Riverina Oils and BioEnergy

Integrated Oilseed Processing Plant

Appendix H
Groundwater Review

Lennon Salvestro planning

ENSR | AECOM

Prepared for:
Riverina Oils and Bio Energy Pty Ltd
Wagga Wagga

Groundwater Review for Integrated Oilseed Processing and Biodiesel Plant

Wagga Wagga

Final

ENSR Australia Pty Ltd (HLA ENSR)
19 March 2008
Document No.: S6054304_RPTFinal_19Mar08.doc

HLA Merged with ENSR in 2007

Distribution

Groundwater Review for Integrated Oilseed Processing and Biodiesel Plant Wagga Wagga

19 March 2008

Copies	Recipient	Copies	Recipient
1	**Darren Wallett** **Department of Water and Energy** PO Box 5336 Wagga Wagga NSW 2650	1	**ENSR Australia Pty Ltd** Original
1	**Christopher Bulton** **Department of Environment and Climate Change** PO Box J44 Albury NSW 2640	1	**ENSR Australia Pty Ltd** Library
1	**Chris Ritchie** **Department of Planning** 23-33 Bridge Street Sydney NSW 2000		

By
ENSR Australia Pty Ltd (HLA ENSR)
ABN: 34 060 204 702
Level 5, 828 Pacific Highway Gordon NSW 2072
PO Box 726 Pymble NSW 2073

Ainslie Williams
Senior Hydrogeologist

Technical Peer Reviewer:	Date:
	19MAR08
Brad Eismen Principal Hydrogeologist	

Contents

1.0 Introduction

ENSR Australia Pty Ltd (HLA ENSR) has undertaken a review of groundwater data in support of the environmental assessment (EA) currently being prepared for a proposed integrated oilseed processing and bio-diesel plant near Wagga Wagga, NSW.

The proposed development site is approximately 17 ha in size and located about 10 kilometres north of Wagga Wagga, at the intersection of Trahairs Road and Byrnes Road (Refer to **Figure 1**).

The proposed bio-diesel facility would be located immediately to the north of the existing Wool Combing facility, which includes a processing plant and treatment and evaporation ponds which are no longer utilised. It is proposed that the bio-diesel facility will utilise the westernmost existing evaporation pond from the wool combing facility for disposal of wastewater, as well as irrigation of 10 hectares of pasture. It is understood that prior to the use of the existing evaporation pond, the pond would be refurbished and lined in accordance with appropriate industry standards including at least 900 mm of compacted clay with an in-situ permeability of less than 10^{-9} metres per second (m/s). The pond will be constructed to a capacity of 27 megalitres (ML).

1.1 Objective

The objective of this review is to:

- Collate and review available historical groundwater information;
- Anticipate the likely impacts associated with the use of the refurbished evaporation pond and irrigation of effluent on the groundwater system; and
- Provide recommendations for the management of potential impacts.

1.2 Available Information

The main sources of information which were used for the preparation of this report were:

- Charles Sturt University (CSU, 2006) Annual Environmental Report 2006, Riverina Wool Combing Pty Ltd.
- Charles Sturt University (CSU, 2005) Annual Environmental Report 2005, Riverina Wool Combing Pty Ltd.
- Johnstone Centre (2005) Annual Environmental Report 2004, Riverina Wool Combing Pty Ltd. Report No. 114. March 2005.
- HLA ENSR (2008) Irrigation Assessment, Wagga Wagga. 27 February 2008.
- HLA ENSR (2007) Soil Suitability Assessment, Use of Effluent by Irrigation – Riverine Oils and Bio Energy. 12 December 2007.

TABLES

Body Report

Tables Section

List of Figures

Body Report

Figures Section

2.0 Hydrogeological Regime

2.1 Geology

2.1.1 Regional Geology

The geology of the Wagga Wagga region is summarised as extensive folded Ordovician metasediments and large intruded Silurian granite masses as well as minor Devonian sandstones occupying hilly areas. Up to 10 m of Cainozoic alluvial, slope-wash and windblown clay has been deposited in the valley alluvial plains of all drainage systems.

2.1.2 Local Geology

The geology underlying the site is dominated by the Silurian granites, predominantly Wantabadgery Grandiorite and Collingullie Granite (Adamson and Loudon, *Wagga Wagga* 1:250,000 Geological Series Sheet S1-55-15, 1st ed. 1966). Thick clay sequences are present overlying the granite, with significant Aeolian clay in drainage depressions.

During previous investigations in the locality of the subject site (CSIRO, 1990; Coffey Partners, 1992), soils comprising surficial sandy loams over plastic silty to sandy clays were encountered to depths of approximately 6 metres. Fine gravels consistent with weathered granitic bedrock (saprolite) were encountered in clay materials from approximately 3 metres below ground surface. Variably weathered bedrock could occur to depths of approximately 40 metres below grade.

2.2 Soils

The *Soil Landscapes of the Wagga Wagga 1:100,000 Sheet* (DLWC, 1997) describes the soils in the vicinity of the site as being part of the East Bomen soil landscape group, comprising shallow to moderately deep (40-150cm) Eutrophic Red Dermosols on crests and ridges; deep (80-200cm) Eutrophic Red Dermosols on slopes; and moderately deep (80-150cm) Eutrophic Brown Dermosols in drainage lines.

2.3 Surface Water, Topography and Drainage

The topography in the vicinity of the site is generally flat with an elevation of approximately 245 metres (*Wagga Wagga* 8327-1-N 1:25,000 Topographic Map, 2nd ed. NSW Department of Lands 1991).

The site is located within the Wagga Wagga catchment area, located along the Murrumbidgee River. The proposed location for the bio-diesel plant is approximately 7 km north of the Murrumbidgee River. A number of minor tributaries and drainage lines are located in the vicinity of the site and suggest a southerly drainage direction in the event of storm events.

2.4 Hydrogeology

2.4.1 Regional Hydrogeology

The Wagga Wagga catchment area is predominantly situated on a large drainage basin comprising heavy clay soils, with only a small catchment discharge point. The combination of geographical and geological features prevents groundwater from easily migrating away from the area, resulting in waterlogging and increased salinity, affecting both urban and agricultural environments (Wagga Wagga City Council, 2007).

There are three regional hydrogeological units of the Wagga Wagga area, including the Ordovician metasediments, the Silurian granites and Tertiary and Quaternary alluvium (CSIRO, 2001). Groundwater yields within the metasediments typically range between 0.3 and 0.5 litres per second (L/s), with higher yields experienced where well-fractured zones are intersected. Bores constructed within granites have typically been unsuccessful, although yields of up to 0.2 L/s have been recorded. Yields from alluvium production bores are up to 200 L/s. The depth of the water table in the Wagga Wagga area varies, but has been recorded at less than 2 m in areas where salinity has affected urban infrastructure and vegetation (CSIRO, 2001).

2.4.2 Local Hydrogeology

Historical reports have identified the presence of two aquifers beneath the site including:

- A shallow, or perched aquifer is present at approximately 2 metres depth; and
- A deeper aquifer is present between 4 and 13 metres below the surface.

Little data are available regarding shallow groundwater flow directions prior to excavation and use of the evaporation ponds, however groundwater is expected to have flowed in an easterly direction from recharge areas on the elevated ground towards lower ground along the water courses.

Falling head permeability tests reported in previous annual reports indicate lateral infiltration rates of approximately 0.15 m/d in sandy clay and 0.0012 m/d to 0.0018 m/d in clay with minor sand content in the vicinity of the subject site

In addition to groundwater within the weathered granite zone, groundwater is likely to flow through fractures within the underlying granite bedrock, with variable flow rates depending on the local interconnectivity of fractures.

2.5 Rainfall

Wagga Wagga has an average annual rainfall of 572 mm, distributed fairly equally over the full 12 months.

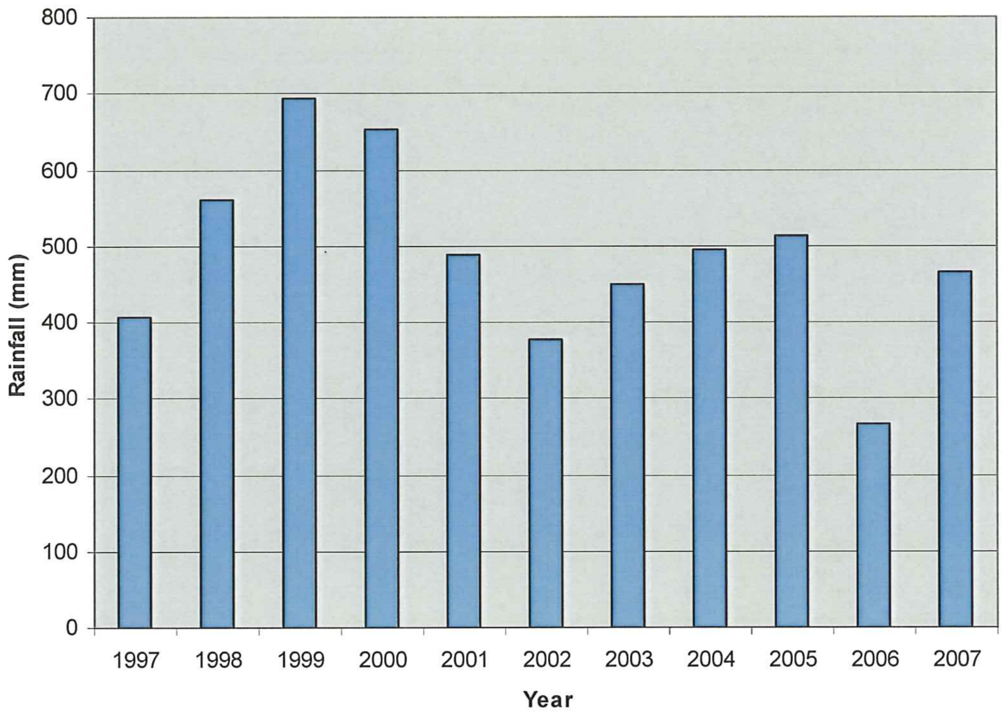
Maximum temperatures in summer are warm, averaging between 29°C and 32°C. The winters are cool to cold with overnight minimums averaging 3°C and daily maximums climbing to only 12°C to 14°C on average.

Average monthly rainfall over the period 1997 to 2007 is presented in **Table 1** below.

Table 1: Monthly Rainfall - Wagga Wagga (Weather Station 072150)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Jan	49.8	25.8	46.6	62.8	22.8	3.6	7.0	22.8	13.2	69.4	40.2
Feb	6.2	32.0	8.8	26.6	86.4	139.8	58.6	9.4	46.8	1.8	54.6
Mar	42.8	2.0	78.4	26.0	56.6	24.0	1.6	0.0	6.6	10.6	23.8
Apr	0.6	77.2	77.6	61.6	31.2	25.0	9.2	15.4	14.6	17.4	46.0
May	57.4	8.0	42.2	71.8	8.0	30.2	28.4	40.8	4.6	4.6	52.4
Jun	34.2	101.4	43.0	55.0	62.8	50.8	69.4	73.4	69.0	39.4	19.4
Jul	26.4	48.8	32.0	56.4	31.6	14.4	60.2	38.0	65.0	49.2	38.2
Aug	42.4	43.4	50.2	92.4	47.6	32.4	67.2	66.8	56.4	7.6	22.2
Sep	81.2	71.8	60.6	46.8	39.2	36.0	26.0	53.6	85.0	20.0	7.4
Oct	17.6	39.6	119.6	102.0	86.8	0.6	55.4	26.0	77.6	3.8	14.6
Nov	23.4	60.4	27.0	32.4	12.0	12.2	28.0	87.6	44.8	34.0	73.0
Dec	25.8	50.6	107.4	19.6	3.2	7.8	39.2	60.6	29.4	9.4	74.6
Reported Annual:	407.8	561.0	693.4	653.4	488.2	376.8	450.2	494.4	513.0	267.2	466.4

Figure 1: Graphical Representation of Annual Rainfall 1999 – 2006



2.6 Existing Groundwater Bores

A search of Department of Water and Energy (DWE – formerly known as the Department of Natural Resources) licensed groundwater bores was undertaken to determine existing groundwater users in the vicinity of the proposed site. The results of this search are shown in **Table 3** and **Figure 2**.

Table 2: Licensed Groundwater Users

Groundwater Bore ID	Authorised Purpose	Distance from Study Area
GW010925	Stock	1 km north west
GW400117	Monitoring Bore	
GW400118	Monitoring Bore	
GW400116	Monitoring Bore	
GW400918	Monitoring Bore	
GW400115	Monitoring Bore	
GW400114	Monitoring Bore	
GW400093	Monitoring Bore	
GW400122	Monitoring Bore	
GW400092	Monitoring Bore	
GW400121	Monitoring Bore	
GW010900	Domestic Stock	2 km west

Groundwater Bore ID	Authorised Purpose	Distance from Study Area
GW400926	Monitoring Bore	
GW400119	Monitoring Bore	
GW402564	Monitoring Bore	
GW402565	Monitoring Bore	
GW024160	Domestic Stock	2 km south east
GW045371	Domestic Stock	2 km north west
GW402563	Monitoring Bore	
GW401827	Domestic Irrigation	2 km west
GW037631	Domestic Stock	2.25 km west
GW019939	Domestic Farming Irrigation Stock	2.25 km north east
GW022006	Stock	2.5 km east

Groundwater bores used for irrigation or stock purposes are not located within two kilometres of the study area.

3.0 Historical Data Review

3.1 Monitoring Well Network

A total of 16 paired groundwater monitoring wells are present in the vicinity of the treatment ponds and evaporation basins associated with wool combing site. A further two paired monitoring wells are located east of the evaporation ponds, with one pair located within and one just east of the irrigated lucerne paddock.

Monitoring wells 1 to 12 and 14 to 20 are nested, with the first (a) intercepting the shallow aquifer (approximately 2 metres) and the second (b) intercepting the deeper aquifer (ranging from 4 to 13 metres). The following table provides a description of the monitoring well network.

Table 3: Monitoring Well Network

Monitoring Well ID	Australian Height Datum	Location Description	Well Depth
P1a (shallow)	227.85	Evaporation Basin 3	1.80
P1b (deep)	227.875	Evaporation Basin 3	11.00
P2a	228.17	Evaporation Basin 3	1.80
P2b	228.17	Evaporation Basin 3	6.90
P3a	228.16	Evaporation Basin 3	1.85
P3b	228.16	Evaporation Basin 3	4.90
P4a	228.52	Evaporation Basin 3	1.70
P4b	228.52	Evaporation Basin 3	11.05
P5a	222.27	Evaporation Basin 4	1.80
P5b	222.27	Evaporation Basin 4	4.40
P6a	222.58	Evaporation Basin 4	1.80
P6b	222.58	Evaporation Basin 4	5.40
P7a	222.47	Evaporation Basin 4	1.80
P7b	222.47	Evaporation Basin 4	4.90
P8a	218.03	Evaporation Basin 5	1.80
P8b	218.03	Evaporation Basin 5	5.50
P9a	218.31	Evaporation Basin 5	1.80
P9b	218.31	Evaporation Basin 5	3.80
P10a	218.28	Evaporation Basin 5	1.80
P10b	218.28	Evaporation Basin 5	8.35
P11a	228.79	North of Terminal Pond	1.70
P11b	228.79	North of Terminal Pond	11.05
P12a	222.67	Base of Terminal Pond	1.90

Monitoring Well ID	Australian Height Datum	Location Description	Well Depth
P12b	222.67	Base of Terminal Pond	12.95
P13	223.81	South of Terminal Pond	4.40
P14a	226.84	North of Waste Cell	6.45
P14b	226.84	North of Waste Cell	10.50
P15a	228.15	East of Waste Cell	10.60
P15b	228.15	East of Waste Cell	6.30
P16a	235.33	South of Waste Cell	6.60
P16b	235.33	South of Waste Cell	10.70
P17a	234.01	South of Waste Cell	2.30
P17b	234.01	South of Waste Cell	-
P18a	239.04	Near Main Entrance	2.10
P18b	239.04	Near Main Entrance	7.60
P19a	224.46	East of Evaporation Basin 4	3.15
P19b	224.53	East of Evaporation Basin 4	8.26
P20a	225.08	East of Evaporation Basin 4	3.20
P20b	225.13	East of Evaporation Basin 4	10.95

Monitoring wells P14 to P17 were located to detect issues associated with leachate from the dry waste cell. Monitoring well P18 provides an indication of off-site groundwater quality, and monitoring wells P19 and P20 were located intercept any problems with wastewater being irrigated on the lucerne paddock.

Monitoring wells P1, P2, P3 P4, P5, P6, P7 and P11 are the closest wells to the subject site and evaporation pond proposed for use. Refer to **Figure 3 to 8** for location of these wells.

Dry weather conditions experienced in the area over the past years have lowered groundwater levels and many of the monitoring wells on-site are now dry. Excluding monitoring wells P19a and P20a located within the adjacent lucerne paddock, all monitoring wells located within the shallow aquifer ('a' series) are currently dry, indicating that the perched aquifer no longer exists, or has lowered to a level beyond the maximum depth of the monitoring wells. A number of wells located within the deeper aquifer ('b' series) are now also dry including P2b, P3b, P7b, P8b, P10b, P11b, P12b, P14b, P16b, P17b and P18b. This decline in water level within the deeper aquifer is considered to reflect regional rainfall patterns.

3.2 Groundwater Level Monitoring

Groundwater levels at the site have been monitored regularly since 1997 and indicate an overall decline in groundwater levels across the site during this time. This is expected to be attributed to the drought conditions experienced in the area during this time. As such, an increase in groundwater levels may be experienced with the onset of wetter weather conditions. Average annual groundwater levels are presented in **Table T1** of the tables section.

Currently, all monitoring wells located within the shallow aquifer are dry, excluding monitoring wells P19a and P20a. Monitoring wells P19a and P20a are located within and adjacent to an irrigated lucerne paddock and the presence of water within the shallow aquifer east of the site may be attributed to different geology or ongoing irrigation of these paddocks.

Changes in the average annual groundwater levels are presented in **Figures 9** to **15**.

Historical results indicated limited correlation between rainfall and groundwater levels in the shallow (perched) aquifer prior to these wells going dry. The average annual standing water levels reported for the shallow wells were more erratic, indicating the shallow aquifer may be influenced more by surface activities and the intermittent use of the evaporation ponds rather then rainfall events.

Standing water levels within the deeper aquifer generally followed trends in regional rainfall patterns, indicating that the deeper aquifer is influenced more by regional rainfall patterns rather than use of the evaporation ponds and irrigation of the adjacent paddock.

A review of water level data indicates that groundwater flow direction of the deeper aquifer in the vicinity of the evaporation ponds is generally in an east to south-easterly direction (refer to **Figures 9** to **15**). Contour plots for the deep aquifer were produced for three years which represented groundwater flow during use of the evaporation ponds (2004), during reduced use of the ponds (2006) and when the ponds were not in use (2007). Two plots were produces for each year to determine any differences between summer and winter months.

The contour plots show little difference in groundwater flow direction during and after use of the evaporation ponds or from season to season.

Groundwater flow directions and contour maps for the shallow aquifer were unable to be produced due to the wells being dry for a majority of the monitoring period.

Reduced production at the Wool Combing facility began in 2005-2006 and the majority of the evaporation ponds ran at very low levels during 2006, which reflects the reduced production throughout the plant and good evaporation rates during an extended period of low rainfall. This reduction in surface water appears to have slightly increased the rate of groundwater level decline in some wells (P1a, P1b and P6b), indicating some connection between the ponds and the groundwater table. However, the overall climatic conditions appear to have had a far greater influence on deep groundwater levels at the site.

It was noted in the report by Charles Sturt University (2006) titled *Soil and Irrigation Monitoring Report* that no irrigation of nearby paddocks was undertaken in 2005-2006. This may also be a contributing factor in the increased rate of decline in water levels over this period.

Groundwater level monitoring data indicate that in 2006 there was approximately four metres difference in water levels between the shallow and deep aquifers in the vicinity of the evaporation ponds (monitoring wells 1A and 1B) and up to seven metres difference in water level in the irrigation paddock (monitoring wells 19A/B and 20 A/B). In addition, annual trends between the shallow and deep aquifers appear to differ in some wells.

3.3 Groundwater Quality Monitoring

Groundwater quality is protected in NSW by the *Protection of the Environment Operations Act 1997* and the *Water Management Act 2000*. Identification of the receiving environment or the likely beneficial use of the water is essential for selection of the most applicable criteria.

The Murrumbidgee River is the dominant surface water feature within the area, although it lies some seven kilometres south of the site. The Murrumbidgee River has previously been extensively used for local irrigation and stock purposes.

Groundwater analytical results presented in the annual environmental reports were assessed against the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC 2000) for Primary Industries (Irrigation) Water. Trigger levels represent the best current estimates of the concentrations of chemicals that should have no significant adverse effects on the aquatic ecosystem. Where trigger levels are not provided, an assessment of the variation between the years was undertaken.

The groundwater quality impact assessment criteria are provided in **Table 4**.

Table 4: Groundwater Quality Assessment Criteria

Indicator	Irrigation Criteria
pH	>6.5 and <8.5
Conductivity (EC)	No criteria available
Total Dissolved Solids (TDS)	13,000 mg/L
Sodium (Na)	460 mg/L
Potassium (K)	No criteria available
Calcium (Ca)	1000 mg/L
Magnesium (Mg)	No criteria available
Chloride (Cl)	700 mg/L
Bicarbonate (HCO3)	No criteria available
Nitrate (NO3)	400 mg/L
Sulfate (SO4)	1000 mg/ L
Hardness	350 mg/L as CaCO3

Groundwater quality data from 2003 to 2006 is available for limited deep groundwater wells, as all shallow wells and some deep wells were dry. A summary of this data is presented in **Table 5**.

The groundwater analytical results indicate that groundwater is neutral to alkaline and is considered brackish in nature. The analytical results indicate the water is generally suitable for irrigation purposes in accordance with the ANZECC guidelines. There was little variation between results reported from when the ponds were in use (2003, 2004, 2005), and when the ponds were no longer in use (2006).

As background water quality samples were not available, the impact of historical use of the evaporation ponds is unable to be determined. Oil and grease was reported as being present in a majority of groundwater samples, albeit at generally low levels. This suggests some infiltration of surface contaminants to the deep aquifer, however it is unclear if this contamination is from the disposal of wastewater at the site or from further up-hydraulic gradient.

No groundwater quality data was available for P19 and P20 (located in the lucerne paddock) therefore no conclusions could be made regarding the effect of irrigating wastewater on groundwater quality.

Table 5: Groundwater Quality Results

		Average Concentration								
Monitoring Well ID	Year	Nitrogen mg/L	Potassium mg/L	Sodium mg/L	pH	EC uS/cm	Bicarbonate mg/L	Calcium mg/L	Magnesium mg/L	Chloride mg/L
P1b	2003	10.6	2.85	106.5	7.2	1253	359	98	38	179
	2004	9.75	2.85	401	7.1	1325	373	106	36.7	210
	2005	7.2	2.8	128	7.3	1328	376	96	40.3	215
	2006	9	3.03	121	7.4	1358	379	104	42.5	195
P4b	2004	DRY								
	2005	18	4.2	220	8.1	1170	543	15	16.8	27.5
	2006	16	4.4	231	8.2	1200	524	23.6	22.1	28.6
P5b	2003	22.4	1.23	63	7.4	941	327	74.2	37.9	57.4
	2004	29	1.7	76.4	7.4	963	340	73.6	37.9	60
	2005	28	1.7	80.9	7.3	1029	341	70.3	39.3	65.1
	2006	31	1.45	73.7	7.5	964	291	71.2	38.7	56.7
P6b	2003	1	4.1	90.4	7.5	1263	333	75.9	47.5	217
	2004	<2	4.9	114	7.5	1280	348	81.6	50.9	218
	2005	4	5.1	106	7.4	1298	353	75.9	52.3	234
	2006	7	5.1	114.6	7.6	1355	352	84.1	55.8	234
P9b	2003	2.3	7.2	287	7.4	2556	860	117	119	447
	2004	5	9.9	327	7.6	2430	2900	33.8	108	476
	2005	DRY								
	2006	DRY								
P13	2003	6.8	4	123.2	7.3	896	194	24	14	102
	2004	4.7	5.85	127	7.2	689	164	16.2	9.8	89.8
	2005	8	4	116	7.1	688	151	13.7	9	89
	2006	5	4.3	131	7.1	730	218	16.1	10.3	79.1

4.0 Potential Impacts of Development on Groundwater Regime

4.1 Infiltration of Effluent

As discussed above, groundwater level monitoring results and trends within the two aquifers present at the site indicate there is little connectivity between aquifers, with differences in water levels from paired wells of up to 7 metres and annual trends differing between the two aquifers in some locations.

Aitken Rowe Testing Laboratories completed a geotechnical evaluation of the development site in December 2007. The evaluation determined that the permeability of clays (compacted to 95% standard maximum dry density) underlying the site were in the order of 1.0×10^{-9} m/sec. The report also stated, "*Based on the test results, visual inspection of the material and subsurface profile as discussed above, the underlying clays are considered impermeable*".

Some infiltration of effluent may occur in the vicinity of the irrigation area, although this should be minimised by the underlying clay soils.

4.2 Changes in Groundwater Level and Flow Direction

The use of the evaporation pond is unlikely to result in changes of water levels or quality because of the reconstructed clay liner. Irrigation of the adjacent paddock may result in some localised mounding of the groundwater table based on data from the monitoring wells in the lucerne paddock.

Review of the available historical groundwater level data indicates that the previous use of the ponds caused little variation in deep groundwater flow direction. An assessment of the impact to shallow groundwater was unable to be undertaken due to limited historical data.

Historical data suggest that impacts to groundwater levels as a result of use of the evaporation pond and irrigation of the adjacent paddock will be localised and have no significant effect on the surrounding environment.

4.3 Changes in Water Quality

The quality of effluent to be discharged to the evaporation pond and irrigated on the adjacent paddock is detailed in the following table, from HLA ENSR (2008):

Table 6: Effluent Quality

	SOURCE							
Parameter	**Vegetable Oil Refining Unit** **mg/L**	**Glycerin Refining Unit** **mg/L**	**Solvent Extraction Unit** **mg/L**	**Water Treatment Plant** **mg/L**	**Boiler** **mg/L**	**Cooling Towers** **mg/L**	**Cooling Water** **mg/L**	**TOTAL** **mg/L**
Volume (kL)	26	40	24	0.5	1.2	58	20	170
pH	8-10		8.0					7-9
Oil and Grease	200	negligible	negligible	negligible	negligible	negligible	negligible	30
Total Dissolved Solids	2000 – 3000	negligible	negligible	20,000	2,000	1,200	1,200	930 – 1,080

	SOURCE							
Parameter	Vegetable Oil Refining Unit mg/L	Glycerin Refining Unit mg/L	Solvent Extraction Unit mg/L	Water Treatment Plant mg/L	Boiler mg/L	Cooling Towers mg/L	Cooling Water mg/L	TOTAL mg/L
Total Nitrogren	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible
Sulfate	N/A	N/A	N/A	negligible	negligible	negligible	negligible	negligible
Total Phosphorus	146	negligible	negligible	negligible	negligible	negligible	negligible	22
Sodium	325	25	25	2,000	125	125	125	120
Potassium	2	2	2	160	10	10	10	6
Magnesium	13	13	13	1200	65	65	65	41
Calcium	16	16	16	1280	80	80	80	50
Biochemical Oxygen Demand (BOD)	100	negligible	negligible	negligible	negligible	negligible	negligible	15
Chloride	30	30	30	2,400	150	150	150	95

The above concentrations are generally below historical groundwater concentrations. HLA ENSR concluded that the proposed 10 hectare irrigation area was adequate to absorb loading of the following:

- BOD
- Nitrogen
- Phosphorus
- Calcium
- Magnesium
- Potassium

Monitoring the sodium content in the effluent, and soils on which the effluent will be irrigated, will be important to ensure irrigation does not result in soil degradation by increasing soil salinity, which may subsequently increase groundwater salinity. The Irrigation Assessment (HLA ENSR, 2008) details methods that will be undertaken to manage salt concentrations in soil.

Regular monitoring of groundwater quality is recommended so that adverse impacts to groundwater quality can be identified and managed accordingly.

4.4 Impacts to Neighboring Properties

Bores used for irrigation and stock watering are located more than two kilometers from the site and are therefore unlikely to be affected by changes in groundwater levels or water quality. Historical data have indicated that changes to deep aquifer water levels in the vicinity of the evaporation ponds were not found to affect the surrounding area.

Monitoring of groundwater quality and standing water levels would identify any potential for off-site impacts

4.5 Aquifer Connectivity

Groundwater level monitoring and quality result trends indicate there is minimal connectivity between the shallow perched aquifer and the deeper regional aquifer. This is further supported by observations and testing conducted as part of the geotechnical assessment (Aitken Rowe 2007).

Data indicate that in 2006 there was approximately four metres difference in water levels between the shallow and deep aquifers in the vicinity of the evaporation ponds (monitoring wells 1A and 1B) and up to seven metres difference in water levels in the irrigation paddock (monitoring wells 19A/B and 20 A/B). In addition, annual trends between the shallow and deep aquifers appear to differ in a wells.

5.0 Management of Impacts

5.1 Changes in Groundwater Levels and Flow Direction

Prior to use of the evaporation pond, a complete refurbishment will be undertaken and the pond will be lined in accordance with appropriate industry standards including at least 900 mm of compacted clay with an in-situ permeability of less than 10^{-9} m/s. This lining will minimise infiltration of effluent into the underlying shallow perched aquifer.

Should significant increases in groundwater levels be recorded or unanticipated changes to groundwater quality be reported during routine monitoring, the lining of the pond should be inspected and the quantity of water being irrigated should be assessed. The extent of the groundwater mounding or changes in flow direction may be further investigated through monitoring of additional monitoring wells. If the impact is localised and not found to be affecting adjacent landholders, no mitigation measures should be necessary. It is unlikely that the impact would be widespread.

5.2 Changes in Water Quality

The refurbishment of the evaporation pond will minimise infiltration of effluent into the underlying shallow perched aquifer and should therefore also minimise the impact to groundwater quality. However, some infiltration of effluent to the underlying shallow perched aquifer is expected in the irrigation area.

The Irrigation Assessment (HLA ENSR 2008) details methods by which the irrigation of effluent will be managed and describs methods to ensure sustainability of the operation.

Routine groundwater monitoring will be undertaken so that adverse impacts to groundwater quality can be identified and managed accordingly.

5.3 Installation of Additional Monitoring Wells

An extensive network of groundwater monitoring wells has been established, however many of the wells are dry and/or are not positioned to adequately monitoring the proposed development.

The installation of additional/replacement monitoring wells is recommended prior to operation of the proposed development for the purpose of assessing potential groundwater impacts associated with the development. Recommended additional wells include:

- One shallow and one deep monitoring well located up-hydraulic gradient of the evaporation pond;
- Two shallow and two deep monitoring wells located on the eastern side of the evaporation pond (down-hydraulic gradient);
- One shallow and one deep monitoring well located east (up-hydraulic gradient) of the area to be irrigated and the site; and
- One shallow and one deep monitoring well located west (down-hydraulic gradient) of the area to be irrigated.

The monitoring well located east of the area to be irrigated will also provide background water quality data for groundwater entering the site.

Further details regarding the construction of the additional monitoring wells will be detailed in the Groundwater Monitoring Plan, discussed below.

5.4 Groundwater Monitoring Plan

Groundwater monitoring is required to provide ongoing assessment of the impacts associated with the evaporation and irrigation of effluent and to also enable detection of adverse impacts on the groundwater regime, so that remedial action can be undertaken, where required.

A Groundwater Monitoring Plan (GMP) will be developed and implemented prior to the operation of the proposed development. The GMP will include:

- Recommendations for the installation of additional monitoring wells including construction details;
- Development of a groundwater monitoring schedule including sampling methodology and timetable; and
- Preparation of a consolidated Groundwater Management Plan to be implemented during operation of the proposed development.

It is recommended that groundwater quality monitoring and the collection of groundwater standing water levels be undertaken prior to operation of the proposed development. This information will provide background data to which future monitoring data can be compared. Following the commencement of operations, quarterly groundwater monitoring in conjunction with irrigation and effluent monitoring is recommended.

ENSR | AECOM

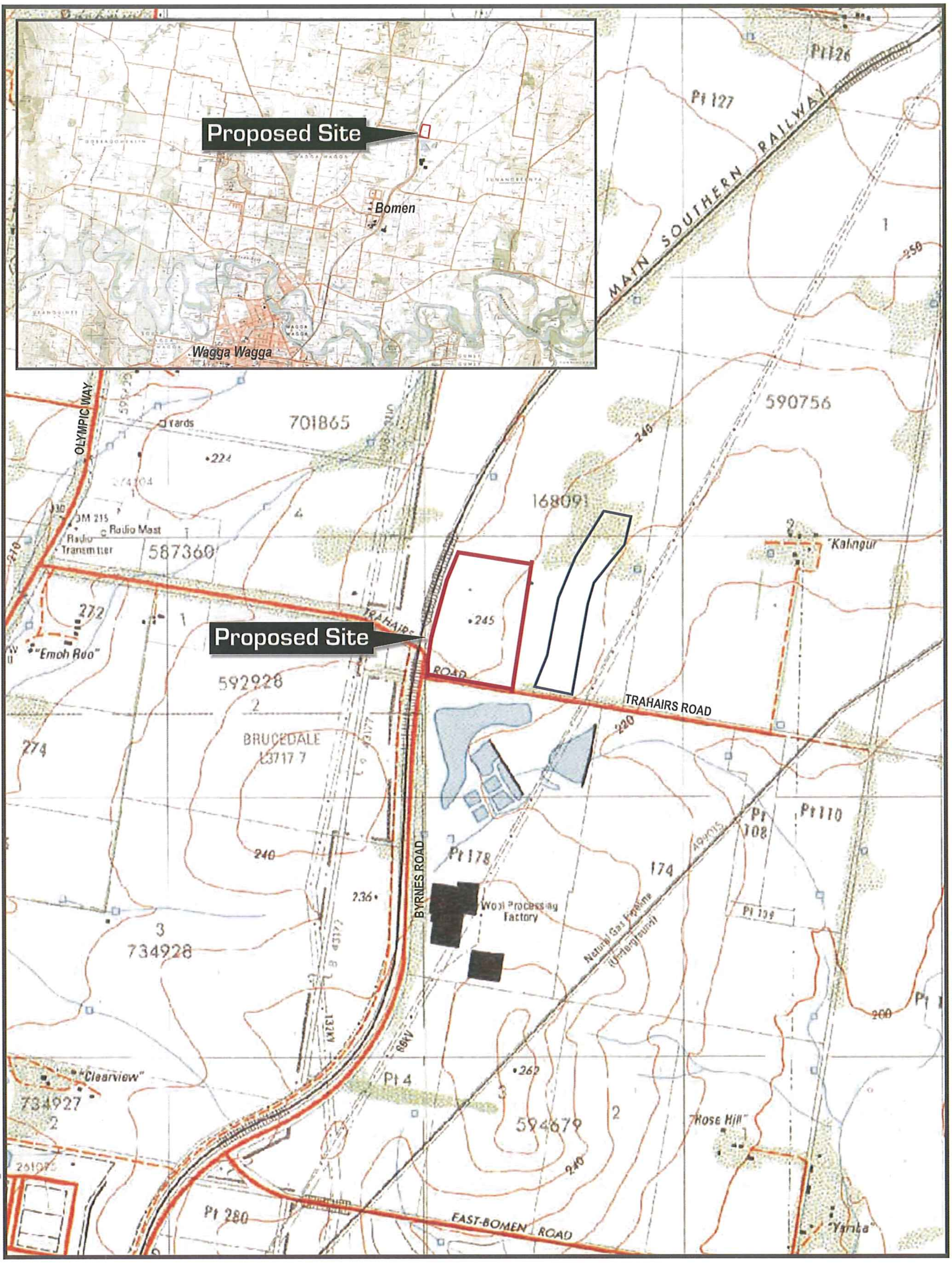
Tables

Table T1: Average Annual Groundwater Standing Water Levels

Bore No.	Well Depth (m from ground surface)	Standpipe Height (m)	AHD (m at ground surface)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1a	**1.80**	**0.49**	**227.85**	DRY	227.00	226.35	226.33	226.19	226.11	225.53	DRY	226.10	224.88	DRY
1b	**11.00**	**0.44**	**227.85**	222.65	222.95	221.98	222.26	221.72	221.23	220.95	220.64	221.03	219.93	219.20
2a	**1.80**	**0.52**	**228.17**	DRY	227.42	226.54	226.55	226.44	226.33	DRY	DRY	DRY	DRY	DRY
2b	**6.90**	**0.43**	**228.17**	DRY	DRY	221.25	222.10	DRY	DRY	DRY	DRY	221.41	DRY	DRY
3a	**1.85**	**0.30**	**228.16**	DRY	DRY	226.10	226.23	DRY	DRY	DRY	DRY	226.24	DRY	DRY
3b	**4.90**	**0.37**	**228.16**	DRY	DRY	DRY	224.16	223.51	DRY	DRY	DRY	223.96	DRY	DRY
4a	**1.70**	**0.31**	**228.52**	DRY	DRY	DRY	219.18	DRY	DRY	DRY	DRY	DRY	DRY	DRY
4b	**11.05**	**0.33**	**228.52**	222.12	221.72	219.41	218.27	217.80	217.27	DRY	DRY	219.42	217.54	214.06
5a	**1.80**	**0.11**	**222.27**	221.15	221.05	220.51	220.84	220.74	220.23	DRY	DRY	220.22	DRY	DRY
5b	**4.40**	**0.31**	**222.27**	221.28	222.08	220.68	220.85	220.81	220.20	219.61	218.94	218.91	217.70	219.63
6a	**1.80**	**0.42**	**222.58**	222.43	221.93	221.05	220.91	220.98	220.81	DRY	DRY	220.68	DRY	DRY
6b	**5.40**	**0.42**	**222.58**	221.33	221.03	220.50	220.66	220.63	219.93	219.28	218.67	218.49	217.13	215.93
7a	**1.80**	**0.41**	**222.47**	221.97	221.67	220.82	220.75	220.61	DRY	DRY	DRY	220.60	DRY	DRY
7b	**4.90**	**0.39**	**222.47**	DRY	DRY	DRY	DRY	217.94	DRY	DRY	DRY	DRY	DRY	DRY
8a	**1.80**	**0.36**	**218.03**	DRY	DRY	216.22	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
8b	**5.50**	**0.33**	**218.03**	217.33	215.73	212.47	213.59	DRY	DRY	DRY	215.92	DRY	DRY	DRY
9a	**1.80**	**0.38**	**218.31**	217.41	217.31	216.73	216.48	216.38	216.37	DRY	DRY	216.15	DRY	DRY
9b	**3.80**	**0.41**	**218.31**	217.41	217.21	216.67	216.65	216.43	215.99	215.62	214.94	214.77	213.52	213.09
10a	**1.80**	**0.44**	**218.28**	DRY	DRY	216.52	216.58	DRY	DRY	DRY	DRY	216.52	DRY	DRY
10b	**8.35**	**0.47**	**218.28**	214.08	213.68	212.31	211.58	211.76	210.66	210.87	DRY	210.73	DRY	DRY
11a	**1.70**	**0.21**	**228.79**	DRY	DRY	DRY	226.71	DRY	DRY	DRY	DRY	DRY	DRY	DRY
11b	**11.05**	**0.32**	**228.79**	DRY	DRY	DRY	DRY	DRY	DRY	DRY	217.25	DRY	DRY	DRY
12a	**1.90**	**0.61**	**222.67**	221.87	222.07	221.09	221.07	221.19	220.76	DRY	DRY	DRY	DRY	DRY
12b	**12.95**	**0.73**	**222.67**	211.57	212.27	210.99	211.73	212.56	213.09	212.84	210.48	209.37	DRY	DRY
13	**4.40**	**0.58**	**223.81**	223.41	223.21	222.61	222.78	222.49	222.48	220.66	222.18	222.33	219.92	215.59
14a	**6.45**	**0.44**	**226.84**	DRY	DRY	DRY	220.68	DRY	DRY	DRY	DRY	221.26	219.85	DRY
14b	**10.50**	**0.53**	**226.84**	DRY	DRY	216.70	221.69	DRY	DRY	DRY	DRY	DRY	DRY	DRY

Bore No.	Well Depth (m from ground surface)	Standpipe Height (m)	AHD (m at ground surface)	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
15a	**10.60**	**0.50**	**228.15**	DRY	DRY	217.93	DRY	DRY	DRY	DRY	DRY	DRY	216.95	DRY
15b	**6.30**	**0.51**	**228.15**	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
16a	**6.60**	**0.42**	**235.33**	DRY	DRY	DRY	230.52	229.23	DRY	DRY	DRY	229.80	DRY	DRY
16b	**10.70**	**0.44**	**235.33**	DRY	DRY	224.87	225.03	DRY	DRY	DRY	225.13	DRY	DRY	DRY
17a	**2.30**	**0.49**	**234.01**	DRY	233.36	DRY	232.07	DRY	DRY	DRY	DRY	232.16	DRY	DRY
17b	**7.50**	**0.51**	**234.01**	DRY	231.83	227.06	DRY	DRY	DRY	228.20	DRY	226.98	225.79	DRY
18a	**2.10**	**0.55**	**239.04**	DRY	DRY	DRY	237.91	DRY	DRY	DRY	DRY	DRY	DRY	DRY
18b	**7.60**	**0.81**	**239.04**	DRY	DRY	DRY	235.18	DRY	DRY	DRY	DRY	DRY	DRY	DRY
19a	**2.75**	**0.52**	**224.46**	Monitoring wells 19a, 19b, 20a and 20b were established in 2003. No water level data was available for these wells prior to 2005.								221.90	220.81	220.80
19b	**7.88**	**0.5**	**224.53**									217.00	215.79	215.46
20a	**2.8**	**0.55**	**225.08**									222.50	221.37	221.40
20b	**10.55**	**0.5**	**225.13**									215.06	213.75	214.56

Figures



ENSR | AECOM

0 500m

Figure 1 | **Regional Context**

Riverina Oils and Bio Energy Pty Ltd

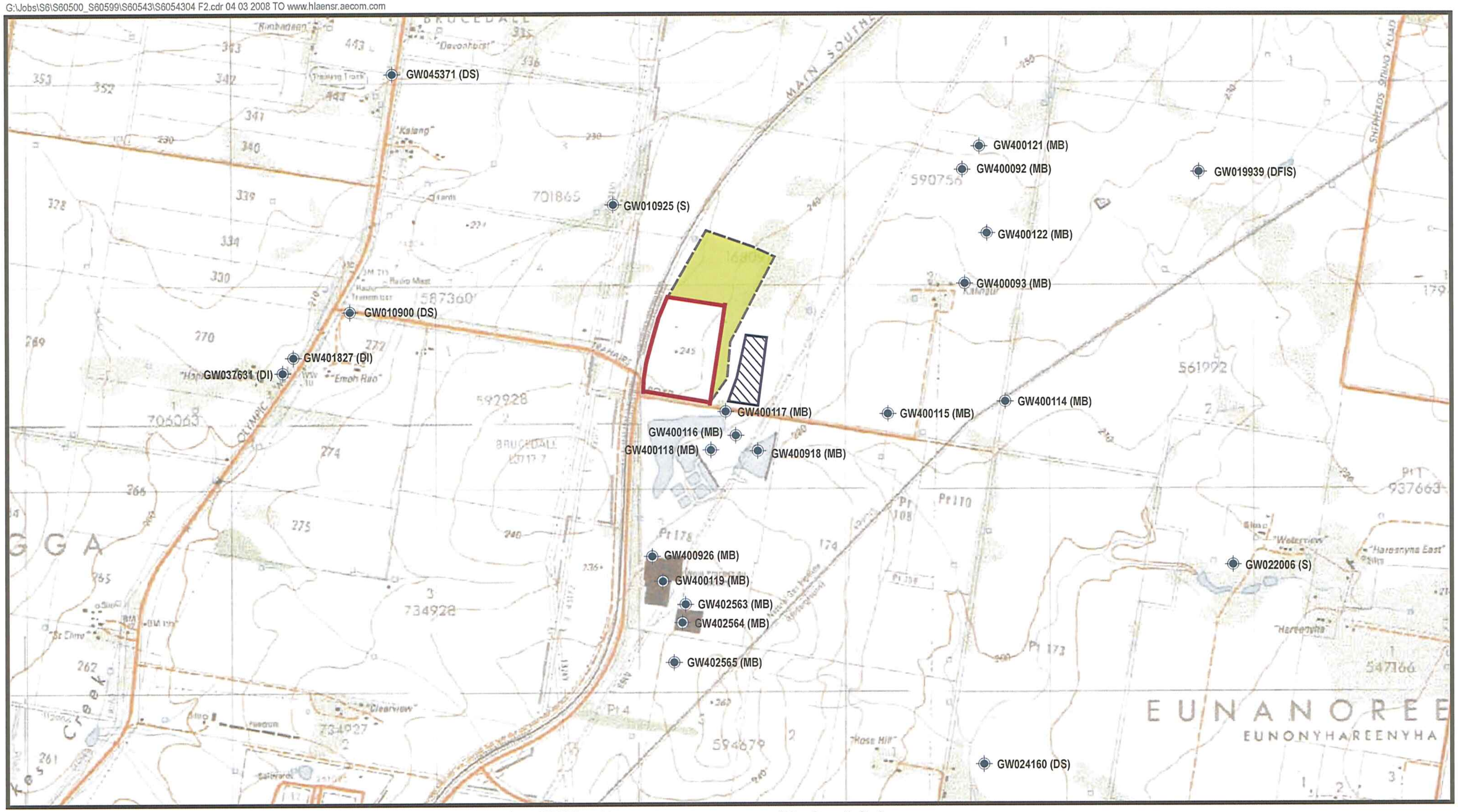
Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant

Approximate IOPBP footprint

Proposed evaporation pond

G:\Jobs\S6\S60500_S60599\S60543\S6054304 F2.cdr 04 03 2008 TO www.hlaensr.aecom.com



Approximate IOPBP footprint	
Proposed 27ML storage pond	
Proposed irrigation area	
Groundwater bore location (Dept of Natural Resources)	

DS	Domestic Stock
S	Stock
MB	Monitoring Bore
DFIS	Domestic Farming Irrigation Stock
DI	Domestic Irrigation

ENSR | AECOM

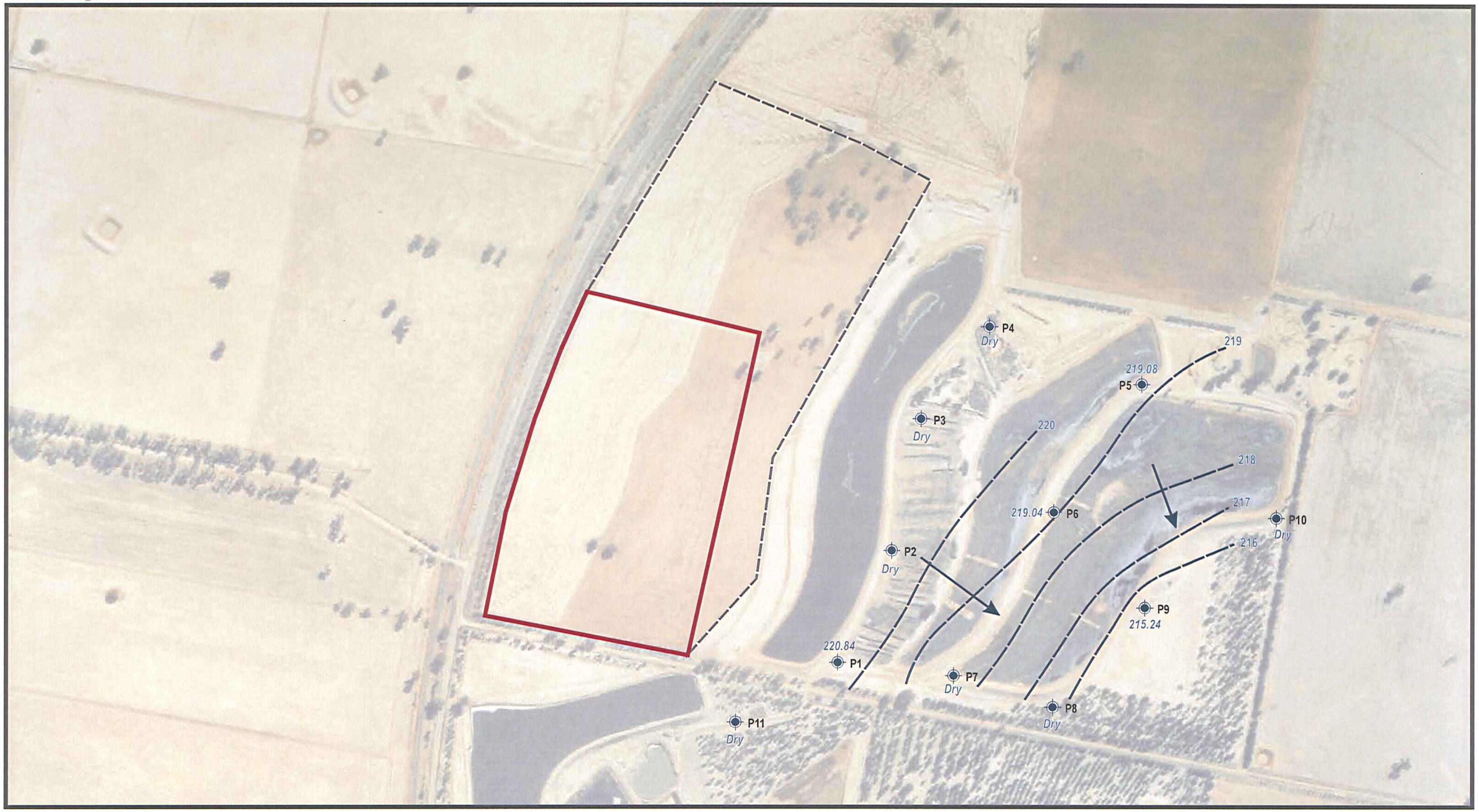
Figure 2 | **Licensed Groundwater Bore Locations**

Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant

G:\Jobs\S6\S60500_S60599\S60543\S6054304 F3.cdr 04 03 2008 TO www.hlaensr.aecom.com



ENSR | AECOM

0 200m

Approximate project footprint
Property boundary
Inferred groundwater contour (mAHD)
Inferred groundwater flow direction
215.24 Standing water level

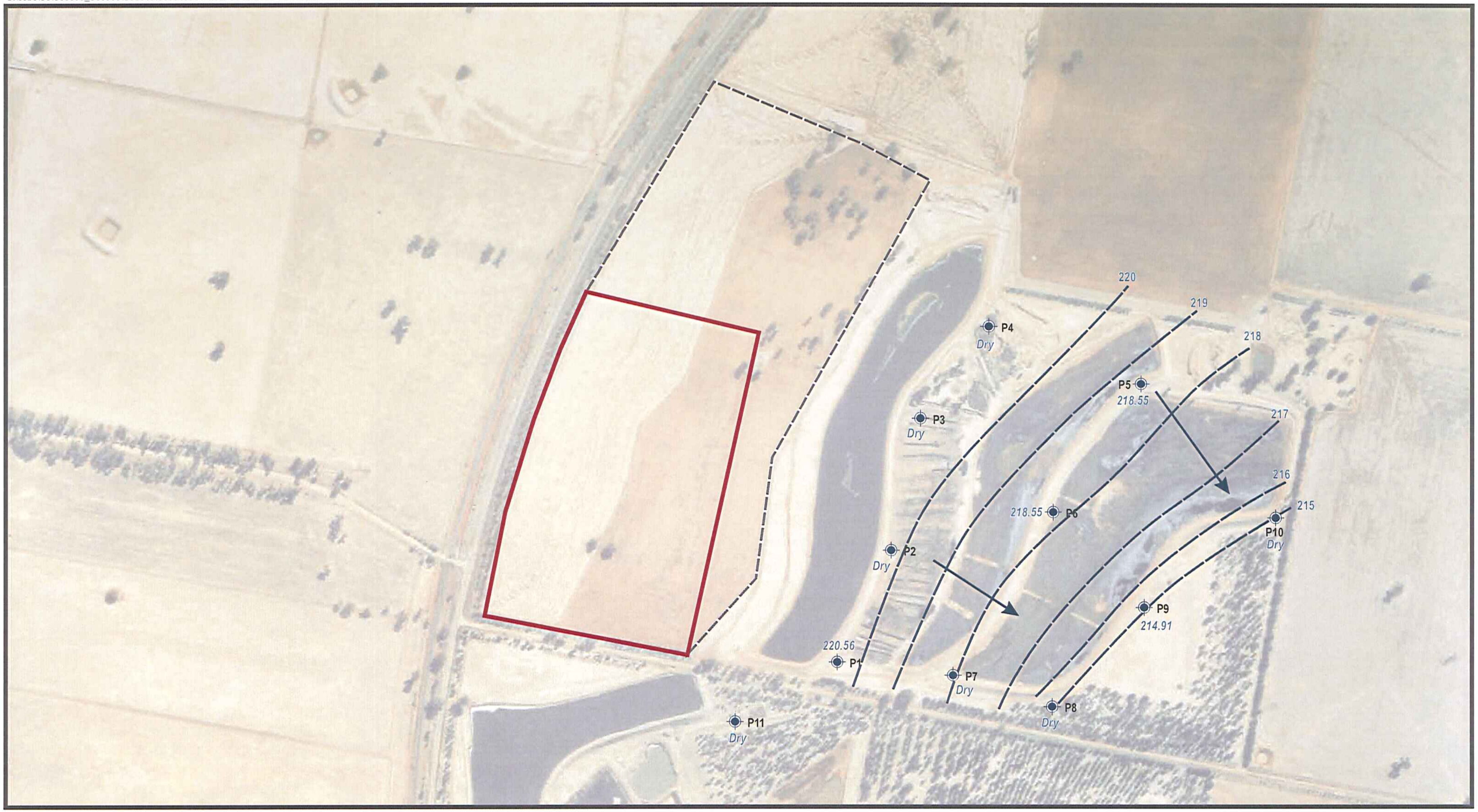
Note: P12 - P20b are located outside the study area

Figure 3 **Goundwater Standing Water Levels: Deep Aquifer Summer 07/01/2004**

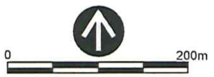
Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant



ENSR | AECOM



- Approximate project footprint
- Property boundary
- Inferred groundwater contour (mAHD)
- Inferred groundwater flow direction
- *215.24* Standing water level

Note: P12 - P20b are located outside the study area

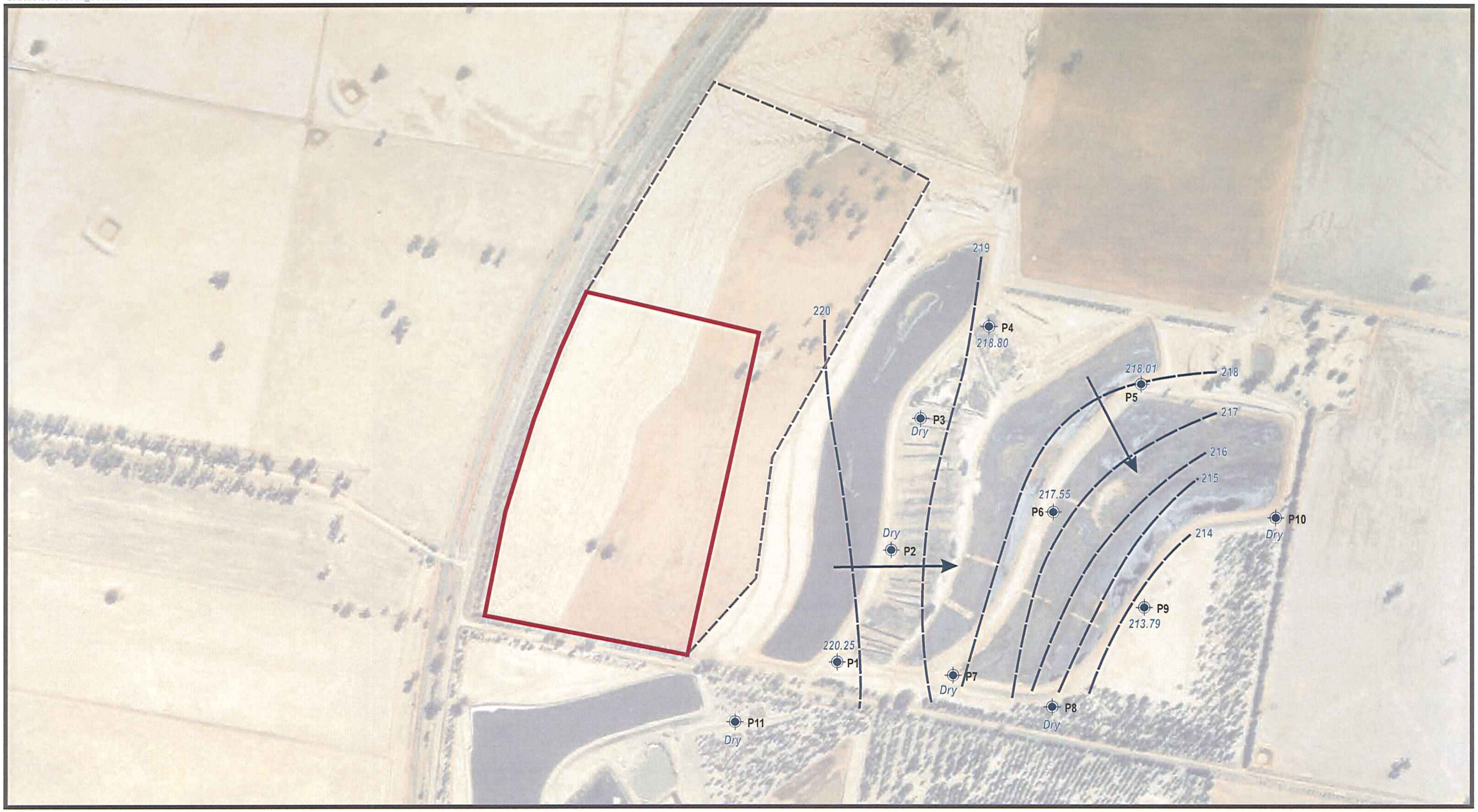
Figure 4 | **Goundwater Standing Water Levels: Deep Aquifer Winter 07/07/2004**

Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant

G:\Jobs\S6\S60500_S60599\S60543\S6054304 F5.cdr 04 03 2008 TO www.hlaensr.aecom.com



Approximate project footprint
Property boundary
Inferred groundwater contour (mAHD)
Inferred groundwater flow direction
215.24 Standing water level

Note: P12 - P20b are located outside the study area

ENSR | AECOM

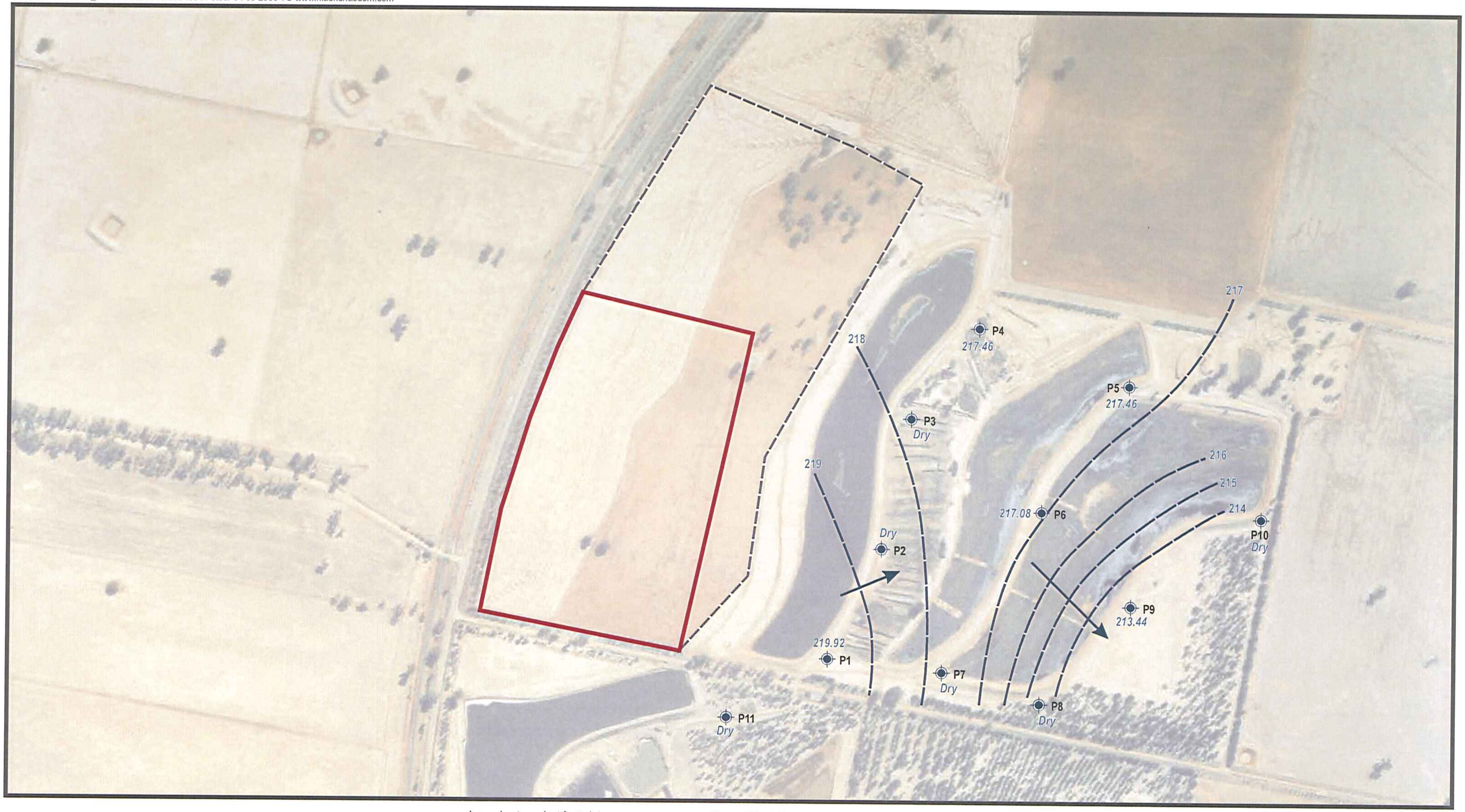
Figure 5 | **Goundwater Standing Water Levels: Deep Aquifer Summer 05/01/2006**

Riverina Oils and Bio Energy Pty Ltd

Environmental Assessment

Integrated Oilseed Processing and Biodiesel Plant

G:\Jobs\S6\S60500_S60599\S60543\S6054304 F6.cdr 04 03 2008 TO www.hlaensr.aecom.com



Approximate project footprint
Property boundary
Inferred groundwater contour (mAHD)
Inferred groundwater flow direction
215.24 Standing water level

Note: P12 - P20b are located outside the study area

ENSR | AECOM

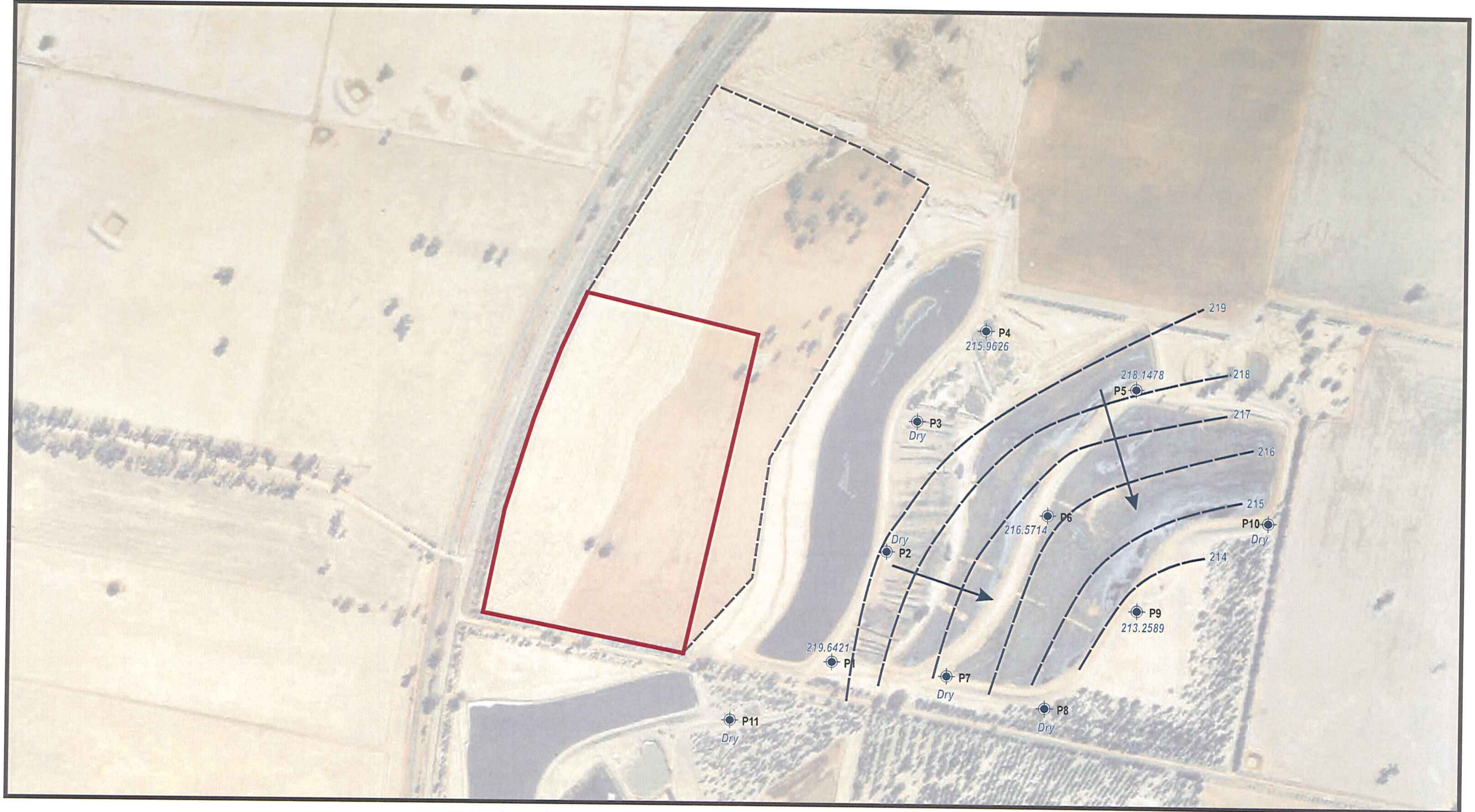
Figure 6 | **Goundwater Standing Water Levels: Deep Aquifer Winter 12/07/2006**

Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant

G:\Jobs\S6\S60500_S60599\S60543\S6054304 F7.cdr 04 03 2008 TO www.hlaensr.aecom.com



ENSR | AECOM

0 200m

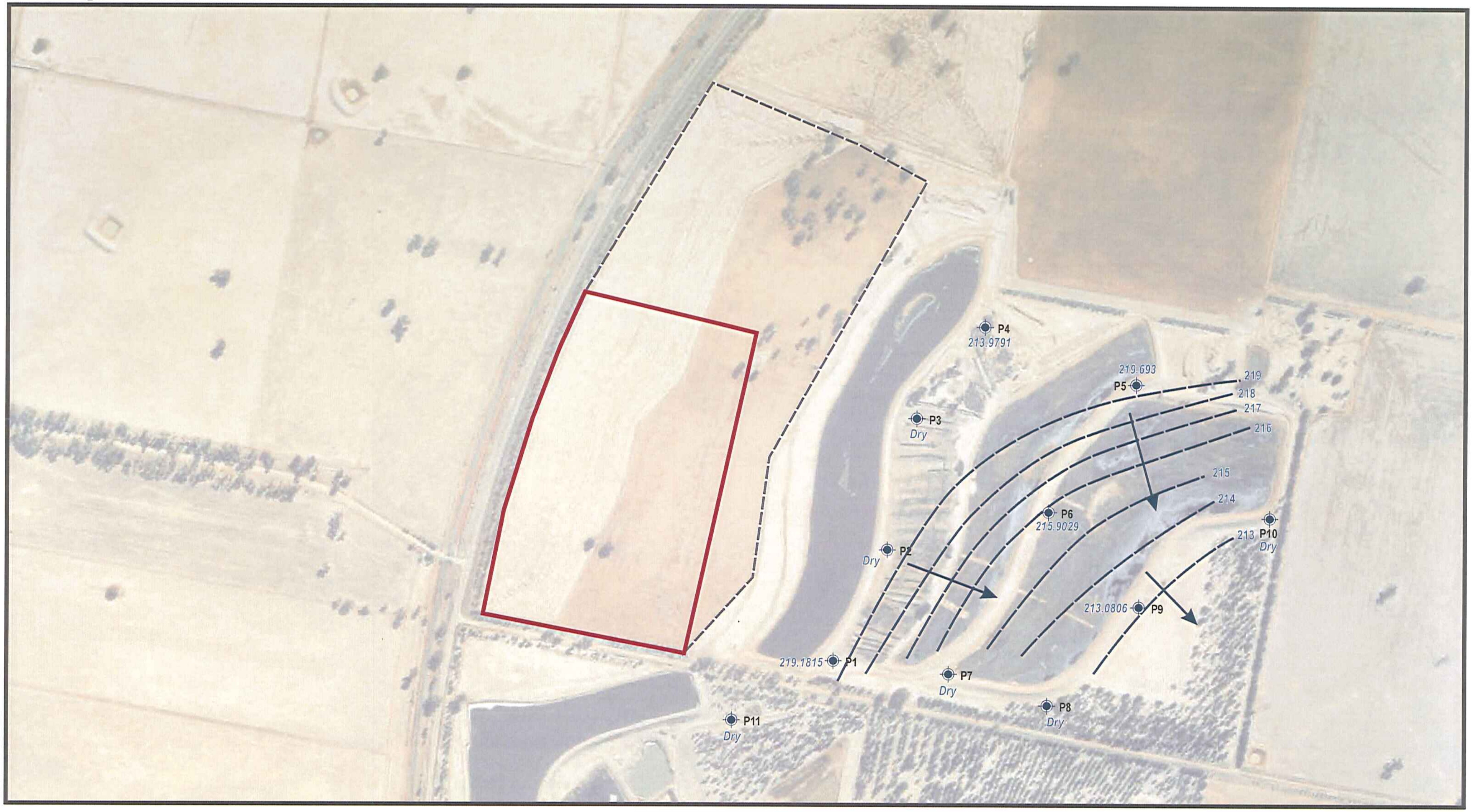
Approximate project footprint
Property boundary
Inferred groundwater contour (mAHD)
Inferred groundwater flow direction
215.24 Standing water level

Note: P12 - P20b are located outside the study area

Figure 7 | **Goundwater Standing Water Levels: Deep Aquifer Summer 01/01/2007**

Riverina Oils and Bio Energy Pty Ltd
Groundwater Review
Integrated Oilseed Processing and Biodiesel Plant

G:\Jobs\S6\S60500_S60599\S60543\S6054304 F8.cdr 04 03 2008 TO www.hlaensr.aecom.com



Approximate project footprint
Property boundary
Inferred groundwater contour (mAHD)
Inferred groundwater flow direction
215.24 Standing water level

Note: P12 - P20b are located outside the study area

ENSR | AECOM

0 200m

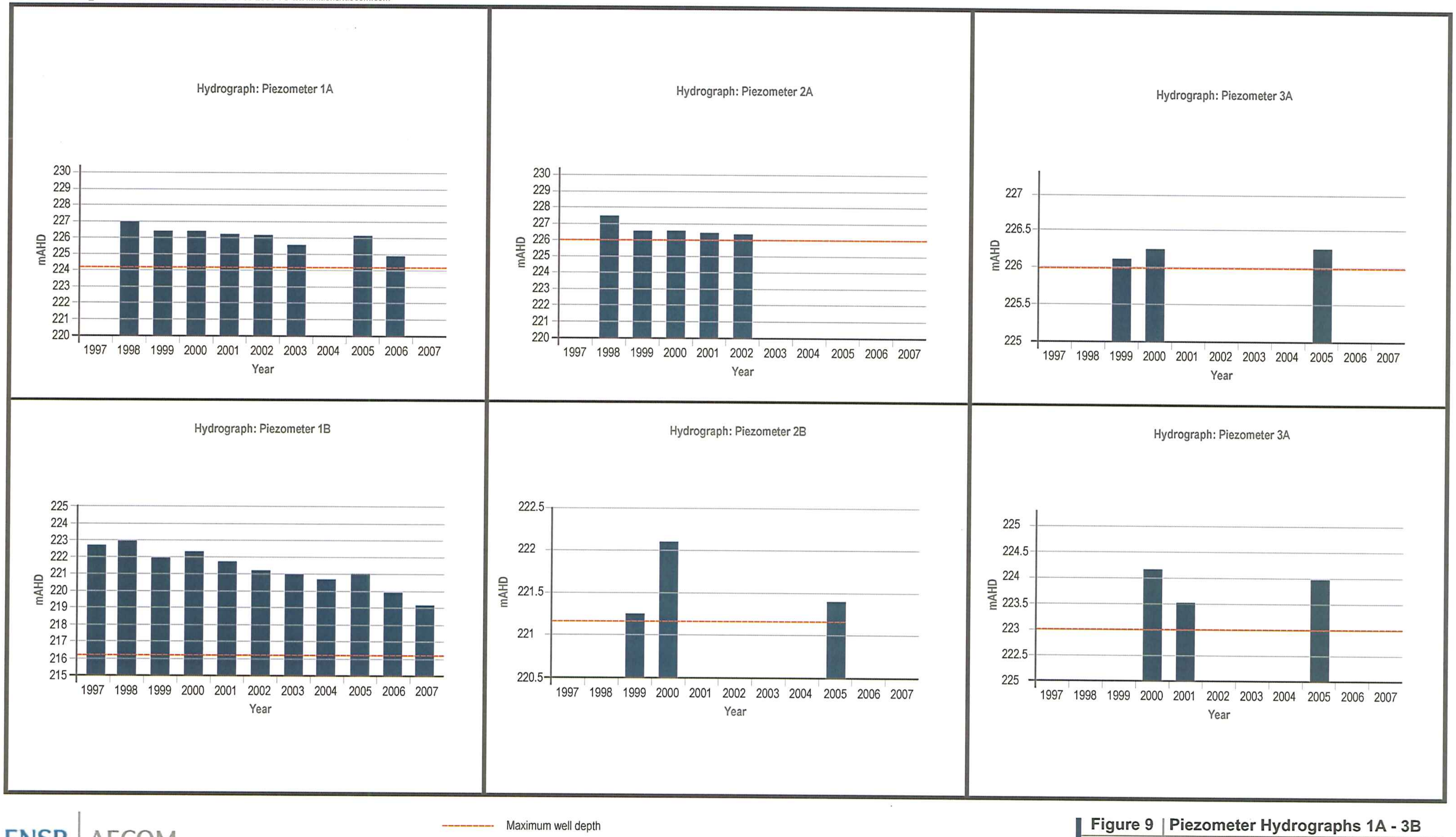
Figure 8 | **Goundwater Standing Water Levels: Deep Aquifer Winter 03/07/2007**

Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant

G:\Jobs\S6\S60500_S60599\S60543\S6054304 F9.cdr 04 03 2008 TO www.hlaensr.aecom.com



ENSR | AECOM

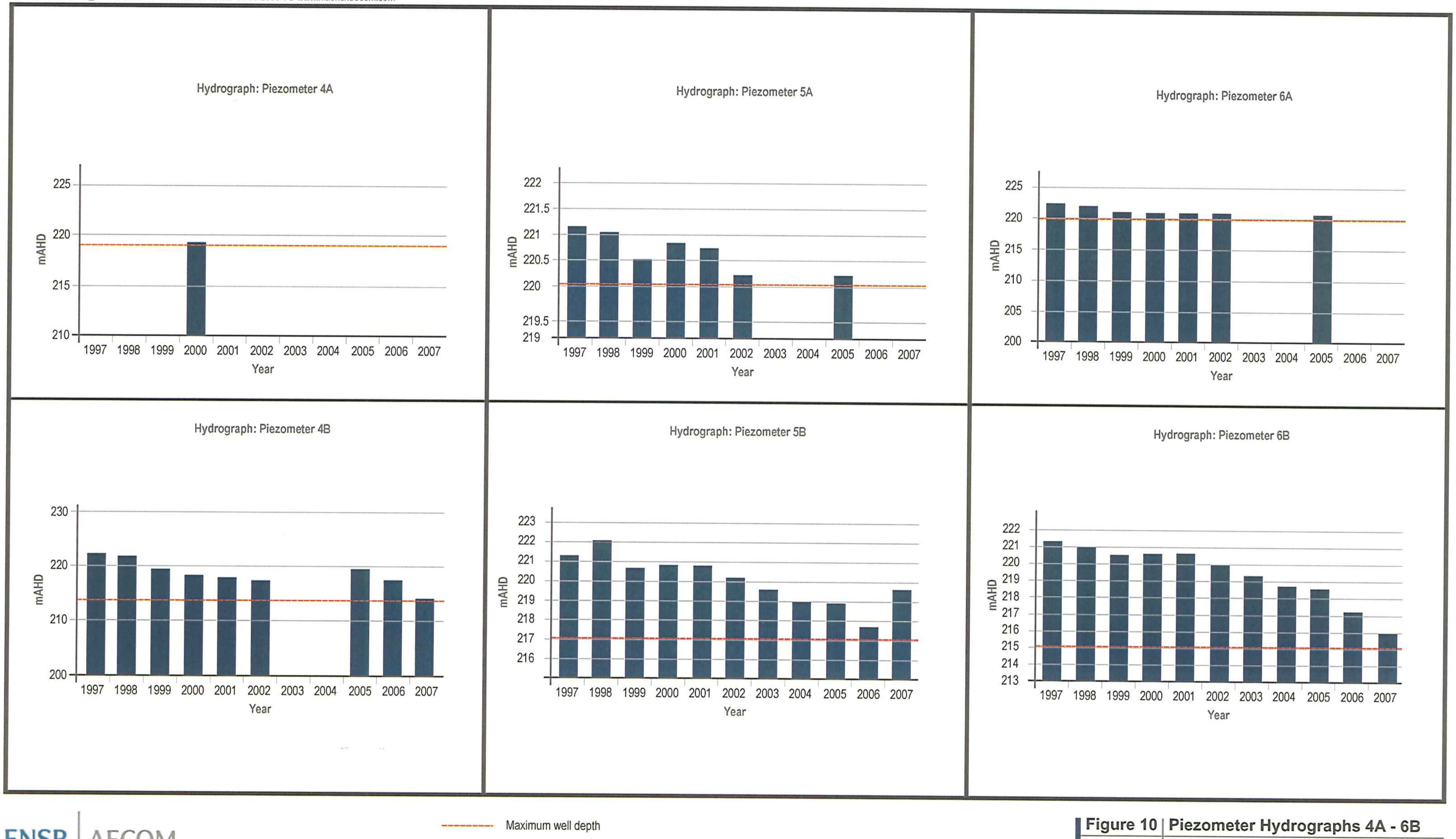
Figure 9 | **Piezometer Hydrographs 1A - 3B**

Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant

G:\Jobs\S6\S60500_S60599\S60543\S6054304 F10.cdr 04 03 2008 TO www.hlaensr.aecom.com



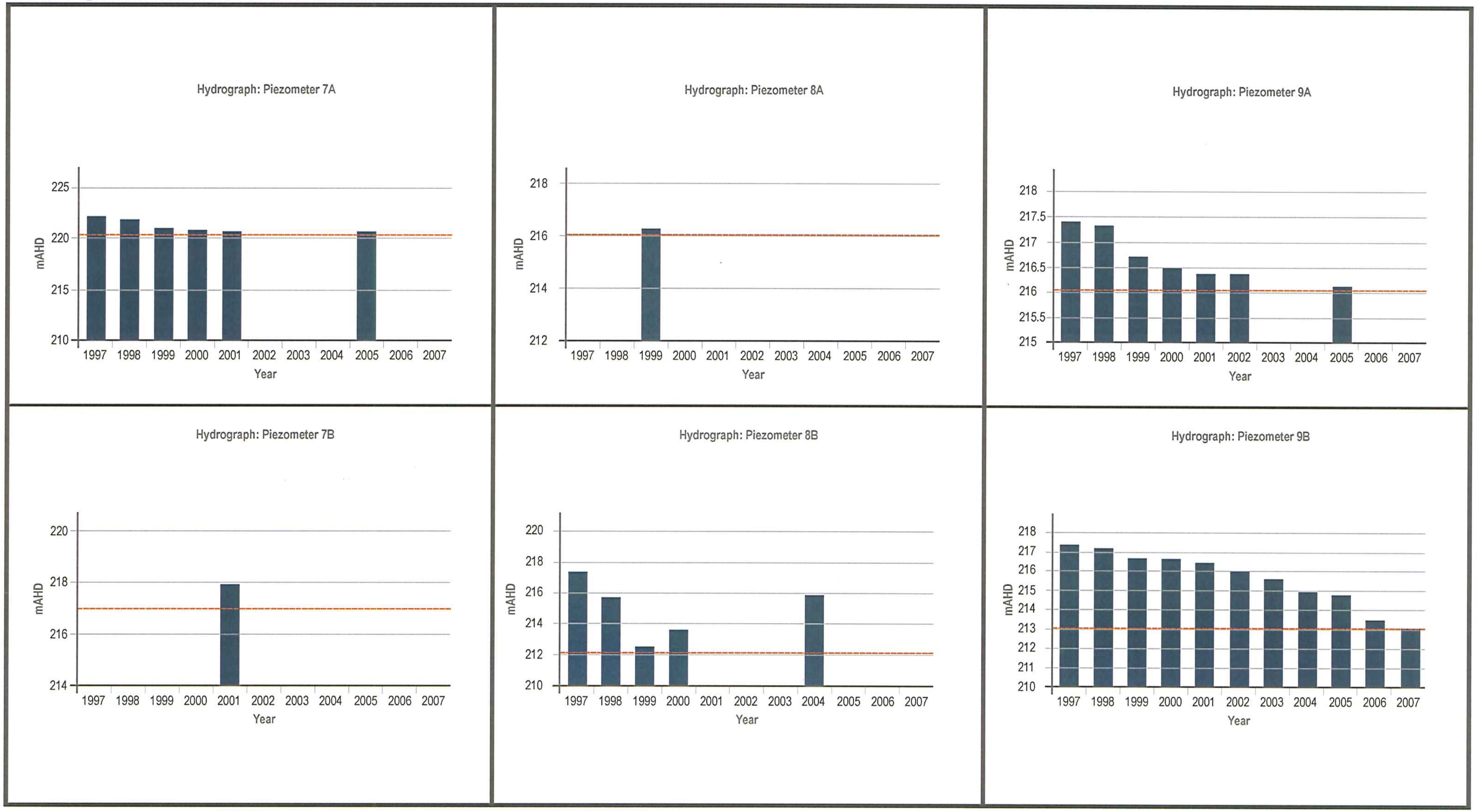
ENSR | AECOM

Figure 10 | **Piezometer Hydrographs 4A - 6B**

Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant



Maximum well depth

ENSR | AECOM

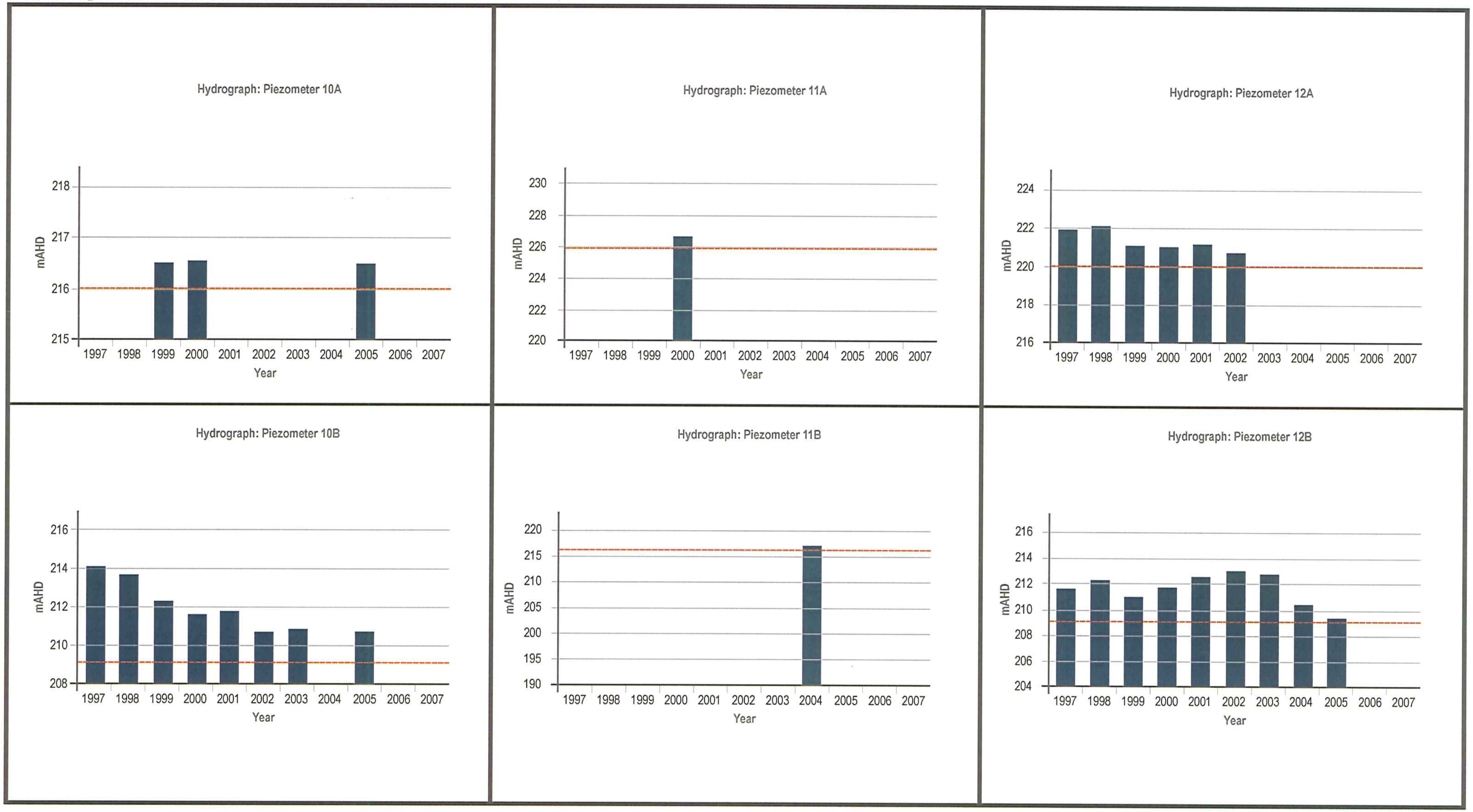
Figure 11 | **Piezometer Hydrographs 7A - 9B**

Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant

G:\Jobs\S6\S60500_S60599\S60543\S6054304 F12.cdr 04 03 2008 TO www.hlaensr.aecom.com



ENSR | AECOM

Maximum well depth

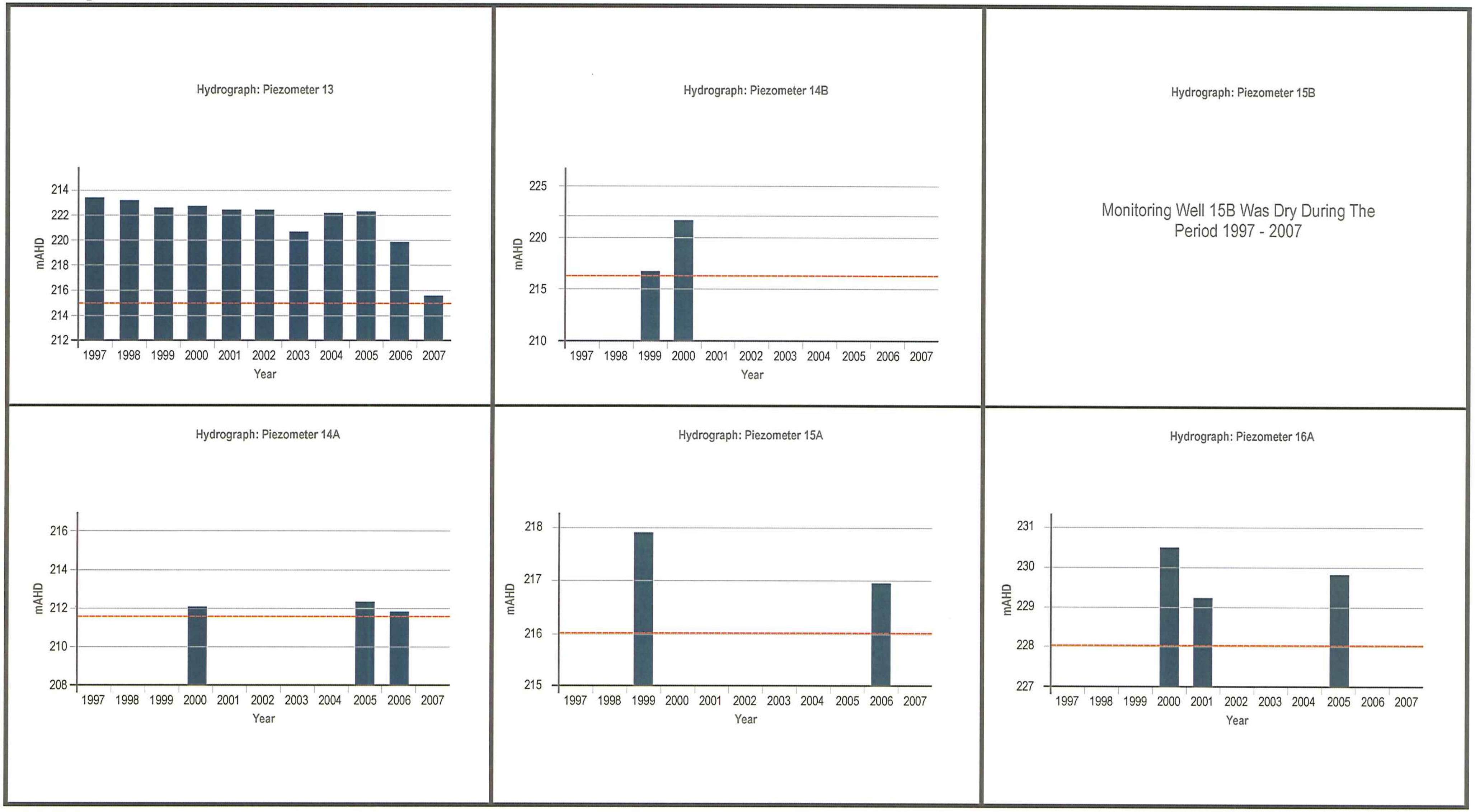
Figure 12 | **Piezometer Hydrographs 10A - 12B**

Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant

G:\Jobs\S6\S60500_S60599\S60543\S6054304 F13.cdr 04 03 2008 TO www.hlaensr.aecom.com



ENSR | AECOM

Maximum well depth

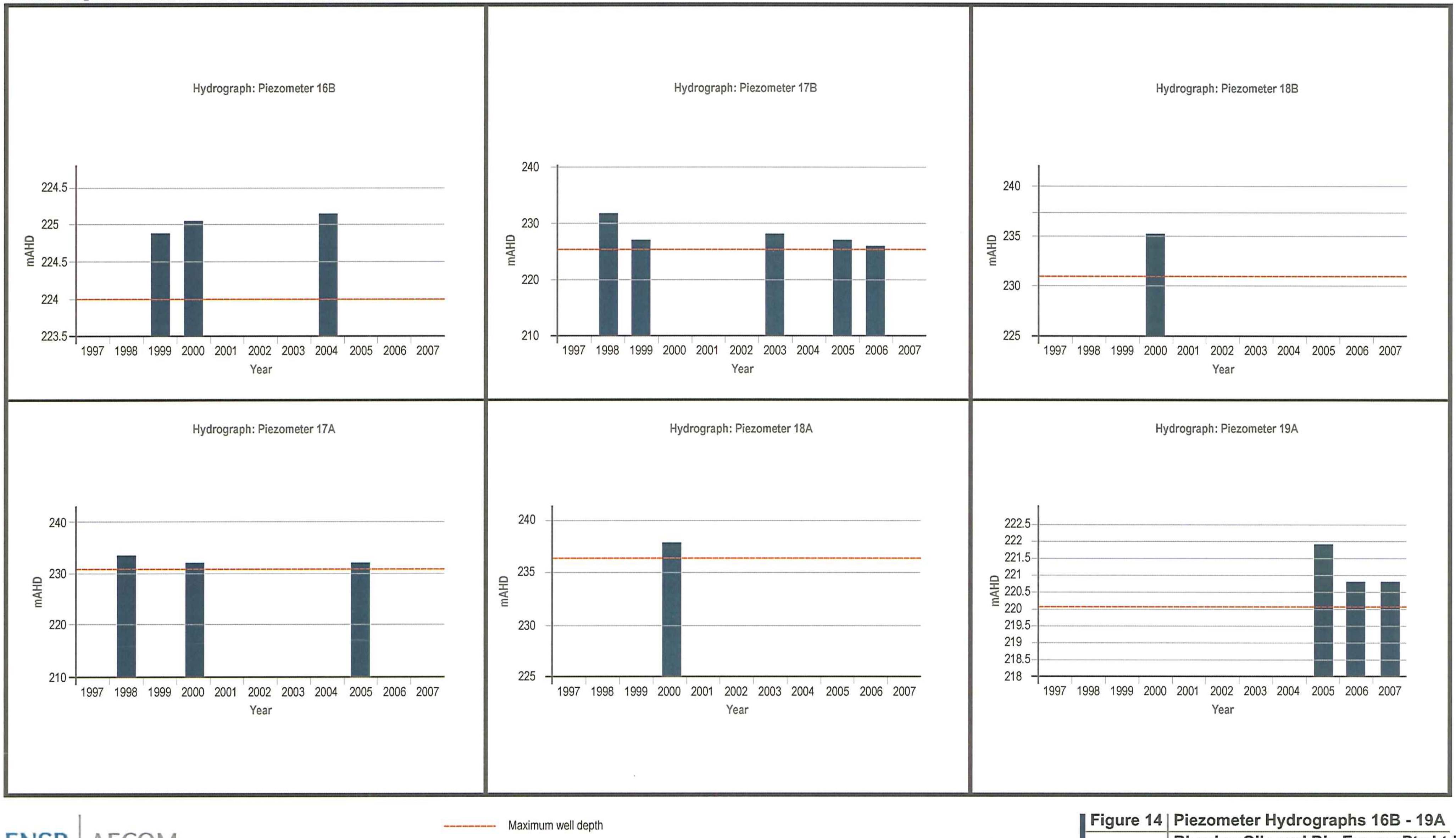
Figure 13 | Piezometer Hydrographs 13 - 16A

Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant

G:\Jobs\S6\S60500_S60599\S60543\S6054304 F14.cdr 04 03 2008 TO www.hlaensr.aecom.com



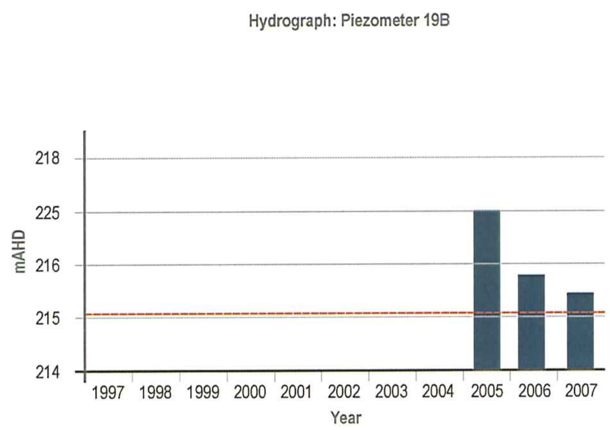
ENSR | AECOM

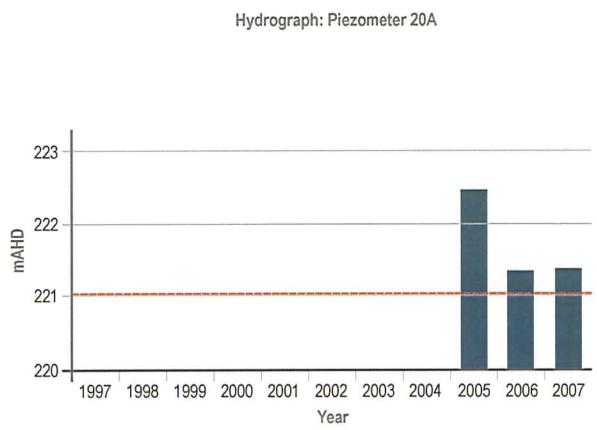
Figure 14 | Piezometer Hydrographs 16B - 19A

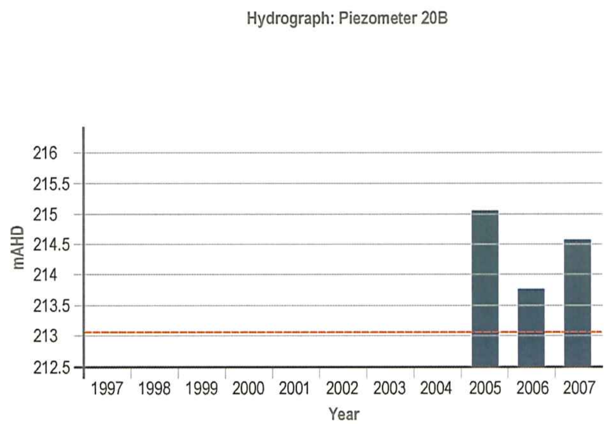
Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant







Maximum well depth

ENSR | AECOM

Figure 15 | Piezometer Hydrographs 19B - 20B

Riverina Oils and Bio Energy Pty Ltd

Groundwater Review

Integrated Oilseed Processing and Biodiesel Plant

Worldwide Locations

Australia	+61-2-8484-8999
Azerbaijan	+994 12 4975881
Belgium	+32-3-540-95-86
Bolivia	+591-3-354-8564
Brazil	+55-21-3526-8160
China	+86-20-8130-3737
England	+44 1928-726006
France	+33(0)1 48 42 59 53
Germany	+49-631-341-13-62
Ireland	+353 1631 9356
Italy	+39-02-3180 77 1
Japan	+813-3541 5926
Malaysia	+603-7725-0380
Netherlands	+31 10 2120 744
Philippines	+632 910 6226
Scotland	+44 (0) 1224-624624
Singapore	+65 6295 5752
Thailand	+662 642 6161
Turkey	+90-312-428-3667
United States	+1 978-589-3200
Venezuela	+58-212-762-63 39

Australian Locations

Adelaide
Brisbane
Canberra
Darwin
Mackay
Melbourne
Newcastle
Sydney
Singleton

www.ensr.aecom.com