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REPORT on

ENSHAM CENTRAL PROJECT - EIA

GROUNDWATER IMPACT ASSESSMENT

prepared for
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EXECUTIVE SUMMARY

Ensham Resources propose to extend their existing open cut coal mine operations across the Nogoa River floodplain. The extension known as Ensham Central, will involve open cut mining and development of a new longwall mining down-dip, where open cut mining becomes uneconomical. Mining will occur on both sides of the Nogoa River with a buffer zone of 100m either side of the river for the open cut mine, and a “subsidence protection zone” 100m either side of the river for longwall mining.

A review of existing data and reports indicated that the hydrogeological regime of the Ensham Central area and surrounds consists of:

- a Quaternary alluvial aquifer system associated with the Nogoa River floodplain; and
- an underlying Permian coal seam aquifers.

The Nogoa River floodplain consists of an alluvial sequence of black soils and an upper silty clay layer about 10m thick, with an underlying sand and gravel layer extending to a depth of up to 25m. The alluvium unconformably overlies the Permian coal measures. A preliminary groundwater assessment for the project identified a number of potential impacts or risks associated with mining across and beneath the floodplain, viz:

- groundwater inflow to the open cut mines from the alluvium and impact on the alluvial aquifer;
- the degree to which the river will provide a constant source of recharge to the alluvium and hence the impact that inflow to the open cuts will have on river flow;
- the impact of goafing and whether the goaf will provide hydraulic connectivity between the longwall mine and the base of the alluvium and impact the alluvial aquifers;
- the potential for goaf induced subsidence to capture river flow;
- the impact of spoil leachate on groundwater quality;
- the potential for poor quality groundwater from the spoil backfilled pits to discharge into the Nogoa River.

The major concern was the degree of hydraulic connectivity between the river and alluvium as this had major implications with respect to inflow from the alluvium to the pits and potentially to the longwall mine; and hence leakage from the river and impact on river flow. A study by the Department of Primary Industries in 1993 involving construction of a line of monitoring bores across the floodplain in the centre of the mine lease, indicated that there was no connection between the river and alluvium. However further investigations were undertaken as part of the current study to confirm this finding. The investigation involved drilling monitoring bores to the base of the alluvium on either side of the river and monitoring groundwater levels and groundwater quality. The sediments forming the base and sides of the river were also investigated. The study found that the groundwater level in the alluvium is 1-6m lower than the river water level and 10 to 100 times more saline (the water types of the river and alluvium are different), and that the base and sides of the river consist of essentially impermeable clays and clay bound sand and gravel. It was proved conclusively that there is no connection between the alluvial sand and gravels and the river, and that groundwater occurrence in the alluvium is “patchy”, with thin saturated zones of poor quality water in deeper sections. The primary recharge mechanism for the alluvium is considered to be upward leakage of poor quality water from the coal seams.

Whereas the spoil piles will be shaped and revegetated, the floodplain will be re-instated to pre-mining ground levels. A waste rock characterization study was undertaken by URS to address the risk of discharge to the Nogoa River of poor quality water from a “spoil aquifer” that would develop in the backfilled open cut voids. The study found that the overburden rock that would form the spoil is relatively benign and will generate slightly alkaline and fresh (non-saline) runoff and seepage following surface exposure.

It is proposed to minimise infiltration through a re-instated floodplain by compacting the upper 10m of spoil to a permeability of 10^{-5}–10^{-6} m/sec or by using an alternative surface treatment which provides a similar low permeability seal. An assessment of the rate at which water from rainfall or flooding events infiltrates the spoil and creates a “spoil aquifer” was requested by the Environmental Protection Agency. A 2D model using SEEP/W software was developed to simulate a Q100 flood event lasting for 5 days, in order to assess the rate of infiltration for a worst case event through the re-instated floodplain. A maximum head (depth) of flooding of 6.7m was applied to the model. Predictive simulations indicated that water infiltrating the compacted spoil was minimal, about 8.2L/sec per hectare and was taken up in unsaturated storage in the spoil within the upper 6m, that is, seepage did not infiltrate to the base of the spoil where it would contribute to aquifer development.

An assessment of the potential impact of goafing and mine subsidence on the alluvial aquifer and river from longwall mining was undertaken based on subsidence predictions, and the thickness of cover (overburden) between the coal seam and base of alluvium. It was found by Seedman Geotechnics that longwall cracking would extend from the seam to the surface/aquifer for thicknesses of Permian overburden of less than 105m. The cover thickness exceeds 105m above panels S1 to S13, but is less than 105m thick in the outbye half of S15 and a very small amount of S14. Vertical cracking therefore may intersect the base of the alluvium above panels S14 and S15, however there will be minimal impact as the alluvium has a thin saturated thickness and much of the groundwater from the saturated sections will have drained into the open cut pits. A “subsidence protection zone” along the river will prevent longwall mining impacting the river.

Numerical modelling using a three dimensional flow model, MODFLOW, was undertaken to assess the impact of open cut mining across and beneath the alluvial plain on the groundwater regime, and in particular to assess the rate of inflow to the mine and rate of recovery of groundwater levels and development of a “spoil aquifer” post mining. The conceptual model of the groundwater regime that was developed through the course of the study was used to define the extent of the model and to assign hydraulic parameters and boundary conditions. The model was calibrated to known groundwater levels and to inflow to the existing pits of the current mining operation.

Transient modelling was undertaken based on the historical and proposed mine plans. Predictive modelling showed that groundwater inflows to the open cut pits and underground mine from the Permian aquifers are relatively low. Typical maximum inflows to the different pits are:

- 10L/s to A and B Pits;
- 17L/s to C and D Pits;
- 1L/S to the Yongala Mine; and
- 27L/s to the longwall mine.

Inflow to the open cut pits decreases as the longwall mine is developed, with the longwall capturing flow that would have discharged to the pits. Given that groundwater occurrence in the alluvium is “patchy” and is only of thin saturated thickness, the alluvium contributes little of the inflow to the pits or underground.

Modelling indicates that due to the confined nature of the coal seams, the radius of influence of dewatering of the coal seams by mining, as indicated by the 1m drawdown contour, is between 9-15km of the mine. There is virtually no influence on groundwater in the alluvium, other than where the alluvium is removed by mining, due to the nature of the groundwater regime of the alluvium, as described.

Predictive modelling of groundwater recovery in the underground mine and spoil backfilled voids indicates that the final voids that will remain on completion of mining will act as sinks to groundwater flow. Modelling was undertaken using conservatively high recharge values of 10% and 15% of rainfall to the spoil piles. The results showed that water levels in the voids will reach equilibrium about 200 years after completion of mining, and will stabilise at between RL 124m and RL 142m, that is generally below the invert level of the Nogoa River. Development of a “spoil aquifer” and equilibrium water table level however will be reduced by on-going rehabilitation of the spoil. Reclamation and revegetation will promote surface runoff and evapo-transpiration, minimizing infiltration into the backfilled spoil.

Spoil geochemical characterization has shown the waste rock to be relatively benign and therefore leachate produced from water infiltrating the spoil should be of higher quality than the existing groundwater in the alluvium which is brackish to saline. The salinity of the final void water will however increase over time due to evaporation, as the voids will remain as sinks to groundwater flow. However as the final voids will always be sinks there is no risk of the voids overtopping and discharging poorer quality water into the Nogoa River.

The saturated thickness of the spoil will range from about 14m at the up-dip end of the mine to about 147m where open pit mining ceased. The goaf in the longwall mine will similarly be saturated. The “spoil aquifer” will contain an estimated 335,000ML of groundwater that will accumulate over a period of 200 years from a combination of coal seam discharge and primarily rainfall infiltration.

In summary, the hydrogeological impact assessment of the proposed Ensham Central Mine has shown:

- that there is no connection between the Nogoa River and the coarse sands and gravels of the associated floodplain;
- the alluvial floodplain constitutes a poor aquifer in that groundwater occurrence is patchy and where it does occur, there is a thin saturated thickness of less than 3m. The quality of the alluvial groundwater is also poor and ranges from brackish to saline;
- the base and sides of the Nogoa River consist of clay and clay bound sand and gravel which form an effective seal;
- re-instating the river floodplain with an upper 10m compacted spoil layer will essentially prevent infiltration of water during flooding events as well as rainfall infiltration; minimising the rate of development of a “spoil” aquifer;
- vertical cracking from the seam to the base of the alluvium as a result of goafing and subsidence during longwall mining will occur where there is less than 105m of cover, that is, above panels S14 and S15. The alluvium however contains little water and the impact on inflow to the mine will be minimal;

- a “subsidence protection zone” will prevent longwall mining impacting the Nogoa River;
- predicted groundwater inflows to the mine pits will range between 3 – 17L/s and to the longwall mine the maximum inflow will be about 27L/s, and as such the pits and longwall mine will be dewatered by strategically located sump pumps. Inflow control strategies such as advance dewatering bores will not be required;
- the radius of influence of the mine on groundwater levels will be between 9-15km but will not impact other groundwater users of either the coal seam or alluvial aquifers apart from potentially one bore;
- groundwater recovery post mining will be very slow relying on inflow from the coal seams and from rainfall recharge of the spoil heaps. Analytical analysis indicates that it will take in excess of 200 years for equilibrium groundwater levels to establish;
- analysis of the waste rock (spoil) has shown it to be benign and any leachate produced in the “spoil aquifer” should be of reasonable quality and better than the existing alluvium groundwater quality;
- the final voids will act as sinks to groundwater flow with worst case equilibrium water levels in the voids ranging from RL 124m to RL 142m, that is, about at or below the Nogoa River level. There is therefore little risk of a shallow water table “spoil aquifer” developing that discharges large volumes of ”spoil aquifer” quality water into the river.

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1.0 INTRODUCTION

Ensham Resources Pty Ltd (Ensham Resources) operates an open cut coal mine in Central Queensland producing up to 12Mtpa of thermal coal, using dragline and truck and shovel mining. Ensham Resources is proposing to expand the existing operations and increase production by mining the underground and open cut resources within the Nogoa River alluvial floodplain. The mine expansion is known as the Ensham Central Project.

A preliminary hydrogeological assessment of the proposed Ensham Central Project was undertaken in 2004 to provide an understanding of the groundwater regime of the area, and to identify potential risks and constraints with respect to groundwater inflow and dewatering that need to be considered in mine planning and infrastructure design. The preliminary hydrogeological assessment which forms part of the impact assessment described in this report identified a number of potential impacts, risks and constraints that would need to be addressed, viz:

- groundwater inflow to the open cut mines from the alluvium and impact on the alluvial aquifer;
- the degree to which the river will provide a constant source of recharge to the alluvium and hence the impact that inflow to the open cuts will have on river flow;
- the impact of goafing and whether the goaf will provide hydraulic connectivity between the longwall mine and the base of the alluvium and impact the alluvial aquifers;
- the potential for goaf induced subsidence to capture river flow;
- the impact of spoil leachate on groundwater quality;
- the potential for poor quality groundwater from the spoil backfilled pits to discharge into the Nogoa River.

This report describes the work undertaken to define the hydrogeological regime of the lease and surrounding area. A groundwater impact assessment involving predictive numerical modelling was then undertaken to address the potential risks and constraints that were identified and if necessary to assess mitigation and/or containment strategies. A groundwater monitoring program was then developed to identify the impact of mining, water storage and spoil management on groundwater quality and quantity. This report was prepared by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) at the request of Hansen Consulting (HC) on behalf of their client Ensham Resources.

2.0 LOCATION AND TOPOGRAPHIC SETTING

The Ensham Coal Mine is located about 40km east, north-east of Emerald in Central Queensland and consists of open cut pits A and D and the Yongala open cut pit, (**Drawing No. 1**).

The main drainage of the area is via the Nogoa River which flows in an east and south-easterly direction through the mine lease and joins the Mackenzie River near the town of Comet. The river is used for irrigation and stock water supply, and is kept flowing by releases from the Fairbairn Dam at Emerald. The Nogoa River forms a large floodplain in the area of the mine, and with an anabranch has created an elongated island to the west of the existing C and D Pits (**Drawing No 1**). The anabranch is reported to be dry except during high flow events.

The river flood plain is a relatively flat, broad alluvial tract about 4-5km wide with an elevation in the range 150-154mAHD. Basement rocks subcrop in the northern part of the proposed mine area to the north-west of C and D Pits, where the topography rises to a maximum elevation of about 242mAHD, and as a hill between C and D Pits and the anabranch, known as Red Hill.

The river dissects the current mining operations with the C and D Pits located to the north of the river and the B and A Pits to the south, as shown on **Drawing No 1**. The Yongala Mine is about 10km along strike to the north of C and D Pits.

Boggy Creek a tributary of the Nogoa River flows southwards, parallel to, and about 200m to the east of the boxcut for C and D Pits, (**Drawing No 1**). The catchment of Boggy Creek is relatively small at 118km^2, and water flows are intermittent and are limited to brief periods after heavy sustained rain (Ensham Resources Pty Ltd, January 1994)[1]. It discharges into the Nogoa River just downstream of the C and D mine pits. Winton Creek, another tributary, is located to the south of the Nogoa River and joins the river just upstream of B Pit, as shown on **Drawing No 1**. Duck Ponds Lagoon, a prominent drainage feature, is filled from overflow of Winton Creek.

The Department of Natural Resources, Mines and Water (NRMW) maintains a river gauging station, Station No. 130219A – “Nogoa River at Duck Ponds” which is located within the lease area, (**Drawing No 1**).

Within the Ensham mine area, the land has been cleared and is used primarily for cultivation of crops in the areas adjacent to the Nogoa River and for cattle grazing in the remainder. Part of the island formed by the river and its anabranch is used for the production of irrigated cotton, cereal crops and legumes. The crops are flood irrigated from irrigation channels constructed across the floodplain.

3.0 CLIMATE

Climatic data from the meteorological stations closest to the project area were obtained from the Australian Bureau of Meteorology. A summary of the rainfall and evaporation data is shown in Table 1.

Table 1 indicates that the annual average rainfall is about 555mm and that the annual average evaporation of 2063mm is almost 4 times the rainfall. The majority of the rainfall occurs between October and March and pan evaporation exceeds rainfall in all months. The evaporation from open

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[1] Ensham Resources Pty Ltd, (Jan. 1994), *“Environmental Management Overview Strategy”,* July 1993.

water bodies, such as final mine voids, was estimated by using a pan evaporation correction factor for each month. The correction factor was provided by NRMW.

Table 1: CLIMATIC DATA

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Rainfall (mm)	86.6	71.8	62.5	38.4	20.6	10.5	8.3	36.4	40.2	55.1	62.8	62.9	555.9
Mean Pan Evaporation (mm)	235.6	187.6	201.5	153.0	111.6	90.0	99.2	127.1	171.0	210.8	222.0	254.2	2063.6
Open Water Body Evaporation (mm)	188.5	163.2	151.1	99.5	62.5	43.2	44.6	69.9	111.2	149.7	166.5	211.0	1460.8

Notes: i) Rainfall data from Emerald Airport BoM Station No. 05264
ii) Evaporation data from Clermont Post Office BoM Station No. 035019
iii) Pan evaporation correction factors for open water body estimated by NRMW[2] for Theodore.

4.0 METHODOLOGY

The methodology adopted for the study was to:

- review various groundwater, geotechnical and environmental reports dating back to 1986 to develop an appreciation of the hydrogeological setting of the area;
- prepare a preliminary hydrogeological assessment to determine any risks and constraints associated with the management of groundwater due to mining in the floodplain area;
- undertake a field investigation program to obtain additional site specific data in order to address the potential impacts, risks and constraints identified;
- analyse all data and conceptualize the groundwater regime of the mine lease and surrounding areas;
- develop a numerical model and undertake predictive modelling of the impact of the mine at various stages during the mine operations and post closure;
- assess the groundwater impacts and develop feasible mitigation and containment measures, and management strategies if potential adverse impacts are identified. Impacts assessed included aquifer water levels, mine inflow and aquifer water quality including spoil leachate issues;
- identify environmental issues, risks and risk management strategies for the mine plan;
- develop a groundwater monitoring plan.

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[2] Queensland Department of Natural Resources and Mines, Mr. Tony Turner, Senior Engineer.

5.0 GROUNDWATER-SURFACE WATER INTERACTION

The preliminary hydrogeological assessment identified the potential for mining across the alluvial floodplain to impact not only groundwater in the alluvium but also flow in the Nogoa River as a significant risk. A study was therefore undertaken to assess the degree of hydraulic connection and interaction between the river and the alluvium. This section of the report describes the work undertaken.

5.1 Previous Investigations

The Department of Primary Industries (DPI) [1995][3], now Department of Primary Industries and Fisheries (DPI&F), undertook a groundwater investigation of the Nogoa River floodplain between Emerald and Comet to *“determine whether there is any interconnexion* (sic) *between groundwater and surface water flows in the river”.* A total of 23 bores were drilled on four lines traversing the alluvial floodplain. One of these lines, the Ensham Line, traverses the middle of the Ensham Mine Lease and the Yamala Line is to the west and upstream of the lease. Six monitoring bores were installed along the Ensham Line, bores 13020**176** to 13020**181** as shown on **Drawing No 2**. The bores have been monitored by DPI&F on a regular basis since installation.

Analysis of the drilling data and data from other sources lead DPI to conclude that *“it is unlikely that there is any connexion* (sic) *between the river system and groundwater. Groundwater is restricted to the deeper sections of the alluvium and there are large tracts of dry alluvium …… A further complication is the lack of good quality groundwater”.*

5.2 Field Investigation Program – Objective and Scope of Works

The primary objective of the field investigation program was to collect additional information to address any uncertainty as to the degree of hydraulic connection between the Nogoa River and the underlying alluvial sand and gravel aquifer along the length of the river within the lease area. Should there be hydraulic connection the data would enable mitigation/containment measures to be ascertained that would prevent the proposed mine from impacting the river. The program was designed to obtain information that would provide data on:

- groundwater levels in the alluvial aquifer, and surface water and bed levels in the Nogoa River;
- hydraulic gradients between the open cut pits and the Nogoa River;
- permeability and transmissivity values for the alluvial sediments; and
- baseline water quality in the alluvial aquifer and in the river.

The scope of work formulated to achieve the objectives included:

- Drilling of 20 test holes (EC01- EC20) along a 4km section of the Nogoa River through the area potentially affected by open cut mining, in order to evaluate groundwater/surface water interaction, (**Drawing No 2**);
- Drilling of 3 test holes (EC21 - EC23) between the Nogoa River and the existing B Pit, to evaluate the hydraulic gradients between the two, (**Drawing No 2**);

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[3] Lloyd J., (July 1995), *“Nogoa River Floodplain Emerald to Comet Groundwater Investigation”*, 27559 RSCI42403.

- Collection of undisturbed sediment samples from selected test holes, from the saturated zone of the alluvial aquifer for physical testing (grain size/bulk density);
- Geophysical logging of the test holes to identify aquifer zones and lower permeability clayey beds in the alluvial sequence;
- Construction of groundwater monitoring bores in each test hole using 50mm diameter uPVC casing;
- Field analysis of groundwater from the bores for pH & electrical conductivity;
- Laboratory analysis of 9 groundwater samples and one sample from the Nogoa River for a suite of analytes to characterise groundwater quality;
- Hydraulic testing (falling head tests) in selected completed monitoring bores, to measure the aquifer permeability;
- Installation of permanent water level loggers in four monitoring bores to examine the relationship between water level fluctuations in the river, rainfall recharge and the alluvial aquifer;
- Surveying of all of the groundwater monitoring bores to determine hydraulic gradients and hydraulic heads; and
- Excavation of three test pits in the Nogoa River (R1- R3) and two test pits in the bank (B1, B2) and collection of sediment samples to assess the nature of the river bed and the potential for leakage and recharge of the alluvial aquifer, (**Drawing No 2**).

A detailed description of the field investigation program and of the data obtained is given in Appendix 1.

5.3 Hydrogeological Characteristics of the Alluvium

The following description of the hydrogeological characteristics of the alluvium is based on the data obtained from the investigation program. Composite logs for each of the bores drilled are given in Appendix 2.

5.3.1 Lithology

The characteristic alluvial sequence encountered in each borehole consists of an upper unit of fine grained flood deposited sandy silt and clay overlying a lower basal unit of alluvial sand and gravel as shown in the exposed alluvial profile in B Pit, (Figure 1). That is, it is a typical fining up sequence.

The thickness of the flood terrace deposits varies between 3m and 14.5m with an average thickness of about 10m. The lower sand and gravel unit ranges between 0.7m and 11m thick with an average thickness of about 5m. The sand and gravel unit is clearly distinguishable on the gamma logs which indicated that the unit is relatively clean and typically does not contain inter-bedded silt/clay layers (refer borehole logs Appendix 2). The exception was borehole EC03 which encountered about 1m of soft grey clay within the sand and gravel unit.

Figure 1 – LHS The typical alluvial profile as exposed in B Pit.
RHS Gravel cuttings from base of bore EC14 – note fines have been washed from cuttings during drilling.

The base of the sand and gravel unit is marked by silty clay, typically in the order of 1m thick, unconformably overlying weathered, grey mudstone of Permian age, (Figure 1). The mudstone is weak and easily broken by hand. Subcropping coal seams were encountered beneath the alluvium in the eastern area of the site in boreholes EC16, EC17, EC18 and EC19.

5.3.2 Groundwater Occurrence

Significant groundwater inflow was not evident in any of the boreholes during drilling. After installation of the casing the monitoring bores were developed using air and/or a pneumatic pump.

Following development, the stabilised water level was measured in each monitoring bore. The water levels indicated that groundwater is present at the base of the sand and gravel unit, with the saturated thickness in the aquifer varying from 0m (dry) to about 3.8m. The sand and gravel unit was dry in twelve boreholes where the basement weathered mudstone was present at relatively high elevations. This indicates that groundwater occurrence in the alluvium is limited, and that it is restricted to sections of the alluvium where the basement Permian sequence has been more deeply eroded, as shown on Figure 1.

5.3.3 Groundwater Quality

Following initial sampling and analysis in November 2004, at the completion of monitoring bore construction, groundwater quality was monitored on a quarterly basis. The groundwater sampling procedure involved purging each bore with the pneumatic pump and measuring EC and pH at regular intervals. During development of the bores this was to ensure that all drilling fluids had been evacuated from the borehole prior to collection of samples for laboratory analysis. The stabilised pH and EC recorded for each bore on a quarterly basis is presented in Table 2.

Table 2: GROUNDWATER QUALITY – FIELD MEASUREMENTS						
Borehole ID	**pH**			**Electrical Conductivity (µS/cm)**		
	Nov 04	**Mar 05**	**Jun 05**	**Nov 04**	**Mar 05**	**Jun 05**
EC01	6.74	7.15	6.74	>30,000	>30,000	>30,000
EC02	-	-	7.68	-	-	4,070
EC03	6.67	6.39	6.49	23,900	20,080	>30,000
EC05	7.33	7.86	7.30	18,830	27,400	>30,000
EC06	7.23	-	7.29	2,530	-	3,260
EC07	6.97	7.47	6.67	5,870	22,700	>30,000
EC09A	8.12	7.62	6.83	6,140	12,360	20,330
EC10	7.5	8.20	7.26	2,110	2,020	2,050
EC11	6.95	6.91	6.83	16,040	16,830	17,930
EC12	6.73	7.14	6.54	6,970	6,380	8,550
EC13	6.74	-	7.68	15,450	-	17,000
EC14	6.98	6.76	6.73	2,800	3,200	5,040
EC21	6.82	6.63	6.66	2,130	3,090	3,730
EC22	6.8	6.61	6.73	2,320	2,180	3,210
EC23	6.91	6.72	7.05	2,000	2,290	3,290
B Pit	-	7.71	7.93	-	7100	10,470

The field data indicates that groundwater in the alluvium varies from brackish to saline and that the pH fluctuates from slightly acid to slightly alkaline.

For the initial sampling round, nine groundwater samples and one surface water sample were collected between 23 and 24 November 2004 and submitted to ALS for a suite of analyses. Four samples; a river water sample, a sample of seepage from the toe of the alluvium exposed in B Pit, and two samples from monitoring bores, were collected during each subsequent monitoring round on 2 March and 31 May 2005. The results of the analyses are presented in Table 3 and the detailed laboratory report is given in Appendix 3.

The results of the laboratory analyses confirm that the groundwater in the alluvial aquifer has a neutral to slightly alkaline pH between 7 and 8. Two samples collected from the Nogoa River also reported an alkaline pH of 8.1-8.2, which is probably related to the soils and geology of the catchment area.

A significant variability of groundwater salinity in the alluvium is evident with concentrations of Total Dissolved Solids (TDS) varying between 1,110mg/L (EC23) and 28,200mg/L (EC01). The TDS concentrations indicate the alluvial groundwater is slightly brackish to moderately saline in quality. In contrast, water in the Nogoa River is fresh with a TDS of about 215mg/L. The most saline groundwater samples were collected from EC1, EC3, EC5, EC11, EC12 and EC13 which all exceeded the recommended limit for beef cattle watering (5000mg/L)[4].

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[4] ANZECC, (2000), *"Australian and New Zealand Guidelines for Fresh and Marine Water Quality - Livestock Drinking Water"*. Australian and New Zealand Environment Council and Agriculture and Resource Management Council of Australia and New Zealand.

Table 3: GROUNDWATER QUALITY – LABORATORY ANALYSIS

Bore ID	**SW1 – Nogoa River**			**B PIT**		**EC01**	**EC03**	**EC05**	**EC11**	**EC12**	**EC13**	**EC14**	**EC21**			**EC22**	**EC23**	
Date	23/11/04	2/3/05	31/5/05	2/3/05	1/6/05	23/11/04	24/11/04	2/3/05	24/11/04	24/11/04	24/11/04	24/11/04	23/11/04	2/3/05	31/5/05	23/11/04	23/11/04	1/6/05
pH (Field)	-	9.2		7.71	7.93	6.74	6.67	7.86	6.95	6.73	6.74	6.98	6.82	6.63	6.66	6.8	6.91	7.05
pH (Lab)	8.23	8.17	8.38	7.4	7.85	7.19	7.58	7.6	7.7	7.72	7.69	7.78	8.04	7.55	7.7	8	7.76	8
Electrical Conductivity – Field (µS/cm)	230	280		7,100	10,470	>25,000	23,900	27,400	16,040	6,970	15,450	2,800	2,130	3090	3,730	2,320	2,000	3,290
– Lab (µS/cm)	271	241	328	8,100	13,700	36,200	23,400	29,300	16,700	7,440	15,800	2,890	2,340	2,710	3,250	2,380	2,040	3,010
Total Dissolved Salts (mg/L)	204	216	228	7,230	8,800	28,200	17,400	24,800	10,900	5,670	12,600	1,860	1,290	1,640	2,200	1,400	1,110	1,820
Calcium (mg/L)	19	19	20	647	373	1,270	933	781	516	372	798	99	83	106	108	96	75	91
Magnesium (mg/L)	9	7	12	458	457	1,610	1,080	1,270	488	423	489	110	78	116	152	77	61	94
Sodium (mg/L)	18	20	23	1,230	1,710	5,410	3,110	5,350	2,330	541	2,010	333	269	345	382	262	265	430
Potassium (mg/L)	10	6	12	13	19	13	12	17	16	10	21	4	3	3	5	4	4	4
Bicarbonate (mg/L)	120	93	127	379	501	1,020	827	802	1,060	380	800	608	511	636	608	337	545	881
Carbonate (mg/L)	<1	<1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chloride (mg/L)	12	15	25	3,650	4,510	15,300	8,970	11,400	5,370	2,170	5,350	657	434	600	892	490	394	585
Sulphate (mg/L)	4	6	6	272	288	1,200	803	1140	505	67	455	17	10	15	17	22	24	33
Nitrate (mg/L)	0.172	0.171	0.024	1.42	3.19	0.014	0.022	<0.010	0.014	0.016	0.048	0.018	<0.010	0.011	0.016	0.01	0.011	0.074
Iron (mg/L)	<0.01	0.06	<0.05	<0.01	<0.05	<0.01	1.04	<0.01	<0.01	0.16	7.25	0.02	0.05	<0.01	<0.05	<0.01	<0.01	<0.05
Manganese (mg/L)	0.001	<0.01	0.063	0.65	0.868	6.25	10.8	0.22	8.77	4.03	17.3	0.915	0.627	1.32	1.12	1.26	0.385	0.26
Silica (mg/L)	10.2	13	4.1	42.3	36.3	61.8	43.6	30	25.4	34.9	27.8	38.1	40	48.3	41.8	32.9	37.7	27.7

Notes: i) The B Pit sample is seepage from the toe of the alluvium

Expression of the relationships between ions in terms of mathematical ratios can be used to highlight differences in groundwater and surface water types. Ratios of different ions for groundwater and surface water from the Nogoa River are presented in Table 4 below.

Table 4 : ION RATIOS – SURFACE WATER AND GROUNDWATER

Sample ID	Sample Date	Ratios			
		Ca/Mg	Na/Cl	SiO_2/TDS	Na/Total Cations
Nogoa River (SW1)	23-Nov-04	2.11	1.50	0.050	0.32
EC01	24-Nov-04	0.79	0.35	0.002	0.65
EC03	24-Nov-04	0.86	0.35	0.003	0.61
EC11	24-Nov-04	1.06	0.43	0.002	0.70
EC12	24-Nov-04	0.88	0.25	0.006	0.40
EC13	24-Nov-04	1.63	0.38	0.002	0.61
EC14	24-Nov-04	0.90	0.51	0.020	0.61
EC21	23-Nov-04	1.06	0.62	0.031	0.62
EC22	23-Nov-04	1.25	0.53	0.024	0.60
EC23	23-Nov-04	1.23	0.67	0.034	0.65

A comparison of the ion ratios in the surface water sample collected from the Nogoa River (SW1) and the groundwater samples indicates a significant difference. The Ca/Mg, Na/Cl and SiO_2/TDS ratios are all lower in the groundwater samples compared to surface water. The Na/Total anions ratio also shows a difference and indicates the surface water in the Nogoa River and the groundwater in the alluvial aquifer can be considered different 'water types' and that therefore there must be very limited, if any, leakage from the river to the aquifer.

5.3.4 Aquifer Permeability

Falling head tests were conducted on eight bores to measure the hydraulic conductivity of the sand and gravel aquifer. Between 10L and 20L of water was added to each bore and the falling head monitored at 10 second intervals with a pressure sensor. The 'slug' of water added to monitoring bores EC12, EC14, EC21, EC22, EC23 drained rapidly into the aquifer and resulted in only very slight changes in water levels in the bore (<0.12m). The rate of water level decline was more rapid than could be captured by the water level logger which recorded at a minimum 10 second intervals and could therefore not be quantitatively analysed. The extremely rapid drainage indicates that the basal sand and gravel unit of the alluvial sequence has a relatively high hydraulic conductivity and based on visual appearance (Figure 1), is assessed to be likely in excess of 100m/day.

The slug of water added to monitoring bores EC01, EC03 and EC11 induced greater changes in head, of between 1m and 3m, and the data generated by these bores could be analysed, using the Hvorslev Method (1951) for unconfined aquifers, with the *Aquifer Test Version 2.5* Software. The results of the analysis are presented in Appendix 4 with the results summarised in Table 5.

Table 5: HYDRAULIC CONDUCTIVITY DATA		
Bore	**Hydraulic Conductivity**	
	(m/sec)	**(m/day)**
EC01	6.86 X10^{-6}	0.59
EC03	5.14 X 10^{-6}	0.44
EC11	2.21 X 10^{-5}	1.91

The falling head tests indicated a moderate permeability ranging from 0.4m/day to 1.9m/day, significantly lower than the other bores tested. The lower hydraulic conductivity recorded in monitoring bores EC03 and EC11 may be related to the bands of clay within the sand and gravel unit detected in these bores. Monitoring bores EC01, EC03 and EC11 were all drilled with mud and it is also possible a 'skin' of drilling fluid and clayey sediments on the borehole wall has resulted in the low hydraulic conductivity measurements recorded from these bores. Given the rapid drainage of water added to bores EC12, EC14, EC21, EC22, EC23 it is considered likely the lower permeability estimates for EC01, EC03 and EC11 are an underestimate of the permeability of the alluvial aquifer.

5.3.5 Water Level Monitoring Program and Results

The groundwater level and the river level were similarly recorded at selected locations on a quarterly basis between November 2004 and June 2005 and the data are presented in Table 6 below.

Groundwater Levels/Gradient

The data indicates that water levels in the alluvial aquifer typically vary between about 1m and 6m below the water level in the Nogoa River, indicating that under current conditions there is no or very minimal leakage from the river to the aquifer and similarly that there is no discharge of groundwater from the alluvial aquifer into the river.

Table 6: GROUNDWATER LEVEL MONITORING DATA

Borehole ID	TOC Elevation (RLmAHD)	Standing Water Level (mbtoc)			Standing Water Level (mAHD)			Nogoa River Level (mAHD)		
		Nov-04	*Mar-05*	*Jun-05*	*Nov-04*	*Mar-05*	*Jun-05*	*Nov 04*	*Dec04*	*Mar05*
EC01	154.325	13.22	13.15	13.15	141.11	141.18	141.18		144.01	141.735
EC02	154.764	16.35	dry		138.41	dry		142.53		
EC03	153.238	12.24	12.16	12.19	141.00	141.08	141.05	142.07	143.58	
EC04	153.65	Dry	Dry		Dry	Dry				141.61
EC05	154.48	14.18	14.17	14.15	140.30	140.31	140.33	141.61		
EC06	153.126	14.66	15.2	14.7	138.47	137.93	138.43	141.64	143.25	
EC07	153.882	14.73	15.5	14.69	139.15	138.38	139.19	141.64		
EC08	154.634	Dry	Dry		Dry	Dry		141.54		
EC09	153.411	Dry	Dry		Dry	Dry		141.54		
EC9A	153.541	15.03	15.3	15.36	138.51	138.24	138.18	141.54		
EC10	154.271	16.77	16.8	16.85	137.50	137.47	137.42			
EC11	152.689	15.36	15.4	15.47	137.33	137.29	137.22	141.58		141.144
EC12	152.069	15.08	15.1	15.2	136.99	136.97	136.87			
EC13	152.038	15.03	15.3	15.38	137.01	136.74	136.66	141.99		
EC14	146.124	9.68	9.8	9.97	136.44	136.32	136.15	141.94		141.274
EC15	153.931	Dry	Dry		Dry	Dry		141.68		
EC16	153.586	Dry	Dry		Dry	Dry				
EC17	150.047	Dry	Dry		Dry	Dry		141.28		
EC18	151.839	Dry	Dry		Dry	Dry		141.28		
EC19	151.713	Dry	Dry		Dry	Dry		140.72	142.74	140.333
EC20	151.077	Dry	Dry		Dry	Dry				
EC21	143.584	7.76	7.92	8.28	135.82	135.66	135.30	141.94		
EC22	153.695	18.04	18.25	18.63	135.66	135.45	135.07	141.94		
EC23	153.946	18.37	18.67	19.05	135.58	135.28	134.90	141.94		
13020176	153.922									
13020177	154.368									
13020178	153.967		13.9	13.9		140.07	140.07			

A cross section through the Nogoa River to B Pit illustrating the relationship between water levels is presented in Figure 2, and the location of the cross section boreholes is shown in **Drawing No 2**. The cross section shows that at that location the groundwater level at about RL 136m is about 5.5m below the riverbed and 6m below the river water level. The section also shows that there is a slight gradient towards B Pit where there is discharge of brackish groundwater at the toe of the alluvium as shown on Figure 1.

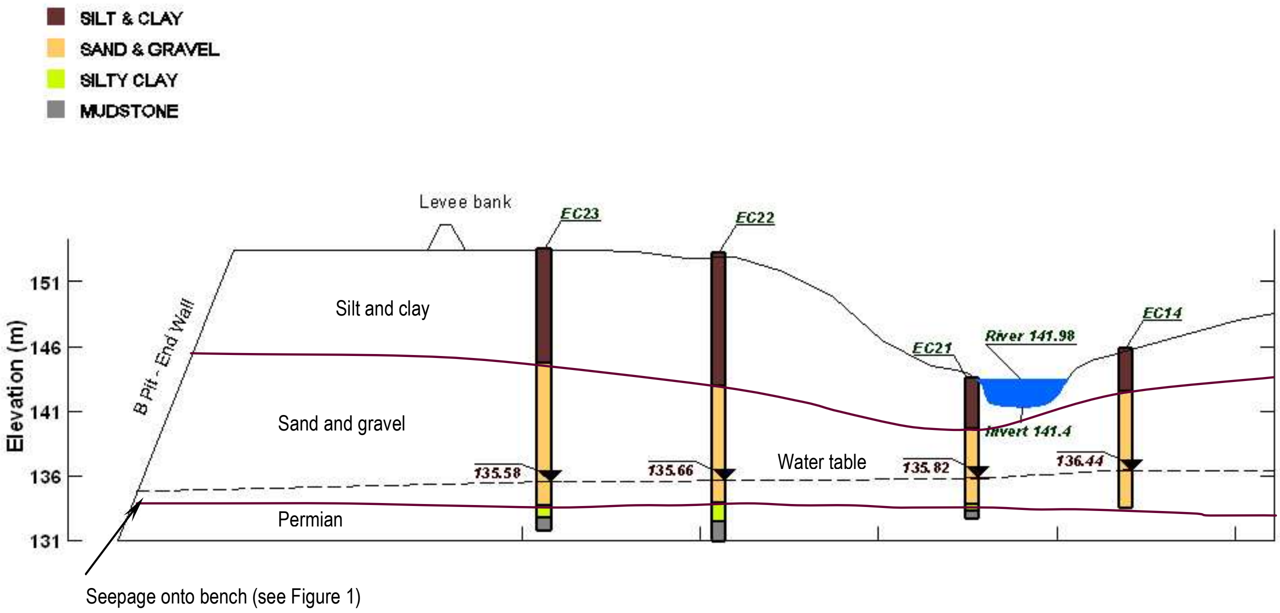

Figure 2 – Cross Section EC 14 to B Pit

Along the length of the Nogoa River groundwater levels in the alluvial aquifer vary from about 141mAHD at the upstream end of the lease to 135.5mAHD at the downstream end, that is, over a distance of 3km, indicating a hydraulic gradient of about 1.8 X 10^{-3} to the east. Regionally the direction of groundwater flow in the alluvium appears to be in the same direction as the flow in the Nogoa River. On a localised scale a hydraulic gradient between EC14 and EC23 indicates some drawdown and groundwater flow towards B Pit as shown on Figure 2, and as discussed. Some drawdown in the groundwater levels is also likely to occur in the area of bore G2 which is equipped with an electric submersible pump and is located on the island formed by the anabranch (**Drawing No 2**).

<u>Groundwater Fluctuations</u>

The hydrographs for boreholes EC03, EC10, EC14 and NRMW monitoring bore 13020**178** are presented as Figures 3 to 6 below. The hydrographs are plotted against daily rainfall totals recorded at the Duckponds Homestead.

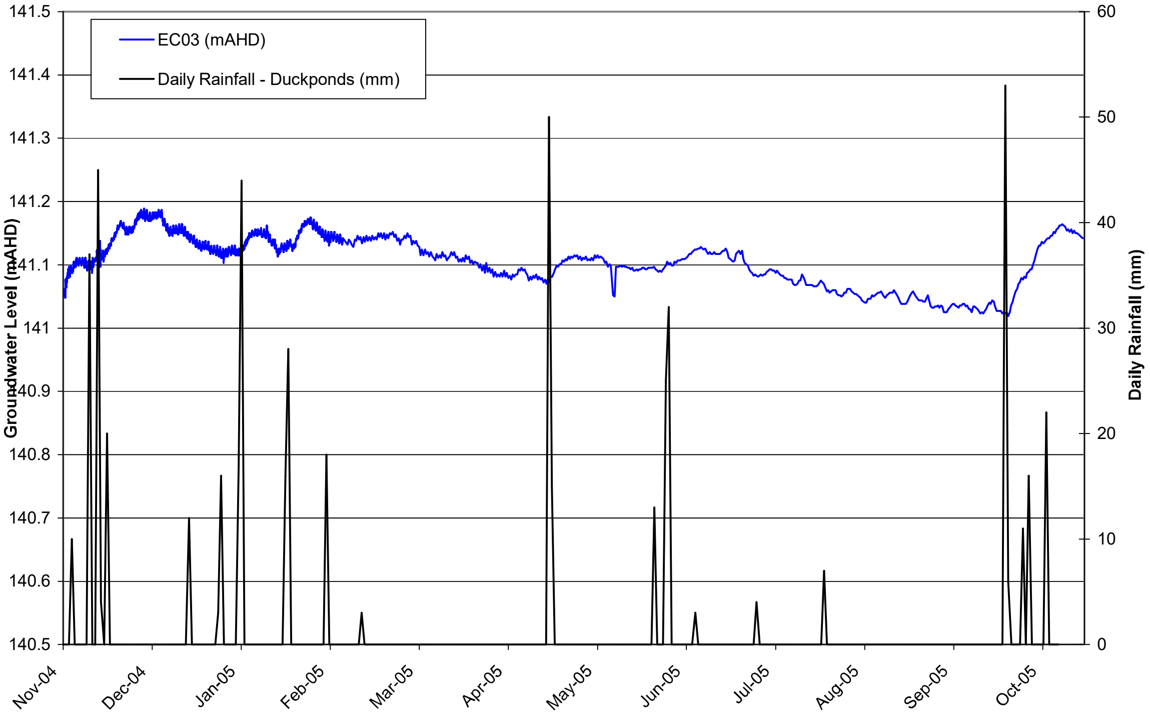

Figure 3 – Hydrograph Monitoring Bore EC03

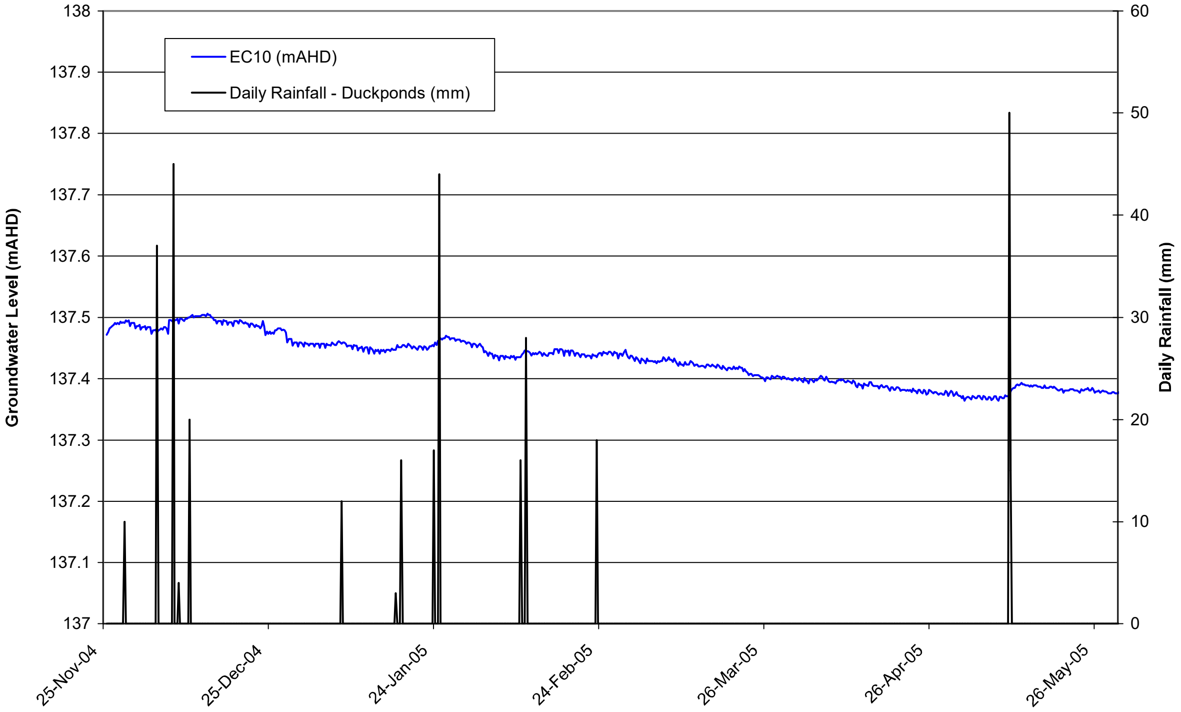

Figure 4 – Hydrograph Monitoring Bore EC10

Between 4 - 10 December 2004, 106mm of rainfall was recorded; however, only a very slight rise in water level (<5mm) was recorded in EC03 and EC10 after this period of rain. Subsequent rainfall events in January, February and April 2005 also induced only a slight rise in water levels in EC03 and EC10.

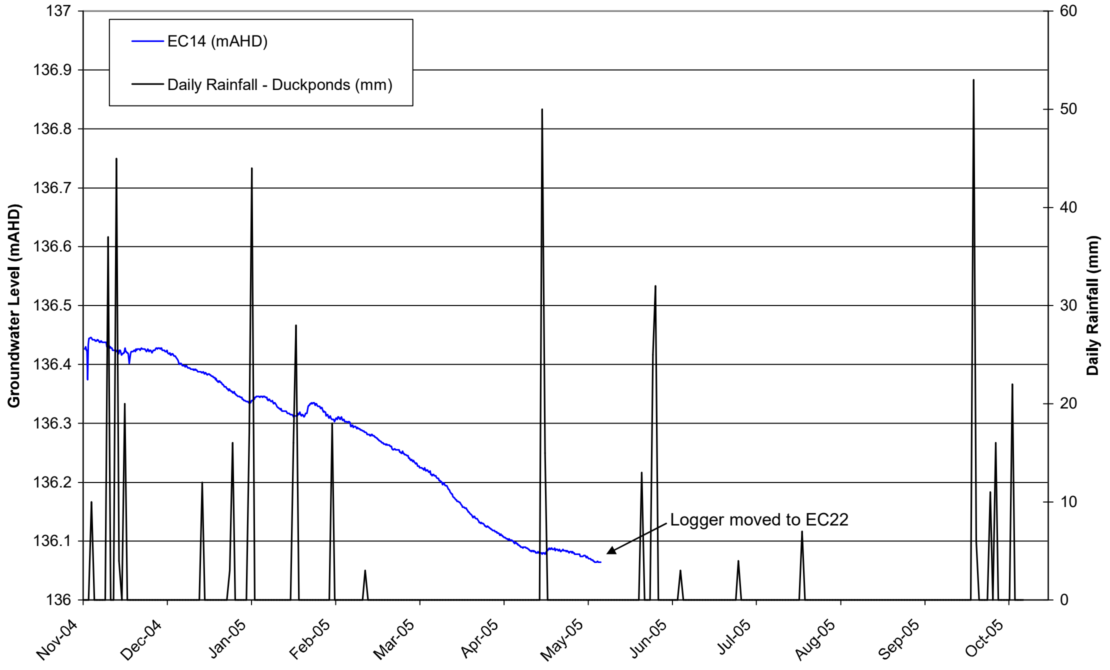

Figure 5 – Hydrograph Monitoring Bore EC14

Groundwater level response to rainfall was also very slight in EC14, which showed a slight but gradual decline in water level over the monitoring period (Figure 5).

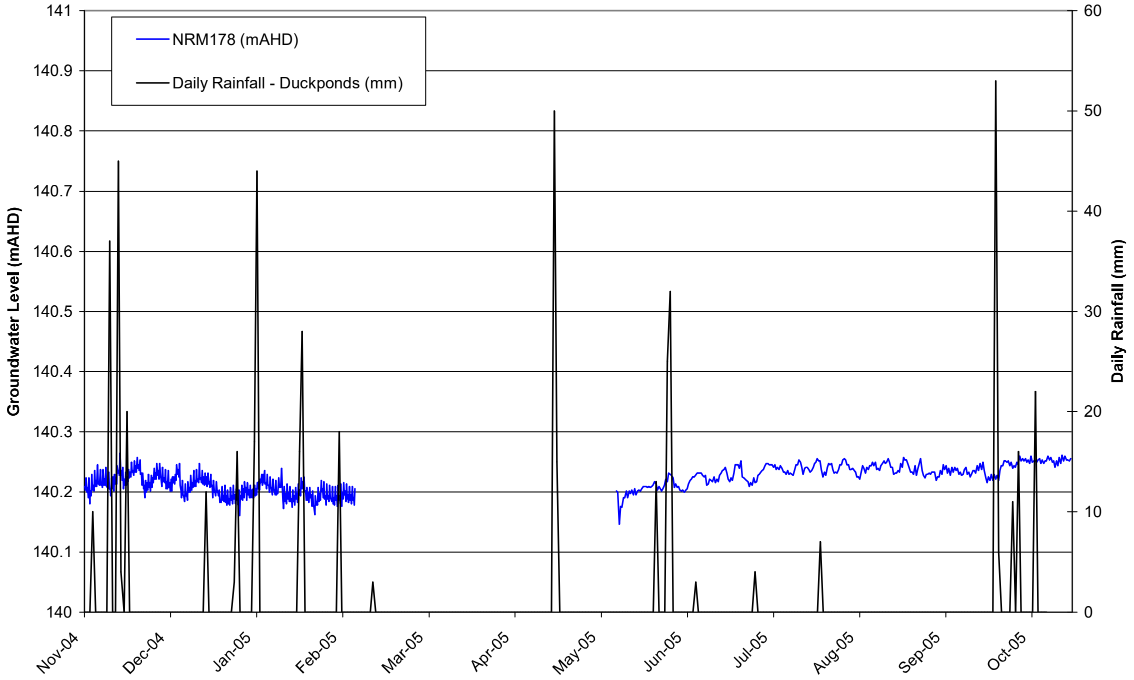

Figure 6 – Hydrograph NRMW Monitoring Bore 13020178

NRMW monitoring bore EC13020**178** exhibits a regular fluctuation of small magnitude as shown on Figure 6 that appears to have no relationship to rainfall events. These fluctuations are likely to be associated with changes in atmospheric pressure or earth tides.

The minor water level responses in the hydrographs to rainfall indicate that recharge of the alluvial aquifer through the black cracking clay soils is very limited. Monitoring Bore EC14 which is located about 10m from the bank of the Nogoa River also exhibited a very muted response to rainfall.

Water levels in the Nogoa River recorded at the NRMW Stream Gauging Station (130219A) are presented in Figure 7 along with groundwater levels recorded in the alluvial aquifer at the above sites.

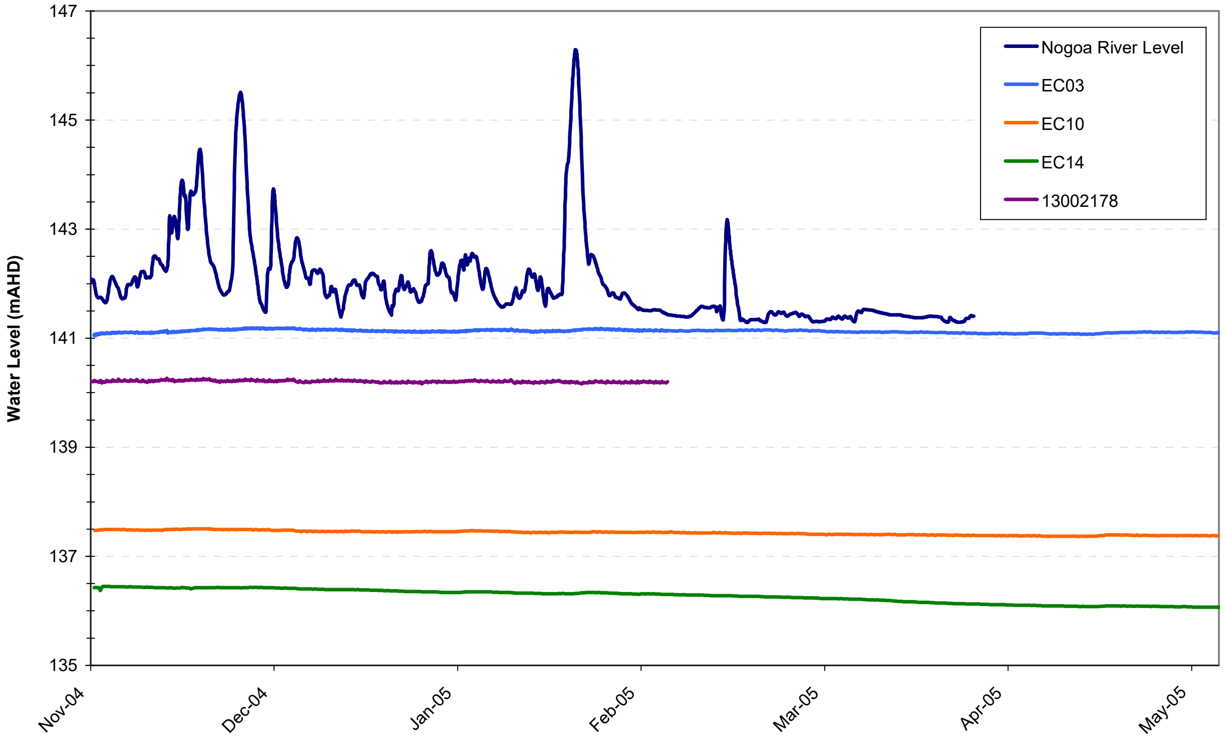

Figure 7 – Groundwater and Nogoa River Water Levels – Nov 04 to Feb 05

From Figure 7 it is evident that fluctuations in water level in the Nogoa River are not reflected in monitoring bores in the alluvial aquifer adjacent to the river, again indicating that there is virtually no connection between the river and the alluvium. The data suggests that recharge through the base of the river is very limited and that direct rainfall recharge through the surface soils is also very limited. The primary recharge mechanism to the base of the alluvium may be due to seepage along fractures from the deeper coal seams, as indicated by the poor quality (brackish to saline) of the groundwater in the alluvium.

5.3.6 River Bed Sediment Sampling and Permeability Testing

Three (3) test pits were excavated into the bed and two (2) into the banks of the Nogoa River on 3 February 2005 to assess the stratigraphic profile at the base and sides of the river, and in particular the characteristics of the sealing layer that prevents seepage of river water into the aquifer. The location of the test pits are shown on **Drawing No 2** and the Test Pit logs are presented in Appendix 5.

Test pit R1 excavated in the river bed at the downstream end of the lease encountered an initial layer of well washed, loose sand at a depth of about 0.15m. This was underlain by clayey sand and gravel to a depth of 0.6m. Grain size analysis of a sample collected from 0.3m reported 10% fines (silt/clay) and 90% sand and gravel. The grain size analysis results are summarised in Table 7 and are presented in Appendix 6.

Test pit B1 was excavated adjacent to test pit R1 (Plate 4, Appendix 1), in a dry section of the river bed. Similar clayey gravel was encountered from ground surface to about 1m below the surface. Grain size analysis of a sample collected from 0.05m reported 9% fines (silt/clay) and 91% sand and gravel. Clayey sand was present from 1m to 1.8m and was underlain by grey plastic clay. The grey clay was very similar to that encountered underlying the alluvial sediments and is considered to be residual Permian mudstone. Test pit B1 was left open for about 10 minutes and a slow groundwater seepage was observed through the clayey sand at about 1.7m depth. A sample of the seepage was collected and recorded an EC of 800µS/cm. A water sample from the Nogoa River adjacent to the pit recorded an EC of 240µS/cm, indicating poor connection between the river and the groundwater in the underlying alluvial sediments.

Test pit B2 was excavated further up the river bank, about 10m from test pit B1. Test pit B2 encountered similar sediments to test pit B1 with clayey gravel present from surface to a depth of 0.5m. Samples from test pit B2 were not submitted for particle size analyses.

Test pit R2 was excavated in the Nogoa River about 10m upstream of monitoring bore EC21 which, as discussed, shows a head difference of about 6m between river level and groundwater level. A thin 0.05m layer of mud was encountered in the bed of the river overlying heavy black plastic clay. Grain size analysis of a sample collected from 0.2m reported 64% fines (silt/clay), 23% sand and 13% gravel. Sand and gravel was encountered at a depth of 0.8m to 0.9m underlying the black clay, (Plates 3 and 4, Appendix 1).

Test pit R3 was excavated close to monitoring bores EC05 and EC06 at the upstream end of the lease (refer **Drawing No 2**). Similar to test pit R2, a thin 0.05m layer of mud was encountered in the bed of the river overlying heavy black plastic clay to a depth of 1m. Grain size analysis of a sample collected from 0.2m reported 69% fines (silt/clay) and 31% sand.

Table 7: PARTICLE SIZE SUMMARY – RIVER BED TEST PIT SAMPLES

Sample ID	Clay (-0.002 mm)	Silt (0.002 - 0.06 mm)	Sand (0.06 - 2mm)	Gravel (+ 2mm)
R1 0.3m	7	3	33	57
R2 0.2m	39	25	23	13
R3 0.2m	43	26	31	0
B1 0.05m	6	3	30	61
R1 0.6m	6	2	46	46
R1 0.6m	4	3	91	2

In June 2005 insitu permeability testing of the upper strata was undertaken in the Nogoa River bank adjacent to test pits R1, R2 and R3. The objective of the testing was to measure the permeability of sediments that underlie the river bed at the same locations where physical samples were collected for particle size analysis. A constant head test was undertaken and analysed generally in accordance with the methods outlined in Australian Standard AS 1547:2000. The results of the testing are presented in Table 8 below.

Table 8: CONSTANT HEAD TEST RESULTS

Sample ID	Borehole Depth (m)	Soil Type	Test Duration (hrs)	Hydraulic Conductivity (m/sec)
R1	0.8	Clayey sand/gravel	1	1.3 X 10^{-7}
R2	0.8	Clay	45	1.1 X 10^{-7}
R3	0.8	Clay	41	2.1 X 10^{-8}

The constant head tests indicated a permeability range of 2.1 x 10^{-8} to 1.3 x 10^{-7}cm/sec (2.1 x 10^{-10} to 1.3 x 10^{-9}m/sec), which is very low and is the standard permeability requirement for compacted landfill or effluent pond liners[5].

The data obtained from the riverbed and riverbank test pits and permeability testing indicates that the base and sides of the river consists of a clay to clayey gravel/sand layer of extremely low permeability which essentially prevents seepage of water from the river to the alluvium.

5.4 Summary and Conclusions

5.4.1 Hydrogeological Characteristics of the Alluvium

The characteristic sequence of the alluvium of the Nogoa River floodplain consists of an upper unit of fine grained flood deposited black cracking clays and sandy silt overlying a lower basal unit of river deposited sand and gravels. The thickness of the flood terrace deposits varies in the test bores drilled between 3m and 14.5m with an average thickness of about 10m. The lower sand and gravel unit ranges between 0.7m and 11m with an average thickness of about 5m.

No significant inflow of groundwater was evident in any of the boreholes during drilling. Groundwater levels measured in the bores indicates that the base of the sand and gravel unit is variably saturated, with the saturated thickness varying from 0m (dry) to about 3.8m. As such the saturated thickness of the alluvial aquifer is relatively small and in much of the flood plain the base of the alluvium is above the water table and the alluvium is unsaturated. The alluvial groundwater is slightly brackish to moderately saline and is commonly too salty for beef cattle watering (TDS >5000mg/L)[2].

The “patchy” nature of groundwater occurrence in the alluvial sediments and the fact that hydraulic gradients are very low, indicates that inflow to the proposed pits from the alluvium will be very low as has been experienced to date. It is assessed that there is essentially no recharge of the alluvium either from river seepage or from rainfall infiltration and that the brackish to saline water that occurs at the base of the alluvium is from seepage along faults and fractures from the underlying coal seams.

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[5] Department of Primary Industries Queensland, (2000), *“Environmental Code of Practice for Queensland Piggeries”.*

5.4.2 Relationship of Groundwater and Surface Water

The degree of hydraulic connection between the Nogoa River and the underlying alluvial sand and gravel aquifer was of primary concern to the proposed extension of the mining operations. Previous investigations assumed there may be good hydraulic connection between the river and the alluvial aquifer which would lead to an adverse impact as a result of mining, and which would therefore require implementation of mitigation/containment strategies. The primary objective of the field investigation was therefore to collect sufficient information on the hydrogeology of the alluvial aquifer and to assess the inter-relationship and degree of hydraulic connectivity between the river and the aquifer. In so doing data would be obtained for mine planning and for use in numerical impact modelling. The data collected from the field investigation indicates there is no, or extremely limited hydraulic connection between the Nogoa River and the alluvium because:

1. Groundwater in the alluvial aquifer is brackish to saline and is at least an order of magnitude more saline than the fresh surface water in the Nogoa River. The ratios of major ions indicate that surface water in the Nogoa River and the groundwater in the alluvial aquifer can be considered different ‘water types’ and that therefore leakage from the river to the aquifer is limited, if at all;

2. Groundwater levels in the alluvial aquifer directly adjacent to or below the river typically vary between about 1m and 6m below the water level in the Nogoa River, confirming extremely limited leakage, if any;

3. Water level monitoring data indicates there is no relationship between water level fluctuations in the Nogoa River and groundwater levels. Periods of higher flow in the river do not result in changes in groundwater levels adjacent to or below the river;

4. Samples of sediment collected from the bed of the river indicate that the alluvial sediments are bound with silt and clay that form a virtual impermeable layer around the river bed preventing leakage of surface water to the underlying aquifer.

The relationship between ground and surface water is illustrated schematically on Figure 8 below.

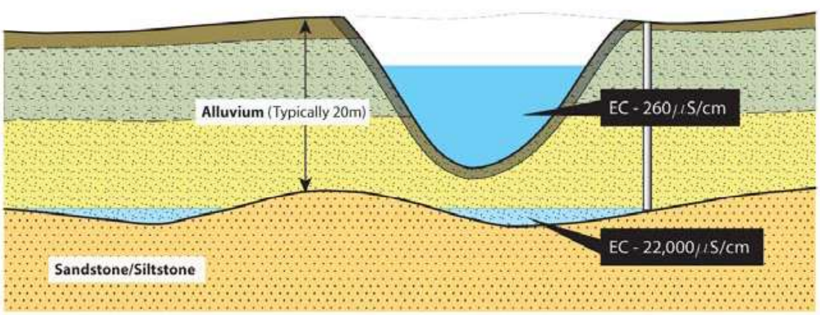

Figure 8 – Schematic Diagram of the Relationship between Ground and Surface Water

In summary the field investigations have shown that there is no or extremely minimal hydraulic connection between the Nogoa River and the alluvial aquifer in the area of the mining lease, because of essentially impermeable river bed sediments which prevent leakage through the bed of the river. This fact was confirmed by the collection of river bed sediment samples and permeability testing. The brackish to saline nature of groundwater in the alluvial aquifer, and the fact that groundwater levels are significantly below the base of the river level, and often below the base of river invert level, also indicate that leakage of water through the bed of the river in the area of the mine is minimal, if at all. In addition water level monitoring showed no increase in water levels in the alluvial aquifer when water levels in the Nogoa River increased.

6.0 HYDROGEOLOGICAL REGIME

The hydrogeological regime described in this section is based on the findings of the field investigation program, on a review of past relevant reports, and on a review of exploration hole data.

6.1 Geology and Structure

6.1.1 Stratigraphy

The stratigraphic sequence across the site comprises two distinct units, a consolidated Permian and Triassic sequence which are unconformably overlain by unconsolidated Quaternary sediments. The Permian and Triassic rocks form a regular layered sedimentary sequence while the Quaternary materials are more complex and irregular. The stratigraphy is summarised in Table 9.

Table 9: SUMMARY OF SITE STRATIGRAPHY

Age	Unit	Description	Thickness
Quaternary		Alluvium – comprising soil, silt, clay, sand and gravel	0-25m
Triassic	Rewan Group	Mudstone with lithic sandstone interbeds	
Permian	Rangal Coal Measures	Feldspathic and lithic sandstone, carbonaceous mudstone, siltstone, tuff and coal seams. Coal seams include: - Aries - Castor - Pollux - Orion	100m
	Burngrove Formation	Sandstones, siltstones and mudstones, and banded coal seams frequently interbedded with tuff and tuffaceous mudstones. Coal seams include: - Virgo - Leo	

The coal seams mined at Ensham belong to the Late Permian Rangal Coal Measures. These Coal Measures are recognised throughout the area and have a thickness of some 100m.

The seams subcrop over a strike length of about 80km around the northern and eastern limits of the area. The top of the Rangal Coal Measures is regarded as the transition from carbonaceous sediments to the fluvial sequence of green coloured, non-carbonaceous siltstones and lithic sandstones of the Triassic Rewan Group.

Underlying the Rangal Coal Measures is the Upper Permian Burngrove Formation which comprises light blue-green coloured sandstones, greenish grey siltstones and mudstones, and banded coal seams which are frequently interbedded with fawn to light brown coloured tuff and tuffaceous mudstones. Major coal seams are also developed within the upper part of the Burngrove Formation and include the thick Virgo and Leo seams. At Ensham, these seams have a thickness of 4-10m.

Tertiary sediments unconformably overlie the Permian and Triassic strata and generally consist of multicoloured claystones and quartzose sandstones with bands of ironstone and silcrete forming cappings on hills and ridges rising up to 80m above the surrounding land surface.

6.1.2 Structure and Site Geology

Permian and Triassic

The controlling structural features of the Ensham deposit are the Comet Ridge to the east, and a broad south-westerly plunging syncline which trends northeast across the central part of the area. Strata dip towards the synclinal axis at generally less than 5° although some areas of flat dip have been interpreted on the flanks of the syncline. Major folding is not apparent within the open-cut areas. The Permian and Triassic rocks form a regular layered sedimentary sequence within the syncline. The project area is located near the northern end of the syncline on its eastern limb as shown on **Drawing No 3**.

The faulting identified or inferred to date has mostly been normal faulting with throws commonly less than 10m, but with some throws of up to 20m. Fault trends are mostly east-west to southeast-northwest. Some low angle thrust faults have been noted in the pit highwalls with the southern side invariably thrust over the northern side. The overthrust section is usually less than 30m horizontal with the vertical throw generally less than 5m. Slickensiding and some very minor drag effects have been noted in the immediate vicinity of the fault plane.

In the central part of the project area, the coal seams of the Upper Permian Rangal Coal Measures subcrop over most of the mine area under an up to 25m thick blanket of Quaternary alluvial deposits. The exception is the northern and southern part of the proposed mine area, beyond the extent of the alluvial plains, where the Permian and/or Triassic sediments outcrop in a form of low hills and plateaus.

The Rangal Coal Measures consist of sandstone, siltstone, mudstone, coal and tuff which, in the project area, dip to the west at an approximate angle of 3º to 4º flattening to about 1º towards the synclinal axis. Along the axis the syncline dips to the south-west at an angle of between 1º - 2º.

Deeper into the basin the coal measures are disconformably overlain by the Lower Triassic Rewan Group which predominantly consists of siltstone and mudstone, and interbeds of lithic and volcanic sandstones. The Rewan Group has been removed by erosion in the subcrop area of the Rangal Coal Measures, and in the area of A, B, C and D Pits the coal measures are either unconformably overlain by the Quaternary deposits, or outcrop directly at surface.

The main seams developed within the Rangal Coal Measures at Ensham are, in descending stratigraphic order:

- Aries (A),
- Castor (C), and
- Pollux (P) Seams.

The seam currently being mined in the open cut pits is the Aries 2-Castor Seam (A2C) which is about 4.3m thick and the Castor Seam Lower Split (C22) which is between 0.2-0.4m thick. The seams are separated by a mudstone parting which varies between 0.1m and 0.4m in thickness. The Pollux Seam which is between 6-12m below the C22 Seam, is a banded seam and is not mined in the open cut. Splitting and coalescing of some of these seams gives rise to a number of other seams. Within the Ensham Central and southern areas, the principal seams developed are the A2C and A22C Seams formed from coalescence of the Aries 2 Seam and the underlying Castor Seam. These seams have an average thickness of 5.3m and 5.0m respectively and have been identified over a strike length of some 11.5km.

Whereas the open cut mine will continue to mine a number of seams, the proposed longwall mine will mine only the A2C Seam.

At Ensham North, the Pollux Seam becomes cleaner over a strike length of approximately 5.5km. The seam averages 2.6m thick and is currently being mined at the Yongala Pit. To the north of Yongala, the Pollux Seam coalesces with the Castor seam to produce a Castor-Pollux Seam with an average thickness in excess of 4m. Other thin seams are identified above the Castor Seam.

A stratigraphic column showing seam correlation and the adopted terminology is shown on Figure 9.

The depth of the mined seams: Aries A1, Aries 2-Castor Seam (A2C) and Castor Seam Lower Split (C22), increase from the open cut areas towards the centre of the syncline to the west and south- west, and reach a depth of about 500m, 20km west of the southern end of A Pit.

The depth of weathering at the top of the Permian ranges from 10m to 20m.

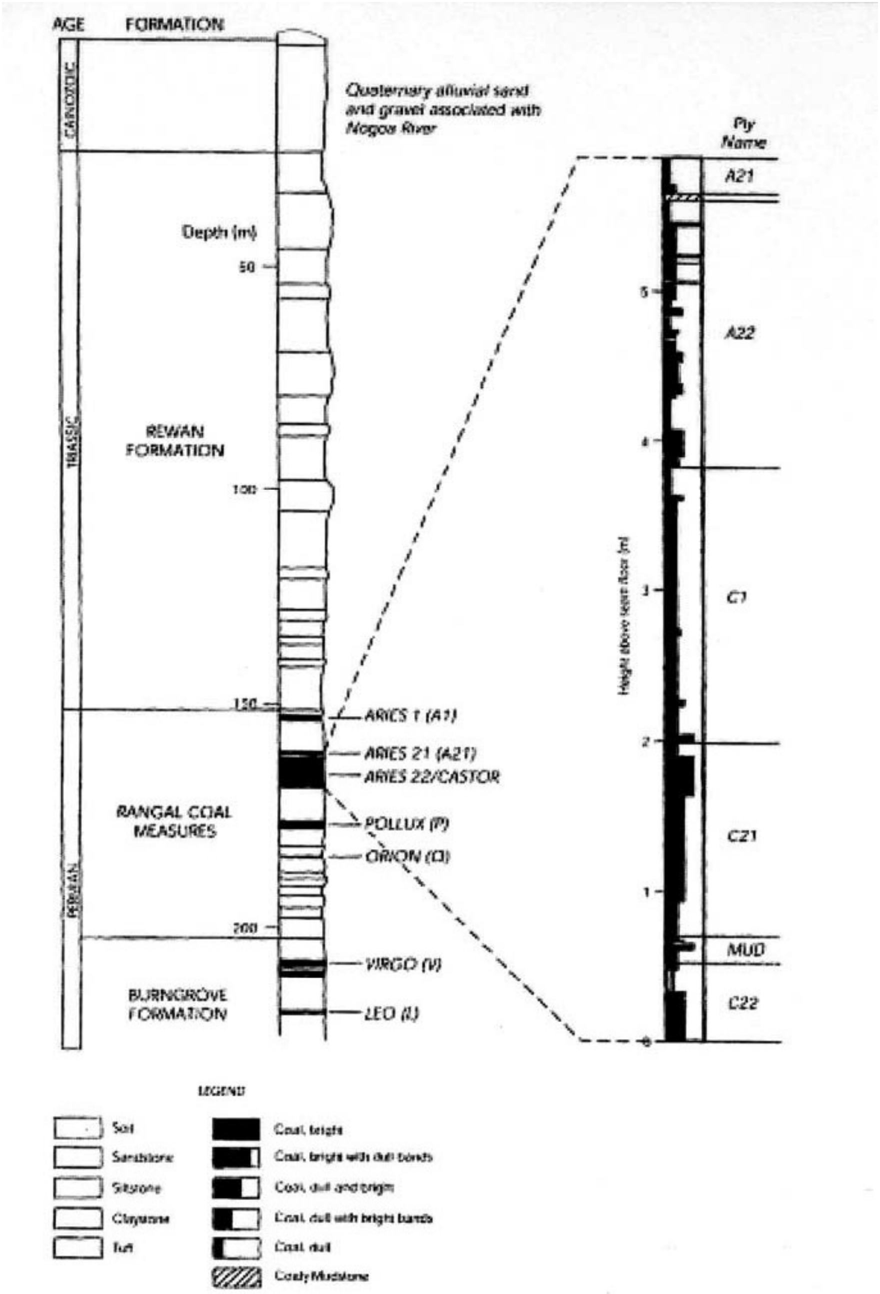

Figure 9 – Typical Stratigraphy – Central Area (after McElroy Bryan 2003)[6]

Quaternary Strata

Quaternary alluvium associated with the Nogoa River covers the central section of the proposed future minable resource, between B and D Pits and the whole of the proposed underground mining area (**Drawing No 4**). The width of the alluvial deposits varies from about 12-13km upstream, some 12km west of the lease area, to about 4km within the lease, and narrows to about 2km some 7km south-east of the lease.

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[6] McElroy Bryan Geological Services, (July 2003*), "Geological Report Ensham – Central Underground Area"* Rpt No. 214/1/1.

The lithology of the alluvium has been described in Section 5.3.1 based on the field investigation program. However on a broader scale J.B. Mining (2004)[7] state that based on lithological data from the large number of resource exploration holes drilled on a grid pattern across the alluvial plain, the average thickness of the unconsolidated Quaternary sediments in the study area is 14m, and that it ranges from 1-25m in thickness. The northern boundary of the alluvial sediments is reasonably clearly defined by a distinct thinning onto Red Hill, whereas the southern boundary is less clearly defined. The southern end of C Pit exposes the alluvium on the northern side of the Nogoa River, and the northern half of B Pit on the southern side of the river has been mined through alluvial deposits.

The generalised alluvial profile comprises a fining upwards sequence. The upper part of the alluvium is generally soils and clay which J.B. Mining (2004)[7] state averages 2m in thickness and ranges from 0.1m to 10m. This upper section is described as clayey and silty with some sand content, and is dark brown to yellow in colour. It is underlain by quartzose sands and gravels which form the bulk of the alluvium, with less dominant sandy silt and clay. J.B. Mining (2004)[7] describe the sand and gravel, as silty and clayey, grading into a basal section of predominantly clean gravel or coarse to medium grained sand. A section of the alluvium exposed in the pre-strip of B Pit is shown on Figure 1.

6.2 Aquifer Systems

The principal aquifers[8] in the project area are associated with the Permian coal seams and with the Quaternary alluvium. The distribution and hydraulic properties of these aquifers are influenced by the geology of the region.

6.2.1 Permian Aquifers

Distribution

The coal seams are confined aquifers which generally exhibit relatively low transmissivity and recharge rates. Groundwater storage and movement occurs within the coal seam cleats and fissures, and within fractures associated with faults intersecting the seams. Other sediments in the coal overburden and interburden sequence are usually relatively impermeable and form aquitards. Some Permian sandstones yield minor groundwater although in the section of the coal measures to be mined, these are rare.

The Permian strata may therefore be categorised into the following hydrogeological units:

- hydrogeologically “tight” and hence very low yielding to essentially dry sandstone and siltstone that comprise the majority of the Permian interburden/overburden;
- low to moderately permeable coal seams which are the prime water bearing strata within the Permian sequence.

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[7] J.B. Mining Services Pty Ltd (April 2004), *“Geology of the Nogoa River Corridor Area”.*

[8] An aquifer is defined as a groundwater bearing formation sufficiently permeable to transmit and yield water in useable quantities.

Groundwater Flow (Yield)

Airlift flow rates were measured in the majority of the 85 holes drilled on a 500m grid across the floodplain, as part of the 2003 resource evaluation program. As the Quaternary alluvium was pre-collared, it is considered that the Quaternary did not contribute to the flow. The holes were drilled to the base of the Pollux Seam and the flow rate is therefore a composite of the Aries, Castor and Pollux Seams, with the majority of flow probably being derived from the seam of major thickness; the A2C seam. Boyd Mining Pty Ltd (1991)[9] state that based on airlift testing at the D Pit area, the A2C Seam yielded between 0.75-1.1L/s and is *"regarded as the prime regional coal seam aquifer"*.

The flow rates were measured using a V-notch weir from open holes during drilling in 2003 and were reported as height (mm) above the weir. The data converted by AGE to flow (yield) in litres per second indicate yields ranging from less than 0.1L/s up to a maximum of about 2.6L/s. The occurrence of higher inflow appears to be random and not related to any structural features such as faults. Higher inflows occur to the west, due to a greater piezometric head in the coal seams, that is, where the coal seams are deeper and have not been impacted (partially depressurised) by the open cut pits.

Hydraulic Parameters

A review of previous studies undertaken at Ensham suggests that there has not been any site specific hydraulic testing of the coal seam aquifers. In the absence of site specific data a literature research was undertaken of studies undertaken of coal seam permeability in both the Hunter Valley and in the Bowen Basin.

Australian Groundwater Consultants Pty Ltd (1984)[10] undertook a study of coal mines in the Upper Hunter Valley and reported that a reduction of the hydraulic conductivity of the coal seam with depth is observed in many coal mines. They observed an exponential decline in hydraulic conductivity with depth of the coal seams as shown on Figure 10. The general equation for the decline in the hydraulic conductivity with depth developed by them was in a form of:

$$k=k_o \text{ x } \exp^{(-0.046 \text{ x } z)}$$

Where: k_o = base hydraulic conductivity near surface (m/day), and

Z = depth of the coal seam (m)

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[9] Boyd Mining Pty Ltd (Dec. 1991), *"Geotechnical Investigation for Pit D Design, Ensham North"* Ref. ENS01G.R02.

[10] Australian Groundwater Consultants Pty Ltd, (June 1984), *"Effects of Mining on Groundwater Resources in the Upper Hunter Valley",* New South Wales Coal Association.

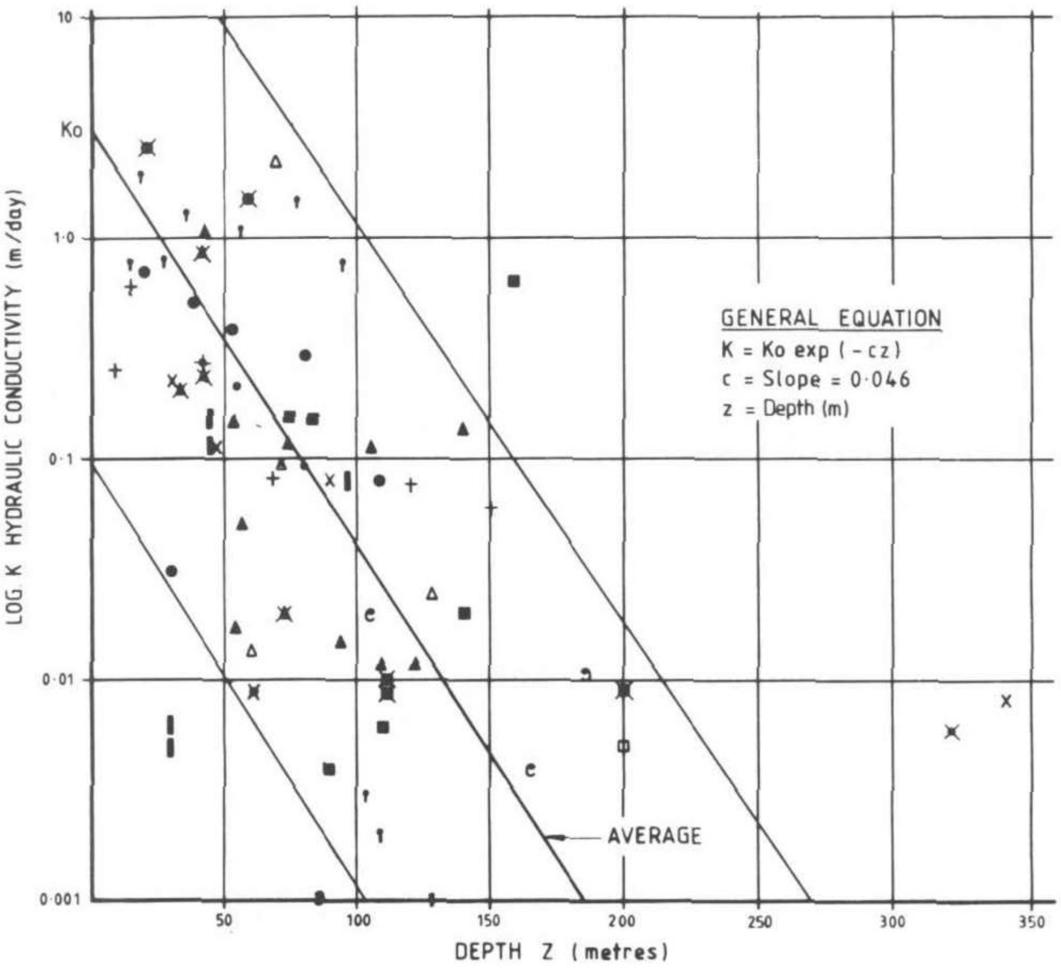

Figure 10 – Coal Seam Hydraulic Conductivity versus Depth (Hunter Valley)

Wold and Esterle (2000)[11] have similarly demonstrated a decline with depth in the hydraulic conductivity of the Bulli Seam in the Sydney Basin as shown in Table 10.

Table 10: COAL PERMEABILITY, BULLI SEAM SYDNEY BASIN **(After Wold And Esterle, 2000[11])**		
	Hydraulic Conductivity (m/day)	
Depth (m)	*Bright Coal*	*Dull Coal*
200	0.668	0.017
400	0.167	0.008
600	0.075	0.006

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[11] Wold, M.B. and Esterle, J., (August 2000), *"Measurements of Permeability, Fracture Density and Coal Petrology on Bulli Seam Core in the Conext of Gas Outburst Risk Assessment",* CSIRO Petroleum Restricted Report No 00-004, CSIRO Australia,16pp.

A similar decline in hydraulic conductivity has also been documented[12] for the coal seams of the Warrior Basin in the USA as well as for the Moura coal mine in the Bowen Basin. A plot of changes in permeability of the coal seams in Warrior Basin and in Moura mine with depth is shown in Figure 11.

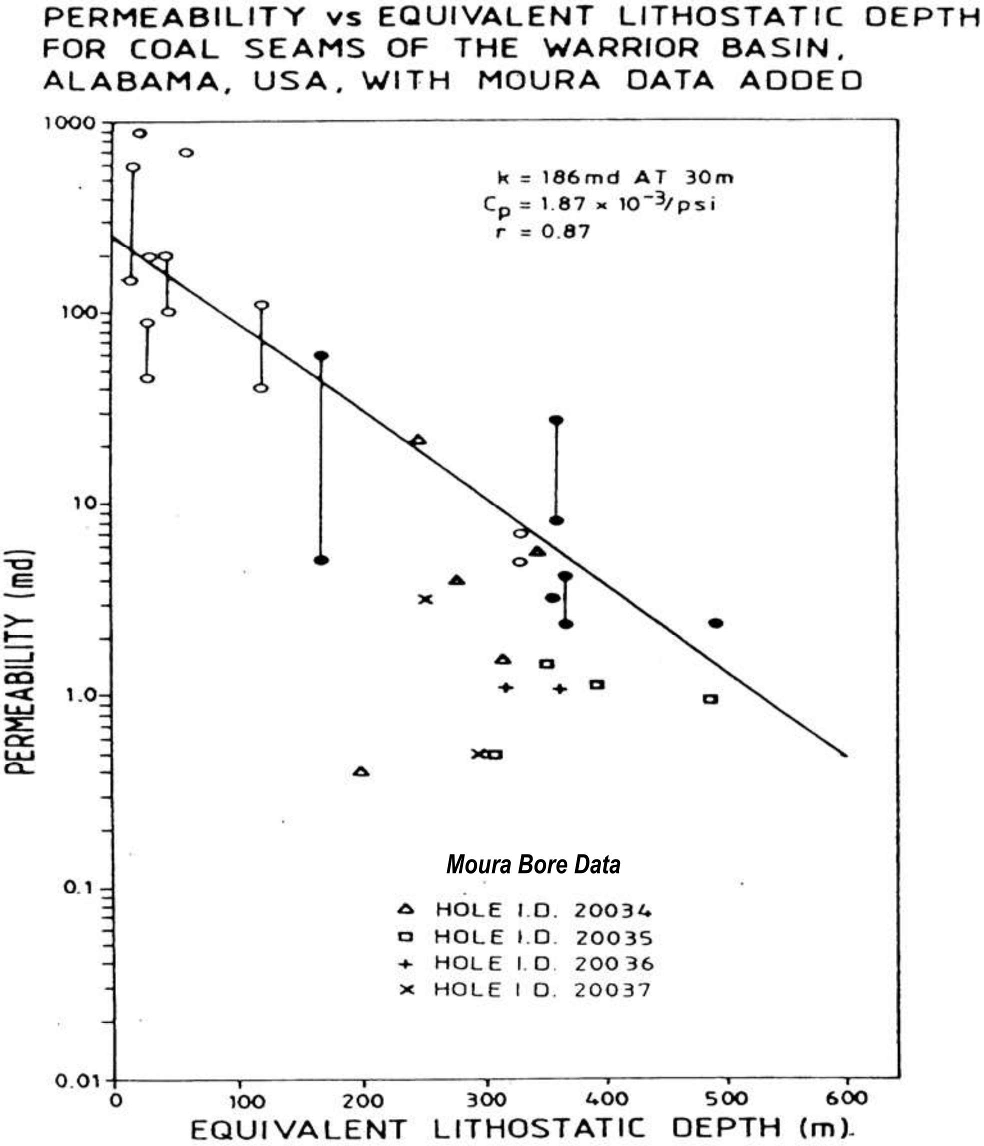

Figure 11 – Coal Seam Permeability versus Depth (USA and Moura)

The above figure shows a decline in coal permeability of about two orders of magnitude with an increase in depth; from about 150md[13] (0.12m/day) at 50m depth to about 5md (4.2×10^{-3}m/day) at depths of 300m to 400m.

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[12] Australasian Groundwater and Environmental Consultants Pty Ltd, (2004), *"Report on Moura Mine 68 Area, Evaluation of Hydrogeological Issues",* Project No. G1231.

[13] 1md (millidarcy) = 9.66×10^{9} m/sec = 8.346×10^{4} m/day

Data from various other studies indicated that:

- pumping test results in the South Blackwater area indicate the existence of impermeable boundaries in the coal seams;
- pumping tests conducted in the Marshmead area indicate multiple impermeable boundaries surrounding test bores.

This would suggest that faulting does compartmentalise the coal seam aquifers and that the faults are essentially impervious to groundwater flow.

The available water levels data within the project area does not indicate any obvious compartmentalisation of the coal seam, but this may in part be due to the level of accuracy of the measurements.

Piezometric Elevations and Discharge
Boyd Mining (1991)[9] state that prior to commencement of mining, standing water levels in the coal seam aquifers in the C and D Pits area north of the river indicated a clear hydraulic gradient from north to south. This corresponded to the general direction of surface drainage away from the coal subcrop and recharge areas, towards the Nogoa River.

Standing water level data were obtained from geophysical logs of the exploration bores across the whole northern end of the syncline. The data, while not accurate in detail because of the measurement method, (different dates of measurements, and measurements conducted in open holes) indicate the general direction of regional groundwater flow. The water levels, after removal of obviously anomalous data, are shown on **Drawing No 5**. The data indicate that the direction of the groundwater flow is towards the Nogoa River from an elevation of about RL 170m to 180m in the north to about RL of 135m in the south-east.

It appears that regional groundwater levels in Permian aquifers may be at a somewhat higher elevation than those in the alluvial aquifer, and therefore the alluvium appears to be the discharge zone for the Permian aquifers, as concluded in Section 5.4.1. However, since the groundwater elevations obtained from geophysical logs are not as accurate as those measured in piezometers, the absolute difference in elevations is not certain.

On a local scale around the existing open cut pits water levels or piezometric elevation in exploration holes were contoured by AGE and indicated higher elevations of up to RL 142m in the southern part of the lease area between Winton Creek and the Nogoa River, and up to RL 138m on the western side of the area. The groundwater flow direction is from these areas of higher elevation to the north and east, that is, towards the open cut pits which have lowered the pre-mining water level, reversing the flow gradient. Locally discharge is from the coal seams into the pits.

Groundwater Quality
During 1985 groundwater samples were obtained from exploration holes in selected coal seams in the open cut area and analysed, as summarized on Table 11. The analytical data indicates that the coal seams contain variable but generally very poor quality water with a high concentration of salts. The electricity conductivity varies from 11700-26700μS/cm and as such the water is unsuitable for stock and domestic consumption or irrigation purposes. The water is alkaline with pH generally in the range 7.90-8.35, and the principal ions are sodium and chloride.

Similarly water quality data from samples of the coal seam aquifer collected during the 2003 exploration drilling program indicates a conductivity range from about 6000-24000μS/cm (about 4000-16000mg/L TDS), with the majority of samples being in excess of 14000μS/cm (9400mg/L).

Table 11: GROUNDWATER QUALITY – COAL SEAM

Sample AQC – Pacific Bore No.		R1481	R1484	C1504	C1505	RI508	R1510	R1523
pH	pH unit	8.06	7.91	7.90	6.70	7.88	8.13	8.04
Specific Conductance at 20°C	(μS/cm)	15,100	15,000	25,700	26,700	16,100	11,700	13,200
Alkalinity	(mg/L)	443.8	573.8	621.9	578.0	417.5	248.8	416.3
Sodium	(mg/L)	2200	3100	6000	6250	3600	2250	2550
Calcium	(mg/L)	354	460	540	560	500	320	500
Magnesium	(mg/L)	450	650	900	970	620	480	450
Potassium	(mg/L)	18.0	22.3	37.0	43.0	43	19.3	21.8
Chloride	(mg/L)	4313	6181	11193	11854	6742	4473	5161
Sulphate	(mg/L)	276.5	431.5	852.6	913.5	708.6	288.9	365.4
Strontium	(mg/L)	15	21	25	21	14	15	26

6.2.2 Alluvial Aquifer

Distribution
The Nogoa River and its major tributaries traverse the study area in a general south-easterly direction. They are contained within a broad alluvial floodplain varying from about 3km wide in the area between B and C Pits, up to 5km wide on the western boundary of the study area (**Drawing No. 3**). The general elevation of the floodplain grades from west to east, across the study area, from about RL 155m to RL 150m; and significant areas are liable to periodic flooding.

The alluvium averages about 14m in thickness and varies from 1-25m in thickness. It thins out completely to the north and north-east against dissected and eroded low hills and plateau remnants of Triassic/Permian outcrop and subcrop. The southern extent of the alluvium corresponds to an extensive broad low rise corresponding to A Pit and to the southern end of B Pit.

The alluvium forms an unconfined aquifer system consisting of fine to coarse grained sand and gravel. Lithological data from the field investigation and exploration holes reviewed by J.B. Mining (2004)[7], indicates that the base of the alluvium is deepest (minimum RL 134m) in the area corresponding to the island formed by the river and its anabranch (**Drawing No 2**). Only the basal part of the sandy and gravely deposits is saturated, the saturated zone varying between 0m and 3.8m thick. The base of the sand and gravel unit is marked by residual mudstone weathered to silty clay typically in the order of 1m thick. The silty clay is overlying weathered grey mudstone of Permian age.

Groundwater Flow (Yield)
There is no information available on the yield from the alluvial aquifers. Only one bore, G2 (RN90430) on the island formed by the anabranch, is known to extract small quantities of water for stock watering, supply to the Duckponds houses and supply to construction camps. Since about 1991 the extraction from this bore averaged between 0.31L/sec and 0.35L/sec

(7,000gal/day and 8,000gal/day), with the bore being pumped at a rate of about 1.2L/sec (1,100gal/hr).

The results of the field investigation program (Section 4.0) indicate that in general the alluvium is very low yielding due to the small saturated thickness and sporadic nature of saturation.

Hydraulic Parameters
The results of falling head permeability (slug) tests of the alluvial aquifer and of a visual assessment of the basal sands and gravels undertaken during the field investigation are described in detail in Section 5.3.4 of this report. In four of seven slug tests the hydraulic conductivity (permeability) of the aquifer was too high to be analysed, indicating that the permeability of the alluvial deposits is highly variable. It was concluded based on the slug tests and visual assessment that the permeability of the alluvial deposits varies between about 0.4m/day and 100m/day.

Golder Associates (1990)[14] state that *"a previous pump test* (borehole G1840) *was run for 72 hours at a constant flow rate of 1.8L/s"*, and that *"falling head permeability (hydraulic conductivity) tests and the pump test analysis gave permeability values in the sand gravels ranging from* 10^{-3} *to* 10^{-5}*m/s"*. This is equivalent to permeability of 0.7 to 86m/day and is similar to the range obtained from the field investigation.

Subsequently Ensham Resources (1991)[15] report that *"in order to provide permanent sites for the assessment and monitoring of water flows and levels within the alluvial gravels adjacent to the Nogoa River, one large diameter borehole and three slim boreholes were drilled at each of two sites south of the river"*. The slim boreholes were placed at 10m, 20m and 30m respectively from the test bore to allow measurement of water level changes during drawdown tests. Relevant data for each site are summarised in Table 12 below.

Table 12: TEST BORE DATA

Site	Co-ordinates		Alluvial Thickness	Sand/Gravel (mbns)	Yield (L/s)	Comment
	mN	*mE*				
A (G1?)	7400200	653000	18.0	10-18	1	
B (G2?)	7402340 (7402222)	651250 (651351)*	17.0	11-17	8	Currently used for mine/farm water supply

*recorded by GPS during site visit on 14 April 2004
? = assumed to be Ensham monitoring bores G1 and G2, (see Section 6.0)

Hydraulic parameters for these two sites were not recorded by Ensham (1991)[15], however in a subsequent report Hollingsworth, Dames and Moore (1991)[16] state that *"permeability and specific yield of the recent sand and gravels aquifer determined from a pumping test were 130m/day and 0.1 respectively"*.

Based on the above reported data, it would appear that the clean, basal sands and gravels which the data suggests is the principal saturated material of the alluvium, has a high permeability, in

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[14] Golders Associates, (Jan. 1990), *"Ensham Coal Project Geotechnical Studies",* Ref.8938223(B).

[15] Ensham Resources Pty Ltd, (May 1991), *"EP505C Ensham, Report for the Six Months Ended 7 May 1991"*

[16] Hollingsworth, Dames and Moore, (Nov. 1991), *"Ensham Coal Project, Final Impact Assessment Study",* Ref. 22353-002-362.

the range 86-130m/day with an average of say 100m/day. This is consistent with published data on the permeability of such aquifer material.

Piezometric Elevations and Discharge

As discussed NRMW established a line of monitoring bores in the alluvium to the west of the pits in 1995[3], and have undertaken regular monitoring of these bores to the present time. The bore locations are shown on **Drawing No 2**. The line is in the middle of the project area and extends from the anabranch to south of Duck Ponds Lagoon. The water level monitoring data from the bores is summarised in Table 13 below and the hydrographs are shown on Figure 12.

Table 13: SUMMARY OF NRMW MONITORING BORE DATA

Bore	Location		RLm AHD		Static Water Level			Comments
	mE	*mN*	*Ref. Level*	*Natural Surface*	*Date*	*m.b.Ref. Level*	*RL (mAHD)*	
13020**176**	651043	7402968	153.92	153.33	1 Oct '02	15.20	138.72	
13020**177**	650552	7402464	154.37	153.91	4 Mar '04	15.52	138.85	Dry – bottom of hole
13020**178**	650040	7401374	153.97	153.41	4 Mar '04	13.89	140.08	
13020**179**	649919	7400548	152.37	151.90	4 Mar '04	12.00	140.37	Dry – bottom of hole

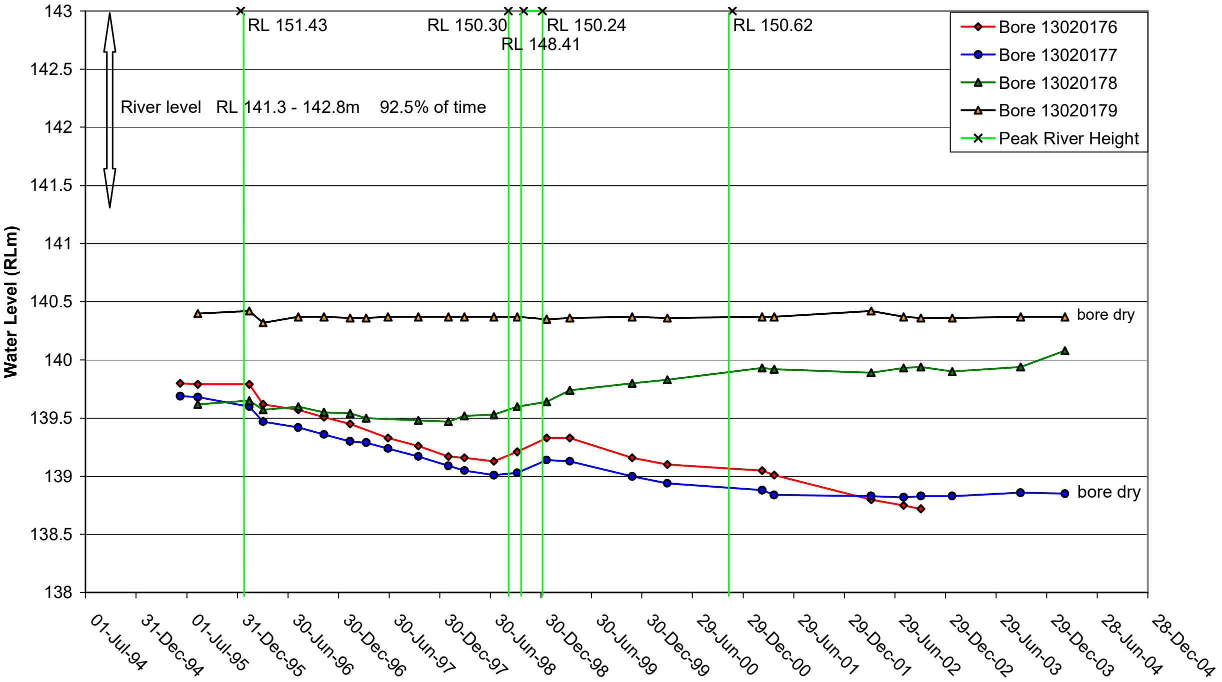

Figure 12 – Alluvium Water Level Data - NRMW Monitoring Bores Middle of Lease Area

The data indicates that along the line Bore 13020**179** has been dry since it was first installed. Bores 13020**176** and 13020**177** located on the island between the anabranch and the Nogoa River have shown a steady decline in water level since commencement of monitoring in mid 1995, with the exception of a minor increase in water level in December/January 1998-99. The steady decline in water levels may be due to pumping from the nearby bore G2 by the mine, or it may be due to drainage into C Pit, although this is unlikely as there is no evidence of seepage from the alluvium into the pit, and it would appear that the base of the pit is above the level of the water table. Bore 13020**178** located between Winton Creek and the Nogoa River has shown a steady rise in water level of about 0.6m since December 1997, which may be related to irrigation.

Based on the above data and data from the monitoring bores installed along the river as part of the field investigation program (Section 5.0), groundwater levels in the alluvial aquifer are about RL 141m at the upstream, western limits of the proposed open cut area declining to about RL 135.5m near current limit of the B Pit. The direction of the groundwater flow appears to be from west to east in agreement with the slope of the ground surface and similar to the flow in the Nogoa River. Dewatering of the aquifer by B Pit has locally modified the direction of groundwater flow in the area of the pit to a south-east flow.

The current elevation of water levels in the alluvial aquifer within the project area, appear to be between about 1m and 6m below the water level in the Nogoa River. This indicates that, under current conditions, there is no discharge of groundwater from the alluvial aquifer into the river within the project area as concluded in Section 5.4.2.

Also, as discussed in Section 5.4.1, the saturated thickness of the alluvial deposits varies between 0m and 3.8m depending on the elevation of the basement Permian.

In order to assess groundwater level response to river levels and in particular to flood events, data from the NRMW gauging station No. 130219A – “Nogoa River at Duck Ponds” were assessed. The gauging station data indicates that since commencement of monitoring at the site in April 1993:

- The maximum river height during flooding was 11.010m above gauge zero (140.77m)[17] in the March 1994, that is, RL 151.78m;

- For 92.5% of the time the river height is between RL 141.32m and RL 142.77m, that is, an average height of say RL 142m.

The gauging station data indicates that given a river height of around RL 142m, the river level is higher than the groundwater level in the surrounding alluvial aquifer (RL 139-140m) in the middle of the project site, confirming the data obtained from the investigation program outlined in Section 5.0.

With respect to flooding events peak river heights between July 1993 and June 2002 were obtained from the gauging station data and summarised, as shown on Table 14.

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[17] Note: NRMW used an assumed gauge zero of 47.200m for Station No. 130219A; however, the station was surveyed to AHD by surveyors associated with the drilling program at Ensham to enable actual stage heights to be obtained.

Table 14: NOGOA RIVER – PEAK LEVELS

Period	No. of Days	Peak Level (mAHD)
2/3/94-16/3/94	14.0	151.78
8/1/96-15/1/96	6.2	151.43
29/8/98-6/9/98	8.5	150.30
25/10/98-2/11/98	8.4	148.41
29/12/98-11/1/99	12.9	150.24
12/11/00-28/11/00	9.6	150.62

Note: No. of days refer to days water levels exceeded RL 142.77m, that is, the upper end of the normal range.

The peak river levels are also plotted on Figure 12. The hydrographs of the line of bores show little if any response of groundwater levels to river flooding, that is, peak heights in the river level are not reflected by a rapid response in groundwater levels, suggesting relatively poor infiltration of flood waters via the overlying silty clay to the basal gravel.

Groundwater Quality
The groundwater quality of the alluvial aquifer is discussed in Section 5.3.3. The results of the analysis indicate that groundwater in the alluvium is generally of poor to very poor quality with TDS varying between 1,110mg/L and 28,200mg/L, and as such is similar to the water from the coal seam aquifer.

7.0 REGIONAL GROUNDWATER USEAGE

A search was undertaken of the NRMW bore database to identify registered bores within a 15km radius of the mine. The location of the registered water bores are shown on **Drawing No 4** and the relevant details are summarised in Table 15 below.

The database indicates that within the alluvial plain area of the mine site and immediate surrounds, the only registered bores are monitoring bores established by NRMW and by Ensham Resources. As discussed in Section 5.1 NRMW established two north-south orientated lines of alluvial aquifer monitoring bores across the floodplain, viz:

- Bores 13020**169** to 13020**175** along the western side of the lease, and
- Bores 13020**176** to 13020**181** in the middle of the lease area.

The bores were constructed to *“determine whether there is any interconnexion* (sic) *between groundwater and surface water flows in the river”* and are currently monitored by NRMW two to three times per year.

Ensham Resources also established monitoring bores G1 (RN90429) and G2 (RN90430) which are monitored regularly as part of their license conditions. An existing bore on the island formed by the Nogoa River and the anabranch is fitted with an electrical submersible pump and is used by Ensham Resources for stock watering, supply to the Duckponds houses and supply to construction camps. It is considered that this may be Bore G2. Since about 1991 the extraction from this bore averaged between 0.31 - 0.35L/sec (7,000 and 8,000gal/day), with the bore being pumped at a rate of about 1.2L/sec (1,100gal/hr).

Stock and domestic bores do not have to be licensed so the NRMW database may not list all bores in the region. Discussions were therefore held with landholders to determine if any bores that had not been registered with NRMW were present within 15km of the mine. Six unregistered private bores were identified on Property No.'s 72, 73, 74 and 75 and are shown as bores 1, 2 and 4-7 on **Drawing No 4** with details provided in Table 15.

Bore 7 was the only one of these bores in use at the time of an inspection in November 2005. Bore 7 is equipped with an electric submersible pump and is used for stock watering purposes. Registered bore 38845 on Property No. 73 is also equipped with a submersible pump but was not operational at the time of the inspection. The remaining bores on private properties are not equipped with pumps. Bores 1 and 2 were both formerly equipped with windmills which have since been removed. Bores 5 and 6 were drilled as part of the coal exploration program by Ensham and cased with PVC. These bores have not been equipped since installation. Bore 4 is cased with PVC and is also not equipped.

Bore 5 is relatively shallow at 18m depth and is likely to be constructed in the alluvial aquifer. All other bores on private property are significantly deeper and likely to be installed in the coal measures that underlie the alluvium.

In addition to the six unregistered private bores there are also two registered bores within a 15km radius of the project. Registered bore RN38845 on the Property No. 73 is the closest registered bore not associated with the mine. The bore is in excess of 5km to the west and south-west of any existing or proposed mine operations. The NRMW database indicates that the bore was drilled in 1900 and was tested in 1972. The depth is not recorded. It yielded 0.6L/s of very poor quality water; EC 8200µS/cm. This quality indicates it could be sourced from either a coal seam or the alluvium. It has been used for stock watering only.

The second registered bore on private property (RN 62511) is located on Property No. 115 south of the Capricorn Highway and approximately 13.5km from the project area. The bore site was inspected in November 2005 in the company of the landholder at which time the pump was not operating. An obstruction in the bore prevented the collection of groundwater samples and the measurement of water levels. A sample of groundwater that had been pumped into a holding tank for stock watering before the pump failed was collected for analysis. The analysis indicated a slightly brackish water quality (TDS 2,240 mg/L) suitable for stock watering.

The lack of bores in the alluvium is consistent with the findings of this study that the alluvial aquifer is low yielding and contains a very limited amount of poor quality groundwater in localized areas at the base of the aquifer. Similarly the coal seam aquifers are poor yielding and of poor quality and are sparsely used.

Table 15: GROUNDWATER BORES WITHIN 15KM RADIUS OF MINE

Registered Number	Drilled Date	Status	Property Name	Depth	Quality	Yield (L/sec)	SWL (mbgl)	Formation	Aquifer Type
Registered Bores									
37512	-	Abandoned	-	392	Salty	0.13	54.3	-	Sub-Artesian
38845	1900	Existing	-	68.9	8200µS/cm	0.6	57.3	-	Sub-Artesian
47121	1976	Abandoned	Stewart Park	97.6	Salty	-	-	Fair Hill Formation	Sub-Artesian
62511	-	Existing	Karanga (Vandersee)	-	2800µS/cm	<0.5	-	-	Sub-Artesian
67026	-	Existing	Freshfields	70	-	-	-	-	Sub-Artesian
84403	1988	-	-	60	-	-	Dry	-	-
84531	1982	Existing	Comet Town Water Supply	39.5	3460	10.1	-12	Basalt	Sub-Artesian
89260	1992	Existing	D-Marc	-	6451	1.1	-21	Basalts & Coal Meas.	Sub-Artesian
89381	1992	Existing	Yongala Mine	103	Brackish	2	82.49	Rangal Coal Measures	Sub-Artesian
89382	1992	Existing	Yongala Mine	69	Brackish	5	52.54	Burngrove Formation	Sub-Artesian
89383	1992	Existing	Yongala Mine	68	Brackish	5	53.47	Burngrove Formation	Sub-Artesian
89384	1992	Existing	Yongala Mine	67	Brackish	5	54.62	Burngrove Formation	Sub-Artesian
90429	1991	Existing	Ensham Resources Pty Ltd	-		-	-	-	Sub-Artesian
90430	1991	Existing	Ensham Resources Pty Ltd	-	2980µS/cm	-	-	-	Sub-Artesian
100037	1992	Existing	-	684				-	Artesian
100169	1993	Existing	-	-	-	-	-	-	Artesian
103027	1997	Existing	-	30.7	1900	1.1	-21	Basalt	Sub-Artesian
103272	-	Existing	Ensham Resources Pty Ltd	17.52	4500µS/cm	-	15.17	Nogoa River Alluvium	Sub-Artesian
103371	1982	Abandoned	Comet Water Supply Test Hole	25	1650	0.6	-	Basalt	Sub-Artesian
103372	1982	Abandoned	Comet Water Supply Test Hole	23	-	-	-	Basalt	-
103373	1982	Abandoned	Comet Water Supply Test Hole		880µS/cm	0.3			Sub-Artesian
103685	2003	Abandoned	Karvella	110	-	-	-	-	-
103754	2003	Existing	Comet River Hotel	59.4	2000µS/cm	2.2	-	Basalt	Sub-Artesian
103788	2003	Existing	Conmurra	65.5	2160µS/cm	1.8		Fair Hill Formation	Sub-Artesian
13020198	2004	Existing	-	66	-	-	-	Back Creek Group	Sub-Artesian
Unregistered Bores									
1	-	Collapsed to 15m	The Bauhinias (Little)	80	-	0.36	dry	Coal measures	Sub-Artesian
2	-	Existing	The Bauhinias (Little)	44.8	1740µS/cm	0.42	9.59	Coal Measures	Sub-Artesian
4	-	Existing	The Bauhinias (Little)	60	4920µS/cm	0.91	20.2	Coal Measures	Sub-Artesian
5	-	Existing	The Bauhinias (Little)	18	4180µS/cm	0.55	10.1	Alluvium	Sub-Artesian
6	-	Existing	The Bauhinias (Little)	90	2860µS/cm	-	45.36	Coal Measures	Sub-Artesian
7	-	Existing	The Bauhinias (Little)	-	2880µS/cm	-	-	Coal Measures	Sub-Artesian

8.0 CURRENT MINE OPERATION AND PROPOSED EXTENSION

The open cut coal mine operated by Ensham Resources currently produces up to 12Mtpa of thermal coal. The mine is using three draglines to remove the overburden and truck and shovel, or excavator, to remove coal.

Ensham Resources is proposing to expand the existing operations and mine coal simultaneously from a line of pits over a length of about 23km, from A Pit in the south to Yongala Pit in the north. The project also includes plans to develop an underground longwall mine under the Nogoa River alluvial floodplain. The expansion of the operation will increase production up to 20Mtpa.

The location of the proposed and existing operations is shown on **Drawing No 6**.

Currently mining is conducted by dragline and truck and shovel operations in A to D Pits. The mined seams include the Aries A1 Seam, Aries 2-Castor Seam (A2C) which is about 4.3m thick and the Castor Seam Lower Split (C22) which is between 0.2-0.4m thick. The seams are separated by a mudstone parting which varies between 0.1m and 0.4m in thickness. The Pollux Seam (P) which, in the Ensham Central area, is between 6-12m below the C22 Seam, is a banded seam and is not mined in A to D Pits; however it is mined at Yongala where it is cleaner and close to the C22 Seam. In places where the underlying Orion (Q) Seam is less than 0.2m below the P seam, and where the quality of this seam is acceptable, the Q seam is also planned to be mined.

Whereas the open cut mine will continue to mine the above seams, the proposed longwall mine will mine only the A2C seam. While the seam is about 5m thick, only a 4.5m thick section will be mined.

The location of the draglines used for open cut mining for the project will be based on the mining plan shown on **Drawing No 6**. Extraction will be conducted in 60m wide strips. The waste rock (spoil) from the over and inter-burden will be placed in the mined out strips. The mined out strips will be backfilled generally about six months after completion of mining, except in the areas adjacent to Nogoa River where they will be backfilled about a year after completion of mining[18]. The river floodplain will be reinstated to approximately the pre-mining level with the top 10m of spoil in the floodplain being compacted to a permeability with a range 10^{-5} – 10^{-6} m/sec, to prevent infiltration of flood waters. Alternatively a surface treatment may be used which provides a similar low permeability seal at the surface of the re-instated floodplain.

At the maximum production rate open cut mining will be completed between Years 12 and 14 in most of the pits except C Pit where it will continue until Year 16. The corresponding mining schedule is shown on **Drawing No 6**.

At the completion of mining, final open voids will remain in all pits. Most of the voids will remain along the western limits of the open pits except B, C and D Pits. In B Pit, the final void will remain only along the access ramp, whereas in C Pit it will remain along the eastern side of the pit, along the last strip to be mined in Year 16. The D Pit final void will remain along the northern access ramp and the most northerly mining strip to be mined in Year 13. The proposed location of the final voids is shown on **Drawing No 7**.

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[18] Peter Bannister, Ensham Resources Development Manager, personal communication (August 2005).

Longwall mining will commence in Year 4 although construction of the drifts will commence in Year 1. By Year 3 access drifts for the first longwall panel S1 will be completed. Longwall panel S1 will commence where the depth of cover between the base of alluvium and top of coal seam is about 135m, that is, about 155m below ground level, and panels S2 to S12 will generally proceed down-dip to the north-west with increasing cover thickness. Panels S13 to S15 will be up-dip from panel S1, to the south-east, and will have a shallower depth of cover. Extraction within the longwall panels, each 300m wide, will progress up-gradient from south-west to north-east. Gateroads will be completed one to four years in advance of commencement of the longwall operation. All longwall mining will be completed by Year 14. The proposed location of the longwall panels and mining schedule is shown on **Drawing No 6**.

9.0 IMPACT OF MINE SUBSIDENCE ON GROUNDWATER

As discussed in Section 8.0 longwall mining will commence at a depth of about 155m below natural surface, that is, about 135m below the base of the alluvium. This section of the report discusses the potential impact of goafing and subsidence on the hydrogeological regime.

9.1 Generic Description of Strata Disturbance Zones

Longwall extraction results in collapse of the overlying rock strata into the void left by coal extraction. The collapsed or disturbed overburden material is referred to as the goaf. The collapse propagates upwards from the extracted seam until bulking of the goaf limits vertical movement and the tensile strength of the rock strata is sufficient to hold up the overburden without failure. The concept of the strata disturbance zone as defined by Kendorski (1993)[19] is illustrated on Figure 13.

Kendorski (1993)[19] defines five zones in the goaf as summarised below:

- Caved Zone: This is the zone of complete disruption of broken and rubble-sized strata extending to 2 to 10 times (2t to 10t) the seam thickness in height above the caving roof.

- Fractured Zone: This zone occurs above the caved zone to a height of 24t to 30t. The strata does not fall and detach but cracks and settles, resulting in fractures extending through individual beds, opening of bedding planes and shearing and dislocation of beds. The caved and fractured zones have increased vertical and horizontal transmissivity and storativity and both attributes decrease exponentially with height above the seam roof.

- Dilated Zone: This zone is often referred to as the “Aquiclude Zone”. In this zone the strata sag allowing bed separations, but not allowing connecting fracturing and drainage into the mine. It occurs at a height of 30t to 60t or greater. The water level of aquifers located in this zone may be lowered in response to the relatively rapid increases in void space laterally, that is, due to an increase in storage volume, but the water level generally recovers given sufficient time, as the voids are filled.

- Constrained Zone: This zone occurs where the extracted seam is deeper than 60t plus about 15m, and is characterised by overall tensile strains of less than 1mm/m, a stress level at which rock masses are not disrupted sufficiently to increase their permeability. Hence there is no

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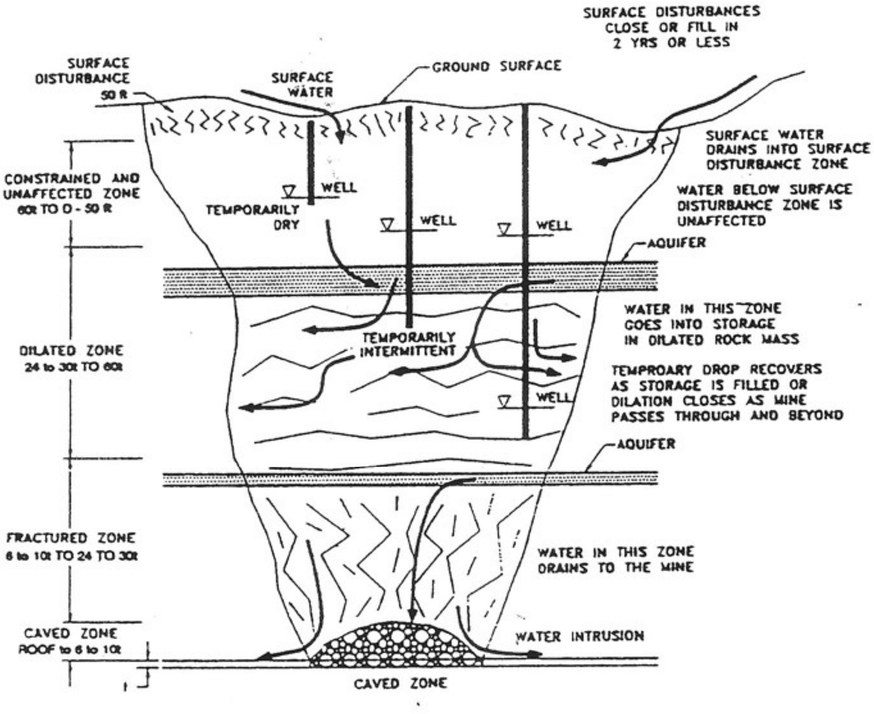
[19] Kendorski F.S., (1993), *“Effect of High-Extraction Coal Mining on Surface and Ground Waters”*, 12th Conf. on Ground Control in Mining 3-5 Aug 1993.

significant change in transmissivity or storativity and therefore aquifers, which occur in this zone, are largely unaffected.



after Kendorski (1993)

Figure 13 – Schematic Subsidence - Groundwater Inflow Model

- Surface Fracture Zone: The surface fractures generally relate to panel and trough edges and extend to a depth of about 15m. If transmitted into soils, the soil properties may allow little or no crack development due to the plastic and non-brittle nature of many soils. If in rock, the natural pre-existing fracturing will be dilated, having little effect on continuity. The cracks are transmissive zones and the increased void space may result in a temporary lowering of shallow groundwater levels as the voids fill. The cracks will not provide pathways for deeper migration of groundwater unless extending into the "fracture zone". This may happen where the "dilated zone" is absent due to shallow mining, that is, shallow overburden thickness. Surface cracks also generally fill quickly with sediment or close due to spalling.

The subsidence zones of Kendorski described above are generic and are based on super critical extraction. They provide a general overview of what can occur, however the depth of cover, overlying stratigraphy and panels widths vary between mines and each of these factors have to be taken into account in assessing the subsidence impact at a specific mine site. The following section provides an assessment of subsidence impact on the groundwater regime at the proposed Ensham Central longwall mine.

9.2 Assessment of Impact of A2C Seam Subsidence

The proposed longwall mine will mine only the A2C Seam which is about 5m thick. The longwall panels will be 300m wide and a 4.5m thick section of the seam will be extracted along each panel. Water will enter the mine and drain from any overlying aquifers or surface water body if vertical fracturing intersects the water body. The Kendorski model indicates that the fractured zone ranges from 24-30 times the extracted thickness, which at Ensham equates to 108-135m. However Seedsman Geotechnics (2005)[20] who undertook the subsidence prediction for the proposed Ensham Central longwall mine state that this range of vertical fracturing is considered too large to be used in an engineering assessment. Seedsman Geotechnics state that *"it is noted that of the various water inflow events to longwalls in the Bowen Basin, none has occurred where the depth of cover has exceeded 120m when the inflows have been from the surface, or for the case of intersecting aquifers, where the distance from the seam to the aquifers is more than about 90-100m"*. Seedsman Geotechnics concluded that *"it should be assumed that longwall cracking would extend from the seam to the surface/aquifer for thicknesses of fresh Permian less than 100m. Considering that the average weathered thickness is 5m, this translates to 105m of interburden".*

This assessment is further supported by evidence from the Crinum Mine in the Bowen Basin where high groundwater inflows of up to 160L/s from overlying Tertiary sand and basalt aquifers, occur where the cover decreases to less than about 90m in thickness. Similarly mine subsidence at the Wambo Mine in the Hunter Valley resulted in surface cracking and inflows of up to 200L/s from a flowing creek, where the overburden (cover) thickness was less than 70m.

For the proposed Ensham Central longwall mine cover thickness exceeds 105m for panels S1-S13, but is less than 105m thick over the south eastern corner of panels S14 and S15 as shown on Figure 14. Therefore vertical cracking may intersect the base of the alluvium above these two panels, however as discussed the alluvium has only a thin saturated thickness and much of this will have drained from above panels S14 and S15, as a result of inflow to the open cut pits. Therefore vertical cracking to the base of the alluvium above these panels will have minimal impact both with respect to inflow to the mine or on alluvium groundwater levels.

Figure 14 – Thickness of Overburden (cover) from Seam to Base of Alluvium

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[20] Seedsman Geotechnics Pty Ltd, (March 2005), *"Subsidence Prediction for Central Area, Ensham Underground",* Ref. ENSHAM05NG-01.

The Ensham Central underground mine layout has been designed such that surface subsidence will not occur within 100m of the edge of the high bank of the main channel of the Nogoa River; a "subsidence exclusion zone". This will ensure that there is no vertical cracking extending to the base of the river and no potential for drainage of the river.

10.0 2D NUMERICAL MODEL – SEEP/W

10.1 Assessment of Impact of A2C Seam Subsidence

As discussed, it is proposed to re-instate the Nogoa River floodplain by progressively backfilling the pits with spoil and compacting the upper 10m of spoil. The permeability of the compacted spoil will be in the range 10^{-5} to 10^{-6}m/sec to prevent infiltration of flood waters. Alternatively a surface treatment may be used which provides a similar low permeability seal at the surface of the re-instated floodplain. An assessment of the rate at which water from rainfall or flooding events infiltrates the spoil and creates a "spoil aquifer" was requested by the Environmental Protection Agency (EPA).

This section of the report describes the modelling undertaken to obtain a maximum infiltration rate through the re-instated floodplain, that would then be used in 3D groundwater flow modelling.

10.2 Model Set-up

Potential seepage through the 10m thick upper compacted spoil layer of the re-instated floodplain was assessed using SEEP/W, a finite element model that can be used to model the movement and pore-water pressure distribution of groundwater in porous materials, such as soil and rock. SEEP/W is a two-dimensional finite element program that models both saturated and unsaturated groundwater flow. The model considers a slice (section) through the subsurface and volume calculations are achieved by considering a unit width for the section.

The ability of SEEP/W to simulate the movement of water in the unsaturated zone is important for obtaining physically realistic analysis results. In soils the hydraulic conductivity and water content changes as a function of pore pressure, and SEEP/W models these relationships as continuous functions, enabling processes such as water storage in the unsaturated zone following rainfall to be simulated. The hydraulic conductivity of the soil decreases once the soil becomes unsaturated which limits the rate of infiltration until the soil "wets up". SEEP/W is able to simulate this process.

The SEEP/W model was formulated to simulate infiltration from a Q100 (worst case) flood through the re-instated floodplain. The model was set up to replicate a 10m thick compacted spoil layer with a saturated hydraulic conductivity of 10^{-5}m/sec (0.9m/day) overlying a 15m uncompacted spoil layer with a hydraulic conductivity of 10^{-3}m/sec (90m/day). The hydraulic conductivity values are the maximum values of the estimated range and hence also represent a worst case scenario.

The saturated and unsaturated moisture content functions of the two layers were modified standard SEEP/W functions adjusted as necessary to represent the various material types and nominated saturated hydraulic conductivities. The parameters used in the model are summarized in Table 16 below.

Table 16: SUMMARY OF SEEP/W PARAMETERS

	Parameter	Value
Layer 1 Compacted Spoil	Thickness (m)	10
	Saturated hydraulic conductivity (m/day)	0.9
	Residual saturated moisture content	16%
	Saturated moisture content	35%
Layer 2 Uncompacted Spoil	Thickness (m)	15
	Saturated hydraulic conductivity (m/day)	90
	Residual moisture content	6%
	Saturated moisture content	38%

The simulation was conducted in three steps as follows:

Step No 1 – steady state simulation applying constant flux to the upper model boundary and constant head to the lower boundary. This step was necessary to provide the unsaturated spoil with initial moisture content prior to transient predictive simulations. It was assumed that the initial conditions will be representative of the average annual state and therefore the simulation in this step was conducted applying an average rainfall recharge of 11mm/year, that is, 2% of the average annual rainfall of 556mm.

Step No 2 – transient simulation of the flood period. Step No 2 was set up to simulate inflow of water into the spoil during a Q100 flood event of five days duration (worst case scenario). The upper boundary condition during this step was set as a constant head with the head elevation equal to that expected during a Q100 flood. Flood levels for this event were assumed to be RL 156.7m at the upstream Ensham lease boundary and RL 155.5m at Duck Ponds Lagoon. A maximum head (recharge flux) of 6.7m of water, that is, the deepest level of flooding on the floodplain was simulated for the five day duration of the event over the whole of the area of the re-instated floodplain. This is an artificially conservative scenario as the flood levels would rise to, and fall from, the peak flood level over the duration of the event. The conservative scenario modelled maintains the peak flood level for the duration of the event.

Step No 3 – transient simulation of the post flooding period. The initial conditions during this step were adopted from the end of the Step No 2. The upper boundary condition during this step was set as a constant flux with a flux of 0. This allowed simulation of downward flow of water through the soil profile following the flood event.

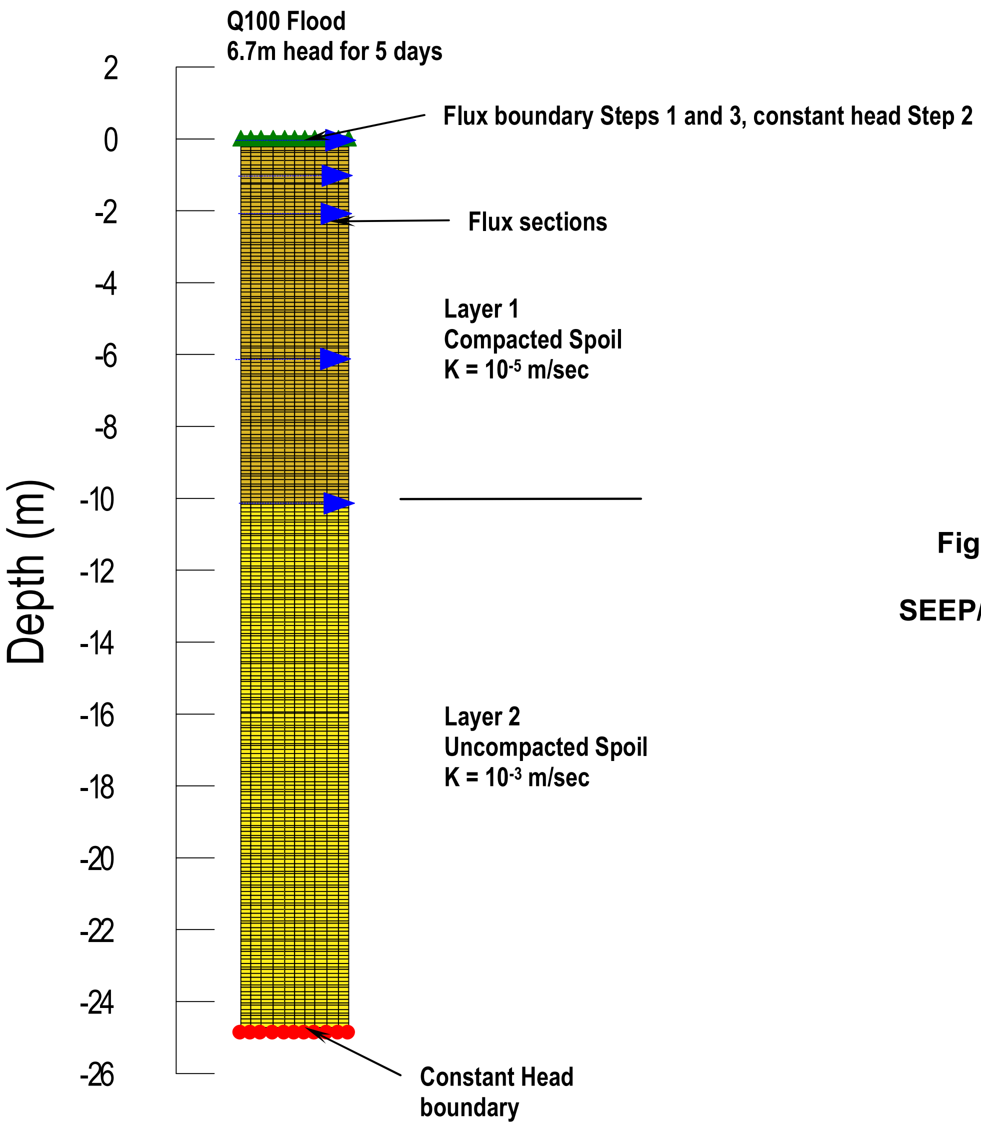

Figure 15

SEEP/W Model

10.3 Modelling Results

The prime focus of the modelling was to assess the seepage flow from a Q100 flood event at various depths in the compacted spoil profile. The model was run for 7300 days (20 years) and the recharge flux (infiltration) was recorded from flux sections at depths of 0m, 1m, 2m, 6m and 10m (Figure 15). The results are shown graphically on Figure 16. Figure 16 indicates that the maximum seepage rate of 8.2L/s per hectare at the surface (0m) occurred during day 5 of the flood, that is, after the surface soils had "wetted up". The seepage front took about 6 days to reach 1m depth and the maximum recharge flux of 3.23L/s per hectare at 1m depth occurred at day 12. The seepage front reached 2m depth on day 13 with the maximum recharge flux of 2.22L/s/ hectare occurring at day 18. Figure 16 illustrates that due to storage in the unsaturated compacted spoil zone and slow times of infiltration there is an 18 day lag between the time the recharge flux (flood event) is applied at the ground surface and the maximum flow at 2m depth. The seepage front did not reach 6m depth in the 20 year period of simulation having dissipated in the compacted spoil profile. That is, it is taken up by storage in the compacted zone; the storage being equivalent to the difference between saturated and residual moisture contents. As can be seen from Table 16, storage, the difference between saturated and residual moisture content, varies between 19% and 32% for the compacted and non-compacted layers respectively. The seepage taken up by storage will either slowly drain to the aquifer or more likely be evapotranspired by capillary action and deep rooted vegetation.

In conclusion, the 2D modelling of a Q100 flood event indicates that the compacted spoil layer is effective in preventing seepage through the spoil and development of a “spoil aquifer”.

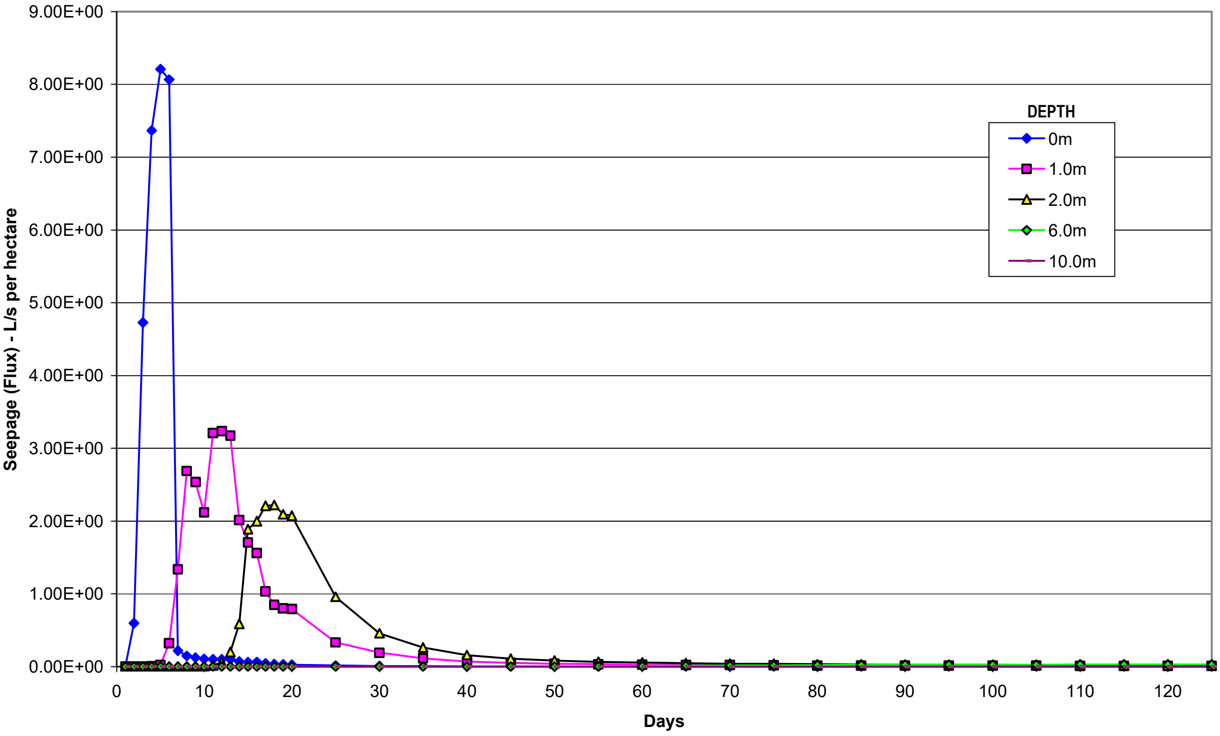

Figure 16 – Re-instated Floodplain - Seepage Rates with Depth from a Q100 Flood

11.0 3D NUMERICAL GROUNDWATER MODEL - MODFLOW

11.1 General

The United States Geological Survey three-dimensional, finite-difference, modular, groundwater flow model MODFLOW (McDonald and Harbaugh, 1984)[21], with the PMWIN (Chaing and Kinzelbach, 1996)[22], pre- and post processing package, was used to simulate the impact of open cut and longwall mining operations on the groundwater regime. The MODFLOW code is the most widely used code for groundwater modelling and is presently considered an industry standard.

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[21] McDonald M.G. and Harbough W., (1984), *“A Modular Three-Dimensional Finite Difference Flow Model”,* US Geol. Survey.

[22] Chaing W.H. and Kinzelbach W., (1996), *“Processing MODFLOW for Windows”.*

The numerical groundwater model was developed in order to assess groundwater inflows to the open cut mine and to the underground workings, to simulate the extent of the cone of depression induced by mine dewatering and the recovery of groundwater levels after mine closure.

11.2 Modelling Objectives

The objectives of the predictive modelling are as follows:

- assess the impact of open cut mining across the alluvial plan and longwall mining beneath the alluvial plain, on the local and regional groundwater regime, including other groundwater users; mines, farms and groundwater dependent ecosystems;
- assess groundwater inflow to the mines;
- identify areas of potential risk where groundwater impact mitigation/control measures may be necessary;
- assess the rate of development of a groundwater aquifer in the spoil;
- simulate and optimise mitigation/control strategies if adverse impacts are identified;
- assess groundwater recovery post mining, and post mining impacts including the potential for poor quality groundwater from the spoil backfilled pits to discharge into the Nogoa River.

11.3 Conceptual Model

Every numerical groundwater model has as its foundation a conceptual model. The conceptual model is the basic idea of how the groundwater system operates and is an idealised and simplified representation of the natural system. It includes all essential features of the system, that is, the hydrogeological regime as described in Section 6.0, to an appropriate level of detail. Extensive information on the natural system is typically required to develop an equivalent and simplified conceptual groundwater model representative of the system. Development of the conceptual groundwater model is a crucial step in groundwater modelling. Great care has to be taken during development of such models since errors in the conceptual model cannot be corrected during the model calibration, or at any later stage of the modelling study, without major revisions. Formulation of the conceptual model often highlights gaps in data or deficiencies in understanding of the groundwater system.

"A conceptual model contains numerous qualitative and subjective interpretations. The appropriateness of the conceptual model can not be tested until a numerical model is built and comparisons between field observations and model simulation results are made" (Zheng and Bennett [1995])[23].

The conceptual groundwater model of the project area illustrated in Figure 17 was developed based on geological and topographical maps of the project area, geological information from coal exploration bores drilled across the project area, results from previous hydrogeological investigations, and relevant data from the NRMW groundwater database.

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[23] Zheng C. and Bennett G., (1995), *"Applied Contaminant Transport Modelling"*. Wiley, New York.

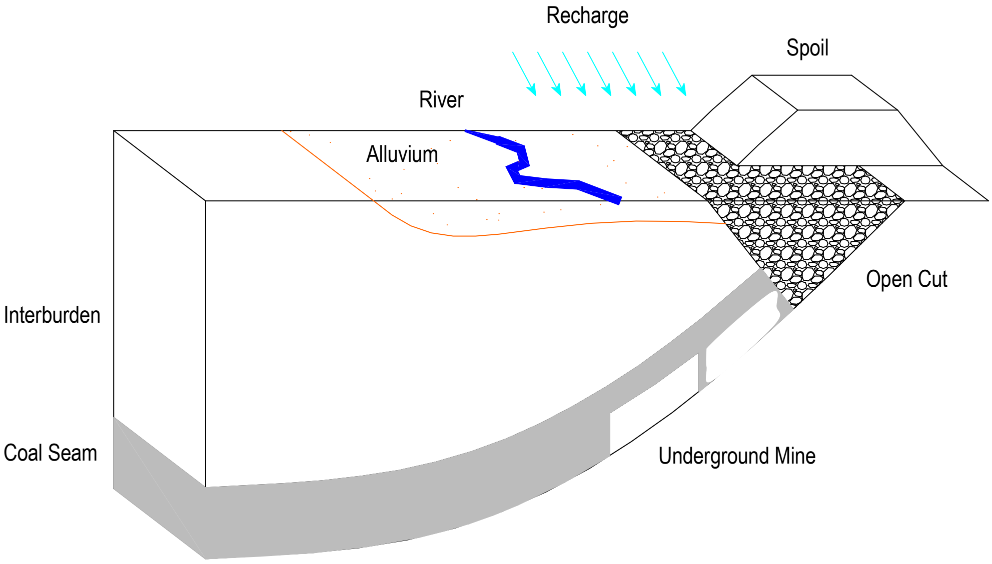

Figure 17 – Conceptual Model of Groundwater Regime

The conceptual model of the region encompasses the area between the subcrop of the Rangal Coal Measures to the north, east and west of the project area. The southern boundaries of the conceptual model are defined by the depth of the A2C (Aries2/22 and Castor) seam of about 400m below the ground surface. As discussed in Section 6.2.1 a decrease in hydraulic conductivity of the coal seam of two orders of magnitude is expected to occur over this depth interval. According to Anderson and Woessner (1992)[24], two orders of magnitude contrast in hydraulic conductivity values is sufficient to justify placement of an impermeable boundary in the groundwater flow model. Remaining model boundaries were set along the interpreted groundwater flow lines at a distance from the proposed mining operation, sufficient to avoid the impact of the boundary on the development of the cone of depression around the mine.

The conceptual model includes two aquifers:

- unconfined alluvial aquifer associated with alluvial deposits of the Nogoa River and Winton Creek, and
- confined Permian aquifers associated with coal seams.

Considering the tight nature of the over- and interburden rocks recharge to the coal seams is expected to occur only along the sub-crop of the coal seams, primarily as a result of rainfall, but possibly also from flow in Boggy Creek. Discharge from the Permian aquifer occurs to the base of alluvial aquifer associated with the Nogoa River and Winton Creek, as indicated by an elevated and variable salinity of the groundwater in the alluvium.

As discussed in Section 5.3.2 groundwater only occurs in the very basal section of the alluvium and recharge of the alluvial aquifer from rainfall infiltration or via occasional flooding across the

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[24] Anderson, M. P. and Woessner, W. W., (1992), *"Applied Groundwater Modeling, Simulation of Flow and Advective Transport"*, Academic Press.

floodplain is minimal. It has been assessed that recharge to the alluvial aquifer may occur primarily from upward seepage along faults and fractures from the deeper Permian aquifers, as discussed. Discharge from the alluvial aquifer occurs to the Nogoa River down-gradient from the project area and outside the limits of the conceptual model. Some discharge from the aquifer may also occur through evapotranspiration along the river where deep rooted remnants of the native vegetation remain.

Considering the hydraulically tight bed of the Nogoa River and elevation of the water level in the river being above groundwater levels in the underlying alluvium, the river appears to have no influence on the aquifers or the groundwater regime in general. The river however, has been included in the conceptual model of the area.

The hydraulic conductivity of the two aquifers differs significantly. The hydraulic conductivity of the basal section of the alluvial aquifer is considered to be very high, in the order of 100m/day, as indicated by the hydraulic tests described in Section 5.3.4 of this report, whereas the hydraulic conductivity of the Permian aquifers (coal seams) is much lower and is considered to decline with depth of the seams. The hydraulic conductivity of the coal seams is considered to be of the order of about 1.0m/day near the surface in the open pits areas, declining to about 1 x 10^{-6}m/day at a depth of 400m. The decline in the hydraulic conductivity of the seam was assumed to follow the exponential decline described in Section 6.2.1.

11.4 Model Development

11.4.1 Model Geometry

In agreement with the conceptual groundwater model of the area the numerical model consists of the two aquifer systems separated by a low permeability interburden represented in the model by three model layers. The upper model layer (Layer 1) represents the shallow alluvial aquifer. The extent of this aquifer is shown on **Drawing No 8** and coincides with the extent of the alluvial deposits of the Nogoa River. The base of this aquifer was interpreted from elevations of the base of the sand/gravel layer from available borehole data.

The interburden between the aquifers is represented in the model by intermediate layer (Layer 2).

The lower aquifer (Layer 3), represents combined coal seams A to C except in F Pit and the Yongala Pit. At these two pits the lower model layer also includes seams Q and P, respectively. The extent of this layer is limited by the subcrop of the Rangal Coal Measures to the north, west and east, and the approximate depth of 400m below surface to the south. The extent of this layer is shown on **Drawing No 8**.

The depth of the base of Layer 3 was assumed to coincide with the base of C Seam, except in the Yongala pit area where it coincides with the base of Q Seam, and in F Pit where it coincides with the base of P seam. The depth of the base of the seams was obtained from J.B. Mining Services Pty Ltd. In areas where the base of the seams was missing the elevation of the base of the Layer 3 was estimated from the available borehole data.

The thickness of the Layer 3 includes all of the main coal seams (A to C, A to Q in Yongala Pit area, and A to P in the F Pit area), and their splits, as interpreted by J.B. Mining.

The model domain was discretized into 204,321 rectangular cells arranged into 3 layers, 169 columns and 403 rows. The dimensions of the model cell size vary from 60m by 60m within the mining area and up to 600m by 600m at the extremities of the model as shown on **Drawing No 8**. The model extent from west to east is about 35km, and about 32km from south to north, covering an area of approximately 728km^2.

The north-west corner of the grid is located at 623637.5mE and 7425323mN, and the grid was rotated 12.53^{o} to the east in order to align it with the eastern subcrop of the seams.

The cells located outside the extent of the conceptual model domain were excluded from the simulation.

11.4.2 Hydraulic Parameters

In agreement with the conceptual model of the area the assessed hydraulic parameters of the model domain are as shown in Table 17. The hydraulic parameters shown in the table were adopted after calibration of the model.

Table 17: HYDRAULIC PARAMETERS

Layer	Parameter	Value
Layer 1 (alluvium aquifer)	Horizontal Hydraulic Conductivity kh (m/day)	100
	Vertical Hydraulic Conductivity kv (m/day)	10
	Specific Yield S_y (1/m)	0.25
	Specific Storage S_s (1/m)	0.001
Layer 2 (interburden)	Horizontal Hydraulic Conductivity kh (m/day)	0.0001 to a depth of 100m (RL 60m), declining to 1x10^{-5} at a depth of 400m (RL -250m)
	Vertical Hydraulic Conductivity kv (m/day)	0.0001 to a depth of 100m (RL 60m), declining to 1x10^{-6} at a depth of 400m (RL -250m)
	Specific Yield S_y (1/m)	0.005
	Specific Storage S_s (1/m)	1x10^{-6}
Layer 3 (coal seams)	Horizontal Hydraulic Conductivity kh (m/day)	1.0 to a depth of 100m (RL 60m) and declining to 1x10^{-6} at a depth of 400m (RL -250m)
	Vertical Hydraulic Conductivity kv (m/day)	1.0 to a depth of 100m (RL 60m) and declining to 1x10^{-6} at a depth of 400m (RL -250m)
	Specific Yield S_y (1/m)	0.01
	Specific Storage S_s (1/m)	1x10^{-6}

11.4.3 Boundary Conditions

With the exception of the small section of the alluvium around the Nogoa River and the anabranch the whole of the model domain is surrounded by “no flow” boundaries. The base of the model was also assumed to be a “no flow” boundary. A “no flow” boundary does not allow any exchange of water between the model domain and the surrounding areas. A small section of the alluvium along the eastern limit of the model domain, around the Nogoa River and the anabranch, was set in model Layer 1 as an outflow from the model using MODFLOW “drain” cells. One cell in the alluvium aquifer was also set as a “constant head” cell in order to improve the stability of the model. The elevation of the groundwater level in this cell was set at RL 135m, the lowest known elevation of the groundwater level within the model domain.

The Nogoa River, its anabranch and Winton Creek were simulated in the model using MODFLOW “river” cells. River cells allow drainage of the aquifer to the river when the simulated groundwater levels in the aquifer around the river are higher than the river stage. When the groundwater level in the surrounding aquifer is lower than the river stage the river can supply water to the aquifer or act as a recharge zone, with the rate of recharge dependent on the difference in elevation between the groundwater in the aquifer and the river stage, and the hydraulic conductivity of the river bed. As discussed in Section 5.4.2 the water flow in the Nogoa River is separated from the underlying groundwater levels and this indicates a very low hydraulic conductivity of the river bed.

11.4.4 Recharge and Discharge

Recharge to the model domain was assumed to occur along the subcrop of the coal seams. The rate of recharge to the aquifers is unknown and was therefore obtained during model calibration. The calibrated rate of recharge to the coal seams adopted in the model was 0.04mm/year, and to the alluvium area 7.3mm/year.

Discharge from the alluvial aquifer within the model domain was assumed to occur at the eastern boundary of the model. MODFLOW “drain” cells were used to simulate the discharge of groundwater from the model domain. The elevation of the “drains” was set at RL135m, that is, between 1m and 2m below the observed groundwater elevation in the alluvial aquifer.

11.5 Model Calibration

“Calibration of a groundwater flow model refers to a demonstration that the model is capable of producing field measured heads and flows which are the calibration values. Calibration is accomplished by finding a set of parameters, boundary conditions and stresses that produce simulated heads and fluxes that match field measured values within an acceptable range of error” (Anderson and Woessner [1992])[24].

The objective of model calibration is to reproduce the estimated groundwater levels that existed in the project area before year 2005 and reproduce inflows to the existing open cut pits. The accuracy of the model calibration depends on the quality of calibration parameters, and the data defining the model domain such as aquifer geometry, boundaries, hydraulic properties and stresses imposed on the aquifer. It is considered that the horizontal and vertical extent of the model and model boundaries are sufficiently well defined to construct and calibrate the Ensham groundwater model. However, the quality of calibration targets such as water levels and inflows to the pits is poor.

11.5.1 Calibration Targets

The primary calibration targets are groundwater levels in the coal seams, alluvium and inflows to the pits. The groundwater levels in the coal seams were interpreted from geophysical logs collected from open exploration bores at different times. The accuracy of these interpretations is of variable quality with some of the bores (R2548) recording water levels as low as RL -17.7m. Of a total of 353 water level data, 29 bores recorded water levels below an elevation of RL 90m, that is the lowest elevation of the open pits in 2005 (B and C Pits) . As it is apparent that these water levels are incorrect, all these bores were removed from the calibration data set. Some bores (e.g. R2063) located close to Yongala Pit, recorded water levels as low as RL 113.1m which is well below the base of the Yongala Pit (RL150m in 2005). Nevertheless, even after removing all obviously incorrect water levels from the calibration data set, the range of water levels in the same general area varies greatly. For instance, the lowest elevation of the water levels in the vicinity of the Yongala Pit in Bore No R2822 was recorded at 141.7m. This is the same as the elevation of the water in the Nogoa River, about 8.5km to the south of this bore. The water levels in other bores in the Yongala Pit area varied up to 189.7m (Bore NoX2399) as shown on **Drawing No 5**. A difference of 10m in water levels in bores in the same general area is common.

The groundwater levels in the alluvium were taken as an average of measurements collected in the EC series of piezometers between November 2004 and June 2005.

The accuracy of the water level data in the calibration data set obtained from coal exploration bores was estimated to be at best approximately ±5m and often as low as about ±35m, as indicated by the difference in water levels in a number of adjacent pairs of bores. An example of the difference in water elevations in adjacent pairs of bores is shown in Table 18.

Table 18: COMPARISON OF WATER LEVELS IN PAIRS OF ADJACENT BORES

Bore/Hole	Water Level (m RL)	Distance Between Bores (m)	Difference in Elevation (m)
R2022 R2210	145.5 150.7	35	5.2
R2146 R2148	128.1 123.7	38	4.4
R1279 R1320	128.8 139.0	50	10.2
R2136 R2736	107.1 117.1	20	10.0
R1631 R1630	112.3 145.5	60	33.2

The accuracy of the water level data in the calibration data set obtained from piezometers installed in alluvial deposits (EC series of bores) was estimated to be approximately ±0.5m after allowing for observed changes in water level elevations during the monitoring period.

In summary the reliability of the water level measurements in the coal seams was estimated to be low and in the alluvial piezometers high to moderate. The main objective of model calibration was to reproduce inflows to the pits, the general pattern of the groundwater contours the direction of the groundwater flow and elevation of the water levels in the alluvial deposits, rather than the water levels observed in individual coal seam exploration bores.

A total of 77 water level data were used for calibration. A summary of the bores used as calibration targets, the measured and simulated water level and the difference between levels is presented in Table 19.

Table 19: CALIBRATION TARGETS AND SIMULATED WATER LEVELS

Bore ID	Easting (m)	Northing (m)	Collar (RLm)	Observed Water Level (RLm)	Simulated Steady State Water Level (RLm)	Difference (m)
C1610	653011	7408925	177.0	147.93	146.95	1.0
C1712	650078	7398304	166.1	142.08	137.42	4.7
C1859	648725	7395605	171.4	154.37	141.17	13.2
C1905	653305	7409820	180.6	140.47	147.66	-7.2
C1988R	653858	7410800	189.3	140.76	148.24	-7.5
C1997	654096	7410534	194.3	143.39	148.19	-4.8
C2499	653772	7414313	224.1	169.09	149.90	19.2
C2539	653194	7413076	233.1	143.81	149.36	-5.5
C2541	653192	7415301	263.5	167.07	149.98	17.7
R1339	650503	7398016	159.1	146.13	137.19	8.9
R1369	651156	7398057	155.2	146.37	136.55	9.8
R1379	653264	7408920	174.3	147.83	147.18	0.7
R1392	650436	7399229	151.6	143.64	136.87	6.8
R1399R	651977	7398493	150.1	144.55	135.80	8.8
R1400	651176	7398103	154.4	144.39	136.52	7.9
R1401	651195	7398148	154.0	147.97	136.50	11.5
R1402	651243	7398128	153.9	147.90	136.47	11.4
R1405	651225	7398083	154.3	146.34	136.50	9.8
R1406	651205	7398037	154.7	150.24	136.53	13.7
R1408	651167	7397946	155.8	149.81	136.57	13.2
R1409	651231	7397975	155.2	149.17	136.55	12.6
R1630	651737	7398371	151.0	145.53	136.05	9.5
R1633	651484	7398257	152.8	149.22	136.28	12.9
R1639	651265	7398478	151.3	145.76	136.35	9.4
R1830	653779	7410049	192.1	144.18	147.94	-3.8
R1856	648678	7395361	171.3	159.26	141.48	17.8
R1890	650518	7398404	157.3	142.32	137.00	5.3
R1891	649015	7395232	166.4	156.87	141.60	15.3
R1923	653658	7410054	186.6	148.56	147.90	0.7
R1951	653840	7410549	190.3	147.68	148.15	-0.5
R1952	653869	7411045	188.1	146.27	148.31	-2.0
R1955	653902	7411792	190.0	140.96	148.55	-7.6
R1973	654151	7411785	193.7	140.28	148.54	-8.3
R1974	654402	7411772	200.8	148.06	148.51	-0.5
R1976	654140	7411535	194.4	145.86	148.46	-2.6
R1977	654387	7411523	202.2	142.23	148.45	-6.2
R1993	653639	7411560	190.6	147.61	148.44	-0.8
R1994	653626	7411311	189.7	147.13	148.36	-1.2
R2013	653615	7411057	187.7	147.26	148.28	-1.0
R2022	653982	7413327	204.5	145.45	149.71	-4.3
R2023	654204	7413776	203.3	151.19	149.84	1.3

Table 19: CALIBRATION TARGETS AND SIMULATED WATER LEVELS

Bore ID	Easting (m)	Northing (m)	Collar (RLm)	Observed Water Level (RLm)	Simulated Steady State Water Level (RLm)	Difference (m)
R2028	652264	7415083	257.4	169.25	149.97	19.3
R2073	627973	7414102	173.4	142.43	159.54	-17.1
R2075	634447	7415706	168.0	144.02	156.74	-12.7
R2076	634296	7416111	166.4	150.43	156.76	-6.3
R2178	653391	7414346	235.2	148.12	149.87	-1.8
R2220	654262	7414027	203.5	148.38	149.90	-1.5
R2222	654286	7414532	204.9	159.80	149.96	9.8
R2224	654534	7414515	202.4	149.17	149.96	-0.8
R2233	654000	7413793	209.0	170.33	149.83	20.5
R2249	653990	7413541	209.1	144.70	149.77	-5.1
R2250	653711	7413057	203.9	146.50	149.43	-2.9
R2443	654399	7414273	201.9	158.87	149.95	8.9
R2444	654525	7414391	201.7	160.66	149.96	10.7
R2448	654065	7415045	231.5	149.31	149.98	-0.7
R2449	654046	7414792	212.0	154.99	149.97	5.0
R2450	653825	7415059	230.4	169.20	149.98	19.2
R2451	654034	7414542	209.0	160.55	149.95	10.6
R2453	654023	7414297	213.7	164.70	149.92	14.8
R2813	649437	7417821	184.0	150.00	154.30	-4.3
R2816	650356	7415971	197.6	141.74	151.23	-9.5
X1885	654260	7409780	199.3	145.50	147.96	-2.5
X2845	650743	7398170	156.3	132.69	136.84	-4.1
EC02	650242	7402745	154.8	138.40	141.37	-2.97
EC03	650225	7402367	153.2	141.10	141.21	-0.11
EC05	650392	7401885	154.5	140.30	140.82	-0.52
EC06	650691	7401896	153.1	138.40	140.52	-2.12
EC07	650860	7401565	153.9	139.20	140.04	-0.84
EC9A	651242	7401324	153.5	138.20	139.30	-1.10
EC10	651504	7401239	154.3	137.40	138.95	-1.55
EC11	651404	7401011	152.7	137.30	138.02	-0.72
EC12	651550	7400739	152.1	136.90	137.02	-0.12
EC13	651405	7400596	152.0	136.70	137.12	-0.42
EC14	651564	7400473	146.1	136.10	136.57	-0.47
EC21	651548	7400413	143.6	135.40	136.50	-1.10
EC22	651581	7400314	153.7	135.10	136.31	-1.21
EC23	651570	7400244	153.9	135.10	136.19	-1.09

Due to a lack of long term monitoring data it was assumed that the water levels in bores selected for steady state calibration were representative of the long term average (steady state) groundwater levels. However, fluctuations in groundwater level in the area are expected. The location of the bores is shown on **Drawing No 5**.

As discussed the second calibration target was pit inflows. A site visit undertaken on 23 April 2003 to visually inspect and assess the mode of groundwater occurrence in each of the open cut pits, and to obtain anecdotal information on groundwater inflow, indicates that groundwater seepage occurs in all pits both from the highwall and from the low-wall. Inflow from the low-wall is not derived from the coal seam but rather from seepage from the spoil and from dam storage areas to the east of the pits, and is therefore not taken into consideration in model calibration. ERM Australia, (May 2002)[25] state in their mine water balance study that *"groundwater inflow estimates were provided for Pits B and C/D by Ensham Resources based on operational experience at the mine".* The groundwater values used by ERM in their model were:

- 500ML/year, about 16L/s for B Pit, and
- 200ML/year, about 6.3L/s for C and D Pits.

11.5.2 Calibration Results

Comparison of observed and simulated groundwater levels in the Ensham model area are given in Table 19, and a scattergram with observed and simulated water heads is shown in Figure 18.

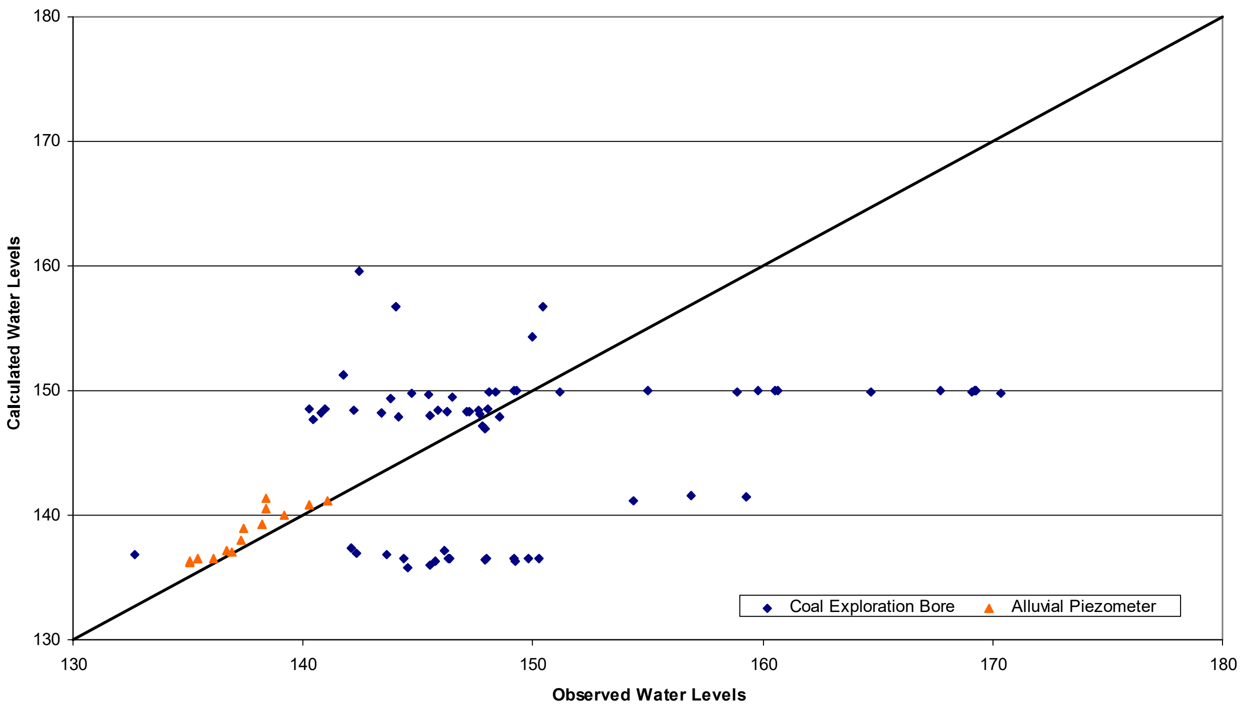

Figure 18 – Observed versus Calibrated Groundwater Levels

An objective method to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration. One such method is by measurement of the error between the modelled and observed (measured) water levels. A root mean square (RMS) expressed as:

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[25] Environmental Resources Management Australia, (May 2002), *""Water Management Assessment",* 010763RPI/ Draft/22 May 2002.

$$RMS = \left[1/n \sum (h_o - h_m)_i^2 \right]^{0.5}$$

where: n = number of measurements
h_o = observed water level
h_m = simulated water level

is considered to be the best measure of error, if errors are normally distributed.

The RMS error calculated for the calibrated model is 8.8m. The maximum acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total head loss in the system is small, the errors are only a small part of the overall model response, (Anderson and Woessner)[24]. The total observed head loss within the model domain is 49.3m, therefore the ratio of RMS to the total head loss is 17.8%. Taking into account the poor accuracy of the calibration targets (error between 10% and 71%) this calibration error is considered to be acceptable.

The mass balance error, that is the difference between calculated inflows and outflows to the model, at the completion of the calibration run, expressed as percent of discrepancy, was 0.75%, indicating good accuracy of the numerical solution and overall stability of the model.

A comparison of observed and simulated inflows to the pits is shown in Table 20.

Table 20: OBSERVED AND SIMULATED INFLOWS TO PITS

Pit	Observed Inflow (L/sec)	Simulated Inflow (L/sec)	Difference (L/sec)
Pit B	16	6.1	-9.9
Pits C and D	6.3	8.5	+2.2

The simulated steady state elevation of the groundwater table is shown on **Drawing No 9**.

11.5.3 Model Budget

The steady state and year 2005 water balance of the calibrated model is shown in Table 21. Year 2005 simulation results were used as initial conditions for the predictive simulations.

Table 21: MODEL WATER BUDGET

	Steady State	Year 2005
Inflow		
Storage (m^3/day)	0.0	835.9
Constant Head (m^3/day)	0.0	0.0
Drains (m^3/day)	0.0	0.0
Recharge (m^3/day)	962.9	958.7
Total Inflow (m^3/day)	962.9	1794.6
Outflow		
Storage (m^3/day)	0.0	6.4
Constant Head (m^3/day)	0.0	0.0
Wells	32.8	32.8

Table 21: MODEL WATER BUDGET		
	Steady State	**Year 2005**
Drains(m^3/day)	911.2	1731.8
Recharge (m^3/day)	0.0	0.0
Total Outflow (m^3/day)	944.0	1771.0
Discrepancy (%)	**1.98**	**1.32**

11.5.4 Sensitivity Analysis

Sensitivity of the model was tested by incrementally changing individual model parameters above and below the calibrated values. Horizontal and vertical hydraulic conductivity were selected for sensitivity analysis. The selected performance measure for testing the sensitivity of the model was the RMS error. A summary of the sensitivity analysis is presented in Table 22.

During some sensitivity simulations a number of calibration points used to calculate the RMS error went dry. In these cases the simulated water levels at the dry calibration points were excluded from the calculation of the RMS error and therefore errors shown in the table are lower than the true value of the error. Therefore, in order to assess the reliability of the RMS calculation the table also shows a number of calibration points used to calculate each error value.

Table 22: SENSITIVITY ANALYSIS					
	RMS (%)				
Multiplication Factor	0.25	0.5	1	2	4
Horizontal Hydraulic Conductivity (k_h) (Number of Calibration Points)	19.1 (63)	10.5 (63)	9.7 (63)	>12.4 (46)	>10.7 (42)
Vertical Hydraulic Conductivity (k_v) (Number of Calibration Points)	9.8 (63)	9.7 (63)	9.7 (63)	9.7 (63)	>9.8 (62)

The analysis indicates that the model is most sensitive to the value of horizontal hydraulic conductivity and is quite insensitive to the vertical hydraulic conductivity. An increase in hydraulic conductivity values by a factor of 4 resulted in drying up of large areas of the aquifer.

As the calibration was for steady state conditions sensitivity of the storage parameters could not be undertaken as storage is not a factor for a steady state condition of the groundwater regime.

12.0 PREDICTIVE SIMULATIONS

12.1 Development of Mining

Open cut mining at Ensham Mine has been undertaken in the past and is continuing at the present as previously discussed. The proposed mine expansion will include further development of the open cut mine and a new underground longwall mine. The development work for underground mining will commence in Year 1 with longwall mining commencing in Year 4. As discussed the open cut operation will continue over a 17-year period and will be completed in Year 16 whereas underground mining will be completed in Year 14. The scheduled development is shown on

Drawing No 6. On the completion of mining the spoil placed in some sections of the pits near the Nogoa River, (B and C Pits) will be used to reinstate the pre-mining floodplain topography. A 10m thick low permeability capping is proposed to be installed in these areas.

12.2 Modelling Strategy

The future response of the groundwater system to the proposed mine schedule and the rate of groundwater inflow to the open cuts and underground longwall panels have been assessed by running the model for a total period of 17 years. Simulated 2005 groundwater elevations have been used as initial conditions.

The open cut mining strips and the underground workings were simulated using MODFLOW "drain" cells. "Drain" cells allow water to be removed from the model domain if the hydraulic head in the cell is above a nominated drainage level. The drainage level specified is the level at which groundwater seepage occurs through the pit walls rather than the actual base of the model cell containing the pit. It was assumed that the elevation of the seepage face will be about 1m above the base of the model layer, that is, the base of Layer 3 representing the Aries2/Castor coal seam. Once the water level in the surrounding cells falls below the drainage level, drainage from that cell ceases. "Drain" cells were moved in three-monthly intervals across the mine area in accordance with the open cut and underground mine plans. In case of open cut mining once the mining strip was backfilled with spoil the "drain" cell within the backfilled strip was removed from the model. In the case of underground mining the "drain" cells were progressively added to the model in accordance with the underground mining plan. Once the "drain" cells were activated in the underground mine area they remained active until the end of the simulation.

As discussed, the creeks and the Nogoa River were simulated as MODFLOW "river" type boundaries which allow for losing or gaining river reaches to be modelled, depending upon the prevailing hydraulic head in the cell relative to the nominated river stage. This was done to assess the rate of discharge to the river should the simulated post mining groundwater regime indicate that a shallow water table aquifer would develop in the spoil. The surface water elevation along the Nogoa River within the model domain was assessed on the basis of Nogoa River survey data described in Section 5.3.5 and on topographic maps of the area. Where the model extended beyond the limits of the survey area, elevations were assigned from published 1:100,000 topographic maps.

The water supply bore G2 (RN90430) was simulated using the MODFLOW "well" cell. "Well" cells allow water to be removed from the model domain at a predetermined rate. A bore extraction rate of 0.38L/sec from the alluvial aquifer was applied based on advice from Peter Howard of Ensham[26].

Time wise, the 17 year long mining period was divided equally into 68 stress periods with four stress periods per year. A stress period is a period of time during which there is no change to stresses, such as pumping rates, recharge or dewatering, imposed on the model.

It was assumed that dewatering of final voids in A and B Pits, where mining will be completed in mid-Year 12, will continue until completion of all mining in mid-Year 16. It was also assumed that groundwater draining to these voids will be used as process water and for road watering purposes for the remainder of the operation.

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[26] E-mail from Peter Howard dated 18 July 2005.

On the completion of mining, recovery of groundwater levels was simulated for the steady state condition. The MODFLOW LAKE package was used to simulate recovery in the final voids. It was assumed that all dewatering will be terminated at the end of mining. Therefore, drain cells used to simulate mine dewatering were removed from the model area during recovery simulation.

As the mining and placement of the waste rock in the mined out areas, and collapse of the seam roof above the longwall panels will change the hydraulic properties of the aquifers, changes to these properties in the affected areas of the model were made prior to the recovery simulations.

According to Seedsman (1996)[27], the available volume of water storage within the seam horizon goaf can be taken as 20% to 25% of the extraction thickness. For the 4.5m extraction thickness, and about 8m combined thickness of coal seams within the goaf above the longwall panels, this translates into about 14% of the thickness of model Layer 3 being available for the water storage. In the case of gate roads the equivalent water storage within the model cell encompassing gate roads was estimated at 25% of the Layer 3 thickness as the gateroad only takes up part of the 60m x 60m cell.

Hydraulic parameters of the waste rock placed within the backfilled open cut areas will be significantly different from those of the in-situ rocks. Investigations at US open cut mines as reported by Hawkins (1998)[28] reveal that the hydraulic conductivity of surface mine spoil has a very broad range of values. The values generated from testing of 103 monitoring wells from 15 surface mines ranged from 3.4×10^{-4}m/day to 6,566m/day with the geometric mean of 2.2m/day. Hawkins also observed that the hydraulic conductivity of the mine spoil in the Appalachian coal fields is about 2 orders of magnitude greater than that of the undisturbed rock. Based on this latter finding it was arbitrarily assumed that the hydraulic conductivity of the spoil replaced in the mined out pits will be 5m/day.

Placement of the spoil in the mined out areas is also likely to change the rate of recharge over the affected areas. Simulation of seepage through the 10m thick compacted low permeability spoil capping of the re-instated floodplain was conducted to estimate the rate of recharge through this part of the spoil. As described in Section 10.0, 2D numerical simulation indicated that there will be no recharge through this capping for a five day flood of 6.7m height, that is, after a 1 in 100 year recurrence interval flood. Therefore the rate of recharge over the re-instated floodplain was assumed to be 0mm/year.

Two recharge rates of 10% and 15% of the average annual rainfall, that is, about 55.6mm/year and 83.4mm/year were assigned to the spoil piles outside of the flood plain, based on studies undertaken on spoil hydrology in the Bowen Basin, summarised by Jones (1997)[29]. The study found that total recharge to the spoil from a 10 day, 175mm rainfall event, was 10-15% of the rainfall and as such the model probably overestimates the average annual recharge as a percentage of rainfall. However in the absence of any other data these values were used in assessing groundwater recovery. A recharge rate of 15% of rainfall is considered a worst case scenario that would provide maximum equilibrium levels in the final voids and the “spoil aquifer”, whereas 10% recharge is considered a more likely scenario, but at the upper end of the range.

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[27] Seedsman R, (Nov. 1996), *“A Review of the Hydrogeological Aspects of Australian Longwalls”*, in Proceedings of Symposium on Geology in Longwall Mining, eds G.H. McNally and C.R. Ward, pp 269-272.

[28] Hawkins J.W., (Oct. 1998), *“Hydrogeologic Characteristics of Surface Mine Spoil”,* in Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania, Pennsylvania Department of Environmental Protection.

[29] Jones D., (Nov. 1997), *“Water Quality and Quantity in Final Voids”.* The Australian Coal Review.

Evaporation from the lakes that will develop in the final voids, that is, from an open water body, was assumed to be 1032mm/yr, which is about 50% of the recorded pan evaporation shown on Table 1. It is less than the 1,461mm evaporation from an open water body (Table 1), estimated from NRMW pan factors, but makes allowance for the fact that the water is in a deep pit that has shading and is protected from winds, both factors reducing evaporation.

The MODFLOW LAKE package was set up to simulate both open water body evaporation of 1032mm and direct rainfall onto the lake of 555.9mm per year.

A summary of the changes made to the model for the recovery simulations is presented in Table 23 below.

Table 23: SUMMARY OF MODEL MODIFICATIONS FOR RECOVERY SIMULATION

Modified Parameter	**Affected Area**	
	Open Cut Areas Spoil Aquifer (Layers 1, 2 and 3)	**Underground Mine Areas Goaf Aquifer (Layer 3 only)**
Hydraulic Conductivity (m/day) - vertical and horizontal	5	5
Specific Yield	0.2	0.14 - long wall panels 0.25 - gate roads
Recharge - floodplain - spoil piles - void lakes	0mm/year 55.6 - 83.4mm/year 555.9mm/year	-
Evaporation from FINAL voids	1032mm/year	

12.3 Impact during Mining

12.3.1 Mine Inflows

The response of the groundwater system to the proposed mining and inflow to the mine has been assessed by running the model from June 2005 to April 2022. Simulated 2005 heads have been used as initial conditions.

Figure 19 shows the simulated inflow to each of the open cut pits (A to F Pits and Yongala), as well as to the underground mine. It appears that the direction and sequence of mining in different pits has the greatest impact on the simulated inflows. Generally mining in the open pits progresses down-dip and during these times the simulated inflows to the pits are steadily increasing. However at times most of the mining is conducted along the seam strike and the down-dip progress of the mine is slower. It is during these times when the simulated inflows stabilize or even slightly decline.

The largest simulated inflow to the open pits was up to about 17L/sec to C and D Pits. These inflows gradually declined after Year 2 and by Year 12 reached an approximate steady value of about 6L/sec. The simulated inflow to A and B Pits peaked at about 10L/sec in Years 4 to 5. After Year 5 it steadily declined and by Year 12 levelled at 3L/sec. Simulated inflows to Pit E and the Yongala open cut were below 1L/sec due to a combination of the higher elevation of these pits and corresponding lower water head above the mined out seams, and the impact of dewatering of

C and D Pits and the Ensham Underground to the south. Inflow to F Pit steadily increased to about 2.5L/sec at the end of mining in Year 16.

A steady increase in inflow to the underground mine of up to about 27L/sec, was simulated between the commencement of developing the gateroads in Year 1, and years 12 to 13 when longwall mining from panel S12 is completed.

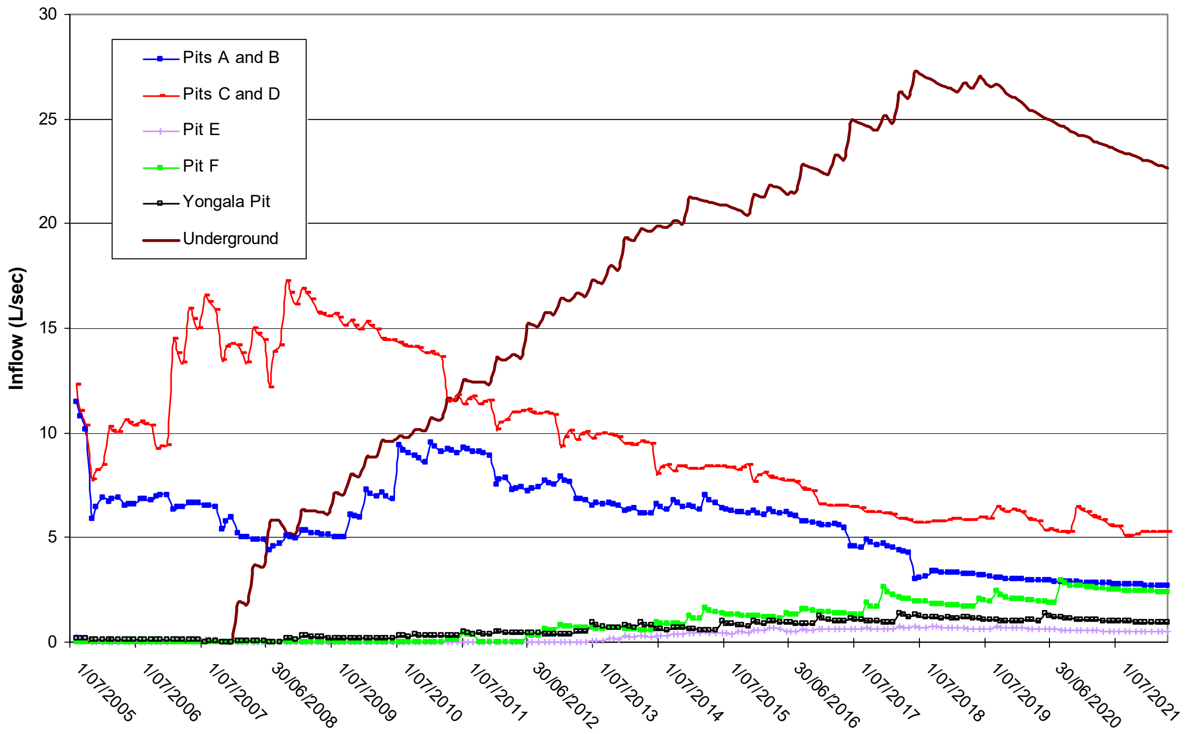

Figure 19 – Simulated Mine Inflows

12.3.2 Water Table/Piezometric Surface

Simulation results indicate that at the end of the mining period the cone of depression around the Ensham mine will be quite limited, due to the general low permeability of the coal seam.

Dewatering of the mine will create a cone of depression in the piezometric surface around the mine. The cone of depression, as defined by the 1m drawdown contour in relation to the simulated 2005 groundwater levels, in the main coal aquifer (model Layer 3), will increase with time as shown on **Drawing No 10** and, by the end of mining in Year 16, is predicted to extend up to between 9km and 15km from the open cut pits and underground mine.

12.4 Impact Post Mining

12.4.1 Groundwater Recovery – Spoil Aquifer and Final Voids

The alluvial aquifer system which occurs in the area of the open cut mine will be replaced by spoil, which will be a mixture of broken sandstone, siltstone, shale, minor coal and alluvial material.

Similarly the goaf of the longwall mine will consist of broken sandstone, siltstone and shale. These materials will have their own unique hydrogeologic characteristics.

Post mining dewatering of the pits and the underground will be discontinued, the void space associated with the goaf of the longwall mine and the spoil of the backfilled open cut mine, will gradually fill with water until an equilibrium water table level establishes within the spoil material. The sources of water that will initially fill the void are:

- seepage from the coal seam aquifers;
- runoff from and rainfall infiltration through the spoil heaps.

It has been shown in this report that there is no seepage loss through the base of the Nogoa River and similarly that there will be no infiltration through the compacted spoil of the reclaimed floodplain. These two potential sources of groundwater recharge will therefore not contribute to development of a spoil aquifer and hence to groundwater recovery.

The cone of depression will continue to expand for some time after the mine closure, until a new steady state condition has established. Both the rate of groundwater recovery and the final extent of the cone of depression will depend on the recharge rates through the spoil in the mined out voids, and the size, location, rate of rise and the equilibrium elevation of the water level in the final open voids left after mining. According to the mine plan final open voids will be left in A to F Pits and in the Yongala Pit. These final voids will be sinks to groundwater seepage, will collect rainfall and runoff, and will loose water through evaporation. A bund will be constructed at the top of the highwall around the final voids both for safety and to divert runoff away from the pit to prevent overtopping.

The final elevation of the water level in the void lakes will depend on the following:

- rate of evaporation from the surface of the void lake,
- rate of recharge to the uncapped spoil,
- rate of groundwater inflow from the coal seams, and
- hydraulic conductivity of the spoil and the goaf of the longwall mine.

The average annual rate of evaporation from the surface water body in the Ensham area was estimated (based on pan evaporation factors supplied by NRMW) at 1461mm. However as discussed, it was estimated that the average annual evaporation rate from an open water body in the final void lake will be about 1032mm/year, that is 50% of the recorded pan evaporation, and about twice the average annual rainfall of 555.9mm/year. It makes allowance for the fact that the final voids are deep, shaded pits, protected from winds, both factors reducing evaporation.

A predictive simulation of the steady state elevation of the water levels in the final voids was conducted assuming two rates of recharge to the spoil of 10% and 15% of rainfall, with 10% being the more likely scenario and 15% being a worst case scenario giving maximum equilibrium levels in the final voids, as discussed in Section 12.2. It was also assumed that the hydraulic conductivity of the spoil will be 5m/day. The simulated final, steady state, water level elevation in the voids, as well as corresponding maximum saturated thickness of the spoil in individual pits, are shown on Table 24. The simulated equilibrium water tables levels are shown on **Drawing No 11.**

Table 24 indicates that equilibrium groundwater levels post mining in the final voids will be similar to pre-mining water levels in a number of pits, that is, around RL 140 -142m, but that other pits with less spoil catchment area with respect to rainfall recharge, will remain as sinks to groundwater flow. As such it is expected that there should be no discharge of spoil aquifer water to the Nogoa River. It is also assessed that it would take in excess of 200 years for the spoil and goaf aquifers to recover to the predicted equilibrium water level, based on an average inflow rate of 15L/s from groundwater and 42L/s from rainfall recharge to the spoil.

Table 24: SIMULATED EQUILIBRIUM WATER LEVEL IN FINAL VOIDS

	Recharge to Spoil 55.6mm/year (10% of annual rainfall)		**Recharge to Spoil 83.4mm/year (15% of annual rainfall)**	
Final Void	**Simulated Water Level Elevation (RLm)**	**Maximum Saturated Thickness of Spoil (m)**	**Simulated Water Level Elevation (RLm)**	**Maximum Saturated Thickness of Spoil (m)**
A Pit	135	69	138	72
B Pit	136	76	138	78
C Pit	142	138	144	140
D Pit	142	147	146	151
DE Pit	141	69	145	73
F Pit	124	39	133	48
Yongala Pit	124	14	132	22

It is estimated that the volume of water in the spoil and goaf aquifers following recovery of groundwater levels to an equilibrium condition is about 335,000ML, based on a storage coefficient of 0.2 for the spoil and 0.14 for the goaf.

12.4.2 Groundwater Balance

The components of the model-derived groundwater balance at the end of the 22 years of the mining operation are shown in Table 25.

Table 25: GROUNDWATER BALANCE - END OF MINING

Flow Term	**In (m^3/day)**	**Out (m^3/day)**	**Gain (+) or Loss (-) (m^3/day)**
Storage	2844.4	392.2	+2452.2
Constant Head	0.0	0	0.0
Drains (Mine dewatering and discharge from model)	0.0	3378.3	-3378.3
Recharge	948.4	0.0	+948.4
River Leakage	0.0	0.0	0.0
Sum	**3792.8**	**3770.5**	**-22.3**
Discrepancy			**+0.59%**

The cumulative discrepancy between inflows and outflows for the whole mining period between 2005 and 2022 was -476.5m^3, a discrepancy 0.43%, which is considered very good.

The two sources of water input to the model are recharge by rainfall and release of water from aquifer storage. The major outputs from the model domain, at the end of mining in Year 16, in order of significance are mine dewatering and aquifer storage.

13.0 POTENTIAL IMPACT OF THE PROJECT ON GROUNDWATER REGIME AND MITIGATION OPTIONS

This section of the report discusses the impact of the mine and where adverse impacts are identified mitigation measures. In particular the potential impacts identified by EPA in their Terms of Reference are addressed.

13.1 Impacts on Existing Bores and Wells

Extraction of groundwater by mine dewatering will lower the elevation of the piezometric surface of the coal seam aquifer, and water table of the alluvial aquifer, that is, it will create a “cone of depression” around the mine. The numerical model simulated the development and extent of the “cone of depression” in the coal seam and it was found that the radius of impact of the mine, as determined by 1m drawdown contour on the piezometric surface is between about 9km and 15km. That is only those bores which draw water from the coal seam that is mined at Ensham, up to a radius of about 15km of the mine, will be impacted by mine dewatering. Bores in alluvium and in other aquifers will not be impacted. As discussed in Section 7.0, and shown on Table 15 and on **Drawing No. 4,** privately owned bores within a 15km radius are mainly completed in other formations and most of the bores are at the extremity of the cone of depression. It is therefore assessed that the mine will not impact on any other groundwater users other than potentially a privately owned bore (RN38845), drilled in 1900, which is about 5km from the mine and the status of which is unknown.

Groundwater in the alluvium is patchy in occurrence and is of thin saturated thickness where it occurs. Apart from bore G2, which is registered to Ensham Resources, there are no other known privately owned bores in the alluvium within 5km from the mine. Therefore it is assessed that the mine will not impact any users of alluvial groundwater.

13.2 Impact on Nogoa River and Creeks

The Nogoa River is hydraulically isolated from the alluvial aquifer as proved conclusively by the field investigation, and hence mining of the alluvial floodplain up to the proposed 100m buffer along the river will not impact flow in the river.

Duck Ponds Lagoon and Winton Creek are the two other surface water features of the floodplain that may potentially be impacted by mine dewatering. Duck Ponds Lagoon is perched on the upper black silty clay horizon and is not connected to the underlying alluvial sand and gravel deposits. Similarly Winton Creek appears to be perched as groundwater occurrence in the alluvium is well below creek level. The creek is ephemeral and is dry for most of the time. It is concluded that mining will not impact these surface water features.

13.3 Groundwater Inflow to Mine and Control Strategies

Groundwater inflow to the open pits primarily occurs from the coal seams as there is little water in the alluvium. To date the maximum inflows have been controlled by in-pit sump pumping. Predictive numerical modelling has indicted that groundwater inflow to the various pits will not increase substantially above existing levels as the pits are developed across the floodplain, and therefore groundwater inflow control strategies, such as advance dewatering, should not be required.

Similarly predicted groundwater inflows of up to 27L/s to the longwall mine can be controlled by strategically located sump pumps.

13.4 Groundwater Quality – Spoil Aquifer and Final Voids

A waste rock characterization study was undertaken by URS (2005)[30] to address the risk of discharge of poor quality water from a "spoil aquifer" to the Nogoa River. The study found that the overburden rock that would form the spoil is relatively benign and will generate slightly alkaline and fresh (non-saline) runoff and seepage following surface exposure.

The conceptual model of the spoil aquifer system and the processes that will occur are summarised below:

- initially the spoil and final voids will fill with seepage from the coal seams and runoff/rainfall infiltration. The coal seam water is of poor quality, however better quality water will result from the passage of rainfall/runoff through the spoil in the mine voids.

- the final voids and spoil will gradually fill and there will probably be stratification of the groundwater in the spoil and voids. The poorest quality water is likely to occur towards the base of the spoil filled open cut voids and goaf of the longwall mine where there are more coal fines and coal waste, and where there is little movement of the water.

- a quasi-steady state water table will develop in the spoil and groundwater quality in the upper part of the spoil aquifer should improve over time as minerals are leached from the unsaturated zone and zone of water table fluctuation, and are flushed from the system to the final voids.

Factors that will influence long term void water quality are as follows:

- the salinity of the void water will increase over time due to evaporation, as the voids will remain as sinks to groundwater flow;
- the chemistry of the spoil is benign and in any case has finite leachable material, so water quality discharging from the spoil will improve with time;
- revegetation of the spoil surfaces will affect the quantity and quality of runoff.

The predicted large storage in the final voids should buffer the void water quality against severe changes in water quality. The URS (2005)[30] report stated *"water extract and kinetic leach column tests indicate that the concentration of soluble metals and salts in runoff and seepage from overburden is likely to remain well within the applied water quality guideline values"* of ANZECC,

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[30] URS Australia Pty Ltd (October 2005) *"Geochemical Characterization and Assessment of Overburden and Potential Reject Material at Ensham Central Coal Development".*

2000[4]. As discussed in Section 12.4.1 the final voids will act as sinks to groundwater flow and therefore water in the voids will not move into other parts of the aquifer and the voids will not overtop and discharge to surface streams or the Nogoa River.

Based on assumed storage coefficients of 25% of the longwall seam extraction thickness, that is the "goaf" aquifer, and 20% for the "spoil" aquifer, the volume of water that is permanently stored or retained in these aquifers once the groundwater level has fully recovered post mining, is estimated to be 335,000ML. This volume of water is estimated to accumulate over a period of 200 years from a combination of coal seam discharge and rainfall infiltration.

13.5 Development of "Spoil Aquifer" and Seepage of Spoil Leachate to the Nogoa River

As discussed in Section 12.4.1 a water table aquifer will develop slowly within the spoil backfilling the voids. A quasi-equilibrium water level will develop over a 200 year period, governed by rainfall recharge to the spoil heaps and inflow from the coal seam and discharge as evaporation from free water in the final voids. Modelling has shown that the post mining, equilibrium, water table level will be at or below the level of the river, and that there should be no discharge of spoil aquifer water to the river. As stated conservatively high rainfall recharge values were used in the model and the simulated post mining water table is a worst case scenario.

The development of a "spoil aquifer" and equilibrium water table level can further be reduced by on-going rehabilitation of the spoil. Reclamation and revegetation will promote surface runoff and evapotranspiration, minimizing infiltration into the backfilled spoil. The disturbed surface area that has not been reclaimed and revegetated at any one time will be limited by the mines progressive rehabilitation program.

Spoil geochemical characterization has shown the waste rock to be relatively benign and therefore leachate produced from water infiltrating the spoil should be of higher quality than the existing groundwater in the alluvium which is brackish to saline.

13.6 Impact of Tailings Dams

The planned location of the tailings dams is to the east of the coal seam subcrop as shown on **Drawing No 1**, and as such is outside of the modelled area. The tailings dams are located over Permian rocks which as discussed consist primarily of feldspathic and lithic sandstone, mudstone and siltstone. The rocks are of very low permeability and the weathered, clay rich, surface profile would most likely be impermeable. Construction of the tailings dams at the planned locations is therefore unlikely to have any impact on the groundwater regime and particularly the alluvium associated with Boggy Creek or the Nogoa River, which are a minimum of 1km and 2km to the west and south respectively.

During the geotechnical investigation and design phase of the tailings dams the necessity for installation of groundwater monitoring bores at strategic locations around the dams will be assessed, and if necessary a groundwater monitoring plan implemented.

14.0 MODEL LIMITATIONS

Development, calibration and the results of predictive simulations from any groundwater model is based on data characterizing the groundwater system under investigation. The data is typically collected from sparsely distributed locations and over a limited period of time. It is neither feasible nor possible to collect all the data characterizing the whole aquifer system in detail and therefore various assumptions have to be made during development of the groundwater model. A number of assumptions were made during development of the groundwater model described in this report and these assumptions together with their impact on the simulation results are discussed below.

- It was assumed that the main aquifer simulated within the model domain area, that is, the coal seam aquifer is hydraulically continuous and without internal boundaries. The impact of such an assumption on the simulation results is such that there are no impediments to the development of the cone of depression around the mine. If there were low permeability (barrier) faults which have the effect of compartmentalising the aquifer into a number of hydraulically distinctive zones then the simulated drawdown would be different. The extent and the shape of the cone of depression would be determined by the geometry and hydraulic parameters of such faults, but would in general be smaller and deeper in the extraction area zones. The inflows to the mine would also most likely be reduced in such case.

  Should there be any hydraulically conductive faults intersecting the coal seams and these faults were intersected by the pit, a cone of depression around the mine would develop primarily along the faults traces. In these circumstances the depth of the cone of depression would be smaller than simulated. The presence of such faults would also result in higher localized inflows to the mine.

- An assumption was made regarding the hydraulic parameters of the coal seams and the overburden, which govern the rate of transfer of groundwater between the coal seam and the alluvial aquifer. An increase in the hydraulic conductivity of the coal seam would decrease the depth of the cone of depression around the mine, increase its extent, and decrease the post mining elevation of groundwater levels.

15.0 GROUNDWATER MONITORING PLAN

The proposed plan for future monitoring of the impact of mining on the groundwater resources around the Ensham Central Mine is based on the installed monitoring bores along the river, the NRMW line of bores across the alluvial plain, monitoring bores that may be installed in future, such as around the tailings dam and selected privately owned bores that modelling has shown may be impacted by mining. The bores will make up the monitoring bore network. The network will continue to monitor the effects of mining activities on the groundwater resource and on other users of the resource in terms of quality and quantity. The groundwater monitoring program will provide both an on-going assessment of the impact of the proposed mine and a timely warning of adverse impacts on the groundwater regime, so that remedial action can be taken if necessary.

The monitoring program is summarised in Table 26. The data from the monitoring program should be reviewed annually and the results held on site. After 3 years of monitoring, a review should be undertaken to assess whether the frequency of monitoring should be changed to bi-annually or annually.

It is recommended that all groundwater monitoring, water level measurements and sample collection, storage and transportation be undertaken in accordance with the procedures outlined by the Murray Darling Basin Commission (Aug 1997)[31].

Table 26: PROPOSED PLAN FOR GROUNDWATER MONITORING

Location	Parameters	Frequency	Comment
Along Nogoa River Bores EC01 – EC23	water level	Every 4 months	**Field Analysis** Assess the impact of mining on the alluvium and river
	pH, EC	Every 4 months	
Along Nogoa River 4 selected "EC" bores	pH, EC, Na, Mg, Ca, Cl, HCO_3, SO_4, Total Fe	Every 4 months	**Laboratory Analysis** Assess the impact of mining on the alluvium and river
Across Floodplain NRMW bores 13020**176** to 13020**181**	water level	Every 4 months	**Field Analysis** Assess the impact of mining on the alluvium.
	pH, EC	Every 4 months	
Landowner Bores	water level	Every 4 months	Assess the impact of mining on landowner bores with respect to existing farm and domestic water supplies.
	pH, EC	Every 4 months	

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ERROL H. BRIESE
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[31] Murray Darling Basin Commission, (Aug. 1997), *"Murray Darling Basin Groundwater Quality Sampling Guidelines"*, Tech. Report No. 3, Groundwater Working Group.

LIMITATIONS OF REPORT

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has prepared this report for the use of Hansen Consulting in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 15 September 2004.

The methodology adopted and sources of information used by AGE are outlined in this report. AGE has made no independent verification of this information beyond the agreed scope of works and AGE assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to AGE was false.

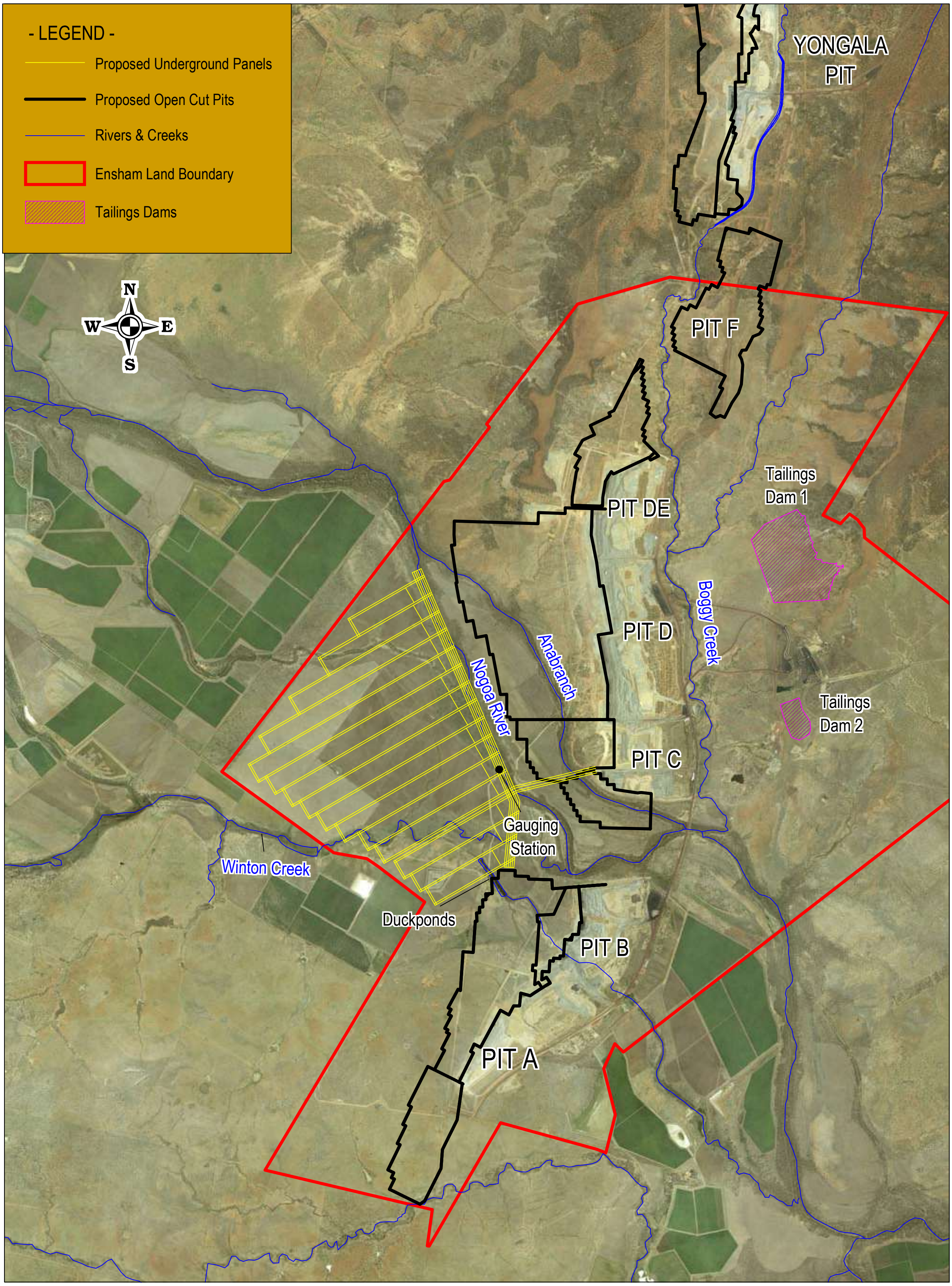
This study was undertaken between 2 August 2004 and February 2006 and is based on the conditions encountered and the information available at the time of preparation of the report. AGE disclaims responsibility for any changes that may occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. It may not contain sufficient information for the purposes of other parties or other users. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing and other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. Where borehole logs are provided they indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of the site, as constrained by the project budget limitations. The behaviour of groundwater is complex. Our conclusions are based upon the analytical data presented in this report and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, AGE must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge, information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.



Aerial Photo - January 2005

0 2 4

Kilometers

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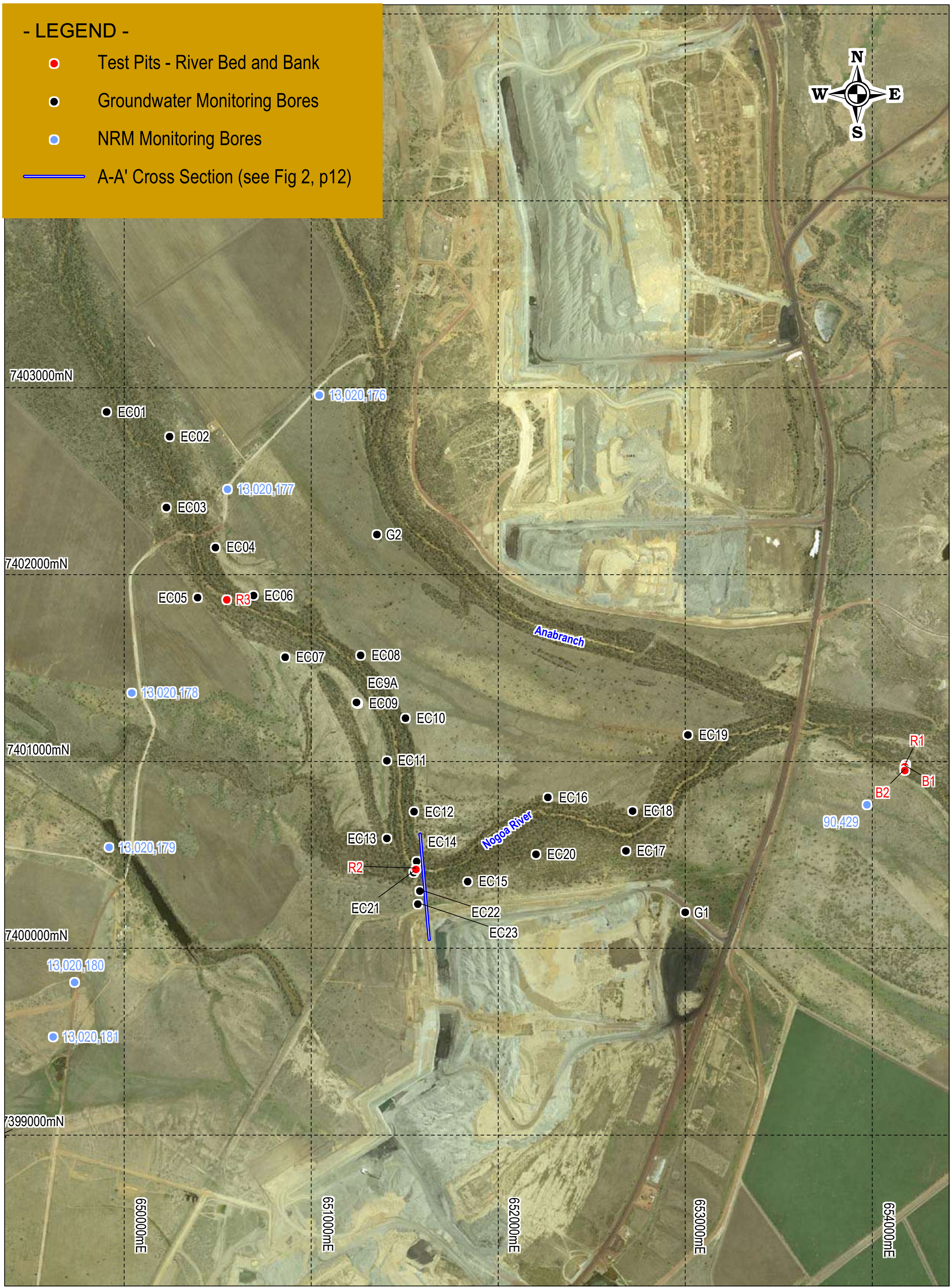
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: ENSHAM CENTRAL PROJECT - EIA
GROUNDWATER IMPACT ASSESSMENT
SITE LOCATION

CLIENT: Hansen Consulting	**OFFICE:** Brisbane
DRAWN BY: JST	**SCALE:** 1:100,000	**PROJECT No:** G1258	**DRAWING No:** 1
APPROVED BY:	**DATE:** August 2005



Aerial Photo - January 2005

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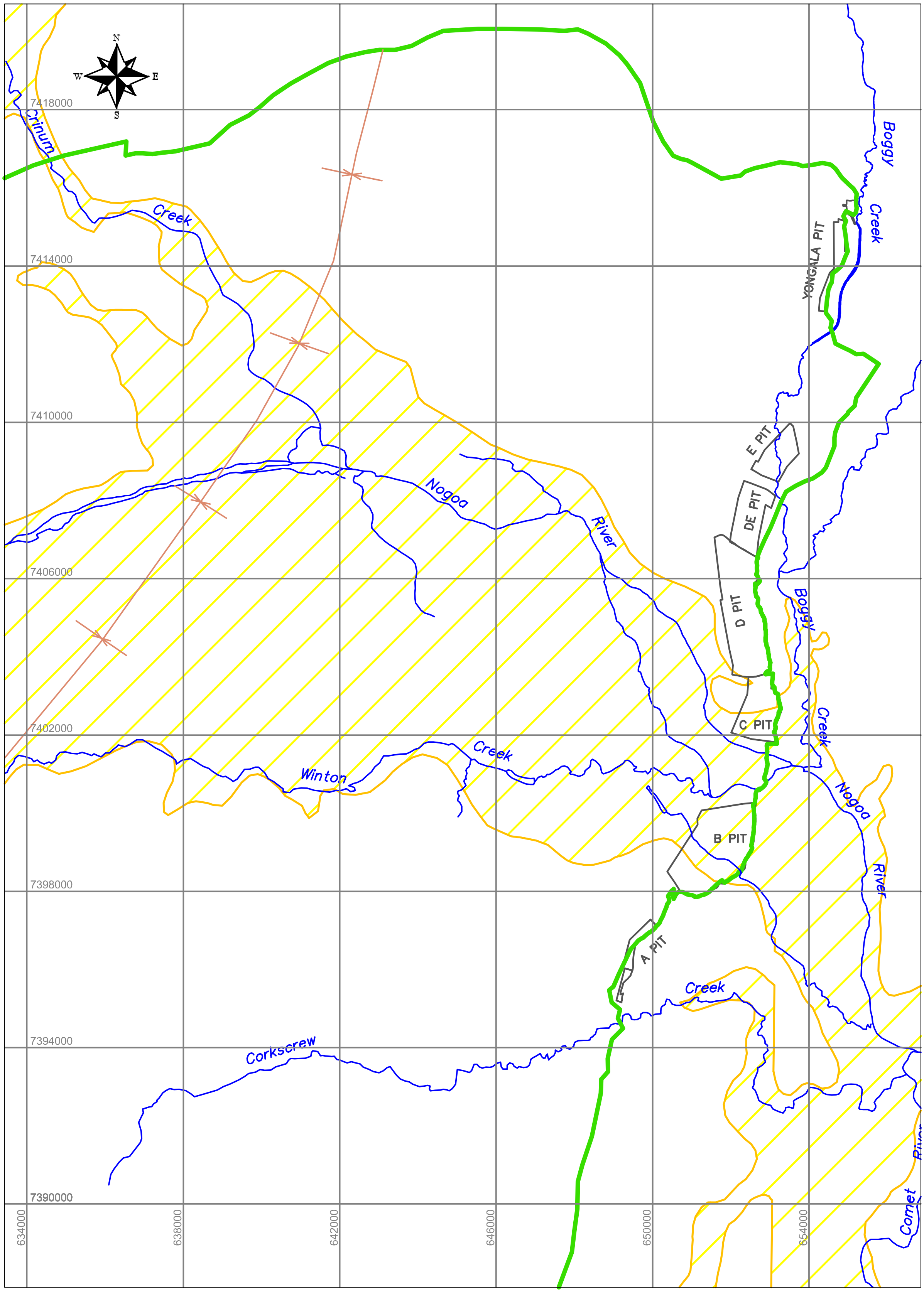
TITLE: ENSHAM CENTRAL PROJECT - EIA
GROUNDWATER IMPACT ASSESSMENT
MONITORING BORE AND TEST PIT LOCATIONS

CLIENT: Hansen Consulting
OFFICE: Brisbane
DRAWN BY: JST
SCALE: 1:30,000 (A4)
PROJECT No: G1258
DRAWING No: 2
APPROVED BY:
DATE: November 2005



LEGEND

- Rangal Coal Measures Subcrop
- Syncline Axis
- ▨ Alluvium
- ☐ Open Cuts (2005)

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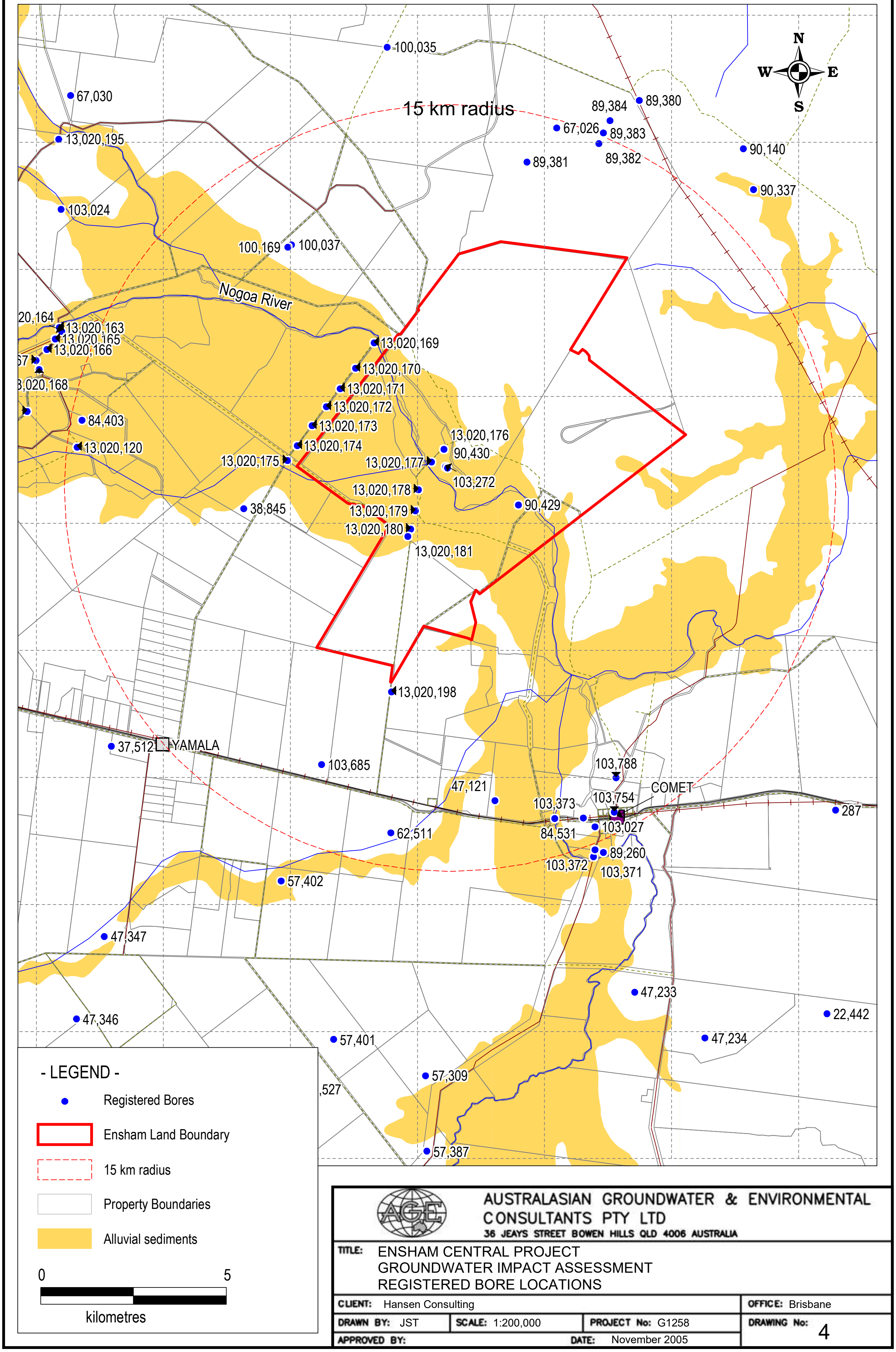
GROUNDWATER IMPACT ASSESSMENT
REGIONAL GEOLOGY

CLIENT: Hansen Consulting
OFFICE: Brisbane
DRAWN BY: B.S.
SCALE: 1:150,000 (A4)
PROJECT No: G1258
DRAWING No: 3
APPROVED BY:
DATE: August 2005



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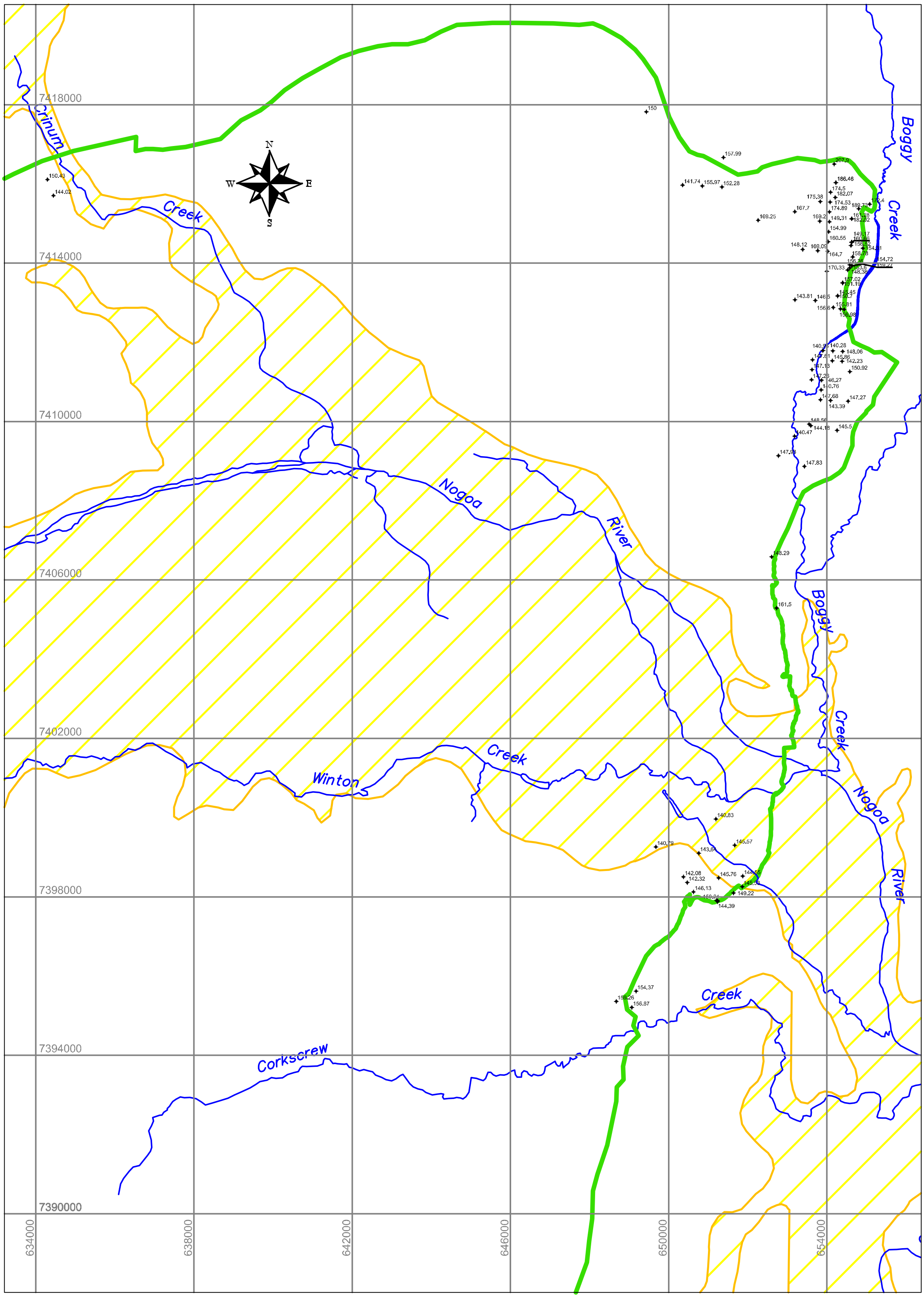
TITLE: ENSHAM CENTRAL PROJECT
GROUNDWATER IMPACT ASSESSMENT
REGISTERED BORE LOCATIONS

CLIENT: Hansen Consulting
OFFICE: Brisbane
DRAWN BY: JST
SCALE: 1:200,000
PROJECT No: G1258
DRAWING No: 4
APPROVED BY:
DATE: November 2005



LEGEND

🟩 Rangal Coal Measures Subcrop

▨ Alluvium

🟦 River/Creek

150.24 ⌖ Groundwater Level Elevation

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TITLE: ENSHAM CENTRAL PROJECT - EIA
GROUNDWATER IMPACT ASSESSMENT
GROUNDWATER LEVELS

CLIENT: Hansen Consulting

OFFICE: Brisbane

DRAWN BY: B.S.

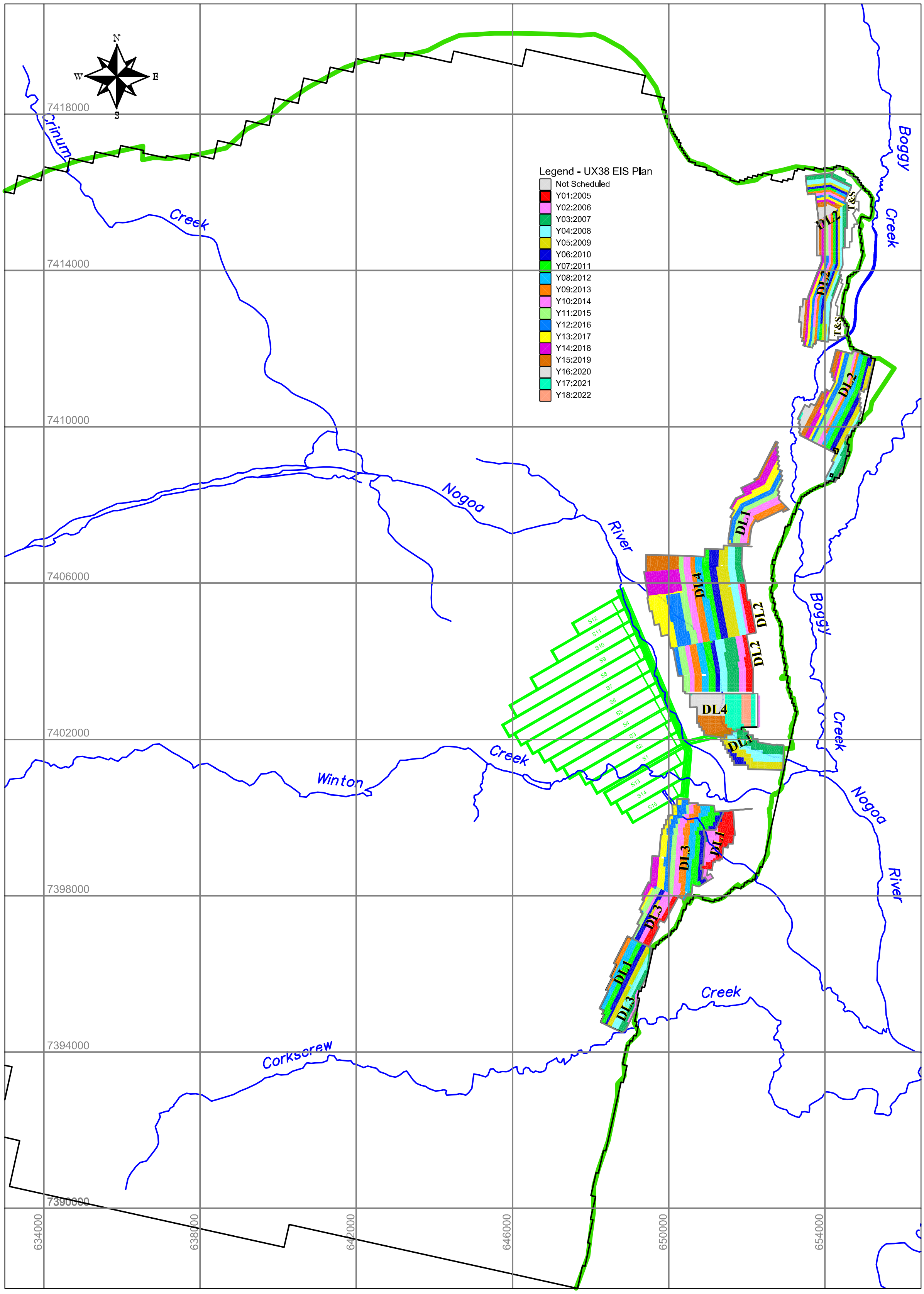
SCALE: 1:250,000 (A4)

PROJECT No: G1258

DRAWING No: 5

APPROVED BY:

DATE: August 2005



LEGEND

Rangal Coal Measures Subcrop

Ensham Underground

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TITLE: ENSHAM CENTRAL PROJECT - EIA
GROUNDWATER IMPACT ASSESSMENT
MINING SCHEDULE

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SCALE: 1:150,000 (A4)
PROJECT No: G1258
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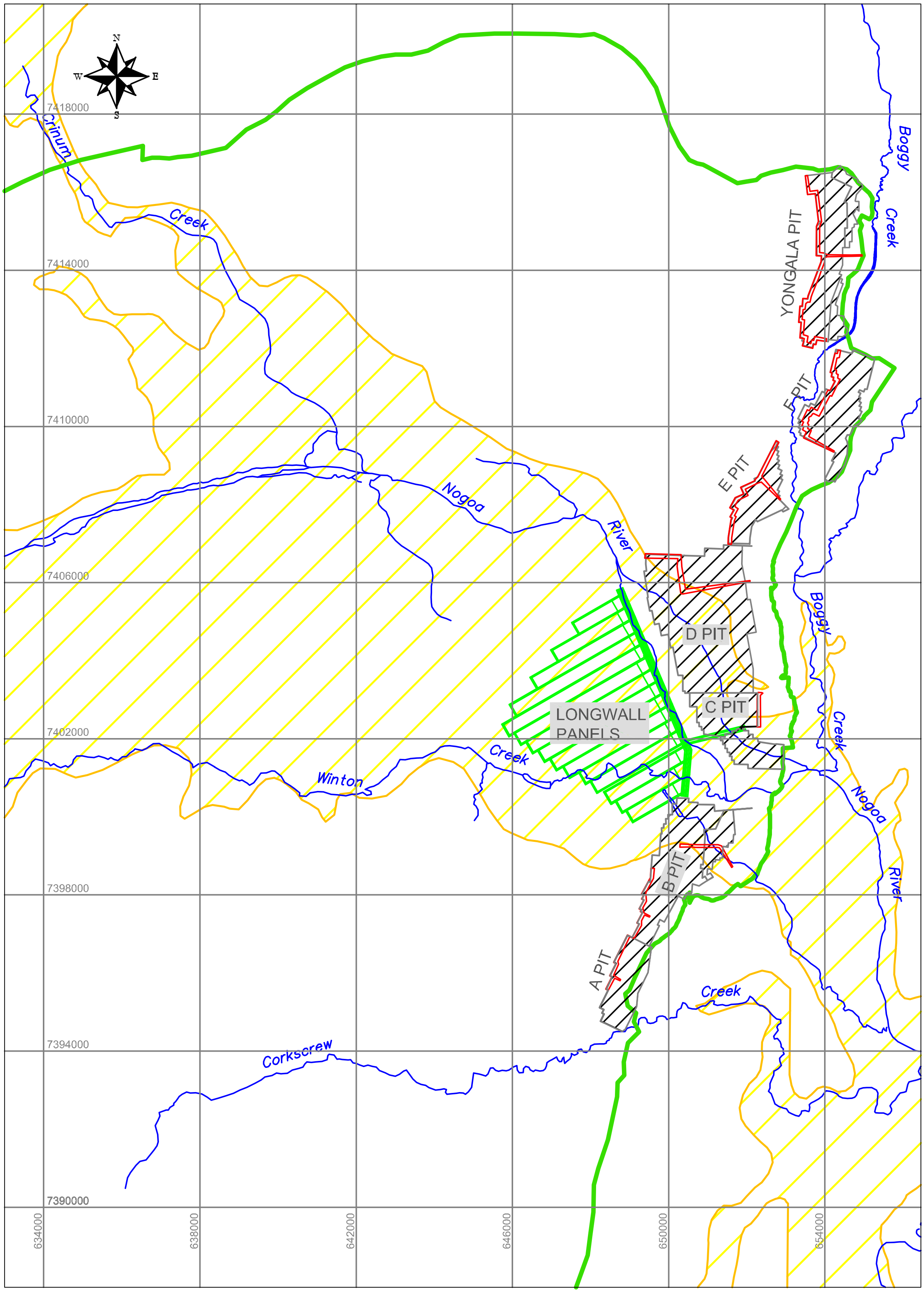

LEGEND

🟩	Rangal Coal Measures Subcrop
▨	Alluvium
🟥	Final Void
🟩	Ensham Underground
▨	Open Cuts

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TITLE: ENSHAM CENTRAL PROJECT - EIA
GROUNDWATER IMPACT ASSESSMENT
FINAL VOIDS

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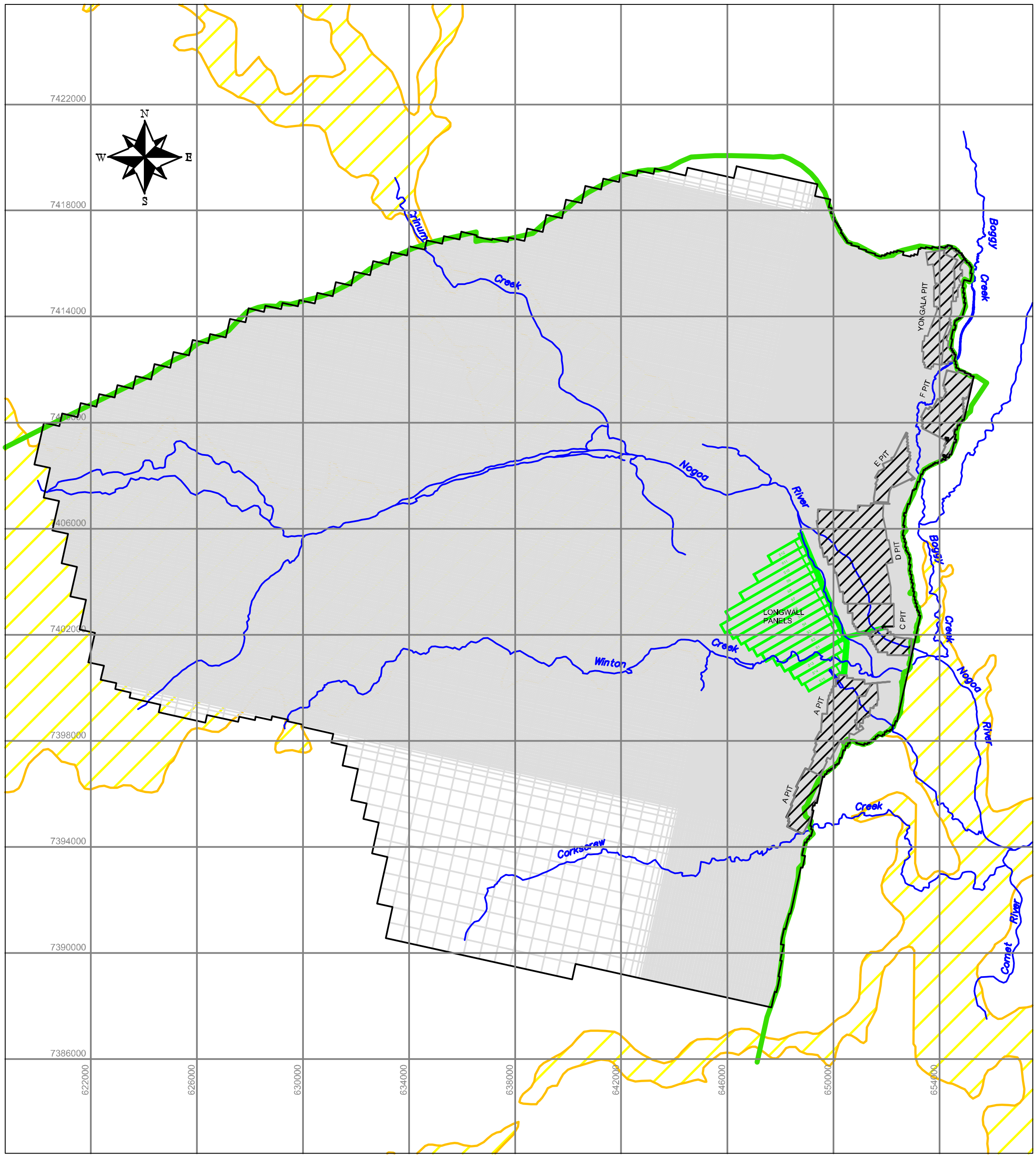
PROJECT No: G1258
DRAWING No: 7
APPROVED BY:
DATE: August 2005



LEGEND

▨ Alluvium

▨ Open Cut Area

🟩 Ensham Underground

▦ Model Grid

〰 Rangal Coal Measures Subcrop

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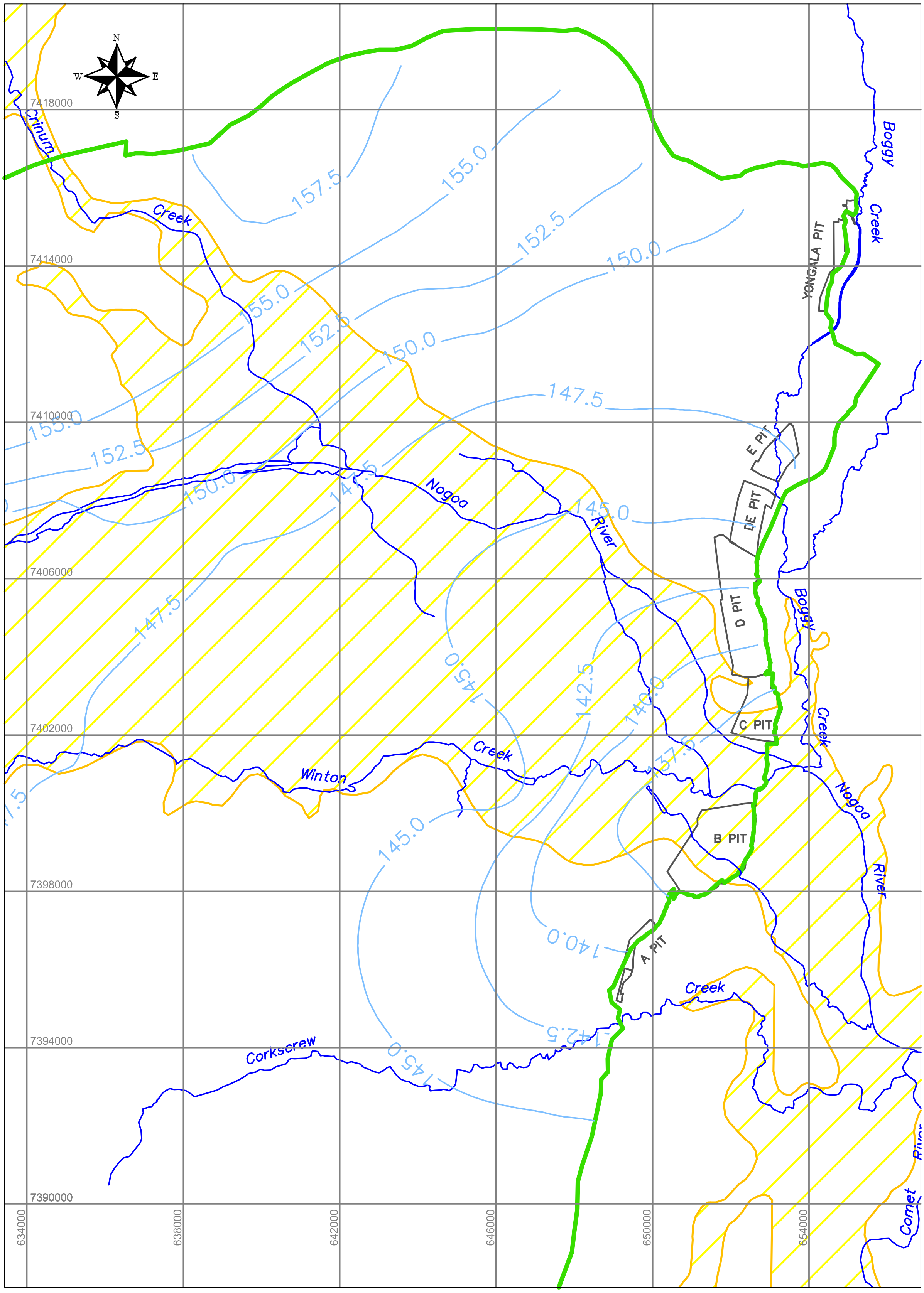
TITLE: ENSHAM CENTRAL PROJECT - EIA
GROUNDWATER IMPACT ASSESSMENT
MODEL GRID OUTLINE

CLIENT: Hansen Consulting
OFFICE: Brisbane
DRAWN BY: B.S.
SCALE: 1:250,000 (A4)
PROJECT No: G1258
DRAWING No: 8
APPROVED BY:
DATE: August 2005



LEGEND

145.0 Simulated Piezometric Surface

Rangal Coal Measures Subcrop

Alluvium

Open Cuts (2005)

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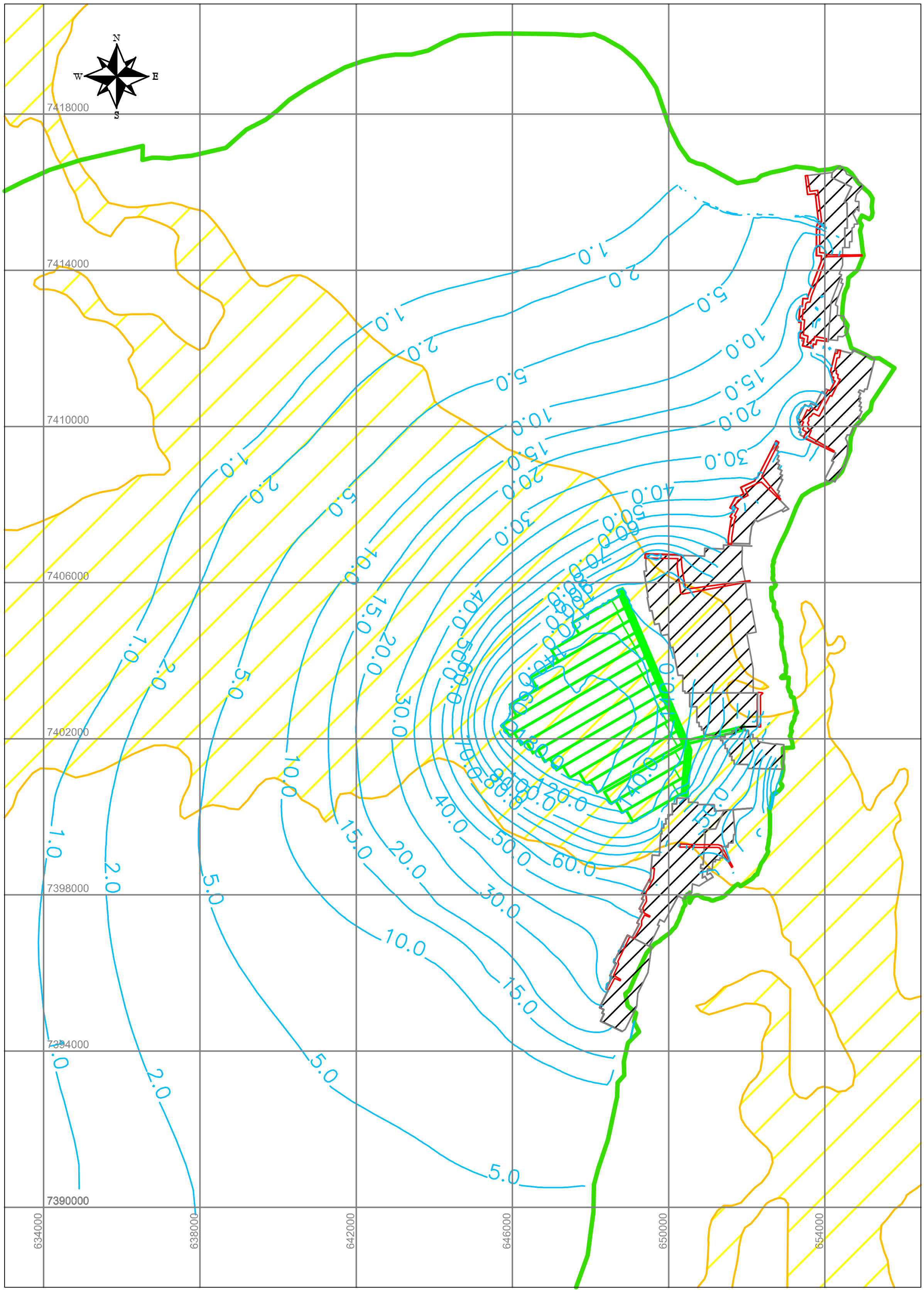
TITLE: ENSHAM CENTRAL PROJECT - EIA
GROUNDWATER IMPACT ASSESSMENT
SIMULATED STEADY STATE GROUNDWATER LEVELS

CLIENT: Hansen Consulting
OFFICE: Brisbane
DRAWN BY: B.S.
SCALE: 1:150,000 (A4)
PROJECT No: G1258
DRAWING No: 9
APPROVED BY:
DATE: August 2005



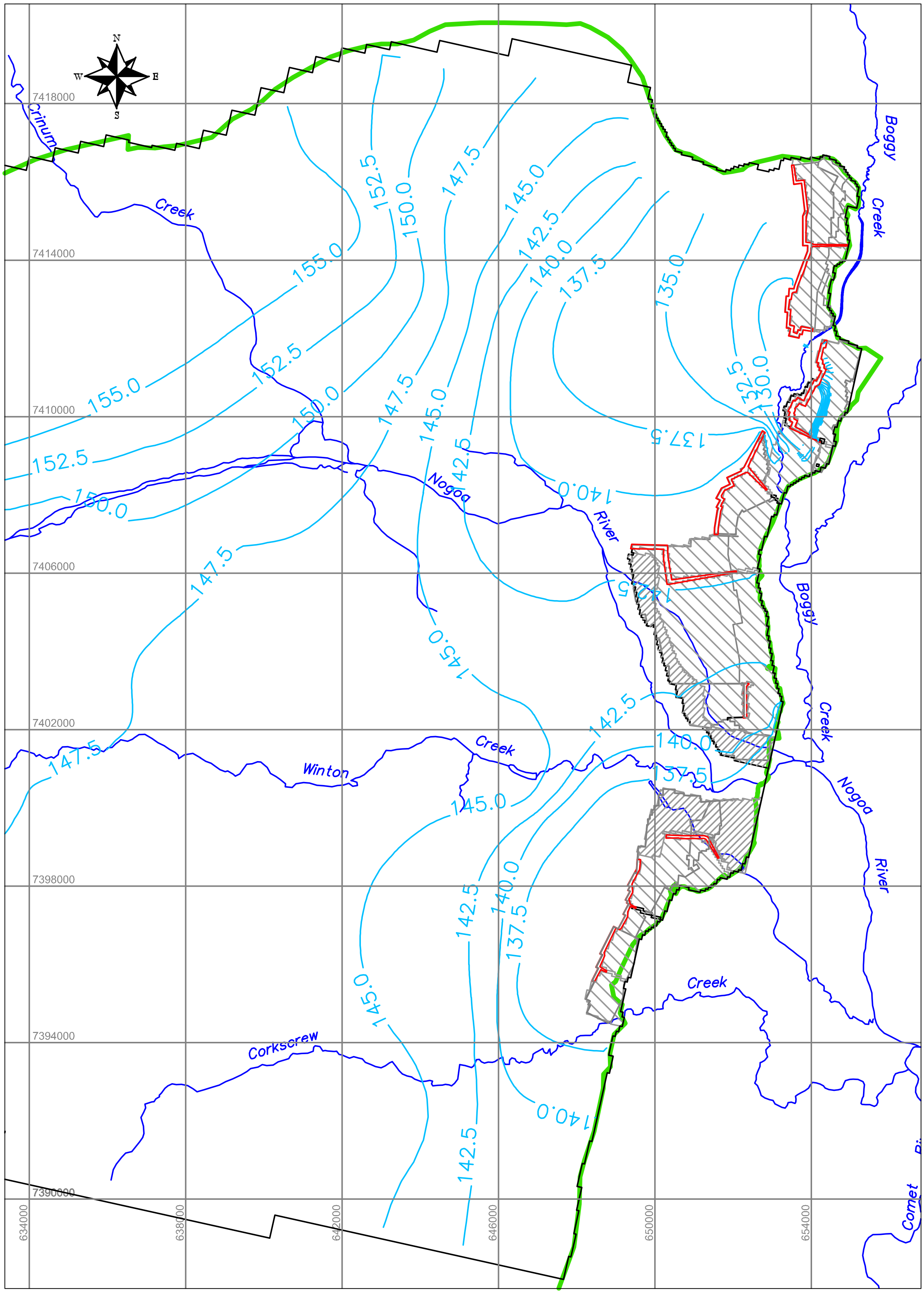
LEGEND

- Simulated Drawdown (m)
- Rangal Coal Measures Subcrop
- ▨ Alluvium
- 🟥 Final Void
- 🟩 Ensham Underground
- ▨ Open Cuts

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: ENSHAM CENTRAL PROJECT - EIA
GROUNDWATER IMPACT ASSESSMENT
SIMULATED DRAWDOWN IN COAL SEAM - YEAR 2022

CLIENT: Hansen Consulting
OFFICE: Brisbane
DRAWN BY: B.S.
SCALE: 1:150,000 (A4)
PROJECT No: G1258
DRAWING No: 10
APPROVED BY:
DATE: August 2005



LEGEND

〰 Simulated Groundwater Level (RLm)

🟥 Final Void

〰 Rangal Coal Measures Subcrop

▧ Spoil Area - Increased Recharge

▨ Spoil Area - No Recharge
- reinstated floodplain

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL
CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: ENSHAM CENTRAL PROJECT - EIA
GROUNDWATER IMPACT ASSESSMENT
SIMULATED GROUNDWATER LEVELS AFTER RECOVERY

CLIENT: Hansen Consulting
OFFICE: Brisbane
DRAWN BY: B.S.
SCALE: 1:150,000 (A4)
PROJECT No: G1258
DRAWING No: 11
APPROVED BY:
DATE: August 2005

Appendix 1

DESCRIPTION OF FIELD INVESTIGATION PROGRAM

DESCRIPTION OF FIELD INVESTIGATION PROGRAM

1.0 Monitoring Bore Installation Program

1.1 Overview

Twenty four new groundwater monitoring bores were installed along the Nogoa River between 2 and 22 November 2004. The drilling, installation and construction of the monitoring bores was undertaken by Integrated Environmental Services Australia Pty Ltd (IESA), with technical advice provided on site by an AGE hydrogeologist. The locations of the groundwater monitoring bores, EC01 to EC23 are shown on Drawing No. 2.

Bores EC01, EC03, EC09, EC11 and EC13 were drilled with an Edson 200 drilling rig using the direct rotary mud method. Biodegradable polymer (Loloss) was used to evacuate the cuttings from the borehole. A 125mm drag bit was used for penetrating the upper silt/clay formation with a 125mm tricone bit used when sand and gravel was encountered. The Edson 200 rig had difficulty penetrating cobble layers and was replaced with a larger Bourne T25 drilling rig on 12 November 2004. The Bourne T25 rig completed the installation of the remaining monitoring bores using compressed air and stiff foam to evacuate the cuttings (Plate 1). The exception was borehole EC09A which was drilled with the direct rotary mud method. The sand and gravel unit is typically loose and unstable with some collapse experienced in most of the boreholes. In most of the boreholes a 2m-3m sump was drilled into the coal measures to allow the sand and gravel to collapse into the base of the borehole to enable logging and emplacement of the casing.

An initial attempt was made to collect undisturbed soil samples from the aquifer using a triple tube core barrel. As the aquifer material was relatively coarse and loose this method proved unsuccessful. Further attempts were made to collect undisturbed sediment samples using a 'dormer brand' auger run into the borehole with the drilling rods. This method proved to be successful for collecting samples of sandy materials but could not successfully retrieve coarser gravel/cobble samples. Therefore when gravel and cobble bands were encountered during drilling no attempt was made to collect undisturbed sediment samples.

Plate 1: Drilling with foam and airlift development of monitoring bore

1.2 Geophysical Logging

When the target depth was reached in each hole, a down-hole geophysical logging tool was run. A combination tool, manufactured by Auslog Pty Ltd, capable of measuring natural gamma, point resistivity and self potential, was used to log the borehole. The geophysical logs were extracted digitally as Log ASCII Files (LAS) with a laptop computer. The gamma log which provides the most information is presented on the borehole logs included in Appendix 2. As there was no water in the boreholes drilled with foam, the electric logs did not provide a reading and are therefore not presented on the borehole logs.

1.3 Monitoring Bore Construction

After logging the boreholes, they were cased with Class 12, 50mm diameter, lead free, uPVC casing. A 3m length of factory slotted uPVC (0.4mm slots) was installed in the bottom of the boreholes with blank casing completing the borehole to the surface. A clean, 3mm sand filter was placed by gravity around the screens and a bentonite seal (¼” bentonite pellets) was placed above the sand to prevent ingress of surface water. The annulus was backfilled with cuttings to within 5m of the surface and a cement/bentonite grout plug placed to the surface. A 100mm X 100mm steel protective cover was placed over the 0.5m of casing protruding at the surface. Borehole logs and construction data for the monitoring bores is included in Appendix 2. Table 1 summarises the construction of the monitoring bores.

Table 1: GROUNDWATER MONITORING BORES – CONSTRUCTION DATA

ID	Drilling Method	Coordinates		TOC Level (RLm)	Depth Drilled (m)	Screen from – to (m)	Static Water Level (25 Nov 04)		
		Easting (m)	Northing (m)				(mbTOC)	(mbGL)	(RLm)
EC01	Polymer mud	649905.4	7402878.3	154.325	17.2	14-17	13.22	12.793	141.105
EC02	Air/foam	650242.2	7402745.5	154.764	18	13.46-16.46	16.35	15.838	138.414
EC03	Polymer mud	650225.4	7402366.8	153.238	16.6	12.28-15.28	12.24	11.749	140.998
EC04	Air/foam	650487.5	7402152.1	153.65	18	11.96-14.96	Dry	Dry	-
EC05	Air/foam	650391.9	7401884.6	154.48	18	13.54-16.54	14.18	13.789	140.3
EC06	Air/foam	650691.3	7401895.7	153.126	18	11.99-14.99	14.66	14.231	138.466
EC07	Air/foam	650860.3	7401565.2	153.882	18	12.57-15.57	14.73	14.223	139.152
EC08	Air/foam	651264.4	7401575.4	154.634	18	13.5-16.5	Dry	Dry	-
EC09	Polymer mud	651249.0	7401318.1	153.411	13.7	-	Dry	Dry	-
EC09A	Polymer mud	651242.2	7401323.7	153.541	18	15.1-18.1	15.03	14.397	138.511
EC10	Air/foam	651504.3	7401239.3	154.271	18	14.61-17.61	16.77	16.255	137.501
EC11	Polymer mud	651404.3	7401011.3	152.689	17.4	14.25-17.25	15.36	14.896	137.329
EC12	Air/foam	651550.0	7400738.9	152.069	18	13.1-16.1	15.08	14.579	136.989
EC13	Polymer mud	651404.7	7400595.7	152.038	15.2	12.19-15.19	15.03	14.554	137.008

Table 1: GROUNDWATER MONITORING BORES – CONSTRUCTION DATA

ID	Drilling Method	Coordinates		TOC Level (RLm)	Depth Drilled (m)	Screen from – to (m)	Static Water Level (25 Nov 04)		
		Easting (m)	Northing (m)				(mbTOC)	(mbGL)	(RLm)
EC14	Air/foam	651564.0	7400472.7	146.124	12	8.7-11.7	9.68	9.328	136.444
EC15	Air/foam	651836.4	7400364.3	153.931	18	14.22-17.22	Dry	Dry	-
EC16	Air/foam	652265.8	7400815.4	153.586	18	12.25-15.25	Dry	Dry	-
EC17	Air/foam	652683.2	7400528.9	150.047	18	13.4-16.4	Dry	Dry	-
EC18	Air/foam	652718.8	7400742.2	151.839	18	13.3-16.3	Dry	Dry	-
EC19	Air/foam	653014.5	7401149.7	151.713	18	13.2-16.2	Dry	Dry	-
EC20	Air/foam	652201.9	7400510.4	151.077	18	13.29-16.29	Dry	Dry	
EC21	Air/foam	651548.0	7400412.6	143.584	10.2	6.41-9.41	7.76	7.178	135.824
EC22	Air/foam	651580.7	7400313.8	153.695	22	16.3-19.3	18.04	17.5	135.655
EC23	Air/foam	651570.4	7400243.8	153.946	21.5	16.29-19.29	18.37	17.891	135.576

Notes: Static water level as at 25 November 2004
mbTOC – metres below Top of PVC Casing
mbGL – metres below Ground Level

1.4 Monitoring Bore Development

Bores EC01, EC03 and EC11 were developed by airlifting using a 400cfm air compressor, (Plate 1). Due to a relatively thin saturated thickness in the aquifer air lifting proved in-effective for development of the remaining bores. The air compressor was replaced with a small pneumatic pump manufactured by QED which was used for development of EC05, EC06, EC07, EC09A, EC10, EC11, EC12, EC13, EC14, EC21, EC22, EC23. The remaining boreholes were dry.

2.0 Water Sample Collection and Analysis

Electrical conductivity (EC) and pH was monitored during development using an MC-81 pH-conductivity-salinity meter manufactured by TPS Electronics Pty Ltd to ensure that all drilling fluids were completely purged from the borehole. The instrument was calibrated prior to undertaking the work using factory-supplied buffer solutions. When the electrical conductivity stabilised and the bores were yielding clear water, samples were collected for analysis. The samples were stored in polyethylene containers supplied by Australian Laboratory Services (ALS) with no added preservatives. Samples for iron and manganese analysis were filtered and acidified by the laboratory on receipt. The groundwater samples were analysed by ALS for:

- pH, EC and Total Dissolved Solids (TDS)
- Major Anions (CO_3, HCO_3, Cl, SO_4) and Cations (Ca, Mg, Na, K)
- Iron, manganese, nitrate, silica

The results of the testing undertaken by ALS are given in Appendix 3.

3.0 Permeability Tests

As a part of the investigation hydraulic, (falling head) permeability tests were conducted in ten monitoring bores. The tests were conducted on 24 November 2004.

The tests were designed to evaluate the hydraulic conductivity of aquifer material surrounding the bore screen. A falling head test requires a “slug” of water being poured into the bore and the rate of decline in water level being monitored. The rate of decline is proportional to the hydraulic conductivity.

The following procedure was used to undertake the falling head tests:

- the static water level in the monitoring bore was measured,
- an Odyssey™ submersible water level data logger was set below the water table in the bore,
- a 'slug' of water, in this case 10L of water, which is equivalent to about 5m of head inside the 50mm PVC casing, was introduced to the bore, and
- the water level decline was logged at 10 second intervals until within 80% of the static level.

The falling head data for each monitoring bore tested is included in Appendix 4. The data was analysed using the Hvorslev Method (1951) for unconfined aquifers using *Aquifer Test Version 2.5* software.

4.0 Water Level and Quality Monitoring

Monitoring of groundwater levels and quality was undertaken on a quarterly basis in November 2004, February 2005 and June 2005.

For measurement of a more detailed and longer term water level fluctuations pressure sensors were installed in four selected bores. The Odyssey™ submersible datalogger with pressure and temperature sensors was used (Plate 2). The sensors have a pressure range of 0 - 20m with a pressure measurement resolution of 6mm. The loggers were set to record at 6 hourly intervals on 25 November 2004. The vent tube on the loggers was cut to an appropriate depth to ensure that when the loggers were hung in the borehole the logger level remained constant throughout the project. The data recorded by each logger was downloaded during each quarterly visit to the site. The setup data for the loggers is provided in Table 2.

Table 2: LOGGER INSTALLATION DATA (25 November 2004)

DETAILS	BOREHOLE ID			
	13020178	**EC03**	**EC14**	**EC10**
Borehole depth (mbTOC)	18	15.68	12.1	18.11
Logger set at (mbTOC)	15.25	15.38	11.77	17.80
Water level (mbTOC)	13.9	12.24	9.67	16.73
Logger depth under water (m)	5.51	3.14	2.1	1.07

Notes: mbTOC – metres below Top of PVC Casing

Groundwater levels were also measured manually in all monitoring bores at the site. Apart from measuring groundwater levels during the quarterly visits, each bore was purged with a submersible pump and pH and EC measured. The bores were purged until pH and EC had stabilised and a minimum of three casing volumes had been removed. Groundwater samples were collected from selected bores and submitted to ALS for a suite of water quality analyses.

Plate 2:

Odyssey™ submersible datalogger with pressure and temperature sensors. Tree roots have grown through the slotted casing and around the logger

5.0 River Bed Investigation

Excavation of test pits in the bed of the Nogoa River using a 30-tonne excavator was undertaken on 3 February 2005. The excavator was supplied by Grahams Contractors of Emerald. Test pits were excavated at three locations along the Nogoa River as shown in Drawing No. 2. Test pits R1, R2 and R3 were excavated in the bed of the river, with pits B1 and B2 excavated on the adjacent bank close to test pit R1. The excavator bucket was lowered into the river until the bed was encountered, the bucket was then rotated to obtain a sample of sediment and gently removed from the river to minimise washing of fine materials. Sediments encountered in the pits were recorded and are presented in the test pit logs included in Appendix 5. Selected sediment samples from the river bed were submitted to Golder and Associates Geotechnical Laboratory for particle size analyses. The results of the particle size analyses are included in Appendix 6. Photographs of the river bed sampling are shown on Plates 3 and 4.

Plate 3:

LHS Excavation of Test Pit R2 in the Nogoa River – 3 February 2005

RHS Clay and claybound sand and gravel from base of river

Plate 4:

LHS	**Test Pit site R2 - monitoring bore EC21 in foreground**
Middle	**Excavation of test pit R1 in Nogoa River – clay and claybound gravels**
RHS	**Clay excavated from Test Pit R3 in Nogoa River**

Appendix 2

BOREHOLE LOGS

Australasian Groundwater & Environmental Consultants Pty Ltd

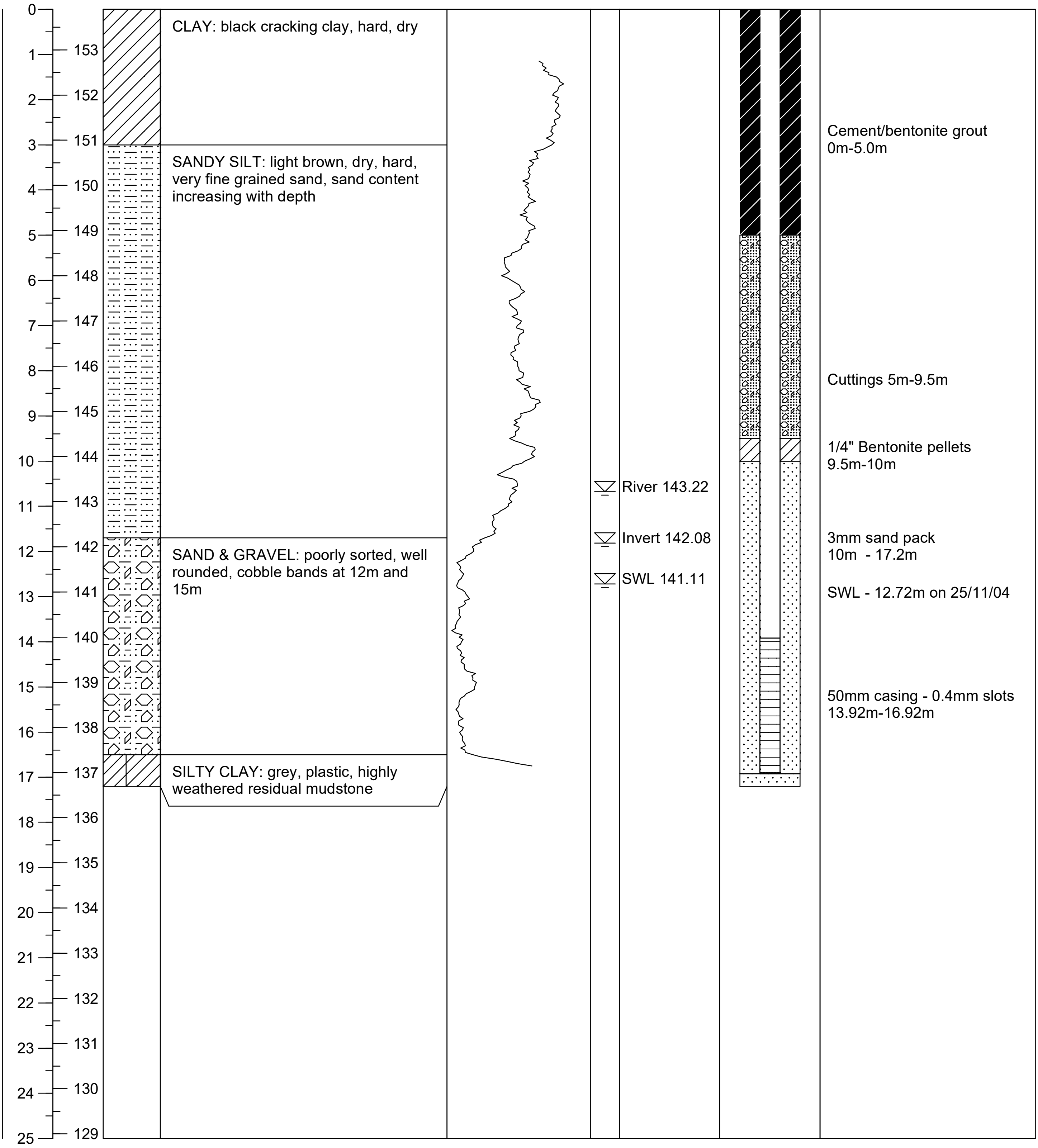
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: EC01

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary mud (polymer)**	GROUND LEVEL:	**153.898m**
DATE:	**2-22 Nov 04**	DRILL RIG:	**Edson 200**	TOP OF CASING LEVEL:	**154.3250m**
CONTRACTOR:	**IESA**	COORDINATES:	**649905.4mE, 74022878.3mN**	LOGGED BY:	**JST**

Depth / Elevation	Graphic	Lithologic Description	Gamma (API)	Water Levels	Construction	Bore Description



CLAY: black cracking clay, hard, dry

SANDY SILT: light brown, dry, hard, very fine grained sand, sand content increasing with depth

SAND & GRAVEL: poorly sorted, well rounded, cobble bands at 12m and 15m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

River 143.22

Invert 142.08

SWL 141.11

Cement/bentonite grout 0m-5.0m

Cuttings 5m-9.5m

1/4" Bentonite pellets 9.5m-10m

3mm sand pack 10m - 17.2m

SWL - 12.72m on 25/11/04

50mm casing - 0.4mm slots 13.92m-16.92m

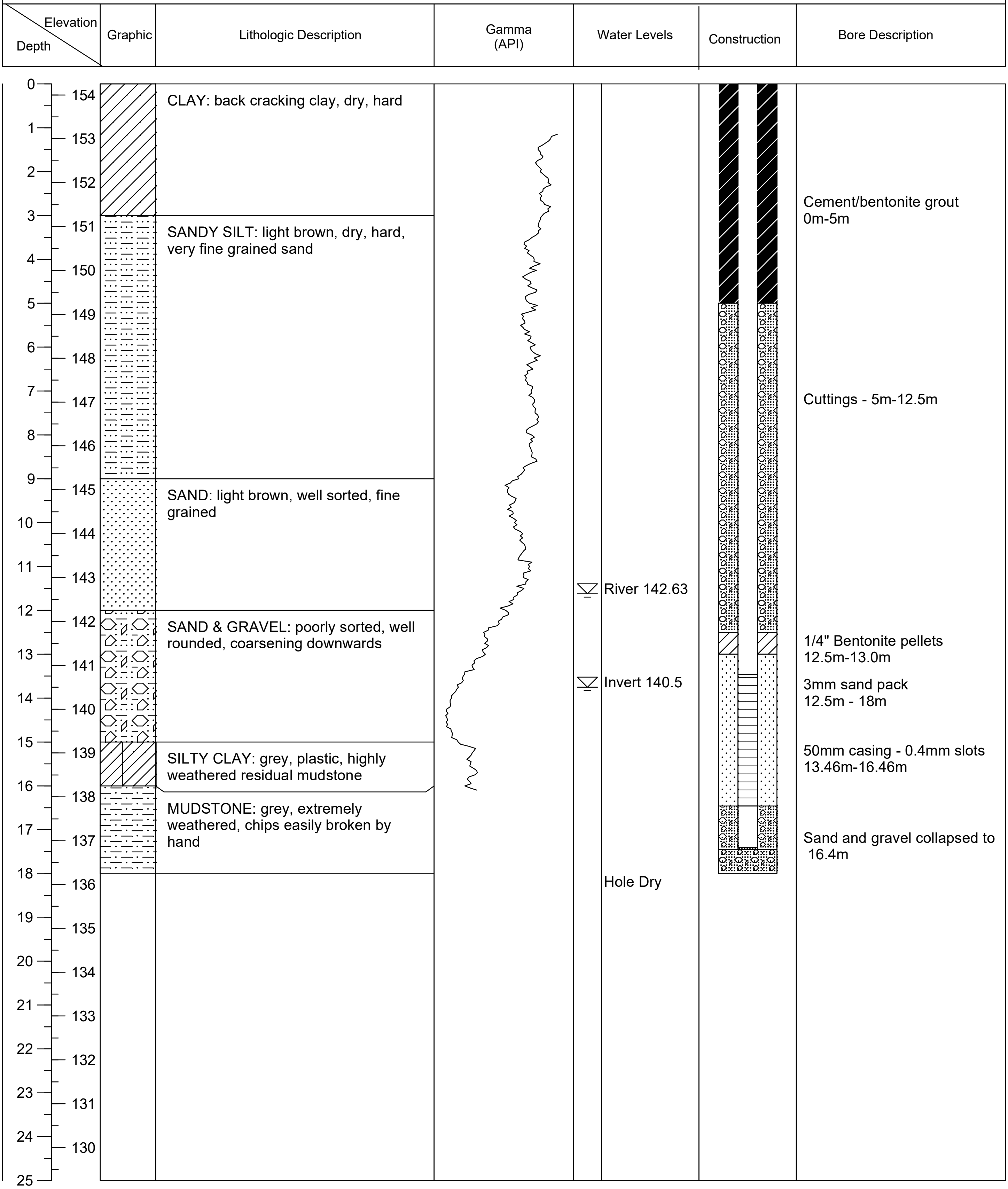
Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: EC02

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**154.252m**
DATE:	**16-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**154.764m**
CONTRACTOR:	**IESA**	COORDINATES:	**650242.2mE, 7402745.5mN**	LOGGED BY:	**JST**



CLAY: back cracking clay, dry, hard

SANDY SILT: light brown, dry, hard, very fine grained sand

SAND: light brown, well sorted, fine grained

SAND & GRAVEL: poorly sorted, well rounded, coarsening downwards

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, extremely weathered, chips easily broken by hand

River 142.63

Invert 140.5

Hole Dry

Cement/bentonite grout 0m-5m

Cuttings - 5m-12.5m

1/4" Bentonite pellets 12.5m-13.0m

3mm sand pack 12.5m - 18m

50mm casing - 0.4mm slots 13.46m-16.46m

Sand and gravel collapsed to 16.4m

Australasian Groundwater & Environmental Consultants Pty Ltd

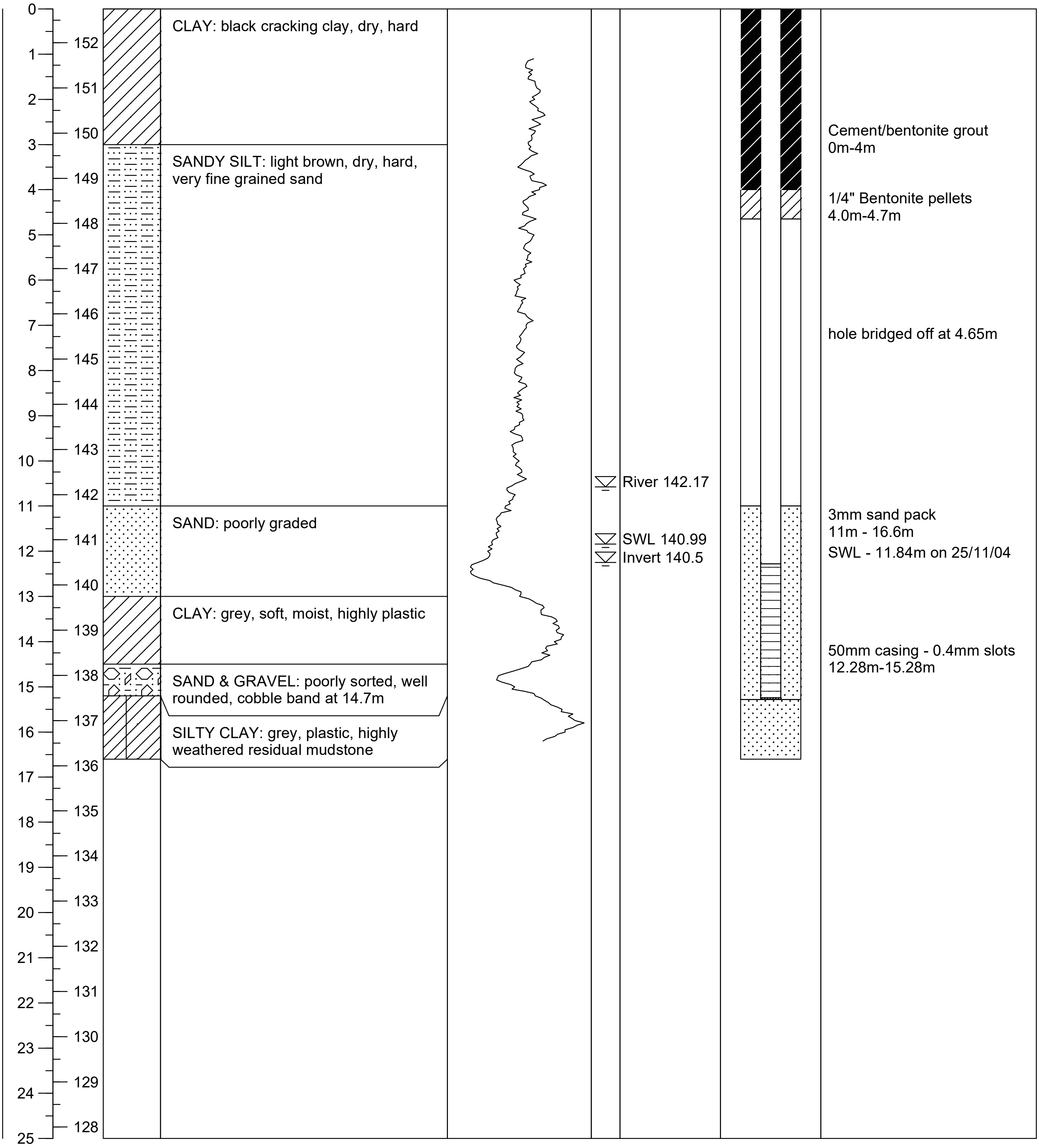
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: EC03

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary mud (polymer)**	GROUND LEVEL:	**152.747m**
DATE:	**3-11 Nov 04**	DRILL RIG:	**Edson 200**	TOP OF CASING LEVEL:	**153.238m**
CONTRACTOR:	**IESA**	COORDINATES:	**650225.4mE, 7402366.8mN**	LOGGED BY:	**JST**

Elevation / Depth	Graphic	Lithologic Description	Gamma (API)	Water Levels	Construction	Bore Description



Lithologic Description:

CLAY: black cracking clay, dry, hard

SANDY SILT: light brown, dry, hard, very fine grained sand

SAND: poorly graded

CLAY: grey, soft, moist, highly plastic

SAND & GRAVEL: poorly sorted, well rounded, cobble band at 14.7m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

Water Levels:

River 142.17

SWL 140.99

Invert 140.5

Bore Description:

Cement/bentonite grout
0m-4m

1/4" Bentonite pellets
4.0m-4.7m

hole bridged off at 4.65m

3mm sand pack
11m - 16.6m

SWL - 11.84m on 25/11/04

50mm casing - 0.4mm slots
12.28m-15.28m

Australasian Groundwater & Environmental Consultants Pty Ltd

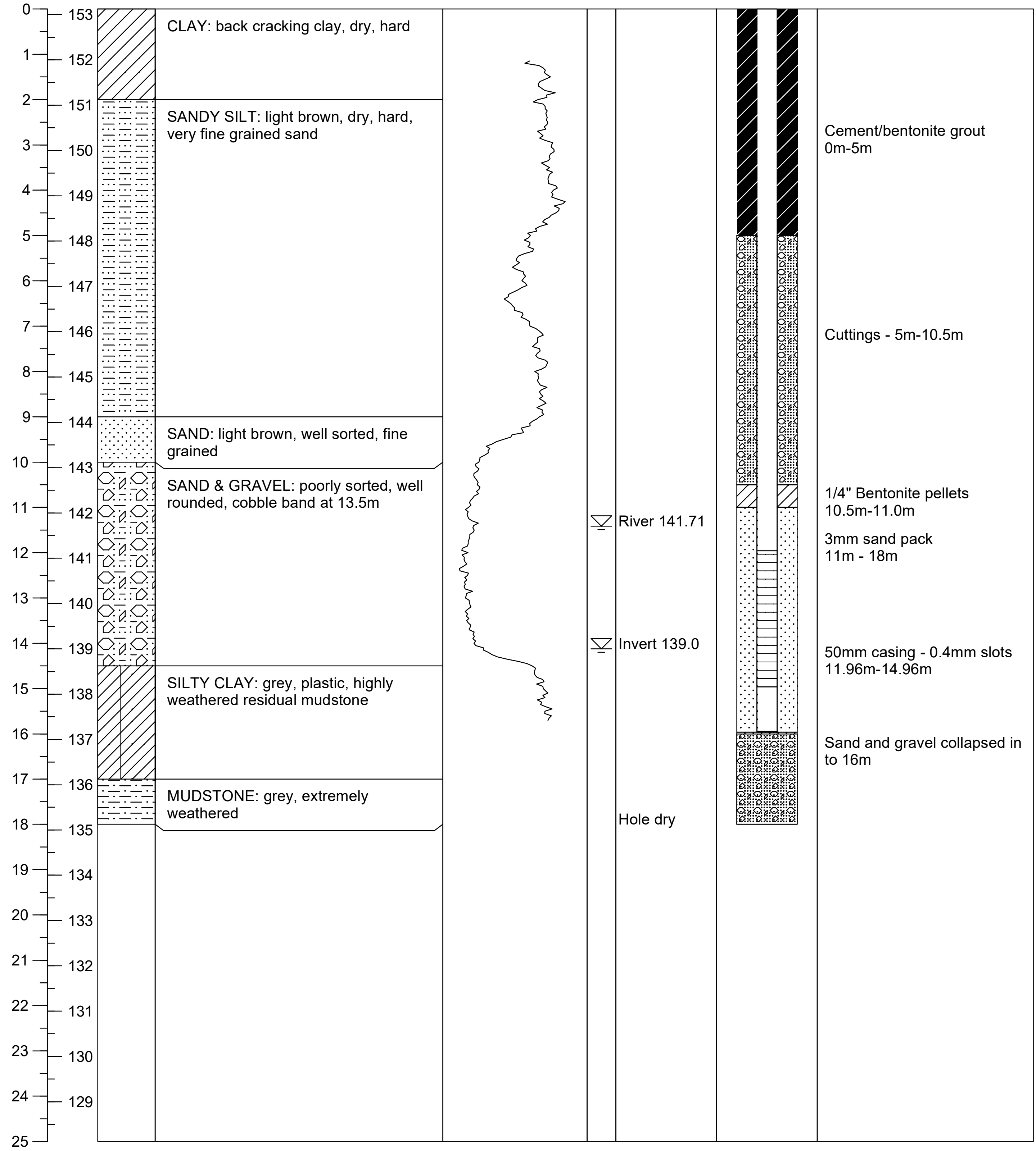
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: EC04

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**153.123m**
DATE:	**16-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**153.65m**
CONTRACTOR:	**IESA**	COORDINATES:	**650487.5mE, 7402152.1mN**	LOGGED BY:	**JST**

Elevation / Depth	Graphic	Lithologic Description	Gamma (API)	Water Levels	Construction	Bore Description



CLAY: back cracking clay, dry, hard

SANDY SILT: light brown, dry, hard, very fine grained sand

SAND: light brown, well sorted, fine grained

SAND & GRAVEL: poorly sorted, well rounded, cobble band at 13.5m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, extremely weathered

River 141.71

Invert 139.0

Hole dry

Cement/bentonite grout 0m-5m

Cuttings - 5m-10.5m

1/4" Bentonite pellets 10.5m-11.0m

3mm sand pack 11m - 18m

50mm casing - 0.4mm slots 11.96m-14.96m

Sand and gravel collapsed in to 16m

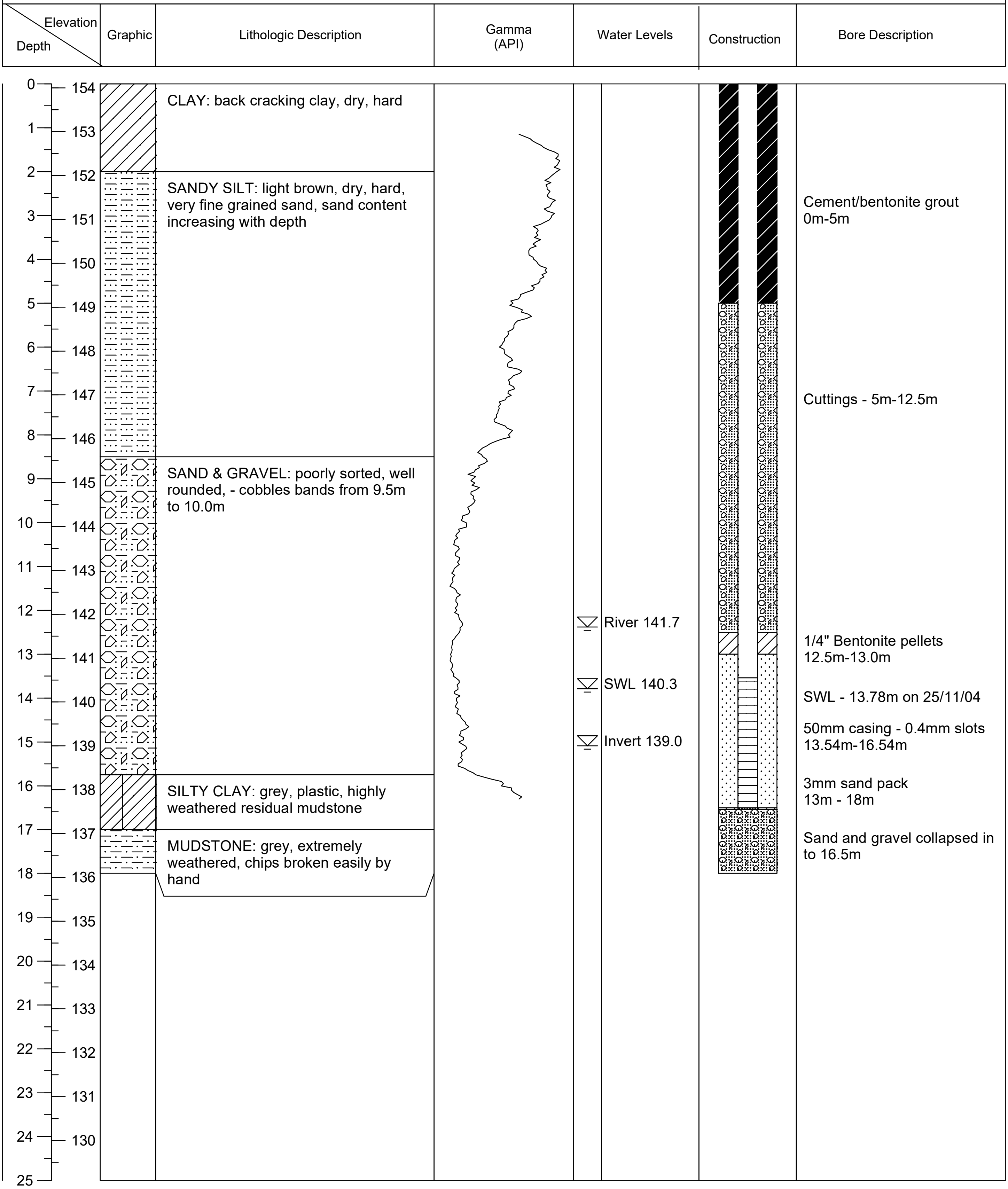
Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: EC05

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**154.089m**
DATE:	**16-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**154.480m**
CONTRACTOR:	**IESA**	COORDINATES:	**650391.9mE, 7401884.6mN**	LOGGED BY:	**JST**



CLAY: back cracking clay, dry, hard

SANDY SILT: light brown, dry, hard, very fine grained sand, sand content increasing with depth

SAND & GRAVEL: poorly sorted, well rounded, - cobbles bands from 9.5m to 10.0m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, extremely weathered, chips broken easily by hand

Cement/bentonite grout 0m-5m

Cuttings - 5m-12.5m

1/4" Bentonite pellets 12.5m-13.0m

SWL - 13.78m on 25/11/04

50mm casing - 0.4mm slots 13.54m-16.54m

3mm sand pack 13m - 18m

Sand and gravel collapsed in to 16.5m

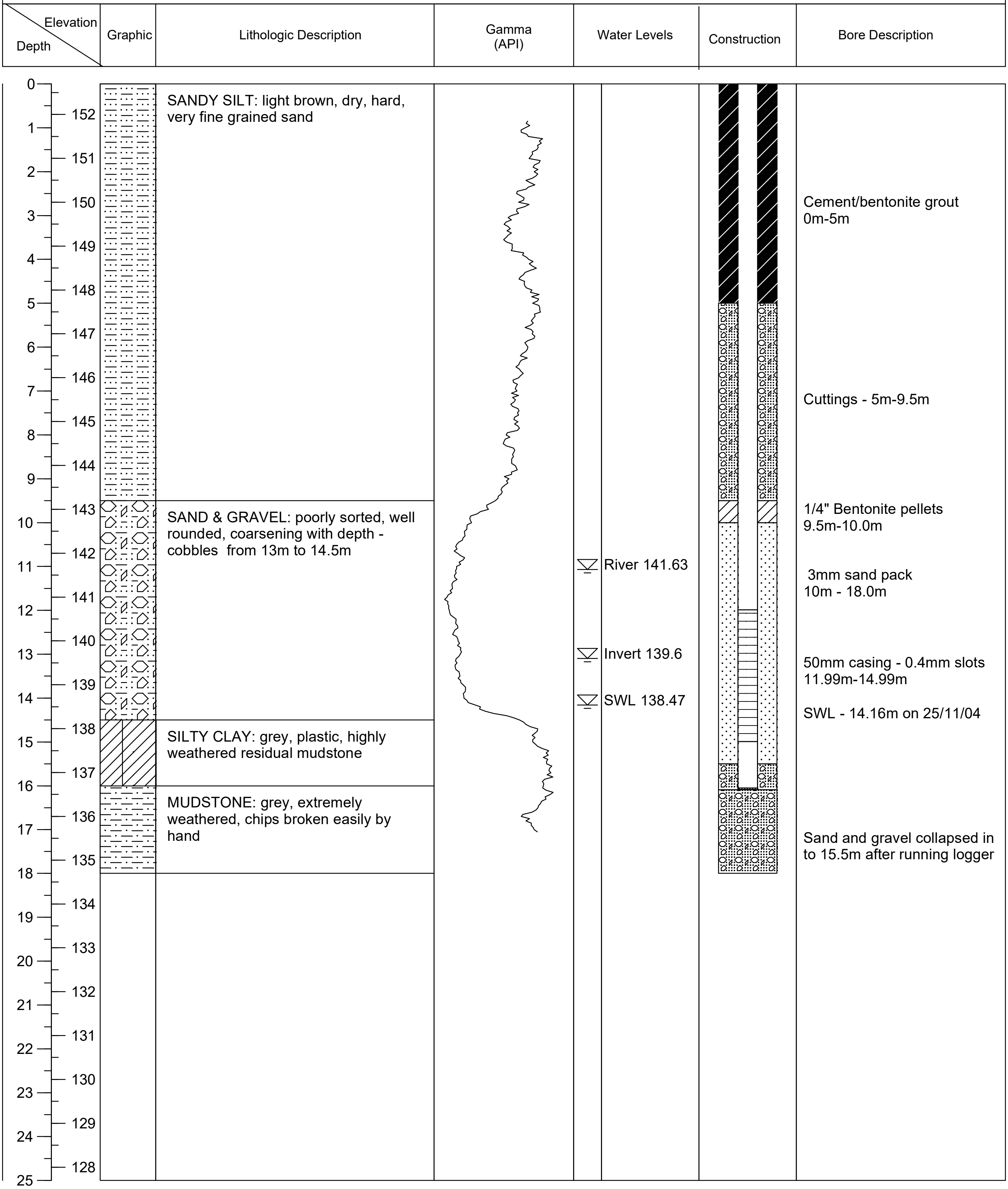
Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: EC06

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**152.697m**
DATE:	**17-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**153.126m**
CONTRACTOR:	**IESA**	COORDINATES:	**650691.3mE, 7401895.7mN**	LOGGED BY:	**JST**



SANDY SILT: light brown, dry, hard, very fine grained sand

SAND & GRAVEL: poorly sorted, well rounded, coarsening with depth - cobbles from 13m to 14.5m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, extremely weathered, chips broken easily by hand

Cement/bentonite grout 0m-5m

Cuttings - 5m-9.5m

1/4" Bentonite pellets 9.5m-10.0m

3mm sand pack 10m - 18.0m

50mm casing - 0.4mm slots 11.99m-14.99m

SWL - 14.16m on 25/11/04

Sand and gravel collapsed in to 15.5m after running logger

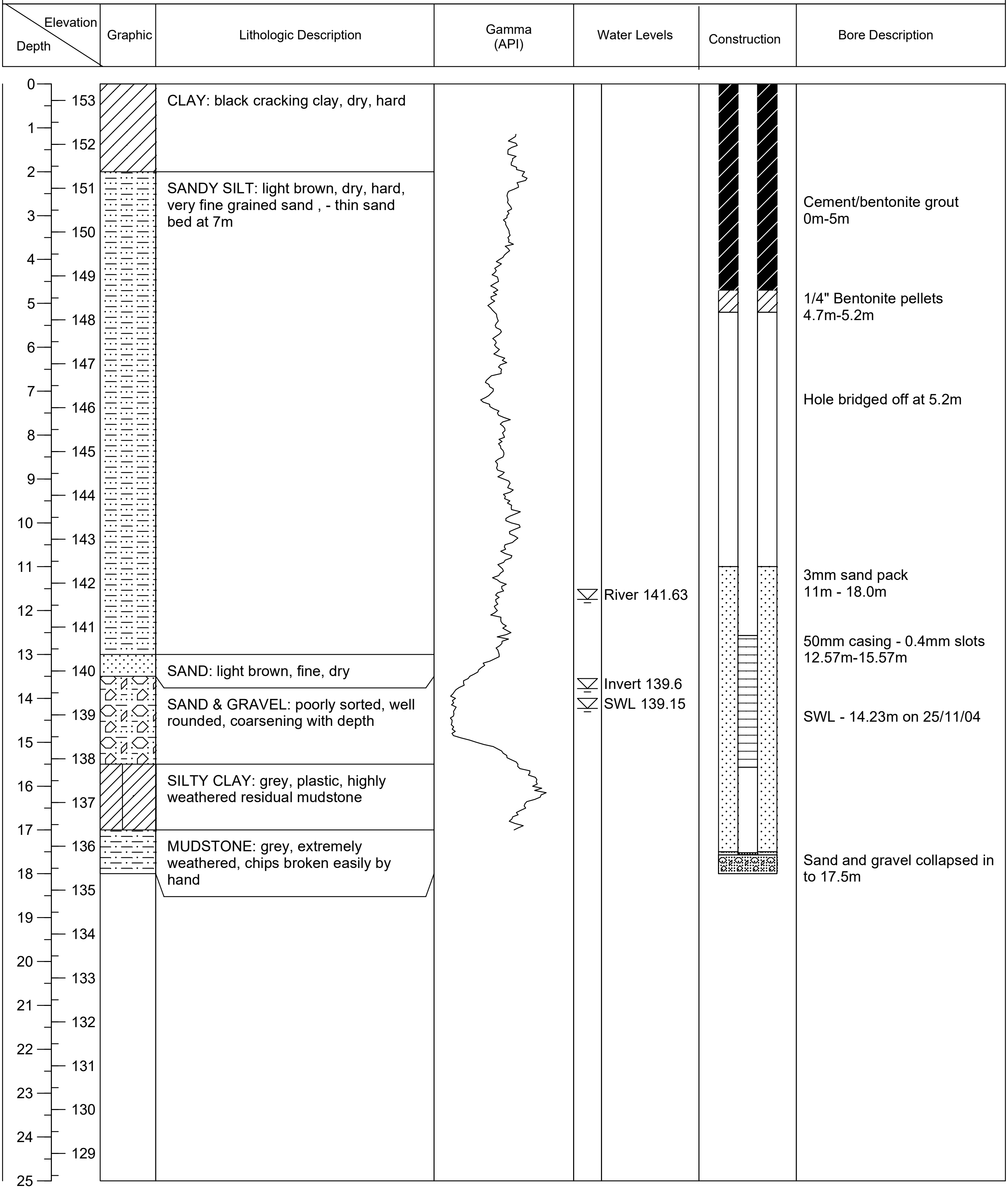
Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: EC07

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**153.375m**
DATE:	**12-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**153.882m**
CONTRACTOR:	**IESA**	COORDINATES:	**650860.3mE, 7401565.2mN**	LOGGED BY:	**JST**



CLAY: black cracking clay, dry, hard

SANDY SILT: light brown, dry, hard, very fine grained sand , - thin sand bed at 7m

SAND: light brown, fine, dry

SAND & GRAVEL: poorly sorted, well rounded, coarsening with depth

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, extremely weathered, chips broken easily by hand

River 141.63

Invert 139.6

SWL 139.15

Cement/bentonite grout 0m-5m

1/4" Bentonite pellets 4.7m-5.2m

Hole bridged off at 5.2m

3mm sand pack 11m - 18.0m

50mm casing - 0.4mm slots 12.57m-15.57m

SWL - 14.23m on 25/11/04

Sand and gravel collapsed in to 17.5m

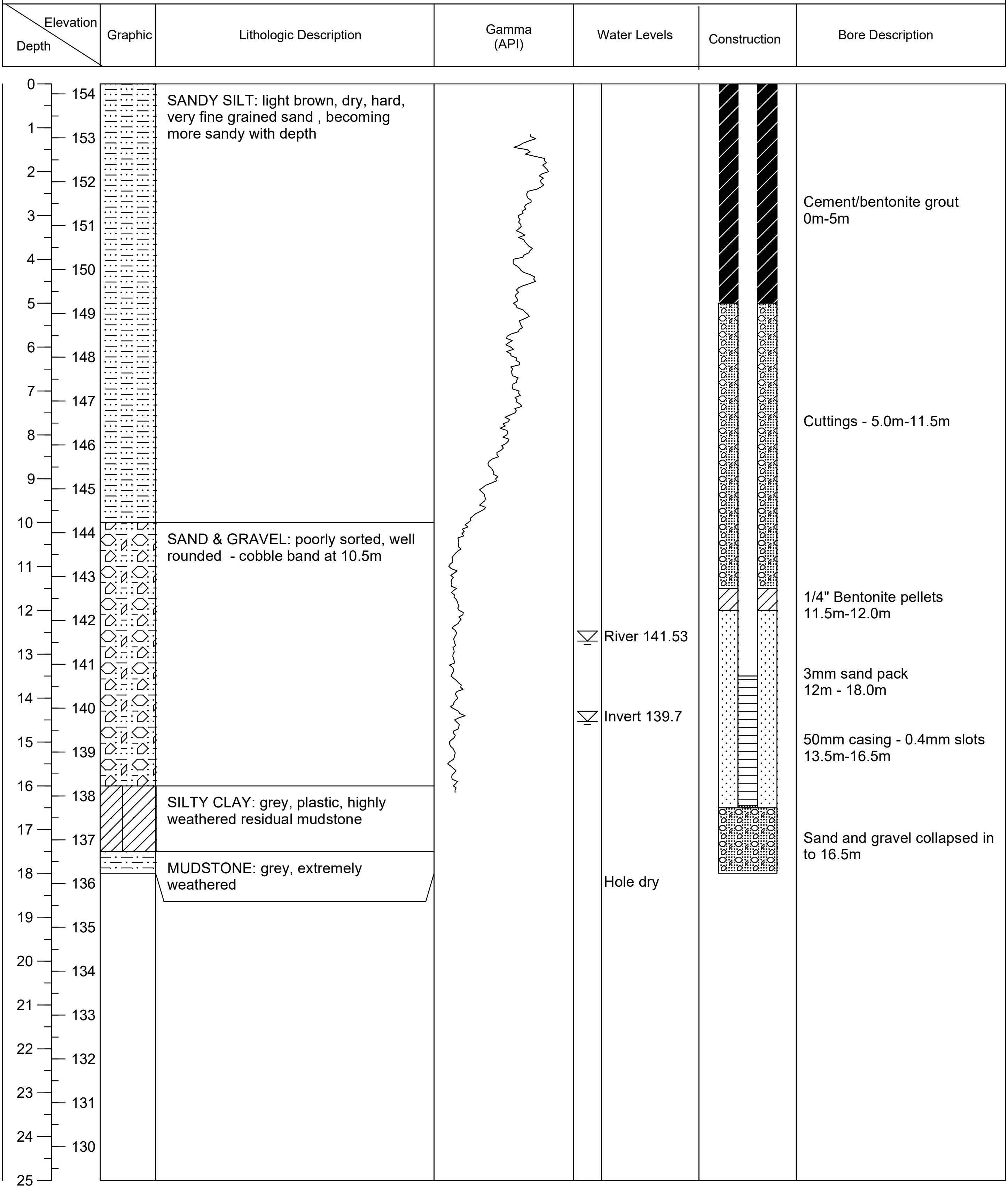
Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: EC08

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**154.230m**
DATE:	**17-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**154.634m**
CONTRACTOR:	**IESA**	COORDINATES:	**651264.4mE, 7401575.4mN**	LOGGED BY:	**JST**



Lithologic Description:

SANDY SILT: light brown, dry, hard, very fine grained sand , becoming more sandy with depth

SAND & GRAVEL: poorly sorted, well rounded - cobble band at 10.5m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, extremely weathered

Water Levels:

River 141.53

Invert 139.7

Hole dry

Bore Description:

Cement/bentonite grout 0m-5m

Cuttings - 5.0m-11.5m

1/4" Bentonite pellets 11.5m-12.0m

3mm sand pack 12m - 18.0m

50mm casing - 0.4mm slots 13.5m-16.5m

Sand and gravel collapsed in to 16.5m

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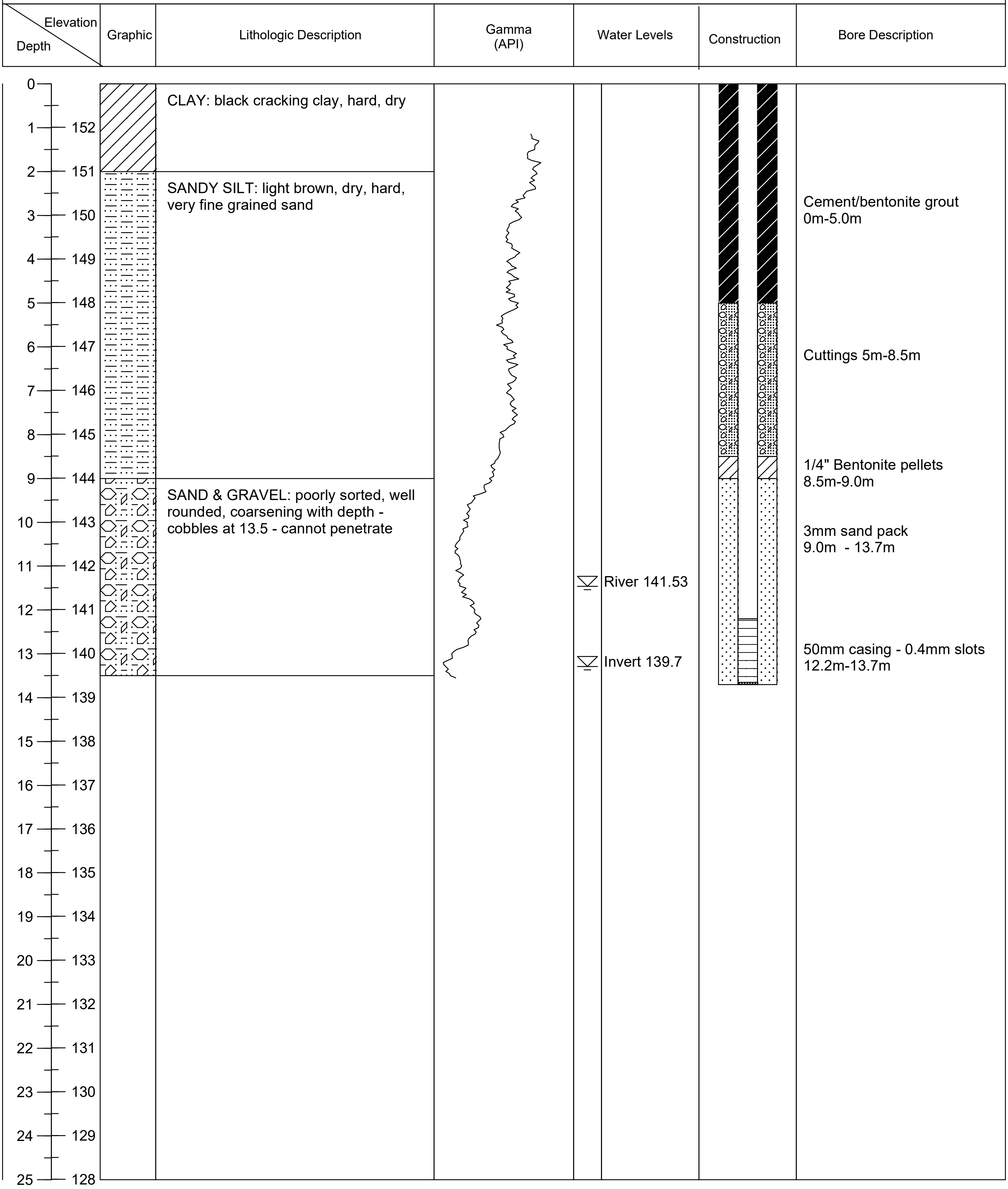
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: EC09

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary mud (polymer)**	GROUND LEVEL:	**152.991m**
DATE:	**5-22 Nov 04**	DRILL RIG:	**Edson 200**	TOP OF CASING LEVEL:	**153.411m**
CONTRACTOR:	**IESA**	COORDINATES:	**651249.0mE, 7401318.1mN**	LOGGED BY:	**JST**



Lithologic Description

CLAY: black cracking clay, hard, dry

SANDY SILT: light brown, dry, hard, very fine grained sand

SAND & GRAVEL: poorly sorted, well rounded, coarsening with depth - cobbles at 13.5 - cannot penetrate

Bore Description

Cement/bentonite grout
0m-5.0m

Cuttings 5m-8.5m

1/4" Bentonite pellets
8.5m-9.0m

3mm sand pack
9.0m - 13.7m

50mm casing - 0.4mm slots
12.2m-13.7m

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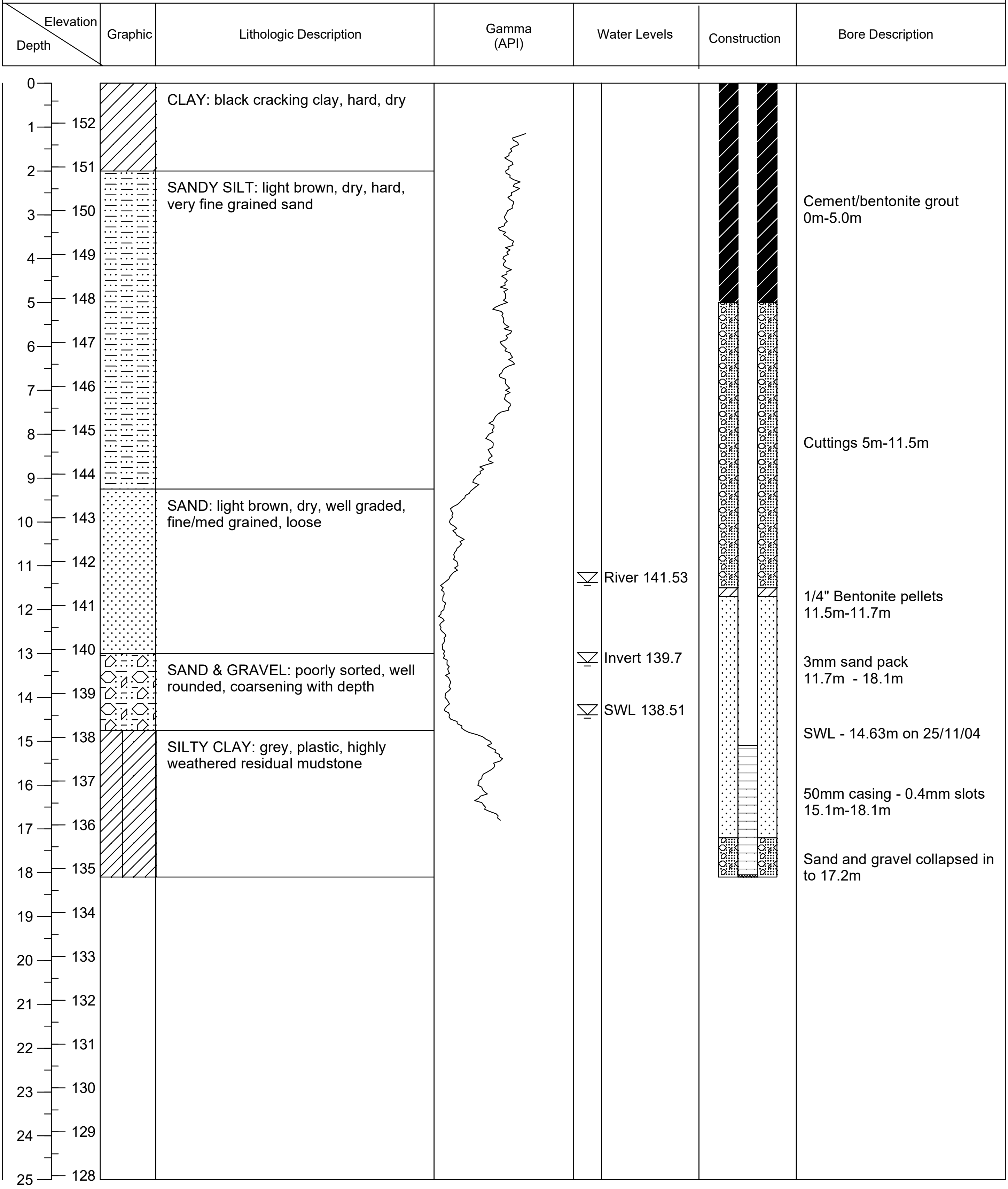
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: EC9A

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary mud**	GROUND LEVEL:	**152.908m**
DATE:	**13-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**153.541m**
CONTRACTOR:	**IESA**	COORDINATES:	**651242.2mE, 7401323.7mN**	LOGGED BY:	**JST**



CLAY: black cracking clay, hard, dry

SANDY SILT: light brown, dry, hard, very fine grained sand

SAND: light brown, dry, well graded, fine/med grained, loose

SAND & GRAVEL: poorly sorted, well rounded, coarsening with depth

SILTY CLAY: grey, plastic, highly weathered residual mudstone

River 141.53

Invert 139.7

SWL 138.51

Cement/bentonite grout
0m-5.0m

Cuttings 5m-11.5m

1/4" Bentonite pellets
11.5m-11.7m

3mm sand pack
11.7m - 18.1m

SWL - 14.63m on 25/11/04

50mm casing - 0.4mm slots
15.1m-18.1m

Sand and gravel collapsed in to 17.2m

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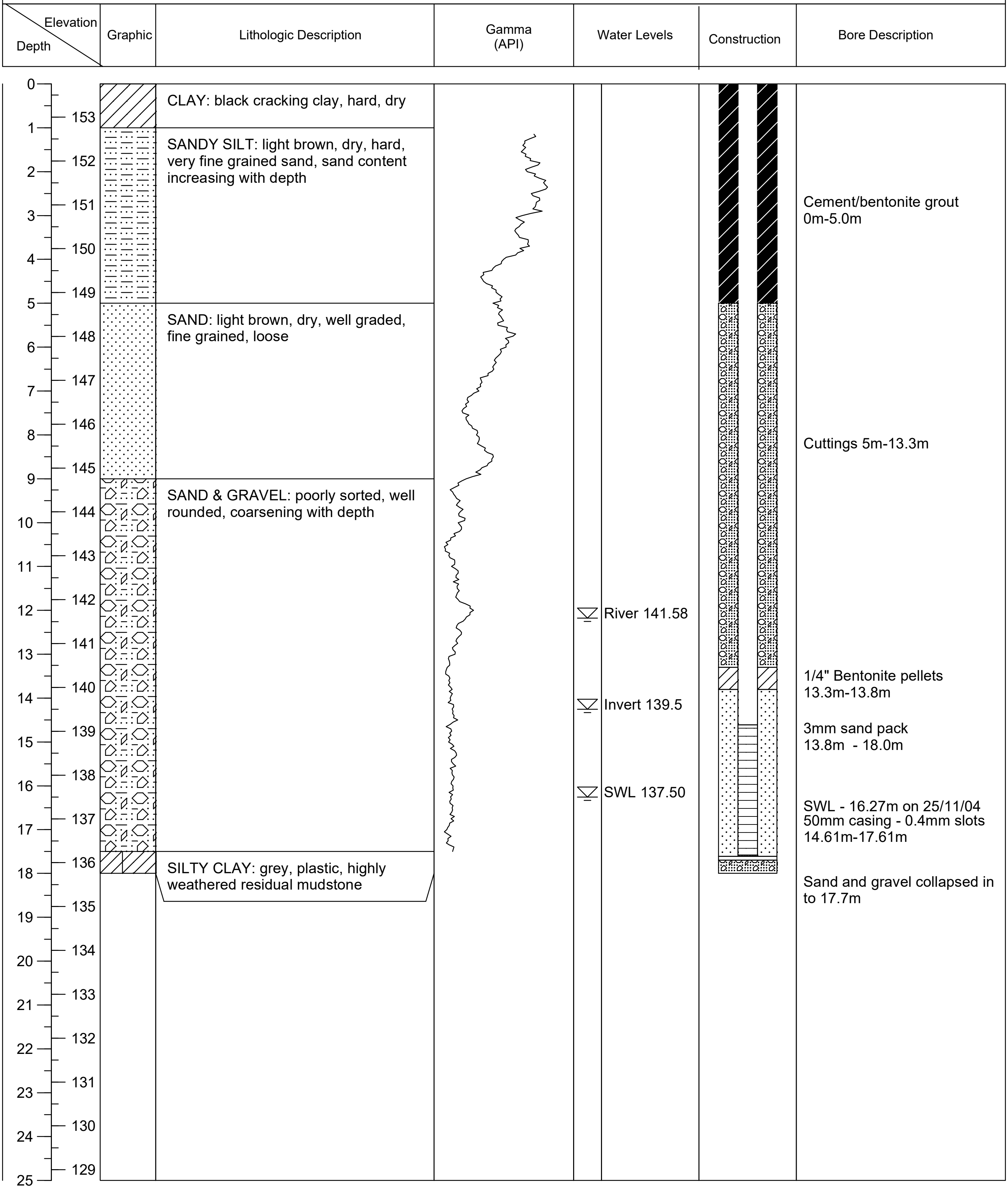
BOREHOLE LOG

BOREHOLE ID: EC10

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary air and stiff foam**	GROUND LEVEL:	**153.756m**
DATE:	**17-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**154.271m**
CONTRACTOR:	**IESA**	COORDINATES:	**651504.3mE, 7401239.3mN**	LOGGED BY:	**JST**



CLAY: black cracking clay, hard, dry

SANDY SILT: light brown, dry, hard, very fine grained sand, sand content increasing with depth

SAND: light brown, dry, well graded, fine grained, loose

SAND & GRAVEL: poorly sorted, well rounded, coarsening with depth

SILTY CLAY: grey, plastic, highly weathered residual mudstone

Cement/bentonite grout
0m-5.0m

Cuttings 5m-13.3m

1/4" Bentonite pellets
13.3m-13.8m

3mm sand pack
13.8m - 18.0m

SWL - 16.27m on 25/11/04
50mm casing - 0.4mm slots
14.61m-17.61m

Sand and gravel collapsed in to 17.7m

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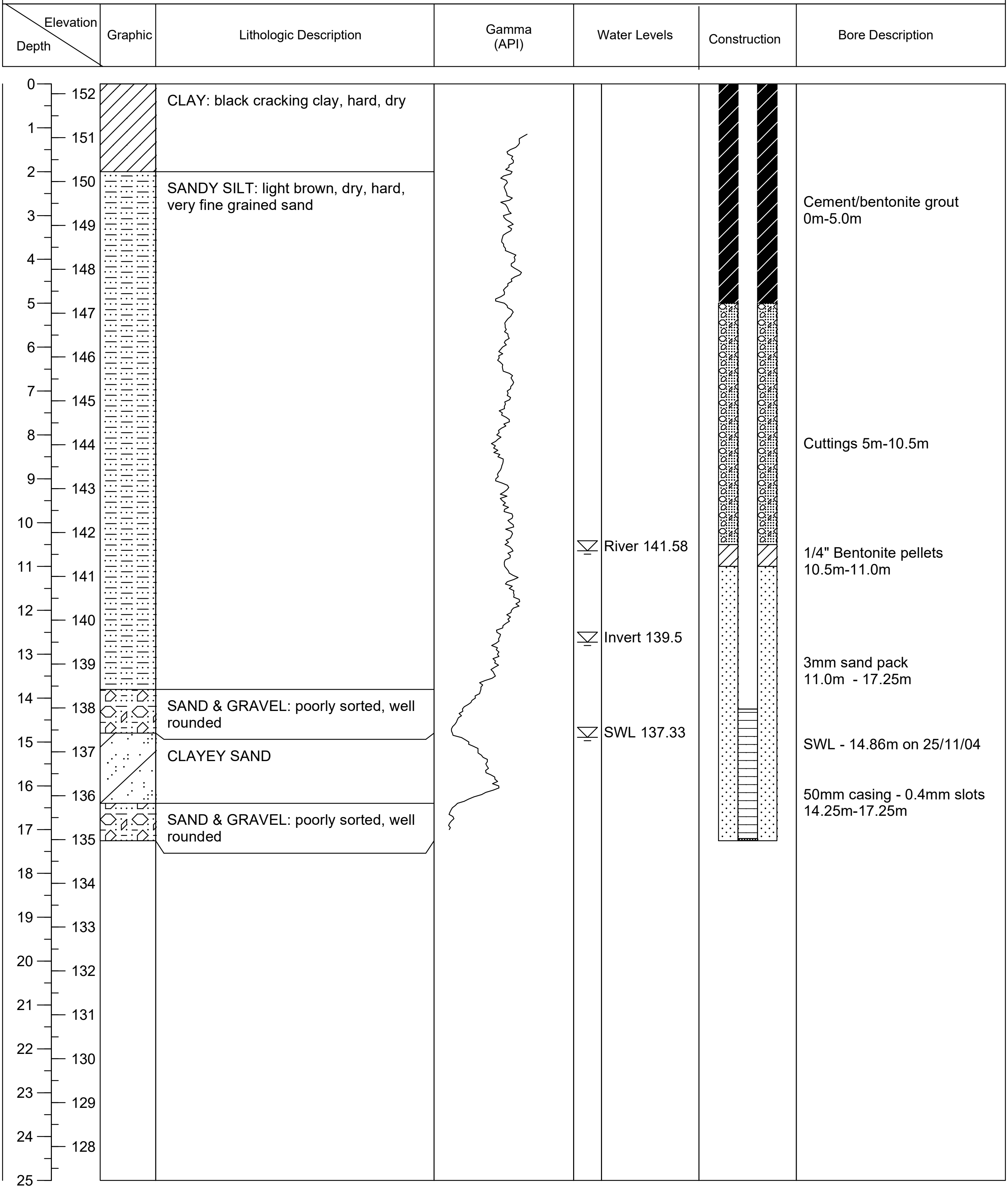
BOREHOLE LOG

BOREHOLE ID: EC11

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary mud (polymer)**	GROUND LEVEL:	**152.225m**
DATE:	**5-22 Nov 04**	DRILL RIG:	**Edson 200**	TOP OF CASING LEVEL:	**152.6890m**
CONTRACTOR:	**IESA**	COORDINATES:	**651404.3mE, 7401011.3mN**	LOGGED BY:	**JST**



CLAY: black cracking clay, hard, dry

SANDY SILT: light brown, dry, hard, very fine grained sand

SAND & GRAVEL: poorly sorted, well rounded

CLAYEY SAND

SAND & GRAVEL: poorly sorted, well rounded

Cement/bentonite grout
0m-5.0m

Cuttings 5m-10.5m

1/4" Bentonite pellets
10.5m-11.0m

3mm sand pack
11.0m - 17.25m

SWL - 14.86m on 25/11/04

50mm casing - 0.4mm slots
14.25m-17.25m

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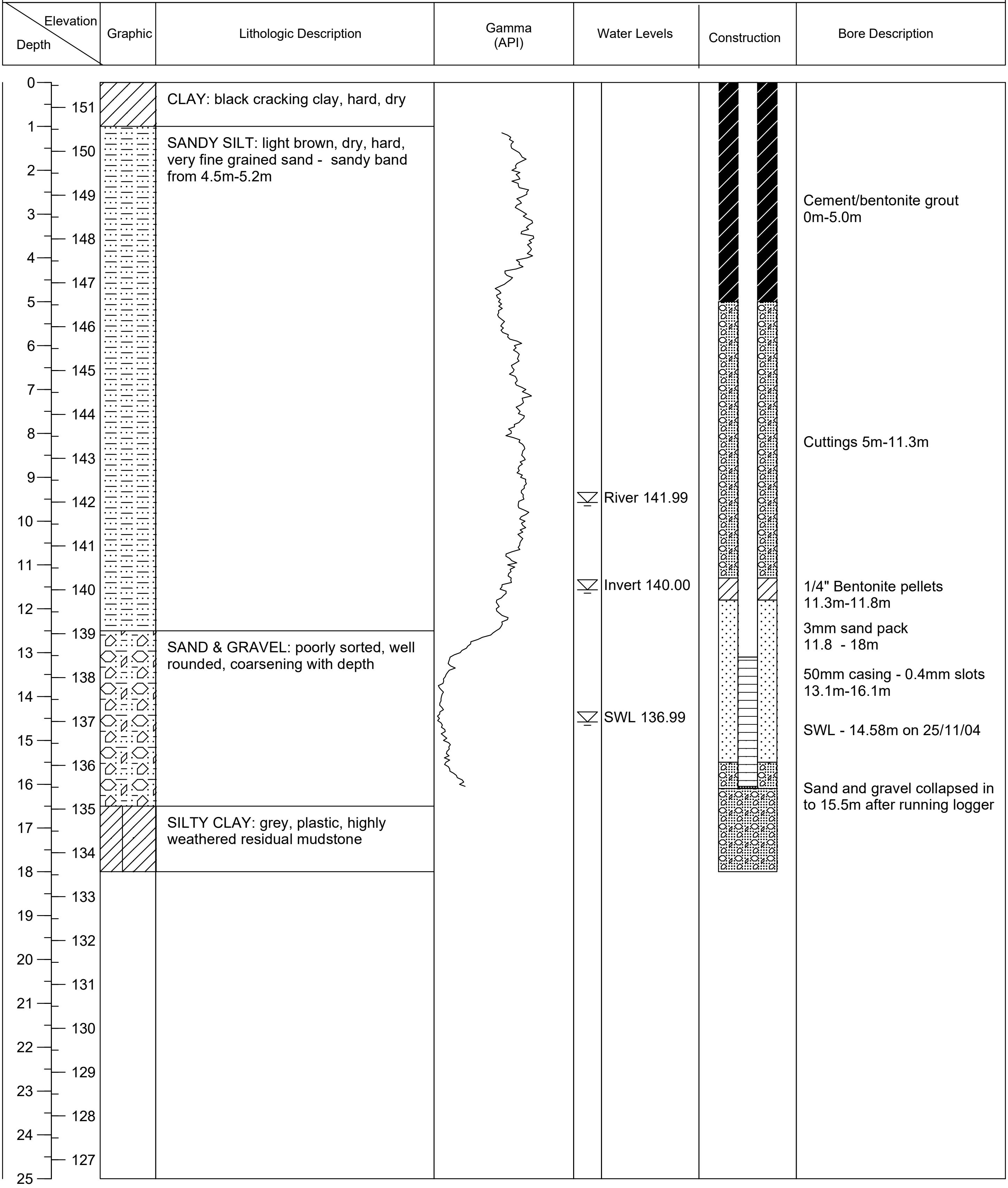
BOREHOLE LOG

BOREHOLE ID: EC12

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**151.568m**
DATE:	**17-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**152.069m**
CONTRACTOR:	**IESA**	COORDINATES:	**651550.0mE, 7400738.9mN**	LOGGED BY:	**JST**



CLAY: black cracking clay, hard, dry

SANDY SILT: light brown, dry, hard, very fine grained sand - sandy band from 4.5m-5.2m

SAND & GRAVEL: poorly sorted, well rounded, coarsening with depth

SILTY CLAY: grey, plastic, highly weathered residual mudstone

River 141.99

Invert 140.00

SWL 136.99

Cement/bentonite grout 0m-5.0m

Cuttings 5m-11.3m

1/4" Bentonite pellets 11.3m-11.8m

3mm sand pack 11.8 - 18m

50mm casing - 0.4mm slots 13.1m-16.1m

SWL - 14.58m on 25/11/04

Sand and gravel collapsed in to 15.5m after running logger

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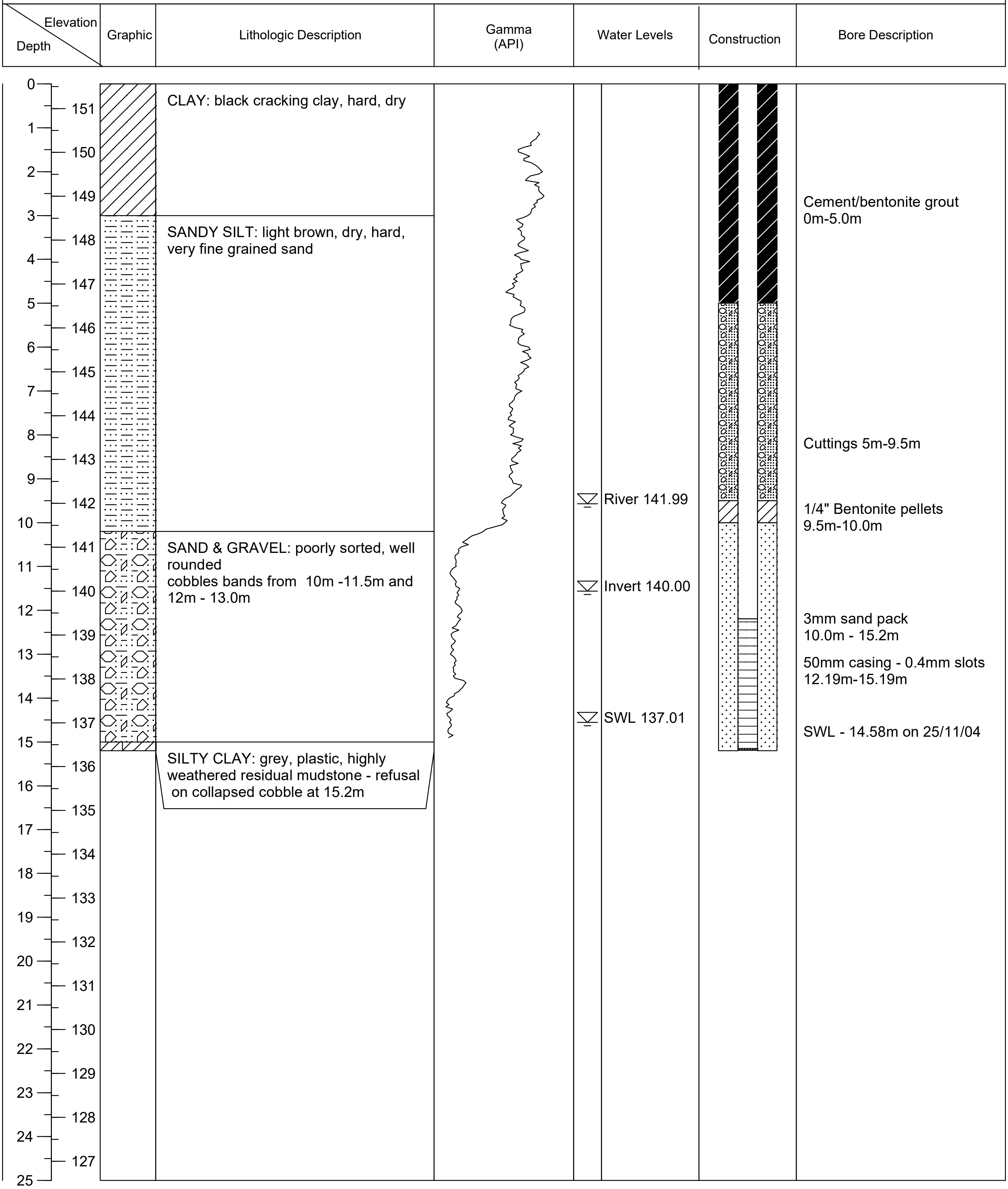
BOREHOLE LOG

BOREHOLE ID: EC13

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary mud**	GROUND LEVEL:	**151.562m**
DATE:	**4-22 Nov 04**	DRILL RIG:	**Edson 200**	TOP OF CASING LEVEL:	**152.038m**
CONTRACTOR:	**IESA**	COORDINATES:	**651404.7mE, 7400595.7mN**	LOGGED BY:	**JST**



CLAY: black cracking clay, hard, dry

SANDY SILT: light brown, dry, hard, very fine grained sand

SAND & GRAVEL: poorly sorted, well rounded
cobbles bands from 10m -11.5m and 12m - 13.0m

SILTY CLAY: grey, plastic, highly weathered residual mudstone - refusal on collapsed cobble at 15.2m

River 141.99

Invert 140.00

SWL 137.01

Cement/bentonite grout
0m-5.0m

Cuttings 5m-9.5m

1/4" Bentonite pellets
9.5m-10.0m

3mm sand pack
10.0m - 15.2m

50mm casing - 0.4mm slots
12.19m-15.19m

SWL - 14.58m on 25/11/04

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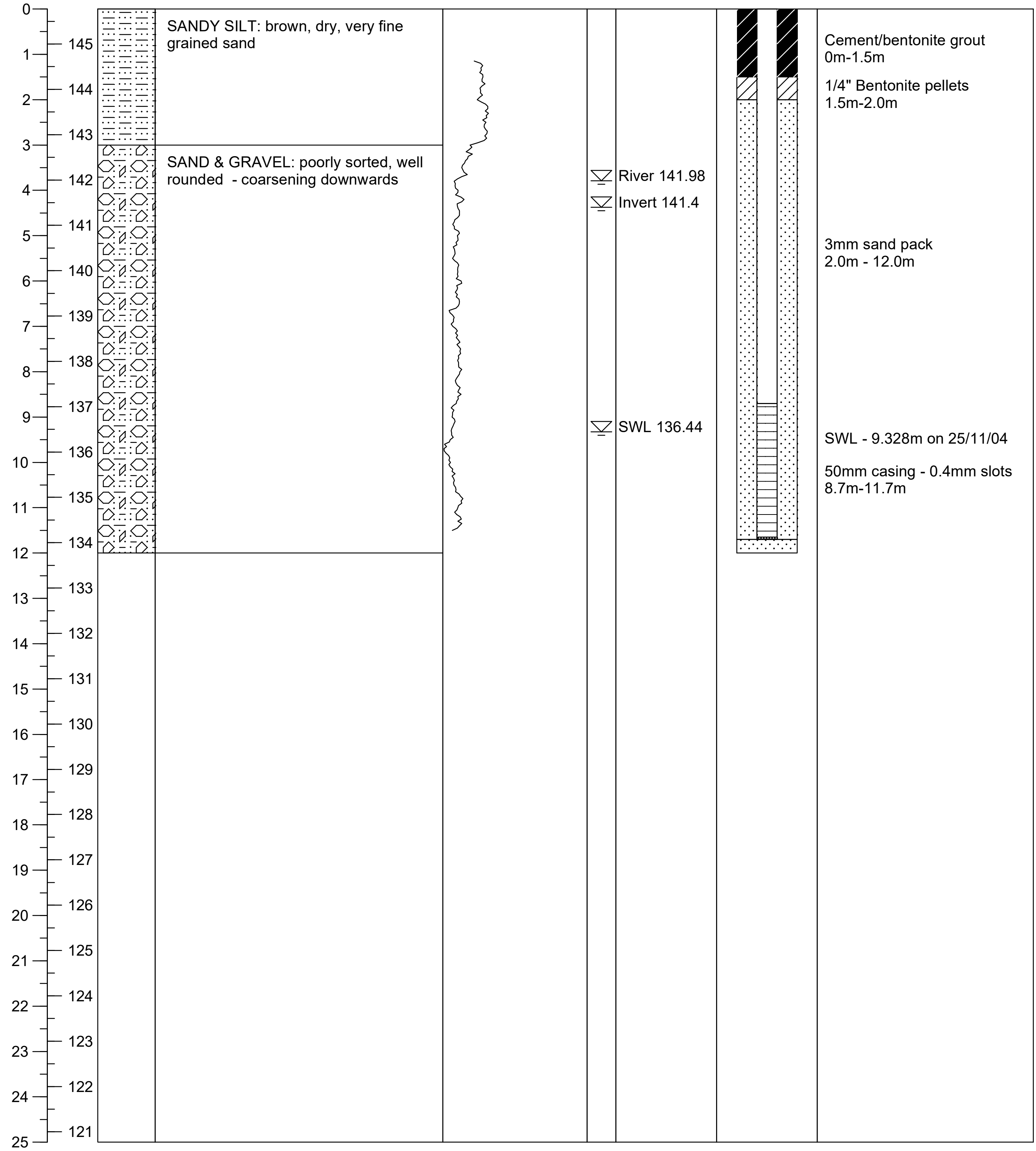
BOREHOLE LOG

BOREHOLE ID: EC14

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**145.772m**
DATE:	**18-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**146.124m**
CONTRACTOR:	**IESA**	COORDINATES:	**651564.0mE, 7400472.7mN**	LOGGED BY:	**JST**

Elevation / Depth	Graphic	Lithologic Description	Gamma (API)	Water Levels	Construction	Bore Description



SANDY SILT: brown, dry, very fine grained sand

SAND & GRAVEL: poorly sorted, well rounded - coarsening downwards

River 141.98

Invert 141.4

SWL 136.44

Cement/bentonite grout 0m-1.5m

1/4" Bentonite pellets 1.5m-2.0m

3mm sand pack 2.0m - 12.0m

SWL - 9.328m on 25/11/04

50mm casing - 0.4mm slots 8.7m-11.7m

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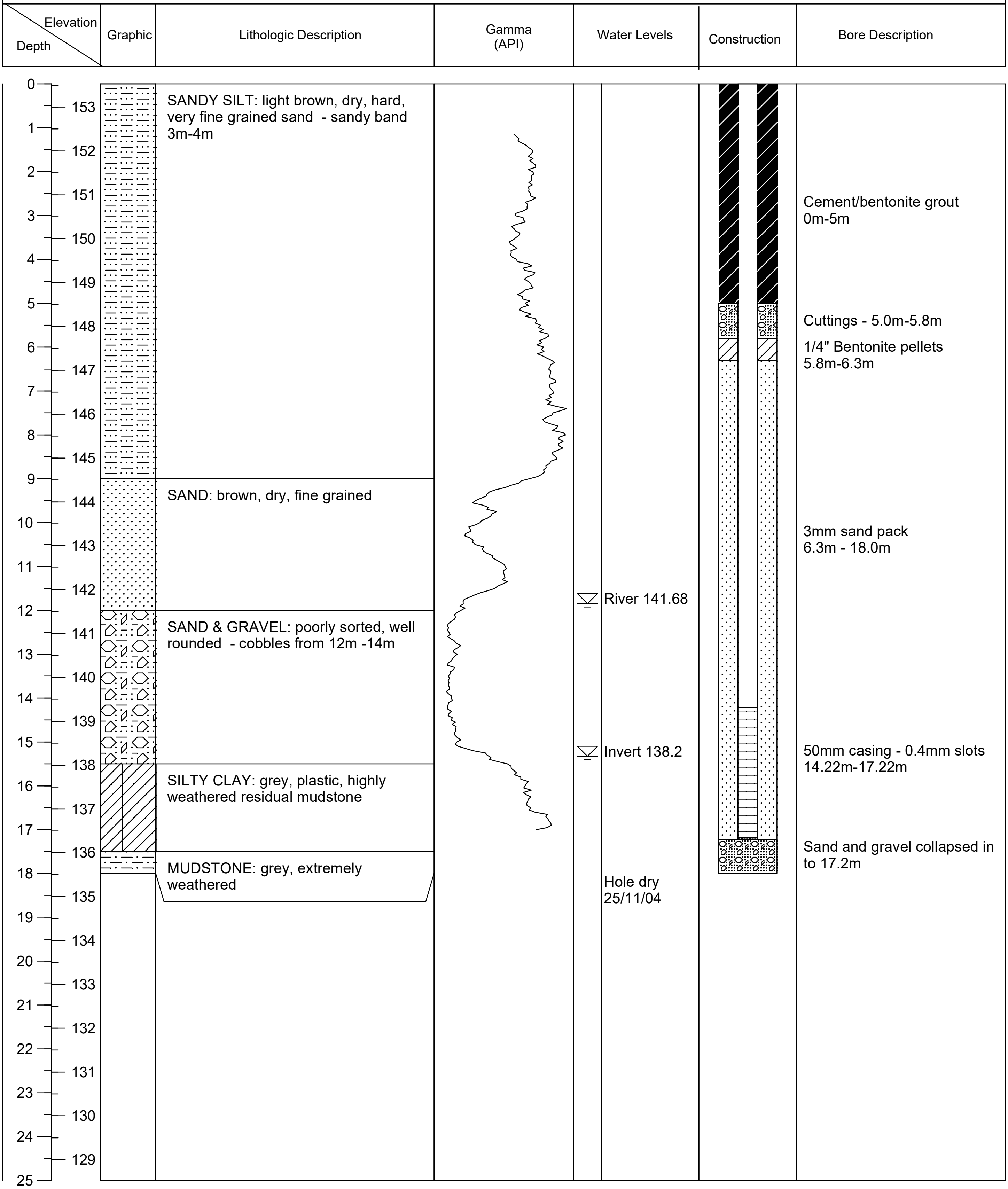
BOREHOLE LOG

BOREHOLE ID: EC15

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**153.528m**
DATE:	**0-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**153.931m**
CONTRACTOR:	**IESA**	COORDINATES:	**651836.4mE, 7400364.4mN**	LOGGED BY:	**JST**



SANDY SILT: light brown, dry, hard, very fine grained sand - sandy band 3m-4m

SAND: brown, dry, fine grained

SAND & GRAVEL: poorly sorted, well rounded - cobbles from 12m -14m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, extremely weathered

River 141.68

Invert 138.2

Hole dry 25/11/04

Cement/bentonite grout 0m-5m

Cuttings - 5.0m-5.8m

1/4" Bentonite pellets 5.8m-6.3m

3mm sand pack 6.3m - 18.0m

50mm casing - 0.4mm slots 14.22m-17.22m

Sand and gravel collapsed in to 17.2m

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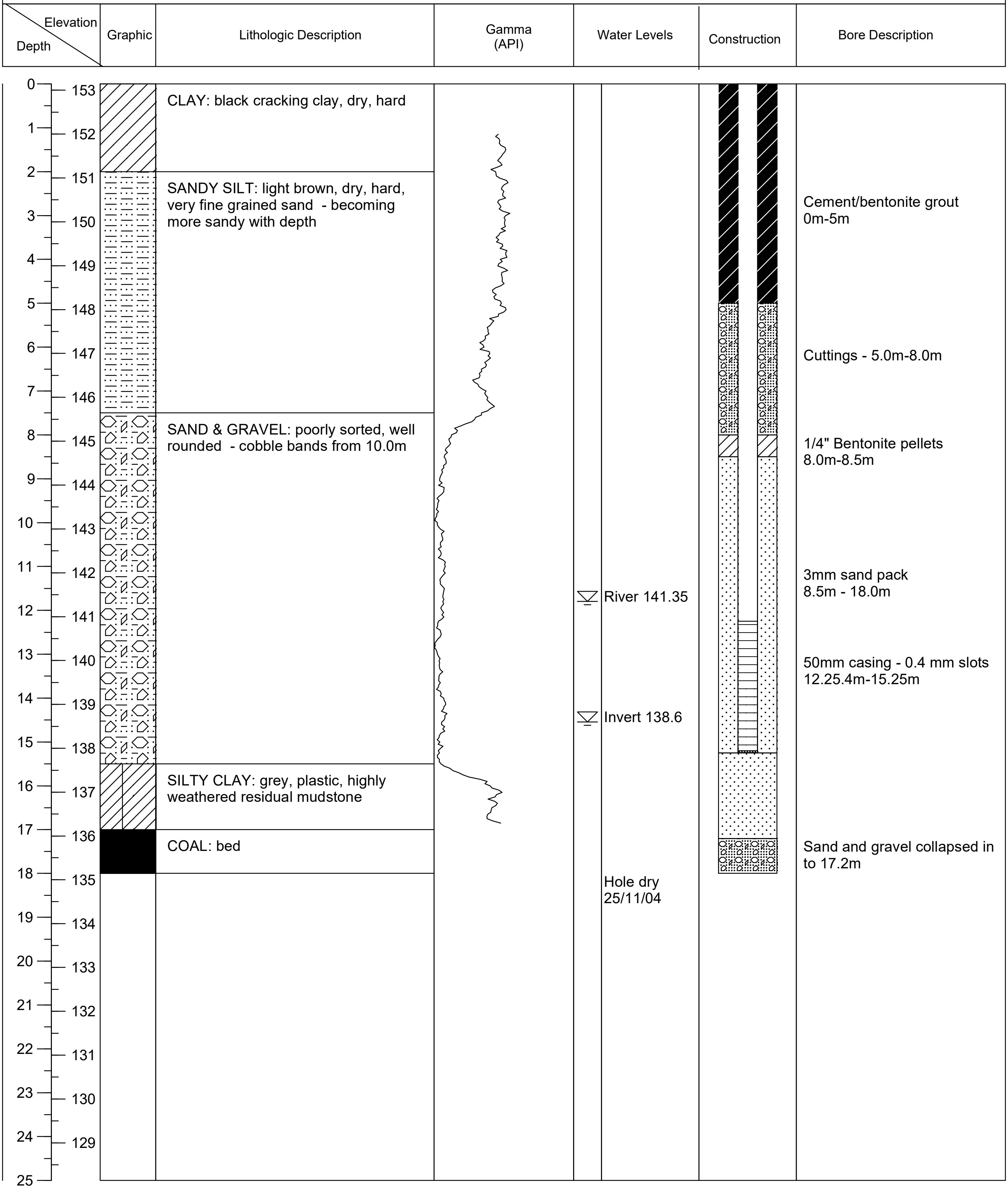
BOREHOLE LOG

BOREHOLE ID: EC16

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**153.144m**
DATE:	**18-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**153.586m**
CONTRACTOR:	**IESA**	COORDINATES:	**652265.8mE, 7400815.4mN**	LOGGED BY:	**JST**



CLAY: black cracking clay, dry, hard

SANDY SILT: light brown, dry, hard, very fine grained sand - becoming more sandy with depth

SAND & GRAVEL: poorly sorted, well rounded - cobble bands from 10.0m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

COAL: bed

River 141.35

Invert 138.6

Hole dry 25/11/04

Cement/bentonite grout 0m-5m

Cuttings - 5.0m-8.0m

1/4" Bentonite pellets 8.0m-8.5m

3mm sand pack 8.5m - 18.0m

50mm casing - 0.4 mm slots 12.25.4m-15.25m

Sand and gravel collapsed in to 17.2m

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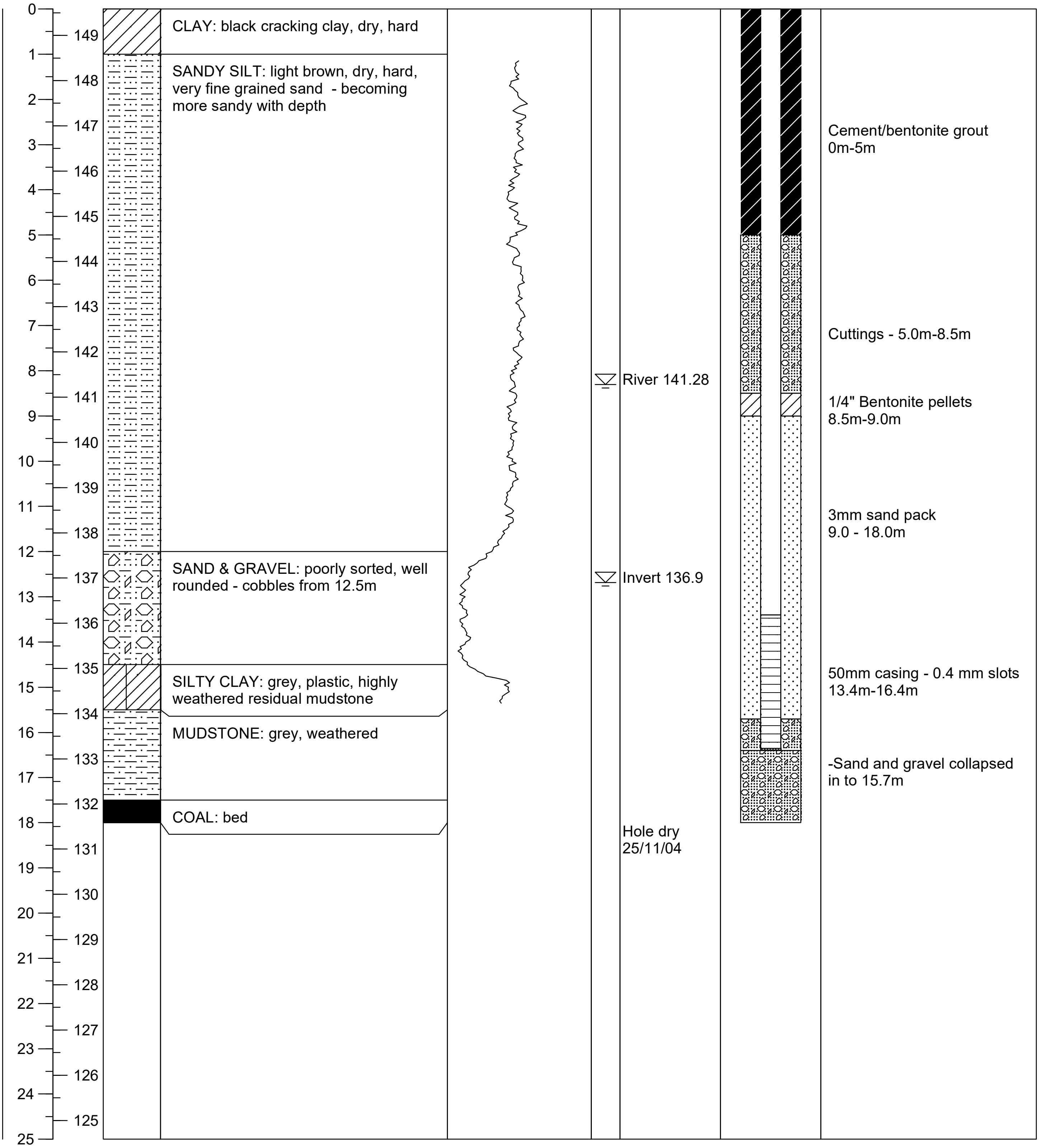
BOREHOLE LOG

BOREHOLE ID: EC17

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**149.585m**
DATE:	**19-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**150.0470m**
CONTRACTOR:	**IESA**	COORDINATES:	**652683.2mE, 7400528.9mN**	LOGGED BY:	**JST**

Depth / Elevation	Graphic	Lithologic Description	Gamma (API)	Water Levels	Construction	Bore Description



CLAY: black cracking clay, dry, hard

SANDY SILT: light brown, dry, hard, very fine grained sand - becoming more sandy with depth

SAND & GRAVEL: poorly sorted, well rounded - cobbles from 12.5m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, weathered

COAL: bed

River 141.28

Invert 136.9

Hole dry
25/11/04

Cement/bentonite grout
0m-5m

Cuttings - 5.0m-8.5m

1/4" Bentonite pellets
8.5m-9.0m

3mm sand pack
9.0 - 18.0m

50mm casing - 0.4 mm slots
13.4m-16.4m

-Sand and gravel collapsed
in to 15.7m

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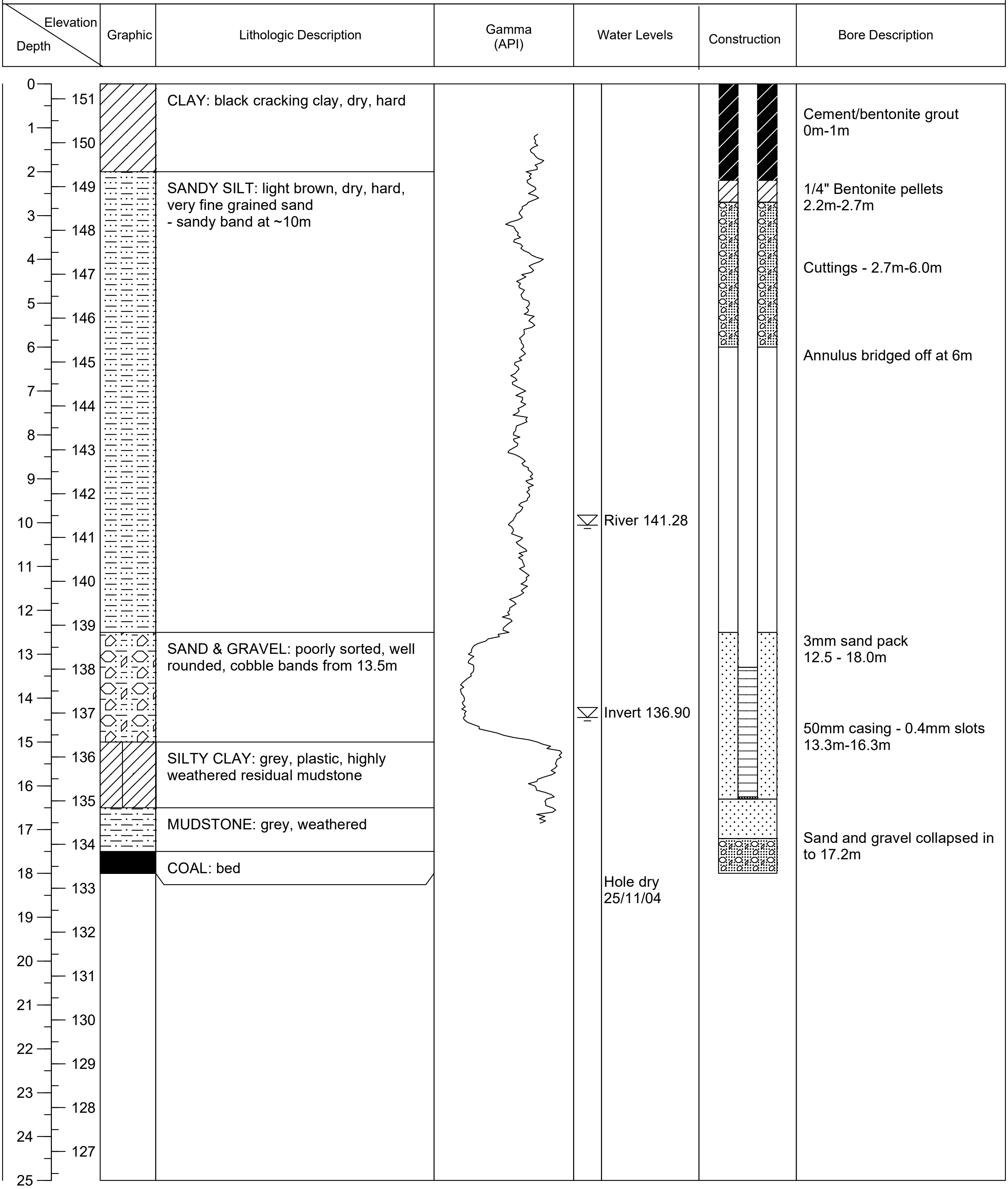
BOREHOLE LOG

BOREHOLE ID: EC18

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**151.340m**
DATE:	**19-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**151.8390m**
CONTRACTOR:	**IESA**	COORDINATES:	**652718.8mE, 7400742.2mN**	LOGGED BY:	**JST**



CLAY: black cracking clay, dry, hard

SANDY SILT: light brown, dry, hard, very fine grained sand
- sandy band at ~10m

SAND & GRAVEL: poorly sorted, well rounded, cobble bands from 13.5m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, weathered

COAL: bed

River 141.28

Invert 136.90

Hole dry
25/11/04

Cement/bentonite grout
0m-1m

1/4" Bentonite pellets
2.2m-2.7m

Cuttings - 2.7m-6.0m

Annulus bridged off at 6m

3mm sand pack
12.5 - 18.0m

50mm casing - 0.4mm slots
13.3m-16.3m

Sand and gravel collapsed in to 17.2m

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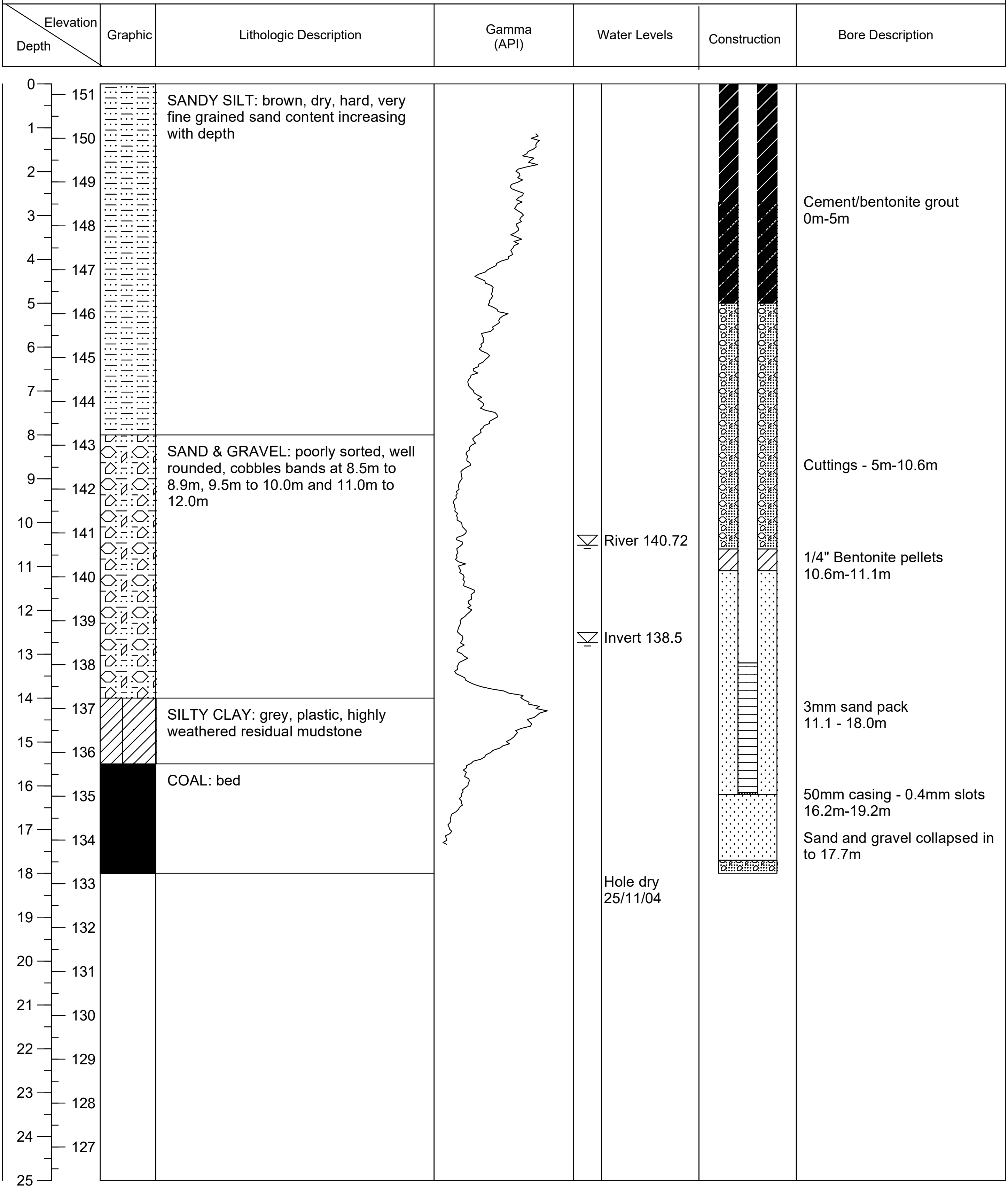
BOREHOLE LOG

BOREHOLE ID: EC19

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**151.237m**
DATE:	**19-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**151.713m**
CONTRACTOR:	**IESA**	COORDINATES:	**653014.5mE, 7401149.7mN**	LOGGED BY:	**JST**



SANDY SILT: brown, dry, hard, very fine grained sand content increasing with depth

SAND & GRAVEL: poorly sorted, well rounded, cobbles bands at 8.5m to 8.9m, 9.5m to 10.0m and 11.0m to 12.0m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

COAL: bed

River 140.72

Invert 138.5

Hole dry 25/11/04

Cement/bentonite grout 0m-5m

Cuttings - 5m-10.6m

1/4" Bentonite pellets 10.6m-11.1m

3mm sand pack 11.1 - 18.0m

50mm casing - 0.4mm slots 16.2m-19.2m

Sand and gravel collapsed in to 17.7m

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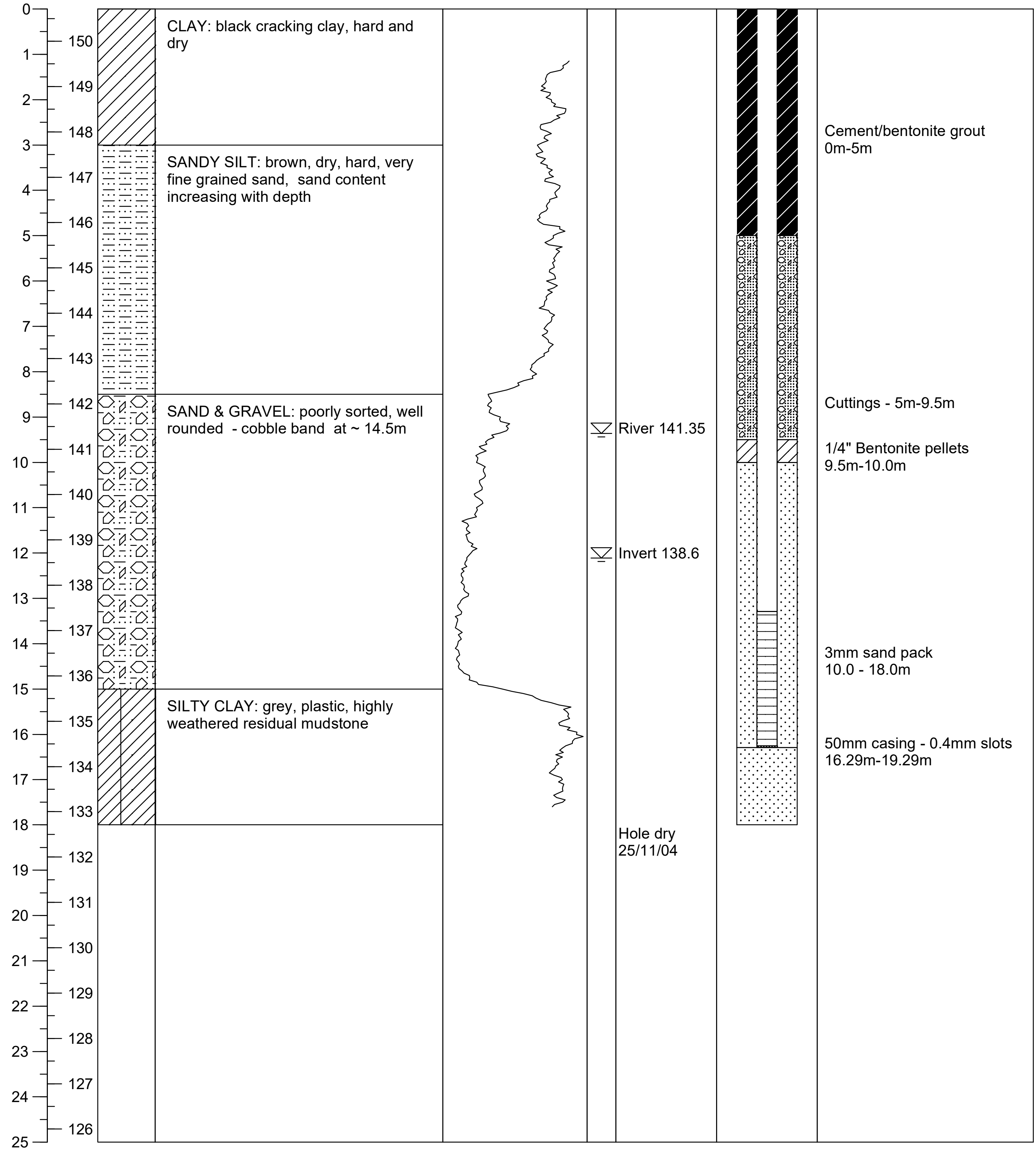
BOREHOLE LOG

BOREHOLE ID: EC20

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**150.711m**
DATE:	**20-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**151.077m**
CONTRACTOR:	**IESA**	COORDINATES:	**652201.9mE, 7400510.4mN**	LOGGED BY:	**JST**

Elevation / Depth	Graphic	Lithologic Description	Gamma (API)	Water Levels	Construction	Bore Description



CLAY: black cracking clay, hard and dry

SANDY SILT: brown, dry, hard, very fine grained sand, sand content increasing with depth

SAND & GRAVEL: poorly sorted, well rounded - cobble band at ~ 14.5m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

River 141.35

Invert 138.6

Hole dry
25/11/04

Cement/bentonite grout
0m-5m

Cuttings - 5m-9.5m

1/4" Bentonite pellets
9.5m-10.0m

3mm sand pack
10.0 - 18.0m

50mm casing - 0.4mm slots
16.29m-19.29m

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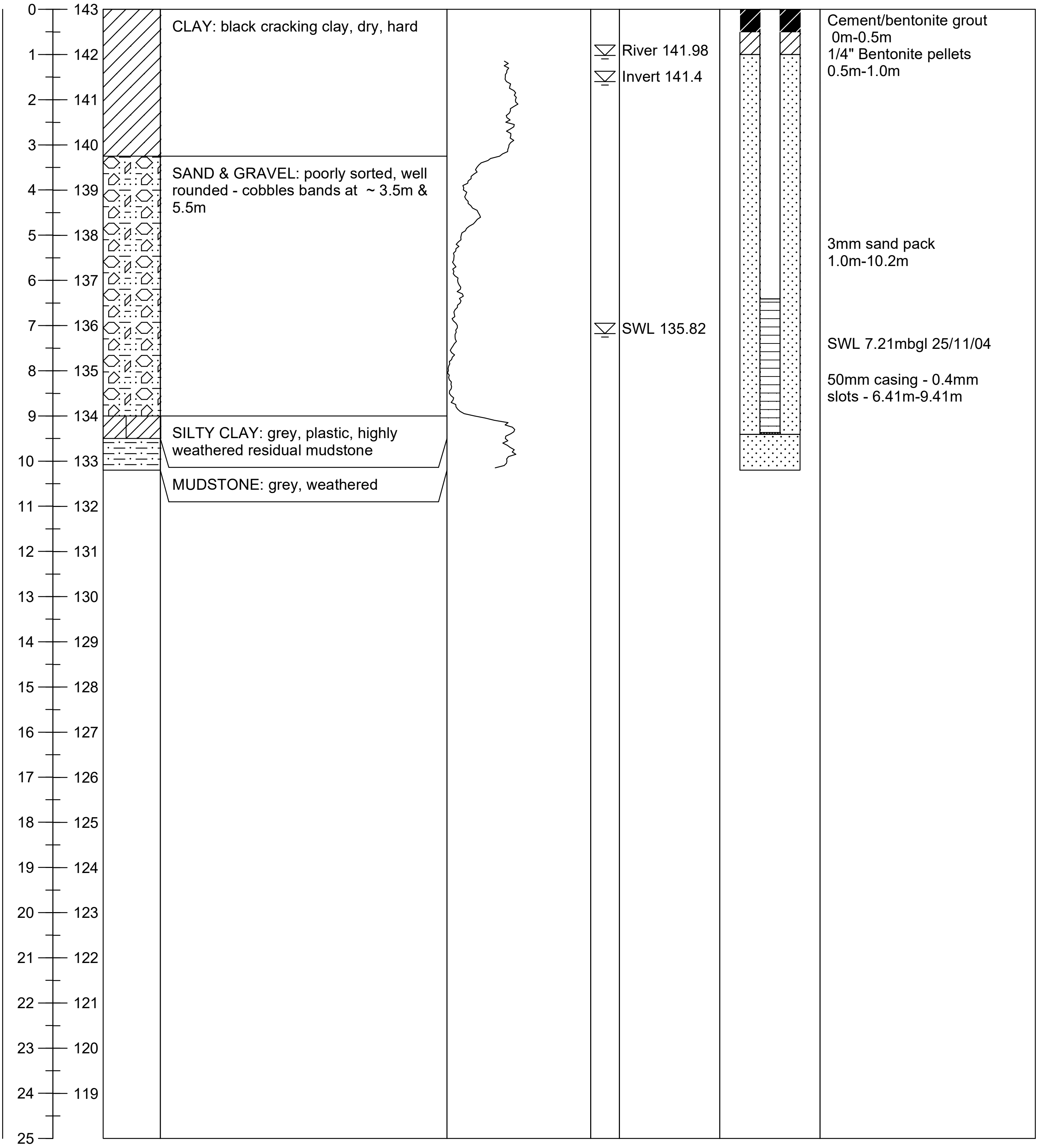
BOREHOLE LOG

BOREHOLE ID: EC21

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**143.002m**
DATE:	**19-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**143.584m**
CONTRACTOR:	**IESA**	COORDINATES:	**651548.0mE, 7400412.6mN**	LOGGED BY:	**JST**

Elevation / Depth	Graphic	Lithologic Description	Gamma (API)	Water Levels	Construction	Bore Description



CLAY: black cracking clay, dry, hard

SAND & GRAVEL: poorly sorted, well rounded - cobbles bands at ~ 3.5m & 5.5m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, weathered

Cement/bentonite grout
0m-0.5m
1/4" Bentonite pellets
0.5m-1.0m

3mm sand pack
1.0m-10.2m

SWL 7.21mbgl 25/11/04

50mm casing - 0.4mm
slots - 6.41m-9.41m

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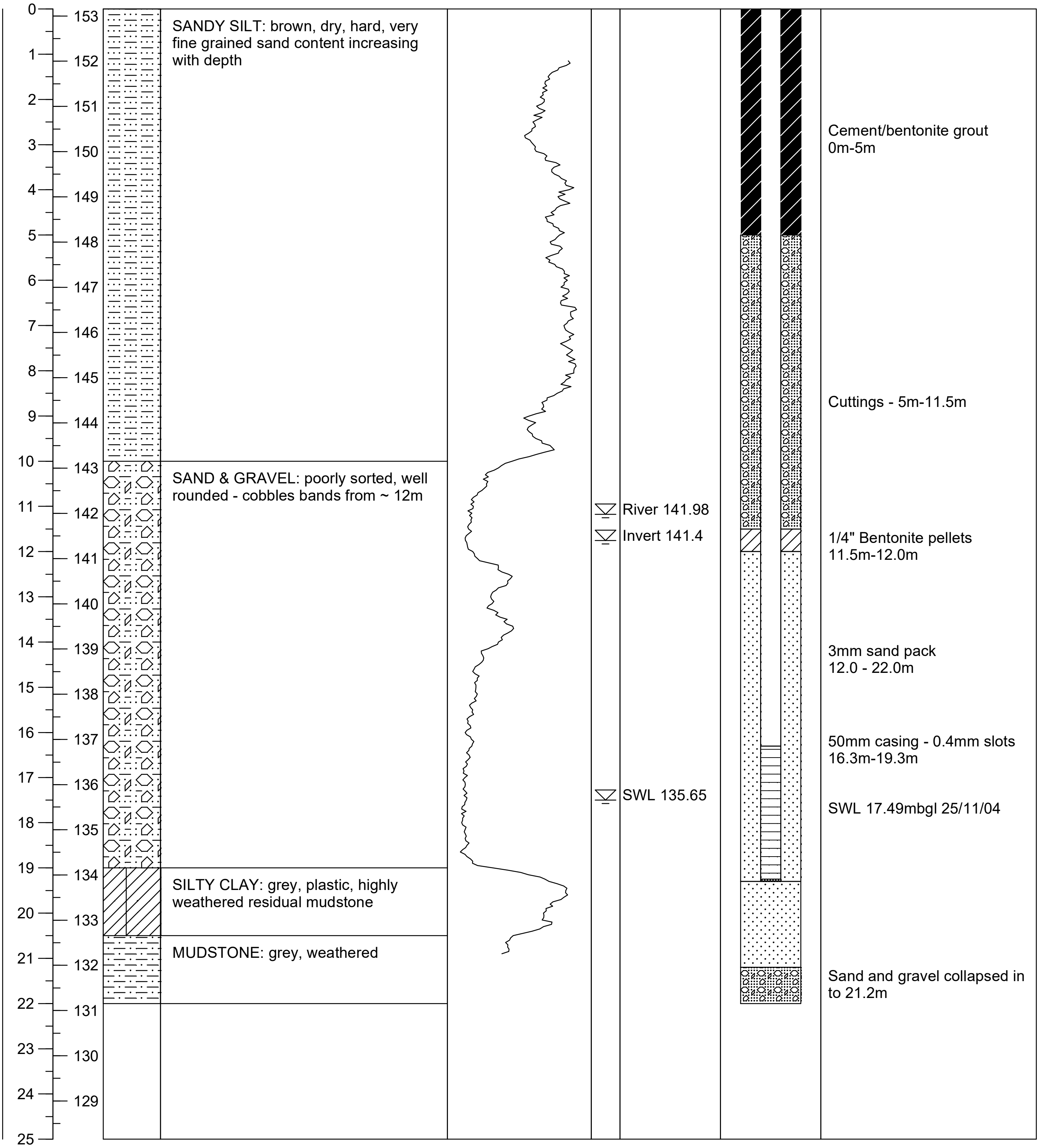
BOREHOLE LOG

BOREHOLE ID: EC22

PROJECT NO. **G1258**
PROJECT NAME: **Ensham Central**
DATE: **21-22 Nov 04**
CONTRACTOR: **IESA**
DRILLER: **Cory**
DRILLING METHOD: **Rotary Air & Stiff Foam**
DRILL RIG: **Bourne T25**
COORDINATES: **651580.7mE, 7400313.8mN**
DATUM: **ADG66**
GROUND LEVEL: **153.155m**
TOP OF CASING LEVEL: **153.685m**
LOGGED BY: **JST**

Depth / Elevation	Graphic	Lithologic Description	Gamma (API)	Water Levels	Construction	Bore Description



SANDY SILT: brown, dry, hard, very fine grained sand content increasing with depth

SAND & GRAVEL: poorly sorted, well rounded - cobbles bands from ~ 12m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, weathered

Cement/bentonite grout 0m-5m

Cuttings - 5m-11.5m

1/4" Bentonite pellets 11.5m-12.0m

3mm sand pack 12.0 - 22.0m

50mm casing - 0.4mm slots 16.3m-19.3m

SWL 17.49mbgl 25/11/04

Sand and gravel collapsed in to 21.2m

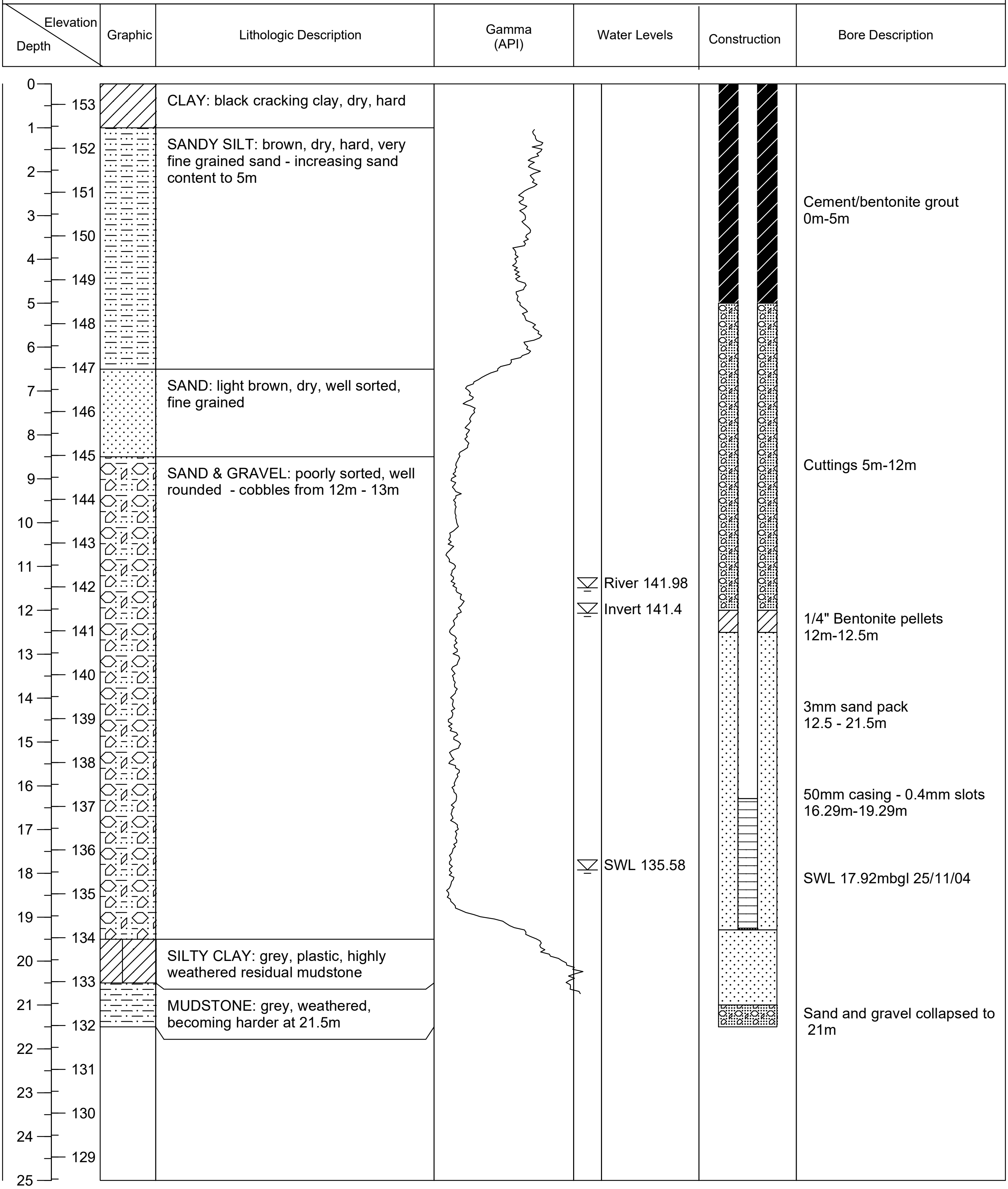
Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: EC23

PROJECT NO.	**G1258**	DRILLER:	**Cory**	DATUM:	**ADG66**
PROJECT NAME:	**Ensham Central**	DRILLING METHOD:	**Rotary Air & Stiff Foam**	GROUND LEVEL:	**153.467m**
DATE:	**21-22 Nov 04**	DRILL RIG:	**Bourne T25**	TOP OF CASING LEVEL:	**153.946m**
CONTRACTOR:	**IESA**	COORDINATES:	**651570.4mE, 7400243.8mN**	LOGGED BY:	**JST**



CLAY: black cracking clay, dry, hard

SANDY SILT: brown, dry, hard, very fine grained sand - increasing sand content to 5m

SAND: light brown, dry, well sorted, fine grained

SAND & GRAVEL: poorly sorted, well rounded - cobbles from 12m - 13m

SILTY CLAY: grey, plastic, highly weathered residual mudstone

MUDSTONE: grey, weathered, becoming harder at 21.5m

Cement/bentonite grout
0m-5m

Cuttings 5m-12m

1/4" Bentonite pellets
12m-12.5m

3mm sand pack
12.5 - 21.5m

50mm casing - 0.4mm slots
16.29m-19.29m

SWL 17.92mbgl 25/11/04

Sand and gravel collapsed to
21m

Appendix 3

WATER QUALITIY ANALYSES LABORATORY REPORTS

CHAIN OF CUSTODY

ALS Environmental
Brisbane
Work Order
EB0407619
Report Version: AliquotLabel 1.01
Telephone : 61-7-32437222

CLIENT: AGE
Contact: James Tomlin
Address: 36 Jeays St
Bowen Hills, Qld
4006
Phone: 32572055
Fax: 32572088

Purchase Order No: Blanket Quote
Project ID: Ensham Central
Quotation:

Final Report: ☐ **E-mail:** ☑ **Fax:** ☐
E-mail Format : ☐ .PDF ☐ Excel ☐ Other
E-mail Address : james.tomlin@ageconsultants.com.au
TAT Required: ☐ 24 hr TAT
☑ Standard TAT (5 - 7 Days)
☐ Specify.........................

SAMPLE INFORMATION | ANALYSIS REQUIRED | COMMENTS

	SAMPLE ID	DATE	MATRIX	TIME	pH, EC, TDS	Ca, Mg, Na, K	CO3, HCO3	Cl, SO4, NO3	Fe, Mn	SiO2					COMMENTS
①	EC01	24/11/04	Water		X	X	X	X	X	X					
②	SW1	23/11/04	↓		X	X	X	X	X	X					Filter then preserve samples for Fe & Mn analysis.
③	EC22	23/11/04			X	X	X	X	X	X					
④	EC14	24/11/04			X	X	X	X	X	X					
⑤	EC12	24/11/04			X	X	X	X	X	X					
⑥	EC21	23/11/04			X	X	X	X	X	X					
⑦	EC03	24/11/04			X	X	X	X	X	X					–Not field filtered
⑧	EC11	24/11/04			X	X	X	X	X	X					
⑨	EC23	23/11/04			X	X	X	X	X	X					
⑩	EC13	24/11/04			X	X	X	X	X	X					

Notes:

RELINQUISHED BY (SIGN / PRINT): JAMES TOMLIN
OF:
DATE: 25/11/04
TIME: 5:10pm.

RECEIVED BY (SIGN / PRINT): Jord
OF: ALS
DATE: 26.11.04
TIME: 9:20

PLEASE SIGN AND FAX BACK UPON RECIEPT

ALS Environmental

CERTIFICATE OF ANALYSIS

Client : **AUST GROUNDWATER & ENVIRO CONSULTANT**
Contact : MR JAMES TOMLIN
Address : 36 JEAYS STREET BOWEN HILLS QLD
AUSTRALIA 4006

Project : Ensham Central
Order number : - Not provided -
C-O-C number : - Not provided -
Site : - Not provided -
E-mail : james.tomlin@ageconsultants.com.au
Telephone : (07)3257-2055
Facsimile : (07)3257-2088

Laboratory : ALS Environmental Brisbane
Contact : Michael Heery
Address : 32 Shand Street Stafford QLD Australia 4053

Quote number : EB20040008

E-mail : Michael.Heery@alsenviro.com
Telephone : 61-7-32437222
Facsimile : 61-7-32437259

Page : **1 of 5**

Work order : **EB0407619**

Date received : 26 Nov 2004
Date issued : 07 Dec 2004

No. of samples
Received : 10
Analysed : 10

This final report was issued on Tuesday, December 7, 2004 for the ALSE work order reference EB0407619 and supersedes any previous reports with this reference.

Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- Analytical results for samples submitted
- Surrogate control limits

ALSE - QUALITY, SERVICE and TECHNOLOGY provided GLOBALLY

NATA Accredited Laboratory - 825

The Laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its scope of accreditation. This document shall not be reproduced except in full.

This document has been digitally signed by those names that appear on this report and are the authorised signatories. Digital signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Department
Kim McCabe	Inorganics - NATA 818 (Brisbane)
Shaun Crabb	Inorganics - NATA 818 (Brisbane)

When moisture determination has been performed, results are reported on a dry weight basis. When a reported 'less than' result is higher than the LOR, this may be due to primary sample extracts/digestion dilution and/or insuffient sample amount for analysis. Surrogate Recovery Limits are static and based on USEPA SW846 or ALS-QWI/EN38 (in the absence of specified USEPA limits).
Abbreviations: ***CAS number** = Chemical Abstract Services number, **LOR** = Limit of Reporting.* ***# Indicates a raised LOR, * Indicates failed Surrogate Recoveries.***
When date(s) are shown bracketed, these have been assumed by the laboratory for process purposes.

Analytical Results

			Client Sample ID :	**EC01**	**SW1**	**EC22**	**EC14**	**EC12**
			Sample Matrix Type / Description : Sample Date / Time :	WATER / WATER 24 Nov 2004 15:00	WATER / WATER 23 Nov 2004 15:00	WATER / WATER 23 Nov 2004 15:00	WATER / WATER 24 Nov 2004 15:00	WATER / WATER 24 Nov 2004 15:00
			Laboratory Sample ID :	**EB0407619-001**	**EB0407619-002**	**EB0407619-003**	**EB0407619-004**	**EB0407619-005**
Analyte	***CAS number***	***LOR***	***Units***					
EA005P: pH by PC Titrator								
pH Value	12408-02-5	0.01	pH Unit	7.19	8.23	8.00	7.78	7.72
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C		1	µS/cm	36200	271	2380	2890	7440
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	GIS-210-010	1	mg/L	28200	204	1400	1860	5670
ED037P: Alkalinity by PC Titrator								
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1020	120	337	608	380
Total Alkalinity as CaCO3		1	mg/L	1020	120	337	608	380
ED040F : Dissolved Sulphate by ICPAES								
Sulphate as SO4 2-	14808-79-8	1	mg/L	1200	4	22	17	67
ED045P: Chloride by PC Titrator								
Chloride	16887-00-6	1	mg/L	15300	12	490	657	2170
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	1270	19	96	99	372
Magnesium	7439-95-4	1	mg/L	1610	9	77	110	423
Sodium	7440-23-5	1	mg/L	5410	18	262	333	541
Potassium	7440-09-7	1	mg/L	13	10	4	4	10
EG005F: Dissolved Metals by ICP-AES								
Iron	7439-89-6	0.01	mg/L	<0.01	<0.01	<0.01	0.02	0.16
Silica	7631-86-9	0.01	mg/L	61.8	10.2	32.9	38.1	34.9
EG020F: Dissolved Metals by ICP-MS								
Manganese	7439-96-5	0.001	mg/L	6.25	0.001	1.26	0.915	4.03
EK057: Nitrite as N								
Nitrite as N		0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010
EK058: Nitrate as N								
Nitrate as N	14797-55-8	0.010	mg/L	0.014	0.172	0.010	0.018	0.016
EK059: Nitrite plus Nitrate as N (NOx)								
Nitrite + Nitrate as N		0.010	mg/L	0.014	0.174	0.010	0.018	0.016
EN055: Ionic Balance								
Total Anions		0.01	meq/L	476	2.82	21.0	31.0	70.1
Total Cations		0.01	meq/L	431	2.71	22.7	28.5	77.2

Analytical Results

			Client Sample ID :	EC01	SW1	EC22	EC14	EC12
			Sample Matrix Type / Description :	WATER / WATER	WATER / WATER	WATER / WATER	WATER / WATER	WATER / WATER
			Sample Date / Time :	24 Nov 2004 15:00	23 Nov 2004 15:00	23 Nov 2004 15:00	24 Nov 2004 15:00	24 Nov 2004 15:00
			Laboratory Sample ID :	**EB0407619-001**	**EB0407619-002**	**EB0407619-003**	**EB0407619-004**	**EB0407619-005**
Analyte	*CAS number*	*LOR*	*Units*					
EN055: Ionic Balance								
Ionic Balance		0.01	%	4.98	----	3.77	4.22	4.78

Analytical Results

			Client Sample ID :	EC21	EC03	EC11	EC23	EC13
			Sample Matrix Type / Description : Sample Date / Time :	WATER / WATER 23 Nov 2004 15:00	WATER / WATER 24 Nov 2004 15:00	WATER / WATER 24 Nov 2004 15:00	WATER / WATER 23 Nov 2004 15:00	WATER / WATER 24 Nov 2004 15:00
			Laboratory Sample ID :	**EB0407619-006**	**EB0407619-007**	**EB0407619-008**	**EB0407619-009**	**EB0407619-010**
Analyte	*CAS number*	*LOR*	*Units*					
EA005P: pH by PC Titrator								
pH Value	12408-02-5	0.01	pH Unit	8.04	7.58	7.70	7.76	7.69
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C		1	µS/cm	2340	23400	16700	2040	15800
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	GIS-210-010	1	mg/L	1290	17400	10900	1110	12600
ED037P: Alkalinity by PC Titrator								
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	511	827	1060	545	800
Total Alkalinity as CaCO3		1	mg/L	511	827	1060	545	800
ED040F : Dissolved Sulphate by ICPAES								
Sulphate as SO4 2-	14808-79-8	1	mg/L	10	803	505	24	455
ED045P: Chloride by PC Titrator								
Chloride	16887-00-6	1	mg/L	434	8970	5370	394	5350
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	83	933	516	75	798
Magnesium	7439-95-4	1	mg/L	78	1080	488	61	489
Sodium	7440-23-5	1	mg/L	269	3110	2330	265	2010
Potassium	7440-09-7	1	mg/L	3	12	16	4	21
EG005F: Dissolved Metals by ICP-AES								
Iron	7439-89-6	0.01	mg/L	0.05	1.04	<0.01	<0.01	7.25
Silica	7631-86-9	0.01	mg/L	40.0	43.6	25.4	37.7	27.8
EG020F: Dissolved Metals by ICP-MS								
Manganese	7439-96-5	0.001	mg/L	0.627	10.8	8.77	0.385	17.3
EK057: Nitrite as N								
Nitrite as N		0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010
EK058: Nitrate as N								
Nitrate as N	14797-55-8	0.010	mg/L	<0.010	0.022	0.014	0.011	0.048
EK059: Nitrite plus Nitrate as N (NOx)								
Nitrite + Nitrate as N		0.010	mg/L	<0.010	0.022	0.014	0.011	0.053
EN055: Ionic Balance								
Total Anions		0.01	meq/L	22.6	286	183	22.5	176
Total Cations		0.01	meq/L	22.3	271	168	20.4	168
Ionic Balance		0.01	%	0.70	2.75	4.35	4.84	2.40

Surrogate Control Limits

The analytical procedures used by ALS Environmental are based on established internationally-recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house procedure are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported herein. Reference methods from which ALSE methods are based are provided in parenthesis.

- **No surrogates present on this report.**

ALS Environmental

QUALITY CONTROL REPORT

Client : **AUST GROUNDWATER & ENVIRO CONSULTANT**
Contact : MR JAMES TOMLIN
Address : 36 JEAYS STREET BOWEN HILLS QLD
AUSTRALIA 4006

Project : Ensham Central
Order number : - Not provided -
C-O-C number : - Not provided -
Site : - Not provided -

E-mail : james.tomlin@ageconsultants.com.au
Telephone : (07)3257-2055
Facsimile : (07)3257-2088

Laboratory : ALS Environmental Brisbane
Contact : Michael Heery
Address : 32 Shand Street Stafford QLD Australia 4053

Quote number : EB20040008

E-mail : Michael.Heery@alsenviro.com
Telephone : 61-7-32437222
Facsimile : 61-7-32437259

Page : **1 of 7**
Work order : **EB0407619**

Date received : 26 Nov 2004
Date issued : 07 Dec 2004

No. of samples
Received : 10
Analysed : 10

This final report was issued on Tuesday, December 7, 2004 for the ALSE work order reference EB0407619 and supersedes any previous reports with this reference.
Results apply to the samples as submitted. All pages of this report have been checked and approved for release.
This report contains the following information:

- Laboratory Duplicates (DUP); Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Samples (LCS); Recovery and Acceptance Limits
- Matrix Spikes (MS); Recovery and Acceptance Limits

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NATA Accredited Laboratory - 825
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This document has been digitally signed by those names that appear on this report and are the authorised signatories. Digital signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Department
Kim McCabe	Inorganics - NATA 818 (Brisbane)
Shaun Crabb	Inorganics - NATA 818 (Brisbane)

Quality Control Report - Laboratory Duplicates (DUP)

The quality control term **Laboratory Duplicate** refers to an intralaboratory split sample randomly selected from the sample batch. Laboratory duplicates provide information on method precision and sample heterogeneity.
- Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. *Abbreviations: **LOR** = Limit of Reporting, **RPD** = Relative Percent Difference.*
* Indicates failed QC. The permitted ranges for the RPD of Laboratory Duplicates (relative percent deviation) are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting:- Result < 10 times LOR, no limit - Result between 10 and 20 times LOR, 0% - 50% - Result > 20 times LOR, 0% - 20%

Matrix Type: WATER

Laboratory Duplicates (DUP) Report

Laboratory Sample ID	*Client Sample ID*	*Analyte name*	*LOR*	*Original Result*	*Duplicate Result*	*RPD*
EA005-P: pH by PC Titrator						
EA005P: pH by PC Titrator - (QC Lot: 25173)				**pH Unit**	**pH Unit**	**%**
EB0407619-001	EC01	pH Value	0.01 pH Unit	7.19	7.21	0.3
EB0407619-008	EC11	pH Value	0.01 pH Unit	7.70	7.73	0.4
EA010-P: Conductivity by PC Titrator						
EA010P: Conductivity by PC Titrator - (QC Lot: 25172)				**µS/cm**	**µS/cm**	**%**
EB0407606-001	- Anonymous -	Electrical Conductivity @ 25°C	1 µS/cm	1720	1720	0.5
EB0407619-008	EC11	Electrical Conductivity @ 25°C	1 µS/cm	16700	16600	0.3
EA015: Total Dissolved Solids						
EA015: Total Dissolved Solids - (QC Lot: 25474)				**mg/L**	**mg/L**	**%**
EB0407510-001	- Anonymous -	Total Dissolved Solids @180°C	1 mg/L	376	360	4.3
EB0407566-008	- Anonymous -	Total Dissolved Solids @180°C	1 mg/L	364	348	4.5
EA015: Total Dissolved Solids - (QC Lot: 25759)				**mg/L**	**mg/L**	**%**
EB0407553-002	- Anonymous -	Total Dissolved Solids @180°C	1 mg/L	216	200	7.7
EB0407569-001	- Anonymous -	Total Dissolved Solids @180°C	1 mg/L	1180	1160	2.0
EA015: Total Dissolved Solids - (QC Lot: 25760)				**mg/L**	**mg/L**	**%**
EB0407619-010	EC13	Total Dissolved Solids @180°C	1 mg/L	12600	12600	0.2
ED037-P: Alkalinity by PC Titrator						
ED037P: Alkalinity by PC Titrator - (QC Lot: 25171)				**mg/L**	**mg/L**	**%**
EB0407577-001	- Anonymous -	Carbonate Alkalinity as CaCO3	1 mg/L	91	109	18.0
		Bicarbonate Alkalinity as CaCO3	1 mg/L	134	141	5.1
		Total Alkalinity as CaCO3	1 mg/L	224	250	11.0
EB0407619-008	EC11	Carbonate Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Bicarbonate Alkalinity as CaCO3	1 mg/L	1060	1060	0.4
		Total Alkalinity as CaCO3	1 mg/L	1060	1060	0.4
ED040F: Dissolved Sulphate by ICPAES						
ED040F : Dissolved Sulphate by ICPAES - (QC Lot: 25079)				**mg/L**	**mg/L**	**%**
EB0407607-005	- Anonymous -	Sulphate as SO4 2-	1 mg/L	1280	1290	1.3
EB0407619-006	EC21	Sulphate as SO4 2-	1 mg/L	10	10	0.0
ED045-P: Chloride by PC Titrator						
ED045P: Chloride by PC Titrator - (QC Lot: 25437)				**mg/L**	**mg/L**	**%**
EB0407607-005	- Anonymous -	Chloride	1 mg/L	60	59	1.7
EB0407668-001	- Anonymous -	Chloride	1 mg/L	156	161	3.2

Matrix Type: WATER

Laboratory Duplicates (DUP) Report

Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD
ED045P: Chloride by PC Titrator - (QC Lot: 25601)				mg/L	mg/L	%
EB0407562-002	- Anonymous -	Chloride	1 mg/L	21	18	15.4
EB0407619-010	EC13	Chloride	1 mg/L	5350	5170	3.3
ED093F: Major Cations - Filtered						
ED093F: Dissolved Major Cations - (QC Lot: 25080)				mg/L	mg/L	%
EB0407607-005	- Anonymous -	Calcium	1 mg/L	137	139	1.0
		Magnesium	1 mg/L	82	82	0.0
		Sodium	1 mg/L	62	63	1.6
		Potassium	1 mg/L	11	11	0.0
EB0407619-006	EC21	Calcium	1 mg/L	83	84	1.5
		Magnesium	1 mg/L	78	79	1.5
		Sodium	1 mg/L	269	268	0.0
		Potassium	1 mg/L	3	3	0.0
EG005F: Dissolved Metals by ICP-AES						
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 25075)				mg/L	mg/L	%
EB0407609-012	- Anonymous -	Iron	0.01 mg/L	0.08	0.08	0.0
		Silicon	0.01 mg/L	4.60	4.59	0.0
		Silica	0.01 mg/L	9.85	9.84	0.2
EB0407617-004	- Anonymous -	Iron	0.01 mg/L	0.07	0.07	0.0
		Silicon	0.01 mg/L	2.90	2.90	0.0
		Silica	0.01 mg/L	6.21	6.22	0.0
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 25076)				mg/L	mg/L	%
EB0407619-009	EC23	Iron	0.01 mg/L	<0.01	<0.01	0.0
		Silicon	0.01 mg/L	17.6	17.8	1.3
		Silica	0.01 mg/L	37.7	38.2	1.3
EB0407668-001	- Anonymous -	Iron	0.01 mg/L	0.12	0.12	0.0
		Silicon	0.01 mg/L	7.70	7.65	0.6
		Silica	0.01 mg/L	16.5	16.4	0.6
EG020A-F: Dissolved Metals by ICP-MS - Suite A						
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 25085)				mg/L	mg/L	%
EB0407553-001	- Anonymous -	Manganese	0.001 mg/L	0.073	0.072	0.0
EB0407607-004	- Anonymous -	Manganese	0.001 mg/L	1.31	1.37	4.7
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 25086)				mg/L	mg/L	%
EB0407619-006	EC21	Manganese	0.001 mg/L	0.627	0.648	3.2
EB0407636-002	- Anonymous -	Manganese	0.001 mg/L	2.32	2.36	1.6
EK057: Nitrite as N						
EK057: Nitrite as N - (QC Lot: 25584)				mg/L	mg/L	%
EB0407619-001	EC01	Nitrite as N	0.010 mg/L	<0.010	<0.010	0.0
EB0407619-010	EC13	Nitrite as N	0.010 mg/L	<0.010	<0.010	0.0

Matrix Type: WATER ***Laboratory Duplicates (DUP) Report***

Laboratory Sample ID	*Client Sample ID*	*Analyte name*	*LOR*	*Original Result*	*Duplicate Result*	*RPD*
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 25585)				**mg/L**	**mg/L**	**%**
EB0407619-001	EC01	Nitrite + Nitrate as N	0.010 mg/L	0.014	0.015	0.0
EB0407619-010	EC13	Nitrite + Nitrate as N	0.010 mg/L	0.053	0.047	11.7

Quality Control Report - Method Blank (MB) and Laboratory Control Samples (LCS)

The quality control term **Method / Laboratory Blank** refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC type is to monitor potential laboratory contamination. The quality control term **Laboratory Control Sample (LCS)** refers to a known, interference free matrix spiked with target analytes or certified reference material. The purpose of this QC type is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of actual laboratory data. Abbreviations: LOR = Limit of reporting.

* Indicates failed QC.

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

		Method blank result	*Actual Results*		*Recovery Limits*	
			Spike concentration	*Spike Recovery*	*Dynamic Recovery Limits*	
Analyte name	*LOR*			*LCS*	*Low*	*High*
EA005-P: pH by PC Titrator						
EA005P: pH by PC Titrator - (QC Lot: 25173)		**pH Unit**	**pH Unit**	**%**	**%**	**%**
pH Value	0.01 pH Unit	----	4	100	70	130
		----	7	100	70	130
EA010-P: Conductivity by PC Titrator						
EA010P: Conductivity by PC Titrator - (QC Lot: 25172)		**µS/cm**	**µS/cm**	**%**	**%**	**%**
Electrical Conductivity @ 25°C	1 µS/cm	<1	----	----	----	----
		----	4000	97.0	70	130
EA015: Total Dissolved Solids						
EA015: Total Dissolved Solids - (QC Lot: 25474)		**mg/L**	**mg/L**	**%**	**%**	**%**
Total Dissolved Solids @180°C	1 mg/L	<1	----	----	----	----
		----	2000	99.2	70	130
EA015: Total Dissolved Solids - (QC Lot: 25759)		**mg/L**	**mg/L**	**%**	**%**	**%**
Total Dissolved Solids @180°C	1 mg/L	<1	----	----	----	----
		----	2000	102	70	130
EA015: Total Dissolved Solids - (QC Lot: 25760)		**mg/L**	**mg/L**	**%**	**%**	**%**
Total Dissolved Solids @180°C	1 mg/L	<1	----	----	----	----
		----	2000	99.2	70	130
ED037-P: Alkalinity by PC Titrator						
ED037P: Alkalinity by PC Titrator - (QC Lot: 25171)		**mg/L**	**mg/L**	**%**	**%**	**%**
Total Alkalinity as CaCO3	1 mg/L	----	200	93.0	70	130
ED040F: Dissolved Sulphate by ICPAES						
ED040F : Dissolved Sulphate by ICPAES - (QC Lot: 25079)		**mg/L**	**mg/L**	**%**	**%**	**%**
Sulphate as SO4 2-	1 mg/L	<1	----	----	----	----
ED045-P: Chloride by PC Titrator						
ED045P: Chloride by PC Titrator - (QC Lot: 25437)		**mg/L**	**mg/L**	**%**	**%**	**%**
Chloride	1 mg/L	<1	----	----	----	----
		----	1000	94.2	70	130
ED045P: Chloride by PC Titrator - (QC Lot: 25601)		**mg/L**	**mg/L**	**%**	**%**	**%**
Chloride	1 mg/L	<1	----	----	----	----
		----	1000	106	70	130

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

		Method blank result	*Actual Results*		*Recovery Limits*	
			Spike concentration	*Spike Recovery*	*Dynamic Recovery Limits*	
Analyte name	*LOR*			*LCS*	*Low*	*High*
ED093F: Major Cations - Filtered						
ED093F: Dissolved Major Cations - (QC Lot: 25080)		**mg/L**	**mg/L**	**%**	**%**	**%**
Calcium	1 mg/L	<1	----	----	----	----
Magnesium	1 mg/L	<1	----	----	----	----
Sodium	1 mg/L	<1	----	----	----	----
Potassium	1 mg/L	<1	----	----	----	----
EG005F: Dissolved Metals by ICP-AES						
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 25075)		**mg/L**	**mg/L**	**%**	**%**	**%**
Iron	0.01 mg/L	<0.01	----	----	----	----
Silicon	0.01 mg/L	<0.01	----	----	----	----
Silica	0.01 mg/L	<0.01	----	----	----	----
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 25076)		**mg/L**	**mg/L**	**%**	**%**	**%**
Iron	0.01 mg/L	<0.01	----	----	----	----
Silicon	0.01 mg/L	<0.01	----	----	----	----
Silica	0.01 mg/L	<0.01	----	----	----	----
EG020A-F: Dissolved Metals by ICP-MS - Suite A						
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 25085)		**mg/L**	**mg/L**	**%**	**%**	**%**
Manganese	0.001 mg/L	<0.001	----	----	----	----
		----	0.100	111	70	130
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 25086)		**mg/L**	**mg/L**	**%**	**%**	**%**
Manganese	0.001 mg/L	<0.001	----	----	----	----
		----	0.100	106	70	130
EK057: Nitrite as N						
EK057: Nitrite as N - (QC Lot: 25584)		**mg/L**	**mg/L**	**%**	**%**	**%**
Nitrite as N	0.010 mg/L	<0.010	----	----	----	----
		----	0.5	107	70	130
EK057: Nitrite as N - (QC Lot: 25586)		**mg/L**	**mg/L**	**%**	**%**	**%**
Nitrite as N	0.010 mg/L	<0.010	----	----	----	----
		----	0.5	110	70	130
EK059: Nitrite and Nitrate as N (NOx)						
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 25585)		**mg/L**	**mg/L**	**%**	**%**	**%**
Nitrite + Nitrate as N	0.010 mg/L	<0.010	----	----	----	----
		----	0.5	100	70	130

Quality Control Report - Matrix Spikes (MS)

The quality control term **Matrix Spike (MS)** refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC type is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQO's). 'Ideal' recovery ranges stated may be waived in the event of sample matrix interferences. - Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. *Abbreviations:* ***LOR*** *= Limit of Reporting,* ***RPD*** *= Relative Percent Difference.*

* Indicates failed QC.

Matrix Type: WATER ***Matrix Spike (MS) Report***

					Actual Results		*Recovery Limits*	
					Sample Result	*Spike Recovery*	*Static Limits*	
Analyte name	*Laboratory Sample ID*	*Client Sample ID*	*LOR*	*Spike Concentration*		*MS*	*Low*	*High*
ED045-P: Chloride by PC Titrator								
ED045P: Chloride by PC Titrator - (QC Lot: 25437)				mg/L	mg/L	%	%	%
Chloride	EB0407607-006	- Anonymous -	1 mg/L	490	33	96.1	70	130
ED045P: Chloride by PC Titrator - (QC Lot: 25601)				mg/L	mg/L	%	%	%
Chloride	EB0407562-003	- Anonymous -	1 mg/L	20	16	105	70	130
EG005F: Dissolved Metals by ICP-AES								
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 25075)				mg/L	mg/L	%	%	%
Iron	EB0407609-013	- Anonymous -	0.01 mg/L	1.00	0.09	110	70	130
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 25076)				mg/L	mg/L	%	%	%
Iron	EB0407619-010	EC13	0.01 mg/L	1.00	7.25	* Not determined	70	130
EG020A-F: Dissolved Metals by ICP-MS - Suite A								
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 25085)				mg/L	mg/L	%	%	%
Manganese	EB0407553-002	- Anonymous -	0.001 mg/L	0.100	0.215	112	70	130
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 25086)				mg/L	mg/L	%	%	%
Manganese	EB0407619-007	EC03	0.001 mg/L	0.100	10.8	* Not determined	70	130
EK057: Nitrite as N								
EK057: Nitrite as N - (QC Lot: 25584)				mg/L	mg/L	%	%	%
Nitrite as N	EB0407566-001	- Anonymous -	0.01 mg/L	2	<0.010	106	70	130
EK057: Nitrite as N - (QC Lot: 25586)				mg/L	mg/L	%	%	%
Nitrite as N	EB0407643-001	- Anonymous -	0.01 mg/L	0.4	<0.010	107	70	130
EK059: Nitrite and Nitrate as N (NOx)								
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 25585)				mg/L	mg/L	%	%	%
Nitrite + Nitrate as N	EB0407597-001	- Anonymous -	0.01 mg/L	0.4	0.148	97.9	70	130

AUSTRALASIAN GROUNDWATER AND
ENVIRONMENTAL CONSULTANTS PTY LTD (AGE)
36 JEAYS STREET
BOWEN HILLS QLD. 4006

Ph: (07) 3257 2055
Fax: (07) 3257 2088
Email: james.tomlin@ageconsultants.com.au

Ensham Resources

CHAIN OF CUSTODY AND ANALYSIS REQUEST (blanket)

DESPATCHED TO: ALS Brisbane
ADDRESS: 32 Shand St
Stafford, Qld
CONTACT: Ian wallace

AGE JOB No. 6258
PURCHASE ORDER No. EN/578/03

PRELIMINARY RESULTS BY: Standard Turnaround
FINAL REPORT BY:
AGE CONTACT: James Tomlin
REMARKS:

SAMPLE ID	COLLECTION DATE/TIME	LAB NO.	MATRIX				PRESERVATION METHOD				ANALYSIS REQUIRED									
			WATER	SOIL	EFFLUENT	OTHER	ICE BRICK	ACIDIFIED	OTHER	NONE	pH, EC, TDS	Ca, Mg, Na, K	CO_3, HCO_3	Cl, SO_4, NO_3	Fe, Mn	SiO_2				
① BPit	2/3/05		X				X				X	X	X	X	X	X				Acid washed
② SW1	3/3/05		X				X				X	X	X	X	X	X				from metals
③ EC021	1/3/05		X				X				X	X	X	X	X	X				bottles - please
④ EC05	2/3/05		X				X				X	X	X	X	X	X				filter & acidify

RELINQUISHED BY:	DATE/TIME	RECEIVED BY:	DATE/TIME
J Tomlin	13:10 4/3/05		4/3 ~~3~~ 13:25.

ALS Environmental
Brisbane
Work Order
EB0501940
Report Version AliquotLabel 1.01
Telephone : 61-7-32437222

ALS Environmental

CERTIFICATE OF ANALYSIS

Client : **AUST GROUNDWATER & ENVIRO CONSULTANT**
Contact : MR JAMES TOMLIN
Address : 36 JEAYS STREET BOWEN HILLS QLD
AUSTRALIA 4006

Project : ENSHAM RESOURCES
Order number : 61255
C-O-C number : - Not provided -
Site : - Not provided -
E-mail : james.tomlin@ageconsultants.com.au
Telephone : (07)3257-2055
Facsimile : (07)3257-2088

Laboratory : ALS Environmental Brisbane
Contact : Michael Heery
Address : 32 Shand Street Stafford QLD Australia 4053

Quote number : EN 578 03

E-mail : Michael.Heery@alsenviro.com
Telephone : 61-7-32437222
Facsimile : 61-7-32437259

Page : **1 of 3**
Work order : **EB0501940**

Date received : 4 Mar 2005
Date issued : 15 Mar 2005

No. of samples
Received : 4
Analysed : 4

This final report for the ALSE work order reference EB0501940 supersedes any previous reports with this reference.

Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- Analytical results for samples submitted
- Surrogate control limits

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This document has been digitally signed by those names that appear on this report and are the authorised signatories. Digital signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Department
Kim McCabe	Inorganics - NATA 818 (Brisbane)

When moisture determination has been performed, results are reported on a dry weight basis. When a reported 'less than' result is higher than the LOR, this may be due to primary sample extracts/digestion dilution and/or insuffient sample amount for analysis. Surrogate Recovery Limits are static and based on USEPA SW846 or ALS-QWI/EN38 (in the absence of specified USEPA limits).
Abbreviations: ***CAS number*** = *Chemical Abstract Services number,* ***LOR*** = *Limit of Reporting.* ***# Indicates a raised LOR, * Indicates failed Surrogate Recoveries.***
When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for process purposes.

Analytical Results

			Client Sample ID :	**BPIT**	**SW1**	**EC021**	**EC05**	
			Sample Matrix Type / Description :	WATER / WATER	WATER / WATER	WATER / WATER	WATER / WATER	
			Sample Date / Time :	2 Mar 2005 15:00	2 Mar 2005 15:00	2 Mar 2005 15:00	2 Mar 2005 15:00	
			Laboratory Sample ID :	**EB0501940-001**	**EB0501940-002**	**EB0501940-003**	**EB0501940-004**	
Analyte	***CAS number***	***LOR***	***Units***					
EA005P: pH by PC Titrator								
pH Value	12408-02-5	0.01	pH Unit	7.40	8.17	7.55	7.60	
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C		1	µS/cm	8100	241	2710	29300	
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	GIS-210-010	1	mg/L	7230	216	1640	24800	
ED037P: Alkalinity by PC Titrator								
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	379	93	636	802	
Total Alkalinity as CaCO3		1	mg/L	379	93	636	802	
ED040F: Dissolved Major Anions								
Sulphate as SO4 2-	14808-79-8	1	mg/L	272	6	15	1140	
Silica	7631-86-9	0.1	mg/L	42.3	13.0	48.3	30.0	
ED045P: Chloride by PC Titrator								
Chloride	16887-00-6	1	mg/L	3650	15	600	11400	
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	647	19	106	781	
Magnesium	7439-95-4	1	mg/L	458	7	116	1270	
Sodium	7440-23-5	1	mg/L	1230	20	345	5350	
Potassium	7440-09-7	1	mg/L	13	6	3	17	
EG005F: Dissolved Metals by ICP-AES								
Iron	7439-89-6	0.01	mg/L	<0.01	0.06	<0.01	<0.01	
Manganese	7439-96-5	0.01	mg/L	0.65	<0.01	1.32	0.22	
EK057: Nitrite as N								
Nitrite as N		0.010	mg/L	<0.010	<0.010	<0.010	<0.010	
EK058: Nitrate as N								
Nitrate as N	14797-55-8	0.010	mg/L	1.42	0.171	0.011	<0.010	
EK059: Nitrite plus Nitrate as N (NOx)								
Nitrite + Nitrate as N		0.010	mg/L	1.42	0.171	0.011	<0.010	
EN055: Ionic Balance								
Total Anions		0.01	meq/L	116	2.41	29.9	363	
Total Cations		0.01	meq/L	124	2.57	29.9	376	
Ionic Balance		0.01	%	3.28	----	0.10	1.82	

Surrogate Control Limits

The analytical procedures used by ALS Environmental are based on established internationally-recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house procedure are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported herein. Reference methods from which ALSE methods are based are provided in parenthesis.

- **No surrogates present on this report.**

ALS Environmental

QUALITY CONTROL REPORT

Client	:	**AUST GROUNDWATER & ENVIRO CONSULTANT**	**Laboratory**	:	ALS Environmental Brisbane	**Page**	: **1 of 6**
Contact	:	MR JAMES TOMLIN	**Contact**	:	Michael Heery		
Address	:	36 JEAYS STREET BOWEN HILLS QLD AUSTRALIA 4006	**Address**	:	32 Shand Street Stafford QLD Australia 4053	**Work order**	: **EB0501940**
Project	:	ENSHAM RESOURCES	**Quote number**	:	EN 578 03	**Date received**	: 4 Mar 2005
Order number	:	61255				**Date issued**	: 15 Mar 2005
C-O-C number	:	- Not provided -					
Site	:	- Not provided -					
E-mail	:	james.tomlin@ageconsultants.com.au	**E-mail**	:	Michael.Heery@alsenviro.com	**No. of samples**	
Telephone	:	(07)3257-2055	**Telephone**	:	61-7-32437222	**Received**	: 4
Facsimile	:	(07)3257-2088	**Facsimile**	:	61-7-32437259	**Analysed**	: 4

This final report for the ALSE work order reference EB0501940 supersedes any previous reports with this reference.

Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- Laboratory Duplicates (DUP); Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Samples (LCS); Recovery and Acceptance Limits
- Matrix Spikes (MS); Recovery and Acceptance Limits

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This document has been digitally signed by those names that appear on this report and are the authorised signatories. Digital signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Department
Kim McCabe	Inorganics - NATA 818 (Brisbane)

Quality Control Report - Laboratory Duplicates (DUP)

The quality control term **Laboratory Duplicate** refers to an intralaboratory split sample randomly selected from the sample batch. Laboratory duplicates provide information on method precision and sample heterogeneity.
- Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. *Abbreviations: **LOR** = Limit of Reporting, **RPD** = Relative Percent Difference.*
* Indicates failed QC. The permitted ranges for the RPD of Laboratory Duplicates (relative percent deviation) are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting:- Result < 10 times LOR, no limit - Result between 10 and 20 times LOR, 0% - 50% - Result > 20 times LOR, 0% - 20%

Matrix Type: WATER ***Laboratory Duplicates (DUP) Report***

Laboratory Sample ID	*Client Sample ID*	*Analyte name*	*LOR*	*Original Result*	*Duplicate Result*	*RPD*
EA005-P: pH by PC Titrator						
EA005P: pH by PC Titrator - (QC Lot: 51021)				**pH Unit**	**pH Unit**	**%**
EB0501916-001	- Anonymous -	pH Value	0.01 pH Unit	7.64	7.63	0.1
EB0501916-010	- Anonymous -	pH Value	0.01 pH Unit	7.74	7.75	0.1
EA010-P: Conductivity by PC Titrator						
EA010P: Conductivity by PC Titrator - (QC Lot: 51022)				**µS/cm**	**µS/cm**	**%**
EB0501916-001	- Anonymous -	Electrical Conductivity @ 25°C	1 µS/cm	601	596	0.8
EB0501916-010	- Anonymous -	Electrical Conductivity @ 25°C	1 µS/cm	23100	22600	2.2
EA015: Total Dissolved Solids						
EA015: Total Dissolved Solids - (QC Lot: 49426)				**mg/L**	**mg/L**	**%**
EB0501932-001	- Anonymous -	Total Dissolved Solids @180°C	1 mg/L	508	521	2.5
EB0501960-001	- Anonymous -	Total Dissolved Solids @180°C	1 mg/L	780	800	2.5
ED037-P: Alkalinity by PC Titrator						
ED037P: Alkalinity by PC Titrator - (QC Lot: 51020)				**mg/L**	**mg/L**	**%**
EB0501916-001	- Anonymous -	Carbonate Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Bicarbonate Alkalinity as CaCO3	1 mg/L	56	57	1.8
		Total Alkalinity as CaCO3	1 mg/L	56	57	1.8
EB0501916-010	- Anonymous -	Carbonate Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Bicarbonate Alkalinity as CaCO3	1 mg/L	103	106	2.9
		Total Alkalinity as CaCO3	1 mg/L	103	106	2.9
ED040F: Major Anions - Filtered						
ED040F: Dissolved Major Anions - (QC Lot: 49840)				**mg/L**	**mg/L**	**%**
EB0501913-001	- Anonymous -	Sulphate as SO4 2-	1 mg/L	13	13	0.0
		Silica	0.1 mg/L	6.9	7.0	0.0
EB0501960-003	- Anonymous -	Sulphate as SO4 2-	1 mg/L	2350	2350	0.0
		Silica	0.1 mg/L	14.8	14.9	0.0
ED045-P: Chloride by PC Titrator						
ED045P: Chloride by PC Titrator - (QC Lot: 50018)				**mg/L**	**mg/L**	**%**
EB0501932-002	- Anonymous -	Chloride	1 mg/L	127	124	2.5
EB0501932-011	- Anonymous -	Chloride	1 mg/L	12000	12300	2.6

Matrix Type: WATER

Laboratory Duplicates (DUP) Report

Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD
ED093F: Major Cations - Filtered						
ED093F: Dissolved Major Cations - (QC Lot: 49839)				mg/L	mg/L	%
EB0501913-001	- Anonymous -	Calcium	1 mg/L	30	31	0.0
		Magnesium	1 mg/L	8	8	0.0
		Sodium	1 mg/L	30	31	0.0
		Potassium	1 mg/L	5	5	0.0
EB0501960-003	- Anonymous -	Calcium	1 mg/L	428	432	0.7
		Magnesium	1 mg/L	410	414	1.0
		Sodium	1 mg/L	320	322	0.7
		Potassium	1 mg/L	48	49	2.2
EG005F: Dissolved Metals by ICP-AES						
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 49865)				mg/L	mg/L	%
EB0501913-001	- Anonymous -	Iron	0.05 mg/L	<0.05	<0.05	0.0
		Manganese	0.01 mg/L	<0.01	<0.01	0.0
EB0501926-002	- Anonymous -	Iron	0.05 mg/L	<0.05	<0.05	0.0
		Manganese	0.01 mg/L	0.07	<0.05	33.2
EK057: Nitrite as N						
EK057: Nitrite as N - (QC Lot: 48960)				mg/L	mg/L	%
EB0501843-002	- Anonymous -	Nitrite as N	0.010 mg/L	<0.010	<0.010	0.0
EB0501932-014	- Anonymous -	Nitrite as N	0.020 mg/L	<0.020	<0.020	0.0
EK059: Nitrite and Nitrate as N (NOx)						
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 48966)				mg/L	mg/L	%
EB0501932-016	- Anonymous -	Nitrite + Nitrate as N	0.020 mg/L	<0.020	<0.020	0.0
EB0501944-003	- Anonymous -	Nitrite + Nitrate as N	0.010 mg/L	<0.010	<0.010	0.0

Quality Control Report - Method Blank (MB) and Laboratory Control Samples (LCS)

The quality control term **Method / Laboratory Blank** refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC type is to monitor potential laboratory contamination. The quality control term **Laboratory Control Sample (LCS)** refers to a known, interference free matrix spiked with target analytes or certified reference material. The purpose of this QC type is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of actual laboratory data. Abbreviations: LOR = Limit of reporting.

* Indicates failed QC.

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

		Method blank result	*Actual Results*		*Recovery Limits*	
			Spike concentration	*Spike Recovery*	*Dynamic Recovery Limits*	
Analyte name	*LOR*			*LCS*	*Low*	*High*
EA005-P: pH by PC Titrator						
EA005P: pH by PC Titrator - (QC Lot: 51021)		pH Unit	pH Unit	%	%	%
pH Value	0.01 pH Unit	----	4	99.5	70	130
		----	6.88	99.8	70	130
EA010-P: Conductivity by PC Titrator						
EA010P: Conductivity by PC Titrator - (QC Lot: 51022)		µS/cm	µS/cm	%	%	%
Electrical Conductivity @ 25°C	1 µS/cm	<1	----	----	----	----
		----	4000	99.0	70	130
EA015: Total Dissolved Solids						
EA015: Total Dissolved Solids - (QC Lot: 49426)		mg/L	mg/L	%	%	%
Total Dissolved Solids @180°C	1 mg/L	<1	----	----	----	----
		----	2000	99.0	70	130
ED037-P: Alkalinity by PC Titrator						
ED037P: Alkalinity by PC Titrator - (QC Lot: 51020)		mg/L	mg/L	%	%	%
Total Alkalinity as CaCO3	1 mg/L	----	200	93.0	70	130
ED040F: Major Anions - Filtered						
ED040F: Dissolved Major Anions - (QC Lot: 49840)		mg/L	mg/L	%	%	%
Sulphate as SO4 2-	1 mg/L	<1	----	----	----	----
Silica	0.1 mg/L	<0.1	----	----	----	----
ED045-P: Chloride by PC Titrator						
ED045P: Chloride by PC Titrator - (QC Lot: 50018)		mg/L	mg/L	%	%	%
Chloride	1 mg/L	<1	----	----	----	----
		----	1000	89.7	70	130
ED093F: Major Cations - Filtered						
ED093F: Dissolved Major Cations - (QC Lot: 49839)		mg/L	mg/L	%	%	%
Calcium	1 mg/L	<1	----	----	----	----
Magnesium	1 mg/L	<1	----	----	----	----
Sodium	1 mg/L	<1	----	----	----	----
Potassium	1 mg/L	<1	----	----	----	----
EG005F: Dissolved Metals by ICP-AES						
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 49865)		mg/L	mg/L	%	%	%
Iron	0.05 mg/L	<0.05	----	----	----	----
Manganese	0.01 mg/L	<0.01	----	----	----	----

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

		Method blank result	*Actual Results*		*Recovery Limits*	
			Spike concentration	*Spike Recovery*	*Dynamic Recovery Limits*	
Analyte name	*LOR*			*LCS*	*Low*	*High*
EK057: Nitrite as N						
EK057: Nitrite as N - (QC Lot: 48960)		mg/L	mg/L	%	%	%
Nitrite as N	0.010 mg/L	<0.010	----	----	----	----
		----	0.5	111	70	130
EK059: Nitrite and Nitrate as N (NOx)						
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 48966)		mg/L	mg/L	%	%	%
Nitrite + Nitrate as N	0.010 mg/L	<0.010	----	----	----	----
		----	0.5	110	70	130

Quality Control Report - Matrix Spikes (MS)

The quality control term **Matrix Spike (MS)** refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC type is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQO's). 'Ideal' recovery ranges stated may be waived in the event of sample matrix interferences. - Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. *Abbreviations: **LOR** = Limit of Reporting, **RPD** = Relative Percent Difference.*

* Indicates failed QC.

Matrix Type: WATER

Matrix Spike (MS) Report

					Actual Results		*Recovery Limits*	
					Sample Result	*Spike Recovery*	*Static Limits*	
Analyte name	*Laboratory Sample ID*	*Client Sample ID*	*LOR*	*Spike Concentration*		*MS*	*Low*	*High*
ED045-P: Chloride by PC Titrator								
ED045P: Chloride by PC Titrator - (QC Lot: 50018)				mg/L	mg/L	%	%	%
Chloride	EB0501932-003	- Anonymous -	1 mg/L	4900	3990	85.4	70	130
EG005F: Dissolved Metals by ICP-AES								
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 49865)				mg/L	mg/L	%	%	%
Iron	EB0501913-002	- Anonymous -	0.05 mg/L	1.00	<0.05	99.0	70	130
Manganese			0.01 mg/L	1.00	0.02	98.8	70	130
EK057: Nitrite as N								
EK057: Nitrite as N - (QC Lot: 48960)				mg/L	mg/L	%	%	%
Nitrite as N	EB0501843-001	- Anonymous -	0.01 mg/L	0.4	<0.010	111	70	130
EK059: Nitrite and Nitrate as N (NOx)								
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 48966)				mg/L	mg/L	%	%	%
Nitrite + Nitrate as N	EB0501932-015	- Anonymous -	0.02 mg/L	4	<0.020	88.4	70	130

AUSTRALASIAN GROUNDWATER AND
ENVIRONMENTAL CONSULTANTS PTY LTD (AGE)
36 JEAYS STREET
BOWEN HILLS QLD. 4006

Ph: (07) 3257 2055
Fax: (07) 3257 2088
Email: james.tomlin@ageconsultants.com.au

Evsham Resources

CHAIN OF CUSTODY AND ANALYSIS REQUEST

DESPATCHED TO:
ADDRESS:
CONTACT:

ALS Environmental
Brisbane
Work Order
EB0504924
Report Version: WOLabel 1.00
Telephone : 61-7-32437222

/4053

AGE JOB No. C1258

PURCHASE ORDER No. EN/578/03.

ULTS BY: Standard Turnaround

FINAL REPORT BY:

AGE CONTACT: James Tomlin

SAMPLE ID	COLLECTION DATE/TIME	LAB NO.	MATRIX: WATER	MATRIX: SOIL	MATRIX: EFFLUENT	MATRIX: OTHER	PRESERVATION METHOD: ICE BRICK	PRESERVATION METHOD: ACIDIFIED	PRESERVATION METHOD: OTHER	PRESERVATION METHOD: NONE	ANALYSIS REQUIRED: pH, EC, TDS	Ca, Mg, Na, K	CO3, HCO3	Cl, SO4, NO3	Fe, Mn	SiO2			
① SW1	31/5/05		X				X				X	X	X	X	X	X			
② EC21	31/5/05		X				X				X	X	X	X	X	X			
③ EC23	1/6/05		X				X				X	X	X	X	X	X			
④ B PIT	1/6/05		X				X				X	X	X	X	X	X			

REMARKS:
Acid washed from metals bottles - please filter & acidify.

RELINQUISHED BY:	DATE/TIME	RECEIVED BY:	DATE/TIME
	3/6/05. 7:49		3/6/05 8:05am.

AUSTRALIAN LABORATORY SERVICES PTY LTD ABN 84 009 936 029
32 Shand Street Stafford QLD 4053 Australia
Telephone: 61-7-32437222 Facsimile: 61-7-32437259 http://www.alsenviro.com/

ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Client Details

Client : **AUST GROUNDWATER & ENVIRO CONSULTANTS**
Contact : **MR JAMES TOMLIN**
Address : 36 JEAYS STREET BOWEN HILLS QLD AUSTRALIA 4006

Project : **61258**
Order number : **- Not provided -**
C-O-C Number : **- Not provided -**
Site : **- Not provided -**
Sampler : **- Not provided -**

E-mail : james.tomlin@ageconsultants.com.au
Telephone : (07)3257-2055
Facsimile : (07)3257-2088

Laboratory Details

Laboratory : **ALS Environmental Brisbane**
Manager : **Michael Heery**
Address : 32 Shand Street Stafford QLD Australia 4053

Quote number : EB20040008
Work order : **EB0504924**

E-mail : Michael.Heery@alsenviro.com
Telephone : 61-7-32437222
Facsimile : 61-7-32437259

Dates

Date Samples Received : 3 Jun 2005
SRA Issue Date : 6 Jun 2005
Scheduled Reporting Date : **15 Jun 2005**

Delivery Details

Mode of Delivery : Client Drop off.
No. of coolers/boxes : 1 LARGE
Security Seal : Intact.

Temperature : 2 C - Ice present
No. of samples - **Received** 4
- **Analysed** 0

Comments

- **Samples received in appropriately pretreated and preserved containers.**
- **Breaches in recommended extraction / analysis holding times may occur.**
- **pH holding time is six hours after sampling.**
- **The recommended holding time for Nitrite, Nitrate +/or reactive phosphorus analysis is 48 hours from the time of sampling.**

- Please direct any turn around / technical queries to the laboratory contact designated above.
- Please direct any queries related to sample condition / numbering / breakages to Jordi Mir.
- Analytical work for this work order will be conducted at ALSE Brisbane.
- Sample Disposal - Aqueous (14 days), Solid (90 days) from date of completion of work order.
- When the sampling time is not supplied on the COC documentation, ALSE defaults the sampling time to that of the COC 'relinquishment' time (if supplied). If this also is not supplied, ALSE defaults the sampling time to the 'time of receipt at Laboratory'.

Requested Reports

- **MR JAMES TOMLIN**

- A4 - Certificate of Analysis - NEPM format	Email	james.tomlin@ageconsultants.com.au
- A4 - Quality Control Report - NEPM format	Email	james.tomlin@ageconsultants.com.au
- ENMRG Export Format	Email	james.tomlin@ageconsultants.com.au
- A4 - Sample Receipt Notification - Standard format	Email	james.tomlin@ageconsultants.com.au
- Chain of Custody Acknowledgement	Email	james.tomlin@ageconsultants.com.au
- Invoice	Email	james.tomlin@ageconsultants.com.au

Sample Container(s) / Preservation Non-Compliance Log

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / presevation non-compliance exist.**

ALS Environmental

CERTIFICATE OF ANALYSIS

Client	:	**AUST GROUNDWATER & ENVIRO CONSULTANT**	**Laboratory**	:	ALS Environmental Brisbane	**Page**	: **1 of 4**
Contact	:	MR JAMES TOMLIN	**Contact**	:	Michael Heery		
Address	:	36 JEAYS STREET BOWEN HILLS QLD AUSTRALIA 4006	**Address**	:	32 Shand Street Stafford QLD Australia 4053	**Work order**	: **EB0504924**
Project	:	61258	**Quote number**	:	EN 578 03	**Date received**	: 3 Jun 2005
Order number	:	- Not provided -				**Date issued**	: 14 Jun 2005
C-O-C number	:	- Not provided -					
Site	:	- Not provided -					
E-mail	:	james.tomlin@ageconsultants.com.au	**E-mail**	:	Michael.Heery@alsenviro.com	**No. of samples**	
Telephone	:	(07)3257-2055	**Telephone**	:	61-7-32437222	**Received**	: 4
Facsimile	:	(07)3257-2088	**Facsimile**	:	61-7-32437259	**Analysed**	: 4

This final report for the ALSE work order reference EB0504924 supersedes any previous reports with this reference.

Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- Analytical results for samples submitted
- Surrogate control limits

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NATA

WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory - 825

This document is issued in accordance with NATA's accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

This document has been digitally signed by those names that appear on this report and are the authorised signatories. Digital signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Department
Kim McCabe	Inorganics - NATA 818 (Brisbane)

When moisture determination has been performed, results are reported on a dry weight basis. When a reported 'less than' result is higher than the LOR, this may be due to primary sample extracts/digestion dilution and/or insuffient sample amount for analysis. Surrogate Recovery Limits are static and based on USEPA SW846 or ALS-QWI/EN38 (in the absence of specified USEPA limits).
Abbreviations*: **CAS number** = Chemical Abstract Services number, **LOR** = Limit of Reporting. **# Indicates a raised LOR, * Indicates failed Surrogate Recoveries.***
When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for process purposes.

Analytical Results

			Client Sample ID :	**SW1**	**EC21**	**EC23**	**BPIT**	
			Sample Matrix Type / Description : Sample Date / Time :	WATER / WATER 31 May 2005 15:00	WATER / WATER 31 May 2005 15:00	WATER / WATER 1 Jun 2005 15:00	WATER / WATER 1 Jun 2005 15:00	
			Laboratory Sample ID :	**EB0504924-001**	**EB0504924-002**	**EB0504924-003**	**EB0504924-004**	
Analyte	***CAS number***	***LOR***	***Units***					
EA005P: pH by PC Titrator								
pH Value	12408-02-5	0.01	pH Unit	8.38	7.70	8.00	7.85	
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C		1	µS/cm	328	3250	3010	13700	
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	GIS-210-010	1	mg/L	228	2200	1820	8800	
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	5	<1	<1	<1	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	127	608	881	501	
Total Alkalinity as CaCO3		1	mg/L	132	608	830	501	
ED040F: Dissolved Major Anions								
Sulphate as SO4 2-	14808-79-8	1	mg/L	6	17	33	288	
Silica	7631-86-9	0.1	mg/L	4.1	41.8	27.7	36.3	
ED045P: Chloride by PC Titrator								
Chloride	16887-00-6	1	mg/L	25	892	585	4510	
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	20	108	91	373	
Magnesium	7439-95-4	1	mg/L	12	152	94	457	
Sodium	7440-23-5	1	mg/L	23	382	430	1710	
Potassium	7440-09-7	1	mg/L	12	5	4	19	
EG005F: Dissolved Metals by ICP-AES								
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	
EG020F: Dissolved Metals by ICP-MS								
Manganese	7439-96-5	0.001	mg/L	0.063	1.12	0.260	0.868	
EK057: Nitrite as N								
Nitrite as N		0.010	mg/L	<0.010	<0.010	<0.010	<0.010	
EK058: Nitrate as N								
Nitrate as N	14797-55-8	0.010	mg/L	0.024	0.016	0.074	3.19	
EK059: Nitrite plus Nitrate as N (NOx)								
Nitrite + Nitrate as N		0.010	mg/L	0.024	0.016	0.074	3.19	
EN055: Ionic Balance								
Total Anions		0.01	meq/L	3.46	37.6	33.8	143	

Analytical Results

			Client Sample ID :	**SW1**	**EC21**	**EC23**	**BPIT**	
			Sample Matrix Type / Description :	WATER / WATER	WATER / WATER	WATER / WATER	WATER / WATER	
			Sample Date / Time :	31 May 2005 15:00	31 May 2005 15:00	1 Jun 2005 15:00	1 Jun 2005 15:00	
			Laboratory Sample ID :	**EB0504924-001**	**EB0504924-002**	**EB0504924-003**	**EB0504924-004**	
Analyte	*CAS number*	*LOR*	*Units*					
EN055: Ionic Balance								
Total Cations		0.01	meq/L	3.33	34.6	31.1	131	
Ionic Balance		0.01	%	1.88	4.22	4.14	4.44	

Surrogate Control Limits

The analytical procedures used by ALS Environmental are based on established internationally-recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house procedure are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported herein. Reference methods from which ALSE methods are based are provided in parenthesis.

- **No surrogates present on this report.**

ALS Environmental

QUALITY CONTROL REPORT

Client : **AUST GROUNDWATER & ENVIRO CONSU**
Contact : MR JAMES TOMLIN
Address : 36 JEAYS STREET BOWEN HILLS
QLD AUSTRALIA 4006

Project : 61258
Order number : - Not provided -
C-O-C number : - Not provided -
Site : - Not provided -

E-mail : james.tomlin@ageconsultants.com.au
Telephone : (07)3257-2055
Facsimile : (07)3257-2088

Laboratory : ALS Environmental Brisbane
Contact : Michael Heery
Address : 32 Shand Street Stafford
QLD Australia 4053

Quote number : EN 578 03

E-mail : Michael.Heery@alsenviro.com
Telephone : 61-7-32437222
Facsimile : 61-7-32437259

Page : **1 of 6**
Work order : **EB0504924**

Amendment No. :
Date received : 2 Jun 2005
Date issued : 14 Jun 2005

No. of samples
Received : 4
Analysed : 4

This final report for the ALSE work order reference EB0504924 supersedes any previous reports with this reference.

Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- Laboratory Duplicates (DUP); Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Samples (LCS); Recovery and Acceptance Limits
- Matrix Spikes (MS); Recovery and Acceptance Limits

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NATA Accredited Laboratory - 825

This document is issued in accordance with NATA's accreditation requirements.

Accredited for compliance with ISO/IED 17025

This document has been digitally signed by those names that appear on this report and are the authorised signatories. Digital signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	**Department**
Kim McCabe	Inorganics - NATA 818 (Brisbane)

Quality Control Report - Laboratory Duplicates (DUP)

The quality control term **Laboratory Duplicate** refers to an intralaboratory split sample randomly selected from the sample batch. Laboratory duplicates provide information on method precision and sample heterogeneity.
- Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. *Abbreviations: **LOR** = Limit of Reporting, **RPD** = Relative Percent Difference.*
* Indicates failed QC. The permitted ranges for the RPD of Laboratory Duplicates (relative percent deviation) are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting:- Result < 10 times LOR, no limit - Result between 10 and 20 times LOR, 0% - 50% - Result > 20 times LOR, 0% - 20%

Matrix Type: WATER ***Laboratory Duplicates (DUP) Report***

Laboratory Sample ID	*Client Sample ID*	*Analyte name*	*LOR*	*Original Result*	*Duplicate Result*	*RPD*
EA005P: pH by PC Titrator						
EA005P: pH by PC Titrator - (QC Lot: 78674)				**pH Unit**	**pH Unit**	**%**
EB0504924-001	SW1	pH Value	0.01 pH Unit	8.38	8.34	0.5
EA010P: Conductivity by PC Titrator						
EA010P: Conductivity by PC Titrator - (QC Lot: 78675)				**µS/cm**	**µS/cm**	**%**
EB0504924-001	SW1	Electrical Conductivity @ 25°C	1 µS/cm	328	316	3.7
EA015: Total Dissolved Solids						
EA015: Total Dissolved Solids - (QC Lot: 78818)				**mg/L**	**mg/L**	**%**
EB0504892-001	Anonymous	Total Dissolved Solids @180°C	1 mg/L	820	800	2.5
EB0504892-013	Anonymous	Total Dissolved Solids @180°C	1 mg/L	2730	2710	0.6
EA015: Total Dissolved Solids - (QC Lot: 78819)				**mg/L**	**mg/L**	**%**
EB0504924-004	BPIT	Total Dissolved Solids @180°C	1 mg/L	8800	8810	0.1
ED037P: Alkalinity by PC Titrator						
ED037P: Alkalinity by PC Titrator - (QC Lot: 78673)				**mg/L**	**mg/L**	**%**
EB0504924-001	SW1	Hydroxide Alkalinity as CaCO3	1 mg/L	<1	<1	0.0
		Carbonate Alkalinity as CaCO3	1 mg/L	5	4	0.0
		Bicarbonate Alkalinity as CaCO3	1 mg/L	127	128	1.0
		Total Alkalinity as CaCO3	1 mg/L	132	132	0.0
ED040F: Dissolved Major Anions						
ED040F: Dissolved Major Anions - (QC Lot: 78652)				**mg/L**	**mg/L**	**%**
EB0504892-014	Anonymous	Sulphate as SO4 2-	1 mg/L	1900	1920	0.5
		Silica	0.1 mg/L	24.4	24.5	0.5
EB0504905-005	Anonymous	Sulphate as SO4 2-	1 mg/L	18	18	0.0
		Silica	0.1 mg/L	0.4	0.4	0.0
ED045P: Chloride by PC Titrator						
ED045P: Chloride by PC Titrator - (QC Lot: 78798)				**mg/L**	**mg/L**	**%**
EB0504892-001	Anonymous	Chloride	1 mg/L	59	59	0.0
EB0504892-012	Anonymous	Chloride	1 mg/L	119	120	0.8
ED045P: Chloride by PC Titrator - (QC Lot: 78799)				**mg/L**	**mg/L**	**%**

Matrix Type: WATER

Laboratory Duplicates (DUP) Report

Laboratory Sample ID	Client Sample ID	Analyte name	LOR	Original Result	Duplicate Result	RPD
ED045P: Chloride by PC Titrator - continued						
ED045P: Chloride by PC Titrator - (QC Lot: 78799) - continued				mg/L	mg/L	%
EB0504924-004	BPIT	Chloride	1 mg/L	4600	4620	0.5
EB0504963-005	Anonymous	Chloride	1 mg/L	7	7	0.0
ED093F: Dissolved Major Cations						
ED093F: Dissolved Major Cations - (QC Lot: 78651)				mg/L	mg/L	%
EB0504892-014	Anonymous	Calcium	1 mg/L	153	157	2.5
		Magnesium	1 mg/L	293	294	0.0
		Sodium	1 mg/L	353	359	1.9
		Potassium	1 mg/L	152	150	1.1
EB0504905-005	Anonymous	Calcium	1 mg/L	<1	<1	0.0
		Magnesium	1 mg/L	1	1	0.0
		Sodium	1 mg/L	2	2	0.0
		Potassium	1 mg/L	<1	<1	0.0
EG005F: Dissolved Metals by ICP-AES						
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 78644)				mg/L	mg/L	%
EB0504924-001	SW1	Iron	0.05 mg/L	<0.05	<0.05	0.0
EG020F: Dissolved Metals by ICP-MS						
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 78659)				mg/L	mg/L	%
EB0504892-008	Anonymous	Manganese	0.001 mg/L	0.004	0.005	0.0
EB0504892-017	Anonymous	Manganese	0.001 mg/L	<0.001	<0.001	0.0
EK057: Nitrite as N						
EK057: Nitrite as N - (QC Lot: 79201)				mg/L	mg/L	%
EB0504892-003	Anonymous	Nitrite as N	0.010 mg/L	<0.010	<0.010	0.0
EB0504892-013	Anonymous	Nitrite as N	0.010 mg/L	<0.010	<0.010	0.0
EK059: Nitrite plus Nitrate as N (NOx)						
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 79202)				mg/L	mg/L	%
EB0504892-003	Anonymous	Nitrite + Nitrate as N	0.010 mg/L	0.061	0.064	3.9
EB0504892-013	Anonymous	Nitrite + Nitrate as N	0.010 mg/L	0.019	0.020	0.0
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 79204)				mg/L	mg/L	%
EB0504924-003	EC23	Nitrite + Nitrate as N	0.010 mg/L	0.074	0.078	5.2
EB0504947-008	Anonymous	Nitrite + Nitrate as N	0.010 mg/L	0.018	0.034	60.6

Quality Control Report - Method Blank (MB) and Laboratory Control Samples (LCS)

The quality control term **Method / Laboratory Blank** refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC type is to monitor potential laboratory contamination. The quality control term **Laboratory Control Sample (LCS)** refers to a known, interference free matrix spiked with target analytes or certified reference material. The purpose of this QC type is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of actual laboratory data. Abbreviations: LOR = Limit of reporting.

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

		Method blank result	*Actual Results*		*Recovery Limits*	
			Spike concentration	*Spike Recovery*	*Dynamic Recovery Limits*	
Analyte name	*LOR*			*LCS*	*Low*	*High*
EA005P: pH by PC Titrator						
EA005P: pH by PC Titrator - (QC Lot: 78674)		pH Unit	pH Unit	%	%	%
pH Value	0.01 pH Unit	----	7	101	70	130
	0.01 pH Unit	----	4	102	70	130
EA010P: Conductivity by PC Titrator						
EA010P: Conductivity by PC Titrator - (QC Lot: 78675)		µS/cm	µS/cm	%	%	%
Electrical Conductivity @ 25°C	1 µS/cm	<1	----	----	----	----
	1 µS/cm	----	4000	100	70	130
EA015: Total Dissolved Solids						
EA015: Total Dissolved Solids - (QC Lot: 78818)		mg/L	mg/L	%	%	%
Total Dissolved Solids @180°C	1 mg/L	<1	----	----	----	----
	1 mg/L	----	2000	97.8	70	130
EA015: Total Dissolved Solids - (QC Lot: 78819)		mg/L	mg/L	%	%	%
Total Dissolved Solids @180°C	1 mg/L	<1	----	----	----	----
	1 mg/L	----	2000	100	70	130
ED037P: Alkalinity by PC Titrator						
ED037P: Alkalinity by PC Titrator - (QC Lot: 78673)		mg/L	mg/L	%	%	%
Total Alkalinity as CaCO3	1 mg/L	----	200	98.2	70	130
ED040F: Dissolved Major Anions						
ED040F: Dissolved Major Anions - (QC Lot: 78652)		mg/L	mg/L	%	%	%
Silica	0.1 mg/L	<0.1	0.1	----	----	----
Sulphate as SO4 2-	1 mg/L	<1	1	----	----	----
ED045P: Chloride by PC Titrator						
ED045P: Chloride by PC Titrator - (QC Lot: 78798)		mg/L	mg/L	%	%	%
Chloride	1 mg/L	<1	----	----	----	----
	1 mg/L	----	1000	103	70	130

Matrix Type: WATER

Method Blank (MB) and Laboratory Control Samples (LCS) Report

		Method blank result	Actual Results		Recovery Limits	
			Spike concentration	Spike Recovery	Dynamic Recovery Limits	
Analyte name	*LOR*			*LCS*	*Low*	*High*
ED045P: Chloride by PC Titrator - continued						
ED045P: Chloride by PC Titrator - (QC Lot: 78799)		mg/L	mg/L	%	%	%
Chloride	1 mg/L	<1	----	----	----	----
	1 mg/L	----	1000	108	70	130
ED093F: Dissolved Major Cations						
ED093F: Dissolved Major Cations - (QC Lot: 78651)		mg/L	mg/L	%	%	%
Calcium	1 mg/L	<1	----	----	----	----
Magnesium	1 mg/L	<1	----	----	----	----
Potassium	1 mg/L	<1	----	----	----	----
Sodium	1 mg/L	<1	----	----	----	----
EG005F: Dissolved Metals by ICP-AES						
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 78644)		mg/L	mg/L	%	%	%
Iron	0.05 mg/L	<0.05	----	----	----	----
EG020F: Dissolved Metals by ICP-MS						
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 78659)		mg/L	mg/L	%	%	%
Manganese	0.001 mg/L	<0.001	----	----	----	----
	0.001 mg/L	----	0.100	83.8	70	130
EK057: Nitrite as N						
EK057: Nitrite as N - (QC Lot: 79201)		mg/L	mg/L	%	%	%
Nitrite as N	0.01 mg/L	----	0.5	108	70	130
	0.010 mg/L	<0.010	----	----	----	----
EK059: Nitrite plus Nitrate as N (NOx)						
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 79202)		mg/L	mg/L	%	%	%
Nitrite + Nitrate as N	0.01 mg/L	----	0.5	107	70	130
	0.010 mg/L	<0.010	----	----	----	----
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 79204)		mg/L	mg/L	%	%	%
Nitrite + Nitrate as N	0.010 mg/L	<0.010	----	----	----	----
	0.01 mg/L	----	0.5	110	70	130

Quality Control Report - Matrix Spikes (MS)

The quality control term **Matrix Spike (MS)** refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC type is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQO's). 'Ideal' recovery ranges stated may be waived in the event of sample matrix interferences. - Anonymous - Client Sample IDs refer to samples which are not specifically part of this work order but formed part of the QC process lot. *Abbreviations:* ***LOR*** *= Limit of Reporting,* ***RPD*** *= Relative Percent Difference.*

* Indicates failed QC

Matrix Type: WATER ***Matrix Spike (MS) Report***

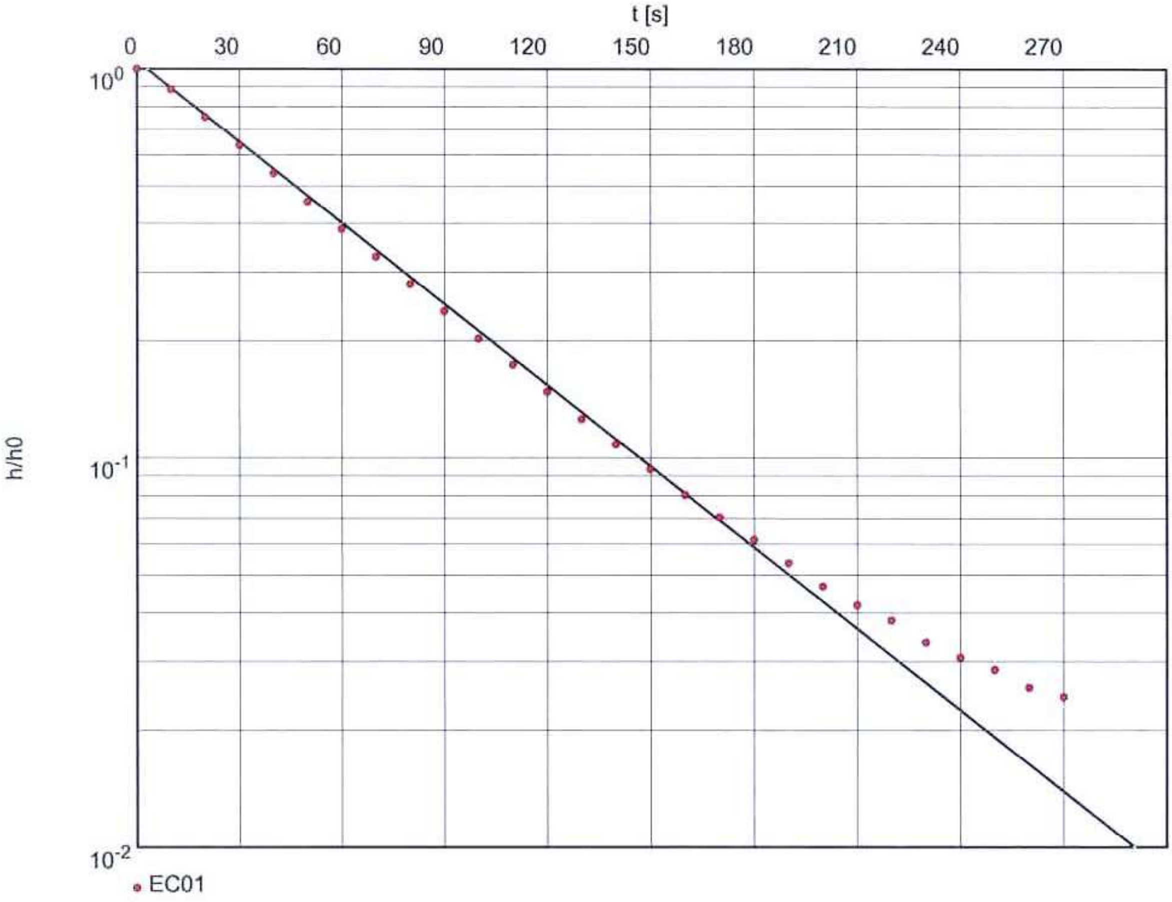
					Actual Results		*Recovery Limits*	
					Sample Result	*Spike Recovery*	*Static Limits*	
Analyte name	*Laboratory Sample ID*	*Client Sample ID*	*LOR*	*Spike Concentration*		*MS*	*Low*	*High*
ED045P: Chloride by PC Titrator								
ED045P: Chloride by PC Titrator - (QC Lot: 78798)				mg/L	mg/L	%	%	%
Chloride	EB0504892-003	Anonymous	1 mg/L	40	74	100	70	130
ED045P: Chloride by PC Titrator - (QC Lot: 78799)				mg/L	mg/L	%	%	%
Chloride	EB0504958-007	Anonymous	1 mg/L	57	243	* Not Determined	70	130
EG005F: Dissolved Metals by ICP-AES								
EG005F: Dissolved Metals by ICP-AES - (QC Lot: 78644)				mg/L	mg/L	%	%	%
Iron	EB0504924-002	EC21	0.05 mg/L	1.00	<0.05	92.8	70	130
EG020F: Dissolved Metals by ICP-MS								
EG020F: Dissolved Metals by ICP-MS - (QC Lot: 78659)				mg/L	mg/L	%	%	%
Manganese	EB0504892-009	Anonymous	0.001 mg/L	0.100	0.346	129	70	130
EK057: Nitrite as N								
EK057: Nitrite as N - (QC Lot: 79201)				mg/L	mg/L	%	%	%
Nitrite as N	EB0504924-002	EC21	0.01 mg/L	0.4	<0.010	90.2	70	130
EK059: Nitrite plus Nitrate as N (NOx)								
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 79202)				mg/L	mg/L	%	%	%
Nitrite + Nitrate as N	EB0504892-001	Anonymous	0.01 mg/L	0.4	0.017	110	70	130
EK059: Nitrite plus Nitrate as N (NOx) - (QC Lot: 79204)				mg/L	mg/L	%	%	%
Nitrite + Nitrate as N	EB0504924-002	EC21	0.01 mg/L	0.4	0.016	105	70	130

Appendix 4

FALLING HEAD PERMEABILITY TEST ANALYSES

AGE Consultants 36 Jeays St BOWEN HILLS QLD 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 30.11.2004	Page 1
		Project: Ensham Central	
		Evaluated by: JST	

Slug Test No. 1	Test conducted on: 25 Nov 04
EC01	



Hydraulic conductivity [m/s]: 6.86 x 10^{-6}

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BOWEN HILLS QLD 4006
AUSTRALIA

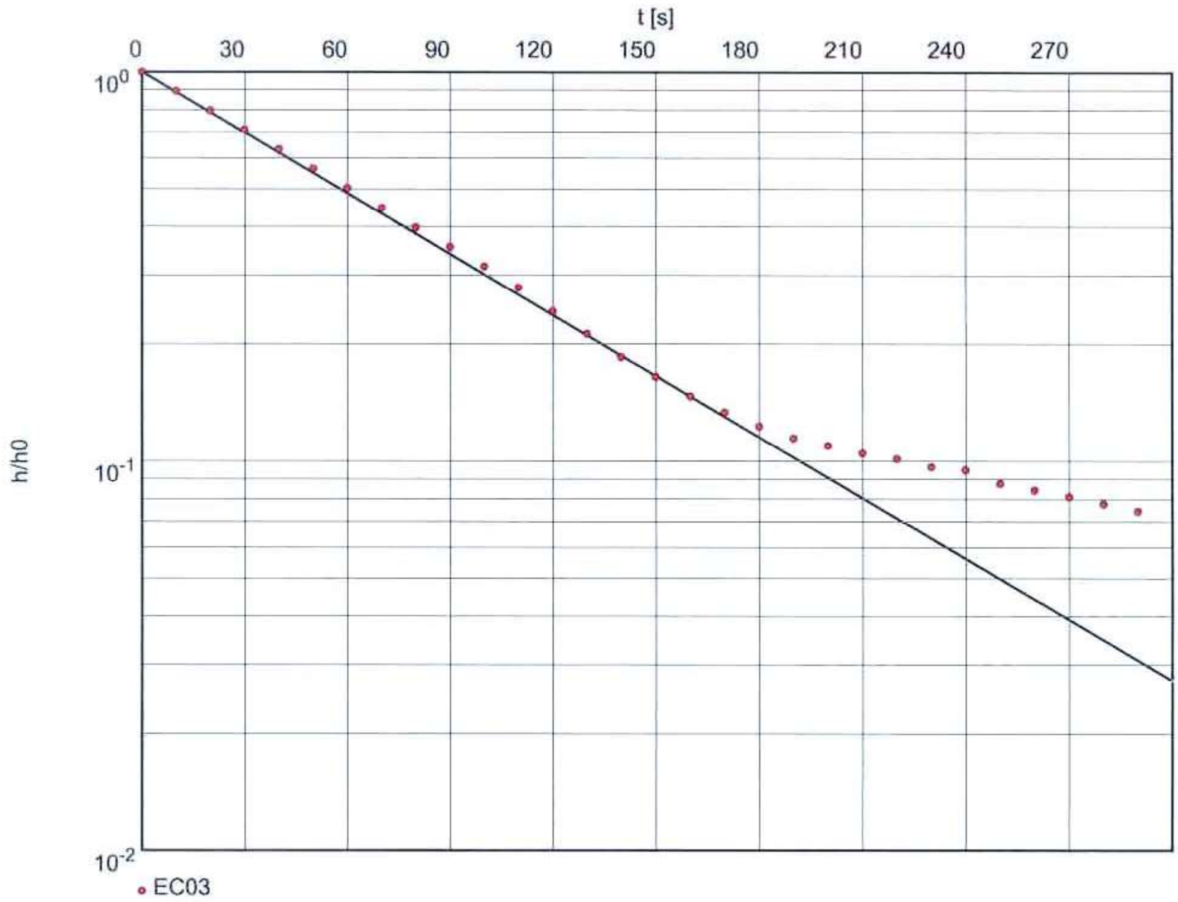
slug/bail test analysis
HVORSLEV's method

Date: 30.11.2004 | Page 2
Project: Ensham Central
Evaluated by: JST

Slug Test No. 1

Test conducted on: 25 Nov 04

EC03



Hydraulic conductivity [m/s]: 5.14×10^{-6}

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BOWEN HILLS QLD 4006
AUSTRALIA

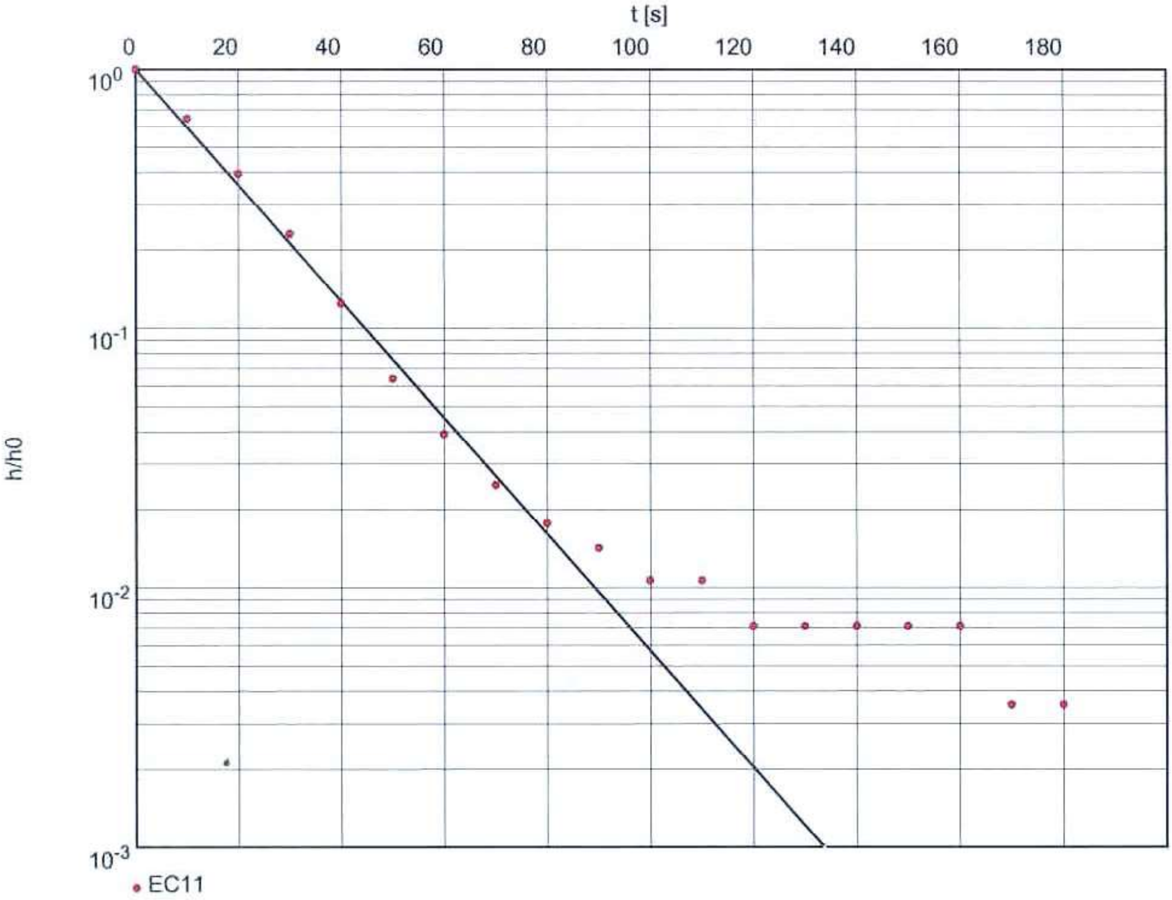
slug/bail test analysis
HVORSLEV's method

Date: 30.11.2004
Page 3
Project: Ensham Central
Evaluated by: JST

Slug Test No. 1

Test conducted on: 25 Nov 04

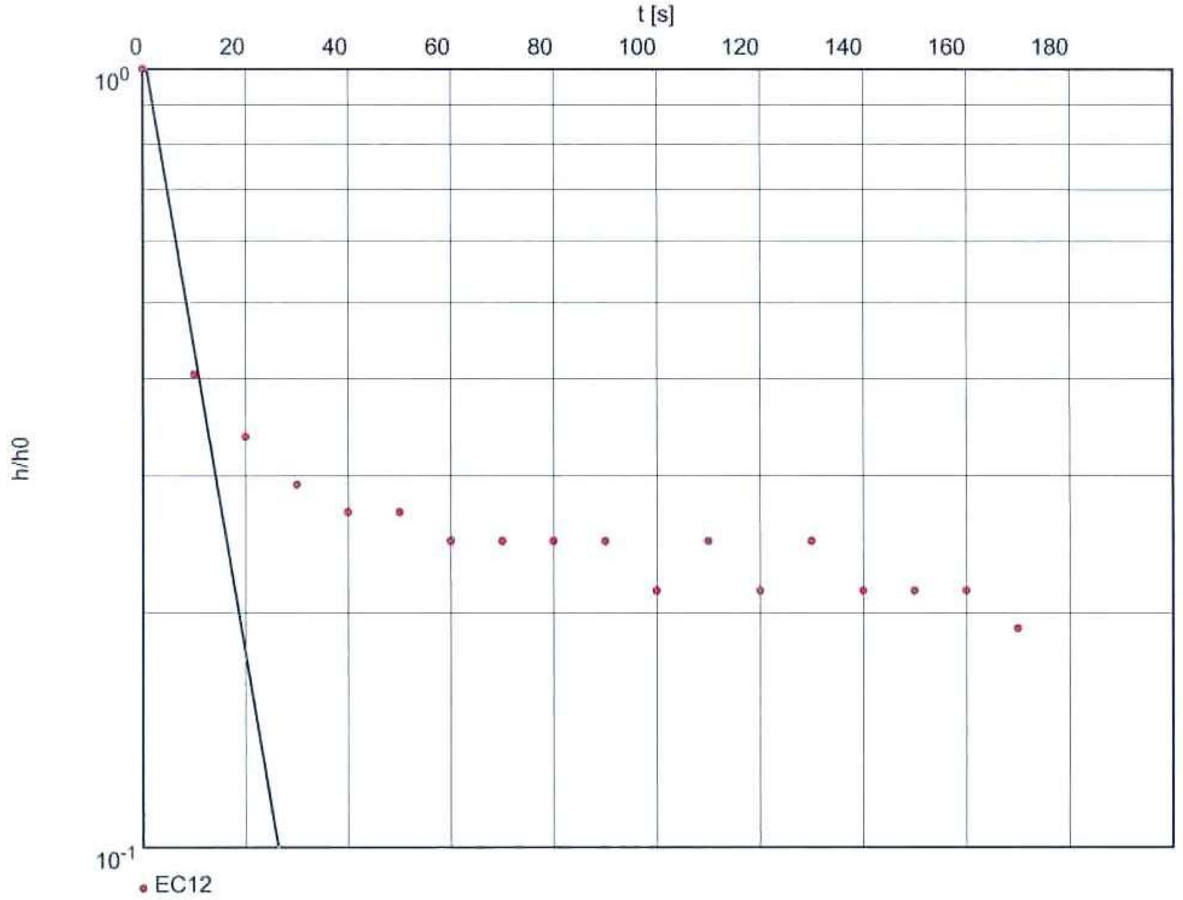
EC11



Hydraulic conductivity [m/s]: 2.21×10^{-5}

AGE Consultants 36 Jeays St BOWEN HILLS QLD 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 30.11.2004	Page 4
		Project: Ensham Central	
		Evaluated by: JST	

Slug Test No. 1	Test conducted on: 25 Nov 04
EC12	



Hydraulic conductivity [m/s]: 3.85×10^{-5}

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AUSTRALIA

slug/bail test analysis
HVORSLEV's method

Date: 30.11.2004 Page 5

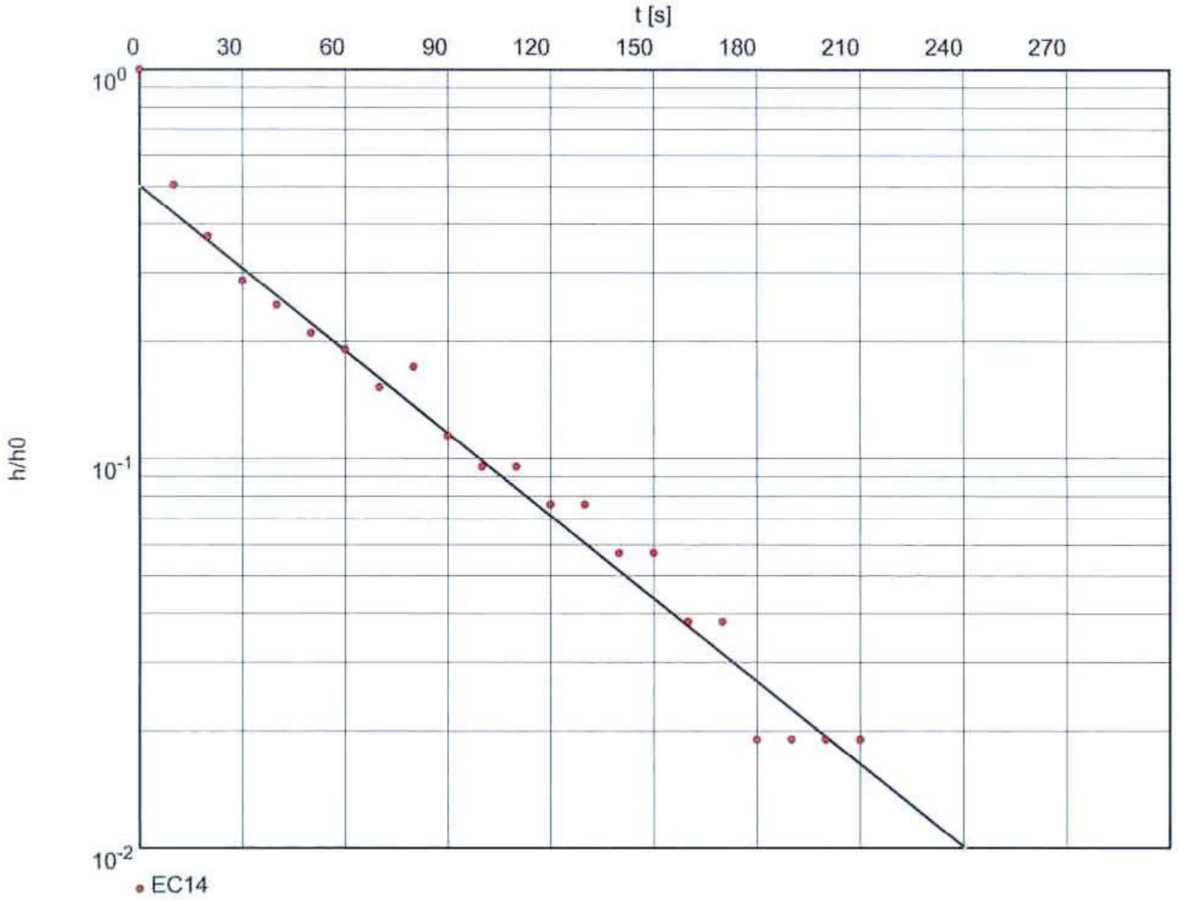
Project: Ensham Central

Evaluated by: JST

Slug Test No. 1

Test conducted on: 25 Nov 04

EC14



Hydraulic conductivity [m/s]: 6.97 x 10^{-6}

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AUSTRALIA

slug/bail test analysis
HVORSLEV's method

Date: 30.11.2004 | Page 6

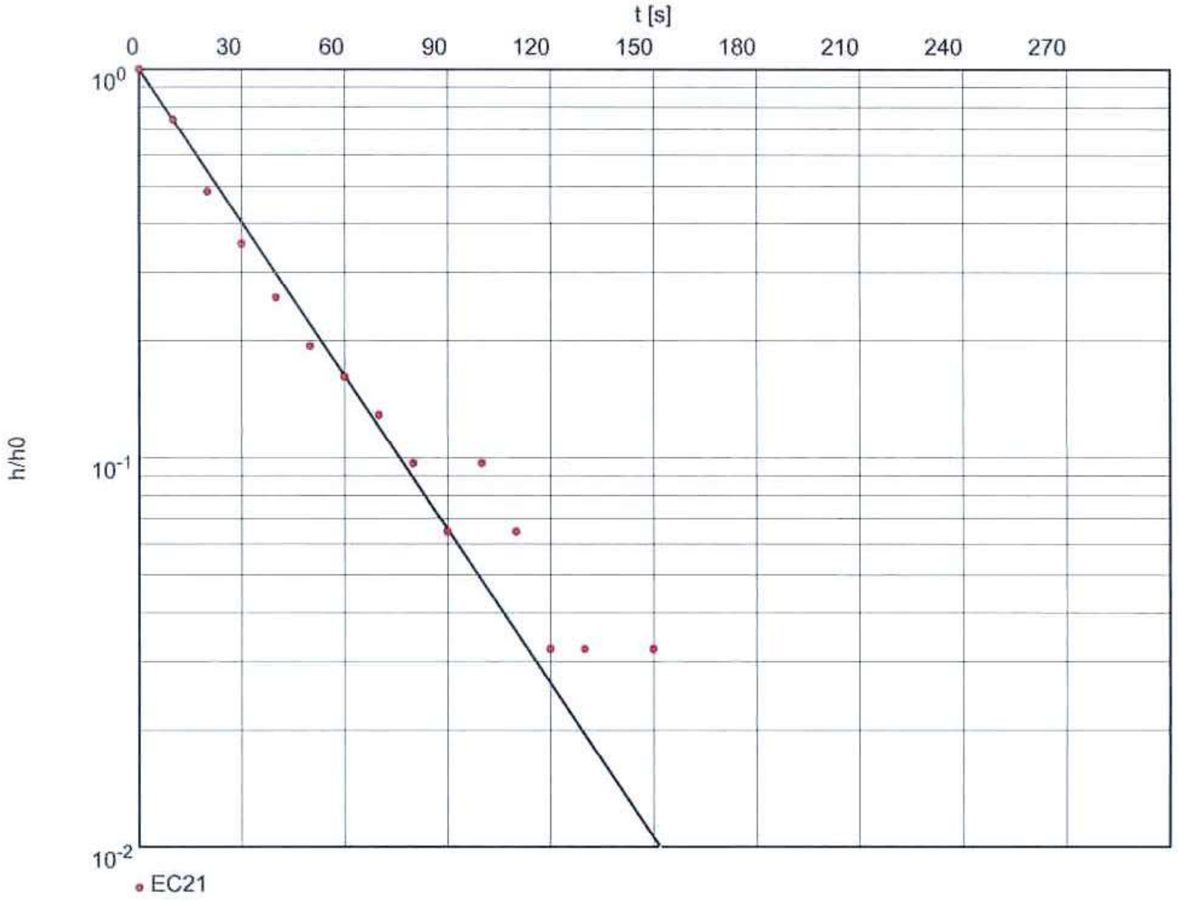
Project: Ensham Central

Evaluated by: JST

Slug Test No. 1

Test conducted on: 25 Nov 04

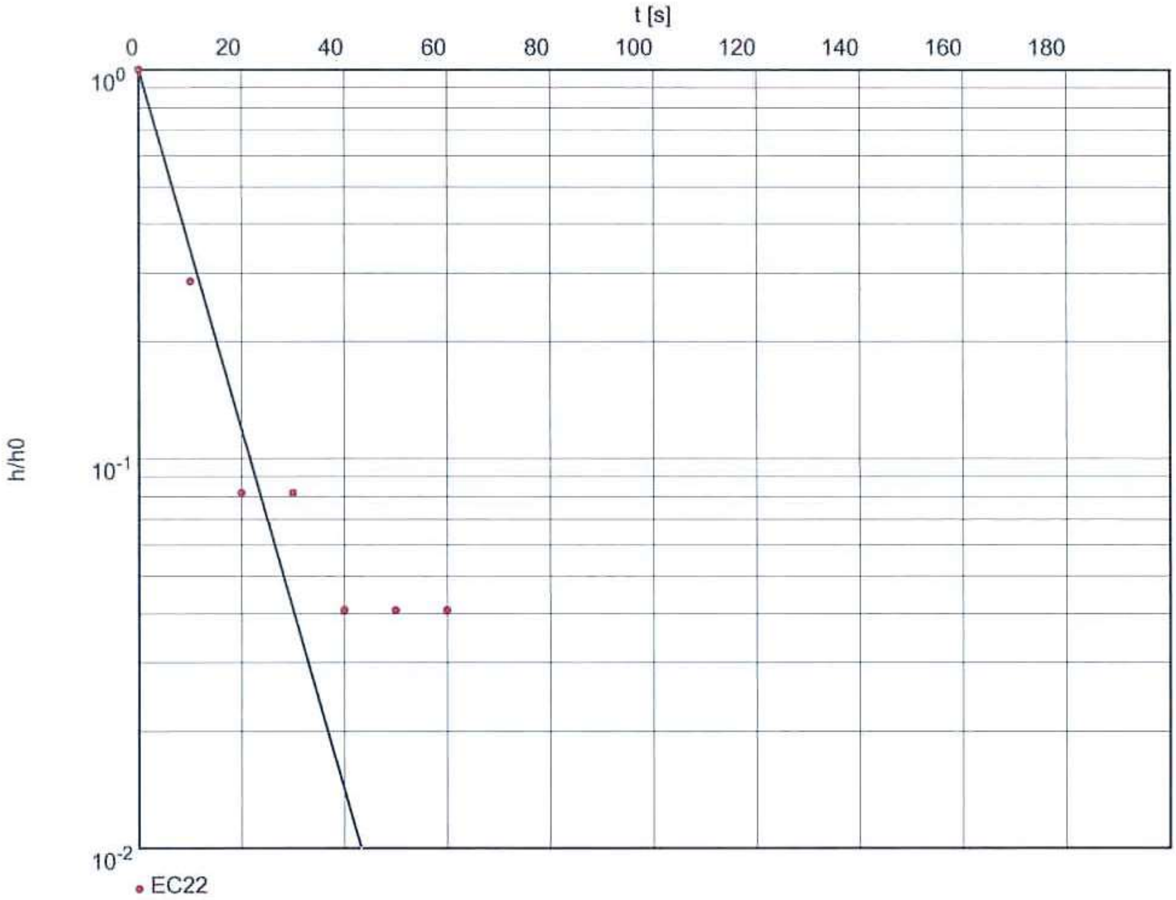
EC21



Hydraulic conductivity [m/s]: 1.29×10^{-5}

AGE Consultants 36 Jeays St BOWEN HILLS QLD 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 30.11.2004	Page 7
		Project: Ensham Central	
		Evaluated by: JST	

Slug Test No. 1	Test conducted on: 25 Nov 04
EC22	

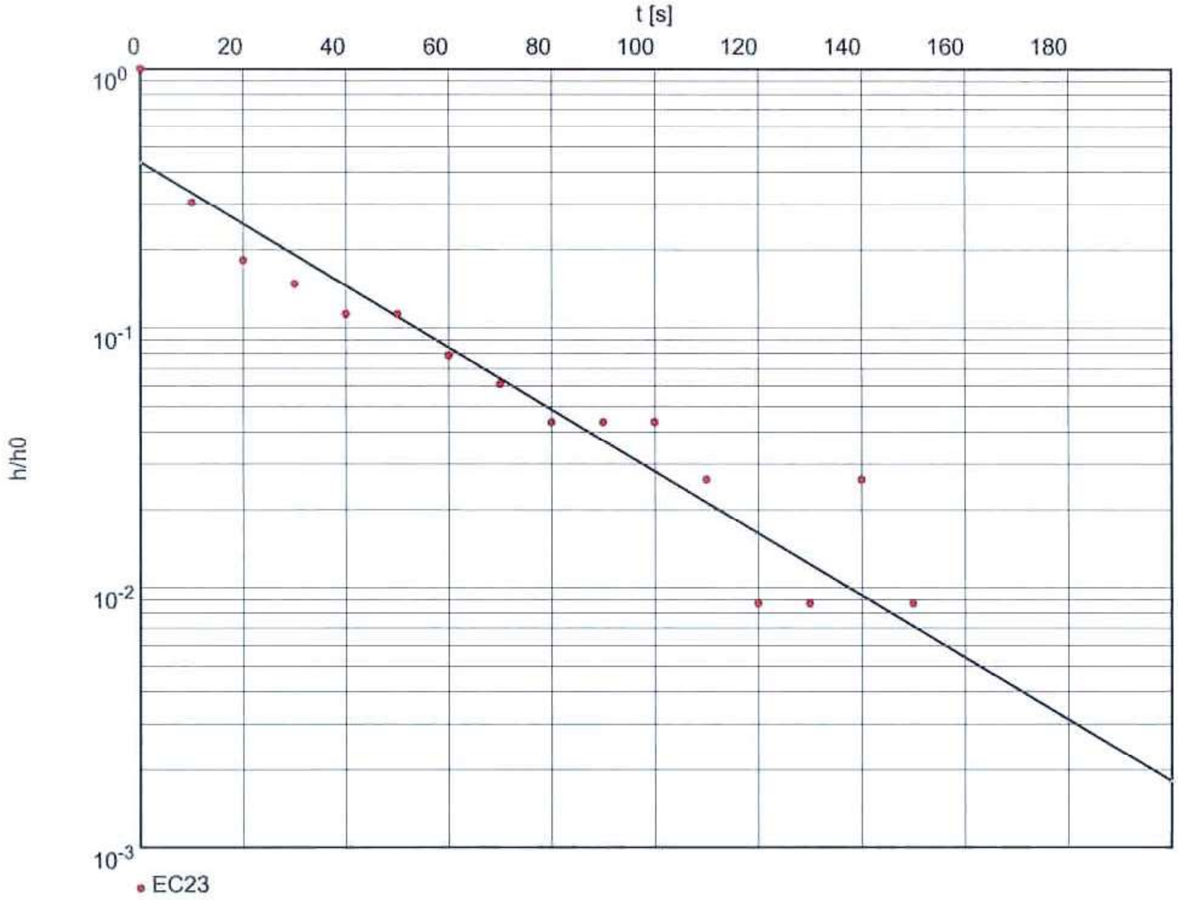


Hydraulic conductivity [m/s]: 4.56 x 10^{-5}

Slug Test No. 1

Test conducted on: 25 Nov 04

EC23



Hydraulic conductivity [m/s]: 1.17×10^{-5}

Appendix 5

TEST PIT LOGS

Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

TESTPIT LOG

TESTPIT ID: R1

Page 1 of 1

PROJECT NO.	**G1258**	OPERATOR:	**Brownie**	DATUM:	**ADG84**
PROJECT NAME:	**Ensham Central**	METHOD:	**Toothless bucket**	GROUND LEVEL:	**-**
DATE:	**3 March 2005**	MACHINE:	**30T Excavator**	TOP OF CASING LEVEL:	**-**
CONTRACTOR:	**Grahams Contractors**	COORDINATES:	**654177mE, 7400981mN**	LOGGED BY:	**JST**

Elevation Depth	Graphic	Lithologic Description	SWL	Sample Depth and ID	Sample Analysis
0 — 0	░	SAND: light brown, poorly graded, no fines, loose	▽	Sample ID R1 (0.1m)	Grain size analysis
	▦	CLAYEY SAND & GRAVEL: grey, poorly graded in silty/clayey matrix		Sample ID R1 (0.3m)	Grain size analysis
				Sample ID R1 (0.6m)	Grain size analysis
1 — -1					
2 — -2					

Australasian Groundwater & Environmental Consultants Pty Ltd

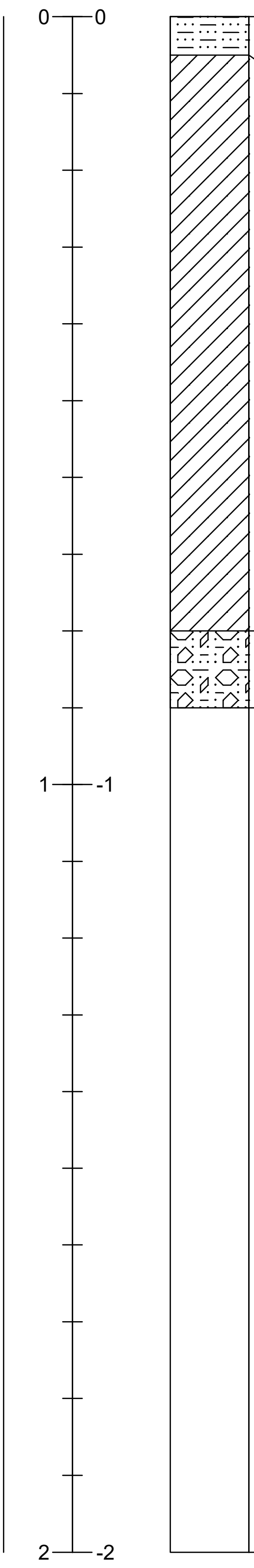
36 Jeays St, Bowen Hills, Queensland 4006

TESTPIT LOG

TESTPIT ID: R2

Page 1 of 1

PROJECT NO.	**G1258**	OPERATOR:	**Brownie**	DATUM:	**ADG84**
PROJECT NAME:	**Ensham Central**	METHOD:	**Toothless bucket**	GROUND LEVEL:	**-**
DATE:	**3 March 2005**	MACHINE:	**30T Excavator**	TOP OF CASING LEVEL:	**-**
CONTRACTOR:	**Grahams Contractors**	COORDINATES:	**651548mE, 7400422mN**	LOGGED BY:	**JST**



Lithologic Description	SWL	Sample Depth and ID	Sample Analysis
MUD: brown, extremely soft and wet	▽	Sample ID R2 (0.01m)	held - not tested
CLAY: black/grey, very heavy and plastic, some tree roots			
		Sample ID R2 (0.2m)	Grain size analysis
SAND & GRAVEL: grey, poorly graded, moist			

Australasian Groundwater & Environmental Consultants Pty Ltd

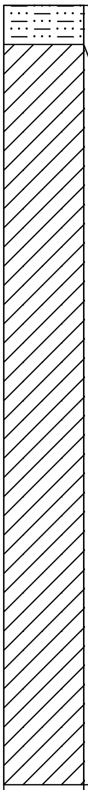
36 Jeays St, Bowen Hills, Queensland 4006

TESTPIT LOG

TESTPIT ID: R3

Page 1 of 1

PROJECT NO.	**G1258**	OPERATOR:	**Brownie**	DATUM:	**ADG84**
PROJECT NAME:	**Ensham Central**	METHOD:	**Toothless bucket**	GROUND LEVEL:	**-**
DATE:	**3 March 2005**	MACHINE:	**30T Excavator**	TOP OF CASING LEVEL:	**-**
CONTRACTOR:	**Grahams Contractors**	COORDINATES:	**650548mE, 7401873mN**	LOGGED BY:	**JST**



Depth	Elevation	Graphic	Lithologic Description	SWL	Sample Depth and ID	Sample Analysis
0	0		MUD: brown, extremely soft and wet, with abundant freshwater mussels	▽		
			CLAY: black/grey mottled, very heavy, plastic, firm			
					Sample ID R3 (0.3m)	Grain size analysis
1	-1					
2	-2					

Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

TESTPIT LOG

TESTPIT ID: B1

Page 1 of 1

PROJECT NO.	**G1258**	OPERATOR:	**Brownie**	DATUM:	**ADG84**
PROJECT NAME:	**Ensham Central**	METHOD:	**Toothless bucket**	GROUND LEVEL:	**-**
DATE:	**3 March 2004**	MACHINE:	**30T Excavator**	TOP OF CASING LEVEL:	**-**
CONTRACTOR:	**Grahams Earthmoving**	COORDINATES:	**654175mE, 7400979mN**	LOGGED BY:	**JST**

Depth	Elevation	Graphic	Lithologic Description	SWL	Sample Depth and ID	Sample Analysis
0	0		CLAYEY SAND & GRAVEL: grey, poorly graded, well rounded sand/gravel in firm silty/clayey matrix, moist		Sample ID B1 (0.05m)	Grain size analysis
1	-1		CLAYEY SAND: grey, poorly graded, quartzose with some moist clay infill			
			seepage at about 1.7m - electrical conductivity 800uS/cm	▽		
			CLAY: grey, firm, highly plastic, residual mudstone		Sample ID B1 (2.0m)	Not tested - held
2	-2					

Australasian Groundwater & Environmental Consultants Pty Ltd

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TESTPIT LOG

TESTPIT ID: B2

Page 1 of 1

PROJECT NO.	**G1258**	OPERATOR:	**Brownie**	DATUM:	**ADG84**
PROJECT NAME:	**Ensham Central**	METHOD:	**Toothless bucket**	GROUND LEVEL:	**-**
DATE:	**3 March 2005**	MACHINE:	**30T Excavator**	TOP OF CASING LEVEL:	**-**
CONTRACTOR:	**Grahams Contractors**	COORDINATES:	**654172mE, 7400971mN**	LOGGED BY:	**JST**

Depth / Elevation	Graphic	Lithologic Description	SWL	Sample Depth and ID	Sample Analysis
0 / 0	▦	CLAYEY SAND & GRAVEL: poorly graded sand in silty/clayey matrix, slightly moist			
	▦			Sample ID B2 (0.4m)	Held - not tested
1 / -1					
2 / -2					

Appendix 6

GRAIN SIZE ANALYSES

AUSTRALIAN LABORATORY SERVICES PTY LTD ABN 84 009 936 029
32 Shand Street Stafford QLD 4053 Australia
Telephone: 61-7-32437222 Facsimile: 61-7-32437259 http://www.alsenviro.com/

ALS Environmental

SUB-CONTRACT LABORATORY RESULTS COVERSHEET for ALS WORKORDER EB0501943

Client Details

Client : AUST GROUNDWATER & ENVIRO CONSULTANTS
Project : 61258
Order number : - Not provided -
C-O-C Number : - Not provided -
Site : - Not provided -
Sampler : - Not provided -

Comments

- **The attached report contains sub-contracted components of ALS Environmental work order EB0501943. This report has been electronically stored for ALS record purposes and has not been altered in any way.**

FOR LABORATORY USE ONLY

Golder Associates

MANSFIELD
LABORATORY

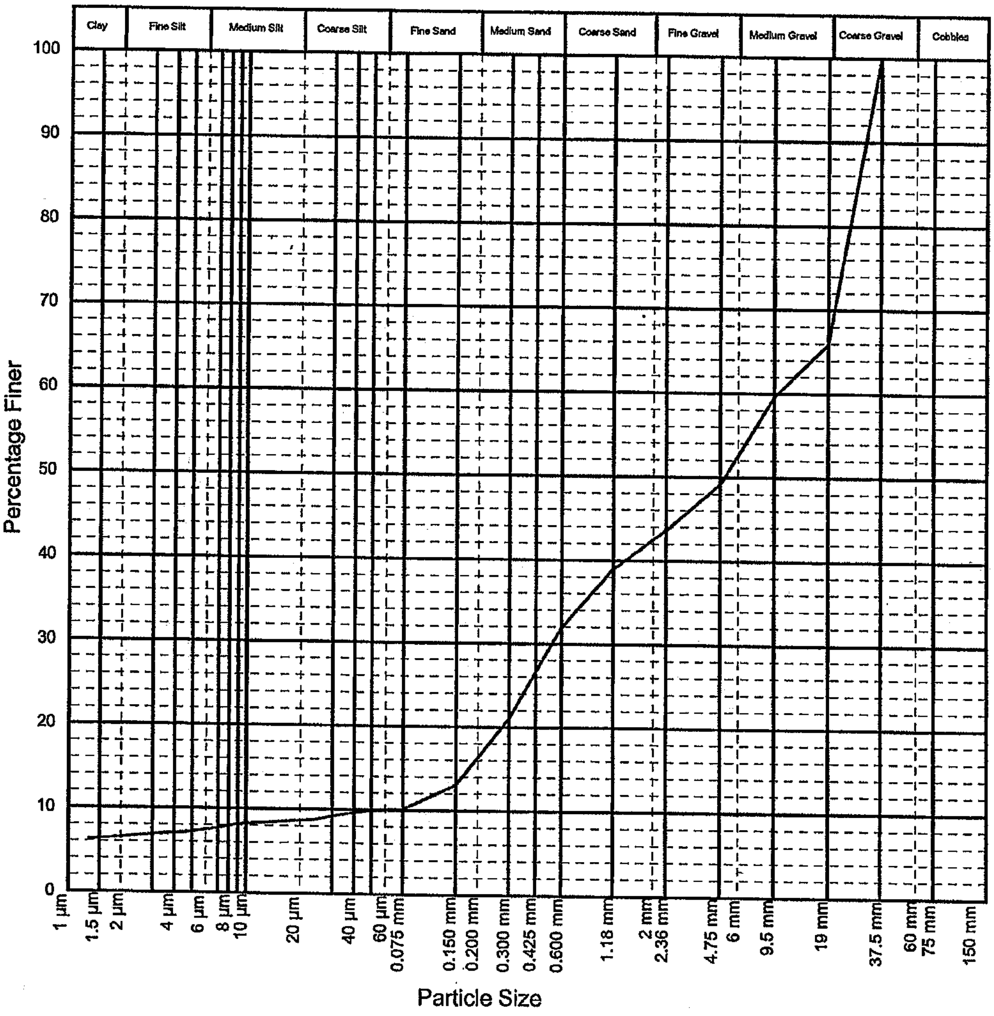
1/51 Secam Street Mansfield Qld 4122
PO Box 2034 Mansfield DC Qld 4122
Ph : (07) 3343 3166 Fax : (07) 3343 4705
www.golder.com.au

PARTICLE SIZE DISTRIBUTION BY HYDROMETER

Client :	ALS Environmental Brisbane	Report No. :	R 5963
Address :	32 Shand Street, Stafford	Job No. :	05634002/1
Project :	Delivered Samples	Reg'n No. :	L1385
Sample ID :	R 1 (0.3)	Batch No. :	EB 0501943 - 1
		Date Received :	07/03/2005
		Sampled By :	Client

Particle Size (mm)	Percent Passing
150	
75	
37.5	100.0
19.0	65.9
9.5	59.5
4.75	49.1
2.36	43.6
1.18	38.9
0.600	31.9
0.425	26.6
0.300	21.0
0.150	13.1
0.075	10.1
Particle Size (Microns)	**Percent Passing**
48.1	9.8
34.2	9.4
24.4	8.8
12.7	8.4
9.0	8.2
6.4	7.5
4.6	7.1
3.2	6.9
1.3	6.2

SIZE FRACTIONS AS PER AUSTRALIAN STANDARDS AS 1726



Pretreatment	Tested as received	Soil Particle Density (assumed)	2.70
Loss in Pretreatment (%)	-	Type of Hydrometer	ASTM E100
Method of Dispersion	Mixer		
Material Description :	Clayey GRAVEL / GRAVEL (GC/GP) grey brown, with some sand		
Test Procedure :	AS 1289 3.6.2, 3.6.3 (up to 24 hours)		
Prepared by : NK		Checked by : JA	

NATA
1446

17/3/05
Authorised Signatory

Golder Associates

MANSFIELD
LABORATORY

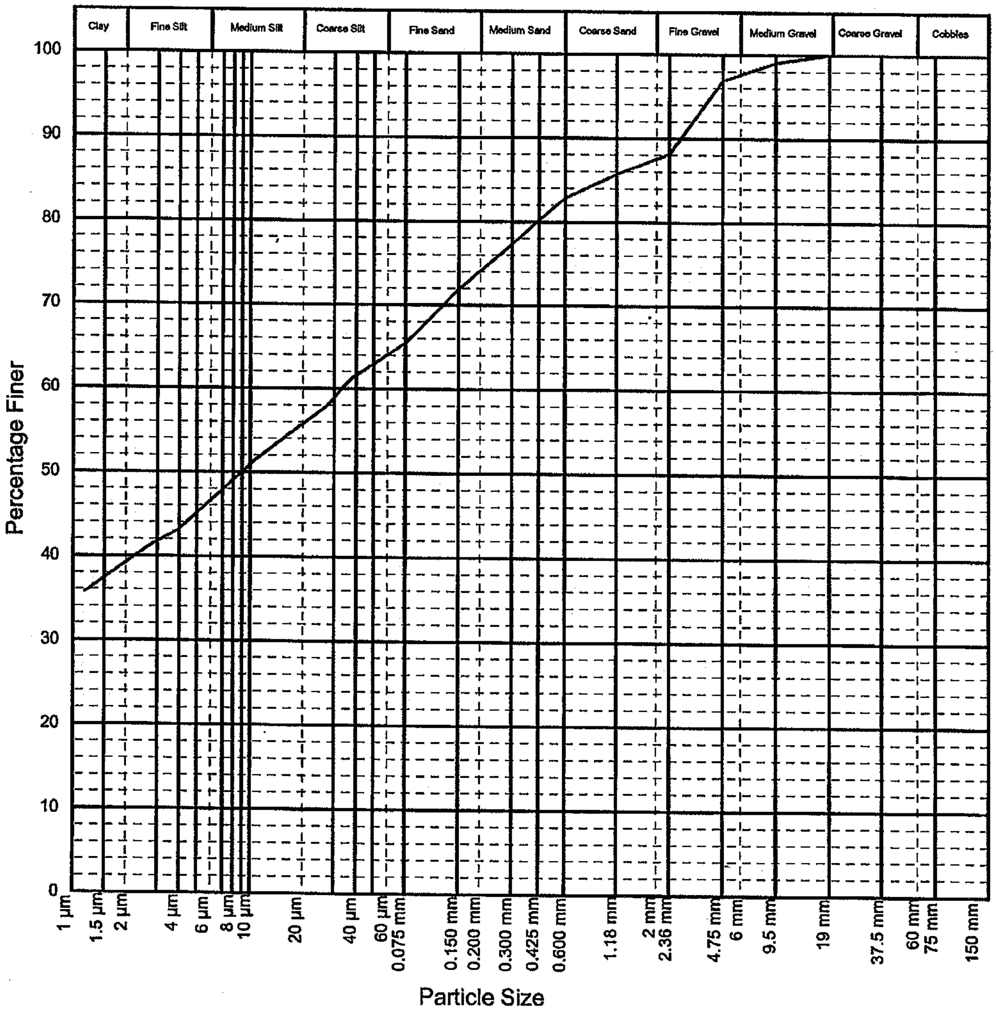
1/51 Secam Street Mansfield Qld 4122
PO Box 2034 Mansfield DC Qld 4122
Ph : (07) 3343 3166 Fax : (07) 3343 4705
www.golder.com.au

PARTICLE SIZE DISTRIBUTION BY HYDROMETER

Client :	ALS Environmental Brisbane	Report No. :	R 5963
Address :	32 Shand Street, Stafford	Job No. :	05634002/1
Project :	Delivered Samples	Reg'n No. :	L1386
Sample ID :	R 2 (0.2)	Batch No. :	EB 0501943 - 2
		Date Received :	07/03/2005
		Sampled By :	Client

Particle Size (mm)	Percent Passing
150	
75	
37.5	
19.0	100.0
9.5	99.0
4.75	96.9
2.36	88.1
1.18	85.7
0.600	82.8
0.425	80.2
0.300	77.3
0.150	71.9
0.075	65.4
Particle Size (Microns)	**Percent Passing**
37.3	61.1
27.1	57.9
19.5	55.7
10.4	51.3
7.5	48.5
5.4	45.8
3.9	43.1
2.8	41.4
1.2	35.7

SIZE FRACTIONS AS PER AUSTRALIAN STANDARDS AS 1726



Pretreatment	Tested as received	Soil Particle Density (assumed)	2.70
Loss in Pretreatment (%)	-	Type of Hydrometer	ASTM E100
Method of Dispersion	Mixer		

Material Description : Sandy CLAY (CI) grey brown, with some gravel

Test Procedure : AS 1289 3.6.2, 3.6.3 (up to 24 hours)

Prepared by : NF | Checked by : JA

NATA 1446

17/3/05

Authorised Signatory

Golder Associates

MANSFIELD
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Ph : (07) 3343 3166 Fax : (07) 3343 4705
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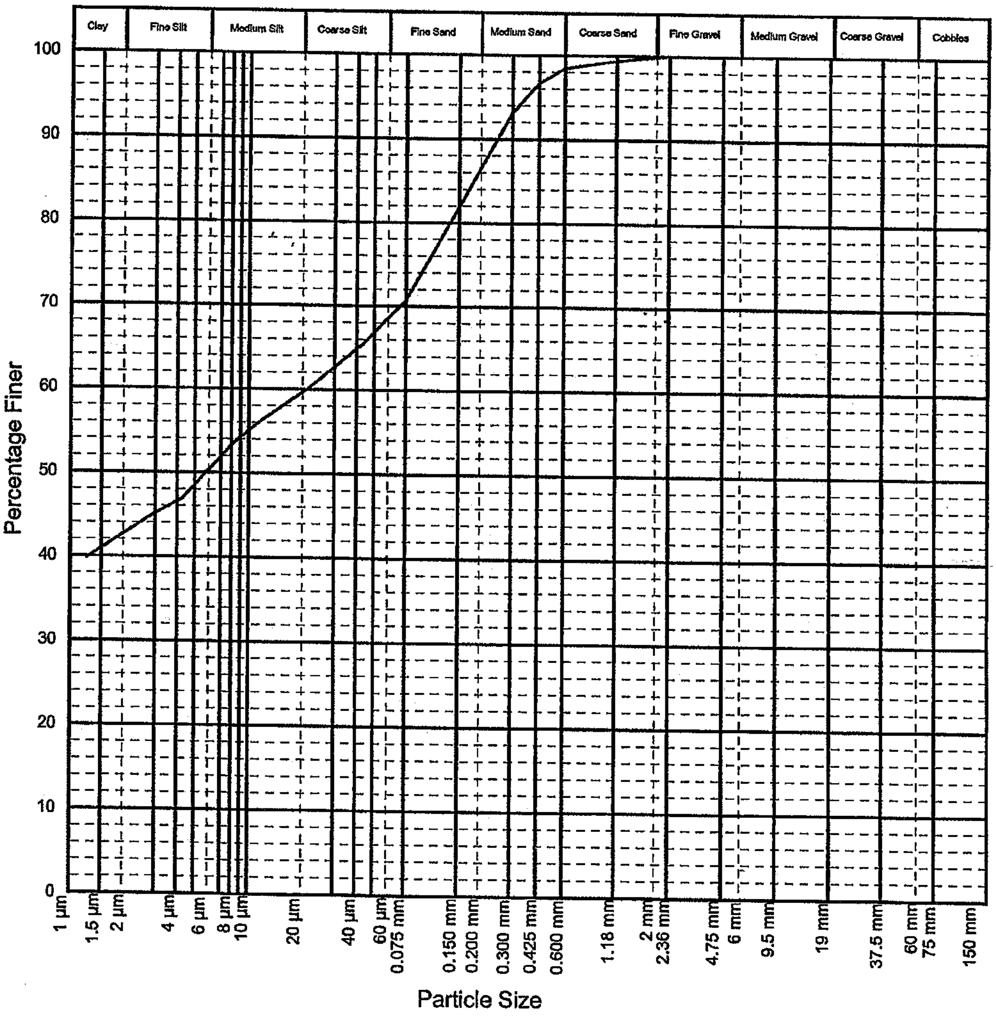
PARTICLE SIZE DISTRIBUTION BY HYDROMETER

Client :	ALS Environmental Brisbane	Report No. :	R 5963
Address :	32 Shand Street, Stafford	Job No. :	05634002/1
Project :	Delivered Samples	Reg'n No. :	L1387
Sample ID :	R 3 (0.2)	Batch No. :	EB 0501943 - 3
		Date Received :	07/03/2005
		Sampled By :	Client

SIZE FRACTIONS AS PER AUSTRALIAN STANDARDS AS 1726

Particle Size (mm)	Percent Passing
150	
75	
37.5	
19.0	
9.5	
4.75	
2.36	100.0
1.18	99.4
0.600	98.5
0.425	96.7
0.300	93.1
0.150	81.8
0.075	70.7
Particle Size (Microns)	**Percent Passing**
43.1	65.4
30.8	62.9
22.1	60.3
11.6	56.1
8.3	53.6
6.0	50.2
4.3	46.9
3.0	45.2
1.2	39.8



Pretreatment	Tested as received	Soil Particle Density (assumed)	2.70
Loss in Pretreatment (%)	-	Type of Hydrometer	ASTM E100
Method of Dispersion	Mixer		

Material Description : Sandy CLAY (CI) grey brown

Test Procedure : AS 1289 3.6.2, 3.6.3 (up to 24 hours)

Prepared by : NF

Checked by : JA

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17/3/05
Authorised Signatory

Golder Associates

MANSFIELD
LABORATORY

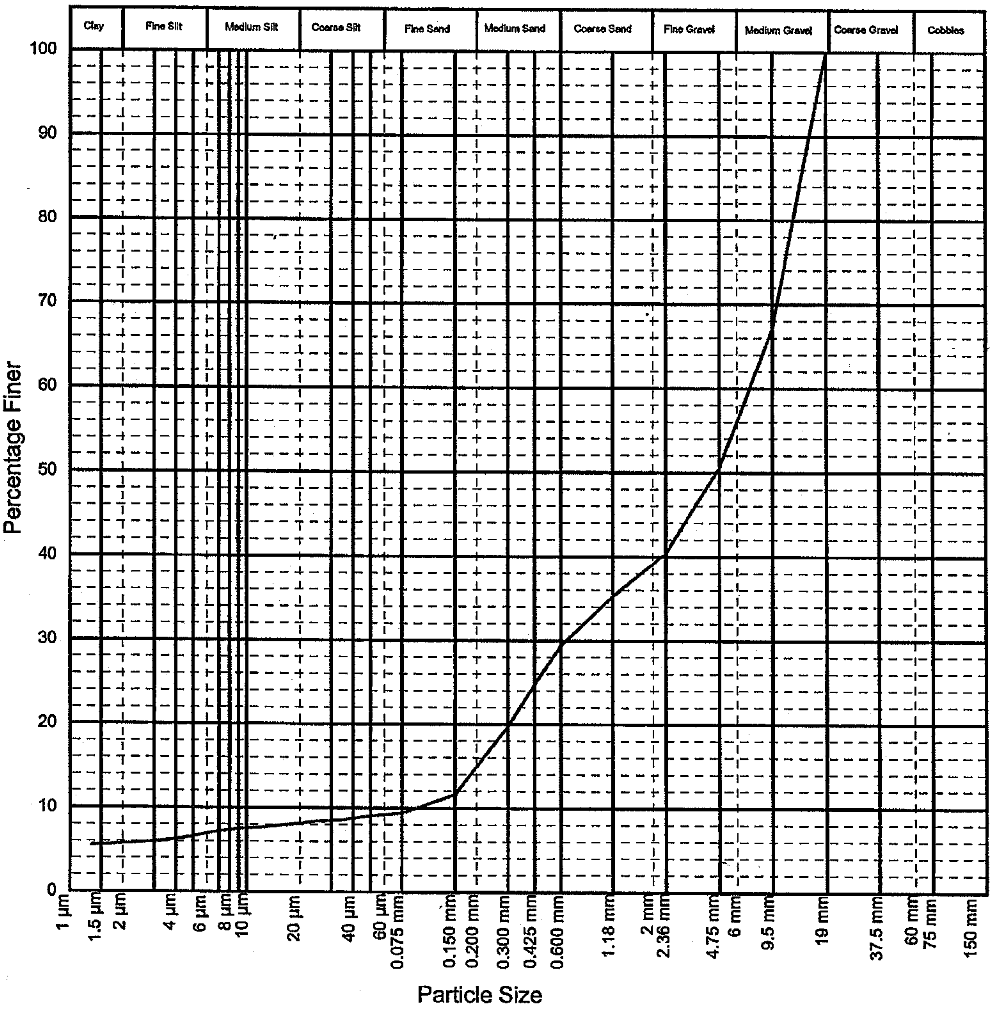
1/51 Secam Street Mansfield Qld 4122
PO Box 2034 Mansfield DC Qld 4122
Ph : (07) 3343 3166 Fax : (07) 3343 4705
www.golder.com.au

PARTICLE SIZE DISTRIBUTION BY HYDROMETER

Client :	ALS Environmental Brisbane	Report No. :	R 5963
Address :	32 Shand Street, Stafford	Job No. :	05634002/1
Project :	Delivered Samples	Reg'n No. :	L1388
Sample ID :	B 1 (0.05)	Batch No. :	EB 0501943 - 4
		Date Received :	07/03/2005
		Sampled By :	Client

Particle Size (mm)	Percent Passing
150	
75	
37.5	
19.0	100.0
9.5	67.0
4.75	50.6
2.36	40.4
1.18	35.3
0.600	29.3
0.425	24.8
0.300	19.7
0.150	11.6
0.075	9.4
Particle Size (Microns)	**Percent Passing**
48.8	9.0
34.7	8.6
24.6	8.4
12.8	7.7
9.1	7.5
6.5	7.1
4.6	6.4
3.3	6.0
1.3	5.5

SIZE FRACTIONS AS PER AUSTRALIAN STANDARDS AS 1726



Pretreatment	Tested as received	Soil Particle Density (assumed)	2.70
Loss in Pretreatment (%)	-	Type of Hydrometer	ASTM E100
Method of Dispersion	Mixer		

Material Description : Clayey GRAVEL / GRAVEL (GC/GP) grey brown, with some sand

Test Procedure : AS 1289 3.6.2, 3.6.3 (up to 24 hours)

Prepared by : NP

Checked by : JA

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Golder Associates

MANSFIELD
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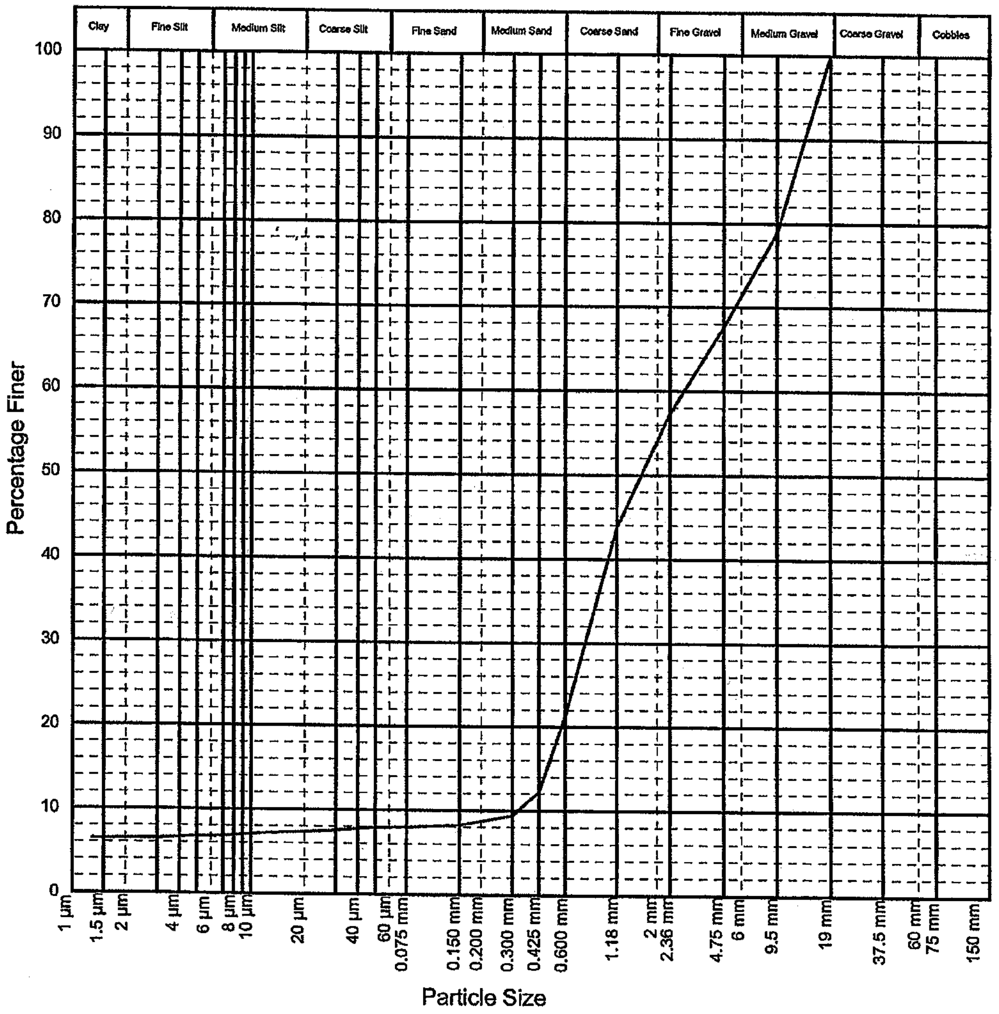
PARTICLE SIZE DISTRIBUTION BY HYDROMETER

Client :	ALS Environmental Brisbane	Report No. :	R 5963
Address :	32 Shand Street, Stafford	Job No. :	05634002/1
Project :	Delivered Samples	Reg'n No. :	L1389
Sample ID :	R 1 (0.6)	Batch No. :	EB 0501943 - 5
		Date Received :	07/03/2005
		Sampled By :	Client

Particle Size (mm)	Percent Passing
150	
75	
37.5	
19.0	100.0
9.5	78.9
4.75	67.6
2.36	57.3
1.18	43.8
0.600	21.1
0.425	12.2
0.300	9.4
0.150	8.3
0.075	8.0
Particle Size (Microns)	**Percent Passing**
49.3	7.9
34.9	7.7
24.8	7.4
12.8	7.2
9.1	7.0
6.5	6.7
4.6	6.7
3.2	6.5
1.3	6.4

SIZE FRACTIONS AS PER AUSTRALIAN STANDARDS AS 1726



Pretreatment	Tested as received	Soil Particle Density (assumed)	2.70
Loss in Pretreatment (%)	-	Type of Hydrometer	ASTM E100
Method of Dispersion	Mixer		

Material Description : Clayey GRAVEL / GRAVEL (GC/GP) grey, with some sand

Test Procedure : AS 1289 3.6.2, 3.6.3 (up to 24 hours)

Prepared by : NK

Checked by : JA

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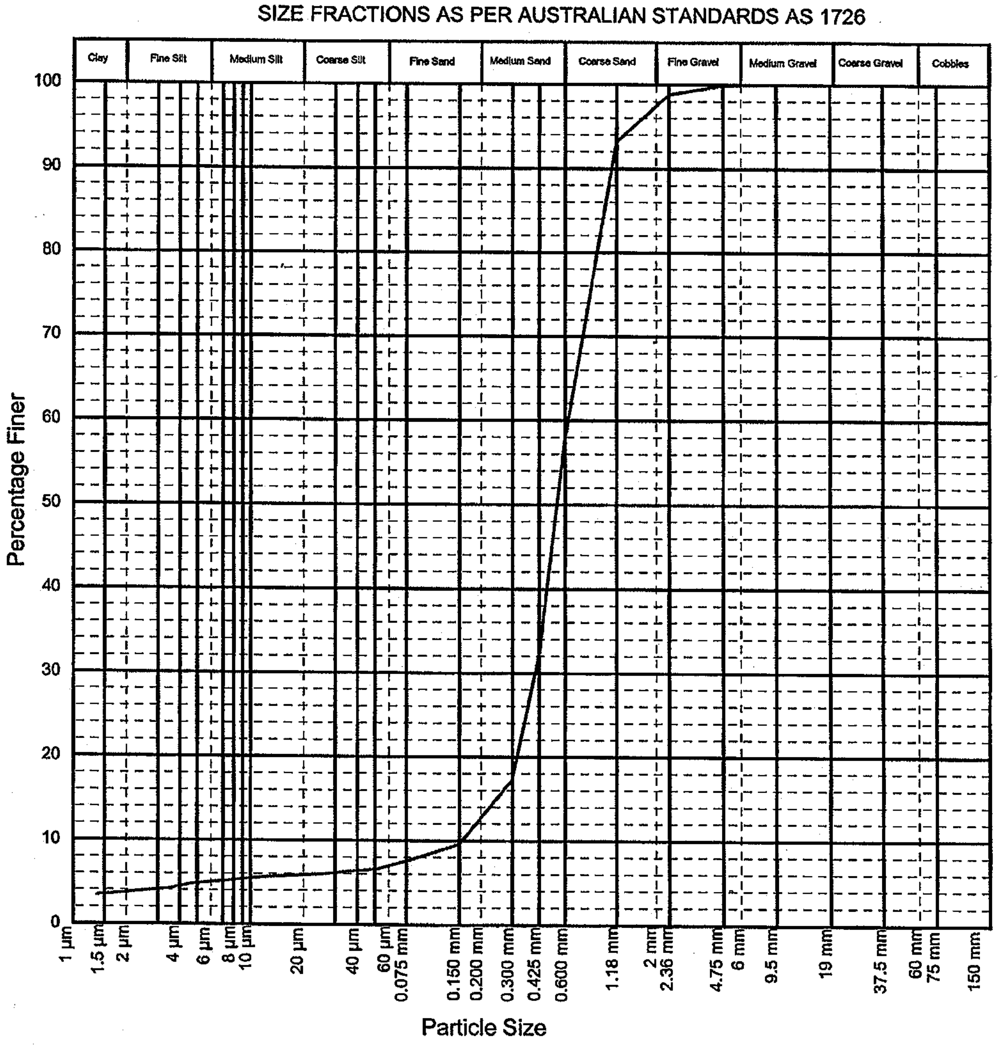
PARTICLE SIZE DISTRIBUTION BY HYDROMETER

Client :	ALS Environmental Brisbane	Report No. :	R 5963
Address :	32 Shand Street, Stafford	Job No. :	05634002/1
Project :	Delivered Samples	Reg'n No. :	L1390
Sample ID :	R 1 (0.1)	Batch No. :	EB 0501943 - 6
		Date Received :	07/03/2005
		Sampled By :	Client

Particle Size (mm)	Percent Passing
150	
75	
37.5	
19.0	
9.5	100.0
4.75	99.9
2.36	98.8
1.18	93.2
0.600	57.9
0.425	32.1
0.300	17.3
0.150	9.6
0.075	7.6
Particle Size (Microns)	Percent Passing
51.2	6.6
36.3	6.3
25.7	6.0
13.3	5.7
9.5	5.4
6.7	5.1
4.8	4.8
3.4	4.2
1.4	3.4


SIZE FRACTIONS AS PER AUSTRALIAN STANDARDS AS 1726

Pretreatment	Tested as received	Soil Particle Density (assumed)	2.70
Loss in Pretreatment (%)	-	Type of Hydrometer	ASTM E100
Method of Dispersion	Mixer		
Material Description :	Clayey SAND / SAND (SC/SP) brown		
Test Procedure :	AS 1289 3.6.2, 3.6.3 (up to 24 hours)		
Prepared by : NF		Checked by : JA	

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TEST RESULTS

Client : ALS Environmental Brisbane
Project : Delivered Samples
Batch No. : EB 0501943

Job No. : 05634002/1
Date Received 07/03/05
Sampled By : Client

PARTICLE SIZE SUMMARY

		Percentage Retained Sizes Shown Below			
Reg'n No.	Sample ID	Gravel (+ 2 mm)	Sand (2 mm - 0.060 mm)	Silt (0.060 mm - 0.002 mm)	Clay (- 0.002 mm)
L1385	R 1 (0.3)	57	33	3	7
L1386	R 2 (0.2)	13	23	25	39
L1387	R 3 (0.2)	0	31	26	43
L1388	B 1 (0.05)	61	30	3	6
L1389	R 1 (0.6)	46	46	2	6
L1390	R 1 (0.1)	2	91	3	4

Remarks :

Test Procedure: AS 1289 3.6.3

Prepared by Nf

Checked by JA