

ADAVALE PROJECT - QUEENSLAND

Exploration Permit for Minerals 17503 (“Ada”)

Annual Report For the Period Ending 3rd December 2009

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30 October 2009**

Report # circ 2009004
TS Shelf Reference 2009/026
File Name: Adavale_EPM17503_Annual Report_2009

ADAVALE PROJECT - QUEENSLAND

EPM 17503 “ADAVALE”

Annual Report For the Period Ending 3rd December 2009

Authors: M C Farmer & R H Lewis

Date: 10th November 2009

Holder: Queensland Potash Pty Ltd

Commodity: Salt, Potash

1:250 000: Adavale (SG 5505)

1:100 000: Listowel Downs (7947)

Distribution: Queensland Potash Pty Ltd Limited (1)
Dept. Mines & Energy (1)

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SUMMARY

The Adavale Project comprises Exploration Permit for Minerals 17503 “Adavale” lie south of the township of Blackall in central western Queensland. The EPM was granted on the 3rd November 2008 for a period of five years. This report is the Annual Report for EPM 17503.

Based on earlier petroleum exploration conducted in the 1980s that included drilling, well logs, and seismic surveys, and on work conducted by the Queensland Department of Mines and the Australian Bureau of Mines (BMR), the Boree Salt Member was identified as the only known significant occurrence of bedded potash in Australia. Since then, additional work by Aus Potash and their contractors have recovered and assembled much of the technical literature of the early 1980s on EPM 17503 including available data, reports, and well logs. Geochemical sampling of previous oil exploration drill holes Bury #1 and Bonnie #1 was carried out with encouraging results. Na values ranged from 23% to 28.3%.

Technical reports have been commissioned on basic technical information of a complete chloralkali plant by Gea Messo AG designing an extraction process. A comprehensive 43-101 compliant report was commissioned and completed by M. D. Campbell and Associates as part of a TSX listing. KBB Underground Technologies GmbH (KBB UT) completed a conceptual design for an extraction process whereby a brine production plant with salt caverns was envisaged to deliver concentrated brine as a feedstock for the electrolysis plant and to support Aus Potash with information relevant for future investment decisions.

Rockwater Pty Ltd was commissioned to conduct a desktop assessment of groundwater supply options for a proposed Salt Solution Mining Project. It was concluded there are no transferable groundwater allocations within 15 km of the proposed project area. However, transferable allocations are available at greater distances and would need to be negotiated with the individuals and organisations. It was recommended if a transfer can be negotiated, an application would need to be made by the owner or legal occupier of the land on which a new bore is to be constructed to obtain a licence and permit from the Queensland DNRW.

Terra Search Pty. Ltd, an independent exploration contractor, has processed the available historical petroleum exploration drilling and seismic interpretation data and created a 3-D model of the Boree Salt geometry. This work indicates that the Boree Salt Member is several tens of cubic kilometers in volume, is up to 500 meters thick at depths between 2,000 and 2,500 meters below the ground surface.

1. INTRODUCTION

The Adavale Project comprises Exploration Permit for Minerals 17503 “Adavale” lie south of the township of Blackall in central western Queensland.

The tenements are held in the name of Queensland Potash Pty Ltd Pty. Ltd which is a wholly-owned subsidiary of Queensland Potash Pty Ltd Holdings Ltd.

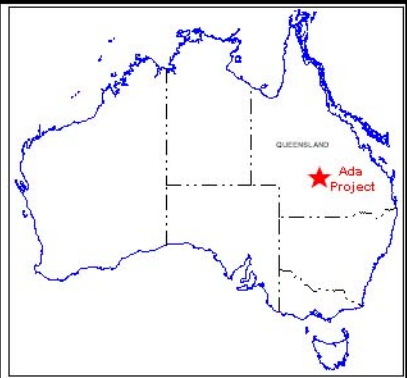
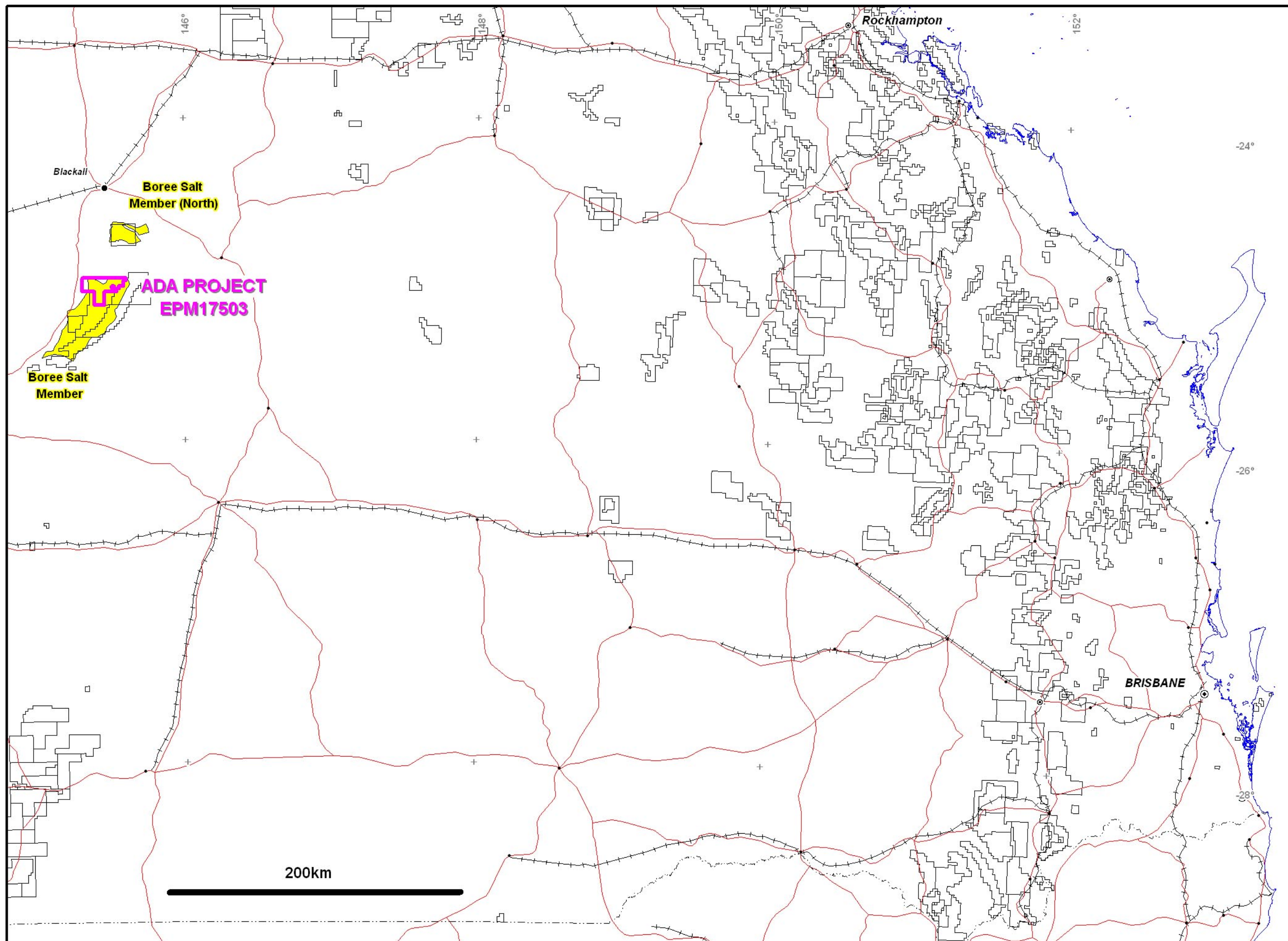
The tenements are held to explore for potash and salt deposits at depth under cover in the Adavale Basin.

2. LOCATION

EPM 17503 is centred at about 151° 18'E, 24° 40'S near the township of Blackall in central western Queensland (Figure 1). The area lies within the Listowel Downs (7947)1:100 000 sheet area and the Adavale (SG 5505)1:250 000 sheet area.

The project is located in the Adavale Shire Council Local Government Authority.

The area is within UTM Zone 55.



- Circle Resources Tenements
- Major Roads
- Railways

**AUSPOTASH CORPORATION
ADA PROJECT**

**EPM17503 Project Location
November 2009**

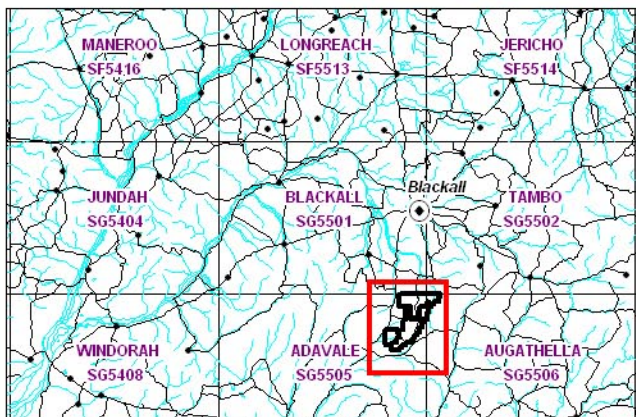
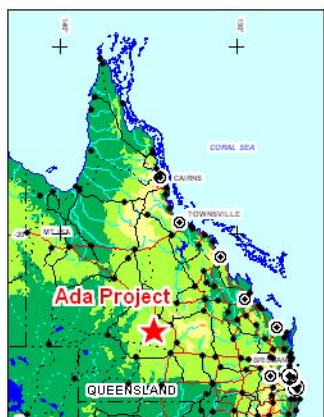
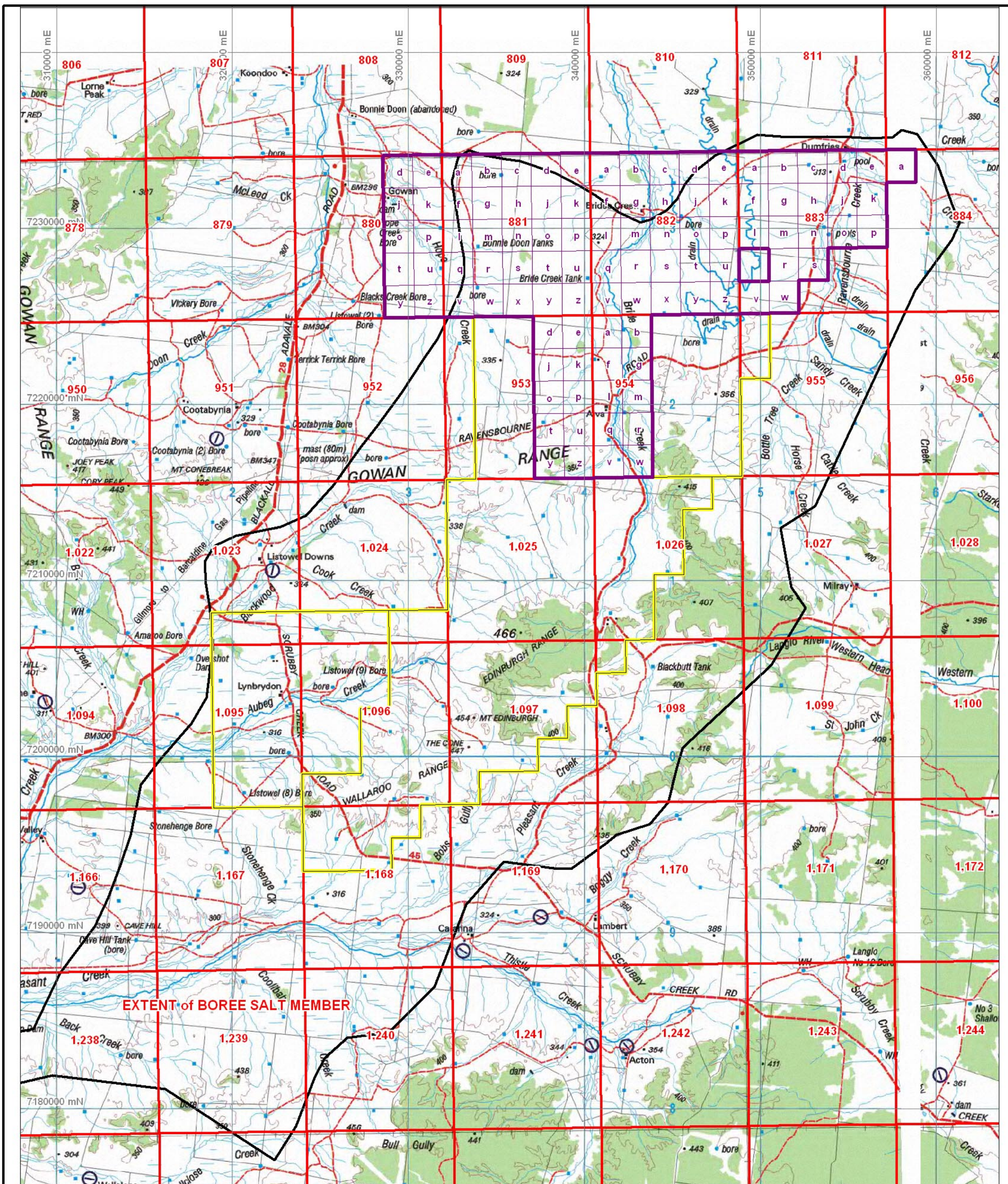
3. TENURE

EPM 17503 “Adavale”, comprising 100 sub-blocks, was granted to Queensland Potash Pty Ltd Pty Ltd on 03 November 2008, for a term of five years (figure 2).

The permit is located within the Charleville 1:1 million Block Identification Map (BIM) Series B. Blocks and sub-blocks held are described in Table 1.

Table 1. EPM 17503 “Adavale” - Blocks and Sub-blocks.

Sheet_Name	Sheet_Ref	Block	Sub Block
Charleville	SG55	880	d,e,j,k,o,p,t,u,y,z
Charleville	SG55	881	a,b,c,d,e,f,g,h,j,k,l,m,n,o,p,q,r,s,t,u,v,w,x,y,z
Charleville	SG55	882	a,b,c,d,e,f,g,h,j,k,l,m,n,o,p,q,r,s,t,u,v,w,x,y,z
Charleville	SG55	883	a,b,c,d,e,f,g,h,j,k,l,m,n,o,p,r,s,v,w
Charleville	SG55	884	a
Charleville	SG55	953	d,e,j,k,o,p,t,u,y,z
Charleville	SG55	954	a,b,f,g,l,m,q,r,v,w



0 5
Kilometers
1:200,000
MGA Zone 55 (GDA94)

AUSPOTASH CORPORATION ADA PROJECT

EPM17503 Sub Block Identification Plan
August 2008

4. GEOLOGY

Regional Geology

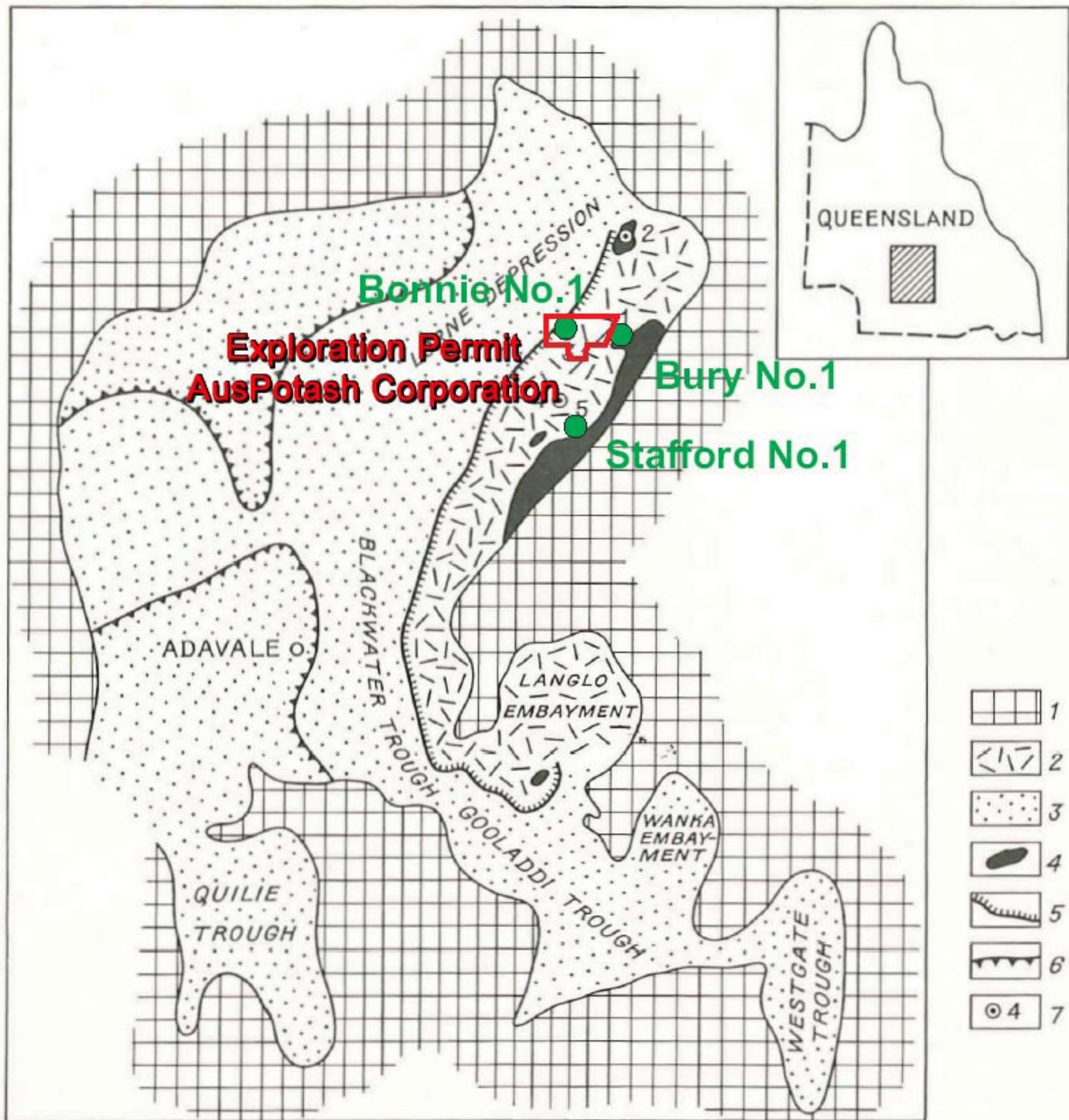
The rocks of the Adavale Basin do not crop out, but are overlain by 1,000 meters to 3,000 meters of sediments of the Galilee Basin (Late Permian to Carboniferous) and of the overlying sediments of Eromanga Basin (Jurassic-Cretaceous). Sediments of the Adavale Basin range in age from the Early Devonian and possibly extend upwards into the Early Carboniferous. The Devonian sediments of the Adavale Basin have been subdivided by McKillop, et al., (2007), with an important hiatus (and the formation of evaporite basins) at the top of the Middle Devonian.

They were deposited during a transgressive-regressive cycle reflecting the westward advance and subsequent retreat of the sea during Devonian time. Transgression reached its maximum during approximately Middle Devonian time, represented in its shoreward facies by a widespread thin dolomite.

The Boree Salt Member consists of up to 580 meters of rock salt with minor dolomitic limestone, anhydrite and clastic sediments. It occupies the position between the evaporitic carbonates to the east and the sandstone member and red beds along the west flank of the Pleasant Creek Arch.

Table 2 Stratigraphic Setting of the Boree Salt Member

AGE	STRATIGRAPHIC UNIT		LITHOLOGY	OBSERVED THICKNESS (m)	DEPOSITIONAL ENVIRONMENT
MID-LATE DEVONIAN	BUCKABIE FORMATION		Sandstone, siltstone, shale	>756m	Continental Red Beds
	ETONVALE FORMATION	Shale/Siltstone Member	Siltstone, shale, sandstone; rare limestone; rare anhydrite; rare shelly fauna	384-612m	?Marine
		Boree Salt Member	Rock salt; rare siltstone, shale, dolomitic limestone and anhydrite	77-583m	Evaporitic
	BURY LIMESTONE		Limestone; rare sandstone and siltstone; rich marine fauna	178-418m	Restricted to high energy shallow marine
EARLY DEVONIAN	GUMBARDOO FORMATION		Sandstone, arkose, siltstone, shale	>107m	Continental Red Beds



Distribution of Boree Salt Member in Adavale Basin. After Tanner (1967) and Wells (1980).
 1 Devonian absent (Permian or Mesozoic on basement), 2 areal extent of Devonian salt deposits, 3 areal extent of carbonate and terrigenous Devonian deposits, 4 salt bodies, 5 westward extent of Boree Salt Member deposition, 6 probable westward extent of Cooladdi Dolomite, 7 wells and their numbers (1 Bury No. 1, 2 Boree No. 1, 3 Bonnie No. 1, 4 Alva No. 6, 5 Stafford No. 1)

Local Geology

Within and around the subject tenements, the Boree Salt Member thickens as it approaches the Warrego Fault to the east in what is likely a graben oriented north-south (see Figure 3). The salt has been remobilized and forms pillows along the western bounding fault, especially in the area of Amoseas Boree No. 1 (see Galloway, 1970, p. 25; Bauer, 1983; and McKillop, et al., 2007).

Three units are interpreted to form a laterally related genetic sequence. Paten (1977) suggests that the continued carbonate sedimentation along the Quilberry-Dartmouth trend caused the isolation of the basin. On the landward margin, the sandstone member represented the eastern encroachment of desert sedimentation. The Boree Salt Member was deposited in the isolated basin(s) between the two. It is probable that gentle downwarp of the basin was occurring at this time (see Paten, 1977).

5. PREVIOUS EXPLORATION

Interest in potash in the Adavale Basin first developed when petroleum exploration began to conduct seismic surveys in the early 1960s and then again in the early 1980s. Poseidon Minerals Limited (Poseidon) commissioned consultants to reinterpret the available seismic information. In 1983, Poseidon Limited commissioned consultants D.W. Edgerley & Associates and Jenny Bauer (Bauer, 1983) to reinterpret the available seismic data to obtain isopach and structure contour maps of the Boree Salt Member interval. In 1985 a total of 45km of 12-fold Vibroseis seismic reflection data was acquired in the Brides Creek survey by Petty Ray Geophysical Crew 6150. The data acquired during the Brides Creek Survey was processed by Hosking Geophysical Corporation (Australia).

A comprehensive interpretation of the Brides Creek seismic data, together with a re-interpretation of all seismic data from previous surveys carried out in the Brides creek area was undertaken for Poseidon by consultant G.R Gatti.

These surveys revealed an extensive evaporate sequence (Bauer, 1983 and White, 1984), which led Poseidon into a joint venture with PPG Industries to explore specifically for potash. White (1986) summarized all the available relevant information on the studies conducted to date.

During the 1980s, a number of deep holes were drilled, cored and logged in the Adavale Basin, some of which confirmed a thick evaporate interval, which was subsequently studied in great detail by Poseidon, Denison Resources, N. L., Mines Exploration Pty. Ltd., and the Queensland Government (see McKillop, et al., 2007). These studies form the basis of the present interest in developing the potash resources in the subject basin, assuming the occurrence of potash minerals is of sufficient volume and chemical grade to merit development.

According to Wells (1980), the presence of potash in the Adavale Basin and the classical evaporate sequence from dolomite through anhydrite to halite and potassium minerals, including sylvite, make it one of the most prospective basins in Australia, the most prospective area being next to the Pleasant Creek Arch. Subsequent drilling by petroleum companies further confirmed the thick sequence of evaporite sediments and likely interbeds of potassium minerals in the upper intervals of the sequence.

Poseidon evaluated the potash potential of the area and Dennison Resources N.L. took their evaluation of the potash potential all the way through the feasibility and engineering stage before they cancelled the project as a result of other business interests. Nothing of record is available since the late 1980s on the subject tenement area until recent interest re-emerged as prices and market needs in South East Asia, Australia, India, and China have made it apparent that fertilizers and specialty chemical products are now in significant demand.

6. EXPLORATION IN THE 12 MONTH PERIOD to 30 OCTOBER 2009

Technical reports have been commissioned on basic technical information of a complete chloralkali plant by Gea Messo AG designing an extraction process. A comprehensive 43-101 compliant report was commissioned and completed by M. D. Campbell and Associates as part of a TSX listing. KBB Underground Technologies GmbH (KBB UT) completed a conceptual design for an extraction process whereby a brine production plant with salt caverns was envisaged to deliver concentrated brine as a feedstock for the electrolysis plant and to support Aus Potash with information relevant for future investment decisions.

Rockwater Pty Ltd was commissioned to conduct a desktop assessment of groundwater supply options for a proposed Salt Solution Mining Project. It was concluded there are no transferable groundwater allocations within 15 km of the proposed project area. However, transferable allocations are available at greater distances and would need to be negotiated with the individuals and organisations. It was recommended if a transfer can be negotiated, an application would need to be made by the owner or legal occupier of the land on which a new bore is to be constructed to obtain a licence and permit from the Queensland DNRW.

Ten samples were taken from the Department of Mines and Energy core storage depot in Brisbane. These samples were from Bury #1 and Bonnie #1 petroleum exploration drill core. The samples were assayed for As, Ca, Cu, Fe, K, Mg, Na, S, Cl. Oregrade ICPOES 'TOTAL' determination was used for Na. Values ranged from 23% to 28.3%.

Assay samples were submitted to ALS Chemex, Townsville where they were crushed, split and pulverized. Samples were analysed for the following elements As, Ca, Cu, Fe, K, Mg, Na, S, Cl :

- As, Ca, Cu, Fe, K, Mg, Na, S by ICP – OES Method ICP 40Q after 4 acid digest (0.2g-20ml) by Method DIG40Q. Where values for Na 200000 ppm Method ICP4B.
- Cl by Method CLA04E hot water soluble chlorine with Volhard titration.

The full range of element and detection limits is set out below :

Table 3: Analytical Methods, Petroleum Well Samples, May 2008

Element	As	Ca	Cu	Fe	K	Mg	Na	S	Cl
unit	ppm	Ppm	ppm	ppm	ppm	ppm	ppm	ppm	%
Method	ICP 40Q	ICP 40Q	ICP 40Q	ICP 40Q	ICP 40Q	ICP 40Q	ICP 40Q	ICP 40Q	ICP 40Q
Det limit	5	50	5	100	100	20	200000	50000	2

The most comprehensive studies were carried out by Terra Search in the first quarter of 2009. Processing of historical petroleum exploration drilling and seismic interpretation data has enabled 3D modelling of the Devonian Boree Salt Member geometry. The modeled surfaces indicate that within Queensland Potash tenements, there are large

volumes of this unit over 250m thick. Modelling indicates volumes in the order of several tens of cubic kilometers, at depths between 2000m and 2500m below surface.

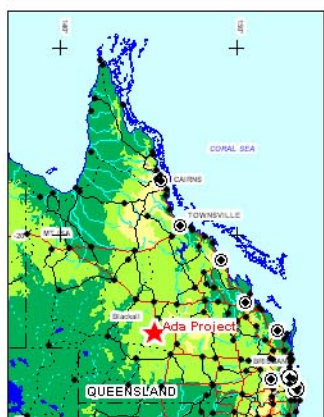
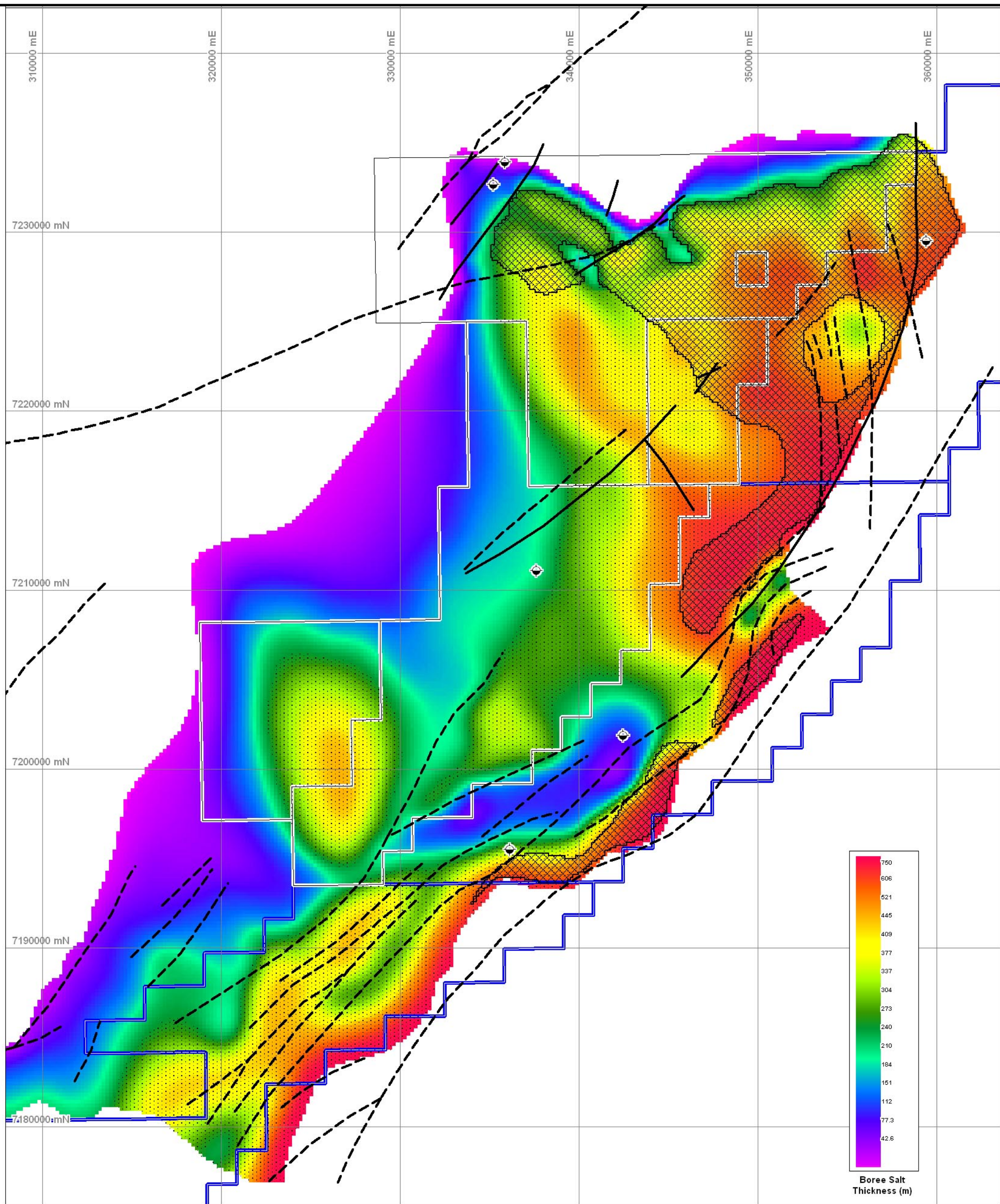
The modeling is based on two data sources: petroleum exploration wells and two generations of seismic interpretation. Petroleum exploration wells were sourced from the Queensland Government Petroleum Well database which includes collar locations and stratigraphic logging intervals. Depths and thicknesses of the Boree Salt Member and Bury Limestone provide the only geological control on the Two-way Time (TWT) seismic interpretations.

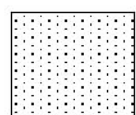
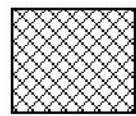
The following estimates of Boree Salt Member volume were generated by intersecting the modeled surfaces with the EPM application areas.

Table 4 Boree Salt Member Estimates

Tenement		TOTAL	>250m thick	<2500m below surface	>250m thick AND <2500m below surface
EPMA(new)	Listowel	34.6	12.5	0	0
EPMA17557	Alva	76.5	45.6	0	0
EPMA17503	Ada	77.4	67.5	36.6	24.8
EPMA17538	Ada Extended	23.5	23.5	2.9	1.3

The area where there is >250m thickness of Boree Salt within 2500m of surface is shown in Figure 4.



-  Boree Salt Member > 250m Thickness
-  Boree Salt Member > 250m Thickness within 2500m of Surface
-  Faults (1986 Seismic Interpretation)
-  Faults (1983 Seismic Interpretation)

0 5
Kilometers
1:200,000
MGA Zone 55 (GDA94)

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**Boree Salt Member
Greater than 250m Thickness
Within 2500m of Surface
June 2009**

It should be noted that the above calculations are estimated on the basis of wide spaced oil drilling, and correlations on the basis of seismic interpretation. The estimates are indicative only in terms of the volume of salt bearing unit that may be present. There is no indication of the grade of this salt bearing formation. The calculation should in no way be regarded as a resource calculation. Significantly more drilling and sampling (with appropriate quality control measures in place) would need to be undertaken before a JORC compliant resource could be contemplated.

7. CONCLUSIONS

- Conceptual studies, including geochemical sampling and recent modelling of the Boree Salt Member have advanced the Adavale salt project significantly.
- Based on a review of the historical reports and associated analyses, well logs, and seismic modelling of earlier well data, it can be concluded that the Boree Salt Member represents a potentially large resource for making fertilizers and various specialty chemicals.
- Significantly more drilling and sampling (with appropriate quality control measures in place) would need to be undertaken before a JORC compliant resource could be contemplated.

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APPENDIX 1

***ANNUAL REPORT FOR EPM 17503 Adavale
12 Months ending 03rd November, 2009
For QUEENSLAND POTASH PTY LTD.***

***Basic technical information of a complete chloralkali
plant: Report by GEA Messo AG***

BASIC TECHNICAL INFORMATION of a complete CHLORALKALI PLANT

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PROPRIETARY INFORMATION

All documents of this Basic Technical Information contain proprietary and confidential information of GEA Messo AG which are to be maintained in strict confidence.

These documents must neither be copied nor used for any other project nor made available to any third party. These documents must be only used for this project for which they have been explicitly released by GEA Messo AG.

1. GENERAL

This presentation describes a typical complete battery limits membrane cell Chloralkali plant.

The electrolysis technology is by one of the worlds leading chlorine producers and suppliers of membrane cell Chloralkali technology which is successfully used by a large number of licensees in many countries of the world.

Process descriptions, process requirements such as raw materials, utilities, treatment chemicals, and type of equipment, materials of construction as well as product qualities and other technical data are typical of such plants.

The plant concept presented in this document applies for production of caustic soda and chlorine by the electrolysis of NaCl brine. For higher or lower production capacities different designs or types of equipment are more suitable or economic.

The final processing arrangement will be adjusted; depending primarily on purchasers works specifications, production capacities, salt quality, and selection of treatment chemicals.

The plant concept presented here comprises all equipment and controls required for a continuous and safe operation. Standby equipment philosophy or degree of automation is defined when establishing the basis of design for a specific project.

The block diagram shown on the next page illustrates the inter-relationship of the various processing Plant Sections in the complete Chloralkali complex.

The mass balance shown on the diagram relates to a production of 1000 kg of NaOH from the Electrolysis Plant Section.

2. PLANT SECTION

The plant will consist of the following process plant sections

11. POWER RECTIFICATION
12. ELECTROLYSIS
13. BRINE PREPARATION
14. CHLORINE PROCESSING
15. CAUSTIC SODA HANDLING AND CONCENTRATION
16. HYDROGEN PROCESSING
17. HYDROCHLORIC ACID
18. CHLORINE ABSORPTION

The details of the plant sections are given in the following chapters.

Notes

1. The onsite production of Hydrochloric Acid (HCl) is not absolutely essential, when HCl could be made available from outside facilities.
2. HCl is mainly used for the pH control and chlorate decomposition of brine. Additional use is required when the chlorine gas should have a low content of Oxygen O₂. To reach a figure of approx. 0.7 Vol. % then the acidification of the feed brine to the electrolyzers is required. The HCl added will be then available as additional chlorine, which could be re-circulated to the onsite HCl synthesis unit.
3. The chlorine absorption section includes the standard facilities for the absorption of chlorine released in the processes as well as the emergency scrubber which is absolutely essential for a Chloralkali plant in order to absorb all chlorine produced at nominal capacity for a certain time. The chlorine processing section could be designed to release under normal conditions either the lowest possible amount of chlorine or that amount of chlorine as required for the production of a certain amount of sodium hypochlorite. There are different concepts available subject to client's requirements.

3. PLANT CAPACITY

The plant should be designed for the production of

Dried compressed chlorine gas	tpd Cl ₂
Liquid chlorine	tpd Cl ₂
Caustic soda as 32% NaOH	tpd NaOH 100%
Caustic Soda as 50 % NaOH	tpd NaOH 100%
Hydrochloric acid as 32 % HCl	tpd HCl 100%
Sodium hypochlorite 18% AC	tpd Hypo

The plant should have the following storage capacities:

Liquid chlorine total	ton
Number of tans	
Size of tank	ton / tank
Caustic soda 32 %	ton
Caustic soda 50 %	ton
Hydrochloric acid	m ³
Sodium hypochlorite	m ³

4. STANDARDS

Equipment		European Suppliers of Equipment and Engineering	
Pressure Tanks	Design	TRB, AD Merkblätter	
	Inspection	TRB, AD Merkblätter TUEV	
	Fabrication	AD Merkblätter	
	Dimension	metric	
Equipment	Regulation	UVV	
	Dimension	metric	
Piping, Flanges	Design	TRR, DIN	
	Dimension	DIN	
Electrical Equipment	Standard	IEC	
	Protection Class	IP65	also for instruments
Motors	Isolation Class	F	
Emissions	Regulation	TA Air	
Noice	Regulation	Arbeitsstätten Richtlinie	
Safety	Regulation	Arbeitsstätten Richtlinie	
General	all Standards and Regulations as applicable in Germany must be considered		

5. PROCESS DESCRIPTION

POWER RECTIFICATION SECTION 11

Production Power Conversion 111

The DC power for the electrolysis is supplied from rectifiers with thyristors. The incoming high tension AC power from outside battery limits is first fed to a transformer that provides for the voltage required by the rectifier in which the AC power is converted to DC power. Both, transformer and rectifier are water cooled, the transformer indirectly via a closed oil circuit and the rectifier indirectly via a closed demineralised water circuit.

The rectifiers are equipped with automatic current control and are operated from the DCS in the control room of the plant.

Polarisation Power Conversion 112

A small polarisation rectifier with DC connections for the individual electrolyzers 121 111 supplies polarisation power for protection of the electrolyzers during shutdown.

ELECTROLYSIS SECTION 12

Cell Room 121

The focal points in this section are the membrane electrolyzers in which the electrolysis of sodium chloride (NaCl) takes place. Chlorine, caustic soda and hydrogen are produced as the result of the electrolysis process.



The electrolysis cells consist of a compartment with an anode (+) and a compartment with a cathode (-). The compartments are separated by an ion exchange membrane that is essentially only permeable to cations.

The sodium chloride is fed to the anode compartments of the cells in the form of an aqueous solution, the feed brine. On the anode, chloride ions are oxidised to chlorine:



The chlorine is removed from the anode compartments together with depleted brine or anolyte.

Sodium ions permeate through the membranes into the cathode compartments of the cells. Water is fed to these compartments and some of the water is reduced on the cathodes to hydrogen and hydroxyl ions:



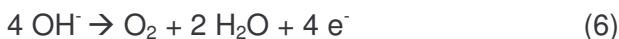
Together with the sodium ions that have crossed the membranes, the hydroxyl ions form caustic soda:



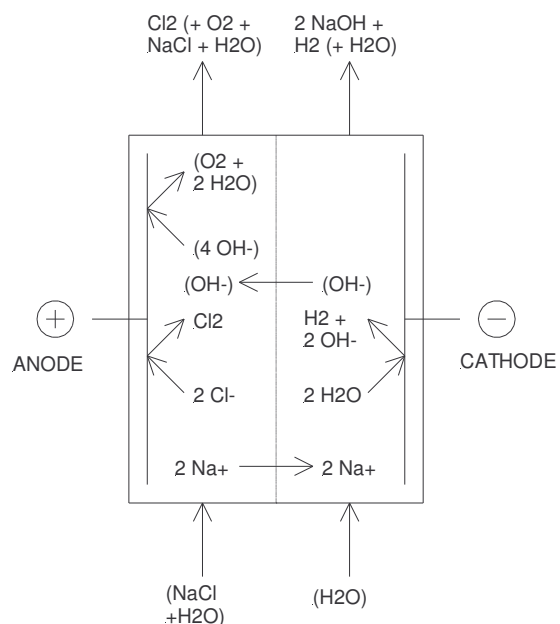
The caustic soda or catholyte and the hydrogen are removed from the cathode compartments.

Because of the large difference in concentration and the difference in electric potential, a small portion of the hydroxyl ions is leaking from the cathode compartments of the cells into the anode compartments, although the membranes are designed only for permeation of cations. Such leaking hydroxyl ions are lost for the production of caustic soda and reduce the current efficiency.

Some of the hydroxyl ions leaking into the anode compartments of the cells react on the anodes to oxygen:



The remaining hydroxyl ions react with chlorine to hypochlorous acid:



Some of the hypochlorous acid reacts on to chloric acid and hydrogen chloride:



Accordingly, a depleted brine containing some hypochlorous acid and some chloric acid and chlorine gas with some oxygen are removed from the anode compartments of the cells.

These side reactions are a consequence of the above mentioned leakage of hydroxyl ions from the cathode compartments of the cells across the membranes into the anode compartments. To keep this leakage at a minimum, and accordingly to maintain a high current efficiency, it is essential that the feed brine is very pure. Impurities contained in the feed brine may precipitate inside the membranes and may lead not only to a reduced current efficiency but also to an increased electric resistance of the membranes and thus to an increased cell voltage.

Bipolar electrolyzers contain up to 90 cell units connected in series. Two electrolyzers are again connected in series, so that the overall circuit voltage is high while the current is low, resulting in small power losses in bus bar and rectifiers. To prevent reverse current during shutdown, each electrolyzer can be isolated from the DC circuit and protected by polarisation.

With respect to brine, chlorine gas, caustic soda and hydrogen, all electrolyzers and also all cells within the electrolyzers are connected in parallel.

Purified brine from the brine preparation section 13 is distributed to the anode compartments of the individual cell units. The anolyte overflows together with the chlorine gas from the individual anode compartments and is separated from the chlorine gas in one of the upper headers of the electrolyzers. From these discharge headers, the anolyte is drained to the depleted brine tank 122 121.

The chlorine gas is likewise collected from the discharge headers of the electrolyzers and is directed to the chlorine processing section 14.

For control of the electrolyser operating temperature, caustic soda is circulated through the cathode compartments of the cell units. The temperature of the recycled caustic soda is adjusted in such a way that the electrolyzers are operated at optimum temperature. Simultaneously, demineralised water is added to the recycled caustic soda as required to maintain the optimum catholyte concentration inside the electrolyzers. The catholyte overflows together with the hydrogen from the individual cathode compartments and is separated from the hydrogen in the other upper headers of the electrolyser. From these discharge headers, the catholyte is drained to the catholyte tank 122 122.

The hydrogen is collected from the discharge headers of the electrolyzers and is directed to the hydrogen processing section 16.

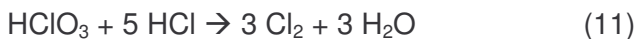
The production of chlorine, caustic soda and hydrogen is easily adjusted by changing the DC current that is fed to the electrolyzers. The overall voltage of the individual electrolyzers and the temperature of the caustic soda from the individual electrolyzers are continuously monitored. For additional safety, the group voltage of each about 10 cell units is also monitored continuously.

Auxiliary Installations 122

The pressure of the purified brine fed to the electrolyzers is automatically controlled and the flow rate is continuously monitored. When the production of chlorine, caustic soda and hydrogen is changed, the feed brine flow rate is adjusted by changing the set pressure of the pressure control in such a way that the electrolyzers operate at optimum anolyte concentration.

The chlorine gas pressure in the main header is automatically controlled by recycling chlorine gas from the discharge side to the suction side of the chlorine compression unit 144 21 in the chlorine processing section 14.

The hypochlorous acid and the chloric acid which are produced in the cell room 121 according to reactions (7), (8) and (9) are decomposed again to chlorine by addition of hydrochloric acid:



The decomposition of hypochlorous acid requires only a small excess of hydrochloric acid and is fast whereas the decomposition of chloric acid requires a large excess of hydrochloric acid and significant reaction time.

For the decomposition of chloric acid, some depleted brine is branched off from the main stream on the discharge side of the depleted brine pump 122 171 and is reacted in the chlorate decomposition tank 122 123 with hydrochloric acid in excess. The mixture of brine and hydrochloric acid overflowing from the chlorate decomposition tank is mixed at the inlet to the depleted brine tank 122 121 with the anolyte from the electrolyzers 121 111 for decomposition of the hypochlorous acid in the depleted brine tank. The chlorine produced by the decomposition of the hypochlorous acid in the depleted brine tank and of chloric acid in the chlorate decomposition tank is added to the chlorine produced in the electrolyzers.

From the depleted brine tank 122 121, the depleted brine is transferred to the brine preparation section 13. The brine level in the depleted brine tank is controlled automatically and the pH of the depleted brine is monitored continuously.

The pressure of the caustic soda which is recycled to the electrolyzers 121 111 is automatically controlled and the flow rate is continuously monitored. The flow rate of the demineralised water that is added to the recycle caustic soda is also automatically controlled. When the production of chlorine, caustic soda and hydrogen is changed, the demineralised water flow rate is adjusted by changing the set flow rate of the flow control in such a way that the electrolyzers operate at optimum catholyte concentration. The catholyte concentration is monitored by continuously measuring the catholyte density on the discharge side of the catholyte pump 122 172.

The catholyte from the electrolyzers is collected in the catholyte tank 122 122. From this tank, most of the caustic soda recycled back to the electrolyzers by the catholyte pump 122 172. On the way to the electrolyzers, the recycle caustic soda is passed through the caustic soda heat exchanger 122 141. In normal operation, the caustic soda is cooled in the caustic soda heat exchanger by cooling water. For start-up and in operation with low production, the caustic soda is heated by steam. In cooling mode, the temperature of the caustic soda is controlled automatically. When the production is changed, the set temperature is adjusted in such way that the electrolyzers operate at optimum temperature.

The caustic soda production is branched off on the discharge side of the catholyte pump 122 172 and is transferred to the caustic soda processing section 15. The caustic soda level in the catholyte tank 122 122 is controlled automatically.

The hydrogen pressure in the main header is automatically controlled by recycling hydrogen from the discharge side to the suction side of the hydrogen blower 161 181 in the hydrogen processing section 16.

Cell Maintenance Area 123

For the periodical replacement of the membranes and gaskets, the respective electrolyser is shut down, drained and washed. Thereafter, the flexible hoses are disconnected and the electrolyser is opened using the hydraulic press 123 91. After installation of the walkways 123 93 on the electrolyser and the mobile membrane stage 123 92 in front of the electrolyser, the cell units are removed from the cell frame and stored in the containers 123 74 for inspection and replacement of the membrane gaskets on the turning jigs 123 94. The reprocessed cell units are again stored in the containers and are installed again in the cell frame together with new membranes which are inspected prior to installation on Inspection Stand 123 95. The cell units are handled with the overhead crane 123 71 and the swivel cranes 123 72, the containers and the maintenance equipment with the overhead crane.

BRINE PREPARATION SECTION 13

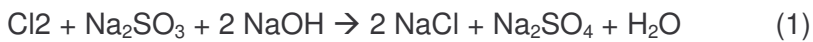
Primary Brine Dechlorination 131

The acidic depleted brine from the electrolysis section still contains dissolved chlorine. For resaturation and purification of the brine, the chlorine must be removed completely. Most of the chlorine is stripped from the brine in the dechlorinator 131 131 by air coming from the dechlorination air blower 131 181.

Hot air containing chlorine and water vapour leaving the dechlorinator 131 131 is cooled in the heat exchanger 131 141 by cooling water. The cooled gas from the heat exchanger is directed to the chlorine absorption section 18. Condensate water vapour containing dissolved chlorine is recycled to the dechlorinator.

Secondary Brine Dechlorination 132

Residual chlorine still contained in the brine overflowing from the dechlorinator is reduced to chloride by addition of sodium sulfite and caustic soda:



Simultaneously, the acidic brine is neutralised. Sodium sulphite solution and caustic soda are mixed with brine in the inline mixer 132 152. After the inline mixer, the redox potential and the pH of the brine are measured and automatically controlled.

Sodium sulphite solution is prepared in the agitated tank 132 151 and added to the brine by the dosing pump 132 172. Caustic soda is added from tank 134 121 by one of the dosing pumps 134 171.

Dechlorinated brine is collected in the depleted brine tank 132 121 and is transferred to saturation 133 by the depleted brine pump 132 171. The brine level in the depleted brine tank is automatically controlled.

Brine Saturation 133

Dechlorinated brine from dechlorination 132 is charged to the saturator 133 122 in which it flows upwards through a bed of salt to become again saturated. Demineralised make-up water is added to the dechlorinated brine at the inlet to the saturator as required to maintain the total brine volume in the overall system. Since the pH of brine is neutral, the pickup of heavy metals, iron and acid soluble impurities in the saturator is minimum.

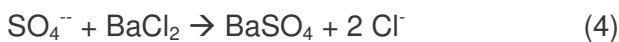
The salt conveyor 133 192, charges salt continuously to the saturator in order to prevent fluctuations of the concentration of soluble impurities in the brine overflow from the saturator, thus facilitating the operation of the subsequent precipitation 134. The salt is charged by front end loader from outside battery limits to the feed hopper 133 121 and metered from the feed hopper with the vibration feeder 133 191 to the salt conveyor.

Coarse insoluble impurities in the salt accumulate at the bottom of the saturator, from where they are drained periodically as sludge to the settling pond 133 161 recovery of brine by settling. The recovered brine is recycled from the settling pond with pump 133 171 to the main saturated brine

stream. The solids are periodically removed from the setting pond and disposed to outside battery limits.

Chemical Brine Treatment 134

Saturated brine from the saturation 133 is treated in the agitated reaction tank 134 111 with soda ash, caustic soda and barium chloride to precipitate most of the calcium and magnesium as magnesium hydroxide and calcium carbonate, and some sulphate as barium sulphate:



The precipitates overflow with the brine to the clarification 135.

Caustic soda is added to the reaction tank 134 111 by one of the dosing pumps 134 171. Soda ash and the barium chloride solutions are prepared in the agitated tanks 134 151 and 134 152 and are fed to the reaction tank 134 111 by dosing pumps 134 172 and 134 173.

Clarification 135

In the clarifier 135 161 most of the precipitates contained in the brine from the precipitation 134 are separated. Coagulant solution is added to the brine to promote efficient settling. Coagulant solution is prepared in the agitated tank 135 151 and is added to the brine by dosing pump 135 171.

The sludge accumulating at the bottom of the clarifier 135 161 is moved by the raker to the centre of the clarifier and is fed with the pump 135 172 to the filter press 135 162 where it is dewatered. The filter cake is discharged into lorries and disposed outside battery limits. The recovered brine is recycled to the clarifier.

Primary Brine Filtration 136

Clarified brine overflows from clarification 135 to the clarified brine tank 136 121 and is then fed by the clarified brine pump 136 171 to the sand filter unit 136 21 for further separation of suspended solids.

The sand filter unit 136 21 comprises two sand bed filters which are operated alternately. The accumulated solids gradually increase the pressure drop across the filter. After some time, the brine feed is switched to the second filter and the first filter is back washed with water and air for removal of the solids. The back wash air is supplied from a blower. The back washed filter is kept as stand-by until the other filter is back washed.

The flow rate of brine which is passed through the sand filter unit 136 21 is automatically controlled.

Secondary Brine Filtration 137

Brine from the primary filtration 136 is collected in the primary filtered brine tank 137 121 and is fed from this tank with one of the primary filtered brine pumps 137 171 to the precoat filter unit 137 21.

The precoat filter unit 137 21 comprises two precoat filters which are operated alternately. Filter aid is added to the feed brine to improve the filtration efficiency. Filter aid suspension is prepared in an agitated tank and is fed to the brine by a dosing pump.

The separated solids gradually increase the pressure drop across the filter. The rate of pressure increase is reduced by the filter aid cake. After some time, brine flow is switched to the second filter and the first filter is back washed with compressed air for dewatering the solids. The filter cake is discharged into a lorry for disposal outside battery limits.

The back washed filter stands by until the other filter is back washed. Before putting into service, the back washed filter is precoat by circulating a filter aid slurry through the filter. The filter aid deposits in the filter and ensures a high filtration efficiency right from the begin. The filter aid slurry is prepared in an agitated tank and circulated by one of the primary filtered brine pumps 137 171.

The brine flow rate through the precoat filter unit 137 21 is automatically controlled.

Ion Exchange Filtration 138

Filtered brine from the secondary filtration 137 is directly fed to the ion exchange filter unit 138 21 for removal of dissolved calcium ions and other polyvalent cations. On the way to the ion exchange filter unit, the brine is heated in the brine heater 138 141 with steam to the temperature at which the performance of the ion exchange filter unit is optimum. The brine temperature is controlled automatically.

The ion exchange filter unit comprises 2 ion exchange filters. In normal operation, the filters are connected in series with respect to the brine flow. The ion exchange resin in the first filter adsorbs the dissolved calcium and most other dissolved polyvalent cations. The second column is working as a safety column to trap any leakage of calcium when the first column reaches its saturation point.

After some time of operation, depending on the feed brine quality, the first column is saturated with calcium and other multivalent cations leading to an calcium breakthrough and therefore requires a regeneration. For this purpose, the first filter is removed from service and the second filter becomes the main adsorbing filter. After completion of regeneration, the regenerated filter will be put back in service as the second filter in the row.

For regeneration, the filter must first be thoroughly flushed with demineralised water to displace the brine. The brine contains some chlorate that would react to chlorine with the strong acid used in the next step chlorine irreversibly damages the ion exchange resin.

Then, the resin is back washed with water flowing upwards for removal of solid impurities that might have accumulated in the resin.

After the back wash step is completed, dilute hydrochloric acid is circulated through the ion exchange resin bed to replace calcium and other polyvalent ions by hydrogen ions.

After another rinse with demineralised water, the resin is converted from its hydrogen form to the sodium form by circulating dilute caustic soda through the resin bed.

Finally, the caustic soda is flushed out from the resin with demineralised water and the regeneration procedure is completed by displacing the demineralised water with purified brine.

Hydrochloric acid and caustic soda used for the regeneration are metered in tanks and are fed and diluted with water jet pumps to the ion exchange filters.

The quality of the purified brine is monitored by measuring the calcium content with an online analyser.

Purified Brine Storage 139

The purified brine is stored in the purified brine tank 139 121 and is transferred to the electrolysis section 12 with the purified brine pump 139 171.

CHLORINE PROCESSING SECTION 14

Chlorine Cooling 141

Hot chlorine gas from the electrolysis section contains water vapour and some brine mist. It is first cooled in the primary chlorine cooler 141 141 by cooling water and then in the secondary chlorine cooler 141 142 by chilled water for maximum condensation of the water vapour. The cooled gas is then passed through the gas filter 141 161 for efficient separation of the entrained brine mist and condensate. The gas filter is self-cleaning.

Condensate from the coolers 141 141 and 141 142 and the gas filter 141 161 is saturated with chlorine. It is collected and recycled by gravity to the electrolysis section 12.

During start-up and in case of a blockage in the downstream equipment, the cooled chlorine gas is automatically vented to the chlorine absorption section 18.

Chlorine Drying 142

Wet filtered chlorine gas from cooling 141 is passed to the chlorine drying unit 142 21 for removal of the residual moisture by sulphuric acid.

Drying of the main stream of cooled and filtered chlorine gas is effected in a 2-stage tower system comprising a packed section and an impingement tray section using sulphuric acid of 98.5 % concentration as drying agent. Concentrated acid is fed to the top of the upper tower part and flowing via several impingement trays to the lower tower part, where the acid is circulated and cooled in a plate type heat exchanger to remove the heat of water absorption and acid dilution. The chlorine gas flows counter-currently to the acid through the towers and is thereby dried to a residual moisture content of less than 20 wppm. By absorption of moisture, the sulphuric acid is diluted to about 75 %. This dilute acid is further treated in tanks for dechlorination by air. The dechlorinated acid is disposed off and may be used for other applications.

The chlorine drying unit comprises two drying columns connected in series with respect to the chlorine gas. The gas is first passed through a packed column in which most of the moisture is absorbed. Sulphuric acid is circulated from the bottom of the column through a cooler back to the top of the column and is diluted by the absorption of water. The heat of absorption and the heat of dilution are removed in the cooler by chilled water.

Finally, drying is completed by passing the chlorine gas through a column with several high efficiency impingement plate trays. Fresh concentrated sulphuric acid is fed to the top of the column and flows counter current to the chlorine gas from tray to tray.

Dried chlorine gas leaving the top of the second drying column is directed to compression 144. Recycle chlorine gas from compression is added at the bottom of the second drying column to maintain the optimum performance at any production of chlorine gas.

From the bottom of the second stage drying column, sulphuric acid is drained to the first stage drying column for further absorption of moisture. An equivalent amount of dilute sulphuric acid overflows from the first drying column. This acid stream contains dissolved chlorine. It is collected in one of the 2 tanks 142 122 which are alternately filled. The acid in the full tank is treated with air for stripping dissolved chlorine. Stripping air is supplied from the blower 142 181. Spent stripping air containing chlorine is vented to the chlorine absorption section 18. Dechlorinated acid is transferred with the pump 142 172 outside battery limits.

Fresh concentrated sulphuric acid from outside battery limits is fed from an intermediate storage tank 142 121 by the dosing pump 142 171 to the chlorine drying unit 142 21.

The concentration of the acid circulated to the top of the first drying column is continuously monitored by measuring the density. In addition, the flow rate and the temperature of the sulfuric acid are also continuously measured to monitor the efficiency of the chlorine drying unit 142 21.

Chlorine Compression 144

For easy liquefaction of chlorine at a reasonable temperature, the pressure of the dried chlorine gas from drying 142 is increased in the chlorine compression unit 144.

This unit consists of a sulphuric acid ring compressor with a complete sulphuric acid circulation system. Dried chlorine gas and sulphuric acid are fed to the compressor in which the sulphuric acid forms a rotating seal ring between the impeller and the casing.

Sulphuric acid leaves the compressor with the compressed chlorine gas and is separated from the compressed chlorine gas in a separator. For thorough separation of the sulphuric acid, a high efficiency fibre bed gas filter is integrated with the separator. From the separator in the chlorine compression unit 144 21, the compressed chlorine gas is sent to liquefaction 145.

The sulphuric acid is recycled from the separator to the compressor. Between separator and compressor, it is cooled in a heat exchanger with chilled water.

The compression of the chlorine could be also achieved in reciprocating piston compressors or centrifugal compressors (turbo) subject to the pressure and the plant capacity.

The suction capacity of the chlorine compression unit 144 21 is constant. The net compression capacity is adjusted to the chlorine production by recycling compressed chlorine gas back to the drying 142 in such way that the chlorine gas pressure in the cell room 121 is constant.

Chlorine Liquefaction 145

Liquefaction of most of the chlorine gas from compression 144 is performed by condensation in a heat exchanger that is cooled by evaporating refrigerant. The heat exchanger is part of the chlorine liquefaction unit 145 21 which comprises the whole closed refrigerant circulation system.

Evaporated refrigerant from the chlorine condenser is compressed by a refrigerant compressor and is then condensate in another heat exchanger with cooling water. The condensate refrigerant is collected in a receiver and is fed to the chlorine condenser as required to maintain therein the correct refrigerant level. The capacity of the refrigerant system is automatically controlled.

Liquid chlorine is drained from the chlorine liquefaction unit 145 21 to storage outside battery limits. Inert components of the chlorine gas are vented to chlorine absorption section 18. In accordance with the chlorine vapour pressure and liquefaction temperature, this vent gas still contains some chlorine. The liquefaction pressure is automatically controlled. An on-line analyser monitors the tail gas continuously for hydrogen which might be contained in the chlorine gas in the remote case of a hole in a membrane in the electrolyzers 121 111.

Liquid Chlorine Storage 146 A

Liquid chlorine is received in one of the Storage Tanks 146 121 at the pressure and temperature prevailing in Chlorine Liquefaction 145. The gas displaced in the tanks by the liquid chlorine contains chlorine and inerts and is vented back to the feed side of the Chlorine Liquefaction Unit 145 21 for recovery of chlorine. The collected liquid chlorine is stored in the other storage tanks, whereby one storage tank is always kept empty for transfer of liquid chlorine from another storage tank in case of an emergency.

From one of the full storage tanks, liquid chlorine is transferred to the consumers by pressurising the tank with dry compressed padding air. The pressure in the storage tank is automatically controlled and the feed of padding nitrogen is automatically stopped in case of inadequate air pressure or stoppage of liquid chlorine transfer.

The liquid chlorine content of each storage tank is monitored by measuring its weight. The storage tanks are equipped with safety relief valves.

CAUSTIC SODA PROCESSING SECTION 15

Cooling 151

Hot caustic soda from the electrolysis section 12 is cooled in the heat exchanger 151 141 with cooling water and is then directed to the storage outside battery limits. The pressure of the hot caustic soda from the electrolysis section is automatically controlled.

Concentration 152

Hot caustic soda from the electrolysis section 12 is fed to the caustic soda concentration unit 152 for concentration to 50 % NaOH.

The caustic soda concentration unit 152 21 comprises two falling film evaporators connected in series with respect to the caustic soda flow. Feed caustic soda is added at the top of the first evaporator. From the bottom of the first evaporator, caustic soda is pumped to heat exchangers for heat recovery from the product caustic soda and from the steam condensate and then to the top of the second evaporator. From the bottom of the second evaporator, caustic soda with a concentration of 50 % NaOH is finally pumped to the respective heat recovery heat exchanger and then to another heat exchanger for further cooling with cooling water and from this cooler to storage outside battery limits.

The second evaporator is heated with fresh steam. Steam condensate is collected in a receiver from which it is passed through the respective heat recovery heat exchanger. From this heat exchanger, it is returned outside battery limits.

The first evaporator is heated with the process vapours from the second evaporator. The process condensate from the first evaporator is added to the return cooling water receiving tank.

The first evaporator is operated at reduced pressure on the caustic soda side. The process vapours from the first evaporator are fed to a mixing condenser for condensation with cooling water. The mixing condenser is vented to a vacuum unit with steam jet vacuum pumps. The steam from the vacuum pumps is also condensate by mixing with cooling water.

The return cooling water is collected in a receiving tank and is pumped outside battery limits.

The boiling pressure and the temperature, and thus the concentration, of the caustic soda from the second evaporator as well as the caustic soda levels in the first and the second evaporator, the condensate level in the steam condensate receiving tank and the water level in the return cooling water receiving tank are all controlled automatically.

HYDROGEN PROCESSING SECTION 16

Cooling 161

Hot hydrogen from the electrolysis section 12 contains a substantial amount of water vapour and some caustic soda mist. It is cooled to 40 °C in a heat exchanger by means of cooling water to condensate most of the water vapour. Most of the water vapour is condensate in the cooler 161 141 by cooling water. The cool gas is then passed through the gas filter 161 161 for efficient separation of entrained caustic soda mist and condensate. The gas filter is self-cleaning.

Filtered hydrogen is fed to the blower 161 181 to increase the pressure as required by the hydrochloric acid section 17 and other consumers. The blower has a constant suction capacity. The net compression capacity is adjusted to the hydrogen production by recycling compressed hydrogen back to the cooler 161 141 in such way that the hydrogen pressure in the cell room 121 is constant. The hydrogen pressure in the cell room is high enough to maintain a positive pressure throughout the hydrogen processing section.

During start-up and shutdown and in case of a blockage in the downstream equipment, the cooled hydrogen and the compressed hydrogen are automatically vented over the roof.

HYDROCHLORIC ACID SECTION 17

Synthesis 171

Hydrochloric acid is easily produced by burning chlorine and hydrogen to hydrogen chloride and absorbing the hydrogen chloride in water:



Reaction and absorption produce a large amount of heat that must be removed before producing high concentration hydrochloric acid. The synthesis is performed at a small excess of hydrogen to ensure conversion of chlorine

Hydrochloric acid production unit comprises a synthesis unit combining reaction and most of the absorption. Chlorine gas and hydrogen are fed to the burner that is integrated in the unit. The combustion chamber and in particular the absorption section of the unit are cooled with cooling water.

Tail gas from the synthesis unit still contains some hydrogen chloride and is scrubbed in a packed column with the fresh demineralised water. The scrubbed tail gas is vented over roof. Before start-up and after shutdown, the system is vented by a steam jet blower. The steam that is fed to the jet blower is condensate by mixing with cooling water.

Spent water from the tail gas scrubbing column is fed to the synthesis unit for use as absorption water. By using demineralised water, a very high purity hydrochloric acid is produced.

The flow rates of chlorine gas and hydrogen are automatically controlled. The concentration of the hydrochloric acid product is maintained at the specified level by automatically controlling its density and adjusting the demineralised water flow rate.

In case of a flame failure or a failure of another essential operating parameter, the production unit is automatically shut down and flushed with nitrogen.

CHLORINE ABSORPTION SECTION 18

Continuous Chlorine Absorption 181

Continuous streams of dilute chlorine gas from various sources, including the tail gas from the liquefaction 145 in the chlorine processing section 14 and air with chlorine from the decolourisation 131 in the brine preparation section 13 and from the drying 142 in the chlorine processing section 14 are collected and absorbed in the chlorine absorption section 18 which is also designed for the absorption of the full chlorine production for a short time in case of emergency. In the absorption equipment, the chlorine reacts very fast with caustic soda to sodium hypochlorite:



Gas is scrubbed with a large amount of sodium hypochlorite with sufficient excess caustic soda in the jet scrubber 181 131. In the hypochlorite circulation tank 181 121, sodium hypochlorite solution is again separated from the gas. The hypochlorite circulation pumps 181 171 charge the sodium hypochlorite solution from the hypochlorite circulation tank to the hypochlorite cooler 181 141 where the heat of reaction of removed by chilled water. From the hypochlorite cooler, the sodium hypochlorite solution is fed back to the jet scrubber.

Dilute caustic soda from the final absorption 183 added on the suction side of the hypochlorite circulation pumps 181 171 and an equivalent amount of finished sodium hypochlorite solution is branched off from the circulated sodium hypochlorite solution after the hypochlorite cooler 181 141.

The suction in the chlorine vent system is automatically controlled by recycling tail gas from the final absorption 183. The excess caustic soda in the circulated sodium hypochlorite solution is automatically controlled by measuring the redox potential of the sodium hypochlorite solution with minimum delay time right after the jet scrubber 181 131 and adjusting the feed of dilute caustic soda to the final absorption 183.

Final and Emergency Chlorine Absorption 182

The absorption of residual chlorine leaving Continuous Absorption 181 or the absorption of chlorine gas released for a short time during emergency is completed by scrubbing the gas with dilute caustic soda in the Chlorine Absorption Column 182 131, which contains only a small amount of sodium hypochlorite and accordingly a very high amount of excess caustic soda.

From the Chlorine Absorption Column 182 131, tail gas is sucked by the Blower 182 181 and vented over the roof. The blower provides for adequate suction throughout the dilute chlorine vent system. The suction in the emergency vent system is automatically controlled by the intake of ambient air into the gas stream leaving the absorption column.

Dilute caustic soda is drained from the Chlorine Absorption Column 182 131 to the Circulation Tank 182 121 and is circulated by the Pumps 182 171 to the Caustic Soda Cooler 182 141 for cooling by chilled water and back to the top of the Chlorine Absorption Column 182 131. The caustic soda circulation tank contains sufficient pre-cooled dilute caustic soda for an emergency absorption of the full chlorine production for a short time, even if no fresh caustic soda and no cooling water are available. An equivalent amount of cooled caustic soda is fed to the Continuous Chlorine Absorption 181.

To the extent required in Continuous Absorption 181, fresh dilute caustic soda is prepared by mixing caustic soda with demineralised water in Inline Mixer 182 151. The resulting dilute caustic soda is added on the top of the Chlorine Absorption Column 182 131.

Fresh caustic soda is automatically controlled by the level in the Circulation Tank 182 121 and the demineralised water flow is automatically controlled by the density of the dilute caustic soda after the Inline Mixer 182 151.

6. PRODUCT QUALITY

The following are typical product qualities achieved by a Chloralkali plant:

Cooled caustic soda solution	32 to 33 % w/w NaOH max. 50 ppm w/w NaCl gauge pressure 3 to 6 bar temperature 20 to 40 °C
Concentrated caustic soda solution	48 to 50 % w/w NaOH max. 80 ppm w/w NaCl gauge pressure 2 to 4 bar temperature 20 to 40 °C
Liquid chlorine	Min. 99.7 % w/w Cl ₂ max. 0.2 % w/w CO ₂ max. 0.1 % w/w O ₂ gauge pressure 1.5 to 2.0 bar temperature -15 to -10 °C
Compressed hydrogen	Min. 99.9 % v/v H ₂ on dry basis saturated with water vapour at 20 to 40 °C gauge pressure 0.10 to 0.15 bar temperature 40 to 60 °C
Hydrochloric acid	30 to 32 % w/w HCl chemically pure grade gauge pressure 0 to 0.5 bar temperature 30 to 50 °C
Sodium hypochlorite solution	80 to 120 gpl available Cl ₂ 5 to gpl NaOH gauge pressure 2 to 5 bar temperature 20 to 30 °C

All pressures are measured at grade.

7. SPECIFICATION OF RAW MATERIALS, CHEMICALS AND UTILITIES

The following raw materials, auxiliary chemicals and utilities are required at battery limits:

Salt	Upgraded solar salt min. 95.3 % w/w NaCl max. 0.29 % w/w Ca^{++} max. 0.20 % w/w Mg^{++} max. 1.2 % w/w SO_4^{--} max. 0.06 % w/w K^+ max. 0.01 % Fe_2O_3 max. 1.4 % w/w H_2O max. 1.02 % w/w insoluble no other impurities $\text{Ca}^{++} / \text{Mg}^{++}$ min. 0.87 mol / mol particle size 2.5 to 4.5 mm in railway cars
Caustic soda	Membrane cell grade 32 to 50 % w/w NaOH max. 45 ppm w/w NaCl gauge pressure 2 to 4 bar temperature 20 to 40 °C in pipeline
Soda ash	Technical grade min. 98 % w/w Na_2CO_3 max. 0.01 % w/w Fe max. 0.005 % w/w Ca^{++} in bags
Coagulant	Nitrogen free quality in bags
Hydrochloric acid	chemically pure grade 30 to 32 % w/w HCl max. 5 ppm w/w ClO^- max. 0.001 % w/w Fe max. 0.5 ppm w/w $\text{Ca}^{++} + \text{Mg}^{--}$ as Ca^{++} gauge pressure 4 to 5 bar temperature 30 to 50 °C in pipeline
Sodium sulfite	Technical grade min. 96 % w/w Na_2SO_3 max. 0.001 % w/w Fe max. 0.005 % w/w Ca^{++} in bags

Calcium chloride	Technical grade min. 98 % w/w CaCO_2 max. 0.001 % w/w Fe max. 0.01 % w/w SO_4^{--} in bags
Sulfuric acid	Technical grade 98 to 99 % w/w H_2SO_4 in pipeline
Process water	Filtered river water P-alkalinity (CaCO_3) max. 0 mgpl M-alkalinity (CaCO_3) max. 165 mgpl Hardness (CaCO_3) max. 400 mgpl Calcium (CaCO_3) max. mgpl Magnesium (CaCO_3) max. mgpl max. 12 mgpl Cl^- max. 1 mgpl PO_4 max. 15 mgpl Na^+ max. 5 mgpl SiO_2 max. 10 mgpl SO_4 max. 5 mgpl NO_3 max. 5 mgpl O_2 max. 0 mgpl CO_2 0 mgpl Cl_2 max. 325 mgpl total dissolved solids max. 5 mgpl suspended solids no other impurities pH 7.0 to 8.3 gauge pressure 4 to 5 bar temperature 0.5 to 25 °C in pipeline
Cooling water	Wet cooling tower water, treated supply temperature 20 to 30 °C supply gauge pressure 4 to 5 bar in pipeline
Chilled water	Treated closed circuit water supply temperature 9 to 11 °C supply gauge pressure 4 to 5 bar in pipeline
Demineralised water	From demineralised water storage conductivity max. 10 microS/cm max. 0.1 wt ppm Fe temperature 10 to 30 °C gauge pressure 4 to 6 bar in pipeline
High pressure nitrogen	Min. 99 % w/w N_2 dew point temperature

	at atmospheric pressure max. -30 °C oil and dust free gauge pressure 5 to 6 bar temperature 20 to 40 °C in pipeline
Low pressure nitrogen	Min. 99 % w/w N₂ dew point temperature at atmospheric pressure max. -30 °C oil and dust free gauge pressure 0.04 to 0.06 bar temperature 20 to 40 °C in pipeline
High pressure steam	Saturated gauge pressure 9 to 10 bar in pipeline
Low pressure steam	Saturated gauge pressure 1.0 to 1.5 bar in pipeline
HT electric power	11 kV +/- 10 %, 50 Hz +/- 2 %, 3 phases for Rectifier unit 6 kV +/- 10 %, 50 Hz +/- 2 %, 3 phases for motors at CDS
Emergency power	400 Volt +/- 10 %, 50 Hz +/- 2 % available within max. 10 s from failure of HT supply in cable
Compressed air	Oil and dust free gauge pressure 6 to 8 bar temperature 20 to 40 °C in pipeline
Padding air	Oil and dust free gauge pressure 9 to 10 bar dew point temperature at atmospheric pressure max - 50 °C in pipeline
Instrument air	Oil and dust free dew point temperature at atmospheric pressure max. -30 °C gauge pressure 6 to 8 bar temperature 20 to 40 °C in pipeline

8. OPERATING REQUIREMENTS

Estimated operating requirements for fabrication of the different products are summarised below. Plant sections and process areas utilised are indicated and are considered to be operated at design capacity.

COOLED CAUSTIC SODA, LIQUID CHLORINE AND COMPRESSED HYDROGEN

Plant sections and process areas 11, 12, 13, 14, 151 and 16,

Raw Materials, Auxiliary Chemicals and Utilities

Expected consumption for production of

1000	kg NaOH in form of cooled caustic soda with 32 to 33 % NaOH,
810	kg Cl ₂ in form of liquid chlorine,
95	kg Cl ₂ in form of dilute chlorine gas and
290	Nm ³ H ₂ in form of compressed hydrogen
25	kg sulfuric acid containing about 80 % H ₂ SO ₄

Raw Materials, Auxiliary Chemicals and Utilities

Salt	1500 kg NaCl	
Caustic soda	15 kg NaOH	
Soda ash	8 kg Na ₂ CO ₃	
Barium chloride	9 kg BaCl ₂	
Coagulant	0.1 kg	
Filter aid	0.5 kg	
Hydrochloric acid	38 kg HCl	
Sodium sulfite	0.4 kg Na ₂ SO ₃	
Sulfuric acid	25 kg H ₂ SO ₄	
Demineralised water	3 m ³	
Process water	0.5 m ³	
High pressure nitrogen	pro memoria	
Low pressure nitrogen	pro memoria	
Low pressure steam	0.2 t	
Cooling water	100 m ³	
Chilled water	10 m ³	
HT electric power	2000 to 2500 kWh, depending on current	density
LT electric power	90 kW	
Emergency power	pro memoria	
Compressed air	pro memoria	
Instrument air	pro memoria	

Shift Labour

Shift supervisors	1
Shift operators	approx. 4
Day shift operators	approx. 2

Effluents and Wastes

Expected production from production of
1000 kg NaOH and related products as listed in 1.1 above

Sludge and filter cake from settling pond 132 161, from filter press 134 162 and from precoat filter unit 136 21
40 kg

Effluent from back wash of sand filter unit 135 21, from regeneration of ion exchange filter unit 137 21 and from hydrogen cooler 161 141
1.1 m3

Effluent from sampling, accidental spillage and floor washing, etc.
pro memoria

CAUSTIC SODA (50 % NaOH)

Process Area 152

Raw Materials, Auxiliary Chemicals and Utilities

Expected consumption for concentration of
1000 kg NaOH in form of cooled caustic soda to caustic soda containing
50 % NaOH,

Demineralised water	0.1 m ³
Process water	pro memoria
High pressure steam	0.8 t
Cooling water	55 m ³
LT electric power	10 kWh
Compressed air	pro memoria
Instrument air	pro memoria

Shift Labour Requirements

Typical shift labour required for operation of process area 152:

Shift operators	approx. 0.5
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Effluents and Wastes

Expected production from concentration of caustic soda in process area 152:

Effluent only from sampling, accidental spillage and floor washing, etc.
pro memoria

HYDROCHLORIC ACID

Plant section 17

Raw Materials, Auxiliary Chemicals and Utilities

Expected consumption for production of

1000 kg HCl in form of hydrochloric acid with 30 to 32 % HCl

Chlorine gas	973 kg Cl ₂
Hydrogen	330 Nm ³ H ₂
Demineralised water	2.3 m ³
Process water	pro memoria
High pressure nitrogen	pro memoria
High pressure steam	pro memoria
Cooling water	175 m ³
LT electric power	pro memoria
Compressed air	pro memoria
Instrument air	pro memoria

Shift Labour Requirements

Typical shift labour required for operation of plant section 17:

Shift operators approx. 0.5

Effluents and Wastes

Expected production from concentration of caustic soda in plant section 17:

Effluent only from sampling, accidental spillage and floor washing, etc.
pro memoria

ABSORPTION OF CHLORINE

Plant section 18

Consumption of Raw Materials, Auxiliary Chemicals and Utilities

Expected consumption for absorption of
1000 kg Cl₂ in caustic soda

Caustic soda	1240 kg NaOH
Process water	7 m ³
Chilled water	75 m ³
LT electric power	25 kWh
Emergency power	pro memoria
Compressed air	pro memoria
Instrument air	pro memoria

Shift Labour Requirements

Typical shift labour required for operation of plant section18:

Shift operatorsapprox. 1

Effluents and Wastes

Expected production from absorption of chlorine in Plant Section 18:

Effluent only from sampling, accidental spillage and floor washing, etc.
pro memoria

9. PLANT LAYOUT

The layout of the plant depends on the dimensions of the plot available, on the type of final products and product mix, on site feed and products storage requirement, existing infrastructure and the like.

10. PLANT LOCATION

The plant is assumed to be constructed indoor at a single and compact site in new civil constructions in accordance with GEA Messo AG basic drawings.

The climatic conditions are assumed to be within the following limits and must be confirmed.

Climatic conditions	moderate
Ambient air temperature	
dry bulb	10 to 40 °C
wet bulb	max. 27 °C
dew point	max. 25 °C
Atmospheric pressure	940 to 1020 mbar
Altitude above sea level	100 m
Rain	Max. 1000 mm per year with max. 50 mm per day and max. 20 mm per hour
Wind	Max. 120 km / h
Special risk	None

11. DESIGN FLEXIBILITY

GENERAL

The above process description and the supporting process flow diagrams and equipment and material list are based on a typical battery limits Chloralkali plant incorporating the various process plant sections described. The design concepts can be changed wherever appropriate to suit the precise requirements of any project. GEA Messo AG specialists have the design capability and the breadth of experience to propose a wide range of alternative processing techniques that may be appropriate to meet individual requirements or to optimise operational efficiency and economy for any particular project:

POWER RECTIFICATION SECTION 11

- High tension switch gear for incoming HT power

ELECTROLYSIS SECTION 12

- On-load DC switches to facilitate shutdown of individual electrolyzers

BRINE PREPARATION SECTION 13

- Primary dechlorination by vacuum stripping instead of by air stripping
- Secondary dechlorination by active carbon instead of by sulfite addition
- Neutralisation of dechlorinated brine with milk of lime instead of caustic soda
- Salt storage and handling
- Control of sulfate concentration by brine purging, suppression of calcium sulfate dissolution, calcium sulfate crystallisation or use of barium carbonate instead of barium chloride
- Filtration by membrane filters instead of by sand filters and precoat filters
- Heat recovery from the hot chlorine gas
- Ion exchange filtration with 3 instead of 2 filters
- Automatic regeneration of sand filters and precoat filters
- Acidification of purified brine, for production of chlorine gas with low carbon dioxide and oxygen concentration.

CHLORINE GAS PROCESSING SECTION 14

- Compression of wet chlorine gas, for direct use
- Compression of dried chlorine gas with reciprocating piston compressors, screw compressors and centrifugal compressors
- Two and three stage compression to higher pressures
- Liquefaction with higher and lower temperatures and pressures
- Higher or lower liquefaction efficiency
- Storage and pumping facilities for concentrated and dilute sulfuric acid
- Liquid chlorine storage
- Evaporation of liquid chlorine
- Filling of liquid chlorine into cylinders, tonners, tank trucks and/or railway tank cars etc.
- Cleaning and testing of liquid chlorine containers

CAUSTIC SODA PROCESSING SECTION 15

- Storage and transfer of caustic soda with 32 % NaOH
- Filling of 32 % caustic soda into containers and / or tankers
- Single effect or triple effect concentration instead of double effect
- Storage and transfer of caustic soda with 50 % NaOH
- Filling of caustic soda with 50 % NaOH into containers and / or tankers
- Evaporation of caustic soda to 98 % NaOH with drum filling or production of flakes or prills and storage and handling of drums and / or bags

HYDROGEN PROCESSING SECTION 16

- Hydrogen drying
- Storage in gasholder(s)
- High pressure compression and filling into cylinders

HYDROCHLORIC ACID SECTION 17

- Production of hydrogen chloride gas instead of hydrochloric acid
- Storage and transfer of hydrochloric acid
- Filling of hydrochloric acid into containers and / or tankers

CHLORINE ABSORPTION SECTION 18

- Production of sodium hypochlorite solution with higher or lower concentration
- Production of calcium hypochlorite solution instead of sodium hypochlorite solution
- Storage and transfer of hypochlorite solution
- Filling of hypochlorite solution into containers and / or tankers
- Recovery of chlorine from hypochlorite solution, using waste acid

OVERALL PLANT

- Installation of stand-by equipment
- Pipe racks with connections between plant sections
- Computerised process control system
- Higher or lower degree of automation
- Manufacture of other products based on chlorine, caustic soda and hydrogen
- Utilities preparation systems
- Off-site facilities

12. SAFETY

Chloralkali plants pose various degrees of hazards. Some of these are of a general nature, such as the use of rotating machines and operation at high temperatures and the extensive use of electric power. A more specific hazard arises from the use of high current and the risk of direct contact with energised electric current conductors. The highest hazards for such plants arise from the presence of highly toxic, corrosive and explosive chemicals. Hence a safety conscious approach and close attention to detail for alleviating and eliminating the hazards are basic requirements for successful conceptual and detailed design of the various plant sections, and of certain individual pieces of equipment and systems in particular.

It must be recognised that total elimination of hazards is not a practical proposition since it is prohibitively expensive. Nevertheless, the requirements for safe design must be considered at every step. Capitalising on the one hand, on the very extensive past experience in this special field, on the other hand, on the newest technological advances.

Chlorine is a very toxic gas that can be lethal at quite low doses. Primary safety is provided by reducing the possibility of its escape. For example, production by electrolysis and drying of the gas is carried out at atmospheric pressure. Additionally, automatic monitoring, alarm systems, control and shut-down instruments are just a few of the devices to be employed to achieve safe operation of the plant.

For corrosive liquids such as sulfuric and hydrochloric acids, sodium hypochlorite and caustic soda the first line of defence is selection of suitable materials of construction, for which concentration and temperature are important parameters. For example, concentrated sulfuric acid at low temperature can be handled safely in carbon steel equipment while for dilute acid, expensive alloys must be used. Similarly, hot concentrated caustic requires nickel while at low temperature steel can be used.

The major explosive hazard in a chloralkali plant originates from mixtures of hydrogen and chlorine. Ingress of air to the hydrogen system is equally dangerous. The hydrogen content in chlorine gas can be detected. It is measured by a suitable device, continuously analysing, monitoring and actuating an alarm in case of high hydrogen content. A typical example being the hydrogen content of sniff gas from chlorine liquefaction.

Mixing of hydrogen with air is prevented by consequently flushing the hydrogen system with nitrogen before start-up and after shutdown. Ingress of air to the hydrogen system is prevented by operating the hydrogen system slightly above atmospheric pressure and by employing suitable means to prevent the system from being at any time under vacuum.

13. BATTERY LIMITS

The battery limits comprise the individual plant sections including the process equipment specified, in the following chapter “Equipment and Material Specifications”.

In detail, the battery limits are defined as follows:

For raw materials, products, auxiliary chemicals and utilities in pipelines	At the boundary of the individual plant sections
For raw materials, products, auxiliary chemicals and utilities in containers	At the respective equipment within the plant sections
For HT electric power supply	At the rectifier units
For LT electric power supply	At the LT distribution boards within the individual plant sections
For process control instrument power and signals	At junction boxes within the individual plant sections
For effluents	At the individual discharge point to the effluent trenches

14. EQUIPMENT AND MATERIAL SPECIFICATIONS

The equipment and material covered by this document is described in the subsequent list. It comprises all materials, equipment instrumentation and controls required for a continuous and safe operation. Standby equipment philosophy or degree of automation is defined when establishing the basis of design for a specific project.

In general, the equipment and material is designed, fabricated and tested in accordance with DIN standards and regulations and codes of practice applicable in Switzerland, Germany and Japan.

Unless specified otherwise, all equipment is supplied complete with supports and foundation bolts. Machinery will be supplied complete with couplings and coupling guards or V belts and V belt guards. Electric equipment is minimum protection class IP54. Where required by the relevant regulations, the electric equipment is explosion proof.

The equipment and material will be purchased from qualified fabricators who have previously supplied similar equipment and material to the Chloralkali industry and dispose of positive experience with such similar equipment and material. The equipment will be fabricated with adequate quality control and will be tested before leaving the fabricator's workshops.

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
11		POWER RECTIFICATION SECTION		
111		Production Power Conversion		
111 21	1	Set of Rectifier Units comprising: - oil immersed transformers with oil expansion tank, air dryer, rollers and standard accessories - oil circulation pumps with motors - double tube heat exchangers for oil cooling by cooling water - rectifier cubicles with silicon thyristors, ignition transformers, internal AC and DC bus bars and internal wiring - demineralised water circulation pumps with motors - heat exchangers for cooling of demineralised water by cooling water - ion exchanger for demineralised water	Conversion of AC power to DC power	

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	(Op.+std-by)			
		- internal piping, valves and fittings - process control instruments for automatic control current monitoring and remote operation and protection of rectifier units by DCS, and local pressure indicators and thermometers - high current connections between transformers and rectifier cubicles - DC bus bars		
112		<i>Polarisation Power Conversion</i>		
112 591	1	Polarisation Rectifier with thyristors, DC connections for individual Electrolysers and instruments for remote control of DC voltage and individual Dc connections and protection of rectifier by DCS	Supply of polarisation power	
110 32	1	Set of Valves	Utilities	Cast iron
110 34	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Utilities	Carbon steel
110 35	1	Lot of Material for Supports and Hangers including fixing material	Process piping and utilities piping	Carbon steel
110 45	1	Set of Cables	Connections between process control instruments and DCS	
110 46	1	Lot of Installation Material such as junction boxes, cable trays, glands, solenoid valves, fixing material	Process control signal cables	
110 5	1	Set of Electrical Equipment comprising push button stations, LT distribution board, power and motor control cables, installation material, etc.	Power distribution and Motor Control	

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i> <i>(Op.+std-by)</i>	<i>Service</i>	<i>Main Material of Construction</i>
110 63	1	Lot of Coating Material	Corrosion protection on outer surfaces of equipment and piping	Epoxy based zinc dust primer, two component epoxy resin for intermediate and top coats
12		ELECTROLYSIS SECTION		
<i>121</i>		<i>Cell Room</i>		
121 111	1	Set of Bipolar Electrolysers complete with coated anodes, coated cathodes and membranes	Chloralkali electrolysis	Anode compartments titanium, cathode compartments nickel, cell frame carbon steel, headers FRP with PVC liner, flexible hoses PTFE
121 41	1	Set of Process Control Instruments comprising: - complete cell voltage monitoring system - transmitters for temperature of caustic soda from individual Electrolysers - local flow meters, pressure indicators and thermometers	DCS supported process control	
121 51	1	Set of Electrodes	Measurement of electric potential in headers and protection of equipment	Coated titanium and nickel
121 54	1	Set of Isolators	Isolation of individual Electrolysers from DC supply	Copper
121 55	1	Set of Bus Bars	DC supply to Electrolysers	Copper

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
122		<i>Auxiliary Installations</i>		
122 121	1	Tank	Depleted brine	FRP
122 122	1	Tank	Caustic soda	Rubber lined steel
122 123	1	Tank	Chlorate decomposition	FRP
122 141	1	Plate Type Heat Exchanger	Cooling and heating of caustic soda by cooling water and steam	Nickel and carbon steel
122 171	1	Centrifugal Pump complete with motor	Depleted brine	Titanium
122 172	1	Centrifugal Pump complete with motor	Caustic soda	Special grade stainless steel
122 41	1	Set of Process Control Instruments comprising: - transmitters for flow rate of feed brine, recirculated caustic soda and demineralised water, level in tanks 122 121 and 122 122, pressure of feed brine, chlorine gas, recirculated caustic soda and hydrogen, temperature of recirculated caustic soda, pH of depleted brine and density of caustic soda - pneumatic control valves for feed brine, depleted brine, recirculated caustic soda, product caustic soda, demineralised water and cooling water - local flow meters, level indicators, pressure indicators and thermometers	DCS supported process control	
123		<i>Cell Maintenance Area</i>		

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	<i>(Op.+std-by)</i>			
123 41	1	Set of Process Control Instruments comprising: - local pressure indicators and thermometers	Process control	
123 71	1	Overhead Travelling Bridge Crane capacity 3 t, span about 17 m, with isolated hook, complete with gear motors	Transportation of Cell Units, Hydraulic Press Unit, Membrane Stage, etc.	Carbon steel
123 72	2	Wall Mounted Swivel Crane capacity 500 kg, complete with gear motor	Handling of Cell Units during maintenance	Carbon steel
123 73	1	Set of Lifting Jigs	Transportation of Cell Units, Hydraulic Press Unit, Membrane Stage, etc.	Carbon steel
123 74	1	Set of Containers	Intermediate storage of Cell Units	Carbon steel
123 91	1	Hydraulic Press Unit complete with oil pump and motor	Opening and closing of Electrolysers	Carbon steel
123 92	1	Membrane Stage	Assembly of Electrolysers	Carbon steel
123 93	1	Set of Temporary Walkways	Assembly of Electrolysers	Carbon steel
123 94	1	Turning Jig	Cell Units	Carbon Steel
123 95	1	Inspection Stand	Membranes	Carbon steel
120 31	1	Set of Valves	Process media	PTFE lined cast iron, PP, PVC, cast iron
120 32	1	Set of Valves	Utilities	Cast iron
120 33	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Process media	FRP, FRP with PP liner, PP, PVC, carbon steel

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	<i>(Op.+std-by)</i>			
120 34	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Utilities	Carbon steel
120 35	1	Lot of Material for Supports and Hangers including fixing material	Process piping and utilities piping	Carbon steel
120 45	1	Set of Cables	Connections between process control instruments and DCS	
120 46	1	Lot of Installation Material such as junction boxes, cable trays, glands, solenoid valves, fixing material	Process control signal cables	
120 5	1	Set of Electrical Equipment comprising push button stations, LT distribution board, power and motor control cables, installation material, etc.	Power distribution and motor control	
120 61	1	Lot of Hot Insulation Material	Process equipment, process piping and utilities piping	Rock wool with galvanised steel sheet cover
120 63	1	Lot of Coating Material	Corrosion protection on outer surfaces of equipment and piping	Epoxy based zinc dust primer, two component epoxy resin for intermediate and top coats
13		BRINE PREPARATION SECTION		
<i>131</i>		<i>Primary Brine Dechlorination</i>		
131 121	1	Tank	Primary dechlorinated brine	FRP

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	<i>(Op.+std-by)</i>			
131 131	1	Dechlorinator complete with air distribution device	Primary brine dechlorination	Tank rubber lined steel, gas distribution device titanium
131 141	1	Shell and Tube Type Heat Exchanger	Cooling of air with chlorine and water vapour by cooling water	Titanium and carbon steel
131 181	1	Ring Blower complete with motor	Air for primary dechlorination of brine	Cast iron
131 41	1	Set of Process Control Instruments comprising: - transmitters for level in Tank 131 121, pressure of feed brine, chlorine gas, pH of dechlorinated brine and redox potential of dechlorinated brine - local flow meters, level indicators, pressure indicators and thermometers	DCS supported process control	
132		<i>Secondary Brine Dechlorination</i>		
132 151	2	Tank with Agitator complete with gear motor	Preparation of sodium sulfite solution	Tank FRP, agitator rubber lined steel
132 152	1	Inline Mixer	Brine, caustic soda solution and sodium sulfite solution	Rubber lined steel with PP inserts
132 171	1	Centrifugal Pump complete with motor	Transfer of dechlorinated brine	PP with cast iron armour
132 41	1	Set of Process Control Instruments comprising: - pneumatic control valve for dechlorinated brine - local flow meters, level indicators,	DCS supported process control	

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
		pressure indicators and thermometers		
133		Brine Saturation		
133 121	1	Feed Hopper	Salt	Carbon steel
133 122	1	Tank with conical bottom and brine distribution device	Brine saturation	Rubber lined steel
133 161	1	Settling Pond	Grit from Saturator 133 122	Reinforced concrete with internal coating
133 171	1	Vertical Centrifugal Pump complete with motor	Transfer of recovered brine from Settling Pond 133 161	PP
133 191	1	Vibration Feeder complete with power unit	Continuous salt metering	Carbon steel
133 192	1	Belt Conveyor complete with gear motor	Salt feed to Saturator 133 122	Carbon steel structure with rubber belt
133 41	1	Set of Process Control Instruments comprising: - local flow meters and pressure indicators	Process control	
134		Chemical Brine Treatment		
134 111	1	Reaction Tank with Agitator complete with gear motor	Chemical brine treatment	Tank FRP, agitator rubber lined steel
134 121	1	Tank	Caustic soda	Carbon steel
134 151	2	Tank with Agitator complete with gear motor	Preparation of soda ash solution	Carbon steel
134 152	1	Tank with Agitator complete with gear motor	Preparation of barium chloride solution	Tank FRP, agitator rubber lined steel

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i> <i>(Op.+std-by)</i>	<i>Service</i>	<i>Main Material of Construction</i>
134 171	2	Dosing Pump complete with gear motor	Caustic soda for neutralisation of dechlorinated brine and for chemical brine treatment	Carbon steel
134 172	1	Dosing Pump complete with gear motor	Soda ash solution for chemical brine treatment	Carbon steel
134 173	1	Dosing Pump complete with gear motor	Barium chloride solution for chemical brine treatment	PVC
134 41	1	Set of Process Control Instruments comprising: - local flow meters and level indicators	Process control	
135		<i>Clarification</i>		
135 151	1	Tank with Agitator complete with gear motor	Preparation of coagulant solution	Carbon steel
135 161	1	Clarifier with Raker complete with gear motor	Separation of precipitated solids from brine	Carbon steel with internal coating
135 162	1	Filter Press	Dewatering of sludge from Clarifier 135 161	Carbon steel support frame, PP filter plates
135 171	1	Dosing Pump complete with gear motor	Coagulant solution for brine clarifying	Carbon steel

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	<i>(Op.+std-by)</i>			
135 172	1	Sludge Pump complete with compressed air drive	Feed of Clarifier underflow to Filter Press 135 162	PP and rubber
135 41	1	Set of Process Control Instruments comprising: - local flow meters, level indicators and pressure indicators	Process control	
136		<i>Primary Filtration</i>		
136 121	1	Tank	Clarified brine	FRP
136 171	1	Centrifugal Pump complete with motor	Feed of clarified brine to Sand Filter Unit 136 21	PP with cast iron armour
136 21	1	Sand Filter Unit comprising - 2 sand filters with anthracite filling - 1 rotary piston blower with motor - 1 set of internal piping, valves and fit- tings - 1 set of process control instruments for manual control of back wash	Separation of solids from clarified brine	Filters rubber lined steel, blower cast iron, pipelines FRP, PP and carbon steel, valves PP
136 41	1	Set of Process Control Instruments comprising: - transmitter for flow rate of clarified brine - pneumatic control valve for clarified brine - local flow meters, level indicators and pressure indicators	DCS supported process control	
137		<i>Secondary Brine Filtration</i>		
137 121	1	Tank	Primary filtered brine	FRP

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	<i>(Op.+std-by)</i>			
137 171	2	Centrifugal Pump complete with motor	Feed of primary filtered brine to Precoat Filter Unit 137 21	PP with cast iron armour
137 21	1	Precoat Filter Unit comprising: - 2 precoat filters complete with filter inserts and bottom outlet for cake discharge - 1 tank with agitator complete with gear motor for precoat slurry preparation - 1 tank with agitator complete with gear motor for body aid slurry preparation - 1 dosing pump with gear motor for body aid slurry - 1 set of internal piping, valves and fittings - 1 set of process control instruments for manual control of cake dewatering, cake discharge and precoating	Secondary brine filtration	Filters rubber lined steel with PP internals, tanks FRP, agitators rubber lined steel, dosing pump PP, pipelines FRP and PP, valves PP
137 41	1	Set of Process Control Instruments comprising: - transmitter for flow rate of primary filtered brine - pneumatic control valve for primary filtered brine - local flow meters, level indicators and pressure indicators	DCS supported process control	
138		<i>Ion Exchange Filtration</i>		
138 141	1	Plate Type Heat Exchanger	Heating of filtered brine by steam	Titanium with palladium and carbon steel
138 21	1	Ion Exchange Filter Unit comprising: - 2 ion exchange filters with internals and ion exchange resin filling - 1 tank for hydrochloric acid	Removal of dissolved calcium and magnesium from filtered	Filters rubber lined steel with PP internals, tanks and jet pumps PP, pipelines FRP and

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	(Op.+std-by)			
		- 1 tank for caustic soda - 1 water jet pump for dilution and feed of hydrochloric acid - 1 water jet pump for dilution and feed of caustic soda - 1 set of internal piping, valves and fittings - 1 set of transmitters and pneumatic valves for automatic control of regeneration by DCS, and locally indicating flow meters, level indicators, pressure gauges and thermometers	brine	PP, valves PP
138 41	1	Set of Process Control Instruments comprising: - analyser for traces of calcium in purified brine - transmitter for temperature of filtered brine - pneumatic control valve for steam - local flow meters, level indicators and pressure indicators	DCS supported process control	
139		<i>Purified Brine Storage</i>		
139 121	1	Tank	Purified brine	FRP
139 171	1	Centrifugal Pump complete with motor	Transfer of purified brine to Electrolysis Section	PP with cast iron armour
139 41	1	Set of Process Control Instruments comprising: - local level indicators and pressure indicators	Process control	
130 31	1	Set of Valves	Process media	PTFE lined cast iron, PP, PVC, cast iron
130 32	1	Set of Valves	Utilities	Cast iron
130 33	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Process media	FRP, PP, PVC, carbon steel

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	<i>(Op.+std-by)</i>			
130 34	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Utilities	Carbon steel
130 35	1	Lot of Material for Supports and Hangers including fixing material	Process piping and utilities piping	Carbon steel
130 45	1	Set of Cables	Connections between process control instruments and DCS	
130 46	1	Lot of Installation Material such as junction boxes, cable trays, glands, solenoid valves, fixing material	Process control signal cables	
130 5	1	Set of Electrical Equipment comprising push button stations, LT distribution board, power and motor control cables, installation material, etc.	Power distribution and motor control	
130 61	1	Lot of Hot Insulation Material	Process equipment, process piping and utilities piping	Rock wool with galvanised steel sheet cover
130 63	1	Lot of Coating Material	Corrosion protection on outer surfaces of equipment and piping	Epoxy based zinc dust primer, two component epoxy resin for intermediate and top coats

14 CHLORINE GAS PROCESSING SECTION

141 Chlorine Cooling

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
		<i>(Op.+std-by)</i>		
141 141	1	Shell and Tube Type Heat Exchanger	Cooling of wet chlorine gas by cooling water	Titanium and carbon steel
141 142	1	Shell and Tube Type Heat Exchanger	Cooling of wet chlorine gas by chilled water	Titanium and carbon steel
141 161	1	Gas Filter with high efficiency fibre bed filter insert	Brine mist separation from chlorine gas	Casing FRP, inserts PVC with glass fibres
141 41	1	Set of Process Control Instruments comprising: - transmitter for pressure of chlorine gas, - pneumatic control valve for chlorine gas - local pressure indicators and thermometers	DCS supported process control	
142		<i>Chlorine Drying</i>		
142 121	1	Tank	Storage of concentrated sulfuric acid	Carbon steel
142 122	2	Tank with air blowing device	Receiving and dechlorination of dilute sulfuric acid	Tank FRP with PVC liner, air blowing device PVC
142 171	1	Dosing Pump for remote control from DCS, complete with gear motor	Sulfuric acid to Chlorine Gas Drying Unit 142 21	Stainless steel
142 172	1	Centrifugal Pump complete with motor	Transfer of dilute sulfuric acid	Cast iron with PFA liner

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
		<i>(Op.+std-by)</i>		
142 181	1	Rotary Piston Blower complete with motor	Feed of air for dechlorination of dilute sulfuric acid	Cast iron
142 21	1	Chlorine Gas Drying Unit comprising: - 1 first stage drying column with packing, packing support and liquid distributor - 1 centrifugal pump with motor for recirculation of sulfuric acid - 1 plate type heat exchanger for cooling of sulfuric acid by chilled water - 1 second stage drying column with impingement baffle trays - 1 set of internal piping, valves and fittings - 1 set of transmitters for remote control of acid concentration and monitoring acid circulation rate and circulated acid temperature by DCS, and locally	Drying of chlorine gas by sulfuric acid	First stage column FRP with PVC liner with ceramic packing, pump cast iron with PFA liner, heat exchanger Hastelloy C and carbon steel, second stage column carbon steel with stainless steel impingement baffle trays, pipelines FRP with PVC liner, PVC and carbon steel, valves PVC and cast iron
		indicating flow meters, level indicators, pressure gauges and thermometers		
142 41	1	Set of Process Control Instruments comprising: - local level indicators and pressure indicators	Process control	
144		<i>Chlorine Compression</i>		

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
		<i>(Op.+std-by)</i>		
144 21		Compression Unit comprising: - 1 sulfuric acid ring compressor with motor - 1 acid separator with integrated fibre bed type gas filter - 1 heat exchanger - 1 set of internal piping, valves and fittings - 1 set of locally indicating flow meters, level indicators, pressure gauges and thermometers	Compression of dried chlorine gas	Compressor cast iron, acid separator carbon steel with glass fibre filter insert, heat exchanger carbon steel, piping carbon steel, valves cast steel and cast iron
144 41	1	Set of Process Control Instruments comprising: - pneumatic control valve for chlorine gas	DCS supported process control	
145		<i>Chlorine Liquefaction</i>		
145 21	1	Liquefaction Unit comprising: - 1 shell and tube type heat exchanger for condensation of chlorine by evaporation of refrigerant - 1 screw type refrigerant compressor with motor - 1 shell and tube type heat exchanger for condensation of refrigerant by cooling water - 1 receiver for liquid refrigerant - 1 set of internal piping, valves and fittings - 1 set of transmitters and pneumatic valves for automatic control of refrigeration capacity and monitoring unit performance by DCS, and locally indicating flow meters, level indicators, pressure gauges and thermometers 1 refrigerant filling	Liquefaction of chlorine	Heat exchangers, receiver and pipelines carbon steel, compressor cast iron, valves cast steel and cast iron

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
		<i>(Op.+std-by)</i>		
145 41	1	Set of Process Control Instruments comprising: - analyser for hydrogen in residual chlorine gas - transmitter for pressure of residual chlorine gas , - pneumatic control valve for residual chlorine gas - local pressure indicators	DCS supported process control	
146		<i>Liquid Chlorine Storage</i>		
146 121	3+1	Storage Tanks complete with support	Storage of liquid chlorine under operating pressure	Low temperature steel
146 41	1	Set of Process Control Instruments comprising: - 4 load cells - 4 transmitter for weight - 4 transmitter for chlorine pressure - 4 transmitter for padding media - 4 pneumatic control valve for padding media - 4 sensor for chlorine gas in air - 1 multi channel receiver and alarm system	DCS supported process control	
146 42	1	Set of Local Instruments comprising: - pressure indicator - thermometer - 4+4 safety valve for chlorine gas	Process control	
140 31	1	Set of Valves	Process media	PTFE lined cast iron, PVC, cast steel, cast iron
140 32	1	Set of Valves	Utilities	Cast iron

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	<i>(Op.+std-by)</i>			
140 33	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Process media	FRP, FRP with PVC liner, PVC, carbon steel
140 34	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Utilities	Carbon steel
140 35	1	Lot of Material for Supports and Hangers including fixing material	Process piping and utilities piping	Carbon steel
140 45	1	Set of Cables	Connections between process control instruments and DCS	
140 46	1	Lot of Installation Material such as junction boxes, cable trays, glands, solenoid valves, fixing material	Process control signal cables	
140 5	1	Set of Electrical Equipment comprising push button stations, LT distribution board, power and motor control cables, installation material, etc.	Power distribution and motor control	
140 61	1	Lot of Hot Insulation Material	Process equipment, process piping and utilities piping	Rock wool with galvanised steel sheet cover
140 62	1	Lot of Cold Insulation Material	Process equipment, process piping and utilities piping	PU foam plates and shells with plastic vapour barrier foil and galvanised steel sheet cover
140 63	1	Lot of Coating Material	Corrosion protection on outer surfaces of equipment and piping	Epoxy based zinc dust primer, two component epoxy resin for intermediate and top coats

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
15		CAUSTIC SODA PROCESSING SECTION		
<i>151</i>		<i>Cooling</i>		
151 141		Plate Type Heat Exchanger	Cooling of caustic soda by cooling water	Special grade stainless steel
151 41	1	Set of Process Control Instruments comprising: - transmitter for pressure of caustic soda - pneumatic control valve for caustic soda - local flow meters, pressure indicators and thermometers	DCS supported process control	
<i>152</i>		<i>Concentration</i>		
152 21	1	Caustic Soda Concentration Unit comprising: - 1 first stage falling film evaporator for caustic soda - 1 centrifugal pump with motor for transfer of caustic soda from first stage evaporator to second stage evaporator - 1 plate type heat exchanger for heat recovery from concentrated caustic soda - 1 plate type heat exchanger for heat recovery from steam condensate - 1 second stage falling film evaporator for caustic soda - 1 centrifugal pump with motor for transfer of concentrated caustic soda from second stage evaporator to storage - 1 plate type heat exchanger for cool-	Concentration of caustic soda from Electrolysis Section to 50 % NaOH	Evaporators nickel and carbon steel, centrifugal pumps for caustic soda nickel, plate heat exchangers nickel, receiving tanks and mixing condensers carbon steel, steam jets and centrifugal pump for return cooling water cast iron, pipelines nickel, stainless steel and carbon steel, valves nickel, stainless steel and cast iron

Item No.	Qty.	Description	Service	Main Material of Construction
(Op.+std-by)				
		ing concentrated caustic soda - 1 receiving tank for steam condensate - 1 mixing condenser for process vapours from first stage evaporator - 1 two stage steam jet vacuum unit with mixing condensers - 1 receiving tank for return cooling water - 1 centrifugal pump with motor for return cooling water - 1 set of internal piping, valves and fittings - 1 set of transmitters and pneumatic control valves for automatic level control in first stage evaporator, second stage evaporator, steam condensate receiving tank and return cooling water receiving tank and automatic pressure and temperature control for caustic soda in second stage evaporator by DCS, and locally indicating flow meters, level indicators, pressure gauges and thermometers		
150 31	1	Set of Valves	Process media	stainless steel, cast iron
150 32	1	Set of Valves	Utilities	Cast iron
150 33	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Process media	stainless steel, carbon steel
150 34	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Utilities	Carbon steel
150 35	1	Lot of Material for Supports and Hangers including fixing material	Process piping and utilities piping	Carbon steel

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
		<i>(Op.+std-by)</i>		
150 45	1	Set of Cables	Connections between process control instruments and DCS	
150 46	1	Lot of Installation Material such as junction boxes, cable trays, glands, solenoid valves, fixing material	Process control signal cables	
150 5	1	Set of Electrical Equipment comprising push button stations, LT distribution board, power and motor control cables, installation material, etc.	Power distribution and motor control	
150 61	1	Lot of Hot Insulation Material	Process equipment, process piping and utilities piping	Rock wool with galvanised steel sheet cover
150 63	1	Lot of Coating Material	Corrosion protection on outer surfaces of equipment and piping	Epoxy based zinc dust primer, two component epoxy resin for intermediate and top coats

16 HYDROGEN PROCESSING SECTION

161 Cooling

161 141	1	Shell and Tube Type Heat Exchanger	Cooling of wet hydrogen by cooling water	Carbon steel
161 161	1	Gas Filter with high efficiency fibre bed filter inserts	Caustic soda mist separation from hydrogen	Casing carbon steel, inserts carbon steel with synthetic fibres
161 181	1	Blower complete with motor	Hydrogen	Cast iron

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	<i>(Op.+std-by)</i>			
161 41	1	Set of Process Control Instruments comprising: - transmitters for pressure of cooled hydrogen and compressed hydrogen - pneumatic control valve for cooled vent hydrogen, compressed vent hydrogen and recycle hydrogen - local pressure indicators and thermometers	DCS supported process control	
160 31	1	Set of Valves	Process media	Cast iron
160 32	1	Set of Valves	Utilities	Cast iron
160 33	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Process media	Carbon steel
160 34	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Utilities	Carbon steel
160 35	1	Lot of Material for Supports and Hangers including fixing material	Process piping and utilities piping	Carbon steel
160 45	1	Set of Cables	Connections between process control instruments and DCS	
160 46	1	Lot of Installation Material such as junction boxes, cable trays, glands, solenoid valves, fixing material	Process control signal cables	
160 5	1	Set of Electrical Equipment comprising push button stations, LT distribution board, power and motor control cables, installation material, etc.	Power distribution and motor control	
160 61	1	Lot of Hot Insulation Material	Process equipment, process piping and utilities piping	Rock wool with galvanised steel sheet cover

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i> <i>(Op.+std-by)</i>	<i>Service</i>	<i>Main Material of Construction</i>
160 63	1	Lot of Coating Material	Corrosion protection on outer surfaces of equipment and piping	Epoxy based zinc dust primer, two component epoxy resin for intermediate and top coats
17		HYDROCHLORIC ACID SECTION		
171		<i>Synthesis</i>		
171 21	1	Hydrochloric Acid Production Unit comprising: - 1 hydrogen chloride synthesis unit with burner, combustion chamber and isothermal absorber - 1 tail gas scrubbing column with packing - 1 steam jet blower with mixing condenser - 1 set of internal piping, valves and fittings including flame arrestors - 1 set of transmitters and pneumatic valves for automatic control by DCS of chlorine gas and hydrogen feed and concentration of hydrochloric acid and for automatic emergency shutdown, and locally indicating flow meters, level indicators, pressure gauges and thermometers	Production of hydrochloric acid	Synthesis unit and scrubbing column grafite, mixing condenser carbon steel, steam jet cast iron, pipelines FRP, PVC and carbon steel, valves PVC and cast iron
170 45	1	Set of Cables	Connections between process control instruments and DCS	
170 46	1	Lot of Installation Material such as junction boxes, cable trays, glands, solenoid valves, fixing material	Process control signal cables	
170 5	1	Set of Electrical Equipment comprising push button stations, LT distribution board, power and motor control cables, installation material, etc.	Power distribution and motor control	

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i> <i>(Op.+std-by)</i>	<i>Service</i>	<i>Main Material of Construction</i>
170 61	1	Lot of Hot Insulation Material	Process equipment, process piping and utilities piping	Rock wool with galvanised steel sheet cover
170 63	1	Lot of Coating Material	Corrosion protection on outer surfaces of equipment and piping	Epoxy based zinc dust primer, two component epoxy resin for intermediate and top coats
18		CHLORINE ABSORPTION SECTION		
<i>181</i>		<i>Continuous Absorption</i>		
181 121	1	Tank	Sodium hypochlorite solution	FRP with PVC liner
181 131	1	Jet Scrubber	Absorption of chlorine in caustic soda	FRP with PVC liner
181 141	1	Plate Type Heat Exchanger	Cooling of recirculated hypochlorite solution by chilled water	Titanium and carbon steel
181 171	1+1	Centrifugal Pump complete with motor	Recirculation and transfer of sodium hypochlorite solution	Titanium

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	<i>(Op.+std-by)</i>			
181 41	1	Set of Process Control Instruments comprising: - transmitters for level in tank 181 121, pressure in vent chlorine gas system and redox potential of sodium hypochlorite solution - pneumatic control valves for recycle tail gas and product sodium hypochlorite solution - local flow meters, level indicators, pressure indicators and thermometers	DCS supported process control	
183		<i>Final Absorption</i>		
183 121	1	Tank	Dilute caustic soda with sodium hypochlorite	FRP with PVC liner
183 131	1	Absorption Column complete with packing, packing support and liquid distributor	Absorption of residual chlorine in gas leaving Continuous Absorption 181 with caustic soda	Column FRP with PVC liner, packing PP
183 141	1	Plate Type Heat Exchanger	Cooling of dilute caustic soda with sodium hypochlorite by chilled water	Titanium and carbon steel
183 151	1	Inline Mixer	dilution of caustic soda with water	Stainless steel
183 171	1+1	Centrifugal Pump complete with motor	Recirculation of dilute caustic soda with sodium hypochlorite	Titanium

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	<i>(Op.+std-by)</i>			
183 181	1+1	Centrifugal Blower complete with motor	Ventilation of equipment, piping and rooms with chlorine	Casing rubber lined steel, impeller titanium
183 41	1	Set of Process Control Instruments comprising: - transmitter for density of dilute caustic soda, - pneumatic control valves for caustic soda and demineralised water - local flow meters, level indicators, pressure indicators and thermometers	DCS supported process control	
180 31	1	Set of Valves	Process media	PVC, stainless steel, cast iron
180 32	1	Set of Valves	Utilities	Cast iron
180 33	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Process media	FRP, FRP with PVC liner, PVC, stainless steel, carbon steel
180 34	1	Set of Piping Material including gaskets and bolts and nuts for flanged connections	Utilities	Carbon steel
180 35	1	Lot of Material for Supports and Hangers including fixing material	Process piping and utilities piping	Carbon steel
180 45	1	Set of Cables	Connections between process control instruments and DCS	
180 46	1	Lot of Installation Material such as junction boxes, cable trays, glands, solenoid valves, fixing material	Process control signal cables	
180 5	1	Set of Electrical Equipment comprising push button stations, LT distribution board, power and motor control cables, installation material, etc.	Power distribution and motor control	

<i>Item No.</i>	<i>Qty.</i>	<i>Description</i>	<i>Service</i>	<i>Main Material of Construction</i>
	<i>(Op.+std-by)</i>			
180 62	1	Lot of Cold Insulation Material	Process equipment, process piping and utilities piping	PU foam plates and shells with plastic vapour barrier foil and galvanised steel sheet cover
180 63	1	Lot of Coating Material	Corrosion protection on outer surfaces of equipment and piping	Epoxy based zinc dust primer, two component epoxy resin for intermediate and top coats

15. CONCEPT FOR PLANT IMPLEMENTATION

GENERAL

This document proposes a concept for the implementation of a plant. It lists the main activities required for the construction and start-up of a plant and specifies the contributions by purchaser, GEA Messo AG and contractor towards this objective.

PROJECT MANAGEMENT AND CO-ORDINATION

Immediately after the effective date of the respective contract between purchaser and contractor, the contractor will appoint a qualified project manager for all communication with the purchaser and the co-ordination of all activities to be performed by GEA Messo AG and contractor. The contractor's project manager will submit to the purchaser monthly a report summarizing the progress of the work performed by the contractor.

BASIC ENGINEERING

Immediately after the effective date of the contract, purchaser, GEA Messo AG and contractor will hold in a kick-off meeting at the plant site, for consolidating the design basis of the plant.

Based on the consolidated design basis, GEA Messo AG will perform the basic engineering for the plant. This basic engineering consists of the preparation of complete and comprehensive information as required for detailed engineering, procurement of equipment and materials, construction and operation of the plant.

GEA Messo AG will submit to the purchaser the resulting design documentation and the operating manual.

Purchaser, GEA Messo AG and contractor will participate in a design review meeting at the purchaser's offices or the plant site for consolidating the basic engineering for the plant.

DETAILED ENGINEERING

Detailed engineering, possibly excluding the electrical and civil engineering, for the equipment specified as "contractor's supply" in the equipment list, will be performed by the contractor based on the basic engineering documents.

Detailed engineering of the equipment specified as "purchaser's supply," in the equipment list, if any, will be performed by the purchaser based on the basic engineering documents.

Electrical and civil engineering, as well as engineering relating to steel structures, will be performed by contractor or purchaser, depending on the provisions of the contract.

REVIEW OF DETAILED ENGINEERING

GEA Messo AG will review the detailed engineering documentation for conformity with GEA Messo' basic engineering. The scope of documents to be reviewed will be agreed upon during the kick-off meeting.

PROCUREMENT AND SUPPLY, OF EQUIPMENT AND MATERIALS

The contractor will supply to the purchaser the equipment and materials specified in the equipment list as „contractor’s supply“, at conditions as defined in the contract.

CIVIL CONSTRUCTIONS

Civil constructions required for the plant will be provided by purchaser or contractor after the respective detailed engineering documents become available and in accordance with the requirements indicated therein by a qualified civil contractor, which purchaser or contractor will select and engage.

ERECTION

Upon completion of civil construction, plant equipment and materials will be erected in accordance with the requirements indicated in the detailed engineering documents and in the documents supplied by the equipment vendors. Erection work will be carried out by a qualified erection contractor, which the purchaser or contractor will select and engage.

Upon completion of erection, GEA Messo AG will delegate a mechanical or process engineer for checking that the plant is erected in compliance with the engineering documents.

PRECOMMISSIONING

After the erection of the plant is completed, the equipment will be cleaned. Mechanical, hydraulic and electrical tests of the equipment will be performed by purchasers and GEA Messo’ personnel in accordance with the instructions of operating manual and/or instructions provided by the equipment suppliers.

These activities will be performed in the presence of a mechanical or process engineer of GEA Messo.

After the pre-commissioning of the plant is completed, GEA Messo AG and the purchaser will record that the plant is ready for commissioning in a Ready for Commissioning Certificate (RFC Certificate), which they will jointly sign.

COMMISSIONING AND PERFORMANCE TESTING

After completion of the pre-commissioning work, the plant will be started-up and run in by the purchaser’s operators and engineers in accordance with the instructions of the operating manual.

The commissioning work will be completed by a performance test, demonstrating the guaranteed performance parameters.

GEA Messo AG will delegate to the plant site a process engineer to assist the purchaser’s personnel during commissioning and performance testing.

16. TECHNICAL DOCUMENTS

All documents will be written in English. Units will be indicated in accordance with ISO standard 1000-1981. Otherwise, the documents will further comply with industrial standards applicable in Germany.

The contractor will supply to the purchaser five copies of the technical documents prepared in accordance with the above stipulations.

17. ENCLOSURES

BASIC BLOCK DIAGRAM

MASS BALANCE

PROJECT FLOW DIAGRAMS

TYPICALLY PLANT LAYOUT

REFERENCE LIST

APPENDIX 2

***ANNUAL REPORT FOR EPM 17503 Adavale
12 Months ending 03rd November, 2009
For QUEENSLAND POTASH PTY LTD LTD.***

***AusPotash Corporation Project Adavale Basin,
Queensland, Australia
NI 43-101: Report by M. D. Campbell and Associates,
L.P.***



M. D. Campbell and Associates, L.P.

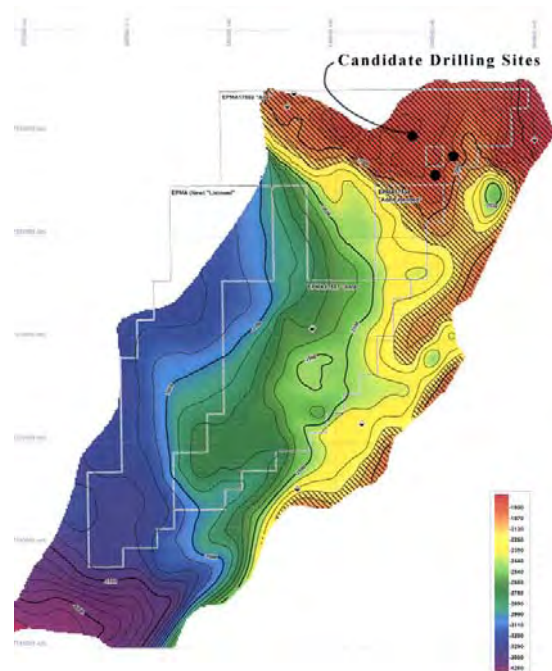
Houston Seattle Phoenix

Draft

**AusPotash Corporation Project:
Adavale Basin, Queensland, Australia
NI 43-101 Report**

for:

**AusPotash Corporation
Toronto, Ontario
Canada**



By

Michael D. Campbell, P.G., P.H.
and
Jeffrey D. King, P.G.

M. D. Campbell and Associates, L.P.
Houston, Texas and Seattle, Washington

March 12, 2009



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M. D. Campbell and Associates, L.P.

Houston

Seattle

Phoenix

3.0 Summary

The AusPotash Corporation (AusPotash) engaged M. D. Campbell and Associates, L.P. (C&A) to prepare a Qualifying National Instrument (NI) 43-101 report for their potash tenements located in Queensland, Australia. This report is to be used by AusPotash as part of a TSX listing.

AusPotash acquired an interest in four (4) potash exploration licenses (subject tenements) covering lands overlying the Devonian Boree Salt Member of the Etonvale Formation. The Boree Salt Member lies within the Adavale Basin located in the subsurface approximately 50 kilometers (kms) south of Blackall, central western Queensland, some 650 kms inland from the Queensland coast and 840 kilometers west-northwest of Brisbane, Queensland.

Based on earlier petroleum exploration conducted in the 1980s that included drilling, well logs, and seismic surveys, and on work conducted by the Queensland Department of Mines and the Australian Bureau of Mines (BMR), the Boree Salt Member was identified as the only known significant occurrence of bedded potash in Australia. Since then, additional work by AusPotash and their contractors have recovered and assembled much of the technical literature of the early 1980s on the subject tenements including available data, reports, and well logs.

Terra Search Pty. Ltd, an AusPotash contractor, has processed the available historical petroleum exploration drilling and seismic interpretation data and created a 3-D model of the Boree Salt geometry. This work indicates that the Boree Salt Member is several tens of cubic kilometers in volume, is up to 500 meters thick at depths between 2,000 and 2,500 meters below the ground surface.



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Based on a review of the available information, including well logs, company reports, and government publications, we have concluded that substantial potential exists for the presence of economic potash within the tenements controlled by AusPotash. Sufficient merit exists for C&A to recommend drilling and coring exploration in the areas identified by recent re-interpretations of earlier seismic data collected in the 1960s through the 1980s.

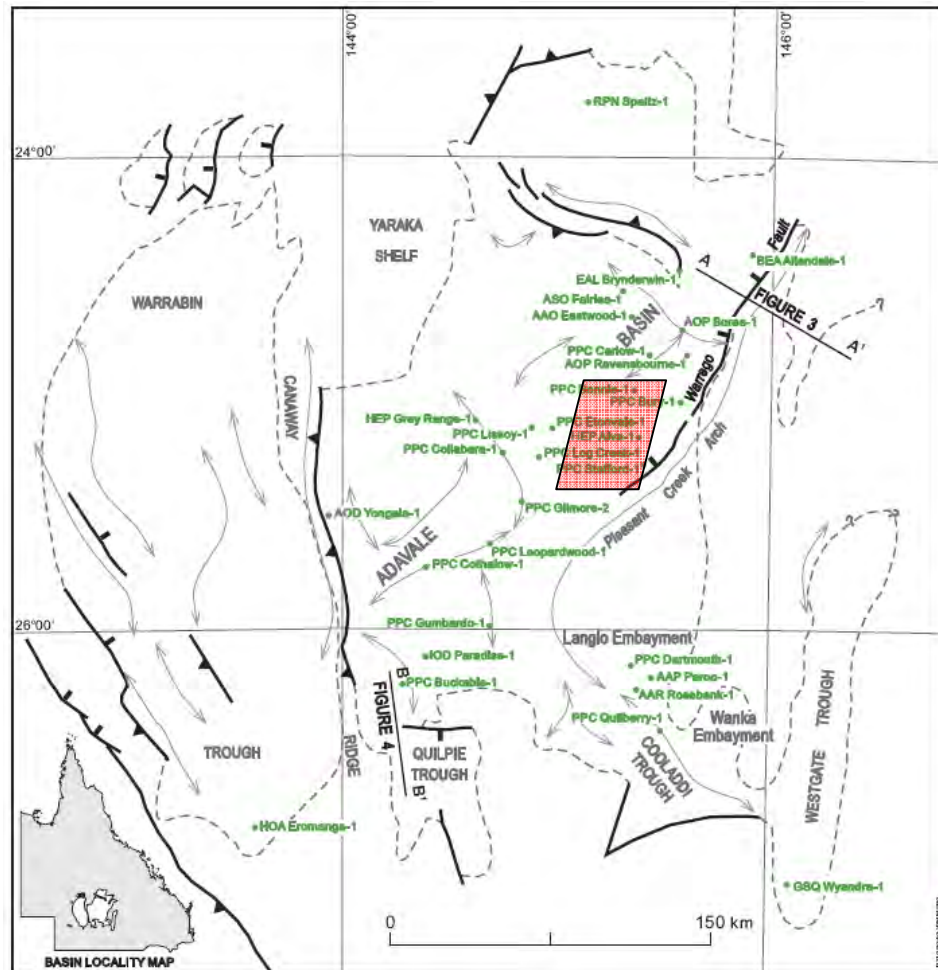
Once the proposed drilling and coring are complete and the potash content of the upper Boree Salt has been characterized, the available resources will need to be re-assessed. Additional data collected during future phases of the project will determine if the potash is economically recoverable by standard in situ solution mining and surface evaporation processing methods that are available at this time.

The estimated cost of the next phase of the AusPotash project (the proposed coring and drilling project) will likely be approximately AUS\$1.5 million over a two-year period. This work would include pre-drilling geological assessment, drilling, coring, and well logging, and associated geological and engineering supervision of such operations.

4.0 Introduction

AusPotash engaged Michael D. Campbell, P.G., P.H., Managing Partner and Principal Geologist of C&A located in Houston, Texas as a Qualified Person to prepare a Qualifying National Instrument (NI) 43-101 report for their potash tenements located in south-central Queensland, Australia (see Figure 1). This report is to be used by AusPotash as part of a TSX listing.

The information available on the Boree Salt Member used by Terra Search Pty. Ltd. to create a 3-D model of the Boree Salt geometry originated from previously drilled petroleum well data available in the Queensland Government Petroleum Well database and from seismic data shot in the early 1960s by Amoseas and Phillips-Sunny DX and by Esso Australia and AAR Ltd in the early 1980s. All such references are cited in the report by Terra Search (2008). See **Section 23. References.**



*** Figure 1- General Location of Adavale Basin and Subject Tenements with Structural Components. (From McKillop, et al., 2007)**

* For Enlarged Versions of Figures, See Section 26.0

The original outline of the subject tenements shown in Figure 1 is illustrated at a larger scale in Figure 2. The seismic lines and the wells drilled are also shown in Figure 2. More than one generation of seismic interpretations were used in the modeling by Terra Search (2008). Two of the seismic studies were commissioned by Poseidon Limited in 1983 and 1986 (see Terra Search, 2008 report listed with URL in **Section 23.0 References**). Other technical literature and reports consulted during the C&A investigations and in the preparation of this report have been cited in **Section 23.0 References**.

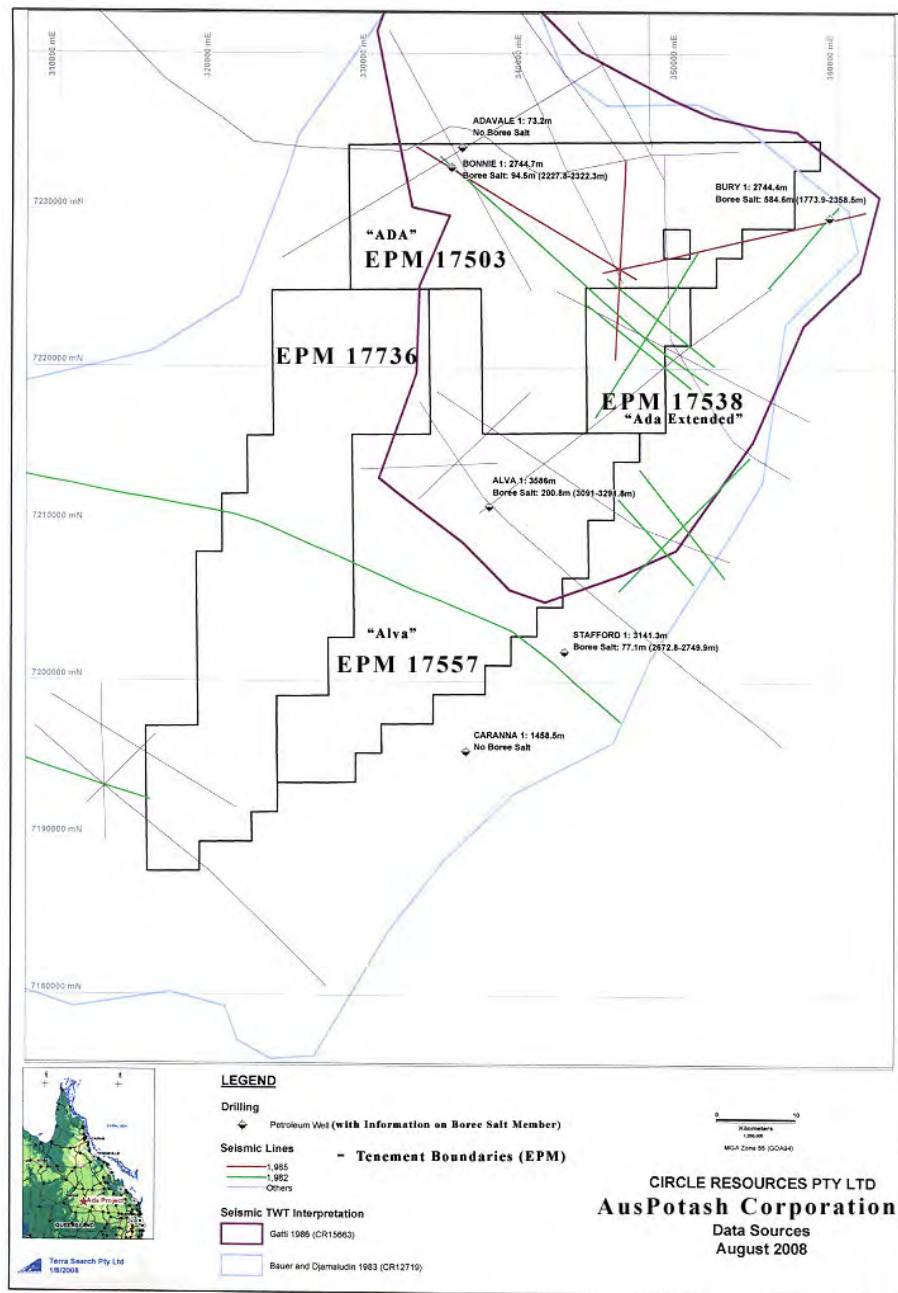


Figure 2 – Original Tenement Boundaries, Seismic Data Sources, and Petroleum Drilling Locations. See Figure 2A for Updated Tenement Boundaries. (From Terra Search Pty. Ltd., 2008)

Updated tenement boundaries are shown in Figure 2A as of late February, 2009. The three granted EPMs are shown in a dark pattern and the one that is still in the application process is shown in light



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colors. It should be noted that other companies hold tenements that have either been granted and are in the application stage along the eastern boundary of AusPotash tenements, e.g., EPM #16409 (including out-sub block within EPM #17503), #16410, and #16413 are held by Holocene Pty. Ltd., EPM #17708 is held by NQ Metals Pty. Ltd., and EPM # 17581 is held by Leigh Margaret Wilson.

Along the southern boundary of AusPotash's EPM #17557 (in application), is the northern boundary of the Queensland South Native Title Representative Body Aboriginal Corporation. For further details and updates, the Queensland Department of Mines and Energy provides an interactive and tenure mapping website that should be consulted, see citation and link: **Section 23.0 References**.

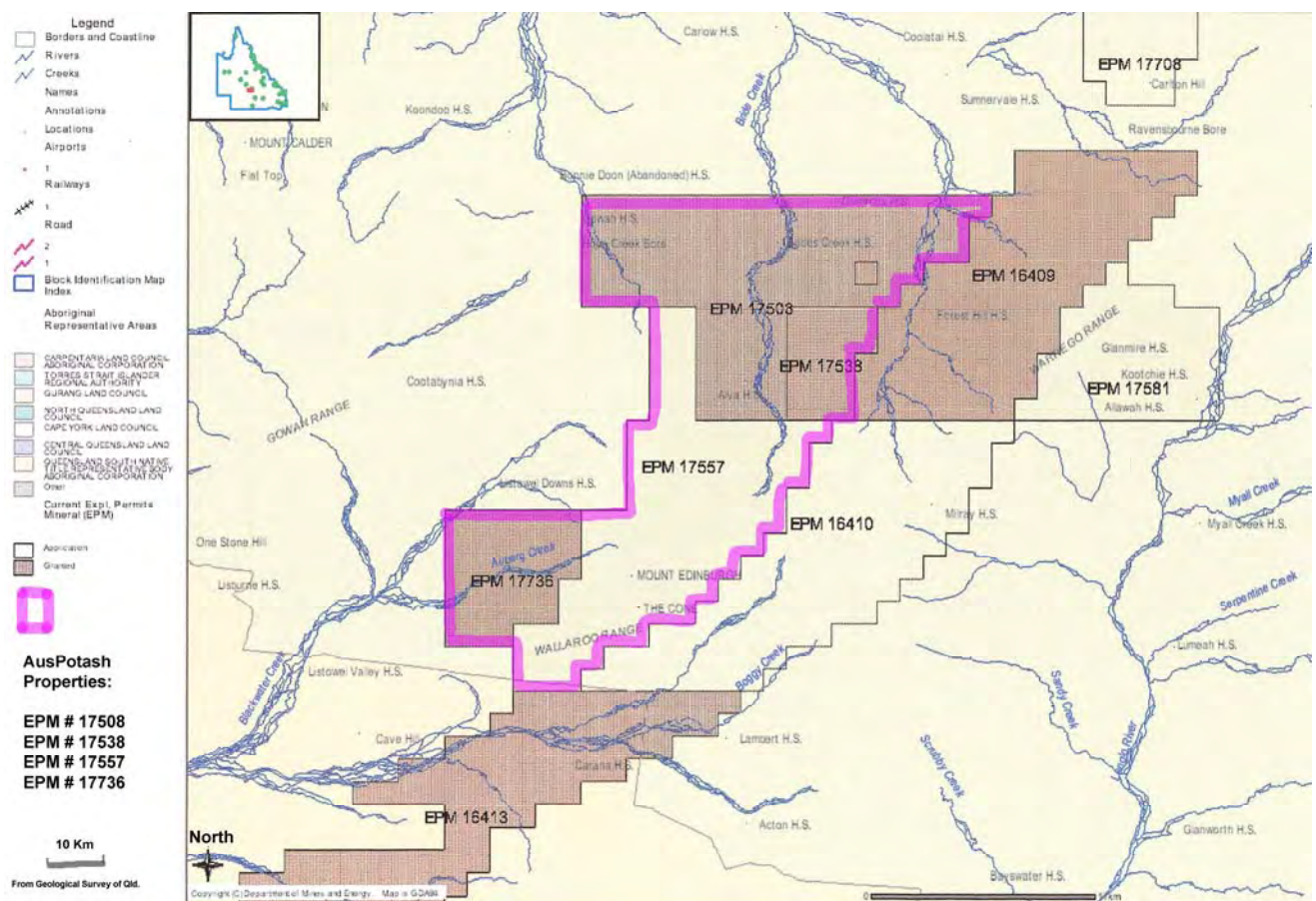


**Figure 2A – Updated Tenement Boundaries as of late February, 2009
(from Queensland Department of Mines and Energy, 2009).**



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C&A personnel (the qualified person and a C&A Senior Project Manager, both authors of this report) inspected the subject tenements by helicopter and on foot during August 30 and 31, 2008. C&A personnel observed the Blackall-Adavale Road south from Blackall, Queensland and the area along the Gilmore-to-Barcaldine Gas Pipeline. C&A personnel also observed the terrain and access to the areas of likely drilling (see Figures 3 and 4).



Figure 3 – Typical Terrain in Area of Prospective Drilling.



Figure 4 – C&A's Michael D. Campbell, P.G., P.H., Qualified Person, and Jeffrey D. King, P.G., C&A's Senior Project Manager, Inspected Likely Drilling Sites on the Subject Tenements, August, 2008.



5.0 Reliance on Other Experts

The authors of this report have relied on the available reports and the associated consultants, the technical literature produced by the Queensland Government Department of Mines and other government departments, and by the Australian Bureau of Mineral Resources, and the authors' own professional experiences in evaluating natural resources. Of particular note is that the Qualified Person was employed by the Continental Oil Company of Australia (ConAus) based in Sydney, N.S.W. and was granted Resident Status in Australia from 1966 to 1970 to work on phosphate and other minerals in Queensland, the Northern Territory and elsewhere in South East Asia and on potash in Western Australia and elsewhere in the World.

C&A was provided a summary of the 3-D seismic modeling of the Boree Salt Member in a meeting during the week of August 25, 2008 with Mr. Rob Lewis, Computing Geologist, at Terra Search Pty. Ltd. offices located in Townsville, Queensland. Also, information was provided on the Queensland ground-water allocations system regarding the subject areas in a meeting held during the week of August 25, 2008 with Mr. Manfred Thienenkamp, Senior Hydrogeologist/Hydrogeochemist of Rockwater Pty. Ltd., at his office located in Hermit Park, Queensland. While in Brisbane, C&A personnel met with Queensland Government personnel regarding the subject tenements and availability of historical reports. C&A was provided access to the QDEX, the Queensland database of historical documents and maps. C&A personnel also spent two days in the library at Mineral House reviewing the technical reports and associated literature.

6.0 Property Description and Location

6.1 General Description

The subject tenements cover an area of approximately 64,230 hectares and are located approximately 50 kilometers south of Blackall, Queensland. The regional and local infrastructure is illustrated in Figure 5. This includes a location grid, roads and tracks to the subject tenements, the subject four (4) tenement boundaries, the corners of which



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were located by calibrated Global Positioning System (GPS) equipment, locations of water bores and tanks, railways, and an outline of the extent of the Boree Salt Member in the subsurface, the objective of AusPotash's interest in the Adavale Basin.

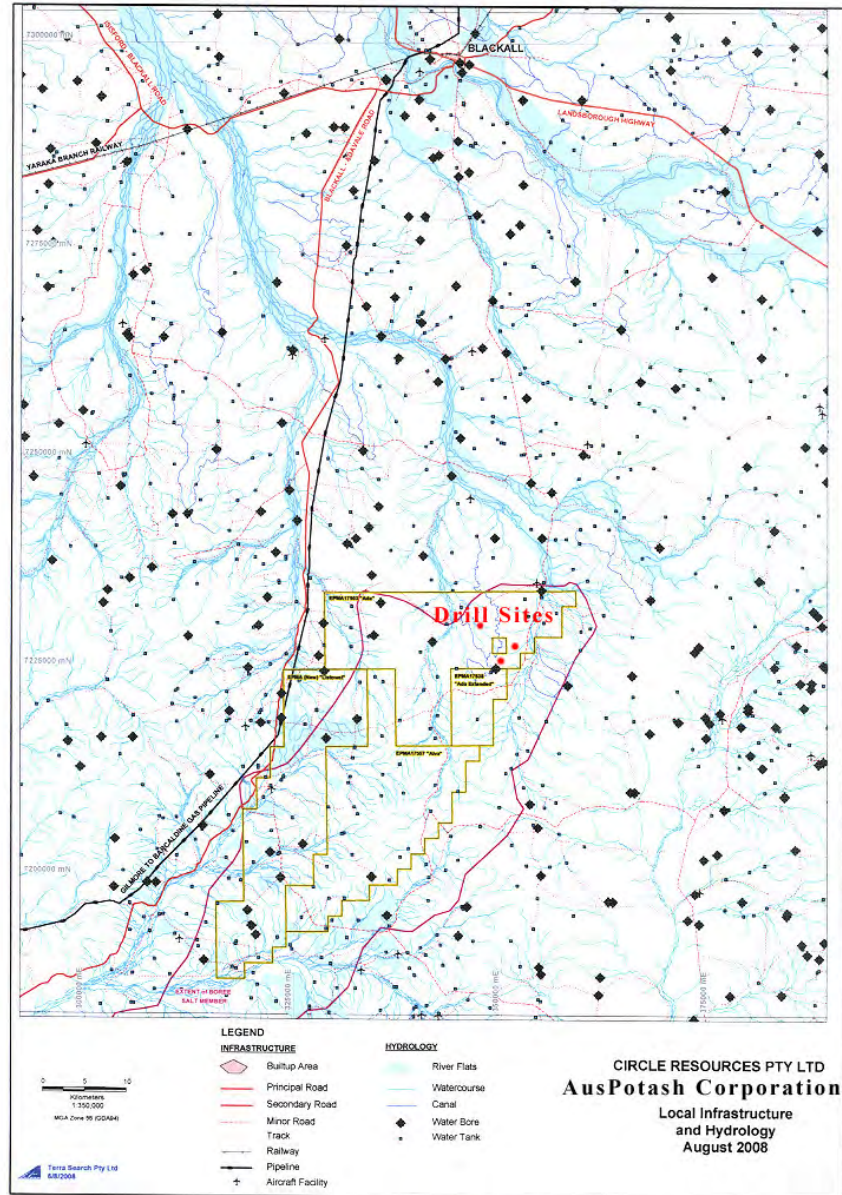


**Figure 5 – Bore Census, Regional Infrastructure and Property Location –
See Figure 2A for Updated Tenement Boundaries.
(From Terra Search Pty. Ltd., 2008)**



6.2 Property Ownership and Financial Obligations

The mineral tenure is granted for exploration for minerals for a term of 5 years from date of granting. AusPotash and partners hold 100% ownership with financial obligations to spend funds while classified as an EPM, prior to any development activities.

The requirements include yearly rentals (Table 1) and minimum annual expenditures (MAE) (see Table 2). The initial tenements of interest to AusPotash (EPMs 17503 and 17538) have been granted. The annual rentals for 2008 have been paid, according to Mr. Kevin Doyle of Circle Resources Pty. Ltd., and MAEs have been confirmed. Two other tenements adjacent to the granted EPMs are in the process of being granted. For example, the application for EPM #17736 is further along in the process and will likely be granted by April, 2009, while EPM #17557 (see Figure 2A for updated location of the EPMs) is subject to advertising (normally conducted by the government to insure that there are no owner conflicts) and will likely not be granted until about July, 2009. Once granted, the MAE requirements will be confirmed by the Queensland Government and the rentals will be due for both EPMs.

We have included our estimates of the likely rentals fees (integrated in Table 1) and the MAEs (shown in Table 2) for all four EPMs. It is the responsibility of the EPM holder to check the current rental rate and to pay the rentals before the indicated due date.

The anticipated increase in the annual rental rates through 2012 have been estimated at \$6.30 and incorporated in Table 1. As incorporated in both Tables 1 and 2, after two years, each EPM is required to be reduced in holdings by 50% and each year thereafter.



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Table 1
Rentals for Sub-Blocks Held

Year of Project	Cost per Sub Block	Number of Sub Blocks	Total Cost
Year 2008	\$124.60*	117	\$14,578.20
Year 2009	130.90**	241	31,546.90
Year 2010	137.20***	182	24,970.40
Year 2011	143.50	91	13,058.50
Year 2012	149.80	45	6,741.00
Total			\$90,895.00

* Based on Tenure Rental Current Yearly Rates – 2008 for EPMs at AUS\$124.60 per sub-block

** Based on 2009 Rate Sheet

*** Anticipated increase of \$6.30 per year for 2010 through 2012.

At some point in the exploration program, assuming results are favorable, a Mineral Development Licence (MDL) and lease will be required to permit the mining venture to proceed. The MDL is designed to allow time to conduct various permitting requirements, one of which will be the presentation of a Native Title Agreement. Others include agreements on water-use rights, railway agreements, and others focusing on the construction of facilities or infrastructure (see **Section 6.3 Permitting**).

Table 2
Minimum Annual Expenditure (MAE) Requirements
(per Year per Exploration Permit – Minerals (EPM))*

Year	#17503	#SB	#17538	#SB	#17557	#SB	#17736	#SB	Total \$
2008	100,000	100	17,000	17	-	-	-	-	117,000
2009	100,000	100	17,000	17	92,000	92	32,000	32	241,000
2010	50,000	50	8,000	8	92,000	92	32,000	32	182,000
2011	70,000	25	60,000	4	46,000	46	16,000	16	192,000
2012	15,000	12	15,000	2	23,000	23	8,000	8	61,000
Total	335,000		117,000		253,000		88,000		\$793,000

* In AUS\$ ** SB = # of Sub Blocks held.



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The MAE is included in the application by the applicant and is based on a scope of work (and cost estimate), the latter becoming the MAE if approved by the Queensland Government. Furthermore, there is a MAE of \$1,000 per sub block; hence, for Project Years 2008 through 2010, the minimum was invoked by the Applicant (i.e., Mr. Kevin Doyle of Circle Resources Pty. Ltd.). For subsequent years, the estimates in the initial application filed were increased for EPMs 17503 and 17538, leaving the other two EPMs at minimum MAE levels. Actual expenditures will likely be well above the MAEs indicated in Table 2 in some years.

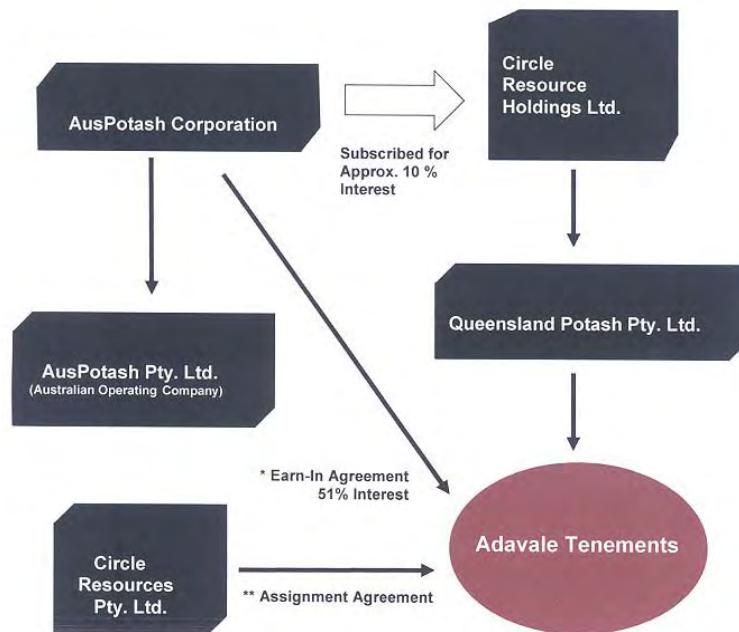
A bond will be required to be paid to the Australian Environmental Protection Agency of \$ 2,500 per EPM for a five-year period amounting to \$ 10,000.00 for the 4 EPMs. At the end of 5 years, the bond is refundable if all required restoration activities (if any) have been carried out.

We have reviewed the executed agreement in place between Queensland Potash Pty Ltd (QPPL) and AusPotash with the following general elements (see Figure 6). QPPL and CRPL are Queensland corporations and AusPotash is an Ontario corporation according to the incorporation documents we reviewed.

The specific terms of the respective agreements can be consulted via **Section 23.0 References** (see the URL citation for the QPPL-AusPotash Agreement, dated July 3, 2008, and the CRPL-QPPL Agreements, dated June 1, 2008, for EPM #17503, and dated June 12, 2008 for EPMs 17538, 17557, and 17736, which confirm QPPL's ownership of the subject properties via CRPL until the share exchange agreement has been finalized and the terms met).



Figure 6
AusPotash - Queensland Potash Relationships



Also, we have reviewed the Share Sale Agreement, dated as of December 2, 2008 between AusPotash and QPPL, CRPL, Ashton Nominees Inc., Circle Resource Holdings Ltd., Odaka Enterprises Inc., St. Cloud Capital, S.A., and Transparent Holdings Ltd. (see the URL citation for the AusPotash Share Sale Agreement and associated signatories dated December 2, 2008 (see **Section 23. References**). Finally, we have reviewed the Revised Term Sheet, dated January 9, 2008 (likely meant to be dated 2009), that provides a history of the AusPotash project, the transactions involved, including the plan for the acquisition of QPPL and subsequent TSX-V listing of AusPotash through an amalgamation with Greenwich Global Capital Inc. and associated terms (see the URL citation for the AusPotash Revised Term Sheet in **Section 23 References**).



6.3 Permitting

A permit will be required to drill deep test wells; coring and logging are considered part of the drilling program. Drilling of the test holes will require a Class 3 driller with all the appropriate certificates for permission to drill in the Great Artesian Basin. Yearly reports are required on the exploration program with the information to be submitted to the Queensland Department of Natural Resources & Water.

Also, a ground-water allocation will be required for process water. Mr. Manfred Thienenkamp, Senior Hydrogeologist/Hydrogeochemist of Rockwater Pty. Ltd. reported in his August, 2008 preliminary consulting report to Circle Resources Pty. Ltd., one of the partners with AusPotash in this venture (see **Section 6.2**), that the acquisition of an existing allocation or a number of existing ground-water allocations offers the best possibility to obtain a water license for the in situ mining venture presently contemplated by AusPotash in the subject tenements south of Blackall, Queensland.

Rockwater personnel reviewed the current legislation concerning ground-water allocations in the Great Artesian Basin area and the following documents:

- The Water Resource (Great Artesian Basin) Plan, 2006
- Great Artesian Basin Resource Operations Plan, 2007
- State Development and Public Works Organization Act, 1971

Supplementary information was gained by Rockwater personnel through communications with the staff at the Department of Natural Resources and Water (DNRW) and the Department of Infrastructure and Planning (DIP) offices in Longreach, Brisbane, and Townsville.

A part of Rockwater's scope of work was to perform a bore census followed by a title search. These activities indentified the most suitable bores in the area so that selected



landowners could be contacted and negotiations initiated concerning the possible transfer of the ground-water license for use in the AusPotash project (see Rockwater Pty. Ltd., 2008, URL in **Section 23.0 References**). We understand that those negotiations are underway.

6.4 Environmental Issues

Because the Boree Salt Member, as part of the Adavale Basin, is entirely covered by younger rocks, the prospective potash beds do not outcrop and are known only by previous petroleum drilling of the 1980s, via cores and wireline logs. Since this resource has not been developed to date, there are no tailing ponds, industrial waste deposits, or other anthropogenic features apparent within the subject tenements aside from rusting bore and tank equipment. Therefore, we are not aware of any residual environmental issues that could impact the subject tenements.

7.0 Accessibility, Climate, Local Resources, Infrastructure and Physiography

7.1 Topography, Elevation, and Vegetation

The topography and associated elevation in the general area of the subject tenements are illustrated in Figure 6, along with the boundaries of the subject tenements, the modeled outline of the Boree Salt Member, and three of the candidate sites planned for future test drilling, coring, and geophysical logging of the indicated potash intervals within the Boree Salt Member.

The vegetation in the area of interest is of lightly grassed paddocks with some forest areas and narrow belts of trees. These tree-lines mainly occur along creek banks as well as in specific areas designed to act as wind breaks along the edge of cleared paddocks. The average diameter of the trees varies from about 15 centimeters to 30 centimeters.



Many of the paddocks have in recent years been cleared of trees and are strewn with dead wood, some scattered, some in piles.

The subject areas are within The Mulga Lands bioregion, which consists of undulating plains and low hills on Cenozoic sediments supporting a vegetation range of Mulga (*Acacia aneura*) shrub lands and low woodlands. Soils are generally very infertile and sandy, derived from Quaternary sediments deposited over a Tertiary land surface (see Australian Natural Resources Atlas, 2008).

7.2 Accessibility to Properties

Access to the tenements is from the north by the Blackall-Adavale Road originating in Blackall, Queensland and then approximately east 20 kilometers from the Blackall-Adavale Road to the area of likely preliminary drilling and coring of test holes (see Figures 6 and 7).

7.3 Local Resources

Ground-water resources available from water bores and water tanks are abundant in the area (see Figure 6). Only a few cattle were observed during the C&A site inspection during the week of the 25th of August, 2008 within the subject tenements, but the large “red” kangaroos (*Macropus rufus*) were abundant in the area. The Gilmore-to-Barcaldine gas pipeline runs roughly adjacent to the Blackall-Adavale Road along the western edge of the subject tenements (see Figures 6 and 7). The nearest railway is located in Blackall, approximately 70 kilometers north of the north-most boundary of the subject tenements (see Figures 6 and 7).

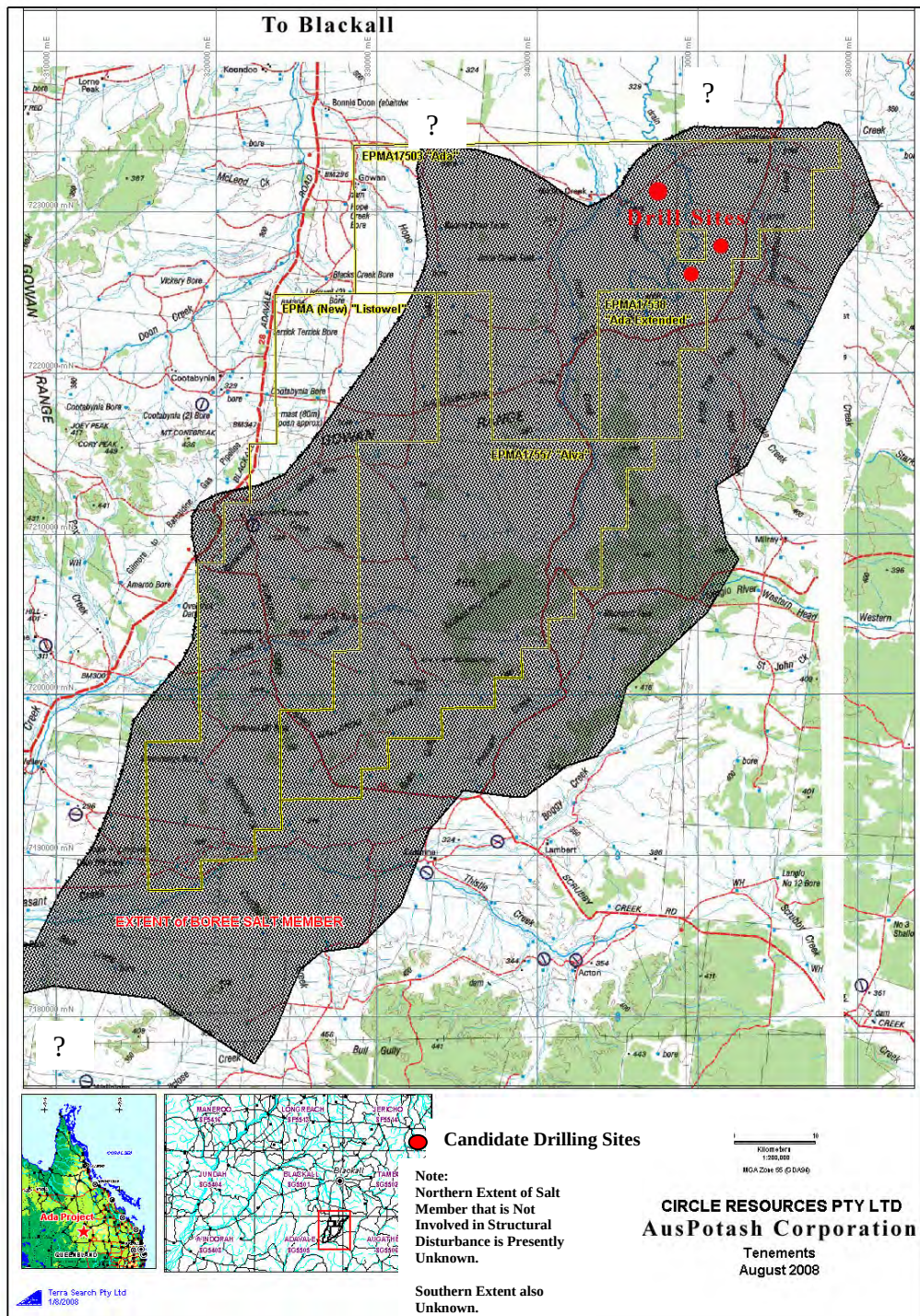
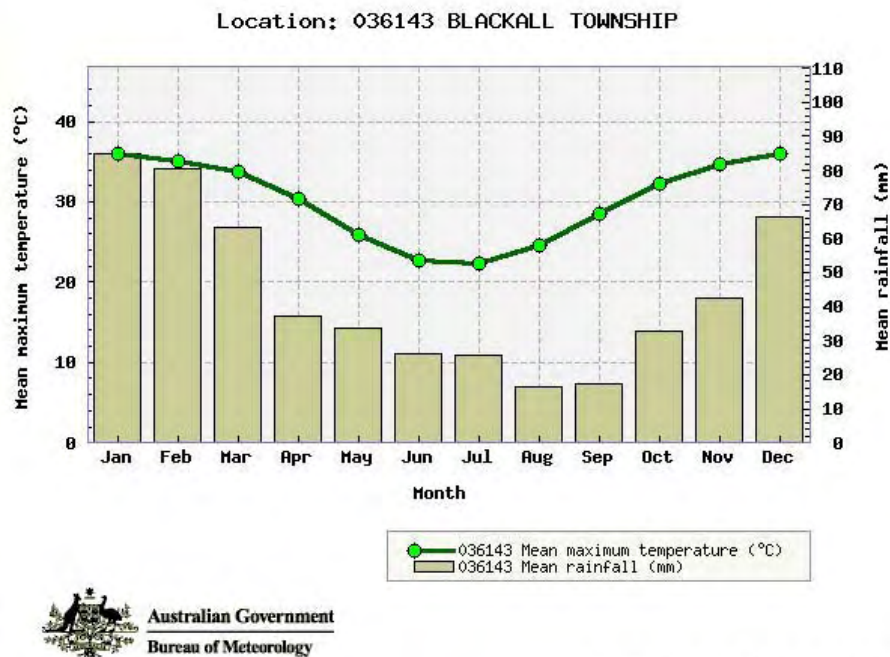


Figure 7 – Topography, Elevation, and Extent of Boree Salt Member
See Figure 2A for Updated Tenement Boundaries.
(From Terra Search Pty. Ltd., 2008)



7.4 Climate and Seasonal Operations

High temperatures, low rainfall, and low humidity in the area of potential industrial development are not usually conducive to optimal production. However, for a project involving the drilling of exploration holes and for the possible subsequent production of potash, halite and specialty brine products, the prevailing climatic factors such as high temperatures, low rainfall, low humidity, high wind speed, along with high solar exposure (clear days) are especially favorable for year-round operations such as those contemplated by AusPotash (see Figures 8, 9, and 10).



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Figure 8 – Mean Maximum Monthly Temperatures and Rainfall



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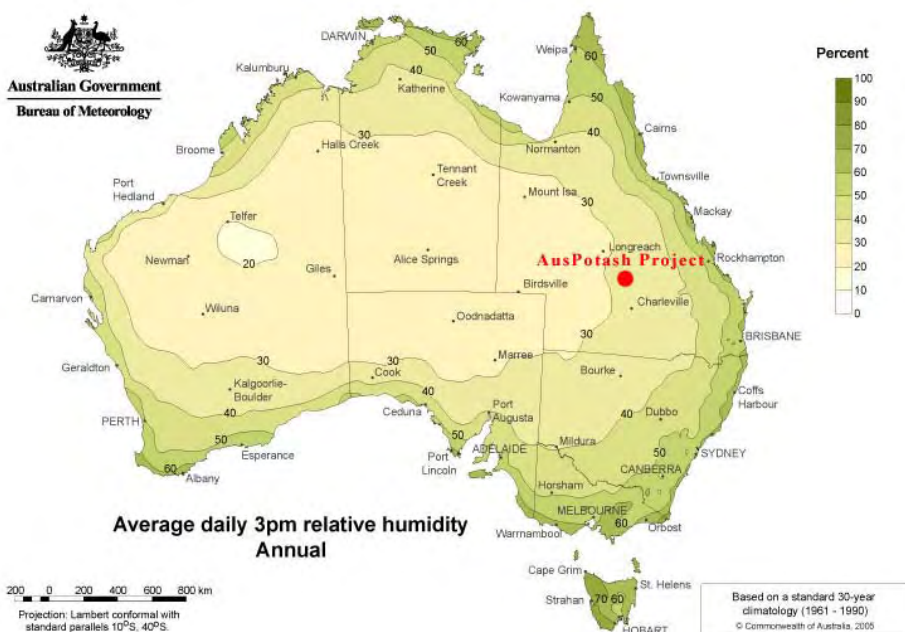
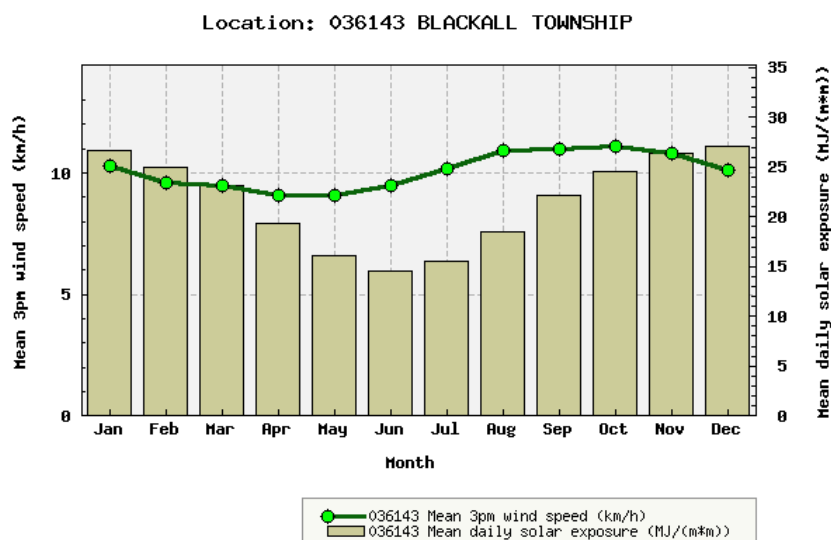


Figure 9 – Average Daily Relative Humidity (@ 3:00 PM)



Australian Government
Bureau of Meteorology

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Figure 10 – Mean Monthly Wind Speed (@ 3:00 PM)
and Mean Daily Solar Exposure



7.5 Available Infrastructure

As discussed in **Sections 7.2 Accessibility to Properties** and **7.3 Local Resources**, supporting infrastructure is available in Blackall some 70 kilometers to the north via the Blackall–Adavale Road, and in Longreach some 200 kilometers to the northwest of Blackall along a bitumen highway. A railway passes through Blackall to Brisbane, and Qantas Airlines makes regular stops at the Blackall airport. Also, the available infrastructure includes the Gilmore-to-Barcaldine gas pipeline that runs along the Blackall–Adavale Road to Blackall along the western edge of the subject tenements (see Figures 6 and 7).

8.0 History

8.1 Previous Activities

Interest in potash in the Adavale Basin first developed when petroleum exploration began to conduct seismic surveys in the early 1960s and then again in the early 1980s. Poseidon Minerals Limited (Poseidon) commissioned consultants to reinterpret the available seismic information. These surveys revealed an extensive evaporate sequence (Bauer, 1983 and White, 1984), which led Poseidon into a joint venture with PPG Industries to explore specifically for potash. White (1986) summarized all the available relevant information on the studies conducted to date.

During the 1980s, a number of deep holes were drilled, cored and logged in the Adavale Basin, some of which confirmed a thick evaporate interval, which was subsequently studied in great detail by Poseidon, Denison Resources, N. L., Mines Exploration Pty. Ltd., and the Queensland Government (see McKillop, *et al.*, 2007). These studies form the basis of the present interest in developing the potash resources in the subject basin, assuming the occurrence of potash minerals is of sufficient volume and chemical grade to merit development.



8.2 Previous Exploration Results

According to Wells (1980), the presence of potash in the Adavale Basin and the classical evaporate sequence from dolomite through anhydrite to halite and potassium minerals, including sylvite, make it one of the most prospective basins in Australia, the most prospective area being next to the Pleasant Creek Arch. Subsequent drilling by petroleum companies further confirmed the thick sequence of evaporite sediments and likely interbeds of potassium minerals in the upper intervals of the sequence (see Figure 11).

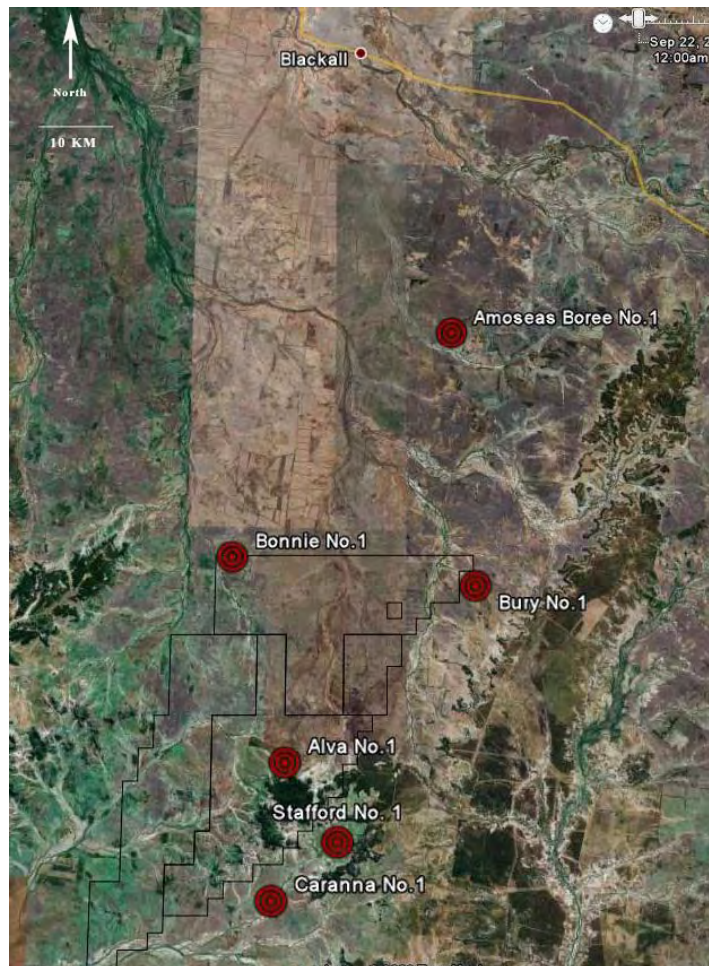


**Figure 11 – Location of Principal Historical Petroleum Exploration Well Sites and Tenement Boundaries.
(A Google Earth Photograph)**



Poseidon evaluated the potash potential of the area and Dennison Resources N.L. took their evaluation of the potash potential all the way through the feasibility and engineering stage before they cancelled the project as a result of other business interests. Nothing of record is available since the late 1980s on the subject tenement area until recent interest re-emerged as prices and market needs in South East Asia, Australia, India, and China have made it apparent that fertilizers and specialty chemical products are now in significant demand.

9.0 Geology

9.1 Regional Geology

The rocks of the Adavale Basin do not crop out, but are overlain by 1,000 meters to 3,000 meters of sediments of the Galilee Basin (Late Permian to Carboniferous) and of the overlying sediments of Eromanga Basin (Jurassic-Cretaceous). Sediments of the Adavale Basin range in age from the Early Devonian and possibly extend upwards into the Early Carboniferous. The Devonian sediments of the Adavale Basin have been subdivided by McKillop, *et al.*, (2007), with an important hiatus (and the formation of evaporite basins) at the top of the Middle Devonian (see Figure 12).

They were deposited during a transgressive-regressive cycle reflecting the westward advance and subsequent retreat of the sea during Devonian time. Transgression reached its maximum during approximately Middle Devonian time, represented in its shoreward facies by a widespread thin dolomite.

The Boree Salt Member consists of up to 580 meters of rock salt with minor dolomitic limestone, anhydrite and clastic sediments. It occupies the position between the evaporitic carbonates to the east and the sandstone member and red beds along the west flank of the Pleasant Creek Arch (see Figure 1).

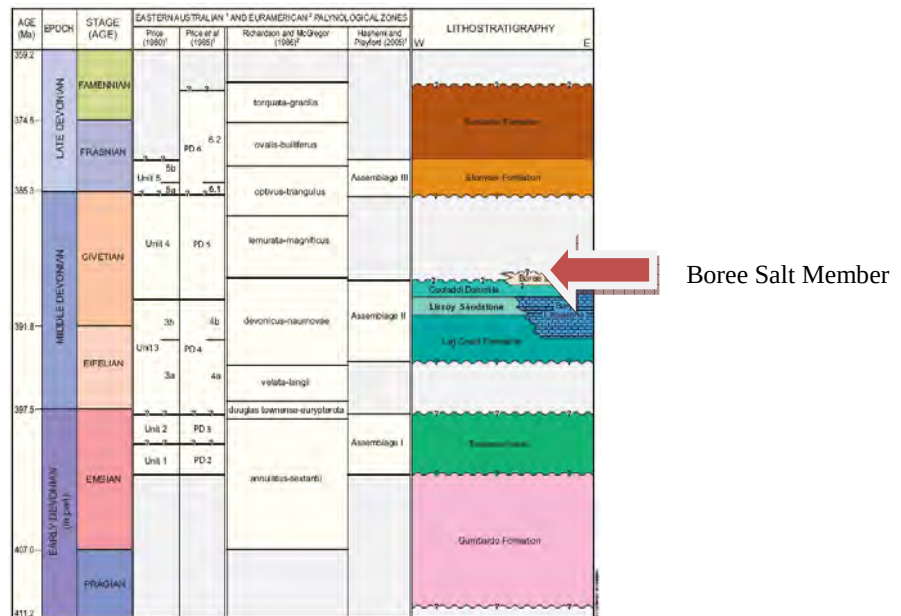


Figure 12 – Devonian Stratigraphy within the Adavale Basin
(After Queensland Government, 2007)

9.2 Local Geology

Within and around the subject tenements, the Boree Salt Member thickens as it approaches the Warrego Fault to the east in what is likely a graben oriented north-south (see Figure 1). This can be inferred from the cross-section illustrated in Figure 13. The salt has been remobilized and forms pillows along the western bounding fault, especially in the area of Amoseas Boree No. 1 (see Galloway, 1970, p. 25; Bauer, 1983; and McKillop, *et al.*, 2007).

Three units are interpreted to form a laterally related genetic sequence. Paten (1977) suggests that the continued carbonate sedimentation along the Quilberry-Dartmouth trend caused the isolation of the basin. On the landward margin, the sandstone member represented the eastern encroachment of desert sedimentation. The Boree Salt Member was deposited in the isolated basin(s) between the two. It is probable that gentle downwarp of the basin was occurring at this time (see Paten, 1977).



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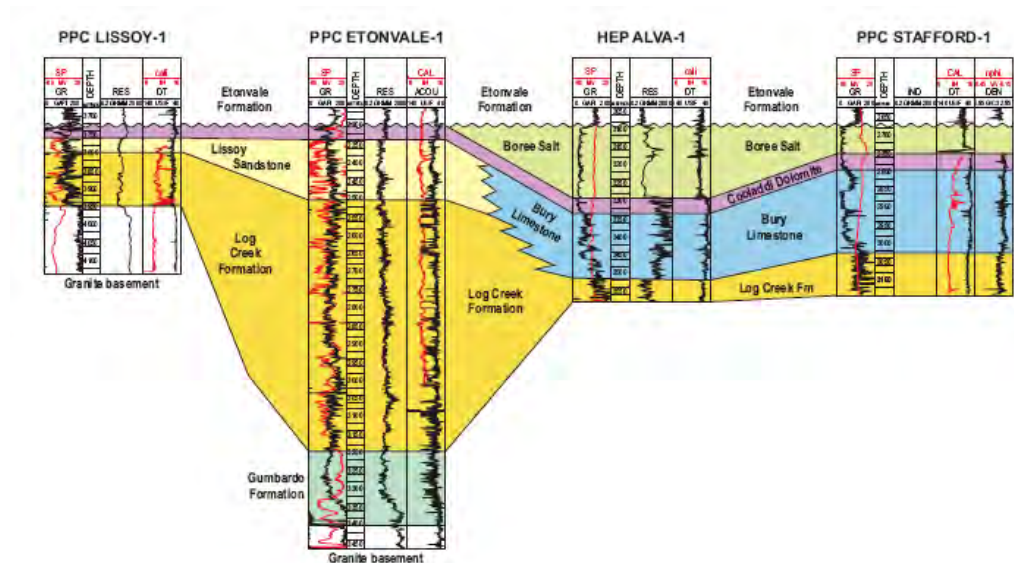


Figure 13 – Geologic Cross Section through Subject Tenements
(From McKillop, *et al.*, 2007)

10.0 Deposit Types

On Earth, marine evaporites occur in both cratonic basins and grabens associated with continental marginal rift systems. The potash deposits of the cratonic basins are generally of Paleozoic age and are characterized by assemblages containing sylvite and potassium sulphate-bearing phases. The deposits of the marginal rift systems are of Triassic or younger age and commonly contain primary carnallite-bearing assemblages, which can contaminate the potash product (CIM, 2005). Marine evaporite deposits are composed of sequences of tabular beds which are characterized by the proportions of the minerals they contain as well as by color, texture, and grain size. Mappable beds may be a few centimeters to several meters in thickness and may be present over hundreds of square kilometers. These stratigraphic features reflect relatively rapid precipitation in comparatively stable structural settings.

The normal ratio of sodium to potassium in seawater is 27.7 to 1. Mineable potash beds, therefore, are generally accompanied by considerably thicker halite deposits. Furthermore, the



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potassium mineral assemblages commonly occur in the younger, upper portions of the thick halite deposits because the potash salts are precipitated late in the evaporation sequence. Multiple potash horizons may occur in the upper one-quarter to one-third of major halite deposits reflecting the cyclic nature of precipitation (see Figure 14, after Guilbert and Park, 1986).

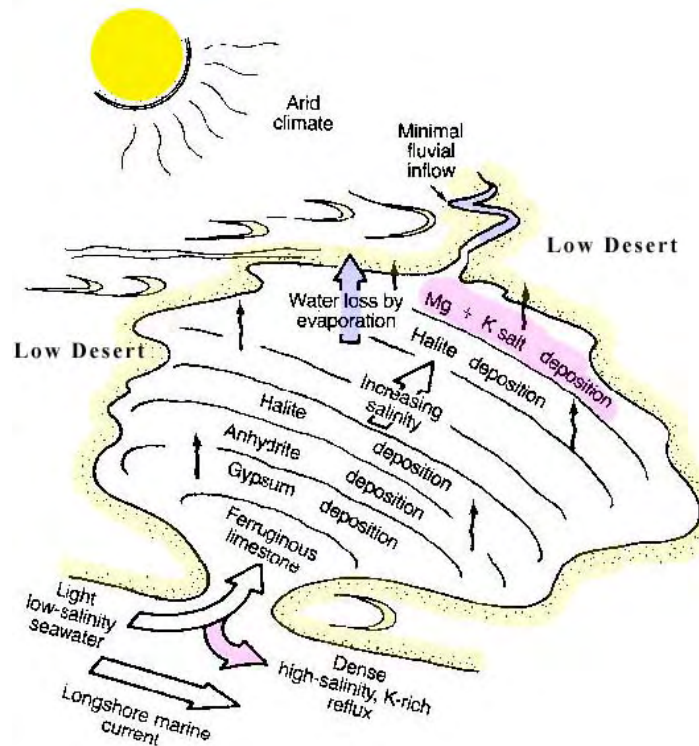


Figure 14 – Typical Sequence of Evaporite Basin Development
(Guilbert and Park, 1986)

Bluck, *et al.*, (1982), in an early assessment of the potential of the Boree Salt Member, indicate that the occurrence of economic potash deposits is essentially restricted to widespread, thick accumulations of marine evaporite deposits. They claim that these bodies yield high grade, large tonnage materials, many of which are amenable to in situ solution mining and beneficiation because they are bedded deposits. The products from these deposits are ideal for use in fertilizer because of the high solubility of the potassium chloride and sulphate evaporite minerals.



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The principal potash deposits may be associated with areas of greatest halite thickness, peripheral to them or in nearby sub-basins, depending of the tectonic history of the area. Thick halite deposits in some basins do not have associated potash deposits, the potash-rich brines having been lost by reflux before potash precipitation or the precipitated salts having been subsequently dissolved by refreshed brines from the ocean.

The exploration for potash deposits in known evaporite basins is based on studies of the chemical and physical characteristics of the salt beds. Bluck, *et al.*, (1982), Guilbert and Park, (1986), and Adams (1975) suggest that stratigraphic criteria favorable for the occurrence of extensive potash deposits include: 1) halite sequences in excess of 60 to 100 meters in thickness, 2) the presence of potassium in sulphate beds (possibly as polyhalite) or as disseminated grains of potassium chloride (sylvite or sulphate minerals in halite beds, and 3) the presence of clastic zones of mixed layer clays, particularly in the upper part of the evaporite section, to serve as seals above beds of soluble minerals. According to the historical reports, all of the above criteria have been met in the Boree Salt Member in the Adavale Basin.

11.0 Mineralization

According to White (1984), an assessment of the Australian evaporite basins was carried out by Mine Exploration Pty. Ltd. during 1968/69. The available oil well cuttings and cores were scanned with X.R.D. and the Boree Salt Member of the Adavale Basin was selected for more detailed work.

The X.R.D. scans of cored samples indicated the presence of potassium minerals (especially sylvite) in the salt sequences in the wells Bury No. 1, Boree No. 1 and Bonnie No. 1 wells. Clean halite was handpicked from the Bury No. 1 cuttings and cores and assayed for bromine. The bromine levels were subsequently redetermined for this and other samples from the wells (see White (1984 and 1986) for the details).



The bromine-in-halite data from Bury No. 1 show near halite-normal bromine contents (75 ppm) in the lower part of the salt section, with a rapid increase above a regionally developed shale marker horizon at 2,133 meters to in excess of 270 ppm of bromine indicating marine waters were the source. The bromine contents are maintained above the 270 ppm level for the next 190 meters with descendent solution-induced breaks at 2,051 metres, 1,975 meters and 1,948 meters below surface, suggesting basin isolation from time to time. Hand-picked samples of halite and sylvite were crushed, separated in heavy media, and assayed with the following results shown in Table 3:

Table 3
Poseidon Sample Analyses for Bromine Content in Halite and Sylvite
(White, 1984)

Well Name	Sample Mark	Bromine in Halite	Bromine in Sylvite
Bonnie	BR6	200 ppm	2,200 ppm
Boree	BR69	260 ppm	2,000 ppm
BR66	(?)	240 ppm	20,100 ppm
Bury	BR197	300 ppm	3,200 ppm

The indicated partitioning of bromine between sylvite and halite of approximately 10 to 1 is equivalent to the theoretically calculated ratio given by Kuhn (1962) for primary sylvite, indicating the geological environment was part of one or more cratonic evaporite basins bordering low deserts.

The most significant finding of the Poseidon study conducted by White (1984) with respect to potash occurrence is the recognition of a thick wedge of salt, probably deposited in an elongate restricted basin adjacent to the Warrego Fault. The thickness of the salt is probably a primary depositional feature and not due to salt flowage as indicated in the area of the Boree No. 1 well to the north of the subject tenements. In such areas of faulting and associated structural disturbance, potash deposits may not be conducive to development because of the disturbance of the horizontal bedding in the area of Boree No. 1 and surrounding area. This is based on work by Galloway, 1970, p. 25, Bauer, 1983 and McKillop, *et al.*, 2007, who all indicate that the salt beds have been disrupted by structural movement (faulting) causing flowage of salt masses and fluids in unpredictable directions.



Figure 15 – Core of Coarsely Crystalline Halite from Area.
(From McKillop, *et al.*, 2007)

In the Denison Resources report by Hill (1988), he indicated the presence of well-developed, horizontal salt horizons in the area of the subject tenement (see Figure 15), in the area of Bonnie No.1, Alva No.1, and Bury No.1. The chemical and structural framework of the Boree Salt Member appears to be suitable for in situ solution production of halite and other soda brine minerals. This is based on an associated report by a Denison consultant that indicates that in preliminary determinations on 11 core samples from the Boree Salt Member, the dissolution rates observed for halite in the samples studied compared favorably with published data, within acceptable parameters, to enable successful extraction of halite and associated minerals by solution-mining techniques.

A detailed petrological study of core samples from the Boree Salt Member was undertaken by Arakel (1987). The sedimentological assessment of the Boree Salt Member was made on available drill cores from the Adavale Basin. The purpose was to determine the most favorable segments and areas of the deposit in terms of: 1) lateral extension and thicknesses, 2) extent of salt-quality variation, and 3) identification of environmentally and technically less problematical areas for in situ solution mining (Dutler, 1987 and Rohr, 1980). Overall, 185 core intervals and



21 polished core slabs from the following drill holes were examined and described to establish the major physio-chemical characteristics of selected samples from the Boree Salt Member.

12.0 Exploration

12.1 Previous Surveys and Investigations

Earlier work by Poseidon (Bluck, *et al.*, 1982) laid the foundation for Poseidon's activities on their eight (8) Authorities to Prospect (ATPs) over the ensuing years of exploration, focusing on potash in the Devonian Boree Salt Member in the Adavale Basin. Later, Denison Resources Limited acquired tenements for the assessment of salt, potash, magnesium chloride, bromine and other minerals covering an area of approximately 430 square kilometers. However, the construction of an ammonium nitrate plant planned by Denison and others near Blackall during the mid 1980s was cancelled in April, 1988 because another site was selected near Moranbah, Queensland. The Boree Salt Project was deemed to be uneconomic due to excessive freight costs and related costs of the raw material, although the Boree Salt resource and the economics of the associated solution mining supported the overall economic viability of the project at the time (see Arakel, 1987).

12.2 Current Concepts

The available data indicate that the halite sequence is relatively thick within the subject tenements. The distribution of the potassium minerals is not well known within the tenements, but guided by the historical petrological studies of the cores and by the recent modeling of the Boree Salt Member by AusPotash consultants, candidate drilling targets have become apparent and are presently under final review.

13.0 Previous Drilling Activities

Petroleum exploration conducted over the past 30 years, as mentioned above, provided early encouragement with clear evidence of the presence of potassium minerals within the upper



section of the thick halite sequence present in the subject tenements. The well logs from earlier petroleum drilling illustrate the salt sequence and likely potassium beds within the halite (see Figure 16). Note the active Gamma Log traces for four of the wells in the figure are in the upper zones of the evaporite sequence encountered, suggesting the presence of thin beds of ⁴⁰Potassium minerals.

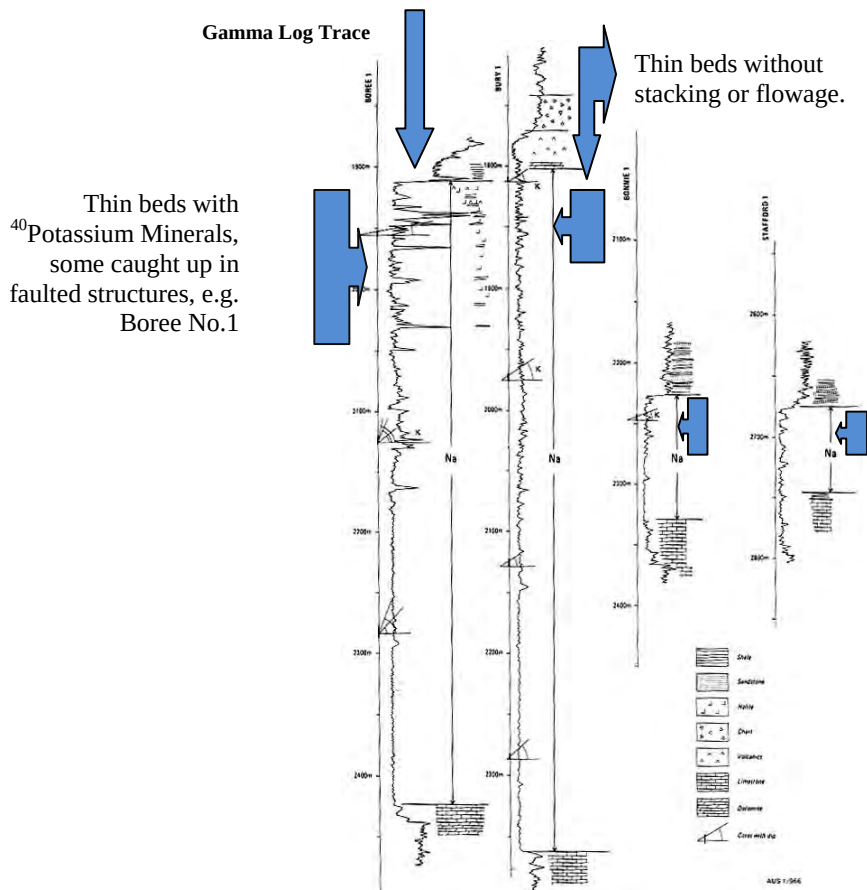


Figure 16 – Discovery Well Logs Showing Salt Sequences.
For locations of the above wells, see Figure 2.
(Wells, 1980)

14.0 Previous Sampling Method and Approach

Petroleum wells logging, coring and so-called ditch samples were examined and analyzed by numerous consultants of Poseidon Limited, of Denison Resources N.L., and by the Geological Survey of Queensland, Department of Mines and Energy, and by the BMR in Canberra (see **Section 23.0 References**). Since the sampling methodology and approaches of these



organizations are not known specifically, this information is none the less suitable to evaluate the potash potential in qualitative terms. Further drilling and assessment will be required to confirm previous information and to provide additional information to permit an assessment of the economic feasibility of developing the resource. According to a report from the Canadian Institute of Mining Subcommittee on Potash, however, potash deposits located in Saskatchewan, Canada are characterized by their remarkable consistency of grade and thickness over tens of kilometers. It is therefore possible to characterize these types of potash deposits with relatively few drill holes, supplemented by sufficient seismic coverage to establish continuity between holes (CIM, 2005).

15.0 Previous Sample Preparation, Analyses, and Security

Many of the chemical analyses we have reviewed were of samples obtained from previous coring by petroleum exploration in the 1970s or earlier. Of these, many of these cores have been held in a reasonably secure manner by the Queensland Government. Other work was conducted by personnel of the Geological Survey of Queensland. White (1983) reports on samples from thin beds of potash minerals (notably sylvite) of a few inches thick that occur with potassium values up to 8%, averaging in the 1000s of parts per million (ppm) over greater intervals. Because the records on the coring are not complete, the actual thickness of the potassium-rich beds from well to well is difficult to correlate. Actual sample preparation, analysis and security protocols used by these organizations are often discussed in the historical records. Arakel (1987) reports that the potassium-rich mineral sylvite is present in many of the core samples.

To date, AusPotash has not conducted drilling and coring so further comments on this subject are not applicable or required at this time.

16.0 Sample Data Verification

Because many of the chemical analyses we have reviewed were of samples obtained from previous petroleum exploration but have been held by the Queensland Government, AusPotash cannot reasonably be expected to have verified sample data used in the historical reports. Other



analyses were conducted by personnel of the Geological Survey of Queensland. Because AusPotash has not conducted drilling and coring to date, further comments on this line item are not applicable or required at this time.

17.0 Adjacent Properties

AusPotash personnel provided information on properties adjacent to the subject properties from the Queensland Government Tenement Database. Reward Minerals Ltd. holds properties along the eastern boundaries of the subject properties (see Figures 2 and 7). In addition, Holocene Pty Ltd (via EPM 16410) holds properties near the east side of AusPotash tenements and NQ Metals Limited (via EPM 17697) hold properties northeast of the corner of the subject tenements designated “Ada” – EPM 17503 (see Figure 2 and 7).

18.0 Mineral Processing and Metallurgical Testing

White (1983) described core “raspings” (vertical scrapings obtained while coring) and cores finding that thin beds of potash minerals (notably sylvite) of a few inches thick occur with potassium values reported up to 8%, averaging in the 1000s of parts per million (ppm) over a core length. A sample of pure sylvite would contain as much as 40% or more of potassium. No recent mineral processing or metallurgical testing has been conducted by AusPotash or any other organization to date. Once drilling and coring have been conducted on the subject tenements, considerations of mineral processing and metallurgical testing are to be undertaken, if merited. A study conducted by Kashani-Nejad, S, *et al.*, (2004) revealed that impurities such as carnallite ($\text{KMgCl} \cdot 6\text{H}_2\text{O}$) in the form of metallic particles and oxides considerably influence all oxide speciation activities during potash production process at the surface. It was concluded that applying these methods without regard for the effects of the impurities and without conducting regular calibration for each of the process plant’s specific electrolyte composition would result in a significantly inaccurate determination of the total oxide content of the electrolyte with commensurate problems in the production of the potassium, magnesium and other metals from evaporite deposits. Therefore, the mineralogical content of the potash deposits will need to be closely investigated during the drilling stages of the AusPotash project to monitor the possible



occurrence of carnallite within the potash deposit. To date, the cores suggest that the sylvite-dominated depositional process prevailed within and around the subject tenements.

19.0 Mineral Resource and Mineral Reserve Estimates

Hill (1988) made a preliminary assessment of the salt (halite) resources in the subject area and indicated that over an area of 25 sub-blocks of the tenement, approximately 13 billion tonnes of halite are present for an assumed average bed thickness of 100 meters. No known potassium-specific mineral resource or mineral reserve estimates for potash have been conducted to date by AusPotash or any other organization, aside from generalized speculations indicating very large potash resources based on similar deposits in the World and their consistency of grade and thickness over tens of kilometers (CIM, 2005).

Estimates of potash resources should be undertaken in context with subsequent mining feasibility and market studies and related petrological and processing studies. These studies should be undertaken once data on the potash content within the halite sequence have been obtained from drilling, coring and geophysical logging of wells to be drilled.

20.0 Other Relevant Data and Information

Of particular interest is the report by Arakel (1987) that indicates that analyses of the Boree Salt Project indicate the presence of thin beds of soluble potassium minerals (notably sylvite) suggesting that solution mining operation would produce a potash-rich brine. This was based on engineering studies on the economics of solution mining of the mid-1980s, but not on a focused assessment of the anticipated potassium resource that was to provide the raw materials to make fertilizers and various specialty chemicals. Confirmation of the potassium resource by advanced coring technology will be required before mining engineering and economic assessments can be initiated.



21.0 Interpretations and Conclusions

Early in 2008, AusPotash and partners engaged Terra Search Pty Ltd. to assemble all available data from previous seismic surveys and petroleum drilling within and around the subject tenements, and from previous investigations by Poseidon and by Denison Resources, N.L. and others on the potential development of the potash resources (see **Section 23.0 References**). These data were used to conduct modeling with current software technology on the thickness and horizontal extent of the halite sequence indicated within the subject tenements. The results of this modeling have produced reasonable extrapolations of the halite bed thickness between the existing well locations in order to begin to assess the nature of the potassium resources and where they are likely to be the most abundant (see Figures 16, 17 and 18).

Based on a review of the historical reports and associated analyses, well logs, and seismic modeling of earlier well data, we have concluded that the Boree Salt Member represents a potentially large resource for making fertilizers and various specialty chemicals. Although this resource was evaluated during the mid-1980s, the decision not to develop this resource was unrelated to the available potassium resources within the subject tenements and surrounding lands but rather to the business decision to develop another, larger project.

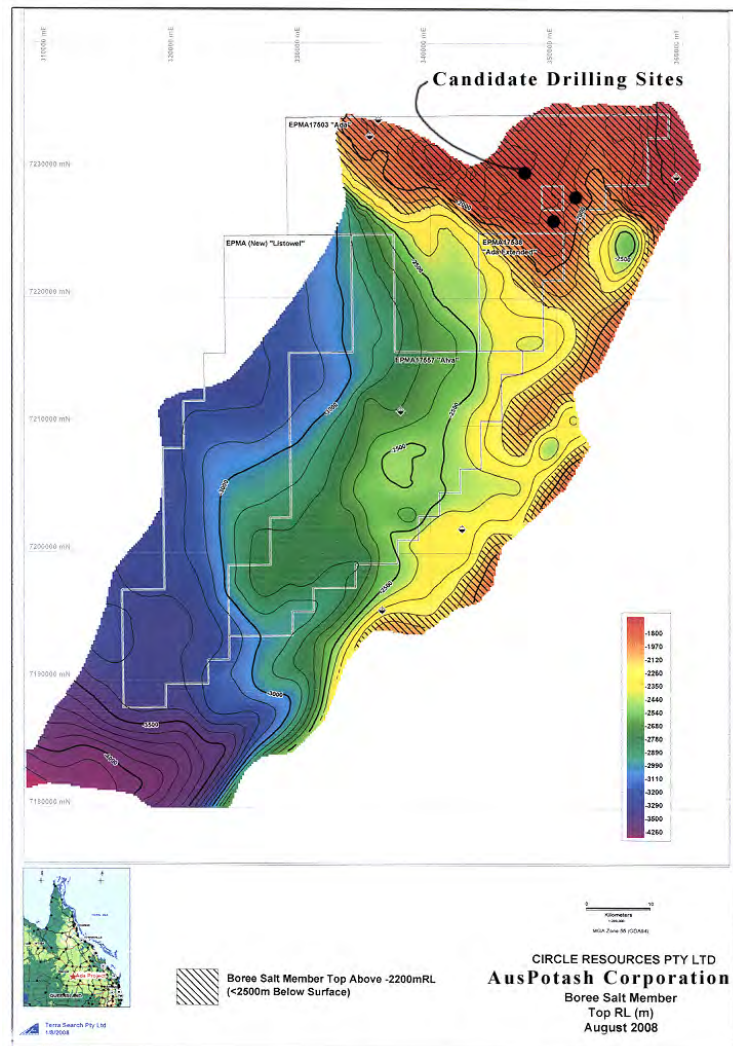


**Figure 17 – Top of Boree Salt Member. See Figure 2A
for Updated Tenement Boundaries.
(From Terra Search Pty. Ltd., 2008)**

Today, a potash project has, once again, become attractive on the basis that the markets for fertilizers and associated specialty chemicals are expanding in South East Asia, Australia, India, and China, and commodity market prices are at historically high levels and are expected to remain high as economic expansion continues in Australia and in South East Asia, Australia, India, and China and elsewhere in the developing World, even as Australia, the United States, China, and others recover from a present world-wide economic recession.

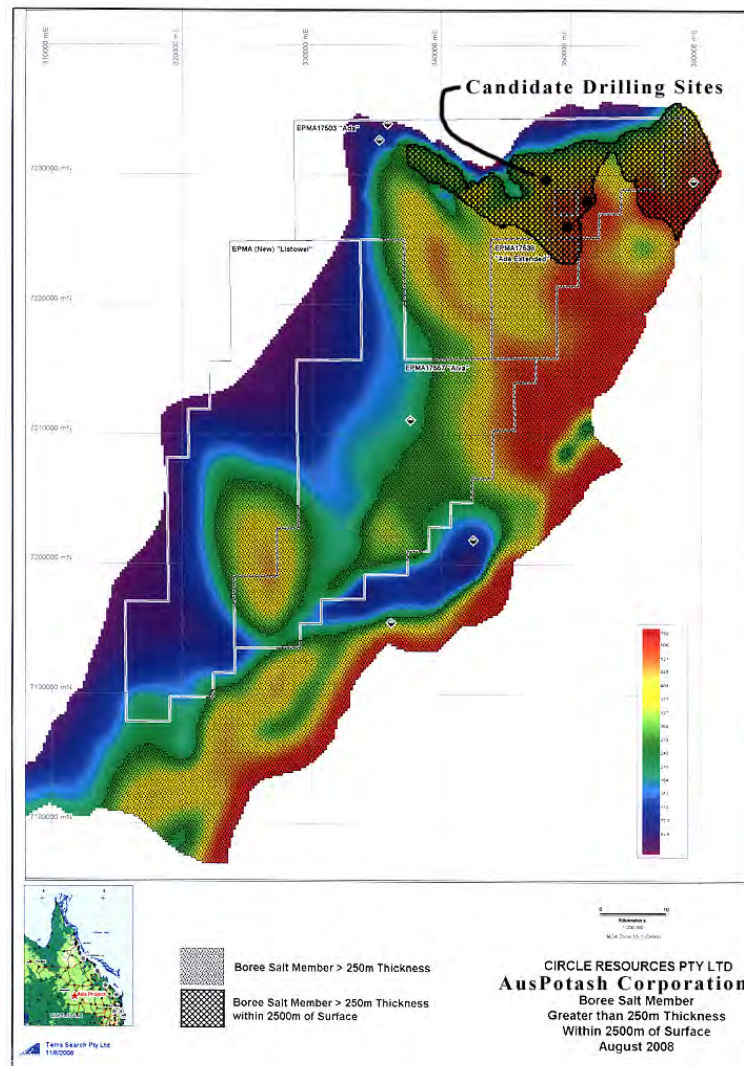


**Figure 18 – Maximum Thickness of Boree Salt Member within 2,500 Meters of Ground Surface.
See Figure 2A for Updated Tenement Boundaries.
(From Terra Search Pty. Ltd., 2008)**

Based on the above, we have concluded that the AusPotash project involving the subject tenements has considerable merit and the potassium resources should be evaluated in detail by drilling, coring and well logging to assess the mineralogical characteristics and quality of the potassium resources in the areas suggested by the recent modeling illustrated in Figures 17 and 18. These activities would form the basis for subsequent engineering and economic feasibility studies according to a business plan created by AusPotash management to address the potential development of the potassium resources and specialty products from the subject tenements.



22.0 Recommendations

We recommend drilling, coring and logging to assess the quality of the indicated potash resources. Recent seismic modeling has indicated candidate drilling sites (see Figures 17 and 18). Prior to drilling the first test hole (Stage 1), however, we recommend that a geological assessment be conducted to fully integrate the new modeling results with the geological views offered by the historical reports and recent technical literature, combined with input from the personnel of the Queensland Geological Survey (especially those personnel involved in the published work by McKillop, M, *et al.*, 2007). The cost for this Stage 1 activity would be in the range of AUS\$75,000 to \$100,000. The purpose of this study would be to optimize Stage 2 drilling locations. The estimated costs for the Stage 1 geological assessment and Stage 2 test drilling, coring and logging for the first hole are presented in Table 4.

Table 4
Estimated Phase I Costs: One Hole Drilled

Phase I Functions:	Total Cost (AU\$)
Stage 1 - Geological Assessment	\$100,000
Stage 2 - Drilling Program:	
Geological Supervision	\$60,000
Drilling Consultant	60,000
Rotary Drilling Contractor	800,000
Coring Contractor	200,000
Laboratory Analyses	25,000
Quality Control/Quality Assurance	10,000
Mud, Bits, Supplies	30,000
Mud Supervision	30,000
Geophysical logging	35,000
Backhoe & Road Repair	10,000
Subtotal:	1,330,000
Contingencies @ 10%	133,000
Estimated Total Phase I:	1,463,000

In the event favorable results are reported from drilling the first test hole in Phase I of the AusPotash program, additional holes will be required in Phase II to characterize the deposit in greater detail. This will provide additional geological and geotechnical information in support of feasibility studies (Phase III) and mine design (Phase IV) in preparation for going into



production within four to seven years after a favorable feasibility study has been completed. The date of initial production will depend on the time required to complete Phase III and IV and all administrative permitting requirements. Start-up of production will also depend on the prevailing world economic conditions at the time, especially in South-East Asia and China.

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24.0 Certificate of Qualified Person

Michael D. Campbell, P.G., P.H.
Senior Geologist and Senior Hydrogeologist

I, Michael D. Campbell, do hereby certify that:

1. I am an Independent Consulting Geologist and Managing Partner in the firm of M. D. Campbell and Associates, L.P. residing at 1810 Elmen Street, Houston, Texas 77019.
2. I graduated with a Bachelor of Arts in Geology in 1966 from The Ohio State University in Columbus, Ohio, and a Master of Arts in Geology from Rice University in Houston, Texas in 1976 and have practiced my profession continuously since 1966 (approximately 42 years).
3. I have worked as a geologist and hydrogeologist for my full working career. I worked for Continental Oil Company (Australia), Sydney, Australia as Staff Geologist/Hydrogeologist, Minerals and Mining Division from 1966 to 1969. I was responsible for conducting, coordinating, and implementing prospect evaluations, mapping and sampling programs, well-site operations, and ground-water supply investigations in various parts of Australia, Micronesia (Caroline Islands) and the South Pacific (Coral Sea) for exploration on: phosphate (NW Queensland, west of Mt. Isa, and Northern Territory, phosphate discovery was made in Alroy Station area), potash (Carnarvon Basin), sulfur, coal, base metals, and uranium. Joint-venture programs with Japanese and Korean companies required extensive travel between Australia and Japan and Southeast Asia. I also investigated uranium prospects on the Nullibar Plains of South Australia. After completing the assignment, Conoco transferred me back to the U.S. to work on Conoco's uranium projects. In 1970, I joined Teton Exploration, Div. of United Nuclear Corporation in Casper, Wyoming and served as District Geologist for uranium exploration. From 1972 to the present I have worked for various engineering and environmental companies involved in natural resource development and mining and on managing and executing environmental



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projects for industry. I am a licensed Professional Geologist in Texas, Washington (and as a Professional Hydrogeologist), Alaska, Mississippi, and Wyoming, and I hold national certification by the American Institute of Professional Geologists and American Institute of Hydrology. I am a member of the Society of Mining Engineers of AIME (1975- Present), and National Ground Water Association (AGWSE), and other professional societies. I have produced numerous publications and was elected a Fellow in the Geological Society of America (see following CV for additional details beginning on page 63 of this report).

4. I have read the definition of “qualified person” as defined in NI 43-101, and I certify that by reason of my education, affiliation with a range of professional organizations (Foreign associations in Appendix A of NI 43-101), and past relevant work experience, I fulfill the requirements to be a “qualified person” for the purposes of NI 43-101.
6. I made a personal inspection of the AusPotash Project in Queensland during the week of August 25, 2008 in the company of C&A’s Senior Project Manager, Mr. Jeffery D. King, P.G., co-author of this report.
7. I have not had any prior involvement with the AusPotash, Queensland Potash Pty Ltd (QPPL) or Circle Resources Pty. Ltd. (CRPL), the companies involved in this project. Therefore, I am independent of AusPotash and its subsidiaries and above joint-venture partners.
8. I have read the Instrument (NI 43-101) and Form 43-101 and this technical report has been prepared in compliance with this Instrument and Form 22-2.
9. As of the date of this certificate, to the best of my knowledge, information and understanding, this technical report contains all the scientific and technical information that is required to be disclosed to make the technical report not misleading.



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10. I consent to the filing of this technical report with any stock exchange and other regulatory authority and any publication by them for regulatory purposes, including electronic publication in the public company files or on their websites accessible by the public of the technical report.

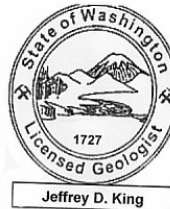
Signed in Houston, Texas this 30th day of September, 2008, and revised March 12, 2009. We reserve the right to revise this report in the future as new information becomes available and as we deem appropriate.

Sincerely,

M. D. Campbell and Associates, L.P.

Michael D. Campbell, P.G., P.H.
Managing Partner

Jeffrey D. King, P.G.
Senior Program Manager





25.0 Appendices

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26.0 Illustrations (Expanded Versions of Figures)

Figures

Figure 1 General Location of Adavale Basin and Subject Tenements 3

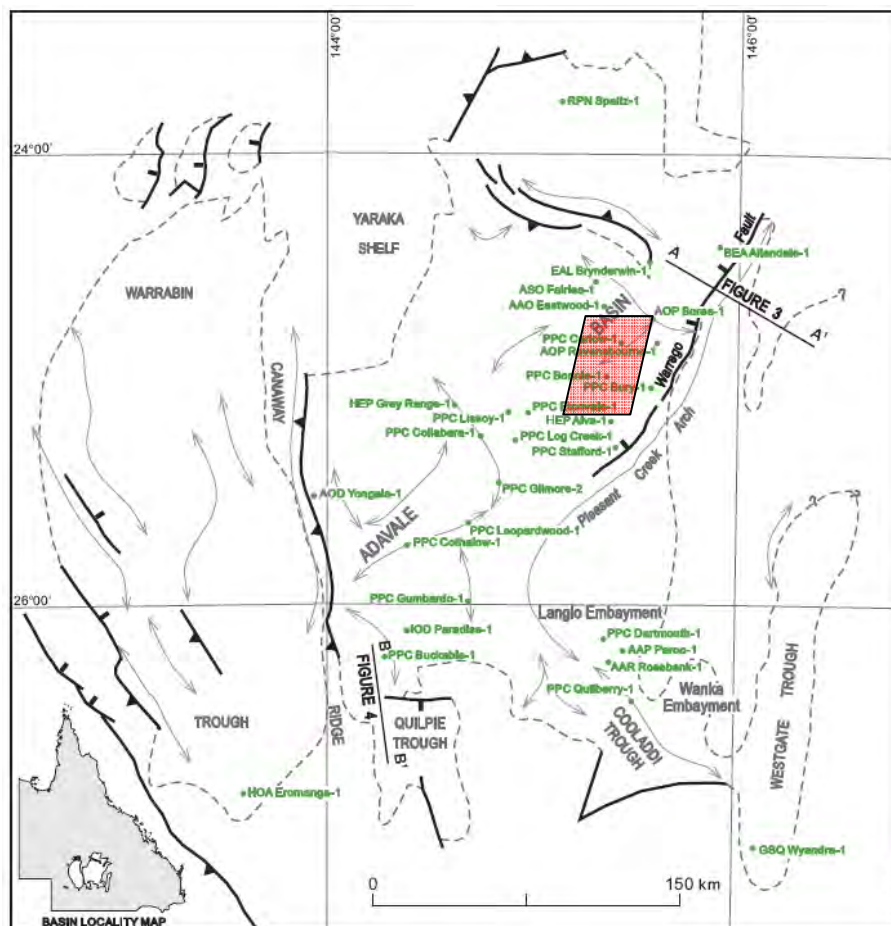


Figure 1- General Location of Adavale Basin and Subject Tenements with Structural Components.
(From McKillop, et al., 2007)

Figure 2 Seismic Data Sources and Petroleum Drilling Locations 4

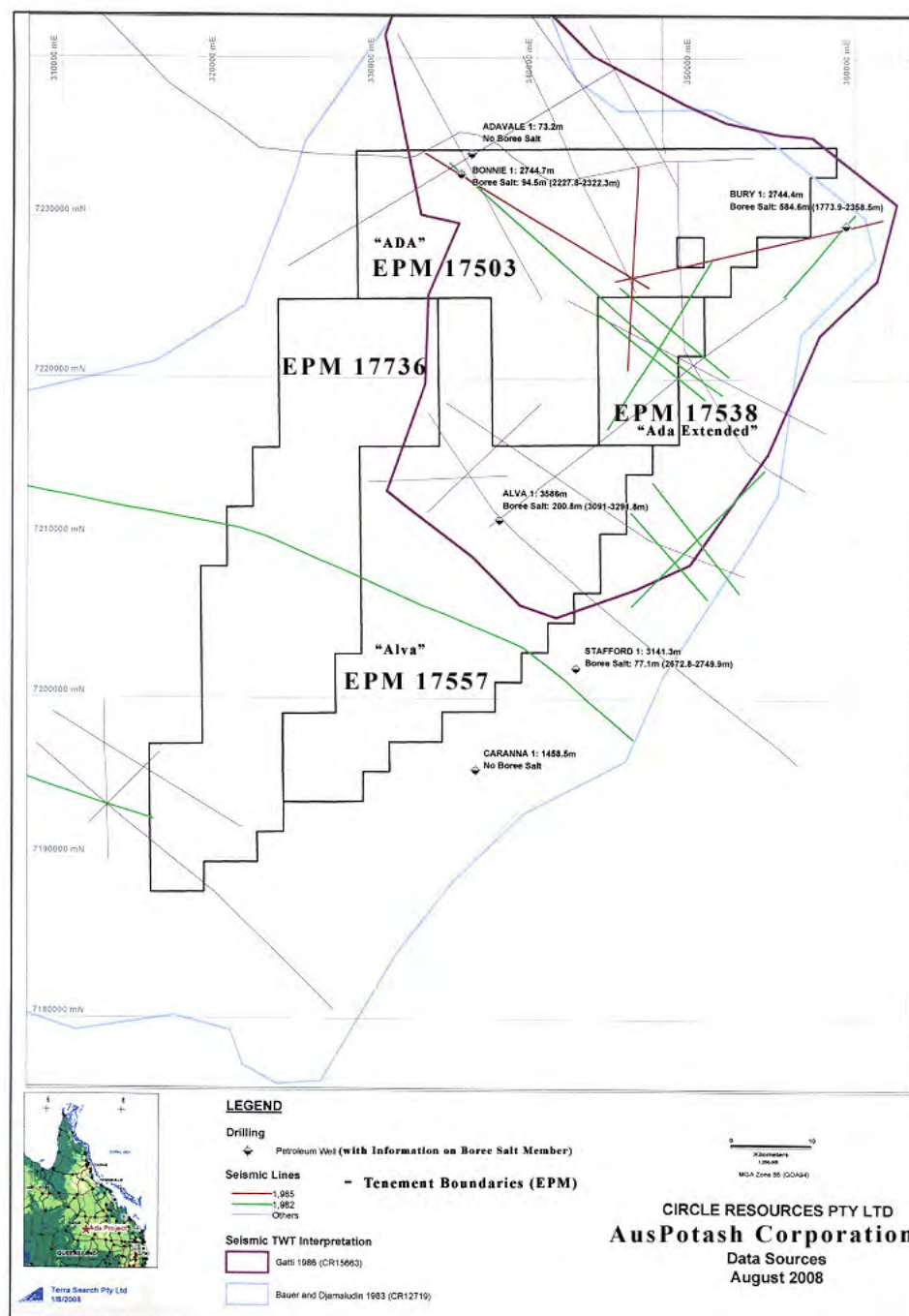


Figure 2 – Seismic Data Sources and Petroleum Drilling Locations
(From Terra Search Pty. Ltd., 2008)



Figure 2A - Updated Tenement Boundaries as of Late February, 2009
(from Queensland Department of Mines and Energy, 2009)..... 5

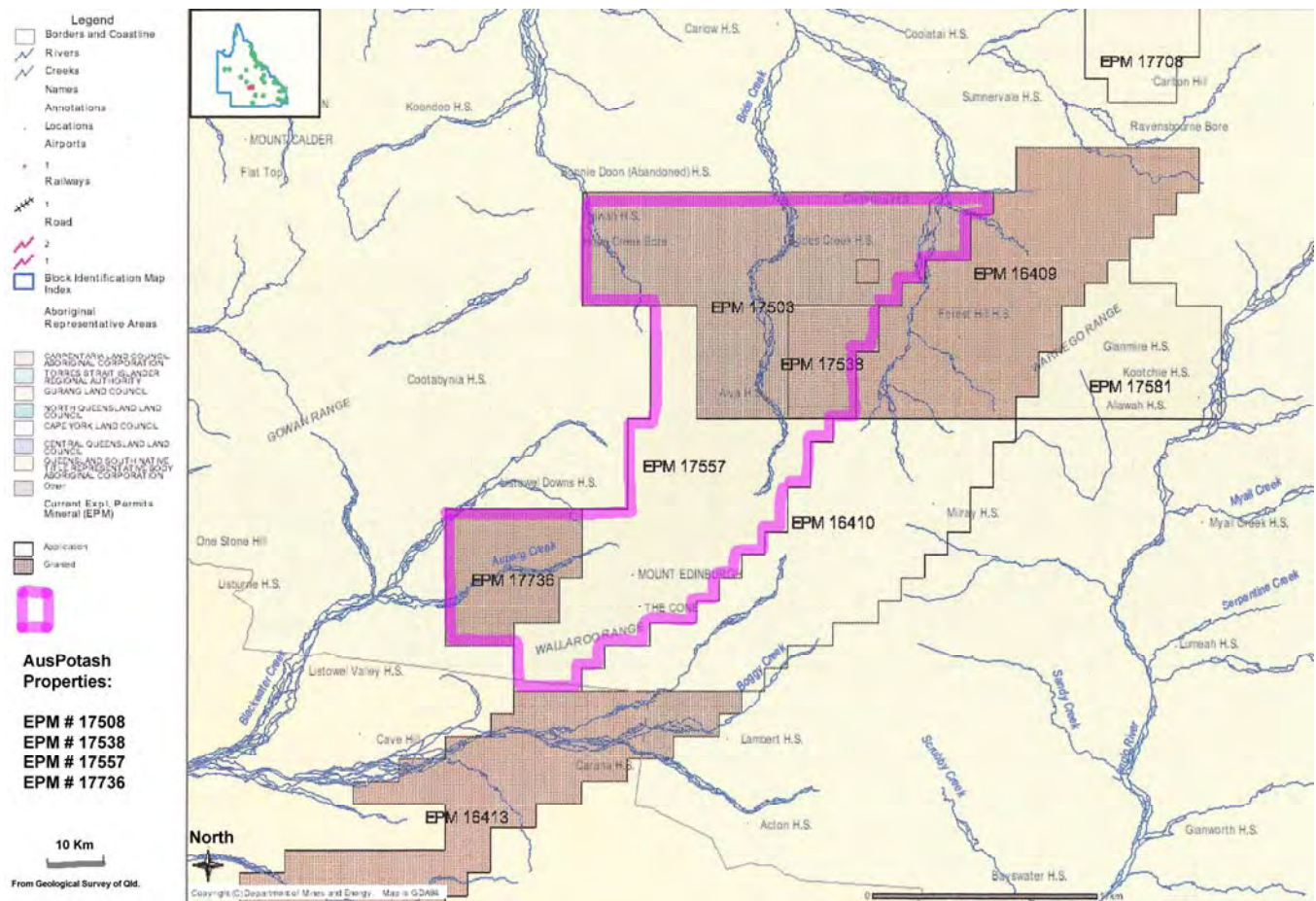


Figure 2A – Updated Tenement Boundaries as of Late February, 2009
(from Queensland Department of Mines and Energy, 2009).



Figure 3 Typical Terrain in Area of Prospective Drilling 6



Figure 3 – Typical Terrain in Area of Prospective Drilling



Figure 4 **C&A's Michael D. Campbell, P.G., P.H. Qualified Person, and**
Jeffrey D. King, C&A's Senior Project Manager, Inspected
Likely Drilling Sites on the Subject Tenements, August, 2008
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Figure 4 – C&A's Michael D. Campbell, P.G., P.H., Qualified Person, and
Jeffrey D. King, P.G., C&A's Senior Project Manager,
Inspected a Likely Drilling Site on the Subject
Tenements, August, 2008



Figure 5 Bore Census Regional Infrastructure and Property Location 8

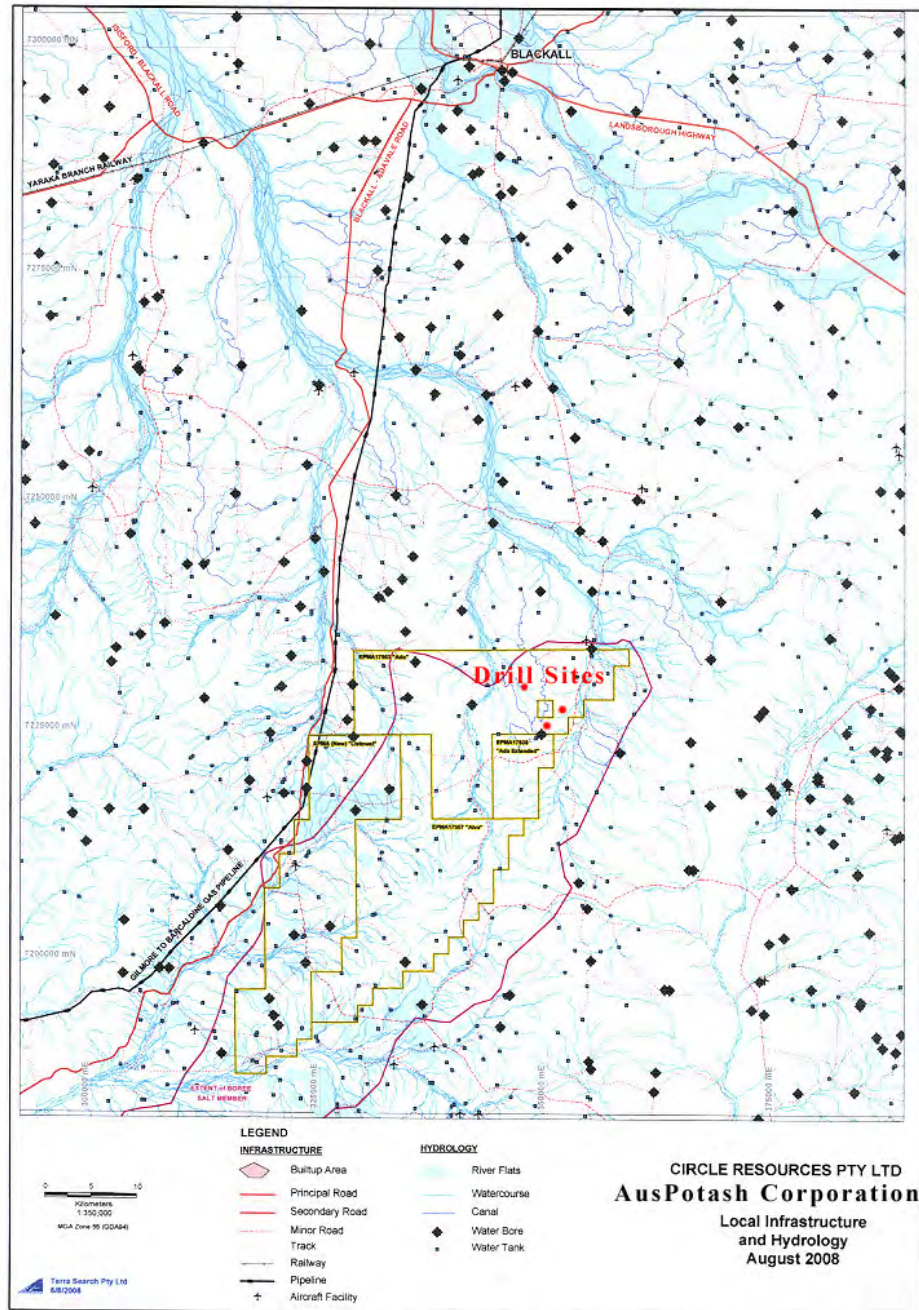


Figure 5 – Bore Census, Regional Infrastructure and Property Location
(From Terra Search Pty. Ltd., 2008)



Figure 6 AusPotash – Queensland Potash Relationships 12

AusPotash - Queensland Potash Relationships

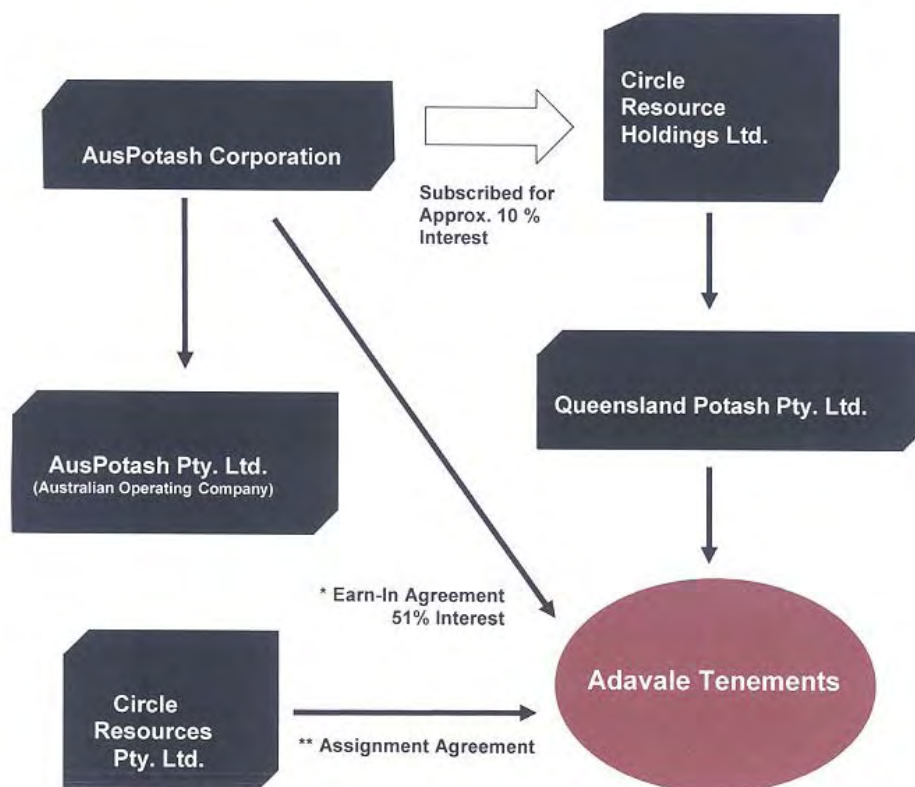




Figure 7- Topography, Elevation, and Boree Salt Member

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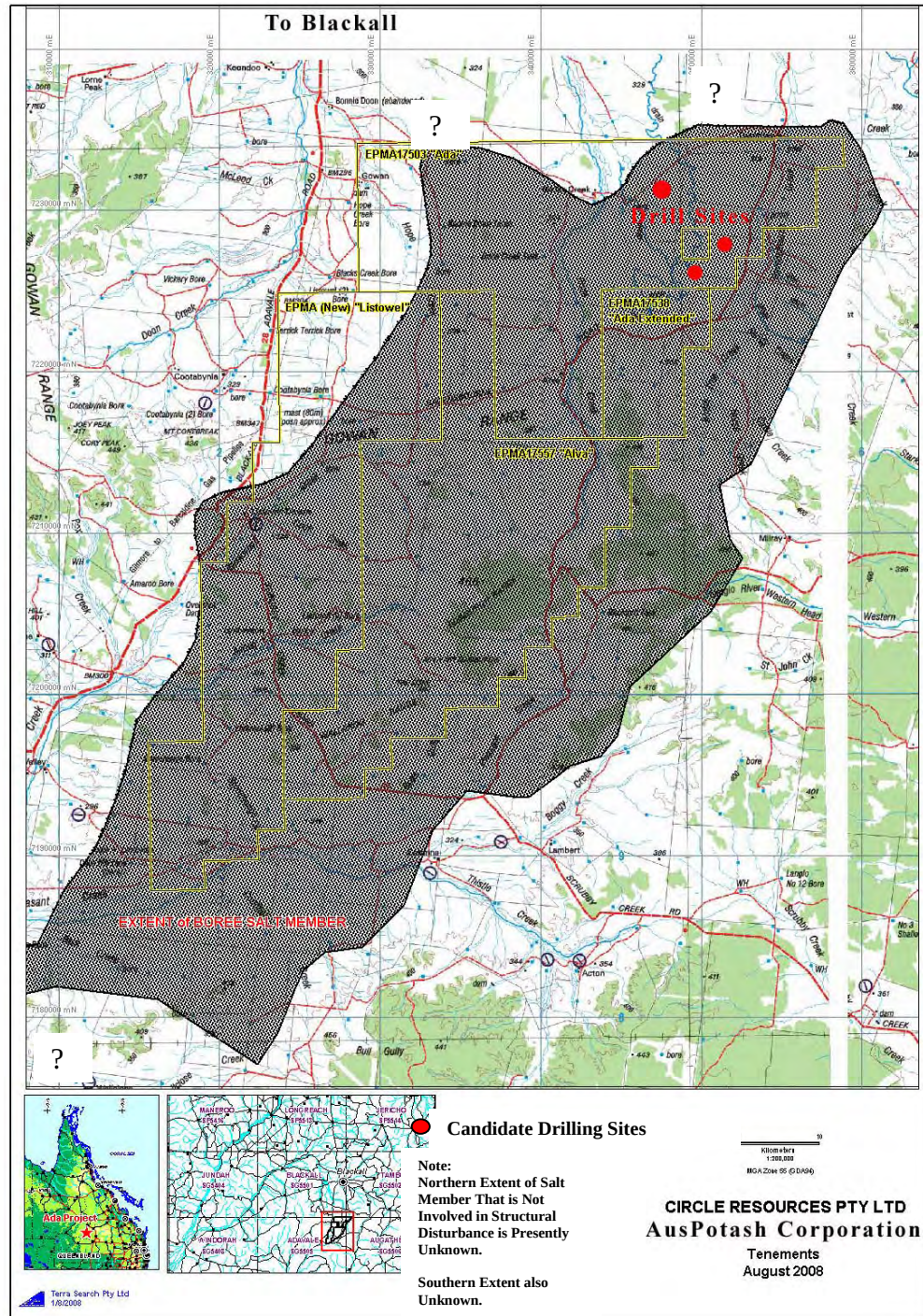


Figure 7 – Topography, Elevation, and Extent of Boree Salt Member
(From Terra Search Pty. Ltd., 2008)

Figure 8 - Mean Maximum Monthly Temperatures and Rainfall 17

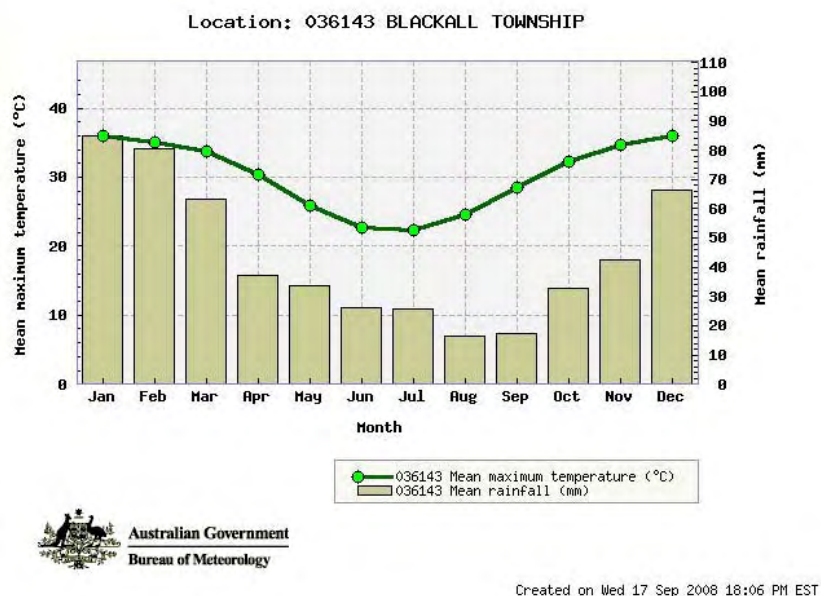


Figure 8 – Mean Maximum Monthly Temperatures and Rainfall

Figure 9 - Average Daily Relative Humidity (@ 3:00 PM) 18

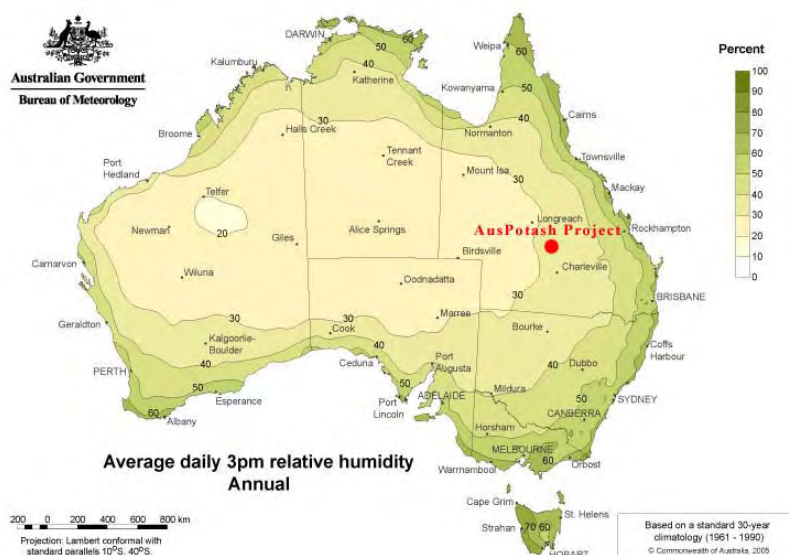
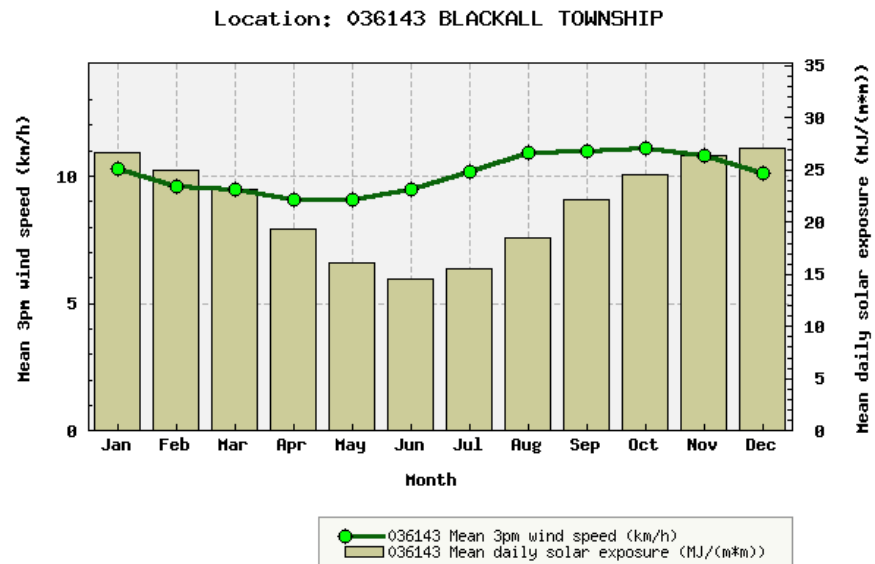


Figure 9 – Average Daily Relative Humidity (@ 3:30 PM)



**Figure 10 - Mean Monthly Wind Speed (@ 3:00 PM)
and Mean Daily Solar Exposure 18**



Australian Government
Bureau of Meteorology

Created on Thu 18 Sep 2008 00:07 AM EST

**Figure 10 – Mean Monthly Wind Speed (@ 3:00 PM)
and Mean Daily Solar Exposure**

Figure 11 **Location of Historical Petroleum Exploration**
Well Sites and Tenement Boundaries 20

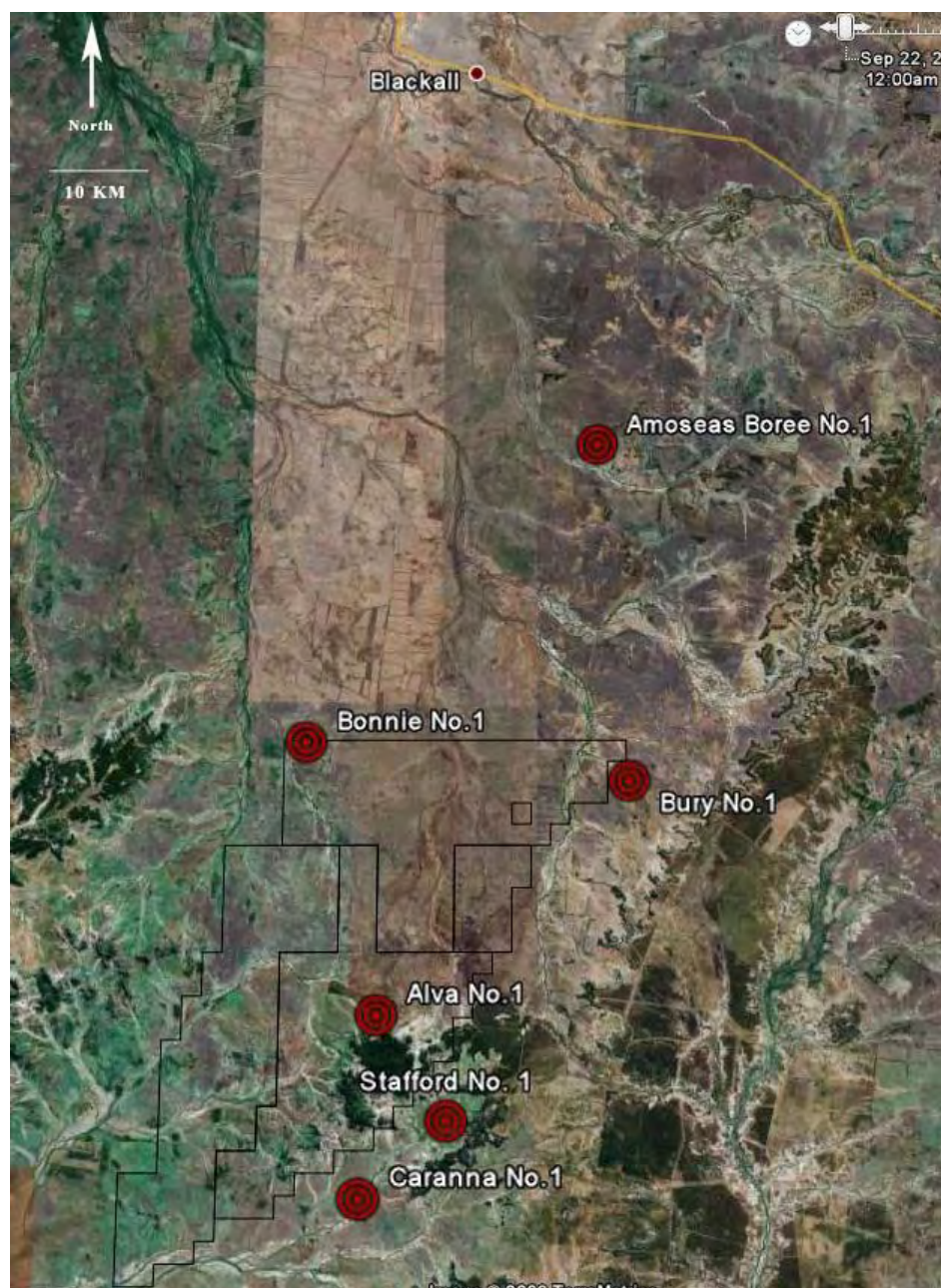


Figure 11 – Location of Principal Historical Petroleum
Exploration Well Sites and Tenement Boundaries.
(A Google Earth Photograph)

Figure 12 Devonian Stratigraphy within the Adavale Basin 22

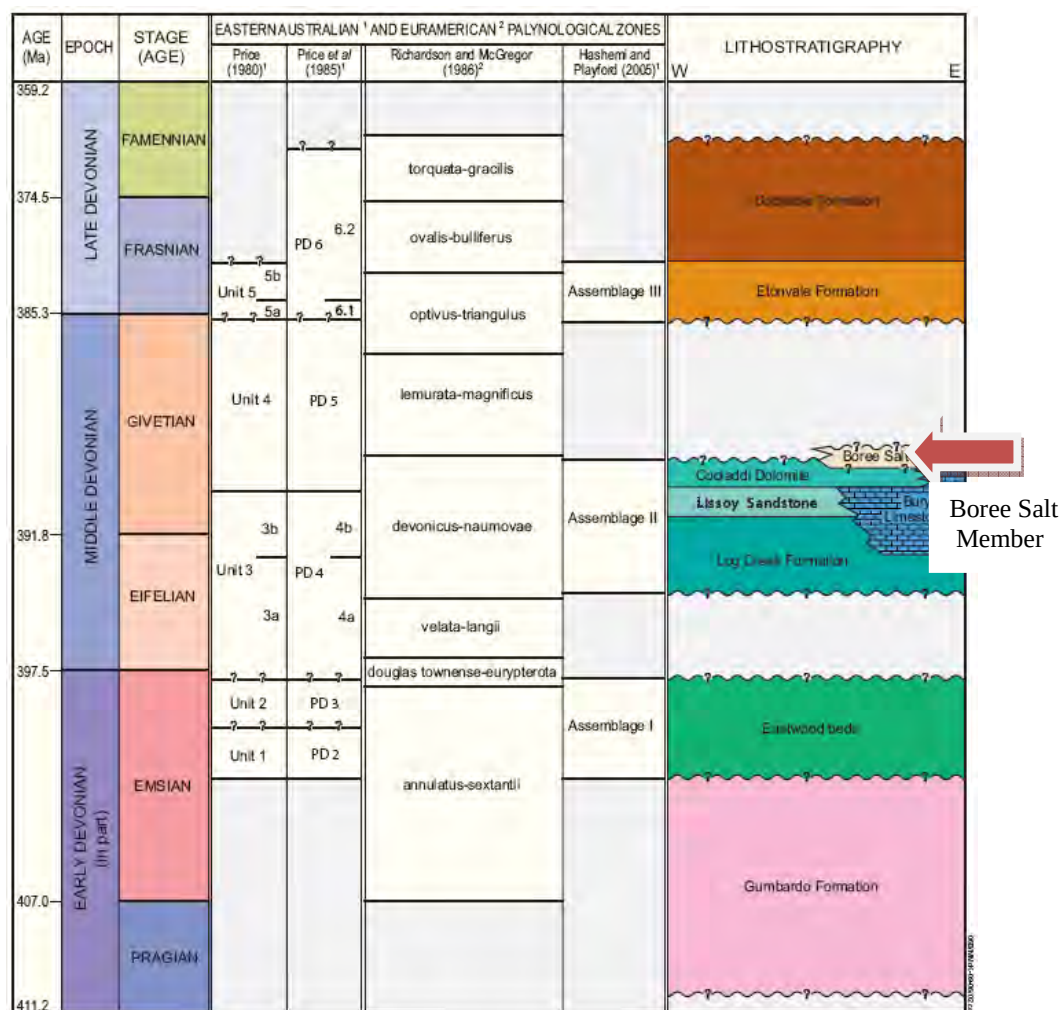


Figure 12 – Devonian Stratigraphy within the Adavale Basin
(After Queensland Government, 2007)



Figure 13 Geologic Cross Section through Subject Tenements 23

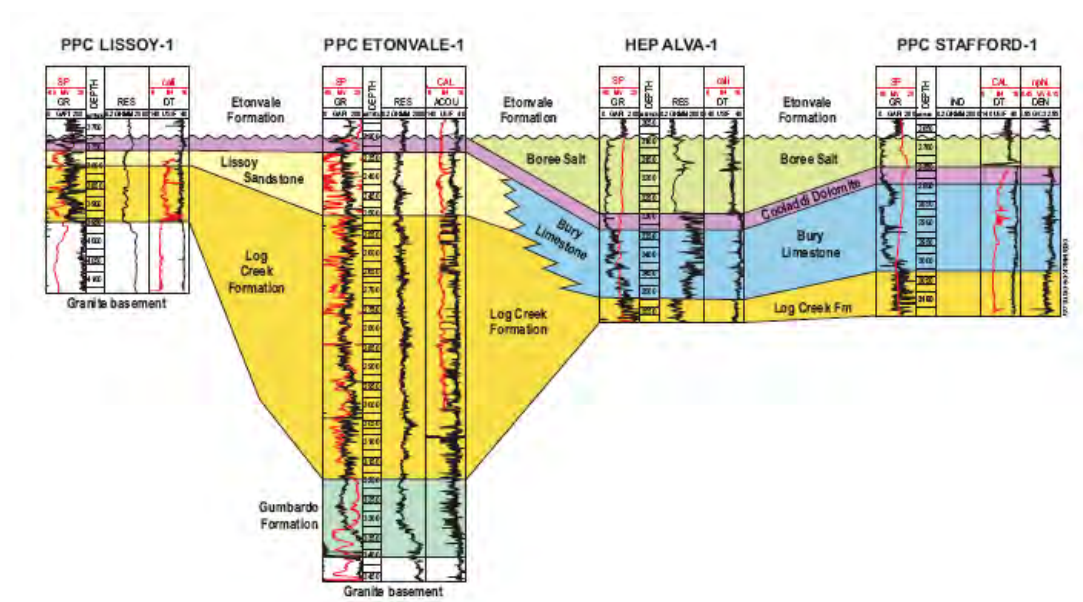


Figure 13 – Geologic Cross Section through Subject Tenements
(From McKillop, *et al.*, 2007)



Figure 14 Typical Sequence of Evaporite Basin Development 24

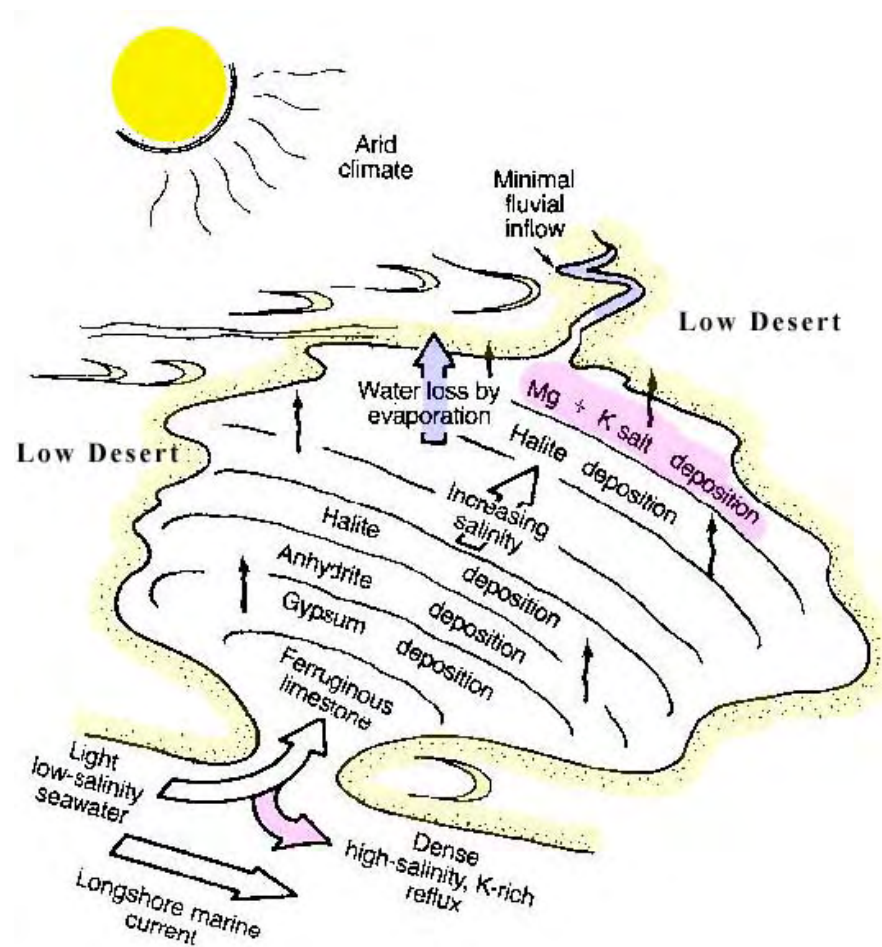


Figure 14 – Typical Sequence of Evaporite Basin Development
(After Guilbert and Park, 1986)



Figure 15 Core of Coarsely Crystalline Halite from Subject Area 27



Figure 15 – Core of Coarsely Crystalline Halite from Area.
(From McKillop, *et al.*, 2007)

Figure 16 Discovery Well Logs Showing Salt Sequences 29

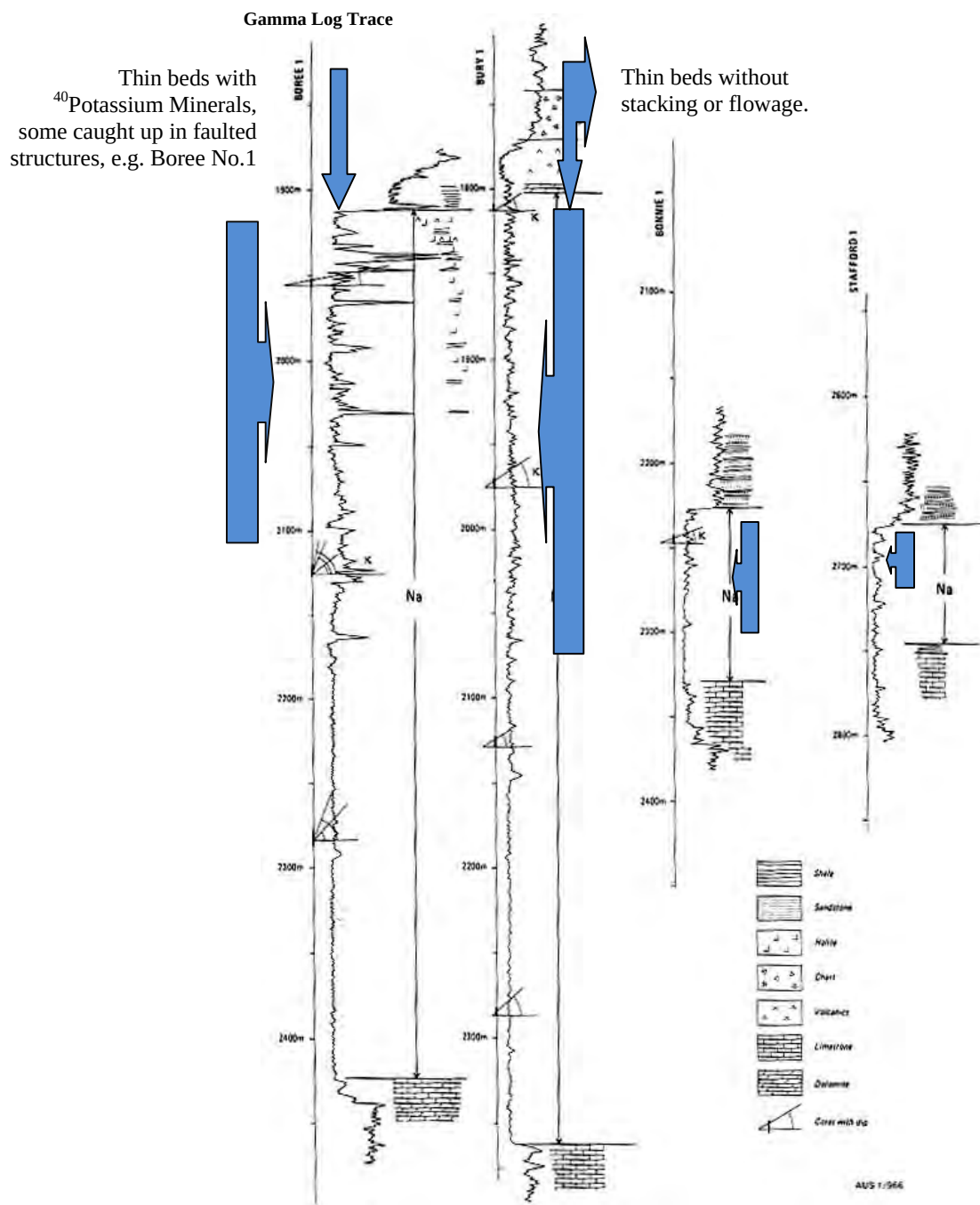


Figure 16 – Discovery Well Logs Showing Salt Sequences.
For locations of the above wells, see Figure 11.
(Wells, 1980)

Figure 17 Top of Boree Salt Member 34

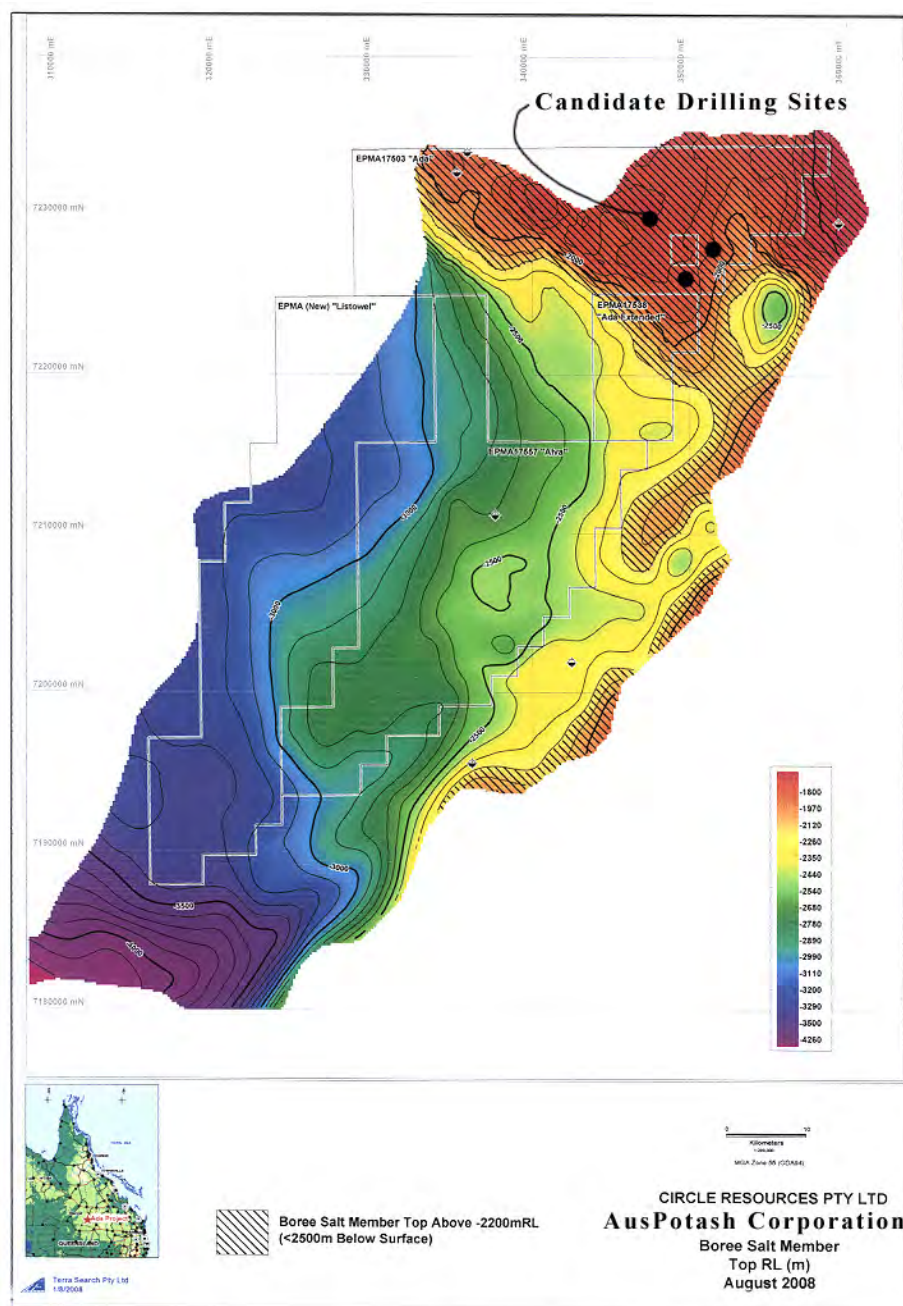


Figure 17 – Top of Boree Salt Member.
(From Terra Search Pty. Ltd., 2008)

**Figure 18 Maximum Thickness of Boree Salt Member
within 2,500 Meters of Ground Surface 35**

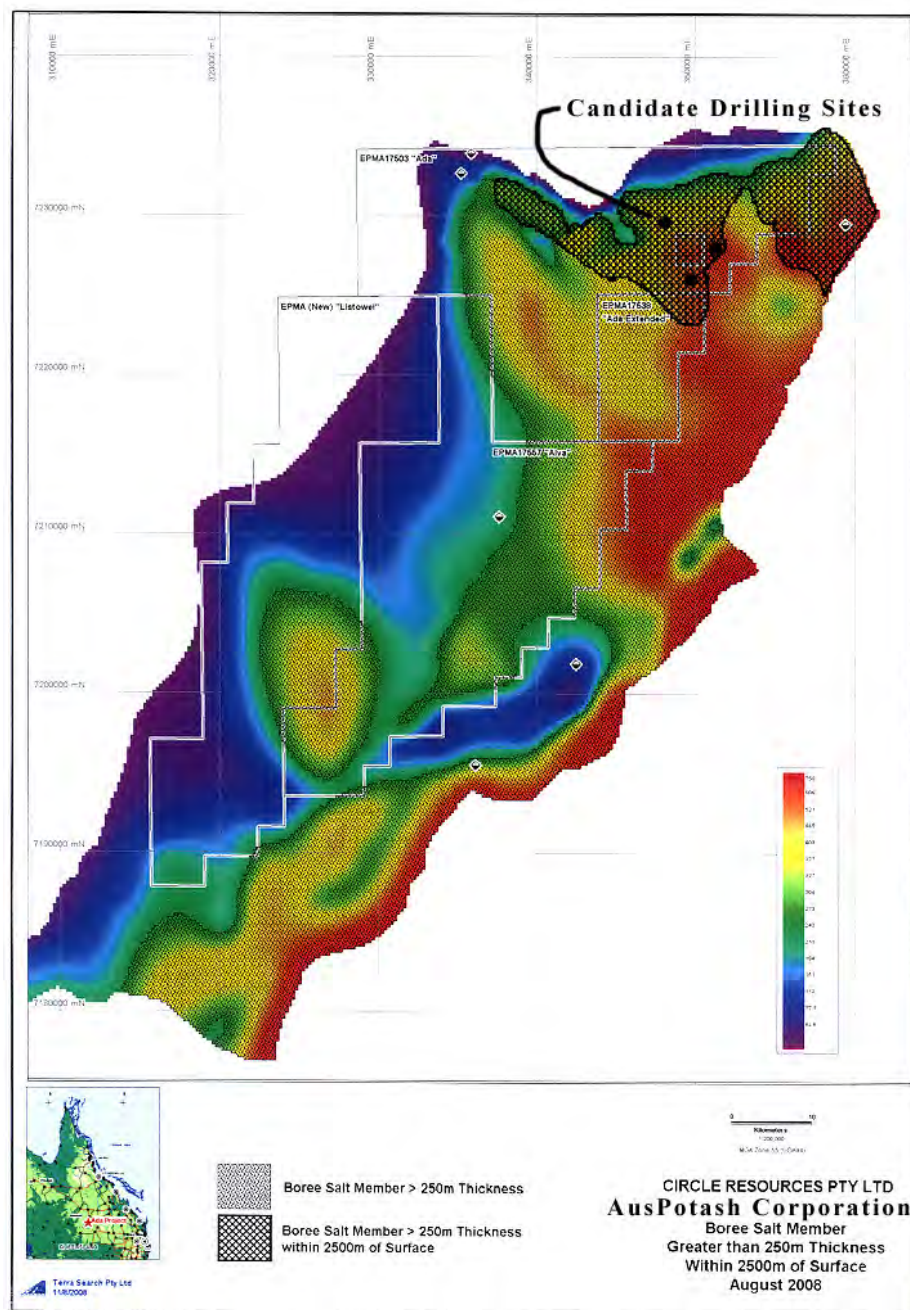


**Figure 18 – Maximum Thickness of Boree Salt Member
within 2,500 Meters of Ground Surface.
(From Terra Search Pty. Ltd., 2008)**



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Appendix

Curriculum Vitae

for:

Michael D. Campbell, P.G., P.H.

And

Jeffrey D. King, P.G.



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Seattle

Phoenix

Curriculum Vitae

Michael D. Campbell, P.G., P.H.,

Managing Partner and Chief Geologist

M. D. Campbell and Associates, L.P.

<http://www.mdcampbell.com>

Online: Summary & CV ([Here](#))

PRINCIPAL MINING CONSULTANT

PRINCIPAL HYDROGEOLOGIST

PRINCIPAL ENVIRONMENTAL GEOLOGIST

1810 Elmen Street

Houston, Texas 77019

Telephone: 713-807-0021

Cell Phone: 713-248-1708

Fax: 713-807-0985

Email: mdc@mdcampbell.com

Education

1976, M.A., in Geology, Rice University under an *Eleanor and Mills Bennett Fellowship in Hydrology* for Research and Seminars in Hydrogeology and Associated Disciplines. 31 Graduate Hours Toward Ph.D., Houston, TX, Thesis: *Paleoenvironmental and Diagenetic Implications of Selected Siderite Zones and Associated Sediments in the Upper Atoka Formation, Arkoma Basin, Oklahoma-Arkansas*, 124 p. (Continuing Research)

1966, B.A., in Geology, The Ohio State University with Courses and Research in Hydrology, Hydrogeology and Associated Environmental Programs. German Secondary Field of Specialty, Columbus, OH. Began college in 1960 in southern California (at San Bernardino Valley College), taking undergraduate courses including: geology, chemistry, engineering drawing, etc. Transferred to OSU in 1962.

Professional Memberships / Affiliations

Association of Ground Water Scientists and Engineers (AGWSE)

American Association of Petroleum Geologists

(Div. of Environmental Geosciences & Energy Minerals - Founding Member, 1977)



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American Society of Testing Materials (ASTM)
Society of Economic Geologists (SEG)
Society of Mining, Metallurgy, and Exploration (AIME)
Geological Society of America (GSA-Fellow)
Association of Geoscientists for International Development (AGID)
Houston Geological Society (HGS)
Association of Environmental & Engineering Geologists (AEEG)
International Association Hydrogeologists (IAH)
American Institute of Professional Geologists (AIPG)
International Society of Environmental Forensics (ISEF)
Texas Association Professional Geoscientists (TAPG)

Professional Certification / Registration

Professional Geologist (AIPG-#3330)
Professional Hydrogeologist (IAH-#480) (Recertification-2004)
Professional Geologist (Wyoming-#546)
Professional Geologist (Mississippi-#347)
Professional Hydrogeologist (Washington-#866)
Professional Geologist (Washington-#866)
Professional Geoscientist (Texas-#53)
Professional Geologist (Alaska-#606)

Professional Honors, Awards and Committees

Who's Who in the Southwest (First Listed: 18th Edition - 1982, etc.)
Who's Who in America (First Listed: 49th Edition - 1995, through 58th Edition for 2004)
Who's Who in Technology (1982, etc.) Listing: (here)
American Men & Women of Science Listing (here) (1st Listed: 14th Ed. -1979, etc.)
Men of Achievement (International) (First Listed: 10th Edition - 1984)
American Institute of Professional Geologists (1975, etc.)
American Institute of Hydrology (1984, etc.)
Ohioana Book Award in Science (1975): by Author, (see online CV); by County (here)
Citation by Law Engineering as Corporate Hydrogeologist (1990)
Citation by Class of the Institute of Environmental Technology (1992 & 1994)
Public Service Award - Outstanding Contributions, Texas Section, AIPG (1998)
Chairman, Environmental & Mining Sessions, AIPG Annual Mtg, Houston, Tx, Oct., 1997
Chairman, Internet Committee, Texas Section, AIPG (1998-Present)
Chairman, Internet Resources Committee, Texas Section, AEG (2003-Present)
Shlemon Mentor Hall of Fame in Applied Geoscience, GSA Mtg., Texas A&M U., March 16, 2004.
Poster at GSA Mtg., Denver
Fellow, Geological Society of America, April, 2004 (Press Release on Induction, see online CV)
Distinguished Alumni Hall of Fame
Mann Mentor in Hydrogeology, GSA South-Central Section Mtg., Trinity U., April 1, 2005



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Chairman, Uranium Committee, EMD, AAPG (2004-Present) -Public Web Page (see online CV).

Continuing Professional Education / Training

Mr. Campbell has attended, presented papers, or served as session chairman in the following technical conferences. He has also maintained the appropriate certifications in health and safety training.

Career Summary

Mr. Campbell is well-known nationally and internationally for his work as a technical leader, program manager, consultant and lecturer in hydrogeology, mining, and associated environmental and geotechnical fields. He has gained a wide range of interdisciplinary experience in business and technical management in the environmental (regulatory, geological and hydrogeological), mining, and financial fields spanning more than 40 years. For a summary of ELA projects, see C&A CV. For a historical summary of selected client projects, see C&A CV.

Mr. Campbell has published widely, most notably: *Water Well Technology* (McGraw-Hill) and *Rural Water Systems Planning and Engineering Guide* (Commission on Rural Water). In the mid to late 1970's, he served on the Editorial Board of the journal: *Ground Water* for eight years and served as cofounder and first Director of Research of the NWWA Research Facility at Rice University. In the late 1970's, he also produced *Geology [and Environmental Considerations] of Alternate Energy Resources* (Houston Geological Society) and many other publications and consulting reports over the years on a variety of applied hydrogeologic, geologic, and injection well and hazardous waste subjects. He maintains an extensive library of more than 300,000 citations on environmental and mining topics covering the U.S. and overseas.

Mr. Campbell interrupted his graduate studies after the master's degree (Ph.D. work at Rice University in 1976) to join a major engineering and environmental consulting company as Director, Alternate Energy, Mining and Environmental Programs. During this period, he also served as an invited technical expert and lecturer for UNESCO-sponsored water-supply projects conducted in many parts of the Earth. Mr. Campbell provided management consulting for a mining project (with revenues/expenses of more than \$8 million/year) and as a principal consultant for exploration, mining, processing/refining and environmental activities. Over the past 15 years, Mr. Campbell has provided senior technical guidance, review, training, litigation support and consultation on numerous hydrogeological, water supply, and



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hazardous waste projects involved in both RCRA and CERCLA programs for major law firms and consulting engineering and environmental companies as well as industry.

Chronological Professional Experience

1993-PRESENT M. D. Campbell and Associates, L.P., Senior Consulting Hydrogeologist and Principal-in-Charge, Houston, Texas. Mr. Campbell and a small support staff serve industry by providing technical consulting on RCRA, CERCLA and related waste management involving a range of contaminants such as BTEX, solvents, brine, etc., risk assessment projects, and water-supply projects in Texas, the US and overseas. Mr. Campbell provides project/document review, and technical and QA/QC training for industry, consulting companies and law firms for RCRA, Superfund, and mining-related projects. He designs, lectures, and produces formal technical short courses and semester-long courses on environmental science, engineering and technology, and has served on the Editorial Board of the *Journal of Applied Ground-Water Protection*, sponsored by the Ground-Water Protection Council, and continues to serve as Special Editor for the journal: *Ground Water*. Mr. Campbell also served on the Editorial Board of the *International Journal of Environmental Forensics*, for the term 2000 to 2003.

During the summer of 1992, Mr. Campbell developed, managed and served as Principal Instructor for a 220-Hr Evening Semester Course: *Introduction to Environmental Technology*, held on the campus of North Harris Community College for the purpose of cross-training petroleum geologists, engineers, chemists, and others as a prelude to entering or advancing in the environmental field. Mr. Campbell lectured on RCRA and CERCLA and on hydrogeology and project management, and selected and managed all guest lecturers from industry, government and local universities. The course was later hosted by the Houston Engineering and Scientific Society (HESS) and recently by The Institute of Environmental Technology. Almost 400 men and women have graduated from the program to date.

He presently serves as: Principal and Chief Geologist of M. D. Campbell and Associates, L.P., Principal Hydrogeologist of Environmental Litigation Associates, and Principal Instructor for the Institute of Environmental Technology, all located in Houston, Texas.

1991-1993 DuPont Environmental Remediation Services, Houston, Texas - Regional Technical Manager and Chief Hydrogeologist. The firm is a wholly-owned subsidiary of E. I. DuPont de Nemours. Mr. Campbell managed the activities of the Technical Group covering DuPont plants and other plants over a seven-state area. He managed five operating departments: Geology, Environmental Specialties, Deepwell, Conceptual Engineering, and Engineering/Construction, involving approximately 60



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technical personnel. He provided technical and administrative leadership, staff recruitment, training, quality control/assurance, risk assessment on various DuPont projects and represented DuPont on technical committees in Superfund projects in the US.

1991 ENSR Consulting and Engineering, Houston, Texas - Regional Director of Geosciences and Chief Hydrogeologist. The firm is a leading environmental services firm specializing in RCRA and CERCLA projects for industry. Mr. Campbell provided senior technical review, managerial direction, guidance, and leadership to the hydrogeologic and geologic staff throughout the company's 22 offices in the US. He also provided and managed regular technical training sessions and performed quality control, assurance functions and litigation support for hydrogeologic projects (i.e., RCRA, CERCLA: Superfund and UST, and landfill investigations). He also initiated, guided and supported marketing efforts in environmental projects.

1988-1990 Law Engineering, Inc., Houston, Texas - Senior Hydrogeologist and Corporate Hydrogeological Consultant. Firm is a large employee-owned geotechnical and environmental engineering company founded in the early 1940's. Mr. Campbell provided senior technical direction, guidance, leadership and motivation to the hydrogeologic staff for the company's 52 offices in the US and overseas on hazardous waste projects including UST, landfill, water supply, dewatering, and RCRA (Part B Permits) and CERCLA (Property Environmental Assessments: Stage I and II projects, and Superfund investigations and representations), including litigation support and expert witness testimony. He was responsible for initiating, guiding and supporting marketing efforts in environmental and relevant geotechnical projects.

Mr. Campbell also provided training sessions and managed technology development programs via in-house research groups throughout the company. He served on Senior Review Boards and performed annual quality control audits for the company.

Mr. Campbell was cited by Law Engineering's corporate management as the Corporate Consultant in Hydrogeology (Chief Hydrogeologist) for his outstanding contributions to the company (1990).

1983-1988 Campbell, Foss & Buchanan, Inc., Houston, Texas - President and Senior Partner. Firm engaged in domestic and international environmental and natural resource management projects involving geological, hydrogeological and engineering programs: environmental investigations and characterizations (Part B Permitting, and Property Transfer Assessments), mine dewatering, project



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management (RCRA Investigations), natural resource assessment, reserve analysis and acquisitions for industry, mining (Alaska and Utah), financial, and banking communities. Precious metal discovery credited in Nevada. Provided consulting services on an \$8-million/year precious metal mining and cyanide heap-leaching project from discovery through development operations and environmental liaison with state and federal regulatory agencies. As part of these services, Mr. Campbell provided guidance and consultation in the daily review and monitoring of the financial and operational activities of the 50-person mining company. In addition, he also served numerous other companies and consulting groups in senior review functions on hazardous waste and RCRA refinery and plant investigations during the period.

1976-1983 Keplinger and Associates, Inc., Houston, Texas - Director, Alternate Energy, Minerals and Environmental Division. Formed group and defined marketing objectives in 1976. Responsible for and managed all non-oil & gas projects: alternate energy (coal/lignite, geothermal energy, uranium), minerals (precious and base metals and industrial commodities-phosphate, potash, sand & gravel, and related environmental projects involving property transfer assessments (Pre-CERCLA activities) for joint-venture negotiations, corporate mergers, and buyouts, financial and litigation preparations, hazardous waste investigations (RCRA Part A and Part B Permitting), geotechnical projects (dewatering), and water resource investigations. He also served on the expert's committee of the United Nations' ground water exploration and development program from 1978 to 1983. Mr. Campbell managed a staff of seven geologists, engineers and specialty consultants. He also presented seminars on a range of subjects involving environmental, hydrogeological, and water-supply issues.

1971-1976 NWWA Research Facility, Columbus, Ohio and Houston, Texas - Director of Research. Co-founded in 1971 and served as first Director of Research. Mr. Campbell conceived, formulated, supervised and conducted investigations on: water well technology, ground-water contamination and investigation practices and procedures, well construction standards, injection well systems' operation & maintenance, rural water systems' planning and engineering. Mr. Campbell was responsible for the early research programs funded by the U.S. Office of Water Resources Research (here), and in the development of EPA's early protocol development and characterization of ground-water contamination and remediation practices (Early RCRA and CERCLA).

The NWWA Research Facility and the staff of six were moved to Rice University, Department of Geology and Geophysics, in 1973 and continued through 1976. He also was an invited lecturer for graduate-level seminar courses on hydrogeology and economic geology for two years. Conducted



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graduate research on paleo-environmental and diagenetic processes under fluvial-deltaic conditions. This project is continuing as new information becomes available. For an interim report on the research, see C&A CV.

1969-1971 Teton Exploration, Div., United Nuclear Corporation, Casper, Wyoming - District Geologist/ Hydrogeologist, Eastern US and Canada, Mr. Campbell was responsible for mineral prospect generation (with emphasis on uranium and other strata-bound mineralization) and for field reconnaissance, mapping, sampling, drilling site operations, recommendations for land acquisition and project budgeting and execution. He also conducted research on the hydrochemistry of the Morton Ranch uranium geochemical cell and nature of mine dewatering and water-supply development in and around the deposit, including the nature of abandoned drill holes plugged with bentonite muds. He advanced the development of hydrochemistry and geochemistry as an aid to frontier uranium exploration and for developing models of mineralization in frontier exploration areas.

1966-1969 Continental Oil Company (Australia), Sydney, Australia - Staff Geologist/ Hydrogeologist, Minerals and Mining Division. Mr. Campbell was responsible for conducting, coordinating, and implementing prospect evaluations, mapping and sampling programs, well-site operations, and ground-water supply programs in various parts of Australia, Micronesia (Caroline Islands) and the South Pacific (Coral Sea) for: phosphate, potash, sulfur, coal, base metals, and uranium. Phosphate discovery credited. Also investigated a new uranium district on the Nullibar Plains of South Australia (see publications list). Joint-venture programs with Japanese and Korean companies required extensive travel between Australia and Japan and Southeast Asia.

Fields of Activities, Major Reports, Publications and Presentations

- 1. Hydrogeological and Environmental Projects**
- 2. Geothermal Exploration and Development Projects**
- 3. Coal / Lignite Exploration and Development Projects**
- 4. Mineral Exploration and Development Projects**
- 5. International Projects**
- 6. Miscellaneous Projects**
- 7. Publications / Papers in Preparation**

Hydrogeological / Environmental Investigations



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In the early 1960's, Mr. Campbell was selected as Undergraduate Research Assistant in the Department of Geology, The Ohio State University and subsequently worked on one of the first long-term, systematic ground-water contamination investigations involving oil-field pollution by open brine disposal pits in Ohio and on early modeling of the associated groundwater flow behavior under Dr. Wayne A. Pettyjohn and others.

In 1966, Mr. Campbell joined Continental Oil Company (CONOCO), Minerals & Mining Group in Sydney, Australia working on mineral exploration, mining and associated ground-water supply projects. He was a Visiting Lecturer, University of Queensland, lecturing on the principles of hydrogeology. After returning to the US, in the early 1970's, Mr. Campbell organized the National Water Well Association's Research Facility becoming its first Director of Research in Ohio and then at Rice University, Houston. Over the period of 1971 to 1976, Mr. Campbell provided technical seminars on hydrogeology for numerous universities and for the US E.P.A. He also served as Technical Consultant to the *Water Well Journal* and as Abstract Editor for the journal: *Ground Water*. During the period, Mr. Campbell managed numerous Association and EPA projects and programs dealing with hydrogeology and shallow drilling, shallow well design, construction, operation and maintenance, injection well, technical education and industrial contamination assessment, providing the early guidance to EPA personnel on ground-water sampling, monitoring well construction protocols and hazardous-waste spill response strategy for subsequent RCRA and CERCLA activities.

In 1975, he received The Ohioana Book Award in Science for the text: *Water Well Technology* (McGraw-Hill). Mr. Campbell was appointed as United Nations Technical Expert to review overseas ground-water programs for the period: 1976 to 1981. While at Rice University, he also conducted graduate fellowship research on a variety of subjects and taught courses in hydrogeology and economic geology. Mr. Campbell and his team provided substantial input for the EPA-sponsored *National Ground Water Information Center Data Base* presently operated by the NWWA. He served as an Editor or as a member of the Editorial Board of the journal: *Ground Water* from 1964 to 1978. During the period, he conducted numerous consulting geotechnical investigations and served as an invited technical expert and lecturer for the United Nations and UNESCO sponsored projects on world-wide ground-water exploration and development in igneous and metamorphic rocks in: Sweden, Italy (Sardinia), India, and Tanzania. Among the hydrogeological consulting projects conducted during the early 1980's, Mr. Campbell completed a series of investigations for a major geotechnical consulting firm on gasoline leaks in and around service stations in Texas. With Campbell, Foss and Buchanan, Inc. (CF&B), he initiated an evaluation of vadose flow of cyanide solutions of a heap-leach precious metals mining project (see



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abstract). A long-term monitoring program was established for evaluating flow and hydrochemical behavior, and for providing data for optimizing process control, and for regulatory monitoring purposes. C,F&B conducted numerous projects in the US and overseas. During the period, Mr. Campbell also provided senior technical review and consultation for hydrogeological and hazardous waste projects associated with lignite mining (mine dewatering) and chemical plants performed by other geotechnical consulting groups in the south-central and northern United States.

While with Law Engineering, Inc., he was promoted to the company's highest technical position in the discipline as Corporate Hydrogeological Consultant, the first such designation in the company's 42-year history. He provided direction and technical support to Law Engineering's 52 offices through the US and overseas. Mr. Campbell served in a similar capacity with ENSR Consulting and Engineering, and in industry, with DuPont Environmental. Presently, he provides consultation on waste management, characterization, remediation, water supply projects, technical training, litigation support and expert witness testimony on hydrogeology, the National Contingency Plan, and related subjects (see Mr. Campbell's litigation summary).

Hydrogeological / Environmental Publications

Major Reports, Publications and Presentations

[For Publications in Preparation (see C&A CV)]

Campbell, M. D., *et al.*, 2008, "Nuclear Fuel Exploration, In Situ Recovery, and Environmental Issues in context with the National Energy Needs through Year 2040," *Proc. Texas Commission of Environmental Quality Conference and Trade Fair*, Session: "Underground Injection Control," Invited Paper, Austin, Texas, April 30, 2008.

Campbell, M. D., *et al.*, 2008 "The Nature and Extent of Uranium Reserves and Resources and Their Environmental Development in the U.S. and Overseas," AAPG – Energy Minerals Division Conference, April 23, 2008, Session: "Uranium Geology and Associated Ground Water Issues", San Antonio, Texas.

Campbell, M. D., *et al.*, 2007, "Uranium In-Situ Leach Development and Associated Environmental Issues," *Proc. Gulf Coast Geological Societies Conference*, Fall, Corpus Christi, Texas, 17 p.

Campbell, M. D., *et al.*, 2007, *Nuclear Power - Winds of Change*, Energy Minerals Division, AAPG, Uranium Committee 2007 Report, March 31.

Campbell, M. D. and M. David Campbell, 2005, "Uranium Industry Re-Development and Expansion in the Early 21st Century: Supplying Fuel for the Expansion of Nuclear Power in the U.S., The Environment vs. The Paradigm," *Rocky Mountain Natural Gas Strategy Conference & Investment Forum*, Session 1: Energy Supply - Quantities and Qualities, Presented by Colorado Oil & Gas Association, August 1, Denver, Colorado, 44 p.



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Bost, R. C., M. D. Campbell, M. David Campbell, T. R. Eckols and Andrew L. Fono , 2005, "Flawed Geoscience in Forensic Environmental Investigations: Part II: How Daubert Affects the Scope and Bases for Expert Opinions" NGWA Environmental Law & Ground Water Conference, Baltimore, MD., July 21-22.

Bost, R. C., M. D. Campbell, M. David Campbell, T. R. Eckols, and Andrew L. Fono, 2005, "Flawed Geoscience in Forensic Environmental Investigations: Part III: How Daubert Is a Surrogate for Ethical Questions Regarding Expert Opinions" NGWA Environmental Law & Ground Water Conference, Baltimore, MD., July 21-22.

Campbell, M. D., *et al.*, 2005, *Recent Uranium Industry Developments, Exploration, Mining and Environmental Programs in the U.S. and Overseas*, Energy Minerals Division, AAPG, Uranium Committee 2005 Report, March 25.

Campbell, M. D., and M. David Campbell, 2004, "Crisis Management: Ground-Water Supplies in the 21st Century," *EnviroTechnology*, Vol. 1, Summer, pp 78-81.

Campbell, M. D., 2004, *Professional Memorial: Ted H. Foss, Ph.D., P.G.*, Geological Society of America Memorials, Vol. 33, April, pp. 17-22.

Campbell, M. D., R. C. Bost, and M. David Campbell, 2004, "*Flawed Geoscience in Forensic Environmental Investigations: The Effect of Daubert Challenges on Improving Investigations*" NGWA Environmental Law & Ground Water Conference, Chicago, IL, May 5-6.

Campbell, M. D., M. David Campbell, and M. Saribudak, 2004, "*Growth Faulting, Associated Geologic Hazards, Economic & Regulatory Impact, and Methods of Investigation for the Houston, Texas Area,*" South-Central Meeting, Geological Society of America and Texas Section of the Association of Engineering Geologists Growth Fault Symposium, Texas A&M University, College Station, TX, March 16, 83 p.

Campbell, M. D., 2004, "Environmental Geoscience and Litigation: Dos and Don'ts, Now or Later," Featured Speaker, Houston Geological Society Environmental and Engineering Geology Dinner Meeting, February 10.

Campbell, M. D., 2000, "Federal and State Regulations and Field Implementation in Hazardous and Solid Waste Investigations and Management," An Invited Lecture for the University of Texas School of Public Health, August 29th and September 19th, Presentation Sponsored by the Institute of Environmental Technology, Houston, Texas.

Campbell, M. D., 1999, "The Role of Environmental Technology in Developing, Maintaining, and Protecting Ground-Water Supplies in the 21st Century," in *The U.S. Water Report*, Saringa Group, Inc., San Francisco, CA, pp. 264-271.



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Campbell, M. D., 1998, "Federal and State Regulations and Field Implementation in Hazardous and Solid Waste Investigations and Management," Invited Lectures for the University of Texas School of Public Health, September 15th and October 27th, Presentation Sponsored by the Institute of Environmental Technology, Houston, Texas.

Campbell, M. D., 1998, "Ground-Water Supply Systems: Hydrogeology and the Delivery of a Municipal Water Supply," *Seminar on New Municipal Ground-Water Supply Issues, Houston, Texas*, April 16, Sponsored by the Institute of Environmental Technology, the Environmental Litigation Associates, and Gardere Wynne Sewell & Riggs, L.L.P., Attorneys, Houston, Texas.

Campbell, M. D., 1996 (5,4,3 & 2), "Environmental Awareness and Its Development: An Emphasis on the Oil & Gas Industry," *Proc. Introduction to Environmental Technology*, Spring Semesters, Institute of Environmental Technology and Houston Engineering & Scientific Society, 28 p.

Campbell, M. D., 1996 (5,4,3 & 2), "Resource Conservation and Recovery Act (RCRA) and Applications," *Proc. Introduction to Environmental Technology*, Spring Semesters, Institute of Environmental Technology and Houston Engineering and Scientific Society, 88 p.

Campbell, M. D., 1996 (5,4,3 & 2), "Applied Hydrogeology: Ground-Water Flow," *Proc. Introduction to Environmental Technology*, Spring Semesters, Institute of Environmental Technology and Houston Engineering and Scientific Society, 54 p.

Campbell, M. D., 1996 (5,4,3 & 2), "Applied Hydrogeology: Typical LNAPL & DNAPL Behavior in the Subsurface," *Proc. Introduction to Environmental Technology*, Spring Semesters, Institute of Environmental Technology and Houston Engineering and Scientific Society, 77 p.

Campbell, M. D., 1996 (5,4,3 & 2), "Ground-Water Modeling: Practices & Pitfalls," *Proc. Introduction to Environmental Technology*, Spring Semesters, Institute of Environmental Technology and Houston Engineering and Scientific Society, 97 p.

Campbell, M. D., 1995, "The State of the Environmental Industry," An Invited Presentation, Society of Texas Environmental Professionals, Held at Houston Engineering and Scientific Soc., August 3, 2-Hour Presentation.

Alyanak, N., J. T. Grace, and M. D. Campbell, 1995, "A Cost-Effective Statistical Screening Method to Detect Oilfield Brine Contamination," *Proc. SPE/EPA Exploration & Production Environmental Conference*, Houston, TX, March 27-29, pp. 631-640.

Alyanak, N., and M. D. Campbell, 1995 (4 & 3), "Statistics in Environmental Investigations," *Proc Introduction to Environmental Technology*, Fall and Spring Semesters, Institute of Environmental Technology and Houston Engineering and Scientific Society, 45 p.

Campbell, M. D., 1995, "On the Spelling of the Term: Ground Water," *Bull. Houston Geological Society*, Vol.37, No.6, February, pp. 23-24.



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Campbell, M. D. and K. H. Forster, 1995, Hydrogeology and Mining, a Study Guide for Workshop presented at *The National Mining Conference*, Knoxville, Tennessee, May 11, 137p.

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Selected Project Experience

Leaking Underground Storage Tank Investigations - Numerous Clients Throughout US - Mr. Campbell and his team have provided senior review and consultation for technical staff on more than 300 investigations ranging from site characterization through remedial design to construction, operation and maintenance of remediation systems. Type of remediation approach varied from pump-and-treat to vapor extraction to in situ bioremediation systems, depending upon subsurface conditions. Litigation support.

Environmental Assessments - Numerous Clients throughout US - Mr. Campbell and his team have provided technical direction and consultation on more than 300 environmental assessments for real estate transactions, corporate mergers or buyouts, and bank foreclosures, many of which involved evaluations of potential brine contamination of oil and gas production facilities and properties.. Approximately 20% of the properties investigated required follow-up investigations involving drilling. Of those, approximately 5% required some type of remedial activities which ultimately led to the design, construction, operation and maintenance of remediation systems. Litigation support.

Superfund Representation and Technical Support - Numerous Clients Throughout US - Mr. Campbell has served on Technical Committees for various Superfund projects representing DuPont, and as senior technical support for a number of environmental consulting companies. Litigation support.

RCRA Technical Support - Numerous Clients Throughout US - Mr. Campbell provides senior technical support on hydrogeologic and contaminant transport investigations for site characterization and remedial design and operation and maintenance. Litigation support.



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Confidential Mfg. Client - A manufacturer of stainless steel casing engaged Mr. Campbell to conduct preliminary investigations and to review available information on the likely cause(s) of casing failures in two large-diameter, high-capacity water wells during completion activities of wells located in an agricultural district of the western U.S.

Confidential Consulting Client - A major consulting firm engaged Mr. Campbell to provide support to the firm's senior personnel and associated staff on a major defending case involving creosote, metals and associated DNAPL constituents present on an industrial property in the southern U.S. Mr. Campbell reviewed and advised the Principal on opposing expert witness positions and opinions. He also supported hydrogeological investigations on ground-water flow and associated natural attenuation of DNAPL constituents.

Confidential Client - A rancher in north-east Texas reported his private water well system began pumping "bad water" in an area with a producing gas well nearby. Mr. Campbell and his team were engaged to investigate the likely source(s) of the contamination. A hydrogeologic investigation was conducted.

Confidential Consulting Client - A major consulting firm engaged Mr. Campbell to conduct hydrogeological investigations on ground-water flow of DNAPL constituents below a refinery located in the mid-west of the U.S. Principal parameters, such as subsurface lithologic relationships, hydraulic conductivity, hydraulic gradient, and others were assessed and modeled.

Confidential Client - The unexplained deaths of a number of calves led a rancher in the mid-continent to initiate investigations downstream from a commercial disposal well facility used by the oil & gas industry in the region for possible causes of the deaths. Mr. Campbell and his team were engaged to conduct Phase I and II investigations involving monitoring well installation, stream sampling, and hydrogeologic analysis of the area. Hydrogeologic investigations were conducted.

Confidential Mfg. Client - Lead has appeared in anomalous concentrations in drinking water from a domestic rural water system. Mr. Campbell and his team were engaged to sample and evaluate likely source(s) of the lead and possible cause(s) of learning disabilities reported in the youngest child of the rural family.



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Confidential Oil & Gas Property Owner Client - Mr. Campbell and his team were engaged to conduct a Preliminary Environmental Site Assessment on a historic oil-and-gas producing property to assess present conditions after decades of boom-and-bust operations on a multi-well oil field operated since the 1930s. Nearby landfill operations, a golf course, and past and present oil and gas production practices were reviewed in some detail for possible impact on the property's surface and shallow ground water below.

Confidential Real Estate Client - A large real estate company engaged an environmental consulting firm to conduct Phase I and Phase II Environmental Site Assessments for a large multi-property shopping center transaction. Initial findings by the consultant led the real-estate company to close on the deal. Subsequent investigations by a second consultant found DNAPL associated with dry-cleaners located on the properties. Mr. Campbell and his team were engaged to evaluate the initial consultant's activities in light of the consultant's experience, staff capability, field procedures and related ASTM guidelines and industry standard of care.

Confidential Commercial Client - A pathogenic variant of *E. coli*, O157:H7, has appeared as the likely source of illness in a rural family. Mr. Campbell and his team were engaged to assess the likely source(s) of the pathogenic bacteria. The area is characterized by numerous, closely spaced, small farms, with cattle, sheep, wildlife, septic tank systems, and a stream, all in the immediate vicinity of a water well used as a source of drinking water. Investigations have been completed.

Confidential Industrial Client - A service station proprietor was accused by the land owner of contaminating soil and ground water with BTEX and MTBE. Mr. Campbell and his team were engaged to review the available sampling and hydrogeologic data and determined that the owner's consultant was less than forthcoming concerning the data used to characterize the ground-water conditions and the configuration of the plume of contamination.

Confidential Client - A major sand and gravel company's consultant drilled on portions of a potential lessor's land without permission on the basis that "the company was doing the land owner a favor." The company sued the land owner for breach of contract (i.e., alleged failure to honor their rights to conduct mining operations on the subject land). Mr. Campbell was engaged to review the issues of the case and found that the company overstepped the agreement and violated the landowner's rights to limit ingress according to standard industry practice.



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Confidential Industrial Client - Mr. Campbell and his team were engaged to conduct confidential industrial mineral resource evaluations in the eastern U.S. The project involved land-record ownership assessment and field reconnaissance, geologic sampling, analyses, and report preparation with recommendations for future direction of the project.

Confidential MUD Client - The failure of a high-capacity water well owned by municipal utility district prompted management to turn to their insurance company for funds to replace the well, according to the terms of the policy. Mr. Campbell and his team conducted a preliminary investigation and found evidence to suggest that regional soft-sediment faulting and lateral movement caused the well structure to fail. As a result of more than 25 years of vertical stress caused by land subsidence associated with ground-water production and subsequent lateral movement in the area, the well screen ruptured and catastrophic failure of the well resulted.

Confidential Industrial Client - A major chemical plant is suing its previous consultant for exacerbating DNAPL contamination below its production facility during and after an ill-conceived monitoring well drilling program. Mr. Campbell and his team were engaged to review the relevant information and to determine if the consultant's activities were likely responsible for the DNAPL contaminating the deep aquifers. Mr. Campbell found that the consultant and their contractors were culpable and should be held responsible for contributing funds for assisting in the clean-up of the deep aquifers below the plant.

Confidential Industrial Client - The National Contingency Plan (NCP) of the 1970s was invoked in an attempt to force an industrial company to join a group of PRPs to clean up a Midwest dump. Mr. Campbell was engaged to evaluate claims made by ex-EPA consultants for the plaintiffs that the NCP carried weight when applied to inland contamination in the mid-1970s. Mr. Campbell found that the NCP had no impact on parties involved in ground-water contamination occurring some distance away from the waters of the United States because the NCP had not been equipped yet with the necessary capabilities to implement such intentions and associated provisions.

Confidential MUD Operator Client - A municipal water supply operator was sued by the community it served for allowing benzene to be distributed in the water supply. Mr. Campbell and his team were engaged to investigate the possible source of the benzene and determined that 1) testing was not required by the operator, and hence did not know of the presence of benzene, and 2) the source of the benzene was likely the gas-producing formation below the drinking-water aquifer breached by over drilling into the confining unit separating the aquifer from the gas-producing sand below.



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Alcoa Aluminum, Inc. - RCRA Part B Permit Application. Provided senior review and analysis of ground-water investigations of subsurface conditions around plant site. Hydrogeologic evaluations involving contaminant transport modeling and long-term monitoring.

Merchants Trucking, Inc. - Cavalcade Superfund Site Investigations. Provided analysis of remediation project proposed by PRP on contamination by BTEX and Coal Tar substances. Investigation involved evaluation of selected technology and estimated capital and O&M costs.

State of Georgia - Landfill Lawsuit. Provided expert witness testimony on litigation involving landfill location in central Georgia with emphasis on present hydrogeologic conditions.

Compaq Computer, Inc. - Geotechnical & Dewatering Investigations. Provided senior review and consultation on ground-water investigations at new plant site in Houston.

Norse Windfall Mines, Inc. - Management and Environmental Investigations. Provided senior review and consultation over a three-year period on water supply development and environmental monitoring of ground-water conditions in area of mill and precious metal processing plant for a mine in central Nevada. Managed start-up operations and cash flow, and instituted daily monitoring program of data collection and analysis of heap leach (pregnant liquor) process hydrochemical data. Conducted analyses of flow behavior in heap-leach operations. Represented company and negotiated with state and federal regulatory agencies. Generated company's personnel and corporate policy manual, including health and safety provisions.

Municipal Landfill Investigations. - Provided senior review and consultation on proposed landfill construction projects involving siting investigations and hydrogeologic characterizations.

Dolet Hills Mining Co., Mansfield, LA - Dewatering/Depressurizing Project. Provided senior consultation and direction on mine dewatering/depressurizing program, involving aquifer testing and analysis, dewatering well system design and construction, flow-net construction and updating as overburden was removed and mining advanced. Installed dewatering/depressurizing well system and monitored and adjusted system operations.



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General Electric - Ground-Water Assessment - Provided senior hydrogeological direction and support for PCE and BETX leaks in plants located in North and South Carolina. Designed assessment plans and designed and implemented remediation systems consisting of pump-and-treat, stripping tower, carbon canisters and recirculation circuit.

Confidential Insurance Company - Ground-Water Assessments of Contaminants Resulting from Manufactured Gas Facilities. Provided direction and consultation to nationwide investigations on reliability and appropriateness of proposed/operating remediation systems and associated site characterizations of LNAPL and DNAPL contaminant plumes and product (and dissolved plume) migration in the subsurface.

United Nations Educational, Scientific and Cultural Organization (UNESCO) - Ground-Water Characterization, Exploration and Development in Igneous and Metamorphic Terrains of the World, Special Project 33. Selected as member of a seven-member international team of specialists on ground-water exploration and development throughout the sphere of influence of UNESCO projects. Conducted extended lectures/seminars and investigations on ground-water development and ground water technology in Sweden, Italy, India, and Tanzania.

United Nations Development Program (UNDP) - Senior Review and Analysis of U.N. Ground-Water Exploration and Development Program in Developing Countries, 1962 through 1977. Conducted multi-year evaluation of UN-sponsored ground-water programs throughout the world via project report analyses and UN personnel interviews.

U.S. Environmental Protection Agency (USEPA) - Nationwide Investigations on Rapid Response to Protect Ground-Water Resources from the Effects of Accidental Spills of Hydrocarbons and Other Hazardous Substances. Selected as Special Consultant to Versar, Inc. and a member of 10-member team of specialists to evaluate and recommend activities to minimize ground-water contamination resulting from accidental spills of contaminants. Mr. Campbell was primarily involved in the detailed evaluation of spills nationwide, the development of non-contamination criteria involved in the hydrogeologic framework, and in the preparation of the EPA guidance document and its final editing.

U.S. Commission on Rural Water (USCRW) - Investigations on Engineering and Economics of Rural Water Systems. Served as Research Director to evaluate and recommend rural water well system design and associated O&M programs within context of low-income environment of the rural communities.



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U.S. Environmental Protection Agency (USEPA) - Nationwide Investigations on Water Well Construction Standards. Served as Principal Investigator of 15-member team of specialists on water well design and construction. Produced manual published by EPA on the subject.

R. J. Reynolds Tobacco Company, North Carolina - Geophysical and Geological Exploration for Development of High Capacity Ground-Water Supply. Conducted and supervised geophysical and geological investigations in igneous and metamorphic rocks of North Carolina for the purpose of providing a ground-water supply in excess of 500 gpm for industrial use.

U.S. Environmental Protection Agency (USEPA) - Investigation on the Mobility of Well-Drilling Additives in the Ground-Water System. Conducted investigations of commercially-available drilling fluids and assessed flow behavior in the ground-water reservoir and potential environmental impact on the hydrochemistry of aquifer systems.

U.S. Office of Water Resources Research (USOWRR) - Investigations on State-of-the-Science and Art of Water Well Technology. Conducted multi-year investigations of all aspects of shallow well technology and related environmental impact, and identified future research needs for EPA-sponsored investigations at the Kerr Ground-Water Research Center, Ada, Oklahoma and EPA Laboratory in Cincinnati, Ohio.

The Ohio State University, Water Resources Division - Investigations on Ground-Water Contamination and Plume Development by Open Brine Disposal Pits, Morrow County, Ohio. Served as undergraduate research assistant to Dr. Jay H. Lehr and Dr. Wayne A. Pettyjohn on investigations including ground-water sampling, data analysis, and laboratory model construction and simulation of field conditions. Conducted contaminant transport and hydrochemical analysis of brine contaminant plume and associated modeling.

Various Clients - Geothermal Energy Investigations. Conducted numerous investigations on the hydrogeologic, structural and geophysical conditions of a number of liquid-dominated and vapor-dominated geothermal reservoirs in Nevada, California, and Texas to determine potential economic value of selected properties. Recommended further exploration and development in Dixie Valley. A significant geothermal reservoir was subsequently discovered and proved to be suitable for commercial



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development. Power plant became operational in 1987 and is producing electricity for the Nevada-California power grid.

International Paper - Lignite Exploration and Development Program, South Central US. Conducted /supervised shallow drilling, geophysical, and geologic logging, reserve calculations and quality assessments of IP properties throughout south central U.S.

Various Clients - Coal and Lignite Development Feasibility Investigations, Texas, Louisiana, Alabama, Mississippi, Washington, Pennsylvania, Australia, and Colombia. Conducted exploration programs for numerous clients to evaluate and estimate reserve base available, preliminary mining feasibility and property value.

Continental Oil Company (CONOCO) - Mining Development Projects in Australia and Southeast Asia. Conducted and managed field exploration programs, geologic mapping, drilling operations, and water-supply investigations (well drilling, aquifer testing, and pipeline transport engineering) for projects involving industrial energy, precious minerals and base metals (discovery credited) and associated mining projects.

United Nuclear Corporation (UNC) - Geologic and Hydrogeologic Investigations, Western US. Conducted investigations in numerous states to screen geologic environments for favorable conditions for the occurrence of uranium and other strata-bound minerals. As a principal part of such investigations, numerous hydrochemical facies of favorable geologic intervals were evaluated to further screen prospective environments. Also, Mr. Campbell conducted water supply investigations (drilling, sampling, and aquifer testing) at UNC's northwest New Mexico and central Wyoming mining operations.

Geologic and Hydrogeologic Investigations - Numerous Clients. Conducted and supervised preliminary mining feasibility studies, mineral property evaluations and environmental assessments for numerous clients in the US, including Alaska, and South America, Central America, Africa, India, and other countries.

City of Houston - Well Field Investigations - Provided analysis of probable causes for unanticipated well/pump failures in city's system. Conducted metallurgical and hydrochemical analyses of failed pump



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components and well conditions prior to pump failures. Recommended improving operation and maintenance procedures and establishing new ground-water sampling and well performance protocol.

Management of Geothermal Exploration and Development Projects

In 1976, Mr. Campbell conducted extensive investigations on the potential geothermal value of selected properties in Dixie Valley, Nevada for a series of clients. Based on the available geological, geophysical, and hydrogeological data, Mr. Campbell recommended further investigations and a preliminary drilling and hot-spring sampling program. Results indicated favorable conditions existed in the subsurface complex of Basin-and-Range geologic structures. Additional federal lands were acquired by the client in Dixie Valley and other geothermal companies became interested in the area. Deep exploratory drilling began and significant discoveries of high temperature, liquid-dominated geothermal energy reservoirs were identified. Economic analyses were conducted on behalf of the client to establish land values for possible buyout or merger with other geothermal companies. The client subsequently sold its interests. Dixie Valley geothermally generated power plants went on stream in 1987 and is producing electricity for the Nevada-California power grid on a regular basis.

Mr. Campbell conducted a series of additional geologic, hydrogeologic and economic investigations for a number of geothermal companies in the western US. He continues to monitor industry activities.

Applicable Geothermal Publications / Major Reports

Campbell, M. D., 1983, "Report of Investigations on Selected Geothermal Properties and Their Potential Productivity, Western United States," a Keplinger Consulting Report (private distribution), 32 p., June.

Campbell, M. D., 1983, "Dixie Valley, Nevada: A Promising Geothermal Area Under Development By Industry," *Proc. 18th Inter. Society Conversion Engineering Conference*, Orlando, Florida, August 21-26, Session 79, 6 p.

Campbell, M. D. and C. C. Wielchowsky, 1982, "A Review of the Dixie Valley, Nevada, Liquid-Dominated Geothermal Resource and the Relationship of Selected Geologic Characteristics to Potential Geothermal Production," *Proc. Am. Chemical Eng. Institute, Ann. Mtg.* (1982), 43 p., 6 figs., 5 tabs., refs.

Campbell, M. D., 1979, "Geopressured Geothermal Energy Potential of the Hidalgo Fairway, Texas," *Proc. Seminar on Geothermal Energy*, Brownsville, Texas, October 4, sponsored by the Brownsville Navigation District, 15 p., October.



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Campbell, M. D., and C. C. Wielchowsky, 1978, "Interim Evaluation and Exploration and Development Status, Geothermal Potential and Associated Economics of Dixie Valley, Nevada," a Keplinger Consulting Report (private distribution), 110 p., September.

Campbell, M. D., and C. C. Wielchowsky, 1977, "Phase II Preliminary Evaluation of Dixie Valley, Nevada: Geothermal Potential and Associated Economics," a Keplinger Consulting Report (private distribution), 44 p., September.

Campbell, M. D., 1977, *Geology [and Environmental Impact] of Alternate Energy Resources, Uranium, Lignite, and Geothermal Energy in the South Central States*, Houston Geological Society, 364 p.

Campbell, M. D., 1977, "A Review of the Mineral Potential (Uranium, Fluorspar, Mercury, Geothermal Energy, Coal and Other Minerals) of Certain Land Holdings in the Big Bend, Texas Area," a Keplinger Consulting Report (private distribution), 20 p., May.

Campbell, M. D., 1977, "A Preliminary Evaluation of the Hughes Geothermal Properties in Churchill County, Nevada," A Keplinger Consulting Report (private distribution), 62 p., April.

Management of Coal / Lignite Exploration and Development Projects

In the mid-1970's, Mr. Campbell initiated and managed the lignite exploration activities for General Crude Oil Company (Div. International Paper, Inc.) in Arkansas, Texas, Mississippi and Alabama. Subsequent consulting assignments on coal and lignite in the 1970's and 1980's involved: exploration programs, preliminary mining feasibility studies, detailed reserve analyses, property evaluations, and mining operations assessment and evaluation.

Applicable Coal-Lignite Publications / Major Reports

Campbell, M. D., 1983, "Preliminary Evaluation of Coal Reserves, Cambria County, Pennsylvania," a Campbell, Foss and Buchanan Consulting Report (private distribution), 10 p., December.

Campbell, M. D., C. C. Colburn, and D. J. Lynch, 1979, "An Evaluation of Coal Resources and Mining Economics, Wayne County, Utah," a Keplinger Consulting Report (private distribution), 295 p., March.

Campbell, M. D., and J. P. Garten, 1977, "Evaluation of a 340 Acre Surface Coal Mining Prospect, Sand Mountain, DeKalb County, Alabama," a Keplinger Consulting Report (private distribution), 31 p., June.

Campbell, M. D., 1977, *Geology [and Environmental Impact] of Alternate Energy Resources, Uranium, Lignite, and Geothermal Energy in the South Central States*, Houston Geological Society, 364 p.



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Campbell, M. D., 1977, "A Review of the Mineral Potential (Uranium, Fluorspar, Mercury, Geothermal Energy, Coal and Other Minerals) of Certain Land Holdings in the Big Bend, Texas Area," a Keplinger Consulting Report (private distribution), 20 p., May.

Campbell, M. D., 1976, "Alternate Energy and Mineral Development: General Outlook and Comparative Economics," *Proc. 1976 Keplinger Energy Seminar*, University Club, New York City, November 23, 30 p.

Management of Mineral Exploration Programs

During the mid-to-late 1960's, Mr. Campbell worked for a major American oil and minerals company (Conoco) in Australia and Southeast Asia, successfully conducting/managing field exploration programs, drilling operations, and water-supply investigations for development projects involving industrial and energy minerals, and precious and base metals (discovery credited). In the early 1970's, after returning to the U.S., he served three years as Regional Geologist with a major uranium exploration and mining company in Wyoming (United Nuclear). While there, he conducted research on hydrochemistry associated with roll-front uranium occurrences and successfully applied the results to the company's field program nationwide.

Mr. Campbell subsequently conducted various exploration programs as a consultant in the U.S. for companies such as Texas Eastern Nuclear, General Crude Oil Company and others during the mid-1970's on targets ranging from uranium, rare earth minerals, sulfur, and industrial minerals to base metals and precious metals.

In 1983, Mr. Campbell and two associates formed a consulting firm and conducted many domestic and international geologic, mining, economic, and hydrogeologic investigations including mineral property valuations and exploration programs (discovery credited), mine operational and financial management projects, mineral reserve analyses, preliminary feasibility studies, environmental investigations of various types, and other geotechnical investigations.

Applicable Minerals Publications / Major Reports / Presentations

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Campbell, M. D., 2004, Preliminary Examination of Mineralogical Samples from Rwanda, April 24, 32 p. (Confidential Client from Rwanda).

Campbell, M. D. and K. H. Forster, 1996, Hydrogeology and Mining, a Study Guide for Workshop presented at The National Mining Conference, Knoxville, Tennessee, May 11, 137p.

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Campbell, M. D., 1974, *Uranium Potential of the United States: Stage I, Frontier Exploration*, United Resources Consulting Report for Pioneer Nuclear, Inc. and Texas Eastern Nuclear, Inc. (copyrighted), 218 p, 21 plates, 46 figs., 7 tabs., 389 refs. (Houston).

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Mine Management

During the mid-1980's, Mr. Campbell provided technical, operational, financial and environmental management consulting for a heap-leach precious metal mine in Nevada. He served as part of a three-man matrix consulting management team that provided management consulting for operations and management of a multiple mine-central mill project with 35 employees and for the prime mining, crushing, hauling and agglomerating contractor with more than 30 employees.

Mr. Campbell's activities included:

- 1) management consulting for the start-up mine operations,
- 2) consulting on operational financial and accounting (\$8 million cash flow/year),
- 3) consulting on company operating and hazardous material safety and bullion security policy development via personnel manual,
- 4) joint-venture representation with major mining companies,
- 5) development of economic modeling programs for detailed financial analyses of month-to-month economic conditions,
- 6) day-to-day monitoring of operational processes and hydrochemical data,
- 7) consulting on exploration programs and of land-acquisition projects,



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- 8) conducted analyses of unsaturated flow in the heap-leach operations, and monitored solution chemistry, and
- 9) initiated ground-water monitoring programs and provided guidance in negotiations with BLM and EPA.

Applicable Mine Management Publications / Major Reports

Campbell, M. D. and J. D. King, 1988, Norse Windfall Mines, Inc. Personnel and Corporate Policy Manual, August, Eureka, Nevada, 30p.

Campbell, M. D., T. H. Foss and K. J. Buchanan, 1986, "Report of Investigations on the Preliminary Feasibility of Development of the Eureka Precious Metals Project, Nevada," a Campbell, Foss & Buchanan, Inc. Consulting Report (private distribution), 123p. (See Summary Report).

International Projects

Mr. Campbell spent his early professional years on projects in Australia, South East Asia and Micronesia, making trips to Japan, Hong Kong and Singapore as joint-venture project negotiation needs required. He has returned on occasions to present invited hydrogeological and water supply papers. Mr. Campbell has initiated or been associated with projects on mineral exploration, mining, and water supply and hydrogeological topics in the following countries: Australia, Canada, Chile, France, Honduras, Jordan, Italy (Sardinia), Liberia, Mexico, Niger, Sri Lanka, Sweden, South Africa, Sudan, and Tanzania.

Applicable International Publications / Major Reports

Campbell, M. D., and M. David Campbell, 2004, "Crisis Management: Ground-Water Supplies in the 21st Century," in *EnviroTechnology (Chinese)*, Vol. 1, Summer, pp 78-81.

Swartz, T. E., K. Montesoglu, M. D. Campbell, and O. Akkol, 1991, "Turkey: Ground-Water Issues in a Country with a Developing Economy" in *Proc. Fifth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring, and Geophysical Methods, AGWSE Conference*, May 13-16, 1991, Las Vegas, Nevada, pp 165-174.

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Pendry, G., (with technical support provided by Campbell, M. D.), 1969, "Report of Potash Potential, Carnarvon Basin, Western Australia," Continental Oil Company of Australia, Minerals Exploration Division, 15 p., 6 figs., 3 tabs. (unpubl.)

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Campbell, M. D., 1968, "Discovery of New Phosphate Deposits: Interim Phosphate Report No. 1: Northern Territory, Australia," Continental Oil Company of Australia, Minerals Exploration Division, 22 p., 3 tabs., 3 plates (unpubl.).

Other Subsurface Investigations

Mr. Campbell also has conducted a number of other scientific, geologic, hydrogeologic and geotechnical investigations involving: growth-fault investigations, remote subsurface data acquisition technology development, technology transfer, human toxicology, moon-earth-meteorite potassium-uranium systematics, paleoenvironmental and diagenetic processes in the subsurface, injection well design and operation, oil shale, sand and gravel reserve assessment and preliminary development feasibility, geologic assessment of cavern integrity and injection operations at Strategic Petroleum Reserve Sites in Texas, and subsurface structural traps for oil and gas. Mr. Campbell has a strong interest in the industrialization of space.

Applicable Publications / Major Reports / Presentations

Campbell, M. D., et al., 1998, "Additional Investigations on the Upper Cretaceous Ferron Sandstone", Wayne County, Utah, Interim Report, (see online C&A CV).

Campbell, M. D., Alexander, T. A., and M. David Campbell, 1990, "Siderite Occurrences in the Atoka Formation, Oklahoma and Arkansas, and their Hydrochemical, Diagenetic and Paleomagnetic Implications, *Geological Society Section Mtg*, Oklahoma State University, Stillwater, March 5-6 (Abstract). See Interim Report, (see online C&A CV).

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Publications / Papers in Preparation

Campbell, M. D. (In Preparation), *Nuclear Energy and the Environment*, for the American Geological Institute Natural Resource Series, ~70 p.

Campbell, M. D., *et al.*, (In Preparation), *The Role of Nuclear Power in Space Exploration and the Associated Environmental Issues: An Overview*, a report of the Uranium Committee of AAPG's Energy Minerals Division, to be released Mid-2009.

Campbell, M. D. and M. David Campbell, (In Preparation), "Growth Faulting in the Houston, Texas Area: Origins and Characteristics, Regional and Local Relationships, Associated Geologic Hazards, Economic Impact and Methods of Investigation", (see online C&A CV).

Campbell, M. D., Alexander, T. A., and M. David Campbell, (In Preparation), "Siderite Occurrences in the Atoka Formation, Oklahoma and Arkansas, and their Hydrochemical, Diagenetic and Paleomagnetic Implications," Geological Society Section Mtg, Oklahoma State University, Stillwater, March 5-6 (Abstract), preparing for subsequent publication in *Geology* or other journal. (See Interim Report, (see online C&A CV).

Manuscripts Reviewed for the Technical Journals

Many manuscripts have been reviewed recently for *Ground Water* and for the *International Journal of Environmental Forensics*. Mr. Campbell also reviewed numerous manuscripts while serving on the *Ground Water* Editorial Board (1971-1978). Request list from Mr. Campbell.



M. D. Campbell and Associates, L.P.

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Curriculum Vitae

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Online: [Summary & CV \(Here\)](#)

Education

1979, B.S. in Geology, Western Washington University, WA

Summary of Experience

Mr. King has over 25 years of technical and managerial experience in the natural resource field. Mr. King has extensive experience in developing successful regulatory- and landowner-negotiation and public-relations programs, has conducted or directly managed all aspects of site permitting, and has been involved in the financial and technical evaluation of mining properties for a major mining company and other projects. He has also founded, developed and operated two successful companies. He is licensed as a Professional Geologist in the State of Washington (#1727).

Mining Experience

Mr. King developed mining process expertise in the late 1970's and early 1980's. During this time he worked for Companies such as Bethlehem Copper, Union Oil (MolyCorp) and the mining consulting firms for Watts, Griffis and McOuat and Campbell, Foss and Buchanan, Inc. including gold mining and gold placer evaluation in the lower states and in Alaska. In 1984, Mr. King was named mine manager of a gold and silver mine in Nevada. He served in that capacity until 1986 when he was named Vice President of Operations.

Selected technical presentations on uranium by Mr. King are cited below:



M. D. Campbell and Associates, L.P.

Houston

Seattle

Phoenix

Campbell, M. D., J. D. King, *et al.*, 2008, "The Nature and Extent of Uranium Reserves and Resources and their Environmental Development in the U.S. and Overseas", *Proc. Conference of the American Association of Petroleum Geologists (AAPG), Energy Minerals Division*, April 23, San Antonio, Texas, 14 p. ([PDF](#)).

Campbell, M. D., H. M. Wise, and J. D. King, 2008, "Nuclear Fuel Exploration, In Situ Recovery, and Environmental Issues in Context with the National Energy Needs through Year 2040", *Proc. Texas Commission on Environmental Quality Conference and Trade Fair*, April 30, An Invited Presentation, Austin, Texas ([PDF](#)).

Environmental Experience

Between 1990 and 1998 Mr. King worked for the DuPont Company directing environmental projects in Washington, Oregon, Alaska and British Columbia, Canada. In 1998, Mr. King formed Pacific Environmental and Redevelopment Corporation to focus on large-scale projects involving the redevelopment of formerly contaminated properties. In completing these projects, Mr. King has developed or managed a team of resources and associates with experience ranging from environmental sciences to master-planned community and golf-course construction.

One such environmental project managed by I2M's Jeff King involved the environmental clean-up of an industrial site south of Tacoma, Washington. Once the contaminants were removed, Mr. King oversaw the construction of a golf course followed by the construction of quality homes. The golf course was completed in 2006 and has just won the "Top Ten New Courses in the World" Award for 2007, given by *Travel and Leisure Golf Magazine* (See Announcement ([Here](#))).

He presently plays a significant role for M. D. Campbell and Associates, L.P. in a variety of support functions, including project management and assessment, property evaluations, and field investigations of environmental and mining projects.

xxx

APPENDIX 3

***ANNUAL REPORT FOR EPM 17503 Adavale
12 Months ending 03rd November, 2009
For QUEENSLAND POTASH PTY LTD.***

***Conceptual Design for a Brine Production Plant based
on Solution Mining Technology near Blackall,
Queensland (Australia): Report by KBB Underground
Technologies.***

DRAFTrev01

**Conceptual Design
for a Brine Production Plant
based on Solution Mining Technology
near Blackall, Queensland (Australia)**

for:

BT Metals

Circle Resources Holdings Limited (Australia)

KBB UT-Project-No.: 0329-01

Author/s: Dipl.-Geol. Dr. Axel Gillhaus
Dipl.-Geol. Christian Weiler
Dipl.-Ing. Botho Saalbach
Dr.-Ing. Dirk Zander-Schiebenhöfer

Date: 23.07.2008

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Table 1: Geological Model of the exploration area for pre-feasibility

1 Introduction

Circle Resources Holdings Ltd has secured an application for an Exploration Permit encompassing an underground salt deposit in the Adavale Basin near Blackall in Queensland, Australia. It is intended to produce brine from the salt deposit by solution mining technology. In a first step the feasibility of the project that has been preliminarily developed in the 1980s and 1990s has to be evaluated.

The salt deposit contains halite and different potash minerals which are not yet explored in detail and therefore it is not yet fixed which evaporite minerals the future exploitation will concentrate on. It was preliminarily decided that the most immediate option would be the construction of an electrolysis plant, therefore KBB Underground Technologies GmbH (KBB UT) has been asked to establish a conceptual design for a brine production plant with salt caverns near Blackall in order to deliver concentrated brine as a feedstock for the electrolysis plant and to support Circle Resources Holdings Ltd with information relevant for future investment decisions. In addition the pre-feasibility study on hand intends to prepare Circle Resources Holdings Ltd for the detailed exploration to be started in 2009 with seismic investigation and a first exploration well.

2 Conceptual Study

The scope of work was discussed by Mr. Walter Doyle and KBB UT during a meeting in Hannover and exclusively comprises the conceptual design of a brine production plant based on the leaching of caverns in a suitable rock salt formation, i.e. a combined and/or subsequent use of the planned caverns for the storage of products such as oil or gas is not considered. If these possibilities are thought of, they have to be taken into account from the very beginning because rock mechanical design will be substantially different. The interface between the brine production and the electrolysis plant was set directly behind the brine producing caverns. Brine purification will therefore be part of the electrolysis plant.

The conceptual study for a brine production plant based on leached caverns is presented in the following chapters. It is subdivided into the description of the subsurface elements of the plant and the description of the facilities on surface.

3 Geology

3.1 Geological Summary

The area of investigation is the Adavale Basin in the north-eastern part of Australia in the state of Queensland.

The Adavale Basin is a Devonian to Carboniferous Basin in Central Queensland, which is overlain by up to 1.500 metres of Mesozoic strata of the Eromanga Basin (WHITE, 1989).

The basin has a length of about 320 km and a width of more than 200 km with an area of approximately 28.500 km². Figure 1 shows a schematic geological map of the Adavale Basin and the extent of the exploration permit of Circle Resources Holdings Ltd in the northern part of the basin.

Five Petroleum exploration wells have penetrated rock salt along the eastern margin of the basin (Figure 2), one in the western part of the exploration permit (Bonnie No. 1) and one east of the exploration permit (Bury No. 1). The salt occurs in the Boree Salt Member of the Middle Devonian Etonvale Formation. Figure 3 shows the lower Palaeozoic stratigraphy of the Adavale Basin.

Westwards the Boree Salt Member is limited by carbonate and terrigenous Devonian deposits of the Lorne Depression and eastwards it is limited by the Warrego Fault.

In the Bonnie No. 1 well rock salt has been encountered between 2225 metres and 2326 metres bgl, in the Bury No. 1 well the Boree Salt Member has a thickness of 584 metres between 1774 metres and 2358 metres bgl (Figure 4).

From seismic surveys the greatest thickness of the salt has been estimated to be up to 900 metres with its top only 900 metres deep in the eastern part of the basin near the Warrego Fault (WELLS 1980). Figure 5 shows a schematic cross section of the Adavale Basin, based on the information of oil wells drilled in the 1960ies. The Bonnie No. 1 well in the northern corner of the license area and the Bury No.1 well east of the license area are shown on the right side of the figure.

ZHARKOV (1984) reports, that the salt in the Bonnie No. 1 well is rock salt with few clayey shale laminae. In the Bury No. 1 well the upper part of the Boree Salt Member contains nearly 24 metres of anhydrite, underlain by about 7 m of shale and limestone. The lower part contains rock salt with traces of anhydrite and few laminae and interbeds of shale.

3.2 Preliminary geological model

The following simplified geological model is based on the information gained from wells Bonnie No. 1 and Bury No. 1. In the western part of the exploration area the thickness of the Boree-Salt-Member was proved in the Bonnie No. 1 well to be about 100 m. In the Bury No. 1 well, salt was drilled from 1775.5 m to 2358.5 m with a thickness of 583 m. Therefore the thickness in the eastern part of the exploration area is expected to be about 500 m. The Boree Salt predominantly contains (clear) halite, which is interbedded by millimeter to decimeter thick layers of insoluble material, mostly anhydrite and carbonates. Denison Resources Ltd. states the amount of insolubles of the Boree No. 1 and the Bury No. 1 well between 6-8 %. Overlying rock consists of 1.775 m (Bury No. 1) to 2.225 m (Bonnie No. 1), mostly flat lying, Paleozoic and Mesozoic sediments.

It is noticeable that the thickness of the Boree Salt increases from West to East, as the depth of the Boree Salt Member decreases. For the geological model of the exploration area the average values of the thickness and depth were assumed as shown in table 1 below.

Summing up, for the geological model the top of the Boree Salt is expected in a depth of about 2.000 meter. The thickness of the salt is 250 meter with one or two potash seams in the upper half with historical assays in the range of 30% to 64% Potassium Chloride (KCL). It is recommended that the thickness, extent and volume of these seams be determined by further drilling.

Table 1: Geological Model of the exploration area for pre-feasibility:

≈ 1000 m	Eromanga Basin	≈ 600 m	Rollings Downs Group		Sandstone, Siltstone, Shale
		≈ 400 m	Injune Creek Group		Sandstone
≈ 600 m	Gallilee Basin	≈ 600 m			Sandstone, Siltstone
≈ 650 m	Adavale Basin	≈ 50 m	Buckabee Formation		Sandstone, Siltstone
		≈ 150 m	Etonvale Formation	D1	Sandstone
		≈ 200 m		D2	Sandstone, Shale
		≈ 250 m		D3 Boree Salt Member	Halite, Anhydrite, Dolomite, (Sylvite)
≈ 350 m	Log Creek Formation	≈ 350 m	Bury List Member		Limestone, Sandstone

4 Preliminary rock mechanical model

The rock mechanical layout is of preliminary character, because essential site specific data are unknown at this point of time. Therefore only knowledge on the basis of experience can be used in a combination with rules of thumb to assemble a preliminary design and layout concept. A definite rock mechanical layout and design will be subject of a rock mechanical expertise in a subsequent step of the project.

4.1 Basics of the Rock Mechanical Layout

The rock mechanical layout has to ensure the geotechnical safety. In detail the following demands have to be met:

- Stability of the rock mass surrounding the cavern(s)
- Serviceability and tightness of each individual cavern
- Subsidence of the surface due to cavern(s) operation
- Environmental safe abandonment of the exploited brine caverns

This leads to recommendations for the limiting layout and design parameters of the individual cavern and the cavern field with respect to

- the geometrical shape of the cavern(s),
- the depth location of the cavern(s),
- the geometrical configuration of the prospected cavern field,
- the distance of each individual cavern to other non rock salt formations and/or possible discontinuities and
- the range of permitted internal cavern pressures

It is state of the art to determine these cavern field layout parameters and/or recommendations for the operation in a rock mechanical expertise that takes into account site specific data and boundary conditions. As illustrated in Figure 6 the rock mechanical expertise includes the four steps of

- describing the theoretical rock mechanical model,
- defining the theoretical calculation model,

- performing numerical calculations,
- giving recommendations for the cavern design and limiting operation conditions.

The theoretical rock mechanical model contains

- the geological model
- the description of the undisturbed primary state of the rock mass,
- the selected adequate material model and
- the description of rock mass parameters.

The geological model, as it is described in its preliminary version in chapter 3.2, provides details about the composition of the rock mass body.

The primary state of the rock mass, i.e. the initial state before the caverns are leached, determines the boundary conditions of the theoretical rock mechanical model in terms of state of stress and temperature with depth. These values can partly be deduced from the geological exploration data, are estimated against the background of experience and/or are determined from specific in-situ tests.

In order to be able to perform rock mechanical calculations, the rock formations that contribute to the load bearing system around the caverns have to be characterized by suitable material laws.

The caverns will be leached out entirely in the rock salt formation. Rock salt is known as a material with pronounced time dependent deformation behaviour, it creeps with time under constant loading. Further, the material behaviour of rock salt differs from location to location, even within the same salt formation there may be substantial differences in the creep behaviour. Especially for bedded salt formations the material characteristics depend on the composition of the salt section (different salt types, intercalated layers, impurities). Therefore, the strength and the time dependent deformation behaviour of the rock salt have to be determined specifically for the location of each individual cavern. Further, it is important to know for bedded salt formations how the mechanical behaviour of the overlying and underlying rock formations can be evaluated, if an optimization of the thickness of the salt roof above the cavern and/or the salt bottom below the cavern is intended. In this case the load bearing as well as the tightness system surrounding the cavern has to take into account the non rock-salt formations also. Detailed, i.e. site specific, information on the rock properties (salt and non-salt) generally results from rock

mechanical laboratory tests with specimen from site specific core material that is gained from the exploration and/or cavern wells.

The theoretical calculation model incorporates the knowledge from the theoretical rock mechanical model and defines project specific boundary conditions with regard to

- geometry of the individual cavern and the cavern field,
- cavern operating conditions in terms of cavern internal pressure and temperature vs. time,
- assessment criteria to ensure the demands on stability of the surrounding rock mass and usability of the cavern(s).

With the purpose to realize an optimized configuration and layout of the cavern(s) a parameter study has to be performed on the basis of the established rock mechanical calculation model. It is state of the art to use numerical methods here. The results of the numerical study then are evaluated applying defined assessment criteria to meet the demands on safety and serviceability as well as protection of the environment. This procedure finally leads to recommendations for the layout and design of the cavern(s).

The essential layout parameters for a cavern field in order to meet the demands on stability, usability and protection of the environment are illustrated in figure 7.

4.2 Preliminary rock mechanical layout

At the present stage of the project a rock mechanical layout of stable and serviceable caverns will be estimated empirically. This includes the dimensions of the individual caverns as well as the layout of the cavern field considering the distances (spacing) between the caverns and to the boundaries of the rock salt formation. No rock mechanical calculations or numerical simulations have been performed so far, because of the lack of detailed geological and rock mechanical information. The assumptions made here, in order to propose a preliminary cavern layout, are thought to be mostly conservative with respect to stability and serviceability.

From the assumed geological model (see chapter 3.2) a minimum thickness of the rock salt formation of 250 m is expected. The depth range is supposed to spread from 2,000 m down to 2,250 m. The overlying and underlying rock layers are assumed to be non-rock salt formations.

The stressing of the rock mass surrounding the cavern(s) due to leaching and operation should be restricted mainly to the rock salt. This is essential for the long-term stability and the long-term tightness of the caverns. To meet these demands a minimum roof thickness equivalent to the value of the maximum diameter of the cavern is looked upon as sufficient as far as no specific information on the material behaviour and the properties of the overlying rock formations is available, but with respect to the relative great depth of the caverns this parameter may not be looked upon as very conservative.

In case of a further proceeding of the project, an optimization of the thickness of the salt roof above the cavern can be carried out on the basis of a more detailed knowledge of the mechanical behaviour and tightness properties of the overlying rock formations as well as the structural integrity of the salt and overlying formations. A future optimization of the minimum salt roof thickness and the maximum cavern diameter provides a substantial potential for an increase of cavern volumes.

The minimum salt cover below the cavern sump is assumed with 20 m. Because here again the mechanical and tightness characteristics of the rock mass below the cavern have necessarily to be known.

Assuming these geometrical boundary conditions for the cavern layout a parameter variation has been carried out with regard to the cavern diameter and the resulting gross geometrical cavern volume, i.e. the geometrical cavern volume resulting from the geometrical layout parameters. The gross volume is not equal to the cavern volume that can be leached out (net volume). The net volume is smaller by a factor of 0.6 to 0.7, depending on the local conditions of the salt layer. Results of some possible diameter variations are given in Figure 9 compared with the resulting gross volume of the cavern. Figure 10 illustrates in more detail and it can be seen that despite an increasing height of the cavern with decreasing diameter the cavern volume and therefore the salt mass that can be extracted from underground is decreasing. At this point of a pre-planning phase KBB UT is recommending a maximum diameter of 80 m.

With reference to the required distance between neighbouring caverns in a regular spaced cavern field pattern (see Figure 8) it is assumed at the present state of the study that the horizontal extension of 250 m thick rock salt formation at Blackall, Queensland, Australia, will be large enough to contain a sufficient number of caverns needed to satisfy the demands of Circle Resources. For a first planning assumption it is recommended to start with a hexagonal grid with a spacing of 220–250 m between cavern axes. According to the generally demand on an economical exploitation of a salt deposit and in order to save

resources for future development the minimum pillar widths, coinciding with the spacing between caverns and their diameters, should be a subject for optimization in a subsequent rock mechanical expert's study.

Internal cavern pressures for brine production caverns are relatively constant during the time of salt production. Normally they are operated with internal cavern pressure resulting from the brine column up to the well head with a small surplus on the brine well head pressure in order to keep up circulation and to overcome friction. Assuming average strength characteristics and values of the rock salt no stability problems are expected at the cavern wall with respect to the intended cavern height and depth. But the strength characteristics and the deformation behaviour of the Blackall specific rock salt have to be tested in the laboratory as a prerequisite for the rock mechanical expertise. As a result, cavern volume, convergence and surface subsidence can be predicted in a reliable way.

Surface subsidence values are expected to be in the order of several decimetres after an operating time of about 30 years. This may differ, if the creep ability of the rock salt at Blackall turns out to be higher than can be expected from experience with rock salt from other locations. The same is true if the rock mass temperatures with depth are higher than expected. These figures can only be estimated more accurately, if the real cavern layout and operating conditions are known in combination with an improved knowledge of the rock salt material and the primary state in the rock mass in terms of stresses and temperature.

All the above assumed layout parameters are selected on the backdrop of KBB UTs experience. The preliminary rock mechanical cavern layout is presented in Figure 9. The layout parameters provide a geometrical cavern volume of about 600,000 m³ for a maximum diameter of 80 m. The shape of this cavern has to be looked upon as the maximum envelope in which the real cavern has to be leached out. This means, the cavern volume that can be realized will be smaller. As a rule of thumb for planning purposes a portion of 60 to 70% of the geometrical rock mechanical volume is feasible. Further the content of impurities has to be considered. This reduces the recoverable salt volume of each cavern to approx. 400,000 m³. Taking into account these limitations approx. 720,000 tons of rock salt are expected to be available per cavern.

5 Preliminary Leaching Concept

5.1 Solution Mining Plant

The target of the planned project is to produce caustic soda (NaOH) at a brine electrolysis plant. The electrolysis plant will be fed with saturated NaCl -brine, the output of the electrolysis plant will be weak NaCl -brine, caustic soda and hydrochloric acid (HCl). Beside of this some slurry (e.g. gypsum) will result from brine purification units.

The electrolysis plant and the brine purification is not part of this study. Merely the production of NaCl -brine as feedstock for the electrolysis plant will be described hereafter. The source of the saturated NaCl -brine will be a solution mining process at salt caverns in the underground at more than 2,000 m depth.

The basic principle of the surface solution mining plant is shown in Figure 11.

During the start up phase of the leaching operation water will be used as injection fluid into the bore hole of the underground salt layer (see also chapter 5.2.2). The water will be produced on site via two water wells at a capacity of each 25 m^3/h , so in total 50 m^3 water/h will be available. One water leaching pump (max. capacity 50 m^3/h at 50 bar) will inject the water in the cavern and dispose weak brine out of the cavern.

The produced brine coming out of the cavern will pass a 200 m^3 brine pond. During the residence time in this pond of approx. 30 minutes any suspended matter may settle down. Also any parts of blanket (gas or oil) can be separated in this pond from the brine.

Regarding the handling of the weak brine, produced during the start up phase, some options will be proposed in chapter 5.4.

If the produced brine from the cavern is nearly saturated, i.e. approx. 270 g/l, the circular flow from the cavern / leaching plant via the electrolysis plant and backwards will start. This production point will be at a flow rate of 50 m^3/h after approx. 200 days leaching time. In parallel to the growing cavern volume the flow rate will be increased stepwise up to the maximum flow rate of 300 m^3/h .

To realise the brine flow of 300 m^3/h through the cavern at a depth of approx. 2,000 m an injection pressure of approx. 80 bar is needed. So the electrical pump motor has to have a capacity of 1 MW.

The saturated brine will be pumped via a (circa) 5 km distance pipeline to the electrolysis plant. After passing the electrolysis plant and production of caustic soda weak brine at approx. 200 g/l and a reduced flow rate of 280 m³/h will be pumped back to the leaching plant. To compensate the reduced brine flow rate approx. 20 m³ water/h will be added to the weak brine flow coming from the electrolysis plant to achieve an injection flow rate into the salt cavern of 300 m³/h.

All pumps installed at the leaching plant should be driven speed regulated, so the flow rate is variable and electrical energy will be saved compared to throttle valves.

Both brine pipelines between leaching plant and electrolysis plant are foreseen as plastic pipes to avoid any corrosion effects. Basically the pipelines shall be installed on surface, only for crossing roads or others the pipelines will be buried.

All pumps are foreseen with a spare pump in parallel standby to avoid standstill times in case of pump disturbance.

At the leaching plant some buildings should be erected as:

- Control /office room
- Social /meeting room
- Workshop
- Electrical station
- Pump housing

5.2 Solution Mining Operation

5.2.1 Basic Principles of Solution Mining

As state of the art the leaching operation is performed by the “multiple stage technology” based on the “controlled leaching method” by using 2 leaching strings and a blanket medium (see Figure 11; 1a vs 1b).

Blanket is a medium lighter than water and brine and does not dissolve salt. Blanket media are oil, oil products or gases as nitrogen or compressed air. At the planned cavern project, it should be decided during the detailed engineering which type of blanket will be used.

Regarding the flow direction in the cavern there are 2 options (see Figure 11; 1a vs 1b):

- “direct” method, i.e. water injection at the bottom and brine production at the top of cavern
- “indirect” or “reverse” method, i.e. water injection at the top and brine production at the bottom of cavern

During the cavern construction the leaching strings are stepwise reset, i.e. mostly lifted up.

In opposite to this method in former times for brine production the “uncontrolled leaching method” was used, i.e. using only 1 leaching string without blanket. The result of this “wild” leaching method often was the appearance of sinkholes at the surface, so this absolutely has to be avoided at least during construction of gas storage caverns.

A basic leaching concept will be prepared by using a leaching simulation programme.

Main input-data for the leaching simulation are results of salt core dissolution tests and the geological interpretation of the salt structure. During the construction of the cavern history match simulations and adjustments of the leaching concept will be prepared according to the real cavern development recognised during sonar surveys.

Blanket level measurements and sonar surveys will be performed at regular intervals as precondition for a controlled solution mining operation. The time intervals for both types of measurements will be determined at the leaching concept.

The blanket level is measured by using radiometric tools as Gamma-Gamma- or Neutron-Pulse-tools. To measure the cavern shape by sonar surveys ultrasonic tools will be used.

5.2.2 Basic Leaching Concept

Based on the dissolution behaviour of solid salt it is difficult to produce saturated brine. During increasing the salt concentration in brine the “driving force” for further salt dissolution in the brine decreases. So to increase a brine concentration from approx. 270 g/l up to 300 g/l, i.e. saturation, it needs:

- Long duration of contact time between brine and solid salt
- Sufficient dissolution surface
- Low flow rate at the dissolution surface

Therefore 2 basic stages of cavern development are foreseen:

2nd stage: Main leaching phases by injection of weak brine and production of saturated brine

Basic leaching simulations have been performed to gain data regarding:

- At the basic leaching concept the following leaching steps are foreseen:

- | <u>Data</u> | <u>per step</u> | <u>cumulative</u> |
|-----------------|-----------------------|-----------------------|
| Duration | 180 d | 180 d |
| Cavern volume | 18,000 m ³ | 18,000 m ³ |
| Salt production | 36,000 t | 36,000 t |

Duration	10 d	190 d
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200 m³/h, 100 d300 m³/h, 240 d

<u>Data</u>	<u>per step</u>	<u>cumulative</u>
Duration	400 d	590 d
Cavern volume	82,000 m ³	100,000 m ³
Salt production	164,000 t	200,000 t

2nd Workover incl. sonar survey

Duration	10 d	600 d
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1st main leaching step: injection of weak brine (200 g/l)

- "indirect method": 300 m³/h, 300 d

<u>Data</u>	<u>per step</u>	<u>cumulative</u>
Duration	300 d	900 d
Cavern volume	100,000 m ³	200,000 m ³
Salt production	200,000 t	400,000 t

3rd Workover incl. sonar survey

Duration	10 d	910 d
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2nd main leaching step: injection of weak brine (200 g/l)

- "indirect method", 300 m³/h, 300 d

<u>Data</u>	<u>per step</u>	<u>cumulative</u>
Duration	300 d	1,210 d

Cavern volume	110,000 m ³	310,000 m ³
Salt production	220,000 t	620,000 t
4 th Workover incl. sonar survey		
Duration	10 d	1,220 d

Cavern roof leaching step: injection of weak brine (200 g/l)

- "indirect method", 300 m³/h, 300 d

<u>Data</u>	<u>per step</u>	<u>cumulative</u>
Duration	220 d	1,440 d
Cavern volume	90,000 m ³	400,000 m ³
Salt production	180,000 t	800,000 t

5th (final) Workover incl. sonar survey

The basic simulation result in the following cavern key data:

Final cavern volume:	400.000 m ³
Total salt mass production:	800.000 t
Lifetime incl. workovers.	1,440 days, i.e. 4 years
No. of blanket level measurements:	approx. 50, at least once per month
No. of workovers (incl. final WO):	5
No. of sonar surveys	5

At Figures 12, 13 and 14 the diagrams regarding development of flow rate, brine concentration, produced salt mass and cavern net volume but also the development of the cavern shape based on the leaching simulation are shown.

The main results regarding brine production to feed the electrolysis plant are:

- During the initial period of leaching operation from 0-90 days (sump leaching step) weak brine at approx. 150 g/l will be produced. This brine can not be used in the electrolysis plant (see also remarks chapter 5.4).
- During the following under cut leaching step from 90-180 days 50 m³/h pure water will be injected. The produced brine is still unsaturated at approx. 220 g/l. There are 2 options to handle this weak brine. A) brine disposal or B) feed to the electrolysis plant. In case B) the back flow of weak brine from the electrolysis plant at 200 g/l and approx. 45 m³/h could be mixed with the cavern injection water. Based on this option during the under cut leaching step the injection would be weak brine at approx. 100 g/l and a flow rate of approx. 100 m³/h. Anyhow the mixing ratio would be flexible depending on the produced brine concentration.
- Beginning from 190 days operation time the cavern injection flow will be the back flow of weak brine from the electrolysis plant at 200 g/l and starting at a flow rate of 100 m³/h. The produced brine concentration will be at approx. 270 g/l. According to the growing cavern volume the produced brine concentration will increase. In parallel the flow rate will also increase up to 300 m³/h beginning from 350 days operation time on, i.e. after approx. 1 year.

At the operation stage of - cavern flow 300 m³/h, injected brine concentration 200 g/l, produced brine concentration 300 g/l – the produced salt amount is 250,000 t NaCl/a.

It has to be pointed out: The basic leaching simulation and concept has been performed without any real drilling and exploration results from the salt deposit onsite.

5.3 Hydraulic Calculations

Regarding the hydraulic conditions and pump capacities the following issues have been calculated:

- Water injection in the cavern during the start up phase
- Injection of weak brine in the cavern during the production phase
- Pipeline flows

The results are as follows:

1. Cavern hydraulics

The cavern installation is assumed as:

- Last cemented casing: 13 3/8"
- Outer leaching string: 10 3/4", uncoated
- Inner leaching string: 6 5/8", internal coated

Based on this casing diameters and depths of approx. 2,000 m the hydraulic data are:

a) Start up phase

- Water injection: 25 m³/h – 50 m³/h
- Produced brine density: 1,100 g/l
- Water injection well head pressure: 22 – 25 bar
- Blanket head pressure (nitrogen): 175 bar
- Pump capacity (pmax = 50 bar): 100 kW, speed regulated

b) Production phase:

- Water injection: 100 m³/h – 300 m³/h
- Produced brine density: 1,200 g/l
- Water injection well head pressure: 25 – 80 bar
- Blanket head pressure (nitrogen): xx - 210 bar
- Pump capacity (pmax = 90 bar): 1,000 kW, speed regulated

2. Pipeline hydraulics

The brine pipelines from and to the electrolysis plant are foreseen as plastic pipes at diameters 10" (250 mm). Based on this pipe diameter and lengths of approx. 5 km the hydraulic data are:

- | | |
|--|-------------------------|
| - Brine flow, concentration 200 – 300 g/ | 300 m ³ /h |
| - Brine concentration: | 200 g/l – 300 g/l |
| - Pipeline injection pressure: | 8 bar |
| - Pump capacity (pmax = 10 bar): | 120 kW, speed regulated |

At this calculation no difference in altitude between leaching plant and electrolysis plant has been considered. If there is the intention in the future to increase the production capacity up to more than 250,000 t salt/a larger pipeline diameters than 10" should be taken in consideration.

3. Water well pump

To take out the water from the underground by water wells 2 surface or submersible pumps are foreseen each at 10 kW capacity (25 m³/h, 10 bar).

Important remark: the above mentioned hydraulic calculations are based on new pipe conditions. During the operation time based on corrosion and crystallisation the hydraulic friction losses will increase.

5.4 Handling of Weak Brine produced during Start up Phase

During the start up phase of the leaching operation, i.e. during the first 90 days of operation approx. 80,000 m³ weak brine at approx. 150 g/l salt concentration will be produced. Because this brine at low concentration can not be used at the electrolysis plant – if any the plant construction is already finished – some options how to handle the weak brine will be named hereafter incl. short pro and cons:

A) Surface disposal (river or others)

- Pro: Easy to realise, low costs
- Con: Permission in question

B) Subsurface (disposal well)

- Pro: Easy to realise
- Con: Higher costs, permission in question

C) Re-saturation by addition of solid salt in saturator pond

- Pro: Easy to realise
- Con: High costs by addition of approx. 10,000 t solid salt (to be bought from outside!)

D) Storing in an evaporation pond

- Pro: Additional production of solid salt, no energy costs for evaporation, at a permanent side flow of saturated brine of 2-3 m³/h (during the later cavern operation) a production of solid salt at approx. 4,000 t/a by solar evaporation would be possible, depending of the local climate conditions for brine evaporation.
- Con: High investment costs for evaporation pond approx. 10,000 m² surface, 2 m depth

E) 2nd well / cavern for re-saturation

- Pro: By drilling a 2nd cavern well just after the first cavern well the 2nd well could be used as re-saturator. Anyhow after 3 years a 2nd cavern well is needed. There will be a clear cost reduction, because additional effort for rig mobilisation / demobilisation to drill the 2nd well is not applicable.
- Con: High investment costs to drill a 2nd cavern well at the beginning of the project.

6 Cavern Reuse after Production Period

Once the 1st cavern is leached out according to the rock mechanical limits, the following options regarding reuse of the cavern can be taken in consideration:

A) Saturator during start up phase following new production caverns

Weak brine produced during the start up phase of the 2nd brine production cavern could become saturated in the 1st cavern.

B) Disposal Cavern (gypsum slurry)

Some slurry from the brine purification (i.e. gypsum slurry or others) at the electrolysis plant could be disposed to the finished cavern. During this procedure the slurry disposes high quality saturated NaCl-brine from this cavern, which can be used as additional production brine.

C) Storage cavern

The finished cavern could be used for storage of liquid or gaseous hydrocarbons as crude oil, LPG or natural gas. For the storage of hydrocarbons in caverns special high safety standards have to be considered. To store natural gas, special cavern design, i.e. reduced cavern diameter and enlarged pillar distances to neighbouring caverns must be taken in consideration.

7 Time Schedule

A time schedule is given in enclosure 3. It shows the simple case including the development of 1 cavern well for brine production. As discussed in chapter 5 there are several options for optimisation to be discussed during an upcoming meeting with KBB UT.

The schedule includes 1 year of project planning followed by another year including permitting, procurement of long lead items and tendering. Partly in parallel the construction of the leaching plant should be started in this second year in order to be able to start with the initial leaching phase immediately after drilling the first cavern well in the third year.

The maximum lifetime of each cavern is preliminarily based on the single cavern option and amounts to approx. 4 years based on a salt production of 200,000 t/a.

8 Cost Estimate

An estimate of all necessary investment costs for the construction of surface and subsurface part of the solution mining plant is given in Enclosures 1 and 2. Furthermore annual operational and maintenance costs are estimated based on KBB UT's experience with brine production plants in Germany.

Because of the 4-years life time per 1 cavern, after approx. 3 years the 2nd cavern well has to be drilled. This means at the latest some new investment costs at this time. After first discussion of the study results on hand one alternative of the preliminary leaching concept discussed above should be chosen.

The cost estimation regarding brine production based on solution mining technology was calculated at a salt mass production of 200,000 t/year.

The costs were divided into 3 main items:

- Investment costs to construct the surface leaching plant incl. pipelines
- Investment costs for subsurface equipment
- Operation costs for 4 years leaching operation period

The costs are based on current EUR-prices known by KBB UT from the market.

The price of electrical energy is based on a preliminary information as has been agreed between Circle Resources Holdings Ltd and KBB UT.

Prices for steel equipment (pipes, casings, pumps) and electrical energy will increase during the next years. This cost escalation effect was not taken in consideration at this cost calculation.

9 Exploration Programme

The salt deposits near Blackall are not yet explored in detail. All geological information on the ideal position, the depth and the thickness of the salt deposit available to date are extrapolated from few hydrocarbon exploration wells which reveal different salt thickness.

Therefore it will be necessary to perform an exploration programme in the area of the mining license of Circle Resources Holdings Ltd. This programme should comprise two main steps:

1. Seismic investigations (3D seismic) in order to determine the depth and thickness of the rock salt formation in this part of the salt basin should be performed. Furthermore the outer shape of halotectonic structures as well as the existence and position of tectonic faults cutting through the sedimentary succession can only be detected with a seismic survey. Typically salt structures like salt pillows or salt welds may also be located in the underground and enable to locate the exploration well and subsequent cavern wells at an ideal position.
2. Subsequently it will be necessary to drill at least one exploration well with a suitable geophysical wireline logging programme. Furthermore continuous coring at least throughout the saliferous section will be necessary to get information on the quality of the rock, especially on the amount of insolubles. Furthermore core material is necessary to gain samples for rock mechanical and leaching tests.

The area to be investigated by a seismic investigation should be as large as possible in order to get a maximum of information on the underground salt formations and to be able to choose the best place for cavern construction. This means:

- Maximum thickness of salt (e.g. salt pillow or salt anticline)
- No faults in the vicinity of the future caverns
- No thick non-salt intercalations in the salt section

It has to be decided by Circle Resources Holdings Ltd whether the whole license area should be investigated by a seismic programme or just the central to eastern part with highest rock salt thickness in contrast to the western part. As an example: To investigate an underground salt deposit of 2x2 km size down to 2000 m accurately the surface area to be covered with seismic equipment and measurements will be at least 6x6 km. The actual

cost for such a survey should be asked for in Australia. The comparable cost will be about 2-3 million EUR inclusive data processing in Europe depending on the location.

The exploration well should be drilled in the same way and with same dimensions as the brine production wells. The exploration well includes the following investigations:

- Mudlogging with detailed geological and geophysical well documentation compiled in a digital sampler log
- Coring at least throughout the saliferous section
- Bromine analyses of cuttings and/or cores of rock salt encountered in the well
- Geophysical logging including:
 - Caliper log
 - Gamma ray log
 - Density log

The abovementioned programme represents the minimum investigation and there are further options which might be helpful depending on the results of the seismic survey. The cost for the exploration well with a comprehensive programme again will be approximately 2-3 million EUR based on European experience.

When the exploration programme has been finished, i.e. after geological documentation of the exploration well the core material will be used for rock mechanical and leaching tests in order to establish a rock mechanical model and numerical simulations as input for the rock mechanical expertise.

In order to get the permits from the authorities for the leaching and operation of caverns the abovementioned rock mechanical expertise has to be performed. The rock mechanical expertise has also to focus on the optimization of the cavern design and layout parameters. As a prerequisite to this, a laboratory test program on the mechanical properties and deformation behaviour of the rock salt from the license area has to be carried out. Here the cores gained during drilling of the exploration/cavern well will be used. In domal salt it generally can be assumed that the primary horizontal and vertical stresses in the rock salt are equal due to the creep ability of rock salt, this may be different for the license area near Blackall, because of possible tectonic influences and because the rock formation can be classified as a layered or bedded salt, this has to be taken into account also in the rock mechanical expertise.

The primary state of the rock mass has to be determined in terms of primary stresses and temperatures. Primary stresses can be deduced indirectly from the determination of the densities. These densities can be determined from the rock core material and cuttings gathered during the drilling process and from a borehole density logs. Further, specific tests can be performed in the well such as hydraulic or pneumatic fracturing tests in order to determine the minimum in-situ stress component. From borehole gravimetry measurements the density profile can be determined. The temperature profile should be measured in the drilled borehole after some idle time after drilling to ensure to get very close to the primary state of temperature.

When the rock mechanical layout for future cavern construction has been established leaching tests of cores from different rock salt sections will be used for leaching tests in order to perform numerical simulations to plan the cavern development.

10 Summary and Recommendations

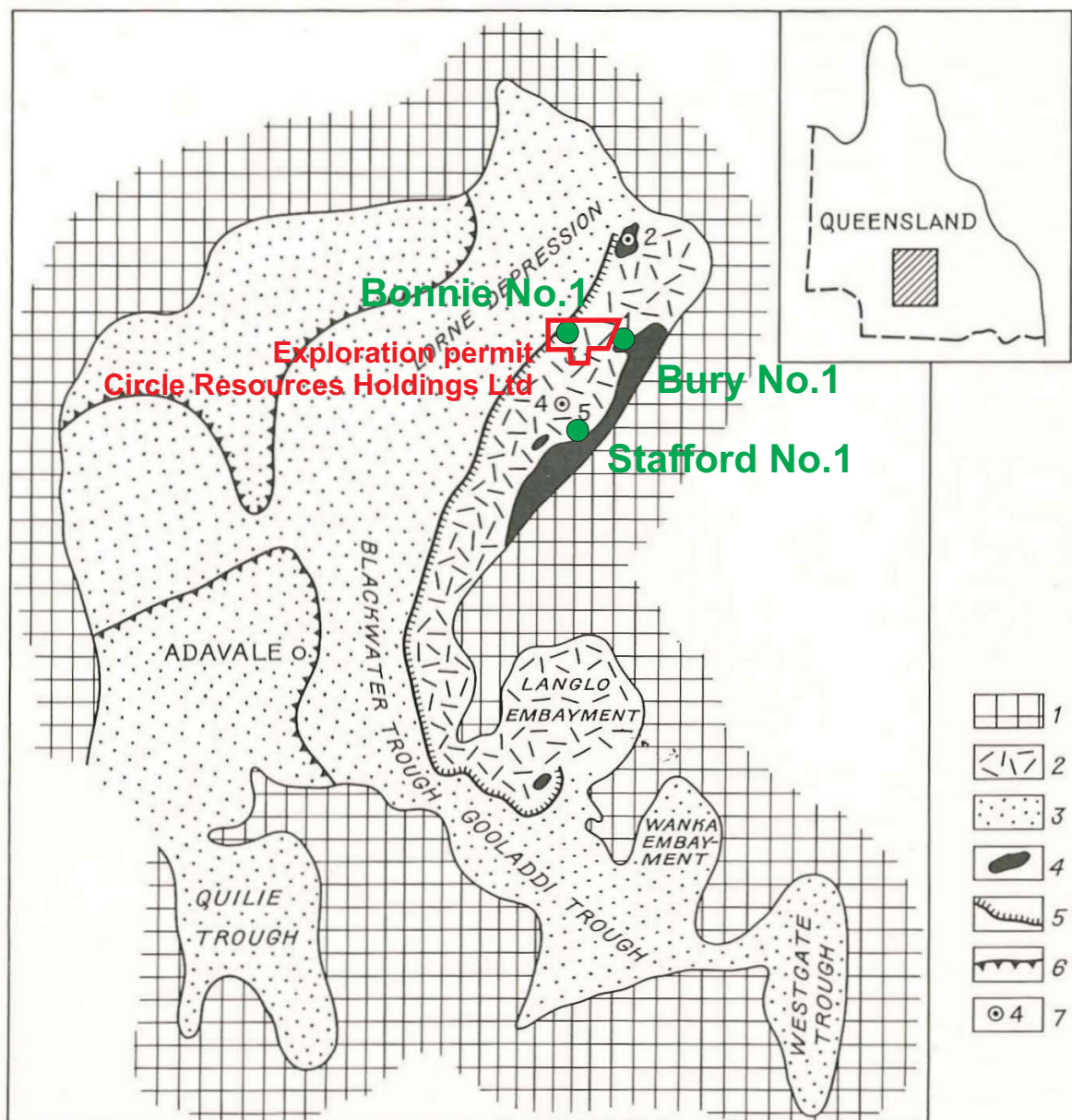
Will be submitted in the final version of the report.

List of Enclosures

Enclosure 1: Cost estimate subsurface equipment

Enclosure 2: Cost estimate surface equipment

Enclosure 3: Basic time schedule for leaching operation



Distribution of Boree Salt Member in Adavale Basin. After Tanner (1967) and Wells (1980).
 1 Devonian absent (Permian or Mesozoic on basement), 2 areal extent of Devonian salt deposits,
 3 areal extent of carbonate and terrigenous Devonian deposits, 4 salt bodies, 5 westward extent
 of Boree Salt Member deposition, 6 probable westward extent of Cooladdi Dolomite, 7 wells and
 their numbers (1 Bury No. 1, 2 Boree No. 1, 3 Bonnie No. 1, 4 Alva No. 6, 5 Stafford No. 1)

Figure 1

Position of existing wells in Adavale Basin in Australia
 (from Zharkov 1984) and extent of exploration permit

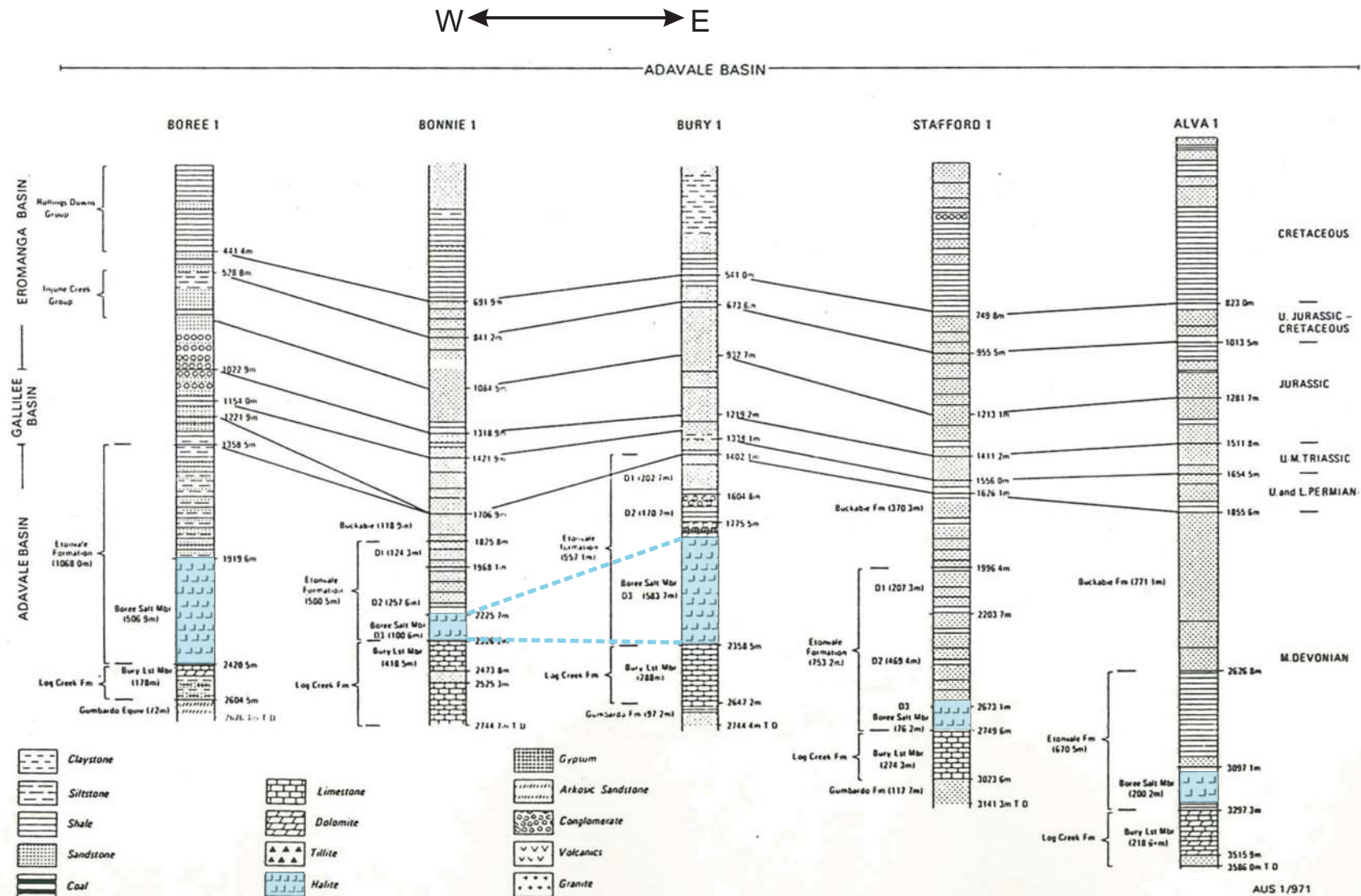


Figure 2
Wells containing evaporites in the Adavale Basin (from WELLS 1980).

Lower Permian			Siltstone, shale
Upper Devonian to Lower Carboniferous	Buckabie Formation	0-2.100 m	Sandstone, siltstone, shale
Major Unconformity			
Middle Devonian	Etonvale Formation	0-240 m	D1 Shale – siltstone member
		0-500 m	D2 Sandstone member
		0-40 m	D3 Cooladdi Dolomite Member
			Boree Salt Member
	Unconformity		
	Log Creek Formation	0-600 m	D4 Gilmore Sandstone Member
		0-450 m	Shale member
		0-600 m	Bury Limestone Member
	Gumbardo Formation	0-750 m	Volcanic rocks, tuffs and sediments
Major Unconformity			
Ordovician to Silurian			Igneous and metamorphic rocks

Figure 3

Lower paleozoic stratigraphy of the Adavale Basin (from WELLS, 1980 after GALLOWAY, 1970).

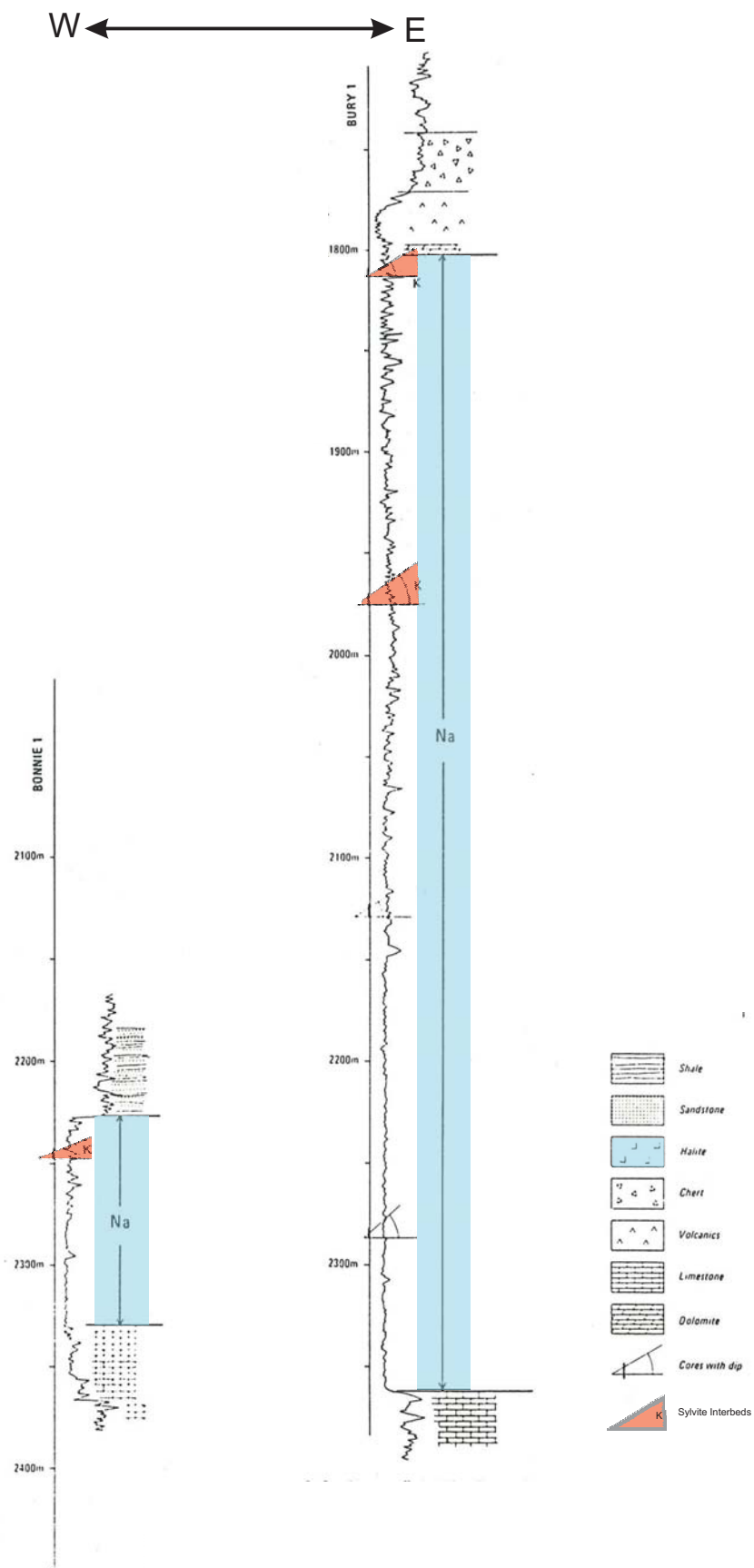


Figure 4
Cross section Bonnie + Bury with GR-Log

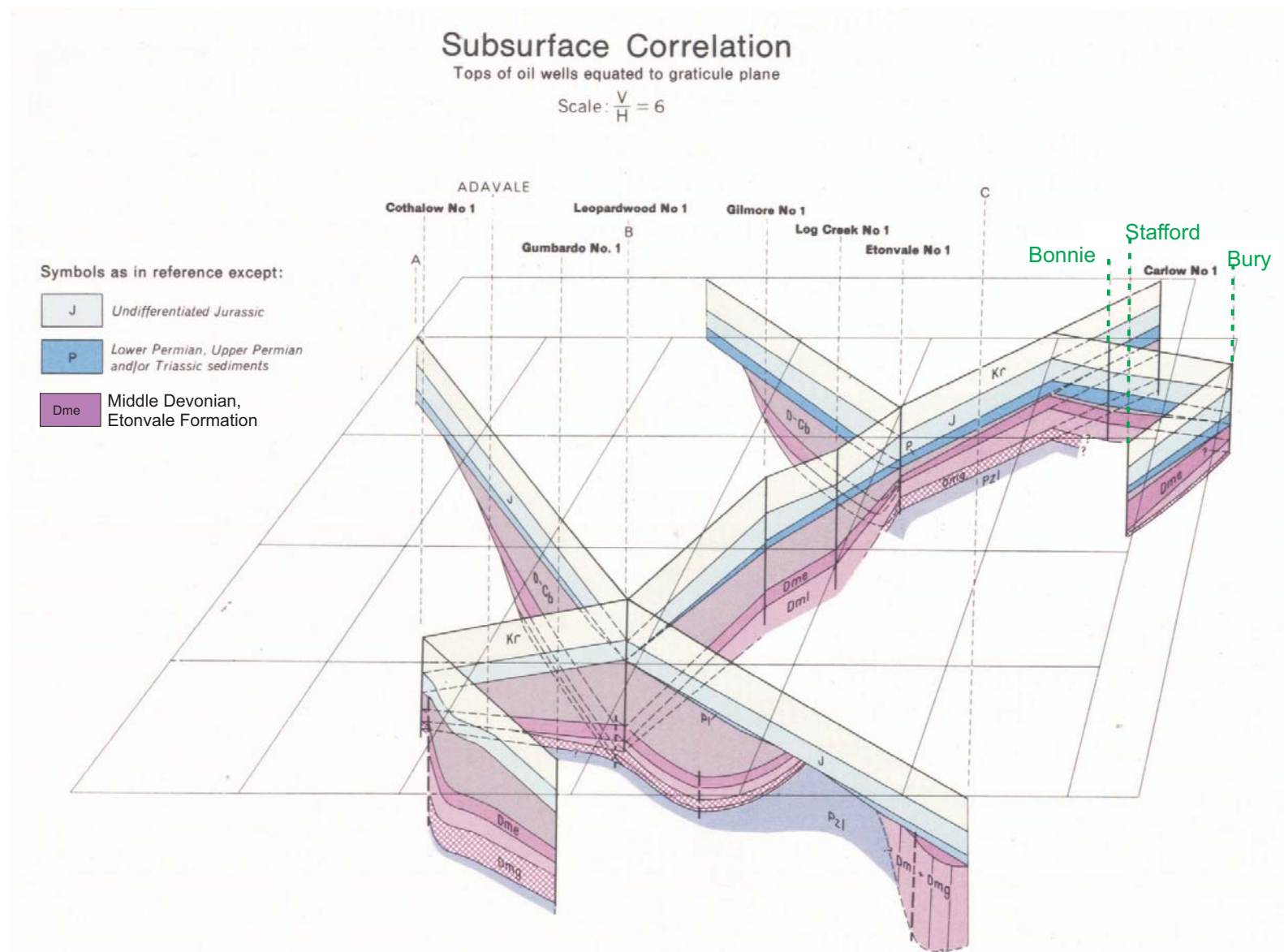


Figure 5

Schematic cross sections Adavale Basin (from Australia 1:250.000 Geological Map, Sheet SG 55-5).

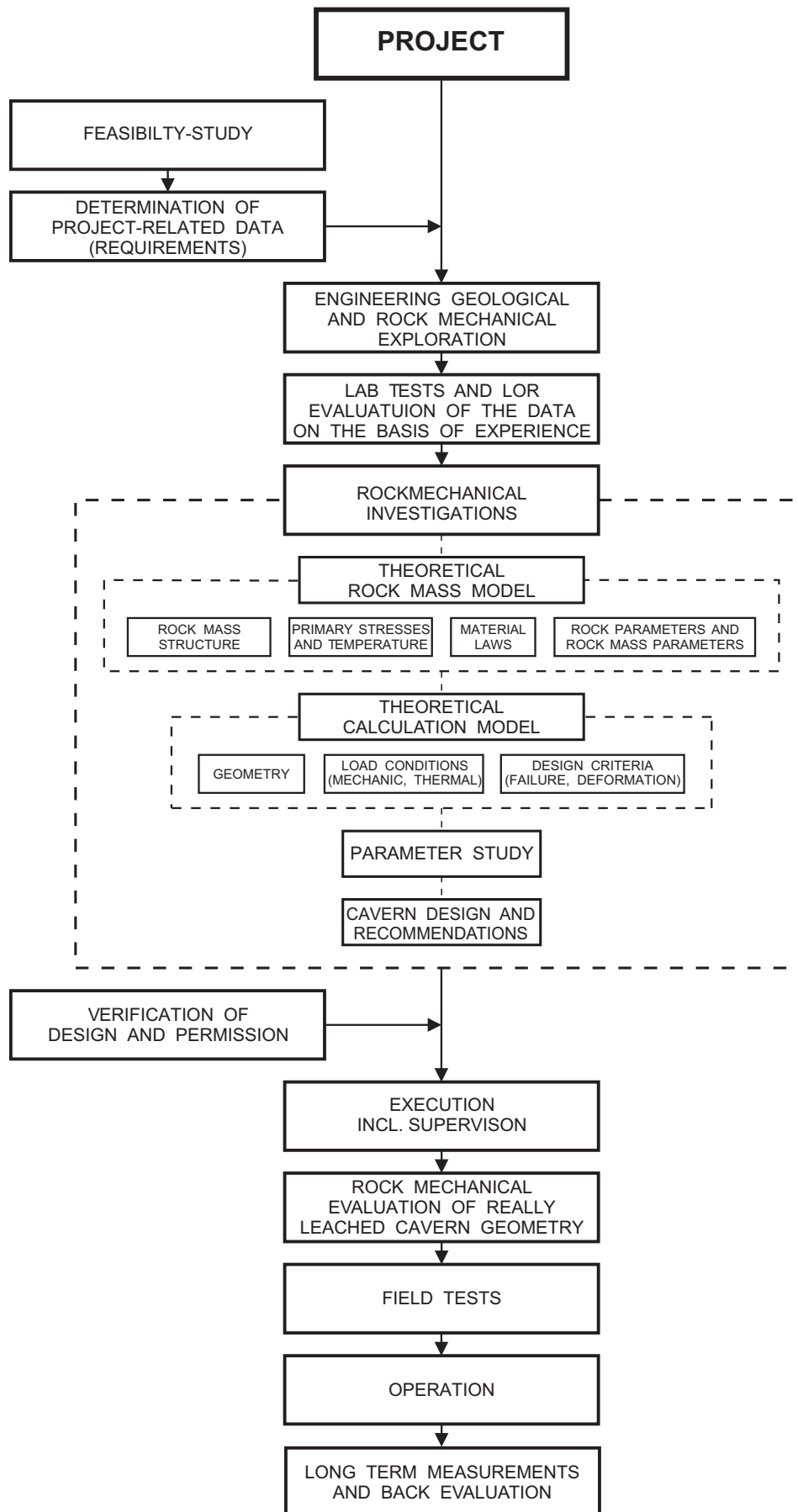
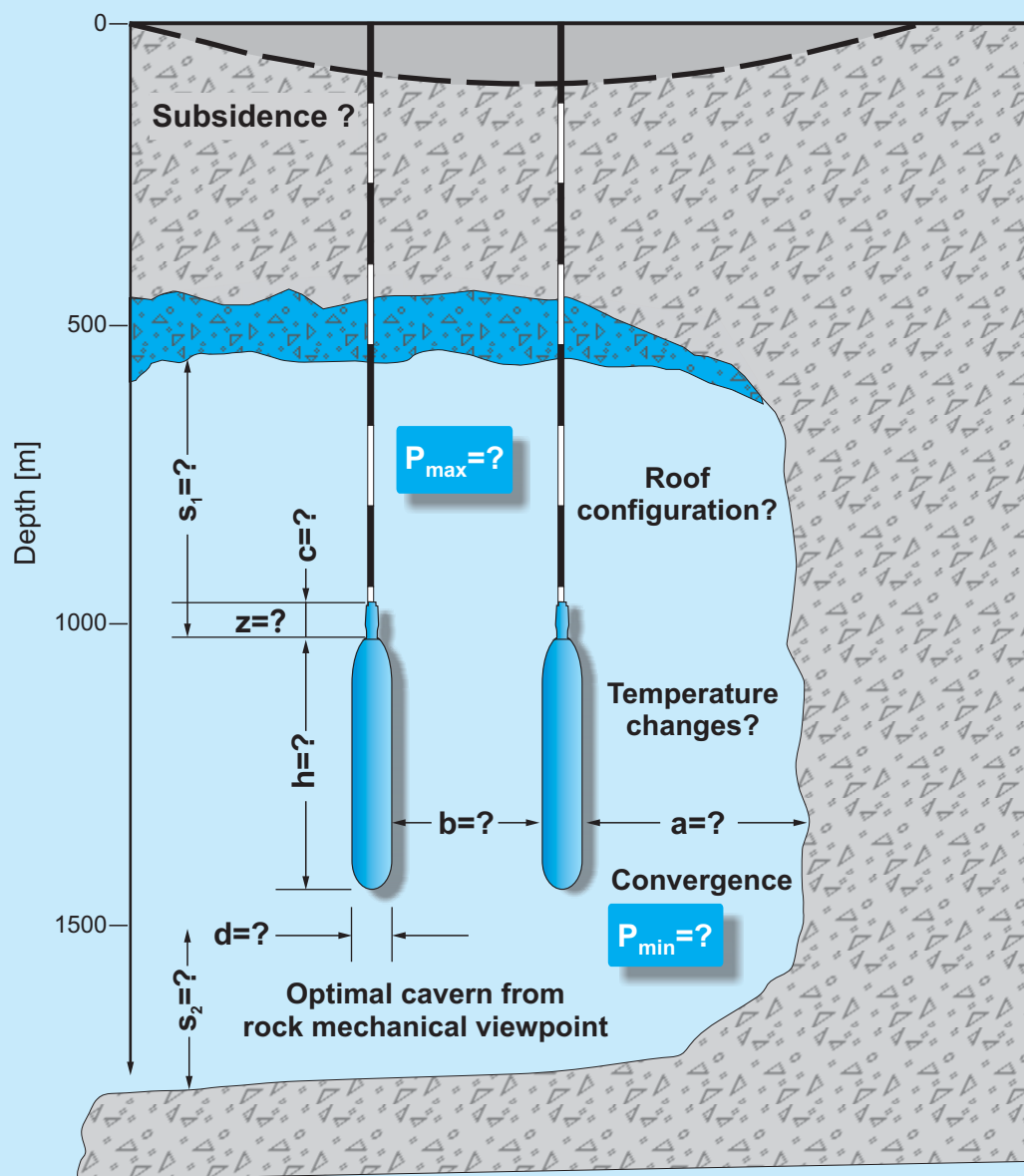


Figure 6
General procedure in cavern design



Geometry parameters

- s_1 = Salt roof thickness
- s_2 = Thickness of salt bottom
- z = Cavern roof depth
- c = Distance casing shoe / cavern roof
- h = Cavern height
- d = Cavern diameter
- b = Pillar width
- a = Distance to the edge of salt structure

Operating parameters

- P_{min} = Minimum permissible operating pressure
- P_{max} = Maximum permissible operating pressure

Figure 7
Rock mechanical questions in design of caverns

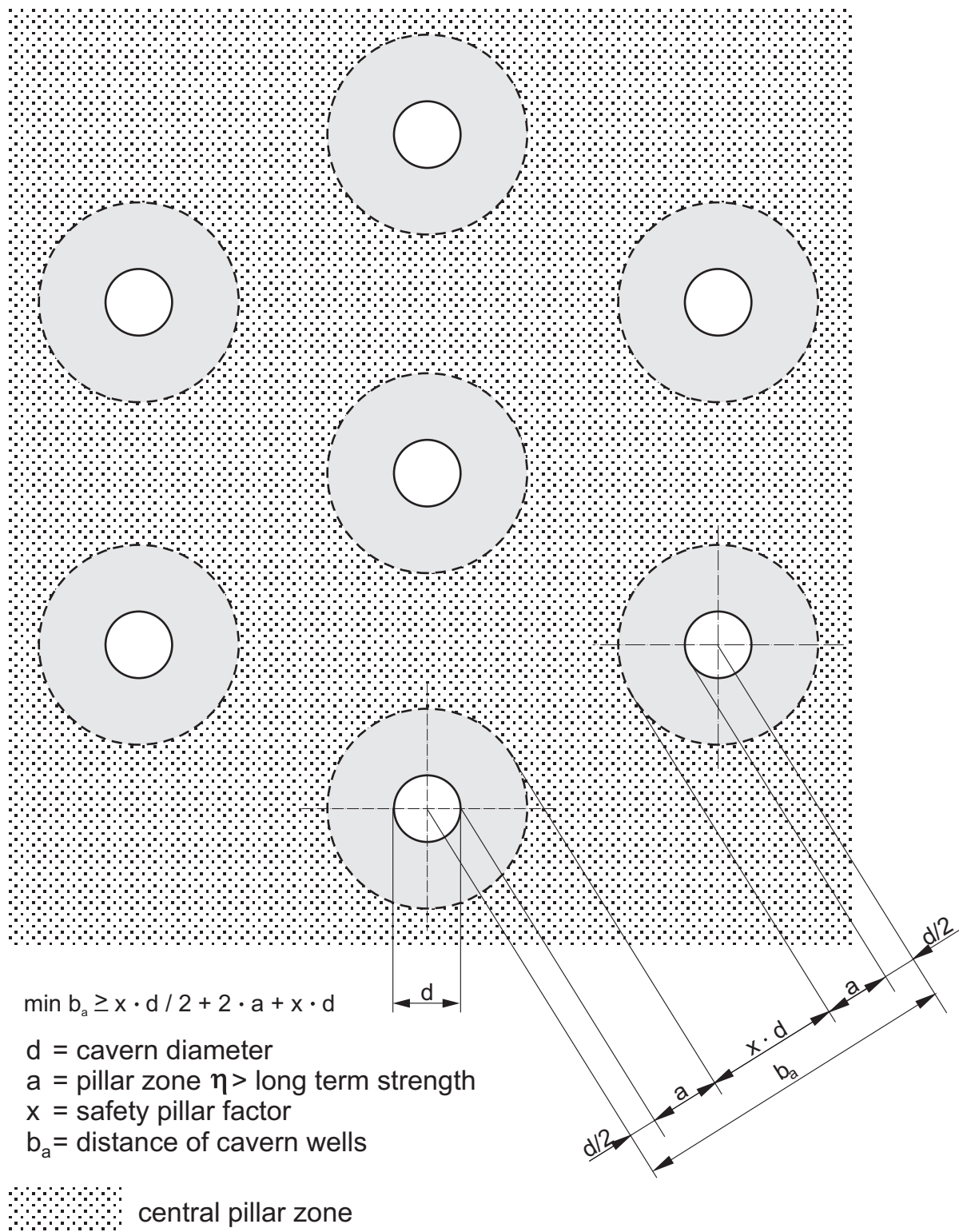


Figure 8
Definition of central pillar zone

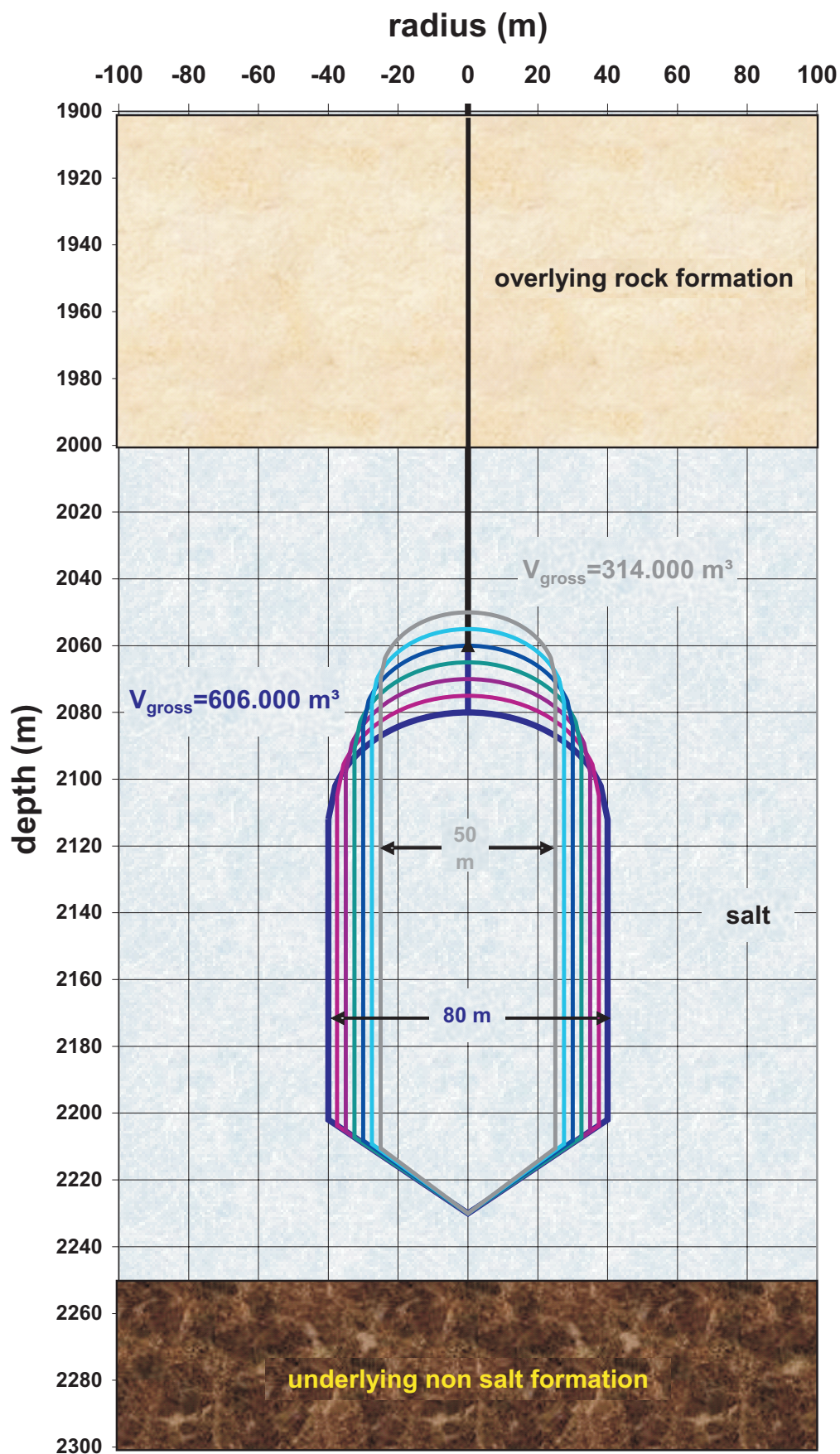


Figure 9
Preliminary cavern design Adavale Basin

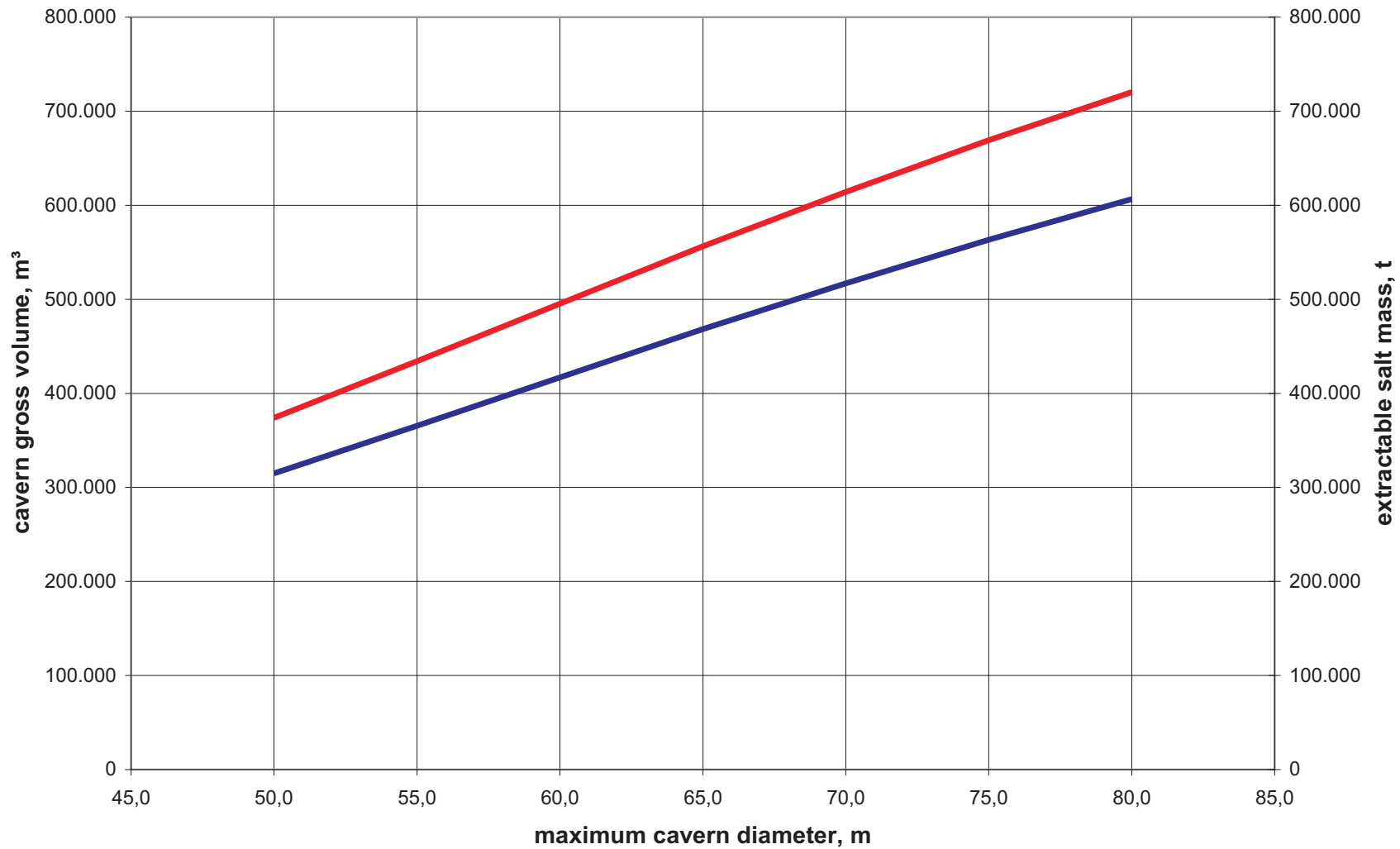


Figure 10
Gross volume vs. maximum cavern diameter.

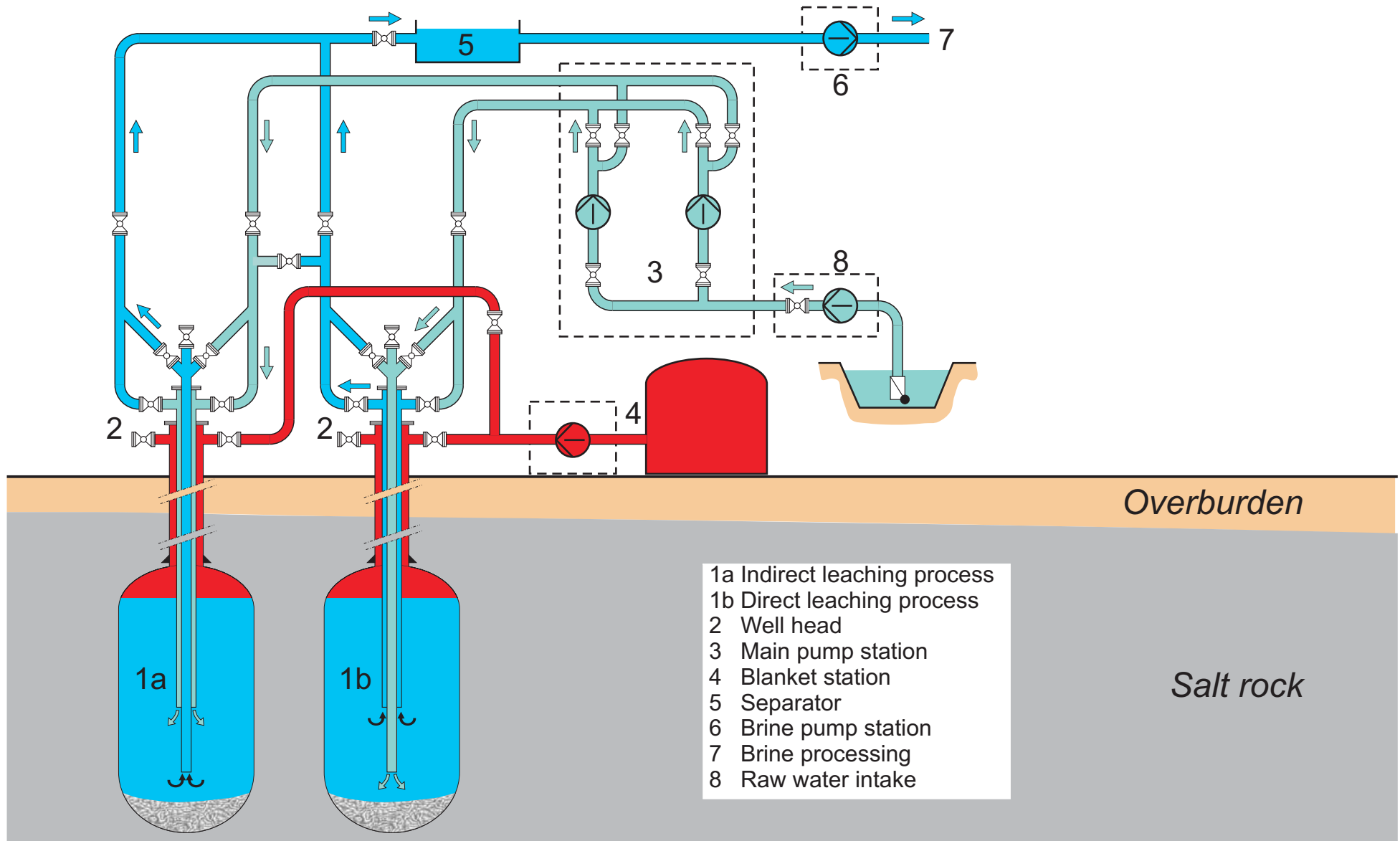


Figure 11
Main components of a leaching plant

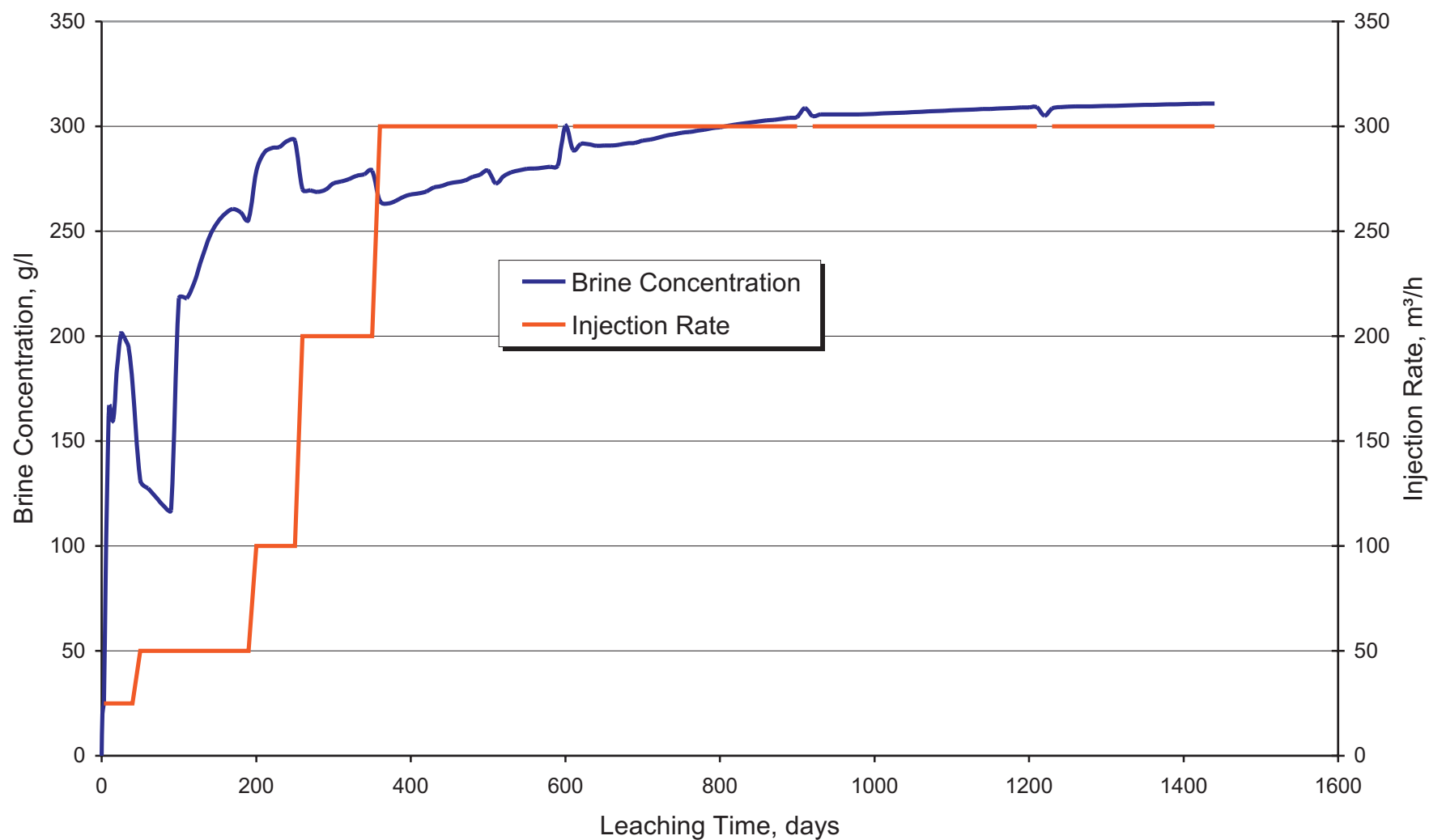


Figure 12

Basic Cavern Simulation - Development of Brine Concentration and Flow Rate

0329\080627 Development Brine Concentration.cdr

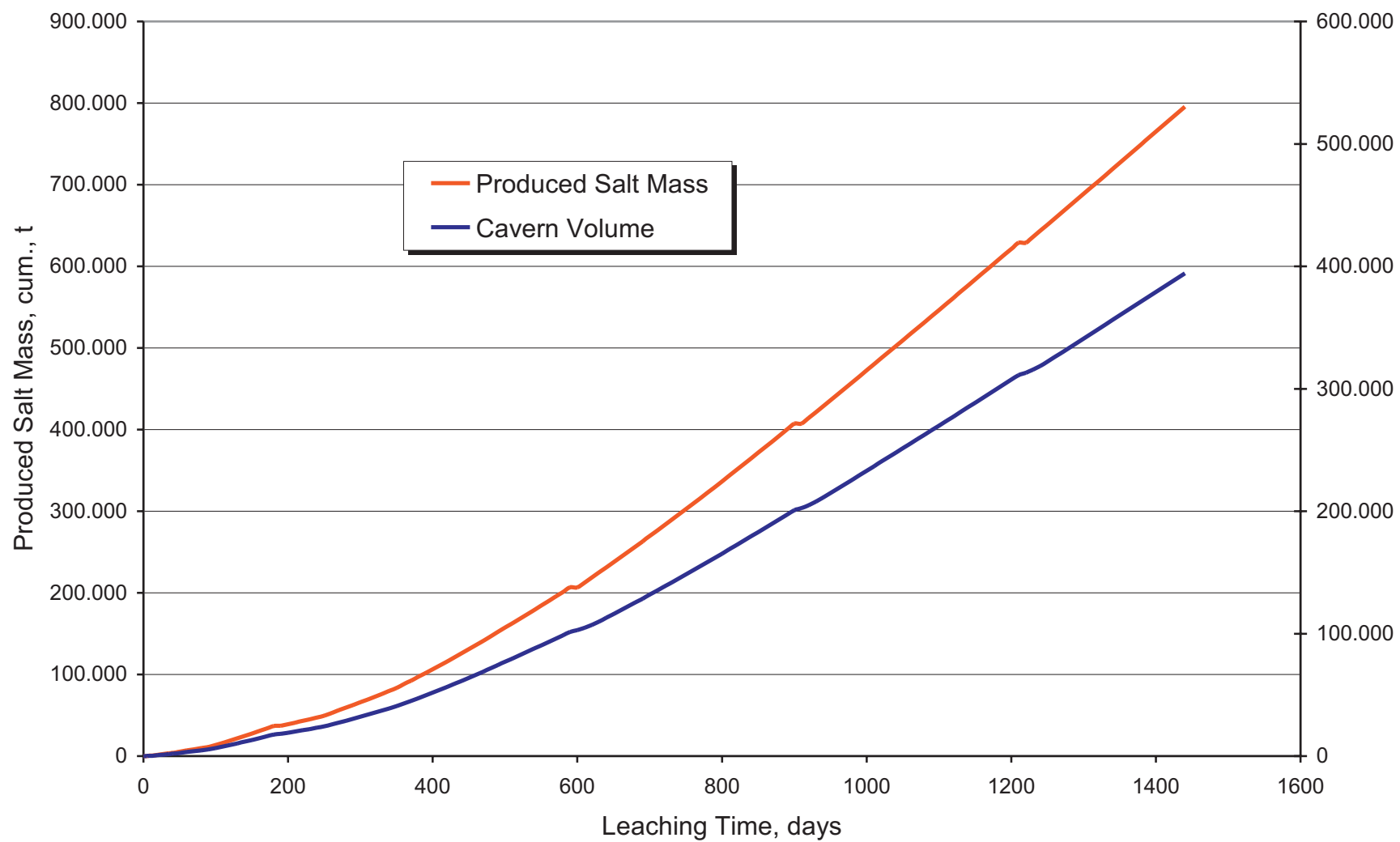


Figure 13

Basic Cavern Simulation - Development of Cavern Volume and Salt Production

0329\080627 Development Cavern Volume and Salt Production.cdr



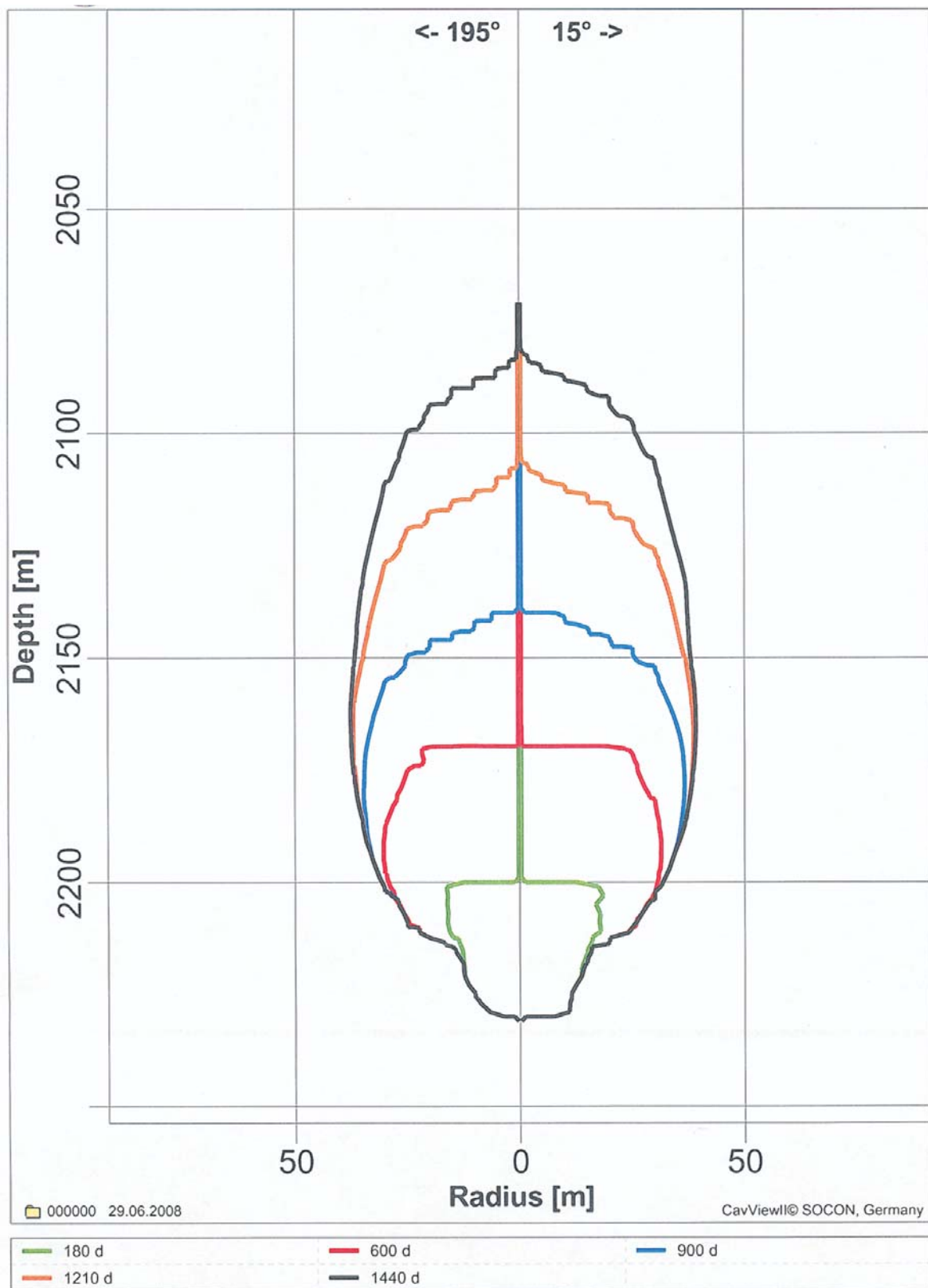


Figure 14
Basic Cavern Simulation

0329\080627 Daten Basic Simulation.cdr

BT Metals Cost Estimation: Subsurface Equipment and Leaching Operation - PART I

Pos.	Activity	Unit	Costs per Unit €/unit	No. of Units	Total Costs €
1.	Preparation before Start Leaching Operation				
1.1	Drilling of Water Well, each 25 m ³ /h (incl. Pump ect.)	pcs	50.000	2	100.000
1.2	Preparation of Cavern Pads, Foundations, Roads etc.	pcs	250.000	2	500.000
1.3	Drilling of Cavern Wells Depth 2,050 m x 1,400 €/m	pcs	2.870.000	1	2.870.000
1.4	Leaching Well Head, API 3,000	pcs	120.000	1	120.000
1.5	Leaching Strings				
1.5.1	10 3/4" Outer String (incl. spare)	m	200	2.100	420.000
1.5.2	6 5/8" Inner String (incl. spare)	m	100	2.500	250.000
1.6	Rock Mechanical Expertise incl. Core Tests	lump sum	100.000	1	100.000
1.7	Leaching Programme incl. Core Tests	lump sum	25.000	1	25.000
1.8	Miscellaneous, Unforeseen, 10% espec. unexpected incidents during drilling	lump sum			438.000
				Total Pos. 1	4.823.000

Enclosure 1
Cost estimate subsurface equipment

BT Metals Cost Estimation: Subsurface Equipment and Leaching Operation - PART II

2.	Leaching Operation 1 cavern in operation	Unit	Costs per Unit €/unit	No. of Units per Life Time (1 Cavern)	Total Costs €
2.1	Workover	Job	100.000	5	500.000
2.2	Sonar Survey	Job	30.000	5	150.000
2.3	Blanket measurements	Job	5.000	50	250.000
2.4	Rental of Nitrogen Blanket Plant	month	5.000	50	250.000
2.5	Nitrogen Blanket Consumption	m ³ (Vst)	0,25	200.000	50.000
2.5	Energy for Pumps				
2.5.1	1 Leaching pump 1,000 kW	kWh	0,060	30.660.000	1.839.600
2.5.2	2 Brine Pipeline Pumps, each 120 kW	kWh	0,060	2.102.404	126.144
2.5.3	2 Water well pumps each 10 kW	kWh	0,060	700.800	42.048
2.6	Supervision on site (stuff) total 2 persons, 7 days per week	monthly rate	20.000	50	1.000.000
2.7	Back up KBB-UT,no travelling	monthly rate	3.000	50	150.000
2.8	Laboratory	included at the electrolysis plant			0
2.9	Replacement for wear and tear Repair, spare parts etc.	monthly rate	20.000	50	1.000.000
Total Pos. 2					5.358.000
Total Pos. 1+2					10.181.000

Enclosure 1
Cost estimate subsurface equipment

BT Metals Cost Estimation: Surface Equipment - PART I



Position	Equipment / Activity	Techn. Data	Quantity	Unit	Factor	Unit price EUR	Subtotal per Pos. EUR	Total EUR
1	Engineering							422.750
1.1	Projektmanagement KBB UT-Anteil	project duration 24 months, * 0,25	1.000	h	1,00	95,00	95.000	
1.2	Basic and Detail design well completion, leaching equipment, process description		1.000	h	1,00	95,00	95.000	
1.3	Specs equipment and services		250	h	1,00	95,00	23.750	
1.4	Permit procedure		100	h	1,00	95,00	9.500	
1.5	HAZOP partizipation	3 Meetings 2 people, preparing and evaluation	100	h	1,00	95,00	9.500	
1.6	Site supervision	1,5 people 6 months, 10h/d	1.800	Mh	1,00	95,00	171.000	
1.7	Reporting and meetings	10 Meetings 2 people	200	h	1,00	95,00	19.000	
2	Procurement							
2.1	Water wells							300.000
	Drilling and completion	DN 50/DN 100	2	pieces	1,00	150.000,00	300.000	
2.2	Small leaching pumps							200.000
2.2.1	Centrifugal pump with motor	50 m3/h, 50 bar, 100 kW	2	pieces	1,00	100.000,00	200.000	
2.3	Leaching pumps							1.300.000
2.3.1	Pump	300 m3/h, 90 bar, 1000 kW	2	pieces	1,00	250.000,00	500.000	
2.3.1	Motor, FC, special transformer	690V, 1000 kW	2	pieces	1,00	400.000,00	800.000	
2.4	Well heads (one well, excl. Drilling and completion)							320.000
2.4.1	Well head, excl. valves, API 3000		1	pieces	1,00	220.000,00	220.000	
2.4.2	Valves API 3000		4	pieces	1,00	15.000,00	60.000	
2.4.3	SAVs		2	pieces	1,00	15.000,00	30.000	
2.4.4	Other valves, piping		1	set	1,00	10.000,00	10.000	

Enclosure 2
Cost estimate surface equipment

BT Metals Cost Estimation: Surface Equipment - PART II



2.5	Blanket system nitrogen							300.000
2.5.1	LN2	1 x 10 t	1	pieces	1,00	300.000,00	300.000	
2.6	Brine tank							120.000
	Steel tank	100 m3	1	pieces	1,00	120.000,00	120.000	
2.7	Brine pumps to factory							200.000
2.7.1	Pumps, motors and FC	300 m3/h, 10 bar, 120 kW	2	pieces	1,00	100.000,00	200.000	
2.8	Weak brine pumps from factory							200.000
2.8.1	Pumps, motors and FC	300 m3/h, 10 bar, 120 kW	2	pieces	1,00	100.000,00	200.000	
2.9	Solar pond	100*100 m * 2m						601.000
2.9.1	Earth works		1.000	m3	1,00	16,00	16.000	
2.9.2	Concrete		500	m3	1,00	600,00	300.000	
2.9.3	Plastic foil		10.000	m2	1,00	3,50	35.000	
2.9.4	Rails, transport equipment, belt conveyer		1	set	1,00	250.000,00	250.000	
2.10	Pumps							50.000
2.10.1	Small pumps for brine handling		10	pieces	1,00	5.000,00	50.000	
2.11	Washing							200.000
2.11.1	Tanks, pipes, pumps		1	set	1,00	200.000,00	200.000	
2.12	Piping material							877.000
2.12.1	DN 300 x 25 PN 12 HDPE	25 kg/m	10.000	m	1,00	85,00	850.000	
2.12.2	DN 80 PN 12 HDPE		200	m	1,00	40,00	8.000	
2.12.3	DN 250 PN 200 steel		100	m	1,00	150,00	15.000	
2.12.4	DN 50 PN 200 steel		100	m	1,00	40,00	4.000	
2.13	Valves							770.000
2.13.1	DN 300 PN 12		20	pieces	1,00	10.000,00	200.000	
2.13.2	DN 80 PN 12		50	pieces	1,00	2.500,00	125.000	
2.13.3	DN 200 PN 200		16	pieces	1,00	20.000,00	320.000	
2.13.4	DN 50 PN 200		25	pieces	1,00	5.000,00	125.000	

Enclosure 2
Cost estimate surface equipment

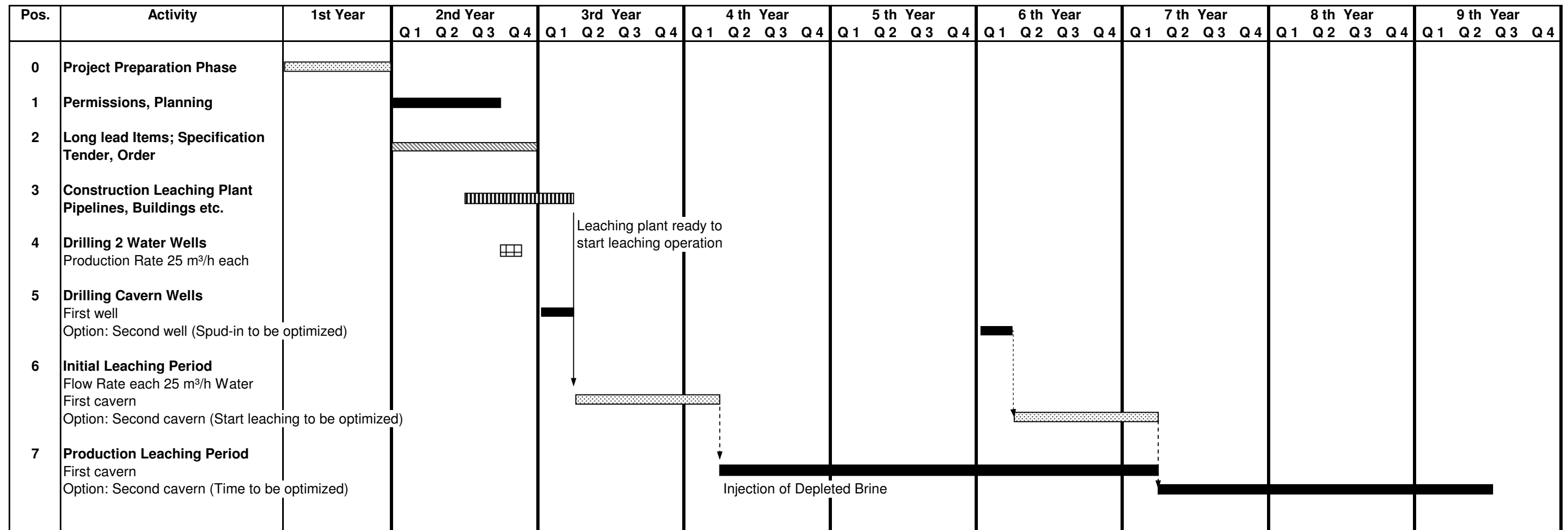
BT Metals Cost Estimation: Surface Equipment - PART III



2.14	Civil (in Pos. 3)							
2.15	Power supply and distribution							250.000
2.15.1	Transformers, switchboards, cables	1	pieces	1,00	250.000,00	250.000		
2.16	Process control system and instrumentation							225.000
2.16.1	Process control system incl. Software	1	pieces	1,00	100.000,00	100.000		
2.16.2	Instruments	50	pieces	1,00	2.500,00	125.000		
2.17	Expediting and QA, suppliers inspections							5.000
2.17.1	Travel	5	travels	1,00	1.000,00	5.000		
3	Construction							
3.1	Civil, foundations, buildings							305.000
3.1.1	Surface preparation, roads and places, foundations, fences	5.000	m2	1,00	40,00	200.000		
3.1.2	Buildings	320	m3	1,00	250,00	80.000		
3.1.3	Infrastructure	1	set	1,00	25.000,00	25.000		
3.2	Mech, pumps, motors, piping							60.000
3.2.1	Installation of all mech. Equipment	1.000	Mh	1,00	60,00	60.000		
3.3	El. and instrum.							36.000
3.3.1	HV and LV supply	200	Mh	1,00	60,00	12.000		
3.3.2	Instrumentation and control system	200	Mh	1,00	60,00	12.000		
3.3.3	Programming	200	Mh	1,00	60,00	12.000		
4	Commissioning							18.000
4.1	Pressure test piping	100	Mh	1,00	60,00	6.000		
4.2	Cold test equipment and el.	100	Mh	1,00	60,00	6.000		
4.3	Hot tests and test runs of all equipment	100	Mh	1,00	60,00	6.000		
Total EUR						6.759.750	6.759.750	

Enclosure 2
Cost estimate surface equipment

Circle Resources Holdings Ltd - Basic Time Schedule of Leaching Operation



APPENDIX 4

***ANNUAL REPORT FOR EPM 17503 Adavale
12 Months ending 03rd November, 2009
For QUEENSLAND POTASH PTY LTD.***

***Report on groundwater supply options stages 3+4
solution mining venture, Blackall Queensland: Report by
Rockwater Pty. Ltd.***



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PROPRIETARY LIMITED

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**REPORT ON
GROUNDWATER SUPPLY OPTIONS STAGES 3+4
SOLUTION MINING VENTURE, BLACKALL QLD**

FOR CIRCLE RESOURCES PTY LTD

SEPTEMBER 2008

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6.0	BORES IN THE PROJECT AREA	6
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REFERENCES

APPENDIX

Tables

Table 1: Aquifer units of the Barcaldine South, Warrego West and Warrego East GAB Management Areas

Table 2: Artesian bores in the vicinity of the project area

Table 3: Groundwater allocations in the Barcaldine South, Warrego West and Warrego East GAB Management Areas

Figures

Figure 1: Location Map

Figure 2: Bores in vicinity of project area

Figure 3: Geological cross section

Figure 4: Extract of Groundwater Resources of Queensland Map

1.0 INTRODUCTION

Circle Resources Pty Ltd commissioned Rockwater Pty Ltd to conduct a desktop assessment of groundwater supply options for a proposed Salt Solution Mining Project near Blackall, Central Queensland (Figure 1).

The project is located across the junction of three Great Artesian Basin Management (GAB) areas; the 'Barcaldine South', 'Warrego West' and 'Warrego East' Management Areas. It is understood that initial water demand for the proposed project will be in the order of 270 ML per year (8.6 L/sec). The only available secure source of water is artesian groundwater.

This report covers Stages 3+4 of the investigation, which assesses the availability of groundwater and construction details of groundwater bores within approximately 15 km to 30 km of the project site (Figure 2). In addition, other bores within the Barcaldine South, Warrego West and Warrego East Management Areas have also been assessed in order to offer alternative groundwater allocations that may be available for transfer.

2.0 OBJECTIVES

The objective of this assessment is to investigate bores within the broader project area that could be utilised, or from which existing groundwater allocations could be transferred. In detail this assessment aimed to:

- Identify all existing bores in the project area (Figure 2);
- Review bore details with regards to depth, water temperature, salinity and possible groundwater flow;
- Investigate any groundwater allocations associated with the bores in the project area that could be utilised; and
- Identify alternative groundwater allocations in the Barcaldine South, Warrego West and Warrego East Management Areas that could potentially be transferred to the project area.

3.0 SCOPE OF WORK

The scope of work comprised:

1. A review of current Department of Natural Resources and Water (DNRW) bore data for the wider project area (Figure 2).
2. The identification of potentially transferable groundwater allocations in the Barcaldine South, Warrego West and Warrego East Management Areas; and
3. The compilation of the relevant information.

4.0 METHODOLOGY

The investigation aimed to identify possible bores that could supply the initial 270 ML per year (8.6 l/sec) needed for the project. Once the bores were identified, information on allocations for these bores was requested from the DNRW. As an alternative, where bores near the project site did not have a groundwater allocation, the potential for transferring allocations from within the individual GAB Management Areas was investigated. The Information sources used for this report consisted of:

- Bore data from the DNRW groundwater database; and
- Additional information gained from staff at the DNRW offices at Longreach, Rockhampton and Brisbane.

5.0 LOCATION

The proposed project area is situated approximately 50 km south of Blackall, Queensland, at the junction of three GAB Management Areas; the Barcaldine South, Warrego West and Warrego East areas. (Figure 2). All three management areas consist of a number of different management units, which in turn represent a number of separate aquifer units (Table 1).

As can be seen from Table 1, the Management Units are based on aquifer units within Management Areas rather than geographical location. Given the large areal extent of these aquifer units, transferring groundwater allocations over hundreds of kilometres within the same Management Area and Unit could be a realistic option. Of particular interest could be allocations for bores in the Wallumbilla Formation, Cadna-owie Formation, Hooray Sandstone, Adori Sandstone and Hutton Sandstone.

Table 1: Aquifer units of the Barcaldine South, Warrego West and Warrego East GAB Management Areas

Management Unit	Aquifer Units
Barcaldine South 1	Toolebuc Formation, Wallumbilla Formation
Barcaldine South 2	Cadna-owie Formation, Wyandra Sandstone Member, Hooray Sandstone
Barcaldine South 3	Westbourne Formation, Adori Sandstone, Birkhead Formation, Injune Creek Group
Barcaldine South 4	Hutton Sandstone, Evergreen Formation, Boxvale Sandstone Member
Barcaldine South 5	Precipice Sandstone
Barcaldine South 6	Moolayember Formation, Clematis Sandstone
Warrego West 1	Toolebuc Formation, Ranmoor Member, Jones Valley Member, Coreena Member, Doncaster Member, Wallumbilla Formation
Warrego West 2	Cadna-owie Formation, Wyandra Sandstone Member
Warrego West 3	Hooray Sandstone, Murta Formation, McKinlay Member, Namur Sandstone
Warrego West 4	Westbourne Formation, Adori Sandstone, Birkhead Formation
Warrego West 5	Hutton Sandstone, Evergreen Formation
Warrego West 6	Poolowanna Formation
Warrego West 7	Moolayember Formation, Warang Sandstone, Clematis Sandstone, Rewan Formation
Warrego East 1	Toolebuc Formation, Ranmoor Member, Jones Valley Member, Coreena Member, Doncaster Member, Wallumbilla Formation
Warrego East 2	Cadna-owie Formation, Wyandra Sandstone Member
Warrego East 3	Hooray Sandstone, Murta Formation, McKinlay Member, Namur Sandstone
Warrego East 4	Westbourne Formation, Adori Sandstone, Birkhead Formation
Warrego East 5	Hutton Sandstone, Evergreen Formation
Warrego East 6	Precipice Sandstone
Warrego East 7	Moolayember Formation, Warang Sandstone, Clematis Sandstone, Rewan Formation

6.0 BORES IN THE PROJECT AREA

There are 43 DNRW-registered artesian bores within the investigation area. Of these, only eight are likely to have sufficient flows for the project. Generally the bores need to be at least 675 m deep to obtain the required flow. Bores shallower than these show to insufficient groundwater yield potential (Table 2) with respect to the project requirements.

In general, higher groundwater flows in the project area are mainly associated with the Hutton Sandstone, as shown in Table 2. This aquifer has been intersected by six bores, all of which are reported to yield more than 8.6 L/s. Alternatively, there is a possibility of obtaining sufficient flows from the shallower Hooray Sandstone. Table 2 shows five bores (RN5139, RN15837, RN50952, RN69133 and RN 93902 which have been drilled to the approximate depth of this formation. All five are east of the project area: the geological cross-section (Figure 3) shows that the Hooray Sandstone is deeper to the west, and so higher yields would probably be available in and west of the project area.

Bores near the project area (Table 2) only have domestic or stock water entitlements; and so their allocations could not be transferred to the project. However, the information gathered does provide valuable information on the depths and yield of aquifers in the area.

Table 2. Artesian bores in the vicinity of the project area

Bore ID	Yield	Total Depth	Formation at total depth
120	?	1162m	Hutton Sandstone
1544	?	192m	Mackunda Formation
3392	0.4 L/sec	158m	Mackunda Formation
3393	?	346m	Mackunda Formation
3402	?	?	?
3794	?	152m	Allura Mudstone
3795	?	152m	Allura Mudstone
3796	0.4	50m	Mackunda Formation
4060	32 L/sec	1077m	Hutton Sandstone
4065	10.5 L/sec	996m	Hutton Sandstone
4489	?	279m	Allura Mudstone
4492	8.26 L/sec	307m	Winton Formation
4494	0.63 L/sec	225m	Mackunda Formation
4496	0.4 L/sec	214m	Winton Formation
4499	?	232m	Mackunda Formation
4500	?	155m	Mackunda Formation
4501	?	368m	Mackunda Formation
4502	6.9 L/sec	163m	Winton Formation
5139	1.6 L/sec	612m	Birkhead Formation
5463	?	126m	Allura Mudstone
5546	1.1 L/sec	149m	Winton Formation
6956	0.63 L/sec	176m	Allura Mudstone
8011	0.6 L/sec	304m	Winton Formation
10550	0.73 L/sec	116m	Winton Formation
11266	0.9 L/sec	129m	Winton Formation
11642	1.13 L/sec	186m	Winton Formation
11965	0.63 L/sec	212m	Winton Formation
13777	1 L/sec	366m	Mackunda Formation
15837	4.55 L/sec	576m	Cadna-owie Formation
17015	1 L/sec	192m	Mackunda Formation
17016	9.5 L/sec	966m/2744m	Birkhead Formation/Burry Limestone (crossing through Hutton Sandstone)
17115	?	2744m	Gumbardo Formation (crossing through Hutton Sandstone)
22786	?	1665m/4627m	Bandanna Formation/Log Creek Formation (crossing through Hutton Sandstone)
26166	?	147m	?
26502	?	218m	Allura Mudstone
50952	5.25 L/sec	602m	?
51407	0.75 L/sec	396m	Mackunda Formation
69133	?	778m	Adori Sandstone
69298	?	?	?
69532	2.8 L/sec	183m	Winton Formation
69557	2.5 L/sec	194m	Mackunda Formation
93902	9 L/sec	675m	?
116101	?	?	?

7.0 ALLOCATIONS IN SURROUNDING GAB MANAGEMENT AREAS

Additional information from the DNRW office in Longreach shows that potentially transferable groundwater allocations have been granted for locations further from the project (Table 3). Additional details are included in Appendix 1.

Table 3: Groundwater allocations in the Barcaldine South, Warrego West and Warrego East GAB Management Areas

Management Unit	Aquifer	Allocation ML	Purpose	Client Name
Barcaldine South 4	Hutton Sandstone	475	Irrigation, Aquaculture (S & D)	W D Krieg and A F Krieg
Warrego East 1	Doncaster	2	Industrial	S K Steinhart and L D Steinhart
Warrego East 1	Doncaster	25	Aquaculture, Stock, Domestic	C S Baker and J R Baker
Warrego East 3	Hooray Sandstone	5	Irrigation, Stock	P D C Clark
Warrego East 3	Hooray Sandstone	24	Aquaculture, Stock, Domestic	M J & S E Lyons
Warrego East 3	Hooray Sandstone	25	Aquaculture, Stock, Domestic	C S Baker and J R Baker
Warrego East 3	Hooray Sandstone	25	Irrigation, Stock, Domestic	A J Banning and S A Banning
Warrego East 3	Hooray Sandstone	30	Irrigation, Stock	N W R Brumpton and R E Brumpton
Warrego East 3	Hooray Sandstone	100	Irrigation, Stock, Domestic	A J O'Sullivan
Warrego East 3	Hooray Sandstone	100	Aquaculture, Stock, Domestic	R W Bignell and K A Bignell
Warrego East 3	Hooray Sandstone	100	Industrial, Stock Intensive	N. Duncan Holdings Pty. Ltd.
Warrego East 3	Hooray Sandstone	240	Irrigation, Stock, Domestic	W G C Dunsdon; I G Dunsdon and D S Dunsdon
Warrego East 3	Hooray Sandstone	300	Irrigation, Stock, Domestic	M D J Kelly and D A Kelly
Warrego East 5	Hutton Sandstone	50	Aquaculture, Stock, Domestic	M J Lyons and L J Lyons
Warrego West 3	Hooray Sandstone	160	Irrigation	A E Lloyd; J D Lloyd and D G Lloyd
Warrego West 3	Hooray Sandstone	60	Industrial, Irrigation, Stock	S J H J Smith

Table 3 shows also that all of the potential transferable allocations with sufficient volume for the proposed project, are for the Hutton Sandstone and Hooray Sandstone aquifer. It indicates that only two of the allocations (Krieg and Kelly) would satisfy the total water requirement of 270 ML/year on their own.

The Water Act allows for allocations to be split or amalgamated for a common use. Therefore a number of options may be available. Obtaining the allocations to satisfy the project water demand may be achieved through:

- the full or partial transfer of one allocation only;
- the transfer of multiple small allocations;
- the partial transfer from multiple large allocations; or
- a combination of the above.

Because a transfer of allocation is tied to a specific management area and unit the groundwater will need to be transferred and extracted from the same management area and management unit. Following this, a transfer of water allocations from multiple different management areas and units will not be desirable as a number of new bores would need to be installed.

For example the transfer of allocations from:

- Smith (full allocation of 60 ML, Warrego West 3, Hooray Sandstone);
- Lyons and Lyons (full allocation of 50 ML, Warrego East 5, Hutton Sandstone); and
- Krieg and Krieg (partial allocation of 160 ML, Barcaldine South 4, Hutton Sandstone)

This scenario will need bores to be drilled in the Warrego West, Warrego East and Barcaldine South Management Areas regardless of two of the bores drawing from the same aquifer unit.

Another example would be the transfer of allocations from:

- Baker and Baker (full allocation of 25 ML, Warrego East 1, Doncaster);
- Kelly and Kelly (partial allocation of 195 ML, Warrego East 3, Hooray Sandstone); and
- Lyons and Lyons (full allocation of 50 ML, Warrego East 5, Hutton Sandstone)

While in the second scenario all bores are located within the Warrego East Management Area, they draw water from different Management Units – therefore again three separate bores are needed.

8.0 SUMMARY AND RECOMMENDATIONS

There are no transferable groundwater allocations within 15 km of the proposed project area. However, transferable allocations are available at greater distances and can be negotiated with

the individuals and organisations listed in Table 3. While the information from DNRW only gives the name of the licence holder, Appendix 1 includes some likely contact details obtained from the Sensis White Pages.

If a transfer can be negotiated, an application needs to be made by the owner or legal occupier of the land on which a new bore is to be constructed to obtain a licence and permit from the Queensland DNRW. The application for a “Transfer of a Water Licence” has to be forwarded to the Chief Executive of the Queensland DNRW who will then issue an “Information Notice” giving conditions under which the relocation of a water licence would be approved. The “Information Notice” is followed by a “Transfer Notice” i.e. a formal notice of intention to proceed with the application to relocate the water licence. Once the transfer of the water licence has been finalised, the drilling of the new bore or bores will require a development application outlining the location and details for the bore(s). The bore would have to be drilled by a licensed Class 3 driller, and would have to be constructed to the minimum construction standards for bores in Australia².

Dated: 25th September 2008

Rockwater Pty Ltd



**Manfred Thienenkamp
Senior Hydrogeologist**



**K L Olzard
Principal Hydrogeologist**

REFERENCES

¹ Groundwater Resources of Queensland 1:2.500.000 Map, Mines Department State Series Map 4. Queensland Department of Mines 1987

²Minimum Construction Requirements for Water Bores in Australia, 2nd Edition, September 2003. Land and Water Biodiversity Committee, 2003.

APPENDIX 1



Management Unit	Formation	Authorisation	Allocation ML	Purpose	Client Name	Contact Details	Expiry
Warrego East 1	4232.DONCA	50748E	2	Industrial	S K STEINOHRT and L D STEINOHRT	LINCOLN & SANDRA STEINOHRT LIVESTOCK & HEAVY HAULAGE Morven (Bulldog Transport) Enquiries 69 Roma St Morven QLD 4468 (07) 4654 8301 Dulcacca Bell St Dulcacca QLD 4425 (07) 4627 6290	29-Mar-10
Warrego East 3	4242.HOORA	06269E	5	Irrigation, Stock	P D C CLARK	?	31-Jan-09
Warrego East 3	4232.HOORA	50638E	24	Aquaculture, Stock, Domestic	M J & S E LYONS	?	31-Jul-20
Warrego East 3	4232.HOORA	02046E	25	Aquaculture, Stock, Domestic	C S BAKER and J R BAKER	?	28-Feb-11
Warrego East 3	4242.HOORA	04885E	25	Irrigation, Stock, Domestic	A J BANNING and S A BANNING	?	31-Oct-09
Warrego East 1	4232.DONCA	50736E	25	Aquaculture, Stock, Domestic	C S BAKER and J R BAKER	Mitchell Hwy Wyandra QLD 4489 (07) 4654 0312	31-Mar-23
Warrego East 3	4232.HOORA	50826E	30	Irrigation, Stock	N W R BRUMPTON and R E BRUMPTON	Baynham Mitchell QLD 4465 (07) 4623 1430 Cottage (07) 4623 6686 Waratah Cunnamulla QLD 4490 (07) 4655 4802 Mobile Service 0427 231 430	31-Jan-13
Warrego East 5	4232.HUTTO	04090E	50	Aquaculture, Stock, Domestic	M J LYONS and L J LYONS	?	31-Jul-10
Warrego East 3	4232.HOORA	04530E	100	Irrigation, Stock, Domestic	A J O'SULLIVAN	"Thurulgoona" Station Cunnamulla QLD 4490 (07) 4655 4950 Mobile Service 0427 027 017	31-Aug-12
Warrego East 3	4232.HOORA	102852	100	Aquaculture, Stock, Domestic	R W BIGNELL and K A BIGNELL	Page St Charleville QLD 4470 (07) 4654 1461	31-Oct-10

Warrego East 3	4225.HOORA	181270	100	Industrial, Stock Intensive	N. DUNCAN HOLDINGS PTY LTD	?	1-Mar-12
Warrego East 3	4232.HOORA	02267E	240	Irrigation, Stock, Domestic	W G C DUNSDON; I G DUNSDON and D S DUNSDON	"Nulla" Cunnamulla QLD 4490 (07) 4655 2232 or (07) 4655 2256	31-Mar-11
Warrego East 3	4232.HOORA	04525E	300	Irrigation, Stock, Domestic	M D J KELLY and D A KELLY	Robina Stn Cunnamulla QLD 4490 (07) 4655 4037	31-May-10

Management Unit	Formation	Authorisation	Allocation	Purpose	Client Name	Contact Details	Expiry
Warrego West 3	0033.HOORA	172340	160	Irrigation	A E LLOYD; J D LLOYD and D G LLOYD	Cootabynia Station Blackall QLD 4472 (07) 4657 5981 Fax (07) 4657 5080 116 Thistle St Blackall QLD 4472 (07) 4657 4309 Stratavon Station Blackall QLD 4472 (07) 4657 5953 Jedburgh Yaraka QLD 4702 (07) 4657 5553 Fax (07) 4657 5573	30-Sep-12
Warrego West 3	0112.HOORA	01263E	60	Industrial, Irrigation, Stock	S J H J SMITH	?	30-Nov-10

Management Unit	Formation	Authorisation	Allocation	Purpose	Client Name	Contact Details	Expiry
Barcaldine South 4	0033.HUTTO	179462 File reference LON/515/006(154)	475	Irrigation, Aquaculture (S & D)	W D KRIEG and A F KRIEG	(07) 4657 5069, Blackall QLD4472	31-Aug-11

FIGURES

Figure 1

LEGEND

 Great Artesian Basin
 Water Resource Plan Area

 Management Area

 Project Area

0km 250km 500km

Scale 1 : 7 500 000

Management Areas

Area No.	Area Name	Plan No.
1	Cape	AP12084
2	Laura	AP12085
3	Gulf	AP12086
4	Gulf East	AP12087
5	Carpentaria	AP12088
6	Carpentaria East	AP12089
7	Flinders	AP12090
8	Flinders East	AP12091
9	Western Carlo	AP12092
10	North West	AP12093
11	Barcaldine West	AP12094
12	Barcaldine North	AP12095
13	Barcaldine East	AP12096
14	Barcaldine South	AP12097
15	Western	AP12098
16	Central	AP12099
17	Warrego West	AP12100
18	Warrego East	AP12101
19	Surat	AP12102
20	Surat North	AP12103
21	Surat East	AP12104
22	Mimosa	AP12105
23	Mulgildie	AP12106
24	Eastern Downs	AP12107
25	Clarence Moreton	AP12108

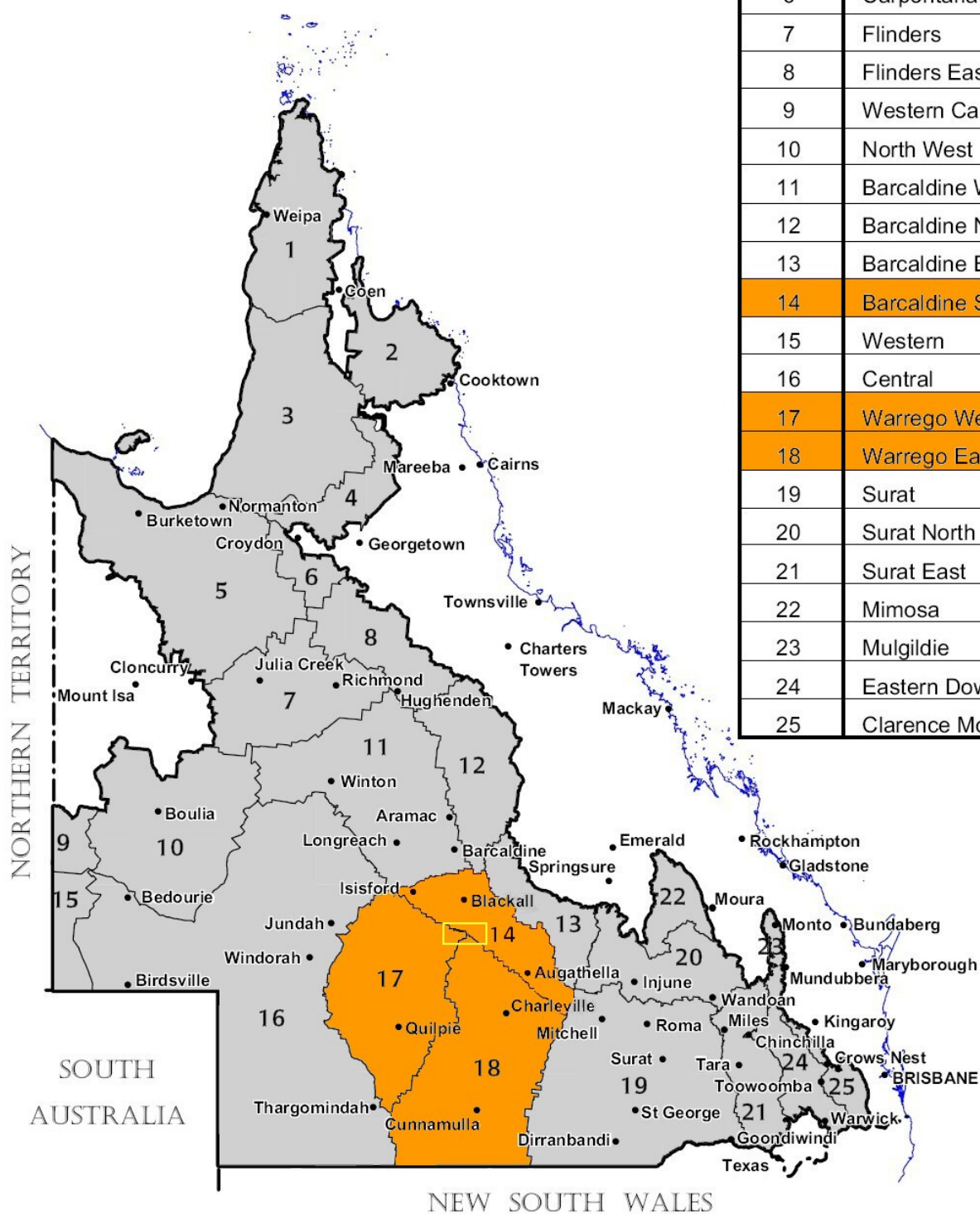
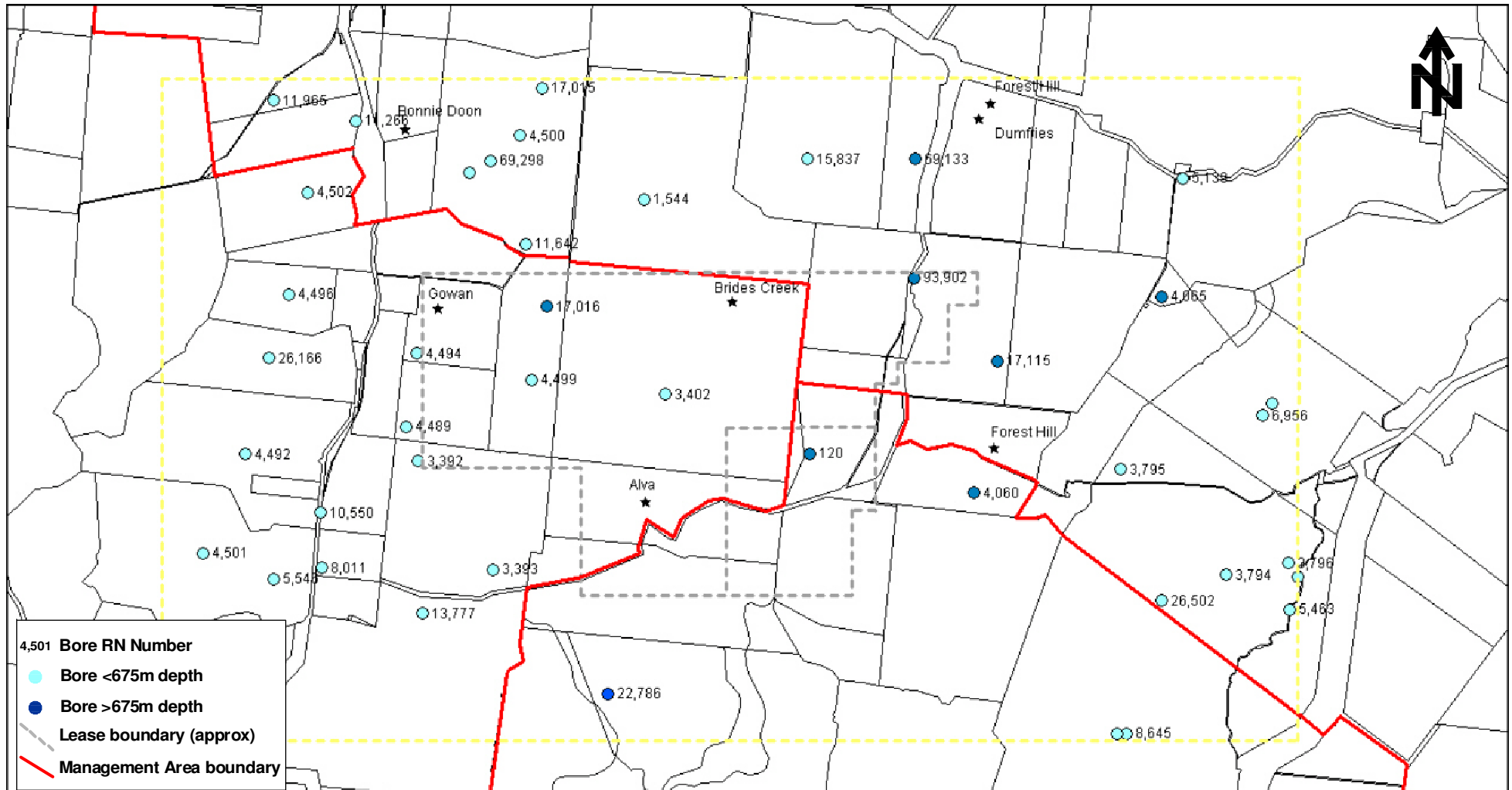


Figure 2



I:/616.0/Report Stage 3+4/Figure 2.srf

CLIENT: Circle Resources

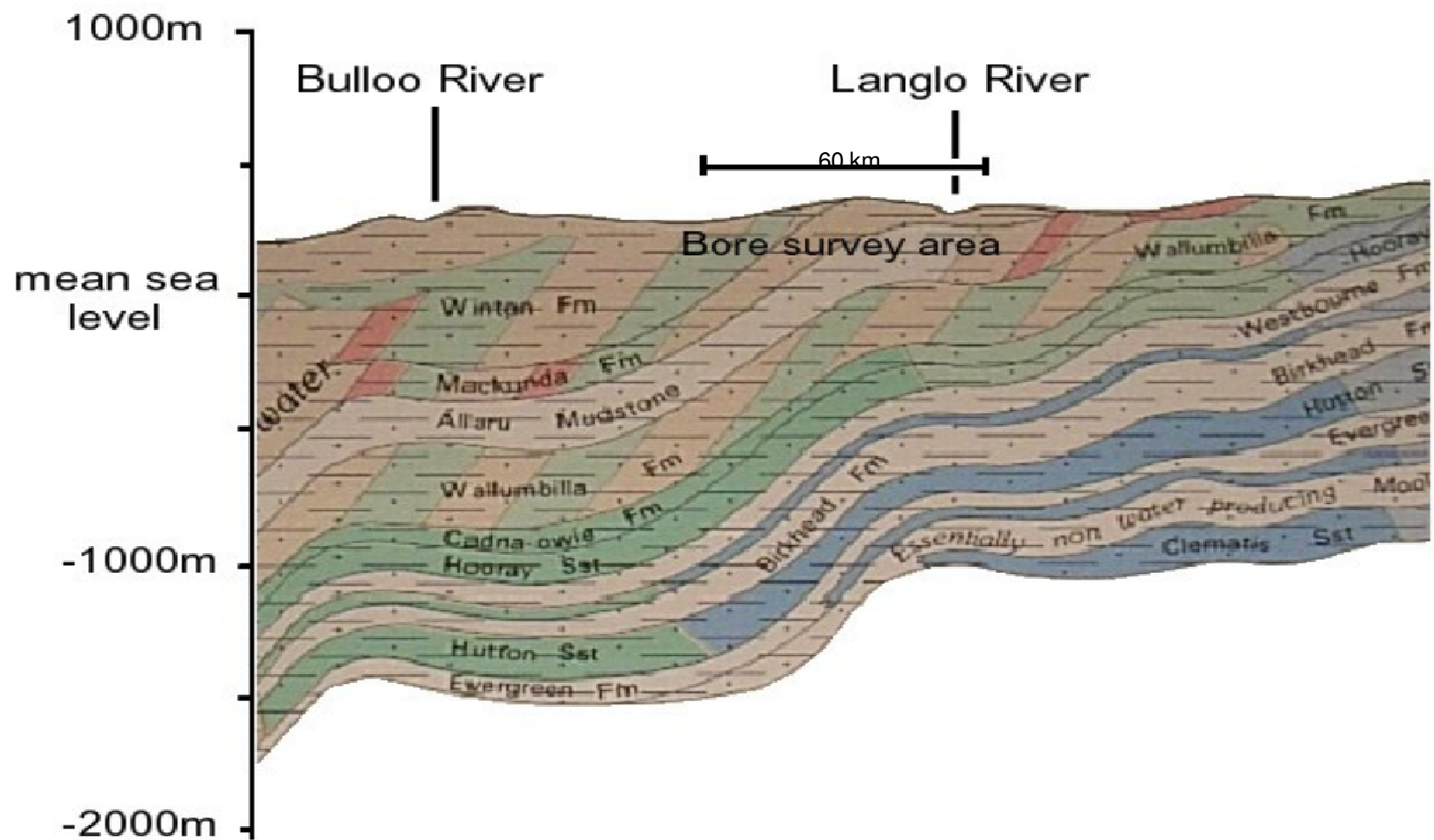
PROJECT: Report on Groundwater supply options Stage 3 + 4

DATE: September 2008

Dwg. No: 616.02

BORES IN VICINITY OF PROJECT AREA

Figure 3



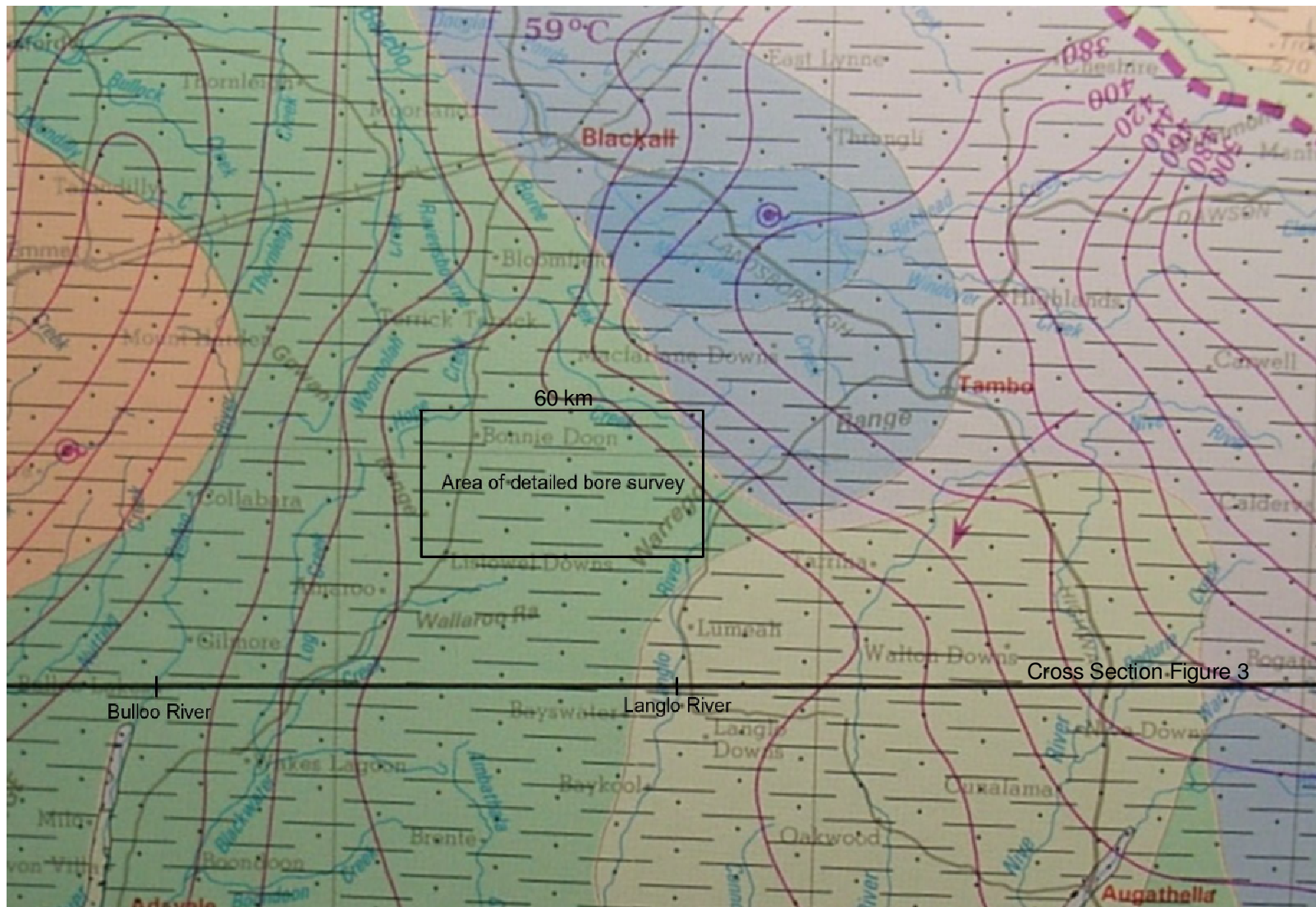
From Groundwater Resources of Queensland 1:1,250,000 Map

I:/616.0/Report Stage 3+4/Figure 3.srf

CLIENT: Circle Resources
 PROJECT: Report on Groundwater supply options Stage 3 + 4
 DATE: September 2008
 Dwg. No: 616.03

GEOLOGICAL CROSS SECTION

Figure 4



From Groundwater Resources of Queensland 1:1.250.000 Map

I:/616.0/Report Stage 3+4/Figure 2.srf

CLIENT: Circle Resources

PROJECT: Report on Groundwater supply options Stage 3 + 4

DATE: September 2008

Dwg. No: 616.04

EXTRACT OF GROUNDWATER RESOURCES OF QUEENSLAND MAP

APPENDIX 5

***ANNUAL REPORT FOR EPM 17503 Adavale
12 Months ending 03rd November, 2009
For QUEENSLAND POTASH PTY LTD.***

***SGS final report assay report on samples taken from
drill core.***

**SGS Townsville Minerals**

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Email: au.townsvillelab@sgs.comInternet: www.au.sgs.com**Cash Sale***Lab Ref* TV065564*Client Ref* **67798 - CIRCLE RESOURCES***Project* POTASH 1*Cost Code**Status* Final*Received* 13/05/08*Reported* 23/05/08*Samples* 10*First Sample* 8040801*Last Sample* 8040810*Pages* 4*Copy**Notes*

Authorised by

On behalf of:

Russell Larsen

Laboratory Manager

The results in this analytical report pertain to the samples provided to this laboratory for preparation and/or analysis as requested by the client. This document is issued by the company subject to its General Conditions of Services (www.sgs.com/generalconditions).

Attention is drawn to the limitations of liability, indemnification and justifications issues established therein.



Lab Ref TV065564
Client Ref **67798 - CIRCLE RESOURCES**
Project POTASH 1
Reported 23/05/08
Status Final
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ANALYTICAL REPORT

Scheme	ICP40Q	ICP40Q	ICP40Q	ICP40Q	ICP40Q	ICP40Q
Units	ppm	ppm	ppm	ppm	ppm	ppm
Detection Limit	5	50	5	100	100	20
Upper Limit	10000	400000	10000	400000	200000	400000
	As	Ca	Cu	Fe	K	Mg
8040801	<5	3190	14	3500	800	270
8040802	<5	660	12	1100	3700	480
8040803	<5	1380	7	1200	3600	710
8040804	<5	3640	7	900	600	920
8040805	<5	3330	5	600	1000	980
8040806	<5	3100	38	8300	3000	1960
8040807	<5	1460	<5	900	2000	980
8040808	<5	3740	<5	400	800	860
8040809	<5	5580	<5	500	400	260
8040810	<5	2350	<5	7600	2600	660

- not analysed / -- element not determined / I.S. insufficient sample / L.N.R. listed not received

Results are not intended for commercial settlement purposes.

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Project POTASH 1
Reported 23/05/08
Status Final
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ANALYTICAL REPORT

Scheme	ICP40Q	ICP40Q	CLA04E	ICP43B
Units	ppm	ppm	%	ppm
Detection Limit	50	50	0.005	400
Upper Limit	200000	50000	2	500000
	Na	S	Cl	Na
8040801	>200000	2590	58.4	25.7%
8040802	>200000	290	58.9	26.9%
8040803	>200000	1140	58.5	23.8%
8040804	>200000	2310	58.8	28.3%
8040805	>200000	2090	58.5	26.6%
8040806	>200000	710	55.4	23.0%
8040807	>200000	960	59.2	24.9%
8040808	>200000	2600	58.5	27.0%
8040809	>200000	4830	58.3	27.7%
8040810	>200000	1930	58.7	26.7%

- not analysed / -- element not determined / I.S. insufficient sample / L.N.R. listed not received

Results are not intended for commercial settlement purposes.



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Description

CLA04E : Hot Water Soluble Cl, Mod Volhard Titn
DIG40Q : 4 Acid Digest 0.2g-20ml
DIG43B : 4 Acid Digest 0.25g-500ml
ICP40Q : ICP-OES after DIG40Q
ICP43B : Oregrade ICPOES 'TOTAL' determination
MSC80 : Miscellaneous preparation charge, per hr
PRP88 : Dry, Crush , Pulv 75µm, <3.5kg