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SECTION 1 - INTRODUCTION

Redport Limited (Redport) is currently involved in a mining feasibility assessment of the uranium deposits at Lake Maitland, south of Wiluna. The proposed process plant throughput will be 1,000tpd with an initial process water demand of 1,500kL/d, ideally with a chloride concentration of less than 2,000mg/L. The use of more saline water is possible, but this would restrict process technology options. The make up water demand may decrease to an average of around 1,000kL/d with time as the TSF decant return system becomes effective. There will also be requirements for a potable camp supply and a dust suppression supply, although there are no real water quality constraints for the latter.

Aquaterra Consulting Pty Ltd (Aquaterra) was commissioned to assess water supply and water management aspects of the Lake Maitland Uranium Project. The overall investigation includes:

- A preliminary assessment of the water supply capacities of the local aquifers, primarily the calcrite and inferred tributary palaeochannel to the north of Lake Maitland.
- The requirements for, and location of, alternative water supply sources.
- Dewatering requirements of the mining operations and the optimum dewatering strategy.
- Project water and salinity balance.
- Likely borefield layouts.

This interim report presents a preliminary assessment of potential water supply sources for the project. The remaining issues (dewatering requirements, project water/salinity balance and notional borefield layouts) will be assessed following a review of the geological and hydrogeological data gathered by Redport as part of their exploration program completed in late 2006 and provision of preliminary mine plans.

There is little to no project area specific hydrogeological data available at present. This review has been based on the published results of a study completed by the Water and Rivers Commission in 1999 (WRC 1999\(^1\)) and on the experience of senior Aquaterra staff who have worked on water supply development projects in the region of over 20 years.

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SECTION 2 - HYDROGEOLOGICAL BACKGROUND

2.1 GEOLOGY
Lake Maitland lies in the Eastern Goldfields Province of the Archaean Yilgarn Craton. It is characterised by granite-greenstone rocks that display a northwest tectonic trend and low to medium grade metamorphism. The Archaean rocks are intruded by east-west dolerite dykes of Proterozoic age. The basement rocks are generally poorly exposed due to low relief, extensive superficial cover and widespread deep weathering. During the early Tertiary period, rivers eroded channels into the basement rocks. The channels have since been infilled with a sequence of basal sand and gravel, which is overlain by a thick sequence of Cainozoic sedimentary deposits. Lake Maitland is located within the Carey Palaeodrainage (Figure 1), where the palaeochannel sediments comprise basal sands and the overlying Cainozoic sediments consist of an interbedded sequence of dense, plastic clays with occasional sand lenses overlain by alluvial sands (Figure 2). Bodies of calcrete occur at the margins of present day salt lakes, and locally in some of the tributaries of the main drainages. Playa lake sediments occur within Lake Maitland and comprise mainly clays (WRC, 1999).

2.2 REGIONAL HYDROGEOLOGY
Four broad aquifiers types have been identified in the Lake Maitland area:

- Shallow alluvium.
- Calcrete.
- Palaeochannel sand.
- Fractured rock.

The shallow alluvium aquifers generally have low permeability but are important localised shallow aquifers. Where developed, the calcrete aquifers exhibit secondary permeability caused by chemical dissolution and they can often provide large local supplies of fresh to brackish groundwater. The playa lake sediments form minor shallow hypersaline aquifers.

The palaeochannel sand aquifers in the Lake Maitland area are marked by a fluvial palaeochannel sand aquifers, confined below dense clay layers, with overlying alluvial/calcrete aquifers in places. The palaeochannel sand is typically permeable and locally capable of containing significant supplies of groundwater (fresh to brackish in the tributaries and saline to hypersaline in the main trunk of the drainage). The palaeochannel sands, however, have limited storage, with most long term groundwater supplies being derived from induced leakage from overlying clays and the surrounding fractured rock aquifers.

The fractured basement rocks are characterised by secondary porosity and permeability and form localised aquifers.

A regional flow system of major palaeo-drainages exists with groundwater flowing towards the salt lakes and then downstream in the palaeochannels. The flow systems in the Northern Goldfields are maintained by rainfall recharge, with most recharge occurring after heavy rainfall events (annual rainfall average at Wiluna 254mm), producing surface runoff and local flooding (WRC, 1999).
2.2.1 Shallow Alluvium Aquifers

Alluvial deposits form the upper portion of the Cainozoic sequence within the palaeodrainages. The deposits consist of silty sand and are characterised by ferruginisation and poor sorting of the predominantly quartz grains.

The shallow alluvium aquifers are unconfined, with a watertable less than 5m below ground level and a saturated thickness typically between 5 and 15m. The permeability is generally low. Reported yields in the alluvium range from 50 to 600kL/d depending upon the local permeability. The alluvium aquifers are generally fresh to brackish (1,000 to 4,000mg/L TDS) becoming hypersaline (TDS >14,000mg/L) towards salt lakes and in the lower parts of the drainage system. Recharge to the aquifers is from irregular, episodic rainfall events and is estimated to be approximately 1% of the annual average rainfall (2.45mm/yr) (WRC, 1999).

Due to typically low permeability and low bore yields, the alluvium aquifers are generally not directly utilised, other than for stock bores. The large groundwater storage in the aquifers can be utilised through downward leakage to the underlying palaeochannel sand and fractured rock aquifers, during regional aquifer depressurisation as a result of borefield pumping.

2.2.2 Calcrete Aquifers

Bodies of calcrete generally occur at the margins of present day salt lakes, and locally in some of the tributaries of the main drainages. The watertable is generally shallow, less than 5m below ground level. The saturated thickness is highly variable (up to a maximum of 30m thick) with an average saturated thickness of between 5 and 10m. The areal extent of the calcrete aquifers is often limited.

Bore yields are variable depending on the nature and degree of vug development. However, the calcrites can form locally high yielding aquifers where secondary porosity and high permeability are well developed. Long term sustainable yields from the calcrete aquifers are typically 500kL/d although short term yields up to 1500kL/d have been reported. The specific yield is also highly variable (0.05 to 0.25) due to its vuggy nature. Specific yields are higher in vuggy areas and lower where it is massive (WRC, 1999). Due to the nature of the calcrete aquifers, with highly transmissive zones generally close to the water table, the aquifer is susceptible to dewatering due to over-pumping. A number of borefields are currently established in the calcrete aquifers in the region. Recorded licensed abstractions for mining use range from 0.2 to 3GL/year (WRC, 1999).

The groundwater is commonly brackish to saline (2,000 to 6,000mg/L TDS), although local areas of fresh groundwater may occur where the calcrete receives enhanced groundwater recharge through direct infiltration from rainfall and surface runoff, during intense rainfall events. Salinities of approximately 14,000mg/L TDS have also been reported in some areas. Recharge rates of approximately 0.7% to 0.8% of rainfall occur to the calcrete aquifers south and east of Wiluna (WRC, 1999).
2.2.3 Palaeochannel Sand Aquifers

The palaeochannel sands form the most important aquifer in the Northern Goldfields, capable of providing significant groundwater supplies. The aquifer can be up to 1km wide and 40m thick in the trunk of major palaeochannels, while widths of several hundred metres may be found in tributaries. The thickness and presence of the palaeochannel sands is related to their origin with the thickest sand sequences occurring within and downstream of granitoid catchments and more clayey and finer sands within and downstream of predominantly greenstone catchments. The palaeochannel sands are inferred to be continuous along the main trunk drainages. The palaeochannel sand aquifers are generally confined below up to 80m of clay.

Reported permeability ranges from 1 to 40m/d, with an average of 10m/d. There is relatively limited storage in the palaeochannel sands, however, long-term pumping induces leakage from the overlying lithologies and surrounding weathered/fractured bedrock. Reported short term yields from the palaeochannel sands are in the range 200 to 1,600kL/d, determined from pumping tests (WRC, 1999).

The groundwater in the main palaeochannels is generally brackish to hyper-saline (TDS >14,000 mg/L). WRC Bore 20073949 is completed in the palaeochannel sand aquifer within the main Carey Palaeodrainage to the west of the project area. A chloride concentration of 41,000mg/L was detected in a water sample collected from this bore with a TDS of 61,000mg/L. Higher salinity water may occur beneath and downstream of Lake Maitland. Lower salinity water (fresh to brackish, TDS 1,000 to 3,000mg/L) has been found in the upper reaches of some tributaries. The interpreted distribution of groundwater salinity of the palaeochannel sand aquifers is illustrated in Figure 3.

Recharge potential is limited, but may occur locally via weathered and fractured bedrock flanking the palaeochannel and vertical leakage from the overlying lithologies. Groundwater flow is along the axes of the palaeochannels, flowing eastwards or south-east in the direction of the original drainage. The hydraulic heads are lower than that in the Archaean bedrock, indicating that the palaeochannels are regional drains. Groundwater discharges through evaporation at the salt lakes with a small amount of groundwater outflow in the palaeochannel sands (WRC, 1999).

2.2.4 Fractured Rock Aquifers

The fractured rock aquifers comprise greenstones, granitoids and minor intrusive rocks that are characterised by structurally (and weathered) induced secondary porosity and permeability. Groundwater occurs within the weathering profile and fractures in the basement rocks. In general, the greenstone rocks are more prospective for groundwater supplies than the granitoids, which are more homogeneous and less fractured. The greenstones form linear, arcuate belts of interbedded mafic and ultramafic volcanic, felsic volcanic and metasedimentary rocks (including chert and banded-iron formation). Within the weathering profile of greenstones, however, typically high clay contents limit groundwater development potential, whereas the weathering profile in granites is more productive due to its sand content (WRC, 1999).

The fractured rock aquifers generally form minor local aquifer with fresh to saline groundwater (1,000 to 14,000mg/L TDS). Yields from the fractured rock aquifers are highly variable and related to geological structure and rock type. The long term sustainability of the fractured rock aquifer is constrained by their
limited storage and availability of direct recharge. The fractured rock aquifers are recharged infrequently by rainfall and runoff from ephemeral drainages into open fractures and weathered zones (WRC, 1999).
SECTION 3 - POTENTIAL WATER SUPPLY OPTIONS

The calcrete aquifer and the palaeochannel sand aquifer are considered to be the optimal potential sources of water supply for the Lake Maitland Uranium Project in terms of proximity, potential sustainability and water quality. However, it may be difficult to obtain a sustainable water supply with the required chloride concentration of less than 2,000mg/L (except from the upper reaches of the palaeochannel tributary to the northeast of Lake Maitland).

The two calcrete bodies immediately to the west of Lake Maitland and the inferred tributary palaeochannel north of Lake Maitland are considered to be the best targets for preliminary groundwater exploration for the project (Figure 4).

3.1 CALCRETE AQUIFER

Exploration drilling by WRC indicates that the calcrete within the largest calcrete body immediately to the west of Lake Maitland is approximately 20m thick. The calcrete is vuggy and cavernous. The water level in the calcrete is reported to be approximately 5m below ground level. WRC Bore 20073950 is completed in the calcrete aquifer and provided an airlift yield of 108kL/d from the 50mm casing installed. A significantly higher yield should be obtainable from a suitably constructed (larger diameter) production bore. Reported long term sustainable yields from the calcrete aquifer are typically 500kL/d although short term yields up to 1500kL/d may be obtainable. Based on the available yield information, the project water demand of approximately 1,500kL/d could be provided by installing approximately 5 production bores into the calcrete aquifer. This would allow for reduced yield in some bores and the provision of a standby bore.

The groundwater resources in the two calcrete bodies immediately to the west of Lake Maitland have been estimated as 63GL and 8.8GL (WRC, 1999). Thus based on the project demand of 1,500kL/d, a long term (over 100 years) water supply from the calcrete aquifer could be sustained from storage alone.

The water quality in the calcrete aquifers is likely to be brackish to saline. A chloride concentration of 3,900mg/L was detected in a water sample collected from the WRC Bore 20073950. Water quality in the calcrete aquifer can vary significantly throughout the year related to recharge and discharge via evapotranspiration. Water quality is likely to be the major constraint regarding using the calcrete aquifer as a water supply option, although blending with better quality water may be an option, especially if dewatering of the calcrete aquifer is required as part of the mining process.

Limitations on the use of the calcrete aquifer include:

- Limited saturated thickness and thus drawdown potential (ie long-term pumping may dewater the aquifer).
- Chloride concentration - which may be too high for processing plant.
- Environmental impacts – phreatophytic vegetation and stygofauna.

3.2 PALAEOCHANNEL SAND AQUIFER

The inferred tributary of the main Carey Palaeodrainage to the north of Lake Maitland is considered to be the primary target for groundwater exploration. The water within the main Carey palaeochannel sand aquifer is hypersaline (approximately 60,000mg/L TDS) in the area and is therefore not considered suitable as a water
supply for the project. However, the tributary channel, if present, has the potential to provide significant volumes of low salinity water.

Short term yields from palaeochannel sands are typically in the range 200 to 1,600kL/d (determined from pumping tests). Based on the available yield information, the project water demand of approximately 1,500kL/d could be provided by installing anywhere between 2 and 8 bores in the tributary palaeochannel aquifer to the north of Lake Maitland. This would allow for reduced yield in some bores and the provision of a standby bore. In order to maximise yields production bores are typically constructed with slotted sections through the alluvium and palaeochannel basal sand aquifer. The groundwater resource in the inferred tributary is estimated to be 1.6 GL (WRC, 1999). Thus based on the project demand of 1,500kL/d, the water supply from storage within the palaeosand aquifer may be sustainable for a period of up to 3 years, although leakage from surrounding strata is likely to extend this time period.

The water within the tributary to the north of Lake Maitland is likely to be fresh in the upper reaches becoming hyper-saline towards the south in the direction of Lake Maitland (see Figure 3).

Limitations on the use of the palaeochannel sands aquifer include:

- The extent of the palaeochannel sand and its supply potential has not been fully established (only inferred).
- High chloride concentrations within the lower reaches of the tributary may restrict processing options.

3.3 ALTERNATIVE WATER SUPPLY OPTIONS

Utilisation of both the calcrete aquifers immediately to the west of Lake Maitland and the inferred tributary palaeochannel sand aquifer to the north of Lake Maitland is likely to provide an adequate supply of water for the Lake Maitland project. However, the elevated chloride content of the water may be restrictive to processing options and the supply potential of the tributary palaeochannel sand aquifer has not been as yet established.

An alternative water resource in the Lake Maitland project area is a calcrete aquifer located further to the west of the project area (Figure 4). The calcrete located approximately 20km to the west of the project area is a potential source of water supply which may have a lower chloride concentration. Bore yields are likely to be similar to those within the two calcrete aquifers within the project area. The groundwater resource in the calcrete aquifer in this area has been estimated as 8.1GL (WRC, 1999). Thus based on the project demand of 1,500kL/d, the water supply from the calcrete aquifer may be sustainable for up to 15 years. The calcrete body is located within a tributary of the main drainage, closer to sources of recharge and further from the salt lake. The groundwater within the calcrete aquifer is likely to be fresh to brackish.

In addition, there is also a potential for water supply from the basal sands in the palaeochannel tributary approximately 30km to the south east of the project area (Figure 4), although, the resource is also unproven. The fractured rock to the north and west of the project area may also provide a supply of water, however, there is uncertainty as to the sustainability of the supply.
SECTION 4 - CONCLUSIONS AND RECOMMENDATIONS

The initial process water demand for the Lake Maitland project is estimated to be 1,500kL/d, decreasing to an average of around 1,000kL/d with time as the TSF decant return system becomes effective. There will also be requirements for a potable camp supply and a dust suppression supply.

Ideally a chloride concentration of less than 2,000mg/L will be required for the process water. The use of more saline water would be possible, but this would restrict process technology options. The camp supply will require potable water, while there are no real water quality restraints for the dust suppression supply.

4.1 CONCLUSIONS

Four broad aquifer systems have been identified in the Lake Maitland area, an alluvial aquifer, a calcrete aquifer, palaeochannel sand aquifer and fractured bedrock aquifer. Utilisation of both the calcrete aquifer (which may require dewatering during mining) adjacent to the proposed mine site and the inferred tributary palaeochannel sand aquifer located to the north east of the project area are considered the most suitable options for development of a water supply to meet the project water requirements. It is possible that blending of the two water supplies will be required to meet the requirement of a chloride concentration of less than 2,000mg/L, while also dealing with excess abstraction from potential mine dewatering.

The two calcrete bodies immediately to the west of Lake Maitland and the inferred tributary palaeochannel north of Lake Maitland are considered to be the best targets for preliminary groundwater exploration. A calcrete aquifer further to the west of the project area may provide a suitable alternative water supply for the Lake Maitland project, as may localised permeable horizons within the basement rocks of the Greenstone belt to the north of Lake Maitland.

4.2 RECOMMENDATIONS

It is recommended that hydrogeological investigation be carried out to prove these resources. The aims of the investigation would be to:

- Confirm the supply potential and water quality within the target calcrete aquifers adjacent to Lake Maitland.
- Confirm the presence and define the extent, supply potential and water quality of the tributary palaeochannel sand aquifer to the north east of Lake Maitland.
- Assess the potential environmental impacts of abstraction.

The recommended scope of work for the hydrogeological investigation includes the following:

Task 1 – Delineation Drilling Programme

- **Inferred palaeochannel sand aquifer** – complete a programme of air-core drilling transects in order to confirm the presence and define the geometry/nature (extent, thickness and permeability) of the palaeochannel sand aquifer; establish depth to water; facilitate the collection of groundwater samples for water quality analysis; and install groundwater monitoring wells.
- **Calcrete aquifer** – complete drilling in conjunction with mineral exploration programme to define geometry/nature (extend, thickness and permeability) of the calcrete aquifer; establish depth to water;
facilitate the collection of groundwater samples for water quality analysis; and install groundwater monitoring wells.

**Task 2 – Test Production Bore Drilling & Test Pumping**
- Drilling of test production bores and associated monitoring bores in both the palaeochannel sand and the calcrete aquifers. Subsequent test pumping of the installed test production bores.

**Task 3 – Groundwater Modelling**
- Develop a numerical groundwater model in order to assess optimal bore spacing, sustainability, impacts on the environment and other local water users, etc.
FIGURES
Figure 2
Typical Palaeochannel Cross Section

Adapted from
Figure 3
Groundwater Salinity Palaeochannels

Adapted from
JOHNSON, S. L., COMMANDER, D.P. & O’BOY, C. A. 1999,
Hydrogeological Record Series, Report HG 2, 57p.
Figure 4
Aquifer Location Map

LEGEND

- Palaeochannel Water Supply Source
- Calcrete Water Supply Source
- Potential Alternative Water Supply Source

Location Map

Author: PH
Report No.: [Redacted]
Projection: GDA94 ZONE51
Revised: 21 December 2006
Job No: 716C
Drawn: KA
Scale: 1:225,000
Date: 22 November 2006

F:\jobs\716C\Figure 4. Aquifer Location Map.pdf