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Logistics report for down-hole conductivity logging in the Paterson AEM Survey area, Western Australia, September 2008.

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Introduction

Down hole induction conductivity data, commonly referred to as conductivity logs, were acquired from nineteen boreholes during September 2008 in support of the Paterson airborne electromagnetic (AEM) survey described in Roach (2010). The geophysical investigations were designed to deliver reliable, pre-competitive AEM data and scientific analysis assessment of the energy resource potential of the Paterson region of Western Australia. The Paterson AEM survey was the first regional AEM survey conducted in the Onshore Energy Security Program (OESP) at Geoscience Australia (GA). The survey was flown by Fugro Airborne Surveys Pty. Ltd. (FAS), for Geoscience Australia, as a combined TEMPEST™ time-domain electromagnetic (TEM) and magnetic survey between the 10th of September 2007 and the 28th of October 2008. The AEM survey covered a total area of 49 000 km^2 in the Paterson region of Western Australia.

Induction conductivity log data were acquired from 19 boreholes in a number geological units over a wide area of the Paterson North AEM survey area. The conductivity logs were used to assist in generating reference models for geophysical inversions of the AEM data, and to provide an independent dataset for assessing the inversion results.

Location

The nineteen boreholes are located within the Paterson North survey area. Three boreholes were located at Telfer mine (Newcrest Mining Ltd.), five were at Woodie Woodie (Consolidated Minerals Ltd.) and two were waterbores located on Telfer Access Road. The remaining bores were either water bores or exploration bores at and around Nifty mine (Aditya Birla Minerals). Most of the holes were cased with PVC, but a few were open, un-cased holes. The majority of the holes had steel casing in the top 6 m. Five conductivity logs collected at Woodie Woodie remain “in-confidence” and are not expanded upon in this report. Table 1.1 provides the location coordinates and depths of the public-domain logged boreholes and Figure 1.1 shows the location of the logged boreholes.

Table 1.1: Coordinates (MGA94 Zone 51) and depths of the 19 boreholes logged for the Paterson AEM survey.

BOREHOLE	EASTING	NORTHING	DEPTH (m)
08DKRCD011	348403	7657601	428
08DKRCD012	348074	7657600	561
08FCHDD002	361302	7590049	285
THRP155	356024	7600376	119
THRP161B	358531	7600035	159
THRP162D	351524	7603738	60
Waterbore B	351524	7604678	125
YNC219	352665	7603678	200
YNC224	352750	7603643	100
WW1	In confidence	In confidence	101
WW2	In confidence	In confidence	120
WW3	In confidence	In confidence	39
WW4	In confidence	In confidence	120
WW5	In confidence	In confidence	62
HB405	373788	7624508	46
HB419	307618	7643890	34
HB326	423671	7589789	148
HB315	420467	7590932	150
HB227	416363	7602972	156

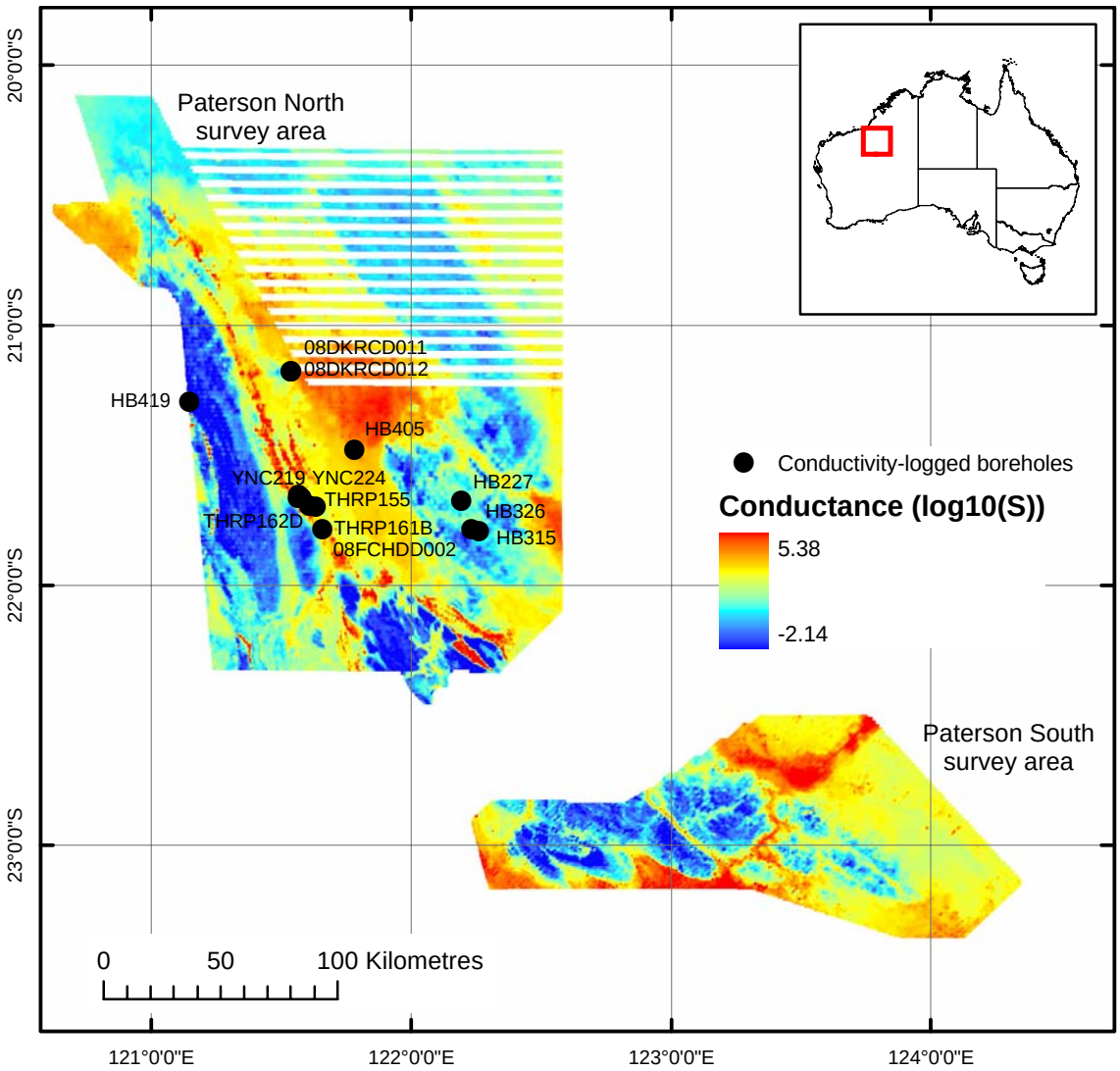

Figure 1.1: Location of public domain boreholes plotted over a 0-200 m conductance image derived from the AEM survey data.

Method

Induction conductivity logging tools measure the electrical conductivity of the material in a volume surrounding the borehole at the measurement point and provide a detailed indication of changes in electrical conductivity with depth. These tools permit measurements of the electrical conductivity of the ground outside PVC cased boreholes, generally without being sensitive to the presence of more conductive borehole fluid within the casing. These tools are capable of making reliable scientific measurements, however, standards for their use and calibration have not been established their method of use has not been standardised. The principle of operation of induction conductivity borehole logging tools (after McNeill *et al.*, 1986) and other conductivity logging information is provided below.

The induction conductivity logging tool functions in a similar way to ground or airborne electromagnetic systems. A small transmitter coil in the probe creates a primary magnetic field which gives rise to an electrical field in the materials surrounding the borehole. This electrical field creates eddy currents within the material, the strength of which depends on the electrical conductivity of the material. These eddy currents then induce a magnetic field which is measured with a receiver coil within the probe. Figure 1.2 shows the principles of operation.

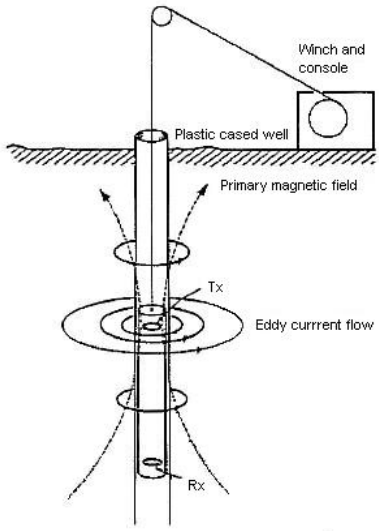

Figure 1.2: The principle of operation of inductive conductivity borehole logging tools, from McNeill *et al*. (1990).

The geophysical logging equipment used on the fieldtrip was rented from Auslog Pty. Ltd. of Brisbane, Queensland, and included:

- Induction conductivity probe (HI327F serial no S500);
- 500 m cable winch;
- Logging matrix console; and,
- Laptop computer with Wellvision^{TM} logging software.

For each log the location and elevation of each borehole was recorded using a Garmin GPSMAP 60CSx handheld GPS receiver. The standing water level was measured using a tape measure or a water level indicator when available. The height of the casing was measured to the nearest centimetre using a tape measure. A steel dummy probe was sent down each hole prior to logging to check for hole depth, hole continuity, obstructions and severe distortions that could hinder the logging process.

The induction conductivity probe was temperature stabilised prior to calibration. Temperature stabilisation was achieved by lowering the tool into the borehole to approximately 30 m depth and leaving it there for 10-15 minutes until the readings had stabilised.

After temperature stabilisation, the induction conductivity probe was calibrated using three calibration rings supplied by Auslog (100, 300 and 2 x 500 mS/m). For each calibration ring the probe was held in air, horizontally at shoulder height by the assistant, taking care to keep well away from any metal objects (cars, bore hole caps, watches, belt buckles, coins, car keys, etc.) while the operator ran the calibration routine on the computer. The probe was then temperature re-stabilised after calibration and prior to logging. Calibration was also carried out immediately after logging the hole. In most cases the post-logging calibration was the most useable as the conductivity tool was calibrated in a state as close as possible to borehole conditions.

The probe is positioned at the zero level prior to conductivity logging. Zero level is defined as the point at which the 'neck' of the probe (the point at which the end of the cable connector meets the probe) is level with the surface of the ground, hence the need to measure the collar height above ground. The probe is then run down and up the hole at a reasonably consistent speed of between 5 and 7 m/min, logging a reading every 2.5 cm. The details of the measuring procedures used for each bore were recorded on field logging sheets (an example is provided in Table 1.2). All holes were logged at least twice; once as the tool descended, and again as the tool ascended.

At the completion of the logging program the first hole logged (THRP161B) was re-logged to ensure repeatability of the instrument during the field campaign.

Field Sheets, as shown in Table 1.2, record the date, time, logging speed, irregularities, weather, run number and other important logging details for each bore hole. These were completed in the field and are included in Appendix 1.

Table 1.2: An example field sheet for induction conductivity logging procedures.

Borehole information

		Method (e.g. tape, GPS etc.)	
Location/Site name			
Easting			
Northing			
Map Datum			
Projection			
Surface elevation (m)			
Height of casing (m)			
Water level (m)			
Depth of hole (m)			
Drill method			
Casing info	**Type**	**Size (mm)**	**Depth interval (m)**
	PVC		

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information

Type of log	**Induction Conductivity**			
Name of operator(s)				
Run #	**1** **Up**	**2** **down**	**3**	**4**
Date				
Time				
Logging speed (m/min)				
Temperature stabilised?				
Repeatability?				
Irregularities				
Weather info				
Logged to depth				
Units of measurement				

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time				
Type				
Temperature stabilised?				
Rings / Values	0 mS/m 100 mS/m 300 mS/m 500 mS/m		0 mS/m 100 mS/m 300 mS/m 500 mS/m	
Comments				

Results

Each calibrated conductivity log was saved as a LAS-format file onto the field laptop using the Wellvision^{TM} software. The LAS files contain header information including software version number, location, service date, null value, well name and depth and induction data. A median filter followed by a moving average filter (filter width between 5 and 31 samples) was applied to the data in the LAS files to remove spikes. Plots showing conductivity versus depth for each logged hole are in Appendix 2.

Results of Borehole THRP161B, which was logged at the start and end of the logging trip to check for repeatability over the course of the logging program, are shown in Figure 1.3. A visual comparison of THRP161B repeat logs shows little variation between the logs, indicating good repeatability with the logging equipment used.

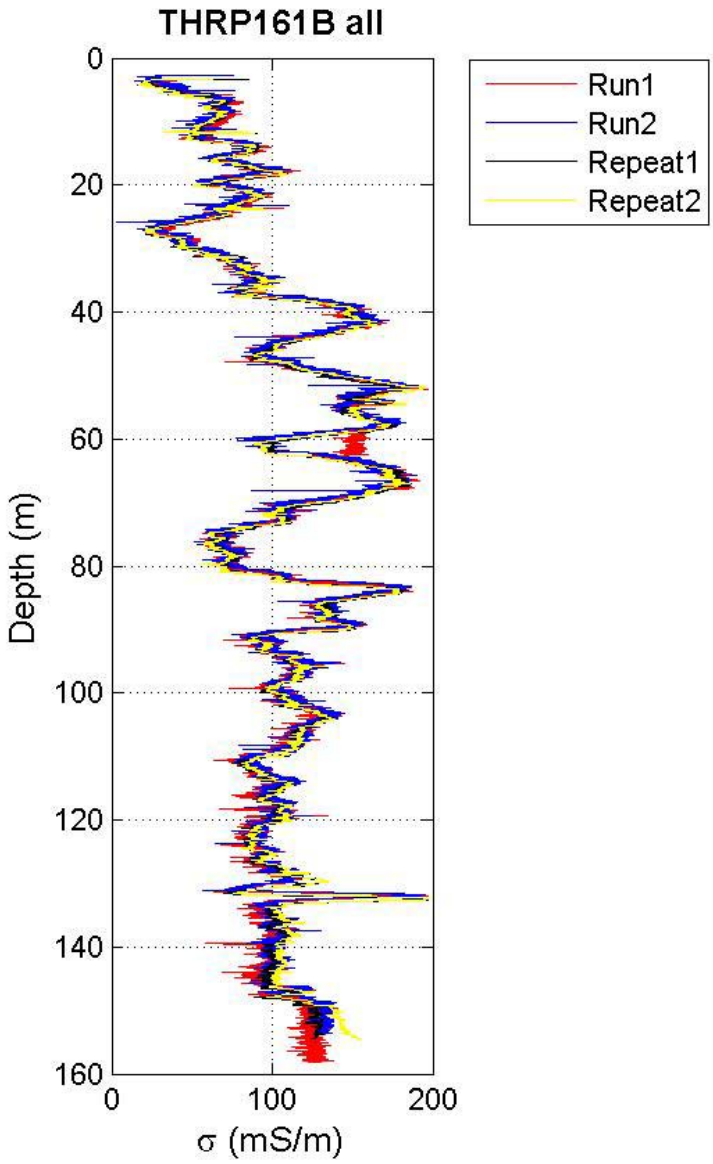

Figure 1.3: Comparison of borehole THRP161B repeat logs, from the beginning and end of field trip. Run1 and Run2 were acquired at the beginning of the trip, and Repeat1 and Repeat2 were acquired at the end of the field trip.

The results of the conductivity logs were compared to known down-hole geology in a drill hole lithology database obtained from company completion reports (Roach, 2009). Figure 1.4 shows the strip log of one run of the induction conductivity log from hole THRP161B compared to the closest down-hole geology log.

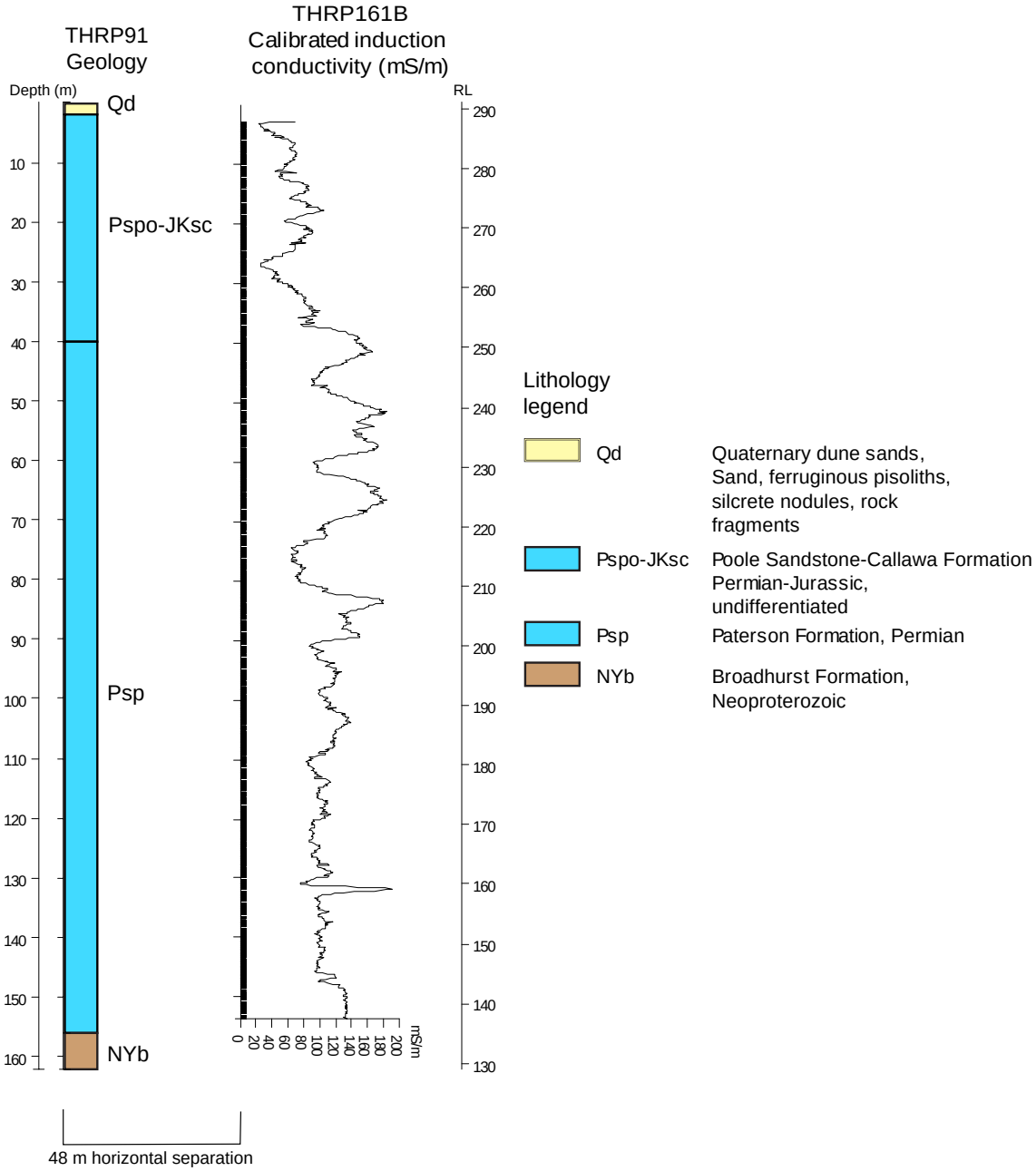

Figure 1.4: Comparison of borehole THRP161B conductivity log to borehole THRP91 lithological log.

Each tenement holder is provided with the raw Wellvision^{TM} data, LAS files and plot files for the boreholes located on their tenement within this data package. Raw and processed conductivity log data for the holes (around Woodie Woodie) to remain in-confidence between GA and the respective tenement holder are provided in the unique data package to the respective tenement holder only. Appendix 3 lists comparisons of induction conductivity logs to the GA Layered Earth Inversions (GA-LEI). Appendix 4 lists the downhole conductivity products released in this data release.

Summary

The nineteen conductivity logs helped define the conductivity signature of rocks within the Paterson AEM survey area. The conductivity logs were used to assist in generating reference models for the geophysical inversions of the AEM data. Since bore holes were sparse and, in many cases not close to the

flight lines, the assessment of logs directly to the Geoscience Australia layered earth inversion (GA-LEI) results was limited. Generally the GA-LEI results show agreement with the borehole logs in close proximity to flight lines. For a full description of the GA-LEI inversion results, see Hutchinson et al. (2010).

Acknowledgements

Geoscience Australia acknowledges Aditya Birla Minerals (Birla Nifty Operations), Consolidated Minerals Ltd. (Woodie Woodie Operations) and Newcrest Mining Limited (Telfer Operations) for their generous support including land access, access to open bore holes, lithological logs and field support. Geoscience Australia also acknowledges the Western Desert Lands Aboriginal Corporation (WDLAC) for granting access to the traditional lands of the Martu people.

Appendix 1

This appendix contains the field sheets for the 19 conductivity logs acquired during the 2008 field trip to the Paterson. The field sheets for bore holes near Woodie Woodie have been altered to conform withto the confidentiality agreement between Consolidated Minerals Ltd. and Geoscience Australia.

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	08DKRCD011		
Easting	51 K 0348403		GPS
Northing	7657601		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	811 ft		GPS
Height of casing			
Water level	3.72 m		
Depth of hole	428 m		
Drill method	RC + DD		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	40 mm	428 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (08DKRCD011)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1**	**2**	**3**	**4**
Date	30/08/08	30/08/08		
Time	09.45	11.00		
Logging speed (m/min)	6 m/min	7 m/min		
Temperature stabilised?	Probe left at 30 m for 10 min	Yes		
Repeatability?	Yes reasonably			
Irregularities	None	None		
Weather info	Hot	Hot		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1** **Before log**	**2**	**3**	**4**
Time	09.30		12.05	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes		Yes	
Rings	0 m S/m 385 cps 100 mS/m 593 cps 300 mS/m 1063 cps 500 mS/m 1542 cps 1000 mS/m 2552 cps		0 mS/m 380 cps 100 mS/m 606 cps 300 mS/m 1075 cps 500 mS/m 1545 cps 1000 mS/m 2566 cps	
Values				

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	08DKRCD012		
Easting	51 K 0348074		GPS
Northing	7657600		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	817 ft		GPS
Height of casing	30 cm		
Water level	3.34 m		
Depth of hole	561 m		
Drill method	RC + DD		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	40 mm	561m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (08DKRCD012)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1**	**2**	**3**	**4**
Date	30/08/08	30/08/08		
Time	12.45	14.05		
Logging speed (m/min)	7 m/min	7 m/min		
Temperature stabilised?	Probe left at 30 m for 10 min	Yes		
Repeatability?	Yes reasonably			
Irregularities	None			
Weather info	Hot Sunny	Hot sunny		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1**	**2**	**3**	**4**
Time	15.15			
Type	Lookup table			
Temperature stabilised?	Yes			
Rings	0 mS/m 387 cps 100 mS/m 605 cps 300 mS/m 1081 cps 500 mS/m 1547 cps 1000 mS/m 2580 cps			
Values				

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	08FCHDD002		
Easting	51 K 0361302		GPS
Northing	7590049		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	973 ft		GPS
Height of casing			
Water level	App 2 m		
Depth of hole	285 m (at this depth our probe did not go any further)		
Drill method	RC + DD		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	40 mm	290 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (08FCHDD002)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1**	**2**	**3**	**4**
Date	29/08/08	29/08/08		
Time	12.20	13.20		
Logging speed (m/min)	6 m/min	6 m/min		
Temperature stabilised?	Probe left at 30 m for 10 min	Yes		
Repeatability?	Yes reasonably			
Irregularities	None	Probe stuck at 160-162 m, logging temp stopped to fix problem		
Weather info	Windy	Windy		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1**	**2**	**3**	**4**
Time	12.15		16.35	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes		Yes	
Rings	0 mS/m 368 cps 100 mS/m 597 cps 300 mS/m 1054 cps 500 mS/m 1525 cps		0 mS/m 375 cps 100 mS/m 609 cps 300 mS/m 1076 cps 500 mS/m 1544 cps 1000 mS/m 2554 cps	
Values				

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	THRP155		
Easting	51 K 0356024		GPS
Northing	7600376		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	980 ft		GPS
Height of casing	0.63 m		
Water level	9.43 m		
Depth of hole	119 m – slots 11-119 m		
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	40 mm	119 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (THRP155)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1**	**2**	**3**	**4**
Date	31/08/08	31/08/08		
Time	10.40	11.00		
Logging speed (m/min)	6 m/min	6 m/min		
Temperature stabilised?	Probe left at 30 m for 10 min	Yes		
Repeatability?				
Irregularities	None	None		
Weather info	Windy, Sunny	Windy, Sunny		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1 Before log**	**2**	**3 After log**	**4**
Time	10.23		13.40	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes		Yes	
Rings	0 mS/m 368 cps 100 mS/m 582 cps 300 mS/m 1057 cps 500 mS/m 1533 cps 1000 mS/m 2544 cps		0 mS/m 373 cps 100 mS/m 602 cps 300 mS/m 1070 cps 500 mS/m 1539 cps	
Values				

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	THRP 161 B		
Easting	51 K 0358531		GPS
Northing	7600035		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	975 ft		GPS
Height of casing			
Water level	Maybe 130 m according to Greg (dewatering guy)		
Depth of hole	159 m (slots 94-159 m)		
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	100 mm	159 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (THRP161B)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1**	**2**	**3**	**4**
Date	28/08/08	28/08/08		
Time	15.30	16.00		
Logging speed (m/min)	5-6 m/min	5-6 m/min		
Temperature stabilised?	Probe left at 30 m for 10 min	Yes		
Repeatability?	Yes reasonably			
Irregularities	Probe stuck at 60-63 m			
Weather info	Hot	Hot		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1**	**2**	**3**	**4**
Time	15.11		16.35	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes		Yes	
Rings	0 mS/m 388 cps 100 mS/m 602 cps 300 mS/m 1062 cps 500 mS/m 1518 cps		0 mS/m 367 cps 300 mS/m 1075 cps 500 mS/m 1542 cps	
Values				

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	THRP162D		
Easting	51 K 0351524		GPS
Northing	7603738		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	1013 ft		GPS
Height of casing	0.50 m		
Water level	N/A as just at depth of hole		
Depth of hole	60 m		
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	40 mm	60 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (THRP162D)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1**	**2**	**3**	**4**
Date	31/08/08	31/08/08	31/08/08	31/08/08
Time	13.15	13.30	13.50	14.00
Logging speed (m/min)	6 m/min	7 m/min	7.5 m/min	8 m/min
Temperature stabilised?	Probe left at 30 m for 10 min	Yes	Yes	Yes
Repeatability?	Not in top 5 m	Not in top 5 m	Not in top 5 m	Not in top 5 m
Irregularities	None	None	None	None
Weather info	Windy, Sunny	Windy, Sunny	Windy, Sunny	Windy, Sunny
Units of measurement	mS/m	mS/m	mS/m	mS/m

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	13.00		13.40	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes		Yes	
Rings **Values**	0 mS/m 373 cps 100 mS/m 589 cps 300 mS/m 1056 cps 500 mS/m 1522 cps		0 mS/m 380 cps 100 mS/m 600 cps 300 mS/m 1071 cps 500 mS/m 1538 cps 1000 mS/m 2552 cps	

Borehole information

	Nifty waterbores		**Method (e.g. tape, GPS etc.)**
Location/Site name	Waterbore “new B”		
Easting	51 K 0351524		GPS
Northing	7604678		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	1001 ft		GPS
Height of casing			
Water level			
Depth of hole			
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	50 mm	125 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (WaterboreB)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1**	**2**	**3**	**4**
Date	06/09/08	06/09/08	06/09/08	06/09/08
Time	08.13	08.34	09.00	09.23
Logging speed (m/min)	6 m/min	6 m/min	6 m/min	6 m/min
Temperature stabilised?	Yes 40 m for 15 min	Yes	Yes	Yes
Repeatability?	Not particularly good		These two runs show great repeatability	
Irregularities	None	None	None	None
Weather info	Overcast	Overcast	Overcast	Overcast
Units of measurement	mS/m	mS/m	mS/m	mS/m

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	07.45		10.00	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 35 m for 15 min		Yes	
Rings	0 mS/m 361 cps 100 mS/m 581 cps 300 mS/m 1043 cps 500 mS/m 1508 cps		0 mS/m 371 cps 100 mS/m 604 cps 300 mS/m 1073 cps 500 mS/m 1544 cps	
Values				

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	YNC219		
Easting	51 K 0352665		GPS
Northing	7603678		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	1001 ft		GPS
Height of casing			
Water level			
Depth of hole			
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	40 mm	200 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (YNC219)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1**	**2**	**3**	**4**
Date	05/09/08	05/09/08		
Time	09.47	10.20		
Logging speed (m/min)	6 m/min	6 m/min		
Temperature stabilised?	Yes 40 m for 15 min	Yes		
Repeatability?	Not particularly good			
Irregularities	None	None		
Weather info	Sunny	Sunny		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	09.24		11.00	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 35 m for 15 min		Yes	
Rings **Values**	0 mS/m 370 cps 100 mS/m 587 cps 300 mS/m 1058 cps 500 mS/m 1526 cps		0 mS/m 367 cps 100 mS/m 588 cps 300 mS/m 1066 cps 500 mS/m 1537 cps 1000 mS/m 2561 cps	

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	YNC224		
Easting	51 K 0352750		GPS
Northing	7603643		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	970 ft		GPS
Height of casing	0.10 m		
Water level			
Depth of hole			
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	Open hole		Logged to 100 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (YNC224)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1**	**2**	**3**	**4**
Date	01/09/08	01/09/08		
Time	07.58	08.15		
Logging speed (m/min)	6 m/min	6 m/min		
Temperature stabilised?	Yes 20 m for 15 min	Yes		
Repeatability?				
Irregularities	None	None		
Weather info	Windy, cool	Windy, cool		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	07.50		08.30	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 20 m for 10 min		Yes	
Rings	0 mS/m 356 cps 100 mS/m 572 cps 300 mS/m 1035 cps 500 mS/m 1502 cps 1000 mS/m 2508 cps		0 mS/m 381 cps 100 mS/m 594 cps 300 mS/m 1065 cps 500 mS/m 1537 cps	
Values				

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	WW1		
Easting	in-confidence		GPS
Northing	in-confidence		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	918 ft		GPS
Height of casing			
Water level	NA		
Depth of hole			
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	50 mm	Logged to 101 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (WW1)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1** **Down**	**2** **Up**	**3**	**4**
Date	02/09/08	02/09/08		
Time	14.43	15.05		
Logging speed (m/min)	6 m/min	6 m/min		
Temperature stabilised?	Yes 30 m for 15 min	Yes		
Repeatability?	impossible to repeat the hole as the probe wouldn't go past the bits it got stuck at on the way down the first time.			
Irregularities	Stuck at 40 m, 60 m and multiple other times	None		
Weather info	Sunny hot	Sunny hot		
Logged to depth	101 m	101 m		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	14.20		15.30	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 30 m for 10 min		Yes	
Rings **Values**	0 mS/m 368 cps 100 mS/m 596 cps 300 mS/m 1052 cps 500 mS/m 1519 cps		0 mS/m 372 cps 100 mS/m 597 cps 300 mS/m 1068 cps 500 mS/m 1526 cps	

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	WW2		
Easting	in-confidence		GPS
Northing	in-confidence		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	922 ft		GPS
Height of casing			
Water level	34.9 m		
Depth of hole			
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	50 mm	Logged to 120 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (WW2)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1**	**2**	**3**	**4**
Date	01/09/08	01/09/08		
Time	14.45	15.05		
Logging speed (m/min)	6 m/min	6 m/min		
Temperature stabilised?	Yes 30 m for 15 min	Yes		
Repeatability?	Within 10 mS/m			
Irregularities	None	None		
Weather info	Sunny hot	Sunny hot		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	14.35		15.27	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 30 m for 10 min		Yes	
Rings **Values**	0 mS/m 379 cps 100 mS/m 591 cps 300 mS/m 1060 cps 500 mS/m 1516 cps		0 mS/m 377 cps 100 mS/m 600 cps 300 mS/m 1070 cps 500 mS/m 1543 cps	

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	WW3		
Easting	in-confidence		GPS
Northing	in-confidence		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	959 ft		GPS
Height of casing			
Water level	NA		
Depth of hole			
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	50 mm	Logged to 39 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (WW3)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1** **Down**	**2** **Up**	**3**	**4**
Date	02/09/08	02/09/08	02/09/08	02/09/08
Time	12.10	12.18	12.29	12.35
Logging speed (m/min)	6 m/min	6 m/min	6m/min	6m/min
Temperature stabilised?	Yes 30 m for 15min	Yes	Yes	Yes
Repeatability?	Repeatability a fter first two holes was fair, decided to rerun the log anyway			
Irregularities	Stopped at 39 m	None	None	None
Weather info	Sunny windy	Sunny,windy	Sunny windy	Sunny,windy
Logged to depth	39 m	39 m	39 m	39 m
Units of measurement	mS/m	mS/m	mS/m	mS/m

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	14.20		15.30	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 30 m for 10 min		Yes	
Rings **Values**	0 mS/m 375 cps 100 mS/m 599 cps 300 mS/m 1065 cps 500 mS/m 1523 cps		0 mS/m 385 cps 100 mS/m 604 cps 300 mS/m 1070 cps 500 mS/m 1543 cps	

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	WW4		
Easting	in-confidence		GPS
Northing	in-confidence		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	909 ft		GPS
Height of casing			
Water level	36.85 m		
Depth of hole			
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	50 mm	Logged to 120 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (WW4)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1**	**2**	**3**	**4**
Date	01/09/08	01/09/08	01/09/08	01/09/08
Time	12.00	12.25	12.55	13.15
Logging speed (m/min)	6 m/min	6 m/min	7 m/min	7 m/min
Temperature stabilised?	Yes 30 m for 15min	Yes	Yes	Yes
Repeatability?		Not in the top bit		
Irregularities	Stuck at 40 m again at 60 m	None	None	
Weather info	Sunny hot	Sunny hot	Sunny	Sunny
Logged depth	120 m	120 m	35 m	33 m
Units of measurement	mS/m	mS/m	mS/m	mS/m

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	11.50		12.45	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 30 m for 10 min		Yes	
Rings **Values**	0 mS/m 373 cps 100 mS/m 586 cps 300 mS/m 1052 cps 500 mS/m 1519 cps		0 mS/m 382 cps 100 mS/m 598 cps 300 mS/m 1070 cps 500 mS/m 1540 cps	

Borehole information

			Method (e.g. tape, GPS etc.)
Location/Site name	WW5		
Easting	in-confidence		GPS
Northing	in-confidence		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	938 ft		GPS
Height of casing			
Water level	NA		
Depth of hole			
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	50 mm	Logged to 62 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (WW5)

Type of log	Induction Conductivity				
Name of operator(s)	Camilla Sorensen (Geoscience Australia)				
Run #	**1 Down**	**2 Up**	**3**	**4**	**5**
Date	02/09/08	02/09/08	02/09/08	02/09/08	02/09/08
Time	09.38	09.47	10.15	10.40	10.50
Logging speed (m/min)	6 m/min	6 m/min	6m/min	6m/min	6m/min
Temperature stabilised?	Yes 30 m for 15min	Yes	Yes	Yes	Yes
Repeatability?	Repeatability a fter first two runs was not particular good, so repeats done				
Irregularities	Stopped at 39m	None	None	None	
Weather info	Sunny windy	Sunny, windy	Sunny windy	Sunny, windy	
Logged to depth	39 m	39 m	39 m	39 m	
Units of measurement	mS/m	mS/m	mS/m	mS/m	

Calibration information

Calibration #	**1 Before log**	**2**	**3 After log**	**4**
Time	09.10		10.00	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 30 m for 10 min		Yes	
Rings	0 mS/m 360 cps 100 mS/m 588 cps 300 mS/m 1048 cps 500 mS/m 1521 cps		0 mS/m 375 cps 100 mS/m 592 cps 300 mS/m 1065 cps 500 mS/m 1535 cps	
Values				

Borehole information

	Telfer Access Road		**Method (e.g. tape, GPS etc.)**
Location/Site name	HB419		
Easting	51 K 0307618		GPS
Northing	7643890		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	870 ft		GPS
Height of casing	0.15 m		
Water level	4.20 m		
Depth of hole			
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	50 mm	Logged to 34 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (HB419)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1** **Up**	**2** **down**	**3**	**4**
Date	03/09/08	03/09/08	03/09/08	
Time	15.20	15.28	15.35	
Logging speed (m/min)	6 m/min	6 m/min	6 m/min	
Temperature stabilised?	Yes 30 m for 15min	Yes	Yes	
Repeatability?	Repeatability good			
Irregularities	None	None	None	
Weather info	Sunny hot	Sunny hot	Sunny hot	
Logged to depth	34 m	34 m	34 m	
Units of measurement	mS/m	mS/m	mS/m	

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	15.0		15.45	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 32 m for 10 min		Yes	
Rings **Values**	0 mS/m 376 cps 100 mS/m 587 cps 300 mS/m 1056 cps 500 mS/m 1514 cps		0 mS/m 379 cps 100 mS/m 597 cps 300 mS/m 1064 cps 500 mS/m 1531 cps	

Borehole information

	Telfer Access Road		**Method (e.g. tape, GPS etc.)**
Location/Site name	HB405		
Easting	51 K 0373788		GPS
Northing	7624508		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	864 ft		GPS
Height of casing	0.35 m		
Water level	2.88 m		
Depth of hole			
Drill method	RC		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	50 mm	Logged to 46 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (HB405)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1** **Down**	**2** **Up**	**3**	**4**
Date	03/09/08	03/09/08		
Time	12.10	12.18		
Logging speed (m/min)	6 m/min	6 m/min		
Temperature stabilised?	Yes 30 m for 15 min	Yes		
Repeatability?	Repeatability after first two holes was good, so repeats not done			
Irregularities	Stopped at 46 m	None		
Weather info	Sunny hot	Sunny hot		
Logged to depth	46 m	46 m		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	11.50		12.18	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 30 m for 10 min		Yes	
Rings **Values**	0 mS/m 368 cps 100 mS/m 588 cps 300 mS/m 1059 cps 500 mS/m 1522 cps 1000 mS/m 2520cps		0 mS/m 375 cps 100 mS/m 597 cps 300 mS/m 1064 cps 500 mS/m 1530 cps	

Borehole information

	Telfer mine		**Method (e.g. tape, GPS etc.)**
Location/Site name	HB326		
Easting	51 K 0423671		GPS
Northing	7589789		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	949 ft		GPS
Height of casing	0.34 m		
Water level	42.15 m bgl		
Depth of hole	150 m		
Drill method	?		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	100 mm	Logged to 148 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (HB336)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1** **Up**	**2** **down**	**3**	**4**
Date	04/09/08	04/09/08	04/09/08	04/09/08
Time	09.18	09.44	10.10	10.33
Logging speed (m/min)	6 m/min	6 m/min	7 m/min	8m/min
Temperature stabilised?	Yes 30 m for 15min	Yes	Yes	Yes
Repeatability?	Repeatability not particular good for the first two runs, so another two done			
Irregularities	None	None	None	None
Weather info	Windy	Windy	Windy	Windy
Logged to depth	148 m	148 m	148 m	148 m
Units of measurement	mS/m	mS/m	mS/m	mS/m

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	08.57		10.58	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 30 m for 10 min		Yes	
Rings **Values**	0 mS/m 364 cps 100 mS/m 588 cps 300 mS/m 1048 cps 500 mS/m 1516 cps		0 mS/m 385 cps 100 mS/m 600 cps 300 mS/m 1065 cps 500 mS/m 1536 cps	

Borehole information

	Telfer mine		**Method (e.g. tape, GPS etc.)**
Location/Site name	HB315		
Easting	51 K 0420467		GPS
Northing	7590932		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	1013 ft		GPS
Height of casing			
Water level			
Depth of hole	150 m		
Drill method	?		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	100 mm	Logged to 150 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (HB315)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1** **Up**	**2** **down**	**3**	**4**
Date	04/09/08	04/09/08		
Time	11.57	12.22		
Logging speed (m/min)	6 m/min	6 m/min		
Temperature stabilised?	Yes 30 m for 15min	Yes		
Repeatability?	Reasonably – within 10 mS/m			
Irregularities	None	None		
Weather info	Hot sunny	Hot sunny		
Logged to depth	150 m	150 m		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	11.37		12.50	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 30 m for 10 min		Yes	
Rings **Values**	0 mS/m 372 cps 100 mS/m 594 cps 300 mS/m 1059 cps 500 mS/m 1523 cps		0 mS/m 377 cps 100 mS/m 596 cps 300 mS/m 1069 cps 500 mS/m 1537 cps	

Borehole information

	Telfer mine		**Method (e.g. tape, GPS etc.)**
Location/Site name	HB227		
Easting	51 K 0416363		GPS
Northing	7602972		GPS
Map Datum	WGS84		GPS
Projection			
Surface elevation	1014 ft		GPS
Height of casing			
Water level	49.92 m		
Depth of hole	156 m		
Drill method	?		
Casing info	**Type**	**Size**	**Depth interval**
	PVC	100 mm	Logged to 143 m

Probe information

Type of probe	**Name**	**Serial number**
Conductivity	A085	S500

Log information (HB227)

Type of log	Induction Conductivity			
Name of operator(s)	Camilla Sorensen (Geoscience Australia)			
Run #	**1** **Up**	**2** **down**	**3**	**4**
Date	04/09/08	04/09/08		
Time	14.35	14.59		
Logging speed (m/min)	6.5 m/min	6 m/min		
Temperature stabilised?	Yes 30 m for 15 min	Yes		
Repeatability?	Reasonably – within 10 mS/m			
Irregularities	None	None		
Weather info	Hot sunny	Hot sunny		
Logged to depth	143 m	143 m		
Units of measurement	mS/m	mS/m		

Calibration information

Calibration #	**1** **Before log**	**2**	**3** **After log**	**4**
Time	14.14		15.24	
Type	Lookup table		Lookup table	
Temperature stabilised?	Yes 30 m for 10 min		Yes	
Rings	0 mS/m 380 cps 100 mS/m 588 cps 300 mS/m 1049 cps 500 mS/m 1509 cps		0 mS/m 381 cps 100 mS/m 595 cps 300 mS/m 1068 cps 500 mS/m 1536 cps	

Appendix 2

The 14 publicly available borehole logs are provided as PDF-format multiplots in this data package. A sample multiplot is shown in Figure A2.1 for bore hole THRP162D. These plots show the calibrated conductivity, along with accompanying system data acquired with the logs.

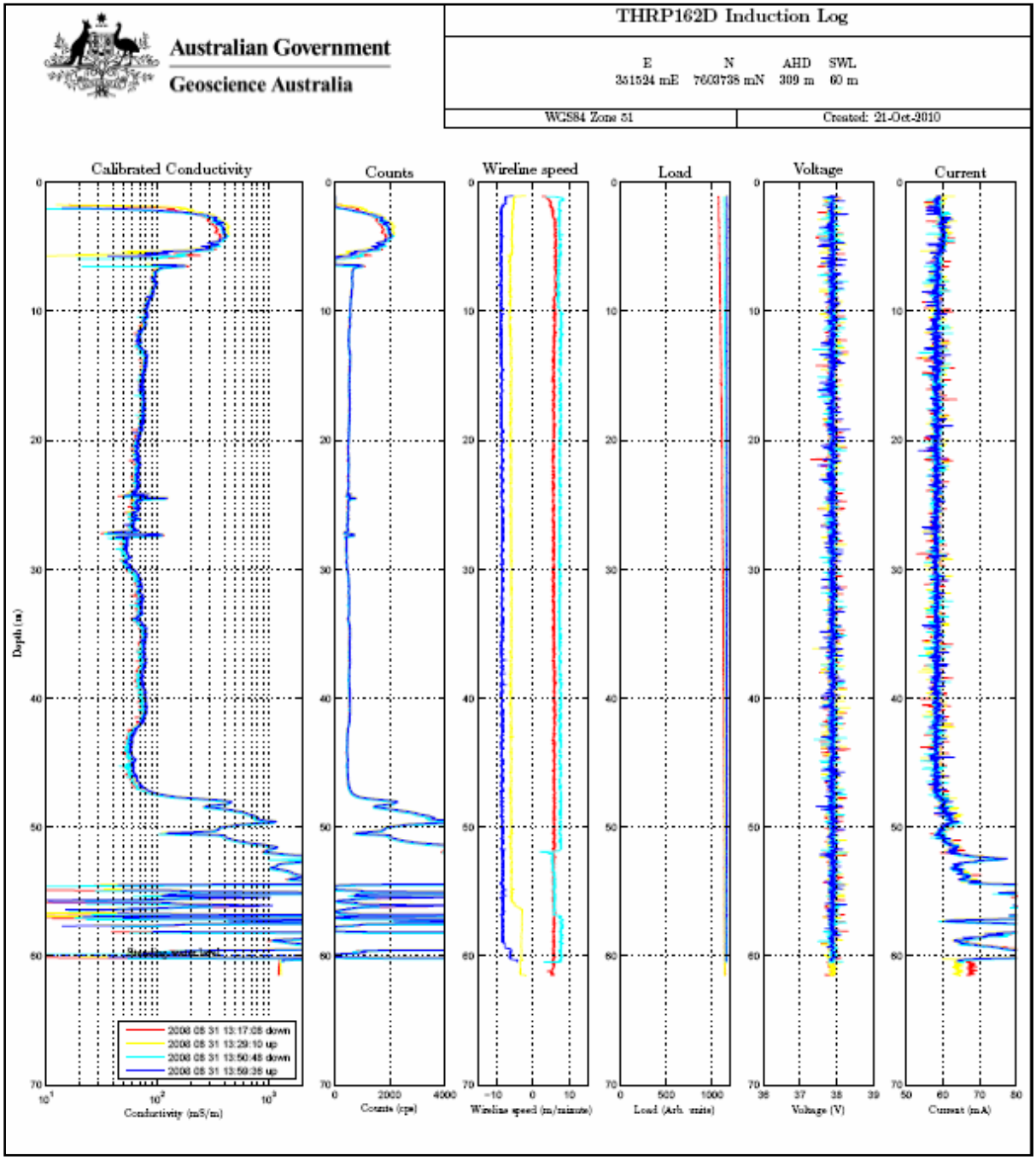

Figure A2.1: A sample borehole log multiplot, showing calibrated conductivity, raw counts, wireline speed, load, voltage and current for each run logged in the well.

Appendix 3

Comparisons of induction conductivity logs to the GA-LEI are shown in Figures A3.1 to A3.4. Borehole induction conductivity data are compared to the inversion of the nearest AEM line data sample. The distance of borehole location to flight line varies from 137 m to 769 m, and the average distance is 441 m. The distance between flight lines and some boreholes are larger than the lateral footprint of the AEM signal, thought to be approximately 470 m (Reid and Vrbancich, 2004).

There are a number of factors that can cause the inconsistencies between the borehole logs and the GA-LEI inversion result. Aside from the separation between the borehole and the flight line, it should be noted that the AEM data is influenced by a much larger volume of earth than the borehole data. The borehole log samples a cylinder with a radius of approximately 1 m (McNeill, 1986), as opposed to the lateral footprint of the TEMPEST system of approximately 470 m. These differences in sampling imply that the borehole log should not be treated as a direct validation of the AEM data, but an indicative comparison. Finally, the inversion is non-unique and is subject to assumptions such as a 1D layered earth structure and vertical smoothness. Therefore the fine structure seen in the borehole logs cannot be reproduced completely by the inversion.

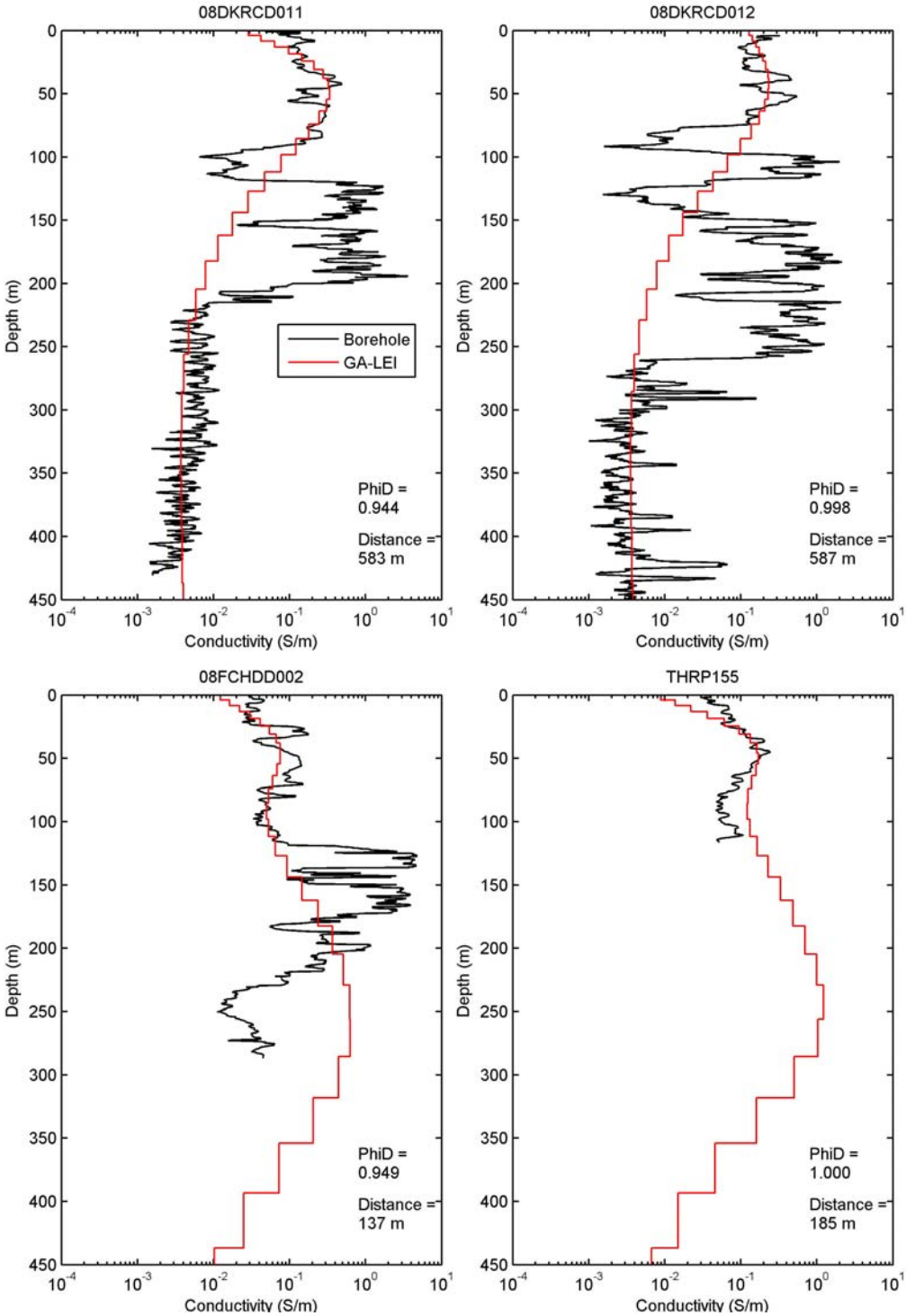

Figure A3.1: Comparison of borehole conductivity logs to the nearest point of the GA-LEI. PhiD shows the inversion data misfit (target misfit = 1), and the distance shown is the distance from the borehole to the inversion point.

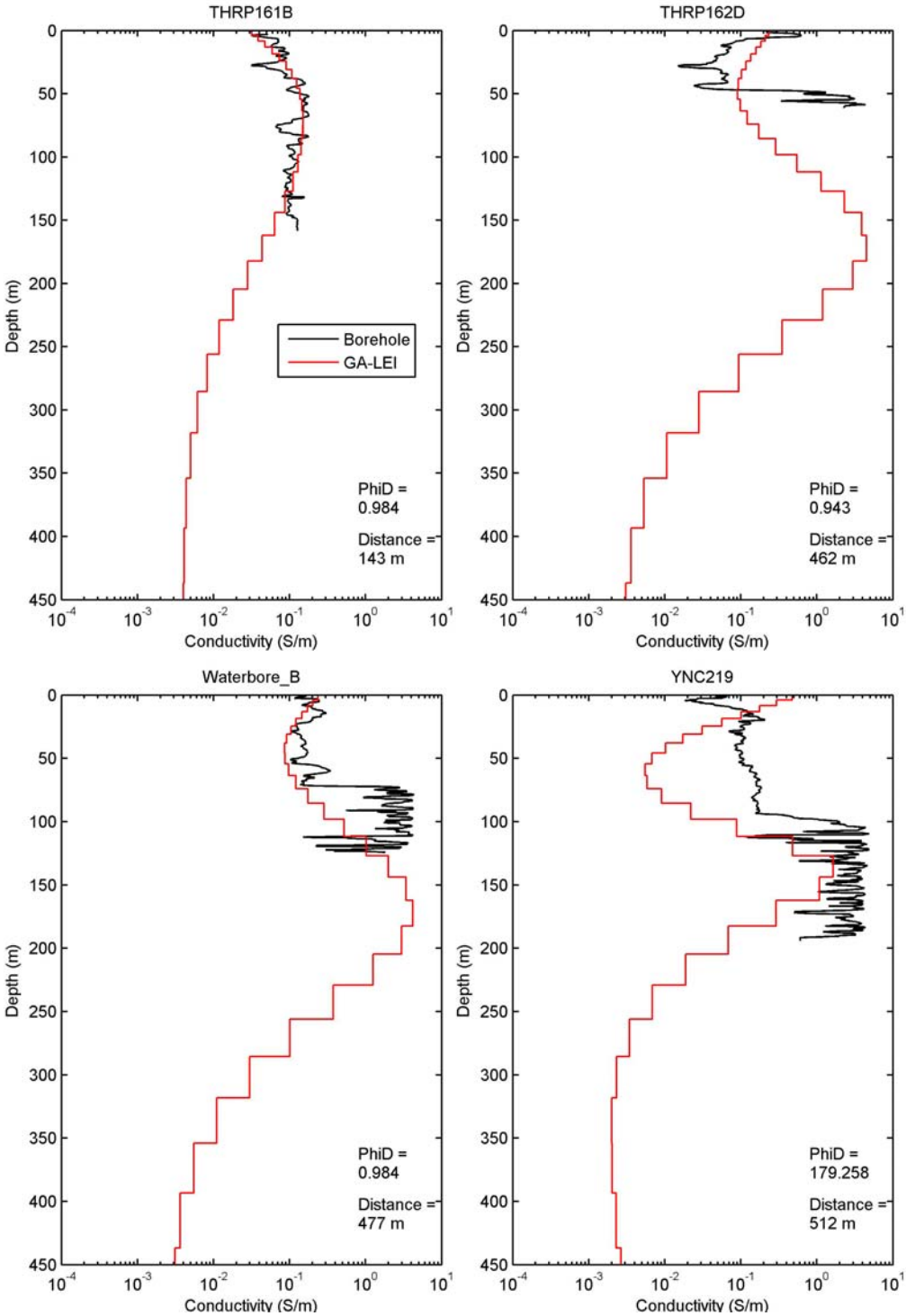

Figure A3.2: Comparison of borehole conductivity logs to the nearest point of the GA-LEI, continued.

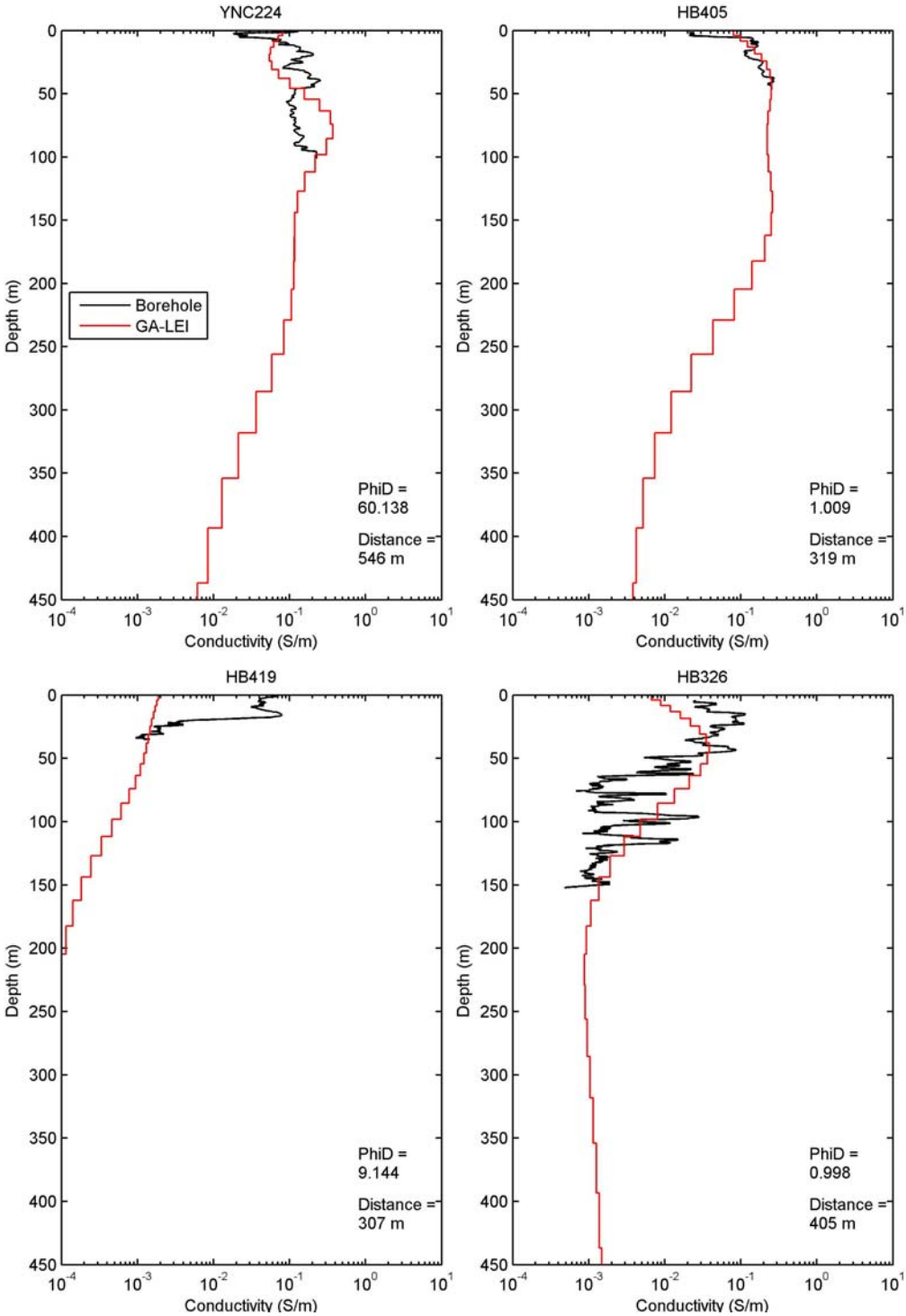

Figure A3.3: Comparison of borehole conductivity logs to the nearest point of the GA-LEI, continued.

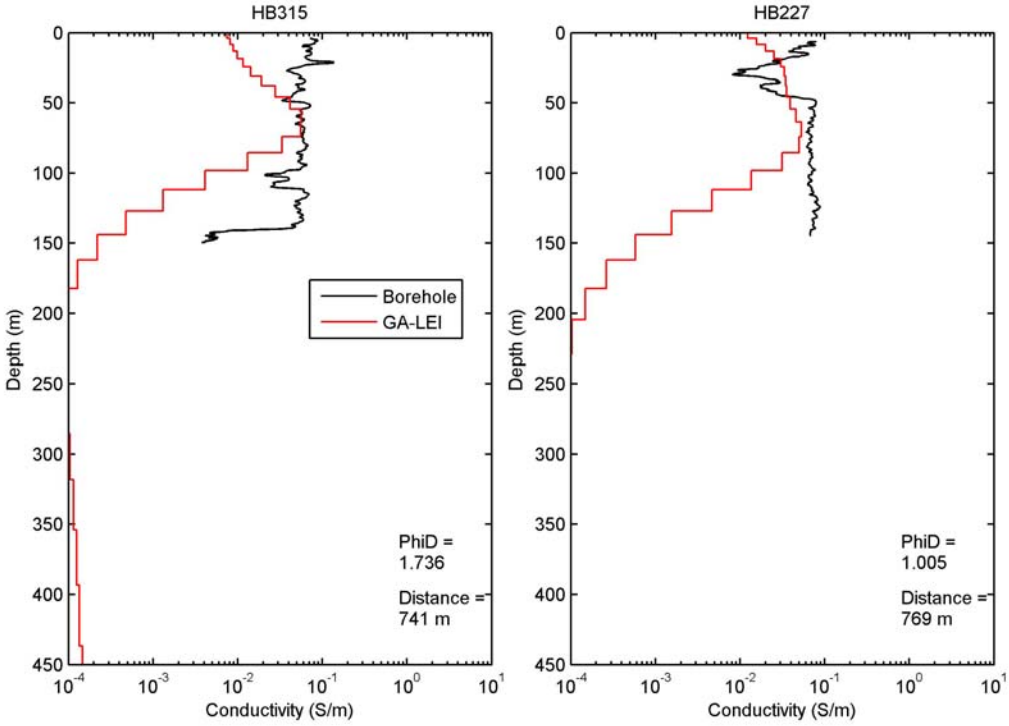

Figure A3.4: Comparison of borehole conductivity logs to the nearest point of the GA-LEI, continued.

A correlation analysis was used to compare the borehole conductivity data with the GA-LEI results. Since the AEM footprint is approximately 470m, this regression was applied only to the boreholes that were within 500 m of the flight lines. To perform this regression, each borehole was re-sampled at 5m depth intervals, using the mean conductivity value of each interval. The corresponding GA-LEI result was similarly re-sampled to 5m intervals, and the results were collated into a scatterplot, shown in Figure A3.5.

The line plotted in Figure A3.5 is a 1:1 comparison line between the borehole and GA-LEI data samples. Each dataset was transformed to logarithm space, and a correlation was performed on the transformed data. This was because the inversion algorithm fits the logarithm of conductivity data, and reflects the variability of conductivity across several orders of magnitude. The correlation yielded a coefficient of determination R^2 of 0.504. This is a statistically significant correlation at a >99 % confidence level.

This scatterplot and regression analysis includes the confidential logs acquired at Woodie Woodie, not shown above.

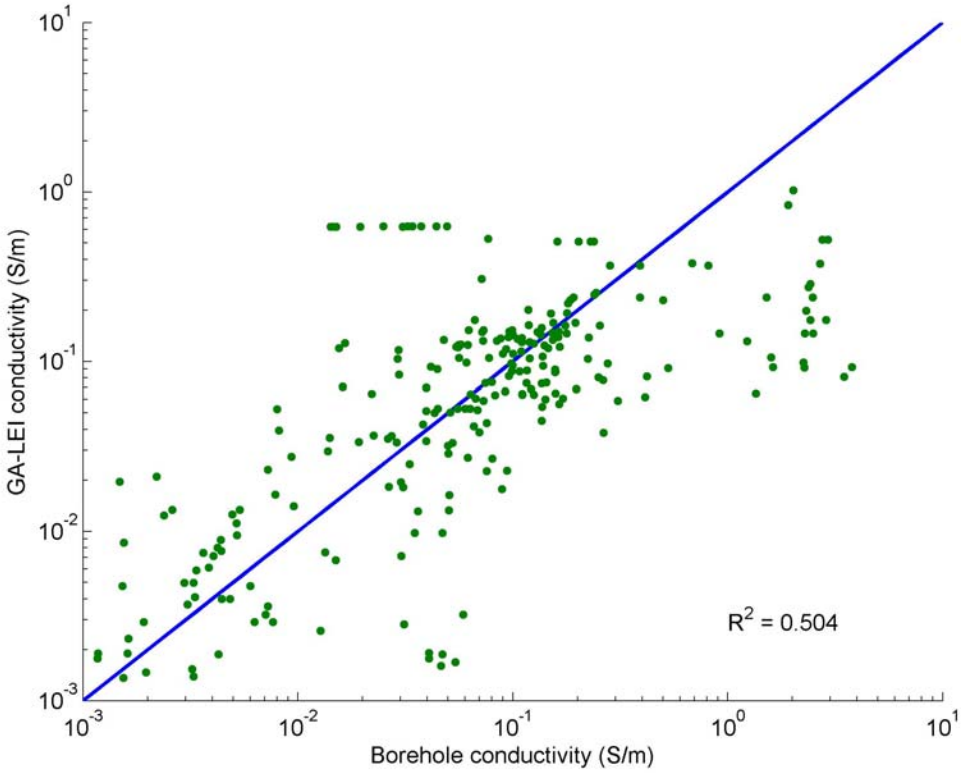

Figure A3.5: Scatterplot showing inversion borehole conductivity values (re-sampled at 5 m depth intervals) compared to the nearest sample of the GA-LEI. The R^2 value was determined after taking the logarithm of each dataset. Only boreholes within 500 m were included in this analysis.

Appendix 4

Accompanying DVD

NAME	FORMAT	DESCRIPTION	COMMENTS
Report Paterson_Conductivity_Logging_report	.pdf	Explanatory Notes	1 file
Well Vision Data FieldLogsProcess	.proj	project data	450 files
Figures holename_Induction_Unprocessed	.pdf	Induction log data	16 files
las_files_edited	.las	las files data	33 files

References

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