

**Hydrogeological Appraisal of the
Proposed Titanium Minerals Project
near Dongara, Western Australia**

Prepared for

Tiwest Pty Ltd

November 2011



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SUMMARY

Tiwest Pty Ltd proposes to mine mineral sand deposits about 27 km southeast of Dongara, Western Australia, within the Arrowsmith Groundwater Area. This report assesses the hydrogeology of the project area and the availability of a suitable groundwater supply for the mining and processing of the minerals. The expected duration of mining the deposits is approximately 10 years. It is expected that dry mining will be carried out on the relatively shallow, mostly above water table, high grade cores of the identified resources, whereas dredge mining will be carried out on deposits that are deeper below the water table. The relative economics of the two methods of mining may change over time.

Groundwater modeling (Parsons Brinckerhoff Pty Ltd, 2011) shows that the highest rate of abstraction of mine pit dewatering water from the superficial aquifer, assuming that the full depth of pits were to be mined by dry mining, would likely be about 25 L/s or approximately 800,000 kL/year, but the annual inflow could reach 1,350,000 kL if both the hydraulic conductivity and the specific yield of the superficial formations are two times higher than estimated.

The most suitable source of groundwater supply for the mining and mineral processing activities is the Yarragadee aquifer which underlies the superficial aquifer. Tiwest seeks an allocation of 5,000,000 kL/year from the Yarragadee aquifer. Part of this abstraction would be obtained from just inside the boundary of the Twin Hills subarea and the rest from within the Eneabba subarea. To assist in managing the wellfield it is requested that one licence be given for abstraction from the Yarragadee aquifer subareas rather than a separate licence for each subarea.

Recharge to the groundwater system is through direct infiltration of rain water over the broad sand plain area and in the east through infiltration of ephemeral streams that flow off the Gingin Scarp after infrequent heavy rain. There is substantial leakage between the superficial aquifer and the shallower levels of the Yarragadee aquifer system.

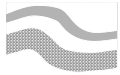


TABLE OF CONTENTS

SUMMARY	I
1 INTRODUCTION	1
1.1 LOCATION	1
1.2 INTENDED LAND AND GROUNDWATER USE	2
1.3 TIWEST COMPANY INFORMATION	3
1.4 CONSULTANT INFORMATION	3
2 CLIMATE, RAINFALL AND STREAMFLOW	4
3 HYDROGEOLOGY	5
3.1 GEOLOGY	5
3.1.1 General Stratigraphy	5
3.1.2 Superficial Formations	6
3.1.3 Yarragadee Formation	6
3.2 SUPERFICIAL AQUIFER	7
3.3 YARRAGADEE AQUIFER	8
3.4 GROUNDWATER RECHARGE	8
3.5 GROUNDWATER THROUGHFLOW	10
3.6 PROPOSED BORE CONSTRUCTION	10
4 EXISTING GROUNDWATER USE	11
4.1 BORES	11
4.2 VEGETATION	11
4.3 STYGOFUNA	11
5 DRILLING INVESTIGATIONS	12
5.1 SUPERFICIAL AQUIFER	12
5.2 YARRAGADEE AQUIFER	12
6 TEST PUMPING	13
6.1 SUPERFICIAL AQUIFER	13
6.1.1 Procedure	13
6.1.2 Interpretation	14
6.2 YARRAGADEE AQUIFER	15
6.2.1 Procedure	15
6.2.2 Interpretation	15
7 GROUNDWATER CHEMISTRY	16
7.1 SUPERFICIAL AQUIFER	16
7.2 YARRAGADEE AQUIFER	17
8 GROUNDWATER MODELING	17
8.1 CONCEPTUAL MODEL	17
8.2 AQUIFER PARAMETERS USED	18
8.3 MODELING RESULTS	18
8.3.1 Water Inflows to Mine Pits	18
8.3.2 Drawdown of the Water Table	19
8.3.3 Drawdown of the Piezometric Head in the Yarragadee Aquifer	19
8.4 GROUND SUBSIDENCE	19
9 GROUNDWATER MONITORING	19
10 ACKNOWLEDGMENTS	20



11	REFERENCES.....	21
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LIST OF TABLES

	<u>Page</u>
Table 1: Estimates of Throughflow	10
Table 2: Superficial Aquifer Transmissivity and Storativity	14
Table 3: Yarragadee Aquifer Transmissivity and Storativity	16

LIST OF CHARTS

Chart 1: Rainfall and Evaporation Monthly Averages	4
Chart 2: Eneabba Annual Rainfall	5

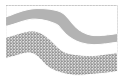
LIST OF FIGURES

Figure 1:	Regional Location Map
Figure 2:	Geographical Features
Figure 3:	Bore Locations and Surface Geology
Figure 4:	Geological Cross Sections copied from Nidagal (1995)
Figure 5:	Water Table Elevation November 2007
Figure 6:	Elevation of the Base of the superficial formations
Figure 7:	Saturated Thickness of the superficial formations
Figure 8:	Depth to Water Table
Figure 9:	Piezometric Head November 2007 in Yarragadee Formation
Figure 10:	Hydrographs of Water Levels in the Department of Water Bores, and Rainfall
Figure 11:	Stratigraphic Cross Section at the Test Site in the superficial formations
Figure 12:	Water levels in Background Piezometers compared to Barometric Pressure
Figure 13:	Drawdown Curves for DOB01 and DOB02 during the superficial Pump Test
Figure 14:	Lithology, Geophysics and Construction Log for DOB03
Figure 15:	Lithology, Geophysics and Construction Log for DPB02
Figure 16:	Geophysical Correlations between LS32A, DOB03 and DPB02
Figure 17:	Seismic Section through the Beharra Springs Gasfield
Figure 18:	Detailed Map of the Yarragadee Pump Test Site
Figure 19:	Log-Linear Drawdown Plots for the Yarragadee Pump Test at DPB02
Figure 20:	Total Dissolved Solids in the superficial Aquifers
Figure 21:	Total Dissolved Solids in the Yarragadee Formation about 100 M Depth



LIST OF APPENDICES

- Appendix A: Bore Survey and Construction Details
- Appendix B: Driller's Bore Construction Logs for Exploration Bores
- Appendix C: Photographs of Strata Samples from DOB03
- Appendix D: Drawdown in DOB01 Matched against Neuman Type Curves
- Appendix E: Major Chemical Component Analysis Data November 2007
- Appendix F: Trace Metal Analysis Data November 2007
- Appendix G: (CD only) Stratigraphy, Bore construction and Pump Test data on the Department of Water template 'WIN_Site_Details-V3_5.xlt'



1 INTRODUCTION

1.1 LOCATION

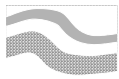
Tiwest Pty Ltd is proposing to extract heavy minerals from sand deposits located approximately 27 km southeast from Dongara, Western Australia on the Eneabba Plain (Figure 1). This report assesses the hydrogeology of the project area and the availability of a suitable groundwater supply for the mining and processing of the minerals.

Figure 2 shows the locations of the ore bodies in relation to relevant geographical features and groundwater management subareas. Six ore bodies have been delineated. The western three (Zeus, Heracles and Hebe) extend below the water table, whereas the eastern three (Hades, Dionysus and Demeter) are essentially above the water table. All resources are within the Eneabba Plains Groundwater Management Subarea of the Arrowsmith Groundwater Area except the northernmost parts of the Hades and Zeus resources, which cross into the Twin Hills Subarea.

The heavy mineral resources occur within Tertiary age sediments on the eastern side of the Eneabba Plain between about 3 km and 7 km west of the Gingin Scarp. The Gingin Scarp is a moderately sloping topographical feature formed by ancient shoreline erosion. The surface lithology in the heavy mineral areas is predominantly aeolian sand of the Bassendean Formation. To the east of the Scarp the Dandaragan Plateau contains surface laterite overlying Yarragadee Formation (Jurassic age). Most of the land to the east of the scarp is cleared farmland.

Most of the land in the project area is vested in the State Government and has native vegetation of shrubs and low woodlands. Only the northernmost resource (Hades) crosses over into cleared farmland. In the area of the heavy mineral deposits the ground surface slopes gently westward from an elevation of about 75 metres above Australian Height Datum (AHD) at the easternmost resources of Dionysus and Demeter to about 35 metres AHD at the westernmost resource (Zeus). To the west of the Zeus resource is an area of low-lying flat ground where the water table is within 10 metres of ground surface. Still further west the land rises again to low calcified sand hills of Tamala Limestone.

The Yardanogo Nature Reserve is situated about 2 km west from the Zeus deposit. There are no permanent surface water bodies near to the proposed mine sites. The nearest groundwater dependent ecosystems (GDE15, GDE16 and GDE26) classified by Rutherford, Roy and Johnson (2005) are each 6-7 km from the nearest heavy mineral resource. There is a gazetted water reserve just west of Zeus as marked on Figure 2. Enquiries with the Department of Water have revealed uncertainty with respect to which government department the water reserve is vested in, and that the reserve was likely originally proclaimed for a spring, soak or watering point used by horsemen and drovers around the start of the 20th century and as such was likely proclaimed to prevent clearing. The Department of Water has advised that historical reserves such as this now have mainly conservation and tourism values rather than water protection values.



The area surrounding the heavy mineral resources has had substantial natural gas exploration and development. The Mondarra and Beharra Springs gas fields are shown on Figure 2. The gas reservoirs are typically about 3 km deep in Mesozoic strata. Numerous seismic exploration tracks exist across the crown land, in various stages of regrowth. The Beharra Springs gas processing facility is located about 3 km south of the Heracles resource. Subsurface gas pipelines extend north-south between the mineral resources and alongside Mt Adams Road, as shown on Figure 2.

Seven Department of Water monitor bore sites (LS27, LS28, LS29, LS31, LS32, LS34 and DL2) are within the area shown on Figure 2.

1.2 INTENDED LAND AND GROUNDWATER USE

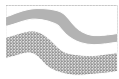
Figure 2 shows the conceptual pit outlines in solid orange colour. Mining is proposed to involve two Stages: Stage 1- Dry mining and Stage 2- Dredge mining. In the dry mining phase bulldozers will most likely be used to extract the ore. Dry mining will focus on the relatively shallow, mostly above water table, high grade cores of the identified resources. Any ore dry mined from below the natural water table will require the water table to be temporarily lowered by dewatering from in-pit sumps. Dredge mining utilises a bucket wheel floating on a pond to mine and slurry the ore. Because a pond is required for dredging it is generally not necessary to dewater when dredge mining is carried out below the water table. The advantage of dredge mining, where applicable, is that it is potentially able to economically mine lower grades than dry mining, and therefore dredging can access a greater proportion of the resources that intersect or are in close proximity to the water table, and are within the mineable limits for dredging. Dredge mining allows higher overall throughput rates and therefore requires a greater volume rate of water supply for the processing plant than dry mining.

The mined ore, regardless of the method of mining, will be fed to a mobile concentrator for separation of the heavy minerals using conventional wet separation methods (e.g. gravity spirals). As the orebody is mined, overburden and sands with little mineral content will be returned to fill the pit voids and the surface will be contoured to resemble the original landscape, prior to respreading topsoil and seeding for rehabilitation. Clay and silt residue (known as "slimes") from the concentrator will be pumped to solar drying cells. The heavy mineral concentrate will be trucked south in road trains to Tiwest's Chandala Processing Plant for separation and processing.

Three alternative mining scenarios have been considered, involving different sequences of mining of the different deposits (Parsons Brinckerhoff Pty Ltd, October 2011). The total expected duration of mining is approximately ten years.

Two allocations of groundwater are needed by Tiwest to allow mining to proceed:

- An allocation of 1,350,000 kL/year from the superficial formations to allow for possible inflow to mine pits. This is in line with the upper limit of modeled annual inflow rate in the extreme case that all mining is carried out by dry mining and both the hydraulic conductivity and the specific yield in the superficial aquifer are two times higher than estimated (Parsons Brinckerhoff Pty Ltd, October 2011).



- An allocation of 5,000,000 kL/year from the Yarragadee Formation for the water supply needed for mining and mineral processing activities at Dredge mining throughput rates (dry mining is likely to require 2,500,000 kL/year). Most of the water is required for the heavy mineral separation process and for transporting the slimes to the settling cells. A small amount of water (approximately 200,000 kL/year) is required for amenities, dust control and rehabilitation

The conceptual locations of four Yarragadee production bores (Figure 3) are along approximately 7 km of a main mine access road extending between the Hades and Dionysus deposits. Each of the bores is planned to be rated at up to 40 L/sec (3460 kL/d). The northernmost conceptual production bore is within the Twin Hills subarea close to the boundary with the Eneabba Plains subarea. The southern three conceptual production bores are within the Eneabba Plains subarea. The boundary between the Twin Hills and Eneabba Plains subareas is aligned along roads and fences and does not represent a hydrogeological barrier that might prevent free groundwater movement between the subareas under the influence of pumping. Therefore it is proposed that for simplification Tiwest be granted one licence for abstraction from the Yarragadee Formation rather than a separate licence for each subarea.

Only the three western deposits (Zeus, Heracles and Hebe) are planned to be mined to below the likely water table level. Dewatering water will be used as partial water supply for the mining and processing operations. Tiwest intends that any dewatering water that is excess to the immediate mineral processing needs will be stored for later use or returned to the aquifer via in-pit ponds.

1.3 TIWEST COMPANY INFORMATION

Tiwest Pty Ltd is operator of the Tiwest Joint Venture. This is an equal share joint venture between Tronox Western Australia Pty Ltd and Exxaro Mineral Sands Pty Ltd (as Yalgoo Minerals Pty Ltd).

The Tiwest contact for this study is:

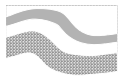
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1.4 CONSULTANT INFORMATION

Hydrosearch Pty Ltd supplies hydrogeological consulting services and has been trading since 1994. Kevin Haselgrove received a degree of Master of Applied Science in hydrogeology and engineering geology from the University of New South Wales in April 1976 and has been employed as a hydrogeologist since 1976. Contact details are given on the front cover of this report.

This report incorporates a brief summary of relevant findings of reports produced for Tiwest Pty Ltd by other consulting firms. These include:

- A numerical modeling study by Parsons Brinckerhoff Pty Ltd (October 2011) of mine pit dewatering and abstraction of groundwater from the Yarragadee Formation.



- A detailed survey by Rockwater Pty Ltd (2011) of subterranean fauna and troglofauna within the project area and impact assessment study for the proposed mine.
- A study by Geoprocc Pty Ltd (April 2008) of background groundwater quality and soil sulphide content.

The full reports of the consultants should be referred to for complete information.

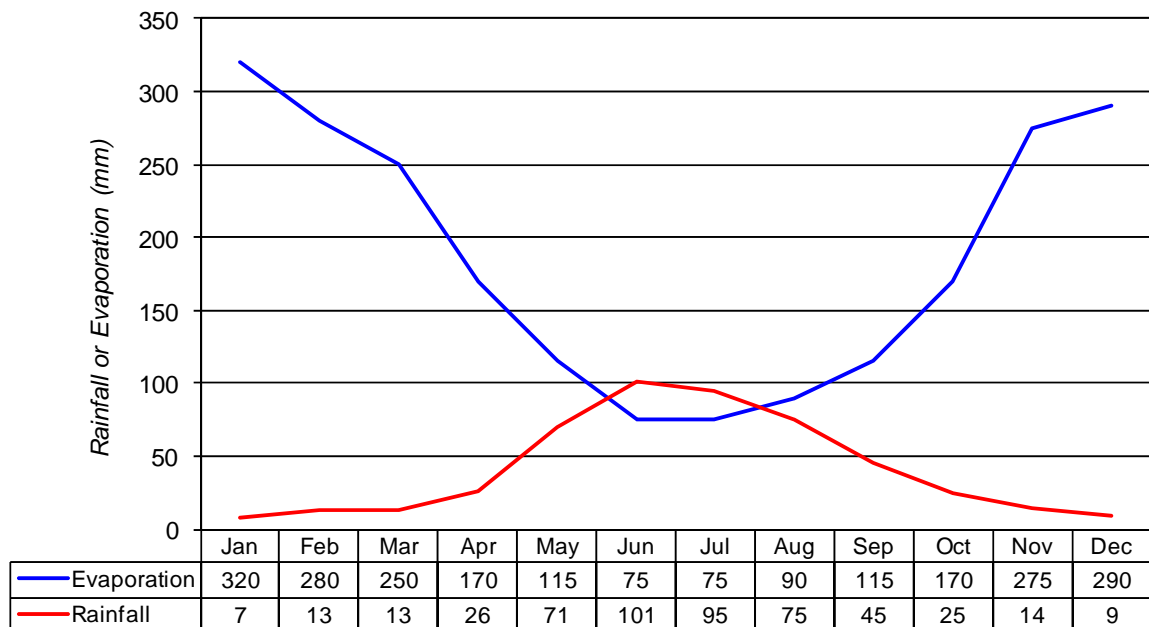
2 CLIMATE, RAINFALL AND STREAMFLOW

Chart 1 shows average monthly rainfall and pan evaporation estimated for the mining area. The rainfall values are long-term averages provided by the Bureau of Meteorology for Eneabba (Station 008225) about 45 km to the south-southeast of the project site. The evaporation values are extrapolated for the proposed mining area from contour maps on the Bureau of Meteorology internet website. Bureau of Meteorology evaporation records are not available at Eneabba or any other site near the proposed mines (the nearest site being Geraldton). The chart illustrates that in the warm season of October to April the rainfall is normally very low and the evaporation high. However, there is potential for significant recharge on the sandy coastal plain in the cooler months from May to September, especially in June and July which are the two months where average rainfall exceeds pan evaporation.

Chart 1

Rainfall and Pan Evaporation (mm)

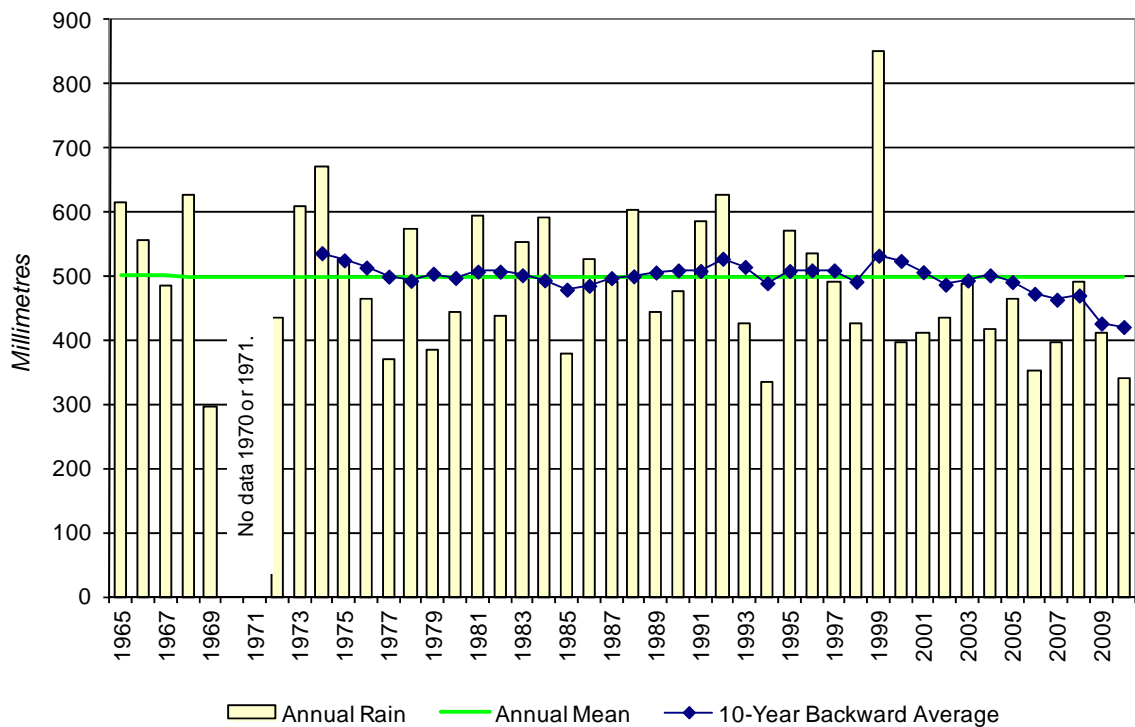
(Rainfall data from Eneabba, evaporation data extrapolated off Bureau of Meteorology contour maps)



Over the 44 years of monitoring at Eneabba the mean annual rainfall (determined as the sum of monthly means) has been 499 mm, compared to 459 mm over 115 years of observation at Dongara (Station 008044). On average 78% of rainfall at Eneabba occurs in the five months May through September.

Chart 2 shows the Eneabba annual rainfall record and the 10-year backward average. The 10-year backward average was relatively steady until 2005, but since 2006 has declined significantly below the long-term average (green line). All the years from 2000 to 2010 have had rainfall below the long-term average, but the previous year (1999) was the wettest on record owing to cyclonic rain in the autumn months March to May 1999, when 423 mm fell.

[Chart 2](#)
Eneabba Rainfall (Station 008225)



The monthly rainfall for Eneabba since 1990 is plotted at the bottom of Figure 10.

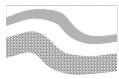
Several drainage lines flow off the Gingin Scarp and disappear in the sand plain where the water infiltrates (Figure 2). The laterite surface comprising the scarp and areas further inland resists infiltration to an extent, allowing runoff water to be channelled to the plain during heavy rain. It is likely that most stream flow infiltrates either before it reaches the sand plain at the foot of the scarp or flows only a short distance on the sand plain before it disappears into the sand. The flow may only reach the Dongara project area during heavy rainfall events and a rainfall event such as this may occur only once every few years.

3 HYDROGEOLOGY

3.1 GEOLOGY

3.1.1 General Stratigraphy

Figure 3 shows simplified surface geology, taken off the 1:100,000 sheets for Mingenew-Dongara (Mory, 1995) and Arrowsmith-Beagle Islands (Mory, 1994).



In the area of the proposed mine sites a sequence of unconsolidated Cainozoic sediments (termed the superficial formations) unconformably overlies a sequence of Yarragadee Formation shale, sand and sandstone. The superficial formations extend typically 30 metres and up to 55 metres depth below ground. The Yarragadee Formation extends to approximately 1 km depth (Nidagal, 1995; Mory, 1995).

The hydrogeology of the superficial formations and the shallow Yarragadee Formation between Leeman and Dongara was investigated by the Leeman Shallow series of monitor bores, and reported by Nidagal (1991 and 1995). The deeper bore at each Leeman Shallow series site was continuously cored to a depth of 100 metres below ground surface, or typically 70 metres below the unconformity boundary between Superficial and Yarragadee formations. The Leeman Shallow bore sites LS27A&B, LS28A&B, LS29A&B, LS31B&C, LS32A&B and LS34A&B are shown on maps in this report such as Figure 3. Bore site DL2 is part of the Dongara line of investigation bores but the shallower bore of the pair (DL2W) was installed as part of the Leeman Shallow bore series.

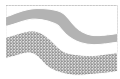
3.1.2 Superficial Formations

Figure 4 shows copies of two cross sections presented in Nidagal (1995) based on the Leeman Shallow series of exploratory drilling. The cross section A-A' passes through the LS34 bore site in the northern part of Figure 3 whereas the cross section B-B' passes through the LS31 and LS32 bore sites in the central part of Figure 3. The sections illustrate that the superficial Formations become thin and unsaturated eastwards towards the Gingin Scarp.

The sediments of the superficial formations in downward order in the area of the heavy mineral deposits comprise Bassendean Sand (Quaternary age), Guildford Formation (Quaternary age) and Yoganup Formation (Tertiary age). The Bassendean Sand in this area tends to exist only at depths of less than 10 metres below ground surface and mostly above water table. The Guildford and Yoganup Formations contain the heavy mineral ore bodies. They are comprised mainly of a mixture of sand and silty or clayey sand. The Yoganup Formation is a shoreline deposit representing a buried prograding coastline of dunes, beach ridges and deltaic deposits (Davidson, 1995, sourcing Baxter, 1982). The stratigraphy of the superficial Formations in the vicinity of the mineral sand deposits has been explored in detail by Tiwest as part of heavy mineral exploration. As part of groundwater investigations described in Section 5, Tiwest has installed a production bore and two observation bores into superficial formations at the Zeus deposit and carried out a controlled rate pump test, and installed a network of piezometers as shown on Figure 3.

3.1.3 Yarragadee Formation

Tiwest has explored the Yarragadee strata near the Department of Water bore site LS32 by an observation bore pilot hole drilled to 229 metres depth and a production bore pilot hole drilled to 153 metres depth, as described in Section 5. The geophysical logs in the observation bore (Figure 14) show that approximately a third of the thickness of the Yarragadee Formation in the



interval drilled is sand¹ of brown to pale grey colour and medium to coarse grain size. The sand occurs both as relatively thin beds (typically 1 metre thick) and relatively thick beds (typically 6 metres thick). The sand beds appear to be randomly distributed throughout the thickness drilled as illustrated by the graphic log on the left-hand side of Figure 14. The other two-thirds of the total Yarragadee thickness drilled at DOB03 is shale which typically appears in mud-rotary drill cuttings as dark grey clay. The best sand sequence found was at relatively shallow depth of 95-114.5 metres below ground.

An apparent dip of 7-10 metres per 100 metres to the east is indicated from geophysical correlations (Figure 16) for the Yarragadee strata near DOB03. As the regional geological strike is approximately north-south the true dip is likely to be similar to this. The apparent eastward dip of Yarragadee strata found in the exploration drilling is consistent with a seismic section through the Beharra Springs gas field produced by Owad-Jones and Ellis (undated) and reproduced as Figure 17 with annotation added. The line of the seismic section is approximately 3 km south of LS32. Cross sections in geological explanatory notes (Mory, 1995) confirm that the heavy mineral deposits are located on the Beharra Springs Terrace above the eastern limb of a gentle anticline in the Mesozoic strata.

Several faults in the Mesozoic strata have been delineated by Mory (1994, 1995) on the basis of seismic data (Figure 3). Most are aligned roughly NNW-SSE although the Eneabba Fault, which passes just south of the Hades deposit, is aligned roughly at right angles to the others. The 1:100,000 Mingenew-Dongara geological map (Mory, 1995) shows an un-named NNW-SSE fault passing approximately 400 metres east of LS32. The Jurassic strata on the eastern side of this fault are downthrown more than 100 metres.

3.2 SUPERFICIAL AQUIFER

The Bassendean Sand mostly exists only above the water table. The Guildford and Yoganup Formations constitute the main aquifers in the superficial Formations.

Figure 3 shows the active bore sites in the area. Tiwest has installed a pair of observation bores and a production bore in the superficial formations for pump testing near the Zeus orebody, and a number of 20-mm piezometers within air core exploration holes. Appendix A summarises the bore survey and construction details.

Figures 5 to 7 show respectively; contours of superficial groundwater level, elevation of the base of the superficial formations, and the saturated thickness of the superficial formations. In the heavy mineral region both the ground surface and the base of the superficial formations slope upward to the east at typically 1.5 metres vertical per 100 metres horizontal. This is about double the slope of the water table. The base of superficial formations intersects the water table slightly west of bore site LS32 (Figure 7), so that beneath the eastern mine sites of Hades, Dionysus and Demeter the superficial formations are totally above the water table. The saturated thickness of the superficial formations increases westward to about 20 metres at Zeus, and reaches a maximum of about 28 metres at bore site LS34.

¹ For this assessment sand was defined as having both gamma count < 125 API and 16-inch resistivity > 42

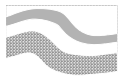


Figure 8 shows that the depth to the water table is 30-40 metres at the eastern mine sites, decreasing to 10 metres at Zeus and to less than 2 metres near bore site LS34 north-northwest of Zeus.

Parsons Brinckerhoff Pty Ltd (2011) assumes a specific yield for the superficial aquifer of 0.15, which is appropriate for an unconfined aquifer composed predominantly of sand.

3.3 YARRAGADEE AQUIFER

The sand beds in the Yarragadee Formation constitute leaky confined aquifers. The degree of confinement of the aquifers increases with depth. The uppermost Yarragadee Formation aquifers have a hydraulic connection to the superficial formations where the dipping aquifers subcrop on the base of the superficial formations. There is also likely to be leakage between aquifers along fault planes. The pump test carried out in the Yarragadee Aquifer (Section 6.2) showed a confined aquifer response in the first few hours after the start of pumping and evidence of recharge into the aquifer at later time.

Figure 9 shows contours of water level elevation in bores screened in Yarragadee aquifers 62-96 metres below water table. There are few bores screened in this interval and estimated values were used for sites DL2 and LS29A taking account of the vertical hydraulic gradients at those sites.

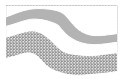
3.4 GROUNDWATER RECHARGE

Figure 10 presents hydrographs for the Department of Water observation bores in the project area². All sites have pairs of bores except for LS29A which is a single bore in the Yarragadee Formation. The shape of the plot for LS29A suggests that this particular bore may not be responding properly to the aquifer in which it is screened. At the other sites where there are pairs of bores the potential vertical movement of groundwater is shown by the water level differentials between the bores at different depths. The depths that the bores are slotted are given in the legend. At sites DL2 and LS32 in the east where the water depth is relatively deep the water level in the shallow bore is at higher elevation than the water level in the deep bore owing to rainfall recharge. At such sites there is downward movement of groundwater driven by the downward hydraulic gradient. At sites LS28, LS31 and LS34 in the west where the water depth is shallow the water level in the shallow bore is at lower elevation than the water level in the deep bore owing to the water level in the shallow bore being affected by evapotranspiration. At such sites there is upward movement of groundwater from the Yarragadee aquifers to the superficial aquifers.

The cross sections on Figure 4 copied from Nidagal (1995) further illustrate the water table level and groundwater movement within the superficial and shallow Yarragadee aquifers. The northern of the cross sections passes through LS34 while

ohm-metres.

² The water level data in the Leeman-Shallow series bores to November 2004 were recorded by the Water and Rivers Commission. The Department of Water has had insufficient manpower to continue monitoring these bores. From May 2007 Tiwest has been monitoring DL2A/W, LS27A/B, LS28A/B, LS29A, LS31B/C, LS32A/B, and LS34A/B with the permission of the Department of Water.



the southern of the cross sections passes through LS31 and LS32 in the central region of the mining area. The cross sections illustrate infiltration of rain recharge water through the sandy surface soils into the superficial formations in the east and from there downward to the shallow Yarragadee Formations. The groundwater flows approximately westward in both the superficial and Yarragadee aquifers. Some groundwater from the superficial formations discharges by evapotranspiration where the water table is shallow. The portion of shallow groundwater that does not discharge by evapotranspiration eventually discharges in the west to the sea via the Tamala Limestone.

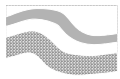
The low salinity in the shallow Yarragadee Formation (Section 7.2) shows that recharge water in the east is able to infiltrate downward past shale confining beds. The recharge pathway could partly result from the dip of the Yarragadee beds which allows the aquifers to subcrop on the base of the permeable superficial formations. Other possible recharge pathways include direct seepage through the shales and seepage along fault planes.

The recharge to groundwater is likely to be high in the infrequent times of high rainfall not only from the streams flowing off the escarpment but also by direct recharge of the rainfall on the plain.

Figure 21 shows low salinity of about 500 mg/L total dissolved solids (TDS) in the shallow Yarragadee aquifers in the north near Hades, at bores LS34A and DL2W. This suggests that the recharge of rain water is high in this area, possibly because of the several small drainage channels from the Gingin Scarp that would carry runoff in heavy rain to soak into the plain.

Figure 10 shows monthly Eneabba rainfall on the bottom graph. Only site LS34A/B where the water table is very shallow shows a significant seasonal water level response (typically 0.8 metres) to the winter rainfall. There appears to have been a substantial water level response to the high rainfall in 1999 at LS27A/B and LS28A/B, although the shape of the response is not defined because of a lack of monitoring data in 1999 and most of 2000. It seems that rainfall recharge is low in most years but high in the occasional wet years. Overall the water levels have stayed reasonably steady since 1990 and do not seem to have been significantly affected by the below-average rainfall since 2000.

Bekele et al (March 2003) made estimates of rainfall recharge to the sandy Parmelia aquifer on the Dandaragan plateau east of Eneabba. The average rainfall in that area is probably about 450 mm/year, similar to that within the project area. The recharge estimates ranged from 7-34 mm/year pre-clearing to 24-50 mm/year post-clearing. Parsons Brinckerhoff (May 2010) assumed recharge of 25 mm per year in the model (Section 8). This is at the lower end of the range of 5-10% of rainfall used by the Department of Water in determining available allocation for the Arrowsmith Groundwater Area (Department of Water, August 2009). At a regional recharge of 25 mm/year (approximately 5% of rainfall) the requested groundwater allocation of 5,000,000 kL/year from the Yarragadee Formation would be equal to the recharge over an area of 200 km². However, it is likely that the long-term rainfall recharge in the area to the east of the mineral deposits is well above the regional average because of the drainage of streams off the Gingin Scarp.



3.5 GROUNDWATER THROUGHFLOW

The natural groundwater throughflow within each kilometer width of aquifer can be estimated from the formula:

$$Q = 1000 \cdot T \cdot I \quad \text{where} \quad \begin{aligned} Q &= \text{throughflow (kL/d) over 1 km width} \\ T &= \text{transmissivity (m}^2\text{/d)} \\ I &= \text{hydraulic gradient} \end{aligned}$$

The transmissivity values are estimated from pump tests (Section 6.2). Hydraulic gradients are estimated from water level contour maps on Figure 5 (Superficial aquifers) and Figure 9 (Yarragadee aquifers). Table 1 provides estimates of throughflow.

Table 1
Estimates of Throughflow

Aquifer	Pump Test Location	Transmissivity m ² /day	Hydraulic Gradient	Throughflow kL/year/km
Superficial	DPB01	70	0.0022	56,000
Yarragadee Pumped Aquifer	DPB02	160	0.0015	88,000
Yarragadee aquifers to 205m depth	DPB02			330,000

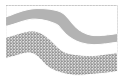
The estimates of hydraulic gradient are uncertain, particularly for the Yarragadee Formation, and therefore the estimates of throughflow have a substantial level of uncertainty. The estimate of total throughflow for all Yarragadee aquifers to 205 metres depth at DPB02 assumes that the same hydraulic conductivity and hydraulic gradient values apply in all Yarragadee aquifers to 205 metres depth as applies in the aquifer that was pump tested by DPB02. The value of 330,000 kL/year/km is therefore a ball-park estimate only. The drilling to 229 metres depth in DOB03 found no major aquifers below 205 metres, hence the use of this cut-off depth.

The annual allocation of groundwater needed by Tiwest from the Yarragadee Formation (5,000,000 kL/year) is equivalent to the estimated throughflow over 15 km width of the Yarragadee aquifers to 205 metres depth. The four conceptual Yarragadee production bore locations shown on Figure 3 are spaced about 2.5 km apart over a distance of 7.3 km.

3.6 PROPOSED BORE CONSTRUCTION

The conceptual production bores in the Yarragadee Formation would have similar construction to DPB02 (Figure 15) but with 250-mm nominal diameter casing rather than 200-mm casing, in order to allow a pump of 40 L/sec capacity to fit inside. The diameter of the reamed drill hole would be nominal 410-mm rather than 350-mm to provide annular space for the screen to be gravel packed and the casing cement grouted.

The bores are sited where the water table is 20-30 metres below ground (Figure 8), which will allow substantial available drawdown without excessive pumping lift requirements in the bores. Each bore would be drilled to a depth that provides sufficient drawdown and a sufficient thickness of aquifer sands to provide a bore capacity of 40 L/sec (3460 kL/d). It is expected that each pilot hole would be drilled to about 170 metres for geophysical logging and that each production bore would be completed to a depth (on average) of about 130 metres. Because of the



folding and faulting of the Yarragadee sediments it is likely that the four bores would be screened in different sand beds even though the bores might be drilled to similar depths.

4 EXISTING GROUNDWATER USE

4.1 BORES

The register of licenced groundwater users on the Department of Water website shows that as of October 2011, within 20 km radius from the centre of the proposed Tiwest wellfield (taken for this purpose as 320800E, 6744750N), are eleven in-force licences for abstraction from the Yarragadee North aquifer totaling 2,451,396 kL per year, and four licences for abstraction from the Superficial Swan aquifer totaling 55,580 kL per year. By far the largest individual allocation is 1,700,000 kL per year from the Yarragadee North aquifer for Licence 156102 owned by the Murion Cattle Company Pty Ltd in the Twin Hills subarea, about 17 km east of the proposed Tiwest wellfield. Origin Energy Resources Limited has an allocation of 20,600 kL per year from the Yarragadee North aquifer on their leases adjacent to the proposed Tiwest wellfield. This modest allocation is assumed to be associated with the operations of the Beharra Springs gas processing plant.

In summary there is relatively little allocation of groundwater in the near vicinity of the proposed Tiwest wellfield.

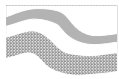
4.2 VEGETATION

Baseline vegetation assessment including detailed survey and mapping of communities and conservation-significant flora was completed by Woodman Environmental Consulting Pty Ltd (2009).

Froend, Bowen, Preston & Associates (2011) studied the vegetation and hydrological regime around the proposed mine pits. They found that in areas of shallow water table silcrete layers may prevent plant roots from accessing shallow groundwater. However, the consultants advise that it is prudent to assume that the majority of the area of shallow water table immediately west of the Zeus deposit relies to some extent on the shallow groundwater resource.

4.3 STYGOFAUNA

In March and September 2009 Rockwater Pty Ltd carried out an extensive study for Tiwest of stygofauna in bores (Rockwater Pty Ltd, 2011). The consultants found a low abundance and low diversity of stygofauna. Six stygofauna species were recorded in the project area but none of these were considered to be restricted to the project area. They also found that there is no evidence that the lithology of the superficial formations in the vicinity of the Dongara project is unique; implying that suitable habitat for stygofauna within the superficial aquifer is likely to exist in surrounding areas of the Swan Coastal Plain where the superficial formations are saturated. A desktop study found that there were not likely to be rocks with suitable voids below water table in the project area for troglodytes to exist.



5 DRILLING INVESTIGATIONS

5.1 SUPERFICIAL AQUIFER

Details of bore survey and construction are given in Appendix A.

In 1990 the Mines Department Drilling Branch installed the Leeman Shallow series of observation bores. Sites DL2, LS27-29, LS31-32 and LS34 are shown on Figure 2. Site LS32 is between the Heracles and Dionysus resources and is approximately in the centre of the heavy mineral resource area. Each of the Leeman Shallow sites consists of a shallow bore generally 20-33 metres depth screened within a superficial aquifer, and a deeper companion bore drilled to 100 metres depth screened within a Yarragadee aquifer. The bore completion reports including natural gamma and resistivity logs are given in Nidagal (1991).

Tiwest has extensively explored the sediments of the superficial formations for heavy minerals by more than 2000 air core drill holes. In October 2006 and September 2008 piezometers were installed into the superficial aquifers in selected holes during exploration drilling in order to better define the background groundwater quality and water table level. Each of these consists of nominal 20-mm uPVC casing with 2 metres of slots near the base. The ones which are not dry are shown on Figure 3. They have been monitored quarterly for water level and 6-monthly for water quality.

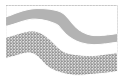
In October 2007 Western Irrigation Pty Ltd for Tiwest installed a pair of shallow and deep observation bores (DOB02 and DOB01 respectively) and a production bore (DPB01) on the eastern side of Zeus (Figure 3) for the purpose of test pumping. These bores were drilled on a line of air core mineral exploration holes where the lithology was already known to the base of the superficial formations from the air core samples. Figure 11 shows in section the screened interval of each of these bores against the distribution of slimes content from the air core drill data, the slimes content being a good inverse indicator of permeability. Appendix B provides the driller's construction logs for the bores.

5.2 YARRAGADEE AQUIFER

The deep bore of the pair of observation bores at each Leeman Shallow site was drilled to 100 metres depth and is screened within a Yarragadee aquifer near that depth. At site DL2 2 km northeast of Hades the shallower bore DL2W was drilled to 102 metres and screened from 63-69 metres depth, while bore DL2A was drilled to 500 metres depth and screened from 421-427 metres depth.

In February 2008 Western Irrigation Pty Ltd for Tiwest installed a Yarragadee observation bore DOB03 and a production bore DPB02 east of the Leeman Shallow site LS32 for the purpose of test pumping. Figure 18 presents a detailed map of the pump test site.

The pilot hole for the observation bore DOB03 was drilled to 229 metres depth for exploratory purposes before constructing the bore with slots from 99-114 metres



depth. Figure 14 provides the log of bore construction, down-hole geophysics and strata. Appendix C provides photographs of the cuttings samples from DOB03 at 3-metre intervals.

The pilot hole for DPB02 was drilled to 153 metres depth for exploratory purposes before constructing the bore with stainless steel screen from 102.5-117.5 metres depth. Figure 15 provides the log of bore construction, down-hole geophysics and strata for the production bore. Appendix B provides the driller's construction logs for the bores.

Correlations between DPB02, DOB03 and LS32A (Figure 16) show that the Yarragadee strata have an apparent dip to the east of 7-10 metres vertical per 100 metres horizontal in that area.

6 TEST PUMPING

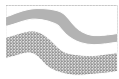
6.1 SUPERFICIAL AQUIFER

6.1.1 Procedure

The site of the superficial pump test bores is shown on Figure 3, while Figure 11 shows the bore intakes on an east-west cross section. It is likely that the deep observation bore DOB01 and the production bore DPB01 are each screened partly in sand of the superficial formations and partly in an underlying sand unit of the Yarragadee Formation that is in direct hydraulic connection to the superficial formations. In a hydraulic sense these stratigraphic units form the one unconfined aquifer system at this location.

The pump testing in November 2007 involved a step test followed next day by a 48-hour pump test. The purpose of the step test was to determine the hydraulic efficiency and available yield of the production bore rather than aquifer parameters. The step test consisted of four steps of 30-minutes each at pump rates of 4, 6, 8.5 and 11 L/sec (346, 518, 734 and 950 kL/d). The constant-rate test was carried out at 11 L/sec (950 kL/d) for 48 hours, followed by two hours of water level recovery monitoring. The abstracted water in each test was discharged via layflat tubing 300 metres to the west where it soaked back into the sandy ground. The electrical conductivity (EC) and pH of the water was monitored during the test and a sample was taken near the end of pumping for laboratory analysis.

During the tests manual water level readings were taken by electric contact probe in the two observation bores DOB01 and DOB02 and the pumping bore DPB01. In addition, capacitance loggers were set up to record at 4-second intervals in these bores and an In-Situ LevelTROLL® Water Level Monitor logged at 10-second intervals in each of a pair of piezometers PZN02 and PZN02S at a distance of 440 metres from the production bore. A barometric pressure logger was also set up at the PZN02 site. The pump test was carried out by Western Irrigation Pty Ltd while the monitoring of the test was primarily carried out by E.C. Envirotech Services Pty Ltd subcontracting to Hydrosearch Pty Ltd.



A summary of the stratigraphy, bore construction and pump testing is given in Appendix G (CD only) in the format of the Department of Water template 'WIN_Site_Details-V3_5.xlt'.

6.1.2 Interpretation

Figure 12 shows a linear plot of logged water levels in the background pair of piezometers PZN02S (upper Superficial) and PZN02 (lower Superficial) compared to barometric pressure. The water level curves follow the barometric pressure curve. This shows that the changes in water level, which cover a range of 0.13 metres, were predominantly due to variable barometric pressure exerting a variable downward force on the water surface in each piezometer. The water level in the deep piezometer diverged about 0.02m from the barometric pressure trace, possibly in response to the pumping of DOB01, whereas the water level in the shallow piezometer followed the barometric pressure trace throughout the test. At PZN02 therefore the superficial aquifers are giving a confined aquifer response with a high level of barometric efficiency. However, when the water level responses in DOB01 and DOB02 were corrected for barometric pressure changes a wavy curve resulted, whereas the uncorrected curves are smooth. Therefore the superficial aquifers at the pump test site have low barometric efficiency. Interpretation was carried out on uncorrected drawdown curves in DOB01 and DOB02.

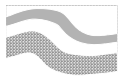
Figure 13 shows the log-log drawdown response in DOB01 and DOB02 (uncorrected for barometric pressure). In the middle stages of the test the water level logging unit in DOB01 was not responsive and therefore manual readings have been used in the middle interval rather than the logger readings. The shallow observation bore DOB02 is screened in a shallower aquifer zone than the pumping bore and shows a muted delayed drawdown response. The deep observation bore DOB01 is screened in the same aquifer zone as the pumping bore and shows a normal unconfined aquifer drawdown response with the drawdown curve, flattening in the middle stages and steepening in the later stages. Appendix D shows matches of early and late drawdown data in DOB01 against standard Neuman type curves for unconfined aquifers, using the procedure given in Kruseman and DeRidder (1990). Table 2 summarises aquifer parameters determined by these matches.

Table 2

Superficial Aquifers Transmissivity and Storativity Values by Neuman Method

Data Segment	Neuman Match Curve	Transmissivity m^2/d	Storativity
Early	Beta = 0.1	85	0.00002
Early	Beta = 0.2	64	0.0001
Late	Beta = 0.1	80	0.01
Late	Beta = 0.2	56	0.12

The average of the transmissivity estimates is **70 m²/d**. It is likely this mainly represents the transmissivity in the bottom half of the unconfined aquifer where the slimes concentration is lower and therefore the hydraulic conductivity is higher.



While the transmissivity of the superficial aquifers is reasonable at this location, there is insufficient available drawdown to support higher bore yields. The drawdown in the production bore DPB01 at the end of 48 hours pumping at 11 L/sec was 7.3 metres compared to 10.5 metres water column length between the standing water level and the top of the screen. Because normal practice is for bore pumps to be placed above the screen, 11 L/sec is close to the maximum sustainable yield for a bore in the superficial aquifers. Tiwest desires bores of 40 L/sec capacity.

6.2 YARRAGADEE AQUIFER

6.2.1 Procedure

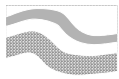
The site of the Yarragadee pump test bores is shown on Figure 3. Figure 18 presents a detailed layout plan of the bores and the water discharge points.

The pump testing in March 2008 involved a step test followed next day by a 40-hour pump test. The step test consisted of four pumping steps in DPB02 of 30-minutes each at pump rates of 5, 10, 15 and 20 L/sec (430, 860, 1300 and 1730 kL/d). The purpose of the step test was to determine the hydraulic efficiency and available yield of the production bore. The constant-rate test was carried out at 20.17 L/sec (1743 kL/d) for 40 hours followed by 8 hours of water level recovery monitoring. It had been intended to run the pump for 48 hours during the constant-rate test but a malfunction in the generator at 40 hours during the middle of the night caused the pumping to be terminated at that time. Manual water level readings were taken by electric contact probe during the tests in the observation bores DOB03, LS32A and LS32B and the pumping bore DPB02. In addition, LevelTROLL® Water Level Monitor probes were set in LS32A (logging every minute) and DOB03 (logging at 10-second intervals). The electrical conductivity (EC) and pH of the water was monitored during the test. The water sample taken after 24 hours of pumping was used for laboratory analysis. The pump test was carried out by Western Irrigation Pty Ltd but the monitoring of water levels and water sample collection during the test was primarily the responsibility of E.C. Envirotech Services Pty Ltd subcontracting to Hydrosearch Pty Ltd.

A summary of the stratigraphy, bore construction and pump testing is given in Appendix G (CD only) in the format of the Department of Water template 'WIN_Site_Details-V3_5.xlt'.

6.2.2 Interpretation

The correlations on Figure 16 show that LS32A appears to be screened in the same aquifer as the Tiwest bores DOB03 and DPB02. This was confirmed by the similarity in drawdown response in each bore (Figure 19) during the pump test in DPB02. Therefore LS32A acted as another observation bore for the pump test and enabled the transmissivity of the pumped aquifer to be determined by distance-drawdown method as well as by the more usual time-drawdown method.



The transmissivity and storativity are determined from the linear segments of the time-drawdown data on Figure 19 by the standard Jacob method. The interpreted values are given in Table 3. Also included in the table is the interpretation of transmissivity using the standard Thiem equation from the difference in water level at 2000 minutes between DOB03 and LS32A.

Table 3
Yarragadee Aquifer Transmissivity and Storativity Values

Observation Bore	Distance from DPB02 (Metres)	Method of Analysis	Data Segment (Mins)	Trans-missivity m ² /d	Storativity
LS32A	298	Jacob	100-1700	150	5.E-05
DOB03	42	Jacob	10-120	173	8.E-05
DOB03	42	Jacob	130-1800	137	2.E-04
LS32A & DOB03	298 & 42	Thiem	2000	181	

The average of the transmissivity estimates is **160 m²/d**. This represents the transmissivity of the sand aquifer screened in DPB02. The geophysical logs on Figure 14 show that the thickness of sand within this aquifer unit is about 17 metres. The average horizontal hydraulic conductivity of the sand is therefore $160/17 = 9.4$ m/d. This is in the middle of the normal range of 5-20 m/d given by Bouwer (1978) for medium grained sand.

A production bore at this site can provide the yield of 40 L/sec (3460 kL/d) desired by Tiwest for each bore. The drawdown in the production bore DPB02 at the end of 40 hours of pumping at 20.17 L/sec was 14.5 metres, which is only 20% of the 70 metres length of water column between the standing water level and the top of the bore screen.

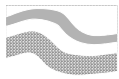
Of significance on the drawdown plots (Figure 19) is that after about 13 hours (780 minutes) the slope of the drawdown curve for each bore starts to decrease, likely indicating that the expanding cone of drawdown is inducing increased recharge into the pumped aquifer. The recharge could involve a combination of:

- downward leakage from the superficial aquifers particularly where the pumped aquifer subcrops;
- recharge along fault planes; and
- seepage directly through the confining beds.

7 GROUNDWATER CHEMISTRY

7.1 SUPERFICIAL AQUIFER

Figure 20 shows a map of TDS concentration in groundwater within the superficial aquifers. The salinity is lowest in the east and generally increases westward, especially at LS31C. The increase in salts westward is attributed to a concentrating of salts by evapotranspiration where the water table is shallow.



Groundwater pH in the superficial and shallow Yarragadee aquifers is mildly acidic (range 6-7) and is mainly governed by NaHCO_3 and high partial pressures of CO_2 (Gerritse, April 2008).

Appendix E presents analysis data for bores in November 2007 taken from Gerritse (April 2008). Appendix F presents analysis of trace metals. The water quality from DPB01 is suitable for Tiwest purposes except that the TDS is above the 500 mg/L limit for good quality drinking water and total activities of radium in groundwater from DPB01 are close to or could slightly exceed the health guideline for alpha-emitting isotopes in drinking water of 500 Bq/m³ (National Health and Medical Research Council and the Agriculture and Resource Management Council of Australia and New Zealand, 2004).

7.2 YARRAGADEE AQUIFER

Figure 21 shows a map of TDS concentration in groundwater within the shallow Yarragadee Formation. The salinity is generally lowest in the northeast and increases southwestward.

The electrical logs in the pilot hole for the Tiwest observation bore DOB03 (Figure 14) show slightly fresher water at shallow depth compared to deeper depth. This is consistent with the total dissolved solids in LS32A (570 mg/L) being slightly lower than in DPB02 (730 mg/L) because the latter is screened about 15 metres deeper. Electrical logs in the deep government exploration bore DL2A, a photocopy of which has been provided by the Department of Water, show higher salinity below 195 metres depth. Bore DL2A is screened from 421-427 metres depth and has TDS 1690 mg/L whereas the adjacent bore DL2W is screened from 63-69 metres depth and has TDS only 420 mg/L.

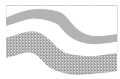
In summary the Yarragadee groundwater is freshest in the northeast of the project area and at shallow depth.

Appendix E presents analysis data for bores in November 2007 (March 2008 for DPB02) taken from Gerritse (April 2008). There are no significant issues with the Yarragadee water quality, except the level of dissolved salts may be above the threshold of 500 mg/L for good quality drinking water. The water is only mildly acidic - the pH measured on DPB02 pump test water was 6.1 in the field and 6.5 subsequently in the laboratory.

8 GROUNDWATER MODELING

8.1 CONCEPTUAL MODEL

Parsons Brinckerhoff Pty Ltd (2011) carried out numerical modeling for Tiwest of both groundwater inflow to the mine pits and drawdown due to proposed Yarragadee production bores, using Visual Modflow software (Version 4.3). The model incorporates four layers. The top layer represents the superficial aquifer and the bottom three layers the Yarragadee aquifer. The details of the model construction and modeling results are given in the referenced report.



The conceptual model on which the numerical model is based incorporates the superficial unconfined aquifer system overlying the Yarragadee Formation, with hydraulic leakage between these two aquifer systems.

8.2 AQUIFER PARAMETERS USED

A critical factor in modeling groundwater inflow to the mine pits is the hydraulic conductivity of the sediments of the superficial formations. Parsons Brinckerhoff Pty Ltd (2011) derived a spatial distribution of horizontal hydraulic conductivity in the superficial formations from sediment grain size analyses using Hazen's equation. This approach was used because of the large amount of grain size and percent slimes data on Tiwest's exploration database. Most of the derived hydraulic conductivity values were within the range 0.03 m/d to 3.2 m/d. The pump test on DPB01 indicated a transmissivity of 70 m²/d which perhaps indicates that the superficial aquifer may be relatively more permeable at that location, but it is difficult to assign a numerical value to the superficial horizontal hydraulic conductivity from this pump test because DPB01 is partly screened in a Yarragadee Formation sand aquifer that directly underlies and is in hydraulic connection with the superficial aquifer. Parsons Brinckerhoff Pty Ltd used an average value of horizontal hydraulic conductivity of 1.0 m/d (close to the average calculated value) for the superficial formations in regional areas where grain size data are not available.

Parsons Brinckerhoff Pty Ltd (2011) use a horizontal hydraulic conductivity value of 9.4 m/d for the Yarragadee aquifer that is screened by bore DPB02, as derived from the pump test on the bore. A value of 1 m/d was used for the Yarragadee Formation above and below this aquifer. The model incorporates a ratio of horizontal to vertical hydraulic conductivity in the Yarragadee Formation of 1000, which is low enough to allow leakage between the superficial and Yarragadee formations. The leakage reduces the modeled drawdown in the Yarragadee aquifer while causing some of the drawdown to be transmitted to the superficial aquifer.

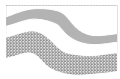
The model uses a specific yield of the superficial formations of 0.15, which is appropriate taking account that the shallow sediments at the water table are largely clayey or silty sand.

The model incorporates uniform rainfall recharge of 25 mm per year (approximately 5% of rainfall). Evapotranspiration is set at a maximum of 500 mm/year with an extinction depth of 1.25 metres (an assumed average rooting depth for vegetation).

8.3 MODELING RESULTS

8.3.1 Water Inflows to Mine Pits

Parsons Brinckerhoff Pty Ltd (2011) modeled inflow to the mine pits for three possible mining plans. The modeling found that for each of the three mining scenarios dewatering water would be produced for between 8 and 9 years. Averaged over 12-month intervals the peak annual rate of mine water inflow is simulated to be between 17 L/s and 21 L/s (550,000 kL/year to 650,000 kL/year) for the three mine plan scenarios. Sensitivity modeling allowing for a doubling of the hydraulic conductivity and doubling of the specific yield in the



superficial aquifer shows that the peak annual inflow to pits may be as high as 1,350,000 kL.

8.3.2 Drawdown of the Water Table

Parsons Brinckerhoff Pty Ltd (2011) produced spatial contours of the maximum combined modeled drawdown of the water table from mine pit dewatering and abstraction from Yarragadee production bores for each of the three mining scenarios. The three mining scenarios produced similar predicted drawdowns beneath the damplands, such that it was not possible to recommend a preferred option based on drawdown extent. The 0.25 metre maximum drawdown contour (maximum combined drawdown due to dewatering and Yarragadee abstraction) extended approximately 0.5 km westward of Hebe and to between 2.5 km and 3.0 km westward of the Heracles and Zeus deposits.

8.3.3 Drawdown of the Piezometric Head in the Yarragadee Aquifer

Parsons Brinckerhoff Pty Ltd (2011) produced spatial contours of the maximum modeled drawdown in the Yarragadee aquifer due to abstraction from the Yarragadee aquifer for mine water supply at an average of 20 L/s from each of the four production bores. The simulation shows that the 2.0 metre groundwater drawdown contour in the Yarragadee aquifer would extend to approximately 1.0 km from each Yarragadee production bore. The predicted drawdown in the Yarragadee aquifer would be dampened by downward leakage from superficial formations to the Yarragadee Formation.

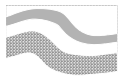
8.4 GROUND SUBSIDENCE

The sediments of neither the superficial formations nor the Yarragadee Formations have potential to undergo significant subsidence from groundwater abstraction because significant thicknesses of unconsolidated fine grained sediments do not exist in those formations. The groundwater abstraction will cause no damage to the aquifers.

9 GROUNDWATER MONITORING

The following monitoring program is proposed to monitor the impacts on groundwater of the proposed wellfield in the Yarragadee Formation and the dewatering of the mine pits during the life of the mining project.

- Each of the proposed Yarragadee production bores should be fitted with a calibrated flow meter and the meter reading and flow from each bore should be recorded at least monthly.
- The abstraction from each in-pit sump should be recorded at least monthly if practical. If it is impractical to meter the sump flows then estimates of monthly abstraction should be made on the basis of pump rate and metered hours of running.



- The water level should be recorded monthly in each of the Yarragadee production bores and the status of the bore (running or not running) should be recorded at the time of monitoring.
- The electrical conductivity and pH should be recorded in water from each production bore and in-pit sump at least quarterly when the bore or sump is operating.
- Annual major component analysis should be carried out on the water from each operable Yarragadee production bore and each active in-pit sump.
- Water level readings should be taken at least quarterly in active Leeman Shallow series bores and active piezometers within the area of Figure 3.
- An appropriate monitoring program should be carried out for monitoring any impact of water table drawdown on vegetation.

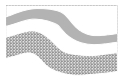
10 ACKNOWLEDGMENTS

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- The Department of Water provided bore construction, strata logs, geophysical logs and monitoring data for government bores, and also information on other bore users.
- The Bureau of Meteorology provided climate data.
- Tiwest Pty Ltd provided the other data used in the report and access to relevant reports by other consultants.

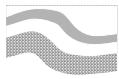
Kevin Haselgrove

November 2011



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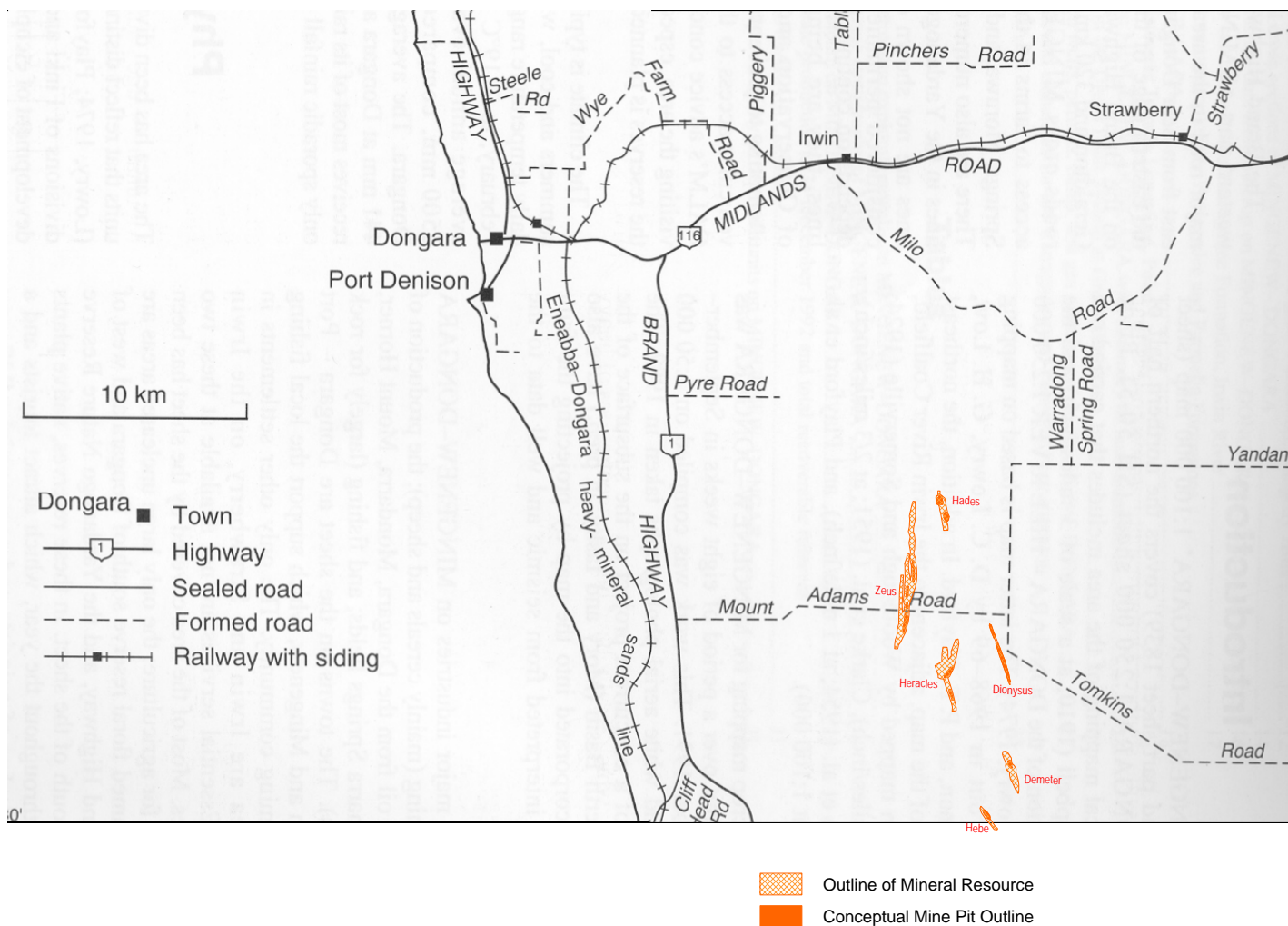


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-

FIGURES



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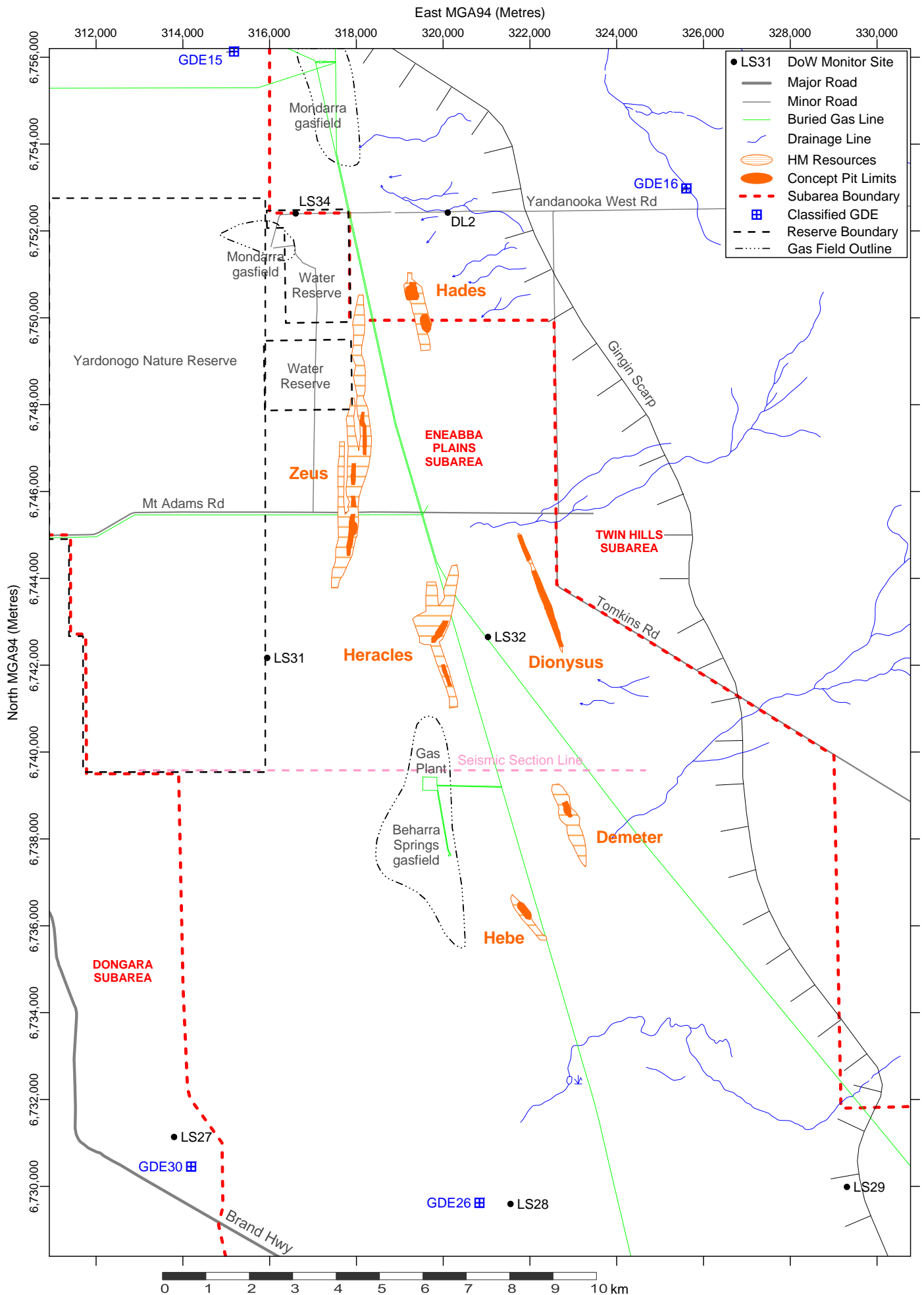


The base map is copied from Mory, A.J., 1995, "Geology of the Mingenew-Dongara 1:100,000 sheet": Western Australia Geological Survey, 1:100,000 Geological Series Explanatory Notes

LOCATION OF TIWEST MINERAL SAND RESOURCES RELATIVE TO DONGARA



Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia



GEOGRAPHICAL FEATURES

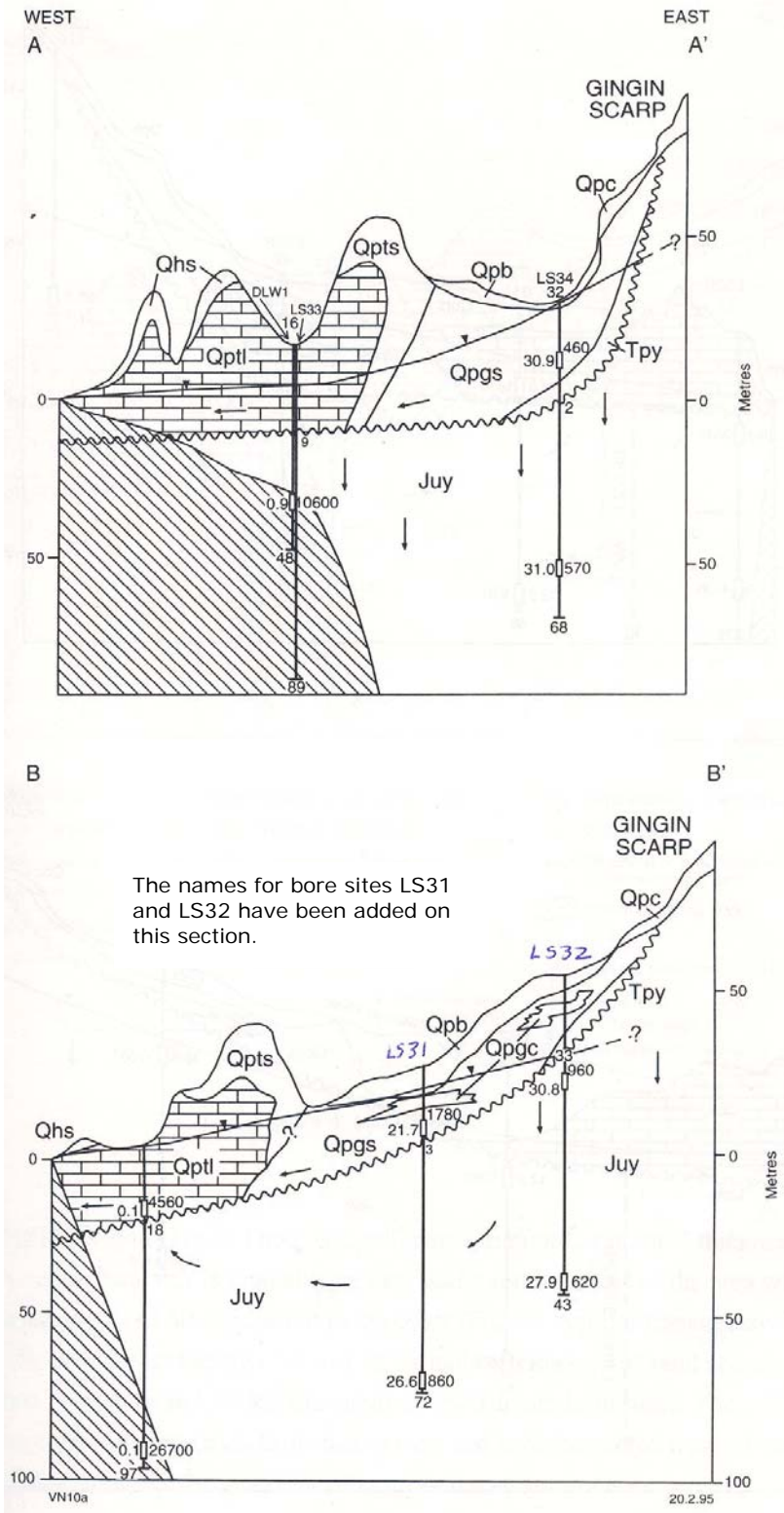
Figure 2



Figure 3



Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia



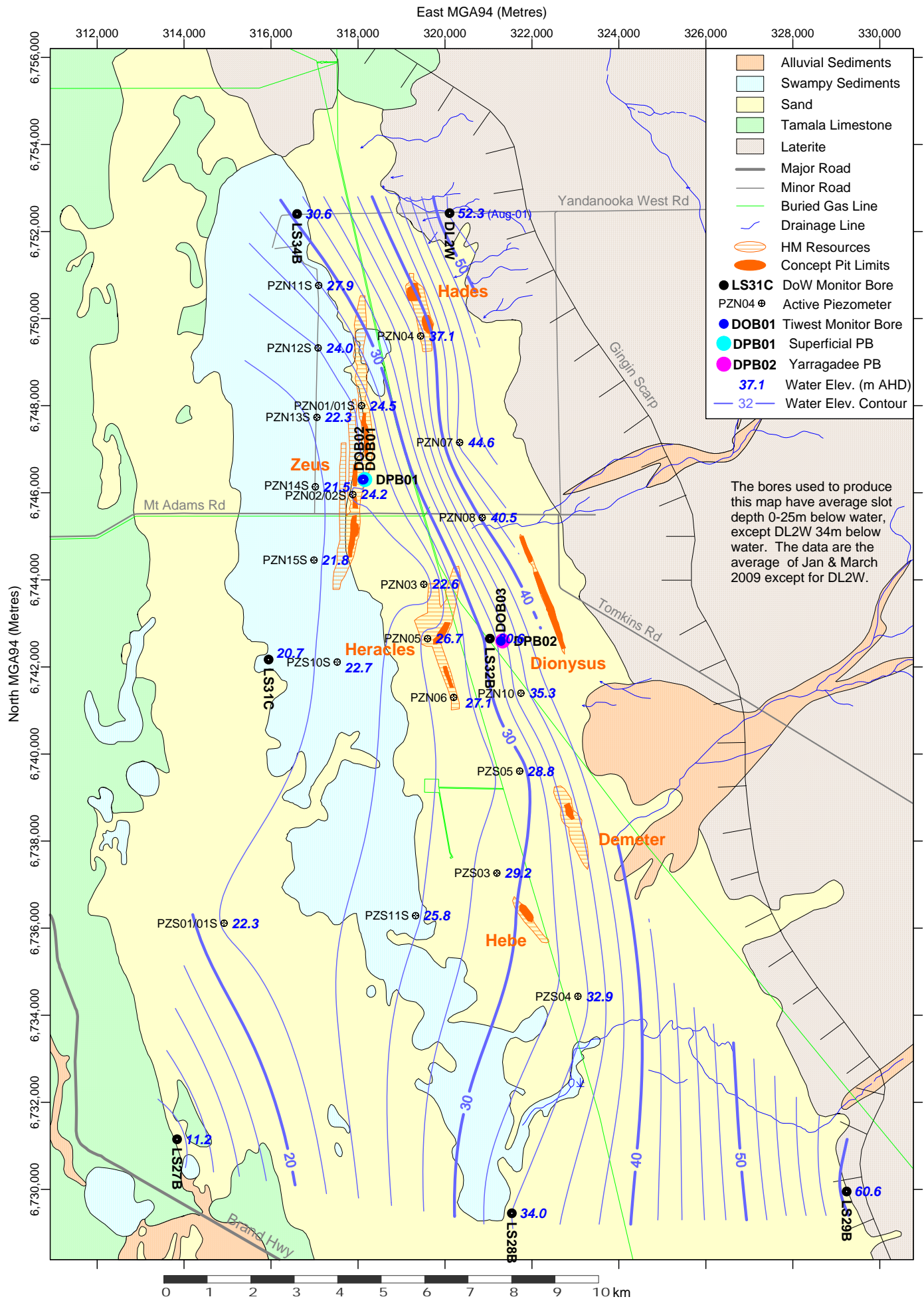
The names for bore sites LS31 and LS32 have been added on this section.

Qhs Safety Bay Sand	Qpgc Guildford Formation - clay	Fault showing direction of movement
Qpc Colluvium and sand	Tpy Yoganup Formation	— Watertable
Qpb Bassendean Sand	Juy Yarragadee Formation	← Direction of groundwater movement (vertical component)
Qptl Tamala Limestone	Jmd Cadda Formation	▨ Extent of saline water
Qpts Tamala Limestone Sand	Jlc Cattamarra Coal Measures	
Qpgs Guildford Formation - sand	Jle Eneabba Formation	
	LS19 Bore site	
	33 Surface elevation (m AHD)	
	11.6 slotted screen	
	1510 Salinity (mg/LTDS)	
	67 Total depth (metres below AHD)	

HYDROGEOLOGICAL CROSS SECTIONS AND LEGEND COPIED FROM NIDAGAL (1995)



Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia



WATER LEVEL ELEVATION IN SUPERFICIAL AQUIFERS Average Jan. & March 2009 (Metres AHD)



Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia

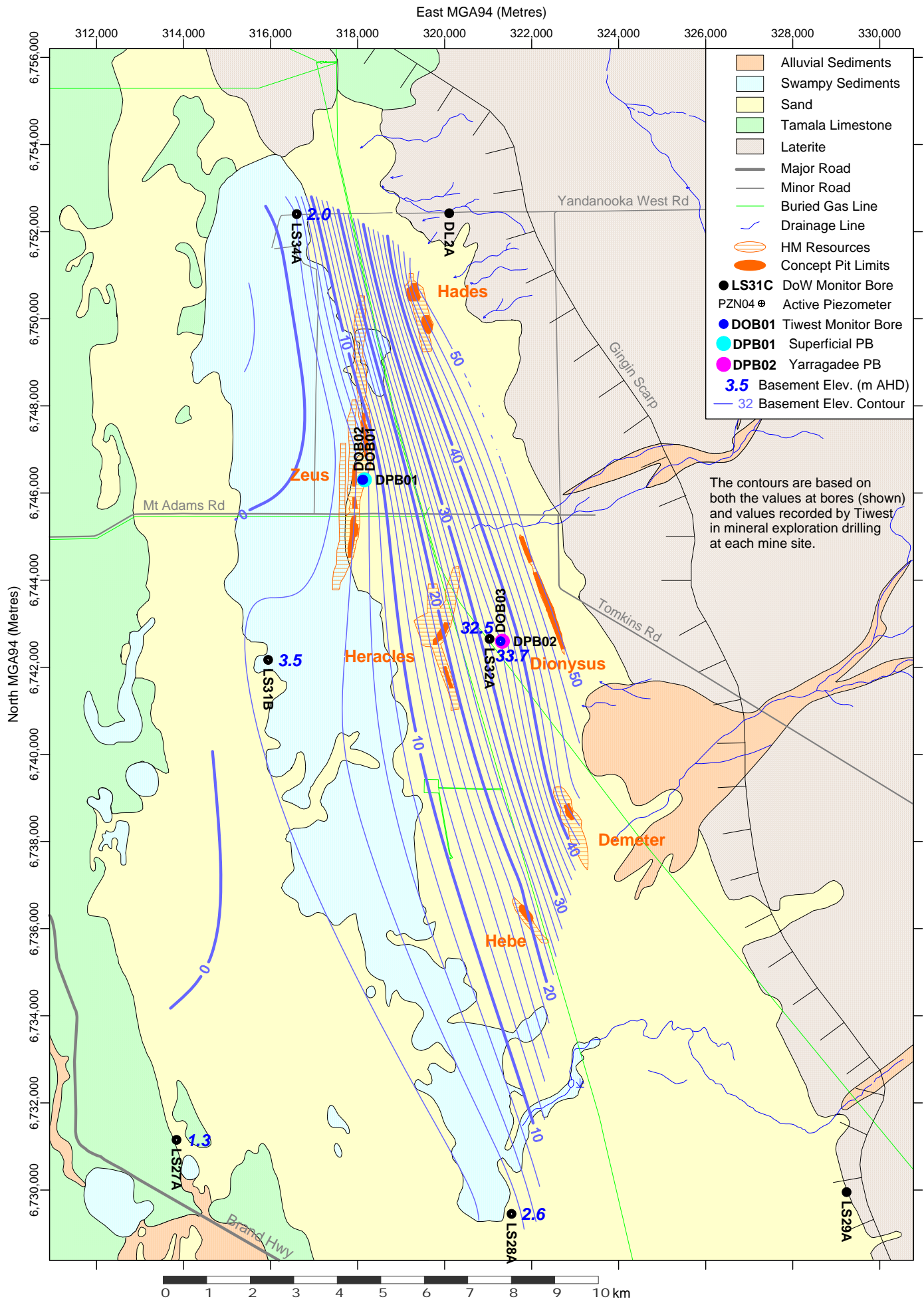
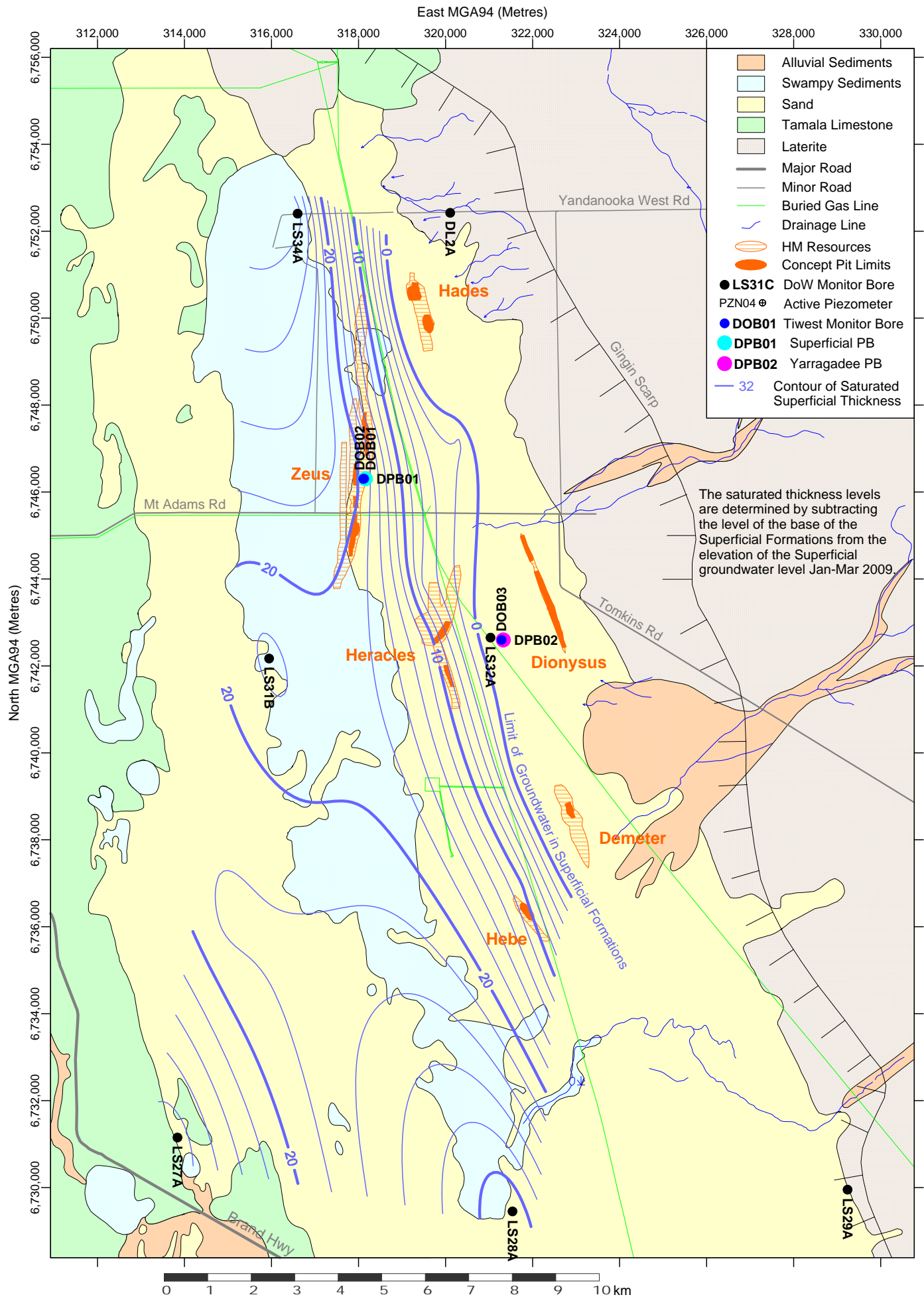


Figure 6



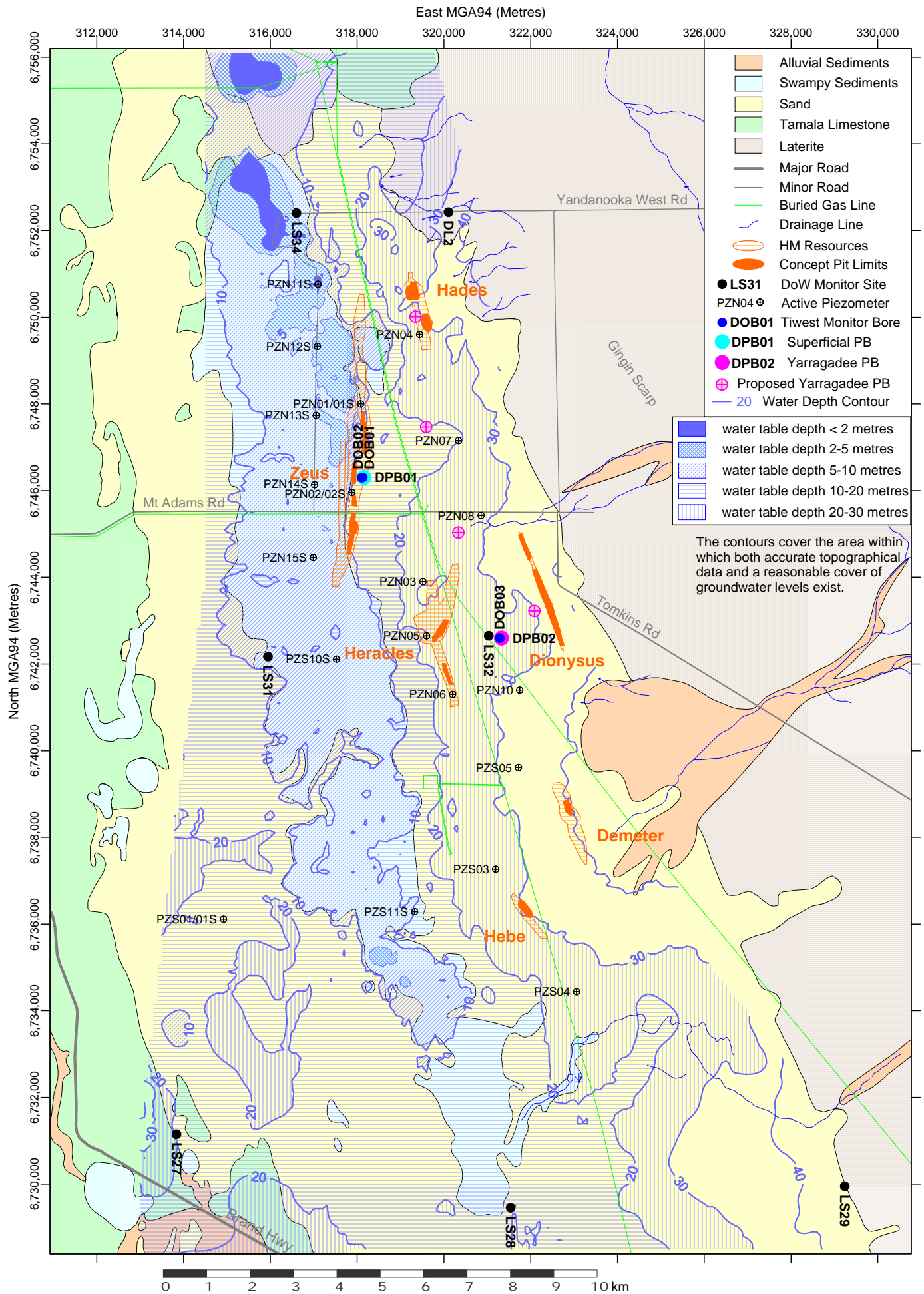
Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia



SATURATED THICKNESS OF SUPERFICIAL FORMATIONS January-March 2009 (Metres)

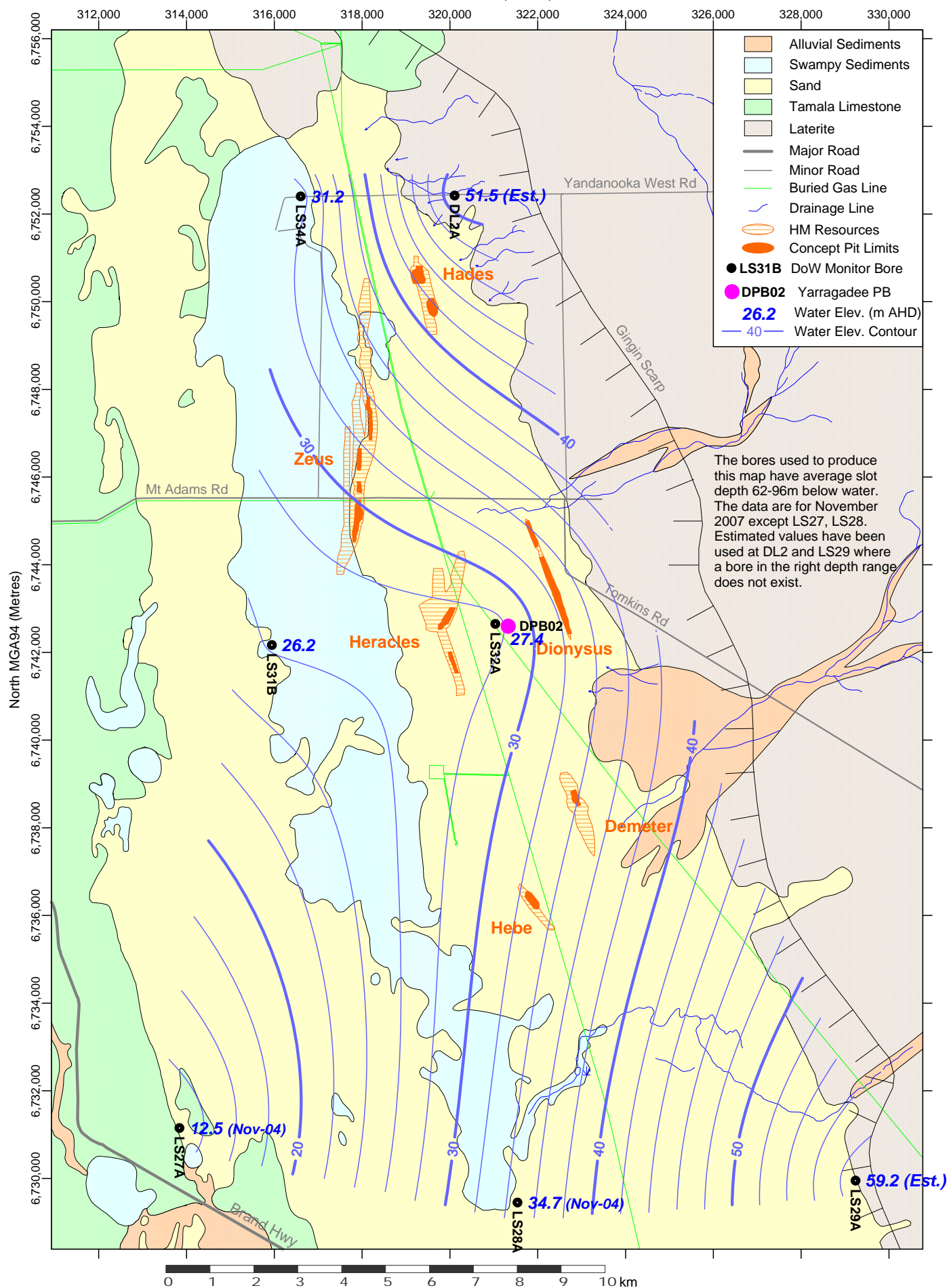


Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia

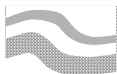




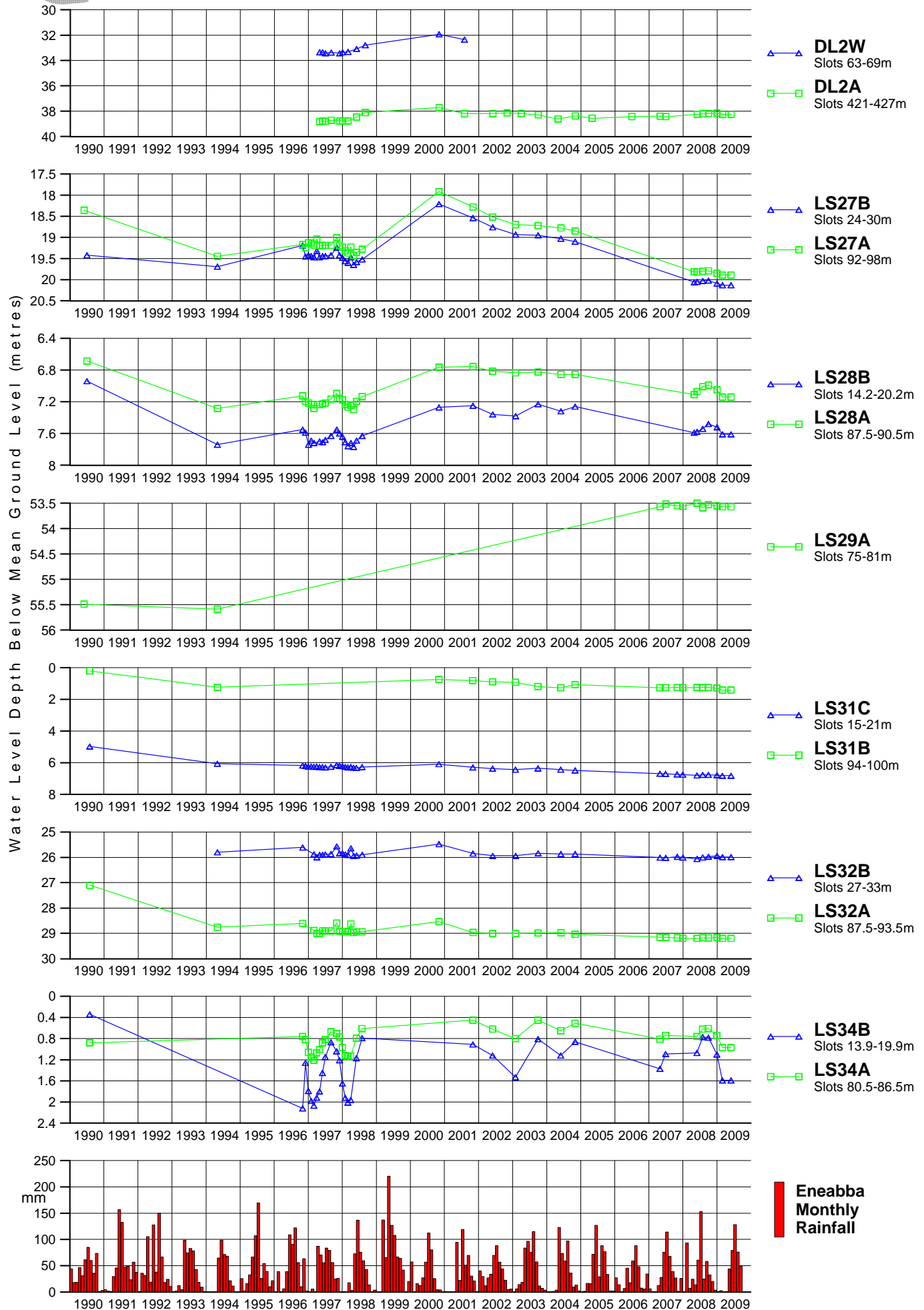
Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia
East MGA94 (Metres)



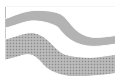
GROUNDWATER LEVEL ELEVATION IN YARRAGADEE AQUIFERS NOVEMBER 2007 (Metres AHD)
For depths 62-96 metres below water table



Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia

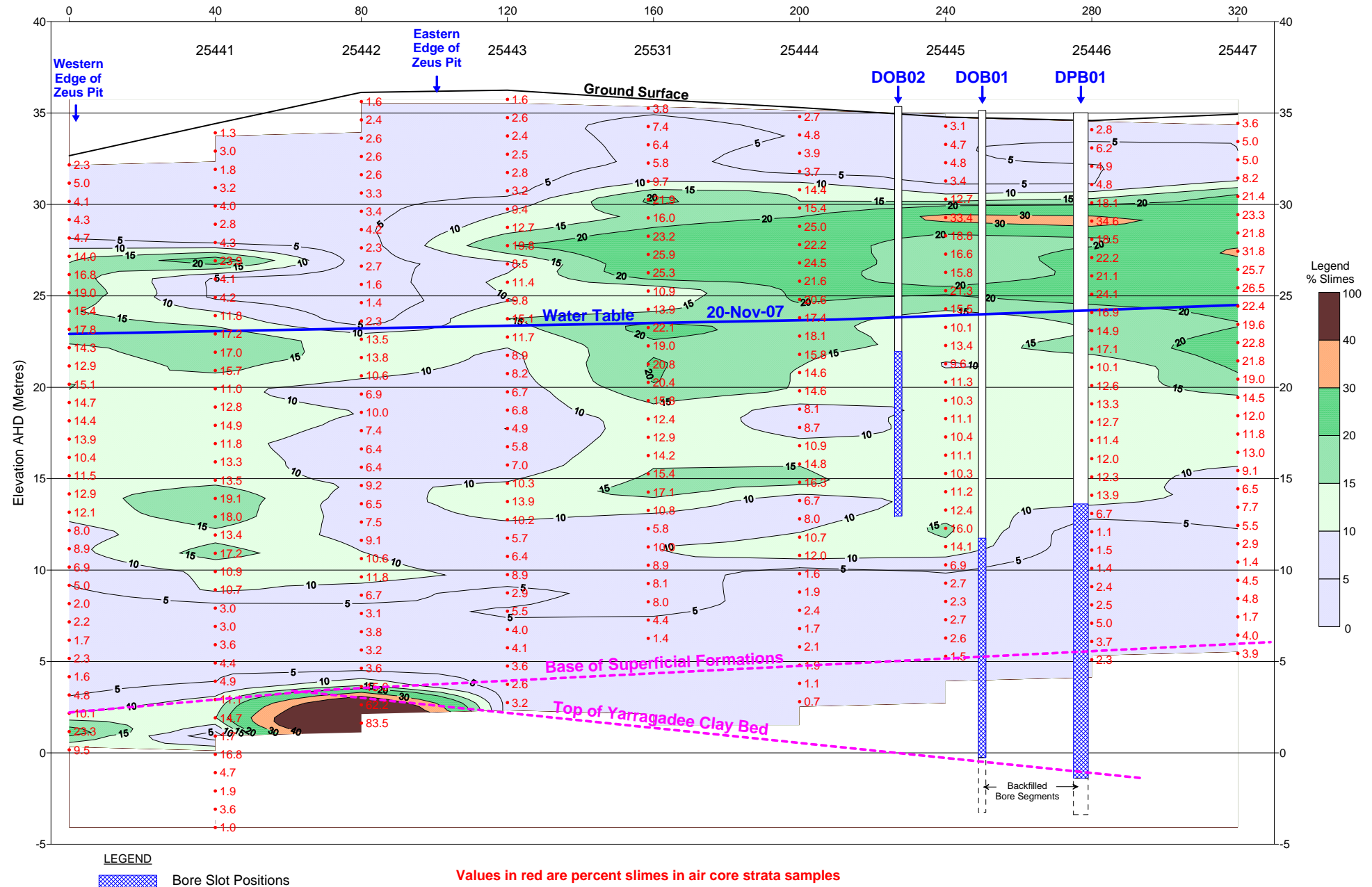


HYDROGRAPHS FOR DoW OBSERVATION BORES, and ENEABBA RAINFALL

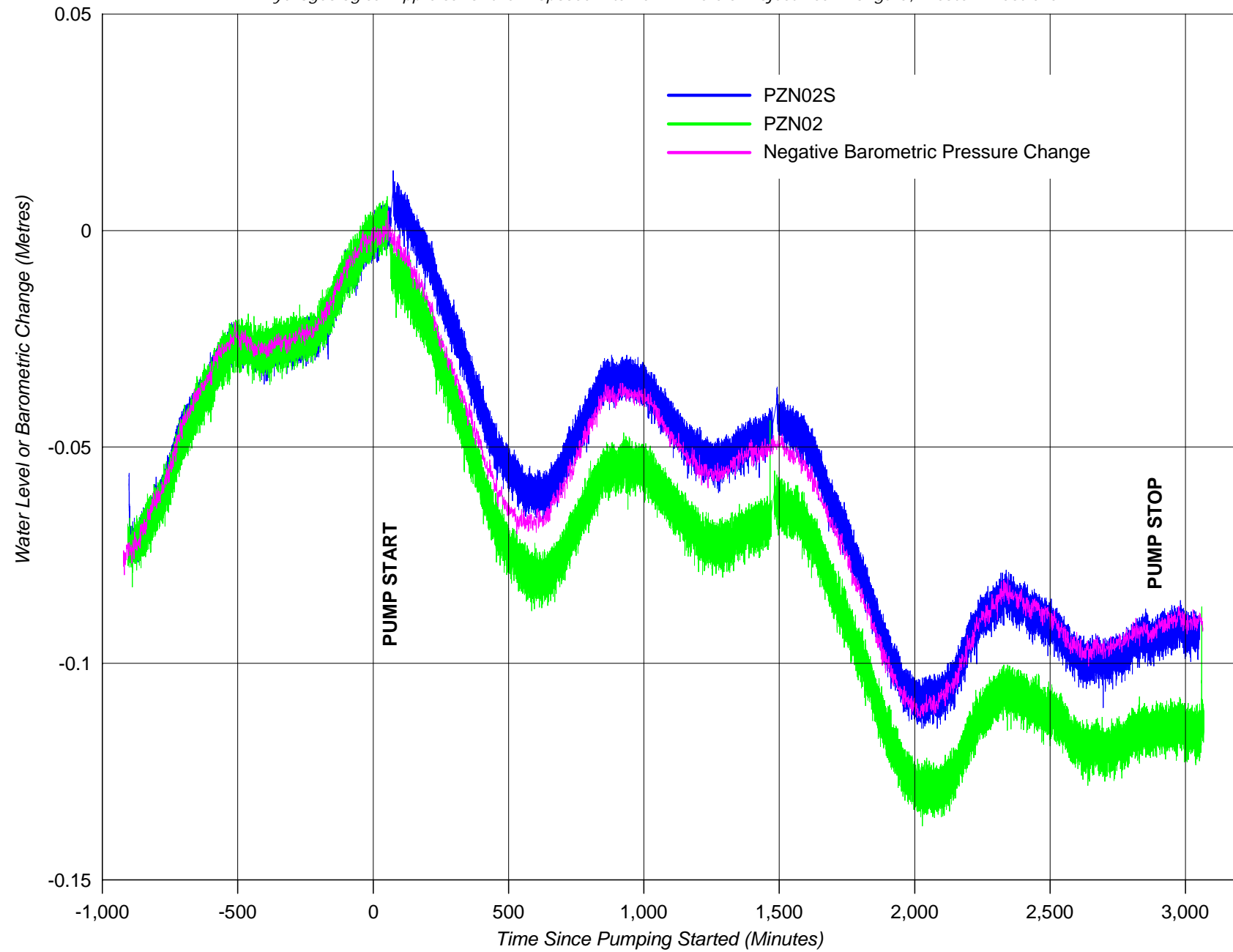
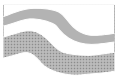


Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara, Western Australia

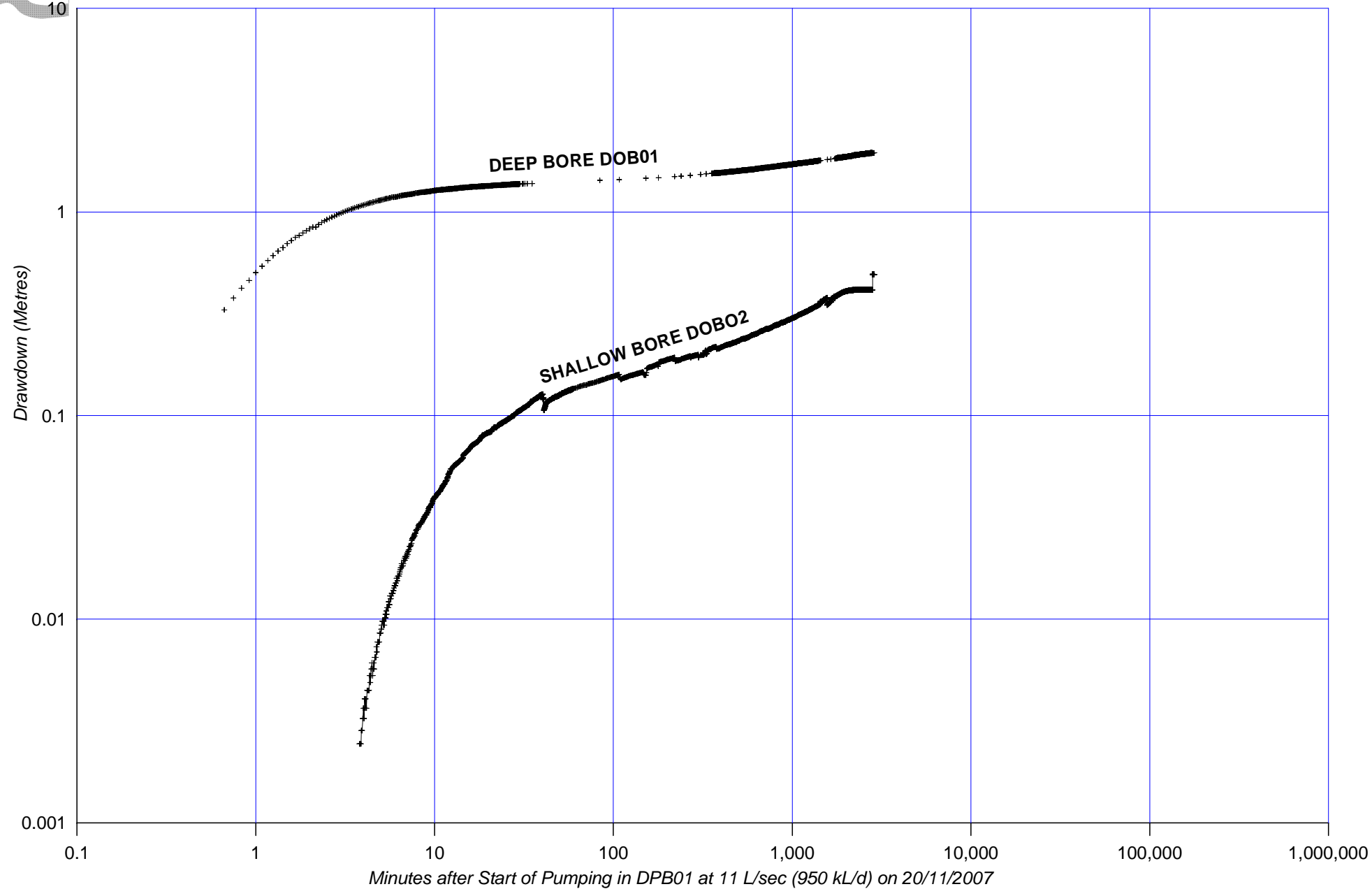
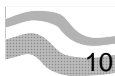
Distance East from Air Core Hole 25440 (Metres)



EAST-WEST CROSS SECTION THROUGH THE SUPERFICIAL PUMP TEST SITE SHOWING CONTOURS OF PERCENT SLIMES



WATER LEVEL AND BAROMETRIC CHANGES IN PZN02 AND PZN02S DURING THE SUPERFICIAL PUMP TEST IN DPB01
(Pump Rate in DOB01 11 L/sec (950 kL/d), Distance = 442 Metres)

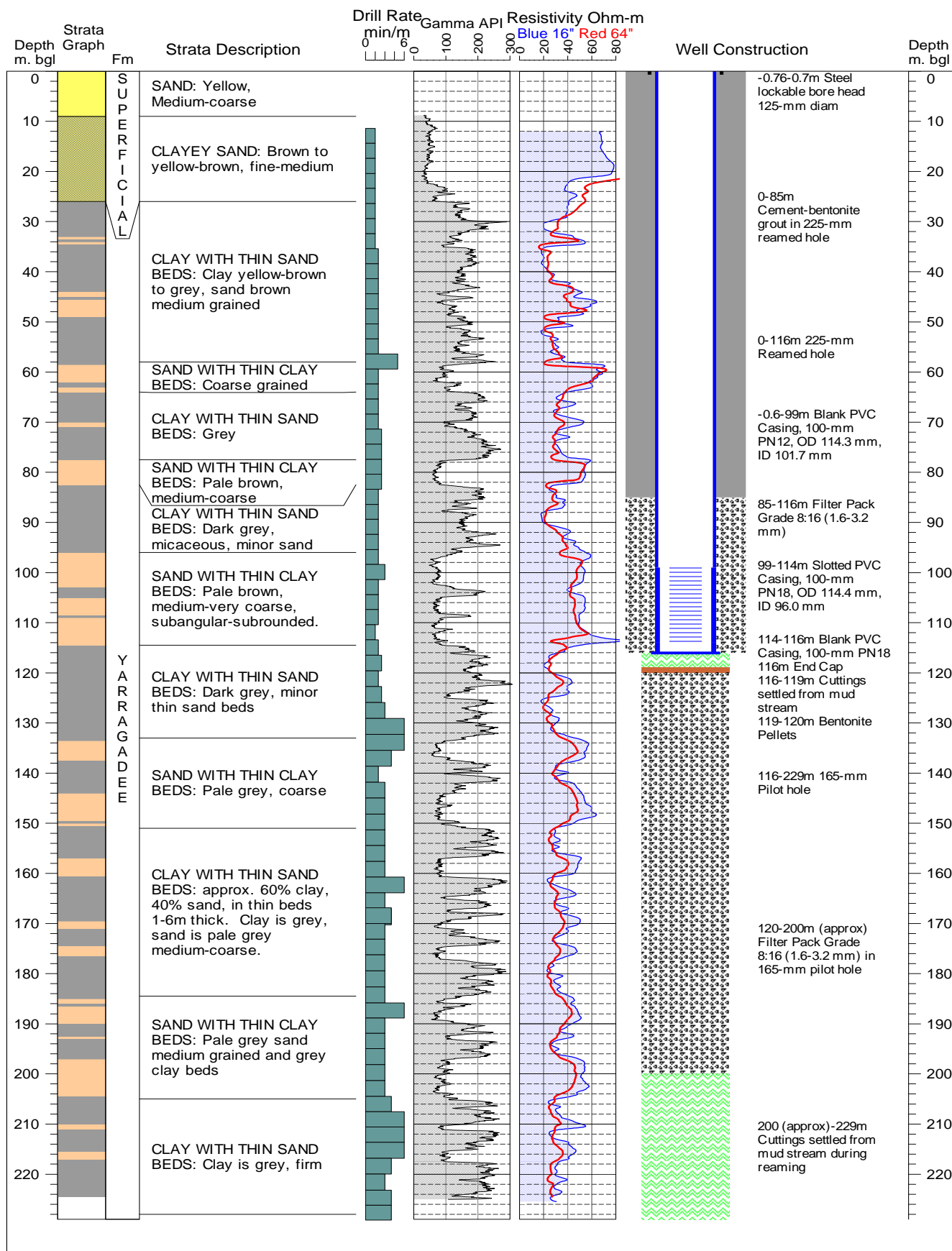


DRAWDOWN CURVES IN DOB01 AND DOB02 DURING THE SUPERFICIAL PUMP TEST IN DPB01



*Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia*

Drilling Contractor:	Western Irrigation	Casing Top stickup (m):	0.76	Bore Type:	Observation
Driller:	Steve Chitney	Ground Level AHD (m):	59.69 (DEM)	Owner:	Tiwest Pty Ltd
Rig:	Gardner Denver 15W	Slotted Casing bgl (m):	99-114	Location:	Dongara, WA
Drill Method:	Mud Rotary	Total Bore Depth bgl (m):	116	Date Started:	08/Feb/2008
Geophysical Contractor:	Westlog	Gravel Pack bgl (m):	85-116	Date Completed:	15/Feb/2008
Geophysical Logger:	Tim Roberts	Development Time (hrs):	10	East MGA94-50 (m):	321284 (GPS)
Hydrogeologist:	Kevin Haselgrove	Water Depth bgl (m):	32.37 on 11/Mar/2008	North MGA94-50 (m):	6742601 (GPS)

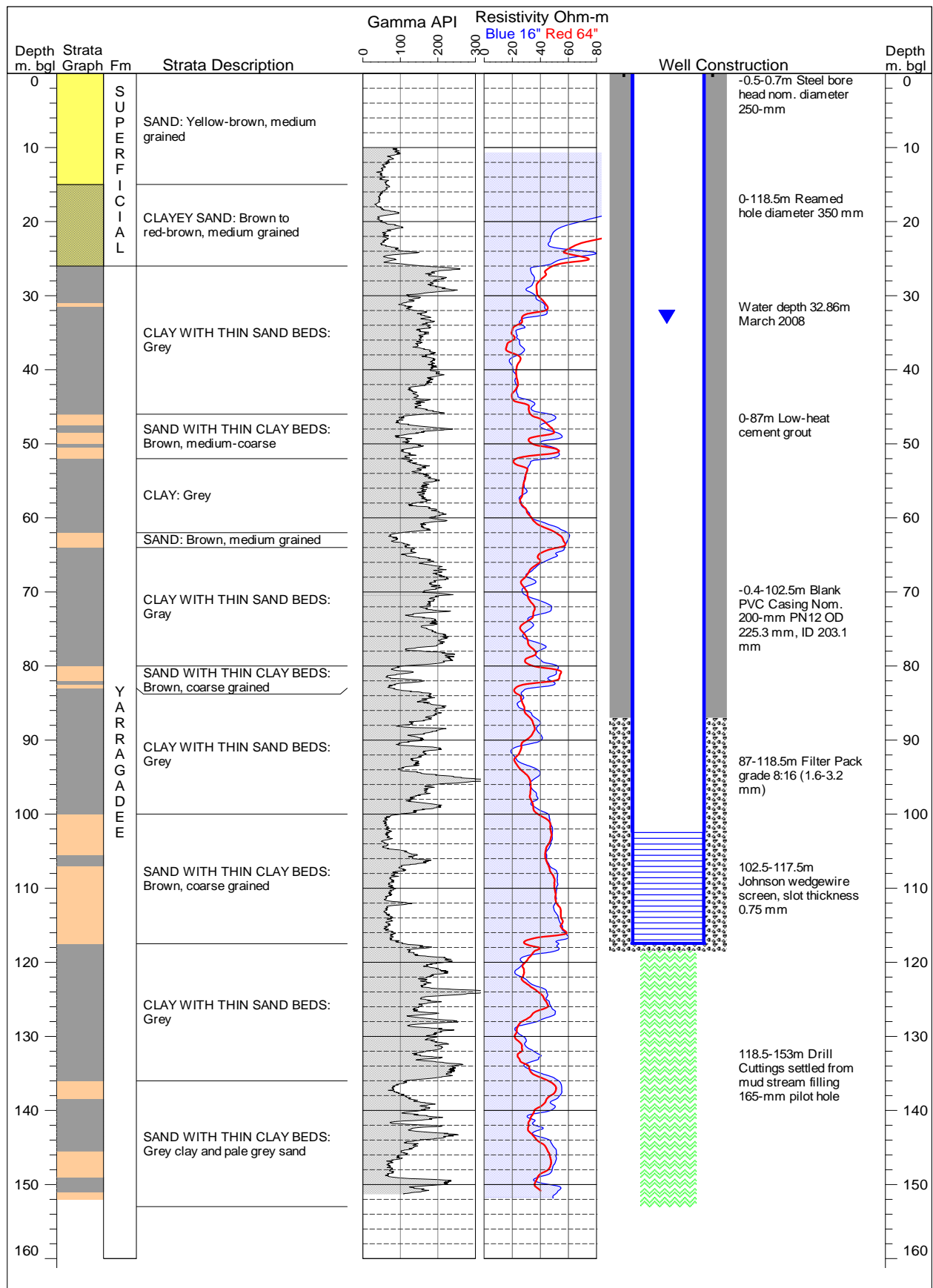


LITHOLOGY, GEOPHYSICS and BORE CONSTRUCTION LOGS for DOB03

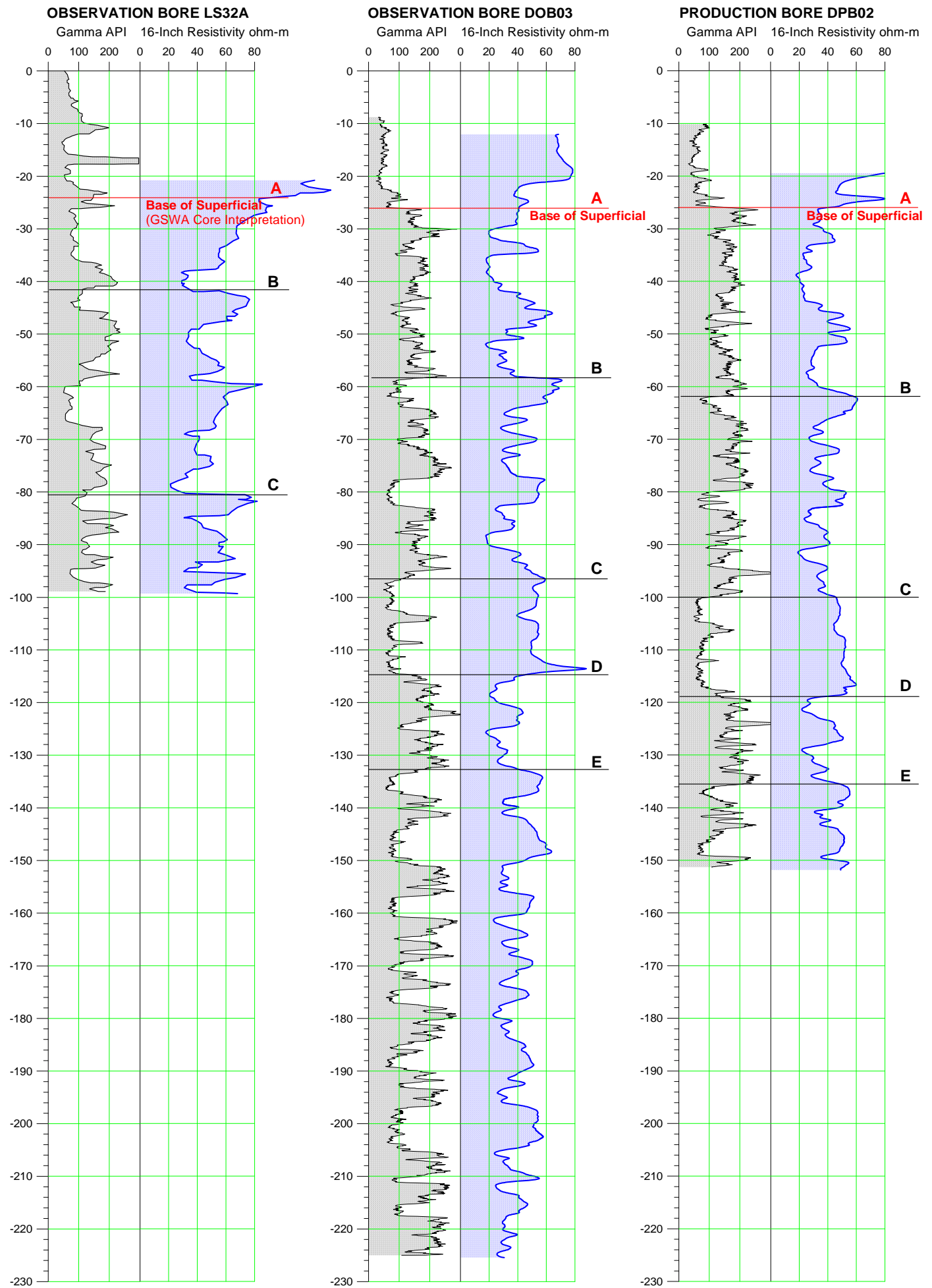


*Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia*

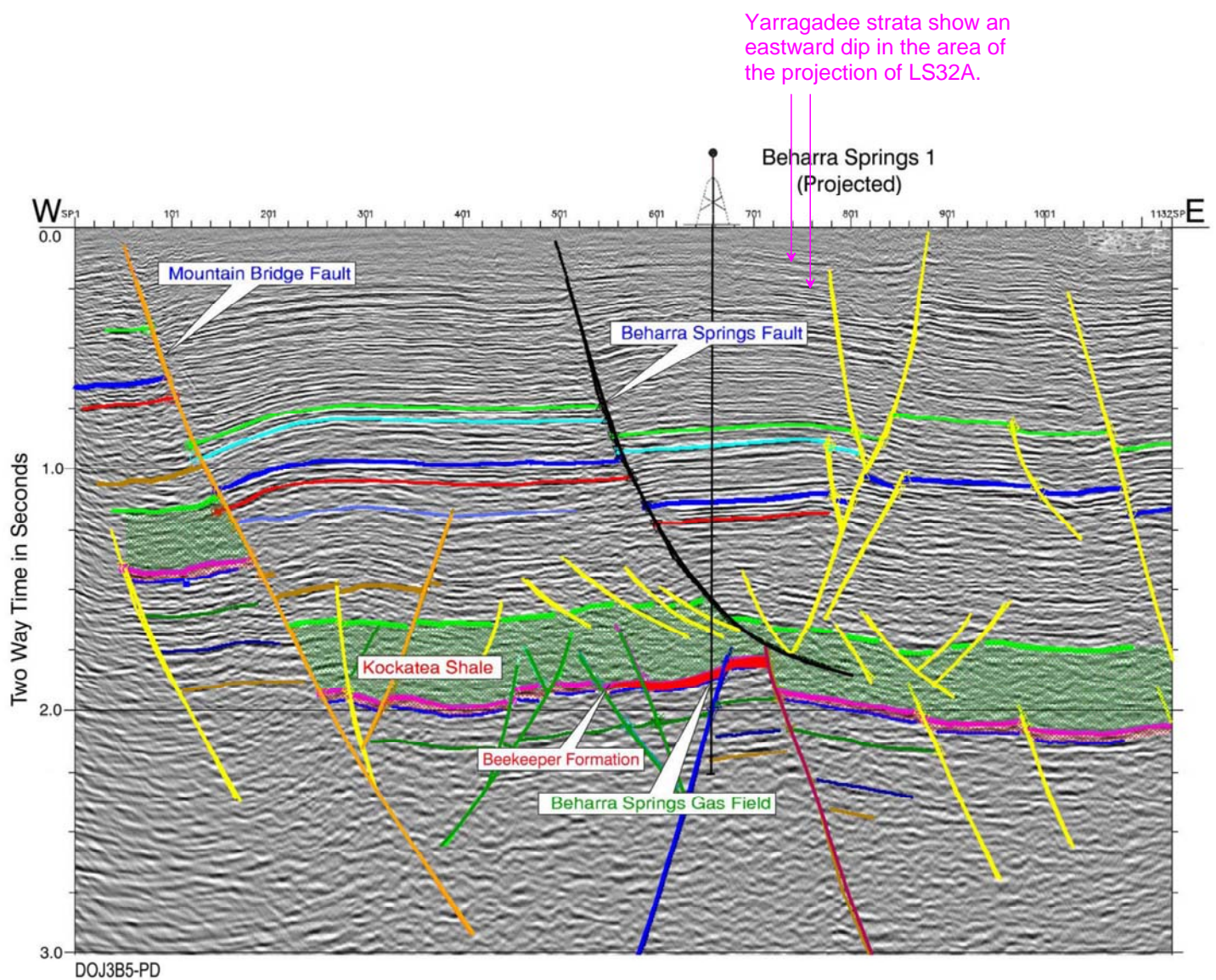
Drilling Contractor:	Western Irrigation	Casing Top stickup (m):	0.51	Bore Type:	Test Production
Driller:	Steve Chitney	Ground Level AHD (m):	59.9 (DEM)	Owner:	Tiwest Pty Ltd
Rig:	Gardner Denver 15W	Screen Depth bgl (m):	102.5-117.5	Location:	Dongara, WA
Drill Method:	Mud Rotary	Total Bore Depth bgl (m):	117.5	Date Started:	15/Feb/2008
Geophysical Contractor:	Westlog	Gravel Pack bgl (m):	87-117.5	Date Completed:	07/Mar/2008
Geophysical Logger:	Tim Roberts	Development Time (hrs):	10 (Airlift and Jet)	East MGA94-50 (m):	321326 (GPS)
Hydrogeologist:	Kevin Haselgrove	Water Depth bgl (m):	32.86 on 13/Mar/2008	North MGA94-50 (m):	6742596 (GPS)



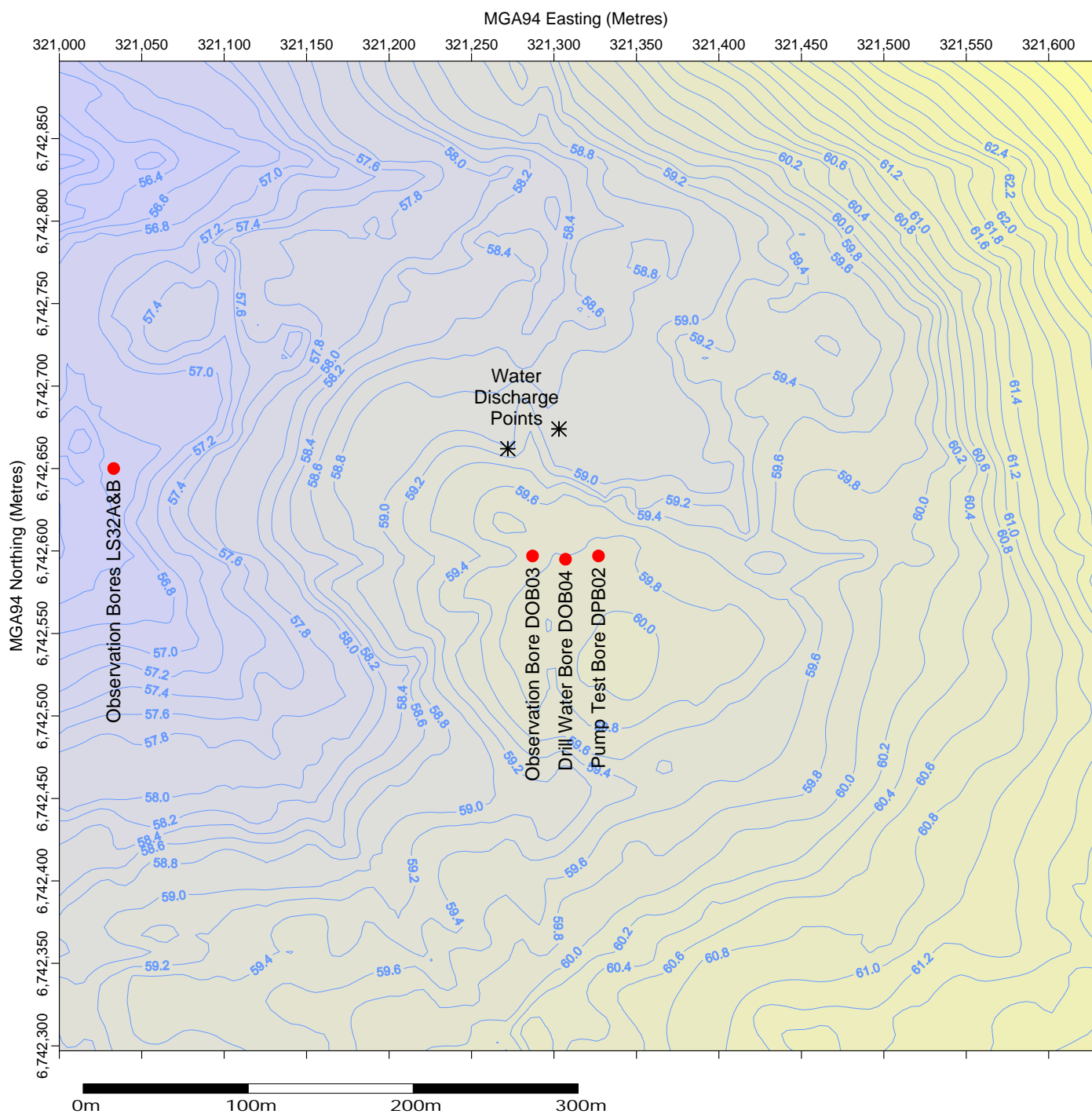
LITHOLOGY, GEOPHYSICS and BORE CONSTRUCTION LOGS for DPB02



CORRELATIONS BETWEEN GEOPHYSICAL LOGS IN LS32A, DOB03 AND DPB02

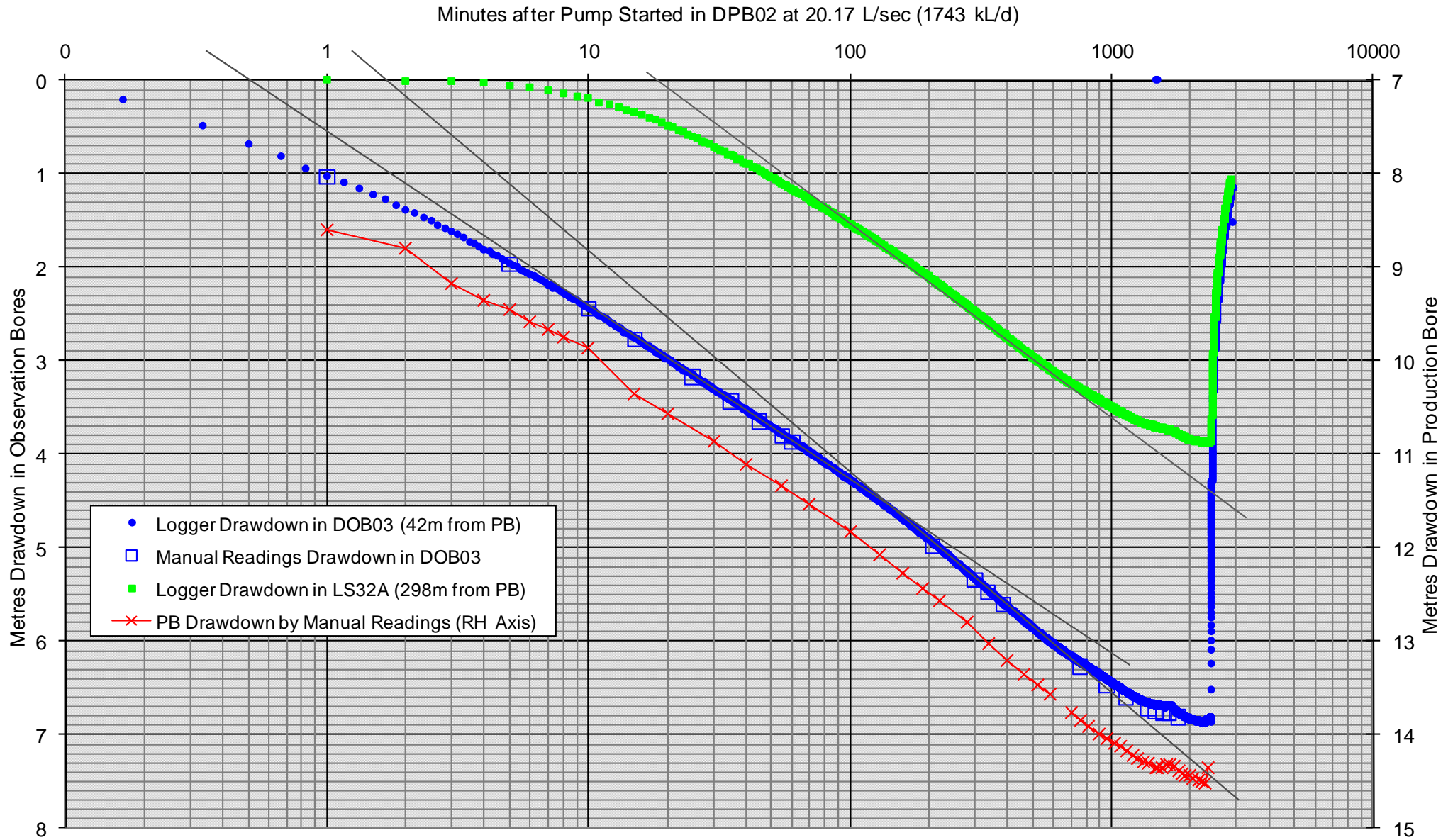


SEISMIC SECTION THROUGH THE BEHARRA SPRINGS GASFIELD
From Owad-Jones and Ellis (undated). Annotation added.



Contours are Digital Elevation Model Topography

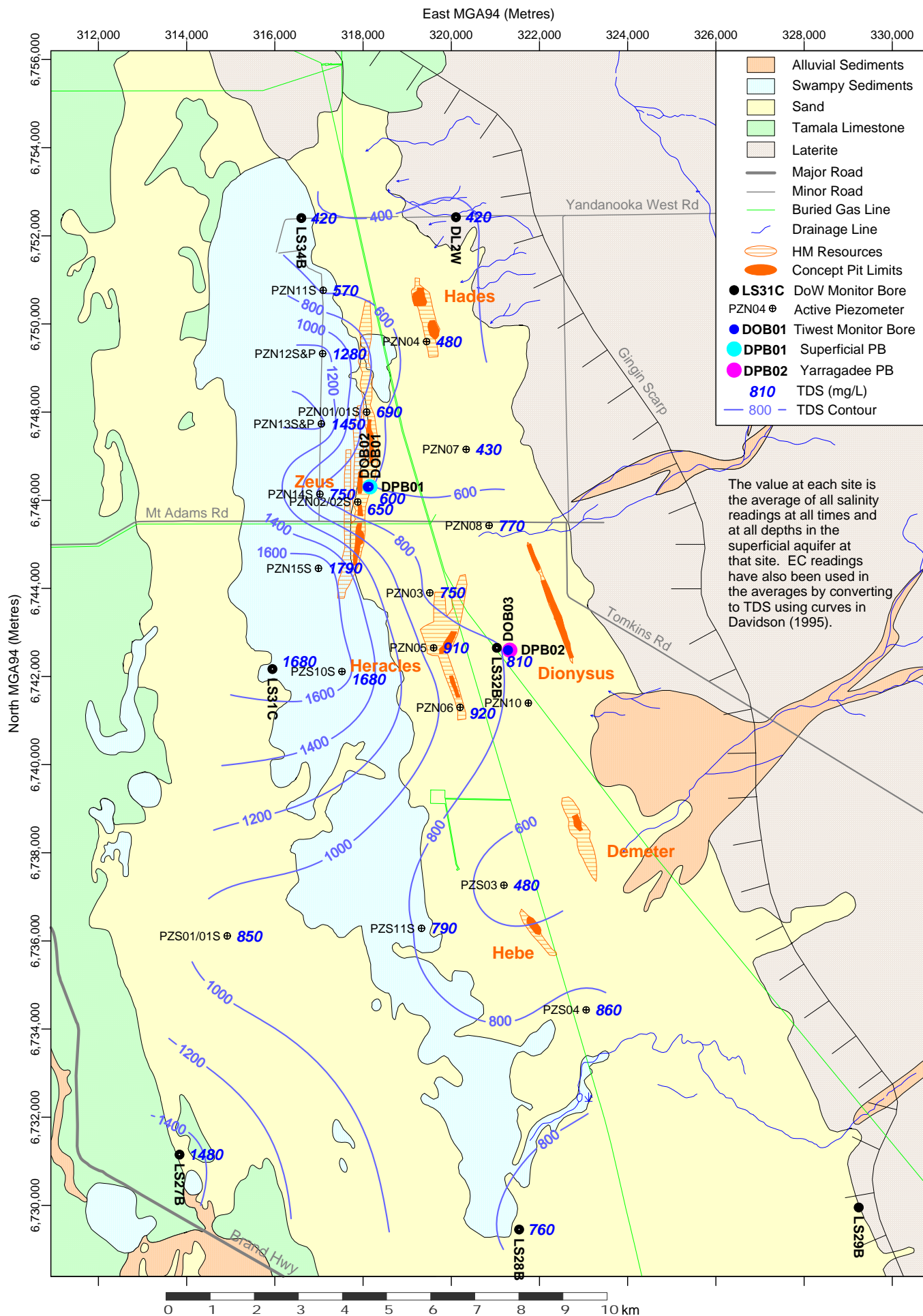
DETAILED MAP OF THE YARRAGADEE PUMP TEST SITE



LOG-LINEAR DRAWDOWN PLOTS FOR THE YARRAGADEE PUMP TEST AT DPB02



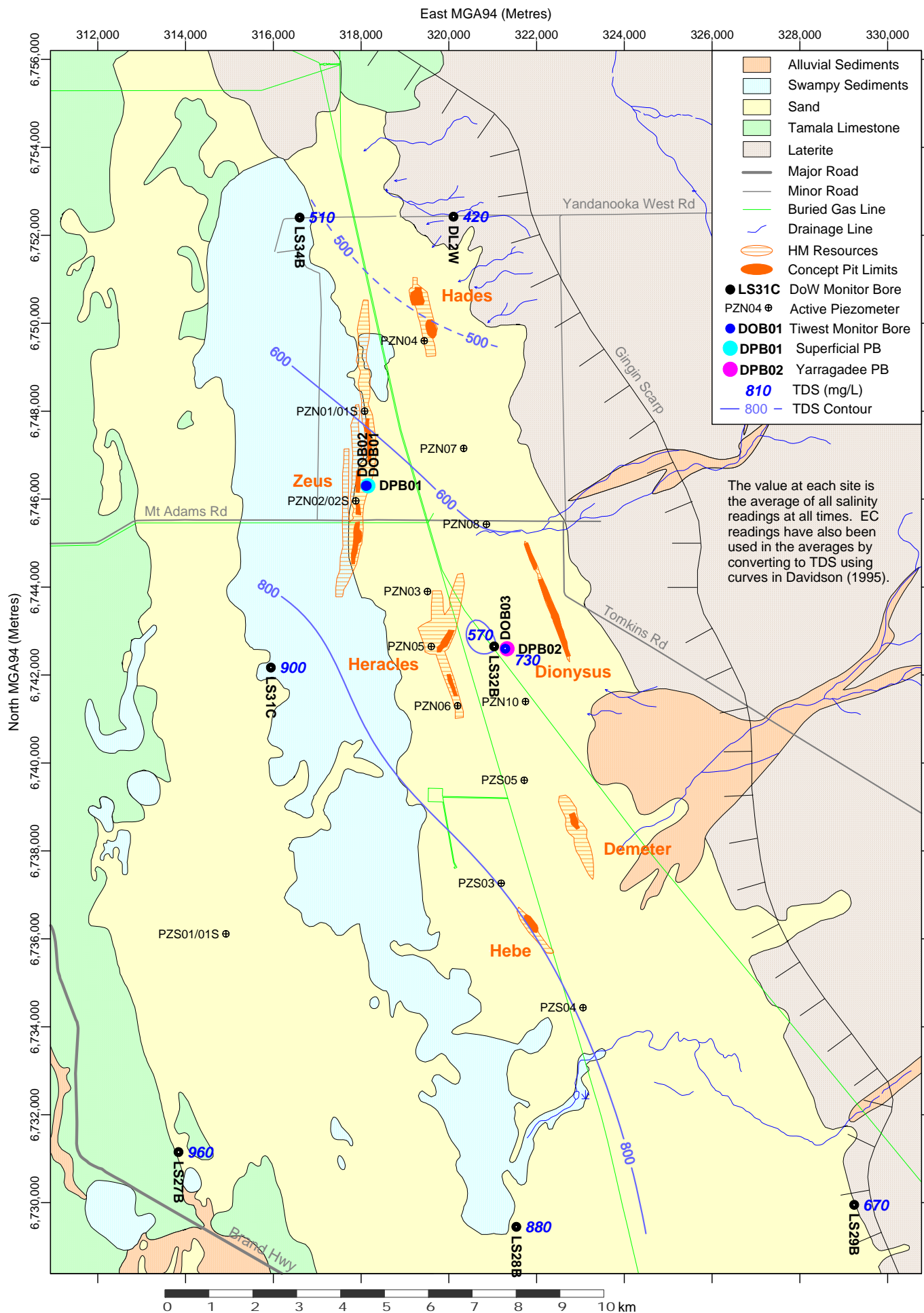
Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia



TOTAL DISSOLVED SOLIDS (mg/L) IN THE SUPERFICIAL AQUIFERS 2009
(within 25m below water table except DL2W 34m below water table)

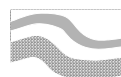


Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara,
Western Australia



TOTAL DISSOLVED SOLIDS (mg/L) IN THE YARRAGADEE FORMATION ABOUT 100 M DEPTH BGL

APPENDICES



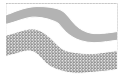
APPENDIX A

Bore Construction Table

Site Number	Owner	Year Instal.	Nom. Casing Diam. (mm)	Casing Type	East-MGA94	North-MGA94	Location Method	Elevn. Top of Casing (mAHD)	Elevn. Ground Level (mAHD)	Elevn. Method	Initial Depth to Water (mbgl)	Top Slot Depth (mbgl)	Bottom Slot Depth (mbgl)
DL2A	DoW	1995	100	Steel	320106	6752422	Survey	85.48	84.63	Survey	38.5	421	427
DL2W	DoW	1990	100	Steel	320106	6752422	Survey	85.20	84.64	Survey	33.4	63	69
DOB01	Tiwest	2007	100	PVC	318130	6746305	GPS	35.3	34.7	DEM	10.8	23	35
DOB02	Tiwest	2007	100	PVC	318107	6746301	GPS	35.4	35.0	DEM	11.1	13	22
DOB03	Tiwest	2008	100	PVC	321328	6742598	GPS	60.5	59.7	DEM	33.5	99	115
DOB04	Tiwest				321307	6742595	GPS	Temporary bore for drill water just below water table					
DPB01	Tiwest	2007	200	PVC	318157	6746304	GPS	35.1	34.6	DEM	10.4	21	36
DPB02	Tiwest	2008	200	PVC	321289	6742601	GPS	60.4	59.9	DEM	32.9	102.5	117.5
LS27A	DoW	1990	50	PVC	313838	6731151	Survey	32.28	31.32	Survey	18.4	92	98
LS27B	DoW	1990	50	PVC	313838	6731151	Survey	32.11	31.35	Survey	18.8	24	30
LS28A	DoW	1990	50	PVC	321538	6729451	Survey	42.31	41.57	Survey	6.8	87.5	90.5
LS28B	DoW	1990	50	PVC	321538	6729451	Survey	42.35	41.61	Survey	7.0	14.2	20.2
LS29A	DoW	1990	50	PVC	329238	6729951	Survey	114.91	114.20	Survey	55.5	75	81
LS31B	DoW	1990	50	PVC	315944	6742169	Survey	28.18	27.48	Survey	0.2	94	100
LS31C	DoW	1990	50	PVC	315944	6742169	Survey	28.31	27.51	Survey	5.0	15	21
LS32A	DoW	1990	50	PVC	321033	6742650	Survey	57.26	56.53	Survey	27.1	87.5	93.5
LS32B	DoW	1990	50	PVC	321033	6742650	Survey	57.26	56.60	Survey	18.9	27	33
LS34A	DoW	1990	50	PVC	316600	6752403	Survey	32.58	31.98	Survey	0.9	80.5	86.5
LS34B	DoW	1990	50	PVC	316600	6752403	Survey	32.62	31.93	Survey	0.3	13.9	19.9
PZN01	Tiwest	2006	20	PVC	318083	6748000	Survey	32.21	31.6	Survey	7.0	26.5	28.5
PZN01S	Tiwest	2006	20	PVC	318084	6748004	Survey	32.23	31.6	Survey	7.0	12	14
PZN02	Tiwest	2006	20	PVC	317880	6745961	Survey	35.07	34.5	Survey	10.2	29.5	31.5
PZN02S	Tiwest	2006	20	PVC	317882	6745957	Survey	35.17	34.6	Survey	10.4	12	14
PZN03S	Tiwest	2006	20	PVC	319519	6743904	Survey	30.34	29.7	Survey	7.1	16.4	18.4
PZN04	Tiwest	2006	20	PVC	319437	6749598	Survey	64.61	64.0	Survey	26.9	29.5	31.5
PZN05	Tiwest	2006	20	PVC	319600	6742650	Survey	46.38	45.8	Survey	18.9	26.5	28.5
PZN06	Tiwest	2006	20	PVC	320200	6741299	Survey	50.48	49.9	Survey	22.6		
PZN07	Tiwest	2006	20	PVC	320339	6747154	Survey	64.05	63.5	Survey	18.9	26.5	28.5
PZN08	Tiwest	2006	20	PVC	320859	6745426	Survey	68.44	67.8	Survey	27.4	29.5	31.5
PZN09	Tiwest	2006	20	PVC	322022	6745435	Survey	83.57	83.0	Survey	36.6	35.5	37.5
PZN10	Tiwest	2006	20	PVC	321747	6741397	Survey	66.63	66.0	Survey	31.5	31	33
PZS01	Tiwest	2006	20	PVC	314919	6736112	Survey	38.34	37.7	Survey	15.5	31	33
PZS01S	Tiwest	2006	20	PVC	314924	6736111	Survey	38.39	37.8	Survey	15.5	23	25
PZS03	Tiwest	2006	20	PVC	321194	6737264	Survey	55.24	54.6	Survey	25.2	43	45
PZS04	Tiwest	2006	20	PVC	323060	6734434	Survey	57.46	56.9	Survey	23.9		
PZS05	Tiwest	2006	20	PVC	321718	6739607	Survey	63.38	62.8	Survey	34.0	32.5	34.5
PZN11S	Tiwest	2008	20	PVC	317096	6750763	GPS	29.66	29.3	DEM	1.0	3.73	5.73
PZN12P	Tiwest	2008	20	PVC	317083	6749326	GPS	27.83	27.7	DEM	dry	0.25	1.25
PZN12S	Tiwest	2008	20	PVC	317083	6749326	GPS	27.98	27.7	DEM	3.5	6.8	8.8
PZN13P	Tiwest	2008	20	PVC	317055	6747732	GPS	27.45	27.1	DEM	5.0	4.33	5.33
PZN13S	Tiwest	2008	20	PVC	317055	6747732	GPS	27.39	27.1	DEM	5.0	8.88	10.88
PZN14S	Tiwest	2008	20	PVC	317020	6746137	GPS	28.71	28.5	DEM	7.0	9.9	11.9
PZN15S	Tiwest	2008	20	PVC	316988	6744454	GPS	27.62	27.3	DEM	5.5	9.78	11.78
PZS10S	Tiwest	2008	20	PVC	317522	6742112	GPS	30.53	30.3	DEM	7.3	9.87	11.87
PZS11S	Tiwest	2008	20	PVC	319325	6736286	GPS	36.19	35.7	DEM	11.0	13.72	15.72

Notes: MGA = Mapping Grid of Australia
AHD = Australian Height Datum
mbgl = metres below ground level
DoW = Department of Water

GPS = Global Positioning system
DEM = Digital Elevation Model



APPENDIX B

Bore Construction Details from Western Irrigation Pty Ltd

Bore Name Legend

Name on Western Irrigation Forms	Tiwest Bore Name
MB-S	DOB02
MB-D	DOB01
SPB-1	DPB01
YOB1	DOB03
YPB1	DPB02

DRILLING REPORT

Driller	W Westphal	Bore No	MB-S	Commenced	12/11/2007
Assistant	M Westphal	Rig:	Mayhew	Completed	13/11/2007
Drillers Licence	22	Property Owner	Tiwest		
Location:	North of Mt Adams Road, Dongara				

Depth of strata (metres)		Description of Strata	Details	
Surface To	3	Yellow sand	Diameter of Bore (mm)	100
3	6	Yellow and white clay	Static Water Level (m)	~11
6	12	Fine white sand and sandy clay	Pumping Level (m)	
12	22	White sandy clay	Supply (L/s)	
			Water Analysis:	
			pH	
			TDS (mg/L)	
			Total Iron (mg/L)	
			Screen length (m)	9
			Screen diameter (mm)	100
			Screen aperture (mm)	0.5
			Top of screen (m)	13
			Total Depth (m)	22
			Developing (Hours)	1
			Testing (Hours)	-

Remarks:

165mm diameter hole drilled, then cased with 100mm PVC casing (9m slotted interval from 13m to 22m).

Annulus gravel packed.

WD: 44287



WESTERN IRRIGATION PTY LTD ABN 58 065 952 230
 19 Shields Crescent Booragoon WA 6154
 Ph: (08) 9330 1144 Fax: (08) 9330 5630



DRILLING REPORT

Driller	W Westphal	Bore No	MB-D	Commenced	12/11/2007
Assistant	M Westphal	Rig:	Mayhew	Completed	12/11/2007
Drillers Licence	22	Property Owner	Tiwest		
Location:	North of Mt Adams Road, Dongara				

Depth of strata (metres)		Description of Strata	Details	
Surface To	3	Yellow sand	Diameter of Bore (mm)	100
3	5	Yellow and white clay	Static Water Level (m)	~11
5	18	White sand and sandy clay	Pumping Level (m)	
18	24	Orange sand with brown clay	Supply (L/s)	
24	35	Orange sand		
35	38+	Black clay	Water Analysis:	
			pH	
			TDS (mg/L)	
			Total Iron (mg/L)	
			Screen length (m)	12
			Screen diameter (mm)	100
			Screen aperture (mm)	0.5
			Top of screen (m)	23
			Total Depth (m)	35
			Developing (Hours)	1
			Testing (Hours)	-

Remarks:

165mm diameter hole drilled, then cased with 100mm PVC casing (12m slotted interval from 23m to 35m).

Annulus gravel packed, except for bentonite seal placed from 17m to 20m.

WD: 44287



WESTERN IRRIGATION PTY LTD ABN 58 065 952 230
 19 Shields Crescent Booragoon WA 6154
 Ph: (08) 9330 1144 Fax: (08) 9330 5630



DRILLING REPORT

Driller	W Westphal	Bore No	SPB-1	Commenced	13/11/2007
Assistant	M Westphal	Rig:	Mayhew	Completed	14/11/2007
Drillers Licence	22	Property Owner	Tiwest		
Location:	North of Mt Adams Road, Dongara				

Depth of strata (metres)		Description of Strata	Details	
Surface To	3	Yellow sand	Diameter of Bore (mm)	202
3	5	Yellow and white clay	Static Water Level (m)	10.91
5	18	White sand with some clay content	Pumping Level (m)	18.24
18	24	Orange sand with brown sandstone	Supply (L/s)	11
24	36	Orange / yellow sands - medium to coarse		
36	38+	Soft black clay	Water Analysis:	
			pH	
			TDS (mg/L)	
			Total Iron (mg/L)	
			Screen length (m)	15
			Screen diameter (mm)	203
			Screen aperture (mm)	0.6
			Top of screen (m)	21
			Total Depth (m)	36
			Developing (Hours)	6.5
			Testing (Hours)	50

Remarks:

165mm diameter hole drilled, then reamed and cased with 200mm PN12 PVC casing and 15m inline stainless steel screen.

Annulus gravel packed, bore developed by airlifting and jetting. Step and constant rate testing undertaken 19 - 22/11/2007.

WD: 44287



WESTERN IRRIGATION PTY LTD ABN 58 065 952 230
 19 Shields Crescent Booragoon WA 6154
 Ph: (08) 9330 1144 Fax: (08) 9330 5630



DRILLING REPORT

Driller	S. Chitty	Bore No	YOB1	Commenced	08/02/2008
Assistant	T. Donaldson	Rig:	Rotary	Completed	15/02/2008
Drillers Licence	39	Property Owner	Tiwest		
Location:	Tiwest Dongara				

Depth of strata (metres)		Description of Strata	Details	
Surface To	8	Clayee yellow sand	Diameter of Bore (mm)	100
8	32	Clay white yellow and orange some sandy	Static Water Level (m)	33.47
32	59	Sandy clays	Pumping Level (m)	
59	64	Medium to coarse clayee sand	Supply (L/s)	
64	78	Grey clay		
78	82	Medium clayee sand	Water Analysis:	
82	95	Clay layers and sandy clay	pH	
95	116	Coarse quartz sands well rounded minor clay	TDS (mg/L)	
116	133	Shale black some sandy	Total Iron (mg/L)	
133	229	Shale layers with fine silty sand aquifers some		
		medium sand in interbedded layers	Screen length (m)	17
			Screen diameter (mm)	100
			Screen aperture (mm)	0.5
			Top of slotted section (m)	99
			Total Depth (m)	116
			Developing (Hours)	10
			Testing (Hours)	-

Remarks:

Drilled 165mm pilot hole to 229m. Backfilled pilot hole to 120m with gravel, and bentonite seal 119-120m.

Reamed pilot hole 225mm to 116m. Installed 100mm PN12 PVC casing to 99m, and 100mm PN18 PVC casing (slotted 0.5mm) from 99m to 116m. Annulus gravel packed with 3 tonne graded sand to 85m, then cemented to surface with low heat cement.

WD: 44287



WESTERN IRRIGATION PTY LTD ABN 68 055 952 230

19 Shields Crescent Booragoon WA 6154

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G:\Clients\tiwest\WD44287 dongara drilling\ Copy of Drilling Report YOB1 Rev 1 YOB1



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WESTERN IRRIGATION

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DRILLING REPORT

Driller	S. Chitty	Bore No	YPB1	Commenced	15/02/2008
Assistant	T. Donaldson	Rig:	Rotary	Completed	07/03/2008
Drillers Licence	39	Property Owner	Tiwest		
Location:	Tiwest Dongara				

Depth of strata (metres)		Description of Strata	Details	
Surface To	8	Clayee yellow sand	Diameter of Bore (mm)	200
8	25	Sandy white clay	Static Water Level (m)	32.86
25	46	Clays and sandy clay layers	Pumping Level (m)	47.22
46	54	Clayee sands layered	Supply (L/s)	20
54	78	Clay layers interbedded with medium-coarse sand		
78	99	Grey clay layers some sandy	Water Analysis:	
99	119	Coarse quartz sand well rounded	pH	
119	151	Interbedded shale and fine silty sand.	TDS (mg/L)	
			Total Iron (mg/L)	
			Screen length (m)	15
			Screen diameter (mm)	200
			Screen aperture (mm)	0.75
			Top of screen (m)	102.5
			Total Depth (m)	117.5
			Developing (Hours)	10
			Testing (Hours)	43

Remarks:

Drilled 165mm pilot hole to 151m. Logged hole. Backfilled pilot hole to 118m with drill cuttings. Reamed pilot hole to 118m.

Installed 200mm PN12 PVC casing with 15m of 8 5/8" API stainless steel screen (0.75mm aperture) from 102.5m to 117.5m.

Annulus gravel packed to 87m with 3 tonne gravel, then cement grouted to surface using low heat cement grout.

WD: 44287



WESTERN IRRIGATION PTY LTD ABN 68 056 952 230

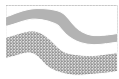
19 Shields Crescent Booragoon WA 6154

Ph: (08) 9330 1144 Fax: (08) 9330 5630

G:\Clients\tiwest\WD44287 dongara drilling\ Drilling Report YPB1 YPB1

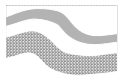


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APPENDIX C

Photographs of Cuttings Samples from the Pilot Hole of DOB03
14th February 2008



Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara, Western Australia

0 - 15 m

15 - 30 m

30 - 45 m

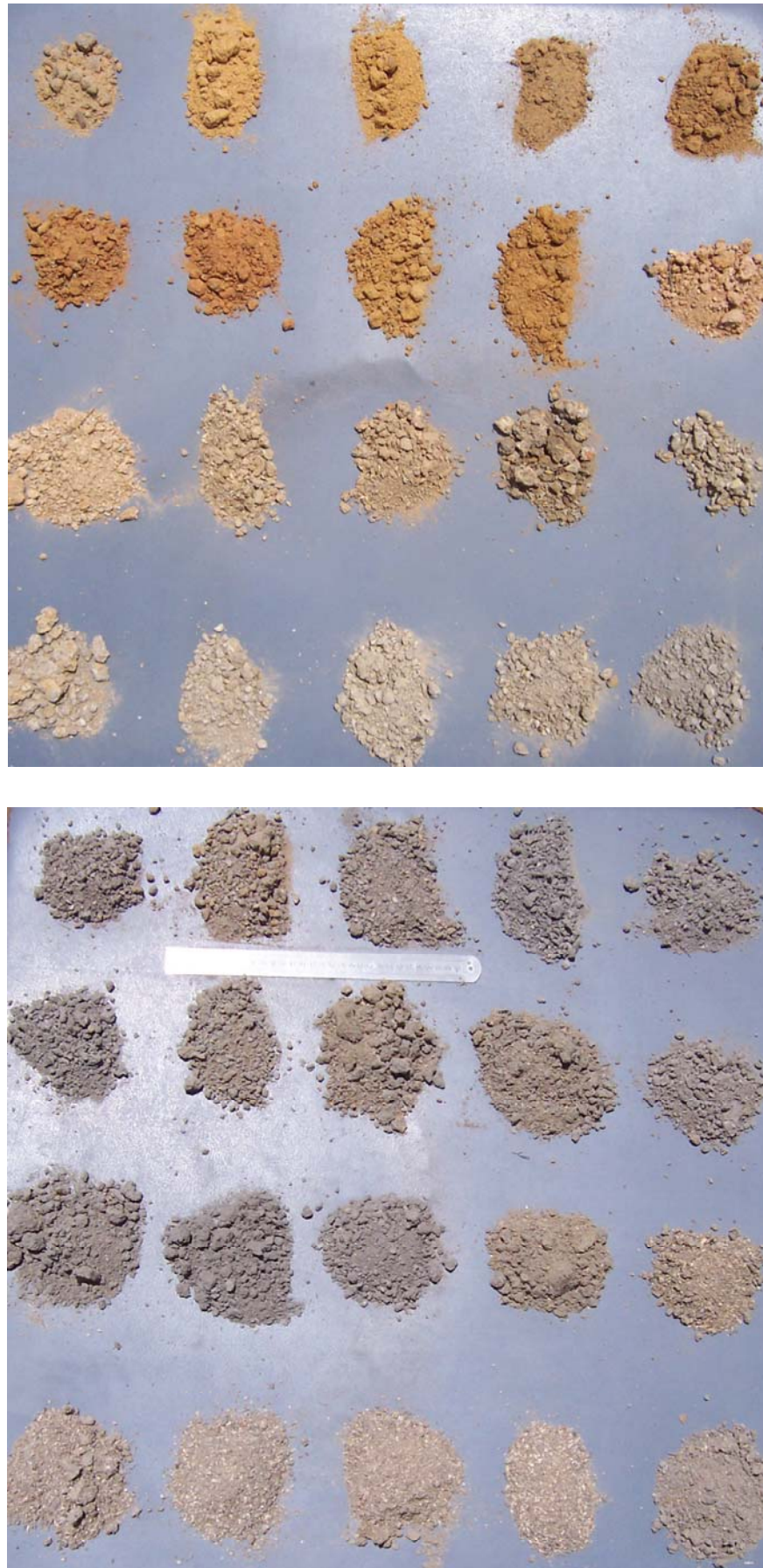
45 - 60 m

60 - 75 m

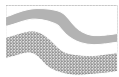
75 - 90 m

90 - 105 m

105 - 120 m



MUD STREAM CUTTINGS 0-120M FROM PILOT HOLE OF BORE DOB03, 14/2/2008
(Each sample represents 3 metres of drilling, samples deepen to right along row)



*Hydrogeological Appraisal of the Proposed Titanium Minerals Project near
Dongara, Western Australia*

120 - 135 m

135 - 150 m

150 - 165 m

165 - 180 m

180 - 195 m

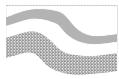
195 - 210 m

210 - 225 m

225 - 228 m



MUD STREAM CUTTINGS 120-228M FROM PILOT HOLE OF BORE DOB03, 14/2/2008
(Each sample represents 3 metres of drilling, samples deepen to right along row)



102 - 105 m



108 - 111 m



114 - 117 m



MUD STREAM CUTTINGS FROM PRODUCTION AQUIFER ZONE OF BORE DOB03, 14/2/2008



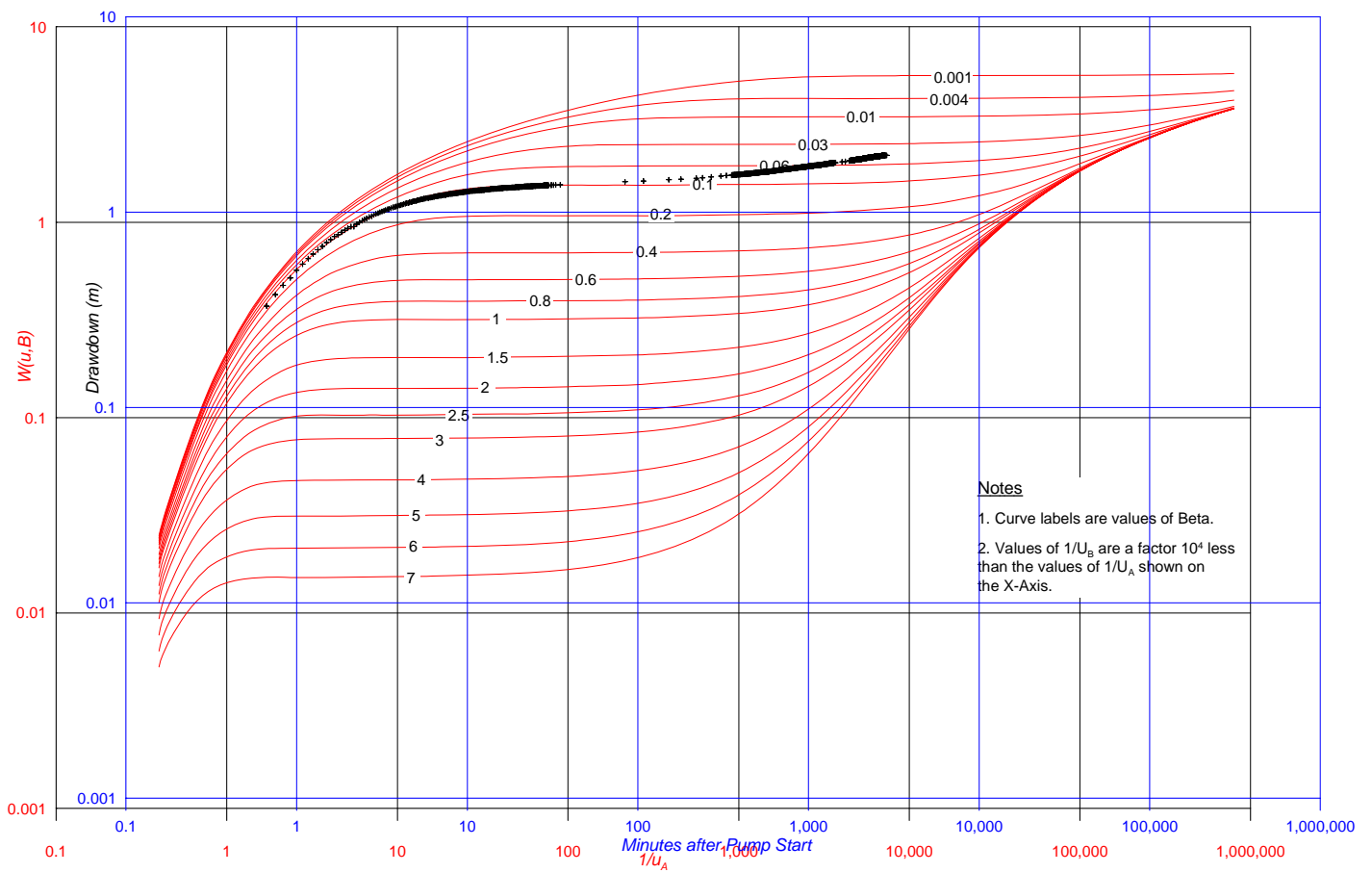
APPENDIX D

Neuman Curve Matches to Drawdown in DOB01

During 48-hour pumping at 11 L/sec (950 kL/d) from DPB01 20th-22nd November 2007



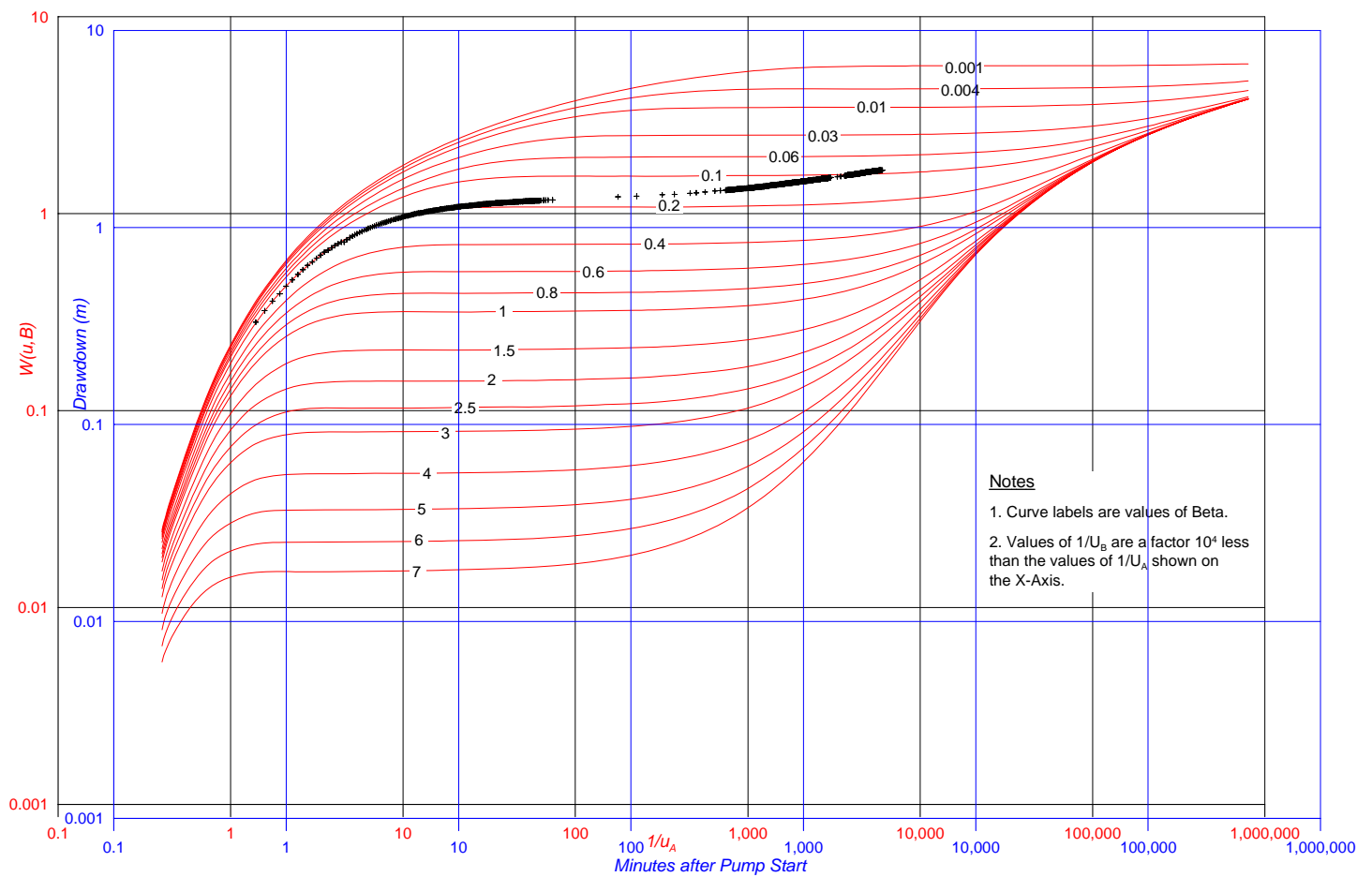
Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara, Western Australia



Match of early data against Neuman curve for Beta = 0.1



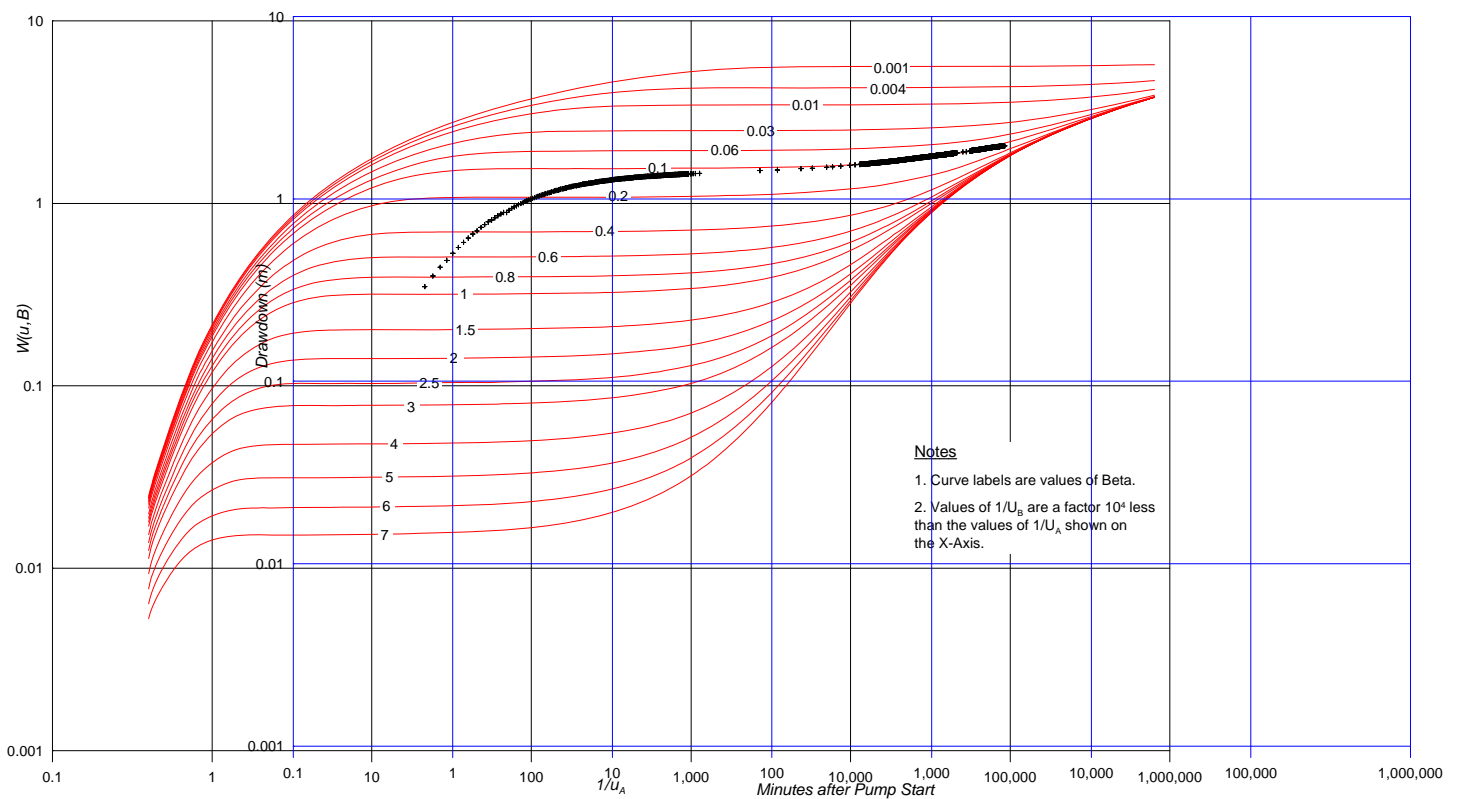
*Hydrogeological Appraisal of the Proposed Titanium Minerals Project near
Dongara, Western Australia*



Match of early data against Neuman curve for Beta = 0.2



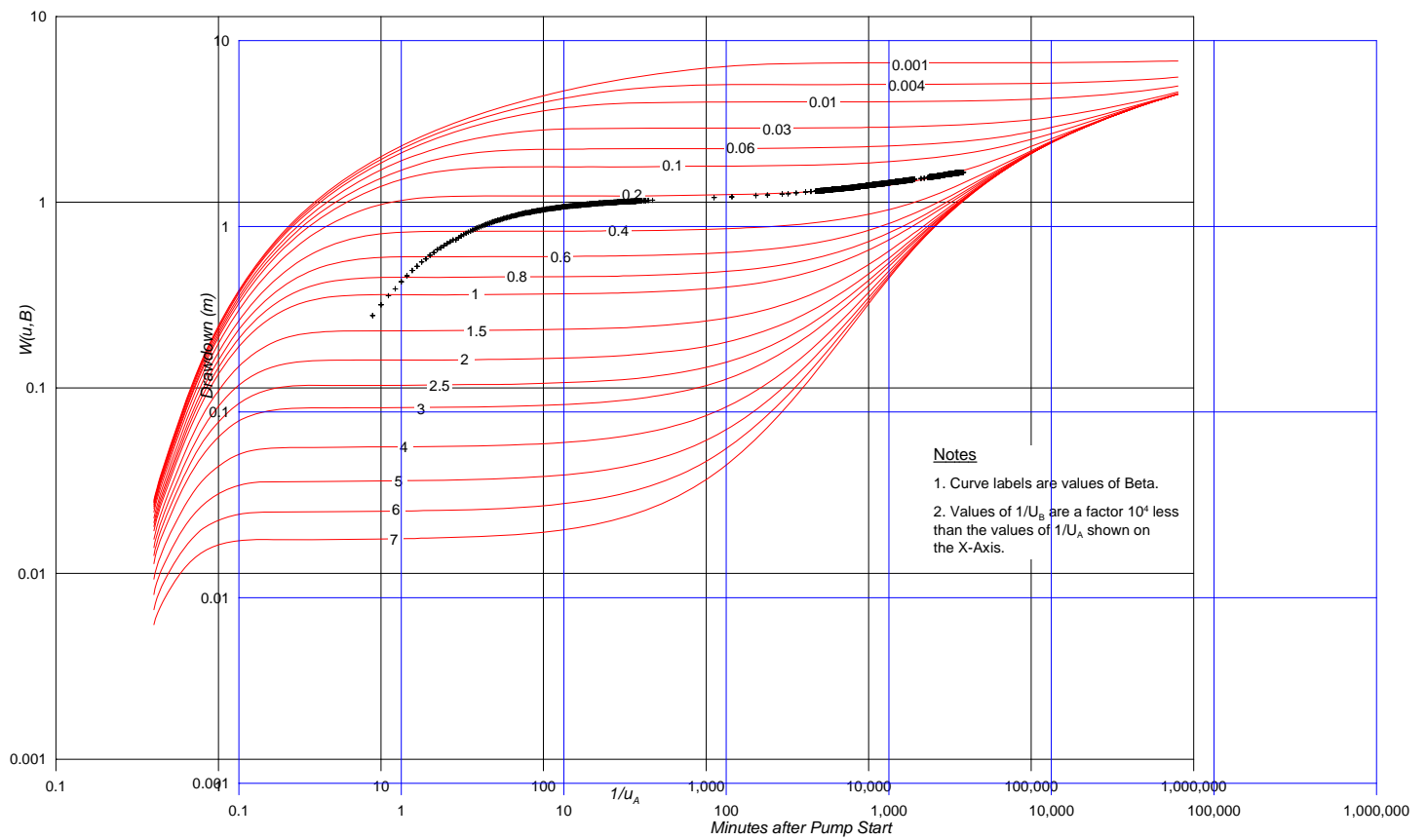
Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara, Western Australia



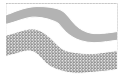
Match of late data against Neuman curve for Beta = 0.1



Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara, Western Australia



Match of late data against Neuman curve for Beta = 0.2



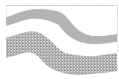
APPENDIX E

Major Component Analyses

Taken from Gerritse (April 2008).

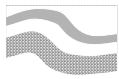
Abbreviations:

Date	= Date of sampling
RL	= ground level in metres AHD
Top slot	= top of screen in metres below ground level
Bottom slot	= bottom of screen in metres below ground level
Sample depth	= approximate depth of sampling in metres below ground level
pH	= pH measured in laboratory
PCO ₂	= partial pressure (in Pa) of CO ₂ , as calculated from the composition of groundwater
EN	= 'Electro Neutrality' balance
SI	= 'Solubility Index' (ratio of logarithms of the ion activity and solubility products: SI=0 indicates equilibrium, SI<0 indicates undersaturation and SI>0 supersaturation)



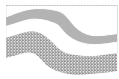
*Hydrogeological Appraisal of the Proposed Titanium Minerals Project near
Dongara, Western Australia*

Bore/ Piezo		DOB01	DPB01	DPB01	DPB02	PZN01	PZN01S	PZN02	PZN02S
Date		13/11/07	13/11/07	23/11/07	14/03/08	23/11/07	23/11/07	23/11/07	23/11/07
Top slot	m	23	21	21	102.5	26.5	12	29.5	12
Bottom slot	m	35	36	36	117.5	28.5	14	31.5	14
Sample depth	m	17.5	28.5	28.5	110	27.5	13	30.5	13
Sample method		Airlift	Airlift	Electric Submers.	Electric Submers.	Waterra hand pump	Waterra hand pump	Waterra hand pump	Waterra hand pump
pH		7.8	7.5	6.6	6.5	6.4	6.2	6.5	6.3
EC	mS/m	133	110	106	135	114	130	90	136
TDS	mg/L	850	620	610	730	630	740	500	780
Alkalinity	mg/L	46	35	35	49	59	40	65	37
Na	mg/L	218	180	180	230	210	230	170	230
K	mg/L	8	10	9	11	10	9	8	8
Ca	mg/L	5	3	2.2	3.3	2.0	3.0	2.0	4.0
Mg	mg/L	16	14	13	15	11	17	7	23
Cl	mg/L	351	295	280	360	280	350	220	370
SO ₄	mg/L	14.3	9.8	9.6	40.5	48	32	28	38
SiO ₂	mg/L	33	25	56	59	-	-	-	-
F	mg/L	0.2	0.2	0.2	0.2	-	-	-	-
N-NO ₃	mg/L	0.34	0.18	0.2	0.06	<0.2	<0.2	<0.2	<0.2
N-NO ₂	mg/L	-	-	-	0.00	-	-	-	-
N-NH ₄	mg/L	-	-	-	<0.01	-	-	-	-
P-PO ₄	mg/L	0.006	0.01	<0.005	<0.005	-	-	-	-
TOC	mg/L	11	<1	<1	<1	-	-	-	-
Al	mg/L	9.3	0.09	<0.005	0.015	-	-	-	-
Fe	mg/L	1.3	0.04	0.04	<0.05	<0.1	<0.1	<0.1	<0.1
Mn	mg/L	0.01	0.03	0.002	<0.05	-	-	-	-
P _{CO2}	Pa	80	120	950	1700	2500	2700	2200	2000
EN	%	0.6	0.9	2.5	-1.2	1.6	1.9	1.2	1.4
SI	Calcite	-1.34	-1.96	-3	-2.8	-3	-3.2	-2.9	-3.04
SI	Magnesite	-1.14	-1.59	-2.52	-2.5	-2.6	-2.8	-2.6	-2.6



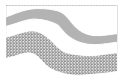
*Hydrogeological Appraisal of the Proposed Titanium Minerals Project near
Dongara, Western Australia*

Bore/ Piezo		PZN03S	PZN05	PZN07	PZS01	PZS01S	LS29A
Date		23/11/07	23/11/07	23/11/07	23/11/07	23/11/07	30/11/07
Top slot	m	16.4	26.5	26.5	31	23	75
Bottom slot	m	18.4	28.5	28.5	33	25	81
Sample depth	m	17.4	27.5	27.5	32	24	78
Sample Method		Waterra hand pump	Waterra hand pump	Waterra hand pump	Waterra hand pump	Waterra hand pump	Bladder Pump
pH		6.8	6.4	6.3	6.9	6.7	7.0
EC	mS/m	145	151	79	154	158	152
TDS	mg/L	510	860	440	830	870	810
Alkalinity	mg/L	100	45	46	99	87	55
Na	mg/L	260	270	140	250	270	250
K	mg/L	12	12	7	25	26	11
Ca	mg/L	5.0	4.0	2.0	10.0	9.0	5.0
Mg	mg/L	23	24	7	26	28	20
Cl	mg/L	400	430	200	370	400	420
SO ₄	mg/L	<5	44	22	63	73	50
SiO ₂	mg/L	-	-	-	-	-	56
F	mg/L	-	-	-	-	-	-
N-NO ₃	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	0.5
N-NO ₂	mg/L	-	-	-	-	-	-
N-NH ₄	mg/L	-	-	-	-	-	-
P-PO ₄	mg/L	-	-	-	-	-	-
TOC	mg/L	-	-	-	-	-	-
Al	mg/L	-	-	-	-	-	<0.005
Fe	mg/L	0.2	<0.1	<0.1	0.2	<0.1	<0.1
Mn	mg/L	-	-	-	-	-	0.2
P _{CO2}	Pa	1900	1900	2500	1300	1800	580
EN	%	1.5	1	-0.5	1.5	2.1	-3.5
SI	Calcite	-2.02	-2.88	-3.2	-1.65	-1.96	-2.09
SI	Magnesite	-1.66	-2.4	-2.95	-1.53	-1.77	-1.79



Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara, Western Australia

Bore/ Piezo		LS31B	LS31C	LS32A	LS32B
Date		30/11/07	30/11/07	30/11/07	30/11/07
Top slot	m	94	15	87.5	27
Bottom slot	m	100	21	93.5	33
Sample depth	m	97	18	90.5	30
Sample Method		Bladder Pump	Bladder Pump	Bladder Pump	Bladder Pump
pH		6.8	7.2	7.0	7.0
EC	mS/m	158	237	99	99
TDS	mg/L	810	1380	510	500
Alkalinity	mg/L	80	130	120	70
Na	mg/L	240	350	170	160
K	mg/L	24	16	10	9
Ca	mg/L	5.0	27.0	4.0	4.0
Mg	mg/L	24	44	11	11
Cl	mg/L	410	610	250	230
SO ₄	mg/L	89	160	14	13
SiO ₂	mg/L	17	66	43	46
F	mg/L	-	-	-	-
N-NO ₃	mg/L	<0.2	<0.2	0.7	0.5
N-NO ₂	mg/L	-	-	-	-
N-NH ₄	mg/L	-	-	-	-
P-PO ₄	mg/L	-	-	-	-
TOC	mg/L	-	-	-	-
Al	mg/L	<0.005	<0.005	<0.005	<0.005
Fe	mg/L	2.3	0.6	<0.1	<0.1
Mn	mg/L	0.3	0.3	0.6	0.6
P _{CO2}	Pa	1300	830	1290	760
EN	%	-6.2	-5.9	-5.35	0.8
SI	Calcite	-2.15	-0.87	-1.8	-2.02
SI	Magnesite	-1.77	-0.96	-1.67	-1.89

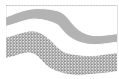


APPENDIX F

Trace Metal Analyses November 2007

Taken from Gerritse (April 2008).

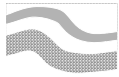
Abbreviations as for Appendix E



*Hydrogeological Appraisal of the Proposed Titanium Minerals Project near
Dongara, Western Australia*

Bore/ Piezo		DOB01	DPB01	DPB01	DPB02	PZN02S	PZN03S	PZN05	PZN07
Date		13/11/07	13/11/07	23/11/07	14/3/08	23/11/07	23/11/07	23/11/07	23/11/07
Sample depth	m	17.5	28.5	28.5	110	13	17.4	27.5	27.5
pH		7.8	7.5	6.6	6.5	6.3	6.8	6.4	6.3
EC	mS/m	133	110	106	135	136	145	151	79
As	mg/L	<0.001	<0.001	<0.001	<0.001	-	-	-	-
B	mg/L	0.1	0.1	0.1	0.1	-	-	-	-
Cd	mg/L	<0.0001	<0.0001	0.0001	<0.0001	-	-	-	-
Cr	mg/L	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Co	mg/L	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Cu	mg/L	<0.001	<0.001	0.01	0.012	<0.005	<0.005	<0.005	<0.005
Pb	mg/L	<0.002	<0.001	0.002	0.001	<0.01	<0.01	<0.01	<0.01
Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	-	-	-	-
Mo	mg/L	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Ni	mg/L	<0.001	<0.001	0.005	0.005	-	-	-	-
Se	mg/L	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Th	mg/L	<0.003	<0.001	<0.001	<0.001	-	-	-	-
U	mg/L	<0.001	<0.001	<0.001	<0.001	-	-	-	-
V	mg/L	<0.013	<0.001	<0.001	<0.001	-	-	-	-
Zn	mg/L	0.004	0.004	0.06	0.2	-	-	-	-

Bore/ Piezo		PZS01	PZS01S	LS29A	LS31B	LS31C	LS32A	LS32B
Date		23/11/07	23/11/07	30/11/07	30/11/07	30/11/07	30/11/07	30/11/07
Sample depth	m	32	24	78	97	18	90.5	30
pH		6.9	6.7	7.0	6.8	7.2	7.0	7.0
EC	mS/m	154	158	152	158	237	99	99
As	mg/L	-	-	<0.005	<0.005	<0.005	<0.005	<0.005
B	mg/L	-	-	0.05	<0.01	0.1	0.03	0.03
Cd	mg/L	-	-	<0.002	<0.002	<0.002	<0.002	<0.002
Cr	mg/L	-	-	<0.005	<0.005	<0.005	<0.005	<0.005
Co	mg/L	-	-	<0.005	<0.005	<0.005	<0.005	<0.005
Cu	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Pb	mg/L	<0.01	<0.01	<0.01	<0.01	0.08	<0.01	<0.01
Hg	mg/L	-	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mo	mg/L	-	-	<0.005	<0.005	<0.005	<0.005	<0.005
Ni	mg/L	-	-	0.006	<0.005	<0.005	0.007	0.008
Se	mg/L	-	-	<0.005	<0.005	<0.005	<0.005	<0.005
Th	mg/L	-	-	<0.001	<0.001	<0.001	<0.001	<0.001
U	mg/L	-	-	<0.001	<0.001	<0.001	<0.001	<0.001
V	mg/L	-	-	<0.005	<0.005	<0.005	<0.005	<0.005
Zn	mg/L	-	-	0.4	0.01	0.1	0.5	0.5



APPENDIX G

Stratigraphy, Bore construction and Chemistry data on the
Department of Water template 'WIN_Site_Details-V3_5.xlt'

APPENDIX G1.	Tiwest Dongara Superficial Exploration 2007
APPENDIX G2.	Tiwest Dongara Yarragadee Exploration 2008
APPENDIX G3.	Tiwest Dongara Piezometers 2008

These files are too large to print and are provided only digitally in the Excel
format on a CD.