10

GROUNDWATER RESOURCES

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10 GROUNDWATER RESOURCES

This section provides a summary of the key findings of the Ensham Central Project Groundwater Assessment. The detailed Groundwater Assessment is presented in Appendix C.

10.1 INTRODUCTION

The Groundwater Assessment was undertaken by Australasian Groundwater and Environmental Consultants. The scope of work for the Groundwater Assessment included definition of the existing groundwater environment of the project area and surrounding region, and a detailed assessment of potential project groundwater impacts. The definition of the existing groundwater environment involved detailed assessment of all relevant existing data and a comprehensive field investigation program. Impact assessment involved numerical modelling using a three dimensional flow model, MODFLOW. Modelling was undertaken to assess the impact of open cut and underground mining operations on the groundwater regime in both the operational and post-mining phases. A groundwater monitoring program has been established to monitor the impact on groundwater.

The existing groundwater environment and the results of the Groundwater Assessment are summarised in the following sections.

10.2 EXISTING GROUNDWATER ENVIRONMENT

10.2.1 Assessment Methodology

The existing groundwater environment in the vicinity of the project has been assessed using:

- Information obtained from the Department of Primary Industries and Fisheries (DPI&F), including the *"Nogoa River Floodplain Emerald to Comet Groundwater Investigation"* published in 1995;
- The Department of Natural Resources, Mines and Water (NRMW) database of results from ongoing monitoring of bores in the vicinity of the project;
- Previous groundwater and environmental reports dating back to 1986;
- Observations made at open cut pits in the existing mine; and
- Comprehensive field investigations carried out as part of this study.

Field investigations carried out as part of this study included:

- Drilling of 20 test holes in the floodplain adjacent to the Nogoa River in the area potentially impacted by the Ensham Central Project, to evaluate the interaction of groundwater and surface water in the area;
- Drilling of four test holes, between the Nogoa River and the existing B Pit, to evaluate the hydraulic gradients between the two;
- Collection of undisturbed sediment samples from the saturated zone of the alluvial aquifer for physical testing;
- Geophysical logging to identify aquifer zones and lower permeability clayey beds in the alluvial sequence;

- Construction of groundwater monitoring bores in each test hole;
- Field analysis of water samples from all bores for pH and electrical conductivity;
- Laboratory analysis of nine groundwater samples and one Nogoa River sample to characterise water quality;
- Hydraulic testing (falling head tests) in the completed monitoring bores, to measure the aquifer permeability;
- Installation of permanent water level loggers in four monitoring bores to examine the relationship between river water level fluctuations, rainfall recharge and the alluvial aquifer;
- Survey of all groundwater monitoring bores to determine hydraulic gradients and hydraulic heads;
- Excavation of three test pits in the Nogoa River and two test pits in the bank, collection of sediment samples and assessment of the nature and permeability of the river bed and the potential for leakage and recharge of the alluvial aquifer; and
- Ongoing quarterly groundwater monitoring at 23 locations in the project area.

A detailed description of the field investigation program and the data obtained from it is given in the *Groundwater Assessment* included in *Appendix C*.

10.2.2 Groundwater Occurrence

Groundwater in the region occurs mainly within two types of aquifer – the shallow Quaternary alluvial aquifer, which is associated with the Nogoa River floodplain, and the deep underlying Permian coal seam aquifers.

The alluvial aquifer consists generally of fine to coarse grained sand and gravel varying in thickness from 1 to 25 m. The base of the sand and gravel is marked by residual mudstone weathered to silty clay typically in the order of 1 m thick. A typical cross section through the Nogoa River showing its relationship with the alluvial aquifer is shown in Figure 10-1.

Field investigations indicate that groundwater occurrence in the alluvial aquifer is limited and restricted to sections where the basement Permian sequence has been more deeply eroded. Aquifer permeability is highly variable ranging between 0.4 m/day and 100 m/day, but is generally high and in the order of 100 m/day. Groundwater levels in the alluvial aquifer range from Reduced Level (RL) 141 m at the upstream western limits of the proposed open cut area, to about RL 135 m near the current limit of B pit, and are generally between 1 and 6 m below the Nogoa River water level (Figure 10-1). Groundwater appears to flow from west to east in agreement with the slope of the ground surface and the general direction of flow of the Nogoa River.

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 are usually relatively impermeable.

Groundwater flow rates calculated from NRMW data collected on site in 2003 indicate borehole yields from the coal seam in the range of 0.1 to 2.6 L/s. Standing water level analysis from exploration bore logs indicate that the coal seam groundwater flow is toward the Nogoa River from an elevation of about RL 170 m to 180 m in the north to about RL 135 m in the south-east.

10.2.3 Groundwater Quality

The environmental values listed in the *Environmental Protection (Water) Policy (1997)* which are applicable to groundwater affected by the project, include:

- suitability for minimal treatment before supply as a drinking water;
- suitability for agricultural use; and

- suitability for industrial use.

Groundwater in the vicinity of the project has been monitored on a regular basis since 2004 and the quality of the alluvial aquifer groundwater is generally poor to very poor. Monitored salinity levels varied significantly with concentrations of total dissolved solids (TDS) ranging from 1,110 mg/L to 28,200 mg/L, indicating slightly brackish to moderately saline water quality. The pH is in the neutral range between 7 to 8. Many samples exceeded the recommended ANZECC (2000) *"Australian and New Zealand Guidelines for Fresh and Marine Water Quality"* which specify 5,000 mg/L TDS for beef cattle watering. Electrical conductivity (EC) ranges from 2,000 to 36,000 μS/cm. Ion ratios range from 0.79 to 1.63 for Ca/Mg, 0.25 to 0.67 for Na/Cl, 0.002 to 0.034 for SiO_2/TDS and 0.40 to 0.70 for Na/Total cations.

The Nogoa River surface water quality is fresh and slightly alkaline with a pH ranging from 8.1 to 8.2, and TDS ranging from 200 to 230 mg/L. Electrical conductivity ranges from 240 to 270 μS/cm. Ion ratios are in the order of 2.11 for Ca/Mg, 1.50 for Na/Cl, 0.050 for SiO_2/TDS and 0.32 for Na/Total cations. The Nogoa River quality contrasts markedly to the alluvial groundwater quality.

Water quality in the coal seam is variable but generally very poor. It is alkaline and highly saline with pH ranging from 7.8 to 8.4, and TDS ranging from 4,000 to 16,000 mg/L, with the majority of samples exceeding 9,400 mg/L. The TDS levels exceed the ANZECC (2000) guidelines for domestic consumption and irrigation and the water quality is also generally unsuitable for stock watering.

Further details of the groundwater and surface water quality in the vicinity of the project are provided in Section 5.3.3 of *Appendix C*.

10.2.4 Groundwater Usage

Identification of groundwater users in the vicinity of the project involved consultation with all surrounding landowners and a search of the NRMW database to identify any registered licensed bores within a 15 km radius of the mine site. The locations and details of all bores identified during this process are shown in Drawing 4 and Table 15 of *Appendix C*.

In the Highlands declared subartesian area, a licence and a development permit are required from the NRMW prior to construction of a bore for irrigation purposes. However bores constructed for stock and domestic purposes are not required to be licensed.

All licensed bores located within the floodplain alluvial aquifer in the vicinity of the project area were found to have been established by either the NRMW or the proponent. NRMW established two north-south orientated lines of alluvial aquifer monitoring bores across the floodplain in 1993. The proponent has established three bores, two of which are monitored regularly in accordance with the bore licence conditions, and another which is used for stock watering.

There are an additional eight identified private bores, within a 15 km radius of the project area (Figure 10-2) which are not associated with Ensham Mine. Of these, only two are licensed and registered on the NRMW database, and all except one inactive bore are sourced from the coal seam.

The closest licensed private bore (RN38845) is located on Property No. 73, approximately 3 km south-west of the closest proposed mine operations. This bore was inactive when inspected in November 2005. When last tested it yielded 0.6 L/s of poor quality water.

The second licensed bore (RN62511) is located on Property No.115, south of the Capricorn Highway and approximately 7 km from the project area. It was not possible to sample the water at the time of inspection however the NRMW database reported the water quality as fair (TDS 2,240 mg/L) and suitable for stock watering.

Only one of the six unlicensed other private bores within the 15 km mine radius was in active use at the time of inspection in November 2005. This bore is located on Property No. 75 and is equipped with a pump. The water quality is suitable for stock watering purposes (TDS 2,380 mg/L).

The five other known unlicensed private bores within the 15 km mine radius were inspected in November 2005 and found to be inactive and not equipped with pumps.

10.3 POTENTIAL GROUNDWATER IMPACTS

10.3.1 Introduction

Based on an assessment of the existing groundwater setting and the proposed mining activities, the key groundwater issues identified for the project were as follows:

- Groundwater inflow to the open cut pits from the alluvial aquifer, and the impact of these inflows on the alluvial aquifer;
- The rate of any recharge of the alluvial aquifer from the river and the potential for effective loss of river flow to the open cut pits;
- Impact of underground mining and whether subsidence cracking will create hydraulic connectivity between the underground mine and the base of the alluvium, and subsequently impact the alluvial aquifer;
- Potential for subsidence cracking to result in loss of river flow;
- Potential for the generation of poor quality overburden leachate in backfilled floodplain areas to impact on groundwater quality;
- Potential for poor quality groundwater from backfilled floodplain areas to discharge into the Nogoa River; and
- Potential groundwater contamination due to seepage from the tailings dams.

The assessment of these issues is summarised within the following sections.

10.3.2 Groundwater and Surface Water Interaction

Confirmation of the degree of hydraulic connection between the Nogoa River and the underlying alluvial sand and gravel aquifer was a key issue for the groundwater impact assessment. A high level of hydraulic connection between the river and the alluvial aquifer would potentially result in drainage of river water to the mining excavations without mitigation/containment strategies. A primary objective of the groundwater field investigation was therefore to confirm the hydrogeology of the alluvial aquifer and to assess the inter-relationship and degree of hydraulic connectivity between the river and the aquifer. The data collected from the field investigation indicates there is no, or extremely limited, hydraulic connection between the Nogoa River and the alluvial aquifer. This conclusion is based on the following findings:

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. A comparison of the ratios of major ions indicates that surface water in the Nogoa River and the groundwater in the alluvial aquifer are significantly different water types and that there is therefore limited, if any, leakage from the river to the aquifer.
2. Groundwater levels in the alluvial aquifer directly adjacent to or below the river typically vary between about 1 m and 6 m below the water level in the Nogoa River, confirming extremely limited, if any, leakage.

3. Water level monitoring data indicates there is no relationship between water level fluctuations in the Nogoa River and the alluvial aquifer groundwater. 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 virtually 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 in Figure 10-1.

The conclusion that there is no hydraulic connection between the river and the alluvial aquifer is supported by operational experience at Ensham Mine. The northern end of B Pit has mined through the depth of the alluvial aquifer and has been within approximately 100 m of the bank of the river for the last four years. Minor inflow to the pit from the alluvial aquifer has to date been limited to low areas of the aquifer floor for short durations. This is consistent with the patchy nature of the alluvial aquifer water. There has not been any inflow from the alluvial aquifer to B Pit that is consistent with recharge or leakage from the river. Water quality of pit inflows is similar to alluvial aquifer water quality.

The lack of connection between the river and alluvial aquifer is also supported by the findings of a NRMW groundwater study conducted in 1995. This study involved construction of a line of monitoring bores across the floodplain in the centre of Ensham Mine.

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 approved Ensham mining operations and project areas, 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 fact that groundwater levels are below the base of the river, 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.

Recharge of the alluvial aquifer from infiltration through the surface of the floodplain is also low due to the low permeability surface clay layer. Monitored groundwater levels are not affected by rainfall. Overall the alluvial aquifer, whilst having high permeability, contains limited water of poor quality and receives no significant recharge either from surface infiltration from rainfall or seepage from the river. Groundwater in the alluvial aquifer is of limited quantity and poor quality and is likely to be sourced from upward leakage from the underlying coal seams.

The results of the field investigation program and the subsequent conclusions about the surface and groundwater relationship in the area are detailed in *Section 5* of *Appendix C*.

10.3.3 Groundwater Inflow to Pits

Groundwater modelling was undertaken based on the historical and proposed mine plans to estimate potential groundwater inflow rates to the open cut pits and the underground mine and to assess the impact of mine dewatering on groundwater levels. Predictive modelling showed that groundwater inflows to the open cut pits and underground mine are relatively low. Typical predicted maximum inflows to the different pits are:

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

Inflow to the open cut pits decreases as the underground mine is developed, with the mined underground area capturing flow that would have otherwise discharged to the pits. Given that groundwater occurrence in the alluvial aquifer is "patchy" and is only of thin saturated thickness, the aquifer will contribute a small proportion of total mine inflows. Inflows will occur primarily from the coal seams.

The predicted future inflow rates are consistent with operating experience to date at Ensham Mine. The predicted inflow rates do not increase substantially above existing levels as the pits are developed across the floodplain. Groundwater inflows to the open cut pits to date have been controlled by in-pit sump pumping. This dewatering strategy will be adequate for future open cut mining pit dewatering and additional inflow controls, such as advance dewatering, should not be required. Similarly predicted groundwater inflows of up to 27 L/s to the underground mine can be controlled by strategically located underground sump pumps.

10.3.4 Groundwater Impacts on Private Bores

Extraction of groundwater by mine dewatering will lower the elevation of both the piezometric surface of the coal seam aquifer and the water table of the alluvial aquifer, by creating a "cone of depression" around Ensham Mine. Groundwater modelling results indicate that due to the confined nature of the coal seams, the radius of influence of dewatering by mining, as indicated by the 1 m drawdown contour, extends a distance of between 9 to 15 km from the mine site.

Due to the limited and patchy nature of the alluvial aquifer (Drawing 5, *Appendix C*), mine dewatering has virtually no effect on groundwater in this aquifer, other than where the alluvium is removed by open cut mining. Therefore, bores which draw from the alluvium will not be impacted. The only bores which may potentially be impacted are bores within the 15 km radius of the influence of mine dewatering which draw water from the target coal seam.

There are six NRMW groundwater monitoring bores located across the Nogoa River floodplain in the vicinity of the project. One of these (RN13020176) is located within the mining lease and will need to be decommissioned as a result of the proposed open cut mining (Drawing 2, *Appendix C*). The groundwater monitoring function of the other five NRMW bores may also be affected by mine dewatering. The proponent has commenced consultation with NRMW regarding its future requirements in relation to these bores.

There are seven private bores located in coal formations within a 15 km radius of the mine site which could potentially be impacted by the project. These private bores are located on Property No.'s 72, 73, 74, 75, and 115. Of these bores, only three, on Property No.'s 73, 75 and 115, are equipped with pumps and in active use. It is proposed that water level and quality monitoring of these bores be undertaken prior to commencement of the project and at four monthly intervals thereafter. In the event that monitoring confirms adverse impacts on bores due to mining, the proponent will address these in consultation with affected landowners.

10.3.5 Groundwater Recovery

It is proposed to reinstate the Nogoa River floodplain by progressively backfilling the pits and compacting the upper layer of overburden. A geochemical characterisation of overburden material was conducted for the purposes of the EIS (*Appendix A*). This study assessed the risk of overburden leachate causing development of poor quality groundwater within the "spoil aquifer". The study concluded that the overburden material is relatively benign and will generate slightly alkaline and fresh (non-saline) runoff and seepage following surface exposure. The leachate water therefore does not pose a significant contamination risk and is likely to be of higher quality than the existing groundwater in the alluvial aquifer which is brackish to saline.

A two-dimensional model using SEEP/W software was developed to predict the rate of infiltration of water through the surface of the reinstated floodplain in the event of a 100 year flood. The model simulated a flood event lasting for five days and corresponding to a maximum depth of flooding of 6.7 m. The results of predictive simulations indicate that flood water will not infiltrate through the surface layer and will not contribute to aquifer development. Infiltration into the compacted surface layer was minimal, at about 8.2 L/sec per hectare, and this was found to be taken up as soil moisture within the upper 6 m of overburden backfill.

Final rehabilitation treatments may vary slightly from those assumed for modelling purposes, however minor differences will not significantly affect groundwater modelling results as all rehabilitation treatments will result in similar permeabilities in overburden backfill.

A water table aquifer will develop in the long term within the spoil backfill in the open cut mining voids, once mine dewatering ceases. Groundwater modelling results indicate that a quasi-equilibrium water table will develop over a period of approximately 200 years, post-mining. The rate of recovery of the water table will be governed by rainfall recharge through the overburden emplacements, groundwater inflow from the coal seam and evaporation losses from free water in the final pit voids.

The modelling assumptions for post-mining groundwater recovery included conservatively high rainfall recharge rates and the simulated post-mining water table level is therefore a conservative worst case scenario. The predicted maximum post-mining equilibrium water table level is at or below the level of the Nogoa River. The modelling results indicate that, even for the worst case (highest water table level), there will be no discharge of spoil aquifer water to the river.

The actual rate of development of a spoil aquifer and equilibrium water table level will be reduced (compared to the model results) by rehabilitation and revegetation of the overburden emplacements. Rehabilitated areas will be designed to drain externally away from the mining voids and promote surface runoff and evapo-transpiration to reduce deep infiltration into the backfilled spoil. Revegetation will include establishment of deep rooted perennial vegetation to further reduce deep infiltration. The extent of disturbed surface area that will not have been rehabilitated and revegetated at any one time will be limited by the mine's progressive rehabilitation program.

10.3.6 Post-Mining Effects

Predictive modelling of post-mining groundwater recovery in the underground mine and open cut mining areas indicates that the final voids will act as sinks to groundwater flow and that water in the final voids will not move into other parts of the aquifer and that voids will not overtop and discharge into the Nogoa River or other surface waters (*Appendix C - Sections 12.4.1 and 13.4*). Water levels in the voids will reach equilibrium approximately 200 years after completion of mining and will stabilise at levels between RL 124 m and RL 142 m, generally below the invert level of the Nogoa River.

The saturated thickness of the spoil backfill will range from about 14 m at the eastern end of the mining area to about 147 m at the western end, where open pit mining will cease. The goaf in the underground mine will similarly be saturated. It is therefore assessed that there is minimal risk of a high water table spoil aquifer developing that would discharge poorer quality water into the Nogoa River.

An assessment of the potential impact of underground mine subsidence on the alluvial aquifer and river was undertaken based on subsidence predictions, and the thickness of cover (overburden) between the coal seam and base of alluvium. It was found by Seedsman Geotechnics that longwall cracking would potentially extend from the seam to the surface/aquifer in areas where the thickness of Permian overburden is less than 105 m.

The cover thickness exceeds 105 m in the areas above longwall panels S1 to S13, but is less than 105 m thick in the southern half of panel S15 and a very small amount of S14. Therefore, vertical cracking 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. The underground mine layout has been designed such there will no vertical subsidence at the surface within 100 m of the river bank. This effectively establishes a "subsidence protection zone" along the river that will prevent underground mining impacting the river.

The conceptual model of the post-mining 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 until an equilibrium is established between evaporation loss from, and inflow to the system. 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 is likely to 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.
- Vegetation of the spoil surfaces will reduce the quantity and improve the quality of runoff.

The predicted large storage in the final voids should buffer the void water quality against severe changes in water quality. The Overburden Geochemistry Assessment (*Appendix A*) concluded *"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, 2000"*. 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.

10.3.7 Tailings Dams Impacts

The proposed location of the tailings dams is to the east of the coal seam subcrop as shown in Figure 10-2. The tailings dams are located over Permian rocks which consist primarily of feldspathic and lithic sandstone, mudstone and siltstone. The rocks are of very low permeability and the weathered, clay rich surface profile is likely to be of low permeability. 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 1 km and 2 km to the west and south, respectively.

The need for any groundwater impact mitigation measures and monitoring will be assessed during the geotechnical investigation and detailed design of the tailings dams.

10.3.8 Summary of Impacts

In summary, the project groundwater assessment has shown:

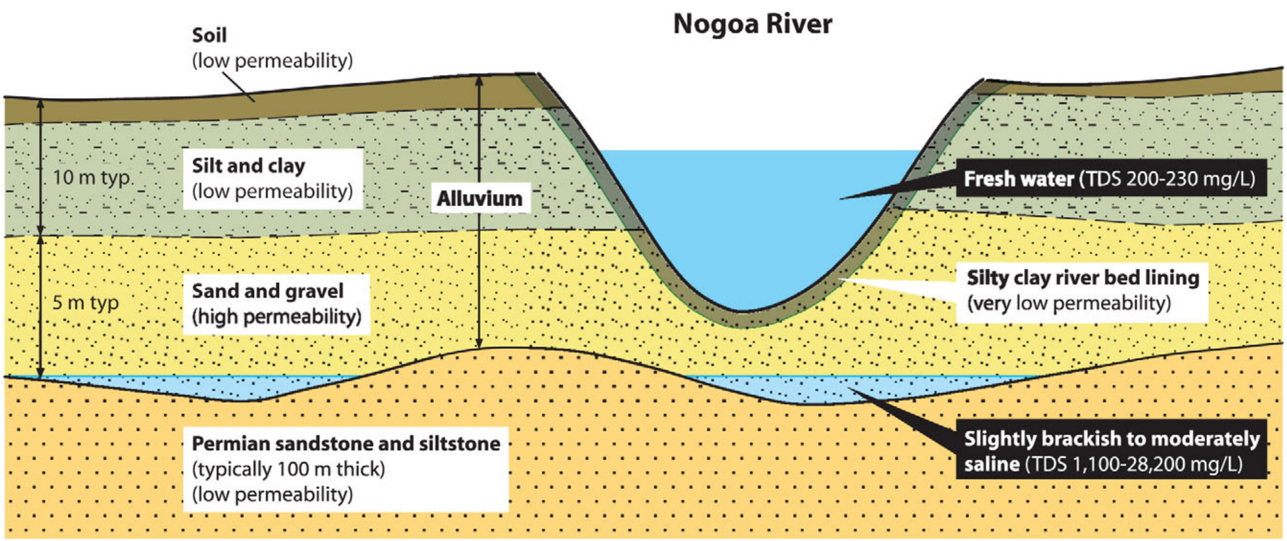
- The base and sides of the Nogoa River bed consist of clay and clay-bound sand and gravel which form an effective seal, and therefore there is effectively no connection between the Nogoa River waters and the coarse sands and gravel aquifer of the associated floodplain alluvium.

- The alluvial floodplain constitutes a poor aquifer due to patchy groundwater occurrence which, where it does occur, is of thin saturated thickness of less than 3 m. The quality of the alluvial groundwater is also poor and ranges from brackish to saline.
- Re-instating the river floodplain with an upper compacted spoil layer, or an alternative surface treatment that achieves a similar low permeability seal, will essentially prevent infiltration of water during flooding events as well as rainfall infiltration limiting the rate of development of a spoil aquifer in the long term, post-mining.
- Vertical cracking from the underground mine to the base of the alluvium as a result of subsidence is likely to occur in a limited area where there is less than 105 m 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.
- The underground mine layout has been designed such that there will be no surface subsidence within 100 m of the top of the high bank of the Nogoa River channel. This "subsidence protection zone" will ensure that there will be no impact from longwall mining on the river.
- Predicted groundwater inflows to the open cut mine pits range between 3-17 L/s and the predicted maximum inflow to the underground mine is 27 L/s. The open cut pits and underground 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 mine dewatering on groundwater levels will be between 9 and 15 km from the mine site. Within this area there are only two known privately owned active groundwater bores that could potentially be affected.
- Long term groundwater recovery, post-mining, will be very slow relying on inflow from the coal seams and from rainfall recharge of the elevated overburden emplacements. Groundwater modelling indicates that it will take in excess of 200 years for equilibrium post-mining groundwater levels to establish.
- Geochemical characterisation of the spoil has shown it to be benign and any leachate produced in the spoil aquifer should be of reasonable quality and higher quality than the groundwater in the existing alluvial aquifer. This predicted leachate water quality will not pose a significant contamination risk.
- The final open cut voids will act as sinks for groundwater flow with worst case long term equilibrium water levels in the voids (established approximately 200 years after the completion of mining) at or below the Nogoa River level. It is therefore assessed that the equilibrium water table that develops in the spoil aquifer will not discharge to the river.
- The proposed tailings dams are located on low permeability, clay rich strata and are therefore unlikely to have any impact on the groundwater regime. This will be confirmed by detailed geotechnical assessment of the dam sites during detailed design.

10.3.9 Groundwater Monitoring Plan

A Groundwater Monitoring Plan is included in Section 15 of *Appendix C*. The purpose of this monitoring plan is to monitor the effects of mining activities on the groundwater resource and on other groundwater users.

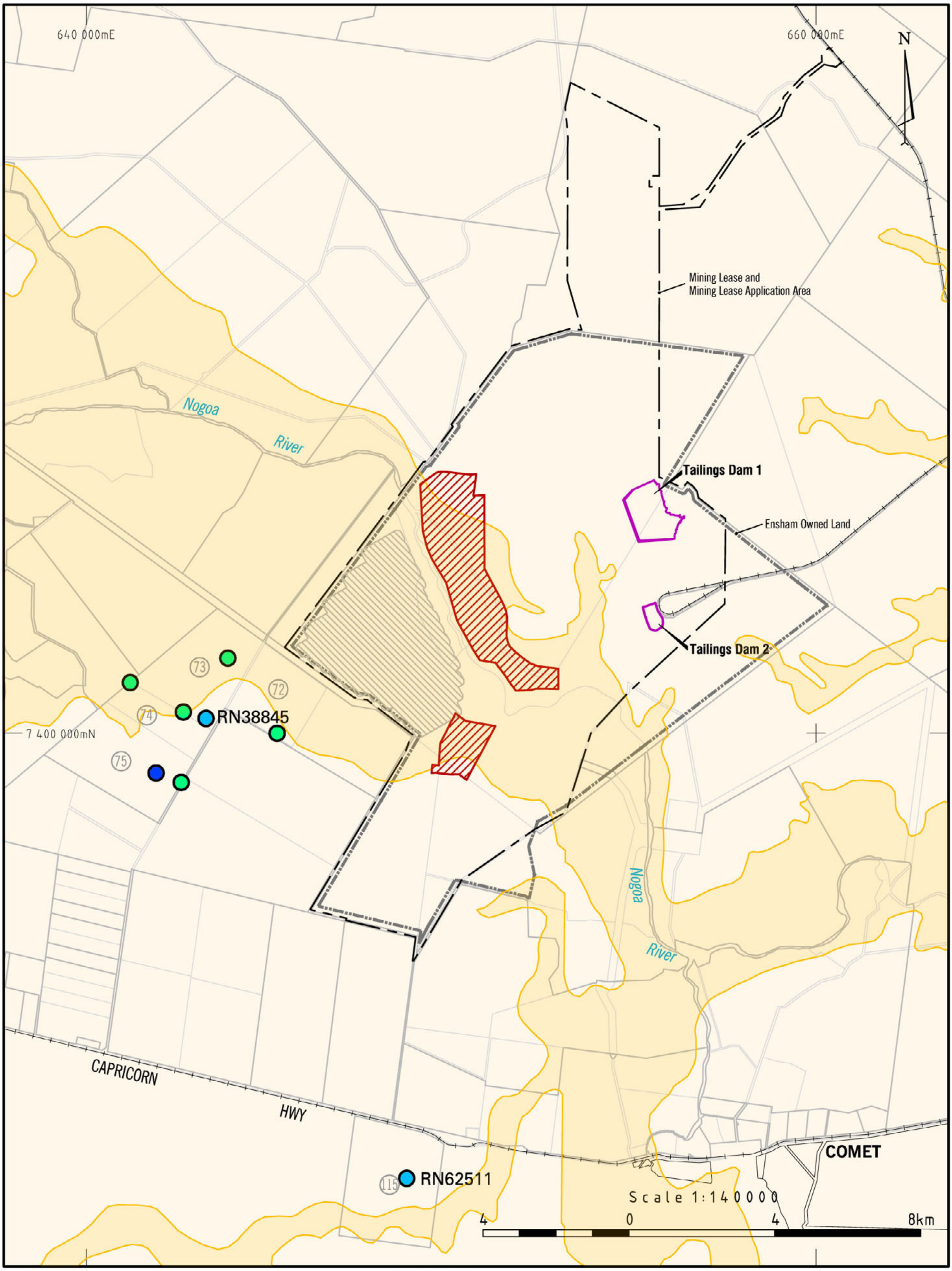
FIGURES



Nogoa River Alluvium Stylised Section

Ensham Resources
Hansen Consulting

FIGURE 10-1



33 EIS Property Reference Number
Ensham Owned Land
Mining Lease and Mining Lease Application Area
Alluvial Aquifer
Project Open Cut Mining Area
Project Underground Mining Area

Private Bores

- Unregistered active private bore
- Unregistered inactive private bore
- Registered private bore

ENSHAM CENTRAL PROJECT

Groundwater Plan

Ensham RESOURCES
HANSEN CONSULTING

FIGURE 10-2