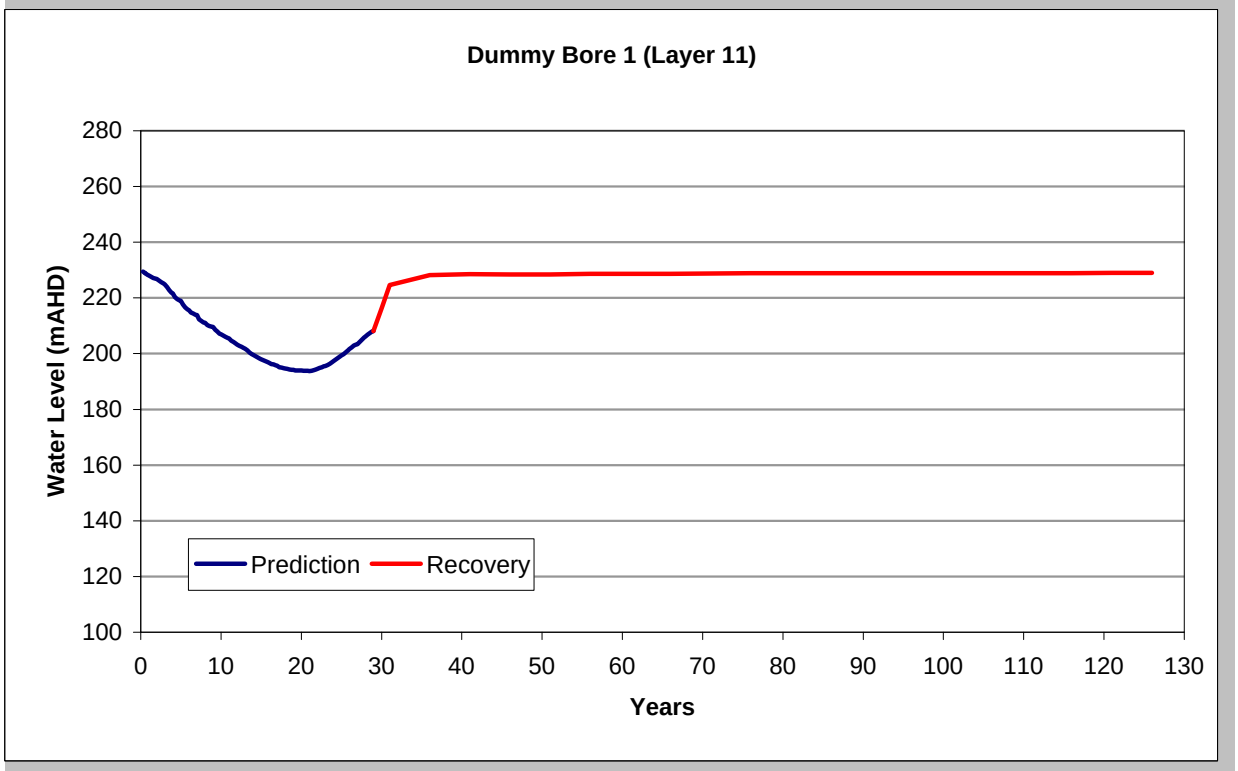
100
110
120
130
Years
Prediction
Recovery


Dummy Bore 1 (Layer 11)
Water Level (mAHD)
280
260
240
220
200
180
160
140
120
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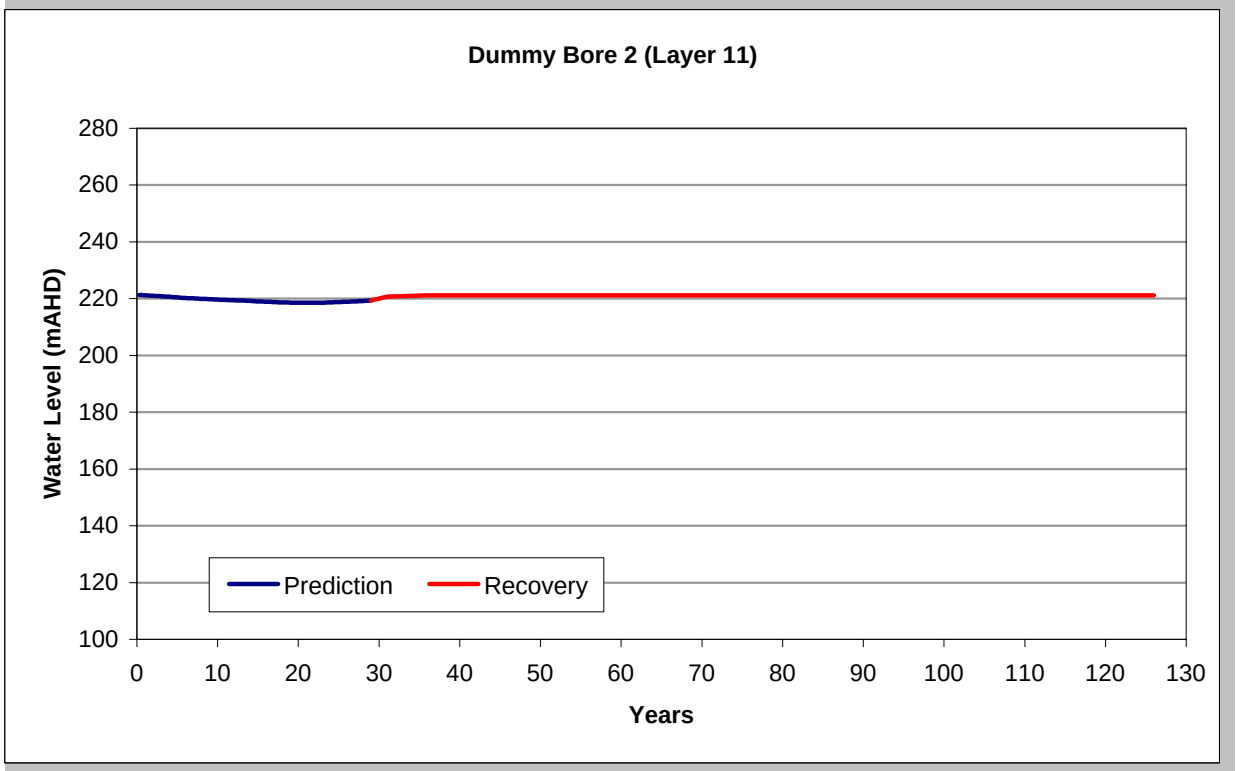
10
20
30
40
50
60
70
80
90
100
110
120
130
Years
Prediction
Recovery


Dummy Bore 2 (Layer 11)
Water Level (mAHD)
280
260
240
220
200
180
160
140
120
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Years
Prediction
Recovery

APPENDIX I

SHORT TERM PUMP TEST - CLAREMONT

Water and Environment

SHORT TERM PUMP TEST - CLAREMONT	
Prepared for	Narrabri Coal
Date of Issue	19 March 2009
Our Reference	S28/B5/043

aquaterra

SHORT TERM PUMP TEST - CLAREMONT	
Prepared for	Narrabri Coal
Date of Issue	19 March 2009
Our Reference	S28/B5/043

SHORT TERM PUMP TEST - CLAREMONT

	Date	Revision Description
Revision		

	Name	Position	Signature	Date
Originator				
Reviewer				

	Location	Address
Issuing Office	Sydney	Suite 9, 1051 Pacific Highway, Pymble NSW 2073 Tel +61 2 9440 2666 Fax +61 2 9449 3193

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TABLES

FIGURES

1 INTRODUCTION

1.1 BACKGROUND

Aquaterra Pty Ltd was engaged by Narrabri Coal to undertake a pump test and groundwater assessment for groundwater bores screened within the Garrawilla Volcanics and the Narrabri Coal Project Site, NSW.

Drilling of coal resource delineation holes has revealed that groundwater bearing zones with airlift rates of up to 2-3 l/s have been encountered in fractured rock above longwall panel 1 (LW1). These areas correlate with sub cropping Garrawilla Volcanics and it is suspected that the volcanics at shallow levels have higher degree of fracturing to that observed at deeper levels due to unloading of overburden.

The concern is that fracturing caused by longwall mining related subsidence could connect the coal seam with the Garrawilla Volcanics at shallow depths of cover (that is over the first longwall panel proposed to be mined) and lead to high rates of inflow into underground workings for short periods.

There are a number of groundwater bores scatted over the local area, which are predominantly windmill driven pumps used for stock watering purposes, which are installed and screened within the volcanic unit. Pump tests carried out on one of these shallow bores resulted in very low yields, which resulted in the bore test being terminated. Consultation with property managers reveals this is typical of most of the bores in the vicinity, and the lower yields are adequate for stock water purposes. Even though some of these bores are in close proximity to exploration holes in which high yields were observed, they do not appear to connect with the high yielding fractures encountered in the exploration drilling.

This could indicate that the fissure systems are not well interconnected or extensive, and hence overall volumes of storage within the volcanics could be low. If this is the case, then boreholes that do not intersect the fissure system should only be capable of yielding at high rates for short periods of time.

One bore has shown reasonable yields and is located on the Claremont Property. It is used to supply a dam and is located approximately 100 m from a monitoring bore (P13) which is screened within the volcanic unit. The bores construction details and pump setting are unknown although it is understood that the bore is screened at 30 m and the pump set 20 meters below ground level (mbgl). The pump is powered at the surface by a small diesel engine and is capable of yielding approximately 1 L/s.

A pump test was undertaken on this bore using the installed infrastructure to assess the basic hydraulic characteristics to assess the levels of storage that may exist within the fractured rock aquifer.

1.2 SCOPE OF WORK

The scope of work for this study comprised:

- Undertaking a 4 hour pump test on the bore with drawdown monitored during pumping and for a maximum of 4 hours during recovery.
- Collection of 1 water sample at 4 hours pumping time and submittal to laboratory for analysis of dissolved constituents.
    - Analysis and reporting comprising an assessment of
    - pump test results;
    - water quality against various criteria; and
    - impacts of bore operation on surrounding groundwater users and the environment.

2 PHYSICAL SETTING

2.1 TOPOGRAPHICAL SETTING

The Narrabri Project is located approximately 30 km southeast of Narrabri (Figure 1). The Project Site occupies the northern half of EL 6243, covers approximately 5 900 hectares and is located primarily in cleared grazing land (Figure 1.2).

The topography of the Project Site generally slopes to the east and northeast from over 300 m AHD in the southwest of the site to 270 m AHD in the east. While topography generally dips to the east and northeast, surface contours exhibit gentle undulations with surface drainage pathways occurring across the site in a north-easterly direction.

2.2 CLIMATE

The climate of the region is cool to temperate with seasonal climatic variations ranging from hot summers to cool winters. The average daily maximum temperature ranges from 35.3 ºC in January to 17.0 ºC in July.

2.2.1 RAINFALL

Rainfall data is available from Narrabri Airport (Station 54038).

Table 2.1 Long-term Average (LTA) Monthly Rainfall at Narrabri Airport (mm/day)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2.18	2.52	1.05	0.91	0.56	2.41	0.92	0.83	0.99	1.23	2.18	3.46	1.60

Source: Bureau of Meteorology (2008)

2.2.2 EVAPORATION

The nearest meteorological station with long term evaporation data is Tamworth Airport (Station 55054).

Table 2: Long-term Average Monthly Potential Evaporation Rates at Tamworth Airport (mm/day)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
8.6	8.1	6.9	4.6	2.9	2.0	2.1	3.0	4.4	6.0	7.6	8.7	5.4

Source: Bureau of Meteorology (2008)

3 PUMP TEST ANALYSIS

3.1 FIELD ACTIVITIES

A 4-hour constant discharge pumping test at a rate of 0.95 L/s was carried out in February 2009. A 10m discharge pipe was run discharge groundwater into a drainage channel to avoid potential recharge to the aquifer during the test. Uniform clay at surface is expected to have sealed the aquifer from recharge during this test. Water level drawdown was measured at appropriate time intervals using an electronic water level meter during the 4 hours of pumping and during the recovery.

One water sample was collected at the end of pumping time for submission to a NATA registered laboratory (Australian Laboratory Services Pty Ltd) for analysis. The sample was analysed for major ions (sodium, calcium, magnesium, potassium, chloride, and sulphate), alkalinity, dissolved metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury, and zinc), pH, electrical conductivity and total dissolved solids to assess the character of the groundwater.

The location of the Claremont property pump bore and P13 are shown in Figure 2.

3.2 PUMP TEST RESULTS

Drawdown data have been analysed using the Cooper-Jacob straight line method (Cooper and Jacob, 1946). Pumping and recovery phase drawdown data, together with the data analysis, are shown in Figures 3 and 4 respectively.

The static water level in the bore prior to the pump test was 5.24 metres below the top of casing (mbtoc). The water level dropped 1.5m in the first 2 minutes of pumping. After 2 minutes, the rate of water level decline decreased markedly. By the end of the 4 hour pumping phase the water level had declined to 6.77 mbgl (a drawdown of 1.77 metres). Following pumping, the water level recovered to 90% of the pre-pumping level in 2 minutes. It is assessed that no hydraulic barrier boundaries were intersected by the drawdown cone during the test.

The results of the pump test analyses are summarised in Table 3. The calculated hydraulic conductivity is an average value calculated using an assumed aquifer thickness of 37m (the interval between the lowest water level during the test to the base of the bore) and does not take into account vertical flow components (which are likely to be small). The average transmissivity of the volcanics is assessed to be around 75 m^2/day. This result indicates a higher permeability for the volcanic unit than normally encountered and suggests the influence of structural features.

No drawdown was observed in the nearest monitoring bore (P13).This is unusual given its proximity to the pumped borehole (approximately 100m) and indicates that almost all of the water abstracted during pumping was being rapidly taken from a fracture system that was not connected to the observation borehole.

Table 3: Summary of Hydraulic Testing

Item	Transmissivity (m^2/day)
Pumping Phase	100
Recovery Phase	75

3.3 LABORATORY ANALYTICAL RESULTS

Laboratory analytical results for water samples collected at end of pumping is summarised in Table 4. Species concentrations have been compared to ANZECC guidelines where concentrations of tested analytes are below relevant ANZECC guidelines except in the case of zinc for freshwater aquatic ecosystems. The groundwater is essentially pH neutral and is

dominated by bicarbonate and sodium ions. The overall water quality is good and the pH is within the ANZECC guideline range.

Table 4: Water Sample Laboratory Analytical Results

Sample ID	INVESTIGATION LEVELS						
Geological Origin							
Date of Sampling	Freshwater		Irrigation		Recreation		24/02/2009
GENERAL PARAMETERS							
pH			6-8.5	[2]	5.0-9.0	[3]	7.26
Electrical Conductivity							1080
MAJOR CATIONS							
Calcium							65
Magnesium							54
Sodium					300	[3]	97
Potassium							1
MAJOR ANIONS							
Sulphate as SO_4^{2-}					400	[3]	38
Chloride					400	[3]	126
Bicarbonate as $CaCO_3$							324
HEAVY METALS							
Arsenic	0.024	[1]	0.1	[2]	0.05	[3]	<0.01
Cadmium	0.0002	[1]	0.01	[2]	0.005	[3]	<0.001
Chromium	0.0033	[1,5]	0.1	[2]	0.05	[3]	<0.001
Copper	0.0014	[1]	0.2	[2]	1	[3]	0.001
Lead	0.0034	[1]	2	[2]	0.05	[3]	<0.001
Nickel	0.011	[1]	0.2	[2]	0.1	[3]	0.004
Zinc	0.008	[1]	2	[2]	5	[3]	0.011
Mercury	0.0006	[1]	0.002	[2]	0.001	[3]	<0.0001

NOTES:

100 Concentration exceeds the ANZECC Guidelines for protection of 95% species

100 Concentration exceeds the ANZECC Guidelines for irrigation (long term)

100 Concentration exceeds the ANZECC Guidelines for recreation purposes (secondary)

[1] Based on ANZECC (2000) trigger values for protection of 95% of fresh water species

[2] Based on ANZECC (2000) Long term trigger values for irrigation

[3] Based on ANZECC (2000) Water quality guidelines for recreational purposes (secondary)

[4]

3.4 LIMITING BORE YIELD

The limiting bore yield is the yield the bore is able to supply over a specified time frame without dewatering the bore. It is an operational concept related to bore completion and intended operation, and does not consider drawdown in the surrounding aquifer. A broad estimate of the limiting bore yield can be made using the method presented in Hazel (1973). This method adopts the following equation:

QL = QT sw/sp

Where (adopted values in brackets):

- QL is the limiting yield
- QT is the pump test discharge rate (0.95L/s)
- sw is the available drawdown (20m)
- sp is the drawdown in the bore measured during the pump test, extrapolated to an arbitrary time considered appropriate for the intended bore pumping schedule (365 days).

This calculation is approximate only, and makes no allowance for intersection of barrier (or recharge) boundaries. A time period of 365 days is adopted taking into account the intended use of the bore (see Hazel, 1973). The drawdown at 365 days extrapolated from pump test results is around 2m. Thus a broad estimate of the limiting bore yield is around 10L/s.

However, given the fact that water is being drawn from a fracture system of unknown size and extent, this may not be representative of the actual yield if abstraction continues for more than a few hours

4 CONCLUSIONS AND RECOMMENDATIONS

The aquifer was not highly stressed during the short pump test at the Claremont property, and the borehole is capable of yielding a significantly higher volume of groundwater than was extracted during this pump test. The lack of response in the nearby monitoring standpipe and the low level of drawdown in the bore during the test indicate that there is a level of storage within the fractured rock aquifer that was not clearly defined by a test of this size.

It is important to understand the level of storage that is contained within the fractured rock aquifer in order to understand the risk that is posed to underground mine workings. It is therefore recommended that the bore be retested at a higher rate of at least 3-5 l/s for a longer period. Ideally this should be at least 12 hours, although this does depend on well performance during the test. A test of this nature is recommended in order to better understand the extent and interconnectivity of the fractured rock aquifer and to better understand the risk this represents to LW1 in terms of elevated groundwater inflows caused by mining disturbance.

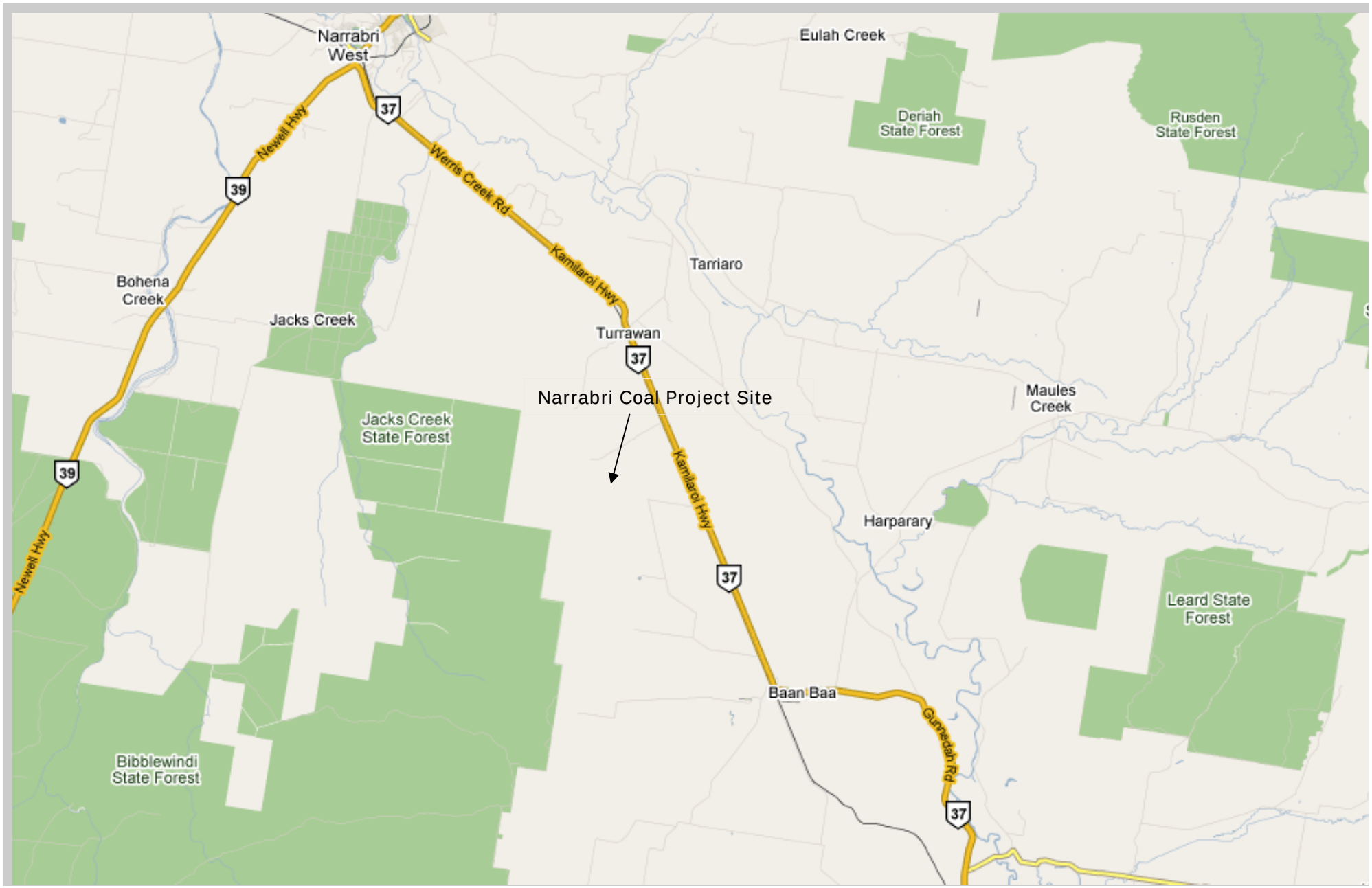
Because of the duration and size of the test, the calculation of bore yield limits (10l/s) is an approximation only and, given that boundary affects are likely to be experienced, constant pumping rates of this magnitude are unlikely to be sustainable. Personal communications with the property manager suggests that rates of 5 l/s lead to maximum drawdown within a 12 hour period.

Laboratory analytical results indicate that water quality is very good with a low overall TDS of 564 mg/l. The groundwater signature was dominated by high proportion of bicarbonate ions may indicate that this is a recharge area. The low overall level of dissolved ions also suggests that a significant proportion of recharge is of rainfall origin.

5 REFERENCES

Kruseman GP and de Ridder NA. 1994. Analysis and Evaluation of Pumping Test Data. Second Edition, International Institute for Land Reclamation and Improvement, Publication 47.

Water Resources Consulting Services, 1997. Bicarbonate Occurrence in Groundwater in the Baan Baa Area, NSW



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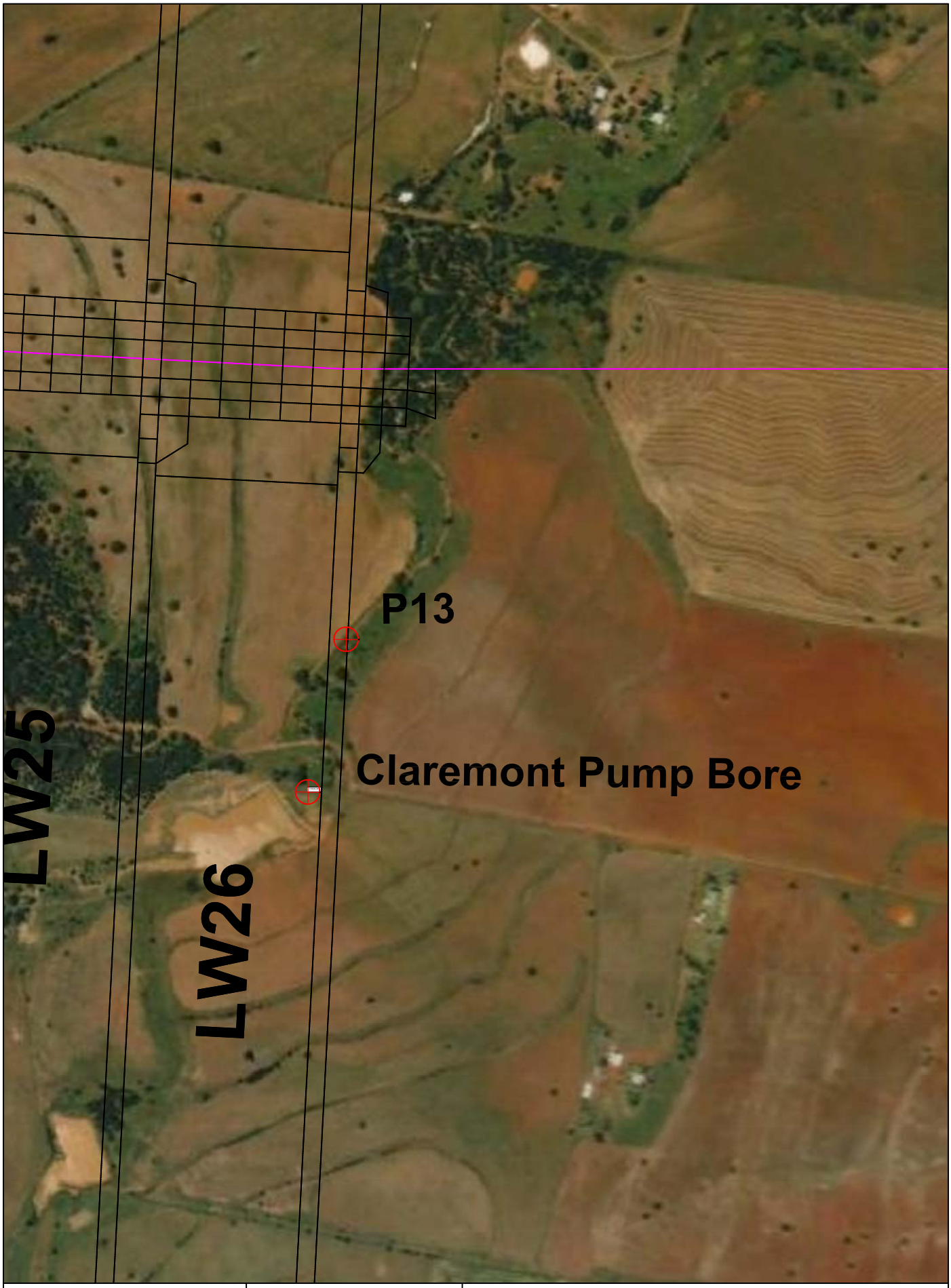
LOCATION DIAGRAM FIGURE 1



Date: 15 March 2009	Scale: NTS	**Narrabri Coal**	
Initials:	Job No: S28 / B5	**Pump Bore Location**	
Drawing No: S28-B5/02	Rev: A		
aquaterra			**Figure 2**

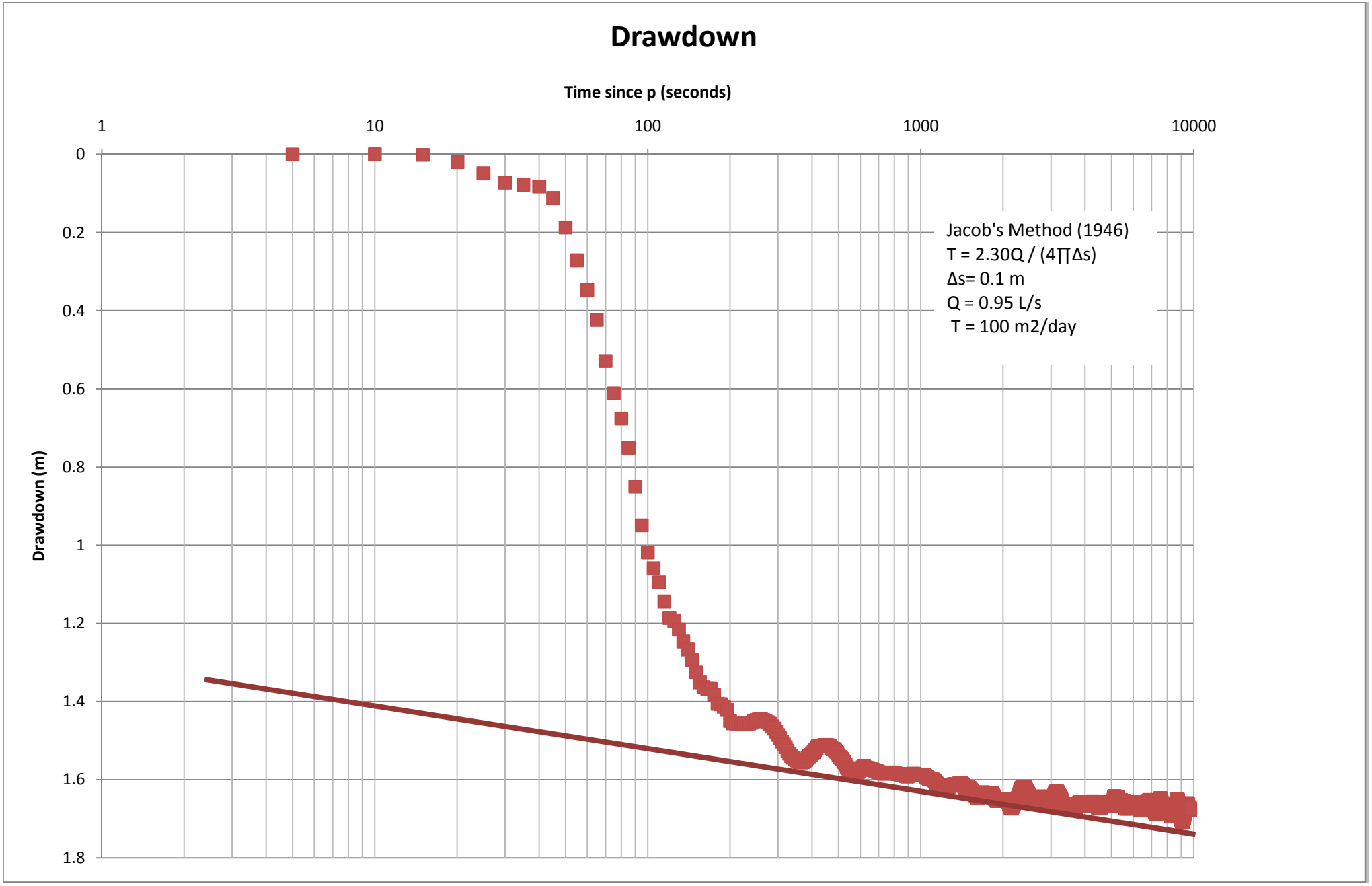


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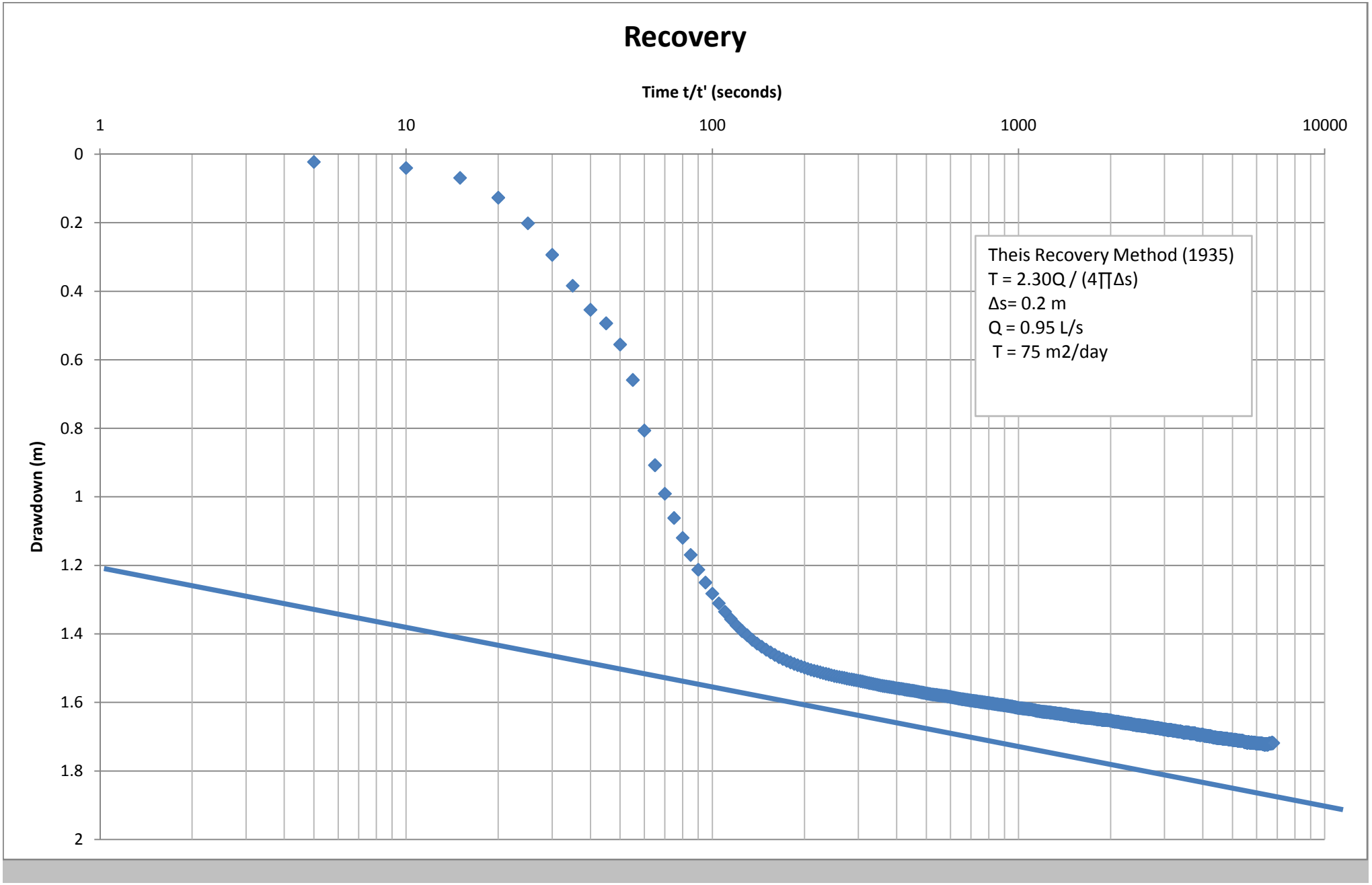
FIGURE 3 Drawdown



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Recovery Test FIGURE 4

In Australia

Perth
Suite 4
125 Melville Parade
Como WA 6152
Australia
Tel +61 8 9368 4044
Fax +61 8 9368 4055
perth@aquaterra.com.au

Adelaide
Ground Floor
15 Bentham Street
Adelaide SA 5000
Australia
Tel +61 8 8410 4000
Fax +61 8 8410 6321
adelaide@aquaterra.com.au

Sydney
Suite 9
1051 Pacific Highway
Pymble NSW 2073
Australia
Tel +61 2 9440 2666
Fax +61 2 9449 3193
sydney@aquaterra.com.au

In the UK

Lewes
Cobbe Barns
Beddingham, Lewes
East Sussex BN8 6JU
United Kingdom
Tel +44 1273 858 223
Fax +44 1273 858 229
lewes@aquaterra.uk.com

In Mongolia

Ulaanbaatar
701 San Business Center
7th khoroo
Sukhbaatar district
Ulaanbaatar
Mongolia
Tel +976 95854921
mongolia@aquaterra.mn

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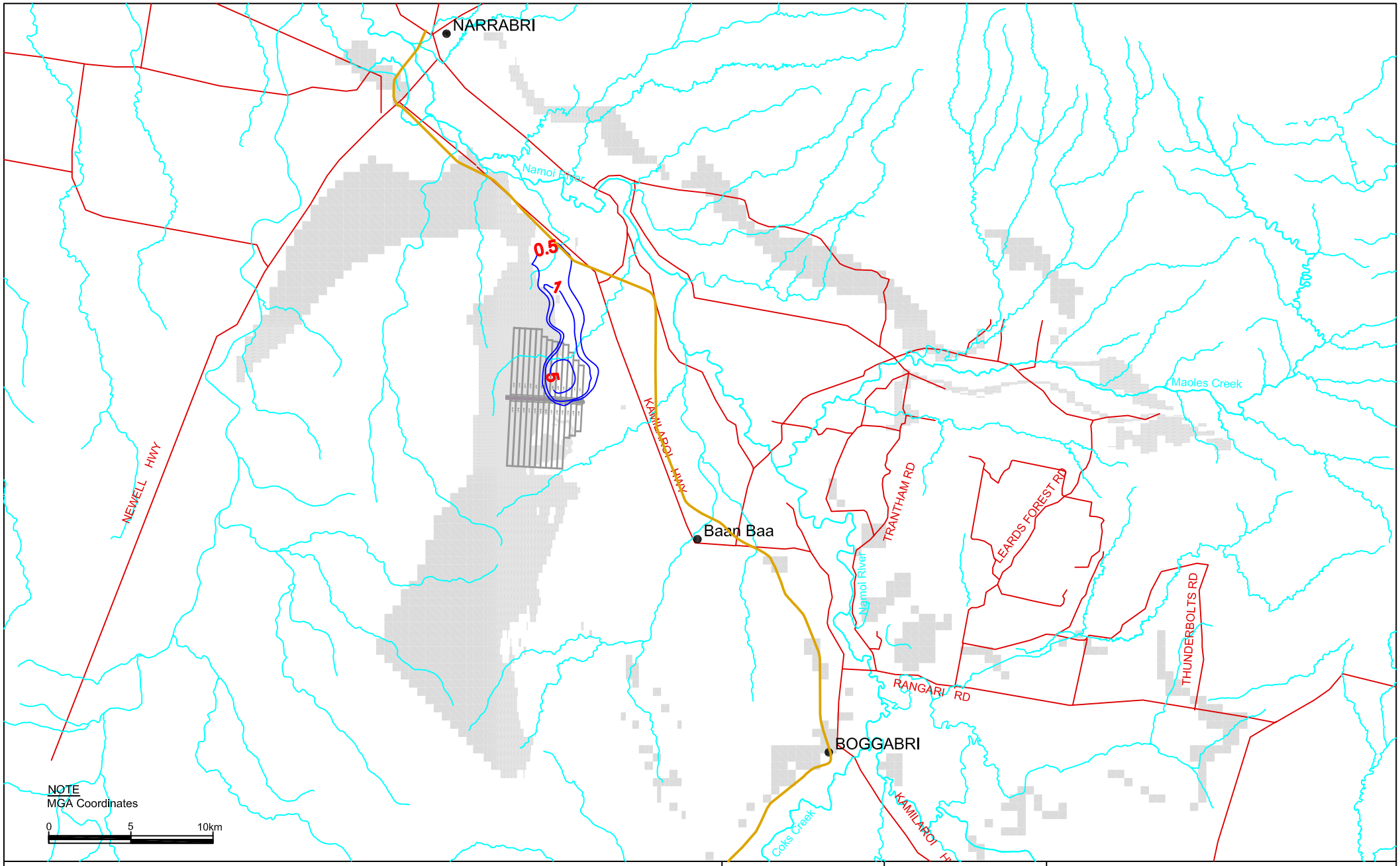
Water and Environment

APPENDIX J

NARRABRI DRAWDOWN AT THE END OF MINING



Legend

- Narrabri Underground Outline
- Roads or tracks
- Surface Water Drainage (Stream/Creek)
- 0.5 Predicted Groundwater Drawdowns (m AHD)
- Unsaturated area
- Alluvium Margin

Date:	17 August 2009	Scale:	As Shown
Initials:	PZ	Job No:	S28
Drawing No:	S28-036c	Rev:	C

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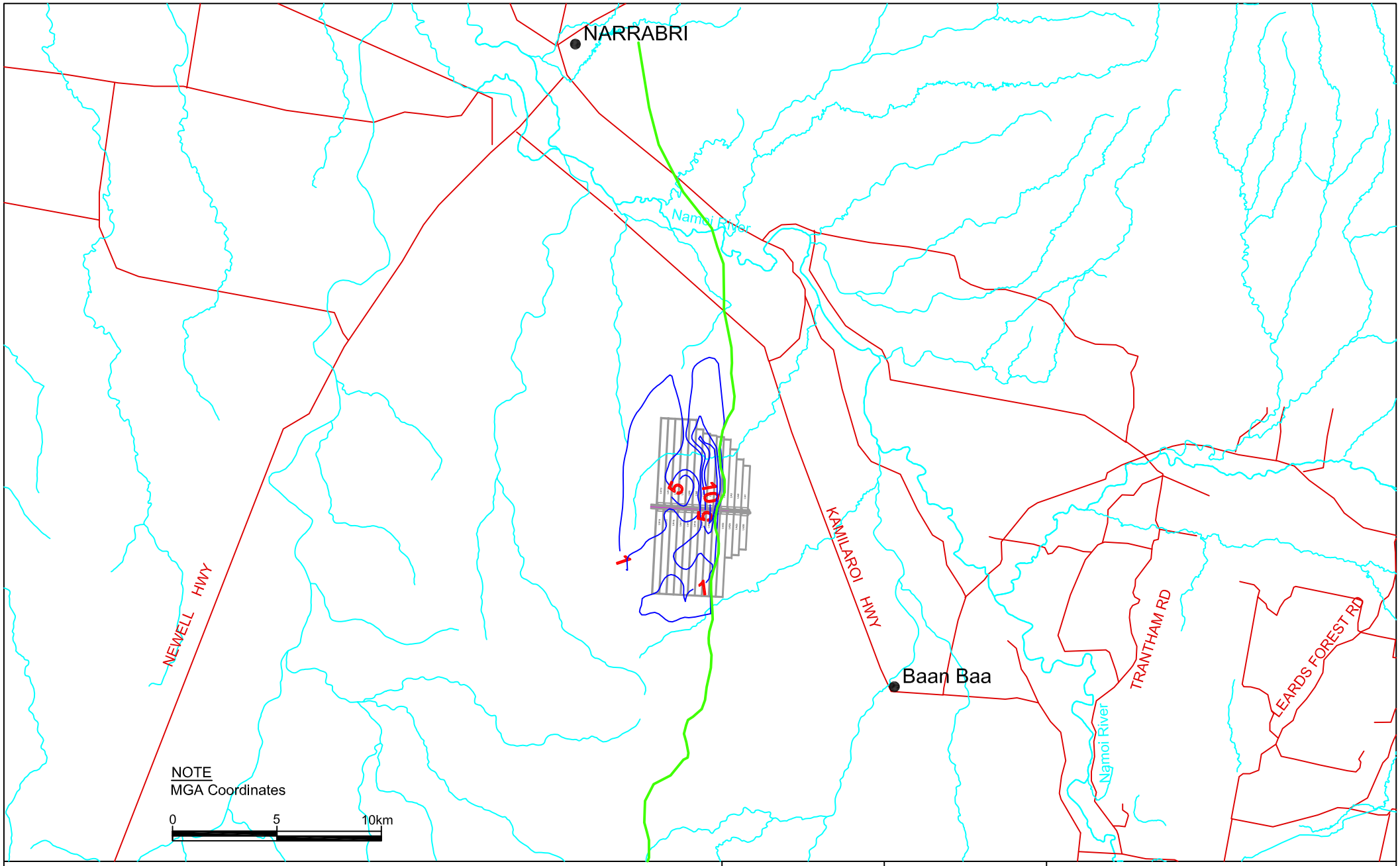
Narrabri Coal Pty Ltd

Drawdown after 29 Year in Alluvium / Colluvium / Regolith (Layer 1)

Appendix J



Legend

- Narrabri Underground Outline
- Roads or tracks
- Surface Water Drainage (Stream/Creek)
- 0.5 Predicted Groundwater Drawdowns (m AHD)
- Unsaturated area
- Pilliga Sandstone Sub Crop Margin

Date:	18 August 2009	Scale:	As Shown
Initials:	PZ	Job No:	S28
Drawing No:	S28-080	Rev:	0

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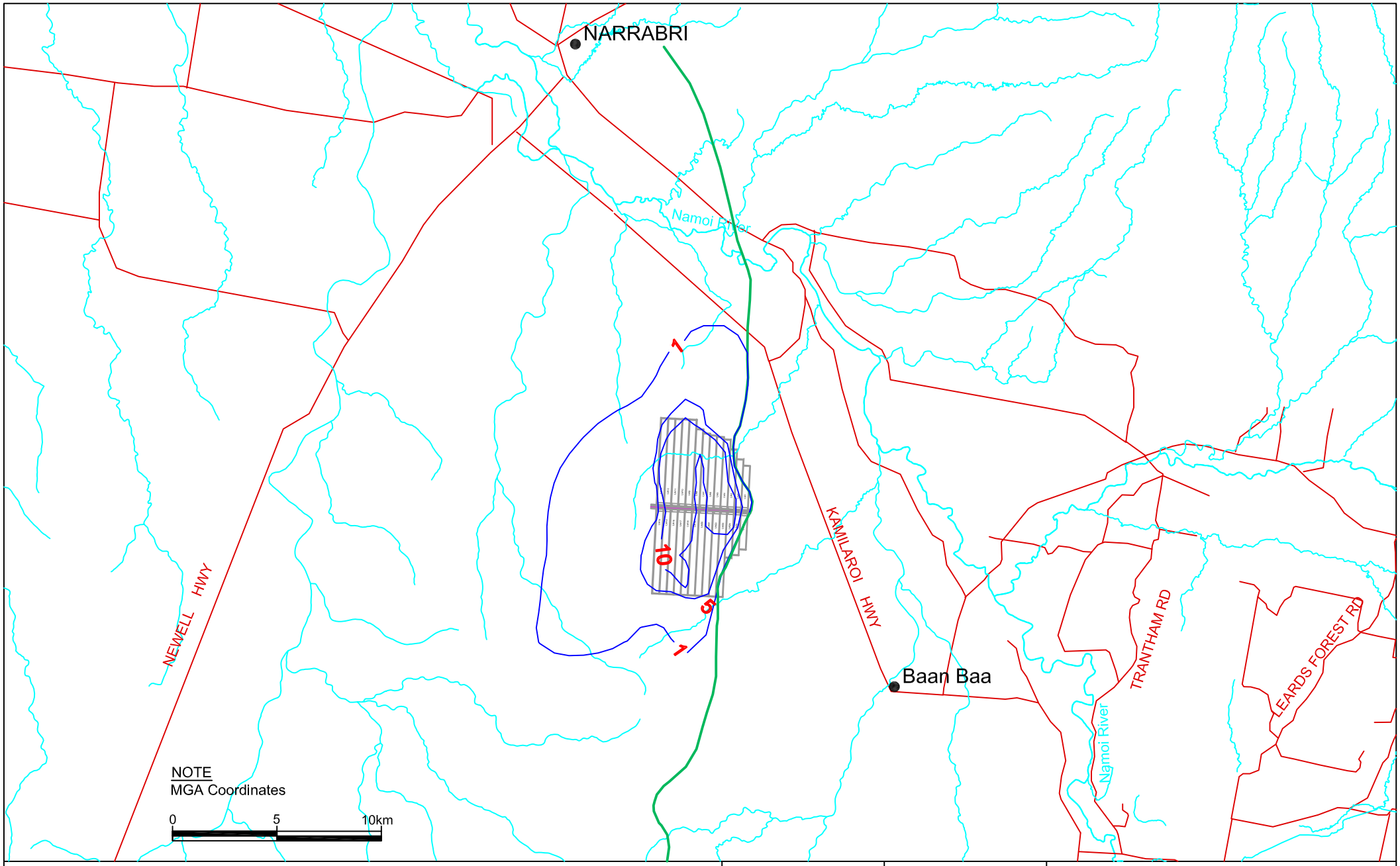
Narrabri Coal Pty Ltd

Drawdown after 29 Year in Pilliga Sandstone (Layer 2)

Appendix J



Legend

- Narrabri Underground Outline
- Roads or tracks
- Surface Water Drainage (Stream/Creek)
- 0.5 Predicted Groundwater Drawdowns (m AHD)
- Unsaturated area
- Purlawaugh Formation Sub Crop Margin

Date:	18 August 2009	Scale:	As Shown
Initials:	PZ	Job No:	S28
Drawing No:	S28-081	Rev:	0

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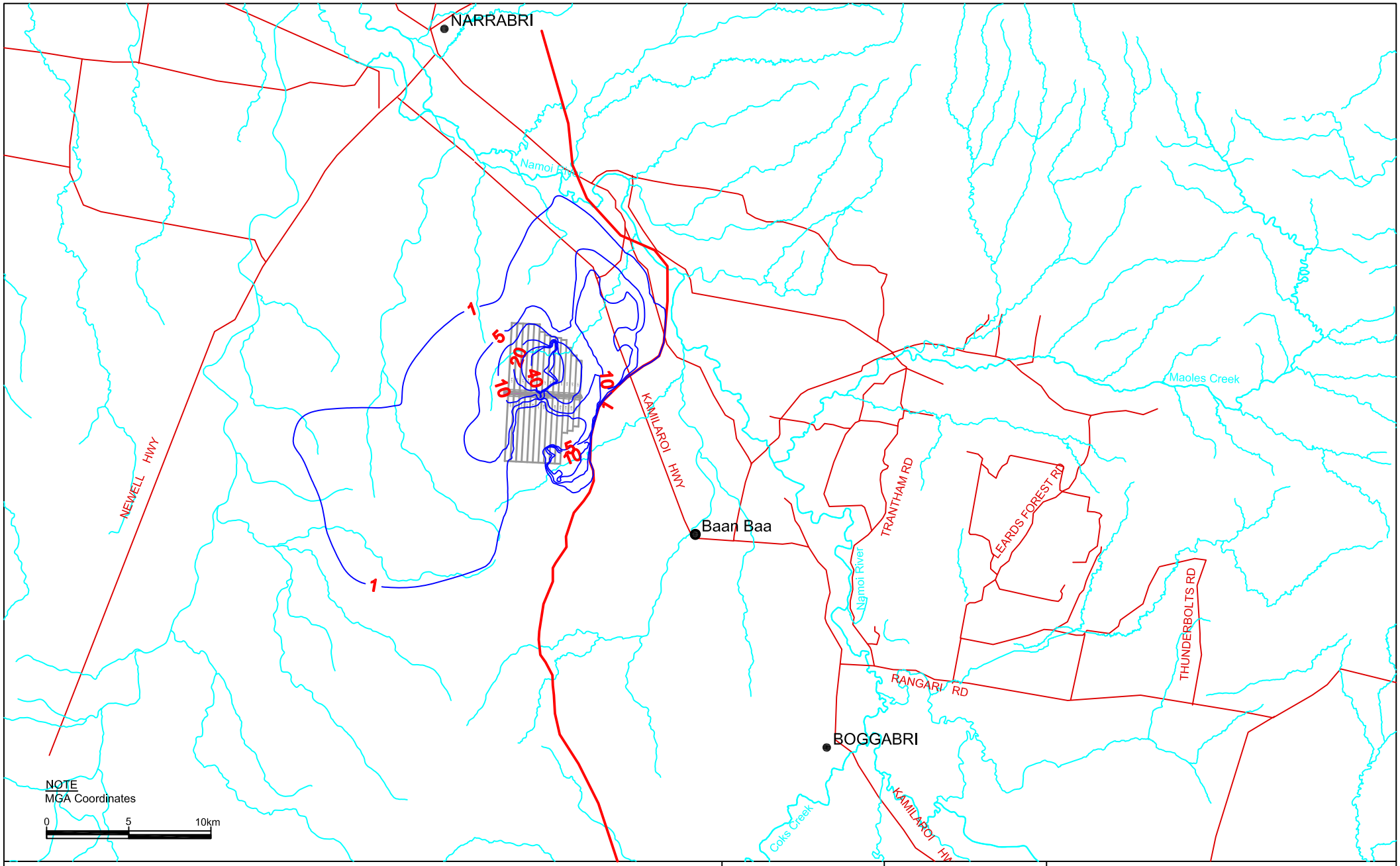
Narrabri Coal Pty Ltd

Drawdown after 29 Year in Purlawaugh Formation (Layer 3)

Appendix J



Legend

- Narrabri Underground Outline
- Roads or tracks
- Surface Water Drainage (Stream/Creek)
- 0.5 Predicted Groundwater Drawdowns (m AHD)
- Garrawilla Volcanics Sub Crop Margin

Date:	12 August 2009	Scale:	As Shown
Initials:	PZ	Job No:	S28
Drawing No:	S28-045g	Rev:	G

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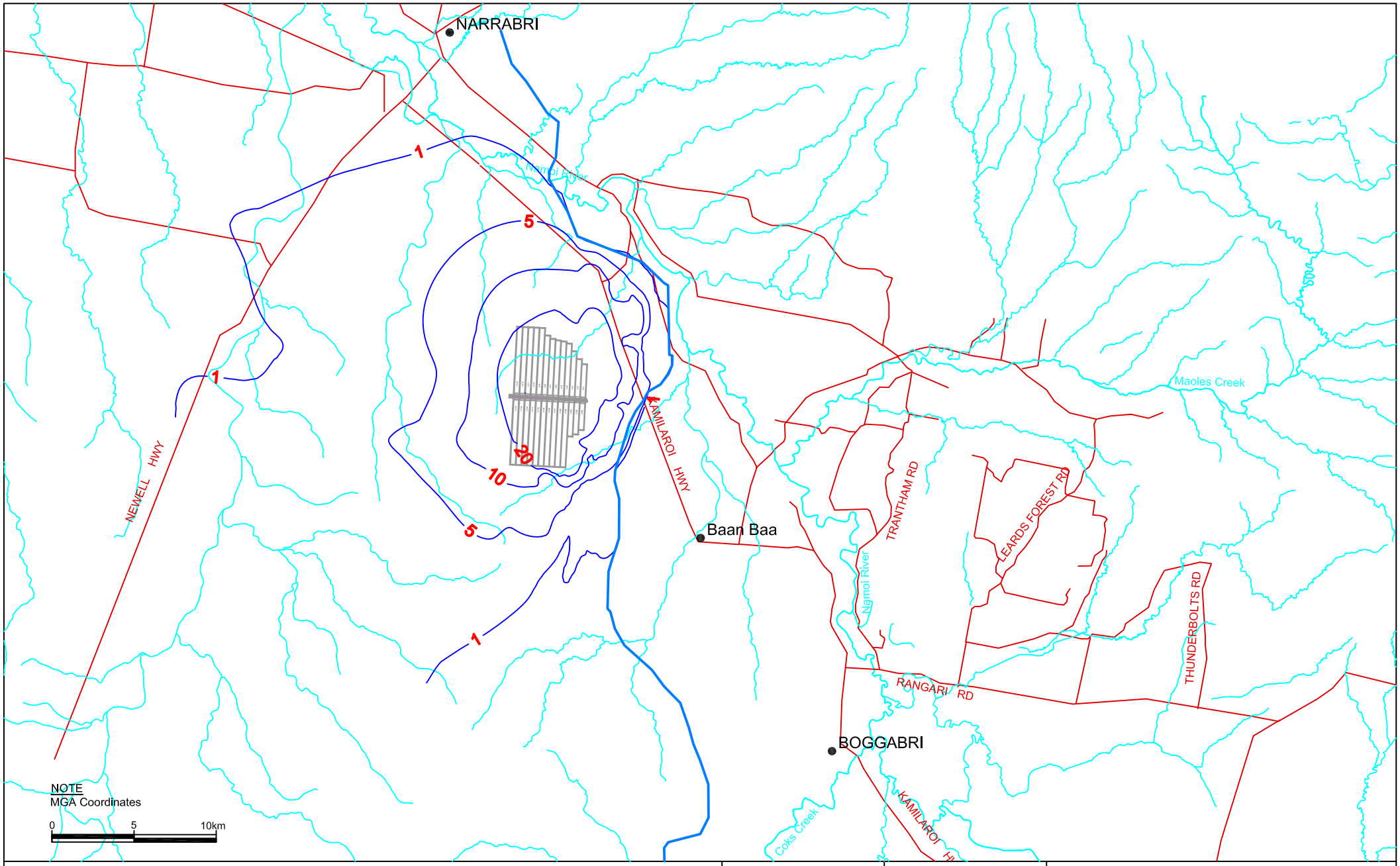
Narrabri Coal Pty Ltd

Drawdown after 29 Year in Garrawilla Volcanics (Layer 4)

Appendix J



Legend

- Narrabri Underground Outline
- Roads or tracks
- Surface Water Drainage (Stream/Creek)
- 5 Predicted Groundwater Drawdowns (m AHD)
- Napperby Formation Boundary

Date:	12 August 2009	Scale:	As Shown
Initials:	PZ	Job No:	S28
Drawing No:	S28-039c	Rev:	C

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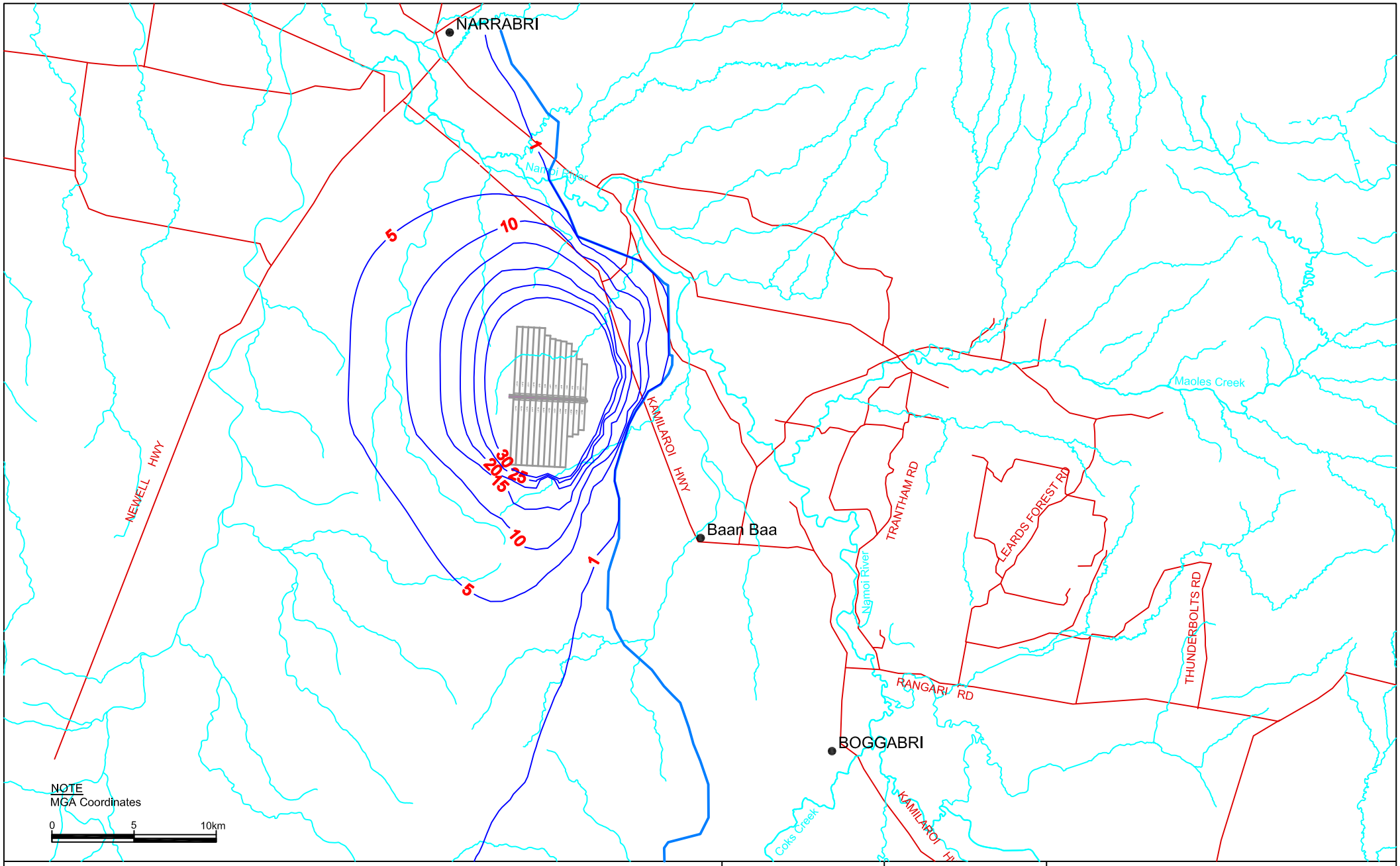
Narrabri Coal Pty Ltd

Drawdown after 29 Year in Napperby Formation (Layer 5)

Appendix J



Legend

- Narrabri Underground Outline
- Roads or tracks
- Surface Water Drainage (Stream/Creek)
- 5 Predicted Groundwater Drawdowns (m AHD)
- Napperby Formation Boundary

Date:	17 August 2009	Scale:	As Shown
Initials:	PZ	Job No:	S28
Drawing No:	S28-082	Rev:	0

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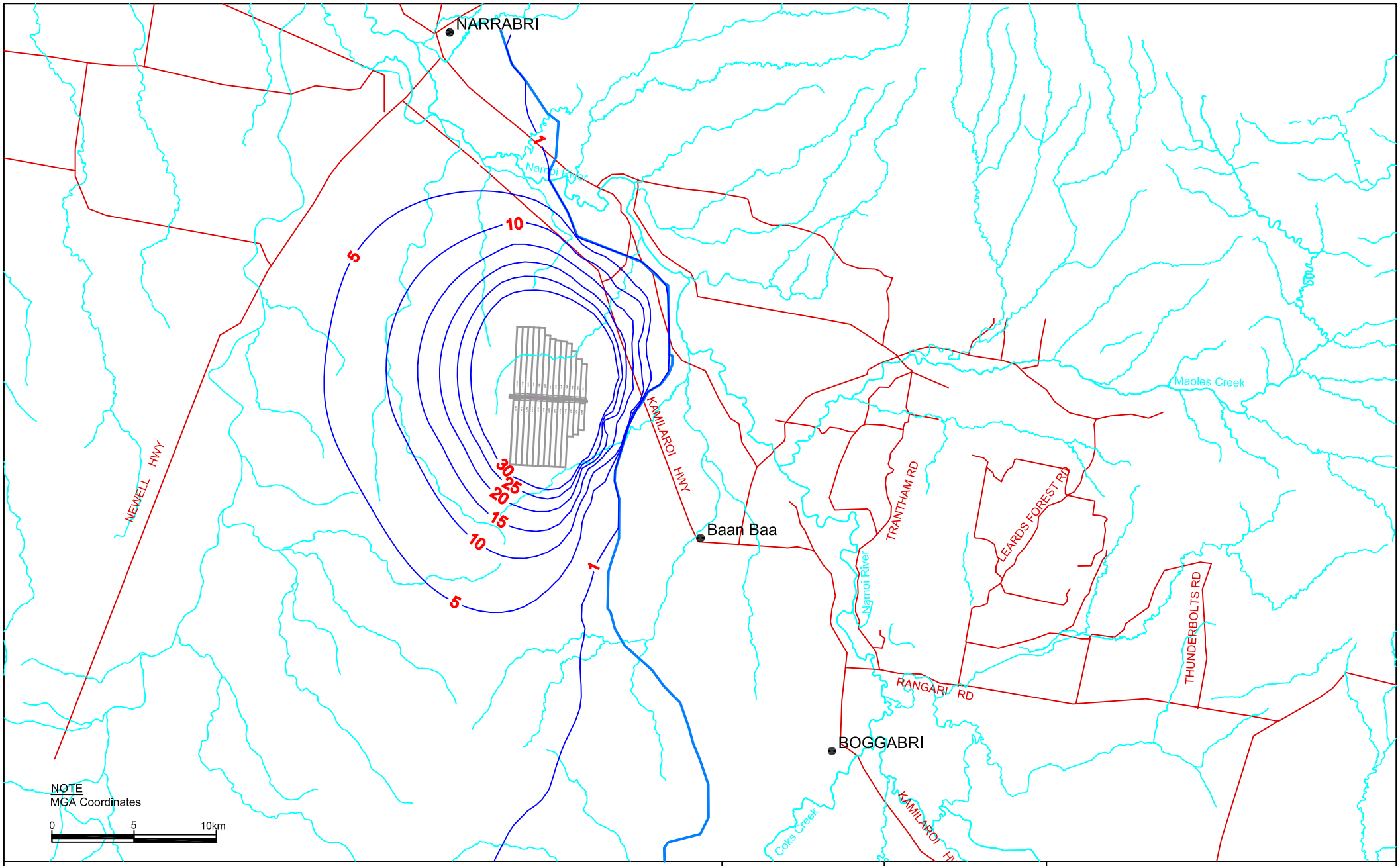
Narrabri Coal Pty Ltd

Drawdown after 29 Year in Napperby Formation (Layer 6)

Appendix J



Legend

- Narrabri Underground Outline
- Roads or tracks
- Surface Water Drainage (Stream/Creek)
- 5 Predicted Groundwater Drawdowns (m AHD)
- Napperby Formation Boundary

Date:	17 August 2009	Scale:	As Shown
Initials:	PZ	Job No:	S28
Drawing No:	S28-082	Rev:	0

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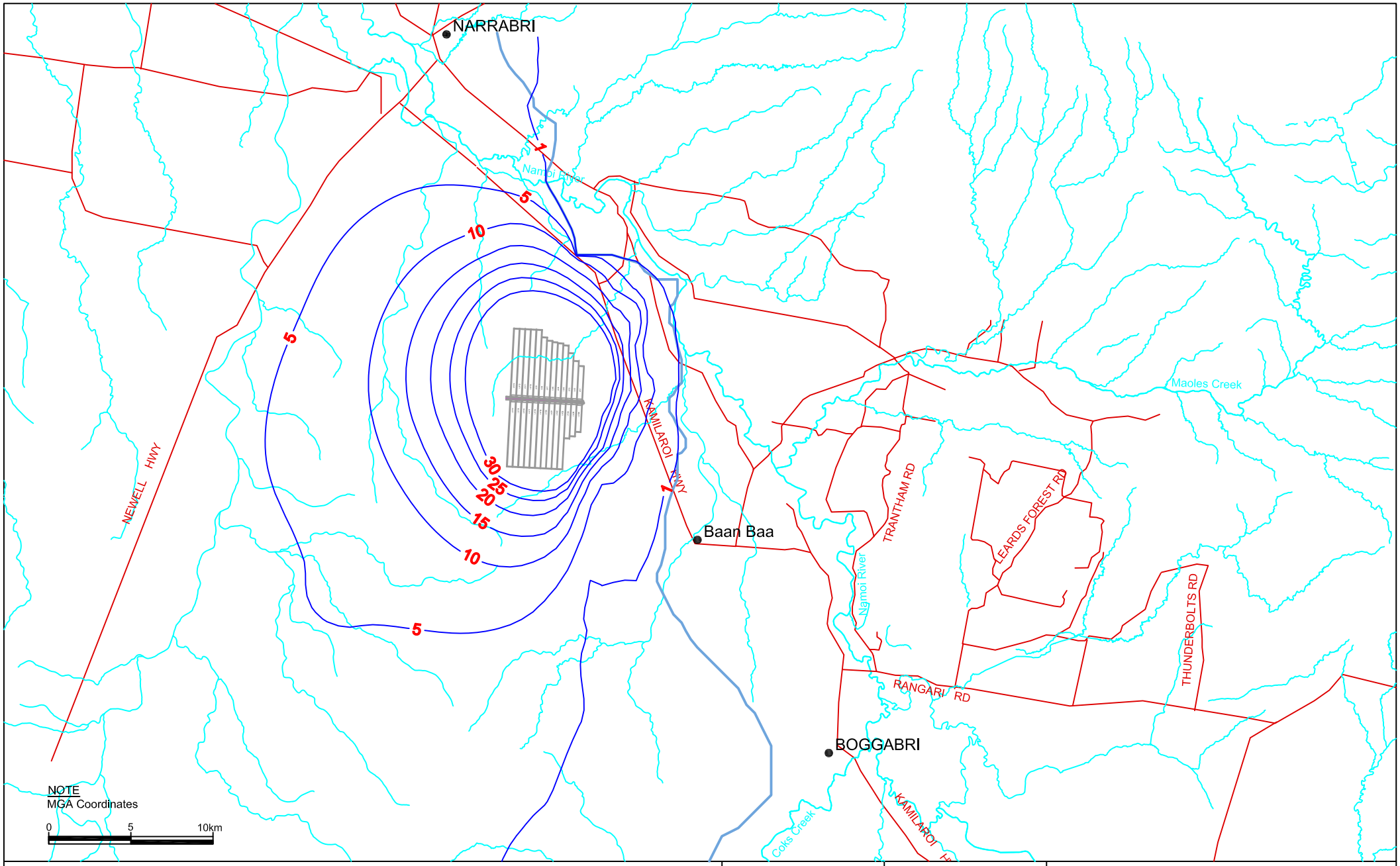
Narrabri Coal Pty Ltd

Drawdown after 29 Year in Napperby Formation (Layer 7)

Appendix J



Legend

- Narrabri Underground Outline
- Roads or tracks
- Surface Water Drainage (Stream/Creek)
- 5 Predicted Groundwater Drawdowns (m AHD)
- Digby Formation Sub Crop Margin

Date:	14 August 2009	Scale:	As Shown
Initials:	PZ	Job No:	S28
Drawing No:	S28-084	Rev:	0

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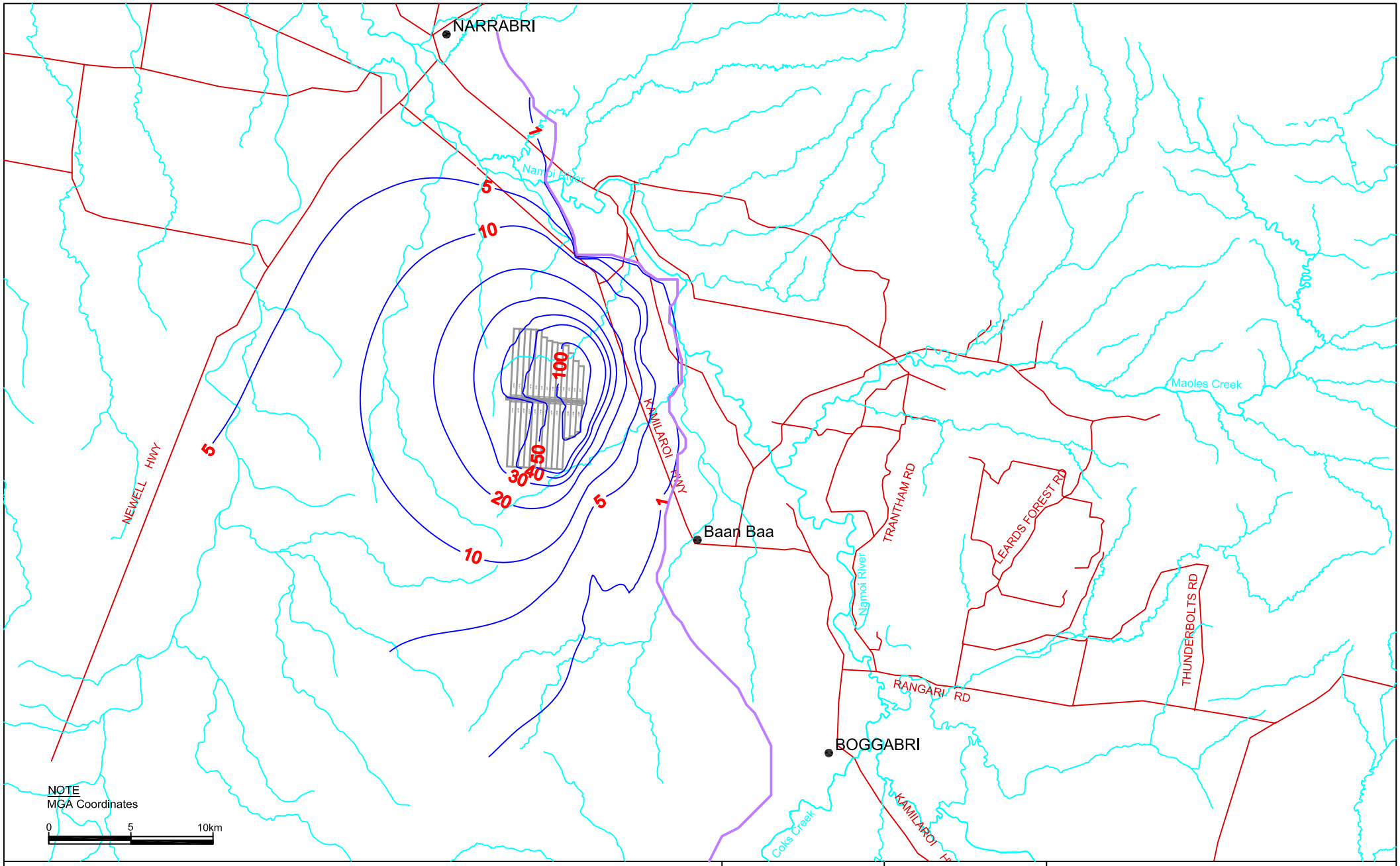
Narrabri Coal Pty Ltd

Drawdown after 29 Year in Digby Formation (Layer 8)

Appendix J



Legend

- Narrabri Underground Outline
- Roads or tracks
- Surface Water Drainage (Stream/Creek)
- 5 Predicted Groundwater Drawdowns (m AHD)
- Hodkissons Seam Sub Crop Margin

Date:	14 August 2009	Scale:	As Shown
Initials:	PZ	Job No:	S28
Drawing No:	S28-042c	Rev:	C

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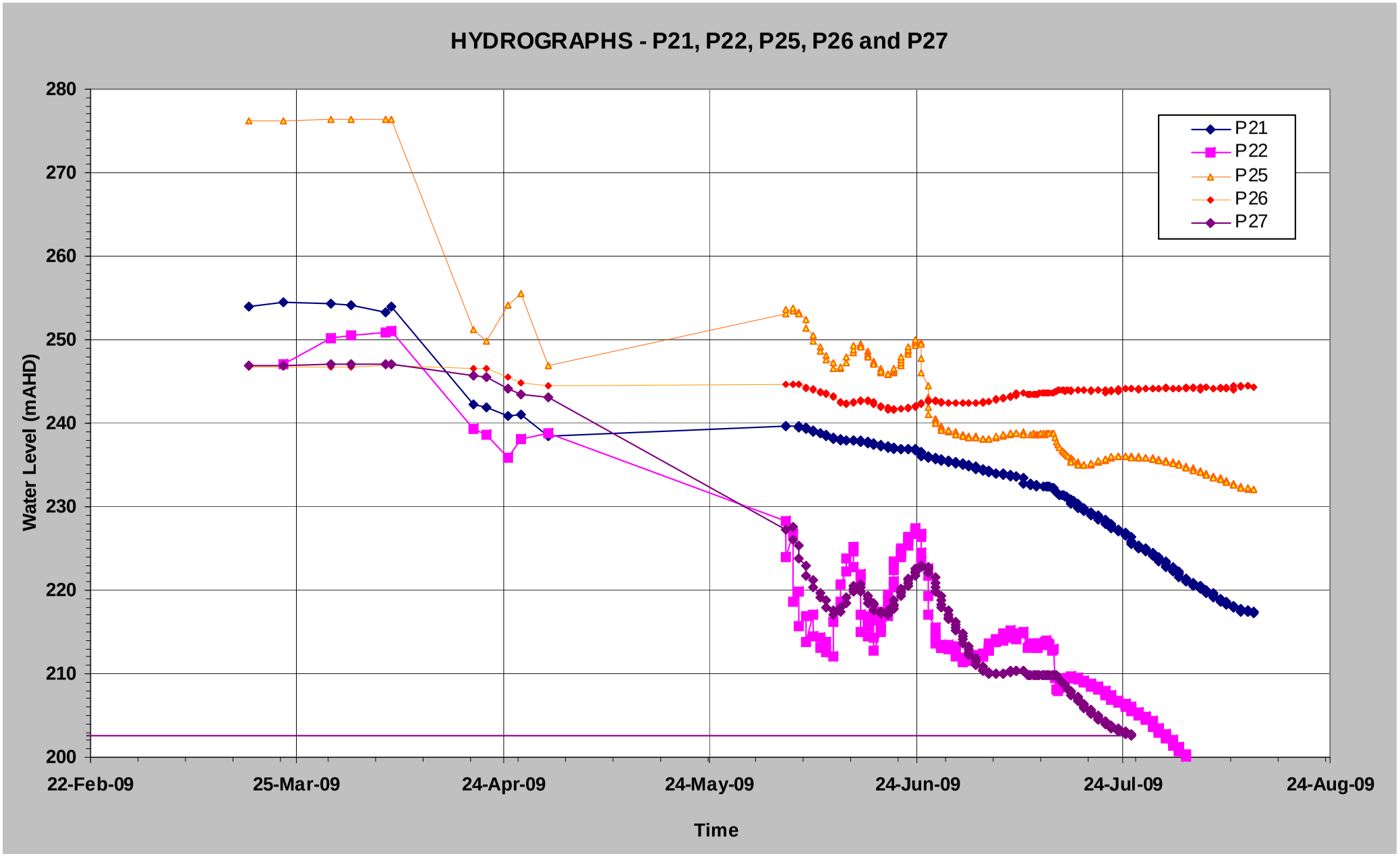
Narrabri Coal Pty Ltd

Drawdown after 29 Year in Hoskissons Seam (Layer 9)

Appendix J

APPENDIX K

VIBRATING WIRE PIEZOMETER RESPONSE TO INSEAM GAS TESTING



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Drawing No:	S28-086	Rev:	0

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Vibrating Wire Piezometer Response to Inseam Gas Testing

Appendix K