Cameco

Development of Tailings and Mine Waste Source Terms for the Proposed Yeelirrie Mine

Yeelirrie

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Geo-environmental Engineering, SHEQ,
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EXECUTIVE SUMMARY

Cameco Corporation is planning to construct a uranium mine/mill operation at the Yeelirrie site in Western Australia. Construction of the facility will result in the production of overburden and waste rock that will be stored in temporary stockpiles and tailings that will be permanently placed in a tailings storage facility (TSF) within the excavated pit (from mining operations).

An alkali leach process will be used to recover uranium from a shallow carnotite deposit. The tailings from this process will be deposited in multiple thin layers in several tailings cells which will be capped and covered at the end of their use. The temporary stockpiles for various grades of ore will be processed by the end of operations, and the mine waste and overburden stockpiles will be placed over the tailings at mine closure.

This document describes the plan for storage and disposal of waste materials and the geochemical characteristics of these materials. Water quality estimates or “source terms” for constituents of concern (COC) for each of these waste materials are given. Source terms were determined using an ensemble based strategy that is fully described in the text..

The source terms developed herein for the TSF considered the post closure conditions that are likely to develop in the tailings. Aged tailings tests in conjunction with thermodynamic geochemical speciation modelling were used to develop conservative source terms that would describe conditions in the TSF in the long term. Sorption controls were not considered in the development of tailings source terms as a further conservative measure despite the presence of significant ferruginous soils available as a sorbent for tailings COCs.

Evaporation of the tailings porewaters are expected to form evaporites in the vadose zone of the pit and to accumulate salts over time. Shortly after closure, groundwater levels will begin to recover and it is projected that the mixing of groundwater with tailings porewater will further drive the precipitation of many of the constituents of concern.

Solute transport modelling will accept the source terms as input and further define the transport of tailings constituents.

Stockpile source terms were assessed for ore and mine waste materials. Stockpile source terms were assessed only during operations as all materials will be either processed or disposed of within the pit at the end of the mine life. The solute release capacity of the stockpile materials is finite; once the solute release has occurred, it is not regenerated. Experimental results indicate that the solute release occurs rapidly so that during a given year all the solutes that can be flushed from surfaces are removed.

Salt loadings of roads and hardstands from dust management during mine operations were also assessed. Solute loadings were estimated based on water application rates and salinity content and are presented as solute loadings per unit surface area.

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1.0 INTRODUCTION

The proposed Yeelirrie development for the recovery of uranium is located approximately 680 km northeast of Perth in Western Australia. Yeelirrie lies in the Murchison Biogeographic region, an area of saltbush scrub and low mulga shrubs on sandy soils derived from weathered granites and greenstone belt rocks of the Yilgarn geological province. The annual rainfall in the region averages about 250 mm while the maximum temperature exceeds 40^{o} C for eight months of the year and temperature minimums can reach -2^{o} C for three months in winter.

The Yeelirrie uranium orebody is approximately 9 km long, up to 1.5 km wide and about 8-10 m thick and lies in a creek line of a broad flat valley which is prone to occasional water flow. Surface and groundwater flow terminate in a salt basin about 30 km downstream to the southeast.

Calcrete, calcium and magnesium carbonate minerals, of varying width, thickness and texture have formed over millions of years in the upper parts of the channel sediments. Below the calcrete is a reddish kaolinitic clay-quartz which overlies deeply weathered granites. Whilst, much of the uranium mineralization is located within the calcrete and lies close to the surface in an ancient drainage channel, the highest grade U mineralization is contained in the clay-quartz and is located just below the water table. Uranium mineralization occurs in the form of carnotite ($K_2(UO_2)_2(VO_4)_2).3H_2O$), a uranium-vanadium mineral phase.

Development of the project will proceed from mine dewatering to mining and then to milling and tailings deposition to closure.

The orebody will be mined through an open pit operation with on-site processing and disposal of tailings in a tailings storage facility (TSF) located within the mined-out pit areas. Tailings from processing of Yeelirrie ore will be deposited back into the mine void below ground level. The Yeelirrie in-pit TSF will cover an area 6.5 km long and 1 km wide and will be approximately 1 km from the mill. In the operational plan the pit is divided into two tailings ponds each consisting of five individual cells of varying sizes ranging from 229,437 m^2 to 358,751 m^2. Tailings Pond 1, comprising five individual tailings cells, will be operated first. Tailings will be deposited sub-aerially in thin layers to maximize evaporation to dewater and consolidate the tailings.

1.1 Background – History

1.1.1 SRK Tailings Investigations

Geochemical assessment for the Yeelirrie project was carried out in 2010 by SRK Consulting. Two documents were produced:

- Proposed Yeelirrie Development: Geochemical Assessment of Tailings and Mine Waste, Issued: 10 March 2011.
  This document is contained in Appendix A.

- Proposed Yeelirrie Development: Assessment of Tailings and Mine Waste Source Terms, Issued: 10 March 2011.
  This document is contained in Appendix B.

The listed objectives of these studies were to:

1. Assess the potential for solute release from tailings in the short and long term;
2. Determine the potential interaction between the solutes and the natural geological materials downstream of the mine facility; and
3. Evaluate the chemical composition of materials (ore, waste, and topsoil) to be stockpiled on site and assess the loadings that may be released from the materials.

The above documents represent a comprehensive analysis of the geochemistry of Yeelirrie tailings, ore stockpiles and waste with the development of constituent source terms. The current study updates the work performed by SRK Consulting using the proposed Cameco processing rate of 2.4 Mtpa (million tonnes of ore per annum).

1.1.2 WMC Studies and Previous Mining Trials at Yeelirrie

WMC Ltd. (Western mining Corporation Ltd.) undertook trial mining of three small pits between 1971 and 1982, with selected ore samples being transported to the Kalgoorlie Research Plant (KRP) for processing trials. The tailings from these trials were deposited in a void excavated at KRP.

Site inspections in 2004 of the ore and overburden stockpiles that were left in place after the cessation of WMC's test mining provided information on:

- the erosion and dispersion of solids from the overburden and ore stockpiles when exposed to normal and extreme meteorological conditions (e.g. cyclone Bobby in 1995)

It is noteworthy that materials mined from Trial Slot 1 were stockpiled for 31 years, yet the tailings solids eroded from the stockpiles remained within tens of meters of the stockpile toe.

- the absence of any detectable effect of the stockpiled material, eroded material or leached metals on nearby vegetation.
  In fact in many instances native vegetation had started to colonise the stockpiles prior to the completion of rehabilitation earthworks in 2004.

Prior to rehabilitation in 2004, samples from pits, stockpiles and undisturbed soils were obtained. Sample pH values ranged from 6.8 to 9.7, with the majority of samples yielding alkaline pH values greater than 8.

1.2 Mine & Milling Plan

A primary driver of the mine plan and schedule is the requirement to deposit the tailings back into the pit (in-pit disposal).

In-pit disposal of tailings requires the preparation of the pit to receive tailings once the mill is brought on-line. During this preparation period, mined material will be stockpiled based on uranium grade and other geo-metallurgical properties.

Stockpile management will be an important activity as ore will be mined in advance of milling to create tailings space. Ore will be characterized into four categories (UHG, VHG, HG and MG) divided into two different smectite grades plus a low grade stockpile for a total of nine ore stockpiles.

The processing plant is designed to treat Yeelirrie ore at a rate of 2.4 Million tonnes per annum (Mtpa) with a uranium feed grade that averages 0.15% U_3O_8. The processing plant will utilize a high temperature alkali leach process followed by direct precipitation to produce uranium oxide concentrate. Uranium processing would require leaching of the ore using sodium bicarbonate/carbonate. This would result in as-discharged tailings with a pH of about 9.5 and a high total alkalinity (>75,000 mg/L $CaCO_3$). The mill discharge slurry is projected to have a solids content of approximately 41%. Other operating parameters of the TSF are provided in Table 1.1.

Table 1.1 TSF Operating parameters

Annual plant feed (million tonnes per year)	2.4
Discharge slurry solids content (nominal %)	41
Tailings discharge	sub-aerial
Temperature of deposited tailings (^oC)	64
Number of Tailings cells (total)	10

Required Tailings cells in use at any given time to meet evaporative requirements	5
Tailings cell lifetime (approximate years)	7
Average size of tailings cells (5) in Pond 1 (m^2)	309,031
Average size of tailings cells (5) in Pond 2 (m^2)	339,436
Deposition time	6 days
Drying time (days)	24

1.3 TSF Operation

Mining would start approximately a year in advance of metallurgical plant operations to provide sufficient area for the construction of the first in-pit tailings storage cells within the open pit. As mining progresses, additional tailings cells would be constructed in the mined-out void. The mine plan ensures that the proposed project would always have sufficient mining void capacity for the construction of new TSF cells well ahead of when they would be required for tailings storage (about three years) and would ensure that a TSF would never be required outside of the pit.

In the initial dewatering phase of the orebody, drainage channels would be established in the pit floor. These may be expanded and left in place for use as underdrains for the first few TSF cells as a contingency measure to aid in the consolidation of the tailings and to measure seepage. If the drains prove to add no value in the earlier TSF cells, they would not be maintained in cells developed later in the project life. In addition, to provide data on tailings performance and evolution, instrumentation (such as vibrating wire piezometers) would be installed in the early TSF cells.

As discussed in the “Yeelirrie TSF Design and Management” document, the primary disposal concept is that the tailings would be deposited sub-aerially directly onto beached (1% beach slope) TSF cells located in the mined-out pit. Each tailings cell would operate a perimeter spigot system as well as a central decant where tailings water could be recovered. Internal berms constructed of consolidated tailings (as this material becomes available and if it is suitable) or waste would contain the tailings. Tailings will be deposited in thin layers in rotation to five tailings cells in order to attain a rate of rise of consolidated tailings of 1.2 m per year.

There will be a total of 10 tailings cells over the mine life operated in two tailings ponds, each containing five tailings cells allowing for the permanent storage of around 2.4 Mtpa of tailings material. Tailings will be deposited in Pond 1 from year three to year 10 (year 1 being the start of dewatering) and in Pond 2 from year 10 to year 17. Capping of tailings cells and other reclamation activities will occur from year 10 to year 19. In order to separate the tailings from the natural groundwater, embankments contacting the pit wall will be constructed of silty clay sourced from on-site.

Tailings would be deposited into each TSF cell in a continuous two-phase cycle; a tailings deposition phase and a drying phase, rotating deposition between five cells so that each cell has a drying time of 24 days (end of filling to beginning of deposition in next cycle). During the tailings deposition phase within each TSF cell, as the tailings solids are left on the TSF beach, tailings supernatant would report to the center or low point in the cell forming a small temporary pond. Water would be retrieved from the pond by a decant system or floating pump system and returned to the metallurgical plant for reuse possibly through a settling or evaporation pond.

1.4 TSF Closure

Overburden material stockpiled during mining would be used to cover decommissioned tailing cells. This cover material would be engineered to provide a durable protective barrier of relatively low permeability and to shed water away from the underlying tailings, minimizing rainfall infiltration. An important aspect of the cover would be a capillary break to prevent solutes from migrating upwards from the tailings into the root zone of the re-vegetated cover. It is anticipated that the total depth of cover would not be less than 2 m.

The most important features of the cover are to i) reduce radiation exposure from radon exhalation, ii) provide an area where vegetation can grow and iii) reduce percolation of water through the cover.

Covering of the TSF cells with overburden would commence as soon as the tailings surface within each completed cell is sufficiently dry and loadbearing to permit safe trafficking by earthmoving equipment. At the proposed average rate of rise of around 1.2 m/year, little if any consolidation is anticipated after the cell has been decommissioned, and the TSF surface should be accessible and trafficable by earthworks equipment within a year after tailings deposition has ceased. As discussed in section 1.3, progressive rehabilitation of tailings cells will commence approximately 8 to 10 years after the initial tailings deposition in tailings pond 1. Progressive rehabilitation of the tailings cells allows for the trialing of several cover system alternatives. It is proposed that the first tailings cells be covered and instrumented to allow for cover performance evaluations and modelling. This will allow the most appropriate cover system to be utilized in the closure of subsequent tailings cells.

Further to the storage of tailings, all material mined from the pit that is not processed during mining operations, and contaminated infrastructure that would not be removed from site, would be backfilled into the pit voids. As a result, there would be no above-surface mining features such as waste rock stockpiles or processing plants, or a pit void, post-closure. The backfilled pit would be covered with overburden materials specifically identified and stockpiled for use as the final exterior cover.

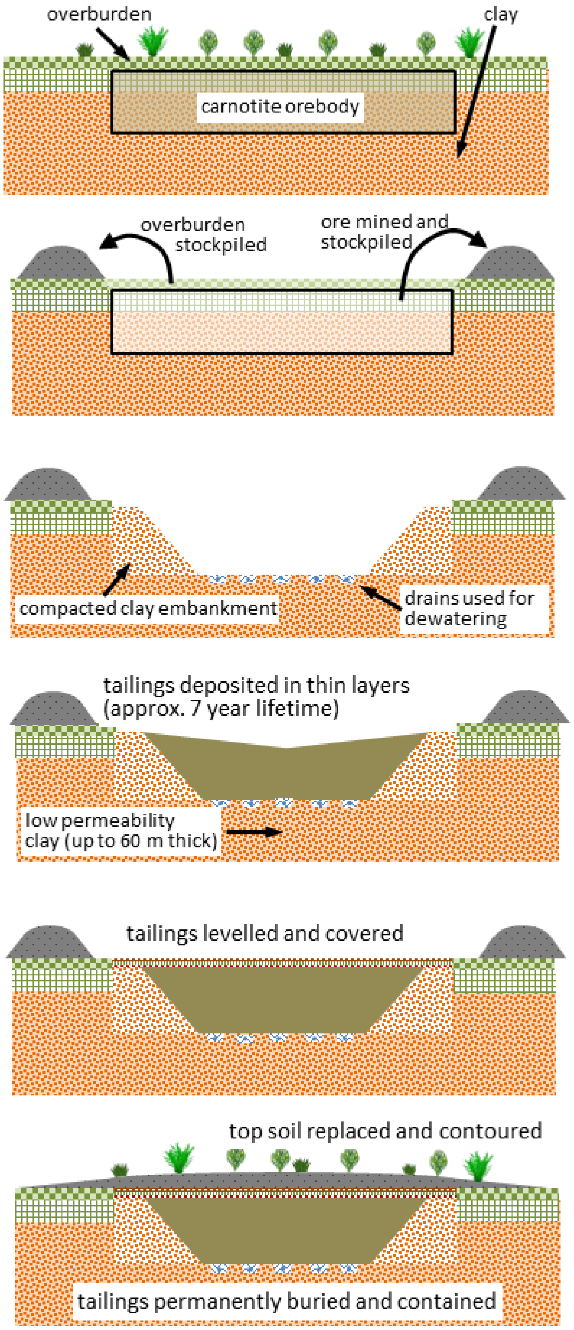


Figure 1.1 Schematic of tailings cover design. Low permeability clay-quartz underlies the tailings storage facility (TSF).

At closure, the palaeochannel would be filled with relatively impermeable tailings. Current mapping shows that the area has continuous calcrete surrounding the orebody that can act as a high permeability conduit for groundwater around the tailings mass. Post-closure solute transport models simulate clay embankments directly against the pit walls. This configuration results in limited solute transport out of the TSF due to diffusion because groundwater flow is primarily parallel to the pit walls (see "Numerical groundwater flow and solute transport model of the Yeelirrie uranium deposit")

The in-pit TSF construction sequence from mining through to closure is illustrated schematically in Figure 1.1. The safety and performance of the post-closure landform is, in part, validated by solute transport modelling, carried out in an accompanying report. The inputs to the solute transport models include climatic data, groundwater flow parameters and the solute source terms for tailings constituents of concern. The following sections detail the development of the Yeelirrie tailings source terms.

2.0 TAILINGS SOURCE TERMS

The tailings constituent source term describes the concentrations of tailings constituents that may enter areas outside the tailings storage facility. This transport of tailings constituents into the undisturbed natural system outside of the TSF occurs as a result of mass flow rates influenced by climatic factors and the natural environment and the physical forms of the tailings constituents as well as other factors. The complexity is such that typically conservative assumptions are made about the processes that occur and the barrier systems in place. In this analysis it has been assumed that there are no sorption controls on the tailings constituents of concern (COC). Sorption controls tend to be more difficult to quantify for a given tailings constituent unless the site has been extremely well characterized. However, sorption controls can be extremely effective at immobilising contaminants and there is no doubt that they occur at Yeelirrie for a number of COCs (arsenic, uranium, selenium, etc.)

Source terms were developed for the following tailings constituents, sodium (Na^+), sulfate (SO_4^{2-}), bromide (Br^-), chloride (Cl^-), boron (B), arsenic (As), chromium (Cr), copper (Cu), molybdenum (Mo), lead (Pb), selenium (Se), vanadium (V), zinc (Zn), uranium (U) and radium (^{226}Ra).

The source term for chloride was developed as a conservative tracer to be used in solute transport models with no retention or interaction with soils in the Yeelirrie region. Given the significant clay content in soils around Yeelirrie, the main constituents of concern are arsenic, selenium, molybdenum because they are likely negatively charged under the groundwater conditions at Yeelirrie and both uranium and vanadium for their importance in Yeelirrie tailings.

Geochemical controls on tailings constituents operate through the control of various chemical parameters. There are four broad areas of control, including pH, oxidation-reduction potential (pe, Eh or $f(O_2)$), solubility controls (precipitation/co-precipitation/dissolution which can be influenced by $f(CO_2)$ and many other constituents that may be present). Sorption, which can include quickly reversible reactions such as ion-exchange and irreversible reactions such as the specific adsorption of certain compounds to (for example) ferrihydrite, will be discussed but has not been incorporated into the geochemical models. The extent of sorption reactions is very dependent on the aqueous speciation (size, charge, type, etc.), the solid speciation (charge, particle size, type) and other chemical conditions that exist.

2.1 Constituents of Concern

Arsenic/Selenium/Molybdenum

Arsenic, selenium and molybdenum all form negatively-charged oxyanions at the conditions present at Yeelirrie.

Molybdenum would be present as the molybdate ion (MoO_4^{2-}) under the pH and oxidizing environment of Yeelirrie. Molybdenum is a tetrahedral anion containing molybdenum in the Mo(VI) oxidation state. Solubility controls that could potentially affect molybdenum are precipitation as powellite ($CaMoO_4$), wulfenite ($PbMoO_4$) and possibly the molybdates of iron, copper or zinc. In alkaline waste materials, studies have predicted that powellite is a geochemical controlling phase (Meima et al., 2002). Both wulfenite and ferrimolybdite have also been proposed as sinks for molybdenum within mine tailings (Petrunic et al., 2006; Langedal, 1997). The geochemical composition of tailings porewater and groundwater has a significant effect on the extent of molybdate adsorption. However, at the pH values existing in the TSF (pH ~10) it is unlikely that significant adsorption takes place. As pH values decrease, molybdenum porewater concentrations will likely decrease from adsorption to aluminum and iron oxides and clays (Goldberg et al., 1996). Potential mixing with groundwater containing calcium also increase the likelihood that precipitation as powellite could occur.

The toxicity and mobility of arsenic depends on its speciation. In aqueous solutions, arsenic forms the As(III) and As(V) oxyanions arsenite ($As(OH)_3$) and arsenate (H_3AsO_4) with aqueous speciation at pH>8 of $H_3AsO_3^0$ and $HAsO_4^{2-}$(Cullen and Reimer, 1989). The arsenite species would be expected to be stable under moderately reducing conditions (Eh ~ -200 mV) at alkaline pH values. Solubility controls acting for arsenic in oxic environments include low solubility calcium arsenates, which is the arsenic removal mechanism with lime treatment (Bothe and Brown, 1999). At alkaline pH values, calcium arsenate precipitates tended to be amorphous and impure (Zhu et al., 2006). There remain some questions about the long term stability of the calcium arsenates. The ferric arsenate, scorodite ($FeAsO_4.2H_2O$), precipitates at low pH but is unstable at pH >3.1 (Moldovan and Hendry, 2005). Barium arsenates are frequently predicted to be oversaturated in mining environments with moderate dissolved arsenic concentrations and sulfate concentrations greater than about 50 mg/L but the kinetics of solid precipitation are very slow and barium arsenates have not been identified in natural environments. Under the conditions of the Yeelirrie TSF, barium arsenate is predicted to be oversaturated. Other secondary minerals predicted to control arsenic include uranyl arsenate and potassium uranyl arsenate (Nielsbohrite) (Gezahegne et al., 2009; Walenta et al., 2009). These compounds do have low solubilities but their log K values are still in dispute and in general are not included in the thermochemical databases or in published literature. Adsorption typically plays an important role in regulating arsenic's aqueous concentration in groundwater and mine environments (Moldovan and Hendry, 2005). Both arsenite and arsenate have strong pH-dependent sorption for iron oxyhydroxides minerals. In oxidizing environments, arsenate binds strongly to iron oxyhydroxides minerals as a stable inner-sphere complex (Foster, 2003).

Similar to arsenic, selenium's solubility, mobility and sorption properties are very dependent on its oxidation state. Selenite (SeO_3^{2-}) sorbs strongly to aluminum, iron and manganese oxyhydroxide surfaces whereas selenite (SeO_4^{2-}) has a lower affinity for those same surfaces and can be easily remobilized by changes in solution parameters. Aqueous selenium concentrations are strongly limited by solubility controls under reducing conditions by the precipitation of elemental selenium or metal selenides (Myneni et al., 1997). It is likely that only sorption controls would operate in the oxidizing environments present at Yeelirrie.

Uranium

Uranium can exist in four oxidation states (+3, +4, +5 and +6) in aqueous environments but the most common oxidation states are U(IV) and U(VI). Uranium exists in the +6 oxidation state under oxidizing and mildly reducing conditions in the form of the uranyl ion, UO_2^{2+}. Uranium species in the +4 oxidation state tend to be relatively immobile under conditions expected for natural waters. The aqueous speciation of uranium in natural waters is complex. Key parameters that influence U(VI) speciation are pH, U(VI) total concentration, partial pressure of CO_2 and/or the presence of carbonate species, and the concentration of certain other key complex forming elements (calcium, magnesium, sulphate, phosphate). Figure 2.1a shows a plot of Eh vs. pH for aqueous concentrations of uranium typical of Yeelirrie tailings (mean porewater concentrations, Table 3.4). These conditions tend to enhance the stability of aqueous uranium (VI), with respect to uranyl carbonate aqueous compounds, however the presence of large dissolved concentrations of calcium and silica result in porewaters that are saturated with respect to the uranyl silicate species, uranophane ($Ca(UO_2)_2(HSiO_4)_2{\bullet}5H_2O$). Generally the uranyl silicates are less soluble than uranyl carbonates or uranyl oxide hydrates under circumneutral pH values. Carnotite ($K_2(UO_2)_2(VO_4)_2{\bullet}3H_2O$) is also a major solubility control at Yeelirrie based on

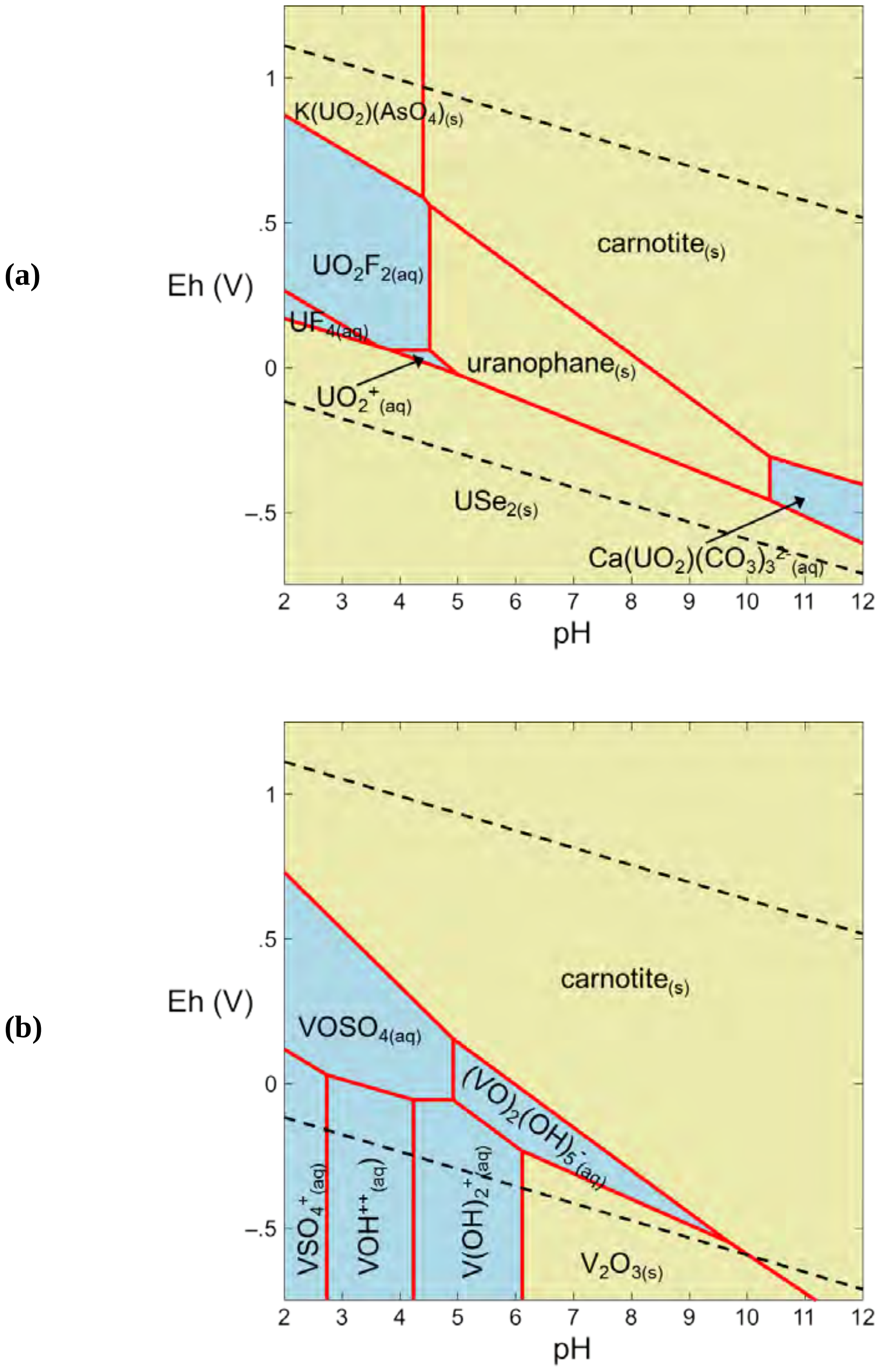


Figure 2.1 Eh-pH diagrams at 25° C for (a) Uranium and (b) Vanadium. Dashed black lines represent the limits of stability for water. If P_{CO2} is changed from 3.5 to 2.5 representing higher CO_2 concentrations, the stability range of $Ca(UO_2)(CO_3)^{2-}{}_{3(aq)}$ is increased towards lower pH values (~ 1 pH unit).

geochemical modelling. Similarly, the calcium analog of carnotite, tyuyamunite, will also precipitate under Yeelirrie conditions. The low solubility of uranyl vanadates strongly competes with uranyl sorption in terms of controlling uranium porewater concentrations in many environments (Tokunaga et al., 2012).

In addition to secondary minerals there are numerous natural sorbents present in the tailings including, smectite, calcite and iron and manganese oxyhydroxides that could serve to lower aqueous concentrations of uranium. Calcite serves as a known sorbent for many other aqueous cations including Ba^{2+}, Cd^{2+}, Sr^{2+} and Zn^{2+} (PNNL-17818). Experiments investigating the uptake of uranium by calcite have documented loadings of 0.2 µg U/g calcite at a pH of 8 and aqueous uranium concentration of 100 µg/L U(VI) (PNNL-17818). These various sorbents have not been explicitly considered in the development of the source term for uranium. As the pH of porewaters is buffered to more neutral values, the conditions for precipitation of uranyl species are improved as the solubility minimum for many environmentally significant uranyl compounds is around pH 7.

Vanadium

Similar to uranium, vanadium is redox sensitive and commonly more soluble under oxidizing conditions. Among U(VI) minerals, uranyl vanadates have very low solubilities and can control both uranium and vanadium concentrations in environments where they occur. The major uranyl vanadate minerals are carnotite, metatyuyamunite and tyuyamunite. At the pH of disposal for Yeelirrie tailings (pH ~9.5-10) vanadium would be speciated primarily as the vanadate ion (VO_4^{3-}) in aqueous solution but would precipitate as carnotite according to geochemical models (Figure 2.1b). At room temperature carnotite is precipitated from aqueous solutions as a stable phase when stoichiometric concentrations of potassium, uranyl and vanadate are mixed in the pH range of about 2 to 9.5. It is likely that the aqueous speciation of uranium in carbonate rich environments, while not inhibiting carnotite precipitation, may increase the solubility to some extent. The solubility of carnotite and tyuyamunite is still an area of active investigation but both have their solubility minima between pH 6-7.

In terms of sorption controls on vanadium, vanadate anions are known to be strongly bound by iron oxides and hydroxides (Peacock and Sherman, 2004). A powerful control on future vanadium concentrations is the mixing of tailings porewater with Yeelirrie groundwater. Calcium vanadates become an important solubility control when excess calcium is present (Figure 2.2).

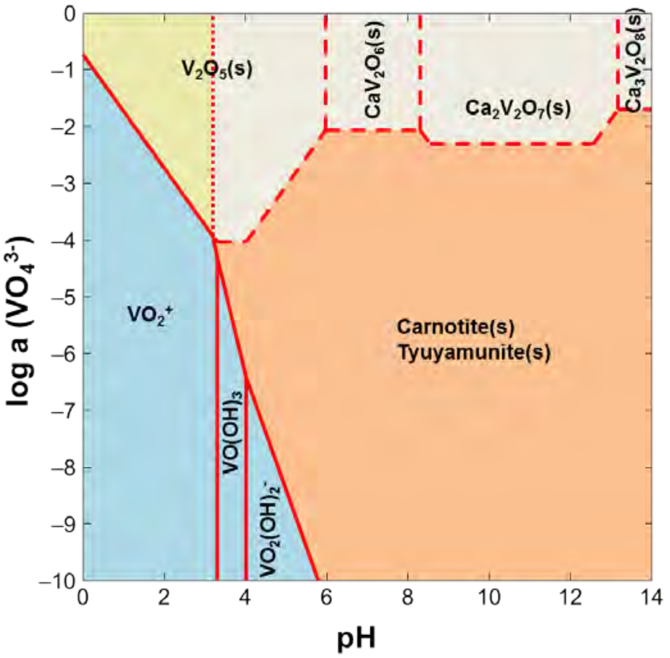


Figure 2.2 Vanadium solubility diagram at 25^{o} C for conditions present in Yeelirrie tailings with $\Sigma U = 10^{-8}$ m and $P_{CO2} = -3.5$. Calcium is an important control for the precipitation of both uranium and vanadium secondary minerals.

^{226}Radium

Tailings from the Yeelirrie processing facility would be placed back into pit voids and covered. After removal of uranium during processing, the remaining radionuclides report to tailings. The long lived radionuclides from the ^{238}U decay chain, which account for the vast majority of the uranium from natural uranium ore, are ^{230}Th, ^{226}Ra, ^{210}Po and ^{210}Pb.

As radionuclide assays were not part of the analytical results of the aged tailings, no update of the ^{226}Ra source term was developed in this report. SRK consulting reported many samples that were below detection in leach tests (section 4.5, Appendix A). In most samples ^{226}Ra was detectable and correlated with barium and strontium for de-ionised water leach tests. In most leach column tests, including those using barren liquor solution, the ^{226}Ra was attenuated though no longer correlated with barium or strontium.

2.2 Laboratory program

The potential for solute release from tailings in the short and long term was evaluated primarily based on aging tests on fresh tailings slurries from various categories of ore material (data contained in the Tails Ageing Test Results section of Appendix A). In addition, the chemical composition of potential stockpile material was evaluated by performing leach tests (deionized water and 'barren liquor' solution) on selected samples in order to determine the solute loadings that could result from these materials. The above tests were performed under the auspices of SRK Consulting and further description is available in Appendix A.

In addition to the above tests, four column tests were run in series containing various rock material types found at Yeelirrie. Only one column contained tailings residue and it experienced some experimental difficulties so that these tests were not considered in this update. It is worth noting that the general trends of the remaining columns were consistent with those demonstrated in the bottle roll (leach) tests (Appendix A).

2.3 Source Term Development

The development of source terms for future Yeelirrie project tailings were completed in a number of steps, outlined as follows:

1. A SysCAD process model for the Yeelirrie project utilizing a production rate of 2.4 million tonnes per year was reviewed. The SysCAD model gives steady state mass and energy balances throughout a process flow diagram but does not provide detailed thermodynamic chemical speciation. As such, it is a good starting point for geochemical modeling of tailings discharge slurries. The SysCAD model includes details of the Yeelirrie ground and process water quality, reagents and production rate but only follows a limited set of constituents. This first step in analysis aids in the identification of unique aspects of the Cameco Yeelirrie process and provides a comparison to subsequent steps. The SysCAD data will not be used to develop the TSF constituent COC source terms.

2. Trends in tailings porewater quality were determined based on tailings aging data available from the SRK Consulting report (Appendix A). In these studies, tailings slurries were monitored over the course of eight months. Collecting aging data on tailings allows the identification of chemical reactions and tailings constituents that may be kinetically controlled in contrast with equilibrium control. It is common to observe significant changes in porewater concentrations between as-discharged tailings and tailings after a period of hours, days, months and years. Statistical parameters of the tailings aging data in conjunction with geochemical modelling predictions were used to determine the tailings source terms.

3. The sensitivity of the source terms was investigated. At closure the mine open pit will be filled with tailings, covered with appropriate materials (at least 2 m of cover), contoured to have a shedding profile that minimizes erosion, and all dewatering activities will have stopped. Hydrologic models suggest that over time the water table will recover to its normal level of approximately 5 m below the natural ground surface. Tailings source terms need to account for the long term scenario of being roughly half saturated and approximately half unsaturated above the groundwater table – similar to the current hydrologic state of the orebody.

   Both the pH (pH 11 to 7, to simulate buffering to neutral values) and the redox potential (0.15 to -0.15 V) were varied to explore the effects on the source terms. Evaporation and the resulting effects on salinity and constituent porewater concentrations were also modelled. Long term predictions indicate that the groundwater would recover within 50 to 150 years to approximately its pre-mining level. As a result of the long contact time prior to the recovery of the water table, equilibrium conditions were assumed to have developed and tailings porewater and groundwater were equilibrated using modelling software to give tailings constituent concentrations.

   The sensitivity analysis provided guidance on parameters to vary in the solute transport modelling.

3.0 REVIEW AND ANALYSIS OF AVAILABLE DATA

3.1 Thermodynamic Database

The thermodynamic data used were those contained in the thermo.dat database for Geochemist's Workbench (Bethke, 2007), with modifications. This database originates from Lawrence Livermore National Laboratory (LLNL) (Delaney and Lundeen, 1990). The database was updated with data from the Harwell/Nirex Thermodynamic Database for Chemical Equilibrium Studies (HATCHES), version 20 released in July 2013 (Table 3.1) as well as recent publications that improve thermodynamic data for relevant species (Finch, R.J. and T. Murakami, 1999; Garrels, R.M. and C.L. Christ, 1965; Helgeson, H.C., 1969; Kelly, S.D., K.M. Kemner and S.C. Brooks, 2007; Langmuir, D., 1997; Peacock, C.L. and D.M. Sherman, 2004). Several specific changes were made to the database based on recommendations from the NEA (e.g. the compound $U(OH)_5^-$ was excluded). The HATCHES database is based on the database provided with the US Geological Survey computer program PHREEQC and is used, in conjunction with chemical and geochemical computer programs, to simulate a wide variety of reactions in aqueous environments. The database is currently maintained by the company amec (HATCHES, 2013) for the Radioactive Waste Management Directorate of the Nuclear Decommissioning Authority. Table 3.1 lists some additions made to the database for the current investigation. Geochemical Modelling was performed using the software program Geochemist's Workbench (Bethke, 2007)

Table 3.1 Updated Constituents added to the Thermodynamic Database†

Species		**ΔG_f^o (kJ.mol^{-1})**	**Source**
$CaUO_2(CO_3)_3^{2-}$		-3,231.8	Kelly et al., 2007
$Ca_2UO_2(CO_3)_3^0$		-3,817.1	Kelly et al., 2007
$UO_2CO_3^0$		-1,537.2	Guillaumont et al., 2003
Mineral name	**Formula**	**ΔG_f^o (kJ.mol^{-1})**	**Source**
uranophane	$Ca(UO_2)_2(HSiO_4)_2 \bullet 5H_2O$ or	-3,099.3	Shvareva et al., 2011
carnotite	$K_2(UO_2)_2(VO_4)_2 \bullet 3H_2O$	-4,589.8	Langmuir, 1997
tyuyamunite	$Ca(UO_2)_2(VO_4)_2 \bullet 8H_2O$	-4,560.6	Langmuir, 1997
becquerelite	$Ca(UO_2)_6O_4(OH)_6 \bullet 8H_2O$	-10,305.6	Gorman-Lewis et al., 2008
rutherfordine	UO_2CO_3	-1,564.7	Guillaumont et al., 2003
metaschoepite	$UO_3(H_2O)_2$	-1,632.2	Gorman-Lewis et al., 2008

† constituents either added or modified from the thermo.dat database

3.1.1 Evaporation

Evaporation from a soil surface is normally considered as a three-phase process (Section 3, Appendix B).

- Phase 1 evaporation occurs directly from a standing water surface or directly from surface pores and occurs at rates approaching the maximum potential rate.
- Phase 2 evaporation begins once the surface water is gone. It involves water being transported to the surface through matric suction from deeper in the soil profile. Phase 2 evaporation slows over time but can be very significant in arid regions. A capillary break interferes with Phase 2 evaporation.
- In Phase 3 evaporation the water moves to the surface in the vapour phase. This is a significant process in areas where there are long dry periods between rain events. In Phase 3 evaporation solutes are not transported to the surface.

At closure the tailings surface will be approximately 2 meters below the natural ground surface with a designed capillary break at the tailings surface that will prevent dissolved constituents from reaching the surface. There is some uncertainty about the evaporative power at depth within the cover or tailings but some reports indicate that solutes could be drawn upwards from greater than 2 meters below surface with Phase 2 evaporation. If the evaporative power is strong enough to reach the tailings area, it is possible that there could be an accumulation of solutes at the capillary break interface. Further testing during detailed cover trials can investigate this possibility. One concern related to the saline tailings porewaters and the evaporative potential is the increase in ionic strength affecting the chemical behaviour of ions in solutions. This well-known effect on the activity coefficient could invalidate many of the predictions from geochemical models. The paragraphs that follow discuss this issue further and detail the measures taken to ensure that the model results are valid for the in-pit TSF.

As porewater solutions become more concentrated, they begin to behave differently from standard model predictions due to increased ion-ion interactions instead of ion-water interactions. The concentration of a chemical constituent in solution is what is most easily measured by analytical methods but this is not what determines its reactivity. At low concentrations in solution, ions interact with water molecules but at higher concentrations they begin to associate with each other through complexation and Coulombic interactions, reducing their effective concentration or activity. Reactions depend on the activity of dissolved species not their concentration. The activity of individual dissolved species is equal to their concentration modified by an activity coefficient ($a_i = \gamma_i m_i$, where a, γ, and m are the activity, activity coefficient and molality, respectively). In dilute solutions, the activity coefficient (γ_i) equals one. As salt concentrations increase (and ionic strength increases), activity coefficients start to diverge from their ideal value of unity. At Yeelirrie, most aqueous solutions are in excess of 1 molal and are considered challenging geochemical systems to numerically model.

The geochemical models used in this study to help predict mineral saturation and dissolved constituent concentrations utilizes the “B-dot” equation to determine activity coefficients. The B-dot equation is an extended form of the Debye-Hückel equation (Helgeson, 1969). This method is applicable to a range of natural waters including Na-Cl type solutions up to ionic strengths of 3 m (molal), though above 0.5 m it is not very accurate. Using an inappropriate equation can have significant effects on the chemical equilibrium determined by the geochemical software. In reality, there is no ideal solution in terms of using an appropriate technique to model the behaviour of ions in concentrated solutions. Other methods use virial techniques but these are semi-empirical in nature and have very limited datasets (limited chemical constituents) and usually can only be used at certain temperatures, such as the Harvie-Møller-Weare formulation of the Pitzer model (Harvie et al., 1984).

The database used for modeling Yeelirrie tailings was compared to databases that utilize the Pitzer model for concentrated solutions by considering the effect of evaporation on the increase in solute concentrations. At Yeelirrie there is a net evaporative gradient producing a net upwards movement of solutes. Table 3.2 shows some of the species predicted to precipitate as a result of evaporation of the tailings porewater. Note that because a reduced dataset has to be used with the Pitzer databases (due to lack of data on ion-ion interaction terms), Table 3.2 shows compounds containing only alkali or alkali earth cations.

Figure 3.1 plots minerals formed against the simulated loss of water during evaporation. Blue lines are predictions using the standard database and data for all known constituents in the tailings porewater. The results indicate that the thermodynamic database (utilizing the "B-dot" equation) used in the rest of this report is adequate for modeling evaporation. Several species however did not precipitate using this database when compared to the results from the Pitzer database. These additional phases that form as the tailings porewater evaporates are listed in Table 3.2.

The primary difference between the approaches to modelling is that the Pitzer approach predicts more carbonate mineral precipitation reducing alkalinity in the remaining water much faster. Some of this alkalinity would be returned to porewater during significant recharge events but the reduction in alkalinity would have the effect of reducing the source terms for elements such as arsenic, uranium and vanadium where solubilities are at a minimum near circumneutral pH values. The Pitzer model cannot predict any precipitation of other metal components of the tailings as these are not included in its database.

On this basis, geochemical modelling was performed using the B-dot equations due to a lack of data in the Pitzer database. The B-dot equations do seem to perform adequately according to Figure 3.1 and are conservative in that they predict i) fewer species precipitating from solution, and, ii) where similar minerals are formed, they form only at higher concentrations (i.e. at higher evaporation levels), leaving more dissolved constituents.

Table 3.2 Mineral Precipitates from Evaporation Predicted by the Pitzer Model

Mineral	Formula
pirssonite	$Na_2Ca(CO_3)_2 \cdot 2H_2O$
magnesite	$MgCO_3$
glaserite	$(K,Na)_3Na(SO_4)_2$
trona	$Na_3(CO_3)(HCO_3) \cdot 2H_2O$
natron	$Na_2CO_3 \cdot 10H_2O$
burkeite	$Na_6(CO_3)(SO_4)_2$ or $(2Na_2SO_4 \cdot Na_2CO_3)$

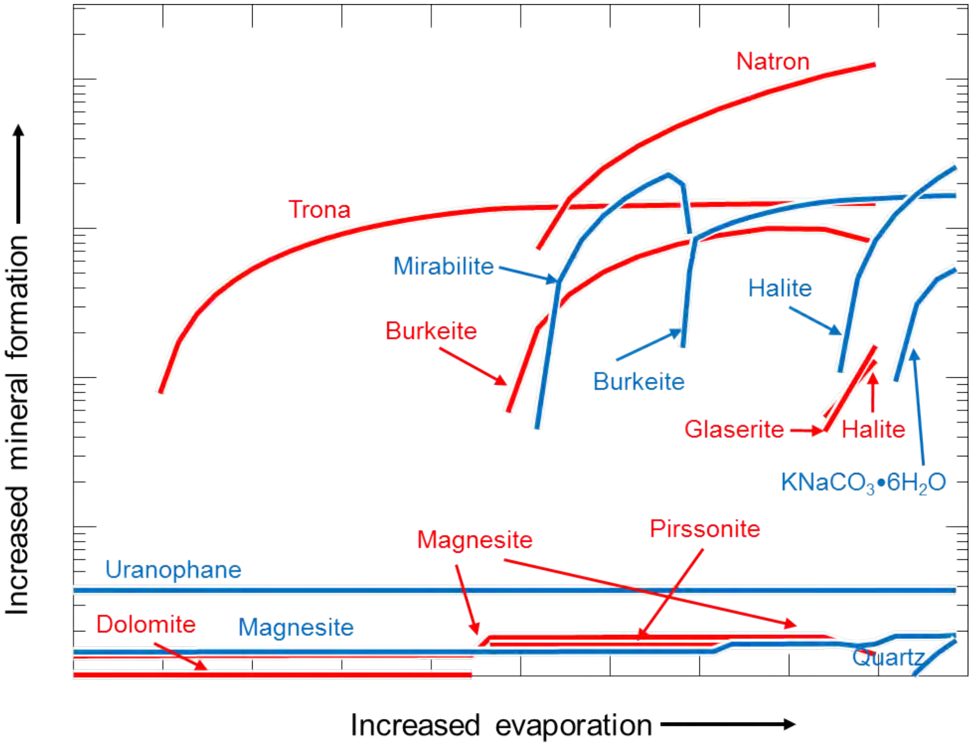


Figure 3.1 Simulated evaporation from high ionic strength Yeelirrie solutions. Red curves are minerals predicted using Pitzer model ion interactions, blue curves were predicted using activity coefficients from the B.dot equation.

3.2 SysCAD Data

The SysCAD model was developed for the purposes of determining the acceptable water quality range for use in the metallurgical process. Particular constituents of concern for this exercise were Na, Cl, SO_4, Ca, Mg, U and V. The SysCAD model provides mass and energy balances but has very limited capability of chemically speciating elements and does not, for example, determine pH values. The output of the SysCAD model has vanadium concentrations at about 370 ppm and uranium concentrations at 68 ppm. These values do not account for any solubility controls or mineral precipitation that could occur. The data was input into the geochemical model and allowed to equilibrate as the tailings slurry cooled from 63°C to 25°C.

Table 3.3 shows the SysCAD predicted constituent dissolved concentrations compared to the geochemical model output equilibrated concentrations at pH 9.5. The geochemical model run output is shown in Appendix C (C1). The table shows the effect of equilibrium with secondary phases on aqueous concentrations with large reductions in strontium, magnesium and calcium due precipitation as carbonate species. Vanadium concentrations are reduced at this stage primarily due to precipitation of calcium vanadates.

Table 3.3 SysCAD Model Outputs (as-discharged dissolved concentrations)

Constituent	SysCAD model (to tailings)	SysCAD model (equilibrated)
	mg/L	mg/L
calcium	540	4.8×10^{-3}
bicarbonate	36,890	26,185
chlorine	15,200	11,843
magnesium	920	0.349
potassium	2,380	1,855
Sodium	42,820	33,372
strontium	240	3.75×10^{-4}
sulfur (as SO_4^{2-})	14,562	11,394
uranium	67.8	53
vanadium	369.6	288

The model suggests that uranium concentrations will be controlled, in part, by uranophane ($Ca(UO_2)_2(HSiO_4)_2•5H_2O$), a uranyl silicate mineral. Uranophane is one of the most common uranyl minerals and will precipitate from near neutral to alkaline groundwaters that contain dissolved uranium, silica and calcium (Finch and Murakami, 1999). In a study at the Hanford site in Washington state, USA, it was found that the solubility minimum for uranophane occurred at pH 8 (25° C); but that the dissolution rate increased as a function of bicarbonate concentration (PNNL-17818). In several model runs the precipitation of uranophane was suppressed only to reveal that both carnotite and tyuyamunite were also saturated (potassium and calcium uranyl vanadates, respectively) under the chemical conditions at Yeelirrie. The reduction in vanadium concentrations is largely due to precipitation of calcium vanadates and carnotite.

While the SysCAD model is specific to the proposed Cameco mill process and mill rate, its lack of speciation capabilities makes it difficult to compare with the processed ore in the aged tailings experiments. In this analysis of tailings porewater chemistry, the SysCAD results provide guidance only with respect to possible controlling solid phases. The output of the model is not used to predict tailings source terms.

3.3 Aged Tailings Data

Long term porewater concentrations are expected to be controlled by mineral saturation and precipitation, equilibration with secondary minerals, co-precipitation of trace elements with other phases (for example As co-precipitation with hydrous ferric oxides (HFO) or ferrihydrite, and sorption to certain mineral phases (for example arsenic or uranium sorption to HFO). These geochemical controls on long term porewater concentrations are a critical aspect of determining appropriate source term concentrations.

The specific analysis approach did not consider any COC adsorption reactions that acted to attenuate porewater concentrations in the source term development. Section 3.8 does recommend distribution coefficients (K_d) for a number of tailings porewater constituents, which are included in solute transport calculations (see “Numerical groundwater flow and solute transport model of the Yeelirrie uranium deposit”).

The tailings laboratory program conducted by SRK Consulting included fresh tailings slurries subjected to aging experiments that included representative samples from high and low uranium grades in calcrete and clay-quartz lithologies as well as samples that were open and closed with respect to the atmosphere (Appendix A). There was no statistical difference between the open and closed subsample flasks so that all subsamples (four for each sample – open A, open B, closed A, and closed B) were considered together in this analysis (Appendix A).

Table 3.4 shows the mean solute concentrations for aged tailings over the course of the entire aging period. The trend over the course of eight months of aging for each tailing’s porewater constituent is also indicated. General observations from the tailings aging experiments indicate:

- Oxyanion constituents – As, Se, Mo, Cr, SO_4^{2-} and NO_3^- decrease with aging time.
- Ca, Si and Al increase with aging time.

Most chemical reactions do not occur instantaneously and, as a result, the as-discharged tailings porewater chemistry differs substantially from porewater collected months or years later. The reasons for this are primarily that slow reactions occur between the solid tails and porewater solutions that result in changes over time to the porewater. The mean tailings porewater chemistry was used as input to geochemical speciation software to determine the equilibrated porewater constituent concentrations (Table 3.4). In addition to the constituent concentrations shown in Table 3.4, the geochemical software included

Table 3.4 Aged Tailings Concentrations and concentration trends after eight months

Constituent	Tailings mean porewater concentrations	Aging trend* (Eight month)	Aged tails equilibrated concentrations**	Tailings 90th % porewater concentrations
	mg/L		mg/L	mg/L
Br^-	74.4	sl decrease	79.0	98.0
Ca	3.4	lg increase	1.1×10^{-26}	5.9
Cl^-	20,259	sl increase	21,525	26,000
F^-	9.5	lg decrease	10.1	12.4
NO_3^-	74.4	lg decrease	79.0	838
K	1649	no change	1,752	1780
Si	15.7	lg increase	9.65	32.2
Na	43,460	no change	46,174	52,600
SO_4^{2-}	9,433	lg decrease	10,021	14,700
U	98.3	sl increase	61.5	180.0
Mg	8.4	no change	0.29	14.8
Al	0.16	lg increase	3.56×10^{-4}	0.4
As	4.4	lg decrease	4.61	11.0
Ba	0.17	no change	1.1×10^{-6}	0.3
B	35.9	sl decrease	38.1	42.0
Cr	1.02	lg decrease	1.1	3.2
Cu	0.161	sl increase	9.6×10^{-5}	0.346
Fe	0.726	ld	2.4×10^{-7}	2.14
Pb	0.274	ld	0.29	0.74
Mo	2.0	sl decrease	2.12	3.1
Ni	0.027	no change	2.71×10^{-5}	0.0479
Se	0.462	lg decrease	0.49	0.757
Sr	0.268	no change	2.71×10^{-4}	0.34
V	50.1	no change	53.2	78.8
Zn	0.49	lg decrease	1.35×10^{-3}	1.8
T. Alkalinity	57,141	sl decrease	84,587	72,000

* sl - slight; lg – large; ld – limited data; no change – final concentration was within 20% of initial concentration

** modelled using the React subroutine of Geochemist’s Workbench (Bethke, 2007) initial conditions of pH=10 and Eh=150 mV. Further observations and notes can be found in the original SRK report in Appendix A.

During the equilibration, the minerals listed in Table 3.5 precipitated in addition to talc and hematite resulting in the decrease in concentration of elements such as, calcium, uranium, magnesium, copper, iron, nickel, strontium and zinc.

Based on the trend for each tailings constituent over the course of eight months of aging either the mean porewater concentration, 90th percentile porewater concentration or the equilibrated porewater concentration value was chosen as the source term. Table 3.4 shows the selected source terms in shaded cells.

Table 3.4 in conjunction with the specific methods described below can be used to determine the tailings source terms. The following procedures were followed with each particular tailing's constituent:

- The aging trend of the tailings' constituent porewater concentration was identified from column 3 of Table 3.4.
- If the aging trend indicated an increase or did not change significantly over the course of eight months of aging then porewater concentrations were taken as either the equilibrated porewater concentration (from geochemical model results – column 4) or the 90th percentile aged tailings porewater concentration (column 5), whichever was greater.
- If porewater concentrations were identified as decreasing over the course of the aging of the tailings slurries then the greater of either the mean aging porewater concentration (column 2) or the equilibrated value (from geochemical model results – column 4) was taken as the source term.

Following these procedures the tailings source terms are shown in shaded cells in Table 3.4 and are also listed separately in Table 3.6. This method of choosing source terms uses the observed data from tailings slurries, the trends over a period of aging and incorporates geochemical modelling. The process also incorporates conservatism through the decision making logic and by taking the largest value among the options.

3.4 Sensitivity to Environmental Conditions

The sensitivity of the source terms to changes in redox potential was tested by allowing the redox potential to vary from 150 mV down to -150 mV in models of the system. During the aging tests the redox potentials varied between 66 to 190 mV but when they were at their highest (at the 2 month aging period) redox potentials averaged 149 mV. The geochemical modelling carried out in the source term determination (Table 3.4) incorporated an initial redox potential of 150 mV. The samples in the aged tailings tests all increased in either the two or four month monitoring periods but had decreased by the

Table 3.5 Minerals frequently saturated in the Aged Yeelirrie Tailings

Mineral	Formula
uranophane	$Ca(UO_2)_2(SiO_2)_2(OH)_6{\bullet}2H_2O$
barium arsenate	$Ba_3(AsO_4)_2$
magnesite	$MgCO_3$
garnierite (talc-like)	Ni_2SiO_4
strontianite	$SrCO_3$
tenorite	CuO
saponite-Na	$Na_{0\ 4}\ (Si_{3\ 6},Al_{0\ 4})(Mg_3)O_{10}(OH)_2$
smithsonite	$ZnCO_3$

Table 3.6 Recommended Source Term Concentrations for the Tailings Contained in the Yeelirrie In-pit TSF at Closure

Constituent	Units	Tailings Source Term Concentrations
As	mg/L	4.6
B	mg/L	38.1
Ca	mg/L	5.9
Cl	mg/L	26,000
Cr	mg/L	1.1
Cu	mg/L	0.35
K	mg/L	1,780
Mo	mg/L	2.1
Ni	mg/L	0.05
Se	mg/L	0.49
Sr	mg/L	0.34
U	mg/L	180
V	mg/L	79
Zn	mg/L	0.5
Ra-226	Bq/L	5.0

eight month period to below the starting redox potential, possibly indicating a downward trend. The input to the sensitivity geochemical model runs in Table 3.7 was the 90th percentile tailings porewater concentrations listed in column 2 of that table. Table 3.7 (column 3) shows the model results when the Eh was forced to move to -150 mV. Solute porewater concentrations were not very sensitive to changes in the redox potential (Table 3.7) with slight increases for most constituents. Certain constituents decreased from increased precipitation (Ca, Si, Na, Mg, Al, Fe, Ni, Sr, U).

The effect of evaporation was explored on the 90th percentile tailings constituents by allowing the porewater to dry to 30 percent of its initial value and geochemically equilibrating the resulting solution (Table 3.7). As expected, most constituents increased significantly in concentration and those that did not were components of minerals that were supersaturated (see Table 3.5). Some of these secondary precipitates may re-dissolve as a result of recharge but the proposed reduced infiltration cover suggests that many of these tailings constituents may be removed from the tailings porewater on a long term basis. The secondary precipitates would most likely accumulate at the interface of a proposed capillary break where mobile solutes would be deposited as phase 2 evaporation transitions to phase 3 evaporation (section 3.1.1).

In a post-closure setting groundwater levels will recover within about 50 to 150 years resulting in mixing with tailings porewaters. This was simulated in a geochemical model by mixing progressively higher ratios of groundwater with tailings porewater (1:1, 10:1, 25:1 and 100:1). The modelling was performed by equilibrating the tailings porewater and then titrating it with the set ratio of groundwater and equilibrating at each step. Initially mixing would occur at a 1:1 ratio but with the progression of time older (deeper) tailings would exist in a predominantly groundwater chemical regime similar to the current state of the orebody. Consistent trends were observed as the ratio of groundwater to tailings porewater increased. The primary geochemical gradient that was introduced was a decrease of the pH value towards neutral values. Table 3.7 shows the equilibrated results from mixing Yeelirrie groundwater with tailings porewater in a 10:1 ratio. At a ratio of 10:1 the pH is predicted to be about 9.6 but at a ratio of 25:1 the pH has reduced to 7.1. There are also predicted to be significant decreases in uranium, vanadium, arsenic, molybdenum, selenium, chromium, and copper as groundwater mixes with the tailings porewater. The major effect on solute concentrations results from buffering the pH towards neutral and the resulting precipitation of secondary minerals. Precipitation is also assisted by the input of calcium from the groundwater (both calcium and magnesium increase). In summary, geochemical models indicate that the recovery of the water table in the post closure TSF and its effect on pH will tend to reduce further the porewater concentrations of many tailings constituents, including uranium and vanadium.

Table 3.7 Sensitivity of Aged Tailings Porewater Concentrations

Constituent	**Input data Aged tails 90th % porewater concentrations**	**Aged tails (Eh = -150 mV)**	**Aged Tails (evap.)**	**Yeelirrie mean Groundwater Concentrations**	**Aged tails (10:1 mixing) grdwater to tails**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Br^-	98.0	104	349	34	38.0
Ca	5.9	1.4×10^{-28}	5.1×10^{-28}	361	7.65×10^{-3}
Cl^-	26,000	27,589	92,598	9115	10,225
F^-	12.4	13.2	44.2	1.6	2.37
NO_3^-	838	889.1	2,985	88.1	87.08
K	1780	1889	6339	460	576.6
Si	32.2	10.7	53	27.1	0.95
Na	52,600	50,219	166,718	5035	8765
SO_4^{2-}	14,700	15,600	48,645	3155	3772.8
U	180.0	116.7	391.5	0.31	1.8×10^{-14}
Mg	14.8	0.31	0.30	737	0.629
Al	0.4	7.27×10^{-7}	1.9×10^{-7}	0.22	2.5×10^{-4}
As	11.0	11.6	38.8	0.02	0.414
Ba	0.3	6.79×10^{-7}	4.2×10^{-7}	0.07	4.5×10^{-6}
B	42.0	44.6	150	11.0	13.5
Cr	3.2	3.40	11.4	0.01	0.11
Cu	0.346	9.68×10^{-5}	8.3×10^{-5}	0.02	2.6×10^{-4}
Fe	2.14	2.36×10^{-7}	2.2×10^{-7}	0.51	1.25×10^{-7}
Pb	0.74	0.79	2.63	---	---
Mo	3.1	3.3	11.0	0.11	0.29
Ni	0.0479	2.84×10^{-5}	2.0×10^{-5}	0.03	1.2×10^{-4}
Se	0.757	0.80	2.7	0.05	0.09
Sr	0.34	3.02×10^{-4}	2.7×10^{-4}	8.31	7.3×10^{-4}
V	78.8	83.6	281	0.03	4.87
Zn	1.8	2.63×10^{-3}	1.6×10^{-2}	0.09	1.1×10^{-2}
T. Alkalinity (mg/L $CaCO_3$)	72,000	57,411	197,082	---	4,105

3.5 Recommended Source Terms

A summary of source terms recommended for assessing future environmental effects from tailings deposited at the proposed Yeelirrie Mine/Mill in a post closure environment is provided in Table 3.6. The source terms for all the tailings constituents considered their respective mineralogy and the conditions present in the tailings storage facility. The source terms in Table 3.6 represent the best estimate assuming conservative (90th percentile) aged tailings porewater data and represent maximum concentrations exiting the mill based on the process model.

Recommended source terms have been tested for their sensitivity towards changing redox conditions, in order to factor in the post closure condition where approximately half the tailings are below the water table (see Table 3.7). Further sensitivity testing will be carried out during solute transport modelling.

During operation the TSF would be actively managed to minimize seepage through dewatering and tailings water reclaim. These hydraulic controls would keep tailings solutes concentrated near the surface of the TSF preventing their mobilization.

At the end of milling, each tailings pond will be capped and the final landform of the TSF established. Due to the evaporative concentration of solutes and their precipitation the potential porewater concentrations are very high but are not reflective of post closure tailings porewater in terms of release to the surrounding environment. Dewatering will not be maintained after closure and the water table will begin to recover. At some point the recovering water table will intersect the tailings resulting in mixing. The source terms in Table 3.6 represent the pore water concentrations when the solutes are remobilized through interaction with Yeelirrie groundwater.

3.6 Radionuclides

SRK Consulting performed radionuclide assays on Yeelirrie rocks and soils (Appendix A, Section 4.5). SRK noted that in the near-surface lithologies proximal to the Yeelirrie orebody (loams, calcrete and transitional calcretes) ^{238}U seemed to be in isotopic disequilibrium with daughter products suggesting that uranium is being preferentially leached. Isotopes within the ^{232}Th decay chain appeared to be in isotopic equilibrium suggesting that no preferential leaching or accumulation has occurred.

SRK consulting did not include radionuclide assays in their aged tailings slurries, which was the main basis for modifying their source terms. Detailed investigations from SRK did establish a source term for ^{226}Ra, which has been adopted here unaltered (Table 3.6).

3.7 Recommended Kd Values

Sorption is an important attenuation mechanism for many metals and radionuclides, however it is often expressed as an umbrella term that includes strong inner-sphere adsorption onto surfaces, weaker outer-sphere adsorption onto surfaces and absorption which may occur with more porous materials like organic matter. Adsorption is a surface complexation process that is heavily influenced by the sorbate solution speciation as well as by the specific mineral phase and particle size. Adsorption is usually considered distinct from electrostatic processes like ion-exchange.

Ion exchange occurs when ions in solution exchange for ions present in the mineral lattice. It can occur on permanent charge materials such as clay minerals or as a pH-dependent process on oxide or hydroxide minerals. Smectites and kaolinites, both present in Yeelirrie soils, have significant cation exchange capacity. While ion exchange plays a role in the retardation of solutes in groundwater it is a reversible mechanism and therefore does not necessarily play a role in the long term retention of contaminants.

The implementation of K_d values does not consider mechanistic processes but is an empirical approach that recognizes the retardation of constituents in solution due to many processes and many solid species. The K_d approach does not consider changes in solubility as a result of pH evolution. The slow mixing of groundwater with tailings porewater is the long term equilibrium condition for Yeelirrie because the tailings are not acid generating and the groundwater pH is close to neutral. Elements such as calcium, which were largely present as precipitated solids in the tailings, will become available from the groundwater potentially reducing the solubility of constituents that precipitate with calcium, such as uranium and vanadium.

SRK Consulting conducted analyses using de-ionized water and using barren process liquor in order to determine sorption coefficients on Yeelirrie materials including loam, clay-quartz and palaeochannel sands. Table 3.8 lists K_d values for some COCs in two different Yeelirrie lithologies. For solute transport modelling purposes the K_d for clay-quartz was used for the clay-quartz, carbonated clay-quartz, calcrete and transitional calcrete systems while the K_d for loam should be used for the carbonated quartz-rich loam, carbonated loam and loam systems. A conservative K_d of zero (no retention) was used for weathered granite and any descriptor including sand. SRK had inferred K_d values for the palaeochannel sands that were much greater than values for the loam systems. A K_d of zero for the palaeochannel sand systems was used in the solute transport modelling conducted as part of this analysis.

Published values for the distribution coefficient, Kd, can vary greatly depending on factors such as the material type and properties, pH and the speciation of the contaminant. In support of the fact that there is strong attenuation of radionuclides at Yeelirrie, gamma radiation surveys obtained after the removal of stockpiled materials during rehabilitation activities in 2004 showed very low readings after removal of the stockpile indicating very limited release of radionuclides during the stockpile’s lifetime (20 to 30 years) (Appendix A).

Table 3.8 Summary of Distribution Coefficients (from SRK) for Yeelirrie Materials*

Constituent	Distribution coefficient, K_d (cm^3g^{-1})	
	loams	**clay-quartz**
As	350	1.3
B	51	3
Cr	4	10
Cu	0.93	1.1
Mo	47	0.67
Ni	0	0
Se	50	0.83
Sr	0	0
U	420	1.1
V	480	2.7
Zn	0	0
Ra-226	0	2.8

* excepting palaeochannel sands, data in table from Table 4.12 of Appendix B

4.0 STOCKPILE AND WASTE SOURCE TERMS

The current plan for development of the Yeelirrie project is to have nine ore stockpiles separated based on uranium and smectite grades. In addition, there will be three categories of waste; mineralised waste, clean waste and topsoil. Each waste category will be placed in 12 separate piles spread across the south side of the pit.

In this analysis the topsoil waste category is not considered to contain any leachable solutes of environmental concern. The main concern for the temporary ore stockpiles, mineralized waste and clean waste stockpiles are their potential for leaching solutes in response to precipitation and runoff. Total mine life is approximately 19 years providing an upward limit to the amount of time stockpiles will remain on the surface. Stockpiled materials would remain on the surface either until they are processed (ore) or until they are backfilled into the pit (waste or topsoil).

Prior to mining, there will be a dewatering period of approximately one year. This period of dewatering is important for allowing material to drain in-situ and removing porewater from ore or waste that may be stockpiled at a later date. The dewatering stage is an important control for limiting any toe seepage that may result from excess porewater at the time of placement, either through percolation or drainage.

After placement, solute release from stockpiled ore is possible from incident rainfall and the resultant runoff. The Yeelirrie area is strongly evaporative in nature and evaporation rates exceed precipitation by at least a factor of ten but the area is susceptible to large rainfall events associated with cyclones in the period December to April.

Previous work conducted by BHPB and their consultants indicated that it is unlikely that percolation would result from incident rain during the period of time that the materials would be stockpiled on the surface (Appendix B, Section 3). Therefore, source terms were developed only for the case for incident rainfall causing ponding leading to runoff and not for the cases of percolation or seepage.

4.1 Approach and Assumptions

The primary mechanisms for release of trace elements from the stockpiled materials were assumed to be dissolution of readily soluble salts present on surfaces and the dissolution of oxide minerals. Concentrations of leached elements were assumed to be limited by solubility controls imposed by secondary mineral formation. Oxidation is not expected to play a role in the leaching of elements as the deposit is already oxic with mineralogy dominated by carbonates, silicates, and clay materials. Solute accumulation on surfaces contributing to the dissolution of readily soluble salts originates from evaporation of water from the surfaces of material (salt wicking).

The various lithologic units present in ore-bearing materials at Yeelirrie have varying solute release properties. The total amount of solute release depends on the type of materials that are exposed at surface, the total area (footprint) exposed to runoff water, and the amount and frequency of runoff.

In the original sampling campaign not all of the material types were equally represented, therefore the results were arranged in order of uranium release with the highest uranium release being assigned to the ultra-high grade and very high grade material and the next highest to the high grade material continuing to the lowest and below grade material (mineralized and clean waste).

The following approach was adopted for determining stockpile source terms:

1. For any given stockpile, the maximum footprint area during its lifetime was used to conservatively estimate the impacted surface area of the pile. That is the calculation always assumes the highest possible exposed surface area. This overestimates the surface area of the pile leading to increased estimates of solute release.

2. The schedule of placement was used to estimate which ore or waste piles were active in any given year. It was assumed that any given surface is active only in the year that is placed (section 4.2).

3. The area of exposure was multiplied by the assumed depth of influence and the total mass of material. In the upper bound model the assumed depth of influence was a maximum of 2 m of new material placed on the stockpile. SRK Consulting estimated the depth of evaporative influence (a primary control on the total loading of solutes on particle surfaces available to runoff) at between 0.19 m and 0.28 m depending on the material type (Appendix B). The base case scenario uses a conservative maximum depth of contribution of 0.5 m for all material types.

4. Estimates of solute release (in mg/kg) were obtained from leach extraction and column tests. (Appendix B). The solute release rates were multiplied by the total mass of rock that might contribute to the salt loading. Solute masses were converted to concentrations by dividing by the total volume of water delivered by the rainfall event (Table 4.1). Rainfall events were characterized by their duration and average recurrence interval (ARI). These concentrations were then compared to equilibrium concentrations that may apply (i.e. where the concentration exceeded the solubility of known phases that form rapidly and at a relevant pH, the concentration was corrected to the equilibrium concentration.

5. The revised concentration was then multiplied by the runoff (Table 4.1) volume to obtain the total solute loading that would result.

Table 4.1 Estimated Precipitation Intensity, Initial Abstraction, and Potential Runoff for Various Material Classes* for the Yeelirrie Site

storm duration / recurrence interval (yrs)	**5 min.**	**1 hr**	**6 hrs**	**12 hrs**	**24 hrs**	**48 hrs**	**72 hrs**
Rainfall Intensity (mm/hr)							
1	43.2	12.5	3.5	2.1	1.3	0.8	0.6
5	54	15.6	5.0	3.3	2.1	1.3	1.0
10	58.8	18.9	6.1	4.1	2.6	1.7	1.2
20	58.8	22.5	7.7	5.3	3.3	2.2	1.6
50	96	27.7	9.9	6.8	4.5	2.9	2.2
100	126	36.0	13.1	8.9	5.8	3.7	2.8
500					6.8	4.3	3.2
1000					8.2	5.1	3.6

storm duration recurrence interval (yrs)		**5 min.**	**1 hr**	**6 hrs**	**12 hrs**	**24 hrs**	**48 hrs**	**72 hrs**
Initial Abstraction (mm)								
1	(UHG/VHG/HG)	1.7	6.4	29.6	66.4	243.5	37.4	40.3
	(MG/LG/MW/CW)	1.0	3.5	14.6	27.9	59.8	233.7	40.3
5	(UHG/VHG/HG)	1.4	5.0	18.3	31.9	68.1	224.0	71.8
	(MG/LG/MW/CW)	0.8	2.8	9.6	15.6	28.4	57.7	105.5
10	(UHG/VHG/HG)	1.3	4.1	14.3	23.5	45.9	111.7	295
	(MG/LG/MW/CW)	0.7	2.3	7.6	12.0	21.0	39.7	64.7
20	(UHG/VHG/HG)	1.3	3.4	10.9	17.2	31.4	61.8	117
	(MG/LG/MW/CW)	0.7	1.9	5.9	9.0	15.3	26.5	41.0
50	(UHG/VHG/HG)	0.8	2.7	8.2	12.6	20.9	37.6	61
	(MG/LG/MW/CW)	0.4	1.5	4.5	6.7	10.7	17.9	26.2
100	(UHG/VHG/HG)	0.6	2.1	6.0	9.2	15.2	27.0	42
	MG/LG/MW/CW)	0.3	1.2	3.4	5.0	8.1	13.5	19.5
500	(UHG/VHG/HG)					12.6	22.0	34
	(MG/LG/MW/CW)					6.7	11.3	16.4
1000	(UHG/VHG/HG)					10.1	18.0	28
	(MG/LG/MW/CW)					5.5	9.4	14.1
Potential Runoff (mm)								
1	(UHG/VHG/HG)	1.9	6.1					
	(MG/LG/MW/CW)	2.6	9.0	6.2				
5	(UHG/VHG/HG)	3.1	10.	11.5	7.6			
	(MG/LG/MW/CW)	3.7	12.97	20.3	23.9	21.3	6.0	
10	(UHG/VHG/HG)	3.6	14.8	22.3	25.7	16.2		
	(MG/LG/MW/CW)	4.2	16.6	29.0	37.3	41.1	39.6	25.1
20	(UHG/VHG/HG)	3.6	19.1	35.3	45.9	48.5	42.9	
	(MG/LG/MW/CW)	4.2	20.6	40.3	54.1	64.5	78.2	75.8
50	(UHG/VHG/HG)	7.2	25.0	51.5	69.1	87.1	103.6	97.7
	(MG/LG/MW/CW)	7.6	26.1	55.2	75.0	97.3	123.3	132.3
100	(UHG/VHG/HG)	9.9	33.9	72.4	97.8	123.9	150.6	156.4
	(MG/LG/MW/CW)	10.2	34.8	75.1	101.9	131.0	164.1	178.6
500	(UHG/VHG/HG)					150.7	185.3	193.1
	(MG/LG/MW/CW)					156.6	196.0	210.6
1000	(UHG/VHG/HG)					187.3	224.9	229.4
	(MG/LG/MW/CW)					191.9	233.5	243.6

* see Appendix A; UHG/VHG/HG materials are classified as silty clayey loam and MG/LG/MW/CW materials are classified as sandy clay.

Table 4.2 Yeelirrie Mineral Resource by Lithology for (a) clay-quartz, (b) loam and (c) calcrete. Material classifications are clean waste (CW), mineralized waste (MW), low grade, 500-670 ppm U3O8 (LG), medium grade, 670-1000 ppm U3O8 (MG), high grade, 1000-1500 and >1500 ppm (UHG)

a)

Material Classification	Clay-Quartz			
	tonnage	volume (m^3)	density (t/m^3)	clay-quartz percent (vol. %)
CW	125	78	1.60	12.5
MW	22,853	14,922	1.53	52
LG	629,854	413,984	1.52	57
MG	4,991,133	3,279,922	1.52	60
HG	7,164,565	4,685,313	1.53	63
VHG	4,105,595	2,682,891	1.53	66
UHG	5,195,348	3,371,563	1.54	66.9

(b)

Material Classification	Loam			
	tonnage	volume (m^3)	density (t/m^3)	loam percent (vol. %)
CW	119	78	1.53	12.5
MW	2,204	1,641	1.34	6
LG	192,125	142,266	1.35	20
MG	992,340	731,094	1.36	14
HG	497,371	371,172	1.34	5
VHG	80,994	60,938	1.33	2
UHG	24,526	18,203	1.35	0.4

(c)

Material Classification	Calcrete			
	tonnage	volume (m^3)	density (t/m^3)	calcrete percent (vol. %)
CW	706	469	1.51	75
MW	19,217	12,188	1.58	42
LG	259,167	170,625	1.52	23
MG	2,145,794	1,408,672	1.52	26
HG	3,589,963	2,330,859	1.54	32
VHG	2,062,836	1,313,594	1.57	32
UHG	2,627,973	1,647,188	1.60	32.7

The source terms were provided as a net mass release per unit surface area over the lifetime of each stockpile specific to the schedule outlined in the tables in this section

(Tables 4.3, 4.6 and 4.7). For any given rain event the total loading is obtained by multiplying the loading per square metre by the applicable surface area. The sole differentiating factor between the base case and the upper bound model is the assumed depth of influence of evaporation in terms of concentrating solutes on the exposed surfaces of the stockpiles. The upper bound case, which does not assume any limits to the influence of evaporation, is very much an overestimation of the solute loading. The base case loading estimates are summarized in Tables 4.9 to 4.11 and the upper bound estimates are located in Appendix D.

4.2 Solute Release

SRK Consulting conducted an analysis of the potential for solute release from incident rainfall and runoff (Appendix B, Chapter 3). Rainfall intensity values as a function of storm duration and the recurrence interval are shown in Table 4.1. Total rainfall can be calculated from Table 4.1 by multiplying the rainfall intensity by the duration of the event. SRK used sequential bottle roll tests and column tests (Appendix B) to determine the amount of solutes that may be released from the mined materials. The mass release was used to infer the mass of solutes that may accumulate on the external surfaces of the stockpiles between consecutive precipitation events that could generate runoff. The tests showed a rapid decrease in solute concentrations for consecutive leach steps indicating a finite capacity of the materials to release solutes. Most of the solutes were removed after the first leach event and by the third event in excess of 87.5% of the solutes had been removed. The climate data imply that surfaces could be flushed two or three times a year (using a maximum observed dry period of 120 days) indicating that most of the solutes would be removed within one year of placement. Therefore it was assumed that any given surface was active only in the year in which it was placed on the stockpile.

4.3 Material Properties

At the time of the initial sampling for the SRK Consulting investigation, the various lithological categories and cut-off grades had not yet been established. In the assessment in Appendix B, stockpiles were categorized into four categories very high grade (VHG), high grade (HG), medium grade (MG) and low grade (LG). Cameco Corporation has added an ultra-high grade (UHG) category to the grade list and has further classified a high smectite and low smectite stockpile for all grades except the low grade category.

The approach followed in this stockpile assessment follows that of the SRK Consulting method (Appendix B) but it applies the highest uranium release rate to both the very high grade (VHG) and ultra-high grade (UHG) categories. Table 4.2 lists the mass and volume properties of the various ore grades as a function of the lithologic type, clay-quartz, loam or calcrete.

Table 4.3 Estimated Total Ore Stockpile Volumes[*] (m^3)

Closing Inventory	UHG HS	UHG LS	VHG HS	VHG LS	HG HS	HG LS	MG HS	MG LS	LG
footprint (m^2)**	71,852	159,393	41,860	108,490	95,341	234,790	281,022	234,789	315,178
Avg. U_3O_8 grade (ppm)	2499	2670	1709	1713	1233	1239	826	835	582
Year									
-1	72,226	466,453	52,031	270,585	147,275	413,742	273,949	344,043	252,226
0	268,556	1,420,531	179,843	664,804	339,757	906,486	554,152	930,593	673,501
1	422,836	1,263,427	262,867	1,015,331	701,495	1,522,280	907,812	1,324,005	1,145,497
2	88,684	656,130	102,902	1,210,074	908,240	1,740,257	1,080,003	1,446,347	1,321,620
3	80,730	201,344	150,528	1,239,973	797,654	1,993,734	1,218,290	1,561,825	1,477,077
4	156,471	121,282	223,196	792,707	959,071	1,893,444	1,406,802	1,673,400	1,662,719
5	119,106	107,832	153,717	395,376	1,168,691	1,837,287	1,654,817	1,797,307	1,889,334
6	54,256	208,466	71,858	352,928	1,063,702	1,691,032	1,815,773	1,950,637	2,105,692
7	5,735	108,099	30,527	189,581	736,524	1,716,239	1,931,424	2,133,792	2,219,995
8	29,716	101,038	93,492	181,033	592,525	1,466,361	2,087,846	2,265,141	2,409,717
9	3,220	33,213	42,559	87,758	223,433	1,258,085	2,205,204	2,471,515	2,655,371
10	475	5,223	17,141	63,809	98,319	797,912	2,052,686	2,790,241	2,937,312
11	2,954	8,219	14,899	52,766	94,637	299,619	1,741,664	2,938,402	3,115,199
12							1,289,922	2,271,066	3,115,199
13							739,572	1,220,562	3,115,199
14							273,949	85,332	3,115,199
15									3,115,199
16									3,115,199
17									3,115,199
18									3,115,199
19									3,115,199
20									

* stockpile volumes assume weighted average densities of UHG – 1.56 tonnes/m^3, VHG - 1.54 tonnes /m^3, HG - 1.52 tonnes/m^3, MG - 1.50 tonnes /m^3 and LG - 1.49 tonnes /m^3

** footprint given is the maximum surface area size of a stockpile at any point in its lifetime

4.4 Stockpile Placement Schedule

Table 4.3 contains the estimated ore stockpile volumes as a function of project year. The footprint is conservatively estimated to be the maximum planned total area of exposed surface throughout that particular stockpile’s existence. This is a conservative estimate as some of the stockpiles are smaller in size throughout much of their lifetime thereby presenting a much smaller exposed surface. In addition, year to year changes in stockpile size were normalized against the entire footprint thereby maximizing the exposed surface area and the resulting predicted solute concentrations.

4.5 Solubility Controls

The dissolution of salts from the stockpile material is controlled by the solubility limits of each particular salt. SRK Consulting (Appendix B) prepared a summary of solubility controls for runoff water quality estimates, which is duplicated here (Table 4.4). Solubility controls are based on well-known mineral phases that are universally present at the Yeelirrie site and are applicable to the pH conditions that exist at Yeelirrie. Controlling phases were chosen based on results from geochemical modelling software which accounted for their solubility and stability over the pH range 7 to 9 and in the temperature range 20 to 40°C. The concentration values chosen in Table 4.4 are conservative and are consistent with an upper bound approach to stockpile runoff solute concentrations.

It is likely that in reality several additional phases could operate as solubility controls in the evaporative environment of Yeelirrie, for example, sodium chloride and sodium sulfate for sodium and chlorine, potassium chloride and magnesium sulfate for potassium and magnesium, lead and barium selenates for selenium, strontium and calcium molybdates for molybdenum and calcium and iron arsenates for arsenic. Solubility controls were not imposed on these constituents in the solute loadings.

Mineral phases that were chosen for limiting the solubility of certain constituents are calcium sulfate (gypsum), gibbsite (aluminum) calcium carbonate (calcite), strontium sulfate (celestite), as well as carnotite for uranium and vanadium.

4.6 Runoff

The Green-Ampt method of infiltration modelling provides an explicit account of relevant soil properties and their effects on infiltration rates and remains in wide use for runoff calculations (Green and Ampt, 1911).

The Green-Ampt infiltration equation is an analytical solution to the Richards equation and therefore model parameters correspond to measureable soil properties. The downward movement of the wetting front is a result of gravitational forces as well as the matric suction of the soil and the head imposed from surface ponding. A brief explanation of the procedure is provided in Appendix B as well as the properties assumed to represent the Yeelirrie site (Table 4.5).

Table 4.4 Solubility Controls applied to Runoff Water Quality Estimates

Constituent	Concentration (mg/L)	Mineral Phase
Al	0.68	Al hydroxides
As	---	no solubility control used
Ca	694	calcite, gypsum
Cl	---	no solubility control used
K	---	no solubility control used
Mg	---	no solubility control used
Mo	---	no solubility control used
Na	---	no solubility control used
Sr	23	celestite, strontianite
Se	---	no solubility control used
U	2.1	carnotite
V	1.4	carnotite
Ra-226	---	no solubility control used

Table 4.5 Assumed Soil Properties for Green-Ampt Parameters

soil type	porosity	effective porosity	suction head (mm)	Hydraulic conductivity (mm/hr)
silty clayey loam UHG/VHG/HG	0.47	0.43	273	1.0
sandy clay MG/LG/MW/CW	0.43	0.32	239	0.6

4.7 Solute Loadings

Tables 4.7 and 4.8 contain the estimated stockpile volumes for mineralized and clean waste as a function of time over the entire operational lifetime of the Yeelirrie mine. The solute loadings for these stockpiles were calculated in a similar manner as the ore stockpiles. The stockpiles, there are 24 in total, were treated together and the solubility controls applied in a manner similar to the ore stockpiles. The solute release capacities

Table 4.6 Estimated Stockpile Solute Release Capacity*

Constituents	units	UHG/ VHG	HG	MG	LG	Waste
Ag	mg/kg	0.033	0.03	0.029	0.033	0.03
Al	mg/kg	0.334	0.245	0.163	0.595	0.177
As	mg/kg	0.107	0.041	0.042	0.07	0.033
B	mg/kg	9.51	2.98	7.37	6.21	8.86
Ba	mg/kg	0.21	0.351	0.189	0.098	0.099
Be	mg/kg	0.03	0.03	0.036	0.033	0.03
Bi	mg/kg	0.033	0.03	0.027	0.033	0.03
Br	mg/kg	18.6	10.8	12.1	7.2	9
Ca	mg/kg	780	139	1172	160	124
Cd	mg/kg	0.04	0.024	0.041	0.032	0.03
Cl	mg/kg	2172	539	2098	2031	2432
Co	mg/kg	0.031	0.03	0.027	0.033	0.03
Cr	mg/kg	0.035	0.032	0.029	0.052	0.03
Cu	mg/kg	0.054	0.084	0.041	0.04	0.035
F	mg/kg	10.686	10.6	12.1	12.2	10.5
Fe	mg/kg	0.623	0.6	0.582	1.068	0.6
Hg	mg/kg	0.002	0.002	0.001	0.001	0.001
K	mg/kg	486	117	387	353	363
Li	mg/kg	0.033	0.03	0.029	0.037	0.03
Mg	mg/kg	288	123	346	204	206
Mn	mg/kg	0.086	0.034	0.031	0.033	0.102
Mo	mg/kg	0.251	0.177	0.22	0.342	0.175
Na	mg/kg	2591	1362	1913	1990	1922
Ni	mg/kg	0.036	0.034	0.044	0.033	0.03
NO_3	mg/kg	148	21.3	41.1	17.2	79.9
P	mg/kg	3.824	2.295	2.691	1.2	0.6
Pb	mg/kg	0.03	0.03	0.027	0.033	0.03
Sb	mg/kg	0.033	0.03	0.029	0.033	0.03
Se	mg/kg	0.068	0.034	0.053	0.05	0.059
Si	mg/kg	144	388	109	92	141
Sn	mg/kg	0.044	0.336	0.031	0.033	0.03
SO_4	mg/kg	4150	753	4216	996	1263
Sr	mg/kg	7.56	1.52	10.5	2.91	2.28
Tl	mg/kg	0.703	0.032	0.498	0.209	0.516
U	mg/kg	4.5	3.84	1.37	0.745	0.294
V	mg/kg	1.23	0.139	0.56	1.12	0.624
Zn	mg/kg	0.843	0.194	0.711	0.677	0.78
Ra-226	Bq/kg	0.657	0.008	0.103	0.019	0

* from Appendix B (Table 3.6)

were generated by SRK from the results of the column and bottle roll tests and represent the solute mass per kilogram of stockpile material (Table 4.6).

Solute loadings utilize the solute release capacities combined with rainfall data and stockpile parameters. Base case solute loadings are shown in Tables 4.9 to 4.11. Solute loadings vary by material type and as a function of time as stockpile sizes vary over time. Loadings are provided per unit area so that total loading can be determined by multiplying the loading with the active area for any given time.

Solute loadings vary according to the storm intensity and duration because the initial abstraction, and thus the proportion of the solute loadings that are returned to the underlying soils, varies by event (Table 4.1). In order to allow an assessment of water quality for any combination of events, it was necessary to generate solute loadings for all the events given in the aforementioned tables.

A Base Case and Upper Bound Case approach were adopted to assess solute loadings. The base case (Tables 4.9 to 4.11) assumed the depth of influence for materials was a maximum of 0.5 m. The upper bound case assumed the total depth of influence was 2 m (Appendix D). For both the base case and upper bound cases it is assumed that materials are active only in the year that they have been placed, which is supported by climate data. In addition, because the solute release capacity is finite and climate data suggests that on average surfaces are flushed three times a year (maximum dry period of 120 days) most solutes are removed within a year and certainly do not deliver the same solute loadings as newly placed material.

In summary, the loading estimates are provided in Tables 4.9 to 4.11 for several key elements. The loadings provided are valid for active surfaces for the first event of the given description (ARI and duration). Loadings in runoff from subsequent events from the same surface would be 50% or less and most solute releases would be depleted to very low levels after the second or third event.

Table 4.7 Estimated Total Clean Waste Stockpile Sizes (tonnes)

	CW01	CW02	CW03	CW04	CW05	CW06	CW07	CW08	CW09	CW10	CW11	CW12
Footprint (m^2)	35,525	88,259	78,958	113,526	150,169	112,275	115,296	102,229	61,492	29,249	169,758	36,615
Year												
-1	386,894	883,571							22,039			
0	398,944	883,571						692,443	620,892			
1	398,944	883,571				669,977	1,184,338	1,122,471	620,892			
2	398,944	883,571			247,239	1,240,279	1,184,338	1,122,471	620,892			
3	398,944	883,571			993,757	1,269,066	1,184,338	1,122,471	620,892			
4	398,944	883,571		155,850	1,540,244	1,269,066	1,184,338	1,122,471	620,892			
5	398,944	883,571		810,078	1,563,063	1,269,066	1,184,338	1,122,471	620,892			
6	25,163	883,571	97,566	1,212,683	1,563,063	1,269,066	1,184,338	1,122,471	620,892			
7			1,274,307	1,219,944	1,563,063	1,269,066	1,184,338	967,981	598,854			
8			1,434,523	1,219,944	1,563,063	599,089	505,786	430,028				530,097
9			1,434,523	1,219,944	632,658	28,787					1,031,027	777,506
10		220,314	1,113,413	7,261							2,082,710	777,506
11		389,966								302,605	2,082,710	353,179
12		389,966								302,605	2,076,109	247,409
13		389,966								302,605	2,076,109	247,409
14		389,966								302,605	2,076,109	247,409
15		389,966								302,605	2,076,109	247,409
16		169,653								302,605	43,831	
17												

Table 4.8 Schedule and Estimate of Total Mineralized Waste (MW) Stockpile Sizes (tonnes)

	MW01	MW02	MW03	MW04	MW05	MW06	MW07	MW08	MW09	MW10	MW11	MW12
Maximum Footprint (m^2)	156,173	123,802	75,801	180,669	199,046	184,347	143,332	109,768	158,257	30,239	147,767	46,256
Year												
-1	1,507,015	1,160,072							58,485			
0	1,636,500	1,160,072						730,730	1,616,737			
1	1,636,500	1,160,072				578,204	1,566,897	1,209,218	1,616,737			
2	1,636,500	1,160,072			141,710	1,732,196	1,566,897	1,209,218	1,616,737			
3	1,636,500	1,160,072			1,060,818	1,915,002	1,566,897	1,209,218	1,616,737			
4	1,636,500	1,160,072		164,801	1,858,608	1,915,002	1,566,897	1,209,218	1,616,737			
5	1,636,500	1,160,072		1,393,975	2,037,207	1,915,002	1,566,897	1,209,218	1,616,737			
6	1,316,231	1,160,072	92,581	2,675,408	2,037,207	1,915,002	1,566,897	1,209,218	1,616,737			
7	398,323	1,160,072	1,328,705	2,743,145	2,037,207	1,915,002	1,566,897	1,209,218	1,616,737			
8			1,607,224	2,743,145	2,037,207	1,915,002	1,566,897	598,014	1,558,253			736,959
9			1,607,224	2,743,145	2,037,207	1,336,799	1,386,359	478,488			635,437	952,195
10		332,387	1,607,224	2,743,145	1,895,497	856,088					1,277,092	952,195
11		644,771	1,607,224	1,997,703	178,599					199,789	1,277,092	952,195
12		644,771	1,514,643	606,162						199,789	1,277,092	952,195
13		644,771	1,514,643	606,162						199,789	1,277,092	952,195
14		644,771	1,514,643	606,162						199,789	1,277,092	952,195
15		644,771	1,514,643	606,162						199,789	1,277,092	952,195
16		644,771								199,789	1,277,092	573,000
17		312,385								199,789	567,408	
18		312,385								199,789	567,408	
19		312,385								199,789	567,408	
20												

Table 4.9 Summary of Estimated Solute Loadings for Selected Rain Events for the Base Case (ARI = 5 years)

Duration (hours)	Stockpile	As mg/m^2	Ca mg/m^2	Cl mg/m^2	K mg/m^2	Mg mg/m^2	Mo mg/m^2	Sr mg/m^2	Se mg/m^2	U mg/m^2	V mg/m^2	^{226}Ra Bq/m^2
1	UHG hs	2.69E+02	7.43E+03	5.47E+06	1.22E+06	7.25E+05	6.32E+02	2.46E+02	1.71E+02	2.25E+01	1.50E+01	1.65E+03
	UHG ls	1.73E+02	7.43E+03	3.51E+06	7.85E+05	4.65E+05	4.05E+02	1.10E+02	1.10E+02	2.25E+01	1.50E+01	1.06E+03
	VHG hs	3.37E+02	7.43E+03	6.83E+06	1.53E+06	9.06E+05	7.90E+02	2.14E+02	2.14E+02	2.25E+01	1.50E+01	2.07E+03
	VHG ls	2.55E+02	7.43E+03	5.18E+06	1.16E+06	6.87E+05	5.99E+02	1.62E+02	1.62E+02	2.25E+01	1.50E+01	1.57E+03
	HG hs	1.28E+02	7.43E+03	1.68E+06	3.64E+05	3.83E+05	5.51E+02	2.46E+02	1.06E+02	2.25E+01	1.50E+01	2.49E+01
	HG ls	1.11E+02	7.43E+03	1.46E+06	3.17E+05	3.33E+05	4.79E+02	2.46E+02	9.21E+01	2.25E+01	1.50E+01	2.17E+01
	MG hs	2.75E+02	8.95E+03	1.38E+07	2.54E+06	2.27E+06	1.44E+03	2.97E+02	3.47E+02	2.71E+01	1.81E+01	6.75E+02
	MG ls	3.35E+02	8.95E+03	1.67E+07	3.08E+06	2.76E+06	1.75E+03	2.97E+02	4.22E+02	2.71E+01	1.81E+01	8.21E+02
	LG	5.43E+02	8.95E+03	1.58E+07	2.74E+06	1.58E+06	2.65E+03	2.97E+02	3.88E+02	2.71E+01	1.81E+01	1.47E+02
	MW/CW	6.04E+08	8.95E+03	4.45E+13	6.64E+12	2.80E+05	3.20E+09	2.97E+02	1.08E+09	2.71E+01	1.81E+01	0.00E+00
6	UHG hs	2.90E+02	7.98E+03	5.88E+06	1.32E+06	7.79E+05	6.79E+02	2.65E+02	1.84E+02	2.42E+01	1.61E+01	1.78E+03
	UHG ls	1.86E+02	7.98E+03	3.77E+06	8.43E+05	5.00E+05	4.36E+02	1.18E+02	1.18E+02	2.42E+01	1.61E+01	1.14E+03
	VHG hs	3.62E+02	7.98E+03	7.34E+06	1.64E+06	9.74E+05	8.49E+02	2.30E+02	2.30E+02	2.42E+01	1.61E+01	2.22E+03
	VHG ls	2.74E+02	7.98E+03	5.57E+06	1.25E+06	7.39E+05	6.44E+02	1.74E+02	1.74E+02	2.42E+01	1.61E+01	1.69E+03
	HG hs	1.37E+02	7.98E+03	1.80E+06	3.92E+05	4.12E+05	5.93E+02	2.65E+02	1.14E+02	2.42E+01	1.61E+01	2.68E+01
	HG ls	1.19E+02	7.98E+03	1.57E+06	3.40E+05	3.58E+05	5.15E+02	2.65E+02	9.89E+01	2.42E+01	1.61E+01	2.33E+01
	MG hs	2.27E+02	1.41E+04	1.14E+07	2.10E+06	1.87E+06	1.19E+03	4.67E+02	2.87E+02	4.26E+01	2.84E+01	5.58E+02
	MG ls	2.76E+02	1.41E+04	1.38E+07	2.55E+06	2.28E+06	1.45E+03	4.67E+02	3.49E+02	4.26E+01	2.84E+01	6.78E+02
	LG	4.49E+02	1.41E+04	1.30E+07	2.26E+06	1.31E+06	2.19E+03	4.67E+02	3.21E+02	4.26E+01	2.84E+01	1.22E+02
	MW/CW	4.99E+08	1.41E+04	3.68E+13	5.49E+12	2.15E+05	2.65E+09	4.67E+02	8.92E+08	4.26E+01	2.84E+01	0.00E+00
48	UHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	UHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG hs	3.16E+01	4.16E+03	1.58E+06	2.91E+05	2.60E+05	1.65E+02	1.38E+02	3.98E+01	1.26E+01	8.40E+00	7.74E+01
	MG ls	3.84E+01	4.16E+03	1.92E+06	3.53E+05	3.16E+05	2.01E+02	1.38E+02	4.84E+01	1.26E+01	8.40E+00	9.41E+01
	LG	6.23E+01	4.16E+03	1.81E+06	3.14E+05	1.81E+05	3.04E+02	1.38E+02	4.45E+01	1.26E+01	8.40E+00	1.69E+01
	MW/CW	6.92E+07	4.16E+03	5.10E+12	7.61E+11	2.80E+04	3.67E+08	1.38E+02	1.24E+08	1.26E+01	8.40E+00	0.00E+00
72	UHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	UHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	LG	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MW/CW	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 4.10 Summary of Estimated Solute Loadings for Selected Rain Events for the Base Case (ARI = 20 years)

Duration (hours)	Stockpile	As mg/m^2	Ca mg/m^2	Cl mg/m^2	K mg/m^2	Mg mg/m^2	Mo mg/m^2	Sr mg/m^2	Se mg/m^2	U mg/m^2	V mg/m^2	^{226}Ra Bq/m^2
1	UHG hs	3.36E+02	1.33E+04	6.81E+06	1.52E+06	9.03E+05	7.87E+02	4.39E+02	2.13E+02	4.01E+01	2.67E+01	2.06E+03
	UHG ls	2.15E+02	1.33E+04	4.37E+06	9.77E+05	5.79E+05	5.05E+02	4.39E+02	1.37E+02	4.01E+01	2.67E+01	1.32E+03
	VHG hs	4.19E+02	1.33E+04	8.51E+06	1.90E+06	1.13E+06	9.84E+02	4.39E+02	2.66E+02	4.01E+01	2.67E+01	2.57E+03
	VHG ls	3.18E+02	1.33E+04	6.46E+06	1.44E+06	8.56E+05	7.46E+02	4.39E+02	2.02E+02	4.01E+01	2.67E+01	1.95E+03
	HG hs	1.59E+02	1.33E+04	2.09E+06	4.54E+05	4.77E+05	6.87E+02	4.39E+02	1.32E+02	4.01E+01	2.67E+01	3.10E+01
	HG ls	1.38E+02	1.33E+04	1.82E+06	3.95E+05	4.15E+05	5.97E+02	4.39E+02	1.15E+02	4.01E+01	2.67E+01	2.70E+01
	MG hs	3.07E+02	1.43E+04	1.53E+07	2.83E+06	2.53E+06	1.61E+03	4.74E+02	3.87E+02	4.33E+01	2.88E+01	7.52E+02
	MG ls	3.73E+02	1.43E+04	1.86E+07	3.44E+06	3.07E+06	1.95E+03	4.74E+02	4.70E+02	4.33E+01	2.88E+01	9.14E+02
	LG	6.05E+02	1.43E+04	1.76E+07	3.05E+06	1.76E+06	2.96E+03	4.74E+02	4.32E+02	4.33E+01	2.88E+01	1.64E+02
	MW/CW	6.73E+08	1.43E+04	4.96E+13	7.40E+12	2.80E+05	3.57E+09	4.74E+02	1.20E+09	4.33E+01	2.88E+01	0.00E+00
6	UHG hs	3.02E+02	2.45E+04	6.13E+06	1.37E+06	8.13E+05	7.08E+02	8.12E+02	1.92E+02	7.41E+01	4.94E+01	1.85E+03
	UHG ls	1.94E+02	2.45E+04	3.93E+06	8.80E+05	5.21E+05	4.54E+02	8.12E+02	1.23E+02	7.41E+01	4.94E+01	1.19E+03
	VHG hs	3.77E+02	2.45E+04	7.66E+06	1.71E+06	1.02E+06	8.85E+02	8.12E+02	2.40E+02	7.41E+01	4.94E+01	2.32E+03
	VHG ls	2.86E+02	2.45E+04	5.81E+06	1.30E+06	7.71E+05	6.72E+02	8.12E+02	1.82E+02	7.41E+01	4.94E+01	1.76E+03
	HG hs	1.43E+02	2.45E+04	1.88E+06	4.09E+05	4.30E+05	6.18E+02	8.12E+02	1.19E+02	7.41E+01	4.94E+01	2.79E+01
	HG ls	1.24E+02	2.45E+04	1.64E+06	3.55E+05	3.73E+05	5.37E+02	8.12E+02	1.03E+02	7.41E+01	4.94E+01	2.43E+01
	MG hs	2.92E+02	2.80E+04	1.46E+07	2.69E+06	2.41E+06	1.53E+03	9.27E+02	3.69E+02	8.46E+01	5.64E+01	7.17E+02
	MG ls	3.55E+02	2.80E+04	1.77E+07	3.27E+06	2.93E+06	1.86E+03	9.27E+02	4.48E+02	8.46E+01	5.64E+01	8.71E+02
	LG	5.77E+02	2.80E+04	1.67E+07	2.91E+06	1.68E+06	2.82E+03	9.27E+02	4.12E+02	8.46E+01	5.64E+01	1.57E+02
	MW/CW	6.41E+08	2.80E+04	4.72E+13	7.05E+12	2.51E+05	3.40E+09	9.27E+02	1.15E+09	8.46E+01	5.64E+01	0.00E+00
48	UHG hs	1.62E+02	2.98E+04	3.29E+06	7.36E+05	4.36E+05	3.80E+02	9.87E+02	1.03E+02	9.01E+01	6.01E+01	9.94E+02
	UHG ls	1.04E+02	2.98E+04	2.11E+06	4.72E+05	2.80E+05	2.44E+02	9.87E+02	6.60E+01	9.01E+01	6.01E+01	6.38E+02
	VHG hs	2.02E+02	2.98E+04	4.11E+06	9.19E+05	5.45E+05	4.75E+02	9.87E+02	1.29E+02	9.01E+01	6.01E+01	1.24E+03
	VHG ls	1.54E+02	2.98E+04	3.12E+06	6.97E+05	4.13E+05	3.60E+02	9.87E+02	9.76E+01	9.01E+01	6.01E+01	9.43E+02
	HG hs	7.68E+01	2.98E+04	1.01E+06	2.19E+05	2.30E+05	3.32E+02	9.87E+02	6.37E+01	9.01E+01	6.01E+01	1.50E+01
	HG ls	6.67E+01	2.98E+04	8.77E+05	1.90E+05	2.00E+05	2.88E+02	9.87E+02	5.53E+01	9.01E+01	6.01E+01	1.30E+01
	MG hs	2.50E+02	5.43E+04	1.25E+07	2.31E+06	2.06E+06	1.31E+03	1.80E+03	3.16E+02	1.64E+02	1.09E+02	6.14E+02
	MG ls	3.04E+02	5.43E+04	1.52E+07	2.80E+06	2.51E+06	1.59E+03	1.80E+03	3.84E+02	1.64E+02	1.09E+02	7.46E+02
	LG	4.94E+02	5.43E+04	1.43E+07	2.49E+06	1.44E+06	2.41E+03	1.80E+03	3.53E+02	1.64E+02	1.09E+02	1.34E+02
	MW/CW	5.49E+08	5.43E+04	4.04E+13	6.04E+12	2.15E+05	2.91E+09	1.80E+03	9.81E+08	1.64E+02	1.09E+02	0.00E+00
72	UHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	UHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG hs	2.17E+02	5.26E+04	1.09E+07	2.00E+06	1.79E+06	1.14E+03	1.74E+03	2.74E+02	1.59E+02	1.06E+02	5.33E+02
	MG ls	2.64E+02	5.26E+04	1.32E+07	2.44E+06	2.18E+06	1.38E+03	1.74E+03	3.33E+02	1.59E+02	1.06E+02	6.48E+02
	LG	4.29E+02	5.26E+04	1.24E+07	2.16E+06	1.25E+06	2.10E+03	1.74E+03	3.06E+02	1.59E+02	1.06E+02	1.16E+02
	MW/CW	4.77E+08	5.26E+04	3.51E+13	5.25E+12	1.87E+05	2.53E+09	1.74E+03	8.53E+08	1.59E+02	1.06E+02	0.00E+00

Table 4.11 Summary of Estimated Solute Loadings for Selected Rain Events for the Base Case (ARI = 100 years)

Duration (hours)	Stockpile	As mg/m^2	Ca mg/m^2	Cl mg/m^2	K mg/m^2	Mg mg/m^2	Mo mg/m^2	Sr mg/m^2	Se mg/m^2	U mg/m^2	V mg/m^2	^{226}Ra Bq/m^2
1	UHG hs	3.72E+02	2.35E+04	7.56E+06	1.69E+06	1.00E+06	8.73E+02	7.80E+02	2.37E+02	7.12E+01	4.75E+01	2.29E+03
	UHG ls	2.39E+02	2.35E+04	4.85E+06	1.08E+06	6.42E+05	5.60E+02	7.80E+02	1.52E+02	7.12E+01	4.75E+01	1.47E+03
	VHG hs	4.65E+02	2.35E+04	9.44E+06	2.11E+06	1.25E+06	1.09E+03	7.80E+02	2.96E+02	7.12E+01	4.75E+01	2.86E+03
	VHG ls	3.53E+02	2.35E+04	7.16E+06	1.60E+06	9.50E+05	8.28E+02	7.80E+02	2.24E+02	7.12E+01	4.75E+01	2.17E+03
	HG hs	1.76E+02	2.35E+04	2.32E+06	5.04E+05	5.29E+05	7.62E+02	7.80E+02	1.46E+02	7.12E+01	4.75E+01	3.44E+01
	HG ls	1.53E+02	2.35E+04	2.02E+06	4.38E+05	4.60E+05	6.62E+02	7.80E+02	1.27E+02	7.12E+01	4.75E+01	2.99E+01
	MG hs	3.24E+02	2.42E+04	1.62E+07	2.98E+06	2.67E+06	1.70E+03	8.00E+02	4.09E+02	7.31E+01	4.87E+01	7.94E+02
	MG ls	3.94E+02	2.42E+04	1.97E+07	3.63E+06	3.24E+06	2.06E+03	8.00E+02	4.97E+02	7.31E+01	4.87E+01	9.65E+02
	LG	6.39E+02	2.42E+04	1.85E+07	3.22E+06	1.86E+06	3.12E+03	8.00E+02	4.57E+02	7.31E+01	4.87E+01	1.73E+02
	MW/CW	7.10E+08	2.42E+04	5.24E+13	7.81E+12	0.00E+00	3.77E+09	8.00E+02	1.27E+09	7.31E+01	4.87E+01	0.00E+00
6	UHG hs	3.65E+02	5.02E+04	7.41E+06	1.66E+06	9.82E+05	8.56E+02	1.67E+03	2.32E+02	1.52E+02	1.01E+02	2.24E+03
	UHG ls	2.34E+02	5.02E+04	4.75E+06	1.06E+06	6.30E+05	5.49E+02	1.67E+03	1.49E+02	1.52E+02	1.01E+02	1.44E+03
	VHG hs	4.56E+02	5.02E+04	9.26E+06	2.07E+06	1.23E+06	1.07E+03	1.67E+03	2.90E+02	1.52E+02	1.01E+02	2.80E+03
	VHG ls	3.46E+02	5.02E+04	7.02E+06	1.57E+06	9.31E+05	8.12E+02	1.67E+03	2.20E+02	1.52E+02	1.01E+02	2.12E+03
	HG hs	1.73E+02	5.02E+04	2.28E+06	4.94E+05	5.19E+05	7.47E+02	1.67E+03	1.44E+02	1.52E+02	1.01E+02	3.38E+01
	HG ls	1.50E+02	5.02E+04	1.98E+06	4.29E+05	4.51E+05	6.49E+02	1.67E+03	1.25E+02	1.52E+02	1.01E+02	2.94E+01
	MG hs	3.21E+02	5.21E+04	1.60E+07	2.95E+06	2.64E+06	1.68E+03	1.73E+03	4.04E+02	1.58E+02	1.05E+02	7.86E+02
	MG ls	3.90E+02	5.21E+04	1.95E+07	3.59E+06	3.21E+06	2.04E+03	1.73E+03	4.92E+02	1.58E+02	1.05E+02	9.55E+02
	LG	6.33E+02	5.21E+04	1.84E+07	3.19E+06	1.84E+06	3.09E+03	1.73E+03	4.52E+02	1.58E+02	1.05E+02	1.72E+02
	MW/CW	7.03E+08	5.21E+04	5.18E+13	7.73E+12	0.00E+00	3.73E+09	1.73E+03	1.26E+09	1.58E+02	1.05E+02	0.00E+00
48	UHG hs	3.35E+02	1.05E+05	6.80E+06	1.52E+06	9.02E+05	7.86E+02	3.46E+03	2.13E+02	3.16E+02	2.11E+02	2.06E+03
	UHG ls	2.15E+02	1.05E+05	4.36E+06	9.76E+05	5.79E+05	5.04E+02	3.46E+03	1.37E+02	3.16E+02	2.11E+02	1.32E+03
	VHG hs	4.19E+02	1.05E+05	8.50E+06	1.90E+06	1.13E+06	9.83E+02	3.46E+03	2.66E+02	3.16E+02	2.11E+02	2.57E+03
	VHG ls	3.18E+02	1.05E+05	6.45E+06	1.44E+06	8.55E+05	7.45E+02	3.46E+03	2.02E+02	3.16E+02	2.11E+02	1.95E+03
	HG hs	1.59E+02	1.05E+05	2.09E+06	4.54E+05	4.77E+05	6.86E+02	3.46E+03	1.32E+02	3.16E+02	2.11E+02	3.10E+01
	HG ls	1.38E+02	1.05E+05	1.82E+06	3.94E+05	4.14E+05	5.96E+02	3.46E+03	1.15E+02	3.16E+02	2.11E+02	2.70E+01
	MG hs	3.10E+02	1.14E+05	1.55E+07	2.85E+06	2.55E+06	1.62E+03	3.77E+03	3.91E+02	3.45E+02	2.30E+02	7.59E+02
	MG ls	3.76E+02	1.14E+05	1.88E+07	3.47E+06	3.10E+06	1.97E+03	3.77E+03	4.75E+02	3.45E+02	2.30E+02	9.23E+02
	LG	6.11E+02	1.14E+05	1.77E+07	3.08E+06	1.78E+06	2.98E+03	3.77E+03	4.36E+02	3.45E+02	2.30E+02	1.66E+02
	MW/CW	6.79E+08	1.14E+05	5.00E+13	7.47E+12	0.00E+00	3.60E+09	3.77E+03	1.21E+09	3.45E+02	2.30E+02	0.00E+00
72	UHG hs	3.12E+02	1.09E+05	6.32E+06	1.42E+06	8.39E+05	7.31E+02	3.60E+03	1.98E+02	3.28E+02	2.19E+02	1.91E+03
	UHG ls	2.00E+02	1.09E+05	4.06E+06	9.08E+05	5.38E+05	4.69E+02	3.60E+03	1.27E+02	3.28E+02	2.19E+02	1.23E+03
	VHG hs	3.89E+02	1.09E+05	7.90E+06	1.77E+06	1.05E+06	9.13E+02	3.60E+03	2.47E+02	3.28E+02	2.19E+02	2.39E+03
	VHG ls	2.95E+02	1.09E+05	6.00E+06	1.34E+06	7.95E+05	6.93E+02	3.60E+03	1.88E+02	3.28E+02	2.19E+02	1.81E+03
	HG hs	1.48E+02	1.09E+05	1.94E+06	4.22E+05	4.43E+05	6.38E+02	3.60E+03	1.23E+02	3.28E+02	2.19E+02	2.88E+01
	HG ls	1.28E+02	1.09E+05	1.69E+06	3.66E+05	3.85E+05	5.54E+02	3.60E+03	1.06E+02	3.28E+02	2.19E+02	2.51E+01
	MG hs	3.02E+02	1.24E+05	1.51E+07	2.78E+06	2.49E+06	1.58E+03	4.11E+03	3.81E+02	3.75E+02	2.50E+02	7.41E+02
	MG ls	3.67E+02	1.24E+05	1.83E+07	3.38E+06	3.02E+06	1.92E+03	4.11E+03	4.63E+02	3.75E+02	2.50E+02	9.00E+02
	LG	5.96E+02	1.24E+05	1.73E+07	3.01E+06	1.74E+06	2.91E+03	4.11E+03	4.26E+02	3.75E+02	2.50E+02	1.62E+02
	MW/CW	6.63E+08	1.24E+05	4.88E+13	7.29E+12	0.00E+00	3.51E+09	4.11E+03	1.18E+09	3.75E+02	2.50E+02	0.00E+00

4.8 Roads and Hardstands

Appendix B, Section 3.3 addresses the accumulated salts that would result from spraying water for dust suppression on site. The origin of the salts is expected to be from the spray water used, which will originate from some combination of supply water wells and recycle water. A water balance was prepared for the Yeelirrie site ("Numerical groundwater flow and solute transport model of the Yeelirrie uranium deposit"), which was used to estimate the general use water quality. In this calculation, we follow the approach used by SRK Consulting and use the dust suppression water application rate of 1 L/m^2/day.

Wetting of the road and other surfaces with spray water is expected to result in the accumulation of salts on the surfaces. The amount of salts that accumulate would depend on the frequency of water application and the salt content of the spray water.

Similar to the stockpile areas, the accumulated salts near the surface of the roads and hardstands are expected to dissolve in runoff and report to surface water during rainfall events. Therefore, a calculation approach similar to that described for the stockpiles, but with a few modifications to account for the ongoing salt accumulation, was adopted to estimate the potential loading from the roads. The steps used to calculate the total available solute available to runoff and the solute loadings are presented in Appendix B (Section 3.3 and accompanying Appendix 2 of that document).

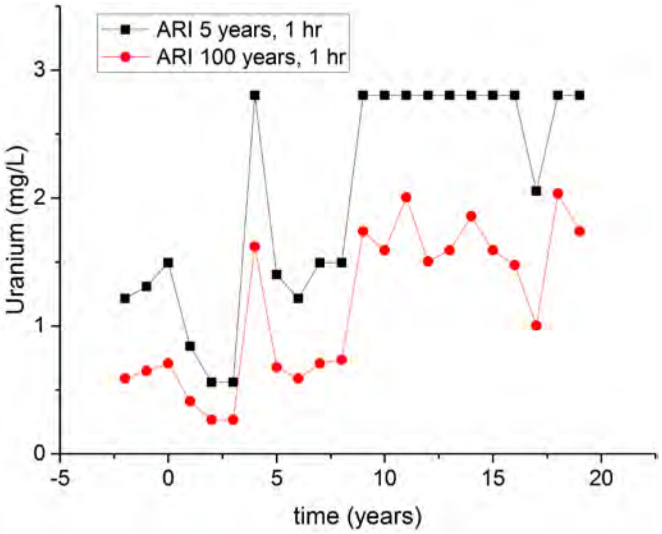


Figure 4.1 Example Roads and Hardstand runoff water quality calculated for an ARI five year, one hour duration storm event

Example runoff water quality results for the roads and hardstands are presented in Figure 4.1 for uranium for an ARI of five and 100 year event of one hour duration. These concentrations represent the water that would flow directly off the applicable surface areas and do not consider any dilution from run-on or other runoff within the catchment.

The solute loadings are continuously re-supplied by the application of spray water. The estimated solute loadings provided in the appendix are therefore applicable to the given year (Appendix B, Section 3.3 and accompanying Appendix 2). The original SRK results are calculated for a longer mine life than is proposed in the current assessment, as a result solute loadings values can be disregarded after 19 years, other parameters have been estimated to be similar.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Laboratory geochemical investigations in combination with the mine plan and schedule, resource information and geochemical modelling were used to develop source terms for:

- The in-pit tailings storage facility (TSF);
- Temporary mine waste and ore stockpiles;
- Roads and hardstands sprayed with saline water for dust control.

The source terms developed for the in-pit TSF were used as input to solute transport models (see “Numerical groundwater flow and solute transport model of the Yeelirrie uranium deposit”) to estimate loadings for tailings constituents of concern (COC) in the post closure environment of the Yeelirrie site and downstream of the site.

5.1 Tailings Source Terms

During active mining and milling operations, dewatering activities as well as the proposed TSF management practices are expected to control seepage of porewater to natural groundwater. At the end of mining after the tailings ponds have been decommissioned and dewatering has stopped, tailings porewater could interact with groundwater. Therefore the tailings source term developed in this report are applicable to the post closure environment at the Yeelirrie site.

The tailings source terms were developed using an empirical approach, which relies on actual measured concentrations from aged tailings slurries. Statistical criteria, in the form of using 90th percentiles, as well as geochemical modelling were used to choose conservative values for the tailings source terms. Source terms were compared to predicted concentration values obtained through modelling Eh, pH and mixing with groundwater. Minor changes were seen with all source terms when varying Eh and pH within expected limits, but significant evaporation predictably increased porewater concentrations of almost all constituents.

Within 50-150 years after closure, the groundwater level will recover to approximately the pre-mining level. This introduction of water is modelled to improve the attenuation of most constituents due to pH buffering towards neutral values where many uranium and vanadium minerals have their minimum solubility. The increased availability of calcium will also aid in the precipitation of secondary minerals (uranophane, tyuyamunite, calcium vanadates).

In summary, tailings porewaters would contain elevated concentrations of certain constituents but modelling and tailings aging experiments suggest that many constituents would be controlled through secondary mineral precipitation. Uranophane, carnotite and calcium vanadates are predicted to control uranium and vanadium concentrations, though vanadium would likely still be released above background concentration levels.

5.2 Mine Waste and Ore Stockpiles

The mine waste and ore stockpile source terms are estimated as solute loadings expressed in terms of a net mass release per unit surface area. Multiplication of these release rates by the applicable surface area gives the total loading for a given rainfall event. The difference between the base case and upper bound release rates is the assumed depth of influence of a given rainfall event.

A number of conservative assumptions are built into the development of the procedures used to estimate the total solute loadings. As mentioned previously the exposed surface area of each stockpile can change as a function of time. Calculations have assumed that the footprint for each waste or ore stockpile remains constant at its maximum size throughout the lifetime of that particular stockpile. For both the base case and upper bound case, any new material added to a stockpile is normalized over the entire surface area thereby presenting a maximum exposed surface.

Sorption controls were not considered for stockpiled materials and only a few solubility controls were included due to uncertainties and complexities of the runoff chemistry (Table 4.4). In contrast to the tailings source terms, the solute loadings values are relevant only during operations as the stockpiles will be processed as ore or put into the pit by the end of the mine life (19 years).

6.0 REFERENCES

Bethke, C.M., 2007, Geochemical and Biogeochemical Reaction modeling. Cambridge University Press, New York, 547 p.

Bothe Jr., J. V., and P.W. Brown, 1999, Arsenic immobilization by calcium arsenate formation, *Environ. Technol. Sci.*. **33**(21), 3806-3811.

Cullen, W.R. and K.J. Reimer, 1989 Arsenic speciation in the environment. *Chemical Reviews* **89**, 713-764.

Delaney, J.M. and S.R. Lundeen, 1990, The LLNL thermochemical database. Lawrence Livermore National laboratory report UCRL-21658, 150 p.

Essilfie-Dughan, J., I.J. Pickering, M.J. Hendry, G.N. George, and T. Kotzer, 2011. Molybdenum speciation in uranium mine tailings using X-ray absorption spectroscopy. *Environmental Science and Technology,* **45**(2), 455-460.

Essington, M.E., 1990, Calcium molybdate solubility in spent oil shale and a preliminary evaluation of the association constants for the formation of $CaMoO_4{}^0{}_{(aq)}$, $KMoO_4{}^-{}_{(aq)}$, and $NaMoO_4{}^-{}_{(aq)}$. *Environmental Science and Technology,* **24** (2), 214-220.

Finch, R.J. and T. Murakami, 1999, Systematics and Paragenesis of Uranium Minerals *in Uranium: Mineralogy, Geochemistry and the Environment*, Reviews in Mineralogy: vol. 38, eds. P.C. Burns and R. Finch.

Foster A.L., 2003, Spectroscopic investigations of arsenic species in solid phases. In: Welch AH, Stollenwerk KG (eds) Arsenic in Groundwater: Geochemistry and Occurrence, Kluwer Academic Publishers, Boston, pp 27-65.

Garrels, R.M. and C.L. Christ, 1965, Solutions, Minerals, and Equilibria. Freeman, Cooper & Co., San Francisco, 450 p.

Gezahegne, W., S. Bachmaf, G. Geipel, B. Planer-Friedrich, and B. Merkel, 2009. Detection of uranylarsenates in acidic and alkaline solutions with time resolved laser-induced fluorescence spectroscopy (TRLFS). *Goldschmidt Conference Abstract*, A430.

Goldberg, S., H.S. Forster, and C.L. Godfrey, 1996. Molybdenum adsorption on oxides, clay minerals, and soils. *Soil Science Society of America Journal* **60**(2), 425-432.

Gorman-Lewis, D., J.B. Fein, P.C. Burns, J.E.S. Szymanowski, and J. Converse, 2008, Solubility measurements of the uranyl oxide hydrate phases metaschoepite, compreignacite, Na-compreignacite, becquerelite and clarkeite, *J. Chem. Thermodynamics*, **40**, 980-990.

Green WH, G. Ampt, 1911, Studies on soil physics, 1. The flow of air and water through soils, *Journal of Agricultural Science* **4**, 1–24.

Guillaumont, R., T. Fanghanel, J. Fuger, I. Grenthe, V. Neck, D. Palmer, and M., Rand, Update on the Chemical Thermodynamics of Uranium, Neptunium, and Plutonium, 2nd ed. Elsevier, Amsterdam, 2003.

HATCHES, 2013, website: www.hatches-database.com*, maintained by amec (now amec foster wheeler)*

Harvie, C.E., N. Møller and J.H. Weare, 1984, The prediction of mineral solubilities in natural waters: The Na-K-Mg-Ca-H-Cl-SO_4-OH-HCO_3-CO_3-CO_2-H_2O system to high ionic strengths at 25oC. *Geochim. Cosmochim. Acta*, **48**, 723-751.

Helgeson, H.C., 1969, Thermodynamics of hydrothermal systems at elevated temperatures and pressures. *Amer. Jour. Sci.*, **267**, 729-804.

Kelly, S.D., K.M. Kemner and S.C. Brooks, 2007, X-ray Absorption spectroscopy identifies calcium-uranyl carbonate complexes at environmental concentrations. *Geochim. Cosmochim. Acta*, **71**, 821-834.

Langedal, M., 1997. Dispersion of Tailings in the Knabeåa–Kvina Drainage Basin, Norway, 2: Mobility of Cu and Mo in Tailings-Derived Fluvial Sediments. *Journal of Geochemical Exploration,* **58**, 173-183.

Langmuir, D., 1997, *Aqueous Environmental Geochemistry*. Prentice-Hall: Upper Saddle River, NJ, p. 552.

Meima, J.A., R.D. van der Weijden, T.T. Eighmy, R.N.J. Comans, 2002. Carbonation Processes in Municipal Solid Waste Incinerator Bottom Ash and their Effect on the Leaching of Copper and Molybdenum. *Applied Geochemistry* **17**, 1503-1513.

Moldovan, B.J., M.J. Hendry, 2005. Characterizing and quantifying controls on arsenic solubility over a pH range of 1-11 in a uranium mill-scale experiment. *Environmental Science and Technology,* **39**, 4913-4920.

Myneni, S.C.B., T.K. Tokunaga, G.E. Brown, Jr., 1997, Abiotic selenium transformations in the presence of Fe(II, III) oxides, *Science*, **278**, 1106-1109.

Peacock, C.L. and D.M. Sherman, 2004, Vanadium(V) adsorption onto goethite (α-FeOOH) at pH 1.5 to 12: A Surface complexation model based on ab initio molecular geometries and EXAFS spectroscopy. *Geochim. Cosmochim. Acta*, **68**, 1723-1733.

Petrunic, B.M., T.A. Al, and L. Weaver, 2006. A transmission electron microscopy analysis of secondary minerals formed in tungsten-mine tailings with an emphasis on arsenopyrite oxidation. *Applied Geochemistry,* **21**(8), 1259-1273.

PNNL-17818, 2008, 300 Area Treatability Test: Laboratory Development of Polyphosphate Remediation Technology for In Situ Treatment of Uranium Contamination in the Vadose Zone and Capillary Fringe, US-DOE Contract DE-AC05-76RL01830

Ryan, G.R., 1977, Uranium in Australia, In Geology, Mining and Extractive Processing of Uranium.

Shvareva, T.Y., L. Mazeina, D. Gorman-Lewis, P.C. Burns, J.E.S. Szymanowski, J.B. Fein, A. Navrotsky, 2011, Thermodynamic characterization of boltwoodite and uranophane: Enthalpy of formation and aqueous solubility, *Geochim. Cosmochim. Acta*, **75**, 5269-5282

Tokunaga, T.K., Y. Kim, J. Wan, and L. Yang, 2012, Aqueous concentrations controlled by calcium uranyl vanadate precipitates, *Environmental Science and Technology,* **46**, 7471-7477.

Walenta, K., F. Hatert, T. Theye, F. Lissner, and K. Röller, 2009. Nielsbohrite, a new potassium uranyl arsenate from the uranium deposit of Menzenschwand, southern Black Forest, Germany. European Journal of Mineralogy, 21(2), 515.

Zhu, Y.N., X.H. Zhang, Q.L. Xie, D.Q. Wang and G.W. Cheng, 2006, Solubility and stability of calcium arsenates at 25^{o} C, *Water, Air, and Soil Pollution,* **169**, 221-238.

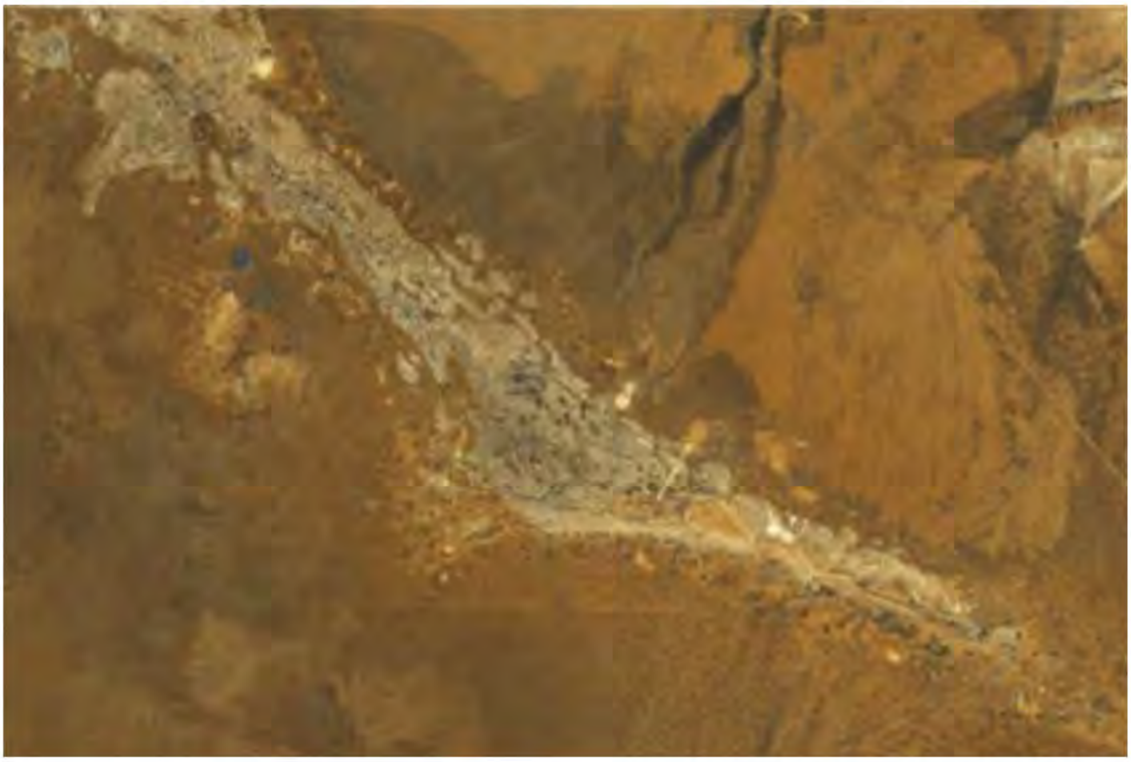
Development of Tailings and Mine Waste Source Terms for the Proposed Yeelirrie Mine

APPENDIX A

Proposed Yeelirrie Development: Geochemical Assessment
of Tailings and Mine Waste

Report prepared by
SRK Consulting

March 2011



Proposed Yeelirrie Development: Geochemical Assessment of Tailings and Mine Waste

Report prepared by

SRK Consulting

March 2011

Project Code: BHP047/1

Proposed Yeelirrie Development
Geochemical Assessment of Tailings and Mine Waste
BHP047/1

BHP Billiton Yeelirrie Development Company Pty Ltd

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SRK Report Distribution Record

Project Number: BHP047/1

Date Issued: 10 March 2011

Name/Title	Company
Keith Ashby	BHP Billiton Yeelirrie Development Company Pty Ltd

Executive Summary

The proposed Yeelirrie Development for the recovery of uranium from carnotite, a uranium-vanadium mineral phase, would include permanent placement of tailings within a tailings storage facility (TSF) located within the mined out pit areas. Temporary storage areas for mine waste, ore and soil would be developed adjacent to the mine. Suitable stockpiled overburden materials would be used to progressively rehabilitate the process tailings. Any low grade stockpiles and waste material remaining at the end of mine life would be used to backfill any residual mine voids, with the low grade material placed preferentially at the base of the mine voids.

This report describes outcomes from a geochemical testing programme designed to:

- Evaluate the chemical composition of the materials to be stockpiled on site and assess the solute release from these materials;
- Assess the potential for solute release from the tailings in the short and the long term; and
- Determine the potential interaction between the solutes and the natural materials downstream of the mine facility.

The work programme included detailed chemical characterisation of selected Yeelirrie materials (ores, mine waste and tailings), and completing a series of bottle roll contact and column tests. Interpretation and modelling of the results were undertaken to develop an understanding of the water-rock interactions that could control solute mobility downstream of the mine area.

The outcomes of this programme were used in the predictive modelling of source terms at the site.

Programme Outcomes

Stockpiled Materials

Readily soluble phases leached in abundance on contact with water, including salts such as halite and sulphates. The contaminants released at significant concentrations include boron, barium, molybdenum, strontium, thallium, uranium, vanadium and zinc. Radionuclide analyses of leachate solutions showed that radium-226 could also be released during flushing.

The results further indicate that the potential for solute release is finite and depleted rapidly. The earliest pore volume exchanges tend to coincide with the highest solute concentrations; concentrations are much reduced in subsequent pore volume exchanges.

Carnotite solubility is expected to place an upper limit on uranium and vanadium concentrations. In many cases, the mass of available carnotite may be limited and the solutions could remain under-saturated with respect to this mineral. Sorption onto iron and aluminium oxy-hydroxides and clays may further limit release of some elements.

Tailings

In the short-term, the tailings porewater quality would be dominated by process water (barren liquor). Barren liquor is alkaline and contains high concentrations of dissolved uranium and vanadium. The excess alkalinity is likely to lead to further dissolution over time of carnotite remaining in the tailings. This leaching will lead to increases in uranium and vanadium concentrations, until equilibrium is reached with carnotite, or until the residual carnotite has been depleted. In time, ion exchange processes would also result in lower dissolved sodium and potassium concentrations in the porewater, and alkalinity may also decrease due to the formation of secondary carbonate minerals. While decreasing potassium concentrations will result in increased carnotite solubility, it could be offset by lower alkalinity concentrations with the net effect that dissolved uranium and vanadium concentrations in the porewater would remain nearly constant.

Ion exchange reactions involving clay minerals may have a secondary outcome with respect to changing the physical characteristics of the materials. There is a correlation between exchange site occupancy and the swelling capacity of the clay. Replacing calcium with sodium will result in swelling, and consequently may reduce the permeability of the material. Reduced permeability in some materials affected the operation of some of the column tests. These effects could occur reduce the permeability of the tailings and affect the rate of porewater displacement.

Downstream Interactions

Initial percolate from the TSF could contain high dissolved sodium concentrations which are likely to result in displacement of ions from exchange sites on clays downstream of the facility. The ion exchange reactions would release calcium, magnesium, barium and strontium to the porewater. The results indicate that, notably, radium-226 would not be released, and is instead attenuated in the clays.

Carnotite solubility is expected to play an important role in limiting the solubility of uranium and vanadium along flow paths downstream of the facility. Geochemical conditions downstream of the TSF are expected to result in carnotite precipitating from solution, leading to lower uranium and vanadium concentrations, principally due to the decrease in alkalinity expected downstream. Solubility controls that could apply to other elements are co-precipitation in sulphate or carbonate phases.

Contaminant transport may also be slowed due to sorption onto mineral surfaces (e.g. iron and aluminium oxyhydroxides and clays). Sorption is not strong under the relatively carbonate-rich conditions expected in Yeelirrie groundwater, however, moderate sorption is expected for many elements, except for the very high dissolved carbonate concentrations in tailings seepage in the near-zone of the TSF.

Conclusions

The geochemical testing of the tailings and the stockpiled materials provide an indication of the potential for solute release from these materials under the conditions expected for the TSF and surrounding areas. These release rates may be used in conjunction with the site water flow conditions (such as recharge, porewater displacement, etc.) to develop source terms for each of the site components. The testing also provides insight into the potential mechanisms that may affect the concentrations and rate of transport of the solutes after they have been released from the tailings and other sources. This information may be used to infer the potential downstream controls on solute mobility that may limit the extent and rate of contaminant transport.

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (Australasia) Pty Ltd (SRK) by BHP Billiton Yeelirrie Development Company (YDC), Amdel Limited, Australian Nuclear Science and Technology Organisation (ANSTO), Australian Laboratory Services (ALS) and Particle and Surface Sciences Pty Ltd. The opinions in this Report are provided in response to a specific request from YDC to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

1. Introduction

The proposed Yeelirrie Development for the recovery of uranium from carnotite (a uranium-vanadium mineral phase) would include construction of a tailings storage facility (TSF) within the mined out pit areas. Temporary storage areas for mine waste, ore and soil would be developed adjacent to the mine. Suitable stockpiled overburden materials would be used to progressively rehabilitate the process tailings as each cell reaches completion. L grade stockpiles and waste material that may remain at the end of mine life would be backfilled to the residual mine voids. The low grade materials would be placed preferentially at the base of the voids approximating the distribution of the material prior to mining.

Processing would entail contacting the ore with a concentrated solution of soda ash to dissolve the carnotite and allow recovery of the uranium in solution. The processed tailings would therefore be alkaline in nature and may contain elevated concentrations of metals (e.g. vanadium) that leach concurrently with the uranium. Therefore, the process water that would be deposited with the tailings is likely to contain elevated concentrations of various solutes.

Similarly, the mine waste materials are likely to contain elevated concentrations of salts due to the presence of evaporites (accumulated salts) or saline porewater. These solutes may be released from the tailings and mine waste during operations and after closure. Solute release from the tailings and the stockpiled materials over time may have the potential to affect ground and surface water quality downstream of the site.

Historic gamma surveys collected for rehabilitated trial mining areas indicated that release of radionuclides from stockpiles was limited (at least over the 30 year period that those stockpiles were in place). It was however necessary to extend the understanding of potential effects to include other solutes, for a wider range of material types and geochemical conditions.

A previous SRK report (SRK, 2009) presented a conceptual geochemical model for the TSF based on the available historical information. The conceptual model considered the ore genesis, the proposed milling and leaching process for uranium recovery, as well as the results from historical testing and monitoring. Based on that understanding, a laboratory programme was initiated in 2009 to gather additional geochemical information describing the leaching and attenuation behaviour of contaminants at the Yeelirrie site. This report documents the outcomes of the laboratory programme. The results obtained by the current laboratory programme are to support predictive modelling of source terms at the site.

2. Background

2.1 Geological Setting

The regional geology of the area is dominated by Archaean granites, gneisses and other high grade metamorphic rocks. Since formation, these rocks have been subjected to prolonged weathering and erosion.

The Yeelirrie ore body is situated in alluvial sediments within the central drainage channel of a wide, shallow valley. The channel cuts into heavily weathered granite. In recent geological history (within the last 2 million years), the climate has become more arid and the current drainage channel comprises a series of clay pans and salt lakes. In the central parts of the channel, alluvial sediments have been replaced by calcrete deposits (the calcrete likely forming as part of near surface evaporative secondary mineral precipitation).

Twelve lithological types are identified in Yeelirrie logs as summarised in Table 2.1.

Table 2.1: Lithological types included in logs of Yeelirrie materials

Lithological Type	Code	Comment
Hardpan	H	
Carbonated hardpan	HT	
Loam	L	
Quartz-rich loam	LQ	
Carbonated quartz-rich loam	LQT	
Carbonated loam	LT	Ore-bearing
Calcrete	T	Ore-bearing
Transition calcrete	TCQ	Ore-bearing
Carbonated Clay-Quartz	CQT	
Arkosic Clay-Quartz	CQA	
Clay-Quartz	CQ	
Granite	G	

Figure 2.1 shows an idealised lithological profile and a cross-section of the Yeelirrie deposit (WMC, 1991). Figure 2.2 shows how the mineralogy varies with depth. As shown in the figure, calcrete carbonate minerals comprise calcite and dolomite, with calcite occurring predominantly nearer the surface whereas dolomite is more abundant at depth.

Calcrete formation is believed to have taken place over a long period of time, and is still taking place. Over time, carbonate minerals present in ‘upstream’ calcrete are mobilized (dissolved) and then precipitated ‘downstream’. The dissolution occurs due to the introduction of carbon dioxide (CO_2)-charged rainwater to the groundwater system, thus increasing the hydrogen ion concentration which lowers the pH of the water as follows:

$$CO_2 + H_2O \Leftrightarrow H_2CO_3 \Leftrightarrow H^+ + HCO_3^-$$

Pre-existing carbonate minerals dissolve when contacted by such waters. For example, calcite dissolves as follows:

$$CaCO_3 + 2H^+ \Leftrightarrow Ca^{2+} + 2HCO_3^-$$

The reactions are reversible and, as carbon dioxide is lost from the system, carbonate minerals precipitate again.

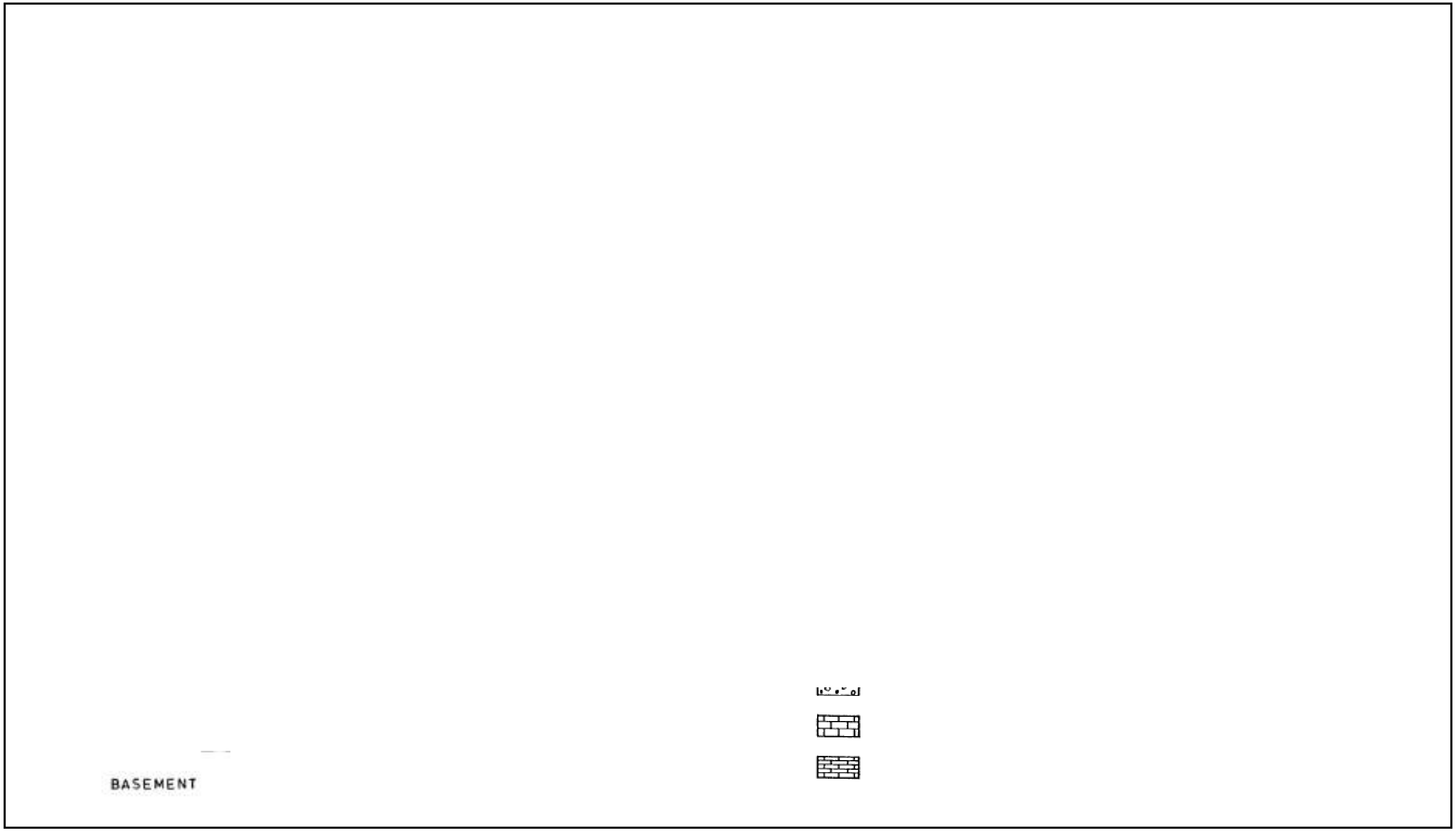


Figure 2.1: Idealised lithological profile and cross-section of the Yeelirrie deposit (WMC, 1991)

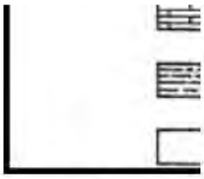


Figure 2.2: Schematic showing the mineralogical composition of the different horizons encountered at Yeelirrie (WMC, 1991)

2.1.1 Bulk Chemistry of Soils and Underlying Rocks

The BHP Billiton geological database[†] of chemical analyses for drill core from the deposit was reviewed to develop an understanding of the variability of key elements within the different lithological units. Figure 2.3 and Figure 2.4 show the calculated median uranium and vanadium concentrations in different Yeelirrie materials. As might be expected, the highest median concentrations are found in ore-bearing lithologies (LT, T and TCQ). Consistent with carnotite being the primary uranium mineral, the vanadium contents follow the same pattern.

Some general comments regarding the distribution of other element of interest are:

- Many metals, e.g. copper, nickel and lead are present at low concentrations in all materials, with median concentrations less than 50 ppm (below crustal 'averages', Bowen, 1979). Concentrations are lowest in calcrete, and highest in the deeper clay-quartz lithologies or in hardpan. There appears to be some correlation between these metals and Al and Si content, suggesting clays may be important as sorption sites (e.g. ion exchange). The hardpan concentrations may be due to evapo-concentration and the formation of evaporites of the metals.
- Median arsenic and molybdenum contents are generally less than 20 ppm and 5 ppm, respectively. Crustal 'average' values for arsenic and molybdenum are 1.5 ppm. Highest median contents are found in the deeper clay-quartz lithologies.
- Strontium contents range up to a maximum of 280,000 ppm, or 28 %, (compared to a crustal average, 370 ppm). The highest median concentrations are close to 600 ppm, for calcrete, transition calcrete and carbonated loam. The high strontium correlates with either high carbonate or high sulphate, suggesting possible control by either strontianite or celestite.

[†] The version of the database reviewed was dated 21st December 2009.

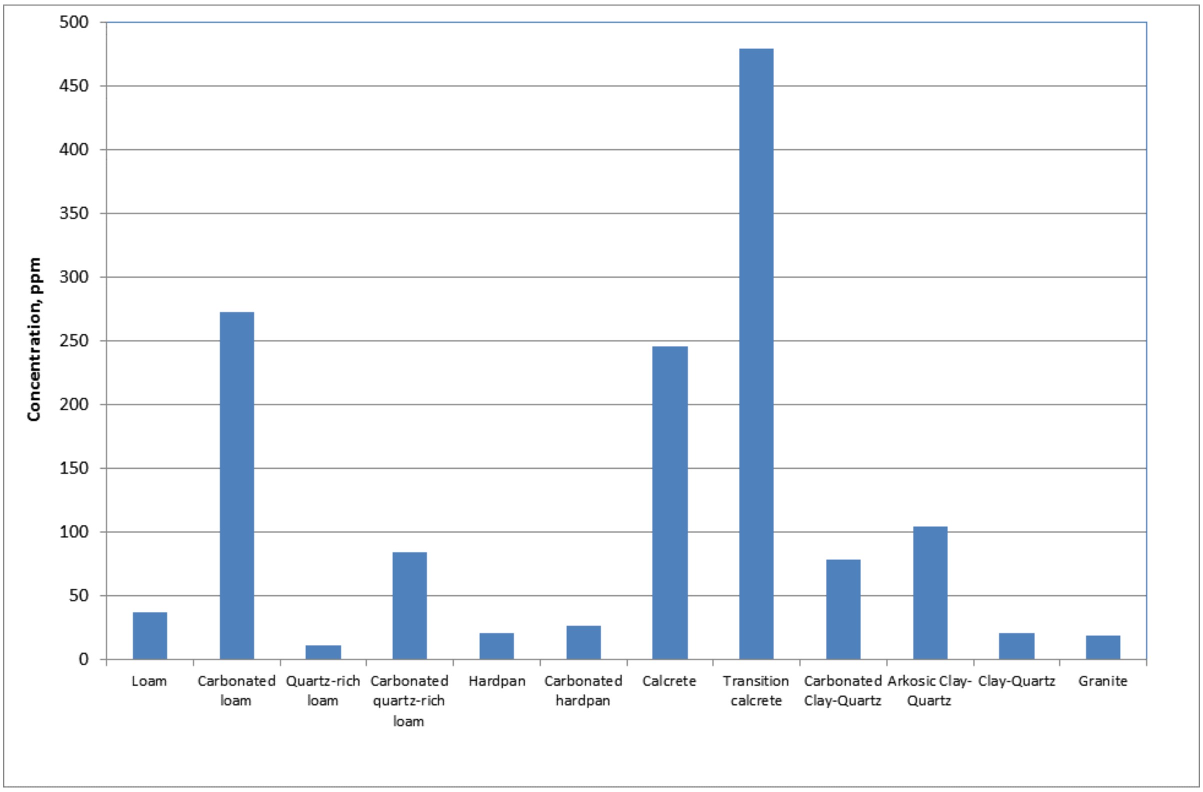


Figure 2.3: Median uranium content of different Yeelirrie materials

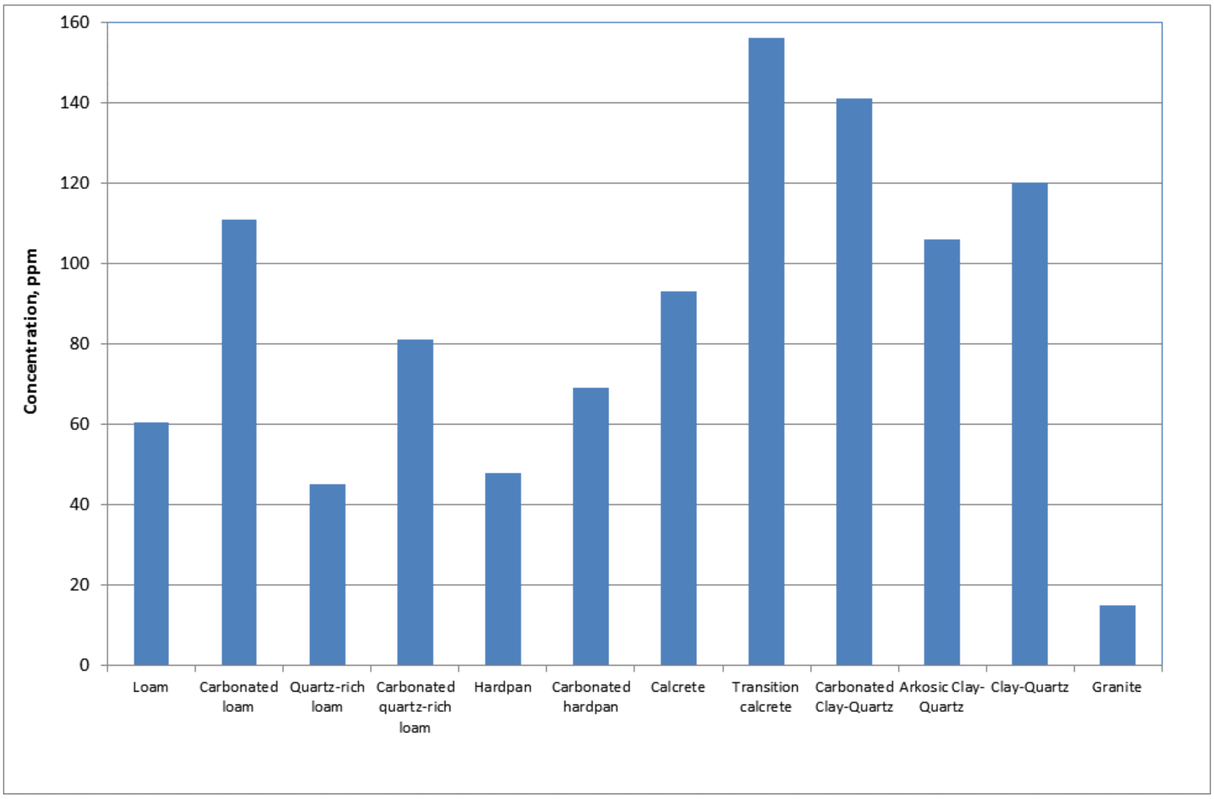


Figure 2.4: Median vanadium content of different Yeelirrie materials

2.1.2 Chemistry of Groundwater

Available groundwater monitoring results provided by URS (based on groundwater sampling that took place in the period from November 2009 to January 2010) represent analyses of samples collected from various boreholes and wells in the Yeelirrie area. A large proportion of these samples were collected from within depth ranges and lithologies analogous to materials that would be mined at Yeelirrie, or were obtained from within possible flow paths downstream of the deposit.

Table 2.2: Groundwater Chemistry - Summary Statistics

Parameter	Units	Miniumum	Maximum	Median	Average
pH (field)		6.0	7.8	7.0	7.0
Eh (field)	(mV)	18	701	340	328
Alkalinity	mgCaCO$_3$/L	41	946	205	226
Al	mg/L	0.01	2.42	0.02	0.22
Ca	mg/L	27	1020	273	361
K	mg/L	10	2100	207	460
Mg	mg/L	16	3500	434	737
Na	mg/L	113	23600	2845	5035
SiO$_2$	mg/L	0.1	112	55	58
Br	mg/L	0.1	169	11	34
Cl	mg/L	81	43900	4985	9115
F	mg/L	0.3	3.8	1.5	1.6
N	mg/L	0.01	56.5	15.8	19.9
P	mg/L	0.01	2.7	0.1	0.2
SO$_4$	mg/L	57	13700	1945	3155
Ag	mg/L	0.001	0.04	0.00	0.00
As	mg/L	0.001	0.05	0.00	0.02
B	mg/L	0.38	47.80	5.23	11.04
Ba	mg/L	0.01	0.53	0.05	0.07
Be	mg/L	0.001	0.05	0.00	0.00
Bi	mg/L	0.001	0.01	0.00	0.00
Cd	mg/L	0.000	0.01	0.00	0.00
Ce	mg/L	0.001	0.01	0.00	0.00
Co	mg/L	0.001	0.18	0.01	0.01
Cr	mg/L	0.001	0.04	0.00	0.01
Cu	mg/L	0.001	0.08	0.01	0.02
Fe	mg/L	0.05	5.06	0.25	0.51
Hg	mg/L	0.000	0.00	0.00	0.00
Li	mg/L	0.001	0.18	0.02	0.04
Mn	mg/L	0.001	21.50	0.17	0.77
Mo	mg/L	0.002	0.62	0.06	0.11
Ni	mg/L	0.001	0.17	0.02	0.03
Pb	mg/L	0.001	0.15	0.00	0.01
Re	mg/L	0.001	0.01	0.00	0.00
Sb	mg/L	0.001	0.01	0.00	0.00
Se	mg/L	0.01	0.23	0.03	0.05
Sn	mg/L	0.001	0.01	0.00	0.00
Sr	mg/L	0.30	25.90	5.36	8.31
Th	mg/L	0.001	0.01	0.00	0.00
Tl	mg/L	0.001	0.01	0.00	0.00
U	mg/L	0.001	2.36	0.16	0.31
V	mg/L	0.01	0.13	0.01	0.03
W	mg/L	0.001	0.20	0.01	0.01
Y	mg/L	0.001	0.01	0.00	0.00
Zn	mg/L	0.01	1.89	0.03	0.09

The results were examined using geochemical modelling techniques to identify potential solubility limits that might apply under field conditions. Using the measured groundwater chemistries as input, the saturation indices of key mineral phases were calculated. The focus of the calculations was to identify minerals close to equilibrium with the measured water chemistries (a saturation index close to zero). Such minerals, if present in the materials, may have dissolved (or precipitated) to attain equilibrium with the groundwater and therefore may be used to infer solubility limitations.

Possible solubility controls identified within the existing groundwater environments include:

- Iron and aluminium oxy-hydroxides – ferrihydrite ($Fe(OH)_3$), gibbsite ($Al(OH)_3$), boehmite ($AlOOH$)
- Carbonates – calcite ($CaCO_3$), dolomite ($CaMg(CO_3)_2$), rhodochrosite ($MnCO_3$), strontianite ($SrCO_3$)
- Sulphates – gypsum ($CaSO_4.2H_2O$), celestite ($SrSO_4$)
- Fluorite (CaF_2)

Carnotite ($K_2(UO_2)_2(VO_4)_2$) was found to be under-saturated in most of the solutions. Given that carnotite is present at Yeelirrie, and many of the groundwaters are likely to have contacted this mineral, uranium solubility was explored further by plotting a uranyl activity diagram (Figure 2.5).

The results plot along a trend consistent with the calculated theoretical line for carnotite, but displaced toward a lower solubility. The scatter in the results may relate to the fact that activities of other relevant species, e.g. K^+ and VO_2^+, vary in individual waters.

The carnotite dissociation reaction contained in the HATCHES database is as follows:

$$K_2(UO_2)_2(VO_4)_2 \Rightarrow 2K^+ + 2UO_2^{+2} + 2VO_4^{-3} \quad \text{[Equilibrium constant: } 10^{-56.18}\text{]}$$

The reaction and the equilibrium constant originated from within the EQ3/6 database, parts of which were merged with the HATCHES database in the early 1990s. The original source of the data is unknown and so it is not possible to assess either the reliability of the data, or its applicability to the Yeelirrie system.

Also shown in Figure 2.5 is a calculated theoretical line for a less soluble version of the carnotite phase (based on data contained within the MINTEQ database). The plot shows that the thermodynamic data contained in the MINTEQ database reasonably reflect the observed trend for carnotite solubility under field conditions and therefore have been adopted for any further modelling.

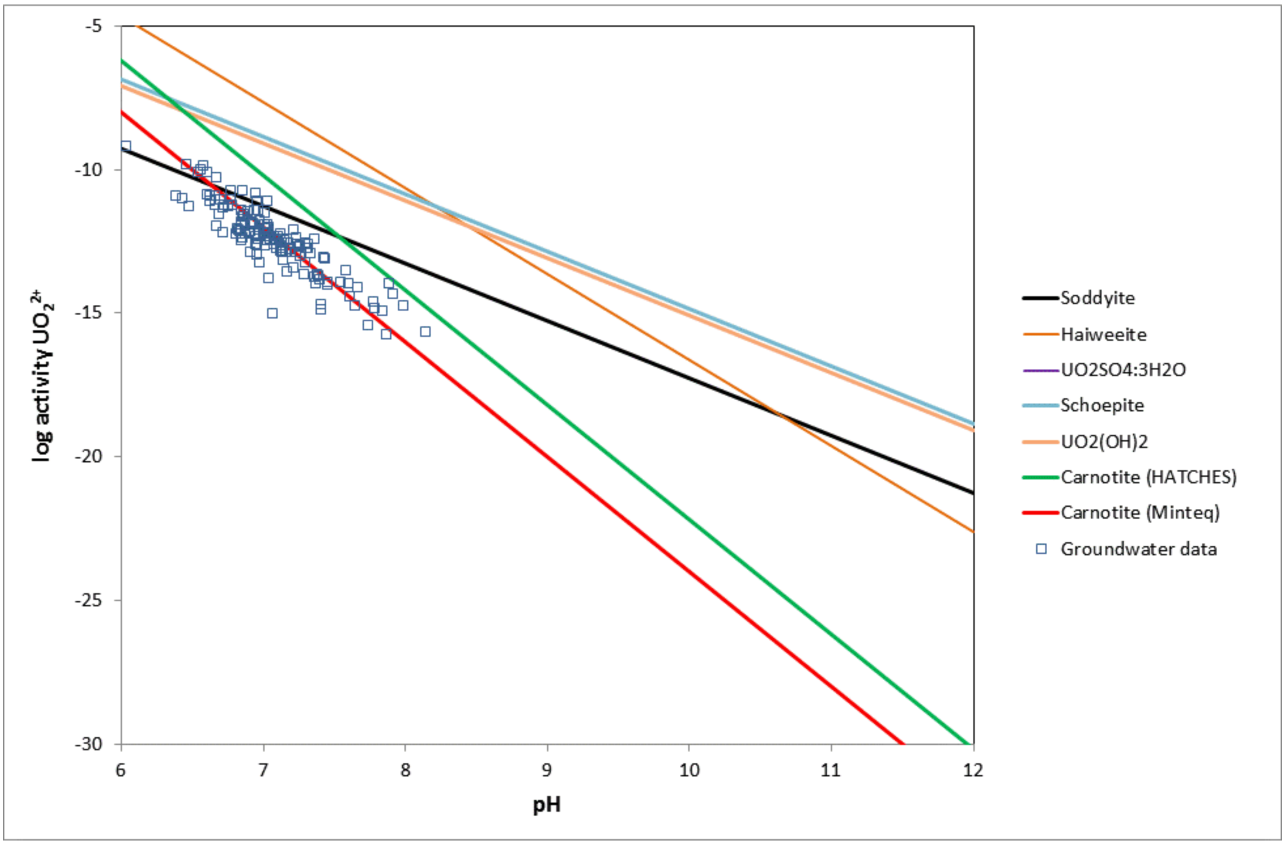


Figure 2.5: Uranyl (UO_2^{2+}) activity diagram showing the calculated activities of measured groundwater results

(Also shown are the theoretical equilibrium lines for a range of minerals)

2.2 Previous Mining Trials at Yeelirrie

During the 70s and 80s, various trial excavations took place at the Yeelirrie site to support investigations of possible mining strategies. The excavations provided ore material suitable for metallurgical testing. A number of stockpiles and waste piles were also constructed during this time.

In 2004, the trial sites were rehabilitated. Prior to rehabilitation activities, a series of soil pH and salinity (inferred from electrical conductivity, EC) measurements were made (Outback Ecology, 2004). Samples were obtained from pits, stockpiles, roads and undisturbed soils. Sample pH values ranged from 6.8 (alluvial plain sample) to 9.7 (calcrete sample from a road surface), with the majority of samples yielding alkaline pH values (pH greater than 8). The EC values ranged from 26 to 1913 µS/cm. Higher EC values tended to correspond with mined materials (stockpiles and calcrete-based road surfaces) whereas lower values were recorded for natural soils from alluvial plains and calcrete platforms.

As part of the rehabilitation activities, stockpiled materials were used to backfill trial pits. Gamma radiation surveys (Fugro Spatial Solutions, 2004) took place before and after rehabilitation. Before closure, readings of up to 45 µS/hr were obtained for stockpiled material. Surveys taken after stockpile removal typically gave readings of less than 1.5 µS/hr. The low readings documented after removal of the stockpile suggests that there was limited or no release of radionuclides from the stockpiles during their lifetime (20 to 30 years). Soil salinity measurements however were not repeated after removal of the stockpiles. The release of other solutes from the stockpiles during this period therefore could not be determined.

2.3 Proposed Yeelirrie Project Development

Full details of the proposed development are given in the ERMP document (BHP, 2011). Brief summaries are given in the following sections.

2.3.1 Mining and Production

Tailings would be stored in mined out pits. Any residual mine waste and stockpiled materials, as well as mine infrastructure for disposal, would also be placed in mined out pits. At closure, tailings and disposal cells would be covered with mine waste and topsoil materials for final rehabilitation.

2.3.2 Ore Processing

Ore would be milled before subjecting it to a high temperature alkali leach using sodium carbonate/bicarbonate to dissolve the carnotite. The uranium bearing solution would be recovered in a counter current decant (CCD) system and would then be subjected to ion exchange with further processing of the concentrated solution (eluant) from the ion exchange system. Once uranium has been removed from the leachate, the final tailings could contain vanadium in excess of the stoichiometric uranium content of the source mineral (carnotite).

The barren solution discharged from the uranium ion exchange recovery circuit would be pumped to the final stage of CCD for use as wash water. The solute concentrations in this stream would also contribute to the solute loading that would be deposited with the tailings in the TSF.

2.3.3 Tailings Production and Storage

Tailings are expected to be produced at a solids content of about 35 % (wt). The primary disposal concept is that the tailings would be deposited sub-aerially directly in the TSF cells located in the mined out areas, utilising internal berms to contain the tailings and separate tailings deposition from mining activities.

Tailings water would be recovered from the TSF and in-pit cells throughout the life of the operation. Water recovery may occur from the tailings decant and/or an underdrainage system.

3. Work Programme and Methods

3.1 Objectives

The primary objectives of the geochemical investigation were to:

- Evaluate the chemical composition of the materials to be stockpiled on site and assess the solute loadings that may be released from these materials.
- Assess the potential for solute release from the tailings in the short and the long term.
- Determine the potential interaction between the solutes and the natural materials downstream of the mine facility.

To meet these objectives, sampling and laboratory testing programmes were developed. These programmes are described briefly in the following sections.

3.2 Field Programme

Samples of the mine materials were collected by others (BHPB and URS) during sonic drilling programs that took place during June and August 2009. Sonic drilling does not require use of drilling fluids or additives and so it is possible to minimise geochemical contamination during sampling.

The samples represented a range of material types from the Yeelirrie site taken at various depths (down to 30 m below ground surface) from drill cuttings for drill holes located within and downstream of the proposed mining area. A total of 199 samples were collected. Relevant drill-hole logs and field measurements are included in Appendix 1. From the 199 samples, 20 were selected for detailed geochemical characterisation and inclusion in the laboratory programme.

In addition to the site samples described above, the following samples were collected:

- Palaeochannel sand samples – two samples were collected from depths between 55 to 65 m below the Yeelirrie deposit (a reverse circulation drilling method was used).
- Pilot plant tailings and underlying sediments collected from the historic Kalgoorlie tailings storage facility - 41 samples were collected during sonic drilling of the facility).

The selected samples were submitted for testing and analysis as summarised below.

3.3 Laboratory Programme

A full description of the laboratory programme is given in Appendix 2. The programme was undertaken by Amdel, supported by Labmark and Minchem/Petroleum, and included the following testing procedures:

- Bottle roll tests. Tailings, soil and rock samples were contacted with solution (either de-ionised water or ‘barren liquor’ solution) for 72 hours. The tests were undertaken at a liquid:solid ratio of 3:1. For the majority of tests, the headspace in the bottles was occupied by air. For selected samples, tests were conducted with the bottle headspace filled by a mixture of CO_2 (10v%) and air.
- Column tests. Four column pairs have been set up to operate in series. The first column in each pair is open to air and operated such that the material drains down and becomes unsaturated between flushing events. The second column is not open to air and is maintained saturated with solution at all times. Effluent from the first column is used as inflow for the second column in that pair.
- Aging tests (tailings). Fresh tailings slurries were placed in open and sealed flasks, to represent atmospheric as well as anoxic conditions respectively. Series of replicate flasks were prepared so that after 1, 2, 4 and 8 months of contact time, selected flasks could be disturbed and the pore water recovered for analysis.

Changes in solution chemistry during the tests described above allow quantification of any contaminant leaching or attenuation that may have taken place.

To support the laboratory program, drill core and tailings samples were submitted for:

- Chemical assays (acid digestion followed by ICP) to determine the elemental composition of samples (conducted by Labmark).
- Mineralogical investigation (X-ray diffraction) (conducted by CSIRO, via BHP).
- Mineral surface characterisation (BET surface area, cation exchange capacity) to support the assessment of potential sorption mechanisms (conducted by Particle and Surface Sciences Pty Ltd and Australian Laboratory Services, respectively).
- Radiological investigation (analysis of radionuclide composition of solids and porewaters) to determine key radionuclide concentrations (conducted by Australian Nuclear Science and Technology Organisation).

3.4 Geochemical Modelling

Geochemical speciation modelling was undertaken to support interpretation of the results and observed trends on the test outcomes. All calculations were undertaken using PHREEQC Interactive, Version 2.12.5.669 (Parkhurst and Appelo, 1999). Unless otherwise indicated, the thermodynamic data used were those contained in the HATCHES thermodynamic database, NEA v18 (Bond *et al.*, 1997). As discussed before, thermodynamic data from the MINTEQ database were adopted for modelling carnotite.

4. Yeelirrie Rocks and Soils

4.1 Introduction

The sampling programme targeted material representative of all the lithological units defined at the site, distributed spatially to capture lateral variability. An assessment of the geochemical database indicated that in general the bulk chemistry of the lithological units were independent of the material classification (as ore or waste), and that the ore is distinguished primarily by uranium and vanadium content. Therefore, with the exception of uranium and vanadium, the material classified as ore would be very similar to a material classified as waste within any given lithological unit. As a result, in this section, the discussion of the geochemical properties and static leach extraction testing is arranged as follows:

- **Ore and Waste Materials** represented by samples of material from within the orebody and mining void. Sample locations were selected to be within and below the ore body. Most samples had low uranium contents and are classed as waste. Waste materials, after being stored in surface facilities, would be used to construct TSF embankments and the TSF cover. Some samples contain relatively high uranium contents and are classed as ore. Ultimately, ores would be processed, but may be subject to temporary storage on the surface. The objectives for testing these sample materials were to define their geochemical characteristics, and assess the potential for solute release during storage (by undertaking bottle roll tests involving de-ionised water).
- **Material Underlying and Adjacent to the TSF** represented by samples of materials located below the ore body and adjacent (downstream) of the TSF, i.e., materials that might lie along possible flow paths for TSF seepage. Most of the samples are from relatively deep locations (the clay-quartz unit and the palaeochannel sands), but some samples from near-surface units are included to cover the possibility that some seepage might flow away laterally from the TSF. The objectives for testing these materials were to define their geochemical characteristics, and examine potential interactions with TSF-derived seepage. TSF ‘seepage’ chemistry was approximated by using barren liquor solutions in the testwork (bottle roll tests). Along potential flow paths from the TSF, it would be expected that water-rock interactions would result in change to seepage chemistry. Use of unaltered barren liquor in the testwork is an approximation only, allowing examination of possible interactions that might take place.

Because the column testing included assessment of potential interaction of leachates from one type of material with another, the column testing as well as implication of solute chemistry were discussed next as follows:

- **Column Testwork** - column tests were operated as pairs, with effluent from the first column being used as influent for the other. The materials selected were representative of ore and waste (first column in the pair), and materials along possible seepage flow paths (second column in the pair). Results from the columns were used to assess leaching and attenuation behaviour under geochemical conditions that differed from those of the bottle roll tests (e.g. lower solution-to-solid ratios, longer solution contact times etc.).
- **Radionuclide Distribution and Behaviour** including analytical results for solid samples and selected solutions from testwork. Daughter/parent activity ratios in the solids were used to infer if preferential leaching or accumulation of radionuclides had taken place in situ at the Yeelirrie site.
- **Geochemical Controls** includes assessments of solubility controls and sorption using geochemical modelling techniques. Sorption was examined by processing all available results to generate sorption coefficients. The effects of geochemical conditions on sorption are discussed.

4.2 Ore and Waste Materials

4.2.1 Mineralogy

The mineralogical compositions of the Yeelirrie ore and waste materials selected for testing are given in Table 4.1. Carbonate minerals form an important constituent of the loams, calcrete and transitional lithologies. Calcite is present in the near surface, whilst dolomite is present at greater depth.

Clays are abundant in all the samples. The clay mineralogy varies with depth. Kaolin is more abundant at greater depth (transitional and clay-quartz lithologies) and is also significant in the near surface (hardpan and some loams). Smectite is the more abundant clay in most near-surface loam samples. Other clay minerals present include palygorskite (accompanies kaolin in the clay-quartz lithology) and small quantities of illite/mica and sepiolite.

Quartz is most abundant in samples from greater depths (e.g. samples from the transitional and clay-quartz lithologies).

Minor minerals identified include oxides (goethite, anatase), sulphates (gypsum), carnotite and halite.

4.2.2 Surface Characteristics

The surface areas measured for the Yeelirrie samples are shown in Table 4.2, and range from 24.6 m^2/g to 114.4 m^2/g. There is no obvious correlation between surface area and mineralogical composition.

The cation exchange capacity ranges from 6.4 to 53.7 meq/100g. There is a positive correlation between exchange capacity and smectite content. Smectite is a swelling clay; spacing between the aluminosilicate sheets can increase to accommodate a greater degree of exchange. In contrast, kaolin does not have swelling capacity and therefore has a more limited exchange capacity.

In most loam and carbonaceous samples, the dominant cation occupying exchange sites is Ca. However, Mg is the dominant cation in the hard pan sample.

4.2.3 Particle Size Distribution

Particle size distributions are provided in Appendix 7. All samples exhibited at least a tri-modal particle size distribution. The samples showed an abundance of particles in the approximate sizes ranges, 1-5μm, 10-20μm, and 60-70μm. A fourth peak (five of the seven samples) corresponded to a coarser grain-size (200-300μm).

4.2.4 Bulk Chemistry

The results for the bulk chemical analyses of the samples are contained in Appendix 3. Selected results are provided in Table 4.3. As would be anticipated, the U_3O_8 contents were consistently elevated when compared to the mean crustal abundance. Sulphate contents also tended to be high compared to mean crustal abundance. Other elements were present at levels both above and below mean crustal abundances.

The bulk chemistry results for samples from each of the lithological units were compared to the results contained within the BHP Billiton chemical assay database (Appendix 3). In most cases, the chemistry of the samples lay within the range of values recorded in the main database for each lithological category. The samples selected for testing were therefore considered to be representative of the lithological units.

Table 4.1: Mineralogical Composition of Yeelirrie Ore and Waste (wt%)

Sample	Lithology	Carbonates		Framework and chain silicates			Sheet silicates and clays					Oxides		Other		
		Calcite	Dolomite	Quartz	Albite	Microcline	Kaolin	Smectite[1]	Illite / Mica	Sepiolite	Palygorskite	Anatase	Goethite	Gypsum	Carnotite	Halite
YYS166 0.4-0.5 m	H			57	1	11	31									
YYS165 1.5-1.6 m	HT	43		7		2	14	27	1		6					
YYS156A 3-4 m	LT	1	54	2	1	1	13	22	1	4	?1	<1			0.1	
YYS156A 1.5-2.5 m	LT	6	24	8	<1	2	6	38		7				9	<0.1	<1
YYS164 4.3-4.4 m[2]	LT	<1		34	2	7	50	5	2			<1				
YYS158 3.75-4.5 m	T	2	82	1	1			6		8						
YYS158 3.5-3.75 m	T	3	76	2	1			7		10						<1
YYS157 3.65-4.1 m	TCQ	45	3	19		3	17	9	1	?3						<1
YYS162 4.5-4.6 m	TCQ	1		60	3	12	6	17	1							
YYS159 4.5-5.2 m	TCQ/CQT	1	1	38	1	6	41	7	2	?3		<1				
YYS156A 12-12.75 m[2]	CQ			30	2	5	39				21	<1	2			<1

Notes:

? denotes uncertainty in mineral identification.

[1] Smectite includes all montmorillonite group clays (montmorillonite, beidellite, nontronite, saponite, etc). The term montmorillonite was used in earlier mineralogical studies (Section 2.1). It is not known whether the term was being used to infer the montmorillonite clay group, or a specific member within this group.

[2] Note that these samples are also mentioned in the following section (Section 4.3 Materials Underlying and Adjacent to the TSF). Treating some samples within both categories allowed study of water -rock interactions for an individual sample under a wider range of geochemical conditions (e.g. de-ionised water and barren liquor contact tests). It also allowed for possible future change in the definition of the ore body, both in terms of lateral extent and depth.

Table 4.2: Surface Characteristics of the Yeelirrie Ore and Waste Rock

Sample	Lithology	BET surface area, m^2/g	Cation exchange capacity, meq/100g	Exchangeable cations,(meq/100g) (grey shading = dominant cation)			
				Ca	Mg	K	Na
YYS166 0.4-0.5 m	H	24.6	6.4	1.2	3.3	1.2	0.7
YYS156A 1.5-2.5 m	LT	82.8	53.7	44.6	6	1.8	1.3
YYS158 3.75-4.5 m	T	68.5	28.4	14.7	12.4	0.7	0.6
YYS157 3.65-4.1 m	TCQ	96.1	36.5	26.2	5.4	2.7	2.2
YYS159 4.5-5.2 m	TCQ/CQT	114.4	23.4	11.1	5.7	3.3	3.3
YYS156A 12-12.75 m	CQ	41.9	18.5	10.8	3.6	2.3	1.8

Table 4.3: Bulk Chemistry of Ore and Waste Rock Samples

Major elements		Al	Ca	CO_2	F	Fe	K	Mg	Mn	Na	S	Si	SO_4
Sample #	Material type	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Average crustal abundance[1]		8.2	4.1			4.1	2.1	2.3	0.095	2.3			0.078
YYS166 0.4 - 0.5 m	H	5.63	0.05	0.4	0.01	2.31	1.36	0.35	0.03	0.2	0.03	36.1	0.4
YYS165 1.5 - 1.6 m	HT	2.54	14.3	17.4	0.33	1.11	0.59	5.85	<0.01	0.13	0.08	18	0.3
YYS156A 3-4 m	LT (ore)	3.81	11.2	23	0.46	1.55	0.7	9.93	<0.01	0.45	<0.01	13.2	0.1
YYS156A 1.5-2.5 m	LT (ore)	2.63	8.3	11.5	0.75	1.23	0.63	9.51	0.01	0.67	2.05	17.9	3
YYS164 4.3-4.4 m	LT	8.44	0.17	0.2	0.1	3.38	1.53	1.08	0.02	0.54	0.1	29.3	0.1
YYS158 3.75-4.5 m	T	0.22	17.4	37.6	0.42	0.16	0.11	12.2	<0.01	0.25	0.03	5.86	<0.05
YYS158 3.5-3.75 m	T	0.13	16.8	34.6	0.59	0.1	0.12	12.4	<0.01	0.36	0.01	7.98	0.15
YYS157 3.65-4.1 m	TCQ	3.6	15.6	18.5	0.17	1.67	0.65	3.01	0.02	0.21	0.03	18.1	0.15
YYS162 4.5-4.6 m	TCQ	2.9	0.61	0.8	0.21	0.99	1.49	2.33	<0.01	0.57	0.04	37	0.15
YYS159 4.5-5.2 m	TCQ/CQT	7.19	0.98	1.5	0.19	3.03	1.41	2.28	0.1	0.35	0.01	29.8	<0.05
YYS156A 12-12.75 m	CQ	8.75	0.14	0.2	0.07	3.44	1.43	1.64	0.02	0.67	0.09	29.1	0.2

Minor elements		As	Ba	Cd	Co	Cr	Cu	Mo	Ni	Pb	Sr	Th	Tl	U_3O_8	V	Zn
Sample #	Material type	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Average crustal abundance[1]		1.5	500	0.11	20	100	50	1.5	80	14	370		0.6	2.8	160	75
YYS166 0.4 - 0.5 m	H	3	415	<0.1	9.5	70	20	3.4	12	9.5	50	10	<3	15	45	17.5
YYS165 1.5 - 1.6 m	HT	5	125	<0.1	3.4	40	13	0.6	13	4.5	290	5	<3	165	35	18
YYS156A 3-4 m	LT (ore)	9.5	40	<0.1	4	45	20.5	2.8	12	6.5	430	10	<3	1100	245	34.5
YYS156A 1.5-2.5 m	LT (ore)	8.5	75	<0.1	4	45	17.5	2.4	11	7	355	5	<3	700	165	700
YYS164 4.3-4.4 m	LT	3	285	<0.1	6.5	115	19.5	2.2	15	13	65	15	<3	15	60	29.5
YYS158 3.75-4.5 m	T	0.5	50	<0.1	0.6	<20	4	1.1	5	1	600	<4	<3	150	75	27
YYS158 3.5-3.75 m	T	1	20	<0.1	0.6	<20	7	1.9	5	1	550	<4	<3	55	50	265
YYS157 3.65-4.1 m	TCQ	3.5	100	<0.1	4.4	50	18.5	2	14	5.5	280	10	<3	140	60	46.5
YYS162 4.5-4.6 m	TCQ	3	315	<0.1	2.8	45	8	2.1	7	3.5	75	5	<3	45	65	14
YYS159 4.5-5.2 m	TCQ/CQT	8.5	295	<0.1	10.5	80	29.5	4.5	17	9.5	80	15	<3	10	120	85
YYS156A 12-12.75 m	CQ	13.5	220	<0.1	4.6	80	19.5	6.5	13	12.5	50	20	<3	65	145	125

Notes:

[1] Mean crustal abundances taken from Bowen 1979.

4.2.5 Solute Release (De-Ionised Water Extractions)

Samples were contacted with de-ionised water in roll bottle and column tests. The bottle roll tests were undertaken at a liquid:solid ratio of 3:1. Generally, the headspace in the bottles open to the atmosphere. However, for selected samples, the headspace was purged and filled with a mixture of CO_2 (10v%) and air. Results from bottle roll tests are documented in Appendix 4.

A summary of the test results is provided in Table 4.4. The summary includes the results from eleven different samples (covering a range of lithological types) and the two imposed atmospheric conditions (air, and a mixture of CO_2 (10v%) and air). The results also include measurements made from progressive (sequential) leach tests. In these tests, following the first bottle roll test, the solution is removed and replaced with distilled water for each of a second and third stage conducted (at the same 3:1 water:rock ratio).

For some elements (silver, bismuth, cobalt, mercury, lead, antimony) the dissolved concentrations at the end of the tests were invariably below the limits of detection. Comparatively, dissolved concentrations measured for boron, strontium, uranium and vanadium were elevated, with maximum concentrations in excess of 500 µg/L. Dissolved concentrations of barium, molybdenum, thallium and zinc were generally above detection limits, with maximum concentrations in excess of 100 µg/L. For many elements, dissolved concentrations were variable. The variability reflects differences in:

- The characteristics of the solid material, e.g. lithology, mineralogy, bulk chemistry
- Solution conditions, e.g. pH, dissolved carbonate

When compared to the groundwater quality monitoring results presented in Table 2.2, the concentrations of most solutes are lower in the leach tests. These results suggest that the solute release is occurring mostly from salinity that would have been present in the porewater of the samples.

Table 4.4: Summary of Solute Concentrations in De-ionised Water Extractions of Ore and Waste Rock Samples

(Bottle Roll Tests at 3:1 Water:Rock Ratio)

Parameter	Units	Detection Limit[1]	Number of Assays (n)	Dissolved Concentration				
				Min	P5	Median	P95	Max
pH	pH Units	0.01	44	7.3	7.5	8.4	9.2	10.0
Eh	mV	1	44	331	348	421	486	510
EC	µS/cm	5	44	120	260	1105	7428	8890
Acidity	$CaCO_3$ (mg/L)	20	42	<20	<20	<20	<20	50
Alkalinity	$CaCO_3$ (mg/L)	1	42	24	49	174	996	1300
Br	mg/L	0.5	44	<0.5	<0.5	<0.5	5	11
Cl	mg/L	0.5	44	2	7	100	1200	1700
F	mg/L	0.5	44	<0.5	<0.5	2	4	5
TOC	mg/L	1, 5	43	1.0	1.2	5	40	200
NO_2	mg N/L	0.02, 0.5	44	<0.02	<0.1	<0.5	1.7	2.2
NO_3	mg N/L	0.1, 0.5	42	<0.1	<0.1	1.6	49	95
SO_4	mg/L	0.5	44	2.8	5.0	63	2040	3200
Al	µg/L	5	44	<5	<5	26	95	680
Ca	µg/L	100	44	<100	500	9800	641700	694000
Fe	µg/L	50, 100	44	<50	<100	<100	109	560
Mg	µg/L	100	44	500	500	13200	170100	237000
P	µg/L	100	44	<100	<100	<100	<1000	2300
K	µg/L	1000	44	3500	12090	29950	201500	211000
Na	µg/L	100	44	13000	27750	137500	1028500	1110000
Si	µg/L	100	44	2970	3595	18000	45700	78000
As	µg/L	5	44	<5	<5	6	28	48
B	µg/L	5	44	110	186	710	4195	4900
Ba	µg/L	0.02, 5	44	<0.02	<5.0	17	74	160
Be	µg/L	1, 5	44	<1	<5	<5	<5	20
Cd	µg/L	0.2, 5	44	<0.2	<5	<5	10	27
Cr	µg/L	5	44	<5	<5	<5	15	37
Cu	µg/L	5	44	<5	<5	<5	12	20
Li	µg/L	5	44	<5	<5	<5	<5	11
Mn	µg/L	5	44	<5	<5	<5	38	53
Mo	µg/L	5	44	<5	<5	29	157	390
Ni	µg/L	1, 5	44	<1	<5	<5	15	17
Se	µg/L	1, 5	44	<1	<5	<5	23	28
Sn	µg/L	5	44	<5	<5	<5	7	24
Sr	µg/L	5	44	<5	7	195	4795	6000
Tl	µg/L	5	44	<5	<5	35	283	360
U	µg/L	5	44	<5	<5	86	1765	2100
V	µg/L	5	44	7	10	81	493	600
Zn	µg/L	5	44	47	69	115	160	200

Notes:

TOC=total organic carbon.

[1] Where more than one detection limit is given, the detection limit reported by the laboratory changed during the programme.

[2] The following constituents were consistently below detection: NH_3, Ag, Bi, Co, Hg, Pb, Sb.

4.2.5.1 Progressive (Sequential) Leach Tests

For most elements, concentrations in the contact solution decreased for consecutive leaching steps. The highest concentrations were observed for the first step, as shown for example by the sodium concentrations detected in the various stages. The results for sodium are shown in Figure 4.1 which show the depletion of leachable sodium from the samples. The figure also illustrates the variability between the various lithological types, but clearly also shows significant variability between the results for two samples from the same unit. For example, the first of the two TCQ samples yielded a sodium concentration in excess of 600,000 µg/L and the second less than 200,000 µg/L. This variability suggests that the wide range of solute release loadings could be expected to occur from the waste materials, even within the same lithological unit.

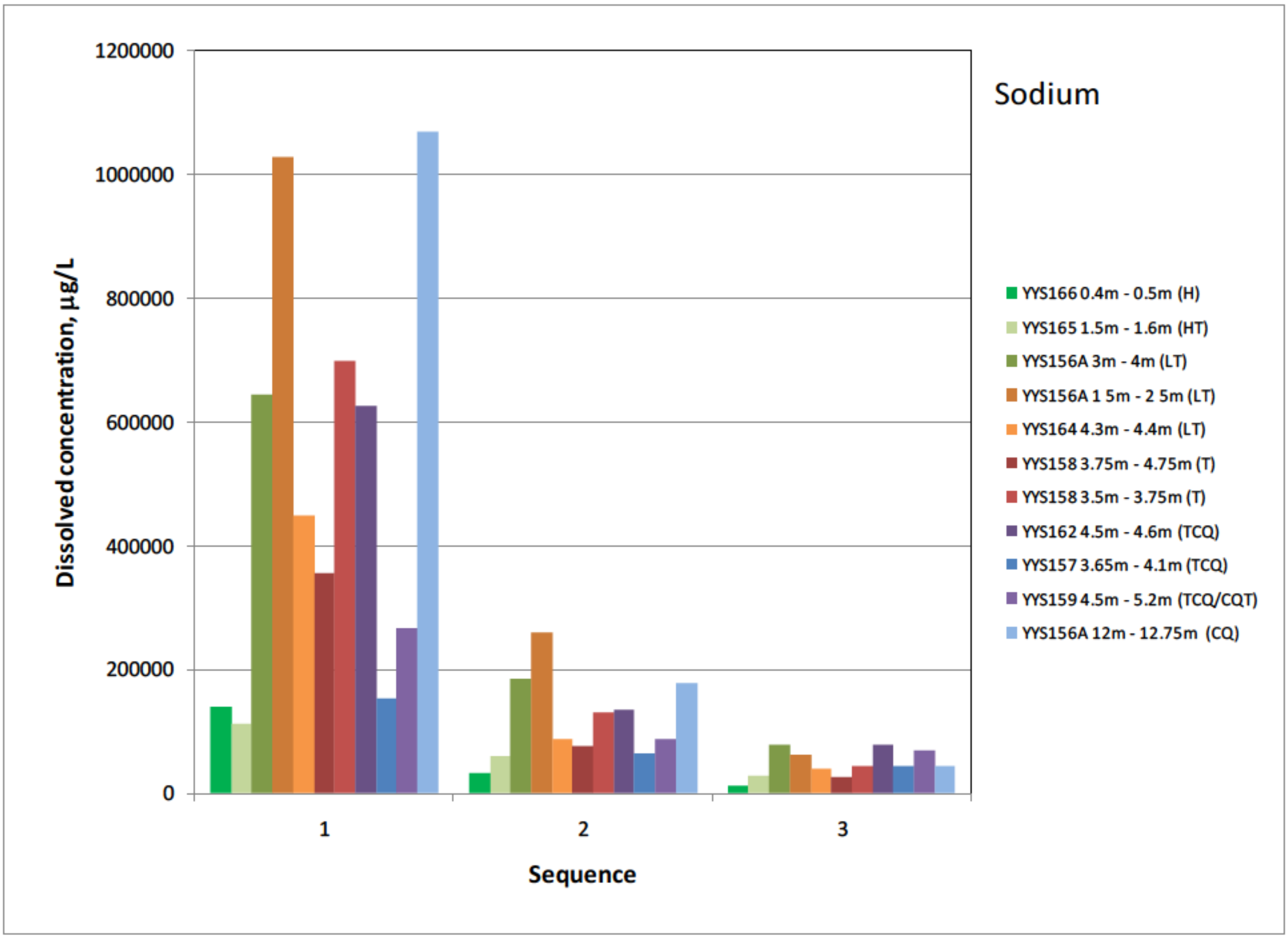


Figure 4.1: Dissolved sodium concentrations in leachates after three consecutive leach tests
(3:1 liquid:solid ratio, air atmosphere)

In contrast to the more soluble salts, uranium, vanadium and thallium leaching do not appear to follow the general trend, as shown in Figure 4.2, Figure 4.3 and Figure 4.4, respectively. The results are variable for these elements. Dissolved uranium and vanadium concentrations often remain relatively constant for the three stages, which may suggest either a solubility constraint or that the dissolution rate is kinetically controlled.

In the case of thallium, occasionally, the concentrations in the second stage of the sequence are greater than that of the first stage, by a factor of up to 10. These results suggest that the higher concentrations of other solutes present during the first stage may limit the release of thallium, whereas in the later stages, when these solutes have largely been removed from the system, thallium leaches more readily.

Possible geochemical controls are discussed in more detail later (Section 4.5).

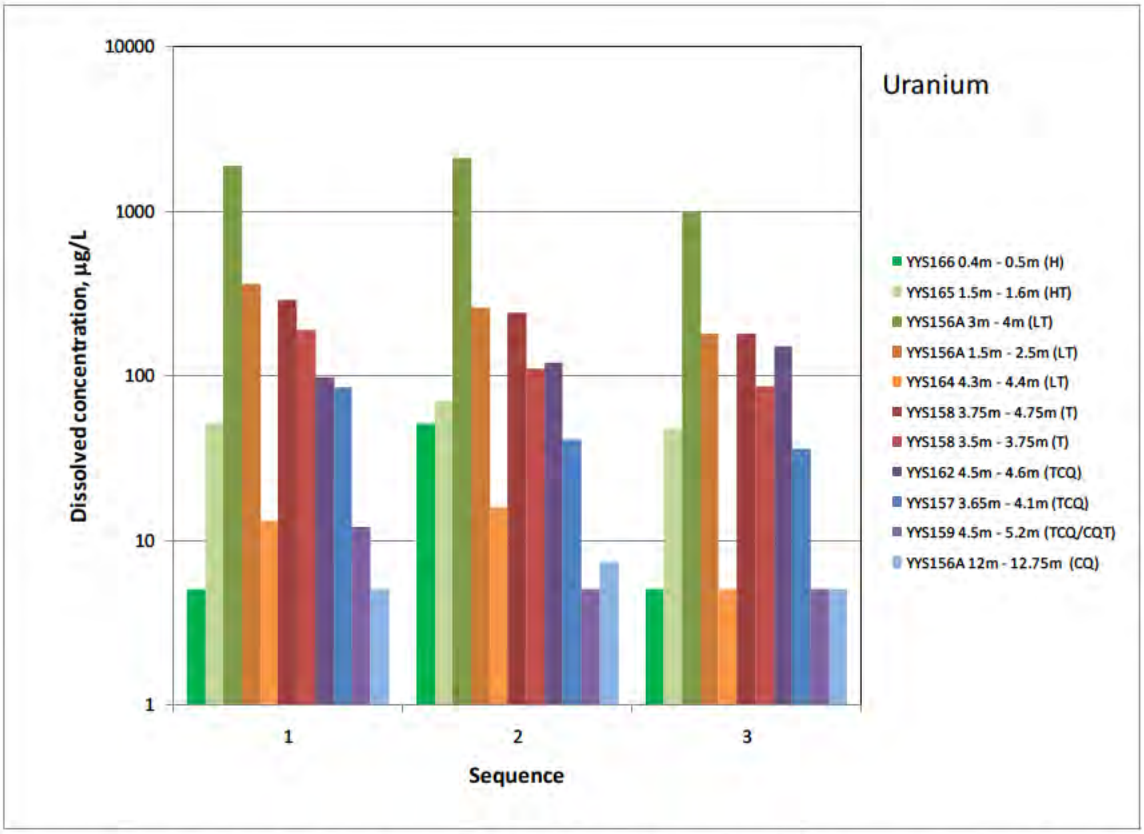


Figure 4.2: Dissolved uranium concentrations in leachates after three consecutive leach tests
(3:1 liquid:solid ratio, air atmosphere)

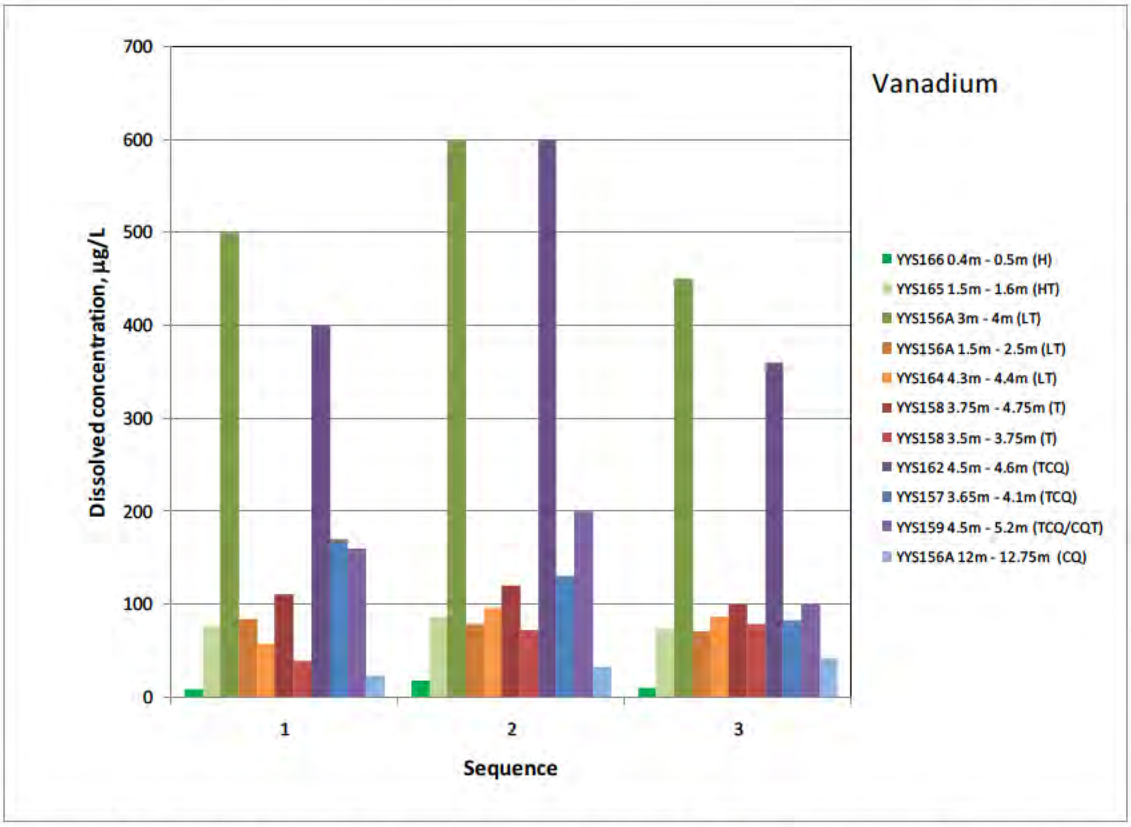


Figure 4.3: Dissolved vanadium concentrations in leachates after three consecutive leach tests
(3:1 liquid:solid ratio, air atmosphere)

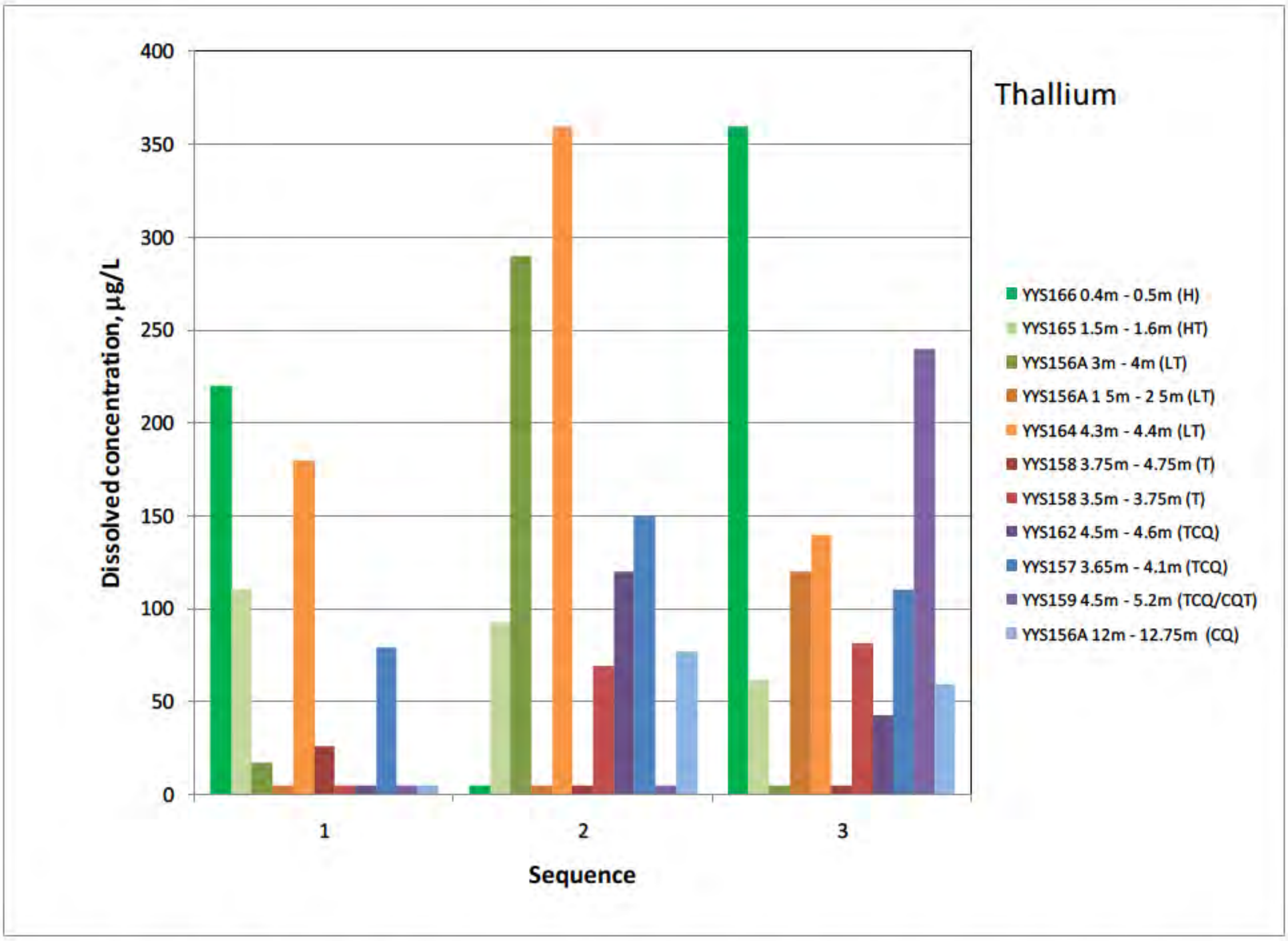


Figure 4.4: Dissolved thallium concentrations in leachates after three consecutive leach tests
(3:1 liquid:solid ratio, air atmosphere)

4.2.5.2 Effect of Lithological Type

Figure 4.5 shows the sodium, potassium, calcium and magnesium concentrations leached from the different samples. The figure is arranged so that near-surface materials (hardpan, loams) are to the left hand side, and deeper materials (clay-quartz) are to the right. Calcrete and transitional material are in the centre.

As noted before, high concentrations of Na (more than 600,000µg/L) leached from several of the samples, indicative of residual salt present in the samples. Mineralogical characterisation recorded the presence of halite in some of these samples (Table 4.1). The calcium concentration for the loam sample, YY156A - 1.5-2.5 m, is consistent with the presence of high quantities of gypsum in this sample (9 wt%, Table 4.1). Consistent with gypsum dissolution, an elevated concentration sulphate was also recorded for this test.

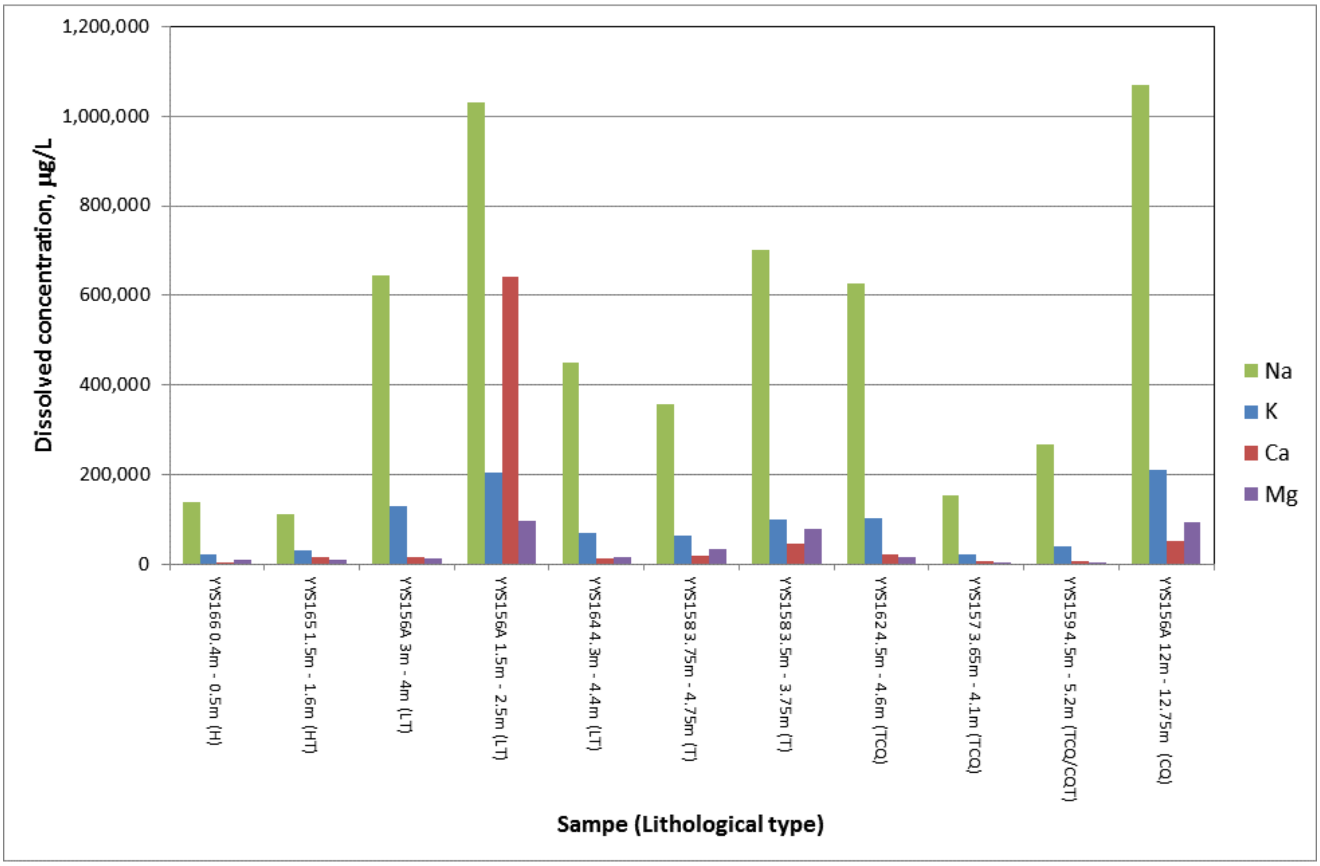


Figure 4.5: Na, K, Ca and Mg leaching from different lithological sample types
(3:1 liquid:solid ratio, sequence 1 results, air atmosphere)

Figure 4.6 shows uranium, vanadium, strontium and barium leaching from the different samples. Highest uranium and vanadium concentrations were measured for the loam, calcrete and transitional samples, probably reflecting the distribution of carnotite mineralisation in the materials. The mineralogical assessment (XRD investigation) identified the presence of carnotite in two of these samples: YYS156A 1.5-2.5 m (LT) and YYS156A 3-4 m (LT).

Strontium and barium may be considered analogues for radium behaviour. Notably, the highest strontium and barium concentrations coincide with the sample that had a high calcium concentration (YY156A 1.5-2.5 m), attributed to the dissolution of gypsum. It is possible that barium and strontium are present as impurities in gypsum.

Figure 4.7 shows molybdenum, zinc, thallium and boron leaching from the different samples. The highest molybdenum and boron concentrations were observed for a clay-quartz sample (YYS156A 12-12.75 m). Otherwise, leaching of these elements is quite variable and does not appear to correlate with lithological type. The same appears to be true for thallium. Zinc leaching is relatively constant for all the samples, with a factor of approximately two between the highest and lowest dissolved zinc concentrations, as shown in the figure.

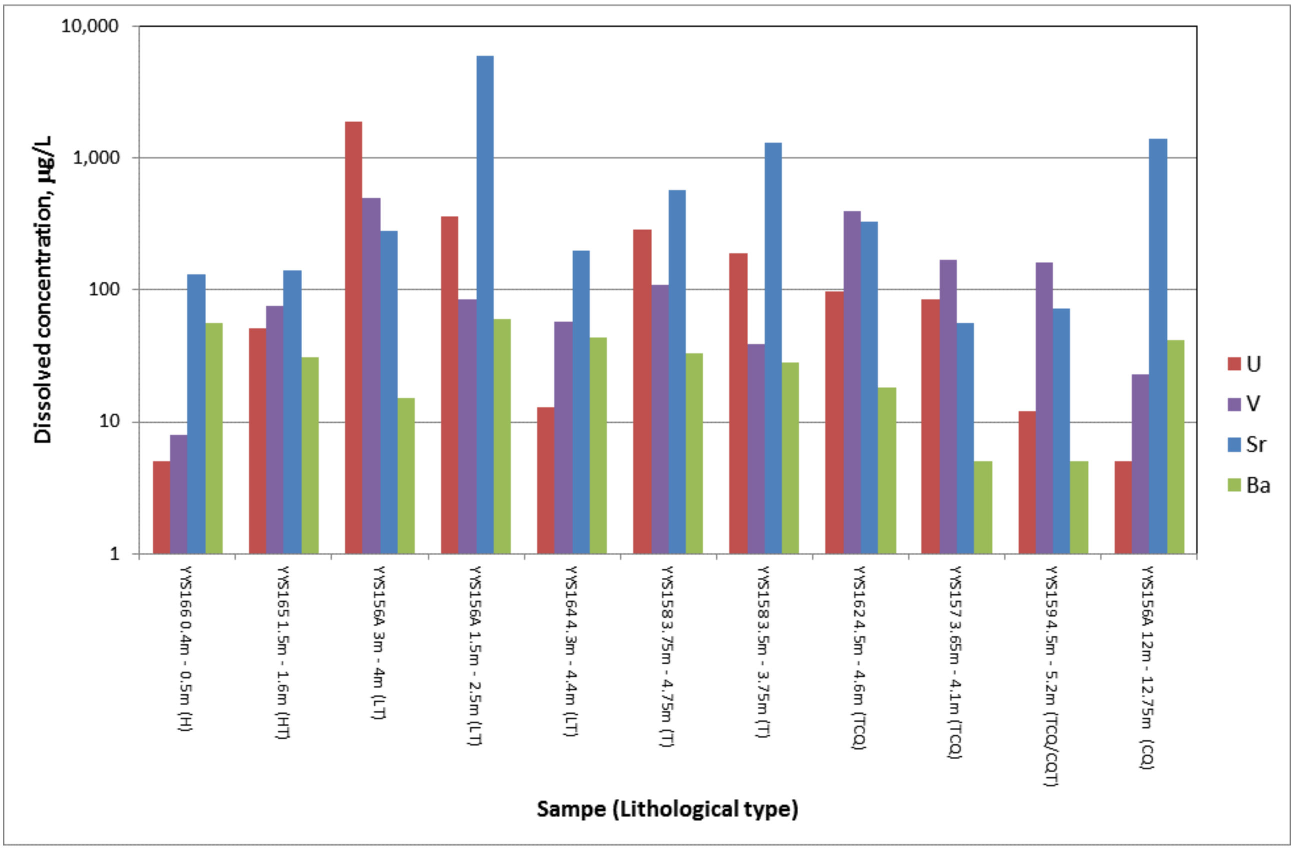


Figure 4.6: U, V, Sr and Ba leaching from different lithological sample types
(3:1 liquid:solid ratio, sequence 1 results, air atmosphere)

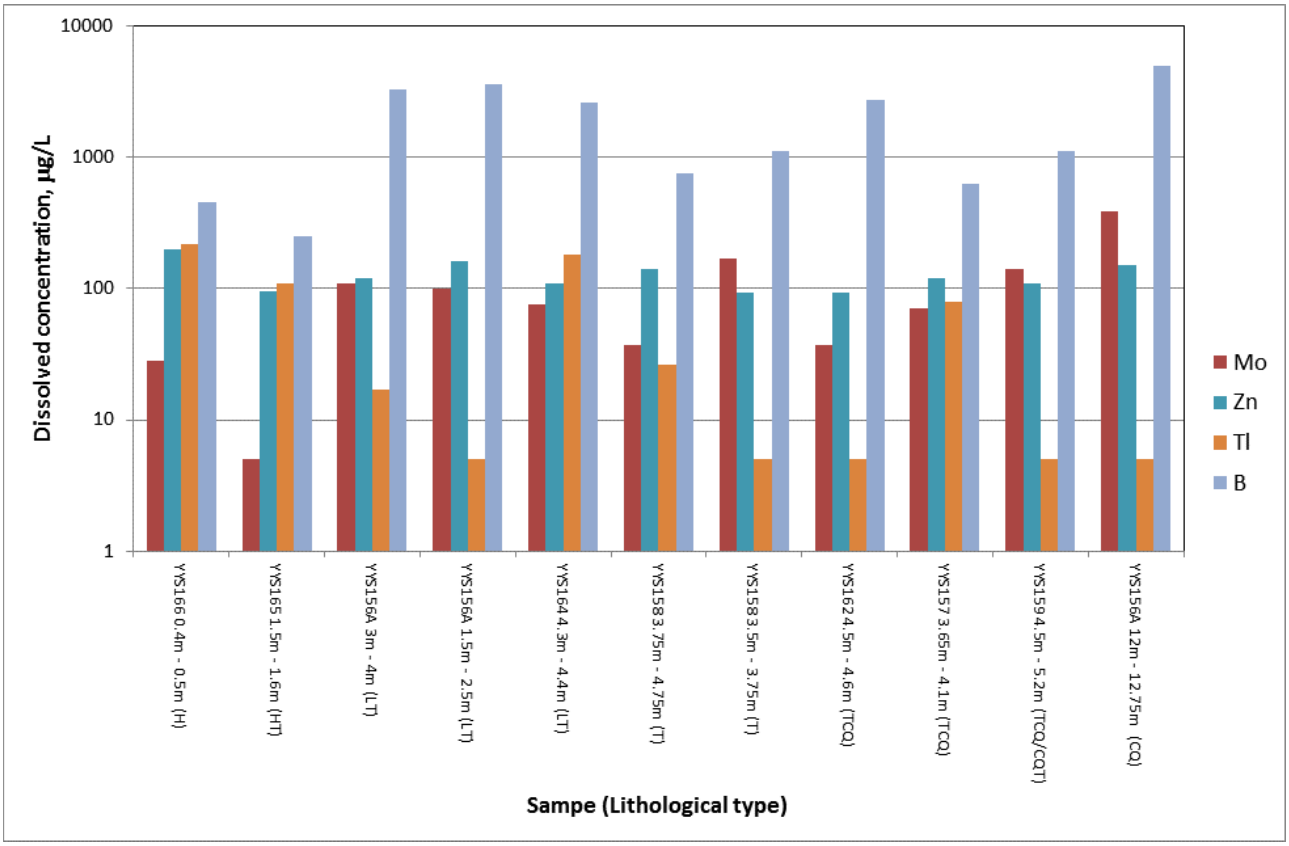


Figure 4.7: Mo, Zn, Tl and B leaching from different lithological sample types
(3:1 liquid:solid ratio, sequence 1 results, air atmosphere)

4.2.5.3 Correlation Between Bulk Chemistry and Leachability

For most of the elements, the amount leached did not correlate with the mass of that element present in the sample (from bulk chemical analysis results). Exceptions were sodium (chloride by default) and uranium. Both these elements showed a positive correlation between mass leached and the bulk elemental content in the sample, Figure 4.8 and Figure 4.9, respectively.

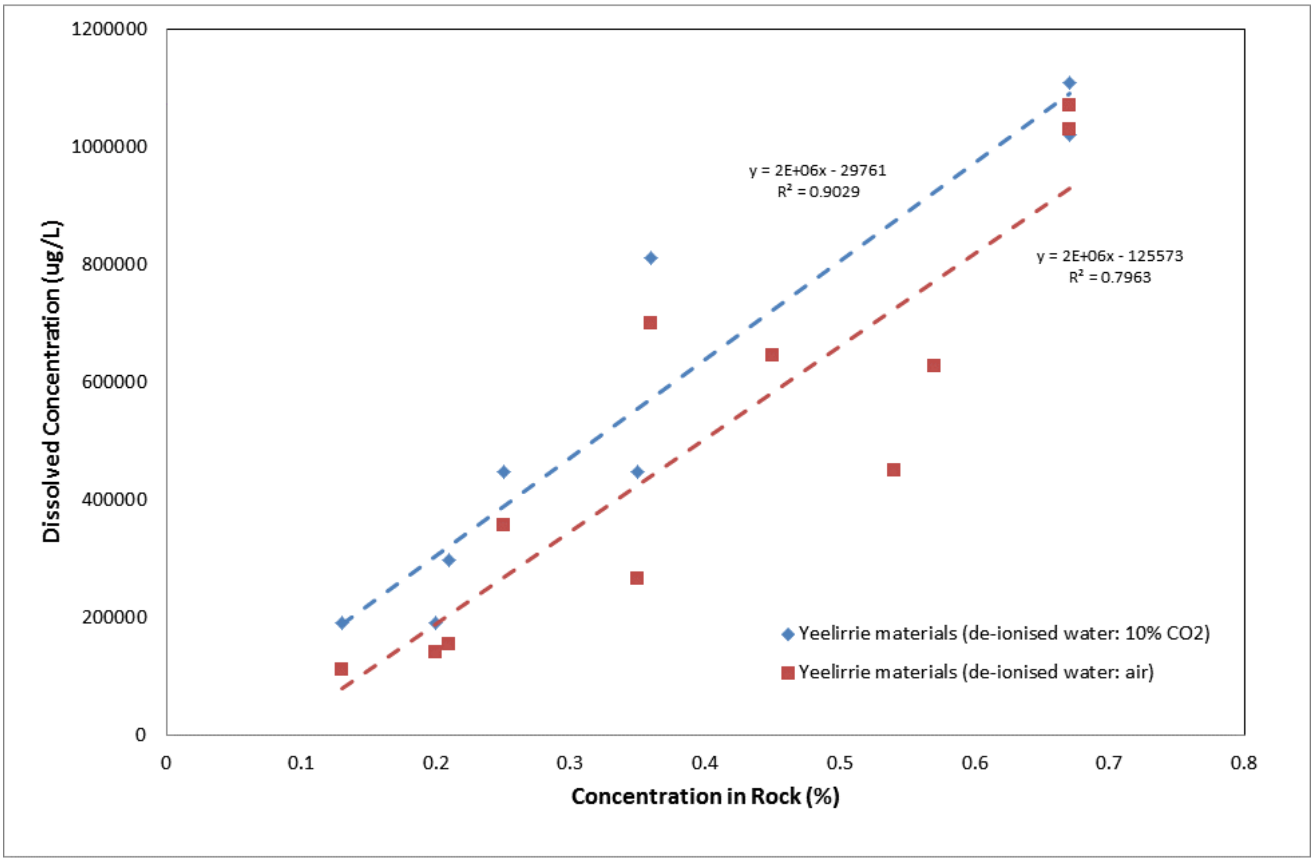


Figure 4.8: Dissolved sodium concentration plotted as a function of sodium content in the solid

(3:1 liquid:solid ratio)

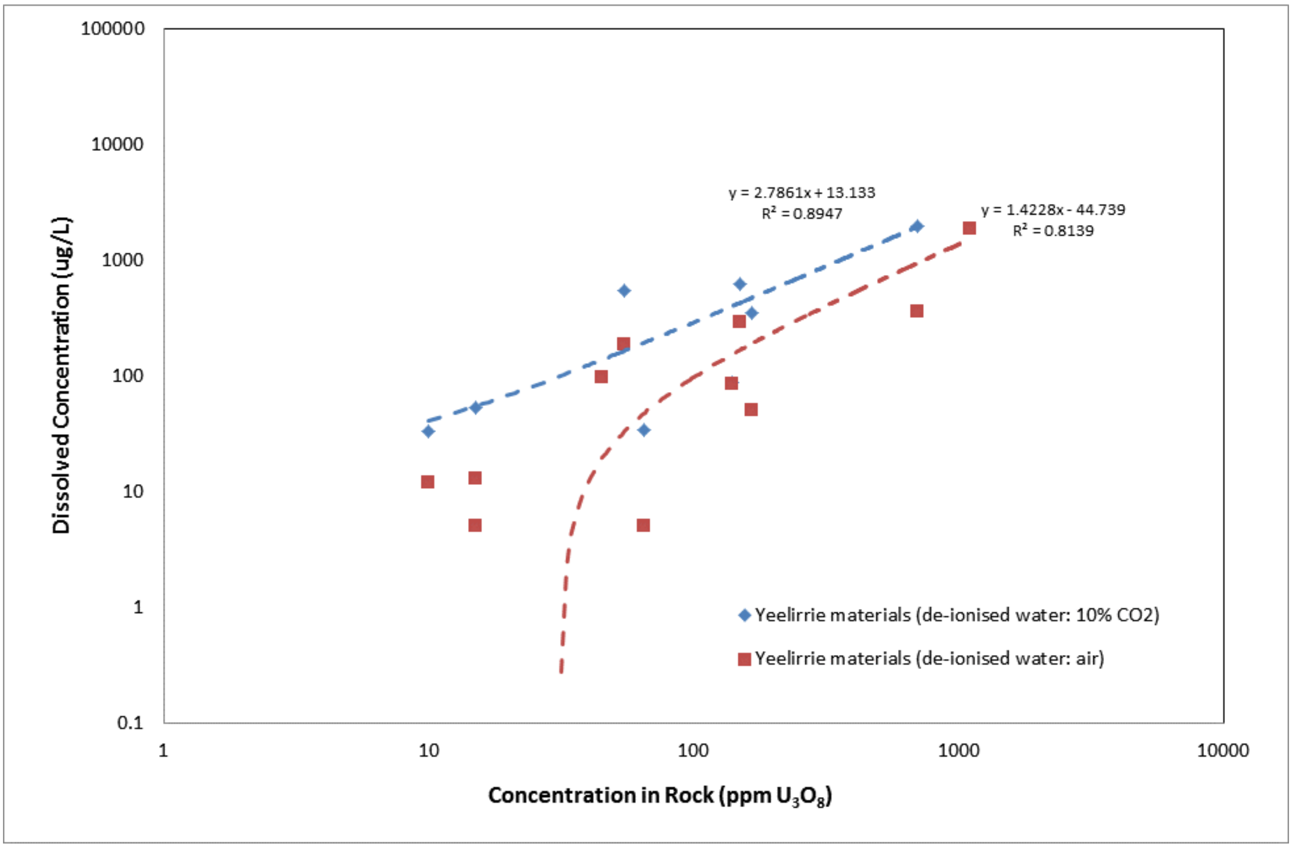


Figure 4.9: Dissolved uranium concentration plotted as a function of uranium content in the solid
(Note logarithmic scale on Y-axis; 3:1 liquid:solid ratio)

4.2.5.4 Effect of Solution Conditions

Solution pH is known to have a strong effect on the geochemical behaviour of many elements. However, because only a small range of pH values (pH 7 to 10) were observed, the effect of pH on solute concentrations was relatively small. Furthermore, pH effects were also likely masked by variability in other test parameters, e.g. lithology. As examples, Figure 4.10 and Figure 4.11 show dissolved uranium and vanadium concentrations plotted as a function of solution pH. There is a lot of scatter in the results but in general the highest solution concentrations coincide with higher pH values. This observation is discussed further in Section 4.5.

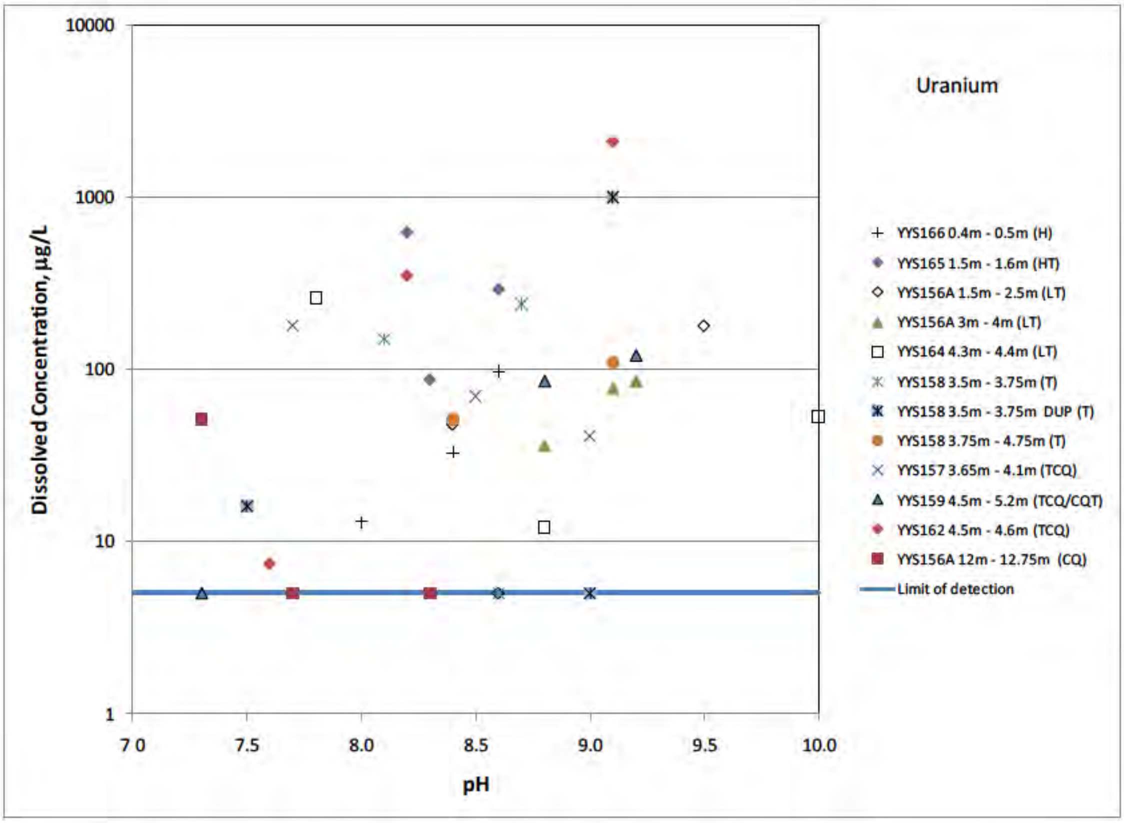


Figure 4.10: Dissolved uranium concentration plotted as a function of solution pH
(3:1 liquid:solid ratio, air atmosphere)

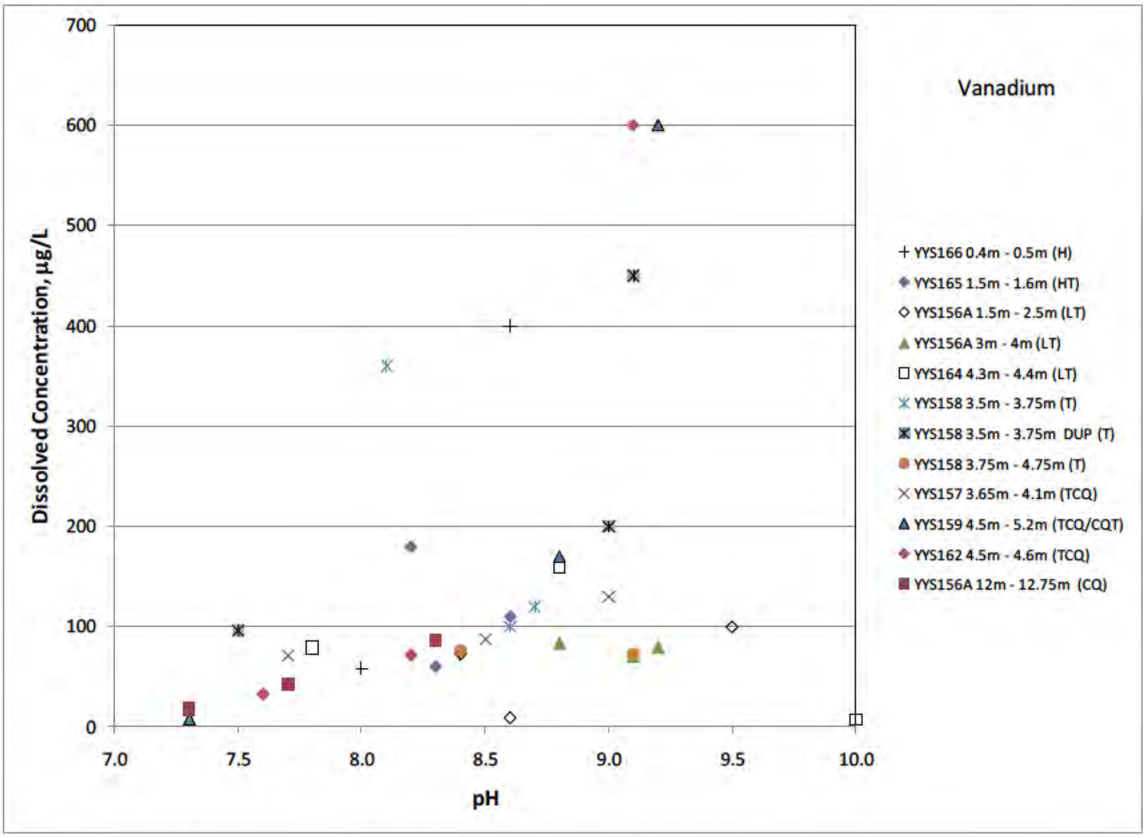


Figure 4.11: Dissolved vanadium concentration plotted as a function of solution pH
(3:1 liquid:solid ratio, air atmosphere)

The presence of a 10% CO_2:air mixture resulted in a significantly higher dissolved carbonate concentration when compared to tests in air (measured alkalinities were 3 and 50 times higher). For some elements, there is a clear trend towards higher dissolved concentrations for solutions containing higher dissolved CO_2. Uranium concentrations were as much as an order of magnitude higher in the presence of higher dissolved carbonate (Figure 4.12). The concentrations of strontium, barium and some transition metals also increased in the presence of excess CO_2. The higher dissolved concentrations likely reflect the role of effects such as (i) the formation of aqueous carbonate complexes and (ii) increased solubility of carbonate minerals.

Geochemical controls are discussed further in Section 4.5.

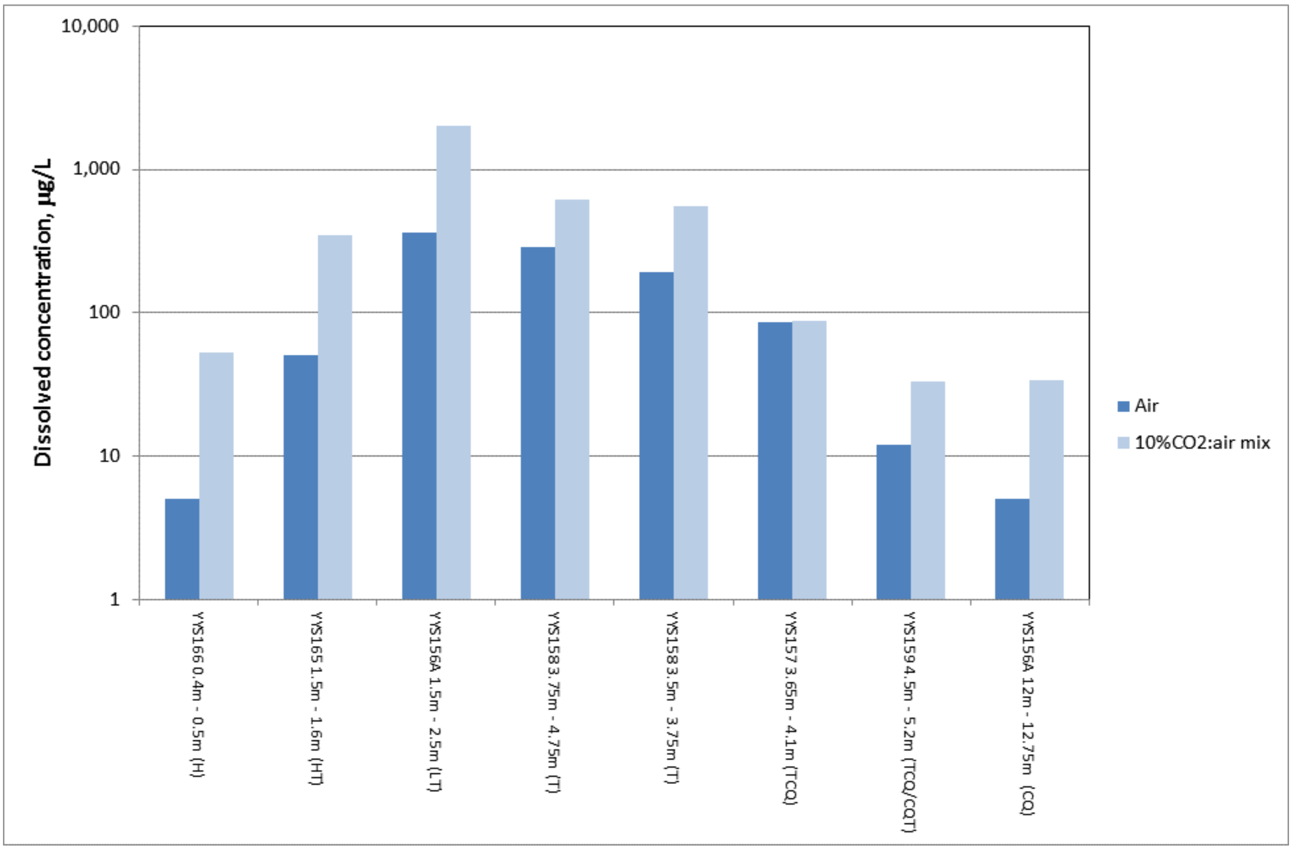


Figure 4.12: Effect of higher dissolved carbonate on dissolved uranium concentrations
(Note logarithmic scale on Y-axis; leachant is de-ionised water, 3:1 liquid:solid ratio)

4.3 Materials Underlying and Adjacent to the TSF

4.3.1 Mineralogy

The mineralogical compositions of materials underlying or adjacent to the proposed TSF are given in Table 4.5. Carbonate minerals form an important constituent of the loams. Both calcite and dolomite are present. In one loam sample, YYS167 2.3-2.4 m, Mg-rich calcite was identified.

Clays are abundant in all the samples. The clay mineralogy varies with depth. Kaolin is more abundant at greater depth (clay-quartz lithologies) and is also significant in the near surface (loams). Smectite is the more abundant clay in most near-surface loam samples. Other clay minerals present include palygorskite (accompanies kaolin in the clay-quartz lithology) and small quantities of illite/mica and sepiolite.

Quartz is most abundant in samples from greater depths (e.g. samples from the clay-quartz lithology and the palaeochannel sands).

Minor minerals identified include oxides (goethite, anatase), sulphates (gypsum) and halite. The presence of halite in the deeper clay-quartz samples may reflect a post-sampling artefact. Residual pore water in these samples may have been saline. During sample drying, it could be expected that residual salts might form.

4.3.2 Surface Characterisation

The surface areas measured are shown in Table 4.6, and range from 3.3 m^2/g to 81.9 m^2/g. There is no obvious correlation between surface area and mineralogical composition.

The cation exchange capacity ranges from 3.3 to 248 meq/100g. There is a positive correlation between exchange capacity and smectite content. Smectite is a swelling clay; spacing between the aluminosilicate sheets can increase to accommodate a greater degree of exchange. In contrast, kaolin does not have swelling capacity and therefore has a more limited exchange capacity. Kaolin is however known to be a strong adsorbent.

In loam samples and the palaeochannel sands, the dominant cation occupying exchange sites is Ca. Mg is the dominant cation for samples from the clay-quartz lithologies.

4.3.3 Particle Size Distribution

Particle size distributions are provided in Appendix 7. All samples exhibited at least a tri-modal particle size distribution. The samples showed an abundance of particles in the approximate sizes ranges, 1-5μm, 10-20μm, and 60-70μm. A fourth peak (five of the seven samples) corresponded to a coarser grain-size (200-300μm).

4.3.4 Bulk Chemistry

The results for the bulk chemical analyses of the samples are contained in Appendix 3. Selected results are provided in Table 4.7. The U_3O_8 contents were consistently elevated when compared to the mean crustal abundance. Other constituents that tended to be high compared to mean crustal abundance were sulphate and arsenic. Remaining elements were present at levels both above and below mean crustal abundances.

The bulk chemistry results for samples from each of the lithological units were compared to the results contained within the BHP Billiton chemical assay database (Appendix 3). In most cases, the chemistry of the samples lay within the range of values recorded in the main database for each lithological category. The samples selected for testing were therefore considered to be representative of the lithological units.

Table 4.5: Mineralogical Composition of Materials Underlying and Adjacent to the TSF (wt%)

Sample	Lithology	Carbonates			Framework and chain silicates			Sheet silicates and clays					Oxides		Other		
		Calcite	Mg-Calcite	Dolomite	Quartz	Albite	Microcline	Kaolin	Smectite [1]	Illite / Mica	Sepiolite	Palygorskite	Anatase	Goethite	Gypsum	Carnotite	Halite
YYS156A 0.7-1.5 m	L/LT	39			6		2	6	28						19		<1
YYS167 2.3-2.4 m	LQT	23	8	3	23	2	5	22	12	2							
YYS158 2.5-3.5 m	LT	8		63	7	1	1		7		13						
YYS164 4.3-4.4 m[2]	LT	<1			34	2	7	50	5	2			<1				
YYS164 5.2-5.3 m	CQT	<1		<1	37	2	8	44	4	2		?3	<1				
YYS156A 12-12.75 m[2]	CQ				30	2	5	39				21	<1	2			<1
YYS156A 11.25-12 m	CQ				28	2	6	48	3	2		8	<1	2			<1
YYS163 23-23.1 m	CQ				22	1	4	61		3		9	<1				
YYS165 6.6-6.7 m	CQ				63	2	8	21	3	1		?2					
YYS167 23-23.1 m	CQ				55	1	5	31	4	2		?2	<1				
YYS164 26.2-26.3 m	CQ				61	2	12	24		1							
YYHC0059C 55-56 m	Palaeochannel Sand				91			9					<1				
YYHC0075 64-65 m	Palaeochannel Sand				91			9					<1				

Notes:

? = denotes uncertainty in mineral identification.

[1] Smectite includes all montmorillonite group clays (montmorillonite, beidellite, nontronite, saponite, etc). The term montmorillonite was used in earlier mineralogical studies (Section 2.1). It is not known whether the term was being used to infer the montmorillonite clay group, or a specific member within this group.

[2] Note that these samples are also mentioned in the preceding section (Section 4.2, Ore and Waste Materials). Treating some samples within both categories allowed study of water-rock interactions for an individual sample under a wider range of geochemical conditions (e.g. de-ionised water and barren liquor contact tests). It also allowed for possible future change in the definition of the ore body, both in terms of lateral extent and depth.

Table 4.6: Surface Characteristics of the Materials Underlying and Adjacent to the TSF

Sample	Lithology	BET surface area, m^2/g	Cation exchange capacity, meq/100g	Exchangeable cations, (meq/100g) (grey shading = dominant cation)			
				Ca	Mg	K	Na
YYS156A 0.7-1.5 m	L/LT	72.9	248	242	3.7	1.1	0.5
YYS158 2.5-3.5 m	LT	81.9	24.9	16.6	6	1	1.3
YYS164 5.2-5.3 m	CQT	76.0	20.6	5.2	7.5	4.1	3.8
YYS156A 12-12.75 m	CQ	41.9	18.5	10.8	3.6	2.3	1.8
YYS156A 11.25-12 m	CQ	63.0	12.6	4	4.6	2.8	1.2
YYS167 23-23.1 m	CQ	31.0	7.0	0.8	2.9	2	1.3
YYHC0059C 55-56 m	Palaeochannel Sand	3.3	3.3	1.4	0.7	0.2	0.9

Table 4.7: Bulk Chemistry of Materials Underlying and Adjacent to the TSF

Major elements		Al	Ca	CO_2	F	Fe	K	Mg	Mn	Na	S	Si	SO_4
Sample #	**Material type**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
Average crustal abundance[1]		8.2	4.1			4.1	2.1	2.3	0.095	2.3			0.078
YYS156A 0.7-1.5 m	L/LT	2.06	16.8	14.2	0.44	0.98	0.47	5.77	<0.01	0.49	4.49	11.6	6
YYS167 2.3 - 2.4 m	LQT	4.63	12.2	15.4	0.13	1.98	1.12	2.96	0.01	0.36	0.07	20.3	<0.05
YYS158 2.5-3.5 m	LT	0.37	15.7	31.5	0.54	0.2	0.19	11.4	<0.01	0.35	0.04	10.8	0.1
YYS164 4.3-4.4 m	LT	8.44	0.17	0.2	0.1	3.38	1.53	1.08	0.02	0.54	0.1	29.3	0.1
YYS164 5.2-5.3 m	CQT	8.39	0.24	0.5	0.05	3.22	1.71	1.29	0.03	0.4	0.03	30.7	<0.05
YYS156A 12-12.75 m	CQ	8.75	0.14	0.2	0.07	3.44	1.43	1.64	0.02	0.67	0.09	29.1	0.2
YYS156A 11.25-12 m	CQ	9.48	0.14	0.2	0.08	4.11	1.66	1	0.02	0.64	0.07	27.4	0.1
YYS163 23 -23.1 m	CQ	10.8	0.08	0.1	0.09	4.06	2.08	1.66	0.02	0.54	0.11	25.9	0.4
YYS165 6.6-6.7 m	CQ	4.32	0.09	0.1	0.13	1.93	1.19	1.16	0.03	0.32	0.03	36.8	0.05
YYS167 23 - 23.1 m	CQ	6.25	0.05	0.1	0.05	2.4	1	0.52	0.01	0.35	0.06	35.1	0.1
YYS164 26.2-26.3 m	CQ	4.88	0.04	<0.07	0.02	1.6	1.4	0.22	<0.01	0.32	0.04	37.8	<0.05
YYHC0075	Palaeo. sands	1.23	0.11	0.2	0.01	0.68	0.1	0.05	<0.01	0.16	0.06	41.8	0.05
YYHC0059C	Palaeo. sands	1.35	0.05	0.2	0.02	0.67	0.09	0.09	<0.01	0.51	0.09	41.4	0.1

Minor elements		As	Ba	Cd	Co	Cr	Cu	Mo	Ni	Pb	Sr	Th	Tl	U_3O_8	V	Zn
Sample #	**Material type**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**
Average crustal abundance[1]		1.5	500	0.11	20	100	50	1.5	80	14	370		0.6	2.8	160	75
YYS156A 0.7-1.5 m	L/LT	11.5	60	<0.1	3	30	11.5	1.4	11	5	700	5	<3	235	85	18
YYS167 2.3 - 2.4 m	LQT	5	320	<0.1	4.8	55	17	1.7	16	7.5	450	5	<3	160	60	25
YYS158 2.5-3.5 m	LT	1.5	40	<0.1	0.8	<20	10	0.9	5	1.5	500	<4	<3	195	60	145
YYS164 4.3-4.4 m	LT	3	285	<0.1	6.5	115	19.5	2.2	15	13	65	15	<3	15	60	29.5
YYS164 5.2-5.3 m	CQT	4	290	<0.1	6.5	85	22	1.9	14	10.5	60	15	<3	20	60	37.5
YYS156A 12-12.75 m	CQ	13.5	220	<0.1	4.6	80	19.5	6.5	13	12.5	50	20	<3	65	145	125
YYS156A 11.25-12 m	CQ	21.5	250	<0.1	6	95	30.5	8	15	16.5	55	25	<3	70	175	46
YYS163 23 -23.1 m	CQ	3	205	<0.1	8	100	31	1.5	20	14	1000	30	<3	15	65	38.5
YYS165 6.6-6.7 m	CQ	5	335	<0.1	7	70	14	2.2	10	7.5	45	10	<3	10	50	21
YYS167 23 - 23.1 m	CQ	2	290	<0.1	2.4	70	11	2.1	9	8	30	20	<3	15	40	15
YYS164 26.2-26.3 m	CQ	4	315	<0.1	1.8	45	15	5.5	8	15.5	40	20	<3	5	45	9.5
YYHC0075	Palaeo. sands	0.5	65	<0.1	1	105	8.5	2.1	3	31.5	10	15	<3	5	<20	17.5
YYHC0059C	Palaeo. sands	1	60	<0.1	1.8	140	20	2.3	4	23	35	15	3	5	<20	37

Notes: [1] Mean crustal abundances taken from Bowen 1979.

4.3.5 Interactions with Barren Liquor

4.3.5.1 Clay-Quartz and Near-Surface Loams

The barren solution contains high concentrations of some solutes (Appendix 4). Results from bottle roll tests contacting solids with barren tailings liquor show evidence for the attenuation of some elements onto some solids. Attenuation is discussed in more detail in Section 4.6.1.

There are numerous instances where overall net leaching is observed when materials are contacted with barren liquor. These include:

- Calcium, magnesium, barium and strontium: overall leaching occurs when in contact with the barren liquor (all lithologies). The results tor the eight samples tested are illustrated in Figure 4.13 and Figure 4.14. In the case of calcium and magnesium, the dissolved concentrations are up to an order of magnitude higher in the final solutions than in the initial barren solution. For the clay-quartz sample (YYS163 23-23.1 m), the final dissolved magnesium is two orders of magnitude higher than in the barren solution. For strontium and barium the trend is similar, with the exception of the transitional TCQ sample, YYS164 5.2-5.3 m, which shows a small amount of attenuation of these elements. Barium and strontium are usually considered analogues of radium behaviour – but note that radionuclide assays (discussed in Section 4.5) suggested that radium is attenuated rather than leached in these tests.
- Uranium and vanadium leaching was observed for two of the clay-rich (CQ) samples (YYS165 6.6-6.7 m and YYS164 26.2-26.3 m) (Figure 4.15).
- Zinc was found to leach from all samples (Figure 4.16).

For most other elements, either no water-rock interaction takes place or attenuation occurs (Section 4.5).

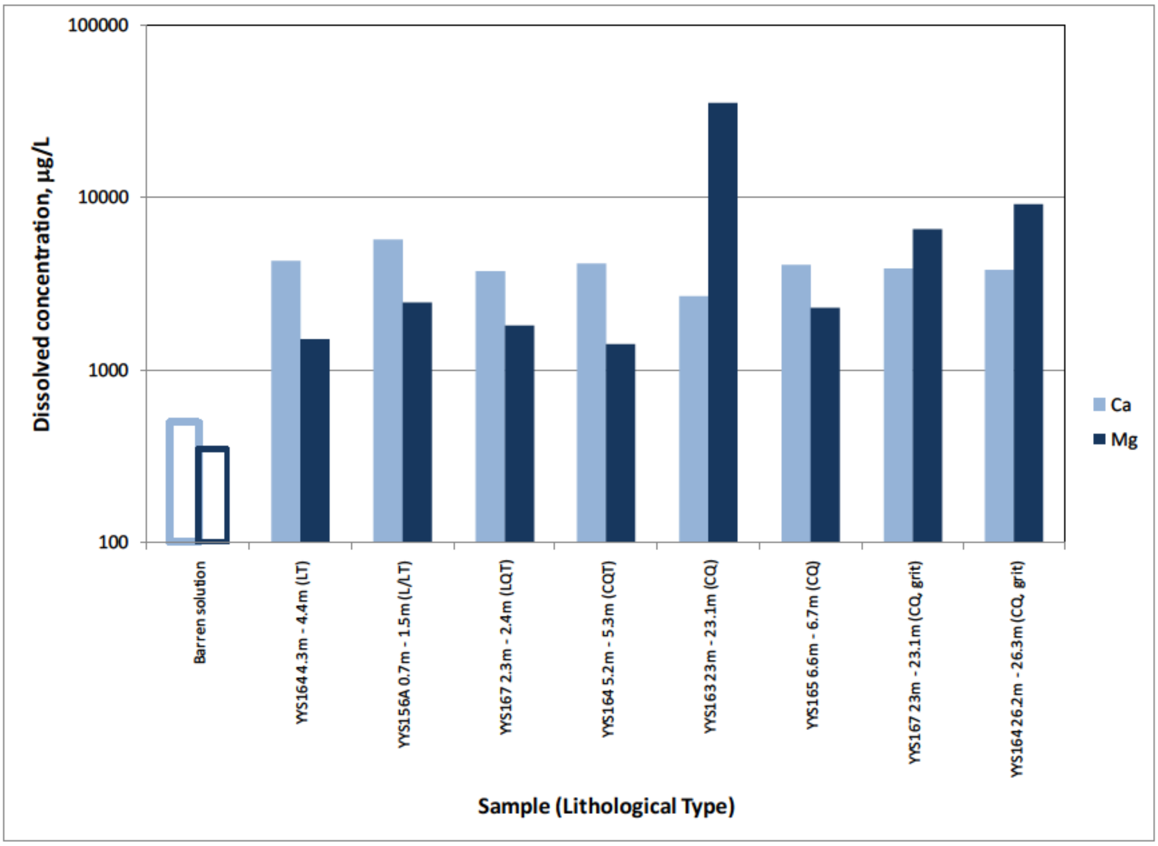


Figure 4.13: Ca and Mg leaching in barren solution
(3:1 liquid:solid ratio, air atmosphere)

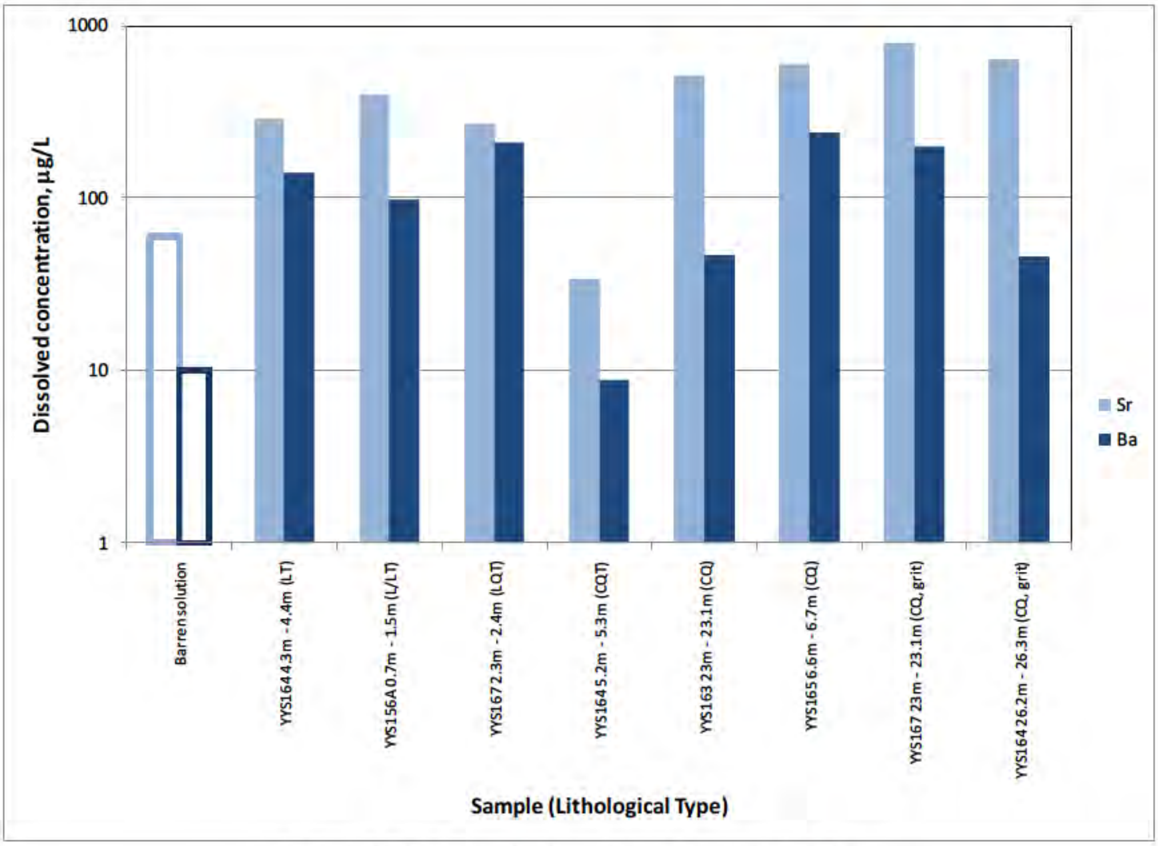


Figure 4.14: Sr and Ba leaching in barren solution
(3:1 liquid:solid ratio, air atmosphere)

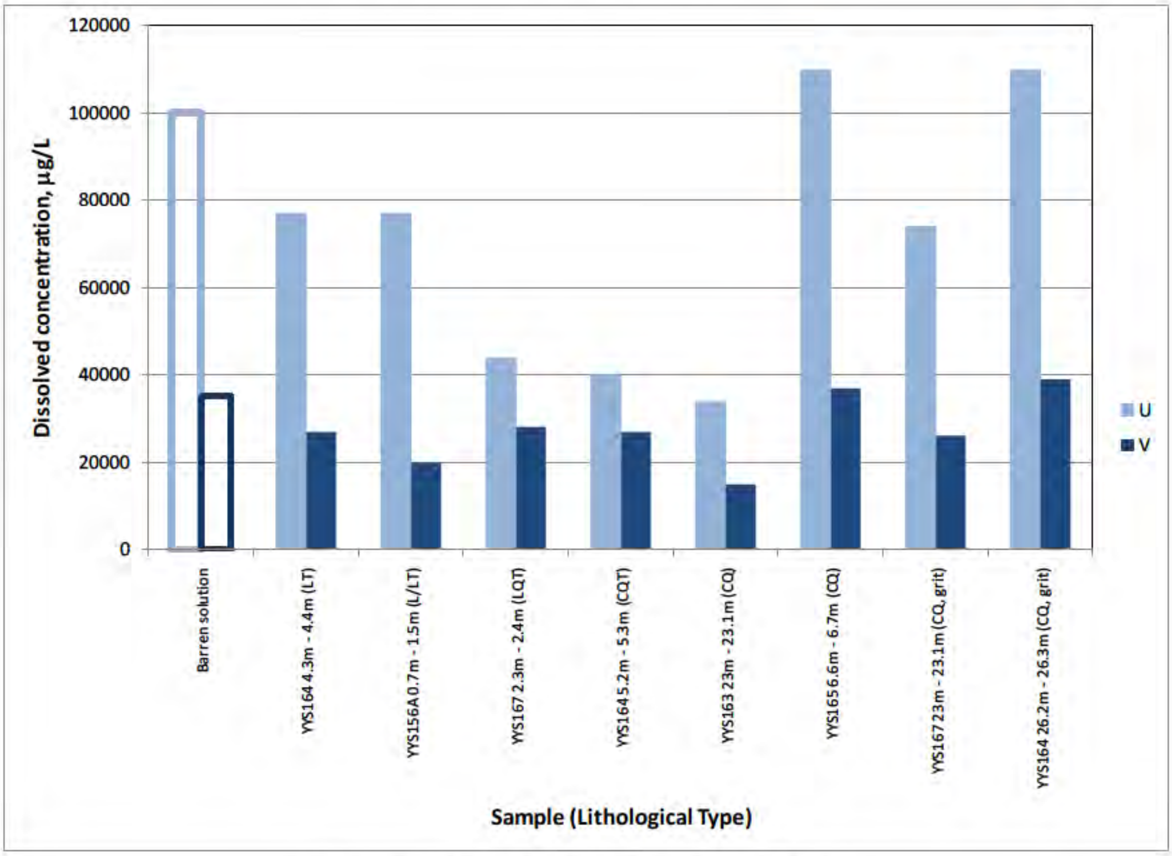


Figure 4.15: U and V leaching in barren solution
(3:1 liquid:solid ratio, air atmosphere)

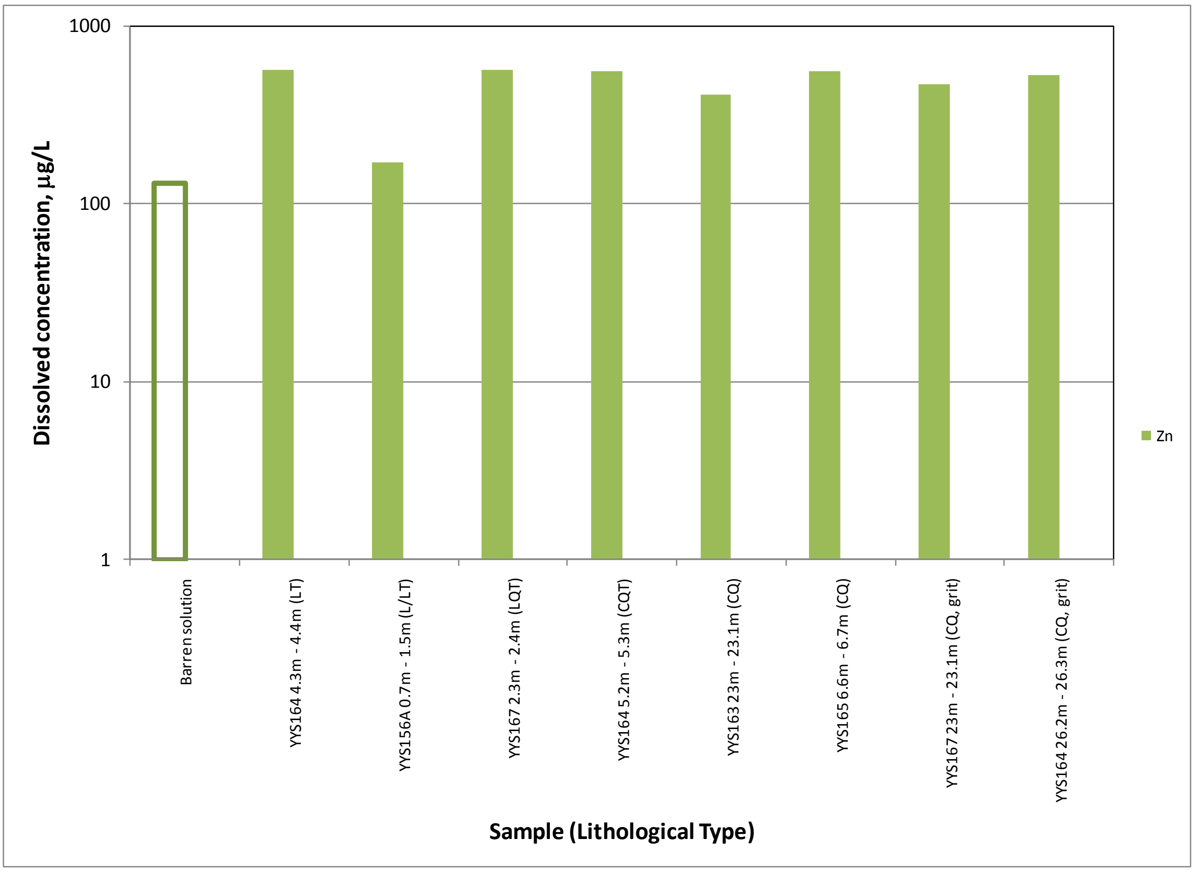


Figure 4.16: Zn leaching in barren solution
(3:1 liquid:solid ratio, air atmosphere)

4.3.5.2 Palaeochannel Sands

The palaeochannel sands were subjected to sequential bottle roll tests. In the first stage, the paleochannel sand was contacted with barren liquor. On completion of the first stage, the solution was removed and replaced with de-ionised water.

Results are given in Appendix 5. Dissolved sodium, calcium, uranium and vanadium concentrations are illustrated in Figure 4.17 to Figure 4.20.

Sodium concentrations decreased slightly during the first stage indicating that the sands have capacity to exchange Na. There is a coincident increase in calcium concentrations suggesting that sodium displaces calcium from exchange sites.

Uranium concentrations in the barren liquor decrease significantly following contact with the sands, suggesting significant sorption of uranium (calculated R_D values are high, 60,000 cm^3g^{-1}). See Section 4.6.1 for further discussion of sorption in Yeelirrie materials. On contact with de-ionised water in the second stage of the tests, very little of the adsorbed uranium enters solution, suggesting that sorption is irreversible under the conditions of the test.

Vanadium concentrations in the barren liquor show only a modest decrease following contact with the sands. This would suggest that vanadium sorbs only weakly. On contact with de-ionised water in the second stage of the test, the adsorbed vanadium is entirely desorbed.

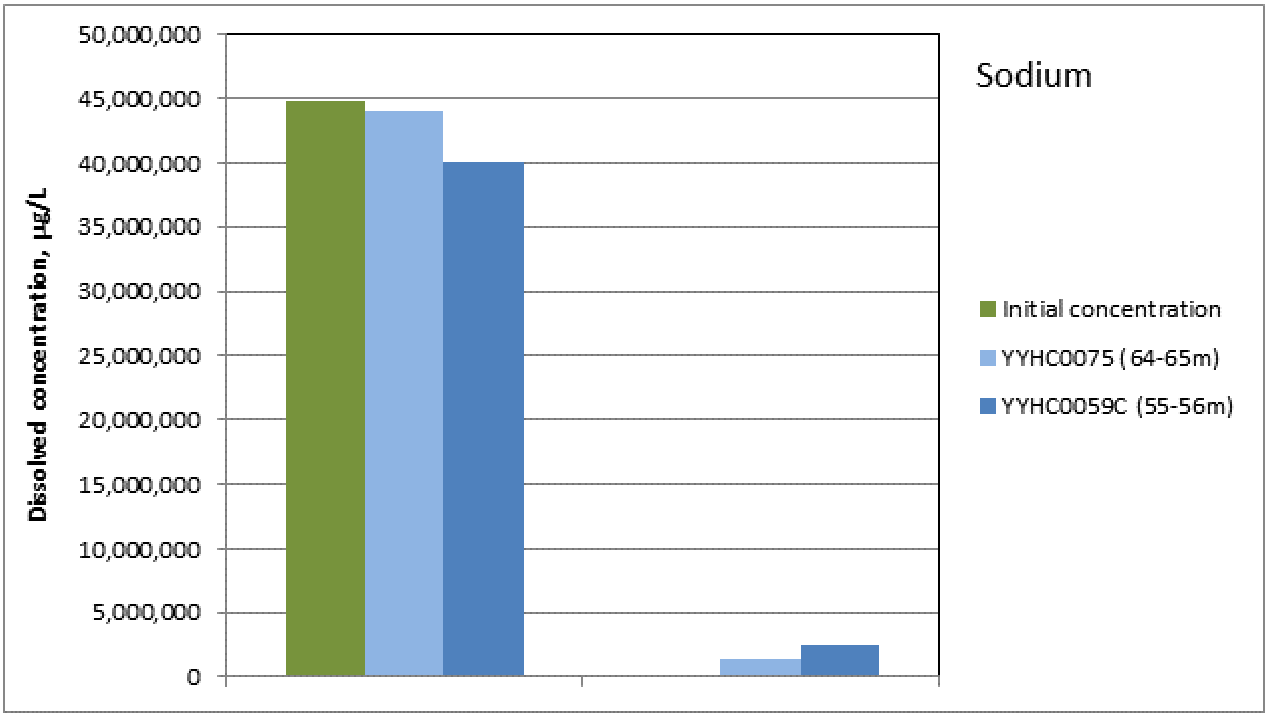


Figure 4.17: Dissolved sodium concentrations in leachates from bottle roll tests involving palaeochannel sands

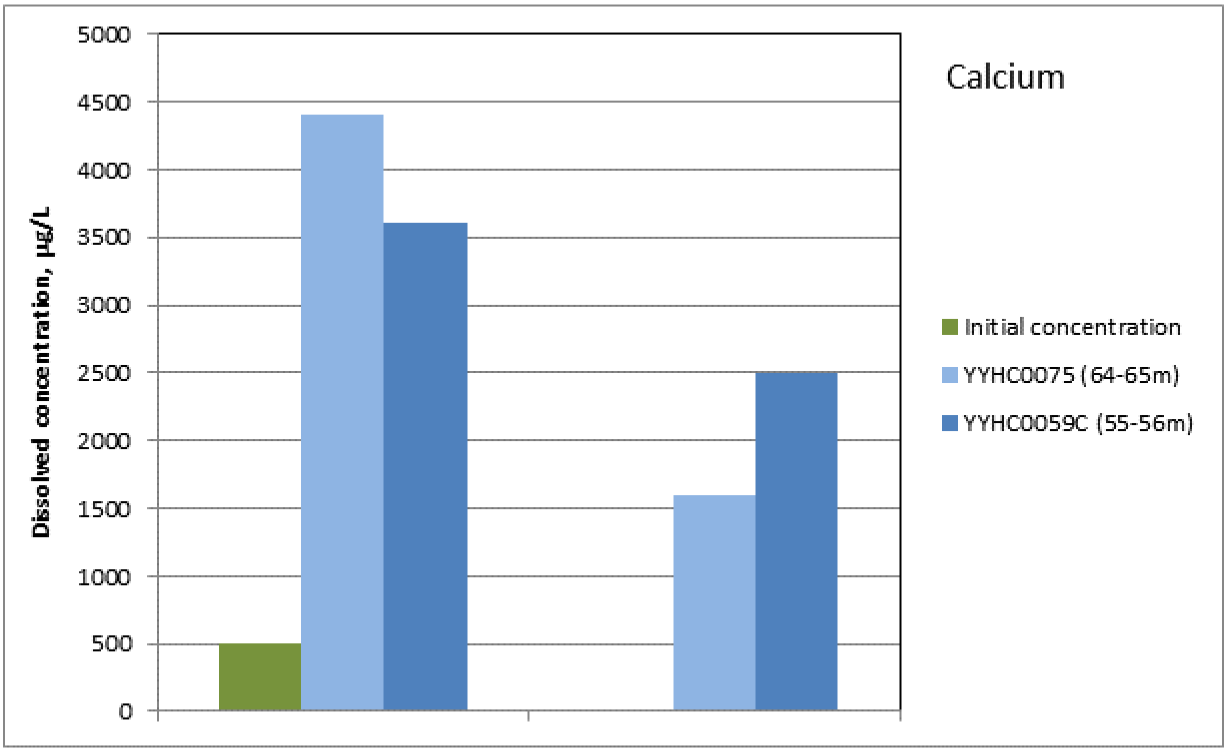


Figure 4.18: Dissolved calcium concentrations in leachates from bottle roll tests involving palaeochannel sands

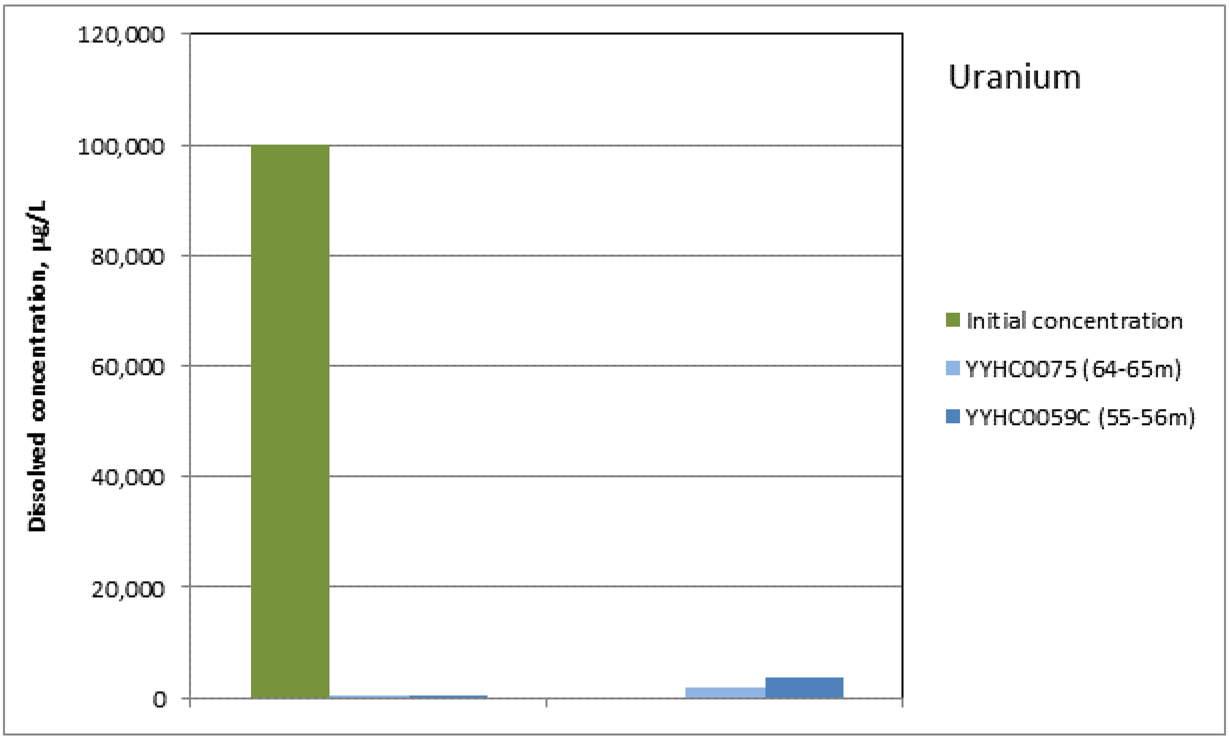


Figure 4.19: Dissolved uranium concentrations in leachates from bottle roll tests involving paleo-channel sands

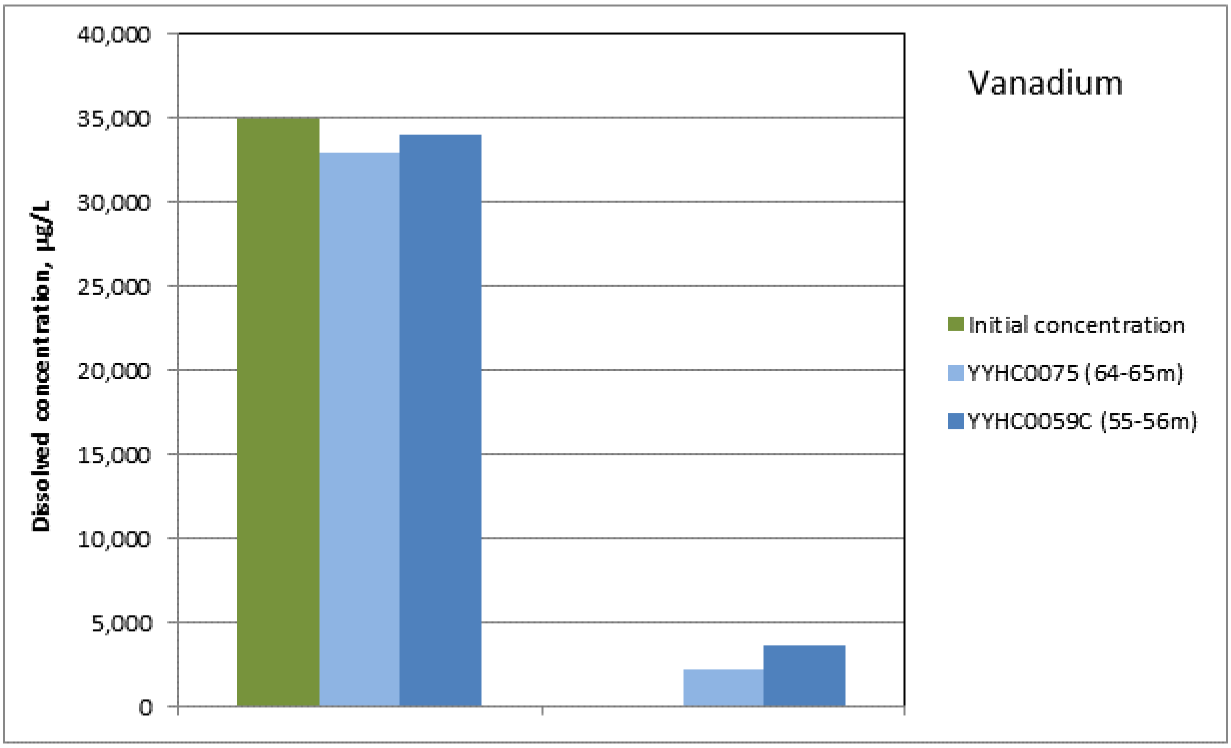


Figure 4.20: Dissolved vanadium concentrations in leachates from bottle roll tests involving palaeochannel sands

4.4 Column Test Results

Four sets of column pairs were set up to operate in series. The first column in each pair was open to air and operated such that the solution drains down and the sample becomes unsaturated between flushing events. The second column was not open to air and was maintained under saturated conditions (filled with solution) at all times. Effluent from the first column was used as inflow for the second column in that pair.

The column test programme is summarised in Table 4.8. Column test results are given in Appendix 5.

Table 4.8: Column Test Programme

Column #	Sample #	Lithology	Approx. W:R ratio[1]	Operating conditions	Inflow Solution
1A	YC3 tails residue	Tailings	0.2	Unsaturated	De-ionised water
1B	YYS156A 11.25-12 m	Clay-quartz (CQ)	0.5	Saturated	Sequences 1 to 5:Outflow from Column 1A; Sequences 6 to 11: De-ionised water[2]
2A	YYS158 3.75-4.5 m	Calcrete (T)	0.2	Unsaturated	De-ionised water
2B	YYS156A 0.7-1.5 m	Loam/calcareous loam (L/LT)	0.5	Saturated	Outflow from Column 2A
3A	YYS156A 1.5-2.5 m	Calcareous loam (LT)	0.3	Unsaturated	De-ionised water
3B	YYS158 2.5-3.5 m	Calcareous loam (LT)	0.5	Saturated	Outflow from Column 3A
4A	YYS159 4.5-5.2 m	Transitional between calcrete and clay-quartz (TCQ/CQT)	0.3	Unsaturated	Barren solution
4B	YYS156A 12-12.75 m	Clay-quartz (CQ)	0.5	Saturated	Outflow from Column 4A

Notes:

[1] Water:rock (W:R) ratio calculated based on the volume of inflow solution and the mass (wet) of solid in the column.

[2] Difficulties encountered with operation of Column 1A and this Column was terminated after Sequence 6. The inflow to Column 1B from Sequence 6 onward was de-ionised water – the aim being to examine whether solute attenuation during Sequences 1 to 5 would be revers ble when contacted with the de-ionised water.

4.4.1 General Trends

The general trends are consistent with those demonstrated in the bottle roll tests. For example, for those columns rinsed with de-ionised water the earliest pore volume exchanges tend to coincide with the highest solute concentrations.

Figure 4.21 shows sodium release from loam under both saturated and unsaturated conditions (Columns 2B and 3A, respectively). The first pore volume exchange contains the highest sodium concentration. Sodium concentrations in subsequent pore volumes decrease steeply at first and then more gradually. The shape of the release curve can be approximated quite well by a power law (see Figure 4.21).

Release of minor and trace elements from the columns also tends to decrease with successive pore volume exchanges, although there are occasional deviations from this overall trend. For example, Figure 4.22 and Figure 4.23 show uranium and vanadium release from Columns 2B and 3B. As shown, the vanadium release in the second pore volume exchange (both columns) is higher than that in the first pore volume exchange. For uranium, there is evidence of a secondary leaching peak (pore volume exchanges 4 and 5). These trends are consistent with some of the trends observed in sequential leach testing, Section 4.2.5.1. The results suggest that the change in solute concentrations that occur after the first displacement (i.e. substantial decrease in the more readily soluble solutes) may affect the solubility (or rate of dissolution) of carnotite (primary source mineral for both uranium and vanadium).

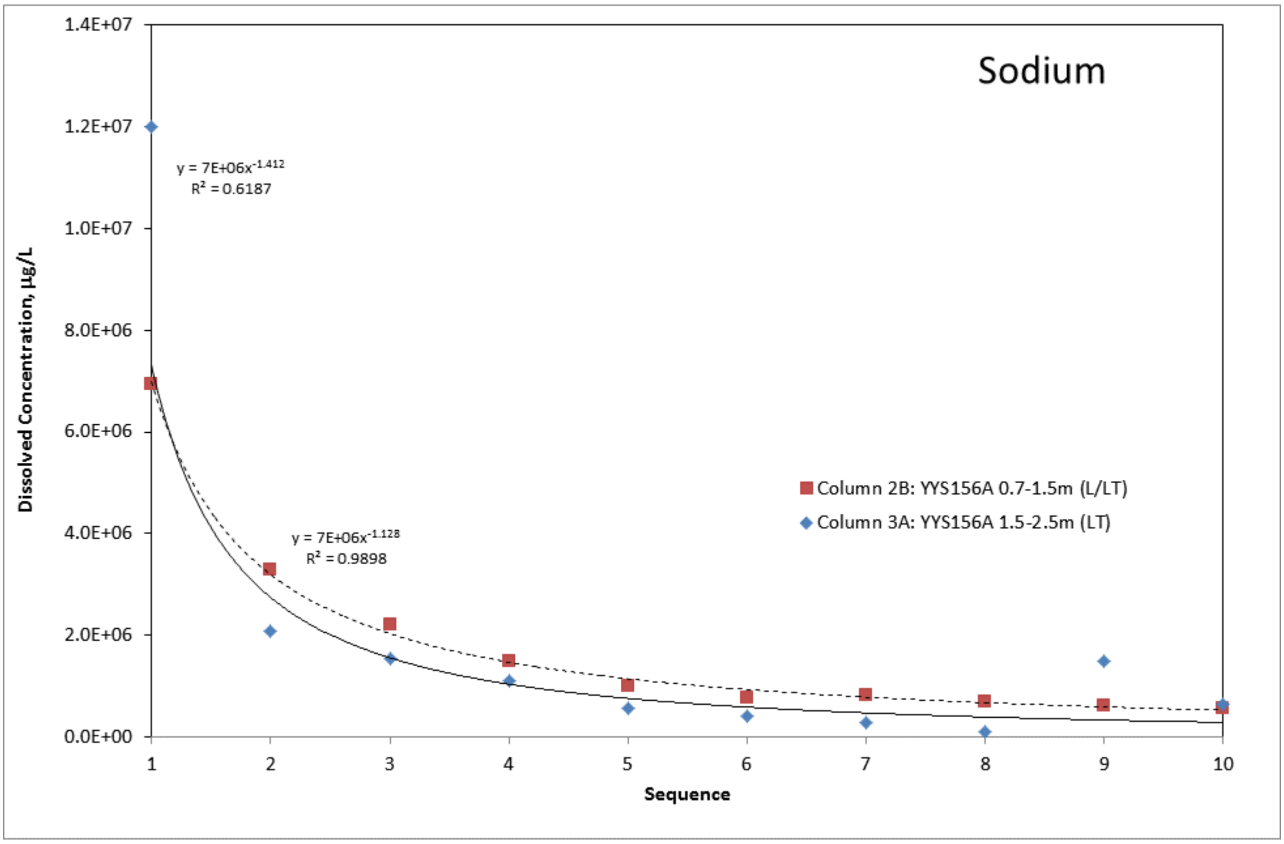


Figure 4.21: Dissolved sodium concentrations in leachates from Columns 2B and 3A

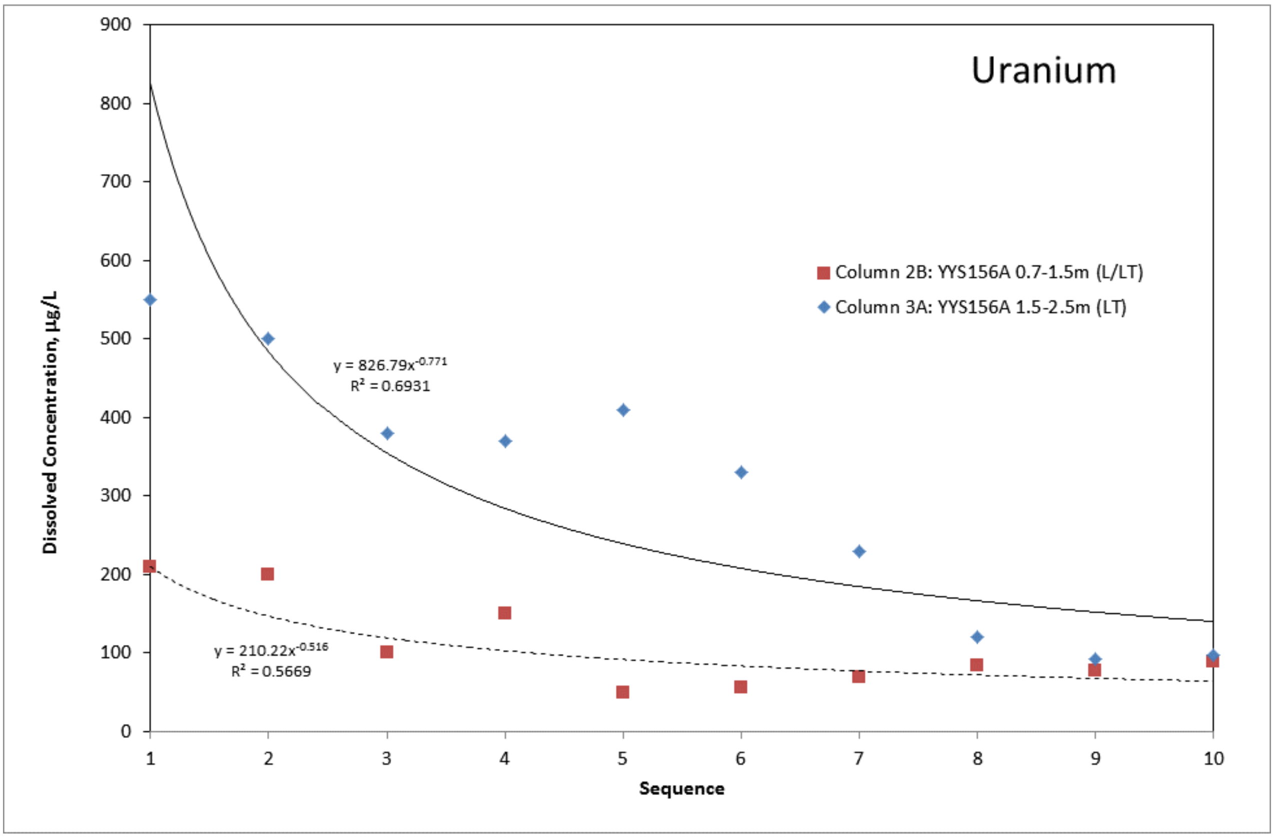


Figure 4.22: Dissolved uranium concentrations in leachates from Columns 2B and 3A

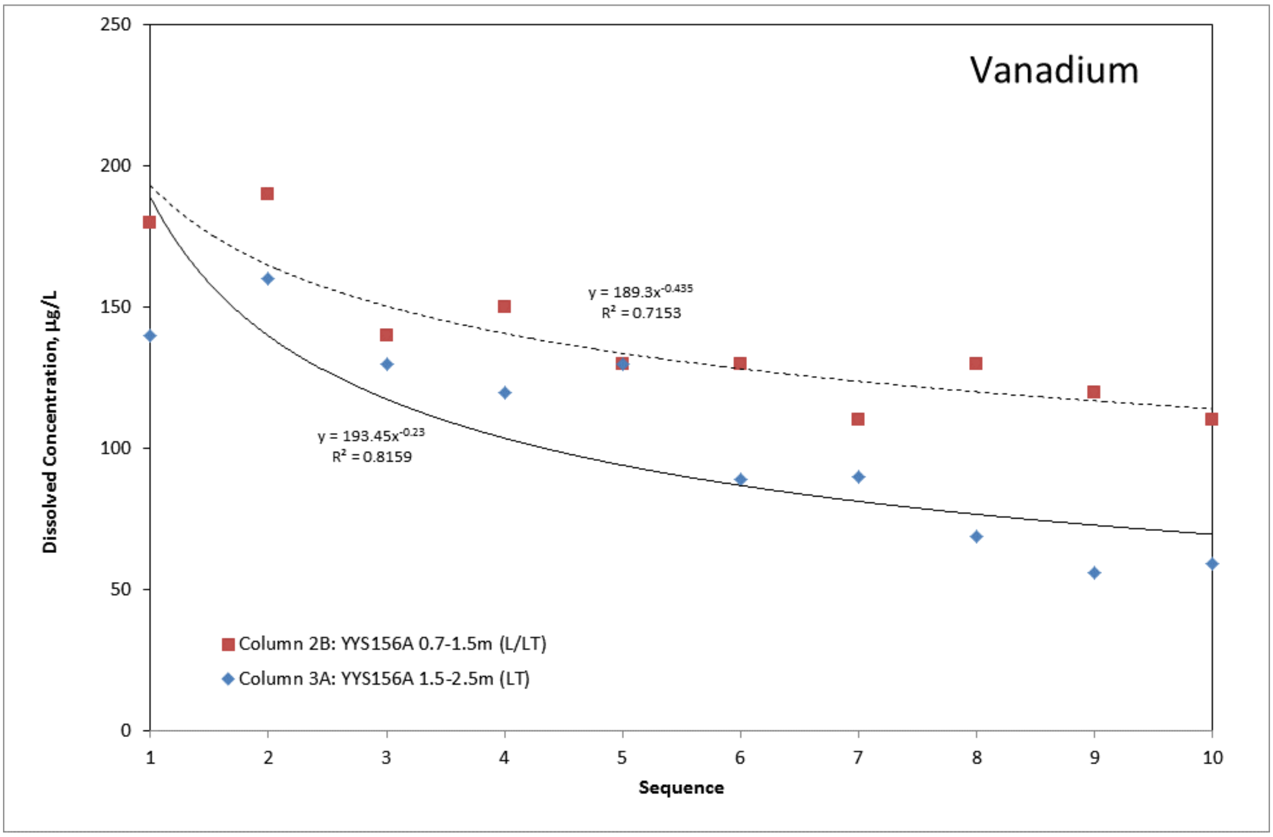


Figure 4.23:Dissolved vanadium concentrations in leachates from Columns 2B and 3A

In Column 4A (containing transitional material, TCQ/CQT), the inflow solution was barren liquor. As can be seen in Figure 4.24, the sodium concentrations in the effluent from the early pore volume exchanges from Column 4A were lower than the inflow concentrations. This reflects attenuation of sodium within the column, probably due to ion exchange (discussed further in Section 4.6.2). After four pore volume exchanges the sodium concentration in outflows are equivalent to those of the inflow suggesting that the capacity of the solid to further attenuate sodium has been exhausted (i.e. the ion exchange capacity has been depleted). In support of this conclusion, calcium was leached from Column 4A (Figure 4.25) (probably displaced by sodium in ion exchange reactions).

Column 4B contained clay-quartz (CQ). The outflow solutions from Column 4A were used as the inflow to Column 4B. The results presented in Figure 4.24 and Figure 4.25 show that trends similar to those described above were being displayed during these early pore volume exchanges (i.e. attenuation of sodium and coincident leaching of calcium).

Uranium leaching trends in Columns 4A and 4B were more complex (Figure 4.26). Attenuation appears to take place during the first pore volume exchange, and again during the fourth and fifth pore volume exchanges and the eighth exchange. Similar trends were observed for chromium and selenium. One possible explanation for this trend relates to iron behaviour in the column. There is some evidence for iron leaching in the early pore volume exchanges (see Appendix 5). The iron may have been displaced from exchange sites (as is the case for calcium) in exchange for the other metals. The displaced iron could re-precipitate in the form of oxy-hydroxides, generating new sorptive capacity to the material and explaining the renewed attenuation.

Figure 4.27 shows vanadium release from Columns 4A and 4B. In Column 4A, vanadium concentration in leachate is gradually increasing, and by the tenth pore volume exchange returned to the initial concentration found in the barren liquor. This suggests that the capacity of the material to attenuate vanadium has been exhausted. The limited results from Column 4B suggests ongoing attenuation of vanadium is likely to occur.

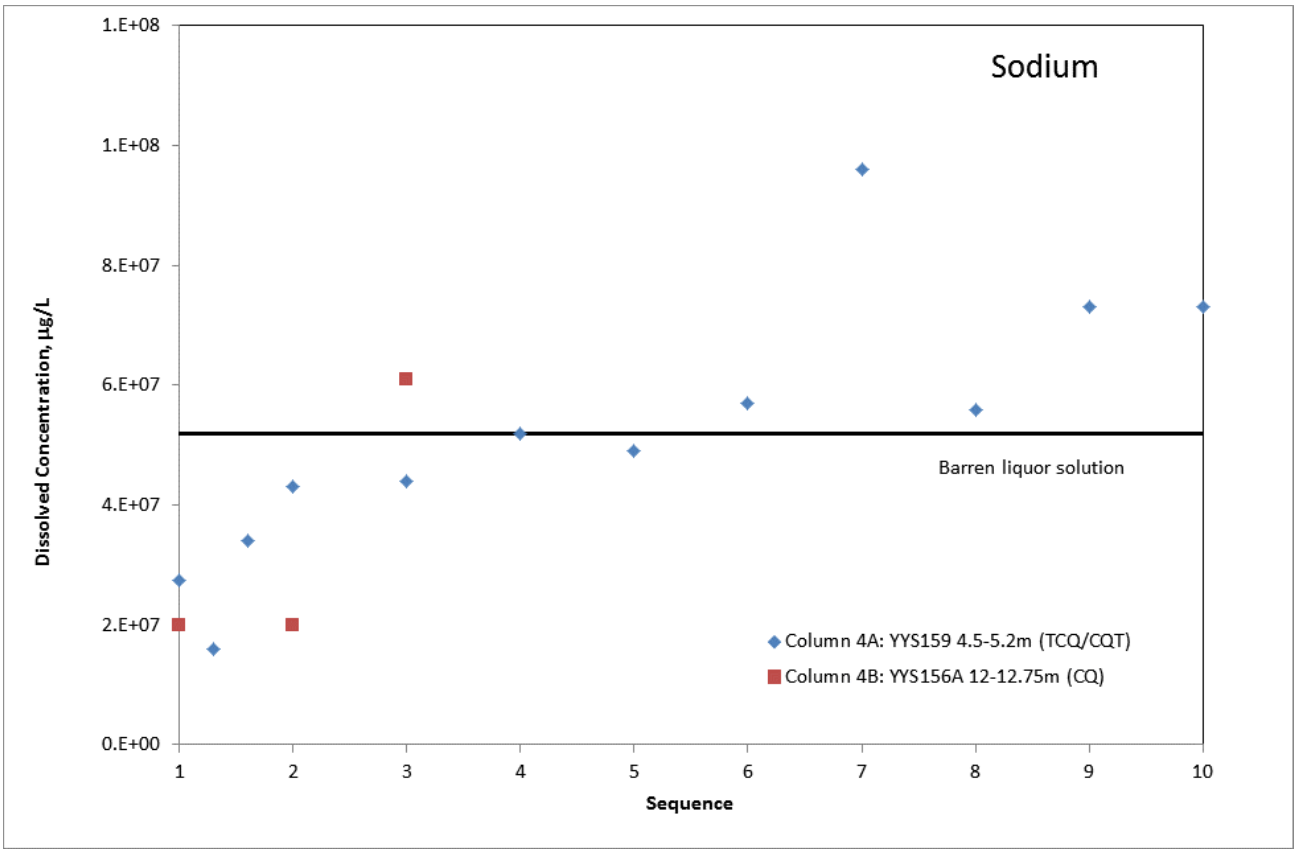


Figure 4.24: Dissolved sodium concentrations in leachates from Columns 4A and 4B

Due to operational difficulties, Column 4B was terminated after three pore volume exchanges.

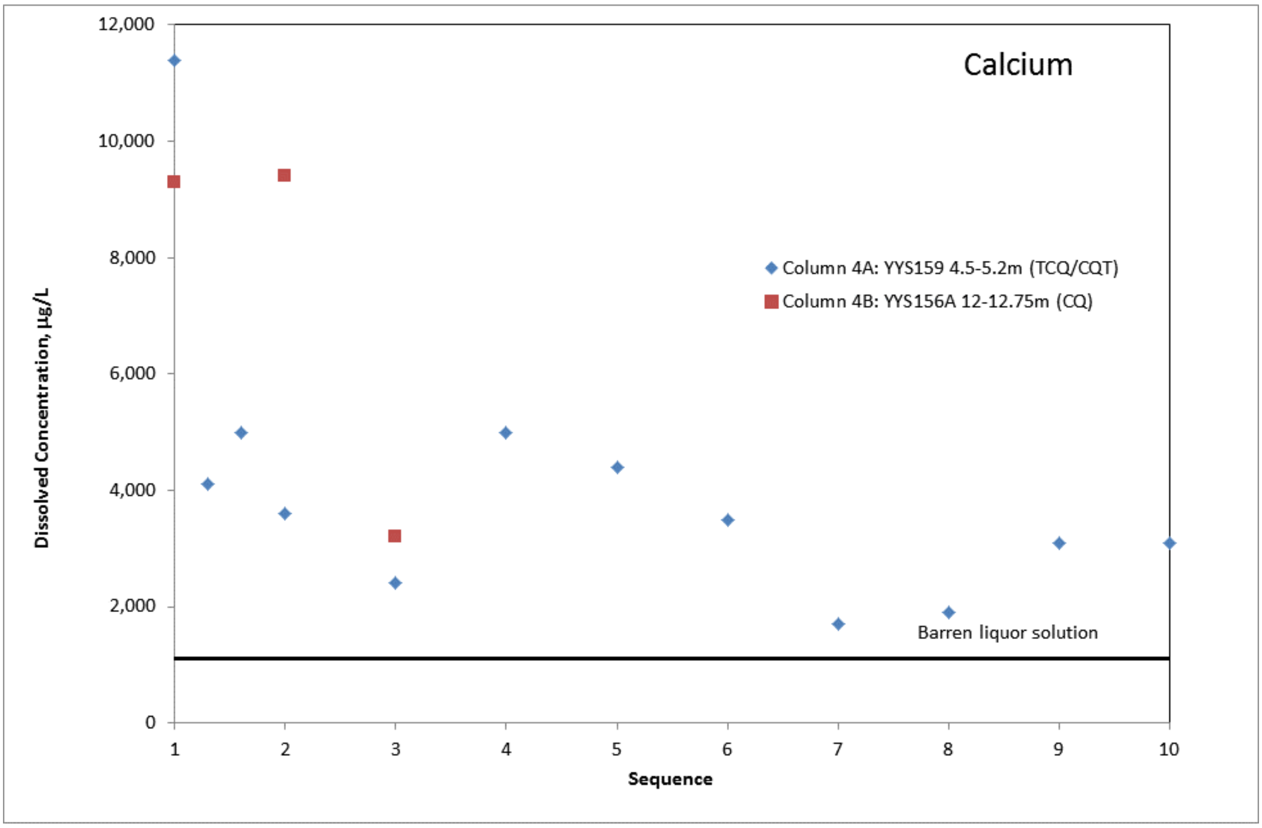


Figure 4.25: Dissolved calcium concentrations in leachates from Columns 4A and 4B

Due to operational difficulties, Column 4B was terminated after three pore volume exchanges.

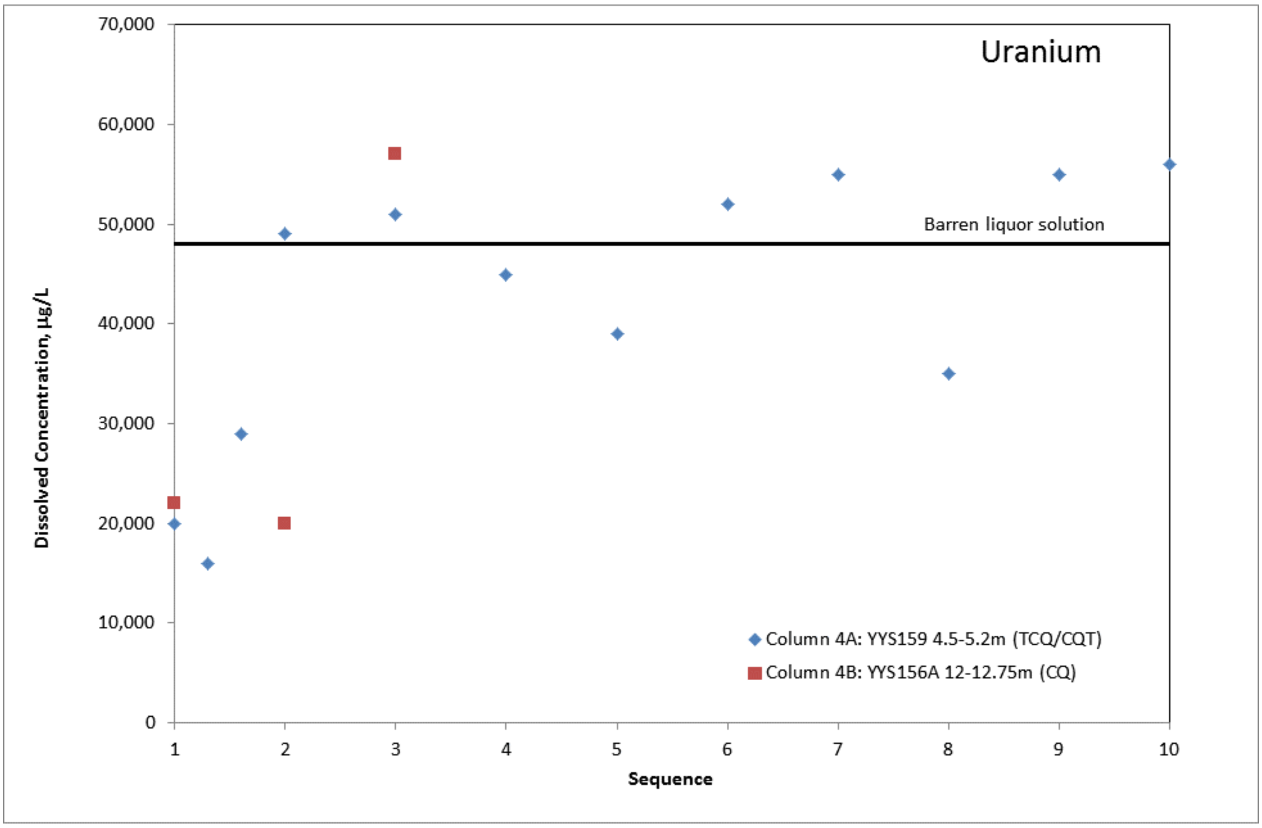


Figure 4.26: Dissolved uranium concentrations in leachates from Columns 4A and 4B

Due to operational difficulties, Column 4B was terminated after three pore volume exchanges.

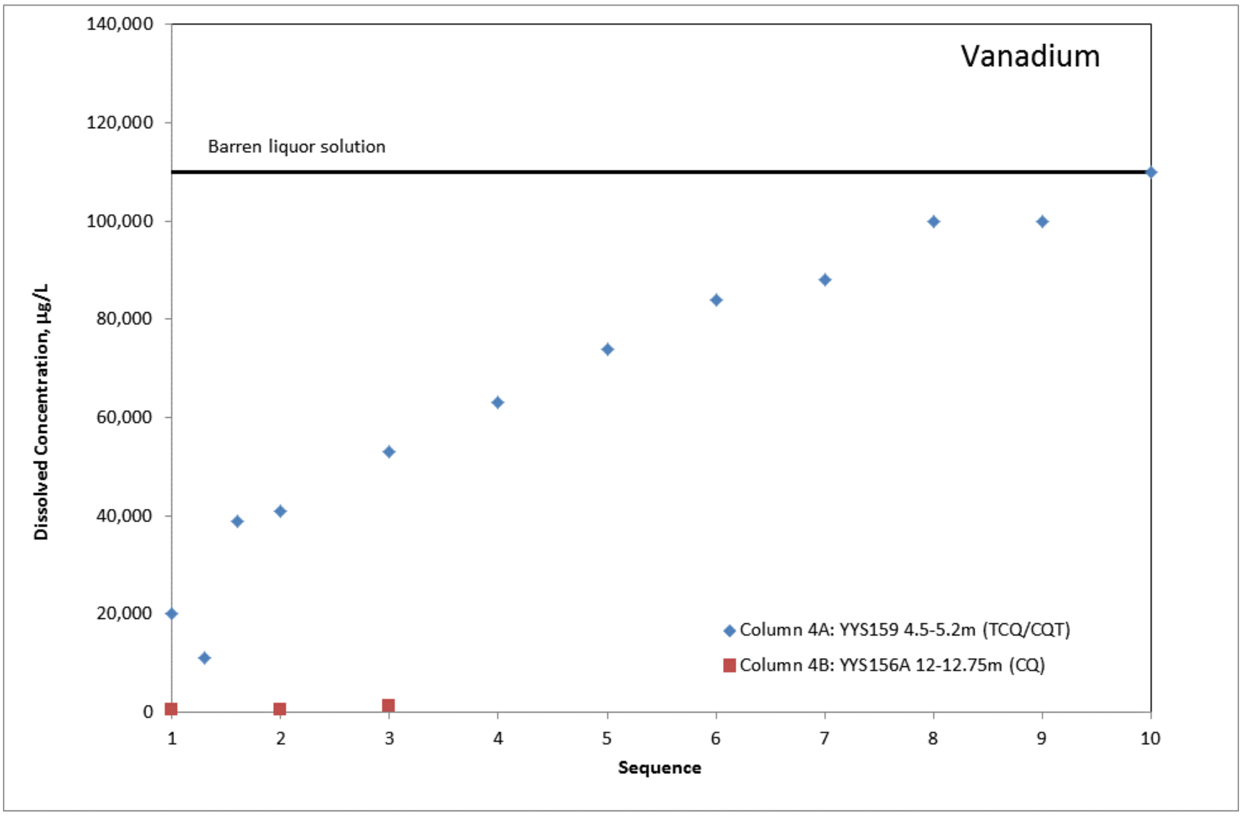


Figure 4.27: Dissolved vanadium concentrations in leachates from Columns 4A and 4B

Due to operational difficulties, Column 4B was terminated after three pore volume exchanges.

4.4.2 Quantitative Comparisons between Column and Bottle Roll Test Results

The column tests involve solid:solution ratios much higher than those of bottle roll tests. Unless solubility limits apply, the higher mass of solid may result in higher solute concentrations in leachates. Table 4.9 summarises the maximum dissolved concentrations observed in the column programme (to-date) and those observed in the bottle roll tests.

Looking first at the de-ionised water results, higher dissolved concentrations were observed in the column effluent (when compared to the roll bottle tests) for most elements. However, the maximum concentrations of thallium, uranium and vanadium were higher in the bottle roll tests. Uranium and vanadium are believed to be solubility limited in the columns, which may explain the limited dissolved concentrations of these elements in column leachates. The same may apply to thallium, however, no thermodynamic data are available with which to assess potential solubility controls for this element.

In the case of the barren liquor leach results, attenuation as well as leaching takes place. For attenuated elements, the higher solid:solution ratio in the columns offers additional sorptive capacity, and so it would be expected that maximum dissolved concentration be less in the column dataset than in the bottle roll dataset. The comparisons within the barren liquor dataset are therefore more complex. Nevertheless, uranium concentrations were elevated in the column and roll bottle tests, suggesting that the uranium contained in the barren solution dominates the solution chemistry after contact with the materials tested.

Table 4.9: Summary of Maximum Solute Concentrations in Column Tests Compared to Outcomes from Bottle Roll Tests

Parameter	Units	Detection Limit[1]	Maximum value			
			De-ionised water		Barren Liquor	
			Columns (2,3)	Bottle Rolls	Columns (1B, 4)	Bottle Rolls
pH	pH Units	0.01	9.1	10.0	11.0	11.0
Eh	mV	1	516	510	426	383
EC	µS/cm	5	57900	8890	275000	258000
Acidity	as $CaCO_3$ (mg/L)	20	890	50	<20	<20
Alkalinity	as $CaCO_3$ (mg/L)	1	1100	1300	124000	81000
Br	mg/L	0.5	48	11	240	92
Cl	mg/L	0.5	18000	1700	22000	23000
F	mg/L	0.5	10	5	42	27
TOC	mg/L	1, 5	80	200	89	2900
NO_2	mg/L	0.02, 0.5	2.2	2.2	1.8	0.63
NO_3	mg/L	0.1, 0.5	840	95	960	740
SO_4	mg/L	0.5	9100	3200	13000	54000
Al	µg/L	5	120	680	88	150
Ca	µg/L	100	2010000	694000	11400	6060
Fe	µg/L	100	<100	560	300	300
Mg	µg/L	100	1470000	237000	490000	88000
P	µg/L	100	5000	2300	6100	1800
K	µg/L	1000	1250000	211000	2100000	1900000
Na	µg/L	100	12000000	1110000	57000000	53000000
Si	µg/L	100	24000	78000	180000	76000
Ag	µg/L	5	6.3	<5	9	5.4
As	µg/L	5	46	48	12000	7800
B	µg/L	5	47000	4900	60000	38000
Ba	µg/L	0.02, 5	530	160	28	550
Cd	µg/L	0.2, 5	19	27	18	31
Co	µg/L	1, 5	9.7	<5	6	<5
Cr	µg/L	5	8.1	37	3400	3500
Cu	µg/L	5	36	20	1400	140
Li	µg/L	5	<5	11	350	15
Mn	µg/L	5	110	53	6.1	15
Mo	µg/L	5	900	390	4500	3100
Ni	µg/L	1, 5	31	17	30	34
Pb	µg/L	1, 5	<5	<5	120	45
Sb	µg/L	5	<5	<5	<5	8
Se	µg/L	1, 5	330	28	650	560
Sn	µg/L	5	660	24	700	27
Sr	µg/L	5	36000	6000	1600	1900
Tl	µg/L	5	10	360	11	180
U	µg/L	5	550	2100	64000	110000
V	µg/L	5	190	600	84000	39000
Zn	µg/L	5	270	200	2200	680

4.5 Radionuclide Distribution and Behaviour

Results from the radionuclide assays of Yeelirrie rock and soils are summarised in Table 4.10. Daughter/parent activity ratios that differ from unity indicate secular disequilibrium.

Notably, in many of the near-surface lithologies (loams, calcrete and transitional calcrete), the activity of ^{238}U is less than the activities of isotopes further down the ^{238}U decay chain, suggesting isotopic disequilibrium within this decay chain. Daughter/parent activity ratios would suggest that whilst thorium, radium and lead isotopes are behaving similarly, uranium isotopes are not. Leaching and preferential removal of uranium would explain the observed disequilibrium relationships. Isotopes within the ^{232}Th decay chain give comparable activities suggesting isotopic equilibrium and suggesting that no preferential leaching or accumulation of thorium or radium isotopes.

In the deeper lithologies (clay-quartz and the palaeochannel sands) isotopes within the ^{232}Th and ^{238}U decay chains generally give comparable activities, suggesting secular equilibrium. This would suggest that within the last several million years, no geochemical processes have resulted in either preferential leaching or accumulation of individual radionuclides within the decay chains.

For many samples, isotopes within the ^{235}U decay chain are present at activities that are below detection. In the six samples, mostly loams, where ^{235}U and ^{227}Ac activities were detectable, the ^{227}Ac activities tend to be slightly less than the ^{235}U activities. This would suggest either accumulation of uranium in the loams, or conversely, leaching of actinium. Leaching of actinium is contrary to expectation. Actinium sorbs very strongly and would be expected to be relatively immobile (Baston et al, 1997). However, data from the ^{238}U decay chain generally suggested uranium leaching rather than accumulation. An exception to this rule was one of the loam samples (YYS156A 0.7-1.5 m), which gave high ^{238}U activities relative to isotopes further down the decay chain, possibly consistent with accumulation of uranium in this sample. Accumulation of uranium in loam could be explained by high sorption within this material type. Sorption is discussed further in Section 4.6.2.

Results from radionuclide assays of leachate solutions are summarised in Table 4.11.

In leach tests involving de-ionised water, the radionuclide concentrations were often below limits of detection. Detectable uranium (^{238}U) was only recorded in one test, leaching from the sample (loam, YYS156A 1.5-2.5 m) under conditions of high dissolved CO_2.

The detection limit for ^{226}Ra was lower, and thus ^{226}Ra concentration were quantified for most samples. In the de-ionised water tests, the measured radium concentration correlates well with that of strontium and barium (dissolved barium and strontium concentrations are also shown in Table 4.11). However, this is not the case for tests involving leaching with barren liquor solution. As noted in Section 4.3.5, calcium, magnesium, barium and strontium leached from solids contacted with barren liquor. An exception is barium behaviour in Column 4A; barium concentrations in leachates from this column are lower than measured in the initial barren liquor suggesting barium attenuation in this column. In all but one test, the ^{226}Ra concentration in the final leachate was lower than that of the starting barren liquor solution, suggesting attenuation rather than leaching was occurring in the majority of tests. It would appear therefore that, in tests involving barren liquor solution, ^{226}Ra behaviour is distinct from that of strontium and barium.

Table 4.10: Radionuclide Assay Results for Yeelirrie Solids

Sample #	Depth range (m)	Material	Concentration (Bq/g)									
			^{232}Th Decay Chain			^{238}U Decay Chain				^{235}U Decay Chain		^{40}K
			^{232}Th	^{228}Ra	^{228}Th	^{238}U	^{230}Th	^{226}Ra	^{210}Pb	^{235}U	^{227}Ac	
YYS166	0.4-0.5	H	0.044	0.048	0.044	0.17	<0.2	0.13	0.11	<0.02	<0.01	0.46
YYS165	1.5-1.6	HT	0.019	<0.02	0.019	1.5	2.4	2.0	2.2	0.074	0.079	0.23
YYS156A	0.7-1.5	L/LT	0.019	<0.04	0.018	2.3	1.5	1.4	1.5	0.10	0.067	<0.2
YYS167	2.3-2.4	LQT	0.033	<0.02	0.033	1.5	2.0	2.1	2.2	<0.04	0.064	0.37
YYS156A	1.5-2.5	LT	0.022	<0.03	0.021	6.0	6.6	5.6	5.5	0.30	0.23	<0.3
YYS158	2.5-3.5	LT	0.0044	<0.02	<0.01	2.0	2.6	2.4	2.7	0.10	0.078	<0.08
YYS156A	3-4	LT	0.024	<0.05	0.024	12	13	11	12	0.55	0.49	0.32
YYS164	4.3-4.4	LT	0.072	0.077	0.077	0.12	<0.2	0.070	0.072	<0.02	<0.01	0.39
YYS158	3.5-3.75	T	0.0014	<0.02	<0.01	0.69	0.98	0.95	1.1	<0.03	0.028	<0.05
YYS158	3.75-4.5	T	0.0016	<0.03	<0.01	1.5	2.0	1.8	1.9	<0.07	0.057	<0.08
YYS157	3.65-4.1	TCQ	0.028	0.032	0.023	1.3	1.5	1.3	1.4	<0.03	0.057	0.20
YYS162	4.5-4.6	TCQ	0.027	<0.04	0.025	0.46	0.79	0.63	0.79	<0.02	0.022	0.47
YYS159	4.5-5.2	TCQ/CQT	0.056	0.061	0.058	0.15	<0.3	0.19	0.21	<0.03	<0.01	0.46
YYS164	5.2-5.3	CQT	0.062	0.053	0.048	0.17	<0.1	0.089	0.11	<0.01	<0.01	0.46
YYS156A	11.25-12	CQ	0.11	0.11	0.11	0.82	0.95	0.82	0.79	<0.03	0.036	0.53
YYS156A	12-12.75	CQ	0.083	0.091	0.076	0.81	1.0	0.81	0.82	0.039	0.032	0.44
YYS163	23-23.1	CQ	0.12	0.13	0.11	0.13	<0.3	0.15	0.16	<0.03	<0.02	0.65
YYS167	23-23.1	CQ	0.068	0.072	0.073	0.11	<0.3	0.14	0.16	<0.03	<0.02	0.33
YYS164	26.2-26.3	CQ	0.074	0.089	0.078	0.071	<0.2	0.087	0.10	<0.02	<0.01	0.45
YYS165	6.6-6.7	CQ	0.042	0.042	0.044	0.15	<0.2	0.17	0.20	<0.02	<0.01	0.37
YYHC0059C	55-56	Palaeochannel sand	0.073	0.076	0.067	0.077	<0.2	0.063	0.083	<0.02	<0.01	0.043
YYHC0075	64-65	Palaeochannel sand	0.058	0.056	0.055	0.063	<0.1	0.062	0.071	<0.01	<0.01	0.037

Table 4.11: Radionuclide Assay Results for Leachate Solutions

Test	Sample	Material type	Leach solution	Concentration (Bq/L)										Concentration (μg/L)	
				^{232}Th Decay Chain			^{238}U Decay Chain				^{235}U Decay Chain		^{40}K	Ba	Sr
				^{232}Th	^{228}Ra	^{228}Th	^{238}U	^{230}Th	^{226}Ra	^{210}Pb	^{235}U	^{227}Ac			
Sequential 3 - Sequence 1	YYS162 4.5-4.6 m	TCQ	DI water	<4	<1	<0.5	<12	<30	<0.6	<5	<3	<2	<6	18	330
Sequential 9 - Sequence 1	YYS156A 1.5-2.5 m	LT	DI water	<4	<0.8	<0.3	<12	<20	4.4	<4	<2	<0.8	<7	60	6000
Sequential 11 - Sequence 1	YYS158 3.5-3.75 m	T	DI water	<4	<1	<0.3	<12	<30	0.57	<4	<2	<1	<8	28	1300
Leach Extraction 19	YYS156A 1.5-2.5 m	LT	DI water (high CO_2)	<4	<0.9	<0.4	26	<20	6.1	<4	<1	<1	<5	82	5400
Leach Extraction 21	YYS158 3.5-3.75 m	T	DI water (high CO_2)	<4	<1	<0.4	<12	<20	3.1	<5	<3	<2	<10	51	2600
Column 2A Sequence 1	YYS158 3.75-4.5 m	T	DI water	<4	<0.9	<0.5	<12	<20	1.6	<5	<2	<2	<7	15	1500
Column 2B Sequence 1	YYS156A 0.7-1.5 m	L/LT	Effluent from column 2A	<4	<1	<0.5	<12	<40	7.1	<5	<2	<2	30	58	21000
Column 3A Sequence 1	YYS156A 1.5-2.5 m	LT	DI water	<4	<10	<6	<12	<260	340	<60	<20	<20	450	530	36000
Column 3A Sequence 3	YYS156A 1.5-2.5 m	LT	DI water	<0.4	< 0.4	< 0.2	3.9	< 5	3.8	< 2	< 0.3	< 0.4	10	46	3900
Column 3B Sequence 1	YYS158 2.5-3.5 m	LT	Effluent from column 3A	<4	<2	<0.4	<12	<50	5.9	<20	<2	<2	<10	42	8100
Column 3B Sequence 3	YYS158 2.5-3.5 m	LT	Effluent from column 3A	<0.4	< 0.5	< 0.3	3.4	< 7	3.9	< 2	< 0.4	< 0.6	10	38	5200
Barren Liquor		-	Barren liquor	<4	<2	<0.5	1160	<110	5	<20	68	<2	28	10	60
Leach Extraction 24	YYS156A 0.7-1.5 m	L/LT	Barren liquor	<4	<0.9	<0.4	1150	<80	4.6	<10	63	<2	43	98	400
Leach Extraction 27	YYS163 23-23.1 m	CQ	Barren liquor	<4	<1	<0.6	1090	<90	2.6	<10	62	<2	49	47	510
Leach Extraction 38	YYS167 2.3-2.4 m	LQT	Barren liquor	<4	<2	<0.6	1150	<100	6.2	<20	71	<2	39	550	1200
Column 4A Sequence 1	YYS159 4.5-5.2 m	TCQ/CQT	Barren liquor	<4	<2	<0.6	320	<60	<0.7	<20	20	<2	15	<5	1400
Column 4A Sequence 3	YYS159 4.5-5.2 m	TCQ/CQT	Barren liquor	<0.4	< 0.4	0.36	292	< 22	< 0.3	< 3	22	< 0.5	60	<5	200
Column 4B Sequence 1	YYS156A 12-12.75 m	CQ	Effluent from column 4A	<4	<1	0.52	200	<30	<0.5	<7	12	<2	28	11	1600
Column 4B Sequence 3	YYS156A 12-12.75 m	CQ	Effluent from column 4A	<0.4	< 0.6	4.1	378	< 33	2.3	< 4	30	< 0.8	54	61	500

4.6 Geochemical Controls

4.6.1 Mineral Solubility

Geochemical modelling techniques have been used to identify potential solubility limits. Using measured leachate chemistries as input, the saturation indices of key mineral phases were calculated. The focus of the calculations was to identify minerals close to equilibrium with the measured leachate water chemistries (a saturation index close to zero). Such minerals, if present in the materials, may have dissolved (or precipitated) to attain equilibrium with the leachate and therefore may be used to infer solubility limitations.

Possible solubility controls identified were:

- Iron and aluminium oxy-hydroxides – ferrihydrite ($Fe(OH)_3$), gibbsite ($Al(OH)_3$), boehmite ($AlOOH$)
- Carbonates – calcite ($CaCO_3$), dolomite ($CaMg(CO_3)_2$), rhodochrosite ($MnCO_3$), strontianite ($SrCO_3$)
- Sulphates – gypsum ($CaSO_4.2H_2O$), celestite ($SrSO_4$)

Carnotite ($K_2(UO_2)_2(VO_4)_2$) solubility was modelled using the Minteq carnotite data as previously discussed in Section 2.1.2. In most of the bottle roll tests involving de-ionised water solutions, carnotite was found to be under-saturated, suggesting that carnotite would leach rather than precipitate in the tests. Test involving barren liquor solutions gave saturation indices closer to equilibrium with carnotite.

Figure 4.28 and Figure 4.29 show uranyl activity diagrams calculated for leachate results plotted as a function of pH. The results that plot closest to the theoretical carnotite line tend to be for barren liquor leachates.

In general, column test leachates were closer to equilibrium with carnotite (Figure 4.30). There is however, a significant degree of scatter, and a significant number of the solutions were found to be oversaturated with respect to carnotite.

Results from the current programme suggests that in most of the de-ionised water bottle roll tests, although carnotite may be dissolving from the solids, equilibrium conditions with the solution were not achieved. Possibly insufficient carnotite mass is available within the samples to attain equilibrium with the contacting solution. It is also possible that (i) in many of these tests the concentration of the key solute, K, remains below the threshold levels required to exceed carnotite solubility or (ii) that carnotite dissolution is subject to kinetic controls and longer contact times are required to reach equilibrium.

In the column tests, the water-to-rock ratios were lower (i.e. more carnotite mass per unit volume water), solute concentrations are higher, and contact time between the solids and the leachate solutions were longer, sometimes up to weeks. All these conditions are more likely to result in equilibration of carnotite with the contacting solution.

Another observation that can be made from the current results is that release of uranium to solution is disproportionate to the vanadium release. The uranium:vanadium molar ratio in carnotite is unity (1.0); therefore congruent dissolution of carnotite would result in a uranium:vanadium molar ratio of 1.0. However, in most of the leachate solutions the uranium:vanadium molar ratio is less than 1.0. The low ratios suggest that uranium is preferentially held within the solid phase, possibly due to a change in the composition of the dissolving phase, or preferential sorption.

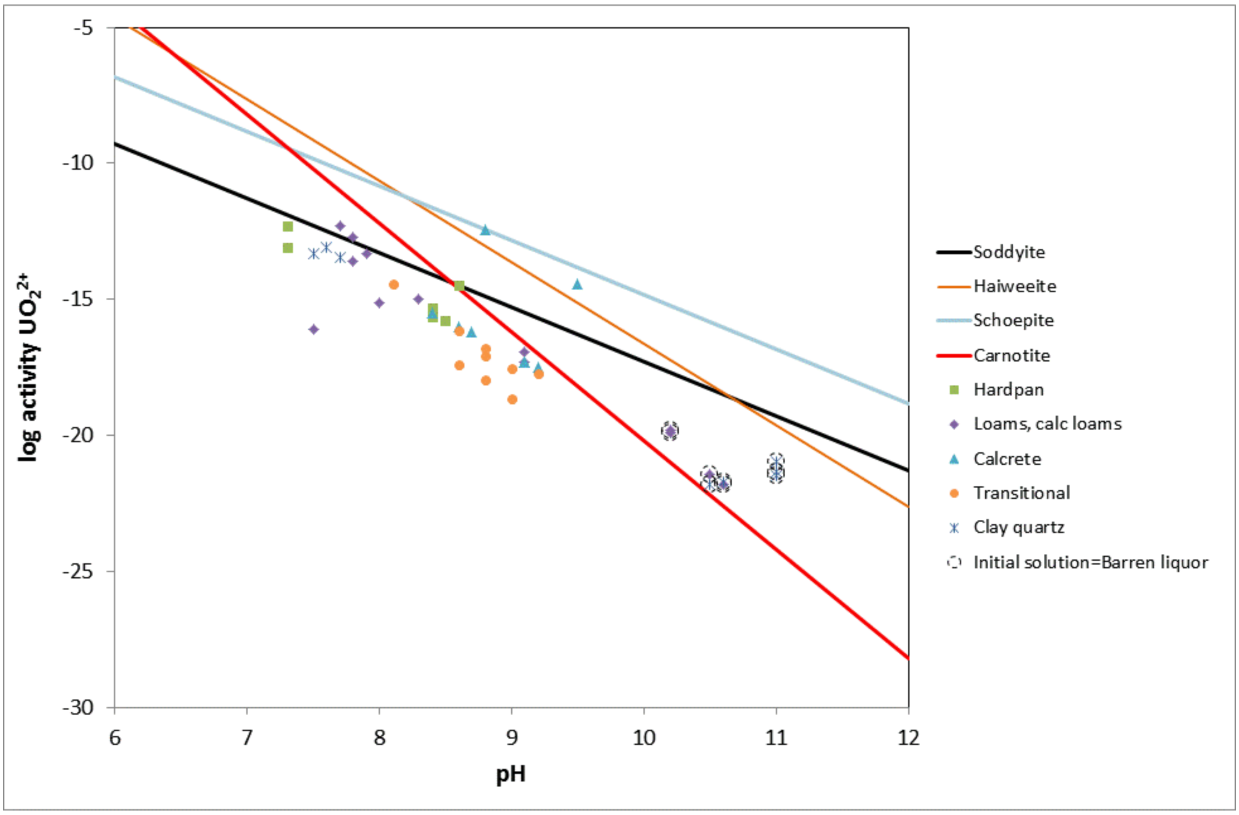


Figure 4.28: Uranyl (UO_2^{2+}) activity diagram showing the calculated activities of bottle roll leach solutions
(3:1 liquid:solid ratio, air atmosphere)
(Also shown are the theoretical equilibrium lines for a range of minerals)

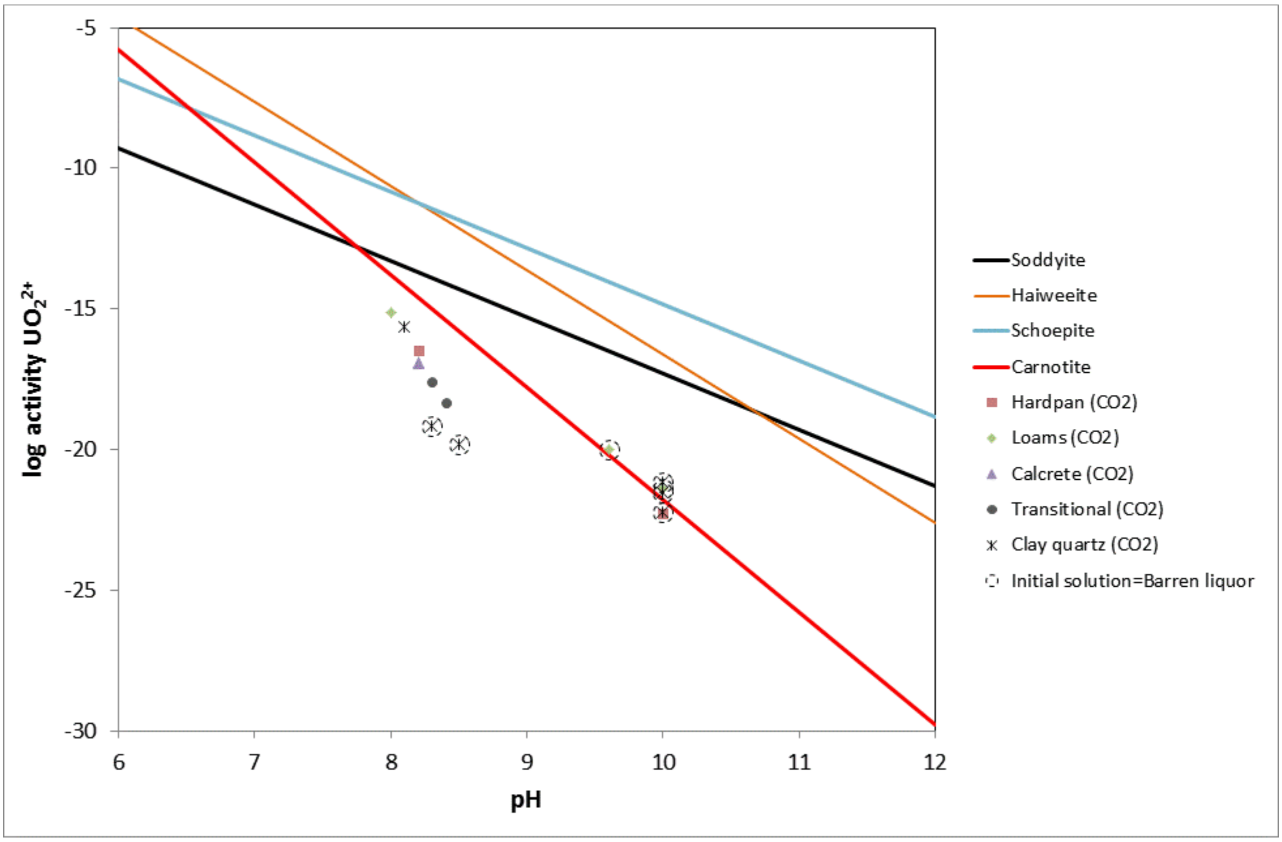


Figure 4.29: Uranyl (UO_2^{2+}) activity diagram showing the calculated activities of bottle roll leach solutions

(3:1 liquid:solid ratio, 10% CO_2: air mixture)
(Also shown are the theoretical equil brium lines for a range of minerals)

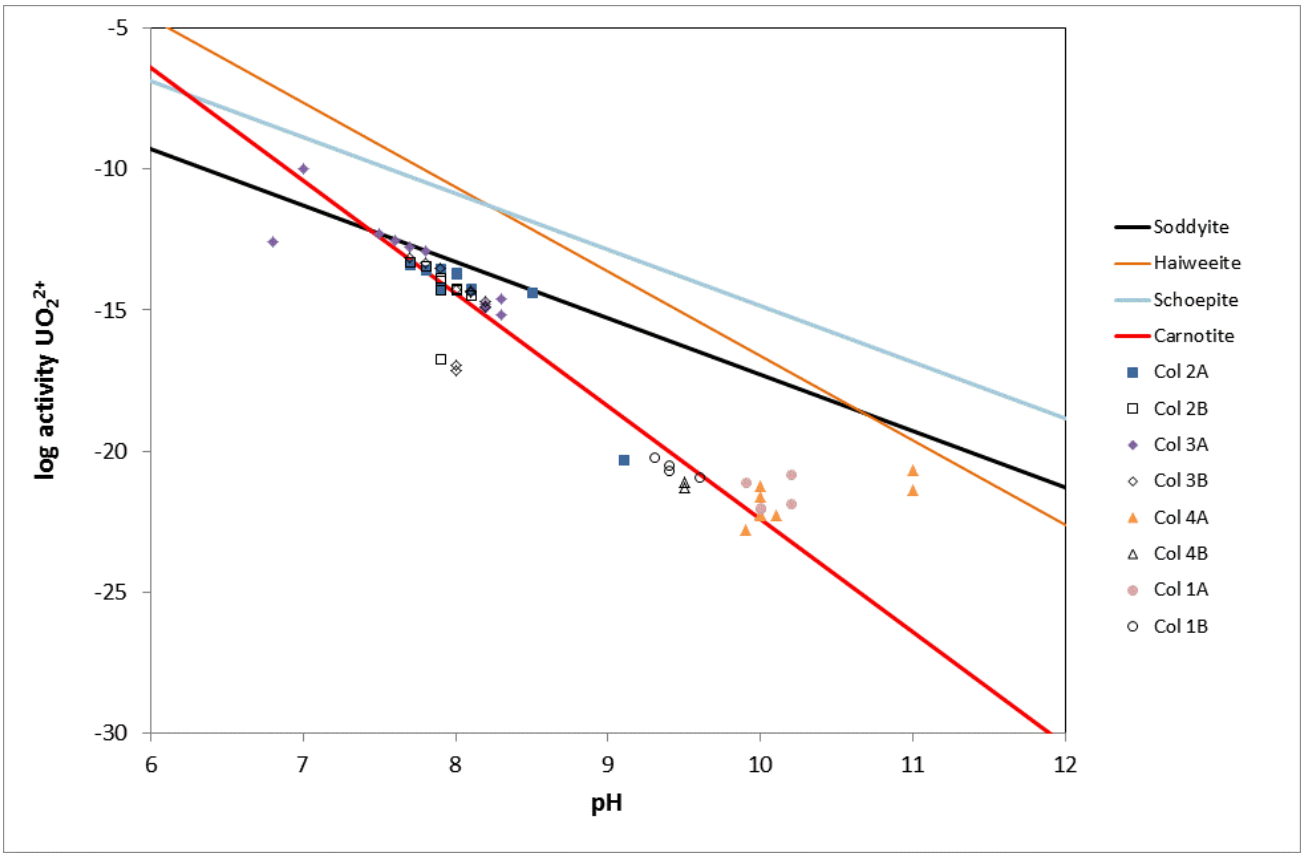


Figure 4.30: Uranyl (UO_2^{2+}) activity diagram showing the calculated activities of column leachates
(Also shown are the theoretical equilibrium lines for a range of minerals)

4.6.2 Sorption

Sorption may be an important attenuation mechanism for metals and radionuclides. It can occur via a number of mechanisms, the most important being surface complexation and ion exchange.

Surface complexation is a pH-dependent process. The outer surfaces of most minerals hydrate when in contact with water. Loss or gain of protons from this hydrated surface layer results in development of surface charge. At acidic pH values, surfaces are predominantly positively charged (protonated), whereas at alkaline pH values the surface charge is predominantly negative (de-protonated). Ideal circumstances for sorption exist when the aqueous species and the surface are of opposite charge. Oxides/hydroxides are known to interact strongly with solution species via surface complexation. However, most minerals have some component of pH-dependent charge. For example, exposed aluminol (Al-OH) and silanol (Si-OH) sites on the surfaces and edges of silicate minerals may hydrate and interact with solution species in a similar manner.

Ion exchange is a process where solution ions exchange for ions that are present in the mineral lattice. For ion exchange to take place, the ions involved must be of similar charge and ionic radius. Ion exchange is largely independent of solution pH; the exchange sites are associated with a permanent charge. Clays and zeolites are known to have a high cation exchange capacity; exchange reactions involve cations that occupy interlayer or inter-framework positions, respectively. Oxides/hydroxides are not normally associated with a high exchange capacity, although impurities within the mineral lattice may result in some component of permanent charge.

The mineralogical investigation (Section 4.1) has identified the presence of iron oxides, e.g. goethite and hematite, in some of the Yeelirrie samples. Solubility modelling indicates that iron and aluminium concentrations in most leachates are consistent with control by iron and aluminium hydroxides. Most of the materials contain some quantity of such minerals, even if present at concentrations below the detection limits of XRD. Even a very small quantity by mass can represent a significant sorptive capacity due to the tendency of such minerals to form surface coatings on other mineral grains.

Clay minerals have been identified as important mineral constituents in all samples. The clay minerals are predominantly kaolin and smectite. The smectite-rich samples in particular were found to have significant cation exchange capacity.

Sorption is often represented by a distribution coefficient, $K_{D,}$ as follows:

$$K_D = C_{ads}/C_{aq}$$

Where C_{ads} is the concentration of element adsorbed to the solid phase and C_{aq} is the concentration remaining in solution. In the current work, K_D values were calculated in two ways:

- Accounting for element 'already present' in the solid, i.e. assuming that it could participate in desorption/sorption during test; and
- Excluding element already present, i.e. assuming the element is present in an insoluble mineral form unlikely to participate in reaction during the test. Significant proportions of many elements may be associated with phases that do not interact with solutions under test conditions, or test timescales.

Distribution coefficients calculated without accounting for element already present are denoted as R_D values as follows:

$$R_D = (C_i-C_f)/C_f \times V/m$$

Where C_i and C_f are the initial and final solution concentrations of the element, and V/m is the volume to mass ratio that applied in the test. R_D values can only calculated for those tests where the initial solutions contain dissolved solute (e.g. barren liquor solutions).

Ranges of calculated sorption coefficients for selected elements are shown in Table 4.12 (based on all lithologies except the palaeochannel sands). The negative R_D values calculated for some tests suggest leaching rather than sorption.

Sorption coefficients for palaeochannel sands are shown in Table 4.13. Palaeochannel sands have been treated separately because the extremely strong uranium sorption onto the sands appears to be at odds with trends shown elsewhere. Based on the high dissolved carbonate levels during the first stage of the barren liquor contact test (Section 4.3.5.2), weak sorption was expected. No explanation has yet been found for this unexpected result. For example, the mineralogical composition of the sands is dominated by quartz (91 wt%, Table 4.5). Quartz is not expected to be a strong adsorbent. The other mineral present is kaolin (9 wt%). Kaolin is known to be a strong adsorbent and could explain the strong sorption. However, other samples contained similar or higher quantities of kaolin, and were not associated with strong uranium sorption.

Within the barren liquor results, for some elements there was good agreement between the calculated K_D and R_D values– for example, sodium, arsenic, molybdenum, selenium, uranium and vanadium. For these elements, the K_D approach can be considered a good estimate of sorption. However, K_D values should still be used with caution as there remains a possibility that sorption is overestimated.

For many elements, the K_D values were significantly higher than the R_D values – for example, barium, chromium, radium and zinc. For these elements a major proportion of element present is likely to be in a form that does not readily interact with solutions under the conditions of the tests. The K_D value is therefore an overestimate of sorption and would be considered unreliable. Values believed to be unreliable are shaded in Table 4.12.

The ranges of sorption coefficients calculated from column test results are often very similar to those calculated from the bottle roll test results. However, for a number of elements including arsenic, boron, molybdenum, selenium, uranium and vanadium the column sorption coefficients ranged values higher than determined for the bottle roll tests. This may reflect a number of factors, such as slightly different chemical conditions in the columns, or the possibility that site saturation had occurred in the bottle rolls. It should also be noted that different ranges of sample types/numbers are represented in each set of results.

Table 4.12: Calculated K_D and R_D values (in units of cm^3g^{-1}) for Yeelirrie Materials (Excepting Palaeochannel Sands): Summary statistics

Parameter		Bottle Rolls (De-ionised Water)[1,2]					Bottle Rolls (Barren Liquor)[1]					Columns (Range of Solution Types)[3]				
		Number of samples = 11; Water:solid ratio 3:1					Number of samples = 8; Water:solid ratio 3:1					Number of samples = 7; Water:solid ratio: 0.2-0.5:1				
		n	Minimum	Maximum	Median	Average	n	Minimum	Maximum	Median	Average	n	Minimum	Maximum	Median	Average
	pH	**44**	**7.3**	**10.0**	**8.4**	**8.4**	**15**	**8.3**	**11**	**10.2**	**10.12**	**57**	**6.8**	**11.0**	**8.1**	**8.5**
As	K_D	44	55	2700	420	620	15	0.55	22	1.3	5.9	56	0.73	1700	99	280
	R_D						15	0.038	19	0.82	4.3	36	-0.3	4.7	0.026	0.48
B[4]	K_D	44	17	890	130	180	15	2	5.3	3.8	3.7	56	1.7	240	16	51
	R_D						15	-0.6	0.91	0.21	0.19	36	-0.3	2.2	-0.04	0.062
Ba	K_D	44	390	14000000	5100	340000	15	580	33000	2000	4500	56	140	59000	3200	15000
	R_D						15	-3	0.41	-3	-2	36	-0.4	6.2	0.032	0.35
Cd[4]	K_D	44	-0.4	500	14	41	15	0.71	570	20	110	56	4.6	510	460	310
	R_D						15	-3	72	0	11	36	-0.4	8.2	0	1.2
Cr	K_D	44	2200	23000	9000	9200	15	10	21000	360	1900	56	24	20000	4000	4700
	R_D						15	-3	310	7.5	25	36	-0.2	29	0	2.4
Cu	K_D	44	440	5900	2600	2600	15	81	760	320	340	56	14	6100	1500	1700
	R_D						15	-1	8.4	1.1	1.7	36	-0.4	1.4	0	0.14
K	K_D	44	5.7	3800	160	380	15	2.7	12	7.6	7.8	56	3.7	69	13	18
	R_D						15	-0.5	0.67	-0.1	-0.07	36	-0.3	1.1	-0.05	-0.04
Mn	K_D	44	0.3	20	2	4	15	-1	6	2	3.1	56	0.1	20	2	4.7
	R_D						15	-2	0	0	-0.2	36	-0.2	5.5	0	0.15
Mo	K_D	44	8.2	520	100	130	15	0.62	2.4	1.4	1.4	56	1.3	410	16	49
	R_D						15	-0.7	1.5	0.43	0.35	36	-0.3	1.1	-0.2	-0.09
Na	K_D	44	1.4	110	11	21	15	-0.4	0.51	0.18	0.19	56	-2	25	0.37	2.3
	R_D						15	-0.5	0.39	0.062	0.095	36	-0.3	11	-0.06	0.28
Ni	K_D	44	640	15000	2400	2500	15	260	4000	2000	2000	56	350	5000	1000	1400
	R_D						15	-3	0	0	-0.7	36	-0.3	1.1	0	0.041
Ra-226	K_D	5	300	1700	1000	1000	3	60	340	300	230	7	16	5200	420	1400
	R_D						3	-0.6	2.8	0.26	0.82	4	-0.3	15	6.8	7
Se[4]	K_D	44	15.0	440	91	91	15	0.52	24	1.7	5.5	56	0.75	490	19	37

Parameter		Bottle Rolls (De-ionised Water)[1,2]					Bottle Rolls (Barren Liquor)[1]					Columns (Range of Solution Types)[3]				
		Number of samples = 11; Water:solid ratio 3:1					Number of samples = 8; Water:solid ratio 3:1					Number of samples = 7; Water:solid ratio: 0.2-0.5:1				
		n	**Minimum**	**Maximum**	**Median**	**Average**	**n**	**Minimum**	**Maximum**	**Median**	**Average**	**n**	**Minimum**	**Maximum**	**Median**	**Average**
	pH	**44**	**7.3**	**10.0**	**8.4**	**8.4**	**15**	**8.3**	**11**	**10.2**	**10.12**	**57**	**6.8**	**11.0**	**8.1**	**8.5**
	R_D						15	-0.4	17	0.5	3.3	36	-0.3	2	-0.2	-0.01
Sn[4]	K_D	44	410	2000	2000	1900	15	370	2000	1500	1400	56	5.2	2000	190	910
	R_D						15	-2	3	1.3	1.1	36	-0.4	0.054	-0.3	-0.2
Sr	K_D	44	33	13000	1600	2900	15	17	19000	220	1900	56	9.6	2900	120	430
	R_D						15	-3	2.3	-3	-2	36	-0.3	0.9	-0.2	-0.1
Tl[4]	K_D	44	3.5	600	85	280	15	14	600	370	340	56	270	3000	600	670
	R_D						15	-3	0	-1	-1	36	-0.2	1.9	0	0.072
U	K_D	44	82	11000	750	1700	15	-0.2	16	1.3	3.3	56	-0.4	9800	1100	1700
	R_D						15	-0.3	16	0.9	2.4	36	-0.3	0.62	-0.02	0.0011
V	K_D	44	100	6400	700	1500	15	0.85	8.9	2.9	4	56	1.5	2900	650	870
	R_D						15	-0.3	4	0.89	1.4	36	-0.3	26	0.047	1.9
Zn	K_D	44	85	5000	380	1200	15	16	280	63	75	56	39	7000	320	1300
	R_D						15	-2	1.3	-2	-2	36	-0.06	2.6	0.26	0.43

Notes:

[1] Each dataset includes a range of atmospheric conditions: air, air:10%CO_2 mixture.

[2] Results from progressive leach testing have been included – i.e. from the second and third leach cycles. For some elements, the second and third leach tests may give better indicators of sorption because the influence of readily soluble salts is less in these later sequences.

[3] Column inflow solutions included de-ionised water, barren liquor and, in the case of the 'B' columns, effluent from the paired 'A' column (Table 4.8). Data from Column 1A (tails) was excluded.

[4] These elements were present in the solids at levels close to or below the limits of detection. Where values were below the detection limit, the detection limit itself was used in the K_D calculation. Thus, the calculated K_D value is the maximum that could apply.

Values shaded grey are considered unreliable as most of the element mass present in the solid may not have interacted with the solution phase during the test.

Table 4.13: Sorption Coefficients Calculated for the Paleochannel Sand Samples

Parameter	R_D values, cm^3g^{-1}	
	YYHC0075 64 m – 65 m	**YYHC0059C 55 m – 56 m**
pH	11	11
K	0.2	0.7
Na	0.1	0.4
As	81.6	53.4
B	0.2	0.3
Cr	10.6	11.0
Cu	45.0	45.0
Mo	0.6	1.0
Se	13.5	17.4
Sn	3.0	3.0
Tl	-2.5	0.0
U	60,000	60,000
V	0.2	0.1
Zn	0.3	1.1

Sorption coefficients calculated for barren liquor conditions were typically less than 10 cm^3g^{-1}. Low sorption is expected under the geochemical conditions in question. The barren liquor contains high dissolved carbonate. Many elements form aqueous complexes with carbonate and carbonate complexation reactions can compete with surface sorption reactions, causing reduced sorption. As well, the solution pH is quite alkaline, ranging up to pH 11. At alkaline pH values the surface charge on most minerals is predominantly negative (de-protonated). Negatively charged aqueous species will be repelled from such surfaces. Under the alkaline, carbonate-rich geochemical conditions of these solutions, many elements form either negatively charged carbonato species (e.g. $UO_2(CO_3)_2^{-2}$, $Cu(CO_3)_2^{-2}$) or negatively charged hydroxyl species (e.g. $Ni(OH)_3^-$). Such an effect may also explain the observation in Section 4.2.5.4 that uranium and vanadium leachate concentrations tend to be higher at more alkaline pH (i.e. reduced sorption under these conditions). The effect of dissolved carbonate on uranium sorption is also illustrated in Figure 4.31, which compares results for equivalent tests in contact with air and tests in contact with an mixture if air and 10% CO_2.

Sorption coefficients calculated for de-ionised water tests were up to three orders of magnitude higher than those for barren liquor tests, reflecting stronger sorption when dissolved carbonate and solution pH are lower.

Figure 4.31 to Figure 4.35 show sorption of uranium, vanadium, arsenic, selenium and zinc onto a range of sample types. Although the lowest sorption coefficients were found for tests involving calcrete, there does not appear to be a strong correlation between sorption and lithological type. Possibly the lower sorption onto calcrete is related to presence of relatively low clay contents in this lithology (Table 4.1). Clays, and in particular kaolin, are known to be a strong sorbents for many elements; the presence of these clays are likely to explain the higher sorption coefficients measured in loams and clay-quartz lithologies.

The high smectite clay content of some samples explains the measurable sorption of sodium (and sometimes potassium) onto the materials. Given the very high concentrations of sodium and potassium in the initial barren liquor solution, the fact that measurable sorption takes place indicates that the smectite clay material has a high capacity to adsorb these elements. This is likely attributable to ion exchange as it also explains the observed calcium, magnesium, strontium and barium leaching (Section 4.3.5). Alkaline earths and alkali metals (e.g. sodium, potassium, calcium and magnesium) are known to participate strongly in ion exchange reactions, in part because they remain in the form of monovalent or divalent cations over a wide pH range. Strongest sodium sorption, and higher degrees of calcium and magnesium leaching coincide with the distribution of smectite (and higher cation exchange capacity) samples.

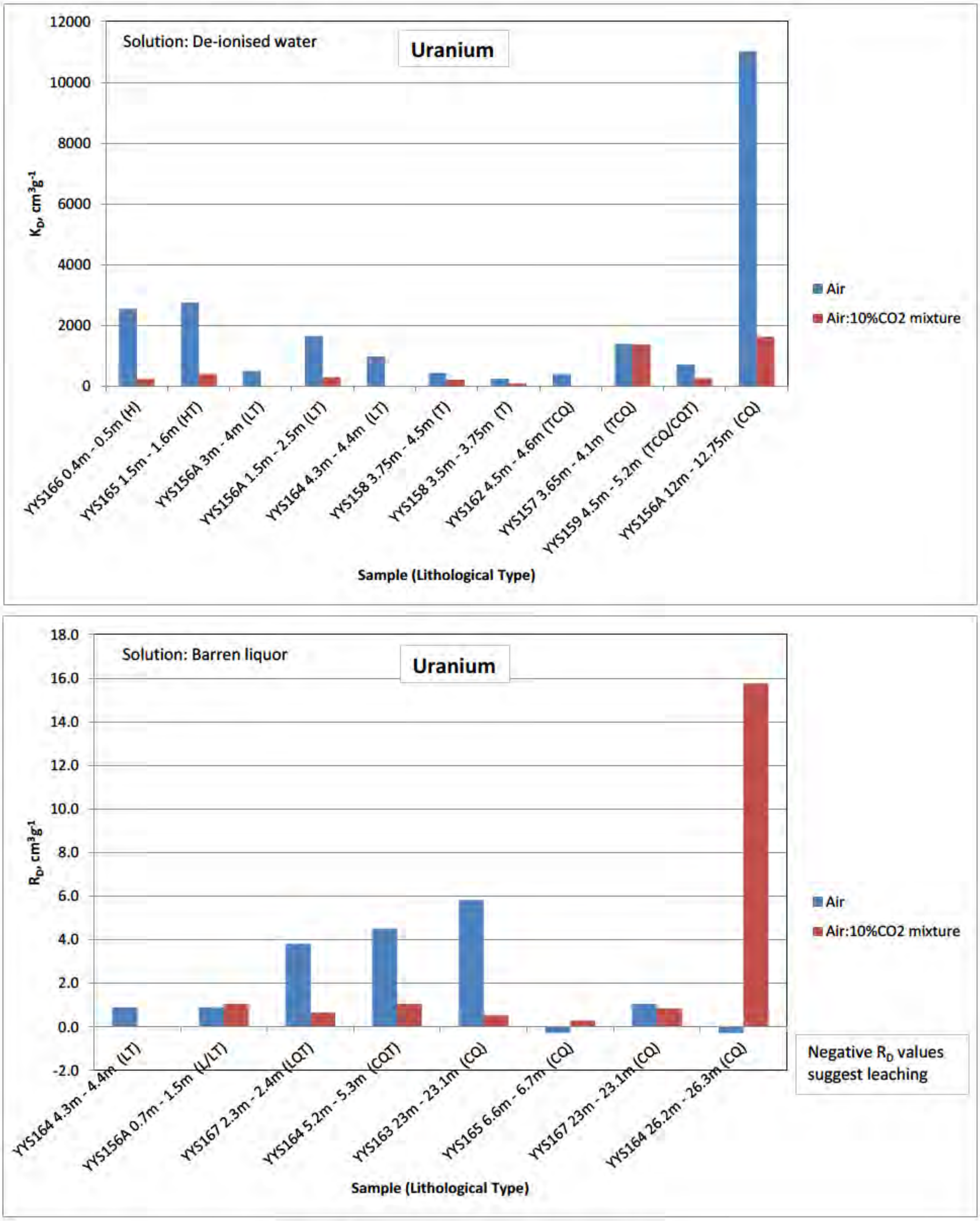


Figure 4.31: Sorption coefficients for uranium

[Note the different scales on the y-axes of the two diagrams]

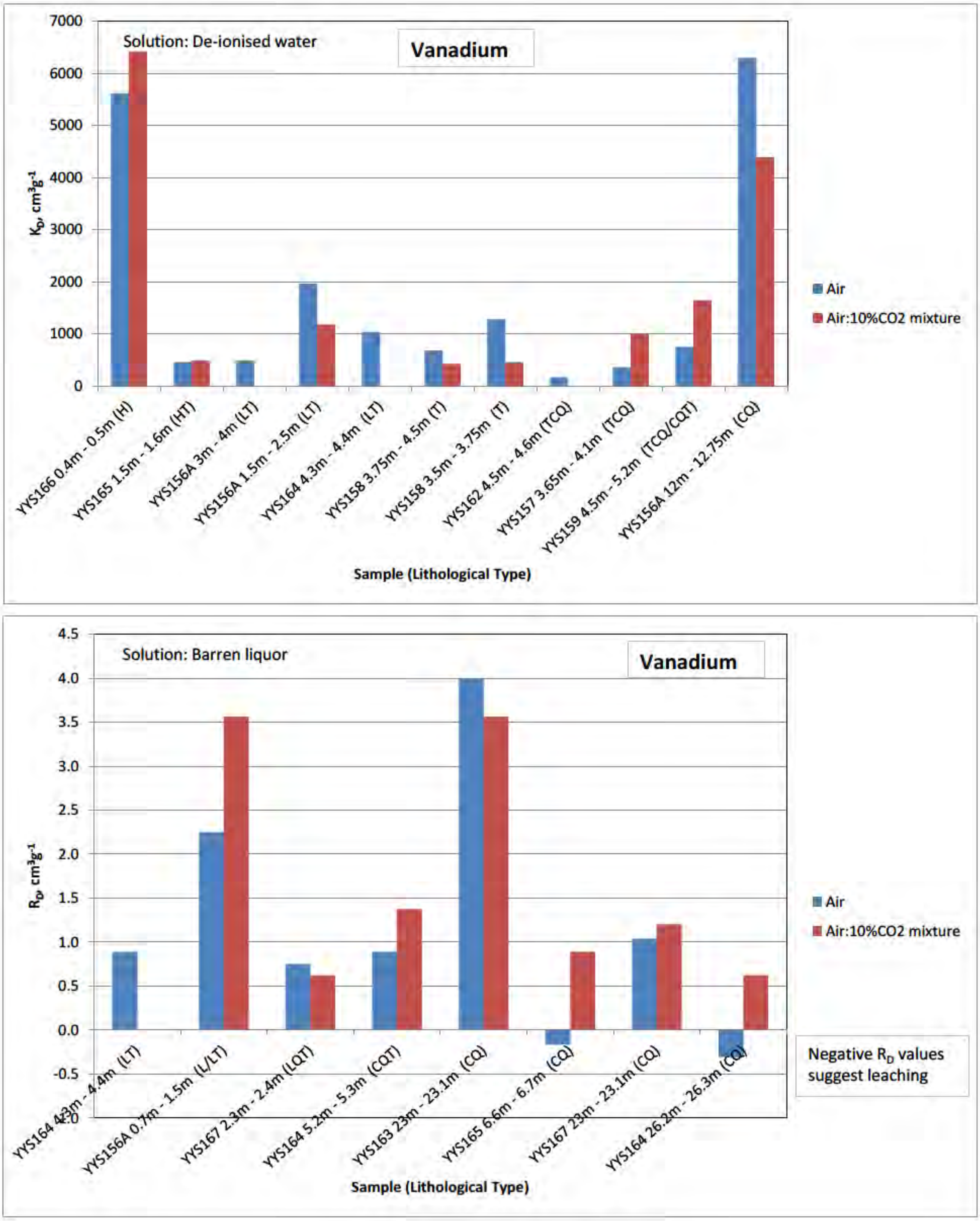


Figure 4.32: Sorption coefficients for vanadium

[Note the different scales on the y-axes of the two diagrams]

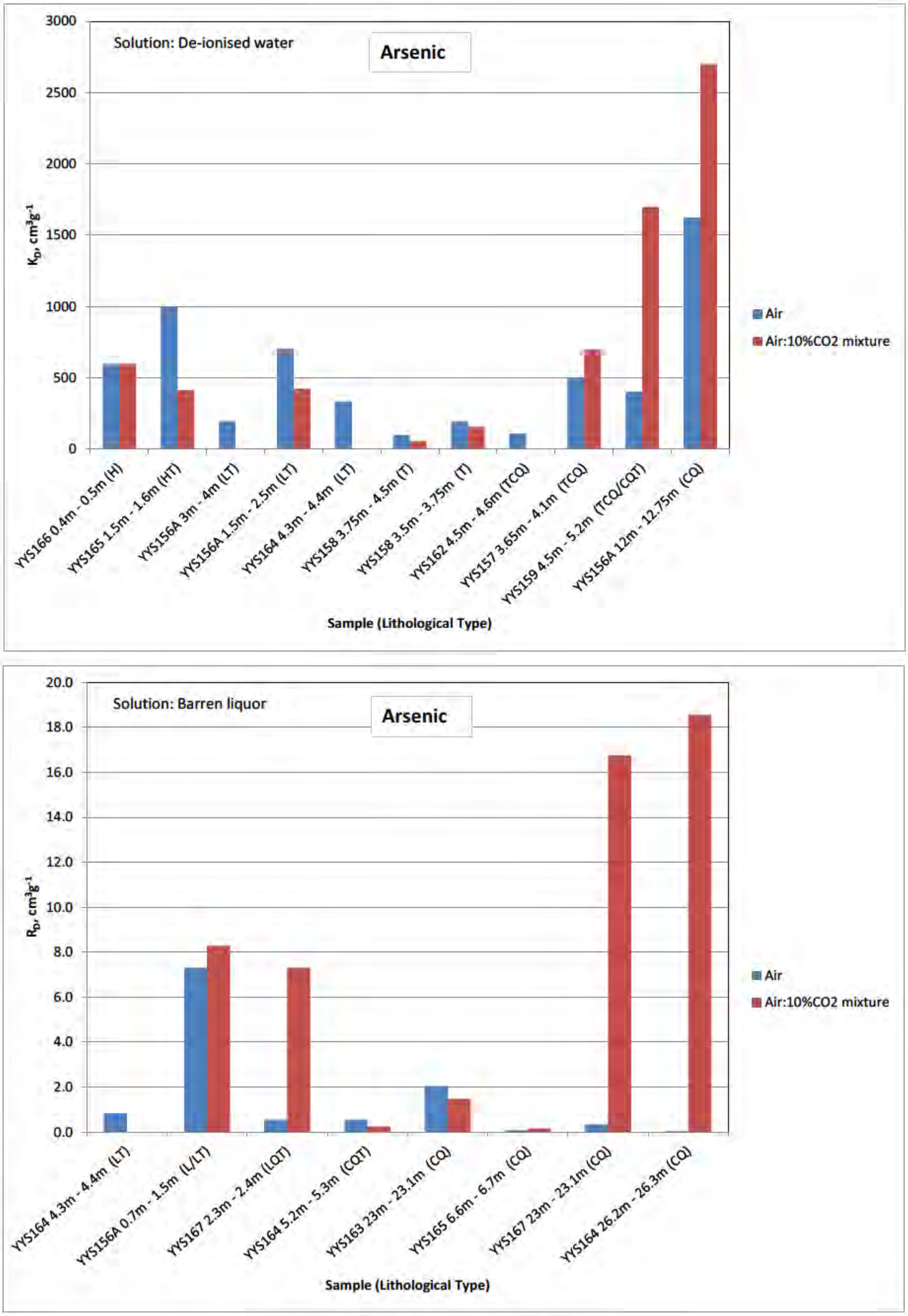


Figure 4.33: Sorption coefficients for arsenic

[Note the different scales on the y-axes of the two diagrams]

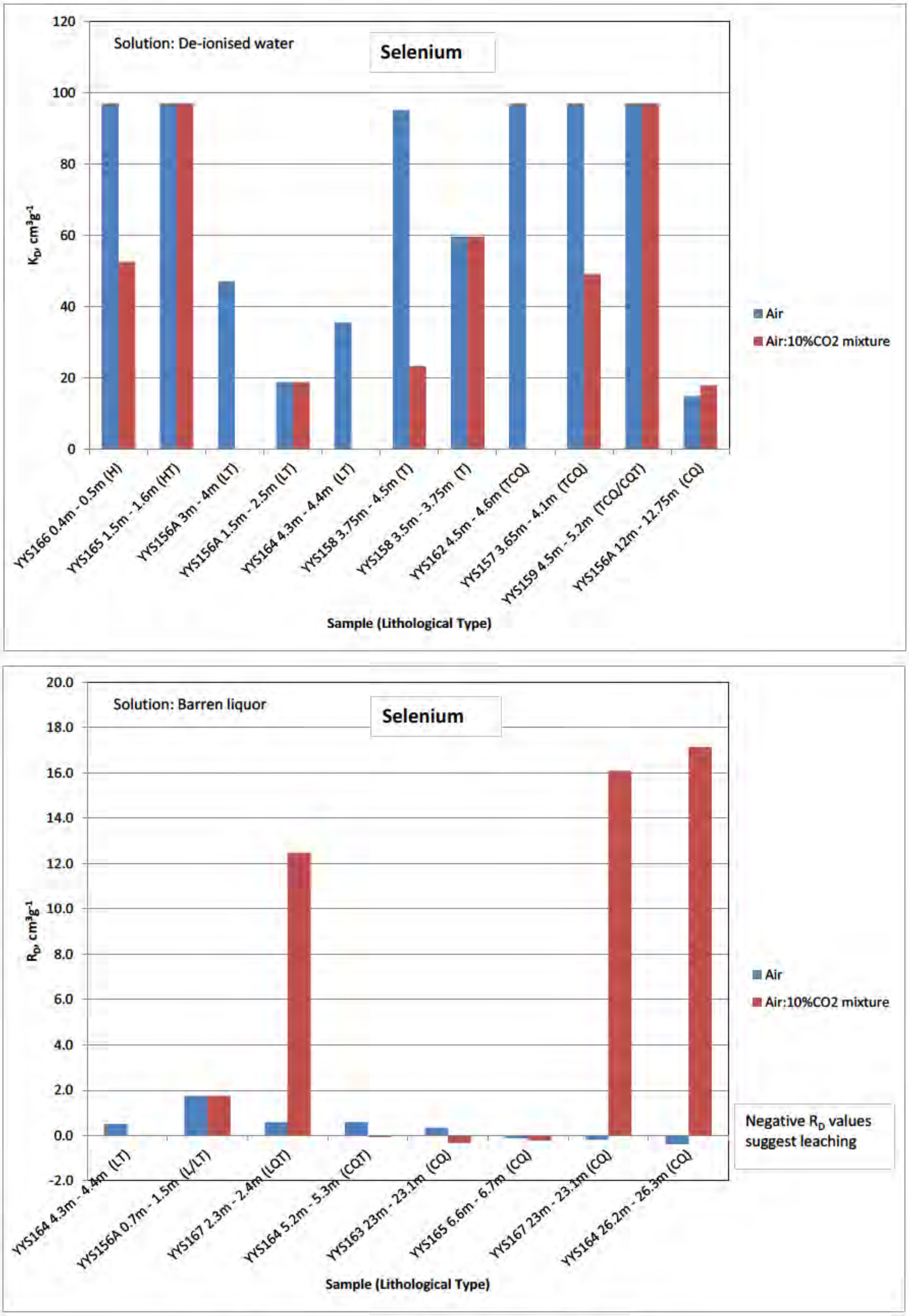


Figure 4.34: Sorption coefficients for selenium

[Note the different scales on the y-axes of the two diagrams]

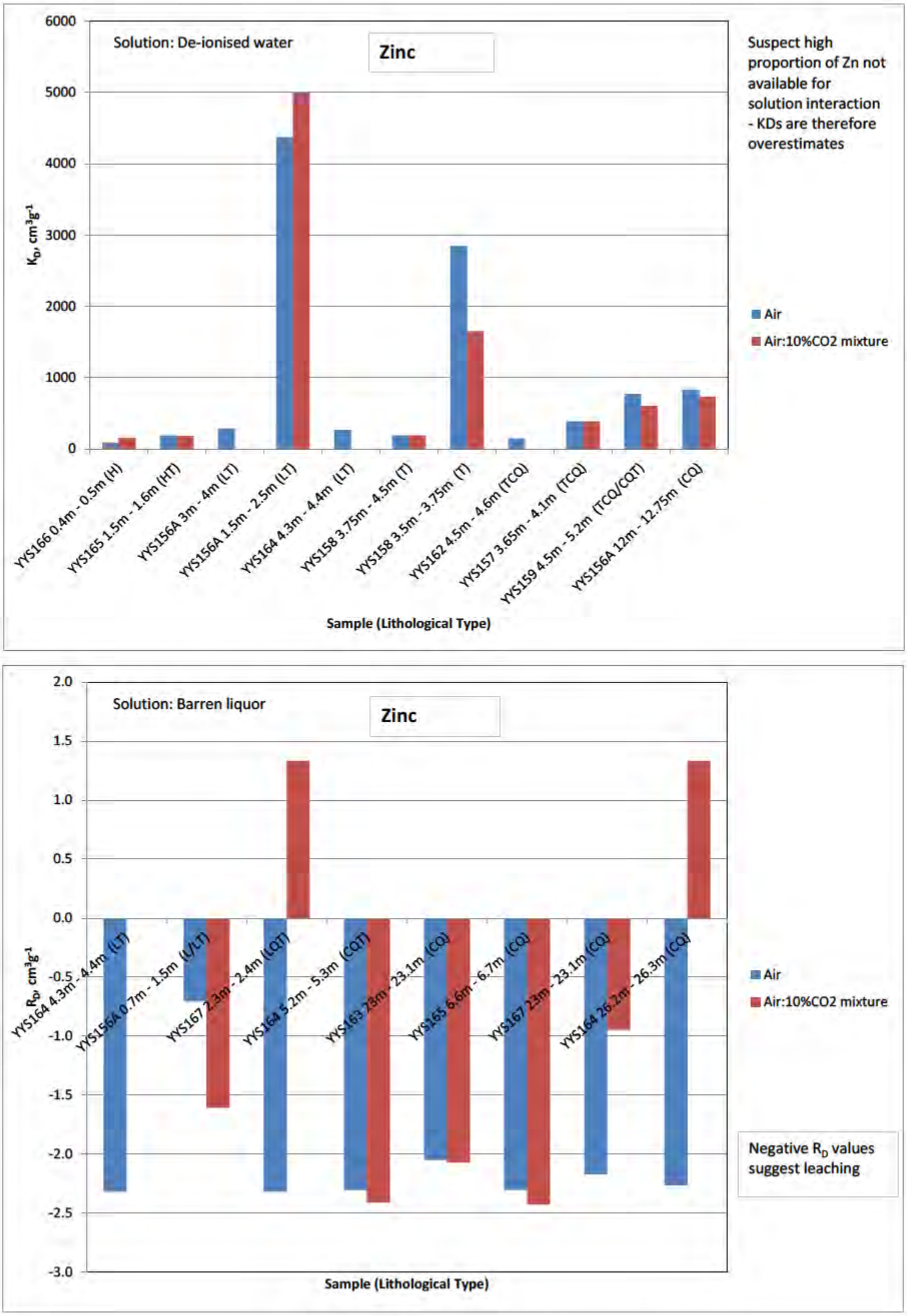


Figure 4.35: Sorption coefficients for zinc

[Note the different scales on the y-axes of the two diagrams]

4.6.3 Summary

Results collected for a range of material types, and under a range of geochemical conditions, have been interpreted to gain insight to geochemical controls on contaminant mobility.

With respect to uranium and vanadium, the main control on mobility is considered to be carnotite solubility. In ore and waste rock stockpiles, uranium and vanadium will leach as the carnotite dissolves. Where the mass of carnotite in the material is low, the dissolved uranium and vanadium may remain under-saturated with respect to carnotite because there is insufficient mass of carnotite present to attain equilibrium with the contacting solution. However, in cases where the mass of carnotite is high, or where the volume of contacting water is low, saturation with respect to carnotite is more likely to occur. Carnotite solubility will define an upper limit on dissolved uranium and vanadium concentrations. Amongst other parameters, carnotite solubility is sensitive to solution pH, dissolved carbonate, potassium concentrations and redox.

Carnotite solubility controls will play an important role in limiting the amount of uranium and vanadium leaching from mine waste rock and tailings materials, and could limit their mobility along flow paths within the groundwater system.

The uranium:vanadium molar ratio in carnotite is unity (1.0). However, solution uranium:vanadium ratios are often less than 1.0, indicating that uranium may be preferentially held within the solid phase, possibly indicative of the influence of sorption. The laboratory results have been assessed to derive estimates of sorption coefficients, for uranium, vanadium and other potential contaminants. Table 4.14 is a summary of sorption coefficients that could apply to loams and clay-quartz materials. These are based on median values calculated from the combined set of calculated R_D and K_D values.

Table 4.14: Recommended Sorption coefficients for Yeelirrie Materials

	Sorption coefficient, cm^3g^{-1}	
	Loams	**Clay-Quartz**
As	350	1.3
Ba	0	0
B	51	3
Cd	0	5.3
Cr	4	10
Cu	0.93	1.1
Mn	2	2
Mo	47	0.67
Ni	0	0
Se	50	0.83
Sr	0	0
Tl	0	0
Sn	0.7	1.9
U	420	1.1
V	480	2.7
Zn	0	0
Ra-226	0	2.8

The highest sorption is expected for loams. Strong U sorption onto loams is consistent with outcomes of the radionuclide assessment (Section 4.5). Lower sorption is expected in the case of the clay-quartz lithology. In the case of calcrete, little or no sorption is expected to occur.

Sorption is dependent upon geochemical conditions, e.g. solution pH, dissolved carbonate and alkalinity. Under the highly alkaline conditions of the TSF porewater sorption will be weak. However, along potential groundwater flow paths away from the TSF, conditions will become less alkaline, and sorption would become a more significant mechanism contributing to the attenuation of solutes.

5. Tailings

5.1 Introduction

Tailings solids and liquors were prepared by the BHP Billiton metallurgical testwork programme:

- YC3 – bulk leach residue, provided during December 2009
- Barren liquor – solution resulting from the bulk leach, following precipitation of uranium and re-carbonation (also provided during December 2009)
- YM0015, YM0046, YM0074, YM0076 – bulk leach residues, provided during March 2010.

5.2 Mineralogy

The mineralogical compositions of the tailings samples are given in Table 5.1. The dominant minerals are carbonates in the case of tailings generated from the processing of calcrete ore, and silicates in the case of tailings generated from clay-quartz ore.

5.3 Surface Characteristics

One sample was submitted for surface area and ion exchange capacity measurements, Sample YC3. The surface area of the sample was 46.2 m^2/g and the cation exchange capacity was 45.2 meq/100g. The dominant cation occupying the sites was Ca.

5.4 Particle Size Distribution

The particle size distribution for sample YC3 is given in Figure 5.1.

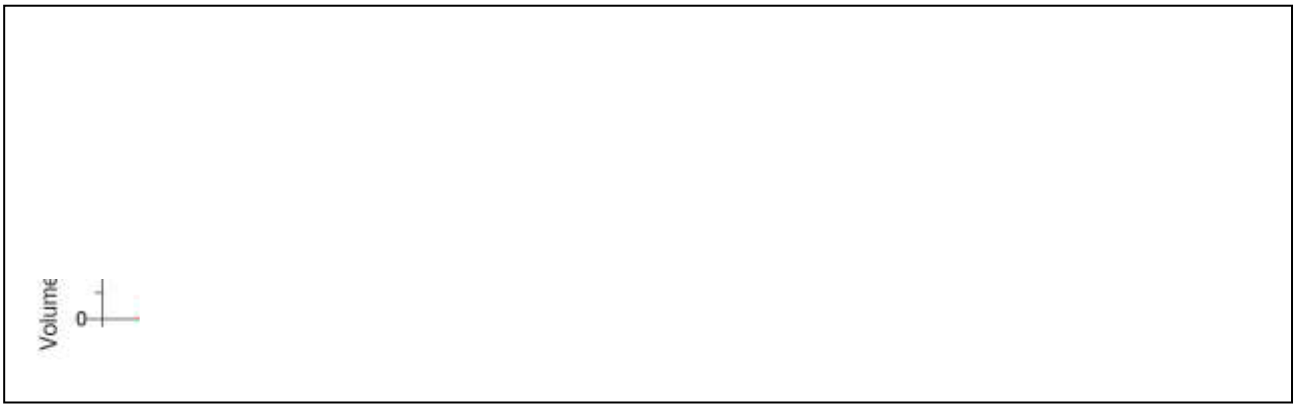


Figure 5.1: Particle size distribution for tailings sample, YC3

5.5 Bulk Chemistry

The results of the bulk chemical analyses of the tailings samples are provided in Appendix 3, and summarised in Table 6.2.

Table 5.1: Mineralogical Composition of Yeelirrie Tailings Samples

Sample	**Description**	**Carbonates**			**Framework and chain silicates**			**Sheet silicates and clays**					**Oxides**		**Sulphates**		**Other**	
		Calcite	**Mg-Calcite**	**Dolomite**	**Quartz**	**Albite**	**Microcline**	**Kaolin**	**Smectite**	**Illite / Mica**	**Sepiolite**	**Palygorskite**	**Anatase**	**Goethite**	**Gypsum**	**Celestine**	**Halite**	**Carnotite**
YC3		10		24	23	1	3	22	10	1	2	3	<1					
YM0015	High U grade, clay/quartz			1	34	1	5	45	5	6			<1	2		1	<1	0.4
YM0074	low U grade, clay/quartz			1	23	1	4	53	4	3		7	<1	2		1	1	0.2
YM0076	high U grade, calcrete	3		78	3	1	1	7	4						1	2	<1	0.3
YM0046	low U grade, calcrete	13		38	5	1	2	6	22	1	8				3		1	

Table 5.2: Chemical Composition of Yeelirrie Tailings Samples

Element	Units	YC0076	YM0015	YM0046	YM0074	YC3	Mean Crustal Abundance[1]
Al	%	1.61	8.99	1.61	10.64	5.48	8.2
Ca	%	17.69	0.42	13.77	0.35	6.85	4.1
CO_2	%	35.98	1.41	24.09	1.16	12.3	
F	%					0.26	
Fe	%	0.73	3.53	0.72	4.31	2.4	4.1
K	%	0.31	1.58	0.4	1.69	1.04	2.1
Mg	%	10.83	1.72	9.37	1.66	5.17	2.3
Mn	%	0.03	0.02	<0.01	0.02	0.03	0.095
Na	%	0.37	1.24	1.12	1.2	1.45	2.3
P	%	0.01	<0.01	<0.01	0.01	0.02	0.1
S	%	0.03	0.05	0.08	0.05	0.04	
Si	%	6.64	28.36	13.28	27.05	20.3	
SO_4	%					0.15	0.078
TOC	%					0.05	
Ag	ppm	<0.05	<0.05	0.05	<0.05	0.1	0.07
As	ppm	2.42	15.16	2.98	21.21	15.5	1.5
B	ppm					100	10
Ba	ppm	<200	400	<200	400	230	500
Be	ppm					1	2.6
Bi	ppm	<0.1	0.22	<0.1	0.27	0.2	0.048
Cd	ppm	<0.1	<0.1	<0.1	<0.1	0.1	0.11
Ce	ppm	<100	<100	<100	<100	32	
Co	ppm	3.67	7.07	2.86	7.47	6	20
Cr	ppm	76	137	52	128	130	100
Cu	ppm	17.2	23.24	18.76	27.98	23.5	50
Hg	ppm					0.05	0.05
Li	ppm					15	20
Mo	ppm	5.4	5.34	3.43	5.58	13	1.5
Ni	ppm	36	45	28	46	60	80
Pb	ppm	4.79	15.81	5.07	17.18	9	14
Sb	ppm	<0.1	0.1	<0.1	<0.1	0.1	0.2
Sc	ppm	<5	11	<5	14	10	
Se	ppm	<0.5	<0.5	<0.5	<0.5	0.5	0.05
Sn	ppm					10	2.2
Sr	ppm	8184	5560	928	4713	2100	370
Th	ppm	3.14	19.61	3.07	20.22	15	
Tl	ppm					3	0.6
U_3O_8	ppm	95	229	63	66	180	2.8
V	ppm	49	222	84	177	230	160
W	ppm					3	
Y	ppm	<10	11	<10	13	9	
Zn	ppm	12.68	40.9	19.26	45.53	37	75

[1] Mean crustal abundances taken from Bowen 1979

[2] Results for samples as tested for current programme; note however that the average U_3O_8 from 56 samples was = 84.6 ppm.

5.6 Metal Leaching

Metal leaching was assessed by column testing (Column 1A). Results are shown in Figure 5.2 to Figure 5.5. As described elsewhere, the leachate from the tailings column was transferred to a second column, which was operated in series to assess the interaction with native materials. The results for the second column, Column 1B, which contained clay-quartz material, are also shown in the figures.

Trends shown in Column 1A results are as follows:

- The shape of the sodium release curve can be approximated quite well by a power law (see Figure 5.2), as can the uranium release (Figure 5.4).
- Calcium release increases during the first four pore volumes displaced, but decreased in the fifth displacement.
- Vanadium concentrations appear to oscillate between 15 and 19 mg/L (if the result for the third pore volume displacement is disregarded).

The results for Column 1B are consistent with some of the geochemical controls discussed in previous sections. For example, attenuation of sodium in the first pore volume displaced. The coincident leaching of calcium is indicative of ion exchange. In later pore volumes sodium concentrations in the outflow are greater than the inflow, suggesting that Na leaching takes place in Column 1B. One possible explanation is that some previously exchanged sodium is displaced by other solutes. From the sixth pore volume exchange onward, the inflow to Column 1B was de-ionised water. Since sodium leached during the sixth pore volume exchange, the attenuation that took place during the first five pore volume exchanges is shown to be reversible.

Both uranium and vanadium are attenuated in Column 1B. In the case of uranium, it appears that the attenuation is exhausted after the second pore volume was displaced, and uranium leaches during the third exchange. In contrast, vanadium continues to be attenuated through to the fourth pore volume displacement. Similar trends in uranium and vanadium attenuation behaviour were observed in the Column 4A and 4B pair (Section 4.4.1). There is evidence of desorption of uranium during the sixth pore volume exchange, when the inflow water becomes de-ionised water instead of the outflow from Column 1A.

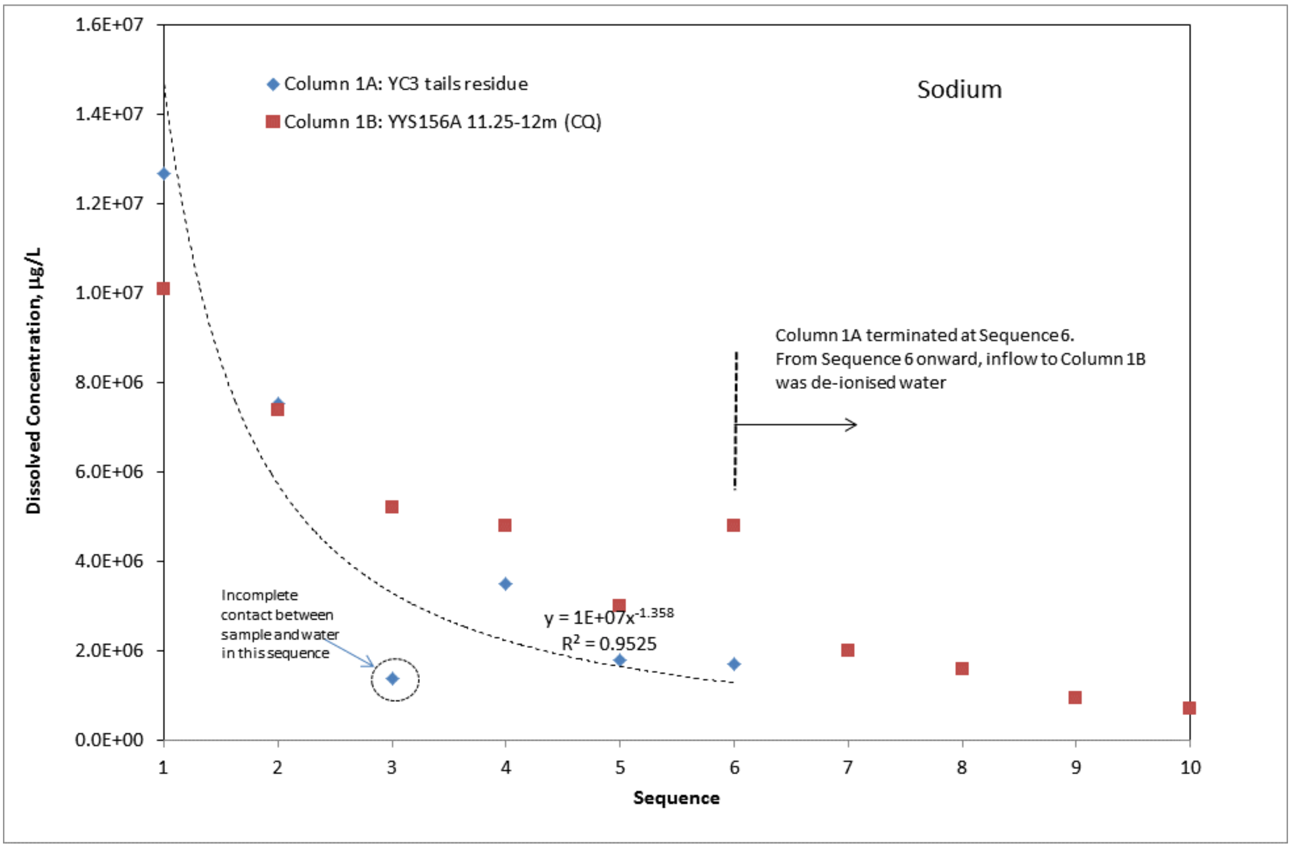


Figure 5.2: Dissolved sodium concentrations in leachates from Columns 1A and 1B

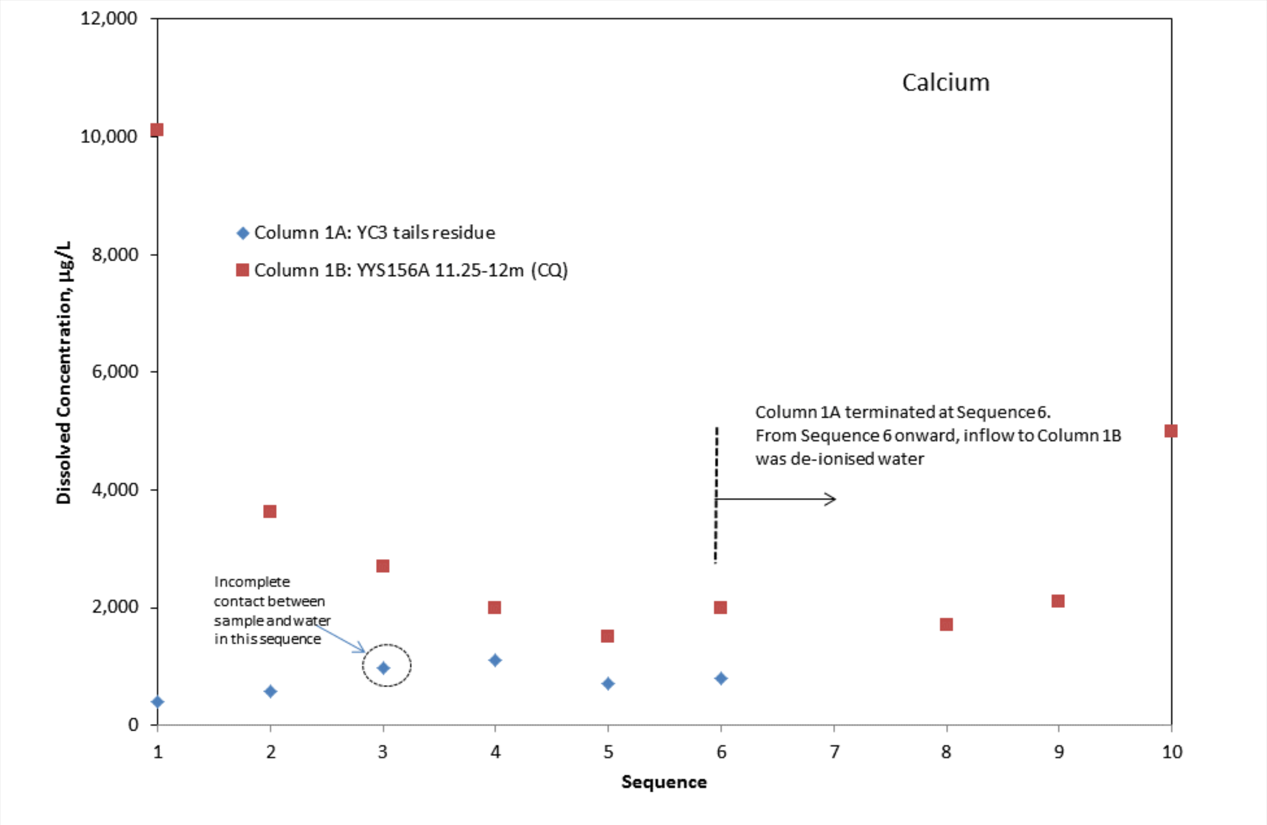


Figure 5.3: Dissolved calcium concentrations in leachates from Columns 1A and 1B

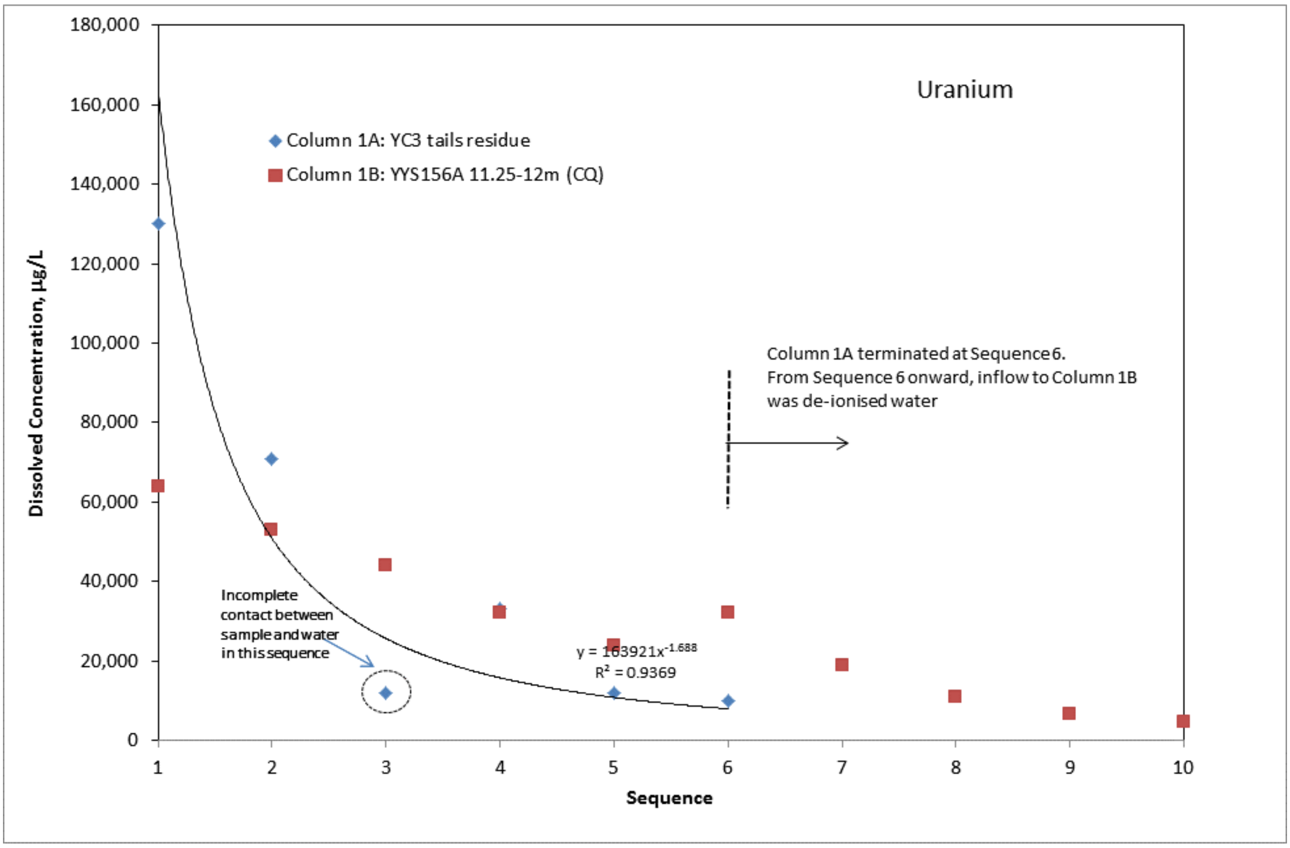


Figure 5.4: Dissolved uranium concentrations in leachates from Columns 1A and 1B

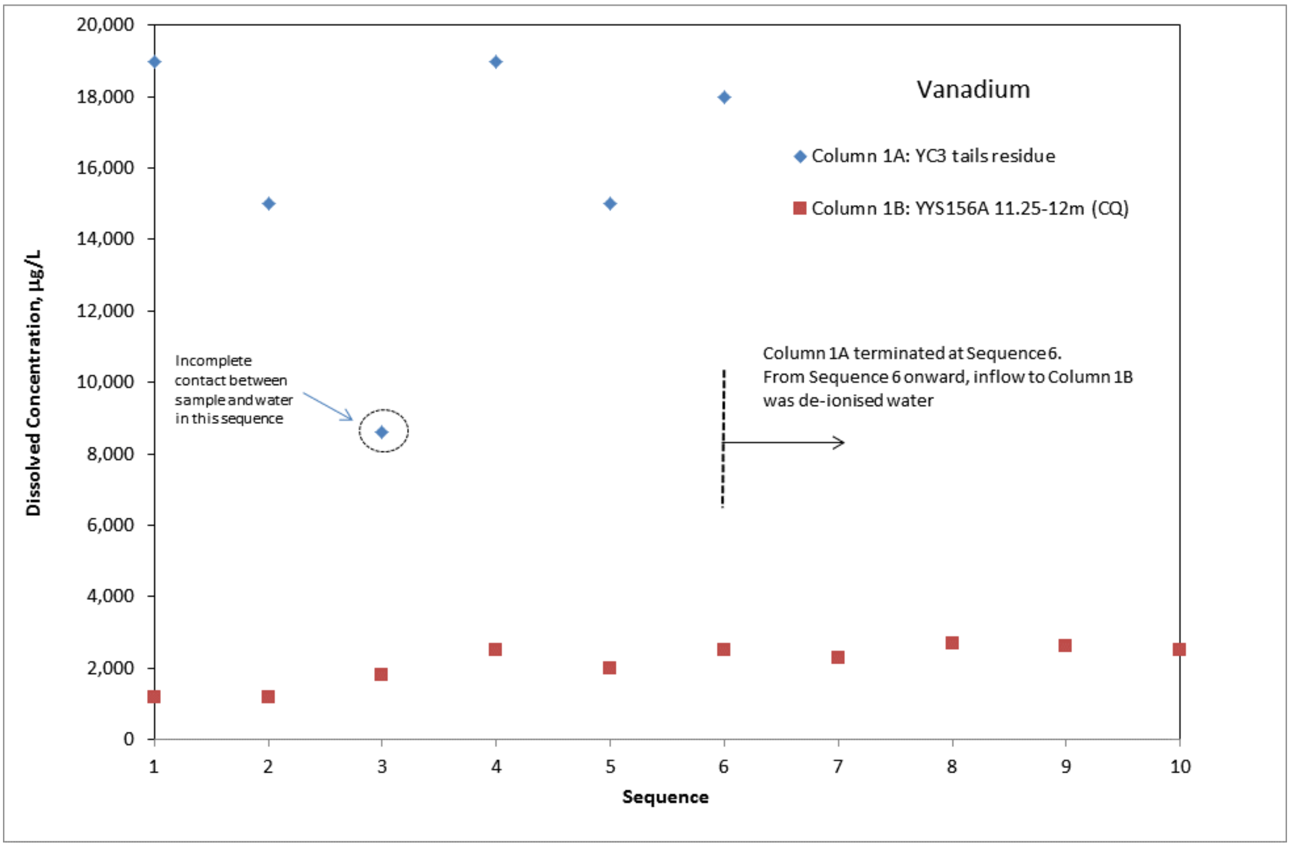


Figure 5.5: Dissolved vanadium concentrations in leachates from Columns 1A and 1B

5.7 Radionuclide Behaviour

Results from radionuclide assays of Yeelirrie tailings are shown in Table 5.3.

All the samples are depleted with respect to uranium isotopes. This is consistent with removal of uranium during processing. Some of the radionuclides further down the decay chain appear to be close to secular equilibrium, except for ^{210}Pb, which gives activities consistently higher than those of ^{230}Th and ^{226}Ra. It would appear therefore that processing has resulted in some preferential fractionation of radionuclides other than uranium.

Table 5.4 shows the results of radionuclides assays of barren liquor solution and leachates from Columns 1A and 1B. Column 1A involved YC3 tailings residue, and the effluent from Column 1A was used as inflow to Column 1B. The solutions contain significant ^{238}U and ^{235}U activities, and detectable ^{226}Ra. Other radionuclides were below detection limits.

Table 5.3: Radionuclide Assay Results for Yeelirrie Tailings

Sample	Concentration (Bq/g)									
	^{232}Th Decay Chain			^{238}U Decay Chain				^{235}U Decay Chain		^{40}K
	^{232}Th	^{228}Ra	^{228}Th	^{238}U	^{230}Th	^{226}Ra	^{210}Pb	^{235}U	^{227}Ac	
YC3 Sample	0.043	<0.09	0.049	1.6	13	10	14	<0.1	0.56	0.36
YM0076	0.013	<0.06	0.021	1.1	21	18	24	<0.2	0.91	<0.2
YM0015	0.069	<0.04	0.077	0.78	15	17	22	<0.02	0.86	0.49
YM0046	0.012	<0.03	<0.02	0.74	6.9	6.7	7.4	<0.06	0.25	0.18
YM0074	0.074	0.11	0.075	0.35	5.7	6.5	8.4	<0.07	0.33	0.52

Table 5.4: Radionuclide Assay Results for Barren Liquor, and the First Leachate Cycles from Columns 1A and 1B

Test	Sample	Description	Leachant	Concentration (Bq/L)									
				^{232}Th Decay Chain			^{238}U Decay Chain				^{235}U Decay Chain		^{40}K
				^{232}Th	^{228}Ra	^{228}Th	^{238}U	^{230}Th	^{226}Ra	^{210}Pb	^{235}U	^{227}Ac	
Barren liquor	-	-	Barren liquor	<4	<2	<0.5	1160	<110	5	<20	68	<2	28
Column 1A Sequence 1	YC3 tails residue	YC3 tails	DI water	<4	<2	<0.6	1520	<130	17	<20	90	<2	<20
Column 1A Sequence 3	YC3 tails residue	YC3 tails	DI water	<0.4	< 0.4	< 0.2	76	< 16	1.9	< 2	7.3	< 0.6	5.8
Column 1B Sequence 1	YYS156A 11.25-12 m	CQ	Effluent from column 1A	<4	<0.7	<0.3	840	<40	<0.4	<5	42	<0.9	29
Column 1B Sequence 3	YYS156A 11.25-12 m	CQ	Effluent from column 1A	<0.4	< 0.4	< 0.2	583	< 25	< 0.2	< 3	31	< 0.5	14
Column 1B Sequence 5	YYS156A 11.25-12 m	CQ	Effluent from column 1A	<0.4	< 0.4	< 0.3	211	< 23	< 0.3	< 3	19	< 0.7	11

5.8 Process Tailings Ageing

Not all chemical reactions occur instantaneously nor is equilibrium always reached in a short time. Therefore, reactions may take place between tails and contacting solutions overtime which could result in changes to the porewater composition in the TSF. To examine the nature and rate of such changes, aging tests were undertaken. Tailings slurries were allowed to contact for a period of up to 8 months, in both sealed (closed) and open flasks. The solution compositions were monitored over time and results are documented in Appendix 6.

The initial solution composition is essentially dominated by sodium carbonate, due to the high reagent addition during processing. In two of the aging tests, the dissolved Na concentration decreased. In Month 8, the sodium concentration was around 80 to 90% of the concentration measured in the first month. A similar trend was observed for potassium in one of the tests. The decreasing concentrations are interpreted as sodium and potassium exchange for calcium and magnesium on clays, possibly combined with precipitation of sodium/potassium-bearing salts. Ion exchange reactions are consistent with:

- Swelling of solids observed in some flasks. This observation was made for some of the flasks containing samples YM0046 and YM0015. These were the samples with the highest swelling clay content (e.g. smectite, illite - Table 5.1).
- Measured increases in dissolved calcium – although it is noted that in terms of milli-equivalents, the calcium increase is less than 1% of the sodium decrease. It is possible that calcium and magnesium released during the exchange reactions do not remain dissolved, but instead precipitate as secondary minerals (see below).

Precipitation of Na/K and Ca/Mg carbonates could explain coincident decreases in alkalinity, and precipitation of Na/K salts (chloride or sulphate phases) could explain the decrease in chlorine and sulphate in the majority of the tests. The XRD results (Appendix 6) show that, with the exception of YM0076, the Month 8 residues contain more calcite than the initial solid, by between 1 and 4 wt%. Geochemical modelling (PHREEQC) suggests that the solution compositions could be consistent with precipitation of phases such as dawsonite ($NaAlCO_3(OH)_2$) or gaylussite ($CaNa_2(CO_3)_2{:}5H_2O$). Most sulphate and chloride phases were under-saturated, and would therefore dissolve rather than precipitate. However, it is possible that phases may have formed in the tests that are not represented in the thermodynamic database used. *[Also note that the high ionic strength of the solutions introduce uncertainty to the solubility calculations.]*

The aging tests included tailings from both high and low-grade calcrete and clay-quartz ores. Major element aging trends appeared unaffected by ore type. However, different trends are observed for some minor elements.

Dissolved uranium and vanadium concentrations were variable among tests and also showed variable trends with time. Figure 5.6 shows the uranium concentrations with time. The samples with little or no carbonate content (YM0015 and YM0074) continued to leach U. Since the residual uranium content of sample YM0015 was well above the average for all tailings samples (see Table 5.2), it could be expected that it would continue to leach uranium; however the results for sample YM0074 indicates that ongoing leaching could be expected even for a below average uranium content. The results for YC0076 showed little or no additional uranium leaching, whereas the uranium concentration of sample YM0046 commenced at a higher initial concentration than the other tests, but then decreased over time.

Geochemical calculations suggest that the uranium concentrations are consistent with a carnotite solubility control. For example, Figure 5.7 shows that at early times, the solutions are close to equilibrium with carnotite (saturation index close to zero). The variable concentrations between tests reflect differences in geochemical conditions between tests, e.g. dissolved K and alkalinity. In month 2 and 4, the solutions start to become under-saturated with respect to carnotite, possibly reflecting the general trend toward reduced K concentrations in solution. This would mean that residual carnotite present in the tailings would start to dissolve over time. The XRD results (Appendix 6) show that whilst detectable in three of the four initial solid samples, carnotite is invariably below detection in the Month 8 residues.

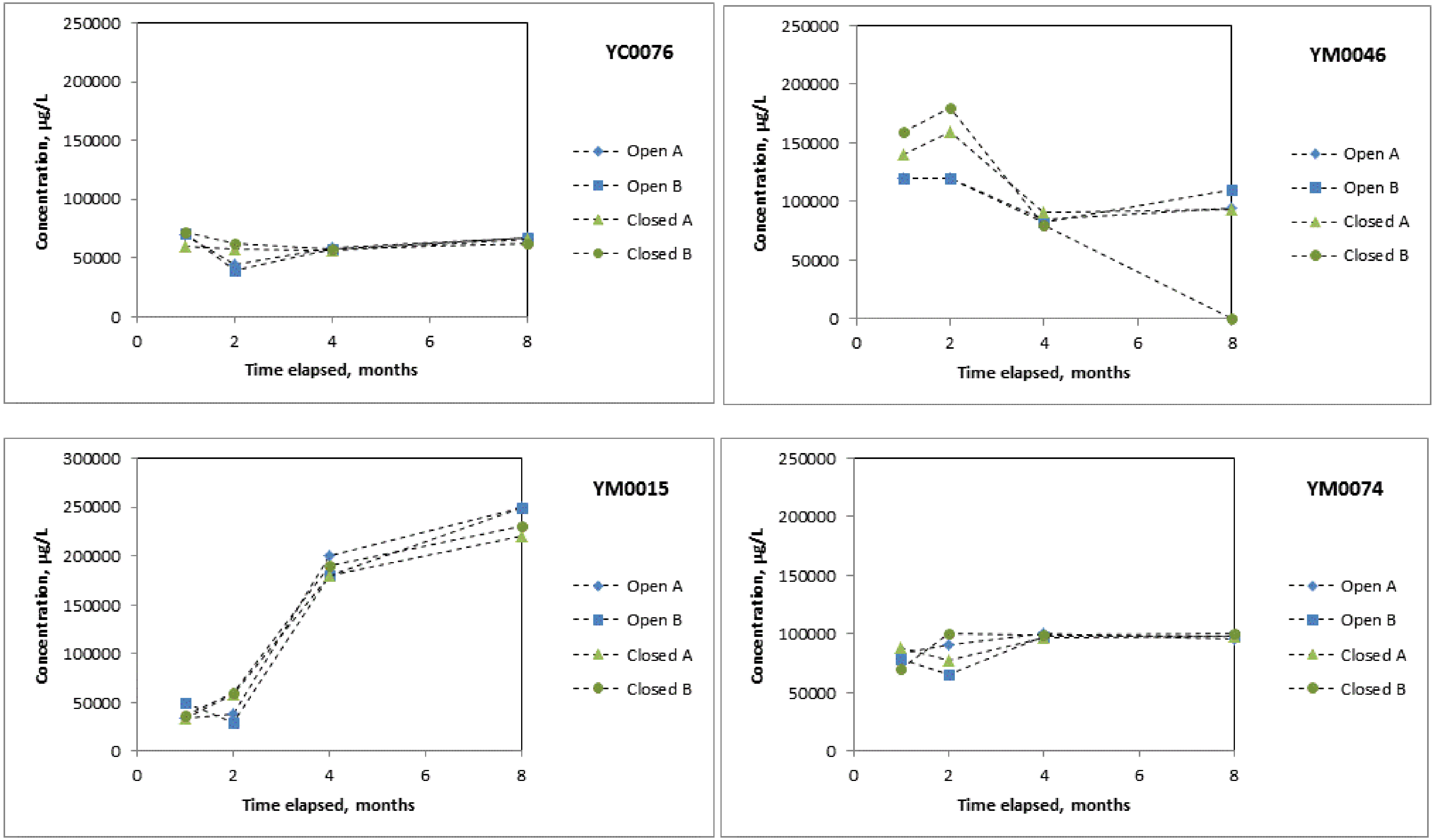


Figure 5.6: Dissolved uranium concentrations in the aging tests as a function of time

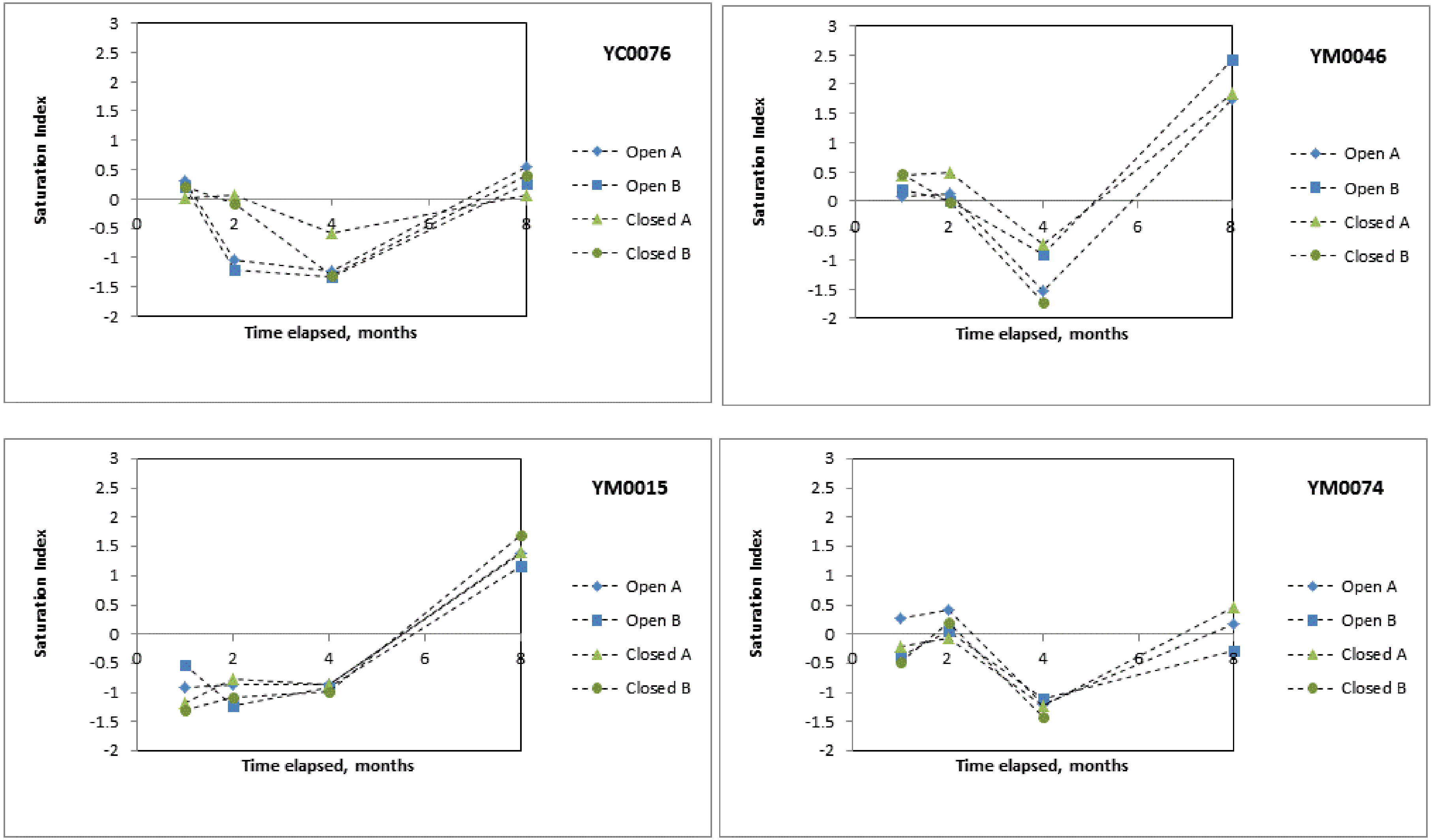


Figure 5.7: Calculated carnotite saturation index as a function of time

In month 8, the calculated carnotite saturation indices suggest over-saturation. These calculations have been influenced by much lower alkalinity values measured for the month 8 tests. (Note that results for month 8 were in fact provided by a different laboratory. A limited comparison of results from the two laboratories suggests that the second laboratory consistently reported alkalinity values around half of those reported by first laboratory. The charge balance was found to be poor; a deficiency in anions suggested that the alkalinity results could be erroneously low. Consequently, the saturation indices for the month 8 results are likely incorrect.

For some elements (barium, strontium, arsenic and molybdenum), there are systematic differences in behaviour depending on the ore-type, suggesting different mineralogical controls could be in operation. In the calcrete tailings, the dissolved concentrations of these elements decrease with time. A possible interpretation of this trend could be gradual incorporation of these elements in carbonate minerals as they recrystallise and age.

In the case of the clay-quartz tailings, the dissolved concentrations of these elements are either constant with time (strontium), increase (barium, arsenic) or both (molybdenum). The clay-quartz samples contain goethite and kaolin, both of which contribute significant sorptive capacity and would be expected to influence trace element behaviour. Aluminium concentrations increased during the tests possibly indicative of kaolin dissolution, although this is inconclusive as there are other aluminium phases present. Kaolin dissolution would reduce sorptive capacity and could cause an increase in solution concentrations as a result of release of sorbed solutes.

In general, only a few elements show major differences in behaviour between open and closed flasks. Most significant was the calcium for calcrete tails (sample YM0076) whereas calcium trends in other flasks showed a minor trend only. Other elements that show a significant response include chromium and zinc. Results for sodium, magnesium, uranium, and vanadium in some of the tests show evidence of a systematic effect – generally minor. The effects are probably linked to carbonate geochemistry, i.e. exchange with atmospheric CO_2 leading to changes in dissolved carbonate.

Other general comments about the tailings test results include:

- Oxy-anion elements like selenium, chromium decrease with time in all tests.
- Metals such as copper, lead increased sharply in month 4 leachates, but decreased in the month 8 test results.
- Clays present in the tailings lead to ion exchange which affects the sodium/potassium ratio (exchanges with calcium/magnesium) and influences the solubility of carnotite due to the loss of potassium from solution.
- Gypsum dissolution and ion exchange reactions increase dissolved calcium which leads to calcite precipitation.
- Dissolved alkalinity is lost from solution due to the formation of calcite and other carbonate minerals.
- Loss of alkalinity reduces carnotite solubility and will result in lower uranium and vanadium equilibrium concentrations.

6. Tailings (Kalgoorlie Storage Facility)

Although the Kalgoorlie tailings may not have been processed in strict accordance with the method that will be used for uranium recovery as proposed for the Yeelirrie Development, the results may be used as an analogue to the proposed TSF facility.

6.1 Mineralogy

The mineralogical composition of Kalgoorlie samples is given in Table 6.1. The main minerals are carbonates (calcite and dolomite), quartz, kaolin and iron oxide (hematite).

The mineralogical differences between the tails and the underlying sediments are slight. The sediments contain higher quantities of kaolin and iron oxide. In Borehole #2 and #3, there is a decrease in calcite and dolomite content across the tails/sediment interface.

6.2 Surface Characteristics

The surface characteristics of Kalgoorlie materials are given in Table 6.2. In the case of samples S2.9 and S3.7, there were distinct colour changes along the length of the core. Two sub-samples were obtained to determine if there were coincident differences in surface characteristics.

The surface area ranges from 18.9 m^2/g to 80.9 m^2/g. There is no obvious correlation between surface area and mineralogy or colour.

The cation exchange capacity shows a small range, from 17 to 36.8 meq/100g. The dominant cation occupying exchange sites is calcium. Note that the tailings cation exchange capacity is about half that measured for the fresh tailings reported herein (Section 5.3).

6.3 Bulk Chemistry

The bulk chemistry analytical results are provided in Appendix 3, and selected results are shown in Table 6.3.

The samples collected from the Kalgoorlie facility span the tailing/sediment interface. Solid assay results plotted as a function of depth indicated:

- Elevated carbonate within the tailings materials (Figure 6.1).
- Variability in the minor element composition of the tailings, over depth scales of less than a metre (Figure 6.2).

Table 6.1: Mineralogical Composition of Kalgoorlie Samples (wt%)

Sample	Borehole	Depth range	Material type	Carbonates		Framework and chain silicates				Sheet silicates and clays					Oxides		
				Calcite	Dolomite	Quartz	Albite	Microcline	Amphibole	Kaolin	Smectite	Illite / Mica	Sepiolite	Chlorite	Hematite	Anatase	Rutile
S1.9	1	4-4.5 m	Tailings	8	26	35	1	4		16	8	1	?1			<1	
S2.14	2	4-4.5 m	Tailings	12	23	15	<1	1		23	21	1			4	<1	
S2.9	2	5.25-6 m	Sediment	10	24	14	<1	2		22	21	1			6	<1	
S3.7	3	5.3-5.75 m	Tailings	3	6	75	3	2	<1	7					4		
S3.8	3	6-7 m	Sediment	<1	2	12				67				<1	15	2	1

Notes:
?=denotes uncertainty in mineral identification

Table 6.2: Surface Characteristics of the Kalgoorlie Tailings and Underlying Soils

Sample	Borehole #	Depth interval, m	Lithology	BET Surface area, m^2/g	Cation exchange capacity, meq/100g	Site Occupancy: exchangeable cations, meq/100g (grey shading indicates dominant cation)			
						Ca	Mg	K	Na
S1.9	1	4-4.5	Tailings	46.6	31.2	21.5	3.1	1.7	4.9
S2.14	2	4-4.5	Tailings	61.2	36.8	21.4	1.1	2.3	12
S2.9A (red)	2	5.25-6	Underlying soil	73.9	19.5	8.3	0.5	1.8	8.9
S2.9B (pale brown)	2	5.25-6	Underlying soil	30.5	35.2	24.5	1.1	1.8	7.8
S3.7A (red)	3	5.3-5.75	Tailings	18.9	30	23.4	3.3	1.1	2.2
S3.7B (pale brown)	3	5.3-5.75	Tailings	27.2	32	24	2.4	1.4	4.1
S3.8	3	6-7	Underlying soil	80.9	17	12.4	1.4	0.2	3

Table 6.3: Bulk Chemistry of Kalgoorlie Tailings and Sediments

Major elements		Al	Ca	CO_2	F	Fe	K	Mg	Mn	Na	S	Si	SO_4
Sample #	**Material type**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
Average crustal abundance		8.2	4.1			4.1	2.1	2.3	0.095	2.3			0.078
S1.8 (4 m)	Tailings	4.28	8.27	15.4	0.312	1.89	0.84	4.88	0.01	0.69	<0.01	20.1	0.55
S1.9 (4-4.5 m)	Tailings	3.78	8.32	14.3	0.218	2.02	0.86	4.74	0.01	0.55	0.07	22.6	0.1
S2.14 (4-4.5 m)	Tailings	5.57	8.41	14.1	0.254	5.29	0.81	5.54	0.02	1.1	0.07	17.3	0.1
S2.8 (4.5-5.25 m)	Tailings	4.18	8.46	16	0.25	1.84	0.9	5.22	0.02	0.76	0.02	20.4	0.2
S2.9 (5.25-6 m)	Underlying soil	6.31	7.57	13	0.226	7	0.62	4.97	0.01	1.2	0.07	16	0.7
S2.10 (6 m)	Underlying soil	9.59	0.31	0.9	0.05	20	0.32	0.39	0.01	0.64	0.06	17.7	0.1
S2.11 (6-6.75 m)	Underlying soil	10.5	0.21	0.8	0.042	16.7	0.25	0.31	<0.01	0.59	0.05	19	0.1
S3.11 (3.75 m)	Tailings	3	6.92	13.1	0.254	1.37	0.86	3.86	0.01	0.37	0.02	25.9	0.1
S3.6 (4.5-5.25 m)	Tailings	5.44	4.66	4.5	0.034	16	0.12	1.82	0.17	1.22	0.27	20.6	<0.05
S3.7 (5.3-5.75 m)	Tailings	2.99	7.98	15.2	0.202	2.58	0.69	4.32	0.02	0.41	0.02	23	0.15
S3.10 (5.75-6 m)	Underlying soil	5.81	5.77	6.1	0.034	14	0.16	2.21	0.15	1.02	0.3	20.5	<0.05
S3.8 (6-7 m)	Underlying soil	11.4	0.47	1	0.018	14.5	0.17	0.34	0.01	0.48	0.06	18.8	<0.05
S3.9 (8 m)	Underlying soil	16.4	0.08	0.5	0.01	4.11	0.08	0.22	<0.01	0.35	0.16	21.3	0.15

Minor elements		As	Ba	Cd	Co	Cr	Cu	Mo	Ni	Pb	Sr	Th	Tl	U_3O_8	V	Zn
Sample #	**Material type**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**
Average crustal abundance		1.5	500	0.11	20	100	50	1.5	80	14	370		0.6	2.8	160	75
S1.8 (4 m)	Tailings	13.5	210	<0.1	4.4	60	21.5	1.8	4.4	60	2300	10	<3	230	375	45
S1.9 (4-4.5 m)	Tailings	11	235	<0.1	3.8	55	16	2.3	3.8	55	1800	10	<3	180	210	180
S2.14 (4-4.5 m)	Tailings	16	205	<0.1	8	130	25	2.1	8	130	1800	15	<3	360	420	120
S2.8 (4.5-5.25 m)	Tailings	10.5	250	<0.1	4.4	50	23.5	1.7	4.4	50	2900	10	<3	160	195	70
S2.9 (5.25-6 m)	Underlying soil	10.5	165	<0.1	7.5	190	18.5	1.6	7.5	190	900	10	<3	450	340	34
S2.10 (6 m)	Underlying soil	15	175	<0.1	5.5	495	22.5	2.6	5.5	495	105	10	<3	215	550	185
S2.11 (6-6.75 m)	Underlying soil	12	125	<0.1	6	440	25	3	6	440	95	5	<3	185	475	30
S3.11 (3.75 m)	Tailings	13.5	230	<0.1	2.8	40	19	1.8	2.8	40	1200	10	<3	250	210	23.5
S3.6 (4.5-5.25 m)	Tailings	11.5	60	<0.1	47	130	41.5	1.4	47	130	135	<4	<3	15	280	130
S3.7 (5.3-5.75 m)	Tailings	10.5	240	<0.1	5.5	70	18	1.8	5.5	70	1300	5	<3	205	185	41.5
S3.10 (5.75-6 m)	Underlying soil	10.5	65	<0.1	47.5	135	55	1.9	47.5	135	150	<4	<3	15	290	280
S3.8 (6-7 m)	Underlying soil	8.5	130	<0.1	10.5	365	20	1.8	10.5	365	20	15	<3	125	410	30.5
S3.9 (8 m)	Underlying soil	1	100	<0.1	7.5	215	9.5	0.5	7.5	215	15	10	<3	5	175	70

Note: [1] Mean crustal abundances taken from Bowen 1979

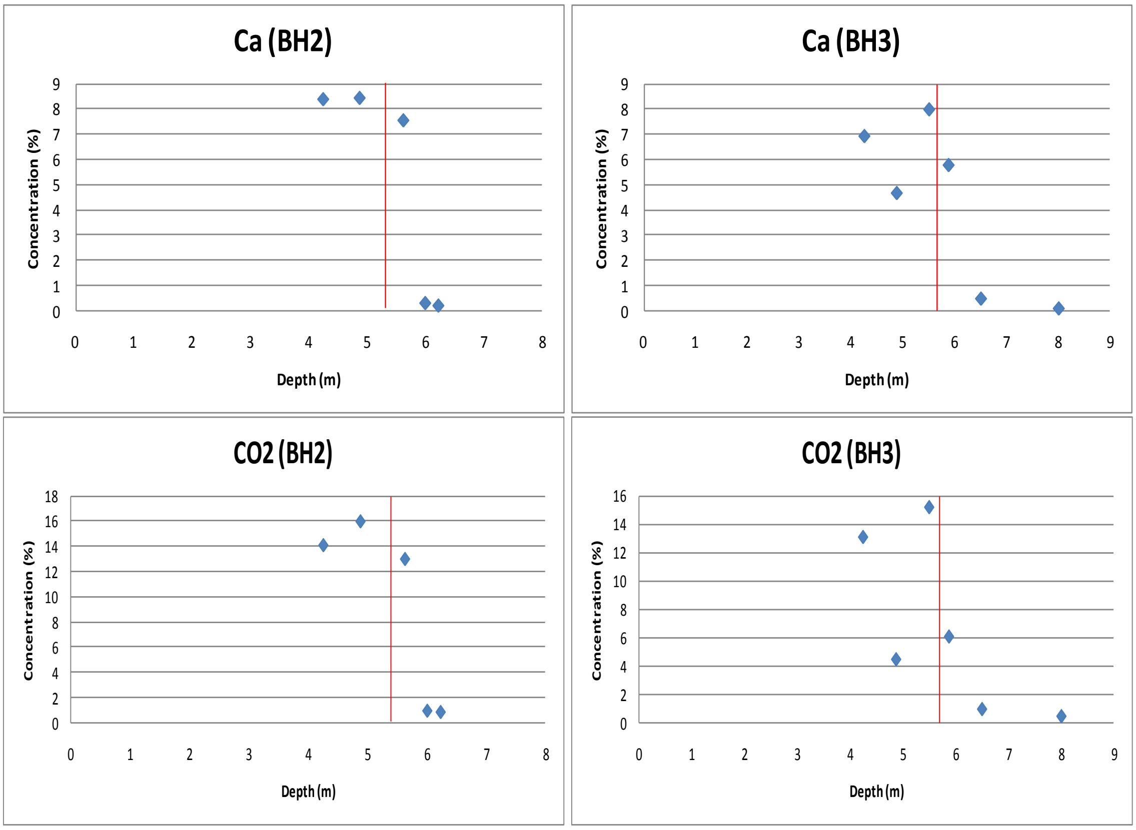


Figure 6.1: Profiles of Ca and inorganic carbon (as CO_2) content in solids as a function of depth, BH2 and BH3 (Kalgoorlie TSF)

Red line indicates the approximate position of the tailings/sediment interface.

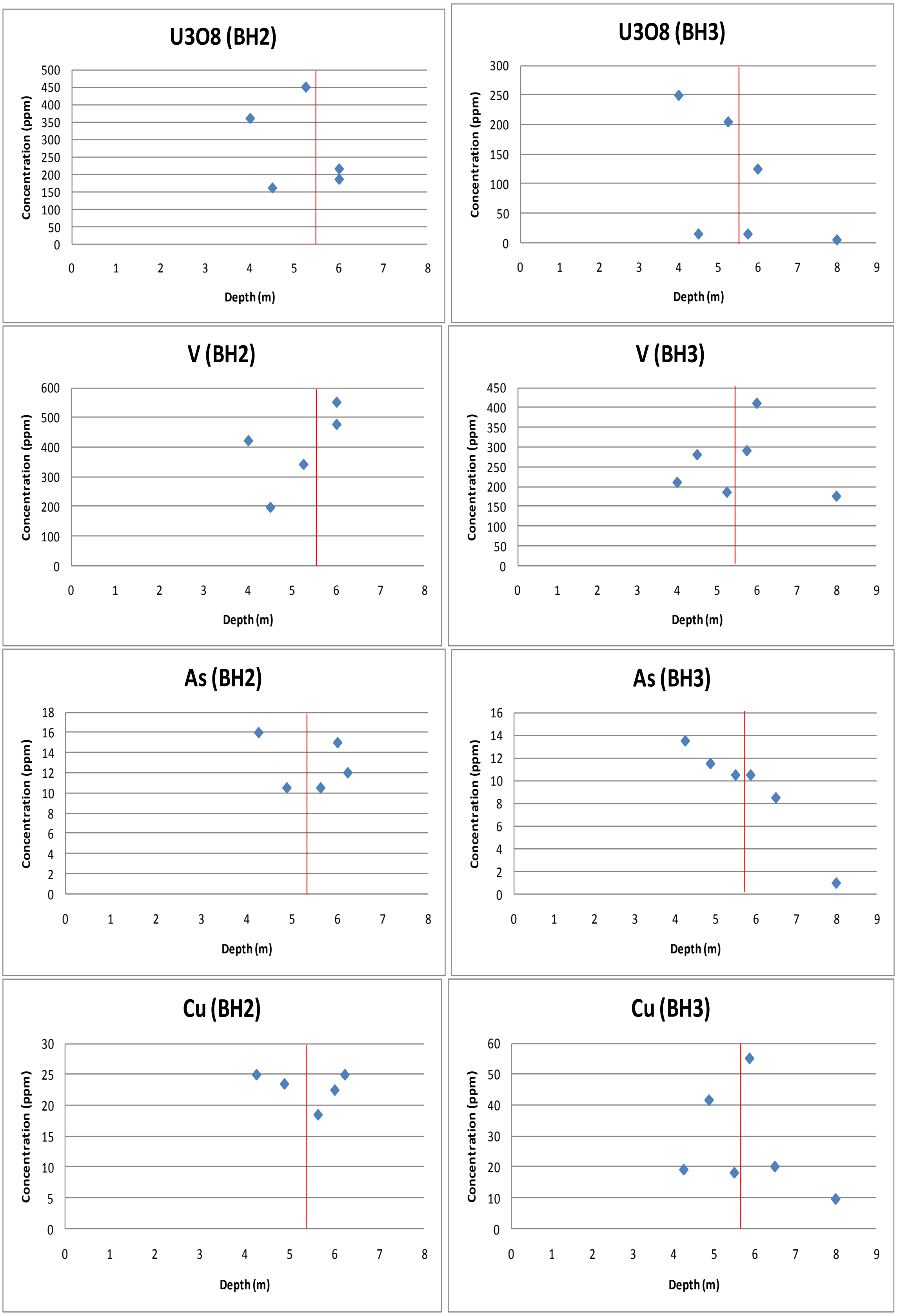


Figure 6.2: Profiles of uranium, vanadium, arsenic and copper content in solids as a function of depth, BH2 and BH3 (Kalgoorlie TSF)

Red line indicates the approximate position of the tailings/sediment interface

6.4 Metal Leaching

Samples were contacted with de-ionised water in bottle tests. The bottle roll tests were undertaken at a liquid:solid ratio of 3:1 and the headspace in the bottles was occupied by air. Results from bottle roll tests are documented in Appendix 4.

Table 6.4 summarises solute concentrations measured in the bottle roll tests. The summary includes results from both tailings and sediment samples, and uses results from progressive (sequential) leach tests. In these tests, following the first bottle roll test, the solution is removed and a second and third test conducted (at the same 3:1 water:rock ratio).

For some elements (silver, beryllium, bismuth, cobalt, lithium, lead, antimony) the dissolved concentrations at the end of the tests were invariably below the limits of detection. Comparatively, dissolved concentrations measured for boron, strontium, thallium, uranium and vanadium were elevated, with maximum concentrations in excess of 500 µg/L. Dissolved concentrations of arsenic and tin were generally above detection limits, with maximum concentrations in excess of 100 µg/L.

With the exception of arsenic and tin, the suite of leachable elements is similar to that observed for the Yeelirrie materials.

As with Yeelirrie materials, the highest concentrations generally were observed for the first stage of the progressive leach tests. Exceptions included tin and zinc where the highest concentrations occurred in the second and third stages of the leaching sequence.

There were no significant differences in leaching behaviour between the tails and sediments samples.

Table 6.4: Summary of Solute Concentrations in De-ionised Water Extractions of Kalgoorlie Materials

(Bottle Roll Tests at 3:1 Water:Rock Ratio)

Parameter	Units	Detection Limit	Underlying Soils (Two samples, six solutions)			Tailings (Three samples, nine solutions)		
			Minimum	Median	Maximum	Minimum	Median	Maximum
pH	pH Units	0.0	8.4	8.6	9.4	8.3	9.1	9.4
Eh	mV	1.0	410	432	453	401	423	443
EC	µS/cm	5.0	351	982	5240	385	1200	5530
Alkalinity	$CaCO_3$ (mg/L)	1.0	229	297	1190	322	443	680
Br	mg/L	0.5	<0.5	<0.5	3.1	<0.5	1.6	3.6
Cl	mg/L	0.5	5.1	51	750	3.2	76	860
F	mg/L	0.5	1.1	2.65	7.2	1.5	3.8	6.1
TOC	mg/L	1	4.2	7.85	28	2.9	6.1	45
NO_2-N	mg/L	0.5	<0.5	<0.5	1.6	<0.5	<0.5	0.6
NO_3-N	mg/L	0.5	<0.5	0.85	51	<0.5	2.25	58
SO_4	mg/L	0.5	7.1	48	480	5.9	87	590
Al	µg/L	5	15	123.5	310	76	190	1100
Ca	µg/L	100	1010	2710	5700	1390	2560	4620
Fe	µg/L	100	<100	<100	<100	<100	<100	120
Mg	µg/L	100	202	491	1740	328	636	1520
P	µg/L	100	<100	220	510	<100	<100	650
K	µg/L	1000	1500	6795	48600	7660	14500	57600
Na	µg/L	100	83500	207000	1080000	87200	312000	1110000
Si	µg/L	100	2980	17500	180000	2500	5180	240000
As	µg/L	5	<5	42	210	52	130	340
B	µg/L	5	370	530	1700	310	1200	2400
Ba	µg/L	5	8.6	12.5	45	<5	8.5	19
Cd	µg/L	5	<5	<5	<5	<5	<5	11
Cr	µg/L	5	<5	<5	6.9	<5	5.3	9.5
Cu	µg/L	5	5.8	19	25	<5	7.8	32
Hg	µg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Mn	µg/L	5	<5	<5	7.4	<5	<5	<5
Mo	µg/L	5	9.7	32	68	<5	15	93
Ni	µg/L	5	<5	<5	7.5	<5	<5	<5
Se	µg/L	5	<5	6	42	<5	<5	27
Sn	µg/L	5	<5	42	240	<5	6	61
Sr	µg/L	5	6.3	61.5	280	110	210	1200
Tl	µg/L	5	<5	<5	<5	<5	<5	3600
U	µg/L	5	280	2450	56000	180	2200	21000
V	µg/L	5	5	704	3100	2200	3700	12000
Zn	µg/L	5	<5	8.1	18	<5	11	93

Notes:
[1] Where more than one detection limit is given, the detection limit reported by the laboratory changed during the programme.
[2] The following constituents were consistently below detection: acidity, NH_3, Ag, Be, Bi, Co, Hg, Li, Pb, Sb.

6.5 Radionuclide Distribution and Behaviour

Results from radionuclide assays of Kalgoorlie solids are shown in Table 6.5.

Daughter/parent activity ratios that differ from unity indicate secular disequilibrium. All three tails samples are depleted with respect to uranium isotopes, consistent with removal of this element during processing. Radionuclides further down the decay chain appear to be in equilibrium. In the case of the longer lived nuclides, e.g. ^{230}Th, ^{226}Ra, this suggests that processing did not disturb pre-existing equilibrium relationships. In the case of shorter lived nuclides, e.g. ^{210}Pb, ^{210}Po, the same could be true.

One of the soils, S2.9, is enriched with respect to uranium. The sample was located immediately below the tails. It is possible that the radionuclide content of this soil is sourced from overlying tails, i.e. represents an attenuation front. This could explain why the sediment reflects the same radionuclide disequilibrium as the overlying tails.

Table 6.6 shows leachate concentrations from the first stage of the progressive leach tests. Most radionuclides are below detection limits suggesting no significant leaching of these nuclides from the solids. However, ^{238}U, ^{235}U and ^{226}Ra were detectable. The ^{226}Ra trends correlate with strontium behaviour providing some confidence in the use of strontium as a chemical analogue for radium.

Table 6.5: Radionuclide Assay Results for Kalgoorlie Tailings and Underlying Sediments

Sample	Concentration (Bq/g)										
	^{232}Th Decay Chain			^{238}U Decay Chain					^{235}U Decay Chain		^{40}K
	^{232}Th	^{228}Ra	^{228}Th	^{238}U	^{230}Th	^{226}Ra	^{210}Pb	^{210}Po	^{235}U	^{227}Ac	
S1.9 (tails)	0.032	0.049	0.034	1.8	8.7	12	13	13	0.14	0.41	0.34
S2.14 (tails)	0.040	<0.05	0.045	3.8	23	18	19	20	0.29	0.84	0.27
S2.9 (underlying soil)	0.036	<0.05	0.045	4.7	23	18	21	17	0.27	0.91	<0.1
S3.7 (tails)	0.028	<0.03	0.031	1.8	8.6	9.9	11	10	<0.08	0.38	0.24
S3.8 (underlying soil)	0.029	0.029	0.027	1.3	<0.2	0.026	<0.03	0.035	0.050	<0.006	<0.05

Table 6.6: Radionuclide Assay Results for De-ionised Water Extraction of Kalgoorlie Tailings and Underlying Sediments

(Sequence 1, Bottle Roll Tests at 3:1 Water:Rock Ratio)

Sample	Concentration (Bq/L)										Concentration (µg/L)	
	^{232}Th Decay Chain			^{238}U Decay Chain				^{235}U Decay Chain		^{40}K	Ba	Sr
	^{232}Th	^{228}Ra	^{228}Th	^{238}U	^{230}Th	^{226}Ra	^{210}Pb	^{235}U	^{227}Ac			
S1.9 (tails)	<4	<0.3	<0.1	<12	<4	0.5	<2	<1	<0.4	<2	8.5	710
S2.14 (tails)	<4	<0.3	<0.2	293	<20	<0.2	<2	8.6	<0.5	<2	10	600
S2.9 (underlying soil)	<4	<0.4	<0.2	755	<30	<0.6	<3	39	<0.6	<2	8.6	280
S3.7 (tails)	<4	<0.5	<0.2	92	<20	0.8	<4	4.3	<0.5	<4	19	1200
S3.8 (underlying soil)	<4	<0.4	<0.1	18	<9	<0.2	<3	<1	<0.4	<4	45	51

6.6 Geochemical Controls

6.6.1 Attenuation

Minor element enrichment is observed at and below the tailings/sediment contact (Figure 6.2). This enrichment is taken as evidence of attenuation at this interface.

6.6.2 Solubility Controls

Figure 6.3 is uranyl activity diagram showing uranyl activities for the Kalgoorlie leachate results plotted as a function of pH. Many of the solutions were under-saturated with respect to carnotite solubility, and the results plot below the theoretical carnotite line. However, there were several solutions that were over-saturated with respect to carnotite. These results actually plot along a trend parallel to the solubility of uranium hydroxide minerals, e.g. schoepite. This introduces the possibility that in tailings-related materials, uranium solubility could be controlled by minerals other than carnotite in the longer term after deposition. However this may depend on the processing route and the physico-chemical conditions that develop after deposition.

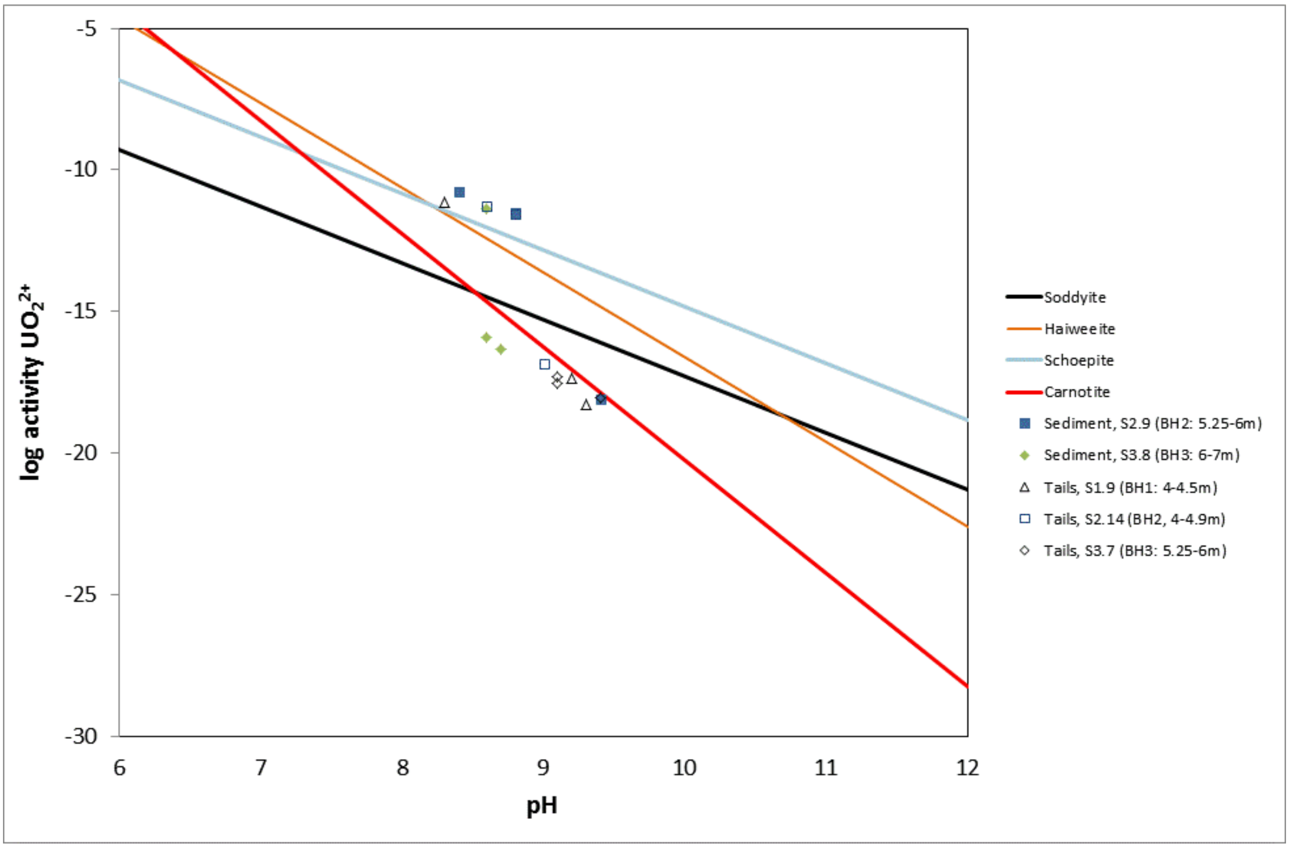


Figure 6.3: Uranyl (UO_2^{2+}) activity diagram showing the calculated activities of bottle roll leach solutions

(3:1 liquid:solid ratio, air)
(Also shown are the theoretical equilibrium lines for a range of minerals)

6.7 Kalgoorlie TSF as an Analogue for the Proposed Yeelirrie TSF

Despite possible differences in processing methodologies, the geochemical characteristics of the Kalgoorlie tailing materials are similar to the more recently produced tailings samples. It might be expected therefore that similar processes would control contaminant mobility within the tails and that the Kalgoorlie system be regarded as an analogue of the Yeelirrie system.

There are parallels observed between the results from the Kalgoorlie programme and those from both the Yeelirrie rocks and soils, and the more recently produced tailings materials. For example, the importance of carnotite as a possible solubility control on uranium and vanadium behaviour. There is additional evidence of an alternative solubility control within the Kalgoorlie results (i.e. schoepite). These observations are valid for an unsaturated system that likely has been affected by evaporation. A significant difference between the Kalgoorlie facility and the proposed Yeelirrie TSF is that the in the proposed TSF the tailings will largely be below the groundwater table and will remain saturated. This may influence the suite of secondary mineral phases that may form.

Of particular interest is the possible evidence of attenuation at the base of the Kalgoorlie TSF. The Kalgoorlie TSF has been in place for more than 30 years. It would appear that during this time, contaminants in seepage from the TSF have been attenuated at the tails/sediment interface. Soils underly the Kalgoorlie TSF and would be expected to present a significant sorptive capacity (e.g. due to high iron oxide and clay content). However, it should be noted that clay-quartz would underly the Yeelirrie TSF and may not present such a high sorptive capacity.

7. Conclusions

This report provides a summary of the field and laboratory investigations completed in support of the source term development for the temporary stockpiles and the tailings area. Outcomes from the programme are summarised below.

Stockpiled Materials

Leaching behaviour is dominated by flushing of readily soluble phases on contact with water, e.g halite, sulphates, carnotite. The main contaminants correlated with such flushing are: boron, barium, molybdenum, strontium, thallium, uranium, vanadium and zinc. Radionuclide assays of leachate solutions showed that ^{226}Ra would also be released during flushing. The earliest pore volume exchanges tend to coincide with the highest solute concentrations. Concentrations are much reduced in subsequent pore volume exchanges. The shape of release curves generated from column testwork can be approximated quite well by a power law.

Carnotite solubility is expected to place an upper limit on uranium and vanadium in leach solutions. In many cases, the mass of available carnotite may be limited and the solutions could remain under-saturated with respect to this mineral. There is a greater likelihood that carnotite saturation would occur where water-to-rock ratios are lower (i.e. more carnotite mass per unit volume water), solute concentrations are higher and contact times are longer. Amongst other parameters, carnotite solubility is sensitive to solution pH, dissolved carbonate, potassium concentrations and redox.

Sorption onto iron and aluminium oxyhydroxides and clays may further limit release of some elements.

Based on outcomes for the leach testwork, tables of leachable solute mass (per kg of material) have been prepared for use as input to the source term modelling.

Tailings

In the short-term, tailings porewater quality is dominated by process water (barren liquor). Barren liquor is highly alkaline and contains relatively high dissolved uranium and vanadium concentrations. Over the longer-term, it is expected that ion exchange processes could result in decreases in dissolved sodium and potassium concentrations in porewater. It is also possible that alkalinity will decrease (although available results are ambiguous with respect to trends in alkalinity) due to the formation of carbonate minerals. Reduced concentrations of potassium in solution will result in increased carnotite solubility; however this could be offset by reduced solubility should alkalinity decrease. The net effect may be that dissolved uranium and vanadium remain constant.

Results from the Kalgoorlie programme suggested that in the long term, in addition to carnotite, alternative solubility controls such as uranium hydroxide minerals (e.g. schoepite) may come into play.

Ion exchange reactions involving clay minerals may have a secondary outcome with respect to changing the physical characteristics of the materials. There is a correlation between exchange site occupancy and the swelling capacity of the clay. Replacing calcium with sodium will result in clay swelling, and consequently may reduce the permeability of the material. [This was observed in the column testwork where permeability decreased progressively in some materials and made it difficult to continue operating the columns in later cycles of testing.] In the field, for example, within and downstream of the tailings storage areas, this effect could reduce the potential for percolate to be released to the surrounding ground and act as a possible physical barrier to contaminant migration.

Downstream Interactions

Initial percolate from the TSF could contain high dissolved sodium. Such high sodium concentrations are likely to result in displacement of ions from exchange sites on contacting clays, and result in leaching of calcium, magnesium, barium and strontium. Notably, ^{226}Ra, rather than being displaced, appears to be attenuated from this percolate. Thus, under these particular geochemical conditions, radium does not behave as other analogous elements such as barium and strontium. [Under less alkaline, more dilute chemical conditions trends in ^{226}Ra behaviour were analogous with trends in calcium, magnesium, barium and strontium behaviour.]

Carnotite solubility controls are expected to play an important role in controlling uranium and vanadium mobility along potential flow paths downstream of the facility. Geochemical conditions are expected to result in reduced carnotite solubility, principally due to the much lower alkalinities expected downstream. Solubility controls that could apply to other elements are co-precipitation in sulphate or carbonate phases.

Contaminant mobility may also be limited due to sorption onto mineral surfaces (e.g. iron and aluminium oxyhydroxides and clays). Sorption is not strong under the relatively carbonate-rich conditions expected in Yeelirrie groundwaters. However, moderate sorption is expected for many elements, except for the very elevated dissolved carbonate levels expected in early tailings seepage. Highest sorption is expected for loams; sorption coefficients in excess of 100 cm^3g^{-1} were calculated for arsenic, uranium and vanadium sorption. Lower sorption is expected in the case of the clay-quartz lithology (sorption coefficients for most elements were less than 10 cm^3g^{-1}). In the case of calcrete, little or no sorption is expected to occur.

Potential attenuation of contaminants at the tailings/sediment interface is supported by observations within the Kalgoorlie programme. However, the Kalgoorlie TSF is underlain by soils that are expected to have a strong sorptive capacity. In contrast, clay-quartz will underly the Yeelirrie TSF and may not present such a high sorptive capacity. The clay quartz may also contain low levels of uranium that could be leached by the process water when first contacted.

8. References

Baston, G.M.N., Berry, J.A., Brownsword, M., Heath, T.G., McCrohon, R., Tweed, C.J. and Yui, M. *The Effect of Temperature on the Sorption of Actinium and Protactinium on Geological Materials*, Presented at Migration 97, Sendai, September 1997.

BHP, 2011, Proposed Yeelirrie Development: Environmental Review and Management Program.

Bond, K.A., Heath T.G., Tweed, C.J., 1997. *HATCHES: A Referenced Thermodynamic Database for Chemical Equilibrium Studies*, Nirex Report NSS/R379.

Bowen, H.J.M. 1979. *Environmental Chemistry of the Elements*, Academic Press, London, (1979).

Outback Ecology, Yeelirrie Rehabilitation Report, July 2004.

Parkhurst, D.L. and Appelo, C.A.J. User's guide to PHREEQC (Version 2) – A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations. Water-Resources Investigations Report 99-4259, 1999.

SRK, 2009. Proposed Yeelirrie Project: Geochemical Assessment of Tailings and Waste rock, SRK Report BHP040, August 2009.

WMC, 1991. Yeelirrie Uranium Project 1991 Study Update.

Appendices

Appendix 1: Field Programme

The following appendix comprises:

- A map showing the locations of drill-holes at the Yeelirrie site.
- A sample log summarising characteristics of samples collected from drilling at the Yeelirrie site.
- Some figures illustrating trends in paste pH, EC and redox as a function of depth at the Yeelirrie site (data based on field measurements undertaken by URS). Also shown on the figures are results from the BHP assay database for CO_2(%), S(%), U_3O_8(ppm) and V(ppm). These latter data are only shown for those cases where the database contained data collected from a drill-hole within 5 m of the current drill-hole.
- Drill logs for boreholes at the Yeelirrie site (excerpts from URS documentation).
- Drill and samples logs prepared to describe sampling at the historic Kalgoorlie tailings storage facility.

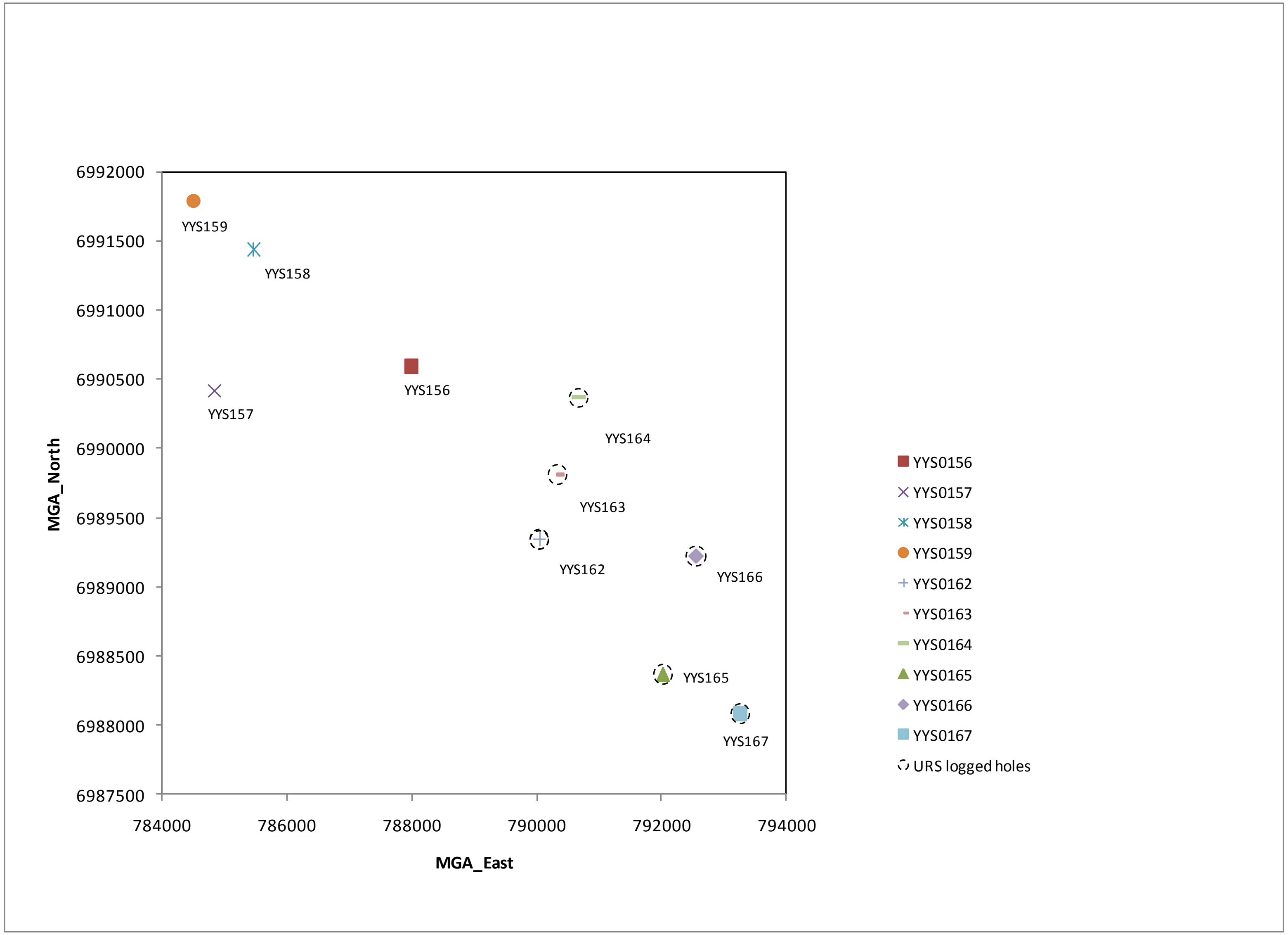


Figure A1.1: Locations of drill-holes at the Yeelirrie project site

Table A1.1 Sample Log summarising characteristics of samples collected from drilling at the Yeelirrie site

Selected [1]	URS #[2]	Drill hole	From	To	Mass	Sample type	Litho type[3]	Paste Parameters[4]		'Minimal' assay results[5]				
								EC µS/cm	pH	TIC	S %	U ppm	U_3O_8 ppm	V ppm
		YYS156A	0	0.75	4.71	Tube	L							
1		YYS156A	0.75	1.5	9.11	Tube	L	10770	7.98					
		YYS156A	1.4	1.5	0.817	Bag	L			0.2	1.56	98.3	348	90
1		YYS156A	1.5	2.5	10.58	Tube	LT	6160	7.95					
		YYS156A	2.4	2.5	0.753	Bag	LT			4.07	0.92	1480	5236	320
1		YYS156A	3	4	13	Tube	LT	5380	8.47					
		YYS156A	4.4	5.9	32.48	Crushed rock	LT			6.79	0.09	524	1854	145
		YYS156A	5.9	7.5	26.63	Crushed rock	TCQ							
		YYS156A	7.5	8.25	9.1	Tube	CQT							
		YYS156A	8.25	9	9.86	Tube	CQT							
		YYS156A	8.9	9	0.89	Bag	CQ			0.01	0.09	232	821	200
		YYS156A	9	9.75	6.65	Tube	CQ							
		YYS156A	10.5	11.25	7.73	Tube	CQ							
		YYS156A	11.1	11.25	1.85	Bag	CQ			0.01	0.08	29.2	103	130
		YYS156A	11.2	12	1.064	Bag	CQ			0.06	0.1	74.1	262	155
1		YYS156A	11.25	12	10.07	Tube	CQ	8370	7.53					
1		YYS156A	12	12.75	9.41	Tube	CQ							
		YYS156A	12.4	12.5	1.051	Bag	CQ			0.02	0.08	47.9	169	185
		YYS156A	12.75	13.5	9.86	Tube	CQ	9220	7.88					
		YYS156A	13.5	14.25	7.04	Tube	CQ							
		YYS156A	14.25	15	9.58	Tube	CQ							
		YYS156A	14.9	15	0.777	Bag	CQ			0	0.1	23.4	83	145
		YYS156A	15	15.75	11.22	Tube	CQ							
		YYS156A	15.75	16.5	10.9	Tube	CQ							
		YYS156A	16.4	16.5	1.093	Bag	CQ			0	0.06	12.2	43	100
		YYS156A	16.5	17.25	11.4	Tube	CQ							
		YYS156A	17.25	18	11.23	Tube	CQ							
		YYS156A	17.9	18	1.369	Bag	CQ			0	0.08	15	53	105
		YYS157	0	1	9.19	Tube	L							
		YYS157	0.75		0.54	Bag	L			0.02	0.02	39.6	140	80
		YYS157	0.75	1.5	8.73	Tube	TCQ	681	7.88					
		YYS157	1.5	2.25	8.87	Tube	TCQ	206	8.46					
		YYS157	2.25		0.857	Bag	TCQ							
		YYS157	2.8		0.749	Bag	TCQ			3.75	0.09	61	216	60
		YYS157	3.2	3.65	7.36	Tube	TCQ	2290	8.69					
1		YYS157	3.65	4.1	6.61	Tube	TCQ	1638	9.01					

Selected [1]	URS #[2]	Drill hole	From	To	Mass	Sample type	Litho type[3]	Paste Parameters[4]		‘Minimal’ assay results[5]				
								EC µS/cm	pH	TIC	S %	U ppm	U_3O_8 ppm	V ppm
		YYS157	5.2		0.843	Bag	CQ			0.09	0.03	18.9	67	85
		YYS157	6	6.5	8.74	Tube	CQ							
		YYS157	6.5	7	8.02	Tube	CQ							
		YYS157	7		1.055	Bag	CQ			0	0.02	4.6	16	80
		YYS157	7	8	10.44	Tube	CQ							
		YYS157	8	8.5	7.38	Tube	CQ							
		YYS157	9		0.942	Bag	CQ			0	0.03	9.4	33	85
		YYS157	9	9.8	8.74	Tube	CQ							
		YYS157	9.8	10.45	6.8	Tube	CQ							
		YYS157	10.45	11.1	7.3	Tube	CQ							
		YYS157	13.35	14.1	11.74	Tube	CQ							
		YYS157	14.1		0.501	Bag	CQ			0	0.04	5.9	21	80
		YYS157	14.1	15	13.57	Tube	CQ							
		YYS157	15	15.75	10.87	Tube	CQ							
		YYS157	15.75	16.5	8.51	Tube	CQ							
		YYS157	16.5		0.891	Bag	CQ			0	0.04	4.5	16	80
		YYS157	16.5	17.25	11.3	Tube	CQ							
		YYS157	17.25	18	7.95	Tube	CQ							
		YYS158	0	1	11.4	Tube	LT							
		YYS158	1	2	9.61	Tube	LT							
		YYS158	2		0.929	Bag	LT			7.74	0.07	412	1458	105
		YYS158	2	2.5	5.17	Tube	LT							
1		YYS158	2.5	3.5	14.13	Tube	LT							
		YYS158	3.5		0.973	Bag	T			8.1	0.08	32.1	114	50
1		YYS158	3.5	3.75	3.66	Tube	T	3154	8.47					
1		YYS158	3.75	4.5	10.76	Tube	T	4800	8.57					
		YYS158	4.5		1.047	Bag	T			7.74	0.08	216	764	95
		YYS158	4.5	5.25	8.7	Tube	T	1949	7.78					
		YYS158	5.25		0.997	Bag	T							
		YYS158	5.25	5.75	7.1	Tube	T							
		YYS158	5.75		0.44	Bag	T			8.41	0.13	52.3	185	75
		YYS158	5.75	6.6	10.46	Tube	T							
		YYS158	6		0.905	Bag	T							
		YYS158	6.6	7.2	8.16	Tube	T							
		YYS158	7.2		0.242	Bag	T			2.64	0.07	52.9	187	145
		YYS158	7.2	7.5	4.07	Tube	T							
		YYS158	7.5	8.25	11.35	Tube	T							
		YYS158	8.25	9	10.66	Tube	T							

Selected [1]	URS #[2]	Drill hole	From	To	Mass	Sample type	Litho type[3]	Paste Parameters[4]		'Minimal' assay results[5]				
								EC µS/cm	pH	TIC	S %	U ppm	U_3O_8 ppm	V ppm
		YYS158	9		1.015	Bag	T			7.88	0.08	205	725	85
		YYS158	9	9.6	7.79	Tube	T							
		YYS158	9.6	10.2	8.4	Tube	CQT							
		YYS158	10		1.1	Bag	CQT							
		YYS158	10.2	11.1	12.23	Tube	CQ							
		YYS158	11.1	12	10.88	Tube	CQ							
		YYS158	12		1.091	Bag	CQ			0.03	0.03	6.6	23	70
		YYS158	12	13.1	13.01	Tube	CQ							
		YYS158	13.1		2.787	Bag	CQ							
		YYS158	13.1	13.7	7.79	Tube	CQ							
		YYS158	13.7		0.38	Bag	CQ							
		YYS158	13.7	14.2	6.65	Tube	CQ							
		YYS158	14.2		0.696	Bag	CQ			0	0.08	10.6	38	125
		YYS158	14.2	14.85	8.98	Tube	CQ							
		YYS158	14.85	15.5	8.73	Tube	CQ							
		YYS158	15.5	15.9	5.33	Bag	CQ							
		YYS158	15.9	16.3	5.55	Bag	CQ							
		YYS158	16.3	17.1	9.48	Bag	CQ			0	0.04	6.9	24	80
		YYS158	17.1	18	13.54	Bag	CQ							
		YYS159	1.5	2.1	7.32	Tube	LT							
		YYS159	2.1	2.7	7.54	Tube	LT			2.31	0.05	34.7	123	90
		YYS159	2.7	3.6	11.54	Tube	T							
		YYS159	3.6	4.5	11.27	Tube	T			5.49	0.06	30.7	109	85
1		YYS159	4.5	5.2	9.42	Tube	TCQ							
		YYS159	5.2	5.9	6.61	Tube	CQT			0.21	0.05	59.3	210	80
		YYS159	5.9	6.9	13.84	Tube	CQT							
		YYS159	7.5	8.15	9.06	Tube	CQ			0.04	0.04	3.4	12	45
		YYS159	8.8	9.2	5.85	Tube	CQ							
		YYS159	9.2	9.8	7.19	Tube	CQ							
		YYS159	10.3	10.85	8.09	Tube	CQ							
		YYS159	10.85	11.4	7.78	Tube	CQ							
		YYS159	11.4	12	8.85	Tube	CQ			0.01	0.04	3.7	13	55
		YYS159	12.6	13.1	7.42	Tube	CQ							
		YYS159	13.5	14.6	13.95	Tube	CQ							
		YYS159	17	18	12.61	Tube	CQ							
	1	YYS162	0.3	*0.4*	1.01	Grab sample	L	10160	6.65					
	2	YYS162	3.8	*3.9*	1.04	Grab sample	T							
1	3	YYS162	4.5	*4.6*	1.59	Grab sample	TCQ	2520	9.1					

Selected [1]	URS #[2]	Drill hole	From	To	Mass	Sample type	Litho type[3]	Paste Parameters[4]		'Minimal' assay results[5]				
								EC µS/cm	pH	TIC	S %	U ppm	U_3O_8 ppm	V ppm
	4	YYS162	5.2	*5.3*	1.86	Grab sample	CQ	2520	9.1					
	5	YYS162	7	*7.1*	1.41	Grab sample	CQ							
	6	YYS162	9	*9.1*	1.55	Grab sample	CQ	2600	8.42					
	7	YYS162	10.8	*10.9*	1.56	Grab sample	CQ							
	8	YYS162	11.8	*11.9*	2.06	Grab sample	CQ							
	9	YYS162	12.7	*12.8*	1.36	Grab sample	CQ	2580	9					
	10	YYS162	15	*15.1*	2.06	Grab sample	CQ	193	8.4					
	11	YYS162	15.2	*15.3*	1.08	Grab sample	CQ	193	8.4					
	12	YYS162	16.3	*16.4*	1.54	Grab sample	CQ							
	13	YYS162	17.4	*17.5*	2.08	Grab sample	CQ							
	14	YYS162	18.8	*18.9*	1.5	Grab sample	CQ	193	8.4					
	15	YYS162	19.6	*19.7*	1.43	Grab sample	CQ							
	16	YYS162	20.9	*21*	2.33	Grab sample	CQ							
	17	YYS162	22.3	*22.4*	2.17	Grab sample	CQ	245	8.65					
	18	YYS162	23	*23.1*	1.63	Grab sample	CQ							
	19	YYS162	25.7	*25.8*	1.23	Grab sample	CQ							
	20	YYS162	27.4	*27.5*	1.2	Grab sample	CQ							
	21	YYS162	28.2	*28.3*	2.09	Grab sample	CQ	248	6.71					
	22	YYS162	29.6	*29.7*	2.2	Grab sample	CQ							
	1	YYS163	0.3	*0.4*		Grab sample	LQT	5830	8.98					
	2	YYS163	2.9	*3*		Grab sample	LQT	3350	9.56					
	3	YYS163	7.5	7.65	1.84	Grab sample	CQ	2137	7.83					
	4	YYS163	11	*11.1*	1.42	Grab sample	Grit	6600	8.07					
	5	YYS163	12.8	13	2.32	Grab sample	CQ							
	6	YYS163	15.7	*15.8*	1.41	Grab sample	CQ	3220	8.07					
	7	YYS163	18.8	*18.9*	1.99	Grab sample	CQ	2347	7.2					
1	8	YYS163	23	*23.1*	0.95	Grab sample	CQ	3920	7.59					
	9	YYS163	26.1	*26.2*	0.98	Grab sample	CQ	3220	7.61					
	1	YYS164	0.5	0.6	1.1	Grab sample	L	1915	4.91					
1	2	YYS164	4.3	*4.4*	1.09	Grab sample	LT							
1	3	YYS164	5.2	5.3	1.99	Grab sample	CQT	51.8	6.24					
	4	YYS164	8.1	8.3	2.96	Grab sample	CQ	15.5	7.57					
	5	YYS164	14	14.1	1.55	Grab sample	CQ							
	6	YYS164	15.5	15.6	2.23	Grab sample	Grit							
	7	YYS164	20.3	20.5	2.26	Grab sample	CQ	2710	6.47					
	8	YYS164	23.5	23.7	2.9	Grab sample	CQ							
1	9	YYS164	26.2	26.3	2	Grab sample	Grit							
	10	YYS164	29.4	29.5	2.36	Grab sample	CQ							

Selected [1]	URS #[2]	Drill hole	From	To	Mass	Sample type	Litho type[3]	Paste Parameters[4]		'Minimal' assay results[5]				
								EC µS/cm	pH	TIC	S %	U ppm	U_3O_8 ppm	V ppm
	1	YYS165	0.2	*0.3*	1.04	Grab sample	LT	196.4	8.6					
	2	YYS165	0.7	*0.8*	1.21	Grab sample	LT	603	8.2					
1	3	YYS165	1.5	*1.6*	0.65	Grab sample	HT	2245	8.94					
	4	YYS165	5.4	5.5	1.49	Grab sample	CQT	2220	8.99					
1	5	YYS165	6.6	*6.7*	2.2	Grab sample	Grit	3360	8.92					
	6	YYS165	8.9	9	1.9	Grab sample	CQ	3220	8.2					
	7	YYS165	11.7	*11.8*	1.51	Grab sample	CQ							
	8	YYS165	14.6	14.8	1.85	Grab sample	CQ	3720	7.55					
	9	YYS165	16	16.1	1.44	Grab sample	CQ							
	10	YYS165	17.4	17.5	1.75	Grab sample	CQ	3290	8.9					
	11	YYS165	18.7	*18.8*	2.15	Grab sample	CQ	4250	7.62					
	12	YYS165	21.7	*21.8*	1.66	Grab sample	CQ	3510	8.05					
	13	YYS165	22	*22.1*	1.71	Grab sample	CQ	3450	7.88					
	14	YYS165	23.8	*23.9*	2.09	Grab sample	CQ	2316	8.24					
	15	YYS165	26.4	*26.5*	1.74	Grab sample	CQ	1329	8.53					
	16	YYS165	28	*28.1*	1.93	Grab sample	CQ							
	17	YYS165	29.8	29.9	1.63	Grab sample	CQ	3450	8.39					
1	1	YYS166	0.4	*0.5*	1.42	Grab sample	H	1493	6.46					
	2	YYS166	1.8	*1.9*	1.94	Grab sample	CQT	6450	8.78					
	3	YYS166	3.5	*3.6*	0.66	Grab sample	CQT	3320	9.38					
	4	YYS166	4	*4.1*	0.84	Grab sample	CQ	2600	8.22					
	5	YYS166	6.7	*6.8*	1.39	Grab sample	CQ	1297	7.95					
	6	YYS166	9.3	9.4	1.41	Grab sample	CQ	1229	7.6					
	7	YYS166	11	*11.1*	1.81	Grab sample	CQ							
	8	YYS166	13.6	*13.7*	1.34	Grab sample	CQ	248000	7.53					
	9	YYS166	14.7	*14.8*	1.26	Grab sample	CQ	1672	7.06					
	10	YYS166	16.9	*17*	1.52	Grab sample	CQ	2420	7					
	11	YYS166	20.1	*20.2*	2.54	Grab sample	CQ	1737	7.08					
	12	YYS166	21.3	*21.4*	1.28	Grab sample	CQ	2750	7.41					
	13	YYS166	23.5	*23.6*	1.43	Grab sample	CQ	3800	7.24					
	14	YYS166	23.9	*24*	0.88	Grab sample	CQ	3800	7.24					
	15	YYS166	25.7	*25.8*	1.34	Grab sample	CQ	4860	7.58					
	16	YYS166	26.8	*26.9*	1.57	Grab sample	CQ	4170	7.48					
	17	YYS166	29.2	*29.3*	1.54	Grab sample	CQ	4500	7.5					
	1	YYS167	0.3	*0.4*	1.51	Grab sample	L	261	5.79					
1	2	YYS167	2.3	*2.4*	1.03	Grab sample	LQT	2016	9.41					
	3	YYS167	3.9	*4*	1.4	Grab sample	CQT	1071	8.71					
	4	YYS167	5.2	*5.3*	0.95	Grab sample	CQ							

Selected [1]	**URS #**[2]	**Drill hole**	**From**	**To**	**Mass**	**Sample type**	**Litho type**[3]	**Paste Parameters**[4]		**'Minimal' assay results**[5]				
								EC µS/cm	**pH**	**TIC**	**S %**	**U ppm**	**U_3O_8 ppm**	**V ppm**
	5	YYS167	7.3	7.4	1.56	Grab sample	CQ	4400	7.27					
	6	YYS167	9.1	*9.2*	1.52	Grab sample	CQ	2460	7.69					
	7	YYS167	11.1	*11.2*	2.17	Grab sample	CQ	2690	7.74					
	8	YYS167	11.8	*11.9*	0.92	Grab sample	CQ	2690	7.74					
	9	YYS167	14.3	*14.4*	1.53	Grab sample	CQ	3370	7.9					
	10	YYS167	16.6	*16.7*	1.8	Grab sample	CQ	4530	7.43					
	11	YYS167	20.4	*20.5*	1.85	Grab sample	CQ							
1	12	YYS167	23	*23.1*	2.49	Grab sample	Grit	4360	7.34					
	13	YYS167	24.5	*24.6*	1.33	Grab sample	CQ	3290	7.31					
	14	YYS167	27.3	27.4	1.37	Grab sample	Grit	2510	7.01					
	15	YYS167	29.3	*29.4*	2.06	Grab sample	CQ	2270	7.6					
						Minimum		15.5	4.91					
						Median		2690	7.88					
						Maximum		248000	9.56					

Notes:

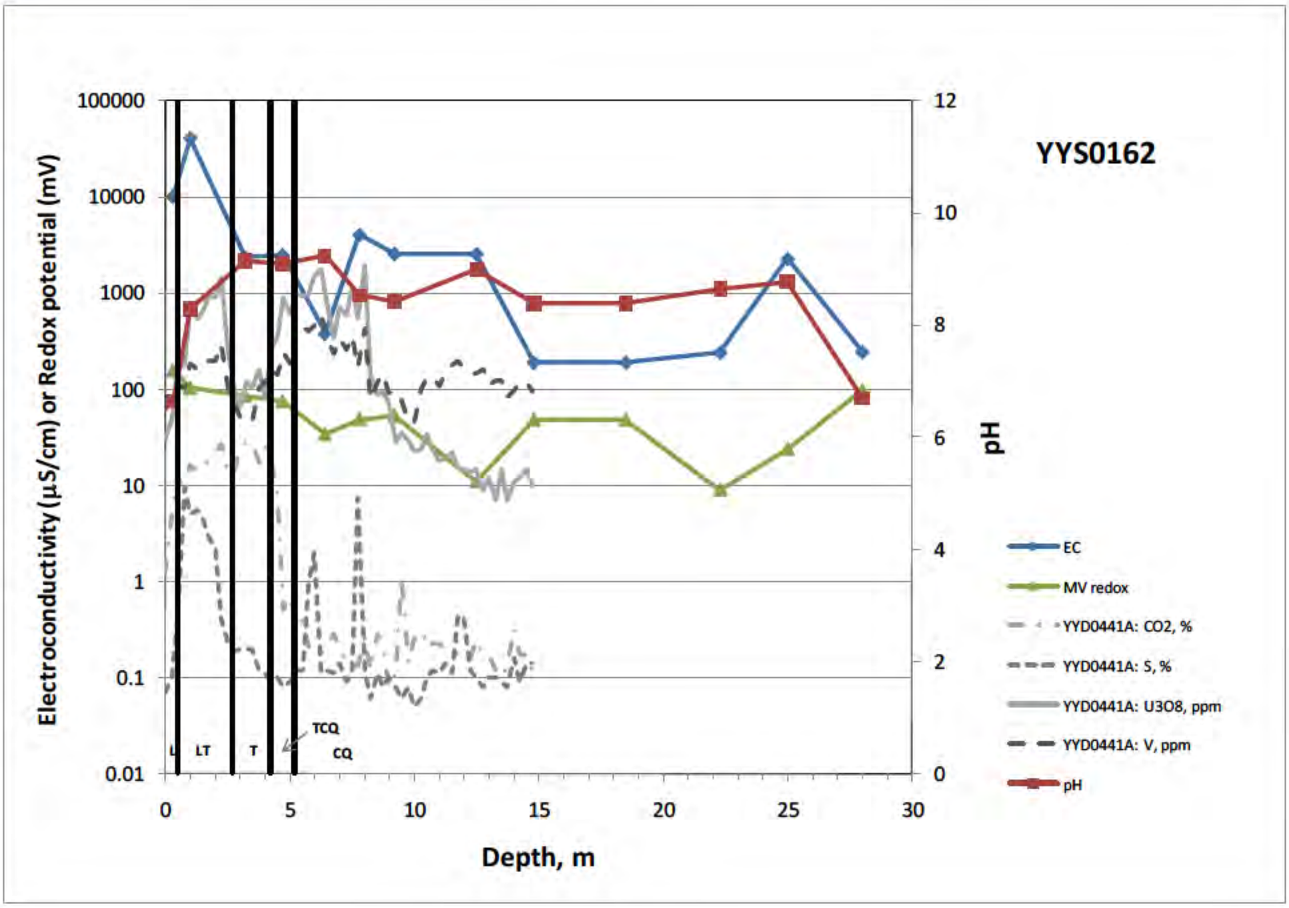
[1] Sample selected for inclusion in the detailed laboratory characterisation programme.

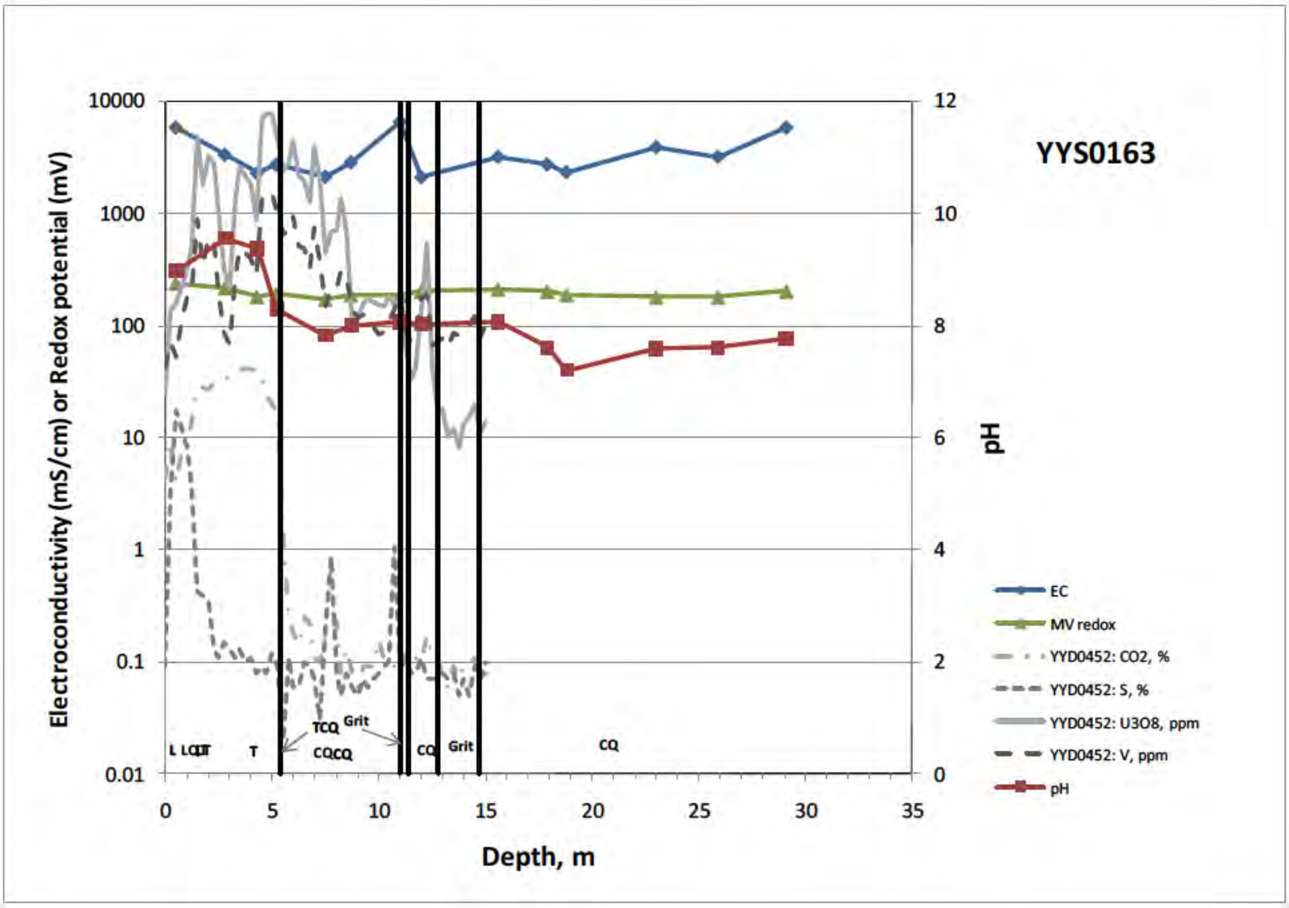
[2] Sample numbering used by URS during sample collection and logging.

[3] Based on URS logging information for Boreholes YYS162 to 167. For Boreholes 156A to 159, based on 'minimal' assay results combined with later assessment in the laboratory (with the assistance of BHP geologists).

[4] Field measurements undertaken by URS (Boreholes YYS162 to 167), laboratory measurements by SRK (Boreholes 156A to 159).

[5] Boreholes 156A to 159 were not logged in the field. To assist with lithological differentiation, bulk chemical assays were undertaken.


YYS0162
Electroconductivity (µS/cm) or Redox potential (mV)
100000
10000
1000
100
10
1
0.1
0.01
pH
12
10
8
6
4
2
0
Depth, m
0
5
10
15
20
25
30
L
LT
T
TCQ
CQ
EC
MV redox
YYD0441A: CO2, %
YYD0441A: S, %
YYD0441A: U3O8, ppm
YYD0441A: V, ppm
pH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Electroconductivity (mS/cm) or Redox potential (mV)
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1000
100
10
1
0.1
0.01
pH
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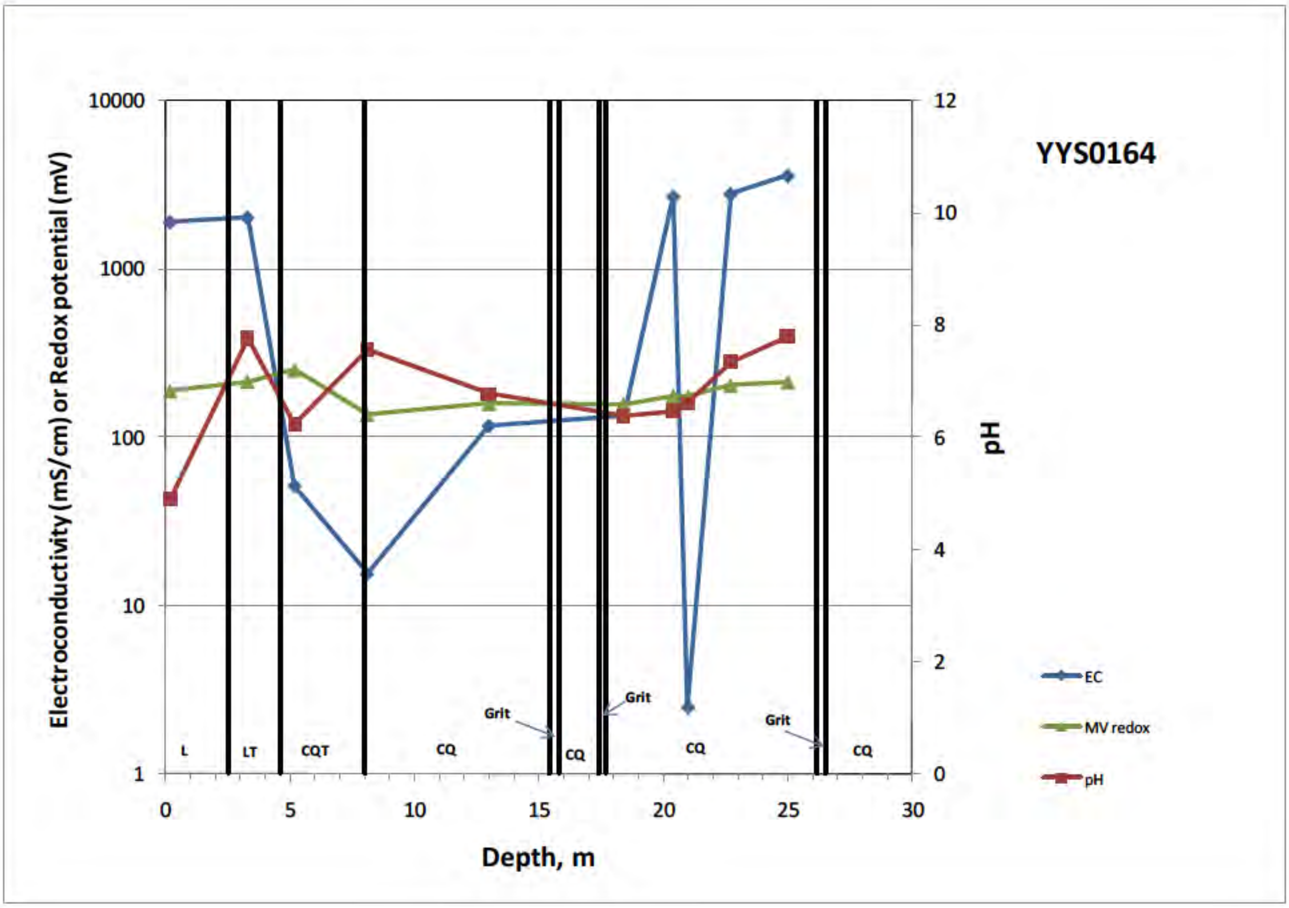
10
8
6
4
2
0
Depth, m
0
5
10
15
20
25
30
35
L
LQT
T
TCQ
Grit
CQCQ
CQ
Grit
CQ
EC
MV redox
YYD0452: CO2, %
YYD0452: S, %
YYD0452: U3O8, ppm
YYD0452: V, ppm
pH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Electroconductivity (mS/cm) or Redox potential (mV)
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100
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pH
12
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8
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4
2
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Depth, m
0
5
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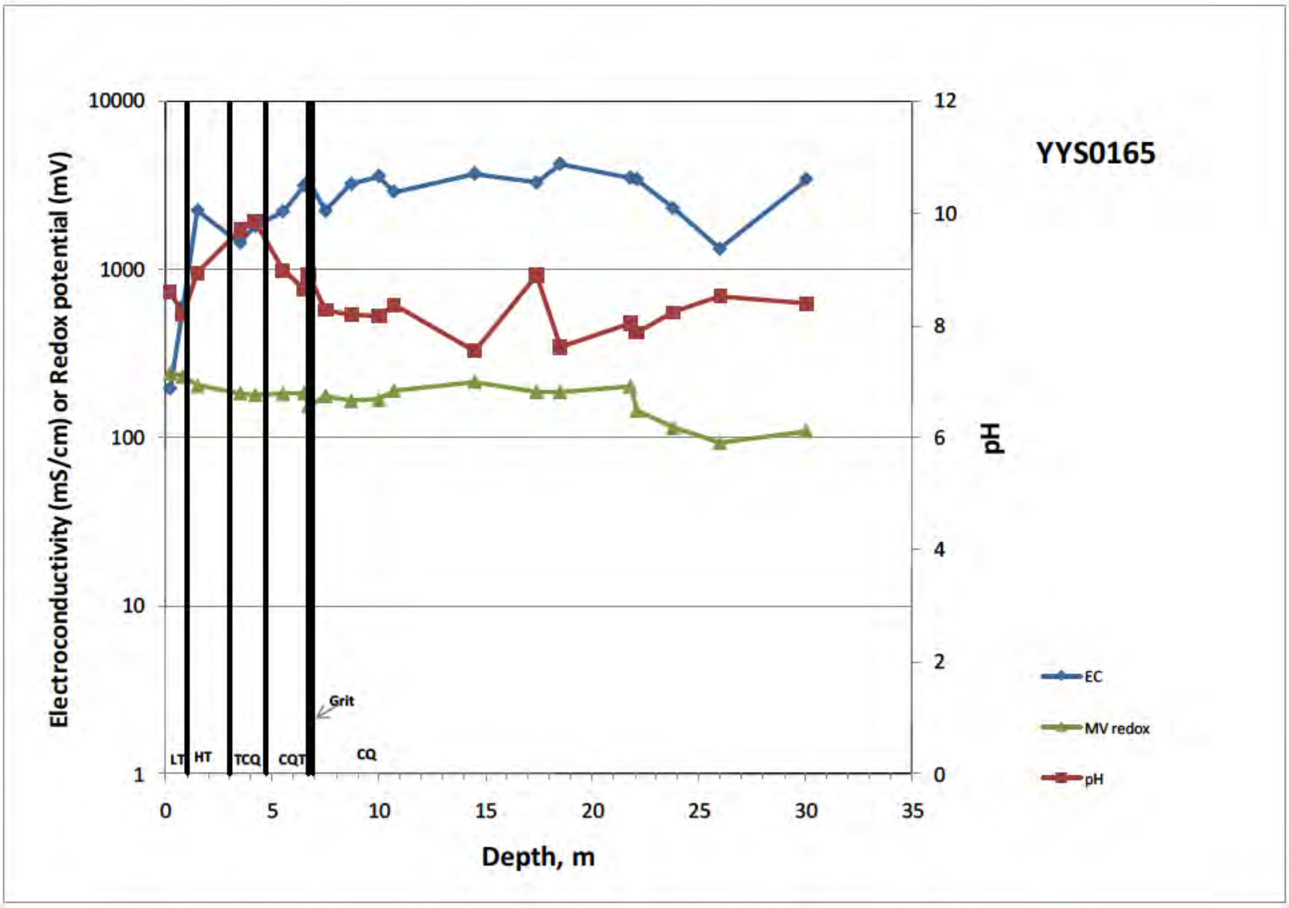
L
LT
CQT
CQ
Grit
CQ
Grit
CQ
Grit
CQ
EC
MV redox
pH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Electroconductivity (mS/cm) or Redox potential (mV)
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1
pH
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8
6
4
2
0
Depth, m
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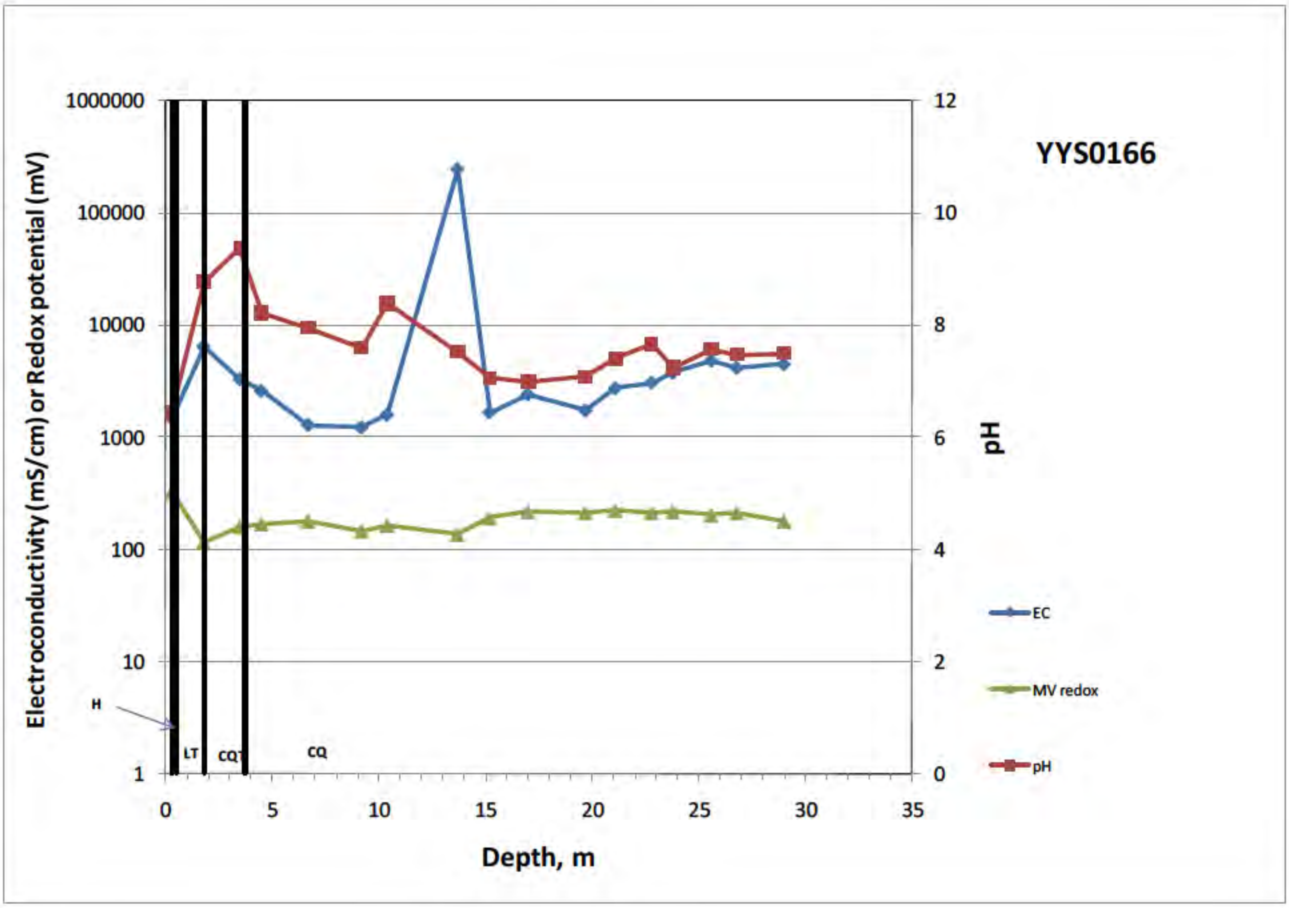
30
35
LT
HT
TCQ
CQT
Grit
CQ
EC
MV redox
pH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6
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CQ
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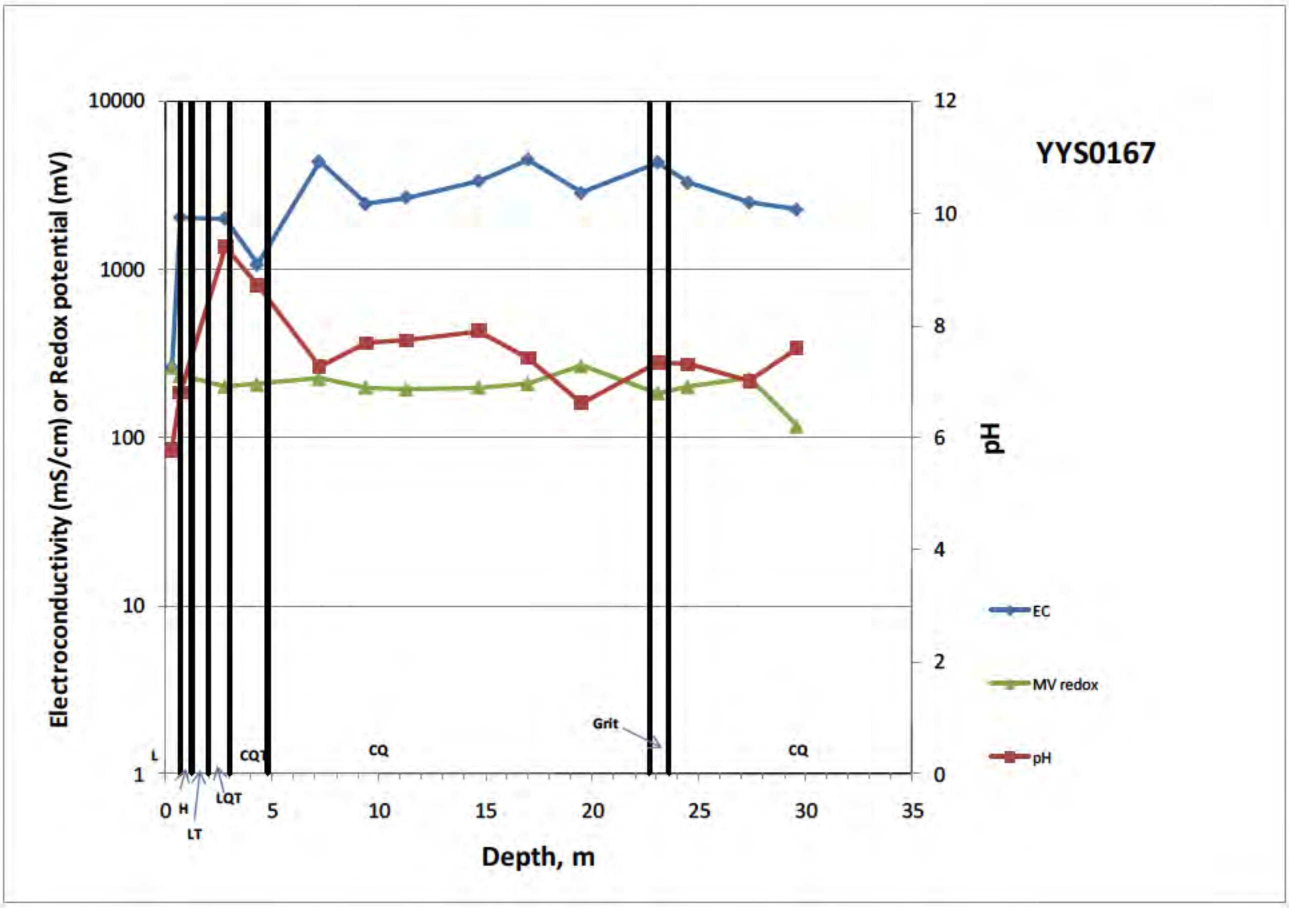
30
35
Depth, m
EC
MV redox
pH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10
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pH
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10
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6
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2
0
L
H
LT
LQT
CQT
CQ
Grit
CQ
0
5
10
15
20
25
30
35
Depth, m
EC
MV redox
pH

Sheet 1 of 3

BOREHOLE YYS0162 - DRAFT

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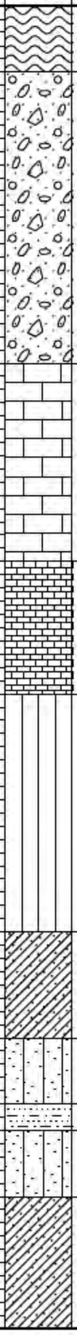
Drilling Contractor:	**Client Contracted - Boart Longyear**	Project Reference:	**Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**	Client:	**BHP Billiton**
		Project No.:	**42907140**	Location:	**Yeelirrie**
Logged By:	**BN**	Relative Level:	**496.60 mRL**	Drill Type:	**Sonic Drilling**
Checked By:		Coordinates:	**6989343.00 mN** **790048.00 mE**	Drill Model:	**300C Prosonic**
Date Started:	**11-8-09**	Permit No:	**N/A**	Drill Fluid:	**N/A**
Date Finished:	**12-8-09**				
Bore Size:	**96 mm**				
Total Depth:	**30.00 m**				
Casing Size:	**127 mm**				



SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
G	0.30 0.50			0	SM	LOAM; Silty SAND, loose, red-brown, angular, poorly graded, dry.			G	Geochem #1	L
■ ☒ ☒	0.95 2.50		8/9/8 N=17 11/33/17 for 30mm N>50	1 2	SM	CARBONATED LOAM; SAND with moderately cemented Quartz (QZ), medium dense, orange-brown with white, reacts with hydrochloric acid (HCl), dry. - Becomes Silty SAND, yellow-brown, low plasticity, reacts highly with HCl, recovered in broken clumps. - Becomes red-brown with patchy pale-white.			■ ☒ ☒	UD #1 SPT #1 SPT #2	LT
G ☒	3.80 4.00		8/12/21 N=33	3 4		CALCRETE; recovered as broken rock fragments in weakly to moderately cemented Clayey SAND, grey-white, very low strength rock, reacts with HCl.			G ☒	Geochem #2 SPT #3	T
G	4.50			5	SM	TRANSITION CALCRETE; recovered as Silty SAND, with 10% QZ content, pale grey-yellow with red-orange staining, sample wet water table at 4.2m. - Becomes red, medium grained QZ grains, weakly cemented. - Becomes moderately cemented.	∇		G	Geochem #3	TCQ
G ☒ ■	5.20 5.50 6.50		8/12/23 N=35	6	ML	CLAY-QUARTZ; Sandy SILT, very stiff, red-brown, fined to medium grained, medium plasticity, does not react with HCl. - Increase 20% QZ content, coarse grained, subangular to subrounded.			G ☒ ■	Geochem #4 SPT #4 UD #2	CQ
G	7.00			7	CL	Becomes Silty CLAY trace Sand, hard, patchy yellow-brown, low plasticity, homogenous, no reaction to HCl.			G	Geochem #5	
				8	SM	Becomes Silty SAND, moderately cemented.					
					SM-CL	Becomes Clayey SAND / Sandy CLAY, very dense, patchy brown, red and yellow, fine to medium grained QZ.					
☒	8.50		50 Blows for 40mm N>50		SM	Becomes Silty SAND, yellow-grey, angular, gap graded wet angular QZ grains. - Becomes mottle brown-grey.			☒	SPT #5	
G	9.00			9	CL	Becomes Sandy CLAY, patchy pale yellow-dark brown, fine to medium grained sand.			G	Geochem #6	

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Drilling Contractor: **Client Contracted - Boart Longyear**

Project Reference: **Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**

Project No.: **42907140**

Client: **BHP Billiton**

Location: **Yeelirrie**

Logged By:	**BN**	Bore Size:	**96 mm**	Relative Level:	**496.60 mRL**	Drill Type:	**Sonic Drilling**
Checked By:		Total Depth:	**30.00 m**	Coordinates:	**6989343.00 mN** **790048.00 mE**	Drill Model:	**300C Prosonic**
Date Started:	**11-8-09**	Casing Size:	**127 mm**			Drill Fluid:	**N/A**
Date Finished:	**12-8-09**			Permit No:	**N/A**		

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
				10		GM	CLAY-QUARTZ; Silty Gravel, very dense, yellow-orange-brown, fine to medium grained, angular QZ grains, well graded, moderately cemented, trace black angular gravels.					
☒	10.50	>200	30/50 for 40mm N>50							☒	SPT #6	
G	10.80					SC-CH	Becomes Silty Sandy CLAY, hard, pale brown-red, high plasticity.			G	Geochem #7	
				11			- Becomes patchy brown-red with yellow, possibly disturbed, very stiff.					
G	11.80									G	Geochem #8	
				12			- Becomes hard, red-brown, homogeneous, trace fine grained QZ.					
G	12.70									G	Geochem #9	
				13			- Becomes Silty CLAY with 5%, hard, orange-brown, angular fine to medium grained QZ, high plasticity, moist.					
						SC-CH	Becomes Clayey SAND, Sandy CLAY, increase QZ sand grains 50%, very stiff, moist.					
				14		CH	Becomes Silty CLAY with 5% angular fine to medium grained QZ, hard, patchy orange-brown, and yellow, moist. - Becomes patchy orange-yellow and pale grey.					
G	15.00			15						G	Geochem #10	CC
G	15.20									G	Geochem #11	
				16			- Becomes CLAY, with trace 5% QZ, hard, yellow-brown, angular QZ grains, medium to high plasticity, moist, homogeneous, shiny surface results when cut into clay with knife.					
G	16.30									G	Geochem #12	
				17			- Becomes Silty CLAY, very s iff, yellow-brown-orange, high plasticity. - With pockets of Silty SAND, pale grey-yellow, angular, moist to wet.					
G	17.40									G	Geochem #13	
L	17.50						- Becomes CLAY, with trace 5% QZ, hard, yellow-brown, angular QZ grains, medium to high plasticity, moist, homogeneous, shiny surface results when cut into clay with knife.			L	Lexan #1 17 5-18 2m extra 0 3m	
				18								
G	18.80									G	Geochem #14	
				19			- Becomes Silty Sandy CLAY, trace 5% QZ grains, hard, pale yellow-brown, high plasticity, homogeneous, moist, smoo h surface results when cut with knife.					
G	19.60									G	Geochem #15 UD #3	
■	19.70	>100								■		
	20.00											

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BOREHOLE YYS0162 - DRAFT

URS Australia level 3 20 Terrace Road EAST PERTH WA 6004	Phone 08 9326 0100 Fax 08 9326 0296	Project Reference: **Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**	Client: **BHP Billiton**
Drilling Contractor: **Client Contracted - Boart Longyear**		Project No.: **42907140**	Location: **Yeelirrie**
Logged By: **BN**	Bore Size: **96 mm**	Relative Level: **496.60 mRL**	Drill Type: **Sonic Drilling**
Checked By:	Total Depth: **30.00 m**	Coordinates: **6989343.00 mN** **790048.00 mE**	Drill Model: **300C Prosonic**
Date Started: **11-8-09**	Casing Size: **127 mm**		
Date Finished: **12-8-09**		Permit No: **N/A**	Drill Fluid: **N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
				20	▨	SC-CH	CLAY-QUARTZ; Silty Sandy CLAY, trace 5% QZ grains, hard, pale yellow-brown, high plasticity, homogeneous, moist, smooth surface results when cut with knife.				Lexan #2 19.7-20 9m extra 0 3m	
					▨		- Becomes pale grey-green.					
G	20.90				▨					G	Geochem #16	
				21	▨	CH	Becomes CLAY, hard, grey-pale green, high plasticity, moist.					
					▨		- Becomes CLAY with 5% QZ, fine to medium grained, intact core. - Becomes very stiff.					
				22	▨							
G	22.30				▨	SC-CH	Becomes Sandy CLAY.			G	Geochem #17	
G	23.00			23	▨					G	Geochem #18	
☒	23.20	>200	18/30/48 N>50		▨		- Becomes patchy pale grey-pale green and brown, very stiff.			☒	SPT #7	
				24	▨							
				25	▨							Cg
G	25.70				▨					G	Geochem #19	
				26	▨							
					▨		- Becomes stiff, possibly disturbed by drilling water.					
				27	▨		- Becomes Silty Sandy CLAY, pale green - pale grey, stiff, high plasticity.					
G	27.40				▨		- Becomes firm.			G	Geochem #20	
■	28.00			28	▨		- Becomes hard, pale green-grey and brown.			■	UD #4	
G	28.45				▨					G	Geochem #21	
				29	▨							
G	29.60				▨					G	Geochem #22	
					▨		EOH at 30.0m.					

Remarks: 1.0 Monitoring well installed, 2.0m screen from 8.8-10.8m.
2.0 Backfilled monitoring well from:
EOH - 13.8m: backfilled with core samples
13.8-11.8m : Gravel pack
11.8-10.8m : Bentonite pellets
10.8-8.0m: Gravel pack
8.0-7.0m: Bentonite pellets
7.0-0m: Gravel pack

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Sheet 1 of 4

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Drilling Contractor:	**Client Contracted - Boart Longyear**		
Project Reference:	**Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**	Client:	**BHP Billiton**
Project No.:	**42907140**	Location:	**Yeelirrie**
Logged By:	**BN**	Bore Size:	**96 mm**
Checked By:		Total Depth:	**30.20 m**
Date Started:	**16-8-09**	Casing Size:	**127 mm**
Date Finished:	**17-8-09**		
Relative Level:	**496.30 mRL**	Drill Type:	**Sonic Drilling**
Coordinates:	**6989813.00 mN** **790334.00 mE**	Drill Model:	**300C Prosonic**
Permit No:	**N/A**	Drill Fluid:	**N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Identification	GEOLOGICAL DESCRIPTION
G	0.30 0.50			0	ML	QUARTZ RICH CARBONATED LOAM; Sandy SILT, disturbed, white - pale pink, fine to medium grained subangular Quartz (QZ), low plasticity, aggressively reacts with hydrochloric acid (HCl).			Geochem#1	LQT
				1		- Becomes very dense, fine to coarse grained QZ.			Lexan#1 0 5-2.0m	
	2.00		13/25/32 N>50	2		- Becomes Gravelly Silty SAND, very dense, brown and patchy white, fine to coarse grained QZ, subangular with assorted homogenous pale white chips subrounded 1-3mm, some black Iron (Fe) staining with yellow-brown induration, reacts with HCl.			SPT#1	
G	2.90 3.00								Geochem#2	
				3		- Becomes Sandy Gravelly CLAY, pale brown - pale grey, disturbed, fine to coarse grained, various sand and gravel particles, brown and black gravels (2-5mm) evident, moderately cemented, trace QZ grains, trace reaction to HCl, trace bright yellow staining.			Lexan#2 3 0-4.0m extra 0.4m	
	4.00		11/17/23 for 10mm N>50	4		- Sandy CLAY (20% Sand / 80% Clay), hard, pale grey-brown, with fine to medium grained QZ, subangular, reacts gently with HCl, friable, moist, interbedded staining of red-brown.			SPT#2	
	5.20			5		- 100-200mm layers of cemented Clay and QZ grains, dark red, fine to medium grained, subangular to subrounded QZ, wet.	∇		UD#1	
	5.61		7/14/20 N=34		ML	CLAY-QUARTZ; Sandy SILT/CLAY (20% Sand / 80% Silt/Clay), hard, fine to medium grained, subangular, low plasticity, moist, no reaction HCl.			SPT#3	CQ
	6.06			6					Lexan#3 5 2-6.7m	
	6.70					- With bright yellow staining, and patchy pale yellow.			UD #2	
	6.98		9/16/11 N=27	7		- Becomes Sandy CLAY (40% Sand / 60% Clay), hard, red, fine to medium grained, occasional coarse grained, subangular to subrounded, moist, brown staining on QZ.			SPT #4	
G	7.50								Geochem #3	
				8		- Becomes more Clay (80%), red-brown with patchy orange, fine to medium grained QZ, evidence of clear crystallisation, no reaction to HCl. - Trace clear crystallisation.				
	8.70 8.83		50 for 130mm N>50			- Become red-brown with patchy pale grey.			SPT #5	
				9					Lexan #4 8.7-10.2m	

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Drilling Contractor: **Client Contracted - Boart Longyear**		Project Reference: **Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling** Project No.: **42907140**	Client: **BHP Billiton** Location: **Yeelirrie**
Logged By: **BN** Checked By: Date Started: **16-8-09** Date Finished: **17-8-09**	Bore Size: **96 mm** Total Depth: **30.20 m** Casing Size: **127 mm**	Relative Level: **496.30 mRL** Coordinates: **6989813.00 mN** **790334.00 mE** Permit No: **N/A**	Drill Type: **Sonic Drilling** Drill Model: **300C Prosonic** Drill Fluid: **N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
	10.20			10		CL	CLAY-QUARTZ; Sandy CLAY (40% Sand / 60% Clay), hard, patchy brown-orange and pale yellow-grey, fine to coarse grained QZ, subrounded, moist.				UD #3	CQ
G	11.00			11		SP	GRIT; QZ Sand with Clay, loose, red, coarse grained, uniform graded, subrounded, wet.			G	Geochem #4 (Grit)	Grit
						CL	CLAY-QUARTZ; Sandy CLAY (40% Sand / 60% Clay), hard, patchy brown-orange and pale yellow-grey, fine to coarse grained QZ, subrounded, moist.					CQ
G	12.00 12.20			12			- Becomes more Clay (70%), patchy brown-pale grey, stiff.			G	Geochem #5	
	12.60										UD #4 (Grit?)	
			11/17/37 N>50				- Becomes hard, patchy red and grey (interbedded colours), fine to coarse grained sand, subrounded.				SPT #6	
				13		SP	GRIT; QZ Sand with Clay, red, loose, coarse grained, uniform graded, subrounded, wet.					Grit
	13.20					CL	- Becomes Sandy CLAY (40% Sand / 60% Clay), red, grit transition zone. - Becomes red-brown, fine to coarse grained, wet.				Lexan #5 13 2-14.7m	
				14								
	14.80			15		CH	CLAY-QUARTZ; CLAY with 10% Sand, hard, patchy pale grey-brown, fine grained sand, moist, friable. - Becomes less Sand (5%) patchy brown and grey, high plasticity, homogenous, moist, intact clay core, casing gets stuck due to hard Clay,				UD #5	CQ
G	15.70 16.00			16						G	Geochem #6	
											Lexan #6 16-17 2m	
				17			- Becomes pale brown orange.					
				18			- Trace subrounded coarse grained QZ.					
G	18.50 18.80		19/22/28 for 100mm N>50				- Becomes pale brown with more QZ grains 10%, sample disturbed and stretched in rod.			G	SPT #7 Geochem #7	
				19		CL-CH	- Becomes Sandy CLAY (20% Sand / 80% Clay), very stiff, pale brown - pale red, fine to medium grained QZ, high plasticity, inclusions of rounded to subrounded Clay gravels, friable, moist. Trace small pockets of QZ, coarse grained (10-20mm).					

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Drilling Contractor:	**Client Contracted - Boart Longyear**	Project Reference:	**Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**
		Project No.:	**42907140**
		Client:	**BHP Billiton**
		Location:	**Yeelirrie**
Logged By:	**BN**	Bore Size:	**96 mm**
Checked By:		Total Depth:	**30.20 m**
Date Started:	**16-8-09**	Casing Size:	**127 mm**
Date Finished:	**17-8-09**		
Relative Level:	**496.30 mRL**	Drill Type:	**Sonic Drilling**
Coordinates:	**6989813.00 mN** **790334.00 mE**	Drill Model:	**300C Prosonic**
Permit No:	**N/A**	Drill Fluid:	**N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
■	20.20 20.46			20	▨	CL-CH	CLAY-QUARTZ; Sandy CLAY (20% Sand / 80% Clay), very stiff, pale brown - pale red, fine to medium grained QZ, high plasticity, inclusions of rounded to subrounded Clay gravels, friable, moist.			■	UD #6	
L				21	▧	CH	Becomes CLAY trace fine grained QZ, hard , pale brown-orange, high plasticity, friable, flaky , moist, homogenous.			L	Lexan #7 20 2-21 2m extra 0 3m	
				22	▨	CL-CH	Becomes Sandy CLAY (20% Sand / 80% Clay), hard, pale brown - pale grey - green, fine grained sand, flaky. (Sample disturbed, outer layer of core sticks to the rods and only the inside core falls out). - Becomes less Clay (70%), trace pockets of moderately cemented subrounded coarse grained QZ, 15-20mm in size.					
G	23.00 23.20			23						G	Geochem #8	
L				24	▧	CH	Becomes CLAY trace fine grained QZ, hard , pale brown-orange, high plasticity, friable, flaky , moist, homogenous, smooth surface results when cut with a knife.			L	Lexan #8 23 2-24 3m extra 0.4m	
■	24.30				▨	CL-CH	Sandy CLAY (30% Sand / 60% Clay), pale grey-brown-green, fine to medium grained, subrounded to subangular QZ, moist.			■	UD #7	
				25	▧	CH	CLAY with 5% QZ, , very stiff - hard, with patchy pale brown-orange and pale grey-green, fine to medium grained sand, high plasticity, moist, homogenous, rapidly dries and hardened when taken out of bags.					CQ
G	26.10 26.20			26						G	Geochem #9	
L				27			- Becomes very stiff-hard, pale grey-pale green with patches of pale brown-orange.			L	Lexan #9 26 2-27 2m extra 0 5m	
				28								
L	29.20			29						L	Lexan #10 29 2-30 2m extra 0 5m	

Remarks: 1.0 Two monitoring wells installed, screens from 10.5-13.0m and 3.5-5.5m.
2.0 Backfilled monitor well from:
EOH - 15.0m: backfilled with core samples
15.0-14.0m : Gravel pack
14.0-13.0m: Bentonite pellets
13.0-9.5m: Gravel pack
9.5-8.5m: Bentonite pellets
8.5-6.5m: Gravel pack
6 5-5 5m: Bentonite pellets
5 5-2.5m: Gravel pack
2.5-1.2m: Bentonite pellets
1.2-0.0m: Gravel pack

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Drilling Contractor: **Client Contracted - Boart Longyear**

Project Reference: **Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**

Project No.: **42907140**

Client: **BHP Billiton**

Location: **Yeelirrie**

Logged By: **BN**

Checked By:

Date Started: **16-8-09**

Date Finished: **17-8-09**

Bore Size: **96 mm**

Total Depth: **30.20 m**

Casing Size: **127 mm**

Relative Level: **496.30 mRL**

Coordinates: **6989813.00 mN**
790334.00 mE

Permit No: **N/A**

Drill Type: **Sonic Drilling**

Drill Model: **300C Prosonic**

Drill Fluid: **N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
☐				30	▨	CH	CLAY-QUARTZ; CLAY, hard.			☐		cq
							EOH at 30.2m.					
				31								
				32								
				33								
				34								
				35								
				36								
				37								
				38								
				39								

Sheet 1 of 3

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BOREHOLE YYS0164 - DRAFT

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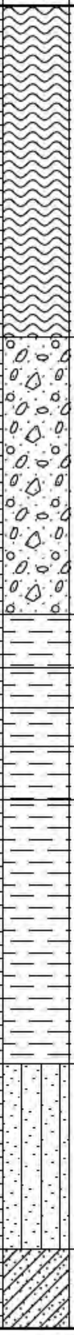
Drilling Contractor:	**Client Contracted - Boart Longyear**	Project Reference:	**Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**
		Project No.:	**42907140**
Client:	**BHP Billiton**	Location:	**Yeelirrie**
Logged By:	**BN**	Bore Size:	**96 mm**
Checked By:		Total Depth:	**30.00 m**
Date Started:	**13-8-09**	Casing Size:	**127 mm**
Date Finished:	**15-8-09**		
Relative Level:	**496.70 mRL**	Drill Type:	**Sonic Drilling**
Coordinates:	**6990368.00 mN** **790673.00 mE**	Drill Model:	**300C Prosonic**
Permit No:	**N/A**	Drill Fluid:	**N/A**



SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
				0	SM	LOAM; Silty SAND, loose, red, fine to medium grained, sub-angular, dry with fragments of moderately cemented sand.					L
G	0.50 0.60								G	Geochem#1	
L				1					L	Lexan#1 0 6-1.5m extra 0 3m	
☒	1.60 1.84		14/50 for 90mm N>50			- Becomes red-brown with highly cemented fragments of Quartz (QZ) grains with trace black grains.			☒	SPT#1	
L				2					L	Lexan#2 1 6-2.5m	
					SM	CARBONATED LOAM; SILT, white with cemented brown sand with trace black minerals. - Becomes Silty SAND (40% Silt / 60% Sand), disturbed loose, red-brown, fine to medium grained, moist.					LT
				3							
☒	3.50		N>50 for 100mm			- Becomes SAND with trace Clay, very dense, fine to medium grained, poorly graded trace moderately cemented fragments. Contains fragments of weakly cemented Silty Sand with carbonate content reacts with hydrochloric acid (HCl).			☒	SPT#2	
G ☒	4.30 4.50		N>50 for 140mm	4		- Becomes Silty Clayey SAND, loose from drilling, red-brown with weakly cemented fragments of Clay, Sand and Carbonate, grey-white. - Becomes more Silt and Clay content 50%.			G ☒	Geochem#2 SPT#3	
					SM	CARBONATED CLAY-QUARTZ; Silty Clayey SAND, red-brown with highly cemented fragments (30-80mm) of Clay, QZ and Carbonate.	▽				CQT
G	5.20			5	CL	- Becomes Sandy CLAY, red-brown, soft to firm probably disturbed, low to medium plasticity, fine to medium grained QZ grains, angular, moist.			G	Geochem#3	
■	5.50				SM	- Silty SAND (30% Silt / 70% Sand), weakly cemented, loose, brown-red, fine to medium grained angular QZ, moist.			■	UD#1	
					SP	- Becomes SAND with 10% Clay, disturbed, red-brown, fine to medium grained gap graded, moist-wet.					
☒	6.00 6.33		16/37/13 for 30mm N>50	6	SM	- Becomes Silty SAND, red-brown, with fragments of highly cemented Clay and QZ, moist to wet.			☒	SPT#4	
L				7					L	Lexan#3 6 0-7.4m extra 0.1m	
☒	7.40		50 blows for 100mm N>50			- With 5-70mm fragments of cemented QZ sand and yellow Clay inclusions, sample was wet due to drilling water for casing.			☒	SPT #5	
G	8.10			8	SM	CLAY-QUARTZ; Silty SAND (20% Silt / 80% Sand), very dense, red-brown, weakly cemented, fine to medium grained, subangular to subrounded grains, well graded wi h 20-30mm pockets of highly cemented material, sample was intact, moist to wet. - Sample disturbed recovered as 5-30mm fragments weakly cemented in Silty SAND, red-brown, with black Fe staining, yellow and red faint layering (5-10mm) in fragments. - Disturbed sample, recovered as loose SAND with 10% Clay, red-brown, no reaction to HCl.			G	Geochem #4	CQ
	9.05			9							
☒ L	9.40		50 blows for 50mm N>50 no recovery		SC	Becomes Clayey SAND, disturbed, red-brown, fine to medium grained, angular to subangular QZ sand, high plasticity Clay content.			☒ L	Lexan #4 9.4-10.4m melted SPT#6	

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Drilling Contractor:	**Client Contracted - Boart Longyear**	Project Reference:	**Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**
		Project No.:	**42907140**
Client:	**BHP Billiton**	Location:	**Yeelirrie**
Logged By:	**BN**	Bore Size:	**96 mm**
Checked By:		Total Depth:	**30.00 m**
Date Started:	**13-8-09**	Casing Size:	**127 mm**
Date Finished:	**15-8-09**		
Relative Level:	**496.70 mRL**	Drill Type:	**Sonic Drilling**
Coordinates:	**6990368.00 mN** **790673.00 mE**	Drill Model:	**300C Prosonic**
Permit No:	**N/A**	Drill Fluid:	**N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
				10	▨	SC	CLAY-QUARTZ; Clayey SAND, disturbed, red-brown, fine to medium grained, angular to subangular QZ sand, high plasticity Clay content, moist. - With fragments of highly cemented Clayey SAND, does not react with HCl.					CQ
■ L	13.20 13.32			11 12 13	▨	CL-CH	Becomes Sandy CLAY, red-brown, disturbed, moist. - Becomes fine to medium with occasional coarse grained QZ Sand, with manganese staining. - Becomes Sandy CLAY (30% Sand / 70% Clay), hard, moderately cemented, recovered in 5-40mm fragments, moist-dry. - Becomes pale yellow-brown, no reaction to HCl. - Becomes SAND trace Silt, possible Grit, disturbed, loose.			■ L	UD #2 Lexan #5 13 2-13 9m	
							Becomes Sandy SILT, very stiff, pale yellow-brown, fine to medium grained QZ.					
☒ G	13.90 14.00		50 blows for 90mm N>50	14	▨	CL-CH	Becomes Sandy CLAY (30% Sand / 70% Clay), hard, high plasticity, pale brown-yellow, with trace pale grey-yellow, fine to medium grained QZ grains, core begins to be more intact. - Becomes pale yellow-brown, 30% fine to medium grained QZ, trace slickensided surfaces.			☒ G	SPT#7 Geochem #5	
				15	⁞	SM	Becomes Silty SAND (20% Silt / 80% Sand), very dense, pale yellow-brown, fine to medium grained QZ, subangular, well graded, weakly cemented, moist. - Becomes yellow-brown-red with majority medium grained.					
G	15.50				⁘	SP	GRIT; SAND, loose to medium dense , pale grey-brown, subangular, fine to coarse grained sand, moist to wet.			G	Geochem #6	Grit
L	16.10			16 17	⁞	SM	CLAY-QUARTZ; Silty SAND (20% Silt / 80% Sand), very dense, pale yellow-brown, fine to medium grained QZ, subangular, well graded, weakly cemented, moist. - Becomes red-brown.			L	Lexan #6 16.1-17.4m	CQ
					⁘	SP	GRIT; SAND, loose to medium dense, pale grey-brown, subangular, fine to coarse grained sand, moist to wet.					Grit
				18	⁞	SM-SC	CLAY-QUARTZ; Clayey SAND (40% Clay / 60% Sand), very dense, grey-brown, fine to medium grained QZ, subangular, well graded, weakly cemented, moist. - Increase SAND content (70%), grey-brown and red.					CQ
■ L	18.40 18.50			19	⁝	SM-CH	Becomes CLAY/SAND, pale yellow-brown and pale grey.			■ L	UD refusal Lexan #7 18.4-19.7m	

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		Project No.:	**42907140**
Client:	**BHP Billiton**	Location:	**Yeelirrie**
Logged By:	**BN**	Bore Size:	**96 mm**
Checked By:		Total Depth:	**30.00 m**
Date Started:	**13-8-09**	Casing Size:	**127 mm**
Date Finished:	**15-8-09**		
Relative Level:	**496.70 mRL**	Drill Type:	**Sonic Drilling**
Coordinates:	**6990368.00 mN** **790673.00 mE**	Drill Model:	**300C Prosonic**
Permit No:	**N/A**	Drill Fluid:	**N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
				20	▨	CH	CLAY-QUARTZ; Sandy CLAY (20% Sand / 80% Clay), hard, orange-brown, with fine grained Sand, high plasticity, dry to moist.					
G	20.30				▨					G	Geochem #7	
				21	▨		- Becomes CLAY trace fine grained QZ, very stiff-hard, pale grey-green, high plasticity, moist, homogeneous. - Becomes orange-brown, hard, refusal of shear vane, experience difficulty pushing casing due to hard Clay. - Becomes pale grey-green.					
■	21.70				▨					■	UD #3	
L	21.90			22	░	SC-CH	Becomes Clayey SAND / Sandy CLAY, hard, pale grey-green with orange staining, fine to medium grained QZ, moist, refusal of shear vane.			L	Lexan #8 21.7-22.8m extra 0.4m	
■	22.80				▨	CH	Becomes CLAY with 5% fine to coarse grained QZ, hard, pale grey-green, medium - high plasticity, moist, friable.			■	UD #4	
☒	22.90		10/34/16 for 20mm N>50	23	▨					☒	SPT #8	CQ
G	23.50				▨					G	Geochem #8	
	23.70				▨		- Becomes pale orange - pale grey, hard.					
L				24	▨		- Becomes pale grey-green.			L	Lexan #9 23.7-25.0m extra 0.2m	
■	25.00			25	▨	CL-CH	Becomes Sandy CLAY (30% Sand / 70% Clay), medium to high plasticity, pale grey- pale green with patchy orange staining, fine to medium grained, angular to subangular QZ, moist.			■	UD #5	
☒	25.20		6/10/26 N=36		▨					☒	SPT#9	
				26	▨	CL-CH	- Becomes Sandy CLAY (40% Sand / 60% Clay), very stiff-stiff, red-brown, fine to medium grained QZ, subangular to subrounded, high plasticity Clay, moist.					
G	26.20				⁘	SP	GRIT; Clayey SAND (20% Clay / 80% Sand), medium dense, red, fine to coarse grained subangular QZ, gap graded, moist to wet.			G	Geochem #9	Grit
				27	▨	CH	CLAY-QUARTZ; Sandy CLAY (20% Sand / 80% Clay), very stiff, with traces of high plasticity pockets (20-30mm) - Becomes stiff to very stiff, patchy pale grey and pale brown, possibly disturbed by drilling.					
■	28.00			28	▨		- Becomes pale grey-pale green, hard, homogeneous.			■	UD #6	CQ
				29	▨							
G	29.40				▨		- Trace pockets of red QZ (10-20mm).			G	Geochem #10	
							EOH at 30.0m.					

Remarks: 1.0 Two monitoring wells installed, screens from 25.5-27.5m and 15.0-20.0m.
2.0 Backfilled monitor well from:
EOH - 28.5m: backfilled with core samples
28.5-27.5m : Bentonite pellets
27.5-25.0m: Gravel pack
25.0-23.5m: Bentonite pellets
23.5-21.0m: Gravel pack
21.0-20.0m: Bentonite pellets
20.0-14.0m: Gravel pack
14.0-13.0m: Bentonite pellets
13.0-0.0m: Gravel pack

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Sheet 1 of 4

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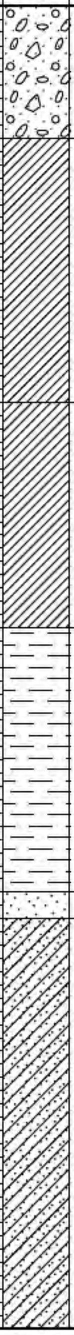
Drilling Contractor:	**Client Contracted - Boart Longyear**	Project Reference:	**Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**
		Project No.:	**42907140**
		Client:	**BHP Billiton**
		Location:	**Yeelirrie**
Logged By:	**BN**	Bore Size:	**96 mm**
Checked By:		Total Depth:	**30.10 m**
Date Started:	**18-8-09**	Casing Size:	**127 mm**
Date Finished:	**19-8-09**		
Relative Level:	**496.00 mRL**	Drill Type:	**Sonic Drilling**
Coordinates:	**6988367.00 mN** **792031.00 mE**	Drill Model:	**300C Prosonic**
Permit No:	**N/A**	Drill Fluid:	**N/A**



Depth (m)	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	GEOLOGICAL DESCRIPTION
0	SC	CARBONATED LOAM; (30% carbonate) Clayey Silty SAND, red-brown, dense, fine to medium grained sand, reacts with hydrochloric acid (HCl), dry. - Increase carbonate content 60%, very dense, red-brown, subangular, poorly graded, slightly cemented, porous, light weight.			LT
1	SC	CARBONATED HARDPAN; Clayey SAND, very dense, recovered with moderately to highly cemented Iron (Fe) stained fragments, 60% carbonate. - Trace white Clay inclusions 2-40mm, subrounded.			HT
3	SC	TRANSITION CALCRETE; Clayey SAND, dense, red-brown, fine to coarse grained, subangular, moderately cemented, various inclusion of dark grey, pale white (1-2mm), moist, 60% carbonate and 30% Quartz (QZ). - Becomes speckled pale grey and red-brown, fine to medium grained, subangular, moist, possibly very dense, trace Clay, subrounded weakly cemented (50% Carbonate / 30% QZ / 20% Clay).	▽		TCQ
	SC	CARBONATED CLAY-QUARTZ; Clayey SAND, very dense, red, fine to medium grained, subangular, poorly graded, moist, 10% carbonate. - Becomes well to poorly graded.			CQT
	SP	Possible GRIT, SAND with 20% Silt/Clay, very dense, dark red, medium to coarse grained, subrounded, gap graded, interbedded sand and high cemented fragments, wet.			GRIT
7	SC	CLAY-QUARTZ; Silty/Clayey SAND, (30% Silt/Clay / 70% Sand), highly cemented fragments evident in material, no reaction to HCl. - Note: While drilling through 7.5-8.5m, soft spot between interval. - Becomes Clayey SAND (40% Clay / 60% Sand), very dense, brown, fine to medium grained, angular to subangular, low reaction to HCl, poorly graded, trace 10-15mm pockets of Sand, moist. - Becomes Clayey SAND (30% Clay / 70% Sand), pale red - pale grey, weakly cemented, fine to coarse grained, subangular to subrounded, moist. - Becomes pale brown, pale yellow. - Sample recovered as broken highly to moderately cemented fragments in Clayey Sand (30% Clay / 70% Sand), trace manganese (Mn) staining, interbedded bands of cemented and non-cemented material, moist (60% loose due to			CQ

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Sample Interval	Sample Identification
G	0.20			G	Geochem #1
G	0.70			G	Geochem #2
☒	1.00		22/50 for 130mm N>50	☒	SPT#1
G	1.50			G	Geochem #3
■	2.30			■	UD #1
☒	2.50 2.72		46 for 70mm N>50	☒	SPT #2
L				L	Lexan #1 2 5-3.5m extra 0 5m
☒	3.50		7/9/26 N=35	☒	SPT#3
G	5.40			G	Geochem #4
☒	5.50 5.55		50 for 130mm N>50	☒	SPT #4
L				L	Lexan #2 5 5-6.5m extra 0.4m
☒	6.50		N>50 refusal a 90mm	☒	SPT #5
G	6.70			G	Geochem #5 (Grit)
■	7.50 7.60			■	UD refusal
L				L	Lexan #3 7 5-8.5m extra 0 5m
☒	8.50		50 blows for 110mm N>50	☒	SPT#6
G	8.90			G	Geochem #6
	10.00				

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Drilling Contractor:	**Client Contracted - Boart Longyear**	Project Reference:	**Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**
Client:	**BHP Billiton**	Project No.:	**42907140**
Location:	**Yeelirrie**		
Logged By:	**BN**	Bore Size:	**96 mm**
Checked By:		Total Depth:	**30.10 m**
Date Started:	**18-8-09**	Casing Size:	**127 mm**
Date Finished:	**19-8-09**		
Relative Level:	**496.00 mRL**	Drill Type:	**Sonic Drilling**
Coordinates:	**6988367.00 mN** **792031.00 mE**	Drill Model:	**300C Prosonic**
Permit No:	**N/A**	Drill Fluid:	**N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
☒	10.07		50 blows for 70mm N>50	10	SC	handling).			☒	SPT#7	
L						CLAY-QUARTZ; Clayey SAND, recovered as broken highly to moderately cemented fragments in Clayey Sand (30% Clay / 70% Sand), trace Mn staining, interbedded bands of cemented and non-cemented material, moist, (60% of material loose due to handling).			L	Lexan #4 10 0-11 3m extra 0 2m	
				11	CL	Becomes Sandy CLAY (30% Sand / 70% Clay), hard, patchy pale brown-pale orange and pale grey-yellow, black Fe staining, fine to medium grained QZ. (Bottom of lexan tube hot and melted).					
G	11.70			12	SM-SC	Becomes Clayey SAND (40% Clay / 60% Sand), very dense, pale brown-pale orange, fine to medium grained Sand, with occasional coarse grained, well graded, moderately cemented, moist to dry. - Sample recovered as broken fragments (20-30mm), weakly cemented, friable. (Possible rock, broken by sonic drilling or harden material due to heat from rock).			G	Geochem#7	
☒	13.10 13.20		50 for 110mm N>50	13					☒	SPT#8	
L				14					L	Lexan #5 13 2-14 2m squashed	
G	14.60			15		Becomes Clayey SAND (20% Clay / 80% Sand), very dense, pale brown-pale grey, fine to medium grained, subangular, moderately to highly cemented, dry. (Retrieve from drill bit a possible Sandstone core, very weak (VW) strength, increase strength in material possibly due from heat of rods.) - Becomes Silty SAND (40% Silt / 60% Sand), dense to very dense (disturbed by drilling), brown-orange, fine to medium grained, subangular to subrounded, poorly graded, non-homogeneous, evident of 10-20mm pockets of rounded highly cemented Sandy CLAY, moist.			G	Geochem#8	CQ
G	16.00			16		- Becomes very dense, patchy pale grey-yellow. - Becomes Clayey SAND (20% Clay / 80% Sand), patchy red-brown, pale yellow, grey, fine to medium grained, with 20-30mm highly cemented fragments. (Evidence of interbedded layers of highly cemented Clayey SAND, with pale yellow 1-2mm thick clay staining layers.)			G	Geochem #9	
L	16.30			17					L	Lexan #6 16 3-17 3m extra 0 5m	
■ G	17.30 17.40				CL	Becomes Sandy CLAY (30% Sand / 70% Clay), hard, brown, fine to medium grained sand, subangular to subrounded, with moderately to highly cemented zones, moist.			■ G	UD refusal Geochem #10	
G	18.00			18					G	Geotech #1	
G	18.70					- With subrounded to rounded Clay cementation. - Trace black-brown Silica cementation. - Brecciated formation with various sizes of cemented clay (5-20mm), and black Fe staining fragments, difficult to push UD.			G	Geochem #11	
L	19.30			19					L	Lexan #7 19 3-20 3m	

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Logged By: **BN**	Bore Size: **96 mm**	Relative Level: **496.00 mRL**	Drill Type: **Sonic Drilling**
Checked By:	Total Depth: **30.10 m**	Coordinates: **6988367.00 mN**	Drill Model: **300C Prosonic**
Date Started: **18-8-09**	Casing Size: **127 mm**	**792031.00 mE**	Drill Fluid: **N/A**
Date Finished: **19-8-09**		Permit No: **N/A**	

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
L				20		CL	CLAY-QUARTZ; Sandy CLAY.			L		
G	20.50					SM-SC	Becomes Clayey SAND (30% Clay / 70% Sand), very dense, red-brown, patchy yellow, fine to medium grained with trace coarse grained, subangular to subrounded, moist, 20-30mm zones of highly cemented areas, difficult to sample with SPT or UD, moist. - Becomes Clayey SAND (40% Clay / 60% Sand), very dense, patchy pale grey-brown, fined grained, subangular-subrounded, weakly cemented, poorly graded, moist. - Recovered as broken weakly cemented fragments in Clayey SAND. - Interbedded red-brown and pale grey.			G	Geotech #2	
				21								
G	21.70									G	Geochem #12	
G	22.00			22						G	Geochem #13	
G	22.10									G	Geotech #3	
L	22.30									L	Lexan #8 22 3-23 0m extra 0 2m	
■	23.00			23			- Becomes very hard, patchy red, orange, brown, pale grey, moderately cemented, sample almost resembles rock strength VL strength, a blow of geopick indents 3-4mm, does not break, indents are smooth, intact core from 100-600mm in length. The red material is moderately cemented and the pale grey is more softer Clay, friable, can be easily sawed through.			■	UD refusal	
G	23.40									G	Geotech #4	
G	23.80									G	Geochem #14	
				24								
G	24.45									G	Geotech #5	
	25.20			25								CQ
L										L	Lexan #9 25 2-26 3m extra 0.4m	
				26								
G	26.40					SM-CL	Recovered as Clayey SAND/Sandy CLAY, very hard, patchy red, orange and grey, VL strength? When hit with point end of geopick, leaves smooth indents, recovered as intact core.			G	Geochem #15	
G	27.10			27						G	Geotech #6	
						SM	Becomes Clayey SAND (20% Clay / 80% Sand) medium to coarse grained, subangular to subrounded.					
G	28.00			28						G	Geochem #16	
L	28.30									L	Lexan #10 28 3-29 3m extra 0.4m	
				29			- Recovered as Clayey SAND/Sandy CLAY, very hard, patchy red, orange and grey, possible VL strength? - Driller no iced easier drilling on last run.					
G	29.40									G	Geotech #7	
						SM-CL	Becomes Clayey SAND / Sandy CLAY, hard, patchy red, orange and grey with dark purple- red, flaky, moist, dark purple-red accumulated coated surface around core, can be					
G	29.80									G	Geochem #17	
	30.00											

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BOREHOLE YYS0165 - DRAFT

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Drilling Contractor: **Client Contracted - Boart Longyear**		Project Reference: **Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**	Client: **BHP Billiton**
		Project No.: **42907140**	Location: **Yeelirrie**
Logged By: **BN**	Bore Size: **96 mm**	Relative Level: **496.00 mRL**	Drill Type: **Sonic Drilling**
Checked By:	Total Depth: **30.10 m**	Coordinates: **6988367.00 mN**	Drill Model: **300C Prosonic**
Date Started: **18-8-09**	Casing Size: **127 mm**	**792031.00 mE**	Drill Fluid: **N/A**
Date Finished: **19-8-09**		Permit No: **N/A**	

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	**USC DESCRIPTION OF STRATA** Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
G				30		SM CL	broken with hand with less difficulty.			G	Geotech #8	cq
							CLAY-QUARTZ; Clayey SAND / Sandy CLAY, hard, patchy red, orange and grey with dark purple- red, flaky, moist, evidence of core spinning, leaving dark purple-red accumulated surfaces around core, can be broken with hand with less difficulty, no rock characteristics.					
				31			EOH at 30.1m.					
				32								
				33								
				34								
				35								
				36								
				37								
				38								
				39								

Remarks: 1.0 Two monitoring wells installed, screens from 18.3-16.3m and 6.0-4.0m.
2.0 Backfilled monitor well from:
EOH - 22.0m: backfilled with core samples
22.0-19.5m: Gravel pack
19.5-18.3m: Bentonite pellets
18.3-15.0m: Gravel pack
15.0-14.0m: Bentonite pellets
14.0-7.0m: Gravel pack
7.0-6.0m: Bentonite pellets
6.0-3.5m: Gravel pack
3.5-2.5m: Bentonite pellets
2 5-0.0m: Gravel pack

Sheet 1 of 3

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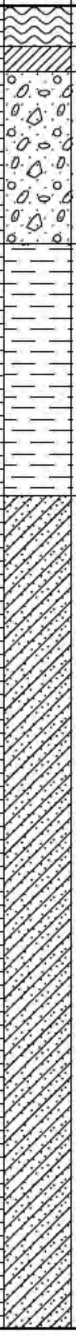
Drilling Contractor:	**Client Contracted - Boart Longyear**	Project Reference:	**Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**
		Project No.:	**42907140**
Client:	**BHP Billiton**	Location:	**Yeelirrie**
Logged By:	**BN**	Bore Size:	**96 mm**
Checked By:		Total Depth:	**30.00 m**
Date Started:	**20-8-09**	Casing Size:	**127 mm**
Date Finished:	**21-8-09**		
Relative Level:	**496.80 mRL**	Drill Type:	**Sonic Drilling**
Coordinates:	**6989221.00 mN** **792552.00 mE**	Drill Model:	**300C Prosonic**
Permit No:	**N/A**	Drill Fluid:	**N/A**



SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
				0	SM	LOAM; Silty SAND, medium dense, red-brown, dry.					L
G ☒	0.40 0.50		50 blows for 50mm N>50		SM	HARDPAN; Silty SAND, dense, red, fine to medium grained, subangular to subrounded, poorly graded, dry, weakly cemented, Iron (Fe) oxide cemented (30%), traced carbonate.			G ☒	Geochem #1 SPT#1	H
L	0.55			1	SM	CARBONATED LOAM; Silty SAND, very dense, recovered with weakly to moderately cemented fragments.			L	Lexan #1 0 5-1.8m extra 0 2m	LT
G	1.80			2	SC	CARBONATED CLAY-QUARTZ; Clayey SAND (20% Clay / 60% Sand / 20% carbonate), red-brown and white, with highly cemented very low (VL) strength rock fragments, possibly Sandstone, brecciated, fine to medium grained, subangular to angular, reacts vigourously with hydrochloric acid (HCl), material powderised and disturbed due to drilling. - Becomes more carbonate 40%.			G	Geochem#2	CQT
☒	2.50		50 blows for 150mm N>50						☒	SPT#2	
G	3.50			3					G	Geochem #3	
					SC	CLAY-QUARTZ; Clayey SAND, red-brown, rock fragments (15-50mm) can be broken by hand, moderately cemented with fine to medium grained, trace coarse grained, less carbonate 10%.					CQ
G	4.00			4		- Clayey SAND (30% Clay / 60% Sand / 10% carbonate), very dense, patchy red and pale grey, fine to medium grained, subangular to subrounded, weakly cemented and trace highly cemented fragments, moist, pale grey material is clay, friable can be broken by one hand, Evidence of intact core within disturbed Clay/Sand.			G	Geochem #4	
☒	5.20 5.29		50 blows for 90mm N>50	5					☒	SPT#3	
L				6			▽		L	Lexan #2 5 2-6.4m extra 0 3m	
G G	6.70 6.80			7		- Becomes (20% Clay / 80% Sand), very dense, red-brown, with trace yellow clay, medium to coarse grained, subangular to subrounded, recovered in intact core, friable, (breaks with gentle force from fingers). Evidence of highly cemented interbedded disc, moist to wet, gap graded, non-homogenous. - Increase zones 20-30mm of uniform graded coarse grained Quartz (QZ) sand, evidence of intact core.			G G	Geochem #5 Geotech #1	
G ■	7.70 7.90 8.00			8					G ■	Geotech #2 UD refusal	
L									L	Lexan #3 7 9-9.1m extra 0 3m	
☒ G G	9.10 9.30 9.40		36/50 for 30mm N>50	9		- Becomes brown-orange. - Becomes more clayey 30%.			☒ G G	SPT#4 Geochem #6 Geotech #3	

Remarks: - Note: For bag samples, at the top the material is softer while the bottom is harder. Material at the bottom could get harder due to heat from drill rods (here are no splits or barrel between sample and rods).

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BOREHOLE YYS0166 - DRAFT

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Drilling Contractor:	**Client Contracted - Boart Longyear**	Project Reference:	**Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**
Client:	**BHP Billiton**	Project No.:	**42907140**
Location:	**Yeelirrie**		
Logged By:	**BN**	Bore Size:	**96 mm**
Checked By:		Total Depth:	**30.00 m**
Date Started:	**20-8-09**	Casing Size:	**127 mm**
Date Finished:	**21-8-09**		
Relative Level:	**496.80 mRL**	Drill Type:	**Sonic Drilling**
Coordinates:	**6989221.00 mN** **792552.00 mE**	Drill Model:	**300C Prosonic**
Permit No:	**N/A**	Drill Fluid:	**N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
G	10.20			10		SC	CLAY-QUARTZ; Clayey SAND (20% Clay / 80% Sand), very dense, orange-brown, fine to medium grained, subrounded, weakly cemented, friable, gap graded, moist - wet, 10% coarse grained, breaks easily between fingers, trace zones of moderately cemented, no reaction to HCl.			G	Geotech #4	
G ☒	11.00 ~~11.10~~		50 for 70mm N>50	11						G ☒	Geochem #7 SPT#5	
L	11.90			12						L	Lexan #4 11 9-12 9m extra 0 5m	
■	12.90			13			- With hin irregular layers of pale yellow clay (1-2mm) and patchy areas of pale grey Clay.			■	UD#1	
						CL	Sandy CLAY (40% Sand / 60% Clay) hard, patchy pale brown - pale yellow, fine to medium grained sand, recovered as broken pieces 5-30mm, up to 70mm, moist to dry, possibly due to heat of drill rods.					
G	13.60									G	Geochem #8	
				14			- Recovered in intact 60-70mm pieces, dry, weakly cemented breaks with finger pressure. - Becomes (30% Sand / 70% Clay) hard, patchy brown, yellow pale grey and black staining, moist, recovered intact core.					
G G	14.70 ~~14.80~~									G G	Geochem #9 Geotech #5	CQ
G	15.20			15						G	Geotech #6	
■	15.50 15.69						- Becomes pale grey with orange-red staining, difficult to break with hand, however plastic characteristic remain when hit with hammer, smooth indentations result with hit of geopick.			■	UD #2	
L				16						L	Lexan #5 15 5-16 5m extra 0 2m	
☒	16.50		14/21/19 N=40			CL-CH	Becomes patchy interbedded 15-30mm layers of brown, orange, pale grey, very stiff-hard, high plasticity pale grey clay.			☒	SPT#6	
G	16.90			17						G	Geochem #10	
G	17.60						- Becomes hard, brown with trace red staining, increase sand (30-40%), evidence of moderately cemented zones (30-70mm thick).			G	Geotech #7	
■	18.00			18						■	UD refusal	
L	18.40			19						L	Lexan #6 18.4-19 6m extra 0 3m	
■	19.60						- Becomes pale brown, pale yellow, pale grey and red staining, fine to medium grained, subangular to subrounded.			■	UD #3	

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Drilling Contractor: **Client Contracted - Boart Longyear**

Project Reference: **Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**
Project No.: **42907140**

Client: **BHP Billiton**
Location: **Yeelirrie**

Logged By: **BN**
Checked By:
Date Started: **20-8-09**
Date Finished: **21-8-09**

Bore Size: **96 mm**
Total Depth: **30.00 m**
Casing Size: **127 mm**

Relative Level: **496.80 mRL**
Coordinates: **6989221.00 mN**
792552.00 mE
Permit No: **N/A**

Drill Type: **Sonic Drilling**
Drill Model: **300C Prosonic**
Drill Fluid: **N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
G	20.10			20		CL-CH	CLAY-QUARTZ; Sandy CLAY, (40% Sand / 60% Clay), 30mm layers of red Sand (grit?), medium to coarse grained Sand, subrounded to subangular.			G	Geochem #11	
G	20.70						- Becomes Sandy CLAY (30% Sand / 70% Clay), hard, patchy layers of red-orange and pale grey-yellow (high plasticity Clay) moist, intact core.			G	Geotech #8	
				21			- Becomes red-brown with 10-20% coarse grained sand, broken pieces of core in 30-40mm fragments. Evidence of core hardened due to drying out. Last 200mm of core run resembles VL strength rock, material hot to touch.					
G	21.30 21.50									G	Geochem #12	
L				22						L	Lexan #7 21 5-22 6m extra 0.4m, bottom melted	
G	22.65						- Becomes brown patchy orange and red, fine to coarse grained, subangular QZ grains, intact core.			G	Geotech #9	
				23								
G	23.50						- Becomes patchy pale yellow-orange, fine to medium grained, moist to dry, recovered in broken disc fragments (20-30mm) towards end of core run.			G	Geochem #13	
G	23.90 24.00			24			- 300mm layer of pale grey-white, hardened Clay fragments in brown Clay matrix, brecciated. (Drilling run between 23.6-24.6m felt hot).			G	Geochem #14	
L						SC	Clayey SAND (40% Clay / 60% Sand), very dense, red-brown, pale yellow, fine to coarse grained sand, subangular to subrounded, moist, friable. When hit with pick indents 3-6mm leaving smooth surface, plastic characteristics, weakly cemented.			L	Lexan #8 24-25 3m extra 0 25	
				25			- Recovered as broken pieces 20-30mm due to extrusion using vibration.					Cg
						CL-CH	Becomes Sandy CLAY (30% Sand / 70% Clay), hard, pale pink-grey, fine to medium grained, friable, harden due to heat (Bottom of lexan tube melted).					
G	25.70 25.85						- Clay band, hard, friable, pale grey-white, homogenous.			G	Geochem #15	
G				26			- Sandy CLAY (20% Sand / 70% Clay), hard, red-brown, fine to coarse grained subangular, gap graded, moist, intact core.			G	Geotech #10	
							- Becomes pale grey-yellow with trace orange staining, recovered disturbed core.					
G	26.80 27.00									G	Geochem #16	
G	27.30			27						G	Geotech #11	
L				28						L	Lexan #9 27 3-28 3m extra 0.4m	
G	28.30									G	Geotech #12	
G	28.70			29						G	Geotech #13	
G	29.20									G	Geochem #17	
							EOH at 30.0m.					

Remarks: 1.0 Two monitoring wells installed, screens from 22.0-25.0m and 4.0-8.0m.
2.0 Backfilled monitor well from:
EOH - 27.0m: backfilled with core samples
27.0-26.0m: Gravel pack
26.0-25.0m: Bentonite pellets
25.0-21.5m: Gravel pack
21.5-20.5m: Bentonite pellets
20.5-9.0m: Gravel pack
9.0-8.0m: Bentonite pellets
8.0-3.5m: Gravel pack
3.5-2.5m: Bentonite pellets
2 5-0.0m: Gravel pack

Sheet 1 of 3

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BOREHOLE YYS0167 - DRAFT

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Drilling Contractor: **Client Contracted - Boart Longyear**	Project Reference: **Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**	Client: **BHP Billiton**	
	Project No.: **42907140**	Location: **Yeelirrie**	
Logged By: **BN**	Bore Size: **96 mm**	Relative Level: **495.60 mRL**	Drill Type: **Sonic Drilling**
Checked By:	Total Depth: **30.00 m**	Coordinates: **6988083.00 mN** **793264.00 mE**	Drill Model: **300C Prosonic**
Date Started: **22-8-09**	Casing Size: **127 mm**		
Date Finished: **23-8-09**		Permit No: **N/A**	Drill Fluid: **N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
G ☒	0.30 0.50 0.68		41/9 for 30mm N>50	0		SM	LOAM; Silty SAND (10% Silt / 90% Sand), medium dense, red-brown, fine to medium grained, subangular to subrounded, poorly graded, dry.			G ☒	Geochem #1 SPT#1	L
L				1		SP	HARDPAN; Silty SAND, Iron (Fe) oxide, black shiny coating, moderately cemented (40%), indurated laminar layers of 20-50mm thick, very dense.			L	Lexan #1 0 5-1.7m extra 0 3m	H
						SM	CARBONATED LOAM; Silty SAND (20% Silt / 60% Sand / 20% carbonate), very dense, pale-orange with mottled white carbonate, fine to medium grained subrounded to subangular, dry, weakly cemented, reacts with hydrochloric acid (HCl).					LT
G	2.30			2		CL	QUARTZ-RICH CARBONATED LOAM; Sandy CLAY, hard recovered as core pieces weakly cemented, brecciated, fine to medium grained with 5-10% subrounded Clay gravels (1-3mm), dry. - Trace moderately cemented broken core disc (20-30%) with Sandy CLAY. - Recovered in 10-30mm pieces, friable, possibly due to end of run.			G	Geochem #2	LQT
☒ G G ☒	3.00 3.60 3.90 4.30		14/26/24 for 140mm N>50 18/50 for 130mm N>50	3 4		SC	CARBONATED CLAY-QUARTZ; Clayey SAND (10/60% and 30% carbonate) with gravels, very dense, red-brown, fine grained, subangular to subrounded QZ, rounded to subrounded gravels (2-6mm) Clay, moist to wet, intact core. - Recovered as Clayey SAND, disturbed due to end of run. - Trace moderately cemented fragments 20-30mm. - Becomes more Sand (70%), medium grained, subrounded, subangular.	∇		☒ G G ☒	SPT#2 Geotech #1 Geochem #3 SPT#3	CQT
G L ■ G L	5.20 5.30 6.45 7.30 7.40 7.44 8.90			5 6 7 8		SC	CLAY-QUARTZ; Clayey SAND (20% Clay / 80% Sand), disturbed - loose, brown, medium grained, trace coarse, subrounded QZ grains, no carbonate reaction. - Becomes Clayey SAND (40% Clay / 60% Sand), very dense, brown with trace red staining, fine to medium grained, subangluar to subrounded, well graded, moist to wet, homogenous. - Becomes more Sandy (80%), disturbed loose, red-brown, fine to coarse grained, majority medium grained, trace 5-20mm moderately cemented, subrounded to subangular, gap to uniform graded, wet. - Clayey SAND (40% Clay / 60% Sand) very dense, red-brown fine to medium grained, subangular to subrounded, well graded, trace coarse grained QZ, moist, intact core, friable breaks easily with fingers. - Observed bottom of UD#2, very intact moderately cemented, pale yellow with black specks. - Clayey SAND (20% Clay / 80% Sand), very dense, brown trace red staining, medium to coarse grained, subrounded, gap graded, moist, first 200mm loose (disturbed).			G L ■ G L	Geochem #4 Lexan #2 5 3-6.4m extra 0 3m UD#1 Geochem #5 UD #2 refusal Lexan #3 7.4-8.2m extra 0.4m	CQ
G G ☒ L	9.10 9.60 9.70		50 for 100mm N>50	9		CL-SM	Sandy CLAY (50% Sand / 50% Clay), hard, pale brown, fine to medium grained, non-homogenous, patchy clay and sand zones, weakly cemented, moist, 1-3mm rounded clay inclusions.			G G ☒ L	Geotech #2 Geochem #6 SPT#4	

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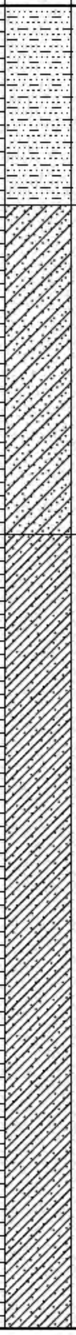
Drilling Contractor: **Client Contracted - Boart Longyear**	Project Reference: **Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**	Client: **BHP Billiton**	
	Project No.: **42907140**	Location: **Yeelirrie**	
Logged By: **BN**	Bore Size: **96 mm**	Relative Level: **495.60 mRL**	Drill Type: **Sonic Drilling**
Checked By:	Total Depth: **30.00 m**	Coordinates: **6988083.00 mN**	Drill Model: **300C Prosonic**
Date Started: **22-8-09**	Casing Size: **127 mm**	**793264.00 mE**	Drill Fluid: **N/A**
Date Finished: **23-8-09**		Permit No: **N/A**	



SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
L				10		CL-SM	CLAY-QUARTZ; Sandy CLAY (50% Sand / 50% Clay), hard, pale brown, fine to medium grained, non-homogenous, patchy clay and sand zones, weakly cemented, moist, 1-3mm rounded clay inclusions.			L	Lexan #4 9 6-10.7m extra 0 3m	
■	10.70 10.80						- Becomes patchy pale brown and yellow.			■	UD#3	
G	11.10			11						G	Geotech #3	
G							- Becomes patchy orange, yellow with trace pale grey, subangular to subrounded, well graded, moist, friable.			G	Geochem #7	
						SC	Becomes Clayey SAND (30% Clay / 70% Sand), very dense, red-orange, trace pale yellow Clay pockets 20mm, fine to coarse grained, moist, material disturbed - stretched, friable.					
G	11.80			12						G	Geochem #8	
■	12.80 12.88			13						■	UD#4	
L										L	Lexan #5 12 8-13 8m bottom melted	
G	14.00			14		CL	Becomes Sandy CLAY (40% Sand / 60% Clay), hard, brown-yellow, fine to medium grained, subangular to subrounded, weakly cemented, intact core, friable, refusal of shear vane, when broken by hand smoo h areas evident where clay and sand were cemented.			G	Geotech #4	
G	14.30									G	Geochem #9	
	15.00			15			- 14.8-15.0 m Core hollowed out due to contact surface harden from heat of rods and stuck to inside of rods.					CQ
L										L	Lexan #6 15 0-15 9m extra 0 6, bottom melted	
G	15.90			16			- Becomes (30% Sand / 70% Clay), pale grey - pale green, pale yellow, moist, recovered as broken moderately cemented fragments (Sample required vibration to retrieve).			G	Geotech #5	
G	16.60			17			- Becomes patchy orange-brown, yellow and pale grey, breaks with 2 hands, when hit with point of geopick indents 10mm deep with 3-4 cracks, smooth surface, plastic characteristics exist, moist, intact core between 150-200mm. - Becomes friable, breaks easily with fingers recovered as 50-70mm discs. 16.7-17.2 Disturbed hollowed out clay core, 10mm thick shell, inside of sample was pushed and vibrated out, material crumbled. - Becomes (40% Sand / 60% Clay), pale brown, intact core. - Disturbed recovered in 20-50 mm pieces in Sandy CLAY.			G	Geochem #10	
L	18.00			18						L	Lexan #7 18 0-18 9m bottom melted	
G	19.10			19			- Becomes patchy red-orange and yellow, recovered intact core (100-200mm).			G	Geotech #6	
							- Sample disturbed recovered as broken pieces 20-30mm in Clayey SAND. Required vibration to retrieve sample.					

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Drilling Contractor:	**Client Contracted - Boart Longyear**	Project Reference:	**Yeelirrie Uranium Project Geochemistry / Geotechnical & Hydrogeological Drilling and Sampling**
		Project No.:	**42907140**
Client:	**BHP Billiton**	Location:	**Yeelirrie**
Logged By:	**BN**	Bore Size:	**96 mm**
Checked By:		Total Depth:	**30.00 m**
Date Started:	**22-8-09**	Casing Size:	**127 mm**
Date Finished:	**23-8-09**		
Relative Level:	**495.60 mRL**	Drill Type:	**Sonic Drilling**
Coordinates:	**6988083.00 mN** **793264.00 mE**	Drill Model:	**300C Prosonic**
Permit No:	**N/A**	Drill Fluid:	**N/A**

SAMPLE TYPE	DRILL RUN (m)	FIELD SHEAR STRENGTH (kPa)	SPT BLOWS (N)	Depth (m)	Graphic Log	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), additional observations	Moisture and Groundwater	Consistency Relative Density	Sample Interval	Sample Identification	GEOLOGICAL DESCRIPTION
				20		CL-SM	CLAY-QUARTZ; Clayey SAND / Sandy CLAY (50% Sand /50% Clay), very dense, pale brown-orange, fine to coarse grained, subangular to subrounded, high plasticity clays, poorly graded, with moderately cemented gravel fragments.					CQ
G	20.40									G	Geochem #11	
				21								
L	21.40						- Becomes patchy brown, with orange staining trace pale grey clay, fine to medium grained, friable, moist, recovered as intact core. - Becomes hard, can not penetrate with finger, easily peeled with knife.			L	Lexan #8 21.4-22.6m extra 0.3m	
				22								
G	22.60						- Becomes pale grey.			G	Geotech #7	
						SP	GRIT; interbedded layers of GRIT, medium grained subrounded to subangular, uniform graded, 20-80mm thick, at 100-300mm spacing.					
G	23.00			23						G	Geochem #12	
						CL-SM	CLAY-QUARTZ; Clayey SAND / Sandy CLAY, pale grey-green, hard, recovered as 20-40mm pieces, required vibration to retrieve sample. - Becomes very dense, pale grey-green with orange staining, fine to coarse grained, subangular to subrounded, moderately to weakly cemented, shatters with one hit of geopick, possibly VL rock, moist, recovered in 100mm core, 40% of material still can be peeled with knife.					CQ
				24								
G	24.50 24.60									G	Geochem #13	
L				25						L	Lexan #9 24.6-25.8m extra 0.3m	
☒	25.80		24/30 for 100mm stuck N>50	26			- Interbedded colours of pale grey and orange-red (10-20mm spaced), broken by finger pressure.			☒	SPT#5	
G	26.30						- Becomes hard, red with pale grey pockets, fine to coarse grained with majority medium grained, moist.			G	Geotech #8	
				27			- Becomes patchy pale grey-orange, recovered as 30-80mm core, dried at bottom of bit, disturbed.					
G	27.30					SP	27.3-27.4m GRIT layer.			G	Geochem #14 (Grit)	
■	27.50					CL-SM	Clayey SAND / Sandy CLAY, interbedded colours of pale grey and orange-red at 10-20mm spacing, can be broken by finger pressure.			■	UD #5	
L	27.60			28						L	Lexan #10 27.5-28.5m extra 0.5m	
							- Becomes Sandy CLAY (40% Sand / 60% Clay), hard, pale grey-white, with 10-20% orange staining, fine to coarse grained QZ, subangular to subrounded, moist.					
G G	29.10 29.30			29						G G	Geotech #9 Geochem #15	
							- Sample disturbed, dried and hardened from heat of drill bit, recovered as 20-100mm broken core disc, moist-dry.					
							EOH at 30.0m.					

Remarks: 1.0 Two monitoring wells installed, screens from 20.0-24.0m and 3.8-7.3m.
2.0 Backfilled monitor well from:
EOH - 25.0m: backfilled with core samples
25.0-24.0m: Bentonite pellets
24.0-19.0m: Gravel pack
19.0-18.0m: Bentonite pellets
18.0-10.0m: Gravel pack
10.0-9.5m: Bentonite pack
9.5-8.3m: Gravel pack
8.3-7.3m: Bentonite pack
7.3-3.0m Gravel pack
3.0-1.5 Bentonite
1.5-0.0m Gravel pack

SOIL PROFILE

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Client: Allen Burgess (BHP)									
Project name:									
Drillhole No.	1	Drill Rig		Inclination		Easting	352602	Bedrock depth (m)	N/A
		Location	Kalgoorlie	Type/Diameter	6"	Northing	6603446	Depth to water (m)	N/A
Project No.	BHP040	Geologist	DvdB	Final Depth (m)	7	Elevation (m)	379.914	Date Drilled 15/06/2007	Date Profiled 16/06/2009

Depth from (m)	Depth to (m)	Soil Name	Description of the soil				Soil Conditions		Structure of Soil			Additional observations		
			Colour	Particle Description			Moisture condition (disturbed)	Consistency (disturbed)	Zoning	Defects	Cementing	Mechanical deposition	Others	
				Coarse -grained soil		Clay-silt								
				Size	Shape	Plasticity			Disturbed Material					
0.00	0.50	MEDIUM TO COARSE GRAVEL (GM) with silty sand	light red-grey	poorly graded	angular to sub-angular		dry	very loose				capping material		Samples taken as per BH1 testing summa
0.50	1.00	SILTY SAND (SM) with some clay and fine sub-angular calcrete gravel	dark red-brown	well graded	sub-angular		dry	loose				borrow cover material		
1.00	1.50	SILTY CLAY (CL) with fine sub-angular calcite gravel	dark red-brown mottled white			medium	moist	stiff				borrow cover material		
1.50	2.00	SILTY CLAY (CL) with coarse sand	dark red-brown			medium	moist	stiff				borrow cover material		
2.00	2.50	SILTY CLAY (CL) with coarse sand	dark red-brown			medium	moist	stiff				borrow cover material		
2.50	3.00	SILTY CLAY (CL) with coarse sand	dark red-brown			medium	moist to wet	stiff				borrow cover material	Sample wettened during drilling	
3.00	3.50	SILTY CLAY (CL) with coarse sand	dark red-brown			medium	moist	stiff				borrow cover material		
3.50	4.00	SILT (ML) with traces of sand	light red-orange			low	moist	soft				tailings		
4.00	4.50	SILT (ML) with traces of sand	light red-orange			low	moist	soft				tailings		Lexan Tube Sample
4.50	5.50	SILTY SAND (SM)	light red-orange	poorly graded	sub-angular		moist	loose				tailings	Lost material between 4.5m and 5.5m due to drilling Sample grabbed at 5.5m	Lost Material
5.50	6.25	SILTY CLAY (CL) with fine sub-angular calcite gravel	dark red-brown mottled white			medium	moist	stiff				residual or borrow material	Compacted clay liner Sample wettened during drilling	Lexan Tube Samples
6.25	7.00	SILTY CLAY (CL) with fine sub-angular calcite gravel	dark red-brown mottled white			medium	moist	very stiff				residual or borrow material	Compacted clay liner Sample wettened during drilling	

BH1 Testing Summary

Depth [m]	Description	Sample Weight [kg]	Redox (Eh)		pH		Conductivity		Comment
			Reading [mV]	Temp [°C]	Reading	Temp [°C]	Reading [mS]	Temp [°C]	
0.5	Sample S1.1	0.4							Calibration 1
1.0	Sample S1.2	0.4	83	25	7.51	25	1.014	21.7	
1.5	Sample S1.3	0.3	106	25	7.15	25	1.801	21.4	
2.0	Sample S1.4	0.3	77	25	8.17	25	1.113	21.8	
2.5	Sample S1.5	0.3	64	25	7.01	25	1.474	26.4	
3.0	Sample S1.6	0.3	78	25	7.48	25	2.350	24.3	
3.5	Sample S1.7	0.3	60	25	7.35	25	3.520	25.7	
4.0	Sample S1.8 (Tailings)	0.3	67	25	8.96	25	4.560	23.8	
4 to 4.5	Lexan Tube Sample S1.9 (Tailings)	4.5	N/T	N/T	N/T	N/T	N/T	N/T	
4.5	Sample S1.10 (Tailings)	0.4	63	25	9.69	25	2.230	20.0	
4.5 to 5.5	Lost material								
5.5 to 6.25	Lexan Tube Sample S1.11 (Tested at 6.25m)	10.2	57	25	9.38	25	2.300	23.3	
6.25 to 7	Lexan Tube Sample S1.12	9.5	N/T	N/T	N/T	N/T	N/T	N/T	
7.0	Sample S1.13	0.4	52	25	8.48	25	2.750	26.1	Calibration 2
	Total Weight Samples	27.6							
	Total Weight Tailings Samples	5.2							

*N/T - no tests

SOIL PROFILE

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Client: Allen Burgess (BHP)								
Project name:								
Drillhole No.	2	Drill Rig		Inclination		Easting	352599	Bedrock depth (m) N/A
		Location	Kalgoorlie	Type/Diameter	6"	Northing	6603446	Depth to water (m) N/A
Project No.	BHP040	Geologist	DvdB	Final Depth (m)	8	Elevation (m)	329.813	Date Drilled 15/06/2009 · Date Profiled 16/06/2009

Depth from (m)	Depth to (m)	Soil Name	Description of the soil				Soil Conditions		Structure of Soil			Additional observations		
			Colour	Particle Description			Moisture condition (disturbed)	Consistency (disturbed)	Zoning	Defects	Cementing	Mechanical deposition	Others	
				Coarse -grained soil		Clay-silt			Disturbed Material					
				Size	Shape	Plasticity								
0.00	0.50	ANGULAR TO SUB-ANGULAR COBBLES with some coarse gravel and sandy silt	light red-grey	poorly graded	angular to sub-angular		dry	very loose				waste rock capping		Samples taken as per BH2 testing summary tabl
0.50	1.00	ANGULAR TO SUB-ANGULAR COBBLES with some coarse gravel and sandy silt	light red-grey	poorly graded	angular to sub-angular		wet	very loose				waste rock capping	Sample wettened during drilling	
1.00	1.20	ANGULAR TO SUB-ANGULAR COBBLES with some coarse gravel and sandy silt	light red-grey	poorly graded	angular to sub-angular		dry	very loose				waste rock capping		
1.20	1.50	SILTY SAND (SM) with some clay and fine sub-angular calcrete gravel	dark red-brown	well graded	sub-angular		dry	loose				cover material		
1.50	2.00	SILTY SAND (SM) with fine sub-angular calcrete gravel	dark red-brown	well graded	sub-angular		dry	very loose				cover material		
2.00	2.50	SILTY SAND (SM) with fine sub-angular calcrete gravel	dark red-brown	well graded	sub-angular		dry	loose				cover material		
2.50	3.00	SILTY SAND (SM) with fine sub-angular calcrete gravel	dark red-brown	well graded	sub-angular		wet	very loose				cover material	Sample wettened during drilling	
3.00	3.50	SILTY SAND (SM) with some clay and fine sub-angular calcrete gravel	dark red-brown	well graded	sub-angular		wet	loose				cover material		
3.50	3.70	SILTY SAND (SM) with some clay and fine sub-angular calcrete gravel	dark red-brown	well graded	sub-angular		wet	loose				cover material	Sample wettened during drilling	
3.70	4.00	SILT (ML)	light red- orange			low	dry	soft				tailings		
4.00	4.50	SILT (ML)	light red- orange			low	wet	firm				tailings	Sample placed into tube post drilling Sample wettened during drilling	Lexan Tube Samples
4.50	5.25	SILT (ML)	light red- orange			low	wet	firm				tailings	Sample wettened during drilling	
5.25	6.20	SILT (ML)	light red- orange			low	wet	firm				tailings	Sample wettened during drilling	
6.20	6.45	SILTY CLAY (CL) with fine sub-angular calcite gravel	dark red-brown mottled white			medium	moist	very stiff				residual or borrow material	Compacted clay liner Sample wettened during drilling	
6.45	7.2	SILTY CLAY (CL) with fine sub-angular calcite gravel	dark red-brown mottled white			medium	moist	very stiff				residual or borrow material	Compacted clay liner Sample wettened during drilling	
7.2	8	SILTY CLAY (CL) with fine sub-angular calcite gravel	dark red-brown mottled white			medium	moist	very stiff				residual or borrow material	Compacted clay liner Sample wettened during drilling	

BH2 Testing Summary

Depth [m]	Description	Sample Weight [kg]	Redox (Eh)		pH		Conductivity		Comment
			Reading [mV]	Temp [°C]	Reading	Temp [°C]	Reading [mS]	Temp [°C]	
1.5	Sample S2.1	1.5	81	25	7.31	25	0.520	23.8	Calibration 2
2.0	Sample S2.2	0.4	90	25	7.10	25	0.820	25.0	
2.5	Sample S2.3	1	88	25	6.75	25	1.705	23.0	
3.0	Sample S2.4	0.5	76	25	7.18	25	1.485	24.8	
3.5	Sample S2.5	1	97	25	6.72	25	3.490	26.2	
4.0	Sample S2.6 (Tailings)	0.8	105	25	8.35	25	3.440	26.5	
4.0 to 4.5	Lexan Tube Sample S2.14 (Tailings)	9	N/T	N/T	N/T	N/T	N/T	N/T	
4.5	Sample S2.7 (Tailings)	1.2	95	25	8.21	25	5.550	23.3	
4.5 to 5.25	Lexan Tube Sample S2.8 (Tested at 5.25m) (Tailings)	8.6	70	25	8.33	25	10.120	24.9	
5.25 to 6.0	Lexan Tube Sample S2.9	8.5	N/T	N/T	N/T	N/T	N/T	N/T	
6.0	Sample S2.10	1	69	25	6.91	25	1.900	23.1	
6.0 to 6.45	Lexan Tube Sample S2.11 (Tested at 6.45m)	10.5	126	25	6.41	25	1.240	22.5	
6.45 to 7.2	Lexan Tube Sample S2.12	9.5	N/T	N/T	N/T	N/T	N/T	N/T	
7.2	Sample S2.15	0.8	141	25	6.21	25	1.401	19.1	
7.2 to 8.0	Lexan Tube Sample S2.13	13	N/T	N/T	N/T	N/T	N/T	N/T	
8.0	Sample S2.16	1	180	25	4.50	25	2.560	21.1	Calibration 3
	Total Weight Samples	68.3							
	Total Weight Tailings Samples	19.6							

*N/T - no tests

SOIL PROFILE

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Client: Allen Burgess (BHP)							
Project name:							
Drillhole No.	3	Drill Rig		Inclination		Easting	352582
Bedrock depth (m)	N/A	Location	Kalgoorlie	Type/Diameter	6"	Northing	6603441
Depth to water (m)	N/A	Project No.	BHP040	Geologist	DvdB	Final Depth (m)	8
Elevation (m)	379.844	Date Drilled	15/06/2009	Date Profiled	16/06/2009		

Depth from (m)	Depth to (m)	Soil Name	Description of the soil: Colour	Particle Description: Coarse -grained soil: Size	Particle Description: Coarse -grained soil: Shape	Clay-silt: Plasticity	Soil Conditions: Moisture condition (disturbed)	Soil Conditions: Consistency (disturbed)	Structure of Soil: Zoning (Disturbed Material)	Structure of Soil: Defects (Disturbed Material)	Structure of Soil: Cementing (Disturbed Material)	Additional observations: Mechanical deposition	Additional observations: Others	
0.0	0.5	ANGULAR TO SUB-ANGULAR COBBLES with some coarse gravel and sandy silt	light red-grey	poorly graded	angular to sub-angular		dry	very loose				waste rock capping		Samples taken as per BH3 testing summary table
0.5	1.0	SILTY SAND (SM) with medium to coarse sub-angular gravel	light red-grey	poorly graded	angular to sub-angular		dry	very loose				cover material		
1.0	2.0	SILTY CLAY (CL) with fine sub-angular calcite gravel	dark red-brown mottled white			medium	moist	stiff				cover material	Sample wettened during drilling	
2.0	2.7	ANGULAR TO SUB-ANGULAR COBBLES with some coarse gravel and sandy silt	light red-grey	poorly graded	angular to sub-angular		dry	very loose				cover material		
2.7	3.0	SILTY CLAY (CL) with fine sub-angular calcite gravel	dark red-brown mottled white			medium	moist	stiff				cover material	Compacted clay liner Sample wettened during drilling	
3.0	3.6	SILTY SAND (SM) with clay and fine sub-angular calcrete gravel	light red-brown	well graded	sub-angular		slightly moist	loose				cover material		
3.6	4.0	SILTY SAND (SM)	light red-orange	poorly graded			slightly moist	loose				tailings		
4.0	4.5	SILTY SAND (SM)	light red-orange	poorly graded			wet	loose				tailings	Sample wettened during drilling	Lexan Tube Samples
4.50	5.25	SILTY SAND (SM)	light red-orange	poorly graded			wet	firm				tailings	Sample wettened during drilling	
5.25	5.75	SANDY SILT (ML)	light red-orange	poorly graded			wet	firm				tailings	Sample wettened during drilling	
5.75	6.0	SILTY CLAY (CL) with fine sub-angular calcite gravel	dark red-brown mottled white			medium	moist	stiff				residual / borrow material	Compacted clay liner Sample wettened during drilling	
6.0	7.0	SILTY CLAY (CL) with fine sub-angular calcite gravel	dark red-brown mottled white			medium	moist	stiff				residual / borrow material	Compacted clay liner Sample wettened during drilling	
7.0	8.0	SILTY CLAY (CL) with fine sub-angular calcite gravel	dark red-brown mottled white			medium	wet	very stiff				residual / borrow material	Compacted clay liner Sample wettened during drilling	Sample

BH3 Testing Summary

Depth [m]	Description	Sample Weight [kg]	Redox (Eh) Reading [mV]	Redox (Eh) Temp [˚C]	pH Reading	pH Temp [˚C]	Conductivity Reading [mS]	Conductivity Temp [˚C]	Comment
1.0	Sample S3.1	1.8	131	25	7.59	25	3.320	17.3	Calibration 3
2.0	Sample S3.2	1	150	25	7.75	25	2.750	17.0	
3.0	Sample S3.3	2.4	139	25	8.08	25	3.090	16.3	
4.0	Sample S3.4 (Tailings)	1.2	127	25	9.22	25	2.710	14.9	
4.0 to 4.5	Lexan Tube Sample S3.11 (Tailings)	2.2	N/T	N/T	N/T	N/T	N/T	N/T	
4.5	Sample S3.5 (Tailings)	1.5	145	25	9.19	25	2.050	11.1	
4.5 to 5.25	Lexan Tube Sample S3.6 (Tested at 5.25m) (Tailings)	13	186	25	8.34	25	1.585	14.3	
5.25 to 5.75	Lexan Tube Sample S3.7 (Tailings)	10	N/T	N/T	N/T	N/T	N/T	N/T	
5.75 to 6.0	Bulk Sample S3.10	8.5	155	25	9.35	25	2.000	14.4	
6.0 to 7.0	Lexan Tube Sample S3.8 (Tested at 7m)	15	132	25	8.03	25	1.730	12.8	
8.0	Sample S3.9	1.5	152	25	8.05	25	1.731	11.8	Calibration 4
	Total Weight Samples	58.1							
	Total Weight Tailings Samples	27.9							

*N/T - no tests

Appendix 2: Laboratory Programme

Methods Used

Sealed Bottle Roll Tests:

The tests were carried out in glass bottles with Teflon inserts in the lids (to produce a good seal and prevent exchange headspace gases exchanging with atmospheric conditions).

The following procedure was adhered to as closely as possible:

1 Weigh out exactly 300 g of sample and add exactly 900 mL of solution (either de-ionised water or barren liquor solution).

2 Measure and record the pH, EC and redox conditions.

3 Seal vessel and place on shaker/rollers for a period of 72 hours.

4 Remove from shakers/rollers and allow solids to settle to provide a clear solution (allow about 1 to 2 hours).

5 Open vessel and decant clear solution.

6 Pour out a small aliquot (about 20 – 30 mL) and immediately record pH, redox and EC.

7 Filter balance of solution through a 0.45 um filtration.

8 Separate and preserve as per analytical laboratory requirements to complete the required analyses (Table A2.1).

9 Retain the final solid sample in a sealed bag in a cool environment until the solution analyses have been analysed.

Atmospheric Conditions:

Most tests were undertaken with air occupying the head space in the bottles. However, selected tests were undertaken using a gas mixture comprising 10%CO_2:90% air. During these latter tests, the bottles were sealed tightly to ensure minimal exchange with air outside the bottle. Filtering for these tests was complete under the same gas conditions, using the setup illustrated in Figure A2.1.

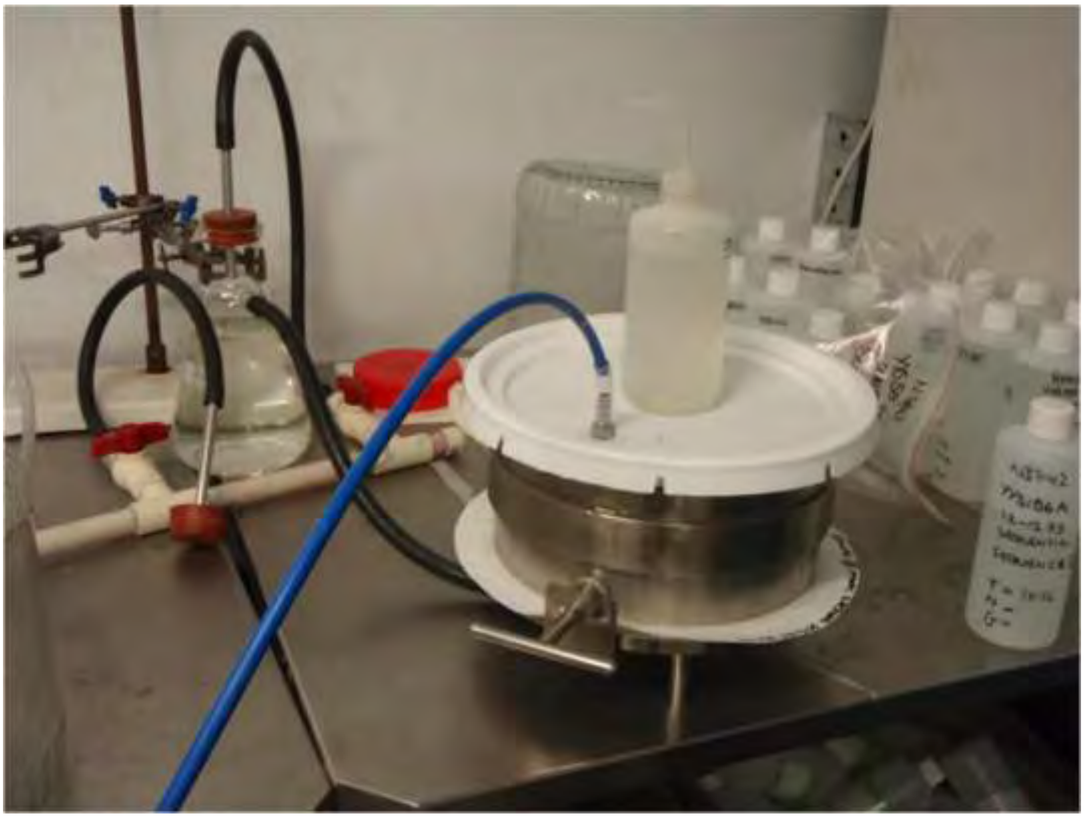


Figure A2.1: Filtering set up to ensure gas conditions remained at required CO_2 level during filtering

Sequential Atmospheric Test Procedure:

These tests were very similar to the sealed bottle roll tests described in the previous section. However, the solid was contacted by three successive volumes of solution as described in the method below.

The following procedure was adhered to as closely as possible:

1 Weigh out exactly 300 g of sample.

2 Add exactly 900 mL of deionised water.

3 Measure and record the pH, EC and redox conditions.

4 After 24 hours remove vessel from shakers/rollers and allow solids to settle to provide a clear solution.

5 Record the pH, EC and redox conditions.

6 Replace on shaker/rollers and repeat Step 4 at 48 hours.

7 At 72 hours remove the vessel from the shaker/rollers and record the pH, EC and redox conditions.

8 Allow the solids to settle and decant the clear solution.

9 Vacuum filter the slurry sample to remove the solution.

10 Filter the clear solution through a 0.45 um filtration and submit for analysis as shown in Table 1 (see Section 5; preserve as per analytical laboratory requirements).

11 Reslurry the sample in 900 mL deionised water.

12 Repeat Step 3 to 11 twice to generate three sequential leach solutions.

13 Retain the final solid sample in a sealed bag in a cool environment until the solution analyses have been analysed.

Column Tests

Four column pairs were set up to operate in series. The first column in each pair is open to air and operated such that the material drains down and the sample becomes unsaturated between flushing events. The second column is not open to air and maintained saturated with solution at all times. Effluent from the first column is used as inflow for the second column in that pair. The column set-up is shown schematically in Figure A2.2.

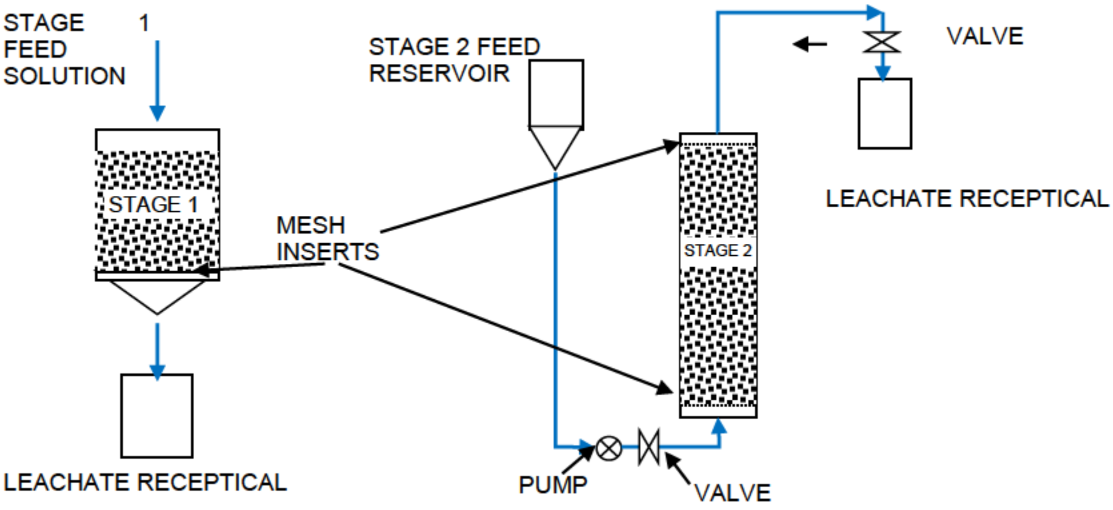


Figure A2.2: Schematic Diagram for Column Set-Up

The first stage columns had a diameter of 150 mm and a height of 300 mm. The base of the column was equipped with mesh to retain the solids in the column and a funnel shaped outlet to capture the leachate.

The top of the column was open to atmospheric conditions and had a capacity of about 7 kg of sample (filled to a height of about 250 mm).

The second stage columns had a diameter of 75 mm and a length of 500 mm. The column was sealed at the base and equipped with a removable lid with an airtight seal. Both ends of the column were equipped with an inlet/outlet respectively. The column had a capacity of about 3.5 kg, when filled, and an estimated porespace of about 700 mL. Figure A2.3 is a photograph of a saturated column.

The second stage saturated column was configured with up-flow to ensure saturated conditions are maintained. The column inlet and outlets were equipped with valves to ensure that atmospheric conditions were excluded to the extent possible. The second stage column was equipped with a pump to transfer solution from the inflow reservoir and displace the porewater from the saturated second stage column. Care was taken to not introduce air during the transfer.

Figure A2.3: Photograph of Saturated Column

The columns were loaded with the required sample quantities and sealed as required. The column operation was as follows:

1 Irrigate column 1 with approximately 1.5 L of water by distributing the flow evenly across the entire surface of the sample.

2 Allow the sample to drain and capture the leachate in the leachate receptacle. Measure pH, EC and redox conditions.

3 Remove approximately 700 mL of solution and place in second stage column feed reservoir. Filter the balance of the sample through 0.45 um filter medium, preserve as required and submit solution for required analysis.

4 Open the outlet valve of the second stage column. Open the inlet valve of the second stage column. Initiate the pump to draw stage 1 leachate solution from the reservoir to pass it through the second stage column. Terminate pumping while a few millilitres of solution remains in the reservoir to preclude air being drawn into the column. Close the inlet valve, close the outlet valve.

5 Measure the pH, EC and redox of the leachate. Filter the leachate sample through 0.45 um filter medium, preserve as required and submit solution for required analysis.

Operational difficulties were encountered with several of the columns. Unsaturated Column 1A was loaded with tailings (YC3). The tailings were found to absorb applied water and become virtually impermeable, resulting in extremely long drainage times. To overcome this difficulty, after each sequence the material was removed from the column and re-mixed prior to addition of solution in the next sequence. Nevertheless, drainage times got progressively longer after each sequence. By Sequence 5, it was taking more than a month for the column to drain. The column was terminated after Sequence 6.

Several of the saturated columns, in particular, Columns 1B and 4B were found to be of low permeability and would facilitate only very slow fluid flow. It was necessary to use a pump with a very slow flow rating and allow for long periods of time for each pore volume exchange. In Column 4B, the problem became progressively worse with each pore volume exchange sequence (probably due to Na exchange onto smectite clay, causing swelling, see discussion in main text). Column 4B was terminated after Sequence 3.

Quality Assurance and Control

The majority of data upon which this report is based were provided by either Amdel or Labmark, both of which are NATA accredited laboratories.

Data review by SRK consisted of comparing analytical results with expected values based on knowledge of material type, sample point of origin, and the experience of the reviewing geochemist. During data reviews, ‘common sense’ assessments of the data were undertaken to identify any gross errors that have resulted from inappropriate data handling or processing. Typical errors of this type might include shifting of columns relative to their headings, dilution errors and incorrect units (e.g. mg/L instead of µg/L), calculation errors, and sample labelling errors.

For some of the bottle rolls, duplicate tests were operated so that the reproducibility of the data obtained could be assessed:

- Sample YYS158 3.5 m - 3.75 m – de-ionised leach extraction test
- Sample YYS156A 0.7 m - 1.5 m – barren liquor contact test

Results from the duplicate tests showed very similar trends.

In addition to duplicate tests, several ‘blank’ bottle roll tests were undertaken so that leaching of elements from vessel walls could be assessed. Following these ‘blank’ tests, most elements were found to be indetectable in the resulting solutions. There was some evidence of small amounts of Ca, Mg, Na and K leaching from walls. The quantities were small relative to those leaching from the solids and so interpretations of the main dataset are not affected.

Appendix 3: Bulk Chemical Assays

The following appendix documents bulk chemical assay data for the samples studied as part of the current programme. Table A3.1 tabulates all assay results for the samples. Tables A3.2 and A3.3 compare the chemical characteristics of the samples with summary statistics calculated based on data contained within the BHP Billiton chemical database (as of 21st December 2009). In general, the chemistry of the samples studied in the current programme lie in the range shown by the Yeelirrie dataset as a whole.

Table A3.1: Bulk Chemical Assays

	Sample #	Material type	Al	Ca	CO2	F	Fe	K	Mg	Mn	Na	P	S	Si	SO4	TOC
			%	%	%	%	%	%	%	%	%	%	%	%	%	%
	Detection limit		0.01	0.01	0.07	0.002	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.05
	Detection limit (tails, aging tests)															
Yeelirrie	YYS156A 0.7-1.5	L/LT	2.06	16.8	14.2	0.44	0.98	0.47	5.77	<0.01	0.49	<0.01	4.49	11.6	6	0.05
Yeelirrie	YYS156A 1.5-2.5	LT	2.63	8.3	11.5	0.75	1.23	0.63	9.51	0.01	0.67	<0.01	2.05	17.9	3	0.15
Yeelirrie	YYS156A 11.25-12	CQ	9.48	0.14	0.2	0.08	4.11	1.66	1	0.02	0.64	0.01	0.07	27.4	0.1	0.05
Yeelirrie	YYS156A 12-12.75	CQ	8.75	0.14	0.2	0.07	3.44	1.43	1.64	0.02	0.67	0.02	0.09	29.1	0.2	<0.05
Yeelirrie	YYS156A 3-4	LT	3.81	11.2	23	0.46	1.55	0.7	9.93	<0.01	0.45	<0.01	<0.01	13.2	0.1	0.05
Yeelirrie	YYS157 3.65-4.1	TCQ	3.6	15.6	18.5	0.17	1.67	0.65	3.01	0.02	0.21	0.02	0.03	18.1	0.15	<0.05
Yeelirrie	YYS158 2.5-3.5	LT	0.37	15.7	31.5	0.54	0.2	0.19	11.4	<0.01	0.35	<0.01	0.04	10.8	0.1	0.1
Yeelirrie	YYS158 3.5-3.75	T	0.13	16.8	34.6	0.59	0.1	0.12	12.4	<0.01	0.36	<0.01	0.01	7.98	0.15	0.1
Yeelirrie	YYS158 3.75-4.5	T	0.22	17.4	37.6	0.42	0.16	0.11	12.2	<0.01	0.25	<0.01	0.03	5.86	<0.05	0.05
Yeelirrie	YYS159 4.5-5.2	TCQ/CQT	7.19	0.98	1.5	0.19	3.03	1.41	2.28	0.1	0.35	0.01	0.01	29.8	<0.05	<0.05
Yeelirrie	YYS162 4.5-4.5 m	TCQ	2.9	0.61	0.8	0.21	0.99	1.49	2.33	<0.01	0.57	<0.01	0.04	37	0.15	0.05
Yeelirrie	YYS163 23 -23.1m	CQ	10.8	0.08	0.1	0.09	4.06	2.08	1.66	0.02	0.54	0.01	0.11	25.9	0.4	<0.05
Yeelirrie	YYS164 26.2-26.3 m	CQ	4.88	0.04	<0.07	0.02	1.6	1.4	0.22	<0.01	0.32	<0.01	0.04	37.8	<0.05	0.15
Yeelirrie	YYS164 4.3-3.3 m	LT	8.44	0.17	0.2	0.1	3.38	1.53	1.08	0.02	0.54	<0.01	0.1	29.3	0.1	<0.05
Yeelirrie	YYS164 5.2-5.3 m	CQT	8.39	0.24	0.5	0.05	3.22	1.71	1.29	0.03	0.4	0.01	0.03	30.7	<0.05	<0.05
Yeelirrie	YYS165 1.5 - 1.6 m	HT	2.54	14.3	17.4	0.33	1.11	0.59	5.85	<0.01	0.13	0.02	0.08	18	0.3	<0.05
Yeelirrie	YYS165 6.6-6.7 m	CQ	4.32	0.09	0.1	0.13	1.93	1.19	1.16	0.03	0.32	<0.01	0.03	36.8	0.05	<0.05
Yeelirrie	YYS166 0.4 - 0.5 m	H	5.63	0.05	0.4	0.01	2.31	1.36	0.35	0.03	0.2	<0.01	0.03	36.1	0.4	<0.05
Yeelirrie	YYS167 2.3 - 2.4 m	LQT	4.63	12.2	15.4	0.13	1.98	1.12	2.96	0.01	0.36	0.02	0.07	20.3	<0.05	0.05
Yeelirrie	YYS167 23 - 23.1 m	CQ	6.25	0.05	0.1	0.05	2.4	1	0.52	0.01	0.35	<0.01	0.06	35.1	0.1	<0.05
Yeelirrie	YYHC0075	Palaeochannel sands	1.23	0.11	0.2	0.01	0.68	0.1	0.05	<0.01	0.16	<0.01	0.06	41.8	0.05	0.05
Yeelirrie	YYHC0059C	Palaeochannel sands	1.35	0.05	0.2	0.02	0.67	0.09	0.09	<0.01	0.51	<0.01	0.09	41.4	0.1	<0.05
Tails	YM0015	Tails (aging test)	8.99	0.42	1.41		3.53	1.58	1.72	0.02	1.24	<0.01	0.05	28.36		
Tails	YM0046	Tails (aging test)	1.61	13.77	24.09		0.72	0.4	9.37	<0.01	1.12	<0.01	0.08	13.28		
Tails	YM0074	Tails (aging test)	10.64	0.35	1.16		4.31	1.69	1.66	0.02	1.2	0.01	0.05	27.05		
Tails	YM0076	Tails (aging test)	1.61	17.69	35.98		0.73	0.31	10.83	0.03	0.37	0.01	0.03	6.64		
Tail	YC003 Leach Residue	Tails	5.48	6.85	12.3	0.26	2.4	1.04	5.17	0.03	1.45	0.02	0.04	20.3	0.15	0.05
Kalgoorlie	S1.8 (4 m)	Tails	4.28	8.27	15.4	0.312	1.89	0.84	4.88	0.01	0.69	<0.01	<0.01	20.1	0.55	0.1
Kalgoorlie	S1.9 (4-4.5 m)	Tails	3.78	8.32	14.3	0.218	2.02	0.86	4.74	0.01	0.55	0.01	0.07	22.6	0.1	0.1

	Sample #	**Material type**	**Al**	**Ca**	**CO2**	**F**	**Fe**	**K**	**Mg**	**Mn**	**Na**	**P**	**S**	**Si**	**SO4**	**TOC**
			%	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
	Detection limit		0.01	0.01	0.07	0.002	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.05
	Detection limit (tails, aging tests)															
Kalgoorlie	S2.10 (6 m)	Underlying soil	9.59	0.31	0.9	0.05	20	0.32	0.39	0.01	0.64	0.01	0.06	17.7	0.1	<0.05
Kalgoorlie	S2.11 (6-6.75 m)	Underlying soil	10.5	0.21	0.8	0.042	16.7	0.25	0.31	<0.01	0.59	<0.01	0.05	19	0.1	0.05
Kalgoorlie	S2.14 (4-4.5 m)	Tails	5.57	8.41	14.1	0.254	5.29	0.81	5.54	0.02	1.1	0.01	0.07	17.3	0.1	0.2
Kalgoorlie	S2.8 (4.5-5.25 m)	Tails	4.18	8.46	16	0.25	1.84	0.9	5.22	0.02	0.76	0.01	0.02	20.4	0.2	0.05
Kalgoorlie	S2.9 (5.25-6 m)	Underlying soil	6.31	7.57	13	0.226	7	0.62	4.97	0.01	1.2	<0.01	0.07	16	0.7	0.15
Kalgoorlie	S3.10 (5.75-6 m)	Underlying soil	5.81	5.77	6.1	0.034	14	0.16	2.21	0.15	1.02	0.06	0.3	20.5	<0.05	<0.05
Kalgoorlie	S3.11 (3.75 m)	Tails	3	6.92	13.1	0.254	1.37	0.86	3.86	0.01	0.37	<0.01	0.02	25.9	0.1	0.05
Kalgoorlie	S3.6 (4.5-5.25 m)	Tails	5.44	4.66	4.5	0.034	16	0.12	1.82	0.17	1.22	0.05	0.27	20.6	<0.05	0.1
Kalgoorlie	S3.7 (5.3-5.75 m)	Tails	2.99	7.98	15.2	0.202	2.58	0.69	4.32	0.02	0.41	<0.01	0.02	23	0.15	0.1
Kalgoorlie	S3.8 (6-7 m)	Underlying soil	11.4	0.47	1	0.018	14.5	0.17	0.34	0.01	0.48	<0.01	0.06	18.8	<0.05	<0.05
Kalgoorlie	S3.9 (8 m)	Underlying soil	16.4	0.08	0.5	0.01	4.11	0.08	0.22	<0.01	0.35	<0.01	0.16	21.3	0.15	0.1

	Sample #	Material type	Ag	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu	Hg	Li	Mo
			(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
	Detection limit		0.05	0.5	100	10	0.5	0.1	0.1	1	0.2	20	0.5	0.05	4	0.1
	Detection limit (tails, aging tests)						200				100					
Yeelirrie	YYS156A 0.7-1.5	L/LT	<0.05	11.5	100	60	<0.5	<0.1	<0.1	18	3	30	11.5	<0.05	10	1.4
Yeelirrie	YYS156A 1.5-2.5	LT	<0.05	8.5	<100	75	<0.5	<0.1	<0.1	20	4	45	17.5	<0.05	10	2.4
Yeelirrie	YYS156A 11.25-12	CQ	<0.05	21.5	200	250	1.5	0.3	<0.1	70	6	95	30.5	<0.05	20	8
Yeelirrie	YYS156A 12-12.75	CQ	<0.05	13.5	100	220	1	0.2	<0.1	55	4.6	80	19.5	<0.05	15	6.5
Yeelirrie	YYS156A 3-4	LT	<0.05	9.5	<100	40	0.5	<0.1	<0.1	24	4	45	20.5	<0.05	10	2.8
Yeelirrie	YYS157 3.65-4.1	TCQ	<0.05	3.5	<100	100	0.5	0.1	<0.1	23	4.4	50	18.5	<0.05	10	2
Yeelirrie	YYS158 2.5-3.5	LT	<0.05	1.5	<100	40	<0.5	<0.1	<0.1	2	0.8	<20	10	<0.05	5	0.9
Yeelirrie	YYS158 3.5-3.75	T	<0.05	1	<100	20	<0.5	<0.1	<0.1	<1	0.6	<20	7	<0.05	5	1.9
Yeelirrie	YYS158 3.75-4.5	T	<0.05	0.5	<100	50	<0.5	<0.1	<0.1	4	0.6	<20	4	<0.05	5	1.1
Yeelirrie	YYS159 4.5-5.2	TCQ/CQT	<0.05	8.5	100	295	1	0.2	<0.1	36	10.5	80	29.5	<0.05	20	4.5
Yeelirrie	YYS162 4.5-4.5 m	TCQ	<0.05	3	<100	315	0.5	<0.1	<0.1	16	2.8	45	8	<0.05	<4	2.1
Yeelirrie	YYS163 23 -23.1 m	CQ	<0.05	3	<100	205	2	0.3	<0.1	60	8	100	31	<0.05	25	1.5
Yeelirrie	YYS164 26.2-26.3 m	CQ	<0.05	4	<100	315	0.5	0.1	<0.1	27	1.8	45	15	<0.05	25	5.5
Yeelirrie	YYS164 4.3-3.3 m	LT	<0.05	3	<100	285	2	0.2	<0.1	47	6.5	115	19.5	<0.05	25	2.2
Yeelirrie	YYS164 5.2-5.3 m	CQT	<0.05	4	<100	290	1	0.2	<0.1	48	6.5	85	22	<0.05	20	1.9
Yeelirrie	YYS165 1.5 - 1.6 m	HT	<0.05	5	<100	125	0.5	<0.1	<0.1	15	3.4	40	13	<0.05	<4	0.6
Yeelirrie	YYS165 6.6-6.7 m	CQ	<0.05	5	<100	335	1	0.1	<0.1	31	7	70	14	<0.05	<4	2.2
Yeelirrie	YYS166 0.4 - 0.5 m	H	<0.05	3	<100	415	1	0.2	<0.1	36	9.5	70	20	<0.05	15	3.4
Yeelirrie	YYS167 2.3 - 2.4 m	LQT	<0.05	5	<100	320	1	0.1	<0.1	26	4.8	55	17	<0.05	<4	1.7
Yeelirrie	YYS167 23 - 23.1 m	CQ	<0.05	2	<100	290	0.5	0.1	<0.1	36	2.4	70	11	<0.05	20	2.1
Yeelirrie	YYHC0075	Palaeochannel sands	0.05	0.5	--	65	0.5	0.1	<0.1	39	1	105	8.5	<0.05	15	2.1
Yeelirrie	YYHC0059C	Palaeochannel sands	0.25	1	--	60	<0.5	<0.1	<0.1	145	1.8	140	20	<0.05	<4	2.3
Tails	YM0015	Tails (aging test)	<0.05	15.16		400		0.22	<0.1	<100	7.07	137	23.24			5.34
Tails	YM0046	Tails (aging test)	0.05	2.98		<200		<0.1	<0.1	<100	2.86	52	18.76			3.43
Tails	YM0074	Tails (aging test)	<0.05	21.21		400		0.27	<0.1	<100	7.47	128	27.98			5.58
Tails	YM0076	Tails (aging test)	<0.05	2.42		<200		<0.1	<0.1	<100	3.67	76	17.2			5.4
Tail	YC003 Leach Residue	Tails	0.1	15.5	100	230	1	0.2	<0.1	32	6	130	23.5	<0.05	15	13
Kalgoorlie	S1.8 (4 m)	Tails	0.05	13.5	35	210	<0.05	0.2	<0.1	26	4.4	60	21.5	<0.05	5	1.8
Kalgoorlie	S1.9 (4-4.5 m)	Tails	0.05	11	45	235	1	0.1	<0.1	22	3.8	55	16	<0.05	10	2.3
Kalgoorlie	S2.10 (6 m)	Underlying soil	<0.05	15	55	175	0.5	0.3	<0.1	8	5.5	495	22.5	<0.05	5	2.6

	Sample #	Material type	Ag	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cu	Hg	Li	Mo
			(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
	Detection limit		0.05	0.5	100	10	0.5	0.1	0.1	1	0.2	20	0.5	0.05	4	0.1
	Detection limit (tails, aging tests)						200				100					
Kalgoorlie	S2.11 (6-6.75 m)	Underlying soil	<0.05	12	70	125	<0.05	0.3	<0.1	7	6	440	25	<0.05	10	3
Kalgoorlie	S2.14 (4-4.5 m)	Tails	0.1	16	60	205	1	0.3	<0.1	31	8	130	25	<0.05	5	2.1
Kalgoorlie	S2.8 (4.5-5.25 m)	Tails	<0.05	10.5	45	250	1	0.2	<0.1	25	4.4	50	23.5	0.05	5	1.7
Kalgoorlie	S2.9 (5.25-6 m)	Underlying soil	<0.05	10.5	85	165	0.5	0.2	<0.1	22	7.5	190	18.5	<0.05	5	1.6
Kalgoorlie	S3.10 (5.75-6 m)	Underlying soil	0.2	10.5	105	65	0.5	<0.1	<0.1	16	47.5	135	55	<0.05	20	1.9
Kalgoorlie	S3.11 (3.75 m)	Tails	<0.05	13.5	50	230	<0.05	0.2	<0.1	19	2.8	40	19	<0.05	<4	1.8
Kalgoorlie	S3.6 (4.5-5.25 m)	Tails	0.2	11.5	110	60	0.5	<0.1	<0.1	17	47	130	41.5	<0.05	20	1.4
Kalgoorlie	S3.7 (5.3-5.75 m)	Tails	0.05	10.5	55	240	<0.05	0.2	<0.1	20	5.5	70	18	<0.05	<4	1.8
Kalgoorlie	S3.8 (6-7 m)	Underlying soil	<0.05	8.5	160	130	<0.05	0.2	<0.1	6	10.5	365	20	<0.05	10	1.8
Kalgoorlie	S3.9 (8 m)	Underlying soil	<0.05	1	270	100	<0.05	<0.1	<0.1	4	7.5	215	9.5	<0.05	20	0.5

	Sample #	Material type	Ni	Pb	Sb	Sc	Se	Sn	Sr	Th	Tl	U3O8	V	W	Y	Zn
			(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
	Detection limit		1	0.5	0.1	5	0.5	10	5	4	3	4	20	3	1	0.5
	Detection limit (tails, aging tests)															
Yeelirrie	YYS156A 0.7-1.5	L/LT	11	5	<0.1	<5	0.5	<10	700	5	<3	235	85	<3	7	18
Yeelirrie	YYS156A 1.5-2.5	LT	11	7	<0.1	<5	<0.5	<10	355	5	<3	700	165	<3	7	700
Yeelirrie	YYS156A 11.25-12	CQ	15	16.5	0.2	10	<0.5	<10	55	25	<3	70	175	<3	19	46
Yeelirrie	YYS156A 12-12.75	CQ	13	12.5	0.1	10	<0.5	<10	50	20	<3	65	145	<3	13	125
Yeelirrie	YYS156A 3-4	LT	12	6.5	<0.1	5	<0.5	<10	430	10	<3	1100	245	<3	7	34.5
Yeelirrie	YYS157 3.65-4.1	TCQ	14	5.5	<0.1	5	<0.5	<10	280	10	<3	140	60	<3	6	46.5
Yeelirrie	YYS158 2.5-3.5	LT	5	1.5	<0.1	<5	<0.5	<10	500	<4	<3	195	60	<3	<1	145
Yeelirrie	YYS158 3.5-3.75	T	5	1	<0.1	<5	1	<10	550	<4	<3	55	50	<3	<1	265
Yeelirrie	YYS158 3.75-4.5	T	5	1	<0.1	<5	0.5	<10	600	<4	<3	150	75	<3	<1	27
Yeelirrie	YYS159 4.5-5.2	TCQ/CQT	17	9.5	0.2	10	<0.5	<10	80	15	<3	10	120	<3	11	85
Yeelirrie	YYS162 4.5-4.5 m	TCQ	7	3.5	<0.1	<5	<0.5	<10	75	5	<3	45	65	<3	3	14
Yeelirrie	YYS163 23 -23.1 m	CQ	20	14	0.1	15	<0.5	<10	1000	30	<3	15	65	<3	15	38.5
Yeelirrie	YYS164 26.2-26.3 m	CQ	8	15.5	0.1	5	<0.5	<10	40	20	<3	5	45	<3	7	9.5
Yeelirrie	YYS164 4.3-3.3 m	LT	15	13	0.1	10	<0.5	<10	65	15	<3	15	60	<3	13	29.5
Yeelirrie	YYS164 5.2-5.3 m	CQT	14	10.5	0.1	10	<0.5	<10	60	15	<3	20	60	<3	11	37.5
Yeelirrie	YYS165 1.5 - 1.6 m	HT	13	4.5	0.1	<5	<0.5	<10	290	5	<3	165	35	<3	5	18
Yeelirrie	YYS165 6.6-6.7 m	CQ	10	7.5	<0.1	5	<0.5	<10	45	10	<3	10	50	4	9	21
Yeelirrie	YYS166 0.4 - 0.5 m	H	12	9.5	0.1	5	<0.5	<10	50	10	<3	15	45	<3	11	17.5
Yeelirrie	YYS167 2.3 - 2.4 m	LQT	16	7.5	<0.1	5	<0.5	<10	450	5	<3	160	60	<3	9	25
Yeelirrie	YYS167 23 - 23.1 m	CQ	9	8	<0.1	10	<0.5	<10	30	20	<3	15	40	8	11	15
Yeelirrie	YYHC0075	Palaeochannel sands	3	31.5	<0.1	<5	<0.5	<10	10	15	<3	5	<20	<3	13	17.5
Yeelirrie	YYHC0059C	Palaeochannel sands	4	23	<0.1	<5	0.5	<10	35	15	<3	5	<20	10	17	37
Tails	YM0015	Tails (aging test)	45	15.81	0.1	11	<0.5		5560	19.61		226	222		11	40.9
Tails	YM0046	Tails (aging test)	28	5.07	<0.1	<5	<0.5		928	3.07		64.4	84		<10	19.26
Tails	YM0074	Tails (aging test)	46	17.18	<0.1	14	<0.5		4713	20.22		63.68	177		13	45.53
Tails	YM0076	Tails (aging test)	36	4.79	<0.1	<5	<0.5		8184	3.14		90.97	49		<10	12.68
Tail	YC003 Leach Residue	Tails	60	9	0.1	10	<0.5	<10	2100	15	<3	180	230	<3	9	37
Kalgoorlie	S1.8 (4 m)	Tails	13	36.5	<0.1	5	<0.5	<10	2300	10	<3	230	375	<3	7	45
Kalgoorlie	S1.9 (4-4.5 m)	Tails	13	20.5	<0.1	5	<0.5	<10	1800	10	<3	180	210	<3	7	180
Kalgoorlie	S2.10 (6 m)	Underlying soil	22	18	0.4	35	0.5	<10	105	10	<3	215	550	<3	11	185

	Sample #	**Material type**	**Ni**	**Pb**	**Sb**	**Sc**	**Se**	**Sn**	**Sr**	**Th**	**Tl**	**U3O8**	**V**	**W**	**Y**	**Zn**
			(ppm)	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**
	Detection limit		1	0.5	0.1	5	0.5	10	5	4	3	4	20	3	1	0.5
	Detection limit (tails, aging tests)															
Kalgoorlie	S2.11 (6-6.75 m)	Underlying soil	24	9.5	0.3	35	1	<10	95	5	<3	185	475	<3	11	30
Kalgoorlie	S2.14 (4-4.5 m)	Tails	26	400	0.2	10	0.5	<10	1800	15	<3	360	420	<3	8	120
Kalgoorlie	S2.8 (4.5-5.25 m)	Tails	28	225	<0.1	5	<0.5	<10	2900	10	<3	160	195	<3	7	70
Kalgoorlie	S2.9 (5.25-6 m)	Underlying soil	33	205	0.2	15	0.5	<10	900	10	<3	450	340	<3	8	34
Kalgoorlie	S3.10 (5.75-6 m)	Underlying soil	26	115	0.3	45	<0.5	<10	150	<4	<3	15	290	4	28	280
Kalgoorlie	S3.11 (3.75 m)	Tails	9	215	<0.1	<5	<0.5	<10	1200	10	<3	250	210	<3	5	23.5
Kalgoorlie	S3.6 (4.5-5.25 m)	Tails	21	25.5	0.4	50	<0.5	<10	135	<4	<3	15	280	6	34	130
Kalgoorlie	S3.7 (5.3-5.75 m)	Tails	13	200	0.1	5	<0.5	<10	1300	5	<3	205	185	<3	6	41.5
Kalgoorlie	S3.8 (6-7 m)	Underlying soil	38	7	0.3	35	0.5	<10	20	15	<3	125	410	<3	16	30.5
Kalgoorlie	S3.9 (8 m)	Underlying soil	25	3	<0.1	30	<0.5	<10	15	10	<3	5	175	4	24	70

Table A3.2: Bulk chemical assay data compared to BHP Billiton chemical database – major elements

Lithology	Element	Al	Ca	Fe	K	Mg	Mn	Na	P	S	Si
	Units	%	%	%	%	%	%	%	%	%	%
Average crustal abundance (Bowen, 1979)		8.2	4.1	4.1	2.1	2.3	0.095	2.3	0.1	0.026	27.7
Summary Statistics taken from BHPBilliton chemical database. SRK sample details given below (grey highlight)											
Loam (L)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	P5	2.3	0.1	1.1	0.6	0.5	0.010	0.2	0.01	0.050	13.5
	Median	4.7	1.4	2.3	1.2	3.9	0.030	0.5	0.01	0.135	25.4
	Mean	4.5	4.0	2.1	1.1	4.8	0.026	0.8	0.01	1.717	25.0
	P95	6.7	12.5	3.0	1.5	9.2	0.050	2.0	0.02	6.891	35.9
	Max	6.7	14.8	3.3	1.6	10.2	0.050	2.0	0.03	7.350	36.9
	n	18	18	18	18	18	18	18	18	18	18
	Stdev	1	4.8	0.7	0.3	3.4	0.012	0.6	0.0	2.545	8.2
L/LT	YYS156 0.7 m - 1.5 m	2.06	16.8	0.98	0.47	5.77	<0.01	0.49	<0.01	6	11.6
Carbonated loam (LT)	Min	0.1	0.1	0.1	0.1	0.3	0.005	0.1	0.005	0.005	2.3
	P5	0.9	2.5	0.4	0.3	1.6	0.005	0.2	0.005	0.060	7.9
	Median	2.4	12.4	1.2	0.6	5.8	0.010	0.5	0.005	2.490	15.2
	Mean	2.8	12.1	1.3	0.6	6.0	0.011	0.6	0.010	3.740	15.8
	P95	6.0	20.4	2.7	1.2	11.3	0.030	1.2	0.020	11.572	25.7
	Max	12.7	25.8	4.7	1.8	13.8	0.160	2.5	0.1	20.690	35.6
	n	1417	1417	1417	1417	1417	1417	1417	1417	1417	1417
	Stdev	2	5.5	0.7	0.3	3.0	0.009	0.3	0.0	3.942	5.5
LT	YYS156A 3 m – 4 m	4	11	2	1	10	<0.01	0.5	<0.01	0.1	13
LT	YYS156A 1.5 m - 2.5 m	3	8	1	1	10	0.01	1	<0.01	3	18
LT	YYS164 4.3 m - 4.4 m	8	0.2	3	2	1	0.02	1	<0.01	0.1	29
L/LT	YYS156 0.7 m - 1.5 m	2.06	16.8	0.98	0.47	5.77	<0.01	0.49	<0.01	6	11.6
Quartz-rich loam (LQ)	Min	2.5	0.1	1.2	0.7	0.1	0.005	0.1	0.005	0.010	19.5
	P5	3.2	0.1	1.6	0.8	0.1	0.010	0.2	0.005	0.014	23.0
	Median	4.5	0.2	2.0	1.2	0.5	0.020	0.3	0.010	0.050	35.1
	Mean	4.8	1.0	2.2	1.2	1.2	0.028	0.4	0.012	0.375	34.3
	P95	7.4	4.9	3.2	1.6	5.8	0.050	0.9	0.020	2.563	39.2
	Max	7.4	12.4	3.3	1.7	7.9	0.080	2.0	0.020	4.750	39.8
	n	28	28	28	28	28	28	28	28	28	28
	Stdev	1	2.6	0.6	0.3	2.0	0.016	0.4	0.0	1.087	5.0

Lithology	Element	Al	Ca	Fe	K	Mg	Mn	Na	P	S	Si
	Units	%	%	%	%	%	%	%	%	%	%
Average crustal abundance (Bowen, 1979)		8.2	4.1	4.1	2.1	2.3	0.095	2.3	0.1	0.026	27.7
Summary Statistics taken from BHPBilliton chemical database. SRK sample details given below (grey highlight)											
LQT	YYS167 2.3 m - 2.4 m	5	12.2	2.0	1.1	3.0	0.010	0.4	0.02	<0.05	20.3
Carbonated-quartz-rich loam (LQT)	Min	0.2	0.03	0.1	0.2	0.1	0.005	0.1	0.005	0.005	5.4
	P5	1.2	0.3	0.6	0.3	0.9	0.005	0.2	0.005	0.040	11.0
	Median	3.4	7.7	1.6	0.8	4.2	0.020	0.4	0.010	0.185	21.4
	Mean	3.9	8.6	1.8	0.8	4.7	0.018	0.5	0.012	1.685	21.6
	P95	8.2	19.6	3.5	1.4	9.9	0.040	1.2	0.030	7.727	34.1
	Max	9.7	26.5	4.6	1.9	12.3	0.080	2.5	0.1	15.270	39.8
	n	482	482	482	482	482	482	482	482	482	482
	Stdev	2	6.2	0.9	0.3	2.9	0.013	0.3	0.008	2.773	7.2
LQT	YYS167 2.3 m - 2.4 m	5	12.2	2.0	1.1	3.0	0.010	0.4	0.02	<0.05	20.3
Carbonated hardpan (HT)	Min	1.9	0.5	0.8	0.4	1.0	0.005	0.1	0.01	0.010	14.1
	P5	2.6	0.8	1.1	0.5	1.1	0.009	0.2	0.01	0.017	15.1
	Median	7.5	2.6	3.1	1.2	2.6	0.040	0.3	0.02	0.060	25.2
	Mean	6.7	5.0	2.9	1.1	3.1	0.032	0.3	0.02	0.108	24.4
	P95	9.3	15.1	4.1	1.4	7.1	0.050	0.5	0.02	0.346	30.6
	Max	9.7	16.9	4.1	1.5	7.5	0.050	0.6	0.02	0.710	30.8
	n	15	15	15	15	15	15	15	15	15	15
	Stdev	2	5.1	1.0	0.3	2.0	0.015	0.1	0.01	0.172	5.1
HT	YYS165 1.5 m - 1.6 m	3	14.3	1.1	0.6	5.9	<0.01	0.1	0.02	0.300	18.0
Calcrete (T)	Min	0.0	0.1	0.0	0.0	1.9	0.005	0.1	0.005	0.005	2.1
	P5	0.1	7.8	0.1	0.1	5.4	0.005	0.2	0.005	0.020	5.8
	Median	1.0	16.5	0.4	0.3	9.9	0.005	0.5	0.010	0.090	10.7
	Mean	1.2	16.1	0.5	0.4	9.5	0.010	0.5	0.009	0.352	11.4
	P95	3.4	23.6	1.4	0.8	12.4	0.030	0.9	0.020	1.999	18.9
	Max	8.2	28.6	3.9	1.8	14.6	0.090	1.7	0.180	12.380	39.0
	n	1402	1402	1402	1402	1402	1402	1402	1402	1402	1402
	Stdev	1	4.7	0.5	0.2	2.2	0.010	0.2	0.0	1.003	4.4

Lithology	**Element**	**Al**	**Ca**	**Fe**	**K**	**Mg**	**Mn**	**Na**	**P**	**S**	**Si**
	Units	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Average crustal abundance (Bowen, 1979)		8.2	4.1	4.1	2.1	2.3	0.095	2.3	0.1	0.026	27.7
Summary Statistics taken from BHPBilliton chemical database. SRK sample details given below (grey highlight)											
T	YYS158 3.75 m - 4.75 m	0.2	17.4	0.2	0.1	12.2	<0.01	0.3	<0.01	<0.05	5.9
T	YYS158 3.5 m - 3.75 m	0.1	16.8	0.1	0.1	12.4	<0.01	0.4	<0.01	0.150	8.0
Transition calcrete (TCQ)	Min	0.1	0.04	0.1	0.1	0.4	0.005	0.1	0.005	0.005	3.3
	P5	0.6	0.2	0.3	0.2	1.8	0.005	0.2	0.005	0.020	6.1
	Median	2.7	13.1	1.2	0.6	8.1	0.020	0.4	0.010	0.080	13.2
	Mean	3.4	12.1	1.5	0.7	7.5	0.020	0.5	0.010	0.417	14.6
	P95	8.8	20.8	3.6	1.5	11.5	0.060	0.8	0.020	2.649	27.5
	Max	13.2	30.0	5.1	2.3	14.4	0.710	1.2	0.1	11.160	37.9
	n	2084	2084	2084	2084	2084	2084	2084	2084	2084	2084
	Stdev	3	6.2	1.0	0.4	2.9	0.025	0.2	0.006	1.152	6.8

Lithology	Element	Al	Ca	Fe	K	Mg	Mn	Na	P	S	Si
	Units	%	%	%	%	%	%	%	%	%	%
Average crustal abundance (Bowen, 1979)		8.2	4.1	4.1	2.1	2.3	0.095	2.3	0.1	0.026	27.7
Summary Statistics taken from BHPBilliton chemical database. SRK sample details given below (grey highlight)											
TCQ	YYS162 4.5 m - 4.6 m	3	0.6	1.0	1.5	2.3	<0.01	0.6	<0.01	0.150	37.0
TCQ	YYS157 3.65 m - 4.1 m	4	15.6	1.7	0.7	3.0	0.020	0.2	0.02	0.150	18.1
TCQ/CQT	YYS159 4.5 m - 5.2 m	7	1.0	3.0	1.4	2.3	0.100	0.4	0.01	<0.05	29.8
Carbonated Clay-Quartz (CQT)	Min	1.0	0.005	0.4	0.3	0.1	0.005	0.2	0.005	0.005	6.1
	P5	4.4	0.1	1.9	1.1	0.4	0.010	0.3	0.005	0.030	19.9
	Median	8.3	0.1	3.5	1.5	1.0	0.020	0.5	0.010	0.080	29.0
	Mean	8.2	0.7	3.4	1.5	1.4	0.019	0.5	0.013	0.193	28.8
	P95	12.0	4.7	4.8	1.8	4.3	0.030	0.7	0.030	0.600	36.5
	Max	14.1	23.1	6.3	2.5	11.4	0.350	1.2	0.1	10.230	40.8
	n	6281	6281	6281	6281	6281	6281	6281	6281	6281	6281
	Stdev	2	2.3	0.9	0.2	1.4	0.015	0.1	0.01	0.624	5.2
CQT	YYS164 5.2 m - 5.3 m	8	0.2	3.2	1.7	1.3	0.030	0.4	0.01	<0.05	30.7
TCQ/CQT	YYS159 4.5 m - 5.2 m	7	1.0	3.0	1.4	2.3	0.100	0.4	0.01	<0.05	29.8
Clay Quartz (CQ)	Min	2.6	0.005	1.0	0.6	0.2	0.005	0.2	0.005	0.005	11.3
	P5	4.7	0.1	1.9	1.2	0.3	0.005	0.3	0.005	0.040	24.1
	Median	8.7	0.1	3.5	1.6	0.8	0.020	0.5	0.010	0.080	29.5
	Mean	8.4	0.1	3.4	1.5	0.9	0.019	0.5	0.011	0.121	29.9
	P95	11.9	0.1	4.8	1.8	1.7	0.030	0.8	0.020	0.170	36.6
	Max	14.4	13.3	6.1	2.5	9.8	0.440	2.4	0.1	8.480	40.4
	n	2571	2571	2571	2571	2571	2571	2571	2571	2571	2571
	Stdev	2	0.5	0.9	0.2	0.5	0.022	0.1	0.01	0.333	4.0
CQ	YYS156A 12 m - 12.75 m	9	0.1	3.4	1.4	1.6	0.020	0.7	0.02	0.200	29.1
CQ (poss channel sand)	YYS163 23 m - 23.1 m	11	0.1	4.1	2.1	1.7	0.020	0.5	0.01	0.400	25.9

Table A3.3: Bulk chemical assay data compared to BHP Billiton chemical database – minor and trace elements

Lithology	Element	Ag	As	Ba	Co	Cr	Cu	Mo	Ni	Pb	Sr	U_3O_8	V	Zn
	Units	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Average crustal abundance (Bowen, 1979)		0.07	1.5	0.05	20	100	50	1.5	80	14	370	2.8	160	75
Summary Statistics taken from BHPBilliton chemical database. SRK sample details given below (grey highlight)														
Loam (L)	Min	0.00	0.0	0.00	0	0	0	0	0	0	0	0	0	0
	P5	0.25	2.0	0.01	3	29	9	0.5	11	7	35	15.9	42	18
	Median	0.25	4.0	0.01	5	68	16	2.0	15	10	143	37.5	61	30
	Mean	0.25	7.1	0.01	5	63	17	1.9	15	10	303	97.5	74	31
	P95	0.25	16.0	0.03	7	92	33	3.6	19	13	852	286	113	46
	Max	0.25	16.0	0.03	8	99	35	7.0	20	16	954	294	115	47
	n	18	18	18	18	18	18	18	18	18	18	18	18	18
	Stdev	0	5.3	0.01	1	23	7	1.5	4	2	302	104	30	11
L/LT	YYS156 0.7 m - 1.5 m	<0.05	11.5	0.006	3	30	11.5	1.4	11	5	700	235	85	18
Carbonated loam (LT)	Min	0.25	0.5	0.01	1	10	2	0.5	1	2	56	2.0	5	2
	P5	0.25	3.0	0.01	1	10	6	0.5	4	3	146	25.8	37	8
	Median	0.25	11.0	0.01	3	37	11	2.0	9	8	589	273	111	18
	Mean	0.26	12.5	0.01	3	39	12	1.8	10	8	1627	399	122	21
	P95	0.25	26	0.02	6	72	20	3.0	18	14	6797	1033	234	41
	Max	1.33	47	0.13	47	132	235	10.0	37	90	42110	10843	1733	215
	n	1417	1417	1417	1417	1417	1417	1417	1417	1417	1417	1417	1417	1416
	Stdev	0.07	7.2	0.01	2	19	8	1.2	4	4	3717	589	100	13
LT	YYS156A 3 m – 4 m	<0.05	10	0.0040	4	45	21	3	12	7	430	1100	245	35
LT	YYS156A 1.5 m - 2.5 m	<0.05	9	0.0075	4	45	18	2	11	7	355	700	165	700
LT	YYS164 4.3 m - 4.4 m	<0.05	3	0.0285	7	115	20	2	15	13	65	15	60	30
L/LT	YYS156 0.7 m - 1.5 m	<0.05	11.5	0.0060	3	30	11.5	1.4	11	5	700	235	85	18
Quartz-rich loam (LQ)	Min	0.25	0.5	0.01	2	38	8	0.5	9	5	28	4	32	13
	P5	0.25	0.5	0.01	3	51	9	0.5	9	6	31	5	33	14
	Median	0.25	2.0	0.03	5	63	13	2.0	12	8	60	11.5	45	24
	Mean	0.25	3.0	0.03	5	67	16	1.5	13	12	98	22.4	51	27
	P95	0.25	8.0	0.05	10	90	35	2.7	20	13	259	72	100	51
	Max	0.25	11.0	0.05	12	94	48	3.0	22	113	846	141	117	52
	n	28	28	28	28	28	28	28	28	28	28	28	28	28
	Stdev	0	2.7	0.01	2	13	9	0.8	4	20	157	29.1	21	12

Lithology	**Element**	**Ag**	**As**	**Ba**	**Co**	**Cr**	**Cu**	**Mo**	**Ni**	**Pb**	**Sr**	**U_3O_8**	**V**	**Zn**
	Units	**ppm**	**ppm**	**%**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
Average crustal abundance (Bowen, 1979)		0.07	1.5	0.05	20	100	50	1.5	80	14	370	2.8	160	75
Summary Statistics taken from BHPBilliton chemical database. SRK sample details given below (grey highlight)														
LQT	YYS167 2.3 m - 2.4 m	<0.05	5.0	0.03	5	55	17	1.7	16	8	450	160	60	25
Carbonated-quartz-rich loam (LQT)	Min	0.25	0.5	0.01	1	10	4	0.5	2	2	30	2.0	14	4
	P5	0.25	1.0	0.01	1	20	8	0.5	5	4	61	11.0	29	10
	Median	0.25	8.0	0.01	4	49	13	2.0	12	9	311	84	81	24
	Mean	0.27	10.0	0.01	4	52	14	1.6	12	10	708	189	91	27
	P95	0.25	26.0	0.03	9	91	25	3.0	23	15	2195	674	186	50
	Max	1.48	42.0	0.06	28	131	75	6.0	30	485	30100	2085	374	182
	n	482	482	482	482	482	482	482	482	482	482	482	482	482
	Stdev	0.1	7.9	0.01	2	23	7	0.8	5	22	1821	249	53	16
LQT	YYS167 2.3 m - 2.4 m	<0.05	5.0	0.03	5	55	17	1.7	16	8	450	160	60	25
Carbonated hardpan (HT)	Min	0.25	0.5	0.01	2	26	9	0.5	7	4	76	8	38	15
	P5	0.25	0.9	0.01	3	33	13	0.9	10	6	83	12.9	46	19
	Median	0.25	3.0	0.01	8	80	20	2.0	22	12	148	27	69	37
	Mean	0.25	6.6	0.02	7	73	19	1.6	20	11	446	69	78	37
	P95	0.25	22.6	0.06	10	95	25	2.3	28	14	1756	311	135	53
	Max	0.25	31.0	0.12	10	99	25	3.0	29	14	2863	364	162	54
	n	15	15	15	15	15	15	15	15	15	15	15	15	15
	Stdev	0	8.7	0.03	3	22	5	0.7	6	3	739	107	32	11
HT	YYS165 1.5 m - 1.6 m	<0.05	5.0	0.01	3	40	13	0.6	13	5	290	165	35	18
Calcrete (T)	Min	0.25	0.5	0.01	1	10	1	0.5	1	2	34	8.0	5	1
	P5	0.25	0.5	0.01	1	10	3	0.5	1	2	301	25	18	3
	Median	0.25	5.0	0.01	1	21	7	2.0	4	6	585	246	93	9
	Mean	0.31	6.9	0.01	2	22	8	1.9	5	7	708	724	172	13
	P95	0.25	20.0	0.02	5	47	16	5.0	10	13	987	3218	615	31
	Max	21.16	45.0	0.87	22	112	40	13.0	24	377	100000	11142	1971	711
	n	1402	1402	1402	1402	1402	1402	1402	1402	1402	1402	1402	1402	1402
	Stdev	1	6.8	0.03	2	14	4	1.5	3	11	2706	1180	220	23

Lithology	**Element**	**Ag**	**As**	**Ba**	**Co**	**Cr**	**Cu**	**Mo**	**Ni**	**Pb**	**Sr**	**U_3O_8**	**V**	**Zn**
	Units	**ppm**	**ppm**	**%**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
Average crustal abundance (Bowen, 1979)		0.07	1.5	0.05	20	100	50	1.5	80	14	370	2.8	160	75
Summary Statistics taken from BHPBilliton chemical database. SRK sample details given below (grey highlight)														
T	YYS158 3.75 m - 4.75 m	<0.05	0.5	0.01	1	<20	4	1.1	5	1	600	150	75	27
T	YYS158 3.5 m - 3.75 m	<0.05	1.0	0.00	1	<20	7	1.9	5	1	550	55	50	265
Transition calcrete (TCQ)	Min	0.25	0.5	0.01	1	10	1	0.5	1	2	37	6.0	11	1
	P5	0.25	1	0.01	1	10	5	0.5	3	3	90	28	33	6
	Median	0.25	8	0.01	4	38	11	2.0	8	10	568	480	156	17
	Mean	0.27	11	0.02	4	43	12	2.9	9	10	2784	1331	296	20
	P95	0.25	26	0.06	8	92	21	8.0	20	19	11767	5172	951	45
	Max	2.90	119	1.45	109	239	104	23.0	44	43	181600	26682	4698	158
	n	2084	2084	2084	2084	2084	2084	2084	2084	2084	2084	2084	2084	2084
	Stdev	0.1	9.6	0.04	5	25	6	2.4	5	5	11587	2295	393	13
TCQ	YYS162 4.5 m - 4.6 m	<0.05	3.0	0.03	3	45	8	2.1	7	4	75	45	65	14
TCQ	YYS157 3.65 m - 4.1 m	<0.05	3.5	0.01	4	50	19	2.0	14	6	280	140	60	47
TCQ/CQT	YYS159 4.5 m - 5.2 m	<0.05	8.5	0.03	11	80	30	4.5	17	10	50	10	120	85
Carbonated Clay-Quartz (CQT)	Min	0.25	0.5	0.01	1	10	2	0.5	4	2	10	2.0	30	10
	P5	0.25	4.0	0.01	3	50	10	1.0	9	8	48	9	59	17
	Median	0.25	15.0	0.03	5	89	19	4.0	16	15	78	79	141	34
	Mean	0.26	19.7	0.03	5	88	19	4.2	16	15	3147	533	207	34
	P95	0.25	51.0	0.05	8	124	31	9.0	23	25	11870	2786	603	52
	Max	9.25	97.0	0.37	60	1503	106	23.0	40	57	282900	21402	3646	176
	n	6281	6281	6281	6281	6281	6281	6281	6281	6281	6281	6279	6281	6281
	Stdev	0.2	15.4	0.02	2	29	7	2.5	4	5	16057	1229	217	11
CQT	YYS164 5.2 m - 5.3 m	<0.05	4.0	0.03	7	85	22	1.9	14	11	60	20	60	38
TCQ/CQT	YYS159 4.5 m - 5.2 m	<0.05	8.5	0.03	11	80	30	4.5	17	10	80	10	120	85
Clay Quartz (CQ)	Min	0.25	0.5	0.01	1	21	6	0.5	6	2	10	2.0	21	12
	P5	0.25	3.0	0.01	3	51	11	1.0	9	8	45	8.0	57	18
	Median	0.25	8.0	0.03	5	94	20	4.0	16	14	65	21	120	32
	Mean	0.26	12.4	0.03	5	91	20	4.7	16	15	999	126	137	33
	P95	0.25	38.0	0.05	8	128	32	10.0	23	24	846	514	259	48
	Max	4.02	95.0	0.28	81	183	60	24.0	34	69	195400	8870	1794	102
	n	2571	2571	2571	2571	2571	2571	2571	2571	2571	2571	2571	2571	2571
	Stdev	0.1	11.5	0.01	2	24	6	2.7	4	5	8038	458	95	10
CQ	YYS156A 12 m - 12.75 m	<0.05	13.5	0.02	5	80	20	6.5	13	13	50	65	145	125
CQ (poss channel sand)	YYS163 23 m - 23.1 m	<0.05	3.0	0.02	8	100	31	1.5	20	14	1000	15	65	39

Appendix 4: Bottle Roll Test Results

Leach Extraction #4	**Start**	**Leach Extraction 4 (De-ionised water)**			
YYS158 3.75m - 4.5m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**2/04/2010 9 00**	**3/04/2010 8 30**	**4/04/2010 10 53**	**5/04/2010 6 40**	
CO2 Addition	**y**	**y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	1 0	2.1	2 9	
Bottle Tare Wt (g)	1633.8				
Solids Mass (g) (wet)	358 9				
Liquor Mass (g)	1076.6			761.35	
Gross Wt (g)	3068.9	3067.9	3062.1	3053.4	
Total Mass	1435.1	1434.1	1428 3	1419.6	
Temp (Deg C)	18.8	18.9	24 8	22.2	
pH	9.09	7.72	7.33	7.27	
ORP (mV Ag/AgCl)	240	218	186	191	192.7
EC (mS/cm)	1.783	2.92	3.11	3.25	
Calcium (µg/L)					126000
Iron (µg/L)					<100
Magnesium (µg/L)					177000
Phosphorus (µg/L)					<1000
Potassium (µg/L)					98800
Silicon (µg/L)					47000
Sodium (µg/L)					447000
Aluminium (µg/L)					28
Antimony (µg/L)					<5
Arsenic (µg/L)					8.6
Barium (µg/L)					57
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					1300
Cadmium (µg/L)					7.4
Chromium (µg/L)					<5
Cobalt (µg/L)					<5
Copper (µg/L)					9.1
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					32
Nickel (µg/L)					<5
Selenium (µg/L)					19
Silver (µg/L)					<5
Strontium (µg/L)					2000
Thallium (µg/L)					74
Tin (µg/L)					7.3
Uranium (µg/L)					620
Vanadium (µg/L)					180
Zinc (µg/L)					140
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					1030
Bicarbonate as CaCO3 (mg/L)					1030
Electrical Conductivity (µS/cm)					3600
Ammonia as N (mg N/L)					<1
pH (pH)					8.2
Total Organic Carbon (mg/L)					200
Chloride (mg/L)					470
Bromide (mg/L)					1.7
Fluoride (mg/L)					2
Nitrate (mg/L)					9.9
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					220

Leach Extraction #15	**Start**	**Leach Extraction 15 (De-ionised water)**			
YYS165 1.5m - 1.6m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**27/04/2010 9 00**	**28/04/2010 9 00**	**29/04/2010 9 00**	**30/04/2010 9 00**	
CO2 Addition	**y**	**y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1634.5				
Solids Mass (g) (wet)	237 8				
Liquor Mass (g)	713 2				
Gross Wt (g)	2585.5	2583.4	2582.4	2572.2	
Total Mass	951 0	948 9	947.9	937.7	
Temp (Deg C)	21.7	19.5	19 6	22	
pH	9.06	7.57	7.22	7.27	
ORP (mV Ag/AgCl)	173	208	190	238	95
EC (mS/cm)	0 391	1.311	1 665	1.479	
Calcium (µg/L)					84000
Iron (µg/L)					<100
Magnesium (µg/L)					80000
Phosphorus (µg/L)					<1000
Potassium (µg/L)					70000
Silicon (µg/L)					78000
Sodium (µg/L)					190000
Aluminium (µg/L)					<5
Antimony (µg/L)					<5
Arsenic (µg/L)					12
Barium (µg/L)					160
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					670
Cadmium (µg/L)					0.8
Chromium (µg/L)					6
Cobalt (µg/L)					<5
Copper (µg/L)					10
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					9
Nickel (µg/L)					<5
Selenium (µg/L)					<5
Silver (µg/L)					<5
Strontium (µg/L)					930
Thallium (µg/L)					6
Tin (µg/L)					<5
Uranium (µg/L)					350
Vanadium (µg/L)					71
Zinc (µg/L)					98
Mercury (µg/L)					<1
Acidity as CaCO3 (mg/L)					< 20
Total Alkalinity as CaCO3 (mg/L)					720
Bicarbonate as CaCO3 (mg/L)					700
Electrical Conductivity (µS/cm)					1500
Ammonia as N (mg N/L)					< 1
pH (pH)					8.2
Total Organic Carbon (mg/L)					19
Chloride (mg/L)					99
Bromide (mg/L)					< 5
Fluoride (mg/L)					0.7
Nitrate (mg/L)					12
Nitrite (mg/L)					< 0.1
Orthophosphate (mg/L)					< 0 05
Sulphate (mg/L)					18

Leach Extraction #18	**Start**	**Leach Extraction 18 (De-ionised water)**			
YYS166 0.4m - 0.5m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**27/04/2010 9 00**	**28/04/2010 9 00**	**29/04/2010 9 00**	**30/04/2010 9 00**	
CO2 Addition	**y**	**y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1632.9				
Solids Mass (g) (wet)	300 2				
Liquor Mass (g)	900 3				
Gross Wt (g)	2833.2	2830.4	2829	2824.9	
Total Mass	1200.3	1197.5	1196.1	1192.0	
Temp (Deg C)	22.5	20.4	19 3	22.1	
pH	8.51	7.19	6.85	6.84	
ORP (mV Ag/AgCl)	165	92	232	255	110
EC (mS/cm)	0 652	1.741	1 076	1.066	
Calcium (µg/L)					9600
Iron (µg/L)					<100
Magnesium (µg/L)					25000
Phosphorus (µg/L)					<1000
Potassium (µg/L)					55000
Silicon (µg/L)					28000
Sodium (µg/L)					190000
Aluminium (µg/L)					<5
Antimony (µg/L)					<5
Arsenic (µg/L)					<5
Barium (µg/L)					77
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					700
Cadmium (µg/L)					<0 2
Chromium (µg/L)					<5
Cobalt (µg/L)					<5
Copper (µg/L)					<5
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					41
Molybdenum (µg/L)					13
Nickel (µg/L)					<5
Selenium (µg/L)					9
Silver (µg/L)					<5
Strontium (µg/L)					260
Thallium (µg/L)					<5
Tin (µg/L)					6
Uranium (µg/L)					53
Vanadium (µg/L)					7
Zinc (µg/L)					110
Mercury (µg/L)					<1
Acidity as CaCO3 (mg/L)					< 20
Total Alkalinity as CaCO3 (mg/L)					1300
Bicarbonate as CaCO3 (mg/L)					38
Electrical Conductivity (µS/cm)					1200
Ammonia as N (mg N/L)					< 1
pH (pH)					10
Total Organic Carbon (mg/L)					6.2
Chloride (mg/L)					240
Bromide (mg/L)					< 5
Fluoride (mg/L)					< 5
Nitrate (mg/L)					12
Nitrite (mg/L)					< 5
Orthophosphate (mg/L)					< 5
Sulphate (mg/L)					74

Leach Extraction #19	**Start**	**Leach Extraction 19 (De-ionised water)**			
YYS156A 1.5m - 2.5m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**30/03/2010 13 00**	**31/03/2010 11 30**	**1/04/2010 12 05**	**2/04/2010 8 00**	
CO2 Addition	**y**	**y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	0 9	2.0	2 8	
Bottle Tare Wt (g)	1630.2				
Solids Mass (g) (wet)	332.4				
Liquor Mass (g)	1002.1			600	
Gross Wt (g)	2963.9	2963.7	2959 2	2938.2	
Total Mass	1333.7	1333.5	1329 0	1308.0	
Temp (Deg C)	22.2	24.5	26 2	19.3	
pH	8.23	7.27	7.27	7 2	
ORP (mV Ag/AgCl)	227	239	200	205	194
EC (mS/cm)	5.85	7.14	7.06	7.01	
Calcium (µg/L)					688000
Iron (µg/L)					<100
Magnesium (µg/L)					189000
Phosphorus (µg/L)					<1000
Potassium (µg/L)					207000
Silicon (µg/L)					37000
Sodium (µg/L)					1110000
Aluminium (µg/L)					35
Antimony (µg/L)					<5
Arsenic (µg/L)					20
Barium (µg/L)					82
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					4300
Cadmium (µg/L)					<5
Chromium (µg/L)					7
Cobalt (µg/L)					<5
Copper (µg/L)					20
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					38
Molybdenum (µg/L)					72
Nickel (µg/L)					8.4
Selenium (µg/L)					23
Silver (µg/L)					<5
Strontium (µg/L)					5400
Thallium (µg/L)					<5
Tin (µg/L)					<5
Uranium (µg/L)					2000
Vanadium (µg/L)					140
Zinc (µg/L)					140
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					486
Bicarbonate as CaCO3 (mg/L)					486
Electrical Conductivity (µS/cm)					8890
Ammonia as N (mg N/L)					<1
pH (pH)					8
Total Organic Carbon (mg/L)					40
Chloride (mg/L)					790
Bromide (mg/L)					1.7
Fluoride (mg/L)					1.5
Nitrate (mg/L)					39
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					2800

Leach Extraction #20	Start	Leach Extraction 20 (De-ionised water)			
YYS157 3.65m - 4.1m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**30/03/2010 13 05**	**31/03/2010 11 40**	**1/04/2010 12 00**	**2/04/2010 8 05**	
CO2 Addition	**y**	**y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	0 9	2.0	2 8	
Bottle Tare Wt (g)	1678.3				
Solids Mass (g) (wet)	321.1				
Liquor Mass (g)	965 8			807.96	
Gross Wt (g)	2964.4	2963.3	2961.4	2949.2	
Total Mass	1286.1	1285.0	1283.1	1270.9	
Temp (Deg C)	22.7	24.5	26.1	19.3	
pH	9.65	7.69	7.47	7.4	
ORP (mV Ag/AgCl)	172	190	178	180	180.9
EC (uS/cm)	434	1498	1675	1945	
Calcium (µg/L)					57900
Iron (µg/L)					<100
Magnesium (µg/L)					55700
Phosphorus (µg/L)					<1000
Potassium (µg/L)					62100
Silicon (µg/L)					46000
Sodium (µg/L)					297000
Aluminium (µg/L)					20
Antimony (µg/L)					<5
Arsenic (µg/L)					<5
Barium (µg/L)					23
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					780
Cadmium (µg/L)					<5
Chromium (µg/L)					<5
Cobalt (µg/L)					<5
Copper (µg/L)					<5
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					35
Nickel (µg/L)					<5
Selenium (µg/L)					9.6
Silver (µg/L)					<5
Strontium (µg/L)					540
Thallium (µg/L)					<5
Tin (µg/L)					<5
Uranium (µg/L)					87
Vanadium (µg/L)					60
Zinc (µg/L)					120
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					827
Bicarbonate as CaCO3 (mg/L)					827
Electrical Conductivity (µS/cm)					2040
Ammonia as N (mg N/L)					<1
pH (pH)					8.3
Total Organic Carbon (mg/L)					1
Chloride (mg/L)					100
Bromide (mg/L)					<0 5
Fluoride (mg/L)					2.1
Nitrate (mg/L)					0.9
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					68

Leach Extraction #21	**Start**	**Leach Extraction 21 (De-ionised water)**			
YYS158 3.5m - 3.75m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**2/04/2010 10 15**	**3/04/2010 8 35**	**4/04/2010 10 56**	**5/04/2010 7 00**	
CO2 Addition	**y**	**y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	0 9	2.0	2 9	
Bottle Tare Wt (g)	1627.3				
Solids Mass (g) (wet)	300 6				
Liquor Mass (g)	901 6			640	
Gross Wt (g)	2829.6	2828.1	2823 5	2817.2	
Total Mass	1202.3	1200.8	1196 2	1189.9	
Temp (Deg C)	20.2	19	24 9	22.3	
pH	8.91	7.52	7.16	7.23	
ORP (mV Ag/AgCl)	235	195	189	179	183.3
EC (mS/cm)	3.54	4.44	3.91	3.94	
Calcium (µg/L)					180000
Iron (µg/L)					<100
Magnesium (µg/L)					237000
Phosphorus (µg/L)					<1000
Potassium (µg/L)					138000
Silicon (µg/L)					44000
Sodium (µg/L)					812000
Aluminium (µg/L)					20
Antimony (µg/L)					<5
Arsenic (µg/L)					6.3
Barium (µg/L)					51
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					2000
Cadmium (µg/L)					7.1
Chromium (µg/L)					<5
Cobalt (µg/L)					<5
Copper (µg/L)					12
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					120
Nickel (µg/L)					<5
Selenium (µg/L)					16
Silver (µg/L)					<5
Strontium (µg/L)					2600
Thallium (µg/L)					74
Tin (µg/L)					<5
Uranium (µg/L)					550
Vanadium (µg/L)					110
Zinc (µg/L)					160
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					922
Bicarbonate as CaCO3 (mg/L)					922
Electrical Conductivity (µS/cm)					6420
Ammonia as N (mg N/L)					<1
pH (pH)					8.2
Total Organic Carbon (mg/L)					43
Chloride (mg/L)					1200
Bromide (mg/L)					4
Fluoride (mg/L)					2.5
Nitrate (mg/L)					14
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					460

Leach Extraction #22	Start	Leach Extraction 22 (De-ionised water)			
YYS156A 12m - 12.75m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**30/03/2010 13 10**	**31/03/2010 11 50**	**1/04/2010 11 52**	**2/04/2010 8 10**	
CO2 Addition	**y**	**y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	0 9	1.9	2 8	
Bottle Tare Wt (g)	1630.3				
Solids Mass (g) (wet)	303 2				
Liquor Mass (g)	910 3			646	
Gross Wt (g)	2843.8	2842.2	2837 8	2830.3	
Total Mass	1213.5	1211.9	1207 5	1200.0	
Temp (Deg C)	22.3	24.9	26.1	19.4	
pH	7.73	7.04	6.85	7.27	
ORP (mV Ag/AgCl)	176	200	204	185	186.2
EC (mS/cm)	4.16	3.87	3.62	3.55	
Calcium (µg/L)					70100
Iron (µg/L)					<100
Magnesium (µg/L)					131000
Phosphorus (µg/L)					<1000
Potassium (µg/L)					193000
Silicon (µg/L)					18000
Sodium (µg/L)					1020000
Aluminium (µg/L)					12
Antimony (µg/L)					<5
Arsenic (µg/L)					<5
Barium (µg/L)					51
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					4600
Cadmium (µg/L)					<5
Chromium (µg/L)					<5
Cobalt (µg/L)					<5
Copper (µg/L)					7.1
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					53
Molybdenum (µg/L)					31
Nickel (µg/L)					<5
Selenium (µg/L)					24
Silver (µg/L)					<5
Strontium (µg/L)					1400
Thallium (µg/L)					<5
Tin (µg/L)					<5
Uranium (µg/L)					34
Vanadium (µg/L)					33
Zinc (µg/L)					170
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					161
Bicarbonate as CaCO3 (mg/L)					161
Electrical Conductivity (µS/cm)					7720
Ammonia as N (mg N/L)					<1
pH (pH)					8.1
Total Organic Carbon (mg/L)					25
Chloride (mg/L)					1500
Bromide (mg/L)					3.6
Fluoride (mg/L)					0.5
Nitrate (mg/L)					51
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					710

Leach Extraction #23	Start	Leach Extraction 23 (De-ionised water)			
YYS159 4.5m - 5.2m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**30/03/2010 13 15**	**31/03/2010 12 00**	**1/04/2010 11 45**	**2/04/2010 8 20**	
CO2 Addition	**y**	**y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	0 9	1.9	2 8	
Bottle Tare Wt (g)	1629.3				
Solids Mass (g) (wet)	319.7				
Liquor Mass (g)	959.1			- Not recorded	
Gross Wt (g)	2907.5	2906.7	2903 6	2900.4	
Total Mass	1278.2	1277.4	1274 3	1271.1	
Temp (Deg C)	22.8	24.7	26.4	19.4	
pH	9.25	7.99	7.47	7.49	
ORP (mV Ag/AgCl)	159	181	229	187	235.4
EC (mS/cm)	1.24	2.073	2.39	2.43	
Calcium (µg/L)					51700
Iron (µg/L)					320
Magnesium (µg/L)					47600
Phosphorus (µg/L)					<1000
Potassium (µg/L)					93300
Silicon (µg/L)					36000
Sodium (µg/L)					447000
Aluminium (µg/L)					24
Antimony (µg/L)					<5
Arsenic (µg/L)					<5
Barium (µg/L)					9.8
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					1400
Cadmium (µg/L)					<5
Chromium (µg/L)					37
Cobalt (µg/L)					<5
Copper (µg/L)					<5
Lead (µg/L)					<5
Lithium (µg/L)					11
Manganese (µg/L)					5.2
Molybdenum (µg/L)					66
Nickel (µg/L)					<5
Selenium (µg/L)					<5
Silver (µg/L)					<5
Strontium (µg/L)					470
Thallium (µg/L)					<5
Tin (µg/L)					<5
Uranium (µg/L)					33
Vanadium (µg/L)					73
Zinc (µg/L)					140
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					827
Bicarbonate as CaCO3 (mg/L)					827
Electrical Conductivity (µS/cm)					2650
Ammonia as N (mg N/L)					<1
pH (pH)					8.4
Total Organic Carbon (mg/L)					35
Chloride (mg/L)					260
Bromide (mg/L)					0.8
Fluoride (mg/L)					2.9
Nitrate (mg/L)					3.4
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					92

BARREN LIQUOR - for bottle rolls	BARREN LIQUOR
	Assay
Elapsed Time (days)	
Bottle Tare Wt (g)	
Solids Mass (g) (wet)	
Liquor Mass (Barren)g	
Gross Wt (g)	
Total Mass	
ORP (mV)	140.1
Calcium (µg/L)	500
Iron (µg/L)	450
Magnesium (µg/L)	350
Phosphorus (µg/L)	<1000
Potassium (µg/L)	1590000
Silicon (µg/L)	13000
Sodium (µg/L)	44800000
Aluminium (µg/L)	780
Antimony (µg/L)	<5
Arsenic (µg/L)	7900
Barium (µg/L)	10
Beryllium (µg/L)	<5
Bismuth (µg/L)	<5
Boron (µg/L)	30000
Cadmium (µg/L)	<5
Chromium (µg/L)	350
Cobalt (µg/L)	<5
Copper (µg/L)	80
Lead (µg/L)	<5
Lithium (µg/L)	6
Manganese (µg/L)	<5
Molybdenum (µg/L)	2400
Nickel (µg/L)	<5
Selenium (µg/L)	490
Silver (µg/L)	<5
Strontium (µg/L)	60
Thallium (µg/L)	<5
Tin (µg/L)	10
Uranium (µg/L)	100000
Vanadium (µg/L)	35000
Zinc (µg/L)	130
Mercury (µg/L)	<0.1
Acidity as CaCO3 (mg/L)	<20
Total Alkalinity as CaCO3 (mg/L)	75300
Bicarbonate as CaCO3 (mg/L)	<10
Electrical Conductivity (µS/cm)	85600
Ammonia as N (mg N/L)	1.4
pH (pH)	10.9
Total Organic Carbon (mg/L)	1000
Chloride (mg/L)	15000
Bromide (mg/L)	43
Fluoride (mg/L)	<0.5
Nitrate (mg/L)	610
Nitrite (mg/L)	<0.5
Orthophosphate (mg/L)	<0.5
Sulphate (mg/L)	8800

Leach Extraction #24	**Start**	**Leach Extraction 24 (Barren liquor)**			
YYS156 0.7m - 1.5m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**22/03/2010 12 14**	**23/03/2010 12 17**	**24/03/2010 12 20**	**25/03/2010 12 21**	
					Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1627.5				
Solids Mass (g) (wet)	309				
Liquor Mass (g)	927 9			755.31	
Gross Wt (g)	2863.3	2862.3	2858	2854.5	
Total Mass	1235.8	1234.8	1230 5	1227.0	
Temp (Deg C)	22.8	24.9	25.4	27.3	
pH	10.5	10 27	10 3	10 22	
ORP (mV Ag/AgCl)	202	144	163	153	121.1
EC (mS/cm)	80.4	82.6	74 8	77.6	
Calcium (µg/L)					5760
Iron (µg/L)					<100
Magnesium (µg/L)					2440
Phosphorus (µg/L)					<1000
Potassium (µg/L)					1660000
Silicon (µg/L)					12000
Sodium (µg/L)					42200000
Aluminium (µg/L)					88
Antimony (µg/L)					<5
Arsenic (µg/L)					2300
Barium (µg/L)					98
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					33000
Cadmium (µg/L)					31
Chromium (µg/L)					150
Cobalt (µg/L)					<5
Copper (µg/L)					140
Lead (µg/L)					11
Lithium (µg/L)					<5
Manganese (µg/L)					15
Molybdenum (µg/L)					1600
Nickel (µg/L)					32
Selenium (µg/L)					310
Silver (µg/L)					<5
Strontium (µg/L)					400
Thallium (µg/L)					160
Tin (µg/L)					8.1
Uranium (µg/L)					77000
Vanadium (µg/L)					20000
Zinc (µg/L)					170
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					23200
Bicarbonate as CaCO3 (mg/L)					2180
Electrical Conductivity (µS/cm)					87900
Ammonia as N (mg N/L)					<1
pH (pH)					10 2
Total Organic Carbon (mg/L)					95
Chloride (mg/L)					16000
Bromide (mg/L)					46
Fluoride (mg/L)					<0 5
Nitrate (mg/L)					650
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					54000

Leach Extraction #25	**Start**	**Leach Extraction 25 (Barren liquor)**			
YYS156A 0.7m - 1.5m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**22/03/2010 13 45**	**23/03/2010 13 54**	**24/03/2010 13 55**	**25/03/2010 13 46**	
					Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1629.9				
Solids Mass (g) (wet)	321				
Liquor Mass (g)	963 2			791	
Gross Wt (g)	2913.8	2909.4	2907.1	2903.3	
Total Mass	1283.9	1279.5	1277 2	1273.4	
Temp (Deg C)	22.6	27	26 8	27.5	
pH	10 55	10 21	10.27	10 21	
ORP (mV Ag/AgCl)	140	120	141	110	117.5
EC (mS/cm)	87.3	82	78	80.2	
Calcium (µg/L)					3490
Iron (µg/L)					<100
Magnesium (µg/L)					3000
Phosphorus (µg/L)					<1000
Potassium (µg/L)					1820000
Silicon (µg/L)					6610
Sodium (µg/L)					41200000
Aluminium (µg/L)					5.1
Antimony (µg/L)					<5
Arsenic (µg/L)					4200
Barium (µg/L)					20
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					36000
Cadmium (µg/L)					<5
Chromium (µg/L)					230
Cobalt (µg/L)					<5
Copper (µg/L)					110
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					5.4
Molybdenum (µg/L)					2500
Nickel (µg/L)					12
Selenium (µg/L)					420
Silver (µg/L)					<5
Strontium (µg/L)					67
Thallium (µg/L)					86
Tin (µg/L)					<5
Uranium (µg/L)					86000
Vanadium (µg/L)					18000
Zinc (µg/L)					130
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					24100
Bicarbonate as CaCO3 (mg/L)					2240
Electrical Conductivity (µS/cm)					88200
Ammonia as N (mg N/L)					<1
pH (pH)					10 2
Total Organic Carbon (mg/L)					54
Chloride (mg/L)					15000
Bromide (mg/L)					46
Fluoride (mg/L)					<0 5
Nitrate (mg/L)					640
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					49000

Leach Extraction #26	Start	Leach Extraction 26 (Barren liquor)			
YYS164 4.3m - 4.4m	inc Head	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	
Time	16/04/2010 11 45	17/04/2010 11 45	18/04/2010 11 45	19/04/2010 11 45	
					Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1627.9				
Solids Mass (g) (wet)	302.1				
Liquor Mass (g)	908.1				
Gross Wt (g)	2837.9	2805.7	2800 8	2792.2	
Total Mass	1210.0	1177.8	1172 9	1164.3	
Temp (Deg C)	22.6	26	24 8	20.9	
pH	10.76	10 57	10.63	10 68	
ORP (mV Ag/AgCl)	201	170	158	161	102
EC (mS/cm)	88.8	82.6	84 2	84.4	
Calcium (µg/L)					4260
Iron (µg/L)					130
Magnesium (µg/L)					1520
Phosphorus (µg/L)					<1000
Potassium (µg/L)					1900000
Silicon (µg/L)					62000
Sodium (µg/L)					44000000
Aluminium (µg/L)					19
Antimony (µg/L)					<5
Arsenic (µg/L)					6200
Barium (µg/L)					140
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					27000
Cadmium (µg/L)					<5
Chromium (µg/L)					320
Cobalt (µg/L)					<5
Copper (µg/L)					61
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					2000
Nickel (µg/L)					<5
Selenium (µg/L)					420
Silver (µg/L)					<5
Strontium (µg/L)					290
Thallium (µg/L)					66
Tin (µg/L)					27
Uranium (µg/L)					77000
Vanadium (µg/L)					27000
Zinc (µg/L)					570
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					70300
Bicarbonate as CaCO3 (mg/L)					1230
Electrical Conductivity (µS/cm)					71800
Ammonia as N (mg N/L)					<1
pH (pH)					10 5
Total Organic Carbon (mg/L)					23
Chloride (mg/L)					14000
Bromide (mg/L)					35
Fluoride (mg/L)					1.6
Nitrate (mg/L)					570
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					7700

Leach Extraction #27	**Start**	**Leach Extraction 27 (Barren liquor)**			
YYS163 23m - 23.1m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**16/04/2010 13 45**	**17/04/2010 13 45**	**18/04/2010 13 45**	**19/04/2010 13 45**	
					Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1630.1				
Solids Mass (g) (wet)	282 6				
Liquor Mass (g)	849				
Gross Wt (g)	2761.7	2760.4	2758 8	2753.3	
Total Mass	1131.6	1130.3	1128.7	1123.2	
Temp (Deg C)	22.5	26.1	25.1	21	
pH	10 86	10.71	10.75	10 81	
ORP (mV Ag/AgCl)	160	144	177	135	89
EC (mS/cm)	93.1	67	75	59.9	
Calcium (µg/L)					2660
Iron (µg/L)					<100
Magnesium (µg/L)					35400
Phosphorus (µg/L)					<1000
Potassium (µg/L)					1820000
Silicon (µg/L)					3320
Sodium (µg/L)					44000000
Aluminium (µg/L)					37
Antimony (µg/L)					<5
Arsenic (µg/L)					4700
Barium (µg/L)					47
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					29000
Cadmium (µg/L)					<5
Chromium (µg/L)					350
Cobalt (µg/L)					<5
Copper (µg/L)					41
Lead (µg/L)					6.7
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					2100
Nickel (µg/L)					<5
Selenium (µg/L)					440
Silver (µg/L)					<5
Strontium (µg/L)					510
Thallium (µg/L)					<5
Tin (µg/L)					5.5
Uranium (µg/L)					34000
Vanadium (µg/L)					15000
Zinc (µg/L)					410
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					67600
Bicarbonate as CaCO3 (mg/L)					914
Electrical Conductivity (µS/cm)					73200
Ammonia as N (mg N/L)					<1
pH (pH)					10 6
Total Organic Carbon (mg/L)					18
Chloride (mg/L)					16000
Bromide (mg/L)					39
Fluoride (mg/L)					2
Nitrate (mg/L)					640
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					10000

Leach Extraction #28	**Start**	**Leach Extraction 28 (Barren liquor)**			
YYS164 5.2m - 5.3m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**16/04/2010 13 45**	**17/04/2010 13 45**	**18/04/2010 13 45**	**19/04/2010 13 45**	
					Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1634.0				
Solids Mass (g) (wet)	300 6				
Liquor Mass (g)	901.1				
Gross Wt (g)	2835.5	2834.4	2828 8	2819.3	
Total Mass	1201.5	1200.4	1194 8	1185.3	
Temp (Deg C)	22.4	21.1	21.7	21.9	
pH	10 81	10.79	10.75	10.72	
ORP (mV Ag/AgCl)	135	214	125	132	116
EC (mS/cm)	92	81	80	80.1	
Calcium (µg/L)					4160
Iron (µg/L)					<100
Magnesium (µg/L)					1400
Phosphorus (µg/L)					<1000
Potassium (µg/L)					1800000
Silicon (µg/L)					76000
Sodium (µg/L)					43900000
Aluminium (µg/L)					<5
Antimony (µg/L)					<5
Arsenic (µg/L)					6700
Barium (µg/L)					8.8
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					25000
Cadmium (µg/L)					<5
Chromium (µg/L)					360
Cobalt (µg/L)					<5
Copper (µg/L)					59
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					2000
Nickel (µg/L)					<5
Selenium (µg/L)					410
Silver (µg/L)					<5
Strontium (µg/L)					34
Thallium (µg/L)					<5
Tin (µg/L)					6.9
Uranium (µg/L)					40000
Vanadium (µg/L)					27000
Zinc (µg/L)					560
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					70000
Bicarbonate as CaCO3 (mg/L)					1730
Electrical Conductivity (µS/cm)					70400
Ammonia as N (mg N/L)					<1
pH (pH)					10 5
Total Organic Carbon (mg/L)					24
Chloride (mg/L)					11000
Bromide (mg/L)					32
Fluoride (mg/L)					2.3
Nitrate (mg/L)					490
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					7000

Leach Extraction #29	Start	Leach Extraction 29 (Barren liquor)			
YYS165 6.6m - 6.7m	inc Head	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	
Time	23/04/2010 13 45	24/04/2010 13 45	25/04/2010 13 45	26/04/2010 13 45	
					Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1630.3				
Solids Mass (g) (wet)	301.7				
Liquor Mass (g)	905 2				
Gross Wt (g)	2837.2	2835.5	2835	2805	
Total Mass	1206.9	1205.2	1204.7	1174.7	
Temp (Deg C)	23.8	23.8	21.4	22.3	
pH	10 95	10.73	10.75	10.77	
ORP (mV Ag/AgCl)	98	161	143	105	17
EC (mS/cm)	93.9	82.1	81.1	83.2	
Calcium (µg/L)					4100
Iron (µg/L)					200
Magnesium (µg/L)					2300
Phosphorus (µg/L)					<1000
Potassium (µg/L)					1400000
Silicon (µg/L)					64000000
Sodium (µg/L)					44000000
Aluminium (µg/L)					50
Antimony (µg/L)					8
Arsenic (µg/L)					7700
Barium (µg/L)					240
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					34000
Cadmium (µg/L)					1
Chromium (µg/L)					3300
Cobalt (µg/L)					<5
Copper (µg/L)					51
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					2500
Nickel (µg/L)					<5
Selenium (µg/L)					510
Silver (µg/L)					<5
Strontium (µg/L)					600
Thallium (µg/L)					<5
Tin (µg/L)					20
Uranium (µg/L)					110000
Vanadium (µg/L)					37000
Zinc (µg/L)					560
Mercury (µg/L)					1
Acidity as CaCO3 (mg/L)					< 20
Total Alkalinity as CaCO3 (mg/L)					71000
Bicarbonate as CaCO3 (mg/L)					3200
Electrical Conductivity (µS/cm)					73000
Ammonia as N (mg N/L)					1
pH (pH)					11
Total Organic Carbon (mg/L)					740
Chloride (mg/L)					14000
Bromide (mg/L)					37
Fluoride (mg/L)					6.6
Nitrate (mg/L)					610
Nitrite (mg/L)					< 5
Orthophosphate (mg/L)					< 5
Sulphate (mg/L)					2500

Leach Extraction #30	**Start**	**Leach Extraction 30 (Barren liquor)**			
YYS167 2.3m - 2.4m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**16/04/2010 13 45**	**17/04/2010 13 45**	**18/04/2010 13 45**	**19/04/2010 13 45**	
					Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1633.6				
Solids Mass (g) (wet)	296 3				
Liquor Mass (g)	888.1				
Gross Wt (g)	2818.1	2818	2815 3	2812	
Total Mass	1184.5	1184.4	1181.7	1178.4	
Temp (Deg C)	22.5	21.1	21 8	21.9	
pH	10 91	10 82	10.79	10.74	
ORP (mV Ag/AgCl)	142	205	156	203	136
EC (mS/cm)	95	81.6	80 3	79.3	
Calcium (µg/L)					3730
Iron (µg/L)					<100
Magnesium (µg/L)					1830
Phosphorus (µg/L)					<1000
Potassium (µg/L)					1890000
Silicon (µg/L)					44000
Sodium (µg/L)					42200000
Aluminium (µg/L)					7.8
Antimony (µg/L)					<5
Arsenic (µg/L)					6700
Barium (µg/L)					210
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					28000
Cadmium (µg/L)					<5
Chromium (µg/L)					350
Cobalt (µg/L)					<5
Copper (µg/L)					59
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					1900
Nickel (µg/L)					<5
Selenium (µg/L)					410
Silver (µg/L)					<5
Strontium (µg/L)					270
Thallium (µg/L)					<5
Tin (µg/L)					5.5
Uranium (µg/L)					44000
Vanadium (µg/L)					28000
Zinc (µg/L)					570
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					72100
Bicarbonate as CaCO3 (mg/L)					1820
Electrical Conductivity (µS/cm)					71500
Ammonia as N (mg N/L)					<1
pH (pH)					10 6
Total Organic Carbon (mg/L)					24
Chloride (mg/L)					16000
Bromide (mg/L)					34
Fluoride (mg/L)					2.2
Nitrate (mg/L)					600
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					9400

Leach Extraction #31	**Start**	**Leach Extraction 31 (Barren liquor)**			
YYS167 23m - 23.1m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**27/04/2010 13 45**	**28/04/2010 13 45**	**29/04/2010 13 45**	**30/04/2010 13 45**	
					Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1630.5				
Solids Mass (g) (wet)	300 9				
Liquor Mass (g)	902 5				
Gross Wt (g)	2833.7	2827.8	2827.7	2823.6	
Total Mass	1203.2	1197.3	1197 2	1193.1	
Temp (Deg C)	19.7	20.2	19.4	17.4	
pH	11 01	10 91	10.86	10 95	
ORP (mV Ag/AgCl)	65	65	205	229	20
EC (mS/cm)	93.2	76.5	83 2	79	
Calcium (µg/L)					3900
Iron (µg/L)					300
Magnesium (µg/L)					6600
Phosphorus (µg/L)					<1000
Potassium (µg/L)					1400000
Silicon (µg/L)					17000
Sodium (µg/L)					44000000
Aluminium (µg/L)					<50
Antimony (µg/L)					<5
Arsenic (µg/L)					7100
Barium (µg/L)					200
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					30000
Cadmium (µg/L)					1.1
Chromium (µg/L)					3.4
Cobalt (µg/L)					<5
Copper (µg/L)					59
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					2500
Nickel (µg/L)					5
Selenium (µg/L)					520
Silver (µg/L)					<5
Strontium (µg/L)					800
Thallium (µg/L)					<5
Tin (µg/L)					5
Uranium (µg/L)					74000
Vanadium (µg/L)					26000
Zinc (µg/L)					470
Mercury (µg/L)					<1
Acidity as CaCO3 (mg/L)					< 20
Total Alkalinity as CaCO3 (mg/L)					70000
Bicarbonate as CaCO3 (mg/L)					2100
Electrical Conductivity (µS/cm)					75000
Ammonia as N (mg N/L)					< 1
pH (pH)					11
Total Organic Carbon (mg/L)					100
Chloride (mg/L)					15000
Bromide (mg/L)					30
Fluoride (mg/L)					5.8
Nitrate (mg/L)					620
Nitrite (mg/L)					< 5
Orthophosphate (mg/L)					< 5
Sulphate (mg/L)					2600

Leach Extraction #33	Start	Leach Extraction 33 (Barren liquor)			
YYS164 26.2m - 26.3m	inc Head	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	
Time	23/04/2010 11 30	24/04/2010 11 30	25/04/2010 11 30	26/04/2010 11 30	
					Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1636.3				
Solids Mass (g) (wet)	300.4				
Liquor Mass (g)	902 2				
Gross Wt (g)	2837.3	2836.2	2836.1	2834.5	
Total Mass	1201.0	1199.9	1199 8	1198.2	
Temp (Deg C)	24.1	23.9	21.4	22.6	
pH	11 02	10 88	10.87	10 92	
ORP (mV Ag/AgCl)	189	172	164	172	29
EC (mS/cm)	94.4	81.4	80 9	84.9	
Calcium (µg/L)					3800
Iron (µg/L)					200
Magnesium (µg/L)					9200
Phosphorus (µg/L)					<1000
Potassium (µg/L)					1600000
Silicon (µg/L)					11000
Sodium (µg/L)					53000000
Aluminium (µg/L)					120
Antimony (µg/L)					<5
Arsenic (µg/L)					7800
Barium (µg/L)					46
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					38000
Cadmium (µg/L)					1.1
Chromium (µg/L)					3500
Cobalt (µg/L)					<5
Copper (µg/L)					86
Lead (µg/L)					5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					3100
Nickel (µg/L)					<5
Selenium (µg/L)					560
Silver (µg/L)					<5
Strontium (µg/L)					640
Thallium (µg/L)					10
Tin (µg/L)					<5
Uranium (µg/L)					110000
Vanadium (µg/L)					39000
Zinc (µg/L)					530
Mercury (µg/L)					1
Acidity as CaCO3 (mg/L)					< 20
Total Alkalinity as CaCO3 (mg/L)					74000
Bicarbonate as CaCO3 (mg/L)					2300
Electrical Conductivity (µS/cm)					76000
Ammonia as N (mg N/L)					1.1
pH (pH)					11
Total Organic Carbon (mg/L)					78
Chloride (mg/L)					5100
Bromide (mg/L)					35
Fluoride (mg/L)					6.6
Nitrate (mg/L)					640
Nitrite (mg/L)					< 5
Orthophosphate (mg/L)					< 5
Sulphate (mg/L)					810

Leach Extraction #34	**Start**	**Leach Extraction 34 (Barren liquor)**			
YYS156A 0.7m - 1.5m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**2/04/2010 11 30**	**3/04/2010 8 45**	**4/04/2010 11 00**	**5/04/2010 7 10**	
CO2	**y**	**y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	0 9	2.0	2 8	
Bottle Tare Wt (g)	1630.0				
Solids Mass (g) (wet)	310.7				
Liquor Mass (g)	934 8			726	
Gross Wt (g)	2875.3	2872.2	2870.7	2868.7	
Total Mass	1245.3	1242.2	1240.7	1238.7	
Temp (Deg C)	21.7	19	24 9	22.3	
pH	10 55	10.15	9.83	9.7	
ORP (mV Ag/AgCl)	1.36	153	160	196	147.3
EC (mS/cm)	70.1	74.7	73	77.6	
Calcium (µg/L)					6060
Iron (µg/L)					<100
Magnesium (µg/L)					12300
Phosphorus (µg/L)					<1000
Potassium (µg/L)					1670000
Silicon (µg/L)					6220
Sodium (µg/L)					39700000
Aluminium (µg/L)					34
Antimony (µg/L)					<5
Arsenic (µg/L)					2100
Barium (µg/L)					26
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					30000
Cadmium (µg/L)					7.9
Chromium (µg/L)					100
Cobalt (µg/L)					<5
Copper (µg/L)					110
Lead (µg/L)					7.3
Lithium (µg/L)					<5
Manganese (µg/L)					7.5
Molybdenum (µg/L)					1600
Nickel (µg/L)					7.2
Selenium (µg/L)					310
Silver (µg/L)					5.4
Strontium (µg/L)					36
Thallium (µg/L)					55
Tin (µg/L)					16
Uranium (µg/L)					74000
Vanadium (µg/L)					16000
Zinc (µg/L)					280
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					25000
Bicarbonate as CaCO3 (mg/L)					7240
Electrical Conductivity (µS/cm)					86700
Ammonia as N (mg N/L)					1.2
pH (pH)					9.6
Total Organic Carbon (mg/L)					2900
Chloride (mg/L)					15000
Bromide (mg/L)					52
Fluoride (mg/L)					<0 5
Nitrate (mg/L)					670
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					47000

Leach Extraction #35	Start	Leach Extraction 35 (Barren liquor)				
YYS163 23.0m - 23.1m	inc Head	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	96hr bottle roll reading	
Time	30/04/2010 11 30	1/05/2010 11 30	2/05/2010 11 30	3/05/2010 11 30	4/05/2010 11 30	
CO2	y	n	n	y	y	Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	4.0	
Bottle Tare Wt (g)	1628.1					
Solids Mass (g) (wet)	282.1					
Liquor Mass (g)	846.1					
Gross Wt (g)	2756	2754.9	2750 5	2750	2746	
Total Mass	1127.9	1126.8	1122.4	1121.9	1117 9	
Temp (Deg C)	20.2	25	23.1	24	18 5	
pH	10 94	10 62	10.66	10 62	10.51	
ORP (mV Ag/AgCl)	151	138	190	113	145	35
EC (mS/cm)	91.3	50.2	65.1	50.4	39.7	
Calcium (µg/L)						100
Iron (µg/L)						<100
Magnesium (µg/L)						88000
Phosphorus (µg/L)						<1000
Potassium (µg/L)						1700000
Silicon (µg/L)						7500
Sodium (µg/L)						44000000
Aluminium (µg/L)						<5
Antimony (µg/L)						<5
Arsenic (µg/L)						5300
Barium (µg/L)						78
Beryllium (µg/L)						<5
Bismuth (µg/L)						<5
Boron (µg/L)						28000
Cadmium (µg/L)						7
Chromium (µg/L)						71
Cobalt (µg/L)						<5
Copper (µg/L)						93
Lead (µg/L)						8
Lithium (µg/L)						<5
Manganese (µg/L)						<5
Molybdenum (µg/L)						2400
Nickel (µg/L)						<5
Selenium (µg/L)						550
Silver (µg/L)						<5
Strontium (µg/L)						660
Thallium (µg/L)						180
Tin (µg/L)						13
Uranium (µg/L)						85000
Vanadium (µg/L)						16000
Zinc (µg/L)						420
Mercury (µg/L)						<1
Acidity as CaCO3 (mg/L)						< 20
Total Alkalinity as CaCO3 (mg/L)						79000
Bicarbonate as CaCO3 (mg/L)						190
Electrical Conductivity (µS/cm)						77000
Ammonia as N (mg N/L)						< 1
pH (pH)						8.3
Total Organic Carbon (mg/L)						16
Chloride (mg/L)						23000
Bromide (mg/L)						46
Fluoride (mg/L)						< 5
Nitrate (mg/L)						740
Nitrite (mg/L)						< 5
Orthophosphate (mg/L)						< 5
Sulphate (mg/L)						12000

Leach Extraction #36	Start	Leach Extraction 36 (Barren liquor)				
YYS164 5.2m-5.3m	inc Head	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	96hr bottle roll reading	
Time	30/04/2010 11 30	1/05/2010 11 30	2/05/2010 11 30	3/05/2010 11 30	4/05/2010 11 30	
CO2	y	n	n	y	y	Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	4.0	
Bottle Tare Wt (g)	1630.1					
Solids Mass (g) (wet)	300 9					
Liquor Mass (g)	902.7					
Gross Wt (g)	2833.4	2831.3	2829 2	2826.7	2820.7	
Total Mass	1203.3	1201.2	1199.1	1196.6	1190 6	
Temp (Deg C)	20.1	25.1	22 8	24.6	19 2	
pH	10 89	10 54	10.63	10 52	10.46	
ORP (mV Ag/AgCl)	123	159	198	139	138	39
EC (mS/cm)	90.3	77.8	79 3	77.9	78.4	
Calcium (µg/L)						3300
Iron (µg/L)						<100
Magnesium (µg/L)						2400
Phosphorus (µg/L)						<1000
Potassium (µg/L)						1900000
Silicon (µg/L)						61000
Sodium (µg/L)						43000000
Aluminium (µg/L)						<5
Antimony (µg/L)						<5
Arsenic (µg/L)						7300
Barium (µg/L)						48
Beryllium (µg/L)						<5
Bismuth (µg/L)						<5
Boron (µg/L)						23000
Cadmium (µg/L)						<0.2
Chromium (µg/L)						75
Cobalt (µg/L)						<5
Copper (µg/L)						66
Lead (µg/L)						<5
Lithium (µg/L)						<5
Manganese (µg/L)						<5
Molybdenum (µg/L)						2300
Nickel (µg/L)						<5
Selenium (µg/L)						500
Silver (µg/L)						<5
Strontium (µg/L)						510
Thallium (µg/L)						<5
Tin (µg/L)						9
Uranium (µg/L)						74000
Vanadium (µg/L)						24000
Zinc (µg/L)						660
Mercury (µg/L)						<1
Acidity as CaCO3 (mg/L)						< 20
Total Alkalinity as CaCO3 (mg/L)						79000
Bicarbonate as CaCO3 (mg/L)						220
Electrical Conductivity (µS/cm)						74000
Ammonia as N (mg N/L)						< 1
pH (pH)						8.5
Total Organic Carbon (mg/L)						18
Chloride (mg/L)						20000
Bromide (mg/L)						36
Fluoride (mg/L)						< 5
Nitrate (mg/L)						700
Nitrite (mg/L)						< 5
Orthophosphate (mg/L)						< 5
Sulphate (mg/L)						8200

Leach Extraction #37	**Start**	**Leach Extraction 37 (Barren liquor)**				
YYS165 6.6m - 6.7m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**96hr bottle roll reading**	
Time	**30/04/2010 11 30**	**1/05/2010 11 30**	**2/05/2010 11 30**	**3/05/2010 11 30**	**4/05/2010 11 30**	
CO2	**y**	**n**	**n**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	1 0	2.0	3 0	4.0	
Bottle Tare Wt (g)	1632.4					
Solids Mass (g) (wet)	301 8					
Liquor Mass (g)	907.1					
Gross Wt (g)	2840.3	2840	2837 6	2835.3	2833 2	
Total Mass	1207.9	1207.6	1205 2	1202.9	1200 8	
Temp (Deg C)	19.7	25.1	23 2	23.9	19.7	
pH	11 08	10 57	10.65	10.6	10.52	
ORP (mV Ag/AgCl)	92	117	200	187	148	48
EC (mS/cm)	89.7	85	82 8	79	81 8	
Calcium (µg/L)						3200
Iron (µg/L)						200
Magnesium (µg/L)						3500
Phosphorus (µg/L)						<1000
Potassium (µg/L)						1900000
Silicon (µg/L)						55000
Sodium (µg/L)						45000000
Aluminium (µg/L)						<5
Antimony (µg/L)						<5
Arsenic (µg/L)						7500
Barium (µg/L)						270
Beryllium (µg/L)						<5
Bismuth (µg/L)						<5
Boron (µg/L)						26000
Cadmium (µg/L)						<0.2
Chromium (µg/L)						77
Cobalt (µg/L)						<5
Copper (µg/L)						120
Lead (µg/L)						<5
Lithium (µg/L)						<5
Manganese (µg/L)						<5
Molybdenum (µg/L)						2600
Nickel (µg/L)						<5
Selenium (µg/L)						530
Silver (µg/L)						<5
Strontium (µg/L)						1000
Thallium (µg/L)						8
Tin (µg/L)						12
Uranium (µg/L)						91000
Vanadium (µg/L)						27000
Zinc (µg/L)						680
Mercury (µg/L)						<1
Acidity as CaCO3 (mg/L)						< 20
Total Alkalinity as CaCO3 (mg/L)						81000
Bicarbonate as CaCO3 (mg/L)						210
Electrical Conductivity (µS/cm)						76000
Ammonia as N (mg N/L)						< 1
pH (pH)						10
Total Organic Carbon (mg/L)						24
Chloride (mg/L)						23000
Bromide (mg/L)						39
Fluoride (mg/L)						6
Nitrate (mg/L)						730
Nitrite (mg/L)						< 5
Orthophosphate (mg/L)						< 5
Sulphate (mg/L)						9600

Leach Extraction #38	Start	Leach Extraction 38 (Barren liquor)			
YYS167 2.3m - 2.4m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**30/04/2010 11 30**	**1/05/2010 11 30**	**2/05/2010 11 30**	**3/05/2010 11 30**	
CO2	**y**	**Y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1630.2				
Solids Mass (g) (wet)	291.4				
Liquor Mass (g)	874.4				
Gross Wt (g)	2794.4	2794.3	2793.4	2792.1	
Total Mass	1164.2	1164.1	1163 2	1161.9	
Temp (Deg C)	20.6	19.2	16 8	19.3	
pH	10 89	10.72	10.53	10.16	
ORP (mV Ag/AgCl)	201	146	231	203	120
EC (mS/cm)	78.4	78.2	64 9	83.7	
Calcium (µg/L)					2200
Iron (µg/L)					<50
Magnesium (µg/L)					11000
Phosphorus (µg/L)					<100
Potassium (µg/L)					1500000
Silicon (µg/L)					55000
Sodium (µg/L)					43000000
Aluminium (µg/L)					<50
Antimony (µg/L)					<5
Arsenic (µg/L)					2300
Barium (µg/L)					550
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					25000
Cadmium (µg/L)					5.8
Chromium (µg/L)					85
Cobalt (µg/L)					<5
Copper (µg/L)					30
Lead (µg/L)					4
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					2000
Nickel (µg/L)					24
Selenium (µg/L)					95
Silver (µg/L)					<5
Strontium (µg/L)					1200
Thallium (µg/L)					40
Tin (µg/L)					<5
Uranium (µg/L)					82000
Vanadium (µg/L)					29000
Zinc (µg/L)					90
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					0.1
Total Alkalinity as CaCO3 (mg/L)					75000
Bicarbonate as CaCO3 (mg/L)					5300
Electrical Conductivity (µS/cm)					238000
Ammonia as N (mg N/L)					1
pH (pH)					10
Total Organic Carbon (mg/L)					2400
Chloride (mg/L)					19000
Bromide (mg/L)					92
Fluoride (mg/L)					17
Nitrate (mg/L)					150
Nitrite (mg/L)					0.59
Orthophosphate (mg/L)					3.4
Sulphate (mg/L)					3600

Leach Extraction #39	**Start**	**Leach Extraction 39 (Barren liquor)**			
YYS167 23m - 23.1m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**30/04/2010 11 30**	**1/05/2010 11 30**	**2/05/2010 11 30**	**3/05/2010 11 30**	
CO2	**y**	**Y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1630.0				
Solids Mass (g) (wet)	301 2				
Liquor Mass (g)	905				
Gross Wt (g)	2833.6	2833.6	2832 3	2829.5	
Total Mass	1203.6	1203.6	1202 3	1199.5	
Temp (Deg C)	20.5	19.2	16 6	15.3	
pH	11 07	10 82	10.63	10 52	
ORP (mV Ag/AgCl)	57	109	215	210	110
EC (mS/cm)	82.7	75.5	83 5	83.5	
Calcium (µg/L)					2500
Iron (µg/L)					150
Magnesium (µg/L)					37000
Phosphorus (µg/L)					<100
Potassium (µg/L)					1400000
Silicon (µg/L)					24000
Sodium (µg/L)					41000000
Aluminium (µg/L)					70
Antimony (µg/L)					<5
Arsenic (µg/L)					1200
Barium (µg/L)					430
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					26000
Cadmium (µg/L)					13
Chromium (µg/L)					78
Cobalt (µg/L)					<1
Copper (µg/L)					21
Lead (µg/L)					17
Lithium (µg/L)					8
Manganese (µg/L)					<5
Molybdenum (µg/L)					2100
Nickel (µg/L)					34
Selenium (µg/L)					77
Silver (µg/L)					<5
Strontium (µg/L)					1500
Thallium (µg/L)					64
Tin (µg/L)					<5
Uranium (µg/L)					78000
Vanadium (µg/L)					25000
Zinc (µg/L)					190
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					< 0.1
Total Alkalinity as CaCO3 (mg/L)					72000
Bicarbonate as CaCO3 (mg/L)					4500
Electrical Conductivity (µS/cm)					258000
Ammonia as N (mg N/L)					1.9
pH (pH)					10
Total Organic Carbon (mg/L)					2300
Chloride (mg/L)					18000
Bromide (mg/L)					87
Fluoride (mg/L)					25
Nitrate (mg/L)					140
Nitrite (mg/L)					0.52
Orthophosphate (mg/L)					0.53
Sulphate (mg/L)					3400

Leach Extraction #40	Start	Leach Extraction 40 (Barren liquor)			
YYS164 26.2m - 26.3m	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**30/04/2010 11 30**	**1/05/2010 11 30**	**2/05/2010 11 30**	**3/05/2010 11 30**	
CO2	**y**	**Y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1628.9				
Solids Mass (g) (wet)	300 3				
Liquor Mass (g)	900 3				
Gross Wt (g)	2828.9	2826.4	2826 3	2823	
Total Mass	1200.0	1197.5	1197.4	1194.1	
Temp (Deg C)	21.2	19.4	16 5	15.1	
pH	11 08	10.76	10 6	10.49	
ORP (mV Ag/AgCl)	276	163	263	132	100
EC (mS/cm)	93.4	76.2	85 2	84.5	
Calcium (µg/L)					2800
Iron (µg/L)					220
Magnesium (µg/L)					64000
Phosphorus (µg/L)					<100
Potassium (µg/L)					1300000
Silicon (µg/L)					16000
Sodium (µg/L)					41000000
Aluminium (µg/L)					150
Antimony (µg/L)					<5
Arsenic (µg/L)					1100
Barium (µg/L)					110
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					28000
Cadmium (µg/L)					<5
Chromium (µg/L)					78
Cobalt (µg/L)					<1
Copper (µg/L)					26
Lead (µg/L)					45
Lithium (µg/L)					15
Manganese (µg/L)					<5
Molybdenum (µg/L)					2500
Nickel (µg/L)					17
Selenium (µg/L)					73
Silver (µg/L)					<5
Strontium (µg/L)					1900
Thallium (µg/L)					<5
Tin (µg/L)					<5
Uranium (µg/L)					16000
Vanadium (µg/L)					29000
Zinc (µg/L)					90
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					< 0.1
Total Alkalinity as CaCO3 (mg/L)					72000
Bicarbonate as CaCO3 (mg/L)					2900
Electrical Conductivity (µS/cm)					227000
Ammonia as N (mg N/L)					1.2
pH (pH)					10
Total Organic Carbon (mg/L)					1300
Chloride (mg/L)					18000
Bromide (mg/L)					90
Fluoride (mg/L)					27
Nitrate (mg/L)					140
Nitrite (mg/L)					0.63
Orthophosphate (mg/L)					0.38
Sulphate (mg/L)					3400

CONTROL #41	Start	CONTROL 41 (No Solid - DI water - Air)			
DI water - Air	inc Head	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	
Time	23/03/2010 12 05	24/03/2010 12 30	25/03/2010 11 34	26/03/2010 11 42	
					Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1632.0				
Solids Mass (g) (wet)	0				
Liquor Mass (DI water)g	900 2			884	
Gross Wt (g)	2531.1	2527.5	2525.4	2522.5	
Total Mass	900 2	895 5	893.4	890 5	
Temp (Deg C)	23.2	25.1	26.1	29.4	
pH	9.59	9.52	9.59	8.43	
ORP (mV Ag/AgCl)	184	122	169	175	193.9
EC (uS/cm)	19.8	42	50	51	
Calcium (µg/L)					1200
Iron (µg/L)					<100
Magnesium (µg/L)					189
Phosphorus (µg/L)					<1000
Potassium (µg/L)					3980
Silicon (µg/L)					328
Sodium (µg/L)					3630
Aluminium (µg/L)					12
Antimony (µg/L)					<5
Arsenic (µg/L)					<5
Barium (µg/L)					<5
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					96
Cadmium (µg/L)					<5
Chromium (µg/L)					<5
Cobalt (µg/L)					<5
Copper (µg/L)					<5
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					10
Nickel (µg/L)					<5
Selenium (µg/L)					<5
Silver (µg/L)					<5
Strontium (µg/L)					5.3
Thallium (µg/L)					<5
Tin (µg/L)					<5
Uranium (µg/L)					22
Vanadium (µg/L)					5.3
Zinc (µg/L)					150
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					36
Bicarbonate as CaCO3 (mg/L)					36
Electrical Conductivity (µS/cm)					39
Ammonia as N (mg N/L)					<1
pH (pH)					7.8
Total Organic Carbon (mg/L)					1.9
Chloride (mg/L)					2.6
Bromide (mg/L)					<0 5
Fluoride (mg/L)					<0 5
Nitrate (mg/L)					<0 5
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					1.3

CONTROL #42	**Start**	**CONTROL 42 (No Solid - DI water - CO2)**			
DI water - CO2	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**11/05/2010 12 05**	**12/05/2010 12 05**	**13/05/2010 12 05**	**14/05/2010 12 05**	
CO2 Addition	**y**	**y**	**y**	**y**	**Assay**
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1629.9				
Solids Mass (g) (wet)	0				
Liquor Mass (DI water)g	900				
Gross Wt (g)	2529.9	2528.2	2525	2450.4	
Total Mass	900 0	898 3	895.1	820 5	
Temp (Deg C)	19.1	17	13 9	138	
pH	9	7.55	7.04	6.66	
ORP (mV Ag/AgCl)	131	281	237	251	58
EC (uS/cm)	26	113	125	145	
Calcium (µg/L)					1500
Iron (µg/L)					<50
Magnesium (µg/L)					<500
Phosphorus (µg/L)					2000
Potassium (µg/L)					17000
Silicon (µg/L)					200
Sodium (µg/L)					16000
Aluminium (µg/L)					<50
Antimony (µg/L)					<5
Arsenic (µg/L)					<5
Barium (µg/L)					<20
Beryllium (µg/L)					<1
Bismuth (µg/L)					< 1
Boron (µg/L)					110
Cadmium (µg/L)					<0 2
Chromium (µg/L)					<1
Cobalt (µg/L)					<1
Copper (µg/L)					<5
Lead (µg/L)					<1
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					<5
Nickel (µg/L)					<5
Selenium (µg/L)					<1
Silver (µg/L)					<5
Strontium (µg/L)					9
Thallium (µg/L)					<1
Tin (µg/L)					<5
Uranium (µg/L)					79
Vanadium (µg/L)					11
Zinc (µg/L)					95
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					25
Total Alkalinity as CaCO3 (mg/L)					30
Bicarbonate as CaCO3 (mg/L)					30
Electrical Conductivity (µS/cm)					380
Ammonia as N (mg N/L)					0.03
pH (pH)					8.2
Total Organic Carbon (mg/L)					< 5
Chloride (mg/L)					20
Bromide (mg/L)					< 20
Fluoride (mg/L)					< 0.5
Nitrate (mg/L)					< 0 02
Nitrite (mg/L)					< 0 02
Orthophosphate (mg/L)					0.08
Sulphate (mg/L)					< 5

CONTROL #43	**Start**	**CONTROL 43 (No Solid - BARREN LIQ - Air)**			
BARREN LIQ - Air	**inc Head**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	
Time	**23/03/2010 12 05**	**24/03/2010 12 30**	**25/03/2010 11 34**	**26/03/2010 11 42**	
					Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1630.8				
Solids Mass (g) (wet)	0				
Liquor Mass (Barren)g	900.1			870	
Gross Wt (g)	2530.9	2513.1	2509 8	2507.9	
Total Mass	900.1	882 3	879.0	877.1	
Temp (Deg C)	22	25.1	26.1	28.9	
pH	10 97	11	10.94	10 91	
ORP (mV Ag/AgCl)	91	107	111	120	117
EC (mS/cm)	98.2	93	97 6	97.4	
Calcium (µg/L)					590
Iron (µg/L)					130
Magnesium (µg/L)					310
Phosphorus (µg/L)					<1000
Potassium (µg/L)					1610000
Silicon (µg/L)					13000
Sodium (µg/L)					42200000
Aluminium (µg/L)					490
Antimony (µg/L)					<5
Arsenic (µg/L)					8400
Barium (µg/L)					17
Beryllium (µg/L)					<5
Bismuth (µg/L)					<5
Boron (µg/L)					31000
Cadmium (µg/L)					<5
Chromium (µg/L)					400
Cobalt (µg/L)					<5
Copper (µg/L)					76
Lead (µg/L)					<5
Lithium (µg/L)					<5
Manganese (µg/L)					<5
Molybdenum (µg/L)					2400
Nickel (µg/L)					<5
Selenium (µg/L)					500
Silver (µg/L)					<5
Strontium (µg/L)					66
Thallium (µg/L)					<5
Tin (µg/L)					12
Uranium (µg/L)					100000
Vanadium (µg/L)					36000
Zinc (µg/L)					58
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					<20
Total Alkalinity as CaCO3 (mg/L)					77200
Bicarbonate as CaCO3 (mg/L)					186
Electrical Conductivity (µS/cm)					85700
Ammonia as N (mg N/L)					1
pH (pH)					10 9
Total Organic Carbon (mg/L)					590
Chloride (mg/L)					14000
Bromide (mg/L)					48
Fluoride (mg/L)					<0 5
Nitrate (mg/L)					630
Nitrite (mg/L)					<0 5
Orthophosphate (mg/L)					<0 5
Sulphate (mg/L)					7000

CONTROL #44	Start	CONTROL 44 (No Solid - BARREN LIQ - CO2)			
BARREN LIQ - CO2	inc Head	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	
Time	11/05/2010 12 05	12/05/2010 12 05	13/05/2010 12 05	14/05/2010 12 05	
CO2 Addition	y	y	y	y	Assay
Elapsed Time (days)	0 0	1 0	2.0	3 0	
Bottle Tare Wt (g)	1629.8				
Solids Mass (g) (wet)	0				
Liquor Mass (Barren)g	900 6			870	
Gross Wt (g)	2530.4	2529.2	2528.7	2527.7	
Total Mass	900 6	899.4	898.9	897 9	
Temp (Deg C)	17.8	17	13 8	13.9	
pH	11.2	10 91	10.71	10 58	
ORP (mV Ag/AgCl)	140	219	144	134	110
EC (mS/cm)	91.1	93.1	93 8	9 6	
Calcium (µg/L)					3200
Iron (µg/L)					<50
Magnesium (µg/L)					600
Phosphorus (µg/L)					<100
Potassium (µg/L)					1400000
Silicon (µg/L)					32000
Sodium (µg/L)					42000000
Aluminium (µg/L)					<50
Antimony (µg/L)					<5
Arsenic (µg/L)					2700
Barium (µg/L)					60
Beryllium (µg/L)					<1
Bismuth (µg/L)					< 1
Boron (µg/L)					28000
Cadmium (µg/L)					<5
Chromium (µg/L)					63
Cobalt (µg/L)					<1
Copper (µg/L)					150
Lead (µg/L)					11
Lithium (µg/L)					<5
Manganese (µg/L)					9
Molybdenum (µg/L)					1900
Nickel (µg/L)					6
Selenium (µg/L)					100
Silver (µg/L)					<5
Strontium (µg/L)					110
Thallium (µg/L)					<5
Tin (µg/L)					10
Uranium (µg/L)					79000
Vanadium (µg/L)					38000
Zinc (µg/L)					290
Mercury (µg/L)					<0.1
Acidity as CaCO3 (mg/L)					< 0.1
Total Alkalinity as CaCO3 (mg/L)					76000
Bicarbonate as CaCO3 (mg/L)					3800
Electrical Conductivity (µS/cm)					222000
Ammonia as N (mg N/L)					1.3
pH (pH)					11
Total Organic Carbon (mg/L)					630
Chloride (mg/L)					18000
Bromide (mg/L)					84
Fluoride (mg/L)					22
Nitrate (mg/L)					150
Nitrite (mg/L)					0.51
Orthophosphate (mg/L)					0.61
Sulphate (mg/L)					3300

SEQUENTIAL #1		Sequence 1				Sequence 2					Sequence 3				
YYS158 3.75m 4.75m	**Start Seq 1**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 1 Liquor**	**Start Seq 2**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 2 Liquor**	**Start Seq 3**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 3 Liquor**
Time	**22/03/2010 11:42**	**23/03/2010 11:42**	**24/03/2010 11:42**	**25/03/2010 11:42**		**25/03/2010 15:00**	**26/03/2010 15:00**	**27/03/2010 15:00**	**28/03/2010 15:00**		**28/03/2010 10:20**	**29/03/2010 10:20**	**30/03/2010 10:20**	**31/03/2010 10:20**	
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	5.0	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1629.0					1629.0					1629.0				
Solids Mass (g) (wet)	314.3					491.3					359.6				
Liquor Mass (g)	943.8					1474.7					1082				
Gross Wt (g)	2887.1					3595.6					3066				
Total Mass (solid+liquor) g	1258.1					1966					1441.6				
Temp (Deg C)	24.4	26.2	24.9	25.6		25.7	28.3	25.9	23.6		21.7	24.9	22.9	23.7	
pH	8.7	9.08	8.94	8.78		9.01	9.12	9.22	9.17		9.74	9.59	9.32	9.42	
ORP (mV Ag/AgCl)	340	173	180	111	168.4	163	192	193	130	169.3	180	175	215	236	406.7
EC (uS/cm)	1931	2190	2110	2190		244	578	625	663		137	287	316	353	
Calcium (µg/L)					20100					8720					8080
Iron (µg/L)					<100					<100					<100
Magnesium (µg/L)					32400					17000					18700
Phosphorus (µg/L)					<100					<100					<100
Potassium (µg/L)					62500					22300					12000
Silicon (µg/L)					5380					4520					3930
Sodium (µg/L)					356000					74600					25800
Aluminium (µg/L)					33					26					19
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					<5					<5					<5
Barium (µg/L)					33					15					11
Beryllium (µg/L)					<5					<5					<5
Bismuth (µg/L)					<5					<5					<5
Boron (µg/L)					750					340					180
Cadmium (µg/L)					<5					<5					<5
Chromium (µg/L)					<5					<5					<5
Cobalt (µg/L)					<5					<5					<5
Copper (µg/L)					5.9					<5					<5
Lead (µg/L)					<5					<5					<5
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					<5					<5					<5
Molybdenum (µg/L)					37					7.9					<5
Nickel (µg/L)					<5					<5					<5
Selenium (µg/L)					5.1					<5					<5
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					570					200					190
Thallium (µg/L)					26					<5					<5
Tin (µg/L)					<5					<5					<5
Uranium (µg/L)					290					240					180
Vanadium (µg/L)					110					120					100
Zinc (µg/L)					140					95					69
Mercury (µg/L)					<0.1					<0.1					<0.1
Acidity as CaCO3 (mg/L)					<20					<20					970
Total Alkalinity as CaCO3 (mg/L)					190					210					<20
Bicarbonate as CaCO3 (mg/L)					165					179					<10
Electrical Conductivity (µS/cm)					2250					705					6840
Ammonia as N (mg N/L)					<2					<1					<2
pH (pH)					8.6					8.7					1.9
Total Organic Carbon (mg/L)					2.5					2.4					1.2
Chloride (mg/L)					500					68					6.8
Bromide (mg/L)					1.1					<0.5					<0.5
Fluoride (mg/L)					1.8					1.8					0.7
Nitrate (mg/L)					7.9					1					1400
Nitrite (mg/L)					<0.5					<0.5					<0.5
Orthophosphate (mg/L)					<0.5					<0.5					<0.5
Sulphate (mg/L)					250					50					7.5

SEQUENTIAL #2		Sequence 1				Sequence 2					Sequence 3				
YYS156A 3m 4m	**Start Seq 1**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 1 Liquor**	**Start Seq 2**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 2 Liquor**	**Start Seq 3**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 3 Liquor**
Time	**22/03/2010 11:42**	**23/03/2010 11:42**	**24/03/2010 11:42**	**25/03/2010 11:42**		**26/03/2010 8:43**	**27/03/2010 8:43**	**28/03/2010 8:43**	**29/03/2010 8:43**		**29/03/2010 12:00**	**30/03/2010 12:00**	**31/03/2010 12:00**	**1/04/2010 12:00**	
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	5.0	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1633.6					1633.6					1633.6				
Solids Mass (g) (wet)	325.4					306.1					424.6				
Liquor Mass (g)	977.5					922.1					1274.5				
Gross Wt (g)	2935.8					2861.9					3332.6				
Total Mass (solid+liquor) g	1302.9					1228.2					1699.1				
Temp (Deg C)	24	26.3	25.2	26		21.7	24.8	23.6	22.9		22.7	24.9	26	24.1	
pH	8.75	9.02	8.96	8.74		9.7	9.26	9.17	9.03		10.01	9.46	9.3	9.34	
ORP (mV Ag/AgCl)	200	143	115	167	172.5	218	184	189	161	166	162	208	166	225	166.6
EC (uS/cm)	2327	2780	2780	3400		688	977	1161	1082		212	507	562	586	
			2780												
Calcium (µg/L)					15600					6510					4130
Iron (µg/L)					<100					<100					<100
Magnesium (µg/L)					14200					3920					2270
Phosphorus (µg/L)					<100					<100					<100
Potassium (µg/L)					130000					40000					26400
Silicon (µg/L)					18000					14000					11000
Sodium (µg/L)					645000					186000					78700
Aluminium (µg/L)					28					28					23
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					48					45					21
Barium (µg/L)					15					5.1					<5
Beryllium (µg/L)					<5					<5					<5
Bismuth (µg/L)					<5					<5					<5
Boron (µg/L)					3300					1300					610
Cadmium (µg/L)					<5					9.4					<5
Chromium (µg/L)					<5					<5					<5
Cobalt (µg/L)					<5					<5					<5
Copper (µg/L)					5.6					5.8					<5
Lead (µg/L)					<5					<5					<5
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					<5					<5					<5
Molybdenum (µg/L)					110					28					7.2
Nickel (µg/L)					<5					<5					<5
Selenium (µg/L)					10					<5					<5
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					280					74					43
Thallium (µg/L)					17					290					<5
Tin (µg/L)					<5					<5					<5
Uranium (µg/L)					1900					2100					1000
Vanadium (µg/L)					500					600					450
Zinc (µg/L)					120					110					110
Mercury (µg/L)					<0.1					<0.1					<0.1
Acidity as CaCO3 (mg/L)					<20					<20					<20
Total Alkalinity as CaCO3 (mg/L)					295					417					270
Bicarbonate as CaCO3 (mg/L)					295					314					197
Electrical Conductivity (µS/cm)					3240					1180					555
Ammonia as N (mg N/L)					<2					<1					<1
pH (pH)					7.8					9.1					9.1
Total Organic Carbon (mg/L)					3.4					3.2					1.6
Chloride (mg/L)					580					84					9.1
Bromide (mg/L)					1.4					<0.5					<0.5
Fluoride (mg/L)					3.7					3.6					2.7
Nitrate (mg/L)					95					3.2					<0.5
Nitrite (mg/L)					<0.5					<0.5					<0.5
Orthophosphate (mg/L)					<0.5					<0.5					<0.5
Sulphate (mg/L)					310					52					6.6

SEQUENTIAL #3		**Sequence 1**				**Sequence 2**					**Sequence 3**				
YYS162 4.5m 4.6m	**Start Seq 1**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 1 Liquor**	**Start Seq 2**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 2 Liquor**	**Start Seq 3**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 3 Liquor**
Time	**16/04/2010 12:12**	**17/04/2010 11:42**	**18/04/2010 11:42**	**19/04/2010 11:42**		**19/04/2010 8:43**	**20/04/2010 8:43**	**21/04/2010 8:43**	**22/04/2010 8:43**		**22/04/2010 8:43**	**23/04/2010 8:43**	**24/04/2010 8:43**	**25/04/2010 8:43**	
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	5.0	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1630.0					1630.0					1630.0				
Solids Mass (g) (wet)	300.9					364.2					436.3				
Liquor Mass (g)	902.4					1091.1					1311.7				
Gross Wt (g)	2833.3					3078.9					3378.0				
Total Mass (solid+liquor) g	1203.3					1455.3					1748				
Temp (Deg C)	23.2	26.1	25	21.4		23.7	22.5	21.6	23.1		24.5	25.4	24.4	21.7	
pH	9.08	8.95	8.8	8.88		9.63	9.59	9.54	9.41		9.8	9.69	9.9	9.38	
ORP (mV Ag/AgCl)	45	139	197	206	210	141	155	176	192	177	194	197	238	116	130
EC (mS/cm)	3.55	3.44	2.88	2.23		0.665	1.034	0.642	0.734		0.207	0.337	0.768	0.425	
Calcium (µg/L)					20900					2800					1700
Iron (µg/L)					560					<100					<100
Magnesium (µg/L)					15700					1160					700
Phosphorus (µg/L)					<100					<100					<1000
Potassium (µg/L)					104000					26400					18000
Silicon (µg/L)					19000					17000					15000
Sodium (µg/L)					627000					135000					77000
Aluminium (µg/L)					680					26					69
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					27					28					22
Barium (µg/L)					18					<5					<5
Beryllium (µg/L)					<5					<5					<5
Bismuth (µg/L)					<5					<5					<5
Boron (µg/L)					2700					860					370
Cadmium (µg/L)					<5					<5					2.6
Chromium (µg/L)					<5					<5					<5
Cobalt (µg/L)					<5					<5					<5
Copper (µg/L)					<5					<5					10
Lead (µg/L)					<5					<5					<5
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					<5					<5					<5
Molybdenum (µg/L)					37					<5					<5
Nickel (µg/L)					<5					<5					<5
Selenium (µg/L)					<5					<5					<5
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					330					22					19
Thallium (µg/L)					<5					120					43
Tin (µg/L)					<5					<5					<5
Uranium (µg/L)					97					120					150
Vanadium (µg/L)					400					600					360
Zinc (µg/L)					93					120					130
Mercury (µg/L)					<0.1					<0.1					<0.1
Acidity as CaCO3 (mg/L)					<20					<20					< 20
Total Alkalinity as CaCO3 (mg/L)					142					202					180
Bicarbonate as CaCO3 (mg/L)					112					122					180
Electrical Conductivity (µS/cm)					2950					676					370
Ammonia as N (mg N/L)					<2					<2					< 1
pH (pH)					8.6					9.2					8.1
Total Organic Carbon (mg/L)					4.7					4.6					27
Chloride (mg/L)					740					75					16
Bromide (mg/L)					<0.5					<0.5					< 5
Fluoride (mg/L)					1.9					2.7					2.1
Nitrate (mg/L)					8.6					0.7					< 0.1
Nitrite (mg/L)					<0.5					<0.5					< 0.1
Orthophosphate (mg/L)					<0.5					<0.5					< 0.05
Sulphate (mg/L)					500					46					< 5

SEQUENTIAL #5		Sequence 1				Sequence 2					Sequence 3				
YYS165 1.5m 1.6m	Start Seq 1	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 1 Liquor	Start Seq 2	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 2 Liquor	Start Seq 3	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 3 Liquor
Time	16/04/2010 12:12	17/04/2010 11:42	18/04/2010 11:42	19/04/2010 11:42		19/04/2010 8:43	20/04/2010 8:43	21/04/2010 8:43	22/04/2010 8:43		22/04/2010 8:43	23/04/2010 8:43	24/04/2010 8:43	25/04/2010 8:43	
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	5.0	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1627.4					1627.4					1627.4				
Solids Mass (g) (wet)	237.1					244.1					349.8				
Liquor Mass (g)	711					694.5					1054.2				
Gross Wt (g)	2575.5					2616.2					3031.2				
Total Mass (solid+liquor) g	948.1					938.6					1404.0				
Temp (Deg C)	23.3	26.1	25.7	20.3		22.9	22	21.5	27.8		25.8	25.7	23.7	22	
pH	8.83	8.53	8.55	8.63		9.28	8.96	8.51	8.4		8.87	8.9	8.87	8.59	
ORP (mV Ag/AgCl)	45	126	164	170	180	128	160	202	213	182	362	172	238	132	120
EC (uS/cm)	564	675	745	731		246	427	375	414		175.7	253	334	327	
														1]]	
Calcium (µg/L)					17300					10700					10000
Iron (µg/L)					<100					<100					< 100
Magnesium (µg/L)					8670					4440					4000
Phosphorus (µg/L)					<100					<100					<1000
Potassium (µg/L)					29600					21300					17000
Silicon (µg/L)					31000					28000					27000
Sodium (µg/L)					112000					60000					27000
Aluminium (µg/L)					<5					8.9					<5
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					<5					<5					<5
Barium (µg/L)					31					18					29
Beryllium (µg/L)					<5					<5					<5
Bismuth (µg/L)					<5					<5					<5
Boron (µg/L)					250					160					110
Cadmium (µg/L)					10					<5					2.9
Chromium (µg/L)					<5					<5					<5
Cobalt (µg/L)					<5					<5					<5
Copper (µg/L)					<5					15					<5
Lead (µg/L)					<5					<5					<5
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					<5					<5					<5
Molybdenum (µg/L)					<5					<5					<5
Nickel (µg/L)					<5					<5					<5
Selenium (µg/L)					<5					<5					<5
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					140					80					92
Thallium (µg/L)					110					93					62
Tin (µg/L)					<5					<5					<5
Uranium (µg/L)					51					70					48
Vanadium (µg/L)					76					87					73
Zinc (µg/L)					96					130					100
Mercury (µg/L)					<0.1					<0.1					<0.1
Acidity as CaCO3 (mg/L)					<20					<20					< 20
Total Alkalinity as CaCO3 (mg/L)					154					164					130
Bicarbonate as CaCO3 (mg/L)					138					142					110
Electrical Conductivity (µS/cm)					703					340					260
Ammonia as N (mg N/L)					<2					<1					< 1
pH (pH)					8.4					8.5					8.4
Total Organic Carbon (mg/L)					6.4					4.7					< 5
Chloride (mg/L)					110					16					11
Bromide (mg/L)					<0.5					<0.5					< 5
Fluoride (mg/L)					1.1					1.6					< 0.5
Nitrate (mg/L)					14					2.7					0.3
Nitrite (mg/L)					<0.5					<0.5					< 0.1
Orthophosphate (mg/L)					<0.5					<0.5					< 0.05
Sulphate (mg/L)					58					31					4.1

SEQUENTIAL #6		**Sequence 1**				**Sequence 2**					**Sequence 3**				
YYS166 0.4m 0.5m	**Start Seq 1**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 1 Liquor**	**Start Seq 2**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 2 Liquor**	**Start Seq 3**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 3 Liquor**
Time	**16/04/2010 12:12**	**17/04/2010 11:42**	**18/04/2010 11:42**	**19/04/2010 11:42**		**27/04/2010 8:43**	**28/04/2010 8:43**	**29/04/2010 8:43**	**30/04/2010 8:43**		**30/04/2010 8:43**	**1/05/2010 8:43**	**2/05/2010 8:43**	**3/05/2010 8:43**	
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	5.0	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1629.6					1629.6					1629.6				
Solids Mass (g) (wet)	300.3					380.9					367.7				
Liquor Mass (g)	904.9					1144.9					1106				
Gross Wt (g)	2575.5					2616.2					3031.2				
Total Mass (solid+liquor) g	1205.2					1525.8					1473.7				
Temp (Deg C)	18.7	20.3	22.7	18		20.6	20.2	23	18.2		23.6	20.4	19.1	16.6	
pH	8.44	8.4	8.27	8.21		8.89	8.51	8.03	8.5		9.14	8.7	8.33	8.3	
ORP (mV Ag/AgCl)	212	172	246	230	160	223	184	162	212	110	153	199	190	163	210
EC (uS/cm)	780	841	921	919		65.7	129	149	146.9		67.9	92.4	62.5	71.9	
Calcium (µg/L)					3800					<100					<500
Iron (µg/L)					<100					<100					<50
Magnesium (µg/L)					10000					<500					<500
Phosphorus (µg/L)					<1000					<1000					2300
Potassium (µg/L)					23000					18000					3500
Silicon (µg/L)					17000					15000					29000
Sodium (µg/L)					140000					32000					13000
Aluminium (µg/L)					<5					360					<50
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					<5					<5					<5
Barium (µg/L)					56					<5					<5
Beryllium (µg/L)					<5					<5					<1
Bismuth (µg/L)					<5					<5					<5
Boron (µg/L)					450					410					220
Cadmium (µg/L)					13					<0.2					9.8
Chromium (µg/L)					6					<5					6
Cobalt (µg/L)					<5					<5					<1
Copper (µg/L)					12					<5					<5
Lead (µg/L)					<5					<5					<1
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					35					19					6
Molybdenum (µg/L)					28					33					15
Nickel (µg/L)					<5					<5					<1
Selenium (µg/L)					<5					<5					<5
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					130					7					<5
Thallium (µg/L)					220					<5					360
Tin (µg/L)					<5					24					<5
Uranium (µg/L)					<5					51					<5
Vanadium (µg/L)					8					18					9
Zinc (µg/L)					200					98					150
Mercury (µg/L)					<0.1					<0.1					<0.1
Acidity as CaCO3 (mg/L)					< 20					< 20					50
Total Alkalinity as CaCO3 (mg/L)					39					250					24
Bicarbonate as CaCO3 (mg/L)					39					< 20					24
Electrical Conductivity (µS/cm)					890					120					160
Ammonia as N (mg N/L)					< 1					< 1					< 0.01
pH (pH)					7.3					7.3					8.6
Total Organic Carbon (mg/L)					18					6.3					18
Chloride (mg/L)					160					15					11
Bromide (mg/L)					< 5					< 5					< 5
Fluoride (mg/L)					< 0.5					0.8					0.61
Nitrate (mg/L)					5.2					< 0.1					< 0.1
Nitrite (mg/L)					< 0.1					< 0.1					< 0.02
Orthophosphate (mg/L)					< 0.5					< 0.5					0.12
Sulphate (mg/L)					23					< 15					< 5

SEQUENTIAL #8		Sequence 1				Sequence 2					Sequence 3				
YYS164 4.3m 4.4m	Start Seq 1	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 1 Liquor	Start Seq 2	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 2 Liquor	Start Seq 3	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 3 Liquor
Time	27/04/2010 8:43	28/04/2010 8:43	29/04/2010 8:43	30/04/2010 8:43		30/04/2010 8:43	1/05/2010 8:43	2/05/2010 8:43	3/05/2010 8:43		3/05/2010 8:43	4/05/2010 8:43	5/05/2010 8:43	6/05/2010 8:43	
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	5.0	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1631.9					1631.9					1631.9				
Solids Mass (g) (wet)	301.0					381.4					361.6				
Liquor Mass (g)	905.8					1145.7					1086.5				
Gross Wt (g)	2838.5					3158.9					3080.0				
Total Mass (solid+liquor) g	1206.8					1527.1					1448.1				
Temp (Deg C)	22.2	20.8	23.1	23		21.8	20.8	23.3	22.3		20	19.1	17.8	20.1	
pH	8.76	8.61	8.48	8.64		9.35	9.29	9.07	9.06		9.48	9.44	9.32	9.14	
ORP (mV Ag/AgCl)	173	162	226	193	160	162	174	170	190	150	184	139	182	163	210
EC (uS/cm)	2300	2510	2530	2500		242	454	505	514		96.9	256	309	229	
Calcium (µg/L)					12000					300					<500
Iron (µg/L)					<100					<100					<100
Magnesium (µg/L)					15000					500					<500
Phosphorus (µg/L)					<1000					<1000					2100
Potassium (µg/L)					69000					21000					6100
Silicon (µg/L)					18000					21000					44000
Sodium (µg/L)					450000					88000					39000
Aluminium (µg/L)					<5					<5					100
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					9					9					8
Barium (µg/L)					44					<5					0.02
Beryllium (µg/L)					<5					<5					<20
Bismuth (µg/L)					<5					<5					< 1
Boron (µg/L)					2600					1100					760
Cadmium (µg/L)					9.5					<0.2					<5
Chromium (µg/L)					<5					<5					<5
Cobalt (µg/L)					<5					<5					<1
Copper (µg/L)					7					<5					<5
Lead (µg/L)					<5					<5					<1
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					<5					<5					<5
Molybdenum (µg/L)					76					14					<5
Nickel (µg/L)					<5					<5					<1
Selenium (µg/L)					13					<5					<1
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					200					7					<5
Thallium (µg/L)					180					360					140
Tin (µg/L)					<5					7					<5
Uranium (µg/L)					13					16					<5
Vanadium (µg/L)					58					96					86
Zinc (µg/L)					110					79					99
Mercury (µg/L)					<0.1					<1					<0.1
Acidity as CaCO3 (mg/L)					< 20					< 20					50
Total Alkalinity as CaCO3 (mg/L)					120					1000					64
Bicarbonate as CaCO3 (mg/L)					120					29					64
Electrical Conductivity (µS/cm)					2400					430					270
Ammonia as N (mg N/L)					< 1					< 1					0.03
pH (pH)					8					7.5					8.3
Total Organic Carbon (mg/L)					18					13					18
Chloride (mg/L)					600					56					12
Bromide (mg/L)					2.3					< 5					< 5
Fluoride (mg/L)					3.7					2.2					4.3
Nitrate (mg/L)					4					0.3					< 0.1
Nitrite (mg/L)					< 0.1					< 0.1					< 0.02
Orthophosphate (mg/L)					< 0.5					< 0.05					0.24
Sulphate (mg/L)					310					33					< 5

SEQUENTIAL #9		Sequence 1				Sequence 2					Sequence 3				
YYS156A 1.5m 2.5m	**Start Seq 1**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 1 Liquor**	**Start Seq 2**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 2 Liquor**	**Start Seq 3**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 3 Liquor**
Time	**22/03/2010 11:42**	**23/03/2010 11:42**	**24/03/2010 11:42**	**25/03/2010 11:42**		**26/03/2010 13:35**	**27/03/2010 13:35**	**28/03/2010 13:35**	**29/03/2010 13:35**		**29/03/2010 12:00**	**30/03/2010 12:00**	**31/03/2010 12:00**	**1/04/2010 12:00**	
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	5.0	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1695.4					1695.4					1695.4				
Solids Mass (g) (wet)	336.7					506.3					491.7				
Liquor Mass (g)	1011					1520.3					1477.5				
Gross Wt (g)	3042.8					3721.8					3664.5				
Total Mass (solid+liquor) g	1347.7					2026.6					1969.2				
Temp (Deg C)	19.4	18.5	21.8	23.8		25.2	26.2	23.7	23.2		23.2	25.3	26	26.6	
pH	7.95	8.35	8.26	8.28		8.48	8.38	8.32	8.46		8.44	8.22	8.36	8.33	
ORP (mV Ag/AgCl)	203	206	209	218	203.2	189	201	164	183	202.6	193	227	233	221	207.1
EC (mS/cm)	6.16	6.59	6.6	6.65		2.18	3.47	3.51	3.48		1.189	2.64	2.68	2.76	
Calcium (µg/L)					640000					642000					694000
Iron (µg/L)					<100					110					<100
Magnesium (µg/L)					95300					49700					33500
Phosphorus (µg/L)					<100					<100					<100
Potassium (µg/L)					203000					72500					38000
Silicon (µg/L)					10000					10000					11000
Sodium (µg/L)					1030000					261000					61800
Aluminium (µg/L)					28					29					21
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					12					7					5.8
Barium (µg/L)					60					52					47
Beryllium (µg/L)					<5					<5					<5
Bismuth (µg/L)					<5					<5					<5
Boron (µg/L)					3600					1200					610
Cadmium (µg/L)					<5					<5					27
Chromium (µg/L)					<5					<5					<5
Cobalt (µg/L)					<5					<5					<5
Copper (µg/L)					10					8.7					6.6
Lead (µg/L)					<5					<5					<5
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					9.1					5					<5
Molybdenum (µg/L)					99					21					5.4
Nickel (µg/L)					17					16					16
Selenium (µg/L)					23					<5					<5
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					6000					4900					4200
Thallium (µg/L)					<5					<5					120
Tin (µg/L)					<5					<5					<5
Uranium (µg/L)					360					260					180
Vanadium (µg/L)					84					79					71
Zinc (µg/L)					160					140					150
Mercury (µg/L)					<0.1					<0.1					<0.1
Acidity as CaCO3 (mg/L)					<20					<20					<20
Total Alkalinity as CaCO3 (mg/L)					85					68					56
Bicarbonate as CaCO3 (mg/L)					85					68					56
Electrical Conductivity (µS/cm)					7510					3070					2420
Ammonia as N (mg N/L)					<1					<1					<1
pH (pH)					7.9					7.8					7.7
Total Organic Carbon (mg/L)					6.1					2.3					1.1
Chloride (mg/L)					890					97					14
Bromide (mg/L)					1.6					<0.5					<0.5
Fluoride (mg/L)					1.5					1.4					1.3
Nitrate (mg/L)					36					3.8					0.6
Nitrite (mg/L)					<0.5					<0.5					<0.5
Orthophosphate (mg/L)					<0.5					<0.5					<0.5
Sulphate (mg/L)					3200					2100					1700

SEQUENTIAL #10		**Sequence 1**					**Sequence 2**					**Sequence 3**			
YYS157 3.65m 4.1m	**Start Seq 1**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 1 Liquor**	**Start Seq 2**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 2 Liquor**	**Start Seq 3**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 3 Liquor**
Time	**23/03/2010 9:50**	**24/03/2010 9:50**	**25/03/2010 9:50**	**26/03/2010 9:50**		**26/03/2010 14:20**	**27/03/2010 13:35**	**28/03/2010 9:35**	**29/03/2010 13:35**		**30/03/2010 8:30**	**31/03/2010 8:30**	**1/04/2010 8:30**	**2/04/2010 8:30**	
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	4.8	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1633.1					1633.1					1633.1				
Solids Mass (g) (wet)	329.7					371.5					384.5				
Liquor Mass (g)	990.6					1116.2					1155.9				
Gross Wt (g)	2953.1					3196.7					3173.3				
Total Mass (solid+liquor) g	1320.3					1487.7					1540.4				
Temp (Deg C)	20	19.9	23.5	25.7		26.1	26.2	23.6	25.6		18.1	19.5	20.6	22.3	
pH	9.81	9.27	9.01	8.95		9.73	9.21	9.26	9.26		9.81	9.42	9.41	9.14	
ORP (mV Ag/AgCl)	175	182	177	184	152.6	182	148	130	184	154	232	225	243	182	160.6
EC (uS/cm)	631	845	1218	938		206	38	413	432		118.9	278	315	323	
Calcium (µg/L)					5730					3370					3590
Iron (µg/L)					<100					<100					<100
Magnesium (µg/L)					3440					1450					1520
Phosphorus (µg/L)					<100					<100					<100
Potassium (µg/L)					22700					14000					12600
Silicon (µg/L)					25000					26000					25000
Sodium (µg/L)					154000					64000					43900
Aluminium (µg/L)					36					39					31
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					7					<5					<5
Barium (µg/L)					<5					<5					<5
Beryllium (µg/L)					<5					<5					<5
Bismuth (µg/L)					<5					<5					<5
Boron (µg/L)					630					380					300
Cadmium (µg/L)					<5					<5					<5
Chromium (µg/L)					<5					<5					<5
Cobalt (µg/L)					<5					<5					<5
Copper (µg/L)					6.5					<5					<5
Lead (µg/L)					<5					<5					<5
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					<5					<5					<5
Molybdenum (µg/L)					71					9.9					<5
Nickel (µg/L)					<5					<5					<5
Selenium (µg/L)					<5					<5					<5
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					56					34					31
Thallium (µg/L)					79					150					110
Tin (µg/L)					<5					<5					<5
Uranium (µg/L)					85					41					36
Vanadium (µg/L)					170					130					83
Zinc (µg/L)					120					110					120
Mercury (µg/L)					<0.1					<0.1					<0.1
Acidity as CaCO3 (mg/L)					<20					<20					<20
Total Alkalinity as CaCO3 (mg/L)					224					190					157
Bicarbonate as CaCO3 (mg/L)					180					136					117
Electrical Conductivity (µS/cm)					1030					384					297
Ammonia as N (mg N/L)					<1					<1					<1
pH (pH)					8.8					9					8.8
Total Organic Carbon (mg/L)					2.9					1.2					1.5
Chloride (mg/L)					110					9.1					2.2
Bromide (mg/L)					1.4					<0.5					<0.5
Fluoride (mg/L)					2.8					2.2					1.5
Nitrate (mg/L)					1.3					<0.5					<0.5
Nitrite (mg/L)					<0.5					<0.5					<0.5
Orthophosphate (mg/L)					<0.5					<0.5					<0.5
Sulphate (mg/L)					95					22					15

SEQUENTIAL #11		Sequence 1				Sequence 2					Sequence 3				
YYS158 3.5m 3.75m	Start Seq 1	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 1 Liquor	Start Seq 2	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 2 Liquor	Start Seq 3	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 3 Liquor
Time	31/03/2010 15:00	1/04/2010 15:00	2/04/2010 15:00	3/04/2010 15:00		3/04/2010 11:20	4/04/2010 11:20	5/04/2010 11:20	6/04/2010 11:20		6/04/2010 10:30	7/04/2010 10:30	8/04/2010 10:30	9/04/2010 10:30	
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	5.0	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1630.5					1630.5					1630.5				
Solids Mass (g) (wet)	292.6					473.8					535.4				
Liquor Mass (g)	878.9					1421.9					1606.6				
Gross Wt (g)	2721.5					3525.9					3772				
Total Mass (solid+liquor) g	1171.5					1895.7					2142				
Temp (Deg C)	25.6	25.7	24.7	20		19	25	27.2	22.6		21.6	23.7	22.4	22.1	
pH	8.65	8.72	8.8	8.88		9.96	9.28	9.18	9.28		9.76	9.45	9.53	9.28	
ORP (mV Ag/AgCl)	216	192	202	194	420.6	176	160	189	172	190	182	220	206	207	190
EC (mS/cm)	3.5	3.97	4.1	3.29		4.48	0.911	0.92	0.942		0.229	0.426	0.393	0.427	
Calcium (µg/L)					46800					11800					7530
Iron (µg/L)					<100					<100					<100
Magnesium (µg/L)					79900					19100					10800
Phosphorus (µg/L)					<100					<100					<100
Potassium (µg/L)					98900					29900					14000
Silicon (µg/L)					3680					3160					4020
Sodium (µg/L)					700000					130000					44200
Aluminium (µg/L)					28					21					20
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					5.1					<5					<5
Barium (µg/L)					28					11					12
Beryllium (µg/L)					<5					<5					<5
Bismuth (µg/L)					<5					<5					<5
Boron (µg/L)					1100					580					360
Cadmium (µg/L)					<5					<5					<5
Chromium (µg/L)					<5					<5					<5
Cobalt (µg/L)					<5					<5					<5
Copper (µg/L)					<5					<5					<5
Lead (µg/L)					<5					<5					<5
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					<5					<5					<5
Molybdenum (µg/L)					170					32					8.3
Nickel (µg/L)					<5					<5					<5
Selenium (µg/L)					16					5					<5
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					1300					260					150
Thallium (µg/L)					<5					69					81
Tin (µg/L)					<5					<5					<5
Uranium (µg/L)					190					110					86
Vanadium (µg/L)					39					72					79
Zinc (µg/L)					93					83					76
Mercury (µg/L)					<0.1					<0.1					<0.1
Acidity as CaCO3 (mg/L)					430					<20					<20
Total Alkalinity as CaCO3 (mg/L)					<20					168					162
Bicarbonate as CaCO3 (mg/L)					<10					120					105
Electrical Conductivity (µS/cm)					6960					927					327
Ammonia as N (mg N/L)					<1					<1					<1
pH (pH)					2.3					9.1					9.2
Total Organic Carbon (mg/L)					3.7					4.1					7.6
Chloride (mg/L)					1200					120					21
Bromide (mg/L)					<0.5					<0.5					<0.5
Fluoride (mg/L)					1.6					1.2					1.6
Nitrate (mg/L)										1.4					<0.5
Nitrite (mg/L)					<0.5					<0.5					1.8
Orthophosphate (mg/L)					<0.5					<0.5					<0.5
Sulphate (mg/L)					460					80					13

SEQUENTIAL #12		**Sequence 1**				**Sequence 2**					**Sequence 3**				
YYS158 3.5m 3.75m DUP	**Start Seq 1**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 1 Liquor**	**Start Seq 2**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 2 Liquor**	**Start Seq 3**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 3 Liquor**
Time	**1/04/2010 14:00**	**2/04/2010 14:00**	**3/04/2010 14:00**	**4/04/2010 14:00**		**4/04/2010 11:20**	**5/04/2010 11:20**	**6/04/2010 11:20**	**7/04/2010 11:20**		**7/04/2010 11:50**	**8/04/2010 11:50**	**9/04/2010 11:50**	**10/04/2010 11:50**	
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	5.0	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1630.5					1630.5					1630.5				
Solids Mass (g) (wet)	291.9					519.2					611.7				
Liquor Mass (g)	877.2					1558.8					1836.6				
Gross Wt (g)	2799.7					3708.1					4079.2				
Total Mass (solid+liquor) g	1169.1					2078					2448.3				
Temp (Deg C)	23.6	25.7	20.3	24.9		20.9	22.8	22.5	21.9		24	22.9	21.7	23	
pH	8.65	8.79	8.87	8.67		9.58	9.38	9.27	9.35		9.43	9.44	9.44	9.31	
ORP (mV Ag/AgCl)	214	148	159	172	274.2	165	154	190	231	200	179	180	182	158	200
EC (mS/cm)	3.79	4.02	3.28	3.15		0.444	0.925	1.072	1.006		0.157	0.309	0.434	0.400	
Calcium (µg/L)					46200					11900					7800
Iron (µg/L)					<100					<100					<100
Magnesium (µg/L)					78900					19800					11900
Phosphorus (µg/L)					<100					<100					<100
Potassium (µg/L)					99700					30000					13100
Silicon (µg/L)					3580					2970					3870
Sodium (µg/L)					677000					133000					49500
Aluminium (µg/L)					27					54					23
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					<5					<5					<5
Barium (µg/L)					28					15					7.7
Beryllium (µg/L)					<5					<5					<5
Bismuth (µg/L)					<5					<5					<5
Boron (µg/L)					1200					650					360
Cadmium (µg/L)					<5					<5					<5
Chromium (µg/L)					<5					<5					<5
Cobalt (µg/L)					<5					<5					<5
Copper (µg/L)					<5					<5					11
Lead (µg/L)					<5					<5					<5
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					<5					<5					<5
Molybdenum (µg/L)					160					43					8.9
Nickel (µg/L)					<5					<5					<5
Selenium (µg/L)					15					8.2					<5
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					1300					310					160
Thallium (µg/L)					<5					<5					<5
Tin (µg/L)					<5					<5					<5
Uranium (µg/L)					180					110					78
Vanadium (µg/L)					37					72					70
Zinc (µg/L)					120					71					82
Mercury (µg/L)					<0.1					<0.1					<0.1
Acidity as CaCO3 (mg/L)					<20					<20					<20
Total Alkalinity as CaCO3 (mg/L)					151					164					159
Bicarbonate as CaCO3 (mg/L)					144					110					101
Electrical Conductivity (µS/cm)					3790					945					320
Ammonia as N (mg N/L)					<1					<1					<1
pH (pH)					8.4					9.1					9.1
Total Organic Carbon (mg/L)					3.8					2.6					2.2
Chloride (mg/L)					700					130					23
Bromide (mg/L)					2.3					<0.5					<0.5
Fluoride (mg/L)					2					1.2					1
Nitrate (mg/L)					11					1.7					<0.5
Nitrite (mg/L)					<0.5					<0.5					2
Orthophosphate (mg/L)					<0.5					<0.5					<0.5
Sulphate (mg/L)					300					82					14

SEQUENTIAL #13		Sequence 1				Sequence 2					Sequence 3				
YYS156A 12m 12.75m	Start Seq 1	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 1 Liquor	Start Seq 2	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 2 Liquor	Start Seq 3	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 3 Liquor
Time	1/04/2010 14:00	2/04/2010 12:00	3/04/2010 14:00	4/04/2010 14:00		4/04/2010 10:40	5/04/2010 11:20	6/04/2010 11:20	7/04/2010 11:20		7/04/2010 11:50	8/04/2010 11:50	9/04/2010 11:50	10/04/2010 11:50	
Elapsed Time (days)	0.0	0.9	2.0	3.0			4.0	5.0	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1634.5					1634.5					1634.5				
Solids Mass (g) (wet)	302.0					532.4					452.7				
Liquor Mass (g)	909.1					1599.2					1358.1				
Gross Wt (g)	2847.4					3766					3445.2				
Total Mass (solid+liquor) g	1211.1					2131.6					1810.8				
Temp (Deg C)	232	26	20.6	24.9		22.4	22	23.6	21.2		23.3	23.1	22	23.4	
pH	8.19	8.38	8.44	8.11		8.96	8.62	8.52	8.5		9.06	9.09	9.08	888	
ORP (mV Ag/AgCl)	200	184	173	181	263.8	180	148	218	213	220	201	184	155	139	210
EC (mS/cm)	3.9	3.74	4.02	3.37		0.571	1.176	0.866	1.22		0.0835	0.1927	0.301	0.317	
Calcium (µg/L)					50400					7310					1820
Iron (µg/L)					<100					<100					<100
Magnesium (µg/L)					94500					12200					1270
Phosphorus (µg/L)					<100					<100					<100
Potassium (µg/L)					211000					47600					14700
Silicon (µg/L)					8650					6830					6290
Sodium (µg/L)					1070000					179000					43900
Aluminium (µg/L)					25					19					19
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					8.3					5.8					9.9
Barium (µg/L)					42					45					8.2
Beryllium (µg/L)					<5					<5					<5
Bismuth (µg/L)					<5					<5					<5
Boron (µg/L)					4900					1400					720
Cadmium (µg/L)					<5					5.9					<5
Chromium (µg/L)					<5					<5					<5
Cobalt (µg/L)					<5					<5					<5
Copper (µg/L)					5.5					<5					<5
Lead (µg/L)					<5					<5					<5
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					6.1					<5					<5
Molybdenum (µg/L)					390					130					46
Nickel (µg/L)					<5					<5					<5
Selenium (µg/L)					28					9.2					<5
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					1400					210					30
Thallium (µg/L)					<5					77					59
Tin (µg/L)					<5					<5					<5
Uranium (µg/L)					<5					7.4					<5
Vanadium (µg/L)					23					32					42
Zinc (µg/L)					150					120					120
Mercury (µg/L)					<0.1					<0.1					<0.1
Acidity as CaCO3 (mg/L)					<20					<20					<20
Total Alkalinity as CaCO3 (mg/L)					49					52					57
Bicarbonate as CaCO3 (mg/L)					49					52					57
Electrical Conductivity (µS/cm)					6570					1230					261
Ammonia as N (mg N/L)					<1					<1					<1
pH (pH)					7.5					7.6					7.7
Total Organic Carbon (mg/L)					2.9					2					4.2
Chloride (mg/L)					1700					250					34
Bromide (mg/L)					11					<0.5					<0.5
Fluoride (mg/L)					2.5					1.1					1
Nitrate (mg/L)					49					6.1					0.7
Nitrite (mg/L)					<0.5					<0.5					0.5
Orthophosphate (mg/L)					<0.5					<0.5					<0.5
Sulphate (mg/L)					740					120					32

SEQUENTIAL #14		Sequence 1				Sequence 2					Sequence 3				
YYS159 4.5m 5.2m	Start Seq 1	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 1 Liquor	Start Seq 2	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 2 Liquor	Start Seq 3	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 3 Liquor
Time	2/04/2010 11:00	3/04/2010 11:00	4/04/2010 11:00	5/04/2010 11:00		5/04/2010 12:15	6/04/2010 12:15	7/04/2010 12:15	8/04/2010 12:15		9/04/2010 12:00	10/04/2010 12:00	11/04/2010 12:00	12/04/2010 12:00	
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	5.0	6.0			7.0	8.0	9.0	
Bottle Tare Wt (g)	1631.6					1631.6					1631.6				
Solids Mass (g) (wet)	314.1					457.5					433.6				
Liquor Mass (g)	943.5					1374.3					1301.9				
Gross Wt (g)	2889.1					3463.4					3367.2				
Total Mass (solid+liquor) g	1257.6					1831.8					1735.5				
Temp (Deg C)	21	20.1	25.7	24.3		24	22.8	25.4	24.1		22	21.9	23.3	20.6	
pH	9.14	9.09	8.84	8.78		9.66	9.38	9.22	9.08		9.61	9.31	9.23	9.18	
ORP (mV Ag/AgCl)	172	152	191	188	252.9	151	153	221	143	190	204	124	157	238	163
EC (uS/cm)	1046	1571	1666	156		183	474	537	538		132	332	357	372	
Calcium (µg/L)					6460					2450					3400
Iron (µg/L)					<100					<100					<100
Magnesium (µg/L)					4900					1200					1450
Phosphorus (µg/L)					<100					<100					<100
Potassium (µg/L)					39300					20500					18300
Silicon (µg/L)					23000					24000					19000
Sodium (µg/L)					266000					86400					68200
Aluminium (µg/L)					32					28					<5
Antimony (µg/L)					<5					<5					<5
Arsenic (µg/L)					21					23					9.8
Barium (µg/L)					<5					<5					<5
Beryllium (µg/L)					<5					<5					<5
Bismuth (µg/L)					<5					<5					<5
Boron (µg/L)					1100					640					310
Cadmium (µg/L)					<5					<5					<5
Chromium (µg/L)					20					16					9.9
Cobalt (µg/L)					<5					<5					<5
Copper (µg/L)					<5					<5					<5
Lead (µg/L)					<5					<5					<5
Lithium (µg/L)					<5					<5					<5
Manganese (µg/L)					<5					<5					<5
Molybdenum (µg/L)					140					30					7.6
Nickel (µg/L)					<5					<5					<5
Selenium (µg/L)					<5					<5					<5
Silver (µg/L)					<5					<5					<5
Strontium (µg/L)					73					22					18
Thallium (µg/L)					<5					<5					240
Tin (µg/L)					<5					<5					<5
Uranium (µg/L)					12					<5					<5
Vanadium (µg/L)					160					200					100
Zinc (µg/L)					110					47					61
Mercury (µg/L)					<0.1					<0.1					<0.1
Acidity as CaCO3 (mg/L)					<20					<20					<20
Total Alkalinity as CaCO3 (mg/L)					215					213					194
Bicarbonate as CaCO3 (mg/L)					177					156					170
Electrical Conductivity (µS/cm)					1590					498					305
Ammonia as N (mg N/L)					<1					<1					<1
pH (pH)					8.8					9					8.6
Total Organic Carbon (mg/L)					1.3					7.7					9.8
Chloride (mg/L)					300					24					3.5
Bromide (mg/L)					<0.5					<0.5					<0.5
Fluoride (mg/L)					4.8					3.3					1.5
Nitrate (mg/L)					1.2					<0.5					<0.5
Nitrite (mg/L)					<0.5					2.2					0.9
Orthophosphate (mg/L)					<0.5					<0.5					<0.5
Sulphate (mg/L)					110					9.6					2.8

PALEOCHANNEL SANDS		Sequence 1 - BARREN LIQUOR				Sequence 2 - DI WATER				
YYHC0075 64m - 65m	**Start Seq 1- Barr**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 1 Liquor**	**Start Seq 2 -DI**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 2 Liquor**
Time	**14/05/2010 11 00**	**15/05/2010 11 00**	**16/05/2010 11 00**	**17/05/2010 11 00**		**18/05/2010 12 15**	**19/05/2010 12 15**	**20/05/2010 12 15**	**21/05/2010 12 15**	
Elapsed Time (days)	0 0	1 0	2.0	3 0			4.0	5 0	6.0	
Bottle Tare Wt (g)	1631.1					1631.1				
Solids Mass (g) (wet)	300 0					290 9				
Liquor Mass (g)	901.1					872 5				
Gross Wt (g)	2832					2769.1				
Total Mass (solid+liquor) g	1201.1					1163.4				
Temp (Deg C)	14.7	18.6	21 2	15		14.8	15 6	17.3	15.1	
pH	11 08	11	11.01	11 05		10.9	10.98	10 84	10.74	
ORP (mV Ag/AgCl)	182	58	222	226	110	189	174	231	160	85
EC (mS/cm)	87	86	83 9	84.1		4.05	5 51	5.53	5.47	
Calcium (µg/L)					4400					1600
Iron (µg/L)					<100					<100
Magnesium (µg/L)					31000					<1000
Phosphorus (µg/L)					<100					<1000
Potassium (µg/L)					1500000					45000
Silicon (µg/L)					49000					2700
Sodium (µg/L)					44000000					1400000
Aluminium (µg/L)					70					6900
Antimony (µg/L)					<5					<5
Arsenic (µg/L)					280					130
Barium (µg/L)					230					6
Beryllium (µg/L)					<5					<5
Bismuth (µg/L)					< 1000					<5
Boron (µg/L)					28000					1500
Cadmium (µg/L)					<5					<0 2
Chromium (µg/L)					77					8
Cobalt (µg/L)					<5					<5
Copper (µg/L)					5					39
Lead (µg/L)					13					<5
Lithium (µg/L)					18					17
Manganese (µg/L)					<5					<5
Molybdenum (µg/L)					2000					79
Nickel (µg/L)					11					<5
Selenium (µg/L)					89					17
Silver (µg/L)					<5					<5
Strontium (µg/L)					4400					20
Thallium (µg/L)					33					26
Tin (µg/L)					<5					<5
Uranium (µg/L)					<5					2000
Vanadium (µg/L)					33000					2200
Zinc (µg/L)					120					170
Mercury (µg/L)					<0.1					<0.1
Acidity as CaCO3 (mg/L)					< 0.1					< 20
Total Alkalinity as CaCO3 (mg/L)					69000					2400
Bicarbonate as CaCO3 (mg/L)					< 10					< 20
Electrical Conductivity (µS/cm)					206000					5800
Ammonia as N (mg N/L)					1.7					< 1
pH (pH)					11					10
Total Organic Carbon (mg/L)					1300					< 10
Chloride (mg/L)					17000					540
Bromide (mg/L)					92					2 3
Fluoride (mg/L)					24					1 8
Nitrate (mg/L)					130					15
Nitrite (mg/L)					0 55					< 0.1
Orthophosphate (mg/L)					0 52					< 0.5
Sulphate (mg/L)					3300					230

PALEOCHANNEL SANDS		Sequence 1 - BARREN LIQUOR					Sequence 2 - D.I WATER			
YYHC0059C 55m - 56m	**Start Seq 1- Barr**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 1 Liquor**	**Start Seq 2- DI**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 2 Liquor**
Time	**14/05/2010 11 00**	**15/05/2010 11 00**	**16/05/2010 11 00**	**17/05/2010 11 00**		**18/05/2010 12 15**	**19/05/2010 12 15**	**20/05/2010 12 15**	**21/05/2010 12 15**	
Elapsed Time (days)	0 0	1.0	2 0	3.0			4 0	5.0	6 0	
Bottle Tare Wt (g)	1629.4					1629.4				
Solids Mass (g) (wet)	299.1					307.1				
Liquor Mass (g)	897.4					920.3				
Gross Wt (g)	2825.4					2835.4				
Total Mass (solid+liquor) g	1196.5					1227.4				
Temp (Deg C)	15	18 6	21.2	14 6		15	15.7	17 8	15.1	
pH	11 06	10.91	10 89	10.92		10.99	11 08	10.96	10 91	
ORP (mV Ag/AgCl)	60	88	262	246	150	115	204	212	182	83
EC (mS/cm)	63	85.7	79.2	82 8		7 95	9.06	8 39	9	
Calcium (µg/L)					3600					2500
Iron (µg/L)					330					<100
Magnesium (µg/L)					14000					1100
Phosphorus (µg/L)					<100					<1000
Potassium (µg/L)					1300000					90000
Silicon (µg/L)					19000					11000
Sodium (µg/L)					40000000					2500000
Aluminium (µg/L)					510					430
Antimony (µg/L)					<5					<5
Arsenic (µg/L)					420					190
Barium (µg/L)					280					10
Beryllium (µg/L)					<1					<5
Bismuth (µg/L)					< 1					<5
Boron (µg/L)					27000					2700
Cadmium (µg/L)					<5					0.2
Chromium (µg/L)					75					16
Cobalt (µg/L)					<1					<5
Copper (µg/L)					<5					64
Lead (µg/L)					16					<5
Lithium (µg/L)					51					7
Manganese (µg/L)					<5					<5
Molybdenum (µg/L)					1800					110
Nickel (µg/L)					6					<5
Selenium (µg/L)					72					27
Silver (µg/L)					<5					<5
Strontium (µg/L)					1000					150
Thallium (µg/L)					<5					<5
Tin (µg/L)					<5					<5
Uranium (µg/L)					<5					3800
Vanadium (µg/L)					34000					3700
Zinc (µg/L)					95					160
Mercury (µg/L)					<0.1					<0.1
Acidity as CaCO3 (mg/L)					< 0.1					< 20
Total Alkalinity as CaCO3 (mg/L)					74000					4700
Bicarbonate as CaCO3 (mg/L)					1500					< 20
Electrical Conductivity (µS/cm)					232000					9500
Ammonia as N (mg N/L)					1.4					< 1
pH (pH)					11					11
Total Organic Carbon (mg/L)					1700					< 10
Chloride (mg/L)					19000					1000
Bromide (mg/L)					89					3.6
Fluoride (mg/L)					24					2.7
Nitrate (mg/L)					140					29
Nitrite (mg/L)					0.36					< 0.1
Orthophosphate (mg/L)					0.4					1.8
Sulphate (mg/L)					3600					410

Bottle 1 S1.9 4.0 4.5	**Start Seq 1**	**Sequence 1**				**Sequence 2**					**Sequence 3**					
	inc Head	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 1 Liquor**	**Start Seq 2**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 2 Liquor**	**Start Seq 3**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 3 Liquor**	**Final**
Time	**10/12/2009 10:45**	**11/12/2009 12:01**	**12/12/2009 12:01**	**13/12/2009 12:01**		**14/12/2009 9:45**	**15/12/2009 10:15**	**16/12/2009 10:15**	**17/12/2009 10:15**		**19/12/2009 17:00**	**20/12/2009 17:00**	**21/12/2009 15:20**	**22/12/2009 16:00**		
Elapsed Time (days)	0.0	1.1	2.1	3.1	3.1		4.1	5.1	6.1	6.1		7.1	8.0	9.0	9.0	
Solids Mass (g) (wet)	626.86					764.73					773.07					554.21
Solids + Liquor Mass (g)	2507.44			2499.35		2321					3032.35		2814.35	2812.35		
Liquor Mass	1880.58				1661	1556.27				2069.76	2259.28				752.61	
Temp (Deg C)	20.2	21.1	19.9	25.2		21.1	25.2	25.8	22.7		21.9	27	27.7	27		
pH	9.81	9.76	9.82	9.61		10.29	10.04	9.95	9.95		10.06	9.89	9.84	9.8		
ORP (mV Ag/AgCl)	199	175	201	171		206	213	217	164		242	210	184	193		
EC (uS/cm)	2556	2662	2735	2810		317	866	841	872		196.7	521	1052	641		
Calcium (µg/L)					4320					1390					2370	
Iron (µg/L)					<100					<100					120	
Magnesium (µg/L)					1380					328					789	
Phosphorus (µg/L)					<100					<100					250	
Potassium (µg/L)					29000					10400					7660	
Silicon (µg/L)					180000					17000					2500	
Sodium (µg/L)					540000					161000					87200	
Aluminium (µg/L)					76					93					270	
Antimony (µg/L)					<5					<5					<5	
Arsenic (µg/L)					180					120					52	
Barium (µg/L)					8.5					<5					7.2	
Beryllium (µg/L)					<5					<5					<5	
Bismuth (µg/L)					<5					<5					<5	
Boron (µg/L)					1700					680					310	
Cadmium (µg/L)					<5					<5					<5	
Chromium (µg/L)					5.6					<5					<5	
Cobalt (µg/L)					<5					<5					<5	
Copper (µg/L)					7.4					<5					5.1	
Lead (µg/L)					<5					<5					<5	
Lithium (µg/L)					<5					<5					<5	
Manganese (µg/L)					<5					<5					<5	
Molybdenum (µg/L)					32					5.8					<5	
Nickel (µg/L)					<5					<5					<5	
Selenium (µg/L)					9.4					<5					<5	
Silver (µg/L)					<5					<5					<5	
Strontium (µg/L)					710					140					160	
Thallium (µg/L)					<5					<5					<5	
Tin (µg/L)					5.6					<5					30	
Uranium (µg/L)					650					320					180	
Vanadium (µg/L)					12000					6000					2200	
Zinc (µg/L)					33					<5					11	
Mercury (µg/L)					0.2					<0.1					<0.1	
Acidity as CaCO3 (mg/L)					<20					<20					<20	
Total Alkalinity as CaCO3 (mg/L)					322					349					-	
Bicarbonate as CaCO3 (mg/L)					204					213					-	
Carbonate as CaCO3 (mg/L)					118					136					-	
Hydroxide as CaCO3 (mg/L)					<10					<10					-	
Electrical Conductivity (µS/cm)					2600					824					385	
Ammonia as N (mg N/L)					<1					<1					<1	
pH (pH)					9.2					9.3					8.3	
Total Organic Carbon (mg/L)					6.1					3.8					8	
Chloride (mg/L)					310					29					3.2	
Bromide (mg/L)					1.9					1.6					<0.5	
Fluoride (mg/L)					3.8					2.3					1.5	
Nitrate (mg/L)					44					2.3					<0.5	
Nitrite (mg/L)					<0.5					0.6					<0.5	
Orthophosphate (mg/L)					<0.5					<0.5					<0.5	
Sulphate (mg/L)					480					44					5.9	

Bottle 2 S2.9 5.25 6.0		**Sequence 1**				**Sequence 2**					**Sequence 3**					
	Start Seq 1	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 1 Liquor**	**Start Seq 2**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 2 Liquor**	**Start Seq 3**	**24 hour bottle readings**	**48 hour bottle readings**	**72 hour bottle readings**	**Sequence 3 Liquor**	**Final**
Time	**10/12/2009 11:00**	**11/12/2009 12:01**	**12/12/2009 12:01**	**13/12/2009 12:01**		**16/12/2009 9:40**	**17/12/2009 12:01**		**19/12/2009 17:15**		**20/12/2009 16:30**	**21/12/2009 15:30**	**22/12/2009 16:25**	**23/12/2009 15:30**		
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.1		6.4			7.3	8.4	9.3		
Solids Mass (g) (wet)	474.02					433.87					402.81					428.35
Solids + Liquor Mass (g)	1895.78			1887.55		1815.19					1619.9		1600.55	1570.55		
Liquor Mass	1421.76				1038.18	1381.32				473.51	1217.09				1300.58	
Temp (Deg C)	19.7	20.4	20.2	24.5		22.4	20.9		25		23.1	28.8	27.3	26.9		
pH	10	9.82	9.79	9.76		10.3	10.1		10.01		10.27	9.98	9.97	9.92		
ORP (mV Ag/AgCl)	156	165	192	184		171	212		221		214	159	210	212		
EC (uS/cm)	1542	4470	4560	4400		701	1540		1581		366	2095	1163	1132		
Calcium (µg/L)					3210					2210					3330	
Iron (µg/L)					<100					<100					<100	
Magnesium (µg/L)					820					381					602	
Phosphorus (µg/L)					270					510					170	
Potassium (µg/L)					48600					12200					8320	
Silicon (µg/L)					180000					18000					2980	
Sodium (µg/L)					1080000					253000					161000	
Aluminium (µg/L)					160					310					170	
Antimony (µg/L)					<5					<5					<5	
Arsenic (µg/L)					210					120					78	
Barium (µg/L)					8.6					11					14	
Beryllium (µg/L)					<5					<5					<5	
Bismuth (µg/L)					<5					<5					<5	
Boron (µg/L)					1700					940					580	
Cadmium (µg/L)					<5					<5					<5	
Chromium (µg/L)					6.9					<5					<5	
Cobalt (µg/L)					<5					<5					<5	
Copper (µg/L)					23					24					9.7	
Lead (µg/L)					<5					<5					<5	
Lithium (µg/L)					<5					<5					<5	
Manganese (µg/L)					<5					<5					<5	
Molybdenum (µg/L)					68					11					9.7	
Nickel (µg/L)					<5					<5					<5	
Selenium (µg/L)					42					8.4					<5	
Silver (µg/L)					<5					<5					<5	
Strontium (µg/L)					280					72					99	
Thallium (µg/L)					<5					<5					<5	
Tin (µg/L)					<5					47					240	
Uranium (µg/L)					56000					9200					3500	
Vanadium (µg/L)					3100					2300					1400	
Zinc (µg/L)					18					5.9					7	
Mercury (µg/L)					<0.1					<0.1					<0.1	
Acidity as CaCO3 (mg/L)					<20					<20					<20	
Total Alkalinity as CaCO3 (mg/L)					1190					-					-	
Bicarbonate as CaCO3 (mg/L)					803					-					-	
Carbonate as CaCO3 (mg/L)					383					-					-	
Hydroxide as CaCO3 (mg/L)					<10					-					-	
Electrical Conductivity (µS/cm)					5240					1180					784	
Ammonia as N (mg N/L)					<1					<1					<1	
pH (pH)					9.4					8.8					8.4	
Total Organic Carbon (mg/L)					4.2					23					5.8	
Chloride (mg/L)					750					88					10	
Bromide (mg/L)					3.1					<0.5					<0.5	
Fluoride (mg/L)					7.2					4.3					2.2	
Nitrate (mg/L)					51					<0.5					25	
Nitrite (mg/L)					<0.5					<0.5					1.6	
Orthophosphate (mg/L)					<0.5					0.61					<0.5	
Sulphate (mg/L)					480					51					7.1	

Bottle 3 S2.14 4.0 4.9		Sequence 1				Sequence 2					Sequence 3					
	Start Seq 1	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 1 Liquor	Start Seq 2	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 2 Liquor	Start Seq 3	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 3 Liquor	Final
Time	**10/12/2009 11:15**	**11/12/2009 12:01**	**12/12/2009 12:01**	**13/12/2009 12:01**		**15/12/2009 10:15**	**16/12/2009 10:15**	**17/12/2009 12:01**	**18/12/2009 9:45**		**19/12/2009 16:30**	**20/12/2009 17:00**	**21/12/2009 15:40**	**22/12/2009 16:25**		
Elapsed Time (days)	0.0	1.0	2.0	3.0			4.0	5.1	6.0			7.0	8.0	9.0		
Solids Mass (g) (wet)	451.52					372.89					286.55					243.32
Solids + Liquor Mass (g)	1806.08			1794.08		1590.12					1232.22			1135.88		
Liquor Mass	1354.56					1217.23				319.14	945.67				265.26	
Temp (Deg C)	19.7	20.6	20.6	24.9		22.1	27.6	21.4	21.9		22.1	27.2	27.3	27.1		
pH	9.98	9.69	9.73	9.6		10.34	9.97	10.06	10.04		10.26	9.83	9.79	9.76		
ORP (mV Ag/AgCl)	169	181	204	178		164	209	184	175		175	167	146	216		
EC (uS/cm)	1835	4580	4500	4220		734	1490	1562	1575		512	1133	1202	1278		
Calcium (µg/L)					4620					3600					2560	
Iron (µg/L)					<100					<100					<100	
Magnesium (µg/L)					1210					636					415	
Phosphorus (µg/L)					220					650					110	
Potassium (µg/L)					57600					19400					8370	
Silicon (µg/L)					240000					35000					4220	
Sodium (µg/L)					1110000					351000					149000	
Aluminium (µg/L)					110					250					190	
Antimony (µg/L)					<5					<5					<5	
Arsenic (µg/L)					340					280					130	
Barium (µg/L)					10					19					19	
Beryllium (µg/L)					<5					<5					<5	
Bismuth (µg/L)					<5					<5					<5	
Boron (µg/L)					2400					1500					610	
Cadmium (µg/L)					<5					<5					<5	
Chromium (µg/L)					9.5					5.3					<5	
Cobalt (µg/L)					<5					<5					<5	
Copper (µg/L)					13					24					21	
Lead (µg/L)					<5					<5					<5	
Lithium (µg/L)					<5					<5					<5	
Manganese (µg/L)					<5					<5					<5	
Molybdenum (µg/L)					93					21					<5	
Nickel (µg/L)					<5					<5					<5	
Selenium (µg/L)					27					6.8					<5	
Silver (µg/L)					<5					<5					<5	
Strontium (µg/L)					600					140					110	
Thallium (µg/L)					<5					<5					<5	
Tin (µg/L)					7.6					61					16	
Uranium (µg/L)					21000					6000					2200	
Vanadium (µg/L)					12000					10000					3700	
Zinc (µg/L)					15					7.1					6.1	
Mercury (µg/L)					<0.1					<0.1					<0.1	
Acidity as CaCO3 (mg/L)					<20					<20					<20	
Total Alkalinity as CaCO3 (mg/L)					680					-					-	
Bicarbonate as CaCO3 (mg/L)					546					-					-	
Carbonate as CaCO3 (mg/L)					133					-					-	
Hydroxide as CaCO3 (mg/L)					<10					-					-	
Electrical Conductivity (µS/cm)					5530					1660					715	
Ammonia as N (mg N/L)					<1					<1					<1	
pH (pH)					9					8.8					8.6	
Total Organic Carbon (mg/L)					8.1					45					5.5	
Chloride (mg/L)					860					120					12	
Bromide (mg/L)					2.3					<0.5					<0.5	
Fluoride (mg/L)					6.1					4.9					2.7	
Nitrate (mg/L)										<0.5					<0.5	
Nitrite (mg/L)					<0.5					<0.5					<0.5	
Orthophosphate (mg/L)					<0.5					<0.5					<0.5	
Sulphate (mg/L)					590					100					11	

Bottle 4 S3.8 6.0 .0		Sequence 1				Sequence 2					Sequence 3					
	Start Seq 1	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 1 Liquor	Start Seq 2	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 2 Liquor	Start Seq 3	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 3 Liquor	Final
Time	**10/12/2009 11:30**	**11/12/2009 12:01**	**12/12/2009 12:01**	**13/12/2009 12:01**		**17/12/2009 11:00**		**19/12/2009 17:00**	**20/12/2009 16:45**		**22/12/2009 16:00**	**23/12/2009 9:30**	**24/12/2009 9:30**			
Elapsed Time (days)	0.0	1.0	2.0	3.0				5.3	6.3			7.0	8.0			
Solids Mass (g) (wet)	662.32					722.29					705.55					612.38
Solids + Liquor Mass (g)	2649.3					3062.16					2943.36		2902.7			
Liquor Mass	1986.98				635.21	2339.87					2237.81				627.29	
Temp (Deg C)	19.6	20.5	20.4	25.4		21.4		25.6	27.8		22.7	27.2	25.2			
pH	9.51	8.76	8.73	8.59		9.58		9.06	8.97		9.48	9.17	9.19			
ORP (mV Ag/AgCl)	157	178	206	178		184		235	162		225	215	212			
EC (uS/cm)	376	2123	2092	2030		259		831	807		85.4	596	608			
Calcium (µg/L)					5700					1960					1010	
Iron (µg/L)					<100					<100					<100	
Magnesium (µg/L)					1740					329					202	
Phosphorus (µg/L)					330					<100					<100	
Potassium (µg/L)					5270					1500					1580	
Silicon (µg/L)					160000					17000					3670	
Sodium (µg/L)					495000					140000					83500	
Aluminium (µg/L)					15					56					87	
Antimony (µg/L)					<5					<5					<5	
Arsenic (µg/L)					5.1					<5					<5	
Barium (µg/L)					45					18					11	
Beryllium (µg/L)					<5					<5					<5	
Bismuth (µg/L)					<5					<5					<5	
Boron (µg/L)					370					480					470	
Cadmium (µg/L)					<5					<5					<5	
Chromium (µg/L)					<5					<5					<5	
Cobalt (µg/L)					<5					<5					<5	
Copper (µg/L)					25					15					5.8	
Lead (µg/L)					<5					<5					<5	
Lithium (µg/L)					<5					<5					<5	
Manganese (µg/L)					7.4					<5					<5	
Molybdenum (µg/L)					45					39					25	
Nickel (µg/L)					7.5					<5					<5	
Selenium (µg/L)					7.7					<5					<5	
Silver (µg/L)					<5					<5					<5	
Strontium (µg/L)					51					26					6.3	
Thallium (µg/L)					<5					<5					<5	
Tin (µg/L)					170					38					11	
Uranium (µg/L)					1400					530					280	
Vanadium (µg/L)					8.5					8					<5	
Zinc (µg/L)					9.2					<5					17	
Mercury (µg/L)					<0.1					<0.1					<0.1	
Acidity as CaCO3 (mg/L)					<20					<20					<20	
Total Alkalinity as CaCO3 (mg/L)					-					297					229	
Bicarbonate as CaCO3 (mg/L)					-					261					229	
Carbonate as CaCO3 (mg/L)					-					36					<10	
Hydroxide as CaCO3 (mg/L)					-					<10					<10	
Electrical Conductivity (µS/cm)					2380					656					351	
Ammonia as N (mg N/L)					<1					<1					<1	
pH (pH)					8.6					8.7					8.6	
Total Organic Carbon (mg/L)					28					9.1					6.6	
Chloride (mg/L)					240					15					5.1	
Bromide (mg/L)					1.2					<0.5					<0.5	
Fluoride (mg/L)					1.1					2.7					2.6	
Nitrate (mg/L)					0.6					<0.5					1.1	
Nitrite (mg/L)					<0.5					<0.5					<0.5	
Orthophosphate (mg/L)					<0.5					<0.5					<0.5	
Sulphate (mg/L)					430					45					9.1	

Bottle 6 S3. 5.25 6.00		Sequence 1				Sequence 2					Sequence 3					
	Start Seq 1	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 1 Liquor	Start Seq 2	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 2 Liquor	Start Seq 3	24 hour bottle readings	48 hour bottle readings	72 hour bottle readings	Sequence 3 Liquor	Final
Time	28/01/2010 10:45	29/01/2010 10:20	30/01/2010 10:10	31/01/2010 18:00		3/02/2010 16:00	4/02/2010 15:30	5/02/2010 14:45	6/02/2010 19:15		10/02/2010 11:20	11/02/2010 13:27	12/02/2010 15:00	13/02/2010 19:46		
Elapsed Time (days)	0.0	1.0	2.0	3.3			4.3	5.3	6.4			7.5	8.6	9.8		
Solids Mass (g) (wet)	1183.3					1969.03					1552.82					720.28
Solids + Liquor Mass (g)	4733.16	4725.8	4722.8	4712.8		4755.8	4728.8	4721.8	4692.8		4732.8	4718.8	4692.8	4668.8		
Liquor Mass	3549.87					2786.77					3179.98					
Temp (Deg C)	22.3	23.9	24.2	28.9		26.3	28.2	26.5	31.1		24.6	26.9	30	29.5		
pH	10.22	9.76	9.8	9.6		10.27	10	10.03	9.75		10.26	9.86	9.73	9.75		
ORP (mV Ag/AgCl)	195	210	177	195		180	190	184	192		164	180	170	145		
EC (uS/cm)	1059	2296	2270	2424		584	1156	1169	1347		246.2	840	880	776		
Calcium (µg/L)					2660					1910					2380	
Iron (µg/L)					110					<100					<100	
Magnesium (µg/L)					1520					611					595	
Phosphorus (µg/L)					<100					<100					<100	
Potassium (µg/L)					30200					13700					14500	
Silicon (µg/L)					3910					4770					5180	
Sodium (µg/L)					744000					312000					271000	
Aluminium (µg/L)					170					230					1100	
Antimony (µg/L)					<5					<5					<5	
Arsenic (µg/L)					140					120					120	
Barium (µg/L)					19					6.8					6.6	
Beryllium (µg/L)					<5					<5					<5	
Bismuth (µg/L)					<5					<5					<5	
Boron (µg/L)					2400					1200					900	
Cadmium (µg/L)					11					<5					<5	
Chromium (µg/L)					7.5					6.9					<5	
Cobalt (µg/L)					<5					<5					<5	
Copper (µg/L)					32					7.8					5	
Lead (µg/L)					<5					<5					<5	
Lithium (µg/L)					<5					<5					<5	
Manganese (µg/L)					<5					<5					<5	
Molybdenum (µg/L)					58					15					12	
Nickel (µg/L)					<5					<5					<5	
Selenium (µg/L)					7.1					<5					<5	
Silver (µg/L)					<5					<5					<5	
Strontium (µg/L)					1200					250					210	
Thallium (µg/L)					3600					2100					6.8	
Tin (µg/L)					<5					<5					<5	
Uranium (µg/L)					6000					2200					1900	
Vanadium (µg/L)					3500					3000					2700	
Zinc (µg/L)					11					7.8					93	
Mercury (µg/L)					<0.1					<0.1					<0.1	
Acidity as CaCO3 (mg/L)					<20					<20					<20	
Total Alkalinity as CaCO3 (mg/L)					524					409					477	
Bicarbonate as CaCO3 (mg/L)					306					291					352	
Carbonate as CaCO3 (mg/L)																
Hydroxide as CaCO3 (mg/L)																
Electrical Conductivity (µS/cm)					2910					1200					1050	
Ammonia as N (mg N/L)					<1					<1					<1	
pH (pH)					9.4					9.1					9.1	
Total Organic Carbon (mg/L)					3.2					2.9					20	
Chloride (mg/L)					370					76					24	
Bromide (mg/L)					1.7					1.4					3.6	
Fluoride (mg/L)					5.9					3.8					3.7	
Nitrate (mg/L)					58					10					2.2	
Nitrite (mg/L)					<0.5					<0.5					<0.5	
Orthophosphate (mg/L)					<0.5					<0.5					<0.5	
Sulphate (mg/L)					380					87					42	

Appendix 5: Column Test Results

COLUMN 1A		Sequence 1	Sequence 2	Sequence 3	Sequence 4	Sequence 5	Sequence 6
Tails Residue + DI water	**Start**						
Date Started		12/3/2010	29/3/2010	15/4/2010	21/4/2010	17/5/2010	30/6/2010
Date Completed		22/3/2010	8/4/2010	16/4/2010	13/5/2010	25/6/2010	23/7/2010
Elapsed Time (days)		10	10	1	22	39	23
Solids Mass (g) (wet)	**7286**	7286	7286				
Final Liquor Mass discharge (g)		1589	1314	1260 34	1427	1277.2	421.37
Calcium (µg/L)		404	573	985	1100	700	800
Iron (µg/L)		170	<100	<100	<100	< 100	< 100
Magnesium (µg/L)		1440	830	360	600	1000	900
Phosphorus (µg/L)		<100	<100	<100	<100	< 100	< 100
Potassium (µg/L)		562000	325000	72800	160000	75000	87000
Silicon (µg/L)		7480	8150	4030	5700	5400	5700
Sodium (µg/L)		12700000	7550000	1380000	3500000	1800000	1700000
Aluminium (µg/L)		65	76	43	50	41	30
Antimony (µg/L)		<5	<5	<5	<5	<5	<5
Arsenic (µg/L)		850	660	200	580	460	600
Barium (µg/L)		100	61	14	30	43	37
Beryllium (µg/L)		<5	<5	<5	<5	<5	<5
Bismuth (µg/L)		<5	<5	<5	<5	<5	<5
Boron (µg/L)		14000	9600	2800	8300	5800	9200
Cadmium (µg/L)		<5	<5	<5	0.2	<0.2	<0.2
Chromium (µg/L)		150	100	15	64	42	56
Cobalt (µg/L)		<5	<5	<5	<5	<5	<5
Copper (µg/L)		26	20	<5	8	6	<5
Lead (µg/L)		<5	<5	<5	<5	<5	<5
Lithium (µg/L)		<5	<5	<5	<5	<5	<5
Manganese (µg/L)		<5	<5	<5	<5	<5	<5
Molybdenum (µg/L)		680	370	48	130	54	32
Nickel (µg/L)		<5	<5	<5	<5	<5	<5
Selenium (µg/L)		83	51	<5	25	6	<5
Silver (µg/L)		<5	<5	<5	<5	<5	<5
Strontium (µg/L)		190	170	100	130	320	230
Thallium (µg/L)		<5	<5	<5	<5	<5	<5
Tin (µg/L)		<5	<5	<5	<5	<5	<5
Uranium (µg/L)		130000	71000	12000	33000	12000	10000
Vanadium (µg/L)		19000	15000	8600	19000	15000	18000
Zinc (µg/L)		170	150	270	550	150	350
Mercury (µg/L)		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acidity as CaCO3 (mg/L)		<20	<20	<20	< 20	< 20	< 20
Total Alkalinity as CaCO3 (mg/L)		23700	12100	2240	8600	3400	4900
Bicarbonate as CaCO3 (mg/L)		5250	2430	666	21	1300	420
Electrical Conductivity (µS/cm)		37700	21900	6020	13000	6100	5900
Ammonia as N (mg N/L)		<2	<2	<1	< 1	< 1	< 1
pH (pH)		10	10 2	10.2	10	9.9	9 8
Total Organic Carbon (mg/L)		23	9.8	2.8	6.6	17	12
Chloride (mg/L)		5300	2800	540	1400	260	140
Bromide (mg/L)		14	7.3	1.4	< 10	< 5	0 9
Fluoride (mg/L)		8.3	5.9	2.2	< 10	< 5	6.7
Nitrate (mg/L)		140	67	15	35	40	< 0.1
Nitrite (mg/L)		<0 5	<0.5	<0.5	< 10	< 5	< 0.1
Orthophosphate (mg/L)		<0 5	<0.5	<0.5	< 10	< 5	< 0.5
Sulphate (mg/L)		2400	1500	310	930	190	130
ORP (mV)		130	140	149	160	150	150

COLUMN 1B		**Sequence 1**	**Sequence 2**	**Sequence 3**	**Sequence 4**	**Sequence 5**	**Sequence 6**	**Sequence 7**	**Sequence 8**	**Sequence 9**	**Sequence 10**	**Sequence 11**
YYS156A 11.25m - 12m	**Start**											
Date Started		23/3/2010	8/4/2010	20/4/2010	17/5/2010	25/6/2010	13/9/2010	30/9/2010	10/10/2010	18/10/2010	1/11/2010	9/11/2010
Date Completed		7/4/2010	20/4/2010	17/5/2010	25/6/2010	13/9/2010	30/9/2010	1/10/2010	11/10/2010	19/10/2010	2/11/2010	10/11/2010
Elapsed Time (days)		15	12	27	39	80	17	1	1	1	1	1
Solids Mass (g) (wet)	**2671**	7286	7286									
Liquor To Displace 1BV (g)		867.4	812.6	772.12	981.66	881.59	798.7	714.49	764.19	759.79	648.51	725.29
Calcium (µg/L)		10100	3620	2700	2000	1500	2000	<10000	1700	2100	<5000	1000
Iron (µg/L)		<100	<100	<100	<100	<100	<100	<10000	<1000	<1000	<500	60
Magnesium (µg/L)		391000	125000	56000	20000	11000	20000	<10000	2300	1600	<5000	600
Phosphorus (µg/L)		<100	<100	<100	200	<1000	200	<10000	7400	2000	13000	540
Potassium (µg/L)		806000	500000	400000	250000	230000	250000	130000	90000	64000	52000	46000
Silicon (µg/L)		3880	2380	2500	5300	280	5300	2600	<100	1600	50000	4100
Sodium (µg/L)		10100000	7380000	5200000	4800000	3000000	4800000	2000000	1600000	960000	720000	490000
Aluminium (µg/L)		54	9.6	<5	<5	15	<5	940	57	57	77	60
Antimony (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Arsenic (µg/L)		140	170	250	330	310	330	270	310	280	280	370
Barium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Beryllium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<1
Bismuth (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10
Boron (µg/L)		9400	6700	7500	9500	10000	9500	8600	8200	7100	5700	8400
Cadmium (µg/L)		15	18	<0.2	<0.2	18	<0.2	<0 2	<0.2	<0.2	<0.2	<0.2
Chromium (µg/L)		76	68	59	52	31	52	10	<5	<5	<5	<1
Cobalt (µg/L)		<5	<5	<5	<5	<5	<5	10	<5	<5	<5	<1
Copper (µg/L)		16	6.2	11	<5	8	<5	190	<5	<5	350	200
Lead (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<1
Lithium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10
Manganese (µg/L)		6.1	<5	<5	<5	<5	<5	36	<5	<5	<5	<5
Molybdenum (µg/L)		1300	1500	1100	490	670	490	520	210	130	94	89
Nickel (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<1
Selenium (µg/L)		150	81	89	65	26	65	19	7	<5	<5	2
Silver (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Strontium (µg/L)		940	330	210	120	87	120	75	48	31	23	21
Thallium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tin (µg/L)		420	610	670	700	620	700	630	420	320	320	310
Uranium (µg/L)		64000	53000	44000	32000	24000	32000	19000	11000	6800	4600	3600
Vanadium (µg/L)		1200	1200	1800	2500	2000	2500	2300	2700	2600	2500	3600
Zinc (µg/L)		150	82	100	73	90	73	170	170	160	130	110
Mercury (µg/L)		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acidity as CaCO3 (mg/L)		<20	<20	< 20	< 20	< 20	<20	<20	<20	<20	<20	<20
Total Alkalinity as CaCO3 (mg/L)		7430	6290	6200	5700	5200	5700	2800	1900	840	1300	960
Bicarbonate as CaCO3 (mg/L)		4170	3570	1200	2700	470	2700	1200	700	840	250	190
Electrical Conductivity (µS/cm)		35300	23900	18000	14000	11000	14000	7700	5100	3200	3000	2400
Ammonia as N (mg N/L)		<2	<1	< 1	< 1	< 1	<1	<1	<1	<1	<1	0.08
pH (pH)		9.3	9.4	9.6	9.4	9.7	9.4	9.8	9.8	8.1	9.7	9.8
Total Organic Carbon (mg/L)		6.6	7.8	< 10	5.3	< 5	5 3	18	730	<5	<5	<5
Chloride (mg/L)		8900	6900	3700	1900	1700	1900	1000	530	260	150	74
Bromide (mg/L)		11	6.1	15	< 0.5	5.1	<0.5	<5	<1.8	1.1	1.5	<5
Fluoride (mg/L)		5.1	1.6	5.8	8.8	10	8 8	8.9	13	13	12	14
Nitrate (mg/L)		220	230	120	40	19	40	7.9	3.7	2100	0.8	<0.02
Nitrite (mg/L)		<0 5	<0.5	< 0.1	< 0.1	< 5	<0.1	10	<5	<10	1.6	0
Orthophosphate (mg/L)		<0 5	<0.5	< 0.5	< 0.5	< 0.5	<0.5	<5	1.2	0.8	1.4	0.6
Sulphate (mg/L)		4300	3600	2000	1100	1000	1100	620	330	680	110	21
ORP (mV)		140	186	70	190	53	190	200	95	210	150	Ins Sample

COLUMN 2A		**Sequence 1**	**Sequence 2**	**Sequence 3**	**Sequence 4**	**Sequence 5**	**Sequence 6**	**Sequence 7**	**Sequence 8**	**Sequence 9**	**Sequence 10**
YYS158 3.75m - 4.5m	**Start**										
Date Started		19/3/2010	31/3/2010	6/4/2010	12/4/2010	19/4/2010	27/4/2010	3/5/2010	10/5/2010	14/5/2010	18/5/2010
Date Completed		23/3/2010	1/4/2010	7/4/2010	13/4/2010	20/4/2010	28/4/2010	4/5/2010	11/5/2010	15/5/2010	19/5/2010
Elapsed Time (days)		4	1	1	1	1	1	1	1	1	1
Solids Mass (g) (wet)	**8219**	7286	7286								
Final Liquor Mass discharge (g)		1438.83	1380.23	1359	1313.79	1354.64	1363.47	1383	1382.69	1422.7	1393 26
Calcium (µg/L)		61600	16000	18000	30500	23300	19000	13000	13000	12000	11000
Iron (µg/L)		<100	<100	<100	<100	<100	<100	<100	<100	<50	<100
Magnesium (µg/L)		79000	19900	22100	38500	29000	24000	18000	16000	15000	14000
Phosphorus (µg/L)		<100	<100	<100	<100	<100	<1000	5000	<1000	<1000	< 100
Potassium (µg/L)		136000	44200	52100	81400	66600	36000	51000	40000	34000	35000
Silicon (µg/L)		3050	1280	1520	2110	2030	1700	1800	1700	3900	1700
Sodium (µg/L)		886000	279000	325000	478000	361000	240000	83000	220000	210000	160000
Aluminium (µg/L)		26	120	27	<5	<5	<5	<5	<5	<50	<5
Antimony (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Arsenic (µg/L)		7.5	<5	<5	<5	<5	<5	<5	<5	<1	<5
Barium (µg/L)		15	8	<5	<5	<5	<5	<5	<5	<5	<5
Beryllium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<1	<5
Bismuth (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Boron (µg/L)		1100	460	530	700	560	490	410	460	410	450
Cadmium (µg/L)		<5	<5	<5	<5	<5	<0.2	<0 2	<0.2	<0.2	<0.2
Chromium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<1	<5
Cobalt (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<1	<5
Copper (µg/L)		5.3	<5	<5	<5	<5	<5	<5	<5	<5	<5
Lead (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<1	<5
Lithium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Manganese (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Molybdenum (µg/L)		100	29	27	23	17	13	13	15	17	47
Nickel (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<1	<5
Selenium (µg/L)		25	9	8.9	<5	<5	<5	11	<5	<1	10
Silver (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Strontium (µg/L)		1500	360	410	640	480	360	300	260	240	210
Thallium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<1	<5
Tin (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Uranium (µg/L)		53	13	14	66	39	43	56	42	80	51
Vanadium (µg/L)		66	36	41	47	46	38	48	47	41	51
Zinc (µg/L)		170	160	90	170	110	130	160	140	140	150
Mercury (µg/L)		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acidity as CaCO3 (mg/L)		300	290	310	<20	<20	< 20	<20	< 20	25	< 20
Total Alkalinity as CaCO3 (mg/L)		104	59	63	83	72	72	78	950	50	72
Bicarbonate as CaCO3 (mg/L)		104	59	63	83	72	72	35	27	50	73
Electrical Conductivity (µS/cm)		5260	1620	1780	2690	2180	1600	1600	1500	1200	1100
Ammonia as N (mg N/L)		<1	<1	<1	<1	<1	< 1	<1	< 1	0.04	< 1
pH (pH)		7.9	7.8	7.7	8.1	8.1	7 9	8	9.1	8.5	8
Total Organic Carbon (mg/L)		2.6	3.9	1.5	1.2	2.7	8 9	10	7.1	< 5	< 10
Chloride (mg/L)		1200	380	440	770	600	360	360	400	290	220
Bromide (mg/L)		1.5	3.9	<0.5	<0.5	1.3	< 5	<5	< 5	< 5	1.5
Fluoride (mg/L)		<0 5	<0.5	<0.5	0.7	0.6	< 5	0.9	< 5	2.5	0.9
Nitrate (mg/L)		23	8	6.8	11	10	8.1	5.4	< 5	1.6	4.2
Nitrite (mg/L)		<0 5	<0.5	<0.5	<0.5	<0.5	< 5	<0.1	< 5	0.24	< 0.1
Orthophosphate (mg/L)		<0 5	<0.5	<0.5	<0.5	<0.5	< 0.5	< 0 5	< 5	0.07	< 0.5
Sulphate (mg/L)		450	120	140	300	220	49	130	170	55	110
ORP (mV)		180	210	210	220	220	110	170	230	70	110

COLUMN 2B		**Sequence 1**	**Sequence 2**	**Sequence 3**	**Sequence 4**	**Sequence 5**	**Sequence 6**	**Sequence 7**	**Sequence 8**	**Sequence 9**	**Sequence 10**
YYS156A 0.7m - 1.5m	**Start**										
Date Started		26/3/2010	7/4/2010	16/4/2010	28/4/2010	5/5/2010	18/5/2010	26/5/2010	3/6/2010	11/6/2010	22/6/2010
Date Completed		6/4/2010	16/4/2010	28/4/2010	5/5/2010	18/5/2010	26/5/2010	3/6/2010	11/6/2010	22/6/2010	5/7/2010
Elapsed Time (days)		11	9	12	7	13	8	8	8	11	13
Solids Mass (g) (wet)	**2783.2**										
Liquor to displace 1 BV (g)		947	895	879	813.81	859.21	874.34	889 32	890.72	825.48	813.92
Calcium (µg/L)		626000	406000	480000	440000	500000	500000	490000	470000	480000	500000
Iron (µg/L)		<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Magnesium (µg/L)		839000	276000	210000	160000	160000	140000	140000	127000	130000	120000
Phosphorus (µg/L)		<100	<100	<1000	<1000	<1000	< 1000	<100	<100	<100	<100
Potassium (µg/L)		952000	493000	410000	370000	370000	330000	310000	270000	230000	240000
Silicon (µg/L)		11000	9340	9700	9500	8000	8200	19000	19000	20000	9500
Sodium (µg/L)		6950000	3300000	2200000	1500000	1000000	780000	810000	690000	620000	550000
Aluminium (µg/L)		110	7.2	<5	<5	<5	<5	<5	<5	<5	<5
Antimony (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Arsenic (µg/L)		45	33	28	24	23	23	19	20	19	16
Barium (µg/L)		58	33	18	21	24	23	20	19	20	20
Beryllium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bismuth (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Boron (µg/L)		47000	28000	16000	12000	10000	7900	6900	5400	4900	4200
Cadmium (µg/L)		6.2	6.2	2.8	<0.2	<0.2	<0.2	<0 2	<0.2	<0.2	<0.2
Chromium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cobalt (µg/L)		5.2	<5	<5	<5	<5	<5	<5	<5	<5	<5
Copper (µg/L)		14	11	<5	36	5	5	<5	<5	<5	<5
Lead (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Lithium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Manganese (µg/L)		17	5.7	<5	<5	<5	<5	<5	<5	<5	<5
Molybdenum (µg/L)		770	200	87	67	53	51	35	45	23	34
Nickel (µg/L)		9.6	5.2	<5	<5	12	13	15	13	15	17
Selenium (µg/L)		170	16	23	25	19	18	26	23	22	12
Silver (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Strontium (µg/L)		21000	8200	6400	5600	5800	5900	5400	5500	5500	5500
Thallium (µg/L)		<5	<5	<5	10	<5	<5	<5	<5	<5	<5
Tin (µg/L)		170	270	110	170	420	120	370	250	290	230
Uranium (µg/L)		210	200	100	150	49	56	69	84	78	89
Vanadium (µg/L)		180	190	140	150	130	130	110	130	120	110
Zinc (µg/L)		64	130	66	67	81	86	99	95	96	86
Mercury (µg/L)		<0.1	<0.1	1	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acidity as CaCO3 (mg/L)		890	20	< 20	23	< 20	< 20	< 20	< 20	< 20	< 20
Total Alkalinity as CaCO3 (mg/L)		125	106	99	770	94	80	79	93	74	87
Bicarbonate as CaCO3 (mg/L)		125	106	99	22	94	80	79	93	74	87
Electrical Conductivity (µS/cm)		22800	14200	10000	8800	7100	6300	5600	5300	5000	3700
Ammonia as N (mg N/L)		<1	<1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
pH (pH)		7.9	7.9	8.1	7.9	7.9	8	7.7	8	7.8	7.7
Total Organic Carbon (mg/L)		28	17	80	12	< 10	10	6	6.6	9.2	< 5
Chloride (mg/L)		5100	1100	< 5	1100	620	500	340	300	240	280
Bromide (mg/L)		8.1	1.3	< 5	< 10	2.8	2.4	< 0 5	< 0.5	< 0.5	0.8
Fluoride (mg/L)		4.5	2.8	< 5	< 10	3.4	3 6	3.5	3.3	3.8	3.2
Nitrate (mg/L)		120	33	25	24	19	12	9.3	9.4	8.4	6.3
Nitrite (mg/L)		<0 5	<0.5	< 5	< 10	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Orthophosphate (mg/L)		<0 5	<0.5	< 5	< 10	< 0.5	< 0.5	< 0 5	< 0.5	< 0.5	< 0.5
Sulphate (mg/L)		9100	9100	1400	4400	3100	3100	2400	2300	2200	2400
ORP (mV)		190	214	110	280	110	120	200	190	190	190

COLUMN 3A		**Sequence 1**	**Sequence 2**	**Sequence 3**	**Sequence 4**	**Sequence 5**	**Sequence 6**	**Sequence 7**	**Sequence 8**	**Sequence 9**	**Sequence 10**
YYS156A 1.5m -2.5m	**Start**										
Date Started		31/3/2010	12/4/2010	19/4/2010	27/4/2010	3/5/2010	10/5/2010	17/5/2010	24/5/2010	8/6/2010	17/6/2010
Date Completed		8/4/2010	13/4/2010	20/4/2010	28/4/2010	5/5/2010	11/5/2010	18/5/2010	25/5/2010	9/6/2010	18/6/2010
Elapsed Time (days)		8	1	1	1	2	1	1	1	1	1
Solids Mass (g) (wet)	**5323.6**	7286	7286								
Final Liquor Mass discharge (g)		1617.48	1270	1502 88	1244 5	1434.49	1376.65	1379.32	1417.02	1374.4	1428 08
Calcium (µg/L)		2010000	293000	398000	440000	420000	460000	480000	530000	400000	490000
Iron (µg/L)		<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Magnesium (µg/L)		1470000	156000	130000	120000	110000	100000	100000	62000	200000	110000
Phosphorus (µg/L)		<100	<100	<100	<1000	<1000	<1000	< 1000	< 1000	<100	<100
Potassium (µg/L)		1250000	305000	276000	240000	250000	200000	190000	99000	260000	130000
Silicon (µg/L)		15000	12000	12000	15000	19000	16000	13000	9000	21000	24000
Sodium (µg/L)		12000000	2080000	1540000	1100000	550000	410000	290000	89000	1500000	650000
Aluminium (µg/L)		42	<5	<5	<5	<5	<5	<5	<5	<5	<5
Antimony (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Arsenic (µg/L)		46	22	18	18	19	12	14	8	5	6
Barium (µg/L)		530	52	46	42	46	40	42	30	30	20
Beryllium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bismuth (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Boron (µg/L)		18000	8300	7100	5000	4800	3500	2800	1200	770	580
Cadmium (µg/L)		<5	<5	<5	<0.2	<0.2	<0.2	<0 2	<0.2	<0.2	<0.2
Chromium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cobalt (µg/L)		9.7	<5	<5	<5	<5	<5	<5	<5	<5	<5
Copper (µg/L)		23	<5	<5	8	<5	10	6	7	5	<5
Lead (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Lithium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Manganese (µg/L)		110	<5	<5	<5	<5	8	<5	<5	<5	<5
Molybdenum (µg/L)		900	76	50	28	19	12	21	<5	<5	<5
Nickel (µg/L)		31	<5	<5	<5	8	<5	9	11	16	15
Selenium (µg/L)		330	<5	<5	<5	12	<5	8	6	14	17
Silver (µg/L)		6.3	<5	<5	<5	<5	<5	<5	<5	<5	<5
Strontium (µg/L)		36000	4200	3900	4300	2100	3700	4000	3500	3100	2800
Thallium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tin (µg/L)		6	<5	<5	<5	<5	<5	<5	<5	<5	<5
Uranium (µg/L)		550	500	380	370	410	330	230	120	93	98
Vanadium (µg/L)		140	160	130	120	130	89	90	69	56	59
Zinc (µg/L)		270	270	130	140	150	130	160	100	200	170
Mercury (µg/L)		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acidity as CaCO3 (mg/L)		26	<20	<20	< 20	<20	< 20	510	< 20	< 20	< 20
Total Alkalinity as CaCO3 (mg/L)		135	146	129	120	140	460	< 20	64	62	64
Bicarbonate as CaCO3 (mg/L)		135	146	129	120	100	< 20	< 20	65	62	64
Electrical Conductivity (µS/cm)		57900	9630	8160	6700	5500	3600	5900	2400	2100	2000
Ammonia as N (mg N/L)		1	<1	<1	< 1	<1	< 1	< 1	< 1	< 1	< 1
pH (pH)		7.6	8.3	8.2	8.3	8.2	6 8	2.3	7.8	7.5	7.7
Total Organic Carbon (mg/L)		28	18	7	19	37	11	< 10	< 10	7.3	6.6
Chloride (mg/L)		18000	80	26	6.4	3.8	< 5	1.4	8.4	< 0.5	< 0.5
Bromide (mg/L)		48	<0.5	<0.5	< 5	<5	< 0.5	< 0 5	< 0.5	< 0.5	< 0.5
Fluoride (mg/L)		<0 5	1.4	1.8	1.7	1	1.1	1.9	1.5	1.5	1.4
Nitrate (mg/L)		840	6.1	4.5	5.7	5.1	6 5	4.7	0.9	< 0.1	< 0.1
Nitrite (mg/L)		<0 5	<0.5	2.2	< 0.1	<0.1	1 2	< 0.1	< 0.1	< 0.1	< 0.1
Orthophosphate (mg/L)		<0 5	<0.5	<0.5	< 0.05	< 0.5	< 0 05	< 0 5	< 0.5	< 0.5	< 0.5
Sulphate (mg/L)		6200	6100	5600	1100	6700	7600	3000	1700	1300	1200
ORP (mV)		210	238	236	120	170	180	240	150	210	220

COLUMN 3B		**Sequence 1**	**Sequence 2**	**Sequence 3**	**Sequence 4**	**Sequence 5**	**Sequence 6**	**Sequence 7**	**Sequence 8**	**Sequence 9**	**Sequence 10**
YYS158 2.5m - 3.5m	**Start**										
Date Started		9/4/2010	19/4/2010	27/4/2010	8/5/2010	18/5/2010	26/5/2010	26/5/2010	2/6/2010	10/6/2010	18/6/2010
Date Completed		19/4/2010	27/4/2010	8/5/2010	16/5/2010	26/5/2010	2/6/2010	2/6/2010	10/6/2010	18/6/2010	29/6/2010
Elapsed Time (days)		10	8	11	8	8	7	7	8	8	11
Solids Mass (g) (wet)	**2948.4**										
Liquor to displace 1 BV (g)		772 38	775 65	1010 66	755.74	941.13	770	789 21	770	775.17	779.7
Calcium (µg/L)		465000	430000	420000	430000	420000	470000	460000	510000	530000	460000
Iron (µg/L)		<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Magnesium (µg/L)		447000	340000	210000	190000	180000	180000	130000	51000	41000	95000
Phosphorus (µg/L)		<100	<1000	<1000	<1000	<1000	<1000	<100	<100	<100	<100
Potassium (µg/L)		478000	390000	320000	290000	250000	260000	150000	71000	50000	120000
Silicon (µg/L)		9130	11000	13000	14000	11000	12000	19000	19000	21000	11000
Sodium (µg/L)		3780000	2900000	1800000	1400000	1100000	930000	740000	60000	34000	590000
Aluminium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Antimony (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Arsenic (µg/L)		22	24	18	16	17	15	10	6	8	7
Barium (µg/L)		42	40	38	37	35	36	19	25	18	18
Beryllium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bismuth (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Boron (µg/L)		10000	8600	7800	6300	5400	4600	5300	2600	2200	1900
Cadmium (µg/L)		19	12	<0.2	<0.2	<0.2	<0.2	<0 2	<0.2	<0.2	<0.2
Chromium (µg/L)		8.1	<5	<5	<5	6	<5	<5	<5	<5	<5
Cobalt (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Copper (µg/L)		<5	8	5	<5	12	7	6	13	<5	<5
Lead (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Lithium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Manganese (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Molybdenum (µg/L)		170	130	76	61	51	47	53	25	19	15
Nickel (µg/L)		6.1	<5	<5	<5	12	10	11	14	14	9
Selenium (µg/L)		38	38	21	14	26	16	37	19	25	11
Silver (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Strontium (µg/L)		8100	7400	5200	5000	5000	4700	4400	3800	3400	3300
Thallium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tin (µg/L)		660	410	370	310	390	450	310	290	280	320
Uranium (µg/L)		450	450	390	400	310	260	260	180	160	190
Vanadium (µg/L)		120	150	110	100	130	94	79	67	66	61
Zinc (µg/L)		91	77	63	62	77	76	94	82	97	84
Mercury (µg/L)		<0.1	<0.1	< 0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acidity as CaCO3 (mg/L)		<20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Total Alkalinity as CaCO3 (mg/L)		139	140	1100	1000	120	110	130	96	93	97
Bicarbonate as CaCO3 (mg/L)		139	140	30	30	120	110	130	96	93	97
Electrical Conductivity (µS/cm)		16700	13000	10000	8700	7400	6600	7400	3900	3600	3200
Ammonia as N (mg N/L)		<1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
pH (pH)		8.2	8.1	8	8	8.2	8.1	8	7.8	7.9	7.7
Total Organic Carbon (mg/L)		14	26	6.5	6.1	< 10	< 10	8.4	12	< 5	6.2
Chloride (mg/L)		2500	< 5	1200	950	590	480	720	390	270	410
Bromide (mg/L)		2.6	< 5	< 10	< 10	3.3	2.4	< 0 5	< 0.5	< 0.5	1.1
Fluoride (mg/L)		1.5	< 5	< 10	< 10	2.7	2 6	2.7	1.7	1.5	2.1
Nitrate (mg/L)		100	65	28	33	22	18	27	14	9.3	8.1
Nitrite (mg/L)		<0 5	< 5	< 10	< 10	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Orthophosphate (mg/L)		<0 5	< 5	< 10	< 10	< 0.5	< 0.5	< 0 5	< 0.5	< 0.5	< 0.5
Sulphate (mg/L)		7800	1800	5600	4600	3700	3300	3000	2000	1700	2700
ORP (mV)		233	100	130	140	94	130	210	200	210	140

COLUMN 4A		YC BARREN	Sequence 1	Sequence - mistake	Sequence - Flush	Sequence 2	Sequence 3	Sequence 4	Sequence 5	Sequence 6	Sequence 7	Sequence 8	Sequence 9	Sequence 10
YYS159 4.5m - 5.2m	Start	FEED LIQUOR		DI Water	Barren Liquor									
Date Started			21/4/2010	27/4/2010	29/4/2010	30/4/2010	5/5/2010	10/5/2010	17/5/2010	24/5/2010	29/9/2010	4/10/2010	10/10/2010	14/10/2010
Date Completed			22/4/2010	28/4/2010	30/4/2010	30/4/2010	6/5/2010	11/5/2010	18/5/2010	25/5/2010	30/9/2010	5/10/2010	11/10/2010	15/10/2010
Elapsed Time (days)		0	1	1	1	1	1	1	1	1	1	1	1	1
Solids Mass (g) (wet)	5904.7		7286			7286								
Final Liquor Mass discharge (g)			1314.8	1466.7	1379	1590.91	1278 51	1453	1370.53	1395.68	988 6	1336.09	1471.59	1358 95
Calcium (µg/L)		1100	11400	4100	5000	3600	2400	5000	4400	3500	1700	1900	3100	3100
Iron (µg/L)		200	<100	<100	200	300	100	200	<50	<100	<100	<100	2800	<100
Magnesium (µg/L)		<500	380000	8400	6300	6900	2000	260	1100	<1000	800	800	1600	1000
Phosphorus (µg/L)		2100	<100	<1000	<1000	<1000	<1000	4000	2400	6100	6100	7200	14000	80000
Potassium (µg/L)		1600000	1200000	650000	1100000	1400000	1600000	2100000	1400000	1600000	2400000	1700000	1800000	1900000
Silicon (µg/L)		52000	26000	21000	42000	44000	65000	99000	180000	110000	81000	100000	64000	65000
Sodium (µg/L)		52000000	27400000	16000000	34000000	43000000	44000000	52000000	49000000	57000000	96000000	56000000	73000000	73000000
Aluminium (µg/L)		170	<5	<5	<5	<5	<5	88	<50	74	70	33	350	110
Antimony (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	14	<5	<5	<5
Arsenic (µg/L)		13000	3900	990	8500	1100	1400	7400	4400	12000	7700	8700	7500	8000
Barium (µg/L)		6	<5	9	<5	<5	<5	<5	11	<5	6	<5	<5	<5
Beryllium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<1	<5	<5	<5	<5	<5
Bismuth (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	
Boron (µg/L)		56000	16000	7700	35000	41000	46000	51000	48000	60000	62000	72000	64000	66000
Cadmium (µg/L)		1.5	<5	0.3	0 8	0.5	<0.2	<0 2	<5	<0.2	<0.2	<0 2	<0.2	<0.2
Chromium (µg/L)		3000	220	42	2500	3000	3400	76	51	2400	350	320	280	320
Cobalt (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Copper (µg/L)		110	37	25	53	58	72	73	33	50	130	120	200	95
Lead (µg/L)		<5	<5	8	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Lithium (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	7	<5	350	<5
Manganese (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Molybdenum (µg/L)		2500	1900	1100	2500	2500	2600	2600	2200	2300	2900	3000	2700	2800
Nickel (µg/L)		25	13	8	15	14	15	20	30	25	31	34	30	31
Selenium (µg/L)		600	370	170	440	550	630	620	120	650	610	700	500	540
Silver (µg/L)		<5	<5	<5	<5	<5	<5	<5	<5	9	<5	<5	<5	<5
Strontium (µg/L)		57	1400	160	200	250	250	230	350	230	230	270	210	210
Thallium (µg/L)		9	<5	<5	<5	<5	<5	<5	<1	<5	<5	<5	<5	<5
Tin (µg/L)		6	19	8	<5	<5	<5	21	<5	41	36	35	7	30
Uranium (µg/L)		48000	20000	16000	29000	49000	51000	45000	39000	52000	55000	35000	55000	56000
Vanadium (µg/L)		110000	20000	11000	39000	41000	53000	63000	74000	84000	88000	100000	100000	110000
Zinc (µg/L)		1600	480	250	620	560	1100	1700	130	2200	1300	1600	1300	1600
Mercury (µg/L)		< 0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1
Acidity as CaCO3 (mg/L)		< 20	<20	< 20	< 20	< 20	<20	< 20	< 0.1	< 20	<20	<20	<20	<20
Total Alkalinity as CaCO3 (mg/L)		79000	38000	26000	52000	64000	124000	92000	83000	84000	135000	120000	83000	84000
Bicarbonate as CaCO3 (mg/L)		110	3230	5900	3100	4900	<20	95	< 10	1200	2700	670	<20	<20
Electrical Conductivity (µS/cm)		78000	60000	38000	63000	74000	83000	81000	275000	78000	25000	24000	76000	76000
Ammonia as N (mg N/L)		< 1	<1	< 1	< 1	< 1	<1	< 1	0.38	< 1	<1	<1	2 8	7
pH (pH)		11	10.1	9.9	10	10	10	10	11	11	11	11	11	11
Total Organic Carbon (mg/L)		770	29	89	55	28	<20	39	32	< 20	3200	860	8800	710
Chloride (mg/L)		15000	13000	5300	9400	11000	20000	19000	22000	21000	22000	20000	14000	10000
Bromide (mg/L)		< 5	28	< 5	35	41	<0.5	57	240	91	99	96	67	59
Fluoride (mg/L)		8.8	2 6	< 5	6 2	< 5	18	8.4	42	28	22	25	23	24
Nitrate (mg/L)		850	440	300	570	700	<0.1	960	180	800	850	840	560	500
Nitrite (mg/L)		< 5	<0.5	< 5	< 5	< 5	<0.1	< 5	1 8	< 5	<5	<5	<5	<5
Orthophosphate (mg/L)		< 0.05	<0.5	< 5	< 5	< 5	16	< 5	8.7	16	18	20	14	13
Sulphate (mg/L)		2900	8800	1100	2100	2200	9700	13000	4400	10000	11000	10000	9800	6700
ORP (mV)		26	146	56	50	41	77	39	86	31	200	140	62	77

COLUMN 4B		**Sequence 1**	**Sequence 2**	**Sequence 3**
YYS156A 12-12.75m	**Start**			
Date Started		22/4/2010	3/5/2010	10/5/2010
Date Completed		3/5/2010	10/5/2010	24/5/2010
Elapsed Time (days)		11	7	14
Solids Mass (g) (wet)	**2558.9**			
Liquor to displace 1 BV (g)		828.07	1092.69	786 21
Calcium (µg/L)		9300	9400	3200
Iron (µg/L)		<100	<100	<100
Magnesium (µg/L)		490000	420000	74000
Phosphorus (µg/L)		<1000	< 1000	800
Potassium (µg/L)		1400000	1100000	1500000
Silicon (µg/L)		2200	12000	2900
Sodium (µg/L)		20000000	20000000	61000000
Aluminium (µg/L)		<5	<5	66
Antimony (µg/L)		<5	<5	<5
Arsenic (µg/L)		250	160	470
Barium (µg/L)		11	28	61
Beryllium (µg/L)		<5	<5	<5
Bismuth (µg/L)		<5	<5	<5
Boron (µg/L)		7700	6600	14000
Cadmium (µg/L)		<0.2	4	<0 2
Chromium (µg/L)		25	43	92
Cobalt (µg/L)		<5	<6	<5
Copper (µg/L)		34	1400	13
Lead (µg/L)		<5	120	23
Lithium (µg/L)		<5	<5	13
Manganese (µg/L)		<5	<5	7
Molybdenum (µg/L)		4500	3300	3700
Nickel (µg/L)		6	10	10
Selenium (µg/L)		440	390	540
Silver (µg/L)		<5	<6	8
Strontium (µg/L)		1600	1200	500
Thallium (µg/L)		<5	11	<5
Tin (µg/L)		69	670	1800
Uranium (µg/L)		22000	20000	57000
Vanadium (µg/L)		530	660	1200
Zinc (µg/L)		120	340	950
Mercury (µg/L)		<0.1	<0.1	<0.1
Acidity as CaCO3 (mg/L)		< 20	< 20	<20
Total Alkalinity as CaCO3 (mg/L)		18000	15000	47000
Bicarbonate as CaCO3 (mg/L)		120	3700	6700
Electrical Conductivity (µS/cm)		56000	54000	65000
Ammonia as N (mg N/L)		< 1	< 1	<1
pH (pH)		9.5	9.5	9 9
Total Organic Carbon (mg/L)		19	22	<5
Chloride (mg/L)		21000	20000	14000
Bromide (mg/L)		55	74	54
Fluoride (mg/L)		< 5	5.9	9
Nitrate (mg/L)		710	560	260
Nitrite (mg/L)		< 5	< 5	130
Orthophosphate (mg/L)		< 5	< 5	<5
Sulphate (mg/L)		9000	9000	7900
ORP (mV)		33	91	100

Appendix 6: Tails Ageing Test Results

SAMPLE - YM0015	1 MONTH				2 MONTH				4 MONTH				8 MONTH			
	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B
Date Started	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010	23/3/2010
Date Completed	23/4/2010	23/4/2010	23/4/2010	23/4/2010	23/5/2010	23/5/2010	23/5/2010	23/5/2010	24/7/2010	24/7/2010	24/7/2010	24/7/2010	2/12/2010	2/12/2010	3/12/2010	3/12/2010
Elapsed Time (days)	31	31	31	31	61	61	61	61	123	123	123	123	253	253	254	
Solids Mass (g) (wet)	923.54	943 24	936.42	918.88	929 85	923.82	927 87	943.92	938.5	931.17	920.43	938.86	990.82	959.07	1001.42	917 92
Liquor + Solids at T = 0 (Barren + wash) g	1581.45	1580.89	1580.01	1584 09	1579 8	1569.7	1575.36	1593 92	1545.77	1542 03	1539.52	1533.57	1597 35	1577.12	1584.36	1588.79
Liquor Mass at T = 0 (g)	657.91	637 65	643.59	665.21	649 95	645.88	647.49	650	607 27	610.86	619 09	594.71	606.53	618.05	582 94	670 87
Liquor Mass at Time End (after filtering) g	390 9	432.16	501.59	547.17	539 02	503.13	507 54	494.36	536.11	566.56	502 68	471.11	463.1	454.49	463.7	472 62
ALL UNITS ARE IN mg/L																
Acidity as CaCO3	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	<0.1	<0.1	<0.1	<0.1
Ammonia(N)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	<0 01	<0.01	<0.01	0 23
Bismuth (filtered)	< 0 005	< 0 005	< 0.005	< 0 005	< 0.005	< 0 005	< 0.005	< 0.005	< 0.05	< 0 05	< 0.05	< 0 05	<0 05	<0 05	<0.05	<0.05
Bromide	100	100	50	49	81	90	89	84	60	57	58	59	81	80	73	70
Calcium (filtered)	< 0.1	< 0.1	< 0.1	< 0.1	1.6	1.7	1.4	1.1	4.9	3 2	3.9	3 2	4	5	4	6
Chloride	24000	26000	22000	20000	17000	18000	18000	8600	15000	18000	16000	16000	25000	27000	22000	23000
Conductivity	83000	84000	85000	82000	70000	71000	70000	69000	66000	67000	67000	65000	81000	83000	79000	79000
Fluoride	9.1	9.6	5 8	5.5	< 0.5	7 6	7.9	7 6	7.4	6.1	6.1	5 9	<0 02	<0 02	<0.02	<0.02
Lithium (filtered)	< 0 005	< 0 005	< 0.005	< 0 005	0 009	0.007	< 0.005	< 0.005	< 0.05	< 0 05	< 0.05	< 0 05	<0 05	<0 05	<0.05	<0.05
Nitrate (as NO3-)	1000	810	760	630	640	670	630	650	530	370	390	430	Insufficient sample	140	120	120
Nitrite (as NO2-)	< 5	< 5	< 0.1	< 0.1	27	35	54	28	< 5	< 5	< 5	< 5	Insufficient sample	26	30	27
pH	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Phosphate ortho (P)	< 5	< 5	6 8	7.5	< 0.5	< 0.5	< 0 5	< 0.5	< 5	< 5	< 5	< 5	17	16	14	15
Phosphorus (filtered)	< 0.1	< 0.1	< 0.1	< 0.1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	Insufficient sample	Insufficient sample	Insufficient sample	Insufficient sample
Potassium (Filtered)	1700	1800	1700	1700	1500	1500	1600	1700	1300	1200	1300	1300	1600	1700	1600	1600
Redox Potential mV	89	89	92	88	160	160	150	150	120	130	130	140	85	86	73	74
Silicon (filtered)	8	8.4	7 2	7.7	8.4	8 2	8.6	8	8.4	8.4	8.4	8 2	28	25	39	34
Sodium (Filtered)	49000	50000	49000	45000	47000	50000	49000	48000	34000	34000	35000	33000	48000	45000	49000	51000
Sulphate (as SO4)	11000	12000	11000	10000	8800	9200	9200	4600	8200	11000	8600	8600	2600	2600	4400	4100
Total Organic Carbon	54	110	140	68	2000	2700	2700	2300	3900	690	3100	800	1100	900	1100	1100
Uranium (Filtered)	140	160	160	180	120	120	120	120	200	180	180	190	250	250	220	230
Magnesium (filtered)	5.3	5	4	3.8	8	9	6.9	8 2	5.4	4.7	4.3	4	5 8	7.1	6.3	6.4
Bicarbonate Alkalinity-mg CaCO3/L	4400	4200	3700	3700	3300	3600	3300	3300	3600	3700	3000	2700	1200	3100	3000	6500
Total Alkalinity as CaCO3	72000	75000	74000	67000	68000	72000	72000	69000	63000	63000	65000	64000	40000	42000	38000	35000
Aluminium (filtered)	0.081	0.069	0.15	0.1	0 074	0.058	0.055	0 044	0 22	0 058	0.3	0.27	0.67	0.7	0 55	N/A
Antimony (filtered)	< 0 005	< 0 005	< 0.005	< 0 005	< 0.005	< 0 005	< 0.005	< 0.005	< 0.05	< 0 05	< 0.05	< 0 05	<0.025	<0.025	<0 025	<0 025
Arsenic (filtered)	12	13	12	11	11	12	12	11	3	2 9	3	3 2	3 2	3 6	2.6	3.5
Barium (filtered)	0 28	0.3	0.29	0 24	0.28	0.28	0 31	0.28	0 24	0.27	0 39	0.19	0.21	0.23	0 24	0 23
Beryllium (filtered)	< 0 005	< 0 005	< 0.005	< 0 005	< 0.005	< 0 005	< 0.005	< 0.005	< 0.05	< 0 05	< 0.05	< 0 05	<0.005	<0.005	<0 005	<0 005
Boron (filtered)	35	35	36	34	33	35	36	36	35	32	33	33	29	30	32	27
Cadmium (filtered)	< 0.0002	0.012	0 013	< 0.0002	0.0058	0 0008	< 0 0002	0.0052	< 0.05	< 0 05	< 0.05	< 0 05	0.12	<0.001	<0 001	0.012
Chromium (filtered)	3.3	3.4	3 3	3.3	0.86	0.86	0 84	0.79	0 27	0.15	0.15	0.15	0 042	0.04	0 04	0.039
Cobalt (filtered)	< 0 005	< 0 005	< 0.005	< 0 005	< 0.005	< 0 005	< 0.005	< 0.005	< 0.05	< 0 05	< 0.05	< 0 05	<0.005	<0.005	<0 005	<0 005
Copper (filtered)	0.082	0.13	0 096	0.058	0 061	0.043	0.036	0 043	1.1	0 067	0.16	0.52	0.25	0 056	0.042	0.059
Iron (filtered)	< 0.1	0.1	< 0.1	0.1	< 1	< 1	< 1	< 1	< 1	< 1	1.1	2.4	0.26	0.31	0.2	<0.05
Lead (filtered)	0.012	0.008	0 005	< 0 005	< 0.005	< 0 005	< 0.005	< 0.005	0.48	0.98	0.11	0.74	<0.005	<0.005	<0 005	<0 005
Manganese (filtered)	< 0 005	< 0 005	< 0.005	< 0 005	< 0.005	< 0 005	< 0.005	< 0.005	< 0.05	< 0 05	< 0.05	< 0 05	<0.025	<0.025	<0 025	<0 025
Mercury (filtered)	< 0 001	< 0 001	< 0 0001	< 0 001	< 0 0001	< 0.0001	< 0 0001	< 0.0001	< 0.0005	< 0 0005	< 0.0005	< 0 0005	<0.001	<0.001	<0 001	<0 001
Molybdenum (filtered)	2.8	2.9	2 8	2.6	2.3	2 5	2.5	2 3	2.2	2	2.1	2.1	1.4	1.4	1.4	1.4
Nickel (filtered)	0.006	0.008	< 0.005	< 0 005	0.01	0.012	0.014	0 012	< 0.05	< 0 05	< 0.05	< 0 05	0 006	<0.005	<0 005	0.005
Selenium (filtered)	0.76	0.8	0 8	0.72	0.59	0.65	0 65	0.58	0 27	0.26	0 27	0.26	0.15	0.15	0.16	0.16
Silver (filtered)	< 0 005	< 0 005	< 0.005	< 0 005	< 0.005	< 0 005	< 0.005	< 0.005	< 0.05	< 0 05	< 0.05	< 0 05	<0.025	<0.025	<0 025	<0 025
Strontium (Filtered)	0 32	0 33	0.26	0 27	0.26	0.28	0.3	0.28	0 24	0.23	0 22	0.17	0.19	0.19	0 25	0 25
Thallium (filtered)	0.015	0 21	0.14	0.009	0.17	0.007	0.008	0.1	< 0.05	< 0 05	< 0.05	< 0 05	N/A	N/A	N/A	N/A
Tin (filtered)	< 0 005	< 0 005	< 0.005	< 0 005	< 0.005	< 0 005	< 0.005	< 0.005	< 0.05	< 0 05	< 0.05	< 0 05	<0.025	<0.025	<0 025	<0 025
Vanadium (filtered)	75	78	75	74	66	69	72	74	63	58	61	62	68	68	76	70
Zinc (filtered)	1.9	2	1 9	1.8	0 076	0.056	0.048	0 054	1.8	0.23	0 32	0.43	0 054	0 014	0.011	0.021

Data from Labmark, except values in blue, which were provided by Minchem/Petroleum

SAMPLE - YM0046	1 MONTH				2 MONTH				4 MONTH				8 MONTH			
	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B
Date Started	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010	27/3/2010
Date Completed	27/4/2010	27/4/2010	27/4/2010	27/4/2010	27/5/2010	27/5/2010	27/5/2010	27/5/2010	26/7/2010	26/7/2010	26/7/2010	26/7/2010	2/12/2010	2/12/2010	6/12/2010	6/12/2010
Elapsed Time (days)	31	31	31	31	61	61	61	61	121	121	121	121	250	250	254	
Solids Mass (g) (wet)	1051 64	1048.05	1051.75	1045.06	1042 07	1047.06	1051.33	1062 63	1055.44	1047 5	1051 36	1062.57	1025.12	1039.92	974.1	988 8
Liquor +Solids T = 0 (Barren + wash) g	1564.74	1568.92	1570.66	1564.28	1564.6	1564.7	1569.49	1569 53	1577.81	1564.67	1567.76	1578.47	1571.16	1561.58	1567.99	1560.74
Liquor Mass at T = 0 (g)	513.1	520.87	518.91	519.22	522.53	517 64	518.16	506 9	522 37	517.17	516.4	515.9	546.04	521.66	593 89	571.94
Liquor Mass at Time End (after filtering) g	345	366.44	421.87	399.43	399.56	373.13	426.06	353.93	293.75	495.48	348.54	404 58	300.69	327.63	362 59	347.4
ALL UNITS ARE IN mg/L																
Acidity as CaCO3	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	<0.1	< 0.1	<0.1	<0.1
Ammonia(N)	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1.1	0.15	0.45	2.2
Bismuth (filtered)	< 0 005	< 0.005	< 0.005	< 0.005	< 0 005	< 0.005	< 0.005	< 0 005	< 0 05	< 0.05	< 0.05	< 0 05	<0.5	< 0 5	<0 5	<0.005
Bromide	100	100	98	110	89	91	84	89	57	57	61	54	86	94	8.7	80
Calcium (filtered)	0 9	0.7	0.7	< 0.1	2.3	1.6	2 5	1.7	5.7	2 8	3.1	2.9	4	3	5	3
Chloride	24000	23000	24000	26000	18000	20000	18000	18000	15000	27000	17000	15000	27000	27000	26000	25000
Conductivity	86000	85000	84000	88000	72000	74000	72000	76000	64000	65000	68000	67000	81000	83000	81000	81000
Fluoride	12	13	13	13	11	12	9 9	10	9.3	9 5	9.7	9.6	<0 02	< 0.02	<0.02	<0 02
Lithium (filtered)	< 0 005	< 0.005	< 0.005	< 0.005	< 0 005	< 0.005	< 0.005	< 0 005	< 0 05	< 0.05	< 0.05	< 0 05	<0.5	< 0 5	<0 5	<0.005
Nitrate (as NO3-)	830	880	840	960	670	840	660	710	550	510	530	460	310	260	290	330
Nitrite (as NO2-)	< 5	< 5	< 5	< 5	29	< 0.1	27	40	< 5	< 5	< 5	< 5	33	31	76	25
pH	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Phosphate ortho (P)	9 2	< 5	< 5	11	< 0.5	< 0 5	< 0.5	< 0.5	< 5	< 5	< 5	< 5	2.4	2	3	2.9
Phosphorus (filtered)	< 0.1	< 0.1	< 0.1	< 0.1	2	1.8	1 6	2.2	< 1	< 1	< 1	< 1	N/A	N/A	N/A	N/A
Potassium (Filtered)	1700	1800	1700	1900	1700	1700	1500	1700	1200	1300	1300	1500	2500	3200	3100	2800
Redox Potential mV	79	82	84	83	140	130	130	130	100	140	140	150	71	72	71	72
Silicon (filtered)	25	18	23	27	27	24	25	21	25	24	26	18	54	54	57	48
Sodium (Filtered)	47000	50000	45000	50000	53000	57000	50000	54000	33000	37000	44000	30000	59000	63000	59000	56000
Sulphate (as SO4)	18000	17000	18000	19000	14000	15000	14000	14000	13000	21000	14000	12000	7500	7300	7200	6900
Total Organic Carbon	60	250	< 50	200	130	3100	130	2800	4100	800	2500	1900	<5	190	1100	1100
Uranium (Filtered)	88	78	70	100	83	91	79	65	85	82	91	80	94	110	93	<0.1
Magnesium (filtered)	3 6	6 3	2.7	2.7	7.2	9.9	6 3	9.2	6.7	4.1	4.3	2.7	8	6	7	6
Bicarbonate Alkalinity-mg CaCO3/L	5200	5000	4600	4700	4800	5200	4100	4500	3800	4200	4100	3800	<1	9000	2500	2300
Total Alkalinity as CaCO3	68000	71000	67000	72000	69000	74000	65000	71000	55000	56000	61000	57000	40000	36000	39000	37000
Aluminium (filtered)	< 0 005	< 0.005	< 0.005	< 0.005	0.063	0 051	0.032	0.051	< 0 05	< 0.05	< 0.05	0.19	<0 25	< 0.25	<0.25	<0 05
Antimony (filtered)	0.007	0 007	< 0.005	0.005	0.008	0 007	0.007	0.007	< 0 05	< 0.05	< 0.05	< 0 05	<0.025	< 0.025	<0.025	<0.005
Arsenic (filtered)	1 8	1.7	1.7	1 9	2.1	2.1	1 8	2.1	0.52	0 5	0 54	1	1.1	1.1	1 3	0.003
Barium (filtered)	0.063	0 082	0 067	0.07	0.071	0 071	0.056	0 07	0 066	0.076	0.11	0 063	0.21	0.16	0.23	0.03
Beryllium (filtered)	< 0 005	< 0.005	< 0.005	< 0.005	< 0 005	< 0.005	< 0.005	< 0 005	< 0 05	< 0.05	< 0.05	< 0 05	<0.005	< 0.005	<0.005	<0.001
Boron (filtered)	40	40	39	44	47	49	41	44	34	35	38	35	42	49	44	0.06
Cadmium (filtered)	< 0.0002	0 034	< 0.0002	0.026	0.017	< 0 0002	0.011	< 0.0002	< 0 05	< 0.05	< 0.05	< 0 05	<0.001	0.094	0.11	<0.0002
Chromium (filtered)	3 3	3 2	3 2	3.4	0 81	0.81	0.7	0.74	0.13	0.12	0.13	0.13	0.16	0.16	0.15	<0.001
Cobalt (filtered)	0.005	0 005	0 005	0.006	0.006	0 006	0.006	0.006	< 0 05	< 0.05	< 0.05	< 0 05	0.005	0.006	0 006	<0.001
Copper (filtered)	0.077	0.25	0 066	0.16	0.16	0 059	0.059	0 04	1	0.28	0 26	0.85	0.14	0.2	0.15	0.002
Iron (filtered)	< 0.1	< 0.1	< 0.1	< 0.1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3.6	<0 25	< 0.25	<0.25	0.17
Lead (filtered)	< 0 005	0 009	< 0.005	< 0.005	< 0 005	< 0.005	< 0.005	< 0 005	0.27	1 8	0 37	0.29	0.024	0.005	0 007	<0.001
Manganese (filtered)	< 0 005	< 0.005	< 0.005	< 0.005	< 0 005	< 0.005	< 0.005	< 0 005	< 0 05	< 0.05	< 0.05	< 0 05	<0.025	< 0.025	<0.025	<0.005
Mercury (filtered)	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0 0001	< 0.0001	< 0.0001	< 0 0005	< 0.0005	< 0 0005	< 0 0005	<0.0001	< 0 0001	<0 0001	<0.0001
Molybdenum (filtered)	1.2	1 3	1 2	1 3	1.2	1.2	1.1	1.2	0.86	0.86	0 89	0.84	1 2	1.2	1 3	<0.005
Nickel (filtered)	0.018	0 019	0 018	0.018	0.032	0 033	0.03	0.034	< 0 05	< 0.05	< 0.05	0.12	0.02	0.021	0 024	<0.001
Selenium (filtered)	0.77	0.78	0.77	0.83	0 67	0.65	0.64	0 66	0.25	0.26	0 28	0.27	0.63	0 61	0.75	0.002
Silver (filtered)	< 0 005	0 007	< 0.005	< 0.005	< 0 005	< 0.005	< 0.005	< 0 005	< 0 05	< 0.05	< 0.05	< 0 05	<0.025	< 0.025	<0.025	<0.005
Strontium (Filtered)	0 31	0 3	0.26	0.27	0 27	0.29	0.26	0 34	0.17	0.19	0.19	0.14	0.42	0 28	0.47	0.17
Thallium (filtered)	0.008	0.33	0 007	0.35	0 23	< 0.005	0.16	< 0 005	< 0 05	< 0.05	< 0.05	< 0 05	<0.005	0 08	0 099	<0.001
Tin (filtered)	< 0 005	< 0.005	< 0.005	< 0.005	< 0 005	< 0.005	< 0.005	< 0 005	< 0 05	< 0.05	< 0.05	< 0 05	<0.025	< 0.025	<0.025	<0.005
Vanadium (filtered)	37	37	36	41	36	38	34	33	26	27	29	27	35	37	36	<0.005
Zinc (filtered)	0 87	0.94	0.88	0.92	0.12	0.09	0 088	0.085	1.4	0.28	0 21	0.27	0.089	0 24	0.21	0.004

Data from Labmark, except values in blue, which were provided by Minchem/Petroleum

SAMPLE - YM0074	1 MONTH				2 MONTH				4 MONTH				8 MONTH			
	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B
Date Started	29/3/2010	29/3/2010	29/3/2010	29/3/2010	29/3/2010	29/3/2010	29/3/2010	29/3/2010	29/3/2010	29/3/2010	29/3/2010	29/3/2010	29/3/2010	19/3/2010	29/3/2010	29/3/2010
Date Completed	29/4/2010	29/4/2010	29/4/2010	29/4/2010	29/5/2010	29/5/2010	29/5/2010	29/5/2010	29/7/2010	29/7/2010	30/7/2010	30/7/2010	1/12/2010	1/12/2010	4/12/2010	4/12/2010
Elapsed Time (days)	31	31	31	31	61	61	61	61	122	122	123	123	247	257	250	
Solids Mass (g) (wet)	937.64	953.47	972.64	947.33	957.46	954.99	942.91	969.87	973.36	965.7	963.34	961.4	956.8	936.62	863.82	903.75
Liquor at T = 0 (Barren + wash) g	1564.33	1564.79	1565.53	1566.84	1569.71	1562.61	1556.68	1568.78	1566.67	1571.2	1569.88	1569.61	1567.38	1564.42	1557.11	1560.87
Liquor Mass at T = 0 (g)	626.69	611.32	592.89	619.51	612.25	607.62	613.77	598.91	593.31	605.5	606.54	608.21	610.58	627.8	693.29	657.12
Liquor Mass at Time End (after filtering) g	530.02	520.14	476.47	519.14	516.94	531.88	520.27	523.74	452.7	425.39	466.65	471.15	531.6	559.81	538.42	494.14
ALL UNITS ARE IN mg/L																
Acidity as CaCO3	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	<0.1	<0.1	<0.1	<0.1
Ammonia(N)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	<0.01	<0.01	0.05	0.16
Bismuth (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.05	<0.05	<0.05	<0.05
Bromide	98	95	100	93	87	79	81	91	67	70	67	75	68	66	74	Insufficient sample
Calcium (filtered)	0.7	0.9	0.4	0.5	5.6	7.1	6.6	5.8	4.2	3.4	4.4	3.5	3	3	3	3
Chloride	24000	22000	24000	21000	18000	17000	19000	22000	25000	26000	19000	19000	24000	22000	25000	24000
Conductivity	82000	84000	82000	81000	71000	69000	71000	71000	72000	70000	68000	71000	76000	77000	78000	79000
Fluoride	11	10	11	10	8	7.9	8	9.2	8.4	7.4	9.7	9.1	<0.02	<0.02	<0.02	<0.02
Lithium (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.05	<0.05	<0.05	<0.05
Nitrate (as NO3-)	870	800	1100	830	690	680	740	670	680	720	650	730	140	140	140	130
Nitrite (as NO2-)	< 5	< 5	< 5	< 5	< 0.1	6.8	6.7	< 5	< 5	< 5	< 5	< 5	9.7	9.6	12	<0.02
pH	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Phosphate ortho (P)	9.9	8.9	10	9.6	< 0.5	8	< 0.5	< 5	< 5	< 5	8.3	< 5	13	13	17	14
Phosphorus (filtered)	< 0.1	< 0.1	< 0.1	< 0.1	2.5	2.7	2.3	2.6	1.8	1.8	1.7	1.8	N/A	N/A	N/A	N/A
Potassium (Filtered)	1700	1700	1700	1700	1600	1600	1500	1600	1500	1500	1400	1500	1600	1600	1600	N/A
Redox Potential mV	82	83	82	78	130	130	130	130	150	150	150	150	77	77	66	90
Silicon (filtered)	7.5	7.7	7.5	7.7	8	9.9	9.6	9.1	9.2	9	11	10	15	12	23	35
Sodium (Filtered)	43000	45000	44000	42000	46000	45000	45000	44000	39000	39000	39000	38000	43000	39000	46000	N/A
Sulphate (as SO4)	10000	9700	11000	9500	8400	8300	9000	10000	14000	16000	9800	9200	3900	3900	4000	4300
Total Organic Carbon	87	68	91	74	2400	1900	2000	1900	1700	1700	< 5	1700	1000	880	1100	1100
Uranium (Filtered)	60	58	72	62	69	44	71	39	100	98	97	99	95	98	98	100
Magnesium (filtered)	4.3	4.8	5.6	5.6	10	7.5	7.6	8.5	5.7	6.2	6.9	3.8	7	6	7	6
Bicarbonate Alkalinity-mg CaCO3/L	3700	12000	3600	3400	3400	3200	2800	3000	4800	4400	3200	3500	2100	<1	1600	2000
Total Alkalinity as CaCO3	64000	75000	67000	63000	65000	61000	63000	62000	70000	66000	62000	67000	33000	35000	33000	60000
Aluminium (filtered)	0.058	0.069	0.056	0.058	< 0.005	< 0.005	< 0.005	< 0.005	0.15	0.13	< 0.05	< 0.05	<0.25	<0.25	<0.25	0.78
Antimony (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.025	<0.025	<0.025	<0.025
Arsenic (filtered)	11	11	12	11	11	11	10	11	3.6	3.4	3.2	3.3	3.4	3.3	4.6	3.5
Barium (filtered)	0.27	0.29	0.26	0.25	0.28	0.27	0.26	0.27	0.36	0.34	0.29	0.31	0.22	0.2	0.2	0.19
Beryllium (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.005	<0.005	<0.005	<0.005
Boron (filtered)	39	38	38	37	41	36	38	37	38	39	37	38	20	19	35	27
Cadmium (filtered)	0.0065	0.0073	0.0096	0.0012	< 0.0002	0.013	< 0.0002	0.0046	< 0.05	< 0.05	< 0.05	< 0.05	0.0014	0.061	0.0012	0.03
Chromium (filtered)	3	3.2	3.1	3	0.68	0.61	0.59	0.62	0.17	0.15	0.14	0.14	0.029	0.049	0.028	0.03
Cobalt (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.005	<0.005	<0.005	<0.005
Copper (filtered)	0.067	0.07	0.08	0.052	0.022	0.047	0.017	0.022	0.066	0.061	< 0.05	< 0.05	0.051	0.17	0.038	0.088
Iron (filtered)	< 0.1	< 0.1	< 0.1	< 0.1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	<0.05	<0.05	<0.05	<0.25
Lead (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.005	<0.005	<0.005	<0.005
Manganese (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.025	<0.025	<0.025	<0.025
Mercury (filtered)	< 0.0001	< 0.0001	< 0.001	< 0.001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0005	< 0.0005	< 0.0005	< 0.0005	<0.001	<0.001	<0.001	<0.001
Molybdenum (filtered)	3.5	3.6	3.6	3.4	3.1	3	3.1	3.1	3.2	3.1	3	3.1	1.5	1.4	1.6	1.6
Nickel (filtered)	0.038	0.041	0.043	0.04	0.055	0.051	0.05	0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.028	0.037	0.03	0.032
Selenium (filtered)	0.7	0.74	0.75	0.71	0.62	0.58	0.57	0.58	0.34	0.33	0.31	0.3	0.15	0.13	0.15	0.15
Silver (filtered)	< 0.005	< 0.005	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.025	0.025	<0.025	<0.025
Strontium (Filtered)	0.31	0.31	0.39	0.34	0.33	0.28	0.29	0.29	0.27	0.28	0.37	0.25	0.28	0.28	0.2	<0.16
Thallium (filtered)	0.2	0.24	0.26	< 0.005	< 0.005	0.1	< 0.005	0.081	< 0.05	0.088	< 0.05	< 0.05	<0.005	N/A	<0.005	<0.025
Tin (filtered)	0.015	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.025	<0.025	N/A	0.043
Vanadium (filtered)	20	19	21	20	19	16	18	16	17	17	17	16	17	16	18	19
Zinc (filtered)	0.49	0.52	0.52	0.52	0.062	0.082	0.056	0.07	0.19	0.29	0.21	0.18	0.02	0.1	0.015	0.031

Data from Labmark, except values in blue, which were provided by Minchem/Petroleum

SAMPLE - YM0076	1 MONTH				2 MONTH				4 MONTH				8 MONTH			
	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B	Open A	Open B	Closed A	Closed B
Date Started	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010	19/3/2010
Date Completed	19/4/2010	19/4/2010	19/4/2010	19/4/2010	19/5/2010	19/5/2010	19/5/2010	19/5/2010	19/7/2010	19/7/2010	19/7/2010	19/7/2010	30/11/2010	30/11/2010	5/12/2010	5/12/2010
Elapsed Time (days)	31	31	31	31	61	61	61	61	122	122	122	122	256	256	261	
Solids Mass (g) (wet)	821.93	790.25	813.32	791.22	786.53	777.01	791.25	801.7	803.27	822.95	784.33	814.16	794.74	789.03	817.92	783.86
Liquor + Solids at T = 0 (Barren + wash) g	1569.74	1569.09	1579.72	1571.07	1554.09	1558.66	1572.38	1578.32	1577.15	1584.71	1565.05	1582.74	1562.24	1571.28	1588.45	1581.53
Liquor Mass at T = 0 (g)	747.81	778.84	766.4	779.85	767.56	781.65	781.13	776.62	773.88	761.76	780.72	768.58	767.5	782.25	770.53	797.67
Liquor Mass at Time End (after filtering) g	695.12	674.58	718.29	718.91	709.43	716.35	708.22	696.61	507.51	456.23	594.81	583.27	654.68	671.11	681.76	713.15
ALL UNITS ARE IN mg/L																
Acidity as CaCO3	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	<0.1	<0.1	<0.1	<0.1
Ammonia(N)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	0.16	0.08	0.02	0.11
Bismuth (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.05	<0.05	<0.05	<0.05
Bromide	50	25	61	71	76	73	73	71	57	53	31	56	71	64	63	62
Calcium (filtered)	0.9	0.6	5.1	< 0.1	4.5	2.8	3.3	3	4.3	2.8	3.7	3.5	9.2	7.1	5.7	6.6
Chloride	18000	18000	17000	16000	16000	15000	15000	14000	15000	15000	15000	15000	22000	22000	22000	25000
Conductivity	77000	78000	75000	76000	64000	65000	65000	64000	64000	63000	63000	64000	76000	77000	76000	75000
Fluoride	11	7.8	11	8.8	16	13	12	12	9.9	12	12	11	<0.02	<0.02	<0.02	<0.02
Lithium (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	0.008	0.011	0.008	0.006	< 0.05	< 0.05	< 0.05	< 0.05	<0.05	<0.05	<0.05	<0.05
Nitrate (as NO3-)	720	650	640	630	640	670	720	660	460	470	420	570	130	130	130	130
Nitrite (as NO2-)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 5	< 0.1	< 5	< 5	5.5	7.2	6.2	7.7
pH	11	11	11	11	10	10	11	11	10	10	11	10	10	10	10	10
Phosphate ortho (P)	6.5	< 5	< 5	< 5	< 0.5	< 0.5	< 0.5	< 0.5	< 5	< 0.5	< 5	< 5	13	15	15	15
Phosphorus (filtered)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	N/A	N/A	N/A	N/A
Potassium (Filtered)	1700	1700	1400	1500	1600	1600	1600	1600	1400	1400	1300	1400	1700	1600	1600	1600
Redox Potential mV	87	87	98	89	190	180	170	170	110	110	110	120	74	72	91	70
Silicon (filtered)	3.1	3.6	3.4	3	7.1	5.2	4.9	4.9	4.7	4.2	4.9	4.6	8.3	8.1	11	11
Sodium (Filtered)	38000	40000	36000	39000	41000	42000	43000	40000	33000	32000	30000	32000	40000	38000	35000	39000
Sulphate (as SO4)	9700	9400	11000	11000	8400	8100	8200	7400	8500	8700	8400	8400	2500	4200	2500	2500
Total Organic Carbon	110	35	220	160	6000	6000	80	220	1000	1100	2400	290	860	920	890	1200
Uranium (Filtered)	33	58	36	59	33	38	50	29	59	57	56	57	67	67	66	62
Magnesium (filtered)	21	23	< 0.1	15	31	28	18	24	10	13	7.5	14	11	11	6.9	7.3
Bicarbonate Alkalinity-mg CaCO3/L	1100	1100	1100	840	820	950	520	740	1500	1900	960	1400	5800	3500	2500	1600
Total Alkalinity as CaCO3	56000	55000	56000	55000	56000	57000	57000	55000	56000	56000	54000	55000	30000	32000	32000	32000
Aluminium (filtered)	< 0.05	< 0.05	< 0.05	< 0.05	0.037	0.084	0.072	0.036	0.056	0.063	0.11	< 0.05	0.14	<0.25	<0.25	0.15
Antimony (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	0.006	<0.025	<0.025	0.005
Arsenic (filtered)	2	2.2	2.3	2	2.6	2.6	2.1	2.2	0.57	0.71	0.65	0.61	0.69	0.94	0.99	0.73
Barium (filtered)	0.043	0.044	0.033	0.026	0.039	0.038	0.037	0.026	0.075	0.065	0.06	0.068	0.08	0.11	<0.1	0.12
Beryllium (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.001	<0.005	<0.005	<0.001
Boron (filtered)	36	38	33	39	40	42	42	40	35	35	37	36	33	32	34	35
Cadmium (filtered)	0.0006	< 0.0002	< 0.0002	0.0014	< 0.0002	< 0.0002	< 0.0002	0.001	< 0.05	< 0.05	< 0.05	< 0.05	0.23	<0.001	<0.001	0.021
Chromium (filtered)	2.6	2.7	2.5	2.6	0.67	0.75	0.73	0.71	0.15	0.16	0.16	0.16	0.043	0.048	0.047	0.048
Cobalt (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	0.001	<0.005	<0.005	0.001
Copper (filtered)	0.06	0.068	0.036	0.054	0.063	0.04	0.034	0.034	0.55	0.31	0.35	0.15	0.58	0.14	0.03	0.073
Iron (filtered)	< 0.1	< 0.1	0.3	< 0.1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	0.73	0.09	<0.05	0.08
Lead (filtered)	< 0.005	0.3	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	0.19	0.1	0.035	0.006	<0.005	0.004
Manganese (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.01	< 0.05	0.008	< 0.05	0.009	<0.025	<0.025	<0.005
Mercury (filtered)	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0005	< 0.0005	< 0.0005	< 0.0005	<0.001	<0.001	<0.001	<0.001
Molybdenum (filtered)	2.2	2.4	2.2	2.3	2	2.2	2.2	2.1	1.9	1.8	1.9	1.9	1.4	1.7	1.7	1.7
Nickel (filtered)	0.015	0.017	0.014	0.015	0.019	0.022	0.023	0.024	< 0.05	< 0.05	< 0.05	< 0.05	0.029	0.02	0.013	0.012
Selenium (filtered)	0.64	0.64	0.68	0.63	0.46	0.51	0.55	0.55	0.25	0.24	0.26	0.27	0.13	0.21	0.2	0.16
Silver (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.005	<0.025	<0.025	0.021
Strontium (Filtered)	0.21	0.27	0.21	0.2	0.24	0.23	0.23	0.22	0.21	0.2	0.2	0.2	0.3	0.42	0.39	0.34
Thallium (filtered)	0.069	0.013	0.011	0.07	0.041	0.009	0.008	0.055	< 0.05	< 0.05	< 0.05	< 0.05	N/A	N/A	N/A	N/A
Tin (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.007	< 0.005	< 0.05	< 0.05	< 0.05	< 0.05	<0.005	<0.025	<0.025	N/A
Vanadium (filtered)	86	96	83	97	79	81	83	75	68	69	71	69	69	72	78	76
Zinc (filtered)	1.9	1.9	1.9	1.8	0.053	0.056	0.046	0.044	0.23	0.18	0.26	0.19	1.7	0.053	0.029	0.16

Data from Labmark, except values in blue, which were provided by Minchem/Petroleum

Chemical assay of residues from 8 month aging tests (composition of initial residues given for comparison)

IDENT	Al	Ca	CO2	F	Fe	K	Mg	Mn	Na	P	S	Si	SO4	TOC	Ag
UNITS	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**ppm**
DETECTION LIMIT	0.01	0.01	0.07	0.01	0.01	0.01	0.01	0.005	0.01	0.005	0.01	0.01	0.05	0.05	0.1
YM0015 (Initial residue)	8.99	0.42	1.41		3.53	1.58	1.72	0.02	1.24	<0.01	0.05	28.36			
YM0015 OPEN A	8.51	0.34	1.8	0.14	3.32	1.47	1.59	0.015	1.76	0.02	0.11	27.1	0.3	0.05	<0.1
YM0015 OPEN B	8.32	0.33	1.8	0.14	3.36	1.4	1.55	0.015	1.85	0.015	0.11	26.9	0.35	<0.05	<0.1
YM0015 CLOSE A	8.37	0.34	1.4	0.13	3.37	1.4	1.56	0.015	1.56	0.02	0.07	27.3	0.25	<0.05	<0.1
YM0015 CLOSE B	8.66	0.35	1.2	0.14	3.42	1.48	1.61	0.015	0.9	0.025	0.05	28.3	0.05	0.05	<0.1
YM0046 (Initial residue)	1.61	13.77	24.09		0.72	0.4	9.37	<0.01	1.12	<0.01	0.08	13.28			0.05
YM0046 OPEN A	1.63	13.5	22.4	0.66	0.66	0.39	8.89	0.005	1.56	0.01	0.1	13.3	0.4	<0.05	<0.1
YM0046 OPEN B	1.58	13.6	22.8	0.67	0.64	0.39	9.03	0.01	1.41	0.01	0.09	13	0.35	0.1	0.2
YM0046 CLOSE A	1.56	13.8	24.2	0.67	0.62	0.38	9.14	0.005	1.13	0.01	0.06	13	0.3	0.1	<0.1
YM0046 CLOSE B	1.58	13.7	24.6	0.66	0.64	0.39	9.08	0.005	1.44	0.01	0.03	13.1	0.4	0.1	0.1
YM0074 (Initial residue)	10.64	0.35	1.16		4.31	1.69	1.66	0.02	1.2	0.01	0.05	27.05			<0.05
YM0074 OPEN A	9.76	0.32	1.4	0.13	4.1	1.55	1.53	0.025	1.55	0.025	0.1	25.3	0.25	0.05	<0.1
YM0074 OPEN B	9.93	0.32	1.2	0.13	4.09	1.58	1.59	0.025	1.09	0.03	0.07	25.6	0.15	<0.05	<0.1
YM0074 CLOSE A	10	0.33	1.4	0.13	4.05	1.52	1.58	0.025	1.46	0.025	0.06	25.6	0.25	<0.05	<0.1
YM0074 CLOSE B	10.1	0.35	1.2	0.13	4.1	1.57	1.6	0.025	0.93	0.03	0.05	26.1	0.1	<0.05	<0.1
YM0076 (Initial residue)	1.61	17.69	35.98		0.73	0.31	10.83	0.03	0.37	0.01	0.03	6.64			<0.05
YM0076 OPEN A	1.59	17	34.8	0.34	0.66	0.29	10.3	0.03	0.43	0.02	0.04	6.56	0.2	0.05	<0.1
YM0076 OPEN B	1.62	17.1	35	0.32	0.66	0.3	10.4	0.03	0.43	0.02	0.04	6.64	0.2	0.15	<0.1
YM0076 CLOSE A	1.65	17.1	35.6	0.33	0.7	0.31	10.3	0.035	0.37	0.02	0.04	6.74	0.2	0.05	<0.1
YM0076 CLOSE B	1.59	17.1	35.6	0.33	0.65	0.3	10.4	0.03	0.41	0.015	0.03	6.61	0.2	0.15	<0.1

Chemical assay of residues from 8 month aging tests (composition of initial residues given for comparison)

IDENT	**As**	**B**	**Ba**	**Be**	**Bi**	**Cd**	**Ce**	**Co**	**Cr**	**Cu**	**Hg**	**Li**	**Mo**	**Ni**	**Pb**
UNITS	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
DETECTION LIMIT	0.5	5	10	0.5	0.1	0.1	1	0.2	20	0.5	0.05	4	0.1	2	0.5
YM0015 (Initial residue)	15.16		400		0.22	<0.1	<100	7.07	137	23.24			5.34	45	15.81
YM0015 OPEN A	15.5	80	340	1	0.2	<0.1	48	6	135	20	<0.05	10	6	43	15
YM0015 OPEN B	16	80	340	1.5	0.2	<0.1	49	6	125	19.5	<0.05	15	7	46	14.5
YM0015 CLOSE A	15.5	110	340	1.5	0.3	<0.1	49	6.5	130	21	<0.05	15	6.5	45	16.5
YM0015 CLOSE B	15	120	340	1.5	0.2	<0.1	52	6.5	125	20	<0.05	15	6	46	16.5
YM0046 (Initial residue)	2.98		<200		<0.1	<0.1	<100	2.86	52	18.76			3.43	28	5.07
YM0046 OPEN A	2.5	20	80	<0.5	<0.1	<0.1	10	2.4	45	14.5	<0.05	5	3.3	21	5
YM0046 OPEN B	2.5	20	80	<0.5	<0.1	<0.1	10	2.4	45	13	<0.05	5	3.3	20	4
YM0046 CLOSE A	2	10	80	<0.5	<0.1	<0.1	10	2.6	45	12	<0.05	5	3.6	22	4.5
YM0046 CLOSE B	2.5	10	80	<0.5	<0.1	<0.1	10	2.2	50	9.5	0.05	5	3	19	4
YM0074 (Initial residue)	21.21		400		0.27	<0.1	<100	7.47	128	27.98			5.58	46	17.18
YM0074 OPEN A	20	160	340	1.5	0.2	<0.1	55	6	135	26.5	<0.05	15	7	41	14.5
YM0074 OPEN B	19.5	140	340	1.5	0.2	<0.1	56	6.5	145	23	<0.05	15	7	44	16
YM0074 CLOSE A	20	90	340	1.5	0.2	<0.1	56	6.5	145	23.5	<0.05	15	6.5	43	16.5
YM0074 CLOSE B	20	90	360	1.5	0.2	<0.1	56	7	145	28	<0.05	15	7	45	17
YM0076 (Initial residue)	2.42		<200		<0.1	<0.1	<100	3.67	76	17.2			5.4	36	4.79
YM0076 OPEN A	2.5	30	180	<0.5	<0.1	<0.1	10	3.4	65	13	0.05	5	6	30	4.5
YM0076 OPEN B	3	30	200	<0.5	<0.1	<0.1	10	3.4	70	13.5	<0.05	5	5.5	30	4.5
YM0076 CLOSE A	3	10	180	<0.5	<0.1	<0.1	10	3.4	65	12.5	0.05	5	6	31	4
YM0076 CLOSE B	3	10	180	<0.5	<0.1	<0.1	10	3.2	70	13.5	0.05	5	5.5	30	4

Chemical assay of residues from 8 month aging tests (composition of initial residues given for comparison)

IDENT	**Sb**	**Sc**	**Se**	**Sn**	**Sr**	**Th**	**Tl**	**U3O8**	**V**	**W**	**Y**	**Zn**
UNITS	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**
DETECTION LIMIT	0.5	5	0.5	10	5	4	3	4	20	3	1	0.5
YM0015 (Initial residue)	0.1	11	<0.5		5560	19.61		226	222		11	40.9
YM0015 OPEN A	<0.5	10	<0.5	<10	5420	20	<3	135	385	<3	10	37
YM0015 OPEN B	<0.5	10	<0.5	<10	4940	15	<3	140	380	<3	10	36.5
YM0015 CLOSE A	<0.5	10	<0.5	<10	5320	20	<3	120	370	<3	10	39.5
YM0015 CLOSE B	<0.5	10	<0.5	<10	5260	20	<3	85	340	<3	10	41
YM0046 (Initial residue)	<0.1	<5	<0.5		928	3.07		64.4	84		<10	19.26
YM0046 OPEN A	<0.5	<5	<0.5	<10	880	5	<3	60	145	<3	3	15
YM0046 OPEN B	<0.5	<5	<0.5	<10	880	5	<3	60	140	<3	3	14.5
YM0046 CLOSE A	<0.5	<5	<0.5	<10	940	5	<3	55	135	<3	3	17.5
YM0046 CLOSE B	<0.5	<5	<0.5	<10	900	5	<3	65	145	<3	3	13.5
YM0074 (Initial residue)	<0.1	14	<0.5		4713	20.22		63.68	177		13	45.53
YM0074 OPEN A	<0.5	15	<0.5	<10	4340	20	<3	60	240	<3	12	41.5
YM0074 OPEN B	<0.5	15	<0.5	<10	4520	20	<3	50	240	<3	12	43
YM0074 CLOSE A	<0.5	15	<0.5	<10	4500	15	<3	55	245	<3	12	44
YM0074 CLOSE B	<0.5	15	<0.5	<10	4760	15	<3	45	240	<3	12	47
YM0076 (Initial residue)	<0.1	<5	<0.5		8184	3.14		90.97	49		<10	12.68
YM0076 OPEN A	<0.5	<5	<0.5	<10	7820	10	<3	105	110	<3	3	14
YM0076 OPEN B	<0.5	<5	<0.5	<10	8180	10	<3	105	95	<3	3	13.5
YM0076 CLOSE A	<0.5	<5	<0.5	<10	7960	5	<3	100	90	<3	3	14
YM0076 CLOSE B	<0.5	<5	<0.5	<10	7800	10	<3	105	95	<3	3	15

Mineralogical composition of residues from 8 month aging tests (composition of initial residues given for comparison)

	Quartz	Calcite	Dolomite	Albite	Microcline	Anatase	Carnotite	Kaolin	Smectite	Illite/ Mica	Sepiolite	Palygorskite	Goethite	Celestine	Gypsum	Halite
YM0015 (Initial residue)	34		1	1	5	<1	0.4	45	5	6			2	1		<1
YM0015-Closed A. 8 months	36	2	1	1	4	<1		43	5	2		4	1			
YM0015-Open A. 8 months	36	2	1	1	4	<1		42	6	2		4	1			
YM0046 (Initial residue)	5	13	38	1	2			6	22	1	8				3	1
YM0046-Closed A. 8 months	5	17	39					4	31		5					
YM0046-Open A. 8 months	4	17	39					4	30		5					
YM0074 (Initial residue)	23		1	1	4	<1	0.2	53	4	3		7	2	1		1
YM0074-Closed A. 8 months	24	1	2	1	3	<1		53	3	3		7	2			
YM0074-Open A. 8 months	23	1	2	1	3	<1		53	3	3		8	2			
YM0076 (Initial residue)	3	3	78	1	1		0.3	7	4					2	1	<1
YM0076-Closed A. 8 months	3	2	79		<1			5	10							
YM0076-Open A. 8 months	3	2	80		<1			5	10							

Appendix 7: Particle Size Distributions

PsS™ Particle & Surface Sciences Pty. Limited
PO Box 1926, Gosford, NSW, Australia 2250. Tel: (61) 02 43 237822 Fax: (61) 02 43 237629 Email: info@pss.aus.net

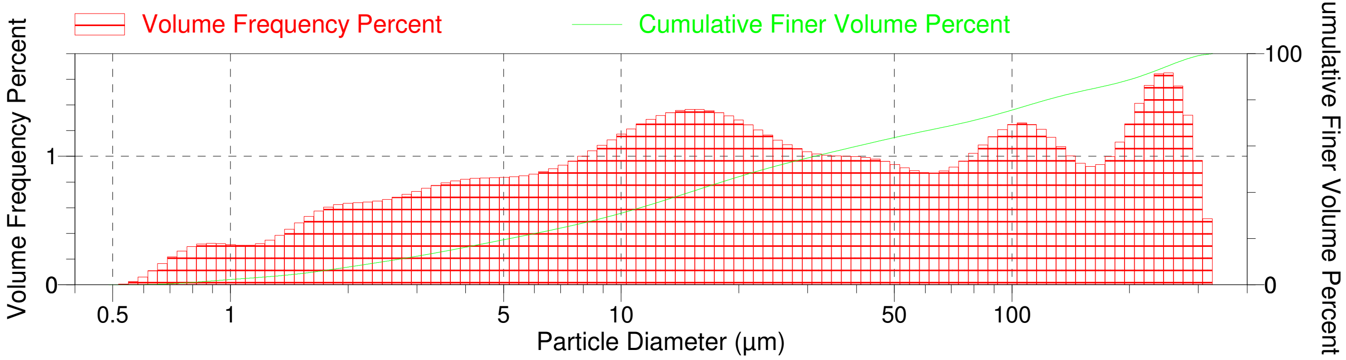
Sample: YYS 159 4.5-5.2m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-038.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 2:30:25PM
Reported: 5/08/2010 11:25:41AM
Background: 2/08/2010 1:34:55PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Combined Report

Volume Frequency vs. Diameter



Summary Report

Analysis Conditions

FlowRate: 12.0 l/m
Circulation time: 120 sec

Ultrasonic intensity: 50 %
Ultrasonic time: 120 sec

Particle Properties

Refractive Index: (Re)0.000, (Im)0.000
Density: 1.000 g/cm³
Smoothing: Medium
Truncate intensity data: No
Minimum signal fraction: 16.0 %

Analysis Liquid Properties

Refractive Index: 1.331
Viscosity: 0.798 cp
Temperature: 29.790 ℃

User Parameters

Parameter 1: 0.000 Parameter 2: 0.000 Parameter 3: 0.000

Sample

Sample Concentration: 0.00523 %
Obscuration: 10.3 %

Volume Distribution Arithmetic Statistics

		Std Dev of 2			Std Dev of 2
Mean	64.84	0.007	Mode	252.0	0.000
Median	23.28	0.104			

Peaks

Peak Number	% of Dist.*	% of Dist. Std Dev of 2	Mean	Mean Std Dev of 2	Median	Median Std Dev of 2	Mode
1	64.5	1.2	17.22	0.470	12.14	0.120	15.45
2	17.7	1.3	106.0	1.281	103.0	1.178	106.2
3	14.9	0.2	234.1	0.403	232.7	0.498	252.0

* Peaks must comprise at least 5.00 % of the distribution.

Sample: YYS 159 4.5-5.2m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-038.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 2:30:25PM
Reported: 5/08/2010 11:25:41AM
Background: 2/08/2010 1:34:55PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
344.747	325.462	334.965	100.0	0.0	0.0
325.462	307.256	316.228	99.4	0.6	0.0
307.256	290.068	298.538	98.5	1.0	0.0
290.068	273.842	281.838	97.1	1.3	0.1
273.842	258.523	266.073	95.6	1.6	0.1
258.523	244.062	251.189	93.9	1.7	0.1
244.062	230.409	237.137	92.3	1.6	0.2
230.409	217.520	223.872	90.7	1.5	0.2
217.520	205.353	211.349	89.3	1.4	0.2
205.353	193.865	199.526	88.1	1.2	0.3
193.865	183.021	188.365	87.0	1.1	0.3
183.021	172.783	177.828	86.0	1.0	0.2
172.783	163.117	167.880	85.0	0.9	0.2
163.117	153.993	158.489	84.1	0.9	0.2
153.993	145.378	149.624	83.2	0.9	0.2
145.378	137.246	141.254	82.2	1.0	0.1
137.246	129.569	133.352	81.1	1.1	0.1
129.569	122.321	125.893	79.9	1.2	0.0
122.321	115.478	118.850	78.7	1.2	0.0
115.478	109.018	112.202	77.5	1.2	0.1
109.018	102.920	105.925	76.2	1.3	0.2
102.920	97.163	100.000	75.0	1.2	0.2
97.163	91.728	94.406	73.8	1.2	0.3
91.728	86.596	89.125	72.6	1.2	0.3
86.596	81.752	84.140	71.5	1.1	0.4
81.752	77.179	79.433	70.5	1.0	0.4
77.179	72.862	74.989	69.5	1.0	0.4
72.862	68.786	70.795	68.6	0.9	0.4
68.786	64.938	66.834	67.7	0.9	0.4
64.938	61.306	63.096	66.9	0.9	0.4
61.306	57.876	59.566	66.0	0.9	0.4
57.876	54.639	56.234	65.1	0.9	0.4
54.639	51.582	53.088	64.2	0.9	0.3
51.582	48.697	50.119	63.2	0.9	0.3
48.697	45.973	47.315	62.3	1.0	0.3
45.973	43.401	44.668	61.3	1.0	0.3
43.401	40.973	42.170	60.3	1.0	0.3
40.973	38.681	39.811	59.3	1.0	0.2
38.681	36.517	37.584	58.3	1.0	0.2
36.517	34.475	35.481	57.3	1.0	0.2
34.475	32.546	33.497	56.3	1.0	0.2
32.546	30.726	31.623	55.3	1.0	0.2
30.726	29.007	29.854	54.2	1.0	0.2
29.007	27.384	28.184	53.2	1.1	0.1
27.384	25.852	26.607	52.1	1.1	0.1
25.852	24.406	25.119	51.0	1.1	0.1
24.406	23.041	23.714	49.8	1.2	0.1

Sample: YYS 159 4.5-5.2m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-038.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 2:30:25PM
Reported: 5/08/2010 11:25:41AM
Background: 2/08/2010 1:34:55PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
23.041	21.752	22.387	48.6	1.2	0.1
21.752	20.535	21.135	47.3	1.2	0.1
20.535	19.387	19.953	46.0	1.3	0.1
19.387	18.302	18.836	44.7	1.3	0.1
18.302	17.278	17.783	43.4	1.3	0.1
17.278	16.312	16.788	42.0	1.4	0.1
16.312	15.399	15.849	40.7	1.4	0.1
15.399	14.538	14.962	39.3	1.4	0.1
14.538	13.725	14.125	37.9	1.4	0.1
13.725	12.957	13.335	36.6	1.3	0.2
12.957	12.232	12.589	35.3	1.3	0.2
12.232	11.548	11.885	34.0	1.3	0.2
11.548	10.902	11.220	32.8	1.3	0.2
10.902	10.292	10.593	31.5	1.2	0.2
10.292	9.716	10.000	30.4	1.2	0.2
9.716	9.173	9.441	29.2	1.1	0.2
9.173	8.660	8.913	28.2	1.1	0.2
8.660	8.175	8.414	27.1	1.0	0.2
8.175	7.718	7.943	26.1	1.0	0.2
7.718	7.286	7.499	25.2	1.0	0.2
7.286	6.879	7.079	24.2	0.9	0.2
6.879	6.494	6.683	23.3	0.9	0.1
6.494	6.131	6.310	22.4	0.9	0.1
6.131	5.788	5.957	21.6	0.9	0.1
5.788	5.464	5.623	20.7	0.8	0.1
5.464	5.158	5.309	19.9	0.8	0.1
5.158	4.870	5.012	19.1	0.8	0.1
4.870	4.597	4.732	18.2	0.8	0.1
4.597	4.340	4.467	17.4	0.8	0.1
4.340	4.097	4.217	16.6	0.8	0.1
4.097	3.868	3.981	15.8	0.8	0.1
3.868	3.652	3.758	14.9	0.8	0.1
3.652	3.447	3.548	14.1	0.8	0.1
3.447	3.255	3.350	13.4	0.8	0.1
3.255	3.073	3.162	12.6	0.7	0.1
3.073	2.901	2.985	11.9	0.7	0.1
2.901	2.738	2.818	11.2	0.7	0.1
2.738	2.585	2.661	10.5	0.7	0.1
2.585	2.441	2.512	9.9	0.7	0.1
2.441	2.304	2.371	9.2	0.7	0.1
2.304	2.175	2.239	8.6	0.6	0.1
2.175	2.054	2.113	7.9	0.6	0.1
2.054	1.939	1.995	7.3	0.6	0.0
1.939	1.830	1.884	6.7	0.6	0.0
1.830	1.728	1.778	6.1	0.6	0.0
1.728	1.631	1.679	5.5	0.6	0.0
1.631	1.540	1.585	5.0	0.5	0.0

Sample: YYS 159 4.5-5.2m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-038.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 2:30:25PM
Reported: 5/08/2010 11:25:41AM
Background: 2/08/2010 1:34:55PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
1.540	1.454	1.496	4.5	0.5	0.0
1.454	1.372	1.413	4.1	0.4	0.0
1.372	1.296	1.334	3.7	0.4	0.0
1.296	1.223	1.259	3.3	0.3	0.0
1.223	1.155	1.189	3.0	0.3	0.0
1.155	1.090	1.122	2.7	0.3	0.0
1.090	1.029	1.059	2.4	0.3	0.0
1.029	0.972	1.000	2.1	0.3	0.0
0.972	0.917	0.944	1.8	0.3	0.0
0.917	0.866	0.891	1.4	0.3	0.0
0.866	0.818	0.841	1.1	0.3	0.0
0.818	0.772	0.794	0.8	0.3	0.0
0.772	0.729	0.750	0.6	0.3	0.0
0.729	0.688	0.708	0.4	0.2	0.0
0.688	0.649	0.668	0.2	0.2	0.0
0.649	0.613	0.631	0.1	0.1	0.0
0.613	0.579	0.596	0.0	0.1	0.0
0.579	0.546	0.562	0.0	0.0	0.0
0.546	0.516	0.531	0.0	0.0	0.0

Sample: YYS 159 4.5-5.2m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-038.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 2:30:25PM
Reported: 5/08/2010 11:25:41AM
Background: 2/08/2010 1:34:55PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Table

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
300.000	99.1	100.000	75.6	20.000	46.7	4.000	16.2
250.000	94.6	80.000	71.1	10.000	31.0	2.000	7.6
200.000	88.7	60.000	66.5	8.000	26.7	1.000	2.2
150.000	83.7	40.000	59.9	6.000	22.1		

Sample: YYS 159 4.5-5.2m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-038.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 2:30:25PM
Reported: 5/08/2010 11:25:42AM
Background: 2/08/2010 1:34:55PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

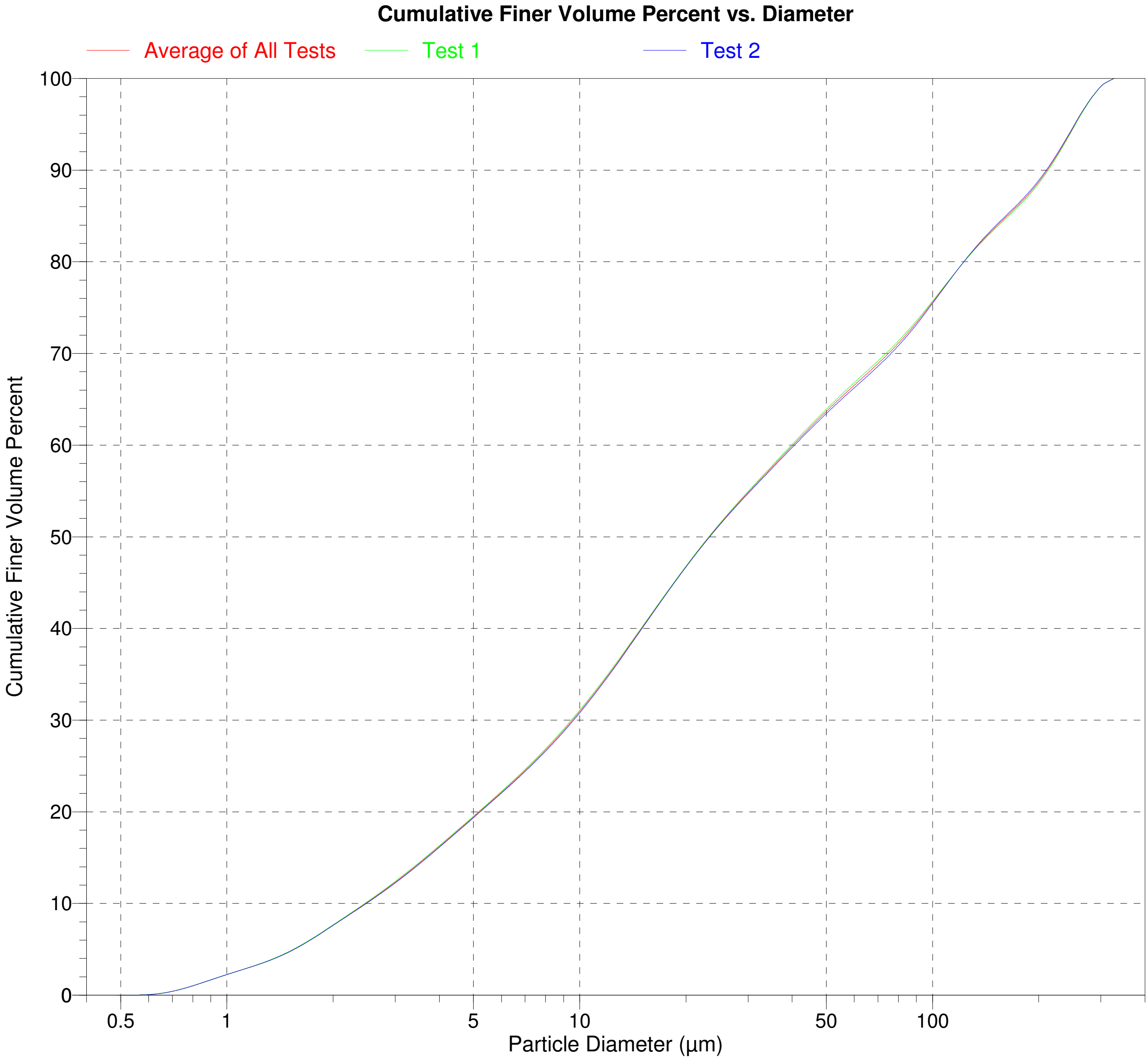
Report by Volume Percent

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
326.451	100.0	74.940	70.0	14.971	40.0	2.472	10.0
253.490	95.0	54.323	65.0	12.075	35.0	1.546	5.0
211.320	90.0	40.245	60.0	9.536	30.0	0.517	0.0
162.736	85.0	30.252	55.0	7.216	25.0		
122.745	80.0	23.277	50.0	5.195	20.0		
97.327	75.0	18.516	45.0	3.667	15.0		

Sample: YYS 159 4.5-5.2m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-038.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 2:30:25PM
Reported: 5/08/2010 11:25:42AM
Background: 2/08/2010 1:34:55PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium



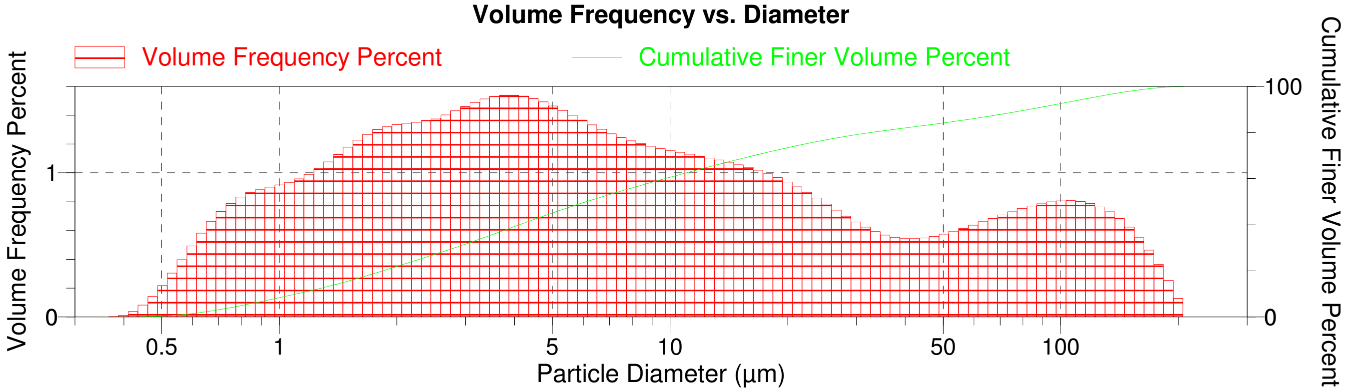
Sample: YYS 158 3.75-4.5m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-034.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 11:30:43AM
Reported: 5/08/2010 11:24:11AM
Background: 2/08/2010 10:53:40AM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Combined Report

Volume Frequency vs. Diameter



Summary Report

Analysis Conditions

FlowRate: 12.0 l/m
Circulation time: 120 sec

Ultrasonic intensity: 50 %
Ultrasonic time: 120 sec

Particle Properties

Refractive Index: (Re)0.000, (Im)0.000
Density: 1.000 g/cm³
Smoothing: Medium
Truncate intensity data: No
Minimum signal fraction: 16.0 %

Analysis Liquid Properties

Refractive Index: 1.331
Viscosity: 0.798 cp
Temperature: 24.815 ℃

User Parameters

Parameter 1: 0.000
Parameter 2: 0.000
Parameter 3: 0.000

Sample

Sample Concentration: 0.00312 %
Obscuration: 14.0 %

Volume Distribution Arithmetic Statistics

		Std Dev of 2			Std Dev of 2
Mean	23.56	0.927	Mode	3.881	0.158
Median	6.110	0.089			

Peaks

Peak Number	% of Dist.*	% of Dist. Std Dev of 2	Mean	Mean Std Dev of 2	Median	Median Std Dev of 2	Mode
1	82.8	0.5	8.076	0.025	4.341	0.013	3.881
2	17.2	0.5	98.16	2.391	91.83	3.057	103.6

* Peaks must comprise at least 5.00 % of the distribution.

Sample: YYS 158 3.75-4.5m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-034.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 11:30:43AM
Reported: 5/08/2010 11:24:11AM
Background: 2/08/2010 10:53:40AM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
217.520	205.353	211.349	100.0	0.0	0.0
205.353	193.865	199.526	99.9	0.1	0.0
193.865	183.021	188.365	99.6	0.3	0.1
183.021	172.783	177.828	99.2	0.4	0.1
172.783	163.117	167.880	98.8	0.5	0.2
163.117	153.993	158.489	98.2	0.6	0.3
153.993	145.378	149.624	97.6	0.6	0.4
145.378	137.246	141.254	96.9	0.7	0.4
137.246	129.569	133.352	96.2	0.7	0.5
129.569	122.321	125.893	95.4	0.8	0.6
122.321	115.478	118.850	94.6	0.8	0.6
115.478	109.018	112.202	93.8	0.8	0.7
109.018	102.920	105.925	93.0	0.8	0.7
102.920	97.163	100.000	92.2	0.8	0.7
97.163	91.728	94.406	91.4	0.8	0.7
91.728	86.596	89.125	90.6	0.8	0.7
86.596	81.752	84.140	89.8	0.8	0.7
81.752	77.179	79.433	89.1	0.8	0.7
77.179	72.862	74.989	88.4	0.7	0.7
72.862	68.786	70.795	87.7	0.7	0.7
68.786	64.938	66.834	87.0	0.7	0.6
64.938	61.306	63.096	86.3	0.7	0.6
61.306	57.876	59.566	85.7	0.6	0.6
57.876	54.639	56.234	85.1	0.6	0.6
54.639	51.582	53.088	84.5	0.6	0.6
51.582	48.697	50.119	83.9	0.6	0.6
48.697	45.973	47.315	83.3	0.6	0.6
45.973	43.401	44.668	82.8	0.5	0.5
43.401	40.973	42.170	82.2	0.5	0.5
40.973	38.681	39.811	81.7	0.5	0.5
38.681	36.517	37.584	81.1	0.6	0.5
36.517	34.475	35.481	80.6	0.6	0.5
34.475	32.546	33.497	80.0	0.6	0.5
32.546	30.726	31.623	79.4	0.6	0.5
30.726	29.007	29.854	78.7	0.7	0.5
29.007	27.384	28.184	78.0	0.7	0.5
27.384	25.852	26.607	77.3	0.7	0.5
25.852	24.406	25.119	76.5	0.8	0.5
24.406	23.041	23.714	75.6	0.8	0.5
23.041	21.752	22.387	74.8	0.9	0.6
21.752	20.535	21.135	73.9	0.9	0.6
20.535	19.387	19.953	72.9	0.9	0.6
19.387	18.302	18.836	72.0	1.0	0.6
18.302	17.278	17.783	71.0	1.0	0.6
17.278	16.312	16.788	69.9	1.0	0.6
16.312	15.399	15.849	68.9	1.0	0.6
15.399	14.538	14.962	67.8	1.1	0.6

Sample: YYS 158 3.75-4.5m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-034.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 11:30:43AM
Reported: 5/08/2010 11:24:11AM
Background: 2/08/2010 10:53:40AM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
14.538	13.725	14.125	66.8	1.1	0.6
13.725	12.957	13.335	65.7	1.1	0.6
12.957	12.232	12.589	64.6	1.1	0.6
12.232	11.548	11.885	63.5	1.1	0.5
11.548	10.902	11.220	62.3	1.1	0.5
10.902	10.292	10.593	61.2	1.1	0.5
10.292	9.716	10.000	60.0	1.2	0.5
9.716	9.173	9.441	58.9	1.2	0.5
9.173	8.660	8.913	57.7	1.2	0.4
8.660	8.175	8.414	56.5	1.2	0.4
8.175	7.718	7.943	55.2	1.2	0.4
7.718	7.286	7.499	54.0	1.2	0.4
7.286	6.879	7.079	52.7	1.3	0.4
6.879	6.494	6.683	51.4	1.3	0.4
6.494	6.131	6.310	50.1	1.3	0.3
6.131	5.788	5.957	48.7	1.4	0.3
5.788	5.464	5.623	47.3	1.4	0.3
5.464	5.158	5.309	45.9	1.4	0.3
5.158	4.870	5.012	44.4	1.5	0.3
4.870	4.597	4.732	42.9	1.5	0.3
4.597	4.340	4.467	41.4	1.5	0.4
4.340	4.097	4.217	39.9	1.5	0.4
4.097	3.868	3.981	38.3	1.5	0.4
3.868	3.652	3.758	36.8	1.5	0.4
3.652	3.447	3.548	35.3	1.5	0.4
3.447	3.255	3.350	33.7	1.5	0.4
3.255	3.073	3.162	32.3	1.5	0.4
3.073	2.901	2.985	30.8	1.5	0.4
2.901	2.738	2.818	29.4	1.4	0.3
2.738	2.585	2.661	28.0	1.4	0.3
2.585	2.441	2.512	26.6	1.4	0.3
2.441	2.304	2.371	25.2	1.4	0.3
2.304	2.175	2.239	23.9	1.4	0.3
2.175	2.054	2.113	22.5	1.3	0.3
2.054	1.939	1.995	21.2	1.3	0.3
1.939	1.830	1.884	19.9	1.3	0.2
1.830	1.728	1.778	18.6	1.3	0.2
1.728	1.631	1.679	17.3	1.3	0.2
1.631	1.540	1.585	16.1	1.2	0.2
1.540	1.454	1.496	14.9	1.2	0.2
1.454	1.372	1.413	13.8	1.1	0.2
1.372	1.296	1.334	12.7	1.1	0.1
1.296	1.223	1.259	11.7	1.0	0.1
1.223	1.155	1.189	10.7	1.0	0.1
1.155	1.090	1.122	9.7	1.0	0.1
1.090	1.029	1.059	8.8	0.9	0.1
1.029	0.972	1.000	7.9	0.9	0.1

Sample: YYS 158 3.75-4.5m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-034.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 11:30:43AM
Reported: 5/08/2010 11:24:11AM
Background: 2/08/2010 10:53:40AM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
0.972	0.917	0.944	7.0	0.9	0.1
0.917	0.866	0.891	6.1	0.9	0.1
0.866	0.818	0.841	5.2	0.9	0.1
0.818	0.772	0.794	4.4	0.8	0.0
0.772	0.729	0.750	3.6	0.8	0.0
0.729	0.688	0.708	2.9	0.7	0.0
0.688	0.649	0.668	2.2	0.7	0.0
0.649	0.613	0.631	1.7	0.6	0.0
0.613	0.579	0.596	1.2	0.5	0.0
0.579	0.546	0.562	0.8	0.4	0.0
0.546	0.516	0.531	0.5	0.3	0.0
0.516	0.487	0.501	0.3	0.2	0.0
0.487	0.460	0.473	0.1	0.1	0.0
0.460	0.434	0.447	0.0	0.1	0.0
0.434	0.410	0.422	0.0	0.0	0.0
0.410	0.387	0.398	0.0	0.0	0.0
0.387	0.365	0.376	0.0	0.0	0.0

Sample: YYS 158 3.75-4.5m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-034.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 11:30:43AM
Reported: 5/08/2010 11:24:11AM
Background: 2/08/2010 10:53:40AM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Table

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
200.000	100.0	60.000	86.1	8.000	56.0	1.000	8.3
150.000	97.9	40.000	82.0	6.000	49.6	0.500	0.4
100.000	92.6	20.000	73.4	4.000	39.2		
80.000	89.6	10.000	60.6	2.000	21.9		

Sample: YYS 158 3.75-4.5m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-034.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 11:30:43AM
Reported: 5/08/2010 11:24:11AM
Background: 2/08/2010 10:53:40AM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Volume Percent

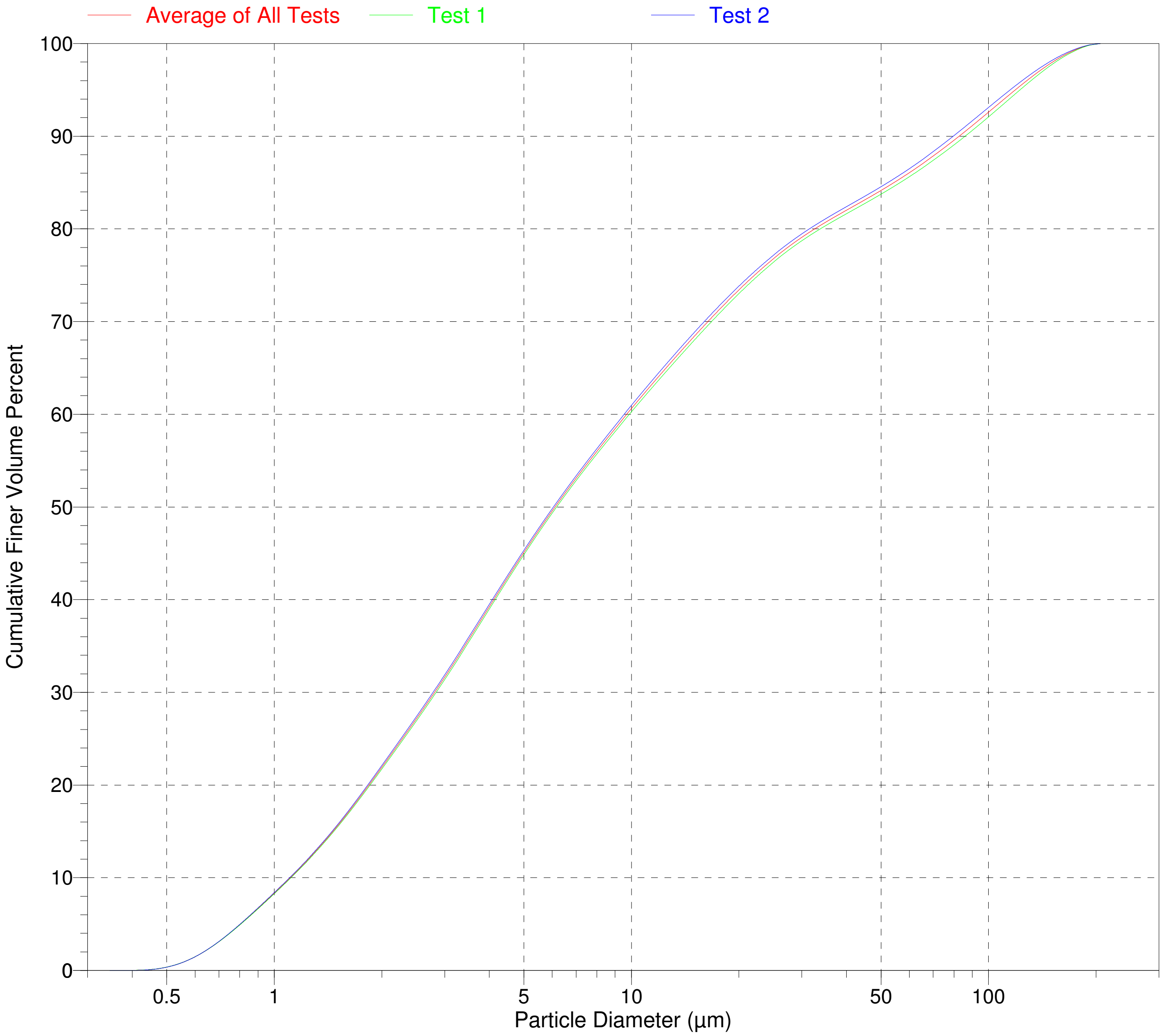
Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
205.977	100.0	16.374	70.0	4.118	40.0	1.108	10.0
118.690	95.0	12.513	65.0	3.415	35.0	0.804	5.0
82.825	90.0	9.708	60.0	2.810	30.0	0.366	0.0
54.372	85.0	7.633	55.0	2.282	25.0		
32.645	80.0	6.110	50.0	1.841	20.0		
22.094	75.0	4.983	45.0	1.461	15.0		

Sample: YYS 158 3.75-4.5m
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-034.SMP

Test Number: Avg of 2
Analyzed: 2/08/2010 11:30:43AM
Reported: 5/08/2010 11:24:11AM
Background: 2/08/2010 10:53:40AM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Cumulative Finer Volume Percent vs. Diameter



Particle & Surface Sciences Pty. Limited

PO Box 1926, Gosford, NSW, Australia 2250. Tel: (61) 02 43 237822 Fax: (61) 02 43 237629 Email: info@pss.aus.net

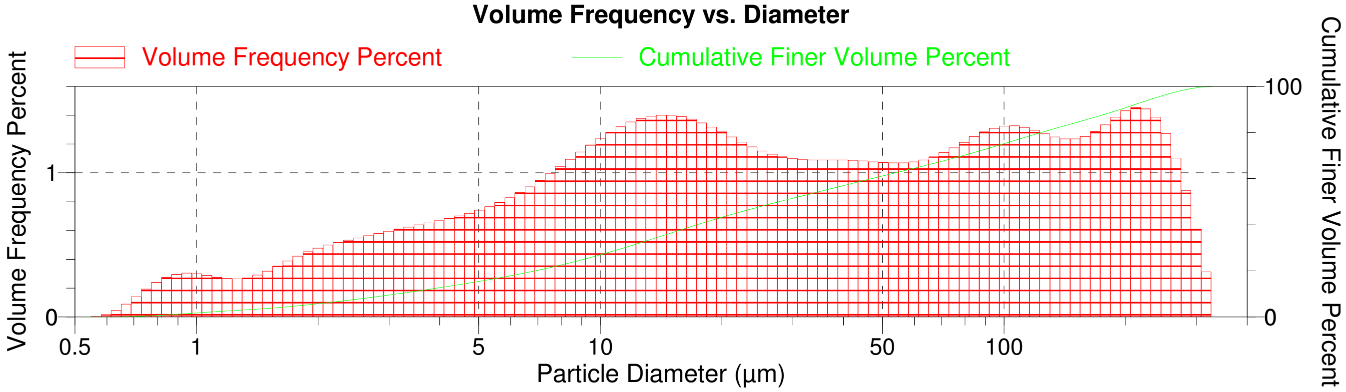
Sample: YYS 158 2.5-3.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-032.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:34:57PM
Reported: 5/08/2010 11:22:19AM
Background: 30/07/2010 4:22:49PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Combined Report

Volume Frequency vs. Diameter



Summary Report

Analysis Conditions

FlowRate: 12.0 l/m
Circulation time: 120 sec

Ultrasonic intensity: 50 %
Ultrasonic time: 120 sec

Particle Properties

Refractive Index: (Re)0.000, (Im)0.000
Density: 1.000 g/cm^3
Smoothing: Medium
Truncate intensity data: No
Minimum signal fraction: 16.0 %

Analysis Liquid Properties

Refractive Index: 1.331
Viscosity: 0.798 cp
Temperature: 26.515 ℃

User Parameters

Parameter 1: 0.000
Parameter 2: 0.000
Parameter 3: 0.000

Sample

Sample Concentration: 0.00445 %
Obscuration: 7.5 %

Volume Distribution Arithmetic Statistics

		Std Dev of 2			Std Dev of 2
Mean	64.83	0.990	Mode	212.0	0.000
Median	27.71	0.041			

Sample: YYS 158 2.5-3.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-032.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:34:57PM
Reported: 5/08/2010 11:22:19AM
Background: 30/07/2010 4:22:49PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
344.747	325.462	334.965	100.0	0.0	0.0
325.462	307.256	316.228	99.7	0.3	0.0
307.256	290.068	298.538	99.0	0.6	0.1
290.068	273.842	281.838	98.1	0.9	0.1
273.842	258.523	266.073	97.0	1.1	0.2
258.523	244.062	251.189	95.8	1.3	0.3
244.062	230.409	237.137	94.4	1.4	0.4
230.409	217.520	223.872	92.9	1.4	0.5
217.520	205.353	211.349	91.5	1.5	0.5
205.353	193.865	199.526	90.0	1.4	0.6
193.865	183.021	188.365	88.7	1.4	0.6
183.021	172.783	177.828	87.3	1.3	0.6
172.783	163.117	167.880	86.0	1.3	0.6
163.117	153.993	158.489	84.8	1.3	0.6
153.993	145.378	149.624	83.5	1.2	0.6
145.378	137.246	141.254	82.3	1.2	0.5
137.246	129.569	133.352	81.1	1.3	0.5
129.569	122.321	125.893	79.8	1.3	0.4
122.321	115.478	118.850	78.5	1.3	0.4
115.478	109.018	112.202	77.2	1.3	0.4
109.018	102.920	105.925	75.9	1.3	0.4
102.920	97.163	100.000	74.5	1.3	0.3
97.163	91.728	94.406	73.2	1.3	0.3
91.728	86.596	89.125	71.9	1.3	0.3
86.596	81.752	84.140	70.7	1.2	0.3
81.752	77.179	79.433	69.5	1.2	0.3
77.179	72.862	74.989	68.3	1.2	0.3
72.862	68.786	70.795	67.2	1.1	0.3
68.786	64.938	66.834	66.1	1.1	0.3
64.938	61.306	63.096	65.0	1.1	0.3
61.306	57.876	59.566	63.9	1.1	0.3
57.876	54.639	56.234	62.8	1.1	0.2
54.639	51.582	53.088	61.8	1.1	0.2
51.582	48.697	50.119	60.7	1.1	0.2
48.697	45.973	47.315	59.6	1.1	0.2
45.973	43.401	44.668	58.5	1.1	0.1
43.401	40.973	42.170	57.4	1.1	0.1
40.973	38.681	39.811	56.3	1.1	0.1
38.681	36.517	37.584	55.3	1.1	0.1
36.517	34.475	35.481	54.2	1.1	0.1
34.475	32.546	33.497	53.1	1.1	0.0
32.546	30.726	31.623	52.0	1.1	0.0
30.726	29.007	29.854	50.9	1.1	0.0
29.007	27.384	28.184	49.8	1.1	0.0
27.384	25.852	26.607	48.6	1.1	0.0
25.852	24.406	25.119	47.5	1.2	0.0
24.406	23.041	23.714	46.3	1.2	0.0

Sample: YYS 158 2.5-3.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-032.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:34:57PM
Reported: 5/08/2010 11:22:19AM
Background: 30/07/2010 4:22:49PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
23.041	21.752	22.387	45.1	1.2	0.0
21.752	20.535	21.135	43.8	1.3	0.0
20.535	19.387	19.953	42.5	1.3	0.0
19.387	18.302	18.836	41.2	1.3	0.0
18.302	17.278	17.783	39.9	1.3	0.0
17.278	16.312	16.788	38.5	1.4	0.0
16.312	15.399	15.849	37.1	1.4	0.0
15.399	14.538	14.962	35.7	1.4	0.0
14.538	13.725	14.125	34.3	1.4	0.0
13.725	12.957	13.335	32.9	1.4	0.0
12.957	12.232	12.589	31.5	1.4	0.0
12.232	11.548	11.885	30.2	1.4	0.1
11.548	10.902	11.220	28.9	1.3	0.1
10.902	10.292	10.593	27.6	1.3	0.1
10.292	9.716	10.000	26.4	1.2	0.1
9.716	9.173	9.441	25.2	1.2	0.1
9.173	8.660	8.913	24.0	1.1	0.1
8.660	8.175	8.414	22.9	1.1	0.1
8.175	7.718	7.943	21.9	1.0	0.1
7.718	7.286	7.499	20.9	1.0	0.1
7.286	6.879	7.079	19.9	0.9	0.1
6.879	6.494	6.683	19.0	0.9	0.0
6.494	6.131	6.310	18.2	0.9	0.0
6.131	5.788	5.957	17.4	0.8	0.0
5.788	5.464	5.623	16.6	0.8	0.0
5.464	5.158	5.309	15.8	0.8	0.0
5.158	4.870	5.012	15.1	0.7	0.0
4.870	4.597	4.732	14.3	0.7	0.0
4.597	4.340	4.467	13.6	0.7	0.0
4.340	4.097	4.217	13.0	0.7	0.0
4.097	3.868	3.981	12.3	0.7	0.0
3.868	3.652	3.758	11.6	0.7	0.1
3.652	3.447	3.548	11.0	0.6	0.1
3.447	3.255	3.350	10.4	0.6	0.1
3.255	3.073	3.162	9.8	0.6	0.1
3.073	2.901	2.985	9.2	0.6	0.1
2.901	2.738	2.818	8.6	0.6	0.1
2.738	2.585	2.661	8.0	0.6	0.1
2.585	2.441	2.512	7.5	0.5	0.1
2.441	2.304	2.371	7.0	0.5	0.1
2.304	2.175	2.239	6.4	0.5	0.1
2.175	2.054	2.113	5.9	0.5	0.1
2.054	1.939	1.995	5.5	0.5	0.1
1.939	1.830	1.884	5.0	0.5	0.1
1.830	1.728	1.778	4.6	0.4	0.1
1.728	1.631	1.679	4.2	0.4	0.1
1.631	1.540	1.585	3.9	0.4	0.1

Sample: YYS 158 2.5-3.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-032.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:34:57PM
Reported: 5/08/2010 11:22:19AM
Background: 30/07/2010 4:22:49PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
1.540	1.454	1.496	3.5	0.3	0.1
1.454	1.372	1.413	3.2	0.3	0.1
1.372	1.296	1.334	3.0	0.3	0.0
1.296	1.223	1.259	2.7	0.3	0.0
1.223	1.155	1.189	2.4	0.3	0.0
1.155	1.090	1.122	2.2	0.3	0.0
1.090	1.029	1.059	1.9	0.3	0.0
1.029	0.972	1.000	1.6	0.3	0.0
0.972	0.917	0.944	1.3	0.3	0.0
0.917	0.866	0.891	1.0	0.3	0.0
0.866	0.818	0.841	0.7	0.3	0.0
0.818	0.772	0.794	0.5	0.2	0.0
0.772	0.729	0.750	0.3	0.2	0.0
0.729	0.688	0.708	0.1	0.1	0.0
0.688	0.649	0.668	0.1	0.1	0.0
0.649	0.613	0.631	0.0	0.0	0.0
0.613	0.579	0.596	0.0	0.0	0.0
0.579	0.546	0.562	0.0	0.0	0.0

Sample: YYS 158 2.5-3.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-032.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:34:57PM
Reported: 5/08/2010 11:22:19AM
Background: 30/07/2010 4:22:49PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Table

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
300.000	99.4	100.000	75.2	20.000	43.2	4.000	12.7
250.000	96.3	80.000	70.2	10.000	27.0	2.000	5.7
200.000	90.8	60.000	64.6	8.000	22.5	1.000	1.7
150.000	84.2	40.000	57.0	6.000	17.9		

Sample: YYS 158 2.5-3.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-032.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:34:57PM
Reported: 5/08/2010 11:22:19AM
Background: 30/07/2010 4:22:49PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

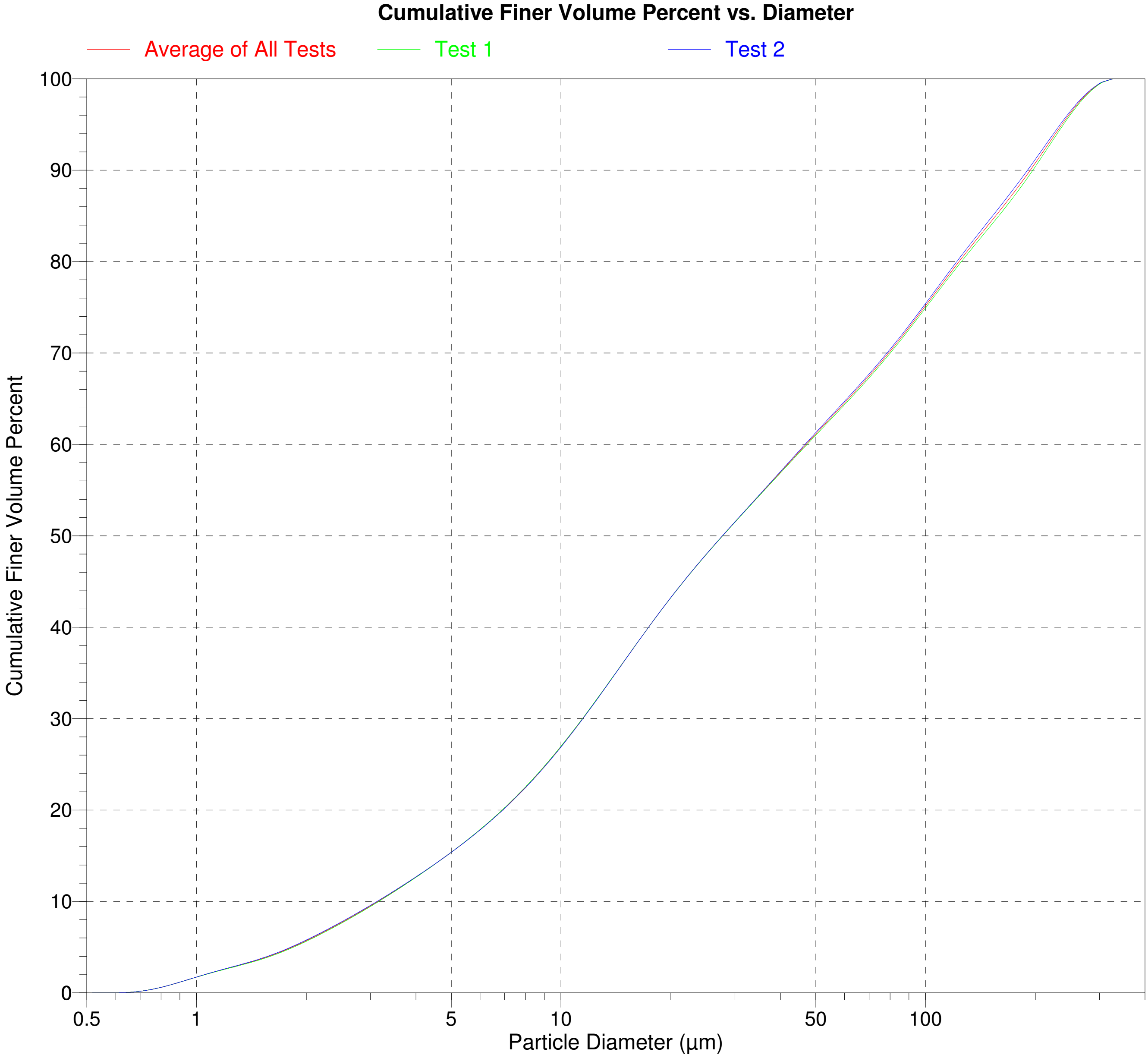
Report by Volume Percent

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
326.451	100.0	79.152	70.0	17.368	40.0	3.141	10.0
236.374	95.0	61.423	65.0	14.118	35.0	1.828	5.0
193.554	90.0	46.969	60.0	11.453	30.0	0.548	0.0
155.609	85.0	36.034	55.0	9.100	25.0		
123.528	80.0	27.714	50.0	6.901	20.0		
99.200	75.0	21.667	45.0	4.847	15.0		

Sample: YYS 158 2.5-3.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-032.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:34:57PM
Reported: 5/08/2010 11:22:19AM
Background: 30/07/2010 4:22:49PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium



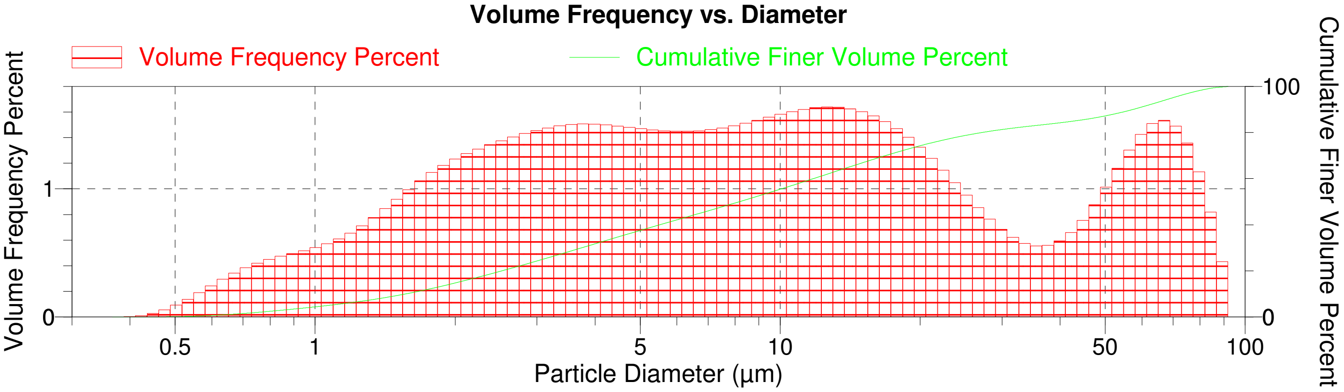
Sample: YYS 156A 12-12.75
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-029.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 2:00:22PM
Reported: 3/08/2010 11:36:52AM
Background: 30/07/2010 1:30:14PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Combined Report

Volume Frequency vs. Diameter



Summary Report

Analysis Conditions

FlowRate: 12.0 l/m
Circulation time: 120 sec

Ultrasonic intensity: 50 %
Ultrasonic time: 120 sec

Particle Properties

Refractive Index: (Re)0.000, (Im)0.000
Density: 1.000 g/cm³
Smoothing: Medium
Truncate intensity data: No
Minimum signal fraction: 16.0 %

Analysis Liquid Properties

Refractive Index: 1.331
Viscosity: 0.798 cp
Temperature: 28.235 ℃

User Parameters

Parameter 1: 0.000
Parameter 2: 0.000
Parameter 3: 0.000

Sample

Sample Concentration: 0.00258 %
Obscuration: 9.2 %

Volume Distribution Arithmetic Statistics

		Std Dev of 2			Std Dev of 2
Mean	17.56	0.126	Mode	12.63	0.000
Median	8.174	0.094			

Peaks

Peak Number	% of Dist.*	% of Dist. Std Dev of 2	Mean	Mean Std Dev of 2	Median	Median Std Dev of 2	Mode
1	43.5	1.3	2.948	0.082	2.710	0.058	3.770
2	39.9	1.1	15.14	0.201	13.30	0.212	12.63
3	16.6	0.2	61.59	0.052	61.41	0.073	67.04

* Peaks must comprise at least 5.00 % of the distribution.

Sample: YYS 156A 12-12.75
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-029.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 2:00:22PM
Reported: 3/08/2010 11:36:52AM
Background: 30/07/2010 1:30:14PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
97.163	91.728	94.406	100.0	0.0	0.0
91.728	86.596	89.125	99.5	0.5	0.0
86.596	81.752	84.140	98.7	0.8	0.0
81.752	77.179	79.433	97.5	1.1	0.0
77.179	72.862	74.989	96.2	1.4	0.1
72.862	68.786	70.795	94.7	1.5	0.1
68.786	64.938	66.834	93.2	1.5	0.1
64.938	61.306	63.096	91.6	1.5	0.1
61.306	57.876	59.566	90.2	1.4	0.1
57.876	54.639	56.234	88.9	1.3	0.1
54.639	51.582	53.088	87.8	1.2	0.1
51.582	48.697	50.119	86.8	1.0	0.1
48.697	45.973	47.315	85.9	0.9	0.1
45.973	43.401	44.668	85.2	0.7	0.1
43.401	40.973	42.170	84.5	0.7	0.2
40.973	38.681	39.811	83.9	0.6	0.2
38.681	36.517	37.584	83.3	0.6	0.2
36.517	34.475	35.481	82.8	0.6	0.2
34.475	32.546	33.497	82.2	0.6	0.2
32.546	30.726	31.623	81.6	0.6	0.2
30.726	29.007	29.854	80.9	0.7	0.2
29.007	27.384	28.184	80.1	0.8	0.2
27.384	25.852	26.607	79.3	0.9	0.2
25.852	24.406	25.119	78.3	1.0	0.2
24.406	23.041	23.714	77.3	1.1	0.2
23.041	21.752	22.387	76.1	1.2	0.2
21.752	20.535	21.135	74.9	1.2	0.2
20.535	19.387	19.953	73.5	1.3	0.2
19.387	18.302	18.836	72.1	1.4	0.2
18.302	17.278	17.783	70.7	1.5	0.2
17.278	16.312	16.788	69.1	1.5	0.2
16.312	15.399	15.849	67.6	1.6	0.2
15.399	14.538	14.962	66.0	1.6	0.3
14.538	13.725	14.125	64.3	1.6	0.3
13.725	12.957	13.335	62.7	1.6	0.3
12.957	12.232	12.589	61.1	1.6	0.3
12.232	11.548	11.885	59.4	1.6	0.3
11.548	10.902	11.220	57.8	1.6	0.3
10.902	10.292	10.593	56.2	1.6	0.3
10.292	9.716	10.000	54.6	1.6	0.3
9.716	9.173	9.441	53.1	1.6	0.3
9.173	8.660	8.913	51.5	1.5	0.3
8.660	8.175	8.414	50.0	1.5	0.3
8.175	7.718	7.943	48.5	1.5	0.3
7.718	7.286	7.499	47.0	1.5	0.3
7.286	6.879	7.079	45.6	1.5	0.3
6.879	6.494	6.683	44.1	1.5	0.3

Sample: YYS 156A 12-12.75
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-029.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 2:00:22PM
Reported: 3/08/2010 11:36:52AM
Background: 30/07/2010 1:30:14PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
6.494	6.131	6.310	42.7	1.4	0.3
6.131	5.788	5.957	41.2	1.4	0.2
5.788	5.464	5.623	39.8	1.5	0.2
5.464	5.158	5.309	38.3	1.5	0.2
5.158	4.870	5.012	36.8	1.5	0.2
4.870	4.597	4.732	35.4	1.5	0.2
4.597	4.340	4.467	33.9	1.5	0.2
4.340	4.097	4.217	32.4	1.5	0.2
4.097	3.868	3.981	30.9	1.5	0.2
3.868	3.652	3.758	29.4	1.5	0.1
3.652	3.447	3.548	27.9	1.5	0.1
3.447	3.255	3.350	26.4	1.5	0.1
3.255	3.073	3.162	24.9	1.5	0.1
3.073	2.901	2.985	23.4	1.5	0.1
2.901	2.738	2.818	22.0	1.4	0.1
2.738	2.585	2.661	20.6	1.4	0.1
2.585	2.441	2.512	19.2	1.4	0.1
2.441	2.304	2.371	17.9	1.3	0.1
2.304	2.175	2.239	16.6	1.3	0.1
2.175	2.054	2.113	15.3	1.3	0.1
2.054	1.939	1.995	14.1	1.2	0.1
1.939	1.830	1.884	12.9	1.2	0.1
1.830	1.728	1.778	11.8	1.1	0.1
1.728	1.631	1.679	10.7	1.1	0.1
1.631	1.540	1.585	9.7	1.0	0.0
1.540	1.454	1.496	8.8	0.9	0.0
1.454	1.372	1.413	8.0	0.8	0.0
1.372	1.296	1.334	7.2	0.8	0.0
1.296	1.223	1.259	6.5	0.7	0.0
1.223	1.155	1.189	5.8	0.7	0.0
1.155	1.090	1.122	5.2	0.6	0.0
1.090	1.029	1.059	4.6	0.6	0.0
1.029	0.972	1.000	4.1	0.5	0.0
0.972	0.917	0.944	3.6	0.5	0.0
0.917	0.866	0.891	3.1	0.5	0.0
0.866	0.818	0.841	2.6	0.5	0.0
0.818	0.772	0.794	2.2	0.4	0.0
0.772	0.729	0.750	1.8	0.4	0.0
0.729	0.688	0.708	1.4	0.4	0.0
0.688	0.649	0.668	1.0	0.3	0.0
0.649	0.613	0.631	0.7	0.3	0.0
0.613	0.579	0.596	0.5	0.2	0.0
0.579	0.546	0.562	0.3	0.2	0.0
0.546	0.516	0.531	0.2	0.1	0.0
0.516	0.487	0.501	0.1	0.1	0.0
0.487	0.460	0.473	0.0	0.1	0.0
0.460	0.434	0.447	0.0	0.0	0.0

Sample: YYS 156A 12-12.75
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-029.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 2:00:22PM
Reported: 3/08/2010 11:36:52AM
Background: 30/07/2010 1:30:14PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
0.434	0.410	0.422	0.0	0.0	0.0

Sample: YYS 156A 12-12.75
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-029.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 2:00:22PM
Reported: 3/08/2010 11:36:52AM
Background: 30/07/2010 1:30:14PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Table

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
80.000	98.3	20.000	74.3	6.000	42.1	1.000	4.4
60.000	91.1	10.000	55.4	4.000	31.7	0.500	0.1
40.000	84.2	8.000	49.4	2.000	14.7		

Sample: YYS 156A 12-12.75
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-029.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 2:00:22PM
Reported: 3/08/2010 11:36:52AM
Background: 30/07/2010 1:30:14PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

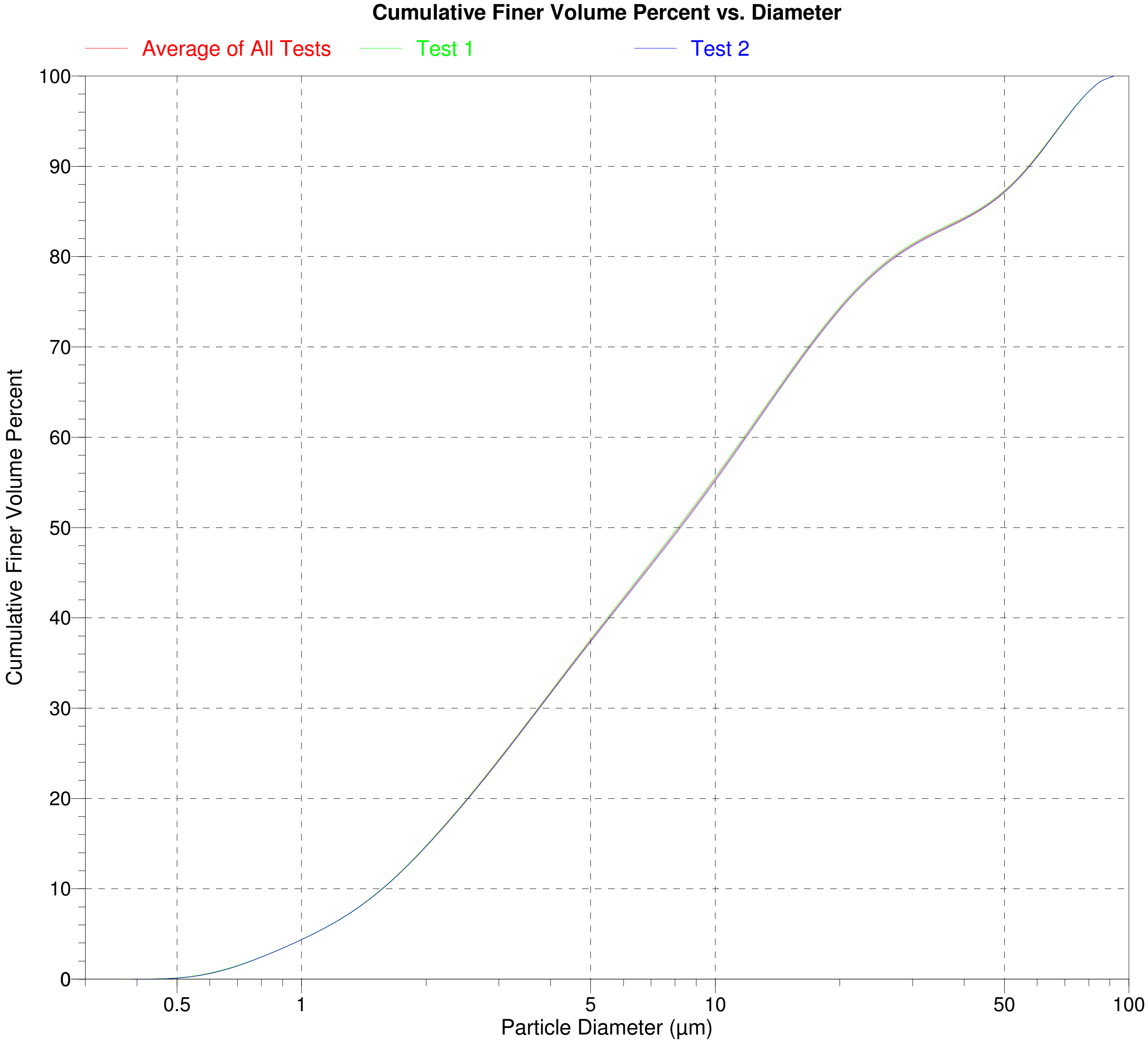
Report by Volume Percent

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
92.006	100.0	16.849	70.0	5.514	40.0	1.567	10.0
69.602	95.0	14.053	65.0	4.534	35.0	1.067	5.0
57.326	90.0	11.788	60.0	3.743	30.0	0.399	0.0
42.850	85.0	9.855	55.0	3.087	25.0		
27.134	80.0	8.174	50.0	2.522	20.0		
20.656	75.0	6.724	45.0	2.026	15.0		

Sample: YYS 156A 12-12.75
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-029.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 2:00:22PM
Reported: 3/08/2010 11:36:52AM
Background: 30/07/2010 1:30:14PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium



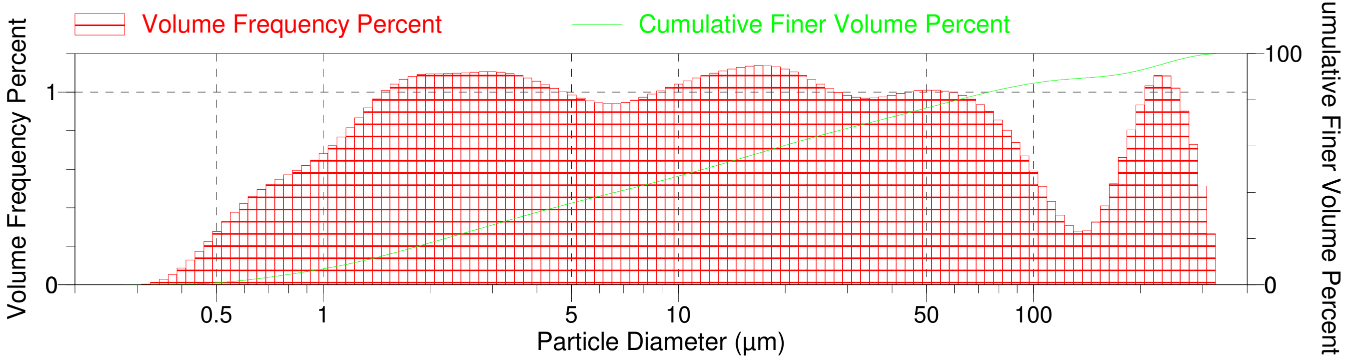
Sample: YYS 156A 11.25-12
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-030.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 3:13:08PM
Reported: 3/08/2010 11:40:41AM
Background: 30/07/2010 2:25:01PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Combined Report

Volume Frequency vs. Diameter



Summary Report

Analysis Conditions

FlowRate: 12.0 l/m
Circulation time: 120 sec

Ultrasonic intensity: 50 %
Ultrasonic time: 120 sec

Particle Properties

Refractive Index: (Re)0.000, (Im)0.000
Density: 1.000 g/cm^3
Smoothing: Medium
Truncate intensity data: No
Minimum signal fraction: 16.0 %

Analysis Liquid Properties

Refractive Index: 1.331
Viscosity: 0.798 cp
Temperature: 30.095 ℃

User Parameters

Parameter 1: 0.000
Parameter 2: 0.000
Parameter 3: 0.000

Sample

Sample Concentration: 0.00666 %
Obscuration: 23.7 %

Volume Distribution Arithmetic Statistics

		Std Dev of 2			Std Dev of 2
Mean	42.51	0.840	Mode	127.3	156.3
Median	11.78	0.013			

Sample: YYS 156A 11.25-12
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-030.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 3:13:08PM
Reported: 3/08/2010 11:40:41AM
Background: 30/07/2010 2:25:01PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
344.747	325.462	334.965	100.0	0.0	0.0
325.462	307.256	316.228	99.7	0.3	0.0
307.256	290.068	298.538	99.2	0.5	0.1
290.068	273.842	281.838	98.5	0.7	0.2
273.842	258.523	266.073	97.5	0.9	0.3
258.523	244.062	251.189	96.5	1.0	0.3
244.062	230.409	237.137	95.4	1.1	0.4
230.409	217.520	223.872	94.3	1.1	0.5
217.520	205.353	211.349	93.3	1.0	0.5
205.353	193.865	199.526	92.4	0.9	0.5
193.865	183.021	188.365	91.6	0.8	0.5
183.021	172.783	177.828	90.9	0.7	0.5
172.783	163.117	167.880	90.4	0.5	0.4
163.117	153.993	158.489	90.0	0.4	0.4
153.993	145.378	149.624	89.7	0.3	0.3
145.378	137.246	141.254	89.4	0.3	0.3
137.246	129.569	133.352	89.1	0.3	0.2
129.569	122.321	125.893	88.8	0.3	0.2
122.321	115.478	118.850	88.5	0.4	0.2
115.478	109.018	112.202	88.0	0.4	0.2
109.018	102.920	105.925	87.5	0.5	0.3
102.920	97.163	100.000	86.9	0.6	0.3
97.163	91.728	94.406	86.2	0.7	0.3
91.728	86.596	89.125	85.5	0.7	0.3
86.596	81.752	84.140	84.7	0.8	0.3
81.752	77.179	79.433	83.8	0.9	0.3
77.179	72.862	74.989	82.9	0.9	0.3
72.862	68.786	70.795	82.0	0.9	0.3
68.786	64.938	66.834	81.0	1.0	0.3
64.938	61.306	63.096	80.0	1.0	0.3
61.306	57.876	59.566	79.0	1.0	0.3
57.876	54.639	56.234	78.0	1.0	0.2
54.639	51.582	53.088	77.0	1.0	0.2
51.582	48.697	50.119	76.0	1.0	0.2
48.697	45.973	47.315	75.0	1.0	0.2
45.973	43.401	44.668	74.0	1.0	0.1
43.401	40.973	42.170	73.0	1.0	0.1
40.973	38.681	39.811	72.0	1.0	0.1
38.681	36.517	37.584	71.1	1.0	0.1
36.517	34.475	35.481	70.1	1.0	0.1
34.475	32.546	33.497	69.1	1.0	0.1
32.546	30.726	31.623	68.1	1.0	0.1
30.726	29.007	29.854	67.2	1.0	0.0
29.007	27.384	28.184	66.2	1.0	0.0
27.384	25.852	26.607	65.1	1.0	0.0
25.852	24.406	25.119	64.1	1.0	0.0
24.406	23.041	23.714	63.0	1.1	0.0

Sample: YYS 156A 11.25-12
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-030.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 3:13:08PM
Reported: 3/08/2010 11:40:41AM
Background: 30/07/2010 2:25:01PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
23.041	21.752	22.387	61.9	1.1	0.0
21.752	20.535	21.135	60.8	1.1	0.0
20.535	19.387	19.953	59.7	1.1	0.0
19.387	18.302	18.836	58.6	1.1	0.0
18.302	17.278	17.783	57.4	1.1	0.0
17.278	16.312	16.788	56.3	1.1	0.0
16.312	15.399	15.849	55.2	1.1	0.0
15.399	14.538	14.962	54.0	1.1	0.0
14.538	13.725	14.125	52.9	1.1	0.0
13.725	12.957	13.335	51.8	1.1	0.0
12.957	12.232	12.589	50.7	1.1	0.0
12.232	11.548	11.885	49.6	1.1	0.0
11.548	10.902	11.220	48.6	1.1	0.0
10.902	10.292	10.593	47.5	1.1	0.0
10.292	9.716	10.000	46.5	1.0	0.1
9.716	9.173	9.441	45.4	1.0	0.1
9.173	8.660	8.913	44.4	1.0	0.1
8.660	8.175	8.414	43.4	1.0	0.1
8.175	7.718	7.943	42.5	1.0	0.1
7.718	7.286	7.499	41.5	1.0	0.1
7.286	6.879	7.079	40.6	0.9	0.1
6.879	6.494	6.683	39.6	0.9	0.1
6.494	6.131	6.310	38.7	0.9	0.1
6.131	5.788	5.957	37.7	0.9	0.2
5.788	5.464	5.623	36.8	1.0	0.2
5.464	5.158	5.309	35.8	1.0	0.2
5.158	4.870	5.012	34.8	1.0	0.2
4.870	4.597	4.732	33.8	1.0	0.2
4.597	4.340	4.467	32.8	1.0	0.2
4.340	4.097	4.217	31.8	1.0	0.2
4.097	3.868	3.981	30.7	1.1	0.2
3.868	3.652	3.758	29.6	1.1	0.2
3.652	3.447	3.548	28.5	1.1	0.2
3.447	3.255	3.350	27.4	1.1	0.2
3.255	3.073	3.162	26.3	1.1	0.2
3.073	2.901	2.985	25.2	1.1	0.2
2.901	2.738	2.818	24.1	1.1	0.2
2.738	2.585	2.661	23.0	1.1	0.2
2.585	2.441	2.512	21.9	1.1	0.2
2.441	2.304	2.371	20.8	1.1	0.1
2.304	2.175	2.239	19.7	1.1	0.1
2.175	2.054	2.113	18.6	1.1	0.1
2.054	1.939	1.995	17.5	1.1	0.1
1.939	1.830	1.884	16.4	1.1	0.1
1.830	1.728	1.778	15.4	1.1	0.1
1.728	1.631	1.679	14.3	1.1	0.1
1.631	1.540	1.585	13.3	1.0	0.0

Sample: YYS 156A 11.25-12
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-030.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 3:13:08PM
Reported: 3/08/2010 11:40:41AM
Background: 30/07/2010 2:25:01PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
1.540	1.454	1.496	12.3	1.0	0.0
1.454	1.372	1.413	11.3	1.0	0.0
1.372	1.296	1.334	10.4	0.9	0.0
1.296	1.223	1.259	9.5	0.9	0.0
1.223	1.155	1.189	8.7	0.8	0.0
1.155	1.090	1.122	7.9	0.8	0.0
1.090	1.029	1.059	7.2	0.7	0.0
1.029	0.972	1.000	6.5	0.7	0.0
0.972	0.917	0.944	5.9	0.6	0.0
0.917	0.866	0.891	5.3	0.6	0.0
0.866	0.818	0.841	4.7	0.6	0.0
0.818	0.772	0.794	4.1	0.6	0.0
0.772	0.729	0.750	3.6	0.5	0.0
0.729	0.688	0.708	3.0	0.5	0.0
0.688	0.649	0.668	2.5	0.5	0.0
0.649	0.613	0.631	2.1	0.5	0.0
0.613	0.579	0.596	1.7	0.4	0.0
0.579	0.546	0.562	1.3	0.4	0.0
0.546	0.516	0.531	1.0	0.3	0.0
0.516	0.487	0.501	0.7	0.3	0.0
0.487	0.460	0.473	0.5	0.2	0.0
0.460	0.434	0.447	0.3	0.2	0.0
0.434	0.410	0.422	0.2	0.1	0.0
0.410	0.387	0.398	0.1	0.1	0.0
0.387	0.365	0.376	0.0	0.1	0.0
0.365	0.345	0.355	0.0	0.0	0.0
0.345	0.325	0.335	0.0	0.0	0.0
0.325	0.307	0.316	0.0	0.0	0.0
0.307	0.290	0.299	0.0	0.0	0.0

Sample: YYS 156A 11.25-12
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-030.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 3:13:08PM
Reported: 3/08/2010 11:40:41AM
Background: 30/07/2010 2:25:01PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Table

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
300.000	99.5	100.000	87.2	20.000	60.3	4.000	31.3
250.000	97.0	80.000	84.4	10.000	47.0	2.000	18.1
200.000	92.9	60.000	79.7	8.000	43.1	1.000	6.9
150.000	89.9	40.000	72.6	6.000	38.3	0.500	0.8

Sample: YYS 156A 11.25-12
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-030.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 3:13:08PM
Reported: 3/08/2010 11:40:41AM
Background: 30/07/2010 2:25:01PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

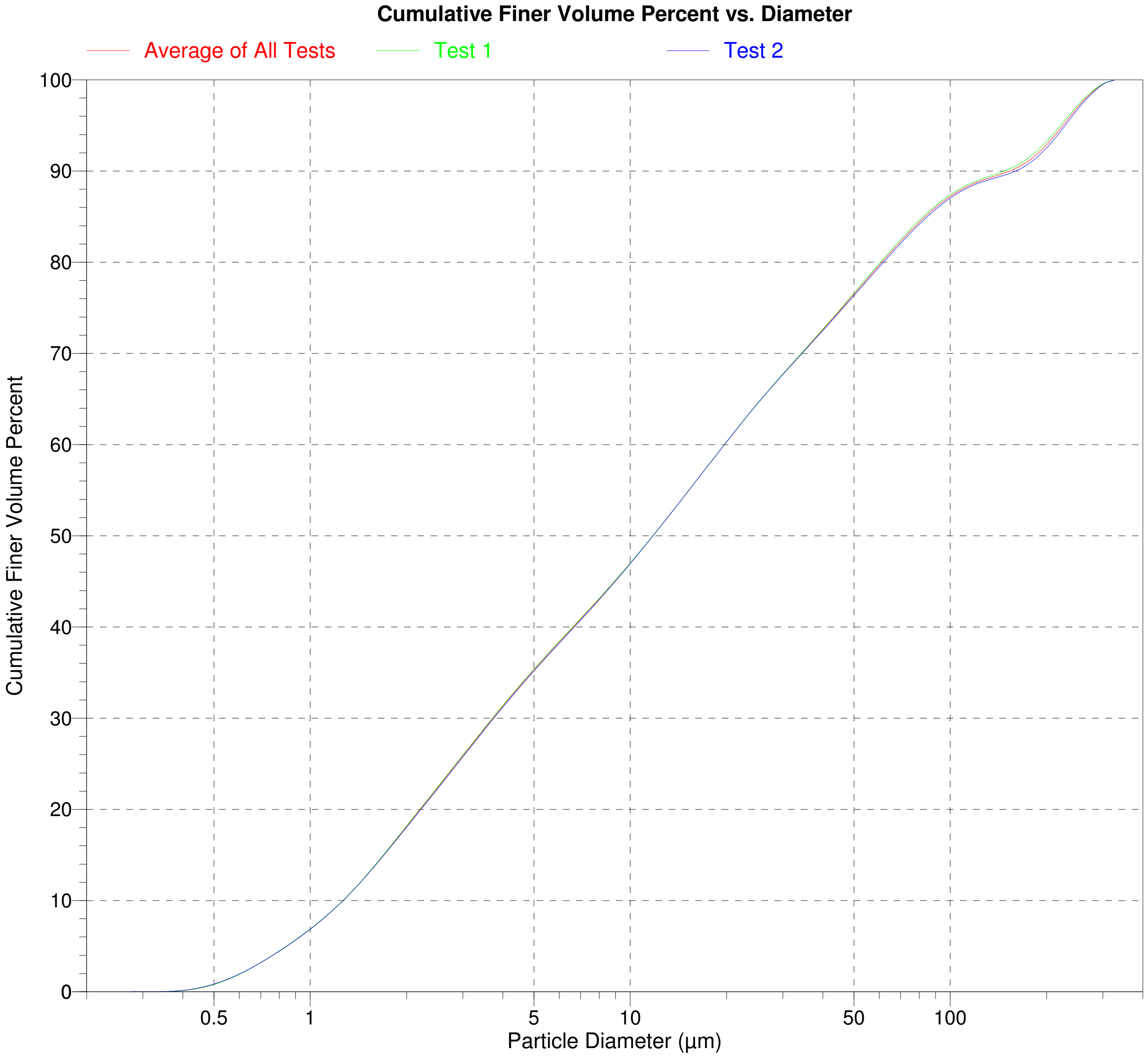
Report by Volume Percent

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
326.451	100.0	34.303	70.0	6.646	40.0	1.264	10.0
225.135	95.0	25.656	65.0	4.919	35.0	0.844	5.0
153.907	90.0	19.673	60.0	3.725	30.0	0.300	0.0
83.570	85.0	15.265	55.0	2.866	25.0		
61.173	80.0	11.778	50.0	2.207	20.0		
45.957	75.0	8.948	45.0	1.694	15.0		

Sample: YYS 156A 11.25-12
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-030.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 3:13:08PM
Reported: 3/08/2010 11:40:41AM
Background: 30/07/2010 2:25:01PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium



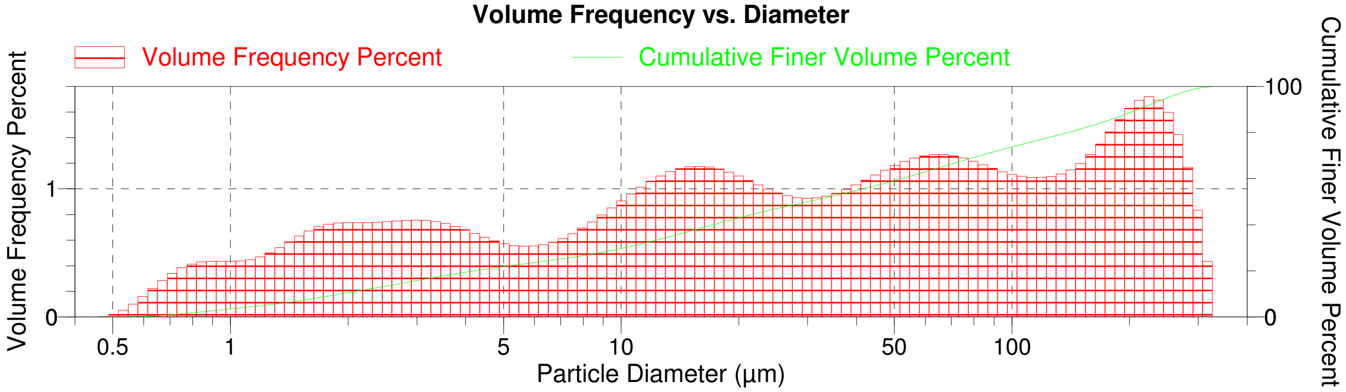
Sample: YYS 156A 1.5-2.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-031.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:05:26PM
Reported: 3/08/2010 12:05:27PM
Background: 30/07/2010 3:34:03PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Combined Report

Volume Frequency vs. Diameter



Summary Report

Analysis Conditions

FlowRate: 12.0 l/m
Circulation time: 120 sec

Ultrasonic intensity: 50 %
Ultrasonic time: 120 sec

Particle Properties

Refractive Index: (Re)0.000, (Im)0.000
Density: 1.000 g/cm^3
Smoothing: Medium
Truncate intensity data: No
Minimum signal fraction: 16.0 %

Analysis Liquid Properties

Refractive Index: 1.331
Viscosity: 0.798 cp
Temperature: 29.420 ℃

User Parameters

Parameter 1: 0.000 Parameter 2: 0.000 Parameter 3: 0.000

Sample

Sample Concentration: 0.00542 %
Obscuration: 12.3 %

Volume Distribution Arithmetic Statistics

		Std Dev of 2			Std Dev of 2
Mean	69.00	1.049	Mode	224.6	0.000
Median	30.02	1.344			

Sample: YYS 156A 1.5-2.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-031.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:05:26PM
Reported: 3/08/2010 12:05:27PM
Background: 30/07/2010 3:34:03PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
344.747	325.462	334.965	100.0	0.0	0.0
325.462	307.256	316.228	99.5	0.5	0.0
307.256	290.068	298.538	98.7	0.9	0.0
290.068	273.842	281.838	97.5	1.2	0.0
273.842	258.523	266.073	96.1	1.4	0.1
258.523	244.062	251.189	94.4	1.6	0.1
244.062	230.409	237.137	92.8	1.7	0.1
230.409	217.520	223.872	91.0	1.7	0.1
217.520	205.353	211.349	89.3	1.7	0.2
205.353	193.865	199.526	87.7	1.6	0.2
193.865	183.021	188.365	86.2	1.5	0.2
183.021	172.783	177.828	84.7	1.4	0.2
172.783	163.117	167.880	83.4	1.3	0.2
163.117	153.993	158.489	82.1	1.3	0.2
153.993	145.378	149.624	80.9	1.2	0.3
145.378	137.246	141.254	79.8	1.1	0.3
137.246	129.569	133.352	78.7	1.1	0.4
129.569	122.321	125.893	77.6	1.1	0.4
122.321	115.478	118.850	76.5	1.1	0.5
115.478	109.018	112.202	75.4	1.1	0.6
109.018	102.920	105.925	74.3	1.1	0.7
102.920	97.163	100.000	73.2	1.1	0.7
97.163	91.728	94.406	72.1	1.1	0.8
91.728	86.596	89.125	70.9	1.2	0.8
86.596	81.752	84.140	69.7	1.2	0.8
81.752	77.179	79.433	68.5	1.2	0.8
77.179	72.862	74.989	67.2	1.2	0.8
72.862	68.786	70.795	66.0	1.3	0.8
68.786	64.938	66.834	64.7	1.3	0.7
64.938	61.306	63.096	63.4	1.3	0.7
61.306	57.876	59.566	62.2	1.3	0.7
57.876	54.639	56.234	60.9	1.2	0.6
54.639	51.582	53.088	59.7	1.2	0.6
51.582	48.697	50.119	58.6	1.2	0.6
48.697	45.973	47.315	57.4	1.1	0.6
45.973	43.401	44.668	56.3	1.1	0.7
43.401	40.973	42.170	55.2	1.1	0.7
40.973	38.681	39.811	54.2	1.0	0.7
38.681	36.517	37.584	53.2	1.0	0.7
36.517	34.475	35.481	52.3	1.0	0.7
34.475	32.546	33.497	51.3	0.9	0.7
32.546	30.726	31.623	50.4	0.9	0.7
30.726	29.007	29.854	49.5	0.9	0.7
29.007	27.384	28.184	48.5	0.9	0.7
27.384	25.852	26.607	47.6	0.9	0.7
25.852	24.406	25.119	46.6	1.0	0.7
24.406	23.041	23.714	45.6	1.0	0.7

Sample: YYS 156A 1.5-2.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-031.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:05:26PM
Reported: 3/08/2010 12:05:27PM
Background: 30/07/2010 3:34:03PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
23.041	21.752	22.387	44.6	1.0	0.7
21.752	20.535	21.135	43.5	1.1	0.7
20.535	19.387	19.953	42.4	1.1	0.6
19.387	18.302	18.836	41.3	1.1	0.6
18.302	17.278	17.783	40.1	1.2	0.6
17.278	16.312	16.788	38.9	1.2	0.6
16.312	15.399	15.849	37.8	1.2	0.5
15.399	14.538	14.962	36.6	1.2	0.5
14.538	13.725	14.125	35.4	1.2	0.5
13.725	12.957	13.335	34.3	1.1	0.4
12.957	12.232	12.589	33.2	1.1	0.4
12.232	11.548	11.885	32.1	1.1	0.4
11.548	10.902	11.220	31.1	1.0	0.3
10.902	10.292	10.593	30.2	1.0	0.3
10.292	9.716	10.000	29.3	0.9	0.3
9.716	9.173	9.441	28.4	0.8	0.2
9.173	8.660	8.913	27.6	0.8	0.2
8.660	8.175	8.414	26.9	0.7	0.2
8.175	7.718	7.943	26.2	0.7	0.2
7.718	7.286	7.499	25.6	0.6	0.2
7.286	6.879	7.079	24.9	0.6	0.2
6.879	6.494	6.683	24.4	0.6	0.2
6.494	6.131	6.310	23.8	0.6	0.2
6.131	5.788	5.957	23.2	0.6	0.2
5.788	5.464	5.623	22.7	0.6	0.2
5.464	5.158	5.309	22.1	0.6	0.2
5.158	4.870	5.012	21.6	0.6	0.2
4.870	4.597	4.732	21.0	0.6	0.2
4.597	4.340	4.467	20.3	0.6	0.2
4.340	4.097	4.217	19.7	0.7	0.2
4.097	3.868	3.981	19.0	0.7	0.2
3.868	3.652	3.758	18.3	0.7	0.2
3.652	3.447	3.548	17.6	0.7	0.2
3.447	3.255	3.350	16.8	0.7	0.2
3.255	3.073	3.162	16.1	0.8	0.2
3.073	2.901	2.985	15.3	0.8	0.2
2.901	2.738	2.818	14.6	0.8	0.2
2.738	2.585	2.661	13.8	0.7	0.1
2.585	2.441	2.512	13.1	0.7	0.1
2.441	2.304	2.371	12.3	0.7	0.1
2.304	2.175	2.239	11.6	0.7	0.1
2.175	2.054	2.113	10.9	0.7	0.1
2.054	1.939	1.995	10.1	0.7	0.1
1.939	1.830	1.884	9.4	0.7	0.1
1.830	1.728	1.778	8.7	0.7	0.1
1.728	1.631	1.679	8.0	0.7	0.1
1.631	1.540	1.585	7.3	0.7	0.1

Sample: YYS 156A 1.5-2.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-031.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:05:26PM
Reported: 3/08/2010 12:05:27PM
Background: 30/07/2010 3:34:03PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
1.540	1.454	1.496	6.7	0.6	0.1
1.454	1.372	1.413	6.1	0.6	0.1
1.372	1.296	1.334	5.5	0.5	0.1
1.296	1.223	1.259	5.0	0.5	0.1
1.223	1.155	1.189	4.6	0.5	0.1
1.155	1.090	1.122	4.1	0.4	0.1
1.090	1.029	1.059	3.7	0.4	0.1
1.029	0.972	1.000	3.3	0.4	0.1
0.972	0.917	0.944	2.8	0.4	0.0
0.917	0.866	0.891	2.4	0.4	0.0
0.866	0.818	0.841	2.0	0.4	0.0
0.818	0.772	0.794	1.5	0.4	0.0
0.772	0.729	0.750	1.2	0.4	0.0
0.729	0.688	0.708	0.8	0.3	0.0
0.688	0.649	0.668	0.5	0.3	0.0
0.649	0.613	0.631	0.3	0.2	0.0
0.613	0.579	0.596	0.2	0.2	0.0
0.579	0.546	0.562	0.1	0.1	0.0
0.546	0.516	0.531	0.0	0.0	0.0
0.516	0.487	0.501	0.0	0.0	0.0
0.487	0.460	0.473	0.0	0.0	0.0

Sample: YYS 156A 1.5-2.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-031.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:05:26PM
Reported: 3/08/2010 12:05:27PM
Background: 30/07/2010 3:34:03PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Table

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
300.000	99.2	100.000	73.7	20.000	43.0	4.000	19.4
250.000	95.1	80.000	69.2	10.000	29.7	2.000	10.5
200.000	88.6	60.000	63.0	8.000	26.6	1.000	3.5
150.000	81.6	40.000	54.8	6.000	23.6	0.500	0.0

Sample: YYS 156A 1.5-2.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-031.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:05:26PM
Reported: 3/08/2010 12:05:27PM
Background: 30/07/2010 3:34:03PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

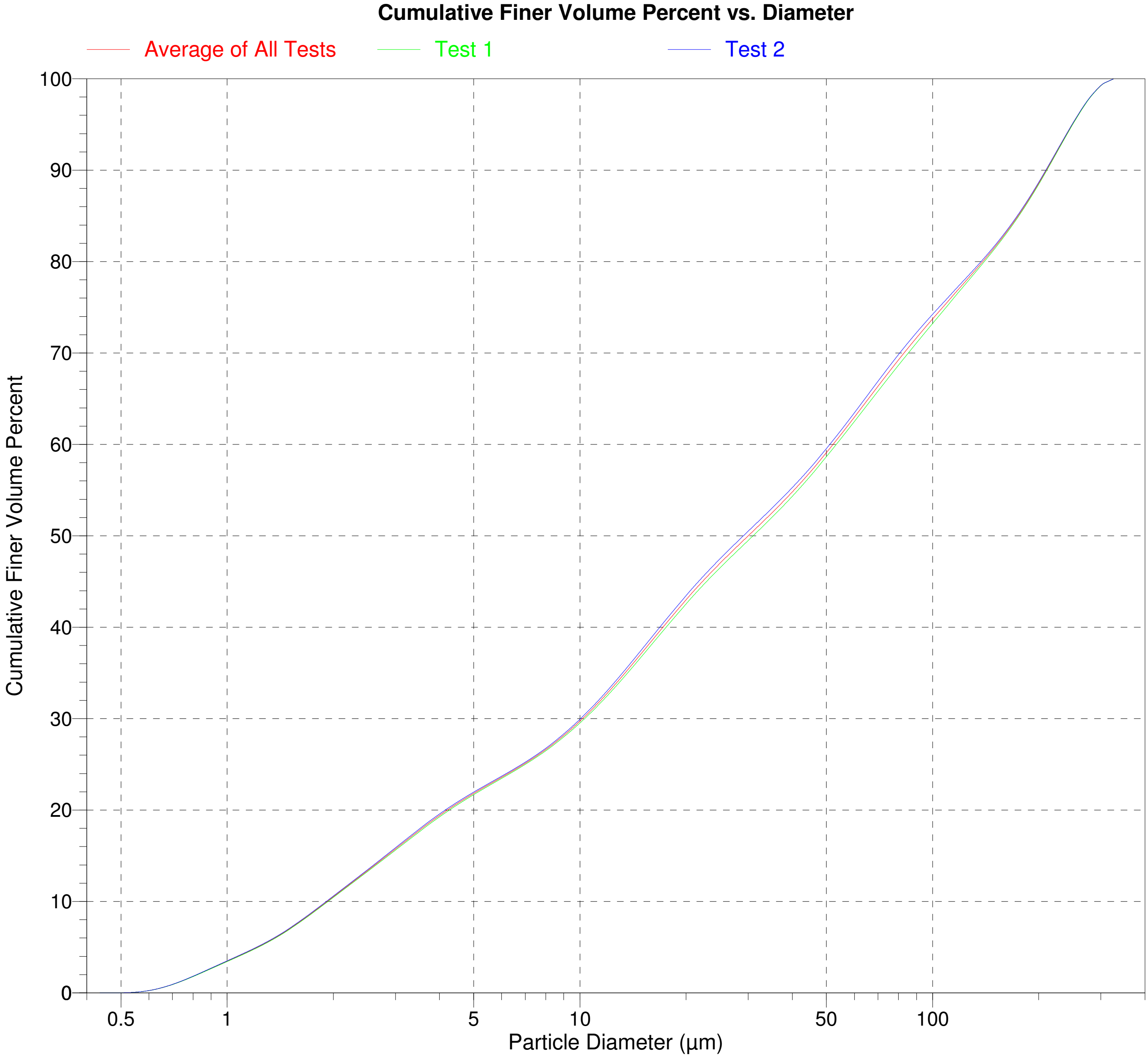
Report by Volume Percent

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
326.451	100.0	82.976	70.0	17.190	40.0	1.921	10.0
248.774	95.0	65.840	65.0	13.432	35.0	1.218	5.0
210.004	90.0	52.248	60.0	10.184	30.0	0.461	0.0
174.632	85.0	40.423	55.0	6.918	25.0		
138.697	80.0	30.019	50.0	4.211	20.0		
106.657	75.0	22.286	45.0	2.833	15.0		

Sample: YYS 156A 1.5-2.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-031.SMP

Test Number: Avg of 2
Analyzed: 30/07/2010 4:05:26PM
Reported: 3/08/2010 12:05:27PM
Background: 30/07/2010 3:34:03PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium



PSS™ Particle & Surface Sciences Pty. Limited
PO Box 1926, Gosford, NSW, Australia 2250. Tel: (61) 02 43 237822 Fax: (61) 02 43 237629 Email: info@pss.aus.net

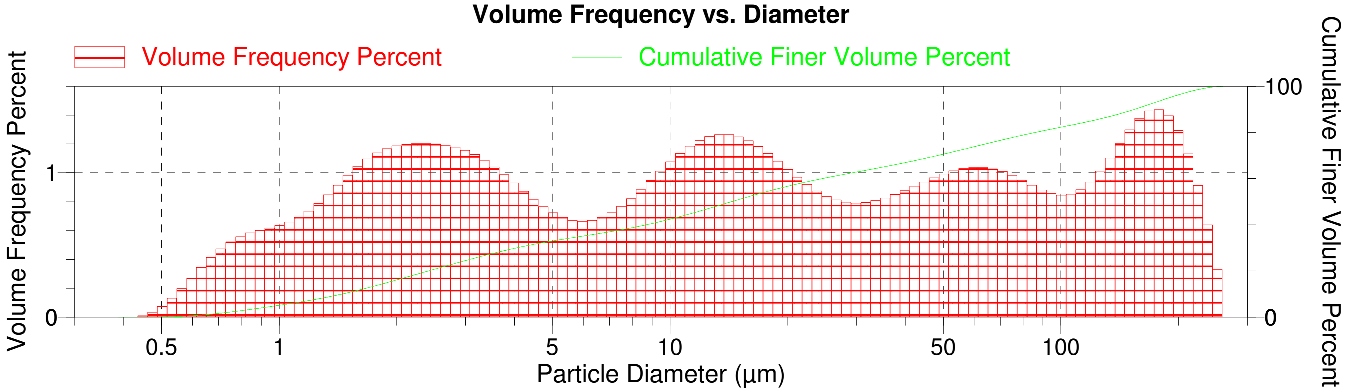
Sample: YYS 156A 0.7-1.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-026.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 2:22:30PM
Reported: 3/08/2010 11:35:10AM
Background: 29/07/2010 1:50:13PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Combined Report

Volume Frequency vs. Diameter



Summary Report

Analysis Conditions

FlowRate: 12.0 l/m
Circulation time: 120 sec

Ultrasonic intensity: 50 %
Ultrasonic time: 120 sec

Particle Properties

Refractive Index: (Re)0.000, (Im)0.000
Density: 1.000 g/cm^3
Smoothing: Medium
Truncate intensity data: No
Minimum signal fraction: 16.0 %

Analysis Liquid Properties

Refractive Index: 1.331
Viscosity: 0.798 cp
Temperature: 27.100 ℃

User Parameters

Parameter 1: 0.000
Parameter 2: 0.000
Parameter 3: 0.000

Sample

Sample Concentration: 0.00413 %
Obscuration: 13.4 %

Volume Distribution Arithmetic Statistics

		Std Dev of 2			Std Dev of 2
Mean	45.48	1.028	Mode	178.4	0.000
Median	14.36	0.280			

Peaks

Peak Number	% of Dist.*	% of Dist. Std Dev of 2	Mean	Mean Std Dev of 2	Median	Median Std Dev of 2	Mode
1	35.4	0.2	2.462	0.029	2.161	0.016	2.312
2	27.8	0.3	15.22	0.164	13.92	0.222	13.77
3	19.5	0.8	60.20	0.407	57.31	0.649	61.52
4	17.2	0.8	166.0	1.254	163.2	1.635	178.4

* Peaks must comprise at least 5.00 % of the distribution.

Sample: YYS 156A 0.7-1.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-026.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 2:22:30PM
Reported: 3/08/2010 11:35:10AM
Background: 29/07/2010 1:50:13PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
273.842	258.523	266.073	100.0	0.0	0.0
258.523	244.062	251.189	99.6	0.4	0.0
244.062	230.409	237.137	99.0	0.7	0.1
230.409	217.520	223.872	98.1	0.9	0.2
217.520	205.353	211.349	96.9	1.1	0.3
205.353	193.865	199.526	95.6	1.3	0.4
193.865	183.021	188.365	94.2	1.4	0.5
183.021	172.783	177.828	92.8	1.4	0.6
172.783	163.117	167.880	91.4	1.4	0.6
163.117	153.993	158.489	90.0	1.4	0.7
153.993	145.378	149.624	88.7	1.3	0.8
145.378	137.246	141.254	87.5	1.2	0.8
137.246	129.569	133.352	86.4	1.1	0.8
129.569	122.321	125.893	85.4	1.0	0.8
122.321	115.478	118.850	84.5	0.9	0.8
115.478	109.018	112.202	83.6	0.9	0.8
109.018	102.920	105.925	82.7	0.9	0.8
102.920	97.163	100.000	81.9	0.8	0.8
97.163	91.728	94.406	81.0	0.9	0.7
91.728	86.596	89.125	80.1	0.9	0.7
86.596	81.752	84.140	79.2	0.9	0.6
81.752	77.179	79.433	78.3	1.0	0.5
77.179	72.862	74.989	77.3	1.0	0.5
72.862	68.786	70.795	76.3	1.0	0.4
68.786	64.938	66.834	75.2	1.0	0.3
64.938	61.306	63.096	74.2	1.0	0.3
61.306	57.876	59.566	73.2	1.0	0.2
57.876	54.639	56.234	72.1	1.0	0.1
54.639	51.582	53.088	71.1	1.0	0.1
51.582	48.697	50.119	70.1	1.0	0.0
48.697	45.973	47.315	69.2	1.0	0.0
45.973	43.401	44.668	68.2	0.9	0.0
43.401	40.973	42.170	67.3	0.9	0.0
40.973	38.681	39.811	66.5	0.9	0.1
38.681	36.517	37.584	65.6	0.8	0.1
36.517	34.475	35.481	64.8	0.8	0.0
34.475	32.546	33.497	64.0	0.8	0.0
32.546	30.726	31.623	63.2	0.8	0.0
30.726	29.007	29.854	62.4	0.8	0.0
29.007	27.384	28.184	61.6	0.8	0.0
27.384	25.852	26.607	60.8	0.8	0.0
25.852	24.406	25.119	59.9	0.8	0.1
24.406	23.041	23.714	59.1	0.9	0.1
23.041	21.752	22.387	58.1	0.9	0.1
21.752	20.535	21.135	57.2	1.0	0.1
20.535	19.387	19.953	56.1	1.0	0.2
19.387	18.302	18.836	55.1	1.1	0.2

Sample: YYS 156A 0.7-1.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-026.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 2:22:30PM
Reported: 3/08/2010 11:35:10AM
Background: 29/07/2010 1:50:13PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
18.302	17.278	17.783	53.9	1.1	0.3
17.278	16.312	16.788	52.7	1.2	0.3
16.312	15.399	15.849	51.5	1.2	0.4
15.399	14.538	14.962	50.3	1.3	0.4
14.538	13.725	14.125	49.0	1.3	0.5
13.725	12.957	13.335	47.7	1.3	0.5
12.957	12.232	12.589	46.5	1.3	0.5
12.232	11.548	11.885	45.3	1.2	0.6
11.548	10.902	11.220	44.1	1.2	0.6
10.902	10.292	10.593	42.9	1.1	0.6
10.292	9.716	10.000	41.9	1.1	0.6
9.716	9.173	9.441	40.9	1.0	0.6
9.173	8.660	8.913	39.9	0.9	0.6
8.660	8.175	8.414	39.0	0.9	0.5
8.175	7.718	7.943	38.2	0.8	0.5
7.718	7.286	7.499	37.5	0.8	0.4
7.286	6.879	7.079	36.7	0.7	0.4
6.879	6.494	6.683	36.0	0.7	0.3
6.494	6.131	6.310	35.4	0.7	0.2
6.131	5.788	5.957	34.7	0.7	0.2
5.788	5.464	5.623	34.0	0.7	0.1
5.464	5.158	5.309	33.4	0.7	0.0
5.158	4.870	5.012	32.6	0.7	0.0
4.870	4.597	4.732	31.9	0.8	0.1
4.597	4.340	4.467	31.0	0.8	0.1
4.340	4.097	4.217	30.2	0.9	0.1
4.097	3.868	3.981	29.2	0.9	0.2
3.868	3.652	3.758	28.2	1.0	0.2
3.652	3.447	3.548	27.2	1.0	0.2
3.447	3.255	3.350	26.1	1.1	0.2
3.255	3.073	3.162	25.0	1.1	0.2
3.073	2.901	2.985	23.8	1.2	0.1
2.901	2.738	2.818	22.6	1.2	0.1
2.738	2.585	2.661	21.5	1.2	0.1
2.585	2.441	2.512	20.3	1.2	0.1
2.441	2.304	2.371	19.0	1.2	0.1
2.304	2.175	2.239	17.8	1.2	0.0
2.175	2.054	2.113	16.6	1.2	0.0
2.054	1.939	1.995	15.5	1.2	0.0
1.939	1.830	1.884	14.3	1.2	0.0
1.830	1.728	1.778	13.2	1.1	0.0
1.728	1.631	1.679	12.1	1.1	0.0
1.631	1.540	1.585	11.0	1.0	0.0
1.540	1.454	1.496	10.0	1.0	0.0
1.454	1.372	1.413	9.1	0.9	0.0
1.372	1.296	1.334	8.3	0.8	0.0
1.296	1.223	1.259	7.5	0.8	0.0

Sample: YYS 156A 0.7-1.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-026.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 2:22:30PM
Reported: 3/08/2010 11:35:10AM
Background: 29/07/2010 1:50:13PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
1.223	1.155	1.189	6.8	0.7	0.0
1.155	1.090	1.122	6.1	0.7	0.0
1.090	1.029	1.059	5.4	0.7	0.0
1.029	0.972	1.000	4.8	0.6	0.0
0.972	0.917	0.944	4.2	0.6	0.0
0.917	0.866	0.891	3.6	0.6	0.0
0.866	0.818	0.841	3.0	0.6	0.0
0.818	0.772	0.794	2.4	0.6	0.0
0.772	0.729	0.750	1.9	0.5	0.0
0.729	0.688	0.708	1.4	0.5	0.0
0.688	0.649	0.668	1.0	0.4	0.0
0.649	0.613	0.631	0.7	0.3	0.0
0.613	0.579	0.596	0.4	0.3	0.0
0.579	0.546	0.562	0.2	0.2	0.0
0.546	0.516	0.531	0.1	0.1	0.0
0.516	0.487	0.501	0.0	0.1	0.0
0.487	0.460	0.473	0.0	0.0	0.0
0.460	0.434	0.447	0.0	0.0	0.0

Sample: YYS 156A 0.7-1.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-026.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 2:22:30PM
Reported: 3/08/2010 11:35:10AM
Background: 29/07/2010 1:50:13PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Table

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
250.000	99.8	80.000	78.9	10.000	42.4	2.000	16.1
200.000	96.3	60.000	73.8	8.000	38.7	1.000	5.1
150.000	89.4	40.000	67.0	6.000	35.1	0.500	0.1
100.000	82.3	20.000	56.7	4.000	29.8		

Sample: YYS 156A 0.7-1.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-026.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 2:22:30PM
Reported: 3/08/2010 11:35:10AM
Background: 29/07/2010 1:50:13PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

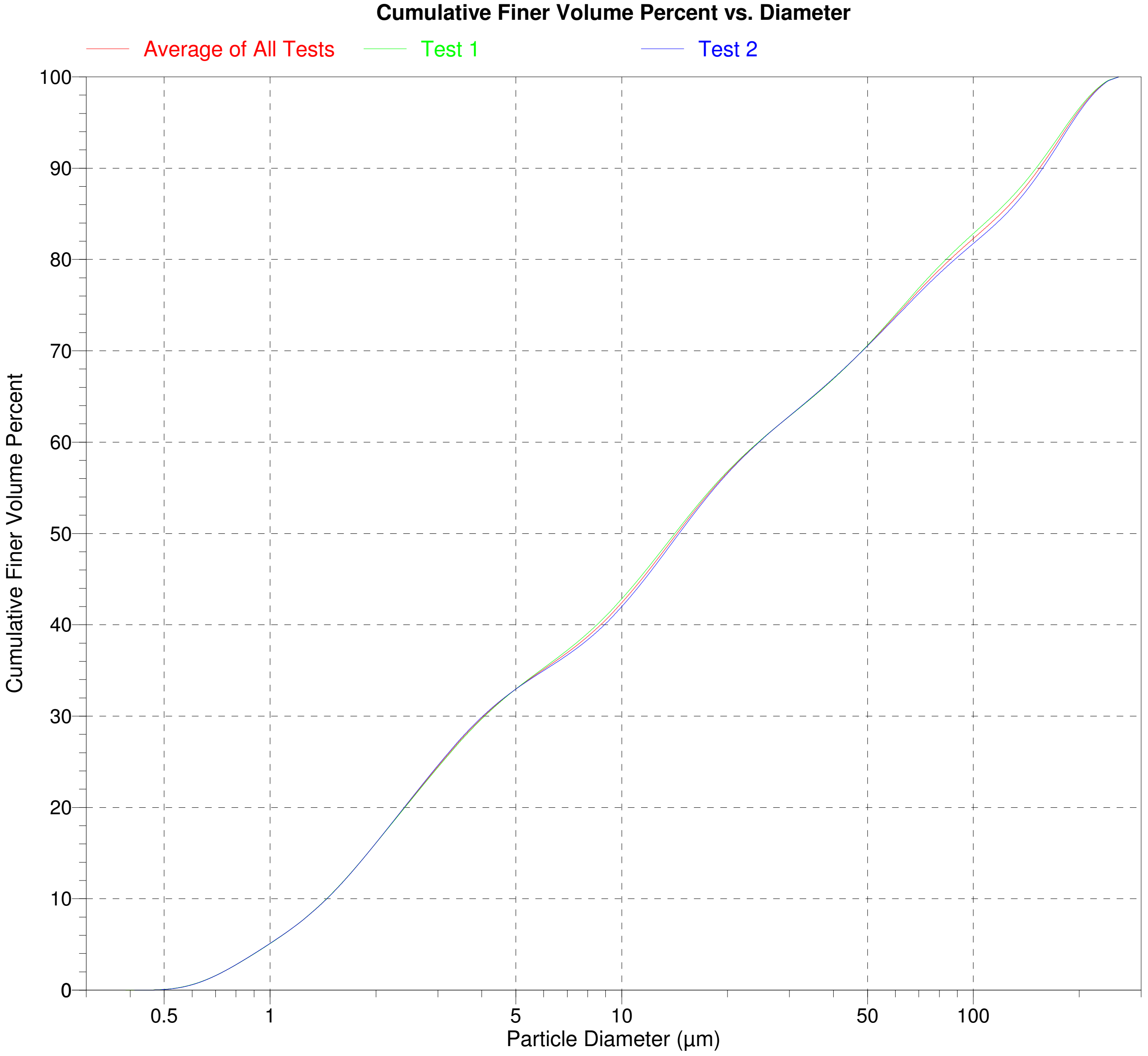
Report by Volume Percent

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
259.309	100.0	48.318	70.0	8.707	40.0	1.450	10.0
188.830	95.0	35.018	65.0	5.937	35.0	0.990	5.0
153.987	90.0	24.506	60.0	4.054	30.0	0.423	0.0
119.506	85.0	18.242	55.0	3.076	25.0		
86.042	80.0	14.360	50.0	2.412	20.0		
64.128	75.0	11.402	45.0	1.895	15.0		

Sample: YYS 156A 0.7-1.5
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-026.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 2:22:30PM
Reported: 3/08/2010 11:35:10AM
Background: 29/07/2010 1:50:13PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium



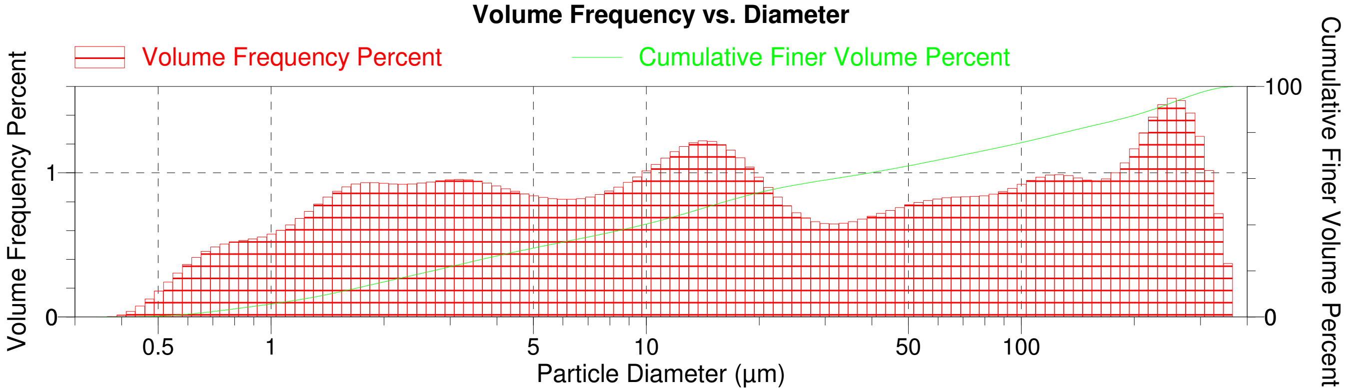
Sample: YC3 Tails
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-025.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 1:09:13PM
Reported: 3/08/2010 11:31:10AM
Background: 29/07/2010 12:36:48PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Combined Report

Volume Frequency vs. Diameter



Summary Report

Analysis Conditions

FlowRate: 12.0 l/m
Circulation time: 120 sec

Ultrasonic intensity: 50 %
Ultrasonic time: 120 sec

Particle Properties

Refractive Index: (Re)0.000, (Im)0.000
Density: 1.000 g/cm³
Smoothing: Medium
Truncate intensity data: No
Minimum signal fraction: 16.0 %

Analysis Liquid Properties

Refractive Index: 1.331
Viscosity: 0.798 cp
Temperature: 26.045 ℃

User Parameters

Parameter 1: 0.000
Parameter 2: 0.000
Parameter 3: 0.000

Sample

Sample Concentration: 0.00825 %
Obscuration: 24.4 %

Volume Distribution Arithmetic Statistics

		Std Dev of 2			Std Dev of 2
Mean	64.73	1.512	Mode	252.0	0.000
Median	16.22	0.194			

Sample: YC3 Tails
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-025.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 1:09:13PM
Reported: 3/08/2010 11:31:10AM
Background: 29/07/2010 12:36:48PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
386.812	365.174	375.837	100.0	0.0	0.0
365.174	344.747	354.813	99.6	0.4	0.0
344.747	325.462	334.965	98.9	0.7	0.1
325.462	307.256	316.228	97.8	1.0	0.2
307.256	290.068	298.538	96.6	1.3	0.3
290.068	273.842	281.838	95.1	1.4	0.5
273.842	258.523	266.073	93.6	1.5	0.6
258.523	244.062	251.189	92.1	1.5	0.7
244.062	230.409	237.137	90.7	1.5	0.9
230.409	217.520	223.872	89.3	1.4	1.0
217.520	205.353	211.349	88.0	1.3	1.0
205.353	193.865	199.526	86.8	1.2	1.1
193.865	183.021	188.365	85.8	1.1	1.1
183.021	172.783	177.828	84.8	1.0	1.1
172.783	163.117	167.880	83.8	1.0	1.1
163.117	153.993	158.489	82.9	0.9	1.0
153.993	145.378	149.624	81.9	1.0	0.9
145.378	137.246	141.254	81.0	1.0	0.8
137.246	129.569	133.352	80.0	1.0	0.7
129.569	122.321	125.893	79.0	1.0	0.5
122.321	115.478	118.850	78.0	1.0	0.4
115.478	109.018	112.202	77.0	1.0	0.3
109.018	102.920	105.925	76.1	0.9	0.2
102.920	97.163	100.000	75.2	0.9	0.1
97.163	91.728	94.406	74.3	0.9	0.1
91.728	86.596	89.125	73.4	0.9	0.0
86.596	81.752	84.140	72.6	0.9	0.0
81.752	77.179	79.433	71.7	0.8	0.1
77.179	72.862	74.989	70.9	0.8	0.1
72.862	68.786	70.795	70.1	0.8	0.2
68.786	64.938	66.834	69.2	0.8	0.2
64.938	61.306	63.096	68.4	0.8	0.2
61.306	57.876	59.566	67.6	0.8	0.2
57.876	54.639	56.234	66.8	0.8	0.2
54.639	51.582	53.088	66.0	0.8	0.3
51.582	48.697	50.119	65.2	0.8	0.2
48.697	45.973	47.315	64.4	0.8	0.2
45.973	43.401	44.668	63.7	0.7	0.2
43.401	40.973	42.170	63.0	0.7	0.2
40.973	38.681	39.811	62.3	0.7	0.1
38.681	36.517	37.584	61.6	0.7	0.1
36.517	34.475	35.481	60.9	0.7	0.0
34.475	32.546	33.497	60.3	0.6	0.0
32.546	30.726	31.623	59.7	0.6	0.0
30.726	29.007	29.854	59.0	0.6	0.0
29.007	27.384	28.184	58.3	0.7	0.0
27.384	25.852	26.607	57.7	0.7	0.1

Sample: YC3 Tails
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-025.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 1:09:13PM
Reported: 3/08/2010 11:31:10AM
Background: 29/07/2010 12:36:48PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
25.852	24.406	25.119	56.9	0.7	0.1
24.406	23.041	23.714	56.2	0.8	0.2
23.041	21.752	22.387	55.3	0.8	0.2
21.752	20.535	21.135	54.4	0.9	0.3
20.535	19.387	19.953	53.4	1.0	0.3
19.387	18.302	18.836	52.4	1.0	0.3
18.302	17.278	17.783	51.3	1.1	0.3
17.278	16.312	16.788	50.1	1.2	0.3
16.312	15.399	15.849	48.9	1.2	0.2
15.399	14.538	14.962	47.7	1.2	0.1
14.538	13.725	14.125	46.5	1.2	0.0
13.725	12.957	13.335	45.3	1.2	0.0
12.957	12.232	12.589	44.1	1.2	0.1
12.232	11.548	11.885	43.0	1.1	0.2
11.548	10.902	11.220	41.9	1.1	0.3
10.902	10.292	10.593	40.8	1.1	0.4
10.292	9.716	10.000	39.8	1.0	0.4
9.716	9.173	9.441	38.8	1.0	0.4
9.173	8.660	8.913	37.9	0.9	0.5
8.660	8.175	8.414	37.0	0.9	0.5
8.175	7.718	7.943	36.1	0.9	0.5
7.718	7.286	7.499	35.3	0.8	0.5
7.286	6.879	7.079	34.4	0.8	0.5
6.879	6.494	6.683	33.6	0.8	0.5
6.494	6.131	6.310	32.8	0.8	0.5
6.131	5.788	5.957	32.0	0.8	0.5
5.788	5.464	5.623	31.1	0.8	0.5
5.464	5.158	5.309	30.3	0.8	0.5
5.158	4.870	5.012	29.5	0.8	0.5
4.870	4.597	4.732	28.6	0.9	0.5
4.597	4.340	4.467	27.8	0.9	0.5
4.340	4.097	4.217	26.9	0.9	0.4
4.097	3.868	3.981	25.9	0.9	0.4
3.868	3.652	3.758	25.0	0.9	0.4
3.652	3.447	3.548	24.1	0.9	0.4
3.447	3.255	3.350	23.1	1.0	0.3
3.255	3.073	3.162	22.2	1.0	0.3
3.073	2.901	2.985	21.2	1.0	0.3
2.901	2.738	2.818	20.3	0.9	0.3
2.738	2.585	2.661	19.3	0.9	0.2
2.585	2.441	2.512	18.4	0.9	0.2
2.441	2.304	2.371	17.5	0.9	0.2
2.304	2.175	2.239	16.6	0.9	0.2
2.175	2.054	2.113	15.6	0.9	0.2
2.054	1.939	1.995	14.7	0.9	0.1
1.939	1.830	1.884	13.8	0.9	0.1
1.830	1.728	1.778	12.8	0.9	0.1

Sample: YC3 Tails
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-025.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 1:09:13PM
Reported: 3/08/2010 11:31:10AM
Background: 29/07/2010 12:36:48PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Class

High Diameter (µm)	Low Diameter (µm)	Average Diameter (µm)	Cumulative Volume Finer (Percent)	Volume Frequency (Percent)	Cum. Vol. Standard Deviation (2 tests)
1.728	1.631	1.679	11.9	0.9	0.1
1.631	1.540	1.585	11.0	0.9	0.1
1.540	1.454	1.496	10.1	0.9	0.1
1.454	1.372	1.413	9.3	0.8	0.1
1.372	1.296	1.334	8.5	0.8	0.1
1.296	1.223	1.259	7.8	0.7	0.1
1.223	1.155	1.189	7.1	0.7	0.1
1.155	1.090	1.122	6.5	0.6	0.1
1.090	1.029	1.059	5.9	0.6	0.0
1.029	0.972	1.000	5.3	0.6	0.0
0.972	0.917	0.944	4.8	0.6	0.0
0.917	0.866	0.891	4.2	0.5	0.0
0.866	0.818	0.841	3.7	0.5	0.0
0.818	0.772	0.794	3.2	0.5	0.0
0.772	0.729	0.750	2.7	0.5	0.0
0.729	0.688	0.708	2.2	0.5	0.0
0.688	0.649	0.668	1.7	0.5	0.0
0.649	0.613	0.631	1.3	0.4	0.0
0.613	0.579	0.596	1.0	0.4	0.0
0.579	0.546	0.562	0.7	0.3	0.0
0.546	0.516	0.531	0.4	0.2	0.0
0.516	0.487	0.501	0.2	0.2	0.0
0.487	0.460	0.473	0.1	0.1	0.0
0.460	0.434	0.447	0.1	0.1	0.0
0.434	0.410	0.422	0.0	0.0	0.0
0.410	0.387	0.398	0.0	0.0	0.0
0.387	0.365	0.376	0.0	0.0	0.0

Sample: YC3 Tails
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-025.SMP

Test Number: Avg of 2
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Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Size Table

Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
350.000	99.7	100.000	75.6	10.000	40.3	1.000	5.6
300.000	97.3	80.000	72.2	8.000	36.6	0.500	0.3
250.000	92.8	60.000	68.1	6.000	32.5		
200.000	87.5	40.000	62.7	4.000	26.5		
150.000	82.4	20.000	54.0	2.000	15.2		

Sample: YC3 Tails
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-025.SMP

Test Number: Avg of 2
Analyzed: 29/07/2010 1:09:13PM
Reported: 3/08/2010 11:31:10AM
Background: 29/07/2010 12:36:48PM

Model: Fraunhofer, 1.331
Material: Fraunhofer / Water
Background: Water RI 1.331
Smoothing: Medium

Report by Volume Percent

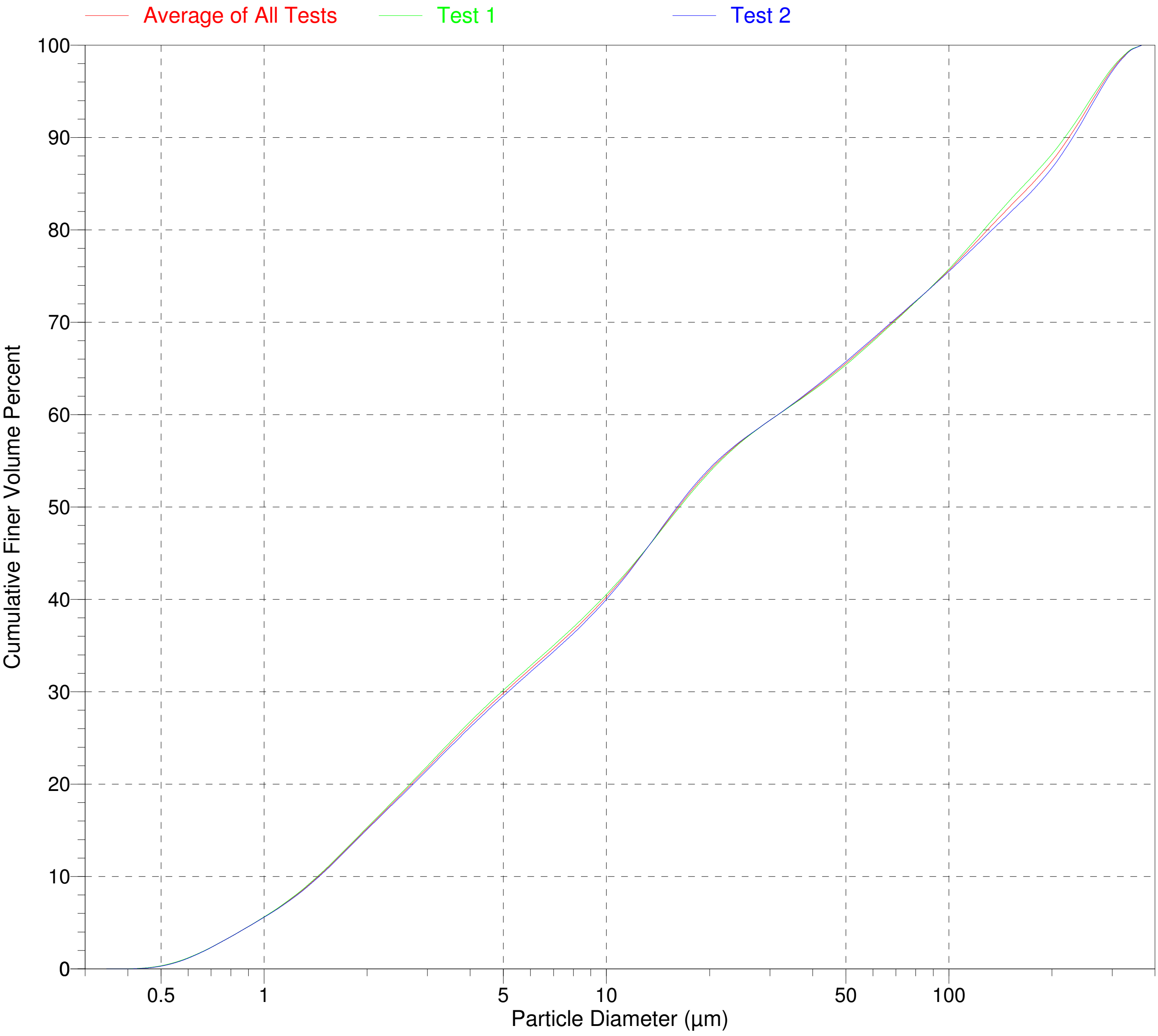
Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)	Low Diameter (µm)	Cumulative Volume Finer (Percent)
366.284	100.0	68.512	70.0	9.835	40.0	1.439	10.0
272.105	95.0	47.980	65.0	7.160	35.0	0.940	5.0
223.980	90.0	31.687	60.0	5.048	30.0	0.366	0.0
175.150	85.0	21.300	55.0	3.650	25.0		
130.085	80.0	16.217	50.0	2.694	20.0		
96.112	75.0	12.783	45.0	1.974	15.0		

Sample: YC3 Tails
Operator: Tim O'Connell
Submitter: SRK Consulting
File: L:\...\3813\000-025.SMP

Test Number:	Avg of 2
Analyzed:	29/07/2010 1:09:13PM
Reported:	3/08/2010 11:31:10AM
Background:	29/07/2010 12:36:48PM

Model:	Fraunhofer, 1.331
Material:	Fraunhofer / Water
Background:	Water RI 1.331
Smoothing:	Medium

Cumulative Finer Volume Percent vs. Diameter



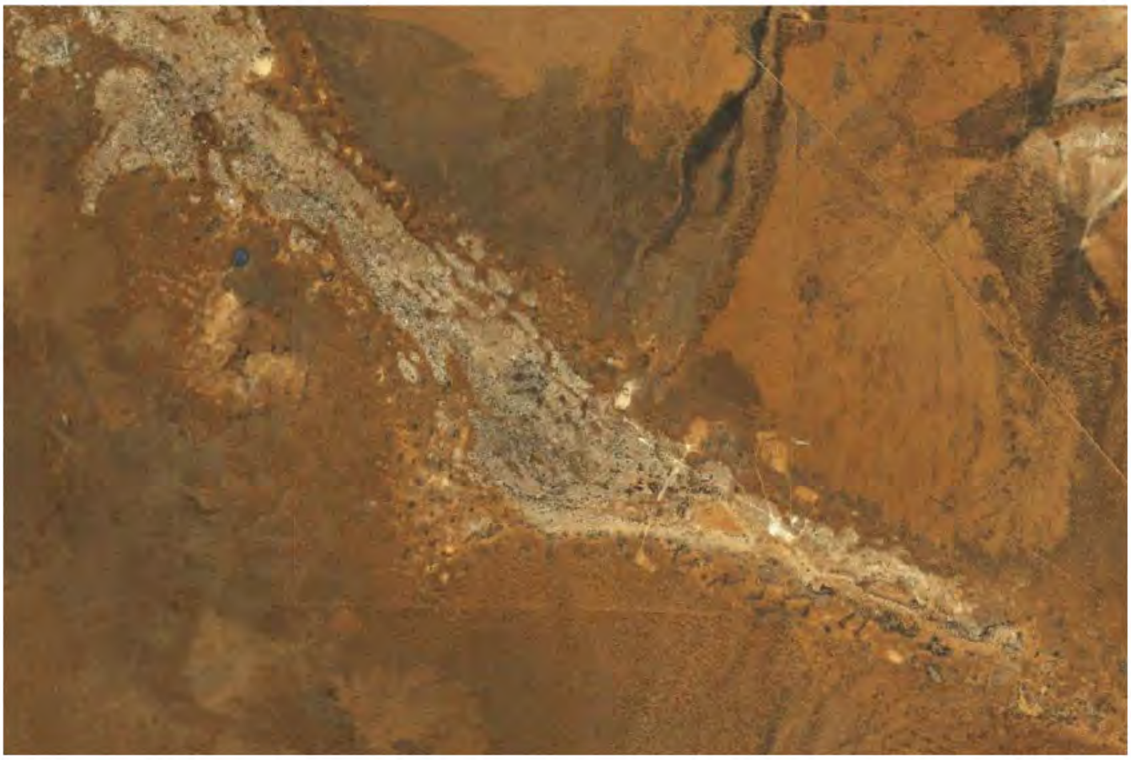
Development of Tailings and Mine Waste Source Terms for the Proposed Yeelirrie Mine

APPENDIX B

Proposed Yeelirrie Development: Assessment of Tailings and Mine Waste Source Terms

Report prepared by
SRK Consulting

March 2011



Proposed Yeelirrie Development Assessment of Tailings and Mine Waste Source Terms

Report prepared by

SRK Consulting

March 2011

Project Code: BHP047/2

Proposed Yeelirrie Development
Assessment of Tailings and Mine Waste Source Terms
BHP047/2

BHP Billiton Yeelirrie Development Company Pty Ltd

SRK Consulting (Australasia) Pty Ltd
Level 2, 44 Market St
Sydney, NSW 2000

SRK Report Distribution Record

Project Number: BHP047/2

Date Issued: 10 March 2011

Name/Title	Company
Keith Ashby	BHP Billiton Yeelirrie Development Company Pty Ltd

Executive Summary

The proposed Yeelirrie Development would mine a shallow uranium ore deposit of the mineral carnotite, a uranium-vanadium mineral phase. The ore would be processed for the recovery of uranium and the process tailings will be placed in the mined-out pit areas. During processing, the ore would be contacted with a concentrated solution of soda ash to dissolve the carnotite. Uranium would be recovered from the solution and the barren solution together with the tailings residue would be deposited in the tailings storage facility (TSF). The final tailings solution would be alkaline in nature and may contain elevated concentrations of metals (e.g. uranium, vanadium).

During operations, temporary storage areas to contain mine waste, ore and soil would be developed adjacent to the mine pit areas to manage mining in advance of production. At completion of operations, the residual ore would be backfilled preferentially to the remaining pit areas, and the balance of the soil and mine waste would be placed over the process tailings as a final closure measure.

Roads and hardstands areas would be sprayed with saline water to suppress dust. The saline water would evaporate on the surfaces of the roads and hardstands and could result in the accumulation of evaporites that may be released from the site during heavy rainfall events.

The objective of this report is to derive and present source term solute concentrations for:

- Temporary mine waste and ore stockpiles;
- The tailings storage facility; and,
- The roads and hardstands.

As well, the potential controls on solute transport in groundwater downstream of the tailings storage facility are discussed.

The report presents procedures for the estimation of solute release rates developed for each of the site components.

Temporary Stockpiles

The approach adopted for the waste and ore stockpile areas relies on experimental test results to assess the overall capacity of the waste and ore materials to release solutes. The physical interaction of rainfall and runoff with the exposed surfaces are also considered.

Base case and upper bound (or worst case) source terms were developed for the stockpile areas. The base case assumes that placed surfaces may leach solutes for up to one year, whereas the upper bound case assumes that all exposed surfaces remain active at all times.

Of significance is that the solute release capacity of the stockpile materials is finite; once the solute release has occurred it is not ‘regenerated’ (no new solutes are generated to replace the solutes that have been washed away). The experimental results further indicate that the solute release occurs rapidly. The rainfall data further indicate that during each calendar year typically two or more events would occur that could generate runoff. This means that salts should be flushed from the exposed surfaces of the waste and ore stockpiles rapidly. Consequently the upper bound case is likely to overestimate the solute release from the waste and ore stockpile areas.

We recommend that the solute release for the base case be adopted for the assessment of potential impacts on surface water quality in or around the mining area.

Tailings Storage Facility

The expectation is that porewater release from the tailings could occur only after the tailings cells have been decommissioned. The source terms developed herein therefore only considered the post closure conditions that may develop in the tailings.

The solute concentrations present the tailings porewater initially would reflect the process discharge water, or barren leach liquor, that would be present in the tailings during deposition.

The recharge and groundwater flow modelling completed by others indicate that the contact time between the tailings and the porewater would be several thousand years to possibly several hundred thousands of years. Therefore, fully equilibrated conditions would be expected to develop in the tailings porewater.

Aging tests were designed to assess the development of equilibrium conditions over time. The results from these tests indicated that equilibration and ion exchange reactions would be expected to occur in the tailings after deposition. However, the contact times expected in the field are much longer than possibly can be assessed in the laboratory tests. Therefore the test results would represent the initial conditions that may exist in the tailings. The upper bound concentrations were estimated by completing geochemical speciation modelling to assess fully equilibrated conditions and indicated that any residual carnotite that remains in the tailings would be leached. The uranium concentrations were predicted to increase in the longer term.

Groundwater modelling indicates high evaporative losses from all the cells causing groundwater flows to be ‘drawn’ into the tailings mass over time. The majority of the groundwater inflow would occur vertically from the base of the cells, with horizontal inflows typically contributing only a small proportion of the total inflows. The modelling further suggests that the vertical outflows from the majority of the cells significantly exceed the horizontal outflows; a reversal of flows at the base of the cells would be expected to release groundwater that was initially drawn into the tailings in the vertical flow direction with no net release of tailings porewater (process water). Horizontal flows would however be expected to displace porewater from the tailings.

Evaporative losses would also be expected to form evaporites in the vadose zone and accumulate salts over time. This would result in a net ‘loss’ of solutes from the tailings that would no longer be available for transport to the groundwater system.

Notwithstanding, we recommend that the average aging test results be adopted as the ‘best estimate’ source term for the tailings. The results from the PHREEQC calculations which show the fully equilibrated conditions that may develop in the tailings, should be adopted as the ‘upper bound’ estimate. We recommend that these source terms be applied to all the flows that leave the cells.

Due to the very long contact times and the relative solubility of the solutes present in the tailings, we expect that most of the soluble secondary minerals would dissolve and be displaced in the first pore volume displacement. The source terms therefore may be represented as step functions for the duration of the first pore volume displacement after which concentrations would be expected to revert to near background levels.

Source term estimates were also developed for the four cells that would be backfilled with unprocessed low grade ore and mine waste. Concentration estimates and source duration estimates are also presented for these cells.

Roads and Hardstands

The salt loadings associated with the roads and hardstands are continuously re-supplied by the application of spray water for dust suppression. Solute loadings for the roads and hardstands have been estimated based on the water application rates and salinity content of the spray water and are presented as solute loadings per unit surface area. Solute loadings have been calculated for a series of rainfall events and may be used to estimate effects on surface runoff water quality.

Solute Mobility

High evaporative losses from the tailings would lead to evapo-concentration of contaminants. Mass balance calculations based on the modelled flows suggest that uranium concentrations in the tailings porewater could increase to more that 1000 mg/L in the very long term. However, geochemical modelling indicates that carnotite should form and that the uranium concentration at the TSF outflow should decrease to very low concentrations, approaching current background levels. Vanadium concentrations however would remain elevated above background levels.

In conclusion, whilst the modelling and testing indicate that in the short term after closure uranium (and vanadium) concentrations would be expected to increase within the tailings porewater, the potential for solute release from the TSF would be limited by the very low flows that would be displaced from the tailings.

In the longer term, evaporation and subsequent interaction would lead to a net loss of alkalinity from the porewater which, together with other equilibration reactions, are expected to lead to the formation of carnotite. This would lead to uranium concentrations similar to current background concentrations. Vanadium concentrations would however remain above background levels and could be as high as 170 mg/L in the tailings porewater. Vanadium would be expected to be attenuated to some degree in the downstream clay quartz materials, but particularly in loams.

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (Australasia) Pty Ltd (SRK) by BHP Billiton (BHPB), Amdel Limited, Australian Nuclear Science and Technology Organisation (ANSTO), Australian Laboratory Services (ALS) and Particle and Surface Sciences Pty Ltd. The opinions in this Report are provided in response to a specific request from BHPB to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

1. Introduction

The proposed Yeelirrie Development would mine a shallow uranium ore deposit of the mineral carnotite, a uranium-vanadium mineral phase. The ore would be processed for the recovery of uranium and the process tailings would be placed in the mined-out pit areas. Temporary storage areas to contain mine waste, ore and soil would be developed adjacent to the mine pit areas to manage mining in advance of production. At completion of operations, the residual ore would be backfilled preferentially to the remaining pit areas, and the balance of the soil and mine waste would be placed over the process tailings as a final closure measure.

Processing would entail contacting the ore with a concentrated solution of soda ash to dissolve the carnotite. Uranium would be recovered from the solution and the barren solution together with the tailings would be deposited in the tailings storage facility (TSF). The final tailings solution would be alkaline in nature and may contain elevated concentrations of metals (e.g. uranium, vanadium).

The mine waste materials are likely to contain elevated concentrations of salts due to the presence of evaporites (accumulated salts) or saline porewater. These solutes may be released from the mine waste during operations and after closure.

During operations, the roads and hardstands would be sprayed with saline water to suppress dust. The saline water would evaporate on the surfaces of the roads and hardstands and would result in the accumulation of evaporites that may be released from the site during heavy rainfall events.

A laboratory program was initiated in 2009 based on a conceptual geochemical model for the TSF to gather further geochemical data describing the leaching and attenuation behaviour of contaminants at the Yeelirrie site. The outcomes of the geochemical characterisation program are reported elsewhere (SRK, 2011). The findings of the geochemical characterisation program together with the groundwater modelling completed by others (URS, 2011), are used herein to estimate solute potential release rates (source terms) for each of the site components.

This report describes the basis of and recommended source terms for the temporary ore and waste stockpiles, the roads and hardstands and the tailings storage facilities.

2. Background

Development of the source terms for the site components requires an understanding of the setting, design and operation of the various facilities. The following sections provide a summary mining and tailings disposal for the proposed development. More details can be found in the ERMP for the proposed Yeelirrie development.

2.1 Climate

The climate at proposed Yeelirrie Development is discussed in detail in Chapter 6 of the ERMP. In summary, the site is located in an arid, semi-desert region of Western Australia. The average annual rainfall is approximately 222 mm (238 mm at Yeelirrie Homestead), and the average net annual evaporation (pan) is approximately 2,900 mm. The monthly evaporation exceeds the monthly rainfall throughout the year.

High rainfall events associated with cyclones moving across the northern regions of Western Australia can occur from December to April.

Table 2.1 Summary of Site Rainfall and Evaporation Data

Month	Yeelirrie Homestead	SILO Data for Yeelirrie	
		Rainfall	Evaporation
January	28	26	418
February	31	29	331
March	32	30	293
April	25	24	200
May	26	24	132
Jun	23	25	90
July	17	17	98
August	13	12	136
September	4	4	201
October	10	7	288
November	10	8	341
December	20	17	392
Annual Average	238	222	2,918

The summers are very hot with maximum temperatures averaging 35 ºC to 38 ºC (with periods of up to 40 ºC to 46 ºC) and mild winters with minimum temperatures averaging 5 ºC to 15 ºC. The temperature very rarely falls below 0 ºC.

2.2 Mining and Production Schedule

The mining and production at the proposed Yeelirrie Development are described in Chapter 3 of the ERMP. Extraction of the uranium-bearing ore from the Yeelirrie ore deposit would require excavation of an open pit mine. In advance of mining, the groundwater level within the ore deposit would be drawn-down to below the final mining elevation to reduce the moisture content of the ore and overburden in order to facilitate materials handling during the mining process.

Surface mining equipment would be used to undertake the mining. The overburden would be placed in stockpiles surrounding the open pit. The ore would be classified according to its uranium grade and stockpiled in specific categories comprising ‘very high grade’, ‘high grade’, medium grade,’ ‘low grade’ and waste. Each of these categories of materials would be segregated and placed in individual temporary stockpiles. The ore stockpiles would be removed during the life of mine as ore is required for processing.

Mining would start approximately a year in advance of when the metallurgical plant would be commissioned to provide in-pit tailings storage capacity for the first tailings produced.

2.3 Ore Processing and Tailings Disposal

Ore processing is described in Chapter 3, Project Description, of the ERMP for the proposed Yeelirrie Development. In summary, the metallurgical processing plant would treat ore mined from the open pit to extract uranium in a series of heated alkali leaching tanks. The leached slurry would then pass through a counter current decant system to recover the uranium-bearing pregnant leach solution (PLS) and thicken the solids to slurry. The thickened slurry would be pumped to the tailings storage facility. The tailings would be deposited at a solids content of about 37 to 41 %(wt), with a final dry density of about 1.2 to 1.4 t/m^3 and a porosity ranging from 0.48 to 0.56.

The in-pit tailings storage facility would comprise a series of cells separated by internal divider walls or embankments. The embankments would be constructed from non-mineralised clay materials. The cells would range from 200,000 to 300,000 m^2, with dimensions of approximately 500 m by 500 m.

A total of 23 cells would be built within the pit void allowing for the permanent storage of the tailings. Three to four cells would be operated simultaneously over the project life. Only about 8 m of tailings would be placed in each cell so that, after filling, the final tailings level would be approximately 2 m below the original ground level. The cells would be operated for six to seven years.

Tailings would be deposited cyclically, with a drying phase following each deposition phase. Deposition would occur from a perimeter spigoting system so that excess water could be decanted and recycled to the process plant from a central pond. Once a cell has been filled, the resultant “bowl” or depression in the centre would be filled with tailings using a central discharge, and the tailings would be covered with low permeability materials, and shaped to shed water away from the underlying tailings. The cover would be engineered for closure but is expected to be no less than 2 m in thickness.

All remaining material mined from the pit would be backfilled into the remaining voids left unused for tailings disposal. As a result, after closure, no above-surface mining features such as waste rock stockpiles, or a pit void, would remain.

2.4 Roads and Hardstands

‘Hardstand’ areas represent all heavily-trafficked areas located adjacent to the haul roads and the pit, and include minor roads, vehicle parking areas, and machinery lay-down areas. It is assumed that they would have a design and composition similar to the haul roads.

The haul roads areas would be constructed from a mixture of slightly weathered to fresh granite mined from the project quarry and clay-quartz Waste from the pits. The road and hardstands would comprise approximately 300 mm of these materials placed on the natural terrain.

All trafficked areas would be sprayed periodically to suppress dust.

2.5 Geochemical Characterisation

Geochemical characterisation comprised several stages of analyses and testing. Initially, as part of the resource drilling program, approximately 14366 samples were analysed by a combination of inductively coupled plasma (ICP) and X-ray fluorescence (XRF) techniques for major and trace element composition (suite of 28 elements), as well as for U_3O_8 and carbonate content (CO_2 analysis). The elemental analysis included a number of key elements such as arsenic, chromium, copper, iron, molybdenum, nickel, lead, vanadium and zinc. Major elements included calcium, magnesium, potassium, sodium and sulphur. The samples analyses represented all of the material types (based on lithological descriptions) and ranged in uranium content to represent all of the material categories that would be mined. These results provided an understanding of the mineralisation of the various material types and provided the basis for selecting specific samples for more detailed characterisation and assessment of leach properties, in the next phase of testing.

A tailings characterisation program included more than 80 analyses of solids and solutions generated as part of the metallurgical investigation. A supplemental program included more detailed assessments of the tailings leaching properties and interaction of the leachates with materials that would underlie the tailings, or be located in the downstream environment.

The laboratory testing included detailed analyses, mineralogical examinations, surface characterisation and various leach testing procedures comprising bottle roll, column and equilibrium or aging testing that spanned 8 months. The evaluations included radionuclide analyses of solids and leach solutions.

The outcomes of the supplemental geochemical investigations are reported elsewhere (SRK, 2011). The key findings can be summarised as follows:

The mine waste and ore type materials contain finite quantities of readily soluble phases, which leach rapidly when contacted with water. These include primarily salts such as halites and sulphate, and to a lesser extent uranium, vanadium and zinc. Dissolution of these solutes is rapid and they are quickly depleted from the solids. Carnotite solubility is expected to place an upper limit on uranium and vanadium concentrations.

The tailings porewater quality initially is dominated by process water (barren liquor), which is alkaline and contains high concentrations of dissolved alkalinity (soda ash), uranium and vanadium. The elevated alkalinity is likely to continue to leach carnotite which would increase uranium and vanadium concentrations in the pore water. Ion exchange processes in the tailings would also result in lower dissolved sodium and potassium concentrations, while the formation of secondary carbonate minerals may decrease the dissolved alkalinity concentration. Combined, these may affect the solubility of carnotite in the very long term. Ion exchange reactions (involving swelling clays) could also reduce the permeability of the tailings and affect the rate of porewater displacement.

In general, carnotite solubility is expected to play an important role in limiting the solubility of uranium and vanadium along flow paths downstream of the facility. Geochemical conditions downstream of the TSF are expected to result in carnotite precipitating from solution, limiting uranium and vanadium concentrations. Contaminant transport may also be slowed due to sorption onto mineral surfaces (e.g. iron and aluminium oxy-hydroxides and clays). Sorption is not strong under the relatively carbonate-rich conditions expected in Yeelirrie groundwater, however, moderate sorption is expected for many elements, except for the very high dissolved carbonate concentrations that are likely to occur in the near-zone of the TSF.

These findings, and specifically the solute release rates determined during the geochemical characterisation program, were used herein to assess the solute release rates from the various site components as described in the next chapter.

3. Source Terms

3.1 Stockpiled Ore and Waste Materials

Based on the operating strategy adopted for the proposed development, the stockpiled materials would be placed on the surface adjacent the mining area only after the materials have been drained in-situ (i.e. the materials would be dewatered by excavating drainage channels around the materials to be mined, allowing the phreatic surface to be lowered before the materials are mined). The stockpiled materials would remain on the surface only for a finite time (higher grade materials until they are processed and waste or below grade materials until they are backfilled at the end of operations).

Possible mechanisms for the release of water and contained solutes from the stockpiled materials include:

- Release of excess porewater (groundwater) present at the time of placement as toe seepage or percolate to groundwater (i.e. drain-down);
- Displacement of porewater by, or percolation of, incident rainfall as toe seepage or percolation to groundwater,
- Runoff from the surfaces of the mined materials due to incident rainfall.

As noted above, the materials would be drained down before they are mined and consequently there should be no porewater release as a result of excess moisture drain-down. Second, rainfall in the area is low (average rainfall 238 mm/year) and evaporation rates are high (about 3,300 mm/year). We understand from the unsaturated modelling undertaken by BHPB and their consultants that it is unlikely that percolation would result from incident rain during the period that the materials would be stockpiled on surface (i.e. within the operational timeframe). Therefore, no source term was developed for the cases listed in the first two bullets above.

The last mechanism for solute release occurs when incident rainfall causes ponding on the surfaces of the stockpiles, which then leads to runoff. During the ponding the water would dissolve any readily soluble solutes that are present on the surfaces of the stockpile materials, and would be transported away in the runoff. The immediately available solute would comprise evaporites that form at the surface after evaporation of residual porewater that may have been present in the material at the time of placement. The solute accumulation may further be enhanced over extended dry periods when, due to the high evaporation rates, water is transported to the surface due to capillary suction, and the salts deposited at the surface when the water is evaporated. The depth of capillary transport would depend on the matric suction of the material, and the duration (i.e. total evaporation that could occur) of the dry period. Therefore, the solute loading that could be brought to surface would be limited to the finite amount associated with the layer affected. This type of accumulation is commonly observed as a salt crust or hardpan in arid areas.

The following sections briefly describe the approach that was adopted for the development of the runoff source terms. The estimates of solute loadings that may be expected to occur from the stockpiled materials are also presented.

3.1.1 Approach

3.1.1.1 Water Quality

The water quality of the runoff that could be generated from the stockpiles would depend on a number of factors. The key factors are as follows:

Type and area of materials exposed

The various lithological units that would be stored would differ in their potential for solute release. Therefore, the total rates of solute release would depend on the types of materials that are exposed at surface, and the total area exposed to runoff water.

Evaporation

Evaporation from soil surface is normally considered as a three-phase process:

- In Phase 1 evaporation, water retained on the soil surface or in near surface pores evaporates directly at rates that approach the maximum potential evaporation rate.
- Phase 2 evaporation begins once the surface water is gone. It requires water to be transported upwards to the surface from deeper in the soil profile. Matric suction provides the driving force. Phase 2 evaporation slows over time, as the water needs to be drawn from increasing depths. Nonetheless, Phase 2 evaporation is very significant in arid regions, and is generally the main reason why net percolation is significantly less than infiltration.
- In Phase 3 evaporation, the water moves to the soil surface as a vapour only. It is generally only noticeable once the Phase 2 process has removed the mobile liquid water from the upper soil. Phase 3 evaporation can be significant in arid regions where there are long dry periods between rain events. Significantly however Phase 3 evaporation does not result in solutes being transported to the surface.

In the stockpiles Phase 2 evaporation is likely to cause a reversal in water flows to the surface which would lead to the net transport of salts to the soil surface. The depth of Phase 2 evaporation that may contribute salt transport (or salt wicking) to the surface is dependant on the soil properties of the materials.

Solute release

The solute release by the materials would determine the amount of solutes that may accumulate on the surface between consecutive events that generate runoff. The sequential bottle roll tests and the column tests in general show a rapid decrease in solute concentrations for consecutive steps. This indicates a finite capacity of the materials to release solutes, and that most of the solutes in general would be removed from the surface after the first runoff event. The contribution from subsequent runoff events would therefore be minimal and may be considered ‘inactive’.

Period of accumulation

The duration over which solutes are accumulated would depend on a number of factors including:

- the period between consecutive rainfall events that generate runoff as well as the period between rainfall events where percolation results and
- the concurrent transport of salts beyond the lower extent of the zone of evaporation that could cause a net transport of solutes to the surface.

A review of the climate data suggest that the maximum period between consecutive events that are likely to result in runoff would be approximately 120 days. This means that the maximum period over which Phase 2 evaporation could contribute to salt wicking to the surfaces of the stockpiles is about 4 months, which would restrict the depth of influence of evaporation.

Clearly the factors that may impact the solute release, transport to the surface and then release to runoff are complex.

3.1.1.2 Runoff

During a rainfall event, surface ponding occurs when the capacity of the soils to take up water is exceeded. When the surface ponding capacity is exceeded runoff occurs.

The rate at which a soil can take in water is dependent on its physical properties, including grain size distribution, permeability and matric suction. Complete consideration of those properties and the physical processes controlling infiltration requires a model that is quite complex. The accuracy of such complex estimates is highly dependent on the assumed material properties, which in the case of the stockpiled materials are not well characterised.

When the main interest is in runoff, a simpler form of infiltration modelling is normally adopted. The Green-Ampt method is one such simplification that was developed nearly 100 years ago and remains in wide usage for runoff calculations. It provides an explicit consideration of key soil properties and their effects on infiltration rates, without requiring numerical solution.

The Green-Ampt method assumes that rainfall produces a front of water moving into the soil. Above the water front, the soil is assumed to be saturated; and below the front it is assumed to be unsaturated at a constant water content. The driving forces for the downward movement of the wetting front are gravity, the head imposed by surface ponding, and the matric suction extorted by the soil just below the wetting front. Putting those assumptions into Darcy's law allows solutions to be derived for many different parameters of interest. The common formulation for infiltration estimates is:

$$I = \frac{\lfloor(\theta_s - \theta_i)\psi_f\rfloor}{[(p/K_s - 1)]}$$

Where:

I is the total amount of water infiltrated (cm),

p is the rainfall rate (cm/s),

K_s is the saturated hydraulic conductivity (cm/s),

Ψ_f is the matric suction at wetting front,

θ_i is the initial moisture content (dimensionless), and,

θ_s is the saturated moisture content (dimensionless).

The Green-Ampt formulation also includes material properties (K_s and θ_s) and parameters dependent on material properties (Ψ_f and θ_i) that, in the case of the stockpile materials, are not well characterised. As discussed further below, that limitation restricts the accuracy of any of the estimates presented herein.

Estimating infiltration is only part of the runoff calculation. The complete sequence of calculations was as follows, for precipitation events of various intensity and duration:

- Estimate the precipitation intensity (p) and the total precipitation (P);
- Estimate the amount "lost" to infiltration (I) by the Green-Ampt method; and,
- Assume the remainder is available for runoff (R=P-I).

3.1.1.3 Source Term Derivation

As noted before, when rainfall occurs there is an initial short-term infiltration that occurs before ponding and run-off occurs. One approach to estimate the net solute release to the surface runoff would be to allow the initial infiltrating water to dissolve and remove salts from the surface of the material. The infiltrated water would remove the dissolved salts from contact with the subsequent ponding that may occur. This approach would be appropriate for salts that dissolve and reach equilibrium conditions rapidly (i.e. within the short timeframe that the initial abstraction would occur). Dissolution of only the most soluble salts, such as sodium chloride, could be expected to occur within the initial timeframe. Most salts would be expected to dissolve slowly, and may not even reach equilibrium conditions for the period that the water ponds on the surface before it is removed as runoff.

For the purpose of this assessment, the following simplified five step approach was adopted:

1 The schedule of placement was used to estimate the total area of exposure for each lithological unit. The placement schedule also provided some indication of the maximum exposure time (before the surface is removed either to be processed or backfilled at the end of operations). However as noted above, i) the solids have a finite capacity to release solutes, ii) that the majority is released within the first contact, and iii) the maximum period between rainfall events that would produce runoff is 120 days. Therefore it was assumed that any given surface is active only in the year that it is placed.

2 The area of exposure was multiplied by the assumed depth of influence of the Phase 2 evaporation and multiplied with the bulk density to calculate the total mass of material that could contribute to the salt loading at the surface through the salt wicking process. (The assumption is conservative as it does not allow for any salt transport out of the zone due to percolation. This also assumes that the salts are available at the surface instantaneously at the time the event occurs; in reality, the wicking process

would be slow and would depend on the frequency and intensity of rainfall events prior to the event that results in runoff.)

3 The solute release estimates (in mg/kg or g/tonne) were obtained from the leach extraction and column tests that were completed on the various materials. Because the sampling program was limited and not all of the material types were equally represented, the results were ordered in terms of uranium release (loading to the leachate). The highest uranium loading assigned to the Very High Grade material, and the next highest to the High Grade material and so on so that the lowest uranium was assigned to the below grade waste materials.

4 The solute release estimates were then multiplied by the total mass of rock (in tonnes) that might contribute to the salt loading (step 2) and divided by the total volume of water yielded by the rainfall event to provide a corresponding concentration. These concentrations were then compared to equilibrium concentrations that may apply (i.e. where the concentrations exceeded the solubility of known phases that form rapidly, the concentration was corrected to the equilibrium concentration).

5 The revised concentration was then multiplied by the net runoff volume to obtain the total solute loading that would result to surface water.

The outcome of the latter approach would yield the maximum possible, or upper bound, estimate of concentrations that may occur in runoff from the stockpiles.

3.1.2 Assumptions and Basis of Calculations

3.1.2.1 Stockpile Placement Schedule

The estimated areas of exposure of the various material types at any given time are shown in Table 3.1. Note that this reflects the area in existence at the time, i.e. not the active or newly placed area. To obtain the active area for any given year, subtract the area from the preceding year.

3.1.2.2 Material Properties

The average mineralogical compositions for the various grades of materials were estimated by BHPB from the resource model. The results are illustrated in Figure 3.1 and show that the VHG and HG materials generally would have a higher carbonate content and a marginally lower clay content when compared to the remaining categories of materials. On that basis it was assumed that the VHG and the HG materials could be represented as “silty clayey loam” whereas the balance of the materials likely could be represented as “sandy clay” materials. The soil properties adopted for these material types are summarised in Table 3.2.

Table 3.1 Estimated Total Stockpile Areas

At end of project year	Stockpile Area (m^2)					
	Very High Grade VHG)	High Grade (HG)	Medium Grade (MG)	Low Grade (LG)	Waste (W)	Topsoil (TS)
-1	147,000	63,000	53,000	79,000	114,000	94,000
1	224,000	105,000	185,000	109,000	259,000	216,000
2	239,000	189,000	303,000	149,000	346,000	328,000
3	*178,500*	*224,000*	*377,000*	*179,500*	*391,500*	*377,000*
4	118,000	259,000	451,000	210,000	437,000	426,000
5	*131,000*	*343,500*	*573,000*	*201,000*	*563,000*	*454,500*
6	144,000	428,000	695,000	192,000	689,000	483,000
7	*72,000*	*376,500*	*695,000*	*192,000*	*652,000*	*454,500*
8	0	325,000	695,000	192,000	615,000	426,000
9	*0*	*205,000*	*695,000*	*192,000*	*615,000*	*426,000*
10	0	85,000	695,000	192,000	615,000	426,000
11	*0*	*42,500*	*678,000*	*209,000*	*735,500*	*407,500*
12	0	0	661,000	226,000	856,000	389,000
13	*0*	*0*	*604,500*	*279,000*	*1,096,000*	*495,500*
14	0	0	548,000	332,000	1,336,000	602,000
15	*0*	*22,000*	*646,000*	*400,000*	*1,399,000*	*671,500*
16	0	44,000	744,000	468,000	1,462,000	741,000
17	*0*	*22,000*	*859,500*	*425,500*	*1,373,000*	*699,500*
18	0	0	975,000	383,000	1,284,000	658,000
19	*0*	*27,000*	*1,086,500*	*435,000*	*1,529,500*	*766,000*
20	0	54,000	1,198,000	487,000	1,775,000	874,000
21	*0*	*27,000*	*1,088,000*	*380,000*	*1,327,500*	*714,000*
22	0	0	978,000	273,000	880,000	554,000
23	*0*	*0*	*906,500*	*257,500*	*846,000*	*526,000*
24	0	0	835,000	242,000	812,000	498,000
25	*0*	*0*	*712,000*	*242,000*	*771,000*	*443,500*
26	0	0	589,000	242,000	730,000	389,000
27	*0*	*0*	*468,500*	*242,000*	*693,000*	*360,500*
28	0	0	348,000	242,000	656,000	332,000
29	*0*	*0*	*305,500*	*242,000*	*607,000*	*271,000*
30	0	0	263,000	242,000	558,000	210,000
31	*0*	*0*	*131,500*	*217,000*	*357,500*	*115,500*
32	0	0	0	192,000	157,000	21,000

Note: Values in italics interpolated.

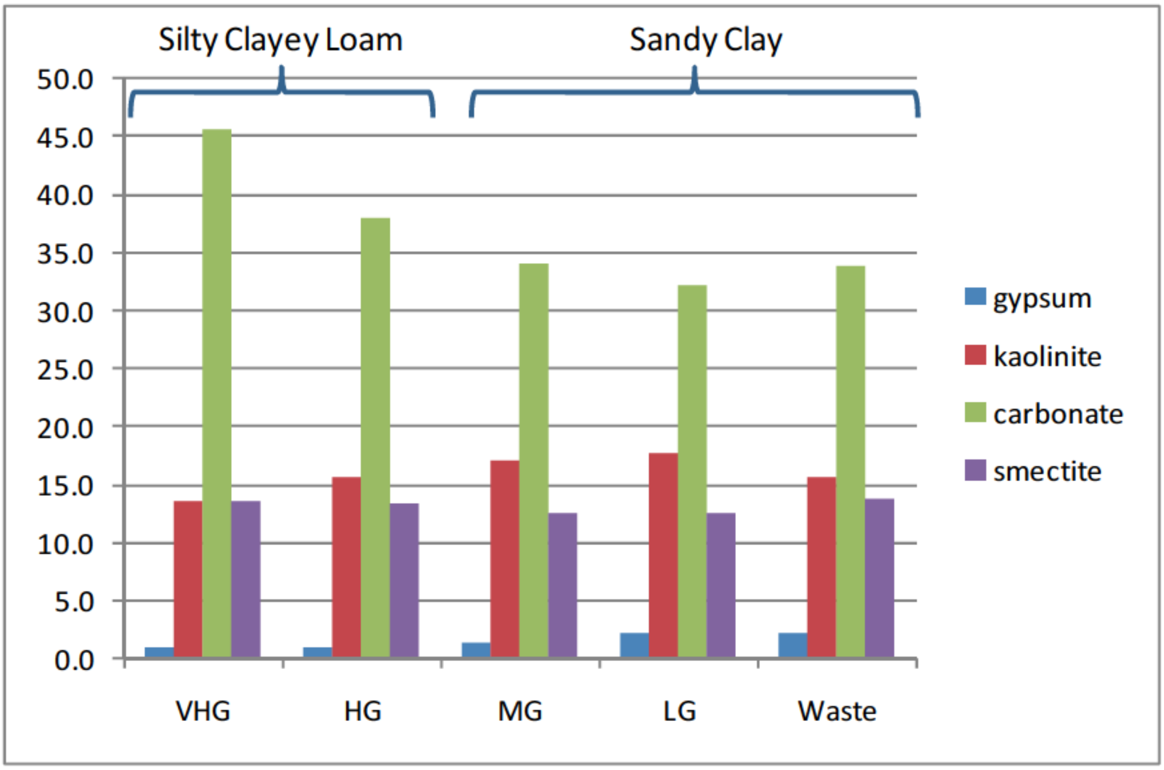

Figure 3.1 Mineralogical Composition of Various Material Categories to be Stockpiled

Table 3.2 Assumed Soil Properties for Green-Ampt Parameters

Soil type	**Porosity**	**Effective porosity**	**Suction Head (mm)**	**Hydraulic Conductivity (mm/h)**
Silty clayey loam	0.47	0.43	273	1.0
Sandy clay	0.43	0.32	239	0.6

Source: *Handbook of Hydrology*, D.R. Maidment, Editor in Chief, McGraw-Hill, Inc., 1993, pp 5.1-5.39

3.1.2.3 Rainfall Data and Runoff

The rainfall intensity – return period estimates were derived by URS (see ERMP, Appendix G1 Surface Water). The data used in the assessments are summarised in Table 3.3. The total rainfall is obtained by multiplying the rainfall intensity with the duration of the event.

As described previously, the Green-Ampt approach was adopted to estimate runoff and initial abstraction for the various rainfall events. The results are summarised in Table 3.4 for the Very High Grade and High Grade materials (silty clayey loam) and in Table 3.5 for the balance of the materials (sandy clay).

Table 3.3 Precipitation Intensity (mm/hr) Estimates for the Yeelirrie Site

Rainfall Intensity (mm/h)							
Return	**Storm duration (hours)**						
Period (yrs)	**0.083**	**1**	**6**	**12**	**24**	**48**	**72**
1	43.2	12.5	3.5	2.1	1.3	0.8	0.6
5	54.0	15.6	5.0	3.3	2.1	1.3	1.0
10	58.8	18.9	6.1	4.1	2.6	1.7	1.2
20	58.8	22.5	7.7	5.3	3.3	2.2	1.6
50	96.0	27.7	9.9	6.8	4.5	2.9	2.2
100	126.0	36.0	13.1	8.9	5.8	3.7	2.8
500	-	-	-	-	6.8	4.3	3.2
1000	-	-	-	-	8.2	5.1	3.6

Table 3.4 Estimated Initial Abstraction and Runoff for VHG and HG Materials

Initial Abstraction (mm)							
Return Period (yrs)	**Storm Duration (hours)**						
	0.083	**1**	**6**	**12**	**24**	**48**	**72**
1	1.7	6.4	29.6	66.4	243.5	37.4	40.3
5	1.4	5.0	18.3	31.9	68.1	224.0	71.8
10	1.3	4.1	14.3	23.5	45.9	111.7	295
20	1.3	3.4	10.9	17.2	31.4	61.8	117
50	0.8	2.7	8.2	12.6	20.9	37.6	61
100	0.6	2.1	6.0	9.2	15.2	27.0	42
500	-	-	-	-	12.6	22.0	34
1000	-	-	-	-	10.1	18.0	28
Potential Runoff (mm) = Total Precipitation - Initial Abstraction							
Return Period (yrs)	**Storm duration (hours)**						
	0.083	**1**	**6**	**12**	**24**	**48**	**72**
1	1.9	6.1	NR	NR	NR	NR	NR
5	3.1	10.7	11.5	7.6	NR	NR	NR
10	3.6	14.8	22.3	25.7	16.2	NR	NR
20	3.6	19.1	35.3	45.9	48.5	42.9	NR
50	7.2	25.0	51.5	69.1	87.1	103.6	97.7
100	9.9	33.9	72.4	97.8	123.9	150.6	156.4
500	NR	NR	NR	NR	150.7	185.3	193.1
1000	NR	NR	NR	NR	187.3	224.9	229.4

Note: NR = no runoff

Table 3.5 Estimated Initial Abstraction and Runoff for MG, LG and Waste Materials

Initial Abstraction (mm)							
Return Period (yrs)	**Storm Duration (hours)**						
	0.083	**1**	**6**	**12**	**24**	**48**	**72**
1	1.0	3.5	14.6	27.9	59.8	233.7	40.3
5	0.8	2.8	9.6	15.6	28.4	57.7	105.5
10	0.7	2.3	7.6	12.0	21.0	39.7	64.7
20	0.7	1.9	5.9	9.0	15.3	26.5	41.0
50	0.4	1.5	4.5	6.7	10.7	17.9	26.2
100	0.3	1.2	3.4	5.0	8.1	13.5	19.5
500	-	-	-	-	6.7	11.3	16.4
1000	-	-	-	-	5.5	9.4	14.1
Potential Runoff (mm) = Total Precipitation - Initial Abstraction							
Return Period (yrs)	**Storm Duration (hours)**						
	0.083	**1**	**6**	**12**	**24**	**48**	**72**
1	2.6	9.0	6.2	NR	NR	NR	NR
5	3.7	12.9	20.3	23.9	21.3	6.0	NR
10	4.2	16.6	29.0	37.3	41.1	39.6	25.1
20	4.2	20.6	40.3	54.1	64.5	78.2	75.8
50	7.6	26.1	55.2	75.0	97.3	123.3	132.3
100	10.2	34.8	75.1	101.9	131.0	164.1	178.6
500	NR	NR	NR	NR	156.6	196.0	210.6
1000	NR	NR	NR	NR	191.9	233.5	243.6

Note: NR = no runoff

3.1.2.4 Solute Loadings

The solute loadings were obtained by i) summing the total solute release from each of the three sequential extraction tests, or, ii) summing the release for all the available pore volume displacements from the column tests. These total loadings were calculated for each of the samples and then sorted by lithological type. The average solute release was then obtained for each lithological type for all the samples from that unit. Since the original sampling programme could not be directed at the various categories (as at the time of sampling the categories had not been defined nor had the cut-off grades been established) the lithological units were arranged according to the uranium release and then assigned to have the highest release rate correspond with the VHG material and so on. The results are summarised on Table 3.6. The following is noted:

- Whilst assignment of the hardpan lithology to the HG material type is not ideal, it does reflect the second highest uranium release capacity and accordingly is considered appropriate.
- Total salt release generally is high for all materials (Cl, Na, K, Mg, SO4) with the exception of the HG material type. The salt release from this material is approximately 50 % lower. This prompted a review of the test results, which indicated that salt release from samples within each material type is very variable. The variability appears to be independent of the depth of the sample location and the material type. It is possible that the salt release from the HG material types has been underestimated. Note however that the HG category represents a relatively minor surface area (see Table 3.1) and the discrepancy may be of little consequence in the overall estimates.

As noted before the release estimates presented in the table represent the maximum possible potential release from the waste rock materials and do not include the potential effects of solubility controls which would limit the total release.

Table 3.6 Estimated Stockpile Total Solute Release Capacity

Category	**Very High Grade (VHG)**	**High Grade (HG)**	**Medium Grade (MG)**	**Low Grade (LG)**	**Waste (W)**
Lithology	**LT**	**HT**	**T**	**TCQ**	**CQ**
	Carbonated Loam	**Carbonated Hardpan**	**Calcrete**	**Transition Calcrete**	**Clay Quartz**
Parameter	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Ag	0.033	0.030	0.029	0.033	0.030
Al	0.334	0.245	0.163	0.595	0.177
As	0.107	0.041	0.042	0.070	0.033
B	9.51	2.98	7.37	6.21	8.86
Ba	0.210	0.351	0.189	0.098	0.099
Be	0.030	0.030	0.036	0.033	0.030
Bi	0.033	0.030	0.027	0.033	0.030
Br	18.6	10.8	12.1	7.2	9.0
Ca	780	139	1172	160	124
Cd	0.040	0.024	0.041	0.032	0.030
Cl	2172	539	2098	2031	2432
Co	0.031	0.030	0.027	0.033	0.030
Cr	0.035	0.032	0.029	0.052	0.030
Cu	0.054	0.084	0.041	0.040	0.035
F	10.686	10.6	12.1	12.2	10.5
Fe	0.623	0.600	0.582	1.068	0.600
Hg	0.002	0.002	0.001	0.001	0.001
K	486	117	387	353	363
Li	0.033	0.030	0.029	0.037	0.030
Mg	288	123	346	204	206
Mn	0.086	0.034	0.031	0.033	0.102
Mo	0.251	0.177	0.220	0.342	0.175
Na	2591	1362	1913	1990	1922
Ni	0.036	0.034	0.044	0.033	0.030
NO3	148	21.3	41.1	17.2	79.9
P	3.824	2.295	2.691	1.200	0.600
Pb	0.030	0.030	0.027	0.033	0.030
Sb	0.033	0.030	0.029	0.033	0.030
Se	0.068	0.034	0.053	0.050	0.059
Si	144	388	109	92	141
Sn	0.044	0.336	0.031	0.033	0.030
SO4	4150	753	4216	996	1263
Sr	7.56	1.52	10.5	2.91	2.28
Tl	0.703	0.032	0.498	0.209	0.516
U	4.50	3.84	1.37	0.745	0.294
V	1.23	0.139	0.560	1.12	0.624
Zn	0.843	0.194	0.711	0.677	0.780
Ra226*	0.657	0.008	0.103	0.019	0.000

Notes: * units for Ra226 are Bq/kg
total loadings above do not consider solubility constraints.

3.1.2.5 Solubility controls

As noted in Section 3.1.1.3, integral to the source term prediction is the application of solubility controls on the dissolution of salts. In order to impose any solubility controls where they may exist, water quality estimates were generated for a range of conditions and, based on speciation modelling, upper solution concentrations were established. These were compared to the experimental results to verify the PHREEQC predicted results, or, to provide a reasonable limit for solutes where thermodynamic data did not exist in the database. Although there was some variability in the concentrations for the different rainfall events assessed, average concentration limits were established that could be imposed across the entire range of rainfall event conditions. These are summarised in Table 3.7.

Table 3.7 Summary of assumed Solubility Controls for Runoff Water Quality Estimates

Parameter	Concentration	Comment
Ag	0.006	experimental results
Al	0.68	Gibbsite, experimental results
Ba	0.53	Barite
Be	0.061	experimental results
Bi	0.059	experimental results
Br	0.034	experimental results
Ca	694	Gypsum; calcite
Cd	0.055	experimental results
Cr	0.072	experimental results
Cu	0.080	Malachite, experimental results
Fe	0.050	Iron oxy-hydroxide
Hg	0.002	experimental results
Pb	0.005	experimental results
Sb	0.005	experimental results
Si	85	Amorphous Silica
Sr	23	Celestite
Tl	0.36	experimental results
U	2.1	Carnotite/Schoepite
V	1.4	Carnotite, experimental results

Note: Experimental data represent maximum concentration observed in all tests

3.1.2.6 Depth of Evaporative Influence

The depth of influence of the Phase 2 evaporation is a primary control on the total loading of solutes that would be available for release to the runoff. The depth of Phase 2 evaporation that may contribute salt transport (or salt wicking) to the surface is dependant on the soil properties, but typically ranges up to about 1 meter. The depth of leaching (i.e. the depth of material for which upward water flux could occur) that could contribute to the salt loading to the surface would also depend on the period during which no precipitation occurs. During this period evaporation near the surface would ‘draw’ water from lower down which would then carry salts from lower down through capillary movement. The longest period in the rainfall record without precipitation is about 120 days. During that period, the evaporation from the soils (i.e. not from the surface) is estimated to be up to 50 mm equivalent. Since the materials would be drained before placement, the field moisture capacity estimates for the material types can be used to estimate the depth of soil moisture depletion for that period. The approximate depth of material to supply 50 mm of evaporation would be about 0.28 m for the sandy-clay material, and about 0.19 m for the silty clay loam material. Conservatively, a depth of contribution of 0.5 m was adopted for both material types.

3.1.3 Source Terms

The purpose of the source term calculations is to generate solute loadings in a form that could be used by others to estimate site wide runoff water quality. Since the solute loadings vary by material type, and since the exposure areas vary over time, the most appropriate output was to provide solute loadings as a function of area for each type of material (i.e. solute loads in units of g/m^2). The total loading can then be determined simply by multiplying the loading with active area for any given time.

As will be shown below, the solute loadings vary according to the storm intensity and duration because the initial abstraction, and thus the proportion of the solute loadings that are ‘returned’ to the underlying soils, varies by event as shown in Table 3.4 and Table 3.5. Therefore, to allow an assessment of water quality for any combination of events, it was necessary to generate solute loadings for all the events given in the aforementioned tables.

As shown by the sequential leach extraction tests and the column tests, the solutes are depleted relatively rapidly from the mine materials, with the majority of solutes removed in the first flush. This indicates that most of the available solutes would similarly be removed from the surface of the stockpiled materials during the first flush, and that subsequent flushes would result in much lower solute concentrations. Therefore, potentially, a surface that had already been flushed by an event, may not contribute significantly to a second event. Since climate data indicate that the maximum period between events that could generate runoff is about 120 days, it would suggest that two to three runoff events could occur each calendar year. Therefore, the solute release potential should largely be depleted from a newly placed surface within a calendar year.

Consequently two approaches were adopted to assess solute loadings: i) Base Case, and ii) Upper Bound Case. For the base case it is assumed that placed surfaces remain active for one calendar year. For the upper bound case it is assumed all surface remain active at all times. Clearly this is very much an upper bound case since it assumes that a surface placed in year one of operations would deliver solutes at the same rate in year 20 as in year 1. Clearly this is not possible and therefore represents an absolute worst case scenario.

In the following sub sections example results are presented and the estimated overall solute loadings are summarised for various rainfall events.

3.1.3.1 Example Results

Example plots have been prepared for key parameters (Cl, U, V) comparing the base case and the upper bound case. Two rainfall events have been selected for illustration purposes. Figure 3.2 shows the results for a rainfall event with a 1:5 year return period and 1 hour duration, whereas the results for a 1:100 return period and a 1 hour duration are shown in Figure 3.3.

As shown in the figures, the salinity concentration in runoff from the HG material is somewhat lower than for the other material types. The reason for this is the difference in solute release from the samples selected to represent the HG material (i.e. based on U release rather than total solute release as discussed before). The concentration in runoff from the remainder of the materials is comparable and proportional to the overall solute release potentials for each material type.

The base case estimates show a rapid decrease after initial placement of the materials. This is because the surfaces remain active for one year only. The inactive surfaces contribute flow but no solute loadings and therefore ‘dilute’ the solute loadings from the newly placed active areas. When no new areas are placed, the concentrations diminish to very low values.

In the upper bound or worst case estimates, all surfaces remain equally active for as long as they are in existence. For example, the waste material remains in place for life of mine and therefore the chloride concentration remains constant for the entire operational period. In the case of the VHG material, the stockpile exists for a finite period and then is removed. The HG material stockpile is placed and removed on three occasions hence the appearance and disappearance of the concentration profile for this material type (see Table 3.1). Note that the uranium and vanadium concentrations tend to reach the solubility constraint for all materials concerned, hence there are no differences in concentrations amongst the different piles.

A comparison between the two rainfall events (which results in different flow volumes) indicates that the concentrations of solutes that are not solubility limited (e.g. Cl) would decrease proportionally with the flow volume. However, in this particular comparison, the concentrations of solutes that are solubility limited (i.e. U and V) would remain constant. Only for much higher flow volumes would a difference in concentrations be observed. To illustrate, Figure 3.4 shows the upper bound concentrations for Cl and U for a 1:50 year, 72 hour event. As shown, the Cl concentrations are much lower than for the above mentioned cases. However, whilst uranium concentrations remain at solubility for the various ore grade materials, the concentration for the waste type material decreases to below equilibrium (i.e. there is insufficient uranium available in the waste materials to reach equilibrium concentrations).

Once the effective solute concentrations have been established for the stockpile surface, the effective loadings are developed that can be used by others in the site water and load balance. The estimated solute loadings are developed and discussed in the next section.

In summary it is important to note that the solute release capacity of the stockpile materials is finite; in other words once the solute release has occurred it is not ‘regenerated’ (no new solutes are generated to replace the solutes that have been washed away). Recognising that runoff typically represents in excess of 50 % of total rainfall, more than 50 % of the solutes would be removed in the first rainfall event that generates runoff. In the second event in excess of 50 % of the remaining load would be removed or in excess of 75 % of the available load, and by the third event in excess of 87.5 %. Recognizing further that the climate data suggest that the surfaces could be flushed two or three times a year (maximum dry period of 120 days) clearly most of the solutes would be removed within one year of placement. Consequently, a surface that has been exposed for 20 years, and flushed on average for three times each year, cannot therefore deliver the same solute loading as a newly placed surface less than one year old. The solute concentrations presented for the upper bound or worst case scenario is therefore possible for any given year only if the surfaces had not been subjected to runoff in any of the preceding years since the surface had been placed.

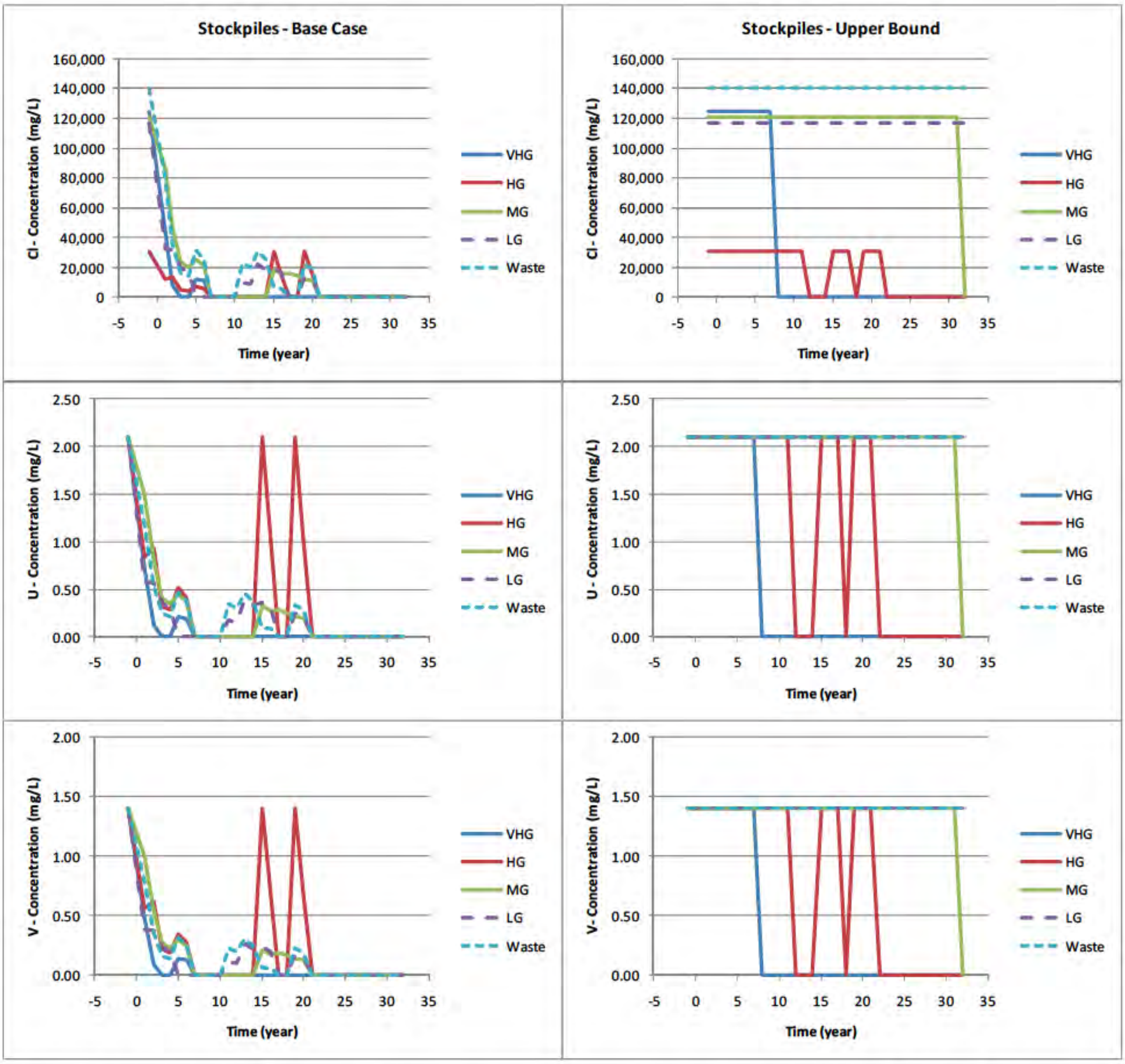

Figure 3.2 Comparison Base Case and Upper Bound of Solute Concentrations in Runoff from the Stockpiles over the Life of Project for a 1:5 year, 1 hour Duration Event

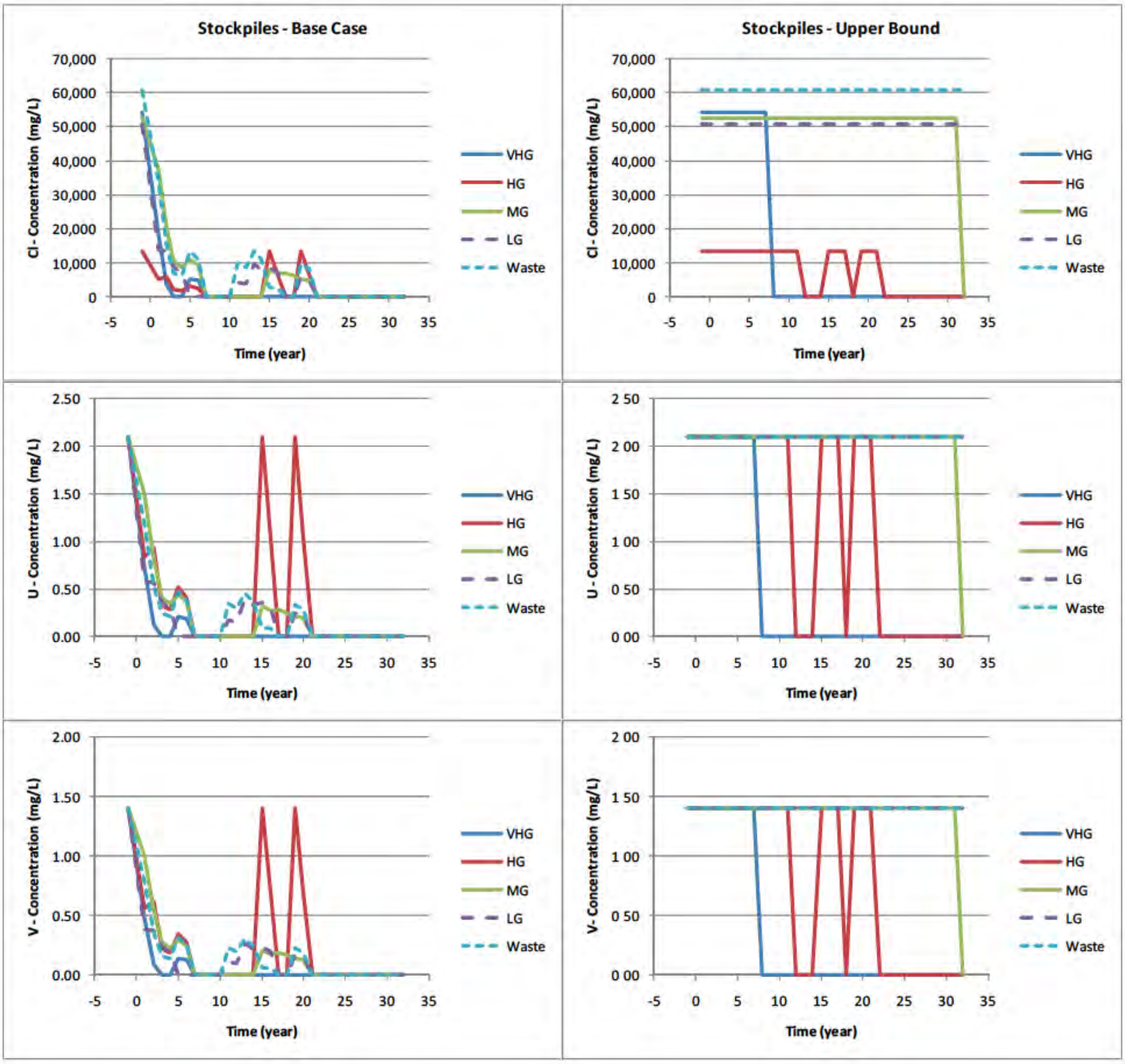

Figure 3.3 Comparison Base Case and Upper Bound of Solute Concentrations in Runoff from the Stockpiles over the Life of Project for a 1:100 year, 1 hour Duration Event

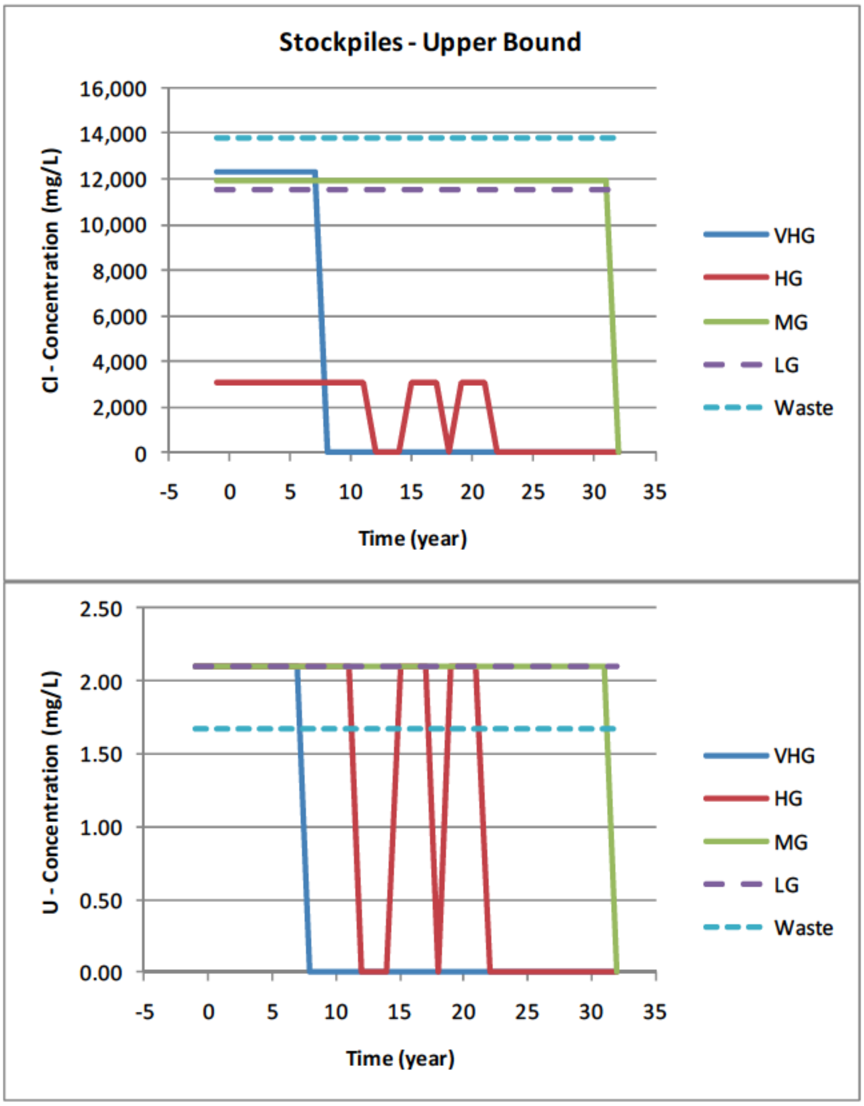

Figure 3.4 Upper Bound Solute Concentrations in Runoff from the Stockpiles over the Life of Project for a 1:50 year, 72 hour Duration Event

3.1.3.2 Solute Loadings

Solute loadings were estimated as a net mass release per unit surface area. The release rate is multiplied by the applicable surface area to obtain the total loading for any given rainfall event. The release applies equally for the base case and the upper bound (or worst) case; the difference is the surface area that is active (i.e. contributes loading).

The loading estimates were prepared for a selection of storm events that would allow development of the site water management strategy. It should be noted that while some events may be predicted to generate runoff, this may not necessarily be the case. First, the surfaces of the stockpiles are not likely to be perfectly flat and level so that in some cases ponding could occur without resulting in runoff. Furthermore, since the materials contain clays, desiccation is likely to lead to cracking which could increase abstraction and reduce runoff. Therefore, only more significant events would be expected to generate runoff.

The loading estimates are summarised in Table 3.8 for key elements and the complete results are provided in Appendix 1. It should be noted that in some cases the VHG and HG material do not generate runoff and therefore no loadings are shown. The reason for this is that the initial abstraction of the VHG and HG materials are greater than that of the MG, LG and waste type materials. In some cases where the solute concentrations for the VHG and HG materials are higher than those estimated for the other materials, it is possible that the net loading from the VHG and HG are lower because the amount of runoff generated is less for these materials than for the MG, LG and waste materials (note: Load = concentration x volume).

Table 3.8 Summary of Estimated Solute Loadings for Selected Rainfall Events

ARI (years)	**Duration** (hours)	**Stockpile**	**Al mg/m2**	**As mg/m2**	**Cl mg/m2**	**K mg/m2**	**Mg mg/m2**	**Na mg/m2**	**Ra226 Bq/m2**	**U mg/m2**	**V mg/m2**
5	1	**VHG**	7.2E+00	6.6E+01	1.3E+06	3.0E+05	1.8E+05	1.6E+06	4.0E+02	2.2E+01	1.5E+01
		HG	7.2E+00	2.5E+01	3.3E+05	7.2E+04	7.6E+04	8.4E+05	5.0E+00	2.2E+01	1.5E+01
		MG	8.7E+00	3.1E+01	1.6E+06	2.9E+05	2.6E+05	1.4E+06	7.6E+01	2.7E+01	1.8E+01
		LG	8.7E+00	5.2E+01	1.5E+06	2.6E+05	1.5E+05	1.5E+06	1.4E+01	2.7E+01	1.8E+01
		Waste	8.7E+00	2.4E+01	1.8E+06	2.7E+05	1.5E+05	1.4E+06	0.0E+00	2.7E+01	1.8E+01
5	6	**VHG**	7.9E+00	3.7E+01	7.6E+05	1.7E+05	1.0E+05	9.0E+05	2.3E+02	2.4E+01	1.6E+01
		HG	7.9E+00	1.4E+01	1.9E+05	4.1E+04	4.3E+04	4.7E+05	2.8E+00	2.4E+01	1.6E+01
		MG	1.4E+01	2.6E+01	1.3E+06	2.4E+05	2.1E+05	1.2E+06	6.3E+01	4.3E+01	2.8E+01
		LG	1.4E+01	4.3E+01	1.2E+06	2.2E+05	1.3E+05	1.2E+06	1.2E+01	4.3E+01	2.8E+01
		Waste	1.4E+01	2.0E+01	1.5E+06	2.2E+05	1.3E+05	1.2E+06	0.0E+00	4.3E+01	2.8E+01
5	48	**VHG**	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		HG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		MG	4.1E+00	3.5E+00	1.8E+05	3.3E+04	2.9E+04	1.6E+05	8.7E+00	1.3E+01	8.4E+00
		LG	4.1E+00	5.9E+00	1.7E+05	3.0E+04	1.7E+04	1.7E+05	1.6E+00	1.3E+01	8.4E+00
		Waste	4.1E+00	2.8E+00	2.1E+05	3.1E+04	1.7E+04	1.6E+05	0.0E+00	1.3E+01	8.4E+00
5	72	**VHG**	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		HG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		MG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		LG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		Waste	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
20	1	**VHG**	1.3E+01	8.2E+01	1.7E+06	3.7E+05	2.2E+05	2.0E+06	5.0E+02	4.0E+01	2.7E+01
		HG	1.3E+01	3.1E+01	4.1E+05	9.0E+04	9.4E+04	1.0E+06	6.2E+00	4.0E+01	2.7E+01
		MG	1.4E+01	3.4E+01	1.7E+06	3.2E+05	2.8E+05	1.6E+06	8.4E+01	4.3E+01	2.9E+01
		LG	1.4E+01	5.8E+01	1.7E+06	2.9E+05	1.7E+05	1.6E+06	1.6E+01	4.3E+01	2.9E+01
		Waste	1.4E+01	2.7E+01	2.0E+06	3.0E+05	1.7E+05	1.6E+06	0.0E+00	4.3E+01	2.9E+01
20	6	**VHG**	2.4E+01	7.4E+01	1.5E+06	3.3E+05	2.0E+05	1.8E+06	4.5E+02	7.4E+01	4.9E+01
		HG	2.4E+01	2.8E+01	3.7E+05	8.1E+04	8.5E+04	9.4E+05	5.6E+00	7.4E+01	4.9E+01
		MG	2.7E+01	3.3E+01	1.6E+06	3.0E+05	2.7E+05	1.5E+06	8.1E+01	8.5E+01	5.7E+01
		LG	2.7E+01	5.5E+01	1.6E+06	2.8E+05	1.6E+05	1.6E+06	1.5E+01	8.5E+01	5.7E+01
		Waste	2.7E+01	2.6E+01	1.9E+06	2.9E+05	1.6E+05	1.5E+06	0.0E+00	8.5E+01	5.7E+01
20	48	**VHG**	2.9E+01	4.0E+01	8.0E+05	1.8E+05	1.1E+05	9.6E+05	2.4E+02	9.0E+01	6.0E+01
		HG	2.9E+01	1.5E+01	2.0E+05	4.3E+04	4.6E+04	5.0E+05	3.0E+00	9.0E+01	5.1E+01
		MG	5.3E+01	2.8E+01	1.4E+06	2.6E+05	2.3E+05	1.3E+06	6.9E+01	1.6E+02	1.1E+02
		LG	5.3E+01	4.7E+01	1.4E+06	2.4E+05	1.4E+05	1.3E+06	1.3E+01	1.6E+02	1.1E+02
		Waste	5.3E+01	2.2E+01	1.6E+06	2.4E+05	1.4E+05	1.3E+06	0.0E+00	1.6E+02	1.1E+02
20	72	**VHG**	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		HG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		MG	5.2E+01	2.4E+01	1.2E+06	2.3E+05	2.0E+05	1.1E+06	6.0E+01	1.6E+02	1.1E+02
		LG	5.2E+01	4.1E+01	1.2E+06	2.1E+05	1.2E+05	1.2E+06	1.1E+01	1.6E+02	1.1E+02
		Waste	5.2E+01	1.9E+01	1.4E+06	2.1E+05	1.2E+05	1.1E+06	0.0E+00	1.6E+02	1.1E+02
100	1	**VHG**	2.3E+01	9.1E+01	1.8E+06	4.1E+05	2.4E+05	2.2E+06	5.6E+02	7.1E+01	4.7E+01
		HG	2.3E+01	3.4E+01	4.6E+05	1.0E+05	1.0E+05	1.2E+06	6.9E+00	7.1E+01	4.7E+01
		MG	2.4E+01	3.6E+01	1.8E+06	3.4E+05	3.0E+05	1.7E+06	8.9E+01	7.3E+01	4.9E+01
		LG	2.4E+01	6.1E+01	1.8E+06	3.1E+05	1.8E+05	1.7E+06	1.7E+01	7.3E+01	4.9E+01
		Waste	2.4E+01	2.9E+01	2.1E+06	3.2E+05	1.8E+05	1.7E+06	0.0E+00	7.3E+01	4.9E+01
100	6	**VHG**	4.9E+01	8.9E+01	1.8E+06	4.0E+05	2.4E+05	2.2E+06	5.5E+02	1.5E+02	1.0E+02
		HG	4.9E+01	3.4E+01	4.5E+05	9.8E+04	1.0E+05	1.1E+06	6.7E+00	1.5E+02	1.0E+02
		MG	5.1E+01	3.6E+01	1.8E+06	3.3E+05	3.0E+05	1.6E+06	8.8E+01	1.6E+02	1.1E+02
		LG	5.1E+01	6.1E+01	1.7E+06	3.0E+05	1.8E+05	1.7E+06	1.6E+01	1.6E+02	1.1E+02
		Waste	5.1E+01	2.8E+01	2.1E+06	3.1E+05	1.8E+05	1.7E+06	0.0E+00	1.6E+02	1.1E+02
100	48	**VHG**	1.0E+02	8.2E+01	1.7E+06	3.7E+05	2.2E+05	2.0E+06	5.0E+02	3.2E+02	2.1E+02
		HG	1.0E+02	3.1E+01	4.1E+05	9.0E+04	9.4E+04	1.0E+06	6.2E+00	3.2E+02	1.1E+02
		MG	1.1E+02	3.5E+01	1.7E+06	3.2E+05	2.9E+05	1.6E+06	8.5E+01	3.4E+02	2.3E+02
		LG	1.1E+02	5.8E+01	1.7E+06	2.9E+05	1.7E+05	1.7E+06	1.6E+01	3.4E+02	2.3E+02
		Waste	1.1E+02	2.7E+01	2.0E+06	3.0E+05	1.7E+05	1.6E+06	0.0E+00	2.4E+02	2.3E+02
100	72	**VHG**	1.1E+02	7.6E+01	1.5E+06	3.5E+05	2.0E+05	1.8E+06	4.7E+02	3.3E+02	2.2E+02
		HG	1.1E+02	2.9E+01	3.8E+05	8.3E+04	8.8E+04	9.7E+05	5.8E+00	3.3E+02	9.9E+01
		MG	1.2E+02	3.4E+01	1.7E+06	3.1E+05	2.8E+05	1.6E+06	8.3E+01	3.8E+02	2.5E+02
		LG	1.2E+02	5.7E+01	1.6E+06	2.9E+05	1.7E+05	1.6E+06	1.5E+01	3.8E+02	2.5E+02
		Waste	1.2E+02	2.7E+01	2.0E+06	2.9E+05	1.7E+05	1.6E+06	0.0E+00	2.4E+02	2.5E+02

In conclusion, as discussed before, the above loadings are valid for active surfaces for the first event of the given proportion. Loadings in runoff from subsequent events from the same surface would be 50 % or less, and most solute release would be depleted to very low levels after the second or third event.

3.2 Tailings Storage Facility

3.2.1 Tailings Cells

The tailings would be deposited with perimeter spigots to form beaches with a pond located centrally in each cell. The excess water would flow towards the pond and would be recovered for recycling to the process. The deposition location would be cycled around the cell to allow the beaches to consolidate before the next layer of tailings is deposited. During tailings deposition, the active cells may be equipped with under-drains, and the surrounding area would be dewatered so that any seepage losses would in effect be captured by the dewatering system and returned to the milling process. It is only after the tailings cells have been decommissioned and operations cease that the porewater from the tailings could potentially be released to groundwater. The source term therefore only considered the post closure conditions that may develop in the tailings.

The solute concentrations present in the tailings porewater initially would reflect the process discharge water, or barren leach liquor, that would be present in the tailings during deposition. The aging tests indicate that different reactions are expected to occur in the tailings after deposition. These include equilibration and ion exchange reactions, both of which would affect the concentrations of a number of solutes. The progress, or degree of equilibrium that would be reached, would depend on the contact time between the porewater and the tailings. The porewater is expected to be displaced over time by recharge from meteoric water that could infiltrate from surface, and/or groundwater that may flow through the tailings, due to hydraulic gradients that may develop across the tailings deposit over time.

The recharge and groundwater flow modelling completed by others (URS, 2011) assess both low and high recharge conditions. The results from their modelling are summarised in Table 3.9 for the low recharge case and in Table 3.10 for the high recharge case. The results in the tables represent average steady state flows.

As shown in the tables, the modelling suggests high evaporative losses from all the cells, which would in effect result in groundwater flows being ‘drawn’ into the tailings mass. The majority of the groundwater inflow would occur vertically from the base of the cells, with horizontal inflows contributing only a small proportion of the total inflows.

The results further indicate that in about 50 % or more of the tailings cells (e.g. 2a, 2b, 6, 7a through 9b, and 13), the vertical outflows significantly exceed the horizontal outflows. For this vertical outflow to occur, a reversal of flows would need to happen at the base of the cells, which could occur only during periods of high recharge and/or low evaporation (i.e. only periodically during the year for short periods). Since the vertical groundwater inflow is much greater than the vertical outflows, essentially groundwater that had flowed into the tailings would be displaced out of the tailings again. Consequently little or none of the porewater originally present in the tailings would be expected to be released to groundwater in the vertical outflow from the cells. Horizontal flows however would be expected to displace porewater from the tailings.

Another consequence of the evaporative losses would be that water would be drawn from the tailings into the vadose zone from where it would be evaporated. The solutes associated with this upward flux would tend to form evaporites in the vadose zone and accumulate over time as a salt build-up, which would remove salts from the porewater of the tailings. The net ‘loss’ of solutes from the tailings would result in a decrease of the total amount of salts that would be available for transport to the groundwater system.

Even though only the horizontal flows would be expected to carry the initial porewater out of the tailings, the total flows were used to assess the time for a complete pore volume displacement from the tailings to occur. The estimates are summarised in Table 3.9 and Table 3.10 respectively for the low and high recharge flows. The estimates assume a tailings porosity of about 0.5 and indicate the time to tailings porewater displacement at steady state flows would vary by cell, and would be dictated by the recharge rate. The retention times are shown to vary from 3000 to in excess of 270 000 years for the tailings cells. The retention time in the backfill cells (10, 11, 22, 23) would be lower and would range from about 100 to 31000 years.

Based on the very long displacement times, equilibrium conditions would be expected to be reached within the tailings porewater.

Table 3.9 Estimated Porewater Retention Times for Backfilled Cells - Low Recharge Estimates

Area	Cell	Cell Area (m^2)	Approx. Tailings Depth (m)	Surface Flows (kL/day)		Groundwater Flows (kL/day)				Source Duration (years)
				Recharge	Evap.	Horizontal Flows		Vertical flows		
				In	Out	In	Out	In	Out	
Tailings	1a	335,000	8	0.218	3.783	0.019	0.007	3.553	0.000	509800
	1b	50,000	8	0.033	0.472	0.006	0.007	0.440	0.000	77200
	2a	117,500	8	0.077	0.638	0.007	0.006	0.585	0.025	42200
	2b	192,500	8	0.126	2.550	0.013	0.003	2.434	0.019	96700
	3a	192,500	8	0.126	4.156	0.011	0.009	4.028	0.000	246700
	3b	207,500	8	0.135	3.584	0.011	0.007	3.445	0.000	332100
	4a	230,000	8	0.150	4.472	0.009	0.013	4.327	0.000	194100
	4b	242,500	8	0.158	2.134	0.008	0.016	1.984	0.000	167300
	5	105,000	8	0.068	1.315	0.005	0.005	1.247	0.000	214100
	6	202,500	8	0.132	0.240	0.001	0.005	0.198	0.086	24400
	7a	52,500	8	0.034	0.299	0.009	0.007	0.275	0.013	29700
	7b	102,500	8	0.067	0.220	0.004	0.007	0.183	0.026	33500
	8a	150,000	8	0.098	0.704	0.016	0.012	0.604	0.003	116600
	8b	147,500	8	0.096	0.603	0.012	0.016	0.527	0.017	49600
	9a	175,000	8	0.114	0.245	0.011	0.005	0.186	0.061	29300
	9b	172,500	8	0.112	0.402	0.008	0.002	0.332	0.048	37900
	12	327,500	8	0.214	5.943	0.052	0.001	5.679	0.000	2397400
	13	292,500	8	0.191	4.180	0.010	0.001	3.992	0.012	253100
Other	10	272,500	8.8	0.256	19.895	86.662	60.257	0.000	5.613	600
	11	172,500	8.7	0.163	9.760	17.614	11.193	5.613	0.000	200
	22	502,500	9.2	0.328	14.842	1.767	0.082	12.960	0.128	30200
	23	425,000	8.6	0.277	15.067	4.764	0.116	10.189	0.045	31000

Table 3.10 Estimated Porewater Retention Times for Backfilled Cells - High Recharge Estimates

Area	Cell	Cell Area (m^2)	Approx. Tailings Depth (m)	Surface Flows (kL/day)		Groundwater Flows (kL/day)				Source Duration (years)
				Recharge	Evap.	Horizontal Flows		Vertical flows		
				In	Out	In	Out	In	Out	
Tailings	1a	335,000	8	2.184	6.234	0.026	0.007	4.030	0.000	520200
	1b	50,000	8	0.326	0.715	0.003	0.006	0.392	0.000	89700
	2a	117,500	8	0.766	1.078	0.019	0.007	0.591	0.292	4300
	2b	192,500	8	1.260	3.579	0.022	0.003	2.448	0.144	14300
	3a	192,500	8	1.260	5.389	0.012	0.007	4.129	0.000	281800
	3b	207,500	8	1.350	4.806	0.013	0.005	3.446	0.000	423900
	4a	230,000	8	1.500	5.746	0.010	0.010	4.246	0.000	255800
	4b	242,500	8	1.580	3.102	0.011	0.014	1.526	0.002	166200
	5	105,000	8	0.685	2.203	0.011	0.007	1.514	0.000	171200
	6	202,500	8	1.320	1.032	0.004	0.007	0.249	0.535	4100
	7a	52,500	8	0.342	0.570	0.025	0.011	0.325	0.111	4700
	7b	102,500	8	0.668	0.714	0.019	0.011	0.282	0.245	4400
	8a	150,000	8	0.978	1.594	0.020	0.013	0.665	0.056	23700
	8b	147,500	8	0.962	1.237	0.019	0.018	0.449	0.175	8400
	9a	175,000	8	1.140	0.658	0.035	0.009	0.116	0.625	3000
	9b	172,500	8	1.120	0.731	0.027	0.002	0.155	0.573	3300
	12	327,500	8	2.140	7.792	0.047	0.001	5.611	0.000	2981200
	13	292,500	8	1.910	5.638	0.011	0.001	3.783	0.062	50400
Other	10	272,500	8.8	2.560	22.763	78.164	53.646	0.000	5.909	100
	11	172,500	8.7	1.630	10.313	18.993	16.607	5.909	0.000	100
	22	502,500	9.2	3.280	16.109	1.638	0.157	12.093	0.741	7100
	23	425,000	8.6	2.771	16.629	4.271	0.139	9.935	0.210	14300

Two strategies were considered for the assessment of the porewater quality that may develop in the tailings. First, the aging tests represent ‘partially’ equilibrated porewater; whilst not fully equilibrated it is the best source of hard data that represent the tailings porewater quality. Second, PHREEQC modelling was undertaken to assess the potential equilibrated conditions that may develop in the tailings.

During processing, the ore is expected to be blended to provide a steady uranium grade feed to the process plant. Consequently, the tailings deposited in the cells would comprise a blend of various ores throughout the life of operations. The blend ratios are likely to vary over time as well. Since the blend ratios are not known, nor which blend ratio would serve as feed for any given cell, it is not possible to assign any particular ore type tested in the current programme to any given cell. For this reason, the average concentrations of aging test results were determined. We recommend that the average aging test results be adopted as the 'best estimate' source term for the tailings. The results are shown in Table 3.11. The table also shows the results from the PHREEQC calculations which show the fully equilibrated condition that may develop. In this case any residual carnotite present in the tailings is expected to dissolve. We therefore recommend that the equilibrated solution concentrations be adopted as the 'upper bound' estimate.

Table 3.11 Summary of Tailings Source Term Estimates

Parameter	**units**	**[1]Best Estimate Concentrations**	**[2]Upper Bound Concentrations**
pH	pH unit	10	10
Total Alkalinity	mgCaCO3/L	58,750	38,524
Ag	mg/L	0.05	<0.05
Al	mg/L	0.12	0.12
As	mg/L	1.42	1.42
B	mg/L	35	35
Ba	mg/L	0.1	0.1
Be	mg/L	<0.05	<0.05
Bi	mg/L	<0.05	<0.05
Br	mg/L	55	55
Ca	mg/L	3.7	0.22
Cd	mg/L	<0.05	<0.05
Cl	mg/L	16583	16461
Co	mg/L	<0.05	<0.05
Cr	mg/L	0.15	0.15
Cu	mg/L	0.46	0.46
F	mg/L	9.0	9.0
Fe	mg/L	1.33	1.33
Hg	mg/L	<0.0005	<0.0005
K	mg/L	1325	1343
Li	mg/L	<0.05	<0.05
Mg	mg/L	6.7	6.7
Mn	mg/L	0.04	0.04
Mo	mg/L	1.6	1.6
Na	mg/L	33917	33686
Ni	mg/L	0.06	0.06
NO3	mg/L	474	471
P	mg/L	1.0	0.32
Pb	mg/L	0.45	0.45
Ra-226	Bq/L	5.0	*5.0*
Sb	mg/L	<0.05	<0.05
Se	mg/L	0.26	0.26
Si	mg/L	12.1	12.0
Sn	mg/L	<0.05	<0.05
SO4	mg/L	10867	29859
Sr	mg/L	0.20	0.20
Tl	mg/L	<0.05	<0.05
U	mg/L	110	249
V	mg/L	53	82
Zn	mg/L	0.5	0.5

Notes: [1] Average of aging test results; [2] PHREEQC predictions

Based on the PHREEQC estimate, the uranium concentration in equilibrium with the residual barren liquor would be expected to increase to about 250 mg/L when in equilibrium with carnotite. We note however that the average U_3O_8 content for numerous tailings samples was about 84.9 ppm. The incremental U concentration that can result in the porewater should this uranium dissolve is about 155 mg/L, and summed with the average barren liquor concentration of about 55 mg/L, the maximum average concentration would be about 210 mg/L. Nevertheless, the uranium content of the tailings is likely to vary due to process upsets and inefficiencies and it is possible that in some cases the upper bound may be reached. Furthermore, the percolate may, as it leaves the tailings, contact below grade material that has been left in place in the surrounding area and additional leaching could occur. We therefore recommend that the PHREEQC predicted equilibrated concentration be retained as the upper bound concentration.

Due to the very long contact times and the relative solubility of the solutes present in the tailings, we expect that most of the soluble secondary minerals would dissolve and be displaced in the first pore volume displacement. We recommend that the concentrations given in the above table be applied as a step function for the duration of the first pore volume displacement after which concentrations would be expected to revert to near background levels.

3.2.2 Other Materials

As noted above, cells 10 and 11, as well as 22 and 23, would be backfilled with materials other than tailings. It is our understanding that these cells are likely to be backfilled primarily with materials from the waste and possibly low grade type stockpiles, with an approximate composition of 33 % LG material and the balance waste. The leach extraction test results were used to calculate potential porewater quality for the backfilled materials based on this ratio. The results are shown in Table 3.12. As for the tailings, the source concentrations would apply for the first pore volume displacement (duration shown in Table 3.9) after which porewater quality would revert to background levels.

Table 3.12 Summary of Estimate Solute Concentration in Percolate from Cells 10 and 11 and Cells 22 and 23

Parameter	Units	Concentrations
Ag	mg/L	0.006
Al	mg/L	1.85
As	mg/L	0.266
B	mg/L	46.7
Ba	mg/L	0.005
Be	mg/L	0.181
Bi	mg/L	0.005
Br	mg/L	49.3
Ca	mg/L	325
Cd	mg/L	0.179
Cl	mg/L	13445
Co	mg/L	0.181
Cr	mg/L	0.219
Cu	mg/L	0.215
F	mg/L	64.7
Fe	mg/L	4.4
Hg	mg/L	0.005
K	mg/L	2107
Li	mg/L	0.188
Mg	mg/L	1203
Mn	mg/L	0.462
Mo	mg/L	1.35
Na	mg/L	11380
Ni	mg/L	0.181
NO3	mg/L	345
P	mg/L	4.68
Pb	mg/L	0.181
Ra226	Bq/L	0.037
Sb	mg/L	0.005
Se	mg/L	0.326
Si	mg/L	47.3
Sn	mg/L	0.181
SO4	mg/L	6868
Sr	mg/L	14.5
Tl	mg/L	0.360
Total Alkalinity (CaCO3)	mg/L	103
U	mg/L	2.60
V	mg/L	4.61
Zn	mg/L	4.36

3.3 Roads and Hardstands

The roads and hard stands around the site would be sprayed with general use water for dust suppression during operations. Whilst the materials that would be used for road and hardstand construction would be sourced locally, they are not expected to generate solutes in themselves. However, the spray water is expected to contain same salts. The general use water would represent a blend of raw water (from supply water wells) and recycled water. A water balance was prepared for the site by others (see ERMP, Appendix G1 Surface Water), which was used to estimate the general use water quality. The water balance enabled calculation of the water quality over time for the life of operations. The results are presented in Appendix 2.

After wetting of the road and other surfaces with the spray water, the water is expected to evaporate rapidly while the salts would accumulate on the surface or near surface of the road and hardstand base. The rate of salt accumulation would depend on the rate of water application and the salt content of the spray water.

Similar to the stockpile areas, the accumulated salts near the surface of the roads and hardstands are expected to dissolve in runoff and report to surface water during rainfall events. Therefore, a calculation approach similar to that described for the stockpiles, but with a few modifications to account for the ongoing salt accumulation, was adopted to estimate the potential loadings from the roads. The calculation steps were as follows:

1 The total solute application rate for any given year was calculated by multiplying the specific water application rate (L/m^2/day) with the solute concentration (mg/L) to give a solute accumulation rate (mg/m^2/day). The dust suppression water application rate was determined by BHPB to be about 0.85 L/m^2/day. As discussed for the stockpiles, the climate data suggest that the longest dry period is about 120 days. Therefore, the maximum solute accumulation was obtained by multiplying the accumulation rate with 120 days. This yields the maximum potential solute load that could report to runoff.

2 As described for the stockpiles, the Green-Ampt model was used to calculate the amount of initial abstraction and runoff for any given rainfall event. The material properties for the roads and hardstands were assumed to be similar to that of a sandy clay loam, with a porosity of 0.40, effective porosity of 0.33, a suction head of 218 mm and a hydraulic conductivity of 1.5 mm/h.

3 As before, the total available solute was dissolved into the total amount of water. The solute concentrations were calculated and corrected for solubility constraints as necessary. Then, accounting for the initial abstraction, the net loading to surface runoff was calculated as a loading per unit surface area for the 120 day period. The solute loadings can then be used to calculate the maximum release for any given event for any given year, with the proviso that the dry period (between runoff generating events) does not exceed 120 days.

Example runoff water quality results for the roads and hardstands are presented in Figure 3.6 for a 1:5 year – 1 hour duration rainfall event, and in Figure 3.6 for a 1:100 year 1 hour duration event. These concentrations represent the water that would flow directly off the applicable surface areas and do not consider any dilution from run-on or other runoff within the catchment. The chloride concentrations are not dissimilar to those estimated for the stockpile runoff. The uranium and vanadium originates primarily from the recycle water.

The solute loadings calculated for a series of rainfall events are provided in Appendix 2. Note that unlike the stockpile loadings, the salt loadings are continuously re-supplied by the application of spray water. The estimated solute loadings provided in the appendix are therefore applicable to the given year.

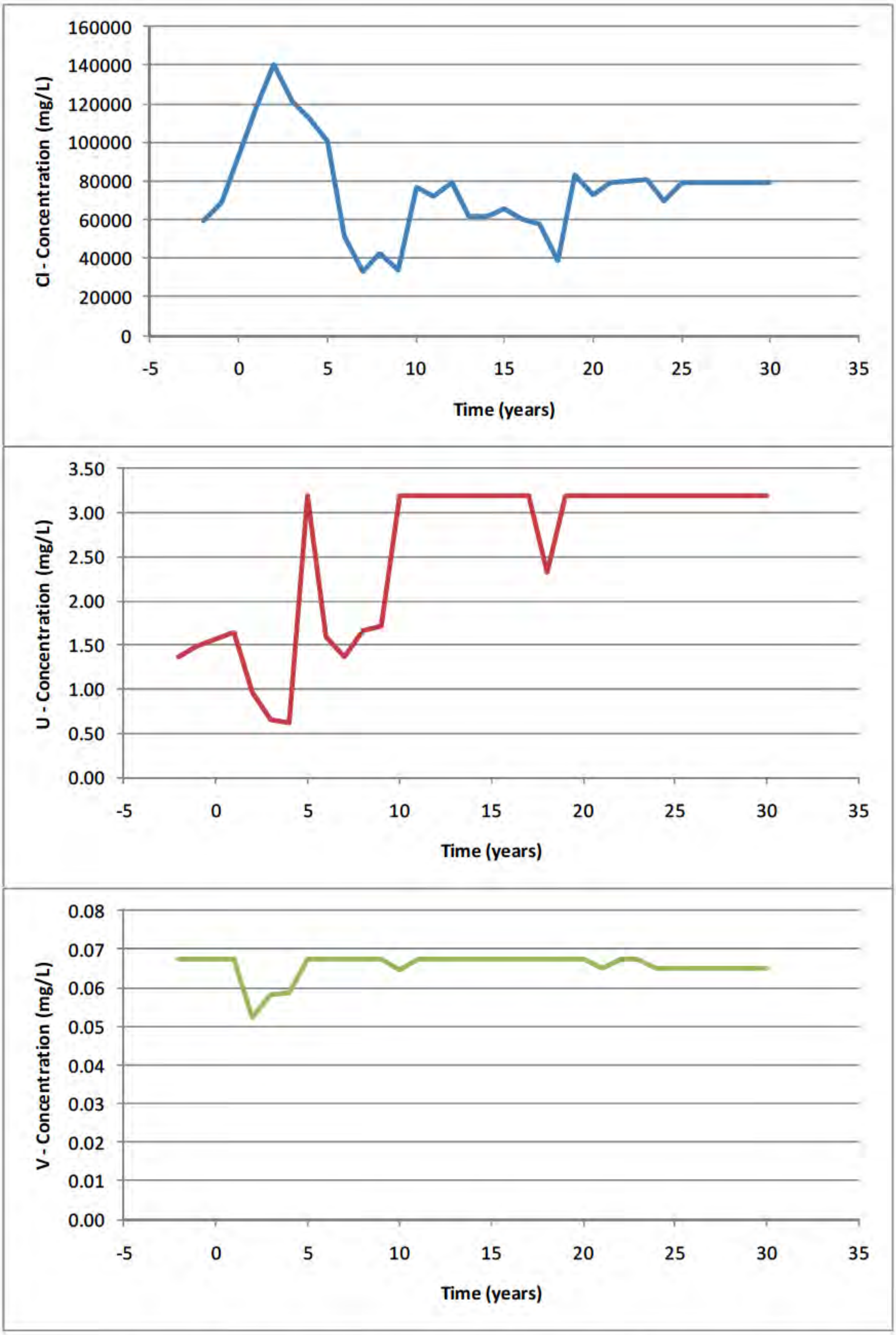

Figure 3.5 Example Roads and Hardstand Runoff Water Quality Calculated for a 1:5 year 1 hour Duration Event

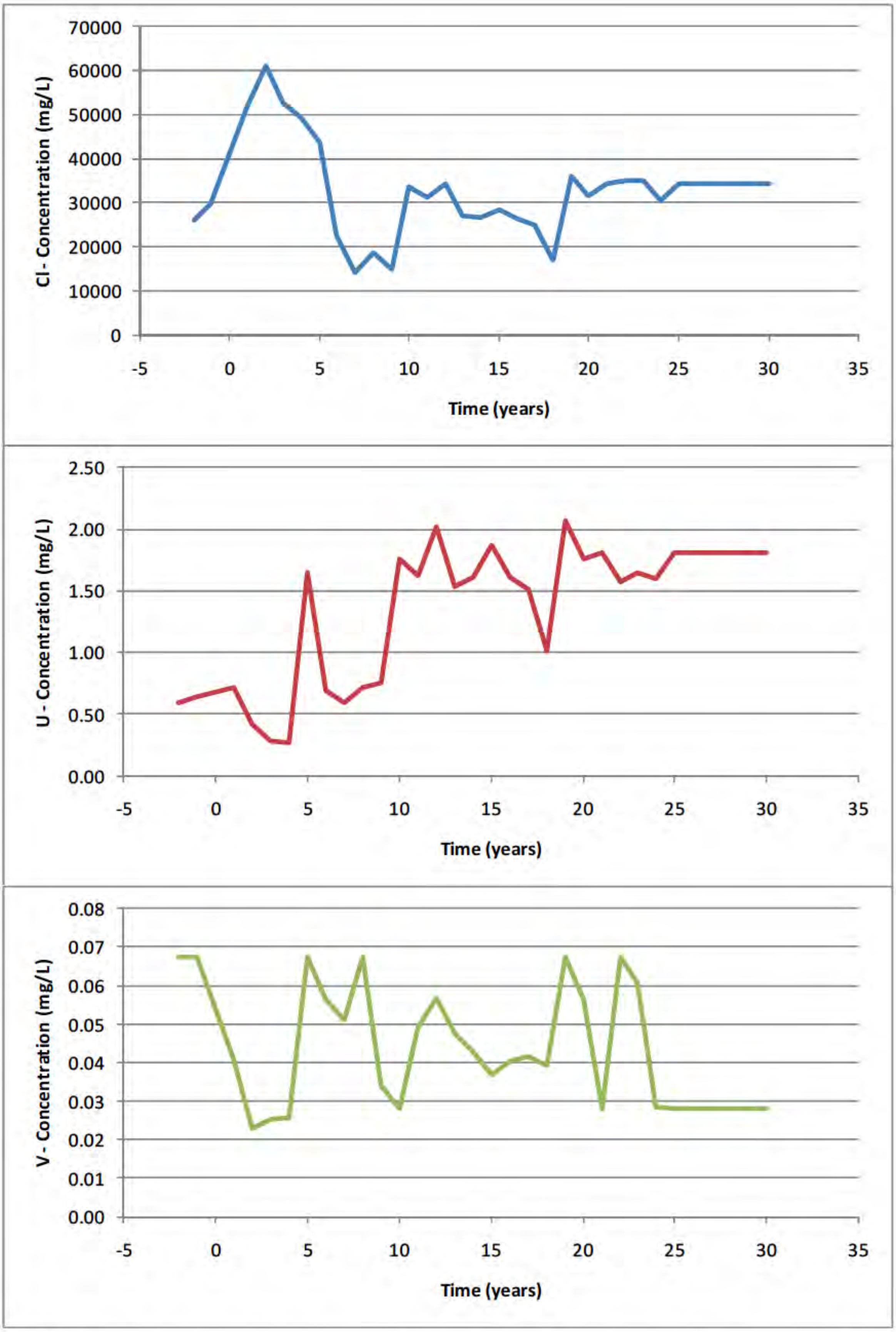

Figure 3.6 Example Roads and Hardstand Runoff Water Quality Calculated for a 1:100 year 1 hour Duration Event

3.4 Contaminant Mobility in the Groundwater System

The transport of contaminants along groundwater flow paths may be attenuated as follows:

- Incorporation within precipitating secondary minerals. Precipitation may occur due to changing chemical conditions along the seepage flow path, e.g. increasing pH, or changes in solute concentrations.
- Mineral surface interactions, such as sorption and ion exchange.

Many contaminants, should they be released into Yeelirrie surface or groundwater, would likely form neutral or anionic species in solution and are unlikely to participate strongly in cation exchange reactions. These contaminants include: U, V, Se, Mo, and As. Mobility of these elements is most likely to be controlled by a combination of sorption and precipitation of minerals such as sulphates and carnotite along the flow path. Sorption would likely be low (at the high dissolved carbonate conditions) to modest (low dissolved carbonate). The likelihood of precipitation is high in the near surface environment due to the high evaporation rates observed, and further afield where carbonate concentrations are expected to decrease).

These effects are discussed briefly in the following sections.

3.4.1 Secondary Mineralisation

The source term concentrations as developed and recommended herein, were used by others as input to some initial groundwater transport modelling and a preliminary estimate of contaminant concentrations downstream of the TSF was made. Simple mass balance calculations were also completed on the basis of the flow modelling results for the high recharge rate case (URS, 2011). Since the groundwater flow modelling suggests that flows would vary through each of the cells the concentrations that would occur would be different for the different cells. Adopting the steady state flow conditions and considering the effects of evaporation on the solute concentrations, the calculations showed that, for example for Cell 2a, the uranium concentration could increase over a period of many centuries to about 1500 mg/L or more. This high concentration would result from the evapo-concentrating effect (from evaporative losses) at the water table interface. The movement of water into the overlying soils through capillary action would lead to some of the solutes accumulating as salts in the vadose zone. Therefore, not all of the solutes may necessarily be available for transport downstream of the TSF.

Nevertheless, these potentially very high concentrations were assessed using the PHREEQC modelling to determine the effects of solubility limits on the uranium concentration within and immediately downstream of the TSF facility. To complete the PHREEQC modelling it was necessary to also estimate other solute concentrations, including the alkalinity, potassium, and sodium and vanadium concentrations at the equivalent location. The concentrations for these solutes were assumed to increase proportionally with the uranium concentration (relative to the initial source concentrations). The concentrations were then corrected first for ion exchange reactions (whereby sodium and potassium would displace calcium from the available ion exchange sites) and second for the formation of calcite (reaction of the liberated calcium with the excess alkalinity). The corrected concentrations were then assessed using PHREEQC.

The results suggest that carnotite would form and that the uranium concentration at the TSF outflow should decrease to less than 0.05 mg/L. The vanadium concentration would decrease from about 500 mg/L to about 170 mg/L. Although also taken up in the formation of carnotite, the vanadium concentration would be higher than the uranium concentration because there is an excess of vanadium that would be released from the tailings (i.e. more vanadium is available than can stoichiometrically be consumed by the formation of carnotite).

In summary, even though the porewater of the tailings at deposition would contain elevated concentrations of uranium, the modelling suggests that the uranium mobility in the long term would be restricted to the near-field of the TSF by the formation of carnotite. This is very much similar to the existing conditions that currently limit the mobility of the uranium within the ore deposit. However, vanadium would be released at concentrations above background levels. The reason for this is that during ore processing uranium is removed while vanadium remains in the solution phase and reports to the tailings. Therefore, when carnotite is re-precipitated, not all of the vanadium would be removed. Some proportion of this vanadium would however be ‘lost’ to the vadose zone and would not be released to the downstream environment.

3.4.2 Sorption and Ion Exchange

Clays are likely to play an important role in controlling contaminant mobility. Most Yeelirrie materials contain significant quantities of clay. Swelling clays in particular, have a high capacity to adsorb cationic species and are particularly strong adsorbents for alkaline metals (Na, K) and alkaline earths (Ca, Mg). Results from the geochemical investigation indicated that the very high Na levels in some leachates (i.e. tailings porewater) result in displacement of other elements from exchange sites when contacted with materials outside the mining area. In other words, high Na 'fronts' moving through Yeelirrie materials may be coincident with Ca leaching fronts (cation exchange studies indicate that current site occupancy is dominated by Ca). If trace contaminants such as Sr and Ra also occupy such sites, there is the possibility that these elements, as well as Ca, would be leached as the Na front advances. The front however would diminish as it moves away from the TSF area, as the sodium is sorbed and other ions released. These effects would therefore be limited to the near range of the TSF.

As part of the geochemical investigation, sorption coefficients were estimated for the various solutes as summarised Table 3.13. These coefficients may be used to assess, for example, the attenuation of vanadium in the downstream environment should it be necessary. Note however that the sorption is a reversible process.

Table 3.13 Summary of Recommended Sorption Coefficients

Solute	**Sorption coefficient, cm^{3}g^{-1}**	
	Loams	**Clay-Quartz**
As	350	1.3
Ba	0	0
B	51	3
Cd	0	5.3
Cr	4	10
Cu	0.93	1.1
Mn	2	2
Mo	47	0.67
Ni	0	0
Se	50	0.83
Sr	0	0
Tl	0	0
Sn	0.7	1.9
U	420	1.1
V	480	2.7
Zn	0	0
Ra-226	0	2.8

4. Conclusions and Recommendations

The outcomes of the supporting field and laboratory geochemical investigations, together with an understanding of the site conditions and the design and proposed development of the site components, were used to develop source terms for:

- Temporary mine waste and ore stockpiles that would be developed adjacent the mining area;
- The tailings storage facility that would be developed in the open pit areas; and,
- The roads and hardstands that would be sprayed with saline water for dust suppression.

In addition, the potential controls on solute transport in groundwater downstream of the tailings storage facility are discussed. The conclusion and recommendations for each area of the site are described below.

4.1 Mine Waste and ore stockpiles

A procedure for the estimation of solute release rates has been developed and is described. The approach relies on experimental test results to assess the overall capacity of the waste and ore materials to release solutes, and considers the physical interaction of rainfall and runoff with the exposed surfaces. Two source terms representing a base case and an upper bound (or worst case) were developed. The two cases are differentiated on the basis of the duration for which the exposed surfaces would continue to leach solutes. The base case assumes that placed surfaces remain active for one calendar year. This is not unreasonable since the experimental test results showed that the solute release occurs rapidly and generally is removed within the first flush.

The upper bound case assumes that all exposed surfaces remain active at all times. The solute release presented for the upper bound or worst case scenario is therefore possible for any given year only if the surfaces had not been subjected to runoff in any of the preceding years since the surface had been placed. Rainfall data indicate that typically during each calendar two or more rainfall events would occur that could generate runoff. Therefore, the upper bound case very much represents an absolute worst case and is considered unlikely to materialise.

Of further significance is that the solute release capacity of the stockpile materials is finite; once the solute release has occurred it is not ‘regenerated’ (no new solutes are generated to replace the solutes that have been washed away). Whilst a proportion of the available solute would be ‘returned’ to the exposed material by abstraction, the majority (> 50 %) would be flushed away during the first runoff event. The proportion of the solutes would continue to diminish by more than 50 % for every subsequent runoff event, so that by the third event solute release would become insignificant. For the base case the surfaces are assumed to remain active for one calendar year. As noted before, during each calendar typically two or more events would occur that could generate runoff. Therefore, the base case is reasonable.

We recommend that the solute release for the base case be adopted for the assessment of potential impacts on surface water quality in or around the mining area.

4.2 Tailings Storage Facility

During operations and active deposition, dewatering activities and water management strategies proposed for the tailings cells would be expected to preclude the loss of porewater to the groundwater system. Only after the tailings cells have been decommissioned and operations cease could the porewater from the tailings potentially be released to groundwater. The source terms developed herein therefore only considered the post closure conditions that may develop in the tailings.

The solute concentrations present the tailings porewater initially would reflect the process discharge water, or barren leach liquor, that would be present in the tailings during deposition.

The aging tests indicated that different reactions would be expected to occur in the tailings after deposition, including equilibration and ion exchange reactions. The recharge and groundwater flow modelling completed by others indicate that the contact time between the tailings and the porewater would be several thousand years to possibly several hundred thousands of years. Fully equilibrated conditions would therefore be expected to develop in the tailings porewater.

The aging tests were designed to assess the development of equilibrium conditions over time. However, the contact times expected in the field are much longer than possibly can be assessed in the laboratory tests. Therefore the test results would represent the initial conditions that may exist in the tailings. The upper bound concentrations were estimated by completing geochemical speciation modelling to assess fully equilibrated conditions. The results indicated that any residual carnotite that remains in the tailings could be leached due to the elevated soda ash concentrations in the porewater. The uranium concentrations were predicted to increase in the longer term.

The groundwater transport modelling indicated that high evaporative losses from all the TSF cells would occur after closure. This would result in groundwater flows 'drawn' into the tailings mass over time. The majority of the groundwater inflow would occur vertically from the base of the cells, with horizontal inflows typically contributing only a small proportion of the total inflows. The modelling further suggests that the vertical outflows from the majority of the cells significantly exceed the horizontal outflows. For this vertical outflow to occur, a reversal of flows would need to happen at the base of the cells, and consequently little or none of the porewater originally present in the tailings would be expected to be released to groundwater in the vertical outflow from the cells. (Consider a sponge that was used to 'suck up' water from a table – when squeezed to discharge the water, the water sucked up last would be released first.) Horizontal flows would be expected to displace porewater from the tailings, however.

Evaporative losses would also be expected to form evaporites in the vadose zone and accumulate over time as a salt build-up, which would remove salts from the porewater of the tailings. The net 'loss' of solutes from the tailings would decrease the total salt loading that would be available for transport to the groundwater system.

Notwithstanding, we recommend that the average aging test results be adopted as the 'best estimate' source term for the tailings. The results from the PHREEQC calculations which show the fully equilibrated conditions that may develop in the tailings, should be adopted as the 'upper bound' estimate. We recommend that these source terms be applied to all the flows that leave the cells.

Due to the very long contact times and the relative solubility of the solutes present in the tailings, we expect that most of the soluble secondary minerals would dissolve and be displaced in the first pore volume displacement. The source terms therefore may be represented as step functions for the duration of the first pore volume displacement after which concentrations would be expected to revert to near background levels.

Source term estimates were also developed for the four cells that would be backfilled with unprocessed low grade ore and mine waste. Concentration estimates and source duration calculations are also presented for these cells.

4.3 Roads and Hardstands

The salt loadings associated with the roads and hardstands are continuously re-supplied by the application of spray water for dust suppression. Solute loadings for the roads and hardstands have been estimated based on the water application rates and salinity content of the spray water and are presented as solute loadings per unit surface area. Solute loadings have been calculated for a series of rainfall events and may be used to estimate effects on surface runoff water quality.

4.4 Effects on Solute Transport

Groundwater transport modelling completed by others indicated very high evaporative losses from the tailings which would lead to evapo-concentration of contaminants (i.e. increased solute concentrations). Simple mass balance calculations based on the modelled flows suggest for example that uranium concentrations could increase to more that 1000 mg/L in the very long term. However, geochemical modelling based on the changes in solute concentrations and the influence of ion exchange, indicates that carnotite would be expected to form and that the uranium concentration at the TSF outflow should decrease to very low concentrations, approaching current background levels. The vanadium concentrations however would remain elevated above background levels (at about 170 mg/L) because there is excess vanadium that would not be taken up in the precipitation reactions (i.e. more vanadium is available than can be consumed by the formation of carnotite).

In conclusion, whilst the modelling and testing indicate that in the short term after closure uranium and other solute concentrations would be expected to increase within the tailings porewater, the potential for solute is first of all limited by the very low flows that would be displaced from the tailings. In the longer term, evaporation and subsequent interaction would lead to a net loss of alkalinity from the porewater and an increase in the potassium concentration, which, together with other equilibration reactions, are expected to lead to carnotite precipitation. The formation of carnotite would lead to uranium concentrations that would be similar to current background concentrations. However, vanadium concentrations would be expected to remain above background levels and could be as high as 170 mg/L in the tailings porewater. As noted before, the rate of vanadium release would be limited by the rate of porewater release from the tailings. Furthermore, vanadium would be expected to be attenuated to some degree in the downstream clay quartz materials (K_D = 2.7 cm^3/g), but particularly in loams (K_D = 480 cm^3/g).

5. References

Parkhurst, D.L. and Appelo, C.A.J. *User's guide to PHREEQC (Version 2) – A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations*. Water-Resources Investigations Report 99-4259, 1999.

SRK, 2011. *Proposed Yeelirrie Development: Geochemical Assessment of Tailings and Mine Waste*, Project Number BHP047/1, March 2011.

URS,2011. Groundwater Study - Proposed Yeelirrie Development. Document Reference 42907583/W0436.498/0, March 2011.

Appendices

Appendix 1: Stockpile Solute Release Rates

Depth of influence (m) 0.5
Dry Period (days) 120

Event Conditions		Location	Loadings																			
ARI	**Duration**	**Stockpile**	**TDS**	**Ag**	**Al**	**As**	**B**	**Ba**	**Be**	**Bi**	**Br**	**Ca**	**Cd**	**Cl**	**Co**	**Cr**	**Cu**	**F**	**Fe**	**Hg**	**K**	**Li**
Years	hours		**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**
5	1	**VHG**	4.9E+06	6.7E-02	7.2E+00	6.6E+01	5.8E+03	5.6E+00	6.5E-01	6.3E-01	3.6E-01	7.4E+03	5.9E-01	1.3E+06	1.9E+01	7.7E-01	8.5E-01	6.5E+03	5.3E-01	2.4E-02	3.0E+05	2.0E+01
		HG	1.6E+06	6.7E-02	7.2E+00	2.5E+01	1.8E+03	5.6E+00	6.5E-01	6.3E-01	3.6E-01	7.4E+03	5.9E-01	3.3E+05	1.8E+01	7.7E-01	8.5E-01	6.5E+03	5.3E-01	2.4E-02	7.2E+04	1.8E+01
		MG	4.6E+06	8.1E-02	8.7E+00	3.1E+01	5.5E+03	6.8E+00	7.9E-01	7.6E-01	4.3E-01	8.9E+03	7.1E-01	1.6E+06	2.0E+01	9.3E-01	1.0E+00	8.9E+03	6.4E-01	2.8E-02	2.9E+05	2.1E+01
		LG	3.9E+06	8.1E-02	8.7E+00	5.2E+01	4.6E+03	6.8E+00	7.9E-01	7.6E-01	4.3E-01	8.9E+03	7.1E-01	1.5E+06	2.4E+01	9.3E-01	1.0E+00	9.0E+03	6.4E-01	2.8E-02	2.6E+05	2.7E+01
		Waste	4.5E+06	8.1E-02	8.7E+00	2.4E+01	6.6E+03	6.8E+00	7.9E-01	7.6E-01	4.3E-01	8.9E+03	7.1E-01	1.8E+06	2.2E+01	9.3E-01	1.0E+00	7.8E+03	6.4E-01	2.8E-02	2.7E+05	2.2E+01
5	6	**VHG**	2.8E+06	7.3E-02	7.9E+00	3.7E+01	3.3E+03	6.1E+00	7.1E-01	6.8E-01	3.9E-01	8.0E+03	6.4E-01	7.6E+05	1.1E+01	8.3E-01	9.2E-01	3.7E+03	5.8E-01	2.6E-02	1.7E+05	1.1E+01
		HG	9.5E+05	7.3E-02	7.9E+00	1.4E+01	1.0E+03	6.1E+00	7.1E-01	6.8E-01	3.9E-01	8.0E+03	6.4E-01	1.9E+05	1.0E+01	8.3E-01	9.2E-01	3.7E+03	5.8E-01	2.6E-02	4.1E+04	1.0E+01
		MG	3.9E+06	1.3E-01	1.4E+01	2.6E+01	4.5E+03	1.1E+01	1.2E+00	1.2E+00	6.9E-01	1.4E+04	1.1E+00	1.3E+06	1.6E+01	1.5E+00	1.6E+00	7.4E+03	1.0E+00	4.5E-02	2.4E+05	1.8E+01
		LG	3.3E+06	1.3E-01	1.4E+01	4.3E+01	3.8E+03	1.1E+01	1.2E+00	1.2E+00	6.9E-01	1.4E+04	1.1E+00	1.2E+06	2.0E+01	1.5E+00	1.6E+00	7.5E+03	1.0E+00	4.5E-02	2.2E+05	2.2E+01
		Waste	3.7E+06	1.3E-01	1.4E+01	2.0E+01	5.4E+03	1.1E+01	1.2E+00	1.2E+00	6.9E-01	1.4E+04	1.1E+00	1.5E+06	1.8E+01	1.5E+00	1.6E+00	6.4E+03	1.0E+00	4.5E-02	2.2E+05	1.8E+01
5	48	**VHG**	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		HG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		MG	5.5E+05	3.8E-02	4.1E+00	3.5E+00	6.2E+02	3.2E+00	3.7E-01	3.5E-01	2.0E-01	4.1E+03	3.3E-01	1.8E+05	2.3E+00	4.3E-01	4.8E-01	1.0E+03	3.0E-01	1.3E-02	3.3E+04	2.4E+00
		LG	4.6E+05	3.8E-02	4.1E+00	5.9E+00	5.3E+02	3.2E+00	3.7E-01	3.5E-01	2.0E-01	4.1E+03	3.3E-01	1.7E+05	2.8E+00	4.3E-01	4.8E-01	1.0E+03	3.0E-01	1.3E-02	3.0E+04	3.1E+00
		Waste	5.3E+05	3.8E-02	4.1E+00	2.8E+00	7.5E+02	3.2E+00	3.7E-01	3.5E-01	2.0E-01	4.1E+03	3.3E-01	2.1E+05	2.5E+00	4.3E-01	4.8E-01	8.9E+02	3.0E-01	1.3E-02	3.1E+04	2.5E+00
5	72	**VHG**	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		HG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		MG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		LG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		Waste	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
20	1	**VHG**	6.2E+06	1.2E-01	1.3E+01	8.2E+01	7.3E+03	1.0E+01	1.2E+00	1.1E+00	6.4E-01	1.3E+04	1.0E+00	1.7E+06	2.3E+01	1.4E+00	1.5E+00	8.2E+03	9.5E-01	4.2E-02	3.7E+05	2.5E+01
		HG	2.1E+06	1.2E-01	1.3E+01	3.1E+01	2.3E+03	1.0E+01	1.2E+00	1.1E+00	6.4E-01	1.3E+04	1.0E+00	4.1E+05	2.3E+01	1.4E+00	1.5E+00	8.1E+03	9.5E-01	4.2E-02	9.0E+04	2.3E+01
		MG	5.2E+06	1.3E-01	1.4E+01	3.4E+01	6.1E+03	1.1E+01	1.3E+00	1.2E+00	6.9E-01	1.4E+04	1.1E+00	1.7E+06	2.2E+01	1.5E+00	1.6E+00	9.9E+03	1.0E+00	4.5E-02	3.2E+05	2.4E+01
		LG	4.4E+06	1.3E-01	1.4E+01	5.8E+01	5.1E+03	1.1E+01	1.3E+00	1.2E+00	6.9E-01	1.4E+04	1.1E+00	1.7E+06	2.7E+01	1.5E+00	1.6E+00	1.0E+04	1.0E+00	4.5E-02	2.9E+05	3.0E+01
		Waste	5.0E+06	1.3E-01	1.4E+01	2.7E+01	7.3E+03	1.1E+01	1.3E+00	1.2E+00	6.9E-01	1.4E+04	1.1E+00	2.0E+06	2.5E+01	1.5E+00	1.6E+00	8.6E+03	1.0E+00	4.5E-02	3.0E+05	2.5E+01
20	6	**VHG**	5.6E+06	2.2E-01	2.4E+01	7.4E+01	6.5E+03	1.9E+01	2.2E+00	2.1E+00	1.2E+00	2.5E+04	1.9E+00	1.5E+06	2.1E+01	2.5E+00	2.8E+00	7.4E+03	1.8E+00	7.8E-02	3.3E+05	2.2E+01
		HG	1.9E+06	2.2E-01	2.4E+01	2.8E+01	2.1E+03	1.9E+01	2.2E+00	2.1E+00	1.2E+00	2.5E+04	1.9E+00	3.7E+05	2.1E+01	2.5E+00	2.8E+00	7.3E+03	1.8E+00	7.8E-02	8.1E+04	2.1E+01
		MG	5.0E+06	2.5E-01	2.7E+01	3.3E+01	5.8E+03	2.1E+01	2.5E+00	2.4E+00	1.4E+00	2.8E+04	2.2E+00	1.6E+06	2.1E+01	2.9E+00	3.2E+00	9.5E+03	2.0E+00	8.9E-02	3.0E+05	2.3E+01
		LG	4.3E+06	2.5E-01	2.7E+01	5.5E+01	4.9E+03	2.1E+01	2.5E+00	2.4E+00	1.4E+00	2.8E+04	2.2E+00	1.6E+06	2.6E+01	2.9E+00	3.2E+00	9.6E+03	2.0E+00	8.9E-02	2.8E+05	2.9E+01
		Waste	4.9E+06	2.5E-01	2.7E+01	2.6E+01	7.0E+03	2.1E+01	2.5E+00	2.4E+00	1.4E+00	2.8E+04	2.2E+00	1.9E+06	2.4E+01	2.9E+00	3.2E+00	8.2E+03	2.0E+00	8.9E-02	2.9E+05	2.4E+01
20	48	**VHG**	3.1E+06	2.7E-01	2.9E+01	4.0E+01	3.5E+03	2.3E+01	2.6E+00	2.5E+00	1.4E+00	3.0E+04	2.4E+00	8.0E+05	1.1E+01	3.1E+00	3.4E+00	3.9E+03	2.1E+00	9.5E-02	1.8E+05	1.2E+01
		HG	1.1E+06	2.7E-01	2.9E+01	1.5E+01	1.1E+03	2.3E+01	2.6E+00	2.5E+00	1.4E+00	3.0E+04	2.4E+00	2.0E+05	1.1E+01	3.1E+00	3.4E+00	3.9E+03	2.1E+00	9.5E-02	4.3E+04	1.1E+01
		MG	4.5E+06	4.9E-01	5.3E+01	2.8E+01	5.0E+03	4.1E+01	4.8E+00	4.6E+00	2.6E+00	5.4E+04	4.3E+00	1.4E+06	1.8E+01	5.6E+00	6.3E+00	8.1E+03	3.9E+00	1.7E-01	2.6E+05	1.9E+01
		LG	3.8E+06	4.9E-01	5.3E+01	4.7E+01	4.2E+03	4.1E+01	4.8E+00	4.6E+00	2.6E+00	5.4E+04	4.3E+00	1.4E+06	2.2E+01	5.6E+00	6.3E+00	8.2E+03	3.9E+00	1.7E-01	2.4E+05	2.5E+01
		Waste	4.3E+06	4.9E-01	5.3E+01	2.2E+01	6.0E+03	4.1E+01	4.8E+00	4.6E+00	2.6E+00	5.4E+04	4.3E+00	1.6E+06	2.0E+01	5.6E+00	6.3E+00	7.1E+03	3.9E+00	1.7E-01	2.4E+05	2.0E+01
20	72	**VHG**	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		HG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		MG	3.9E+06	4.8E-01	5.2E+01	2.4E+01	4.3E+03	4.0E+01	4.6E+00	4.5E+00	2.6E+00	5.3E+04	4.2E+00	1.2E+06	1.6E+01	5.5E+00	6.1E+00	7.1E+03	3.8E+00	1.7E-01	2.3E+05	1.7E+01
		LG	3.3E+06	4.8E-01	5.2E+01	4.1E+01	3.6E+03	4.0E+01	4.6E+00	4.5E+00	2.6E+00	5.3E+04	4.2E+00	1.2E+06	1.9E+01	5.5E+00	6.1E+00	7.1E+03	3.8E+00	1.7E-01	2.1E+05	2.1E+01
		Waste	3.8E+06	4.8E-01	5.2E+01	1.9E+01	5.2E+03	4.0E+01	4.6E+00	4.5E+00	2.6E+00	5.3E+04	4.2E+00	1.4E+06	1.8E+01	5.5E+00	6.1E+00	6.1E+03	3.8E+00	1.7E-01	2.1E+05	1.8E+01
100	1	**VHG**	6.9E+06	2.1E-01	2.3E+01	9.1E+01	8.1E+03	1.8E+01	2.1E+00	2.0E+00	1.1E+00	2.4E+04	1.9E+00	1.8E+06	2.6E+01	2.4E+00	2.7E+00	9.1E+03	1.7E+00	7.5E-02	4.1E+05	2.8E+01
		HG	2.3E+06	2.1E-01	2.3E+01	3.4E+01	2.5E+03	1.8E+01	2.1E+00	2.0E+00	1.1E+00	2.4E+04	1.9E+00	4.6E+05	2.5E+01	2.4E+00	2.7E+00	9.0E+03	1.7E+00	7.5E-02	1.0E+05	2.5E+01
		MG	5.5E+06	2.2E-01	2.4E+01	3.6E+01	6.4E+03	1.8E+01	2.1E+00	2.1E+00	1.2E+00	2.4E+04	1.9E+00	1.8E+06	2.3E+01	2.5E+00	2.8E+00	1.1E+04	1.7E+00	7.7E-02	3.4E+05	2.5E+01
		LG	4.7E+06	2.2E-01	2.4E+01	6.1E+01	5.4E+03	1.8E+01	2.1E+00	2.1E+00	1.2E+00	2.4E+04	1.9E+00	1.8E+06	2.9E+01	2.5E+00	2.8E+00	1.1E+04	1.7E+00	7.7E-02	3.1E+05	3.2E+01
		Waste	5.3E+06	2.2E-01	2.4E+01	2.9E+01	7.7E+03	1.8E+01	2.1E+00	2.1E+00	1.2E+00	2.4E+04	1.9E+00	2.1E+06	2.6E+01	2.5E+00	2.8E+00	9.1E+03	1.7E+00	7.7E-02	3.2E+05	2.6E+01
100	6	**VHG**	6.9E+06	4.6E-01	4.9E+01	8.9E+01	7.9E+03	3.8E+01	4.4E+00	4.3E+00	2.4E+00	5.0E+04	4.0E+00	1.8E+06	2.5E+01	5.2E+00	5.8E+00	8.9E+03	3.6E+00	1.6E-01	4.0E+05	2.7E+01
		HG	2.4E+06	4.6E-01	4.9E+01	3.4E+01	2.5E+03	3.8E+01	4.4E+00	4.3E+00	2.4E+00	5.0E+04	4.0E+00	4.5E+05	2.5E+01	5.2E+00	5.8E+00	8.8E+03	3.6E+00	1.6E-01	9.8E+04	2.5E+01
		MG	5.6E+06	4.7E-01	5.1E+01	3.6E+01	6.4E+03	4.0E+01	4.6E+00	4.5E+00	2.5E+00	5.2E+04	4.1E+00	1.8E+06	2.3E+01	5.4E+00	6.0E+00	1.0E+04	3.7E+00	1.7E-01	3.3E+05	2.5E+01

Depth of influence (m) 0.5
Dry Period (days) 120

Event Conditions		**Location**																			
ARI	**Duration**	**Stockpile**	**Mg**	**Mn**	**Mo**	**Na**	**Ni**	**NO3**	**P**	**Pb**	**Ra226**	**Sb**	**Se**	**Si**	**Sn**	**SO4**	**Sr**	**Tl**	**tal Alkalini**	**U**	**V**	**Zn**
Years	hours		**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**Bq/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**
5	1	**VHG**	1.8E+05	5.3E+01	1.5E+02	1.6E+06	2.2E+01	9.1E+04	5.3E+01	5.3E-02	4.0E+02	5.3E-02	4.2E+01	9.1E+02	2.7E+01	1.4E+06	2.5E+02	3.8E+00	1.4E+04	2.2E+01	1.5E+01	5.2E+02
		HG	7.6E+04	2.1E+01	1.1E+02	8.4E+05	2.1E+01	1.3E+04	5.3E+01	5.3E-02	5.0E+00	5.3E-02	2.1E+01	9.1E+02	2.1E+02	2.7E+05	2.5E+02	3.8E+00	1.4E+04	2.2E+01	1.5E+01	1.2E+02
		MG	2.6E+05	2.3E+01	1.6E+02	1.4E+06	3.2E+01	3.0E+04	6.4E+01	6.4E-02	7.6E+01	6.4E-02	4.0E+01	1.1E+03	2.3E+01	1.1E+06	3.0E+02	4.6E+00	1.7E+04	2.7E+01	1.8E+01	5.3E+02
		LG	1.5E+05	2.5E+01	2.5E+02	1.5E+06	2.4E+01	1.3E+04	6.4E+01	6.4E-02	1.4E+01	6.4E-02	3.7E+01	1.1E+03	2.4E+01	4.7E+05	3.0E+02	4.6E+00	1.7E+04	2.7E+01	1.8E+01	5.0E+02
		Waste	1.5E+05	7.5E+01	1.3E+02	1.4E+06	2.2E+01	5.9E+04	6.4E+01	6.4E-02	0.0E+00	6.4E-02	4.3E+01	1.1E+03	2.2E+01	7.4E+05	3.0E+02	4.6E+00	1.7E+04	2.7E+01	1.8E+01	5.8E+02
5	6	**VHG**	1.0E+05	3.0E+01	8.7E+01	9.0E+05	1.2E+01	5.2E+04	5.8E+01	5.8E-02	2.3E+02	5.8E-02	2.4E+01	9.9E+02	1.5E+01	8.1E+05	2.7E+02	4.2E+00	1.5E+04	2.4E+01	1.6E+01	2.9E+02
		HG	4.3E+04	1.2E+01	6.2E+01	4.7E+05	1.2E+01	7.4E+03	5.8E+01	5.8E-02	2.8E+00	5.8E-02	1.2E+01	9.9E+02	1.2E+02	1.7E+05	2.7E+02	4.2E+00	1.5E+04	2.4E+01	1.6E+01	6.7E+01
		MG	2.1E+05	1.9E+01	1.3E+02	1.2E+06	2.7E+01	2.5E+04	1.0E+02	1.0E-01	6.3E+01	1.0E-01	3.3E+01	1.7E+03	1.9E+01	8.9E+05	4.7E+02	7.3E+00	2.6E+04	4.3E+01	2.8E+01	4.4E+02
		LG	1.3E+05	2.0E+01	2.1E+02	1.2E+06	2.0E+01	1.1E+04	1.0E+02	1.0E-01	1.2E+01	1.0E-01	3.1E+01	1.7E+03	2.0E+01	4.1E+05	4.7E+02	7.3E+00	2.6E+04	4.3E+01	2.8E+01	4.1E+02
		Waste	1.3E+05	6.2E+01	1.1E+02	1.2E+06	1.8E+01	4.9E+04	1.0E+02	1.0E-01	0.0E+00	1.0E-01	3.6E+01	1.7E+03	1.8E+01	6.2E+05	4.7E+02	7.3E+00	2.6E+04	4.3E+01	2.8E+01	4.8E+02
5	48	**VHG**	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		HG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		MG	2.9E+04	2.6E+00	1.9E+01	1.6E+05	3.7E+00	3.5E+03	3.0E+01	3.0E-02	8.7E+00	3.0E-02	4.5E+00	5.1E+02	2.6E+00	1.3E+05	1.4E+02	2.2E+00	7.8E+03	1.3E+01	8.4E+00	6.0E+01
		LG	1.7E+04	2.8E+00	2.9E+01	1.7E+05	2.8E+00	1.5E+03	3.0E+01	3.0E-02	1.6E+00	3.0E-02	4.3E+00	5.1E+02	2.8E+00	6.2E+04	1.4E+02	2.2E+00	7.8E+03	1.3E+01	8.4E+00	5.7E+01
		Waste	1.7E+04	8.6E+00	1.5E+01	1.6E+05	2.5E+00	6.8E+03	3.0E+01	3.0E-02	0.0E+00	3.0E-02	4.9E+00	5.1E+02	2.5E+00	9.2E+04	1.4E+02	2.2E+00	7.8E+03	1.3E+01	8.4E+00	6.6E+01
5	72	**VHG**	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		HG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		MG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		LG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		Waste	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
20	1	**VHG**	2.2E+05	6.6E+01	1.9E+02	2.0E+06	2.7E+01	1.1E+05	9.5E+01	9.5E-02	5.0E+02	9.5E-02	5.2E+01	1.6E+03	3.4E+01	1.8E+06	4.4E+02	6.9E+00	2.5E+04	4.0E+01	2.7E+01	6.4E+02
		HG	9.4E+04	2.6E+01	1.4E+02	1.0E+06	2.6E+01	1.6E+04	9.5E+01	9.5E-02	6.2E+00	9.5E-02	2.6E+01	1.6E+03	2.6E+02	3.5E+05	4.4E+02	6.9E+00	2.5E+04	4.0E+01	2.7E+01	1.5E+02
		MG	2.8E+05	2.5E+01	1.8E+02	1.6E+06	3.6E+01	3.4E+04	1.0E+02	1.0E-01	8.4E+01	1.0E-01	4.4E+01	1.8E+03	2.6E+01	1.2E+06	4.7E+02	7.4E+00	2.7E+04	4.3E+01	2.9E+01	5.9E+02
		LG	1.7E+05	2.7E+01	2.8E+02	1.6E+06	2.7E+01	1.4E+04	1.0E+02	1.0E-01	1.6E+01	1.0E-01	4.1E+01	1.8E+03	2.7E+01	5.4E+05	4.7E+02	7.4E+00	2.7E+04	4.3E+01	2.9E+01	5.6E+02
		Waste	1.7E+05	8.4E+01	1.4E+02	1.6E+06	2.5E+01	6.6E+04	1.0E+02	1.0E-01	0.0E+00	1.0E-01	4.8E+01	1.8E+03	2.5E+01	8.3E+05	4.7E+02	7.4E+00	2.7E+04	4.3E+01	2.9E+01	6.4E+02
20	6	**VHG**	2.0E+05	5.9E+01	1.7E+02	1.8E+06	2.5E+01	1.0E+05	1.8E+02	1.8E-01	4.5E+02	1.8E-01	4.7E+01	3.0E+03	3.0E+01	1.6E+06	8.2E+02	1.3E+01	4.6E+04	7.4E+01	4.9E+01	5.8E+02
		HG	8.5E+04	2.3E+01	1.2E+02	9.4E+05	2.3E+01	1.5E+04	1.8E+02	1.8E-01	5.6E+00	1.8E-01	2.3E+01	3.0E+03	2.3E+02	3.5E+05	8.2E+02	1.3E+01	4.6E+04	7.4E+01	4.9E+01	1.3E+02
		MG	2.7E+05	2.4E+01	1.7E+02	1.5E+06	3.4E+01	3.2E+04	2.0E+02	2.0E-01	8.1E+01	2.0E-01	4.2E+01	3.5E+03	2.4E+01	1.2E+06	9.3E+02	1.5E+01	5.2E+04	8.5E+01	5.7E+01	5.6E+02
		LG	1.6E+05	2.6E+01	2.7E+02	1.6E+06	2.6E+01	1.4E+04	2.0E+02	2.0E-01	1.5E+01	2.0E-01	3.9E+01	3.5E+03	2.6E+01	5.5E+05	9.3E+02	1.5E+01	5.2E+04	8.5E+01	5.7E+01	5.3E+02
		Waste	1.6E+05	8.0E+01	1.4E+02	1.5E+06	2.4E+01	6.3E+04	2.0E+02	2.0E-01	0.0E+00	2.0E-01	4.6E+01	3.5E+03	2.4E+01	8.2E+05	9.3E+02	1.5E+01	5.2E+04	8.5E+01	5.7E+01	6.1E+02
20	48	**VHG**	1.1E+05	3.2E+01	9.3E+01	9.6E+05	1.3E+01	5.5E+04	2.1E+02	2.1E-01	2.4E+02	2.1E-01	2.5E+01	3.7E+03	1.6E+01	9.1E+05	9.9E+02	1.5E+01	5.6E+04	9.0E+01	6.0E+01	3.1E+02
		HG	4.6E+04	1.2E+01	6.5E+01	5.0E+05	1.2E+01	7.9E+03	2.1E+02	2.1E-01	3.0E+00	2.1E-01	1.3E+01	3.7E+03	1.2E+02	2.3E+05	5.6E+02	1.2E+01	5.6E+04	9.0E+01	5.1E+01	7.1E+01
		MG	2.3E+05	2.1E+01	1.5E+02	1.3E+06	2.9E+01	2.8E+04	3.9E+02	3.9E-01	6.9E+01	3.9E-01	3.6E+01	6.7E+03	2.1E+01	1.1E+06	1.8E+03	2.8E+01	1.0E+05	1.6E+02	1.1E+02	4.8E+02
		LG	1.4E+05	2.2E+01	2.3E+02	1.3E+06	2.2E+01	1.2E+04	3.9E+02	3.9E-01	1.3E+01	3.9E-01	3.4E+01	6.7E+03	2.2E+01	5.4E+05	1.8E+03	2.8E+01	1.0E+05	1.6E+02	1.1E+02	4.6E+02
		Waste	1.4E+05	6.9E+01	1.2E+02	1.3E+06	2.0E+01	5.4E+04	3.9E+02	3.9E-01	0.0E+00	3.9E-01	3.9E+01	6.7E+03	2.0E+01	7.8E+05	1.5E+03	2.8E+01	1.0E+05	1.6E+02	1.1E+02	5.2E+02
20	72	**VHG**	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		HG	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		MG	2.0E+05	1.8E+01	1.3E+02	1.1E+06	2.6E+01	2.4E+04	3.8E+02	3.8E-01	6.0E+01	3.8E-01	3.1E+01	6.5E+03	1.8E+01	9.5E+05	1.7E+03	2.7E+01	9.9E+04	1.6E+02	1.1E+02	4.2E+02
		LG	1.2E+05	1.9E+01	2.0E+02	1.2E+06	1.9E+01	1.0E+04	3.8E+02	3.8E-01	1.1E+01	3.8E-01	2.9E+01	6.5E+03	1.9E+01	4.8E+05	1.7E+03	2.7E+01	9.9E+04	1.6E+02	1.1E+02	4.0E+02
		Waste	1.2E+05	6.0E+01	1.0E+02	1.1E+06	1.8E+01	4.7E+04	3.5E+02	3.8E-01	0.0E+00	3.8E-01	3.4E+01	6.5E+03	1.8E+01	6.9E+05	1.3E+03	2.7E+01	9.9E+04	1.6E+02	1.1E+02	4.6E+02
100	1	**VHG**	2.4E+05	7.3E+01	2.1E+02	2.2E+06	3.0E+01	1.3E+05	1.7E+02	1.7E-01	5.6E+02	1.7E-01	5.8E+01	2.9E+03	3.7E+01	2.0E+06	7.8E+02	1.2E+01	4.4E+04	7.1E+01	4.7E+01	7.2E+02
		HG	1.0E+05	2.8E+01	1.5E+02	1.2E+06	2.9E+01	1.8E+04	1.7E+02	1.7E-01	6.9E+00	1.7E-01	2.9E+01	2.9E+03	2.8E+02	4.1E+05	7.8E+02	1.2E+01	4.4E+04	7.1E+01	4.7E+01	1.6E+02
		MG	3.0E+05	2.7E+01	1.9E+02	1.7E+06	3.8E+01	3.6E+04	1.7E+02	1.7E-01	8.9E+01	1.7E-01	4.7E+01	3.0E+03	2.7E+01	1.3E+06	8.0E+02	1.3E+01	4.5E+04	7.3E+01	4.9E+01	6.2E+02
		LG	1.8E+05	2.9E+01	3.0E+02	1.7E+06	2.9E+01	1.5E+04	1.7E+02	1.7E-01	1.7E+01	1.7E-01	4.4E+01	3.0E+03	2.9E+01	5.9E+05	8.0E+02	1.3E+01	4.5E+04	7.3E+01	4.9E+01	5.9E+02
		Waste	1.8E+05	8.9E+01	1.5E+02	1.7E+06	2.6E+01	7.0E+04	1.7E+02	1.7E-01	0.0E+00	1.7E-01	5.1E+01	3.0E+03	2.6E+01	9.0E+05	8.0E+02	1.3E+01	4.5E+04	7.3E+01	4.9E+01	6.8E+02
100	6	**VHG**	2.4E+05	7.1E+01	2.1E+02	2.2E+06	3.0E+01	1.2E+05	3.6E+02	3.6E-01	5.5E+02	3.6E-01	5.6E+01	6.2E+03	3.7E+01	2.0E+06	1.7E+03	2.6E+01	9.4E+04	1.5E+02	1.0E+02	7.0E+02
		HG	1.0E+05	2.8E+01	1.5E+02	1.1E+06	2.8E+01	1.8E+04	3.6E+02	3.6E-01	6.7E+00	3.6E-01	2.8E+01	6.2E+03	2.8E+02	4.7E+05	1.3E+03	2.6E+01	9.4E+04	1.5E+02	1.0E+02	1.6E+02
		MG	3.0E+05	2.7E+01	1.9E+02	1.6E+06	3.8E+01	3.5E+04	3.8E+02	3.8E-01	8.8E+01	3.8E-01	4.6E+01	6.4E+03	2.7E+01	1.3E+06	1.7E+03	2.7E+01	9.8E+04	1.6E+02	1.1E+02	6.1E+02

Depth of influence (m) 0.5
Dry Period (days) 120

Event Conditions		**Location**	**Loadings**																				
ARI	**Duration**	**Stockpile**	**TDS**	**Ag**	**Al**	**As**	**B**	**Ba**	**Be**	**Bi**	**Br**	**Ca**	**Cd**	**Cl**	**Co**	**Cr**	**Cu**	**F**	**Fe**	**Hg**	**K**	**Li**
Years	hours		**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**
		LG	4.8E+06	4.7E-01	5.1E+01	6.1E+01	5.4E+03	4.0E+01	4.6E+00	4.5E+00	2.5E+00	5.2E+04	4.1E+00	1.7E+06	2.8E+01	5.4E+00	6.0E+00	1.0E+04	3.7E+00	1.7E-01	3.0E+05	3.2E+01
		Waste	5.4E+06	4.7E-01	5.1E+01	2.8E+01	7.6E+03	4.0E+01	4.6E+00	4.5E+00	2.5E+00	5.2E+04	4.1E+00	2.1E+06	2.6E+01	5.4E+00	6.0E+00	9.0E+03	3.7E+00	1.7E-01	3.1E+05	2.6E+01
100	48	**VHG**	6.7E+06	9.5E-01	1.0E+02	8.2E+01	7.3E+03	8.0E+01	9.2E+00	8.9E+00	5.1E+00	1.0E+05	8.3E+00	1.7E+06	2.3E+01	1.1E+01	1.2E+01	8.2E+03	7.5E+00	3.3E-01	3.7E+05	2.5E+01
		HG	2.5E+06	9.5E-01	1.0E+02	3.1E+01	2.3E+03	8.0E+01	9.2E+00	8.9E+00	5.1E+00	1.0E+05	8.3E+00	4.1E+05	2.3E+01	1.1E+01	1.2E+01	8.1E+03	7.5E+00	3.3E-01	9.0E+04	2.3E+01
		MG	5.8E+06	1.0E+00	1.1E+02	3.5E+01	6.1E+03	8.7E+01	1.0E+01	9.7E+00	5.5E+00	1.1E+05	9.0E+00	1.7E+06	2.2E+01	1.2E+01	1.3E+01	1.0E+04	8.2E+00	3.6E-01	3.2E+05	2.4E+01
		LG	5.0E+06	1.0E+00	1.1E+02	5.8E+01	5.2E+03	8.1E+01	1.0E+01	9.7E+00	5.5E+00	1.1E+05	9.0E+00	1.7E+06	2.7E+01	1.2E+01	1.3E+01	1.0E+04	8.2E+00	3.6E-01	2.9E+05	3.0E+01
		Waste	5.6E+06	1.0E+00	1.1E+02	2.7E+01	7.4E+03	8.2E+01	1.0E+01	9.7E+00	5.5E+00	1.0E+05	9.0E+00	2.0E+06	2.5E+01	1.2E+01	1.3E+01	8.7E+03	8.2E+00	3.6E-01	3.0E+05	2.5E+01
100	72	**VHG**	6.3E+06	9.9E-01	1.1E+02	7.6E+01	6.8E+03	8.3E+01	9.6E+00	9.3E+00	5.3E+00	1.1E+05	8.6E+00	1.5E+06	2.2E+01	1.1E+01	1.3E+01	7.6E+03	7.8E+00	3.5E-01	3.5E+05	2.3E+01
		HG	2.4E+06	9.9E-01	1.1E+02	2.9E+01	2.1E+03	8.3E+01	9.6E+00	9.3E+00	5.3E+00	9.9E+04	8.6E+00	3.8E+05	2.1E+01	1.1E+01	1.3E+01	7.6E+03	7.8E+00	3.5E-01	8.3E+04	2.1E+01
		MG	5.7E+06	1.1E+00	1.2E+02	3.4E+01	6.0E+03	9.5E+01	1.1E+01	1.1E+01	6.0E+00	1.2E+05	9.8E+00	1.7E+06	2.2E+01	1.3E+01	1.4E+01	9.8E+03	8.9E+00	4.0E-01	3.1E+05	2.3E+01
		LG	4.9E+06	1.1E+00	1.2E+02	5.7E+01	5.0E+03	7.9E+01	1.1E+01	1.1E+01	6.0E+00	1.2E+05	9.8E+00	1.6E+06	2.7E+01	1.3E+01	1.4E+01	9.9E+03	8.9E+00	4.0E-01	2.9E+05	3.0E+01
		Waste	5.5E+06	1.1E+00	1.2E+02	2.7E+01	7.2E+03	8.0E+01	1.1E+01	1.1E+01	6.0E+00	1.0E+05	9.8E+00	2.0E+06	2.4E+01	1.3E+01	1.4E+01	8.5E+03	8.9E+00	4.0E-01	2.9E+05	2.4E+01
1000	24	**VHG**	8.8E+06	1.2E+00	1.3E+02	9.2E+01	8.1E+03	9.9E+01	1.1E+01	1.1E+01	6.3E+00	1.3E+05	1.0E+01	1.9E+06	2.6E+01	1.3E+01	1.5E+01	9.1E+03	9.3E+00	4.1E-01	4.2E+05	2.8E+01
		HG	2.9E+06	1.2E+00	1.3E+02	3.5E+01	2.5E+03	9.9E+01	1.1E+01	1.1E+01	6.3E+00	1.2E+05	1.0E+01	4.6E+05	2.6E+01	1.3E+01	1.5E+01	9.1E+03	9.3E+00	4.1E-01	1.0E+05	2.6E+01
		MG	8.3E+06	1.2E+00	1.3E+02	3.6E+01	6.5E+03	1.0E+02	1.2E+01	1.1E+01	6.5E+00	1.3E+05	1.1E+01	1.8E+06	2.3E+01	1.4E+01	1.5E+01	1.1E+04	9.6E+00	4.2E-01	3.4E+05	2.5E+01
		LG	5.3E+06	1.2E+00	1.3E+02	6.1E+01	5.4E+03	8.5E+01	1.2E+01	1.1E+01	6.5E+00	1.3E+05	1.1E+01	1.8E+06	2.9E+01	1.4E+01	1.5E+01	1.1E+04	9.6E+00	4.2E-01	3.1E+05	3.2E+01
		Waste	5.9E+06	1.2E+00	1.3E+02	2.9E+01	7.8E+03	8.7E+01	1.2E+01	1.1E+01	6.5E+00	1.1E+05	1.1E+01	2.1E+06	2.6E+01	1.4E+01	1.5E+01	9.2E+03	9.6E+00	4.2E-01	3.2E+05	2.6E+01
1000	48	**VHG**	8.7E+06	1.4E+00	1.5E+02	9.0E+01	7.9E+03	1.2E+02	1.4E+01	1.3E+01	7.6E+00	1.6E+05	1.2E+01	1.8E+06	2.5E+01	1.6E+01	1.8E+01	8.9E+03	1.1E+01	5.0E-01	4.1E+05	2.7E+01
		HG	2.9E+06	1.4E+00	1.5E+02	3.4E+01	2.5E+03	1.2E+02	1.4E+01	1.3E+01	7.6E+00	1.2E+05	1.2E+01	4.5E+05	2.5E+01	1.6E+01	1.8E+01	8.9E+03	1.1E+01	5.0E-01	9.8E+04	2.5E+01
		MG	8.3E+06	1.5E+00	1.4E+02	3.6E+01	6.4E+03	1.2E+02	1.4E+01	1.4E+01	7.9E+00	1.6E+05	1.3E+01	1.8E+06	2.3E+01	1.7E+01	1.9E+01	1.0E+04	1.2E+01	5.2E-01	3.4E+05	2.5E+01
		LG	5.3E+06	1.5E+00	1.6E+02	6.1E+01	5.4E+03	8.4E+01	1.4E+01	1.4E+01	7.9E+00	1.4E+05	1.3E+01	1.8E+06	2.9E+01	1.7E+01	1.9E+01	1.1E+04	1.2E+01	5.2E-01	3.1E+05	3.2E+01
		Waste	5.9E+06	1.5E+00	1.5E+02	2.9E+01	7.7E+03	8.6E+01	1.4E+01	1.4E+01	7.9E+00	1.1E+05	1.3E+01	2.1E+06	2.6E+01	1.7E+01	1.9E+01	9.1E+03	1.2E+01	5.2E-01	3.1E+05	2.6E+01
1000	72	**VHG**	8.4E+06	1.4E+00	1.6E+02	8.6E+01	7.6E+03	1.2E+02	1.4E+01	1.4E+01	7.7E+00	1.6E+05	1.3E+01	1.7E+06	2.4E+01	1.7E+01	1.8E+01	8.6E+03	1.1E+01	5.1E-01	3.9E+05	2.6E+01
		HG	2.8E+06	1.4E+00	1.6E+02	3.3E+01	2.4E+03	1.2E+02	1.4E+01	1.4E+01	7.7E+00	1.1E+05	1.3E+01	4.3E+05	2.4E+01	1.7E+01	1.8E+01	8.5E+03	1.1E+01	5.1E-01	9.4E+04	2.4E+01
		MG	8.2E+06	1.5E+00	1.4E+02	3.5E+01	6.3E+03	1.3E+02	1.5E+01	1.4E+01	8.2E+00	1.7E+05	1.3E+01	1.8E+06	2.3E+01	1.8E+01	2.0E+01	1.0E+04	1.2E+01	5.4E-01	3.3E+05	2.5E+01
		LG	5.3E+06	1.5E+00	1.7E+02	6.0E+01	5.3E+03	8.3E+01	1.5E+01	1.4E+01	8.2E+00	1.4E+05	1.3E+01	1.7E+06	2.8E+01	1.8E+01	2.0E+01	1.0E+04	1.2E+01	5.4E-01	3.0E+05	3.1E+01
		Waste	5.8E+06	1.5E+00	1.5E+02	2.8E+01	7.5E+03	8.4E+01	1.5E+01	1.4E+01	8.2E+00	1.1E+05	1.3E+01	2.1E+06	2.6E+01	1.8E+01	2.0E+01	8.9E+03	1.2E+01	5.1E-01	3.1E+05	2.6E+01

Depth of influence (m) 0.5
Dry Period (days) 120

Event Conditions		**Location**																				
ARI	**Duration**	**Stockpile**	**Mg**	**Mn**	**Mo**	**Na**	**Ni**	**NO3**	**P**	**Pb**	**Ra226**	**Sb**	**Se**	**Si**	**Sn**	**SO4**	**Sr**	**Tl**	**tal Alkalini**	**U**	**V**	**Zn**
Years	hours		**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**Bq/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**	**mg/m2**
		LG	1.8E+05	2.9E+01	2.9E+02	1.7E+06	2.8E+01	1.5E+04	3.8E+02	3.8E-01	1.6E+01	3.8E-01	4.3E+01	6.4E+03	2.8E+01	6.5E+05	1.7E+03	2.7E+01	9.8E+04	1.6E+02	1.1E+02	5.8E+02
		Waste	1.8E+05	8.8E+01	1.5E+02	1.7E+06	2.6E+01	6.9E+04	3.8E+02	3.8E-01	0.0E+00	3.8E-01	5.0E+01	6.4E+03	2.6E+01	9.6E+05	1.7E+03	2.7E+01	9.8E+04	1.6E+02	1.1E+02	6.7E+02
100	48	**VHG**	2.2E+05	6.6E+01	1.9E+02	2.0E+06	2.7E+01	1.1E+05	7.5E+02	7.5E-01	5.0E+02	7.5E-01	5.2E+01	1.3E+04	3.4E+01	2.0E+06	3.5E+03	5.4E+01	2.0E+05	3.2E+02	2.1E+02	6.4E+02
		HG	9.4E+04	2.6E+01	1.4E+02	1.0E+06	2.6E+01	1.6E+04	7.5E+02	7.5E-01	6.2E+00	7.5E-01	2.6E+01	1.3E+04	2.6E+02	5.7E+05	1.2E+03	2.4E+01	2.0E+05	3.2E+02	1.1E+02	1.5E+02
		MG	2.9E+05	2.6E+01	1.8E+02	1.6E+06	3.6E+01	3.4E+04	8.2E+02	8.2E-01	8.5E+01	8.2E-01	4.4E+01	1.4E+04	2.6E+01	1.4E+06	3.8E+03	5.9E+01	2.1E+05	3.4E+02	2.3E+02	5.9E+02
		LG	1.7E+05	2.8E+01	2.8E+02	1.7E+06	2.7E+01	1.4E+04	8.2E+02	8.2E-01	1.6E+01	8.2E-01	4.2E+01	1.4E+04	2.7E+01	7.8E+05	2.4E+03	5.9E+01	2.1E+05	3.4E+02	2.3E+02	5.6E+02
		Waste	1.7E+05	8.5E+01	1.5E+02	1.6E+06	2.5E+01	6.6E+04	5.0E+02	8.2E-01	0.0E+00	8.2E-01	4.9E+01	1.4E+04	2.5E+01	1.1E+06	1.9E+03	5.9E+01	2.1E+05	2.4E+02	2.3E+02	6.5E+02
100	72	**VHG**	2.0E+05	6.1E+01	1.8E+02	1.8E+06	2.5E+01	1.1E+05	7.8E+02	7.8E-01	4.7E+02	7.8E-01	4.8E+01	1.3E+04	3.1E+01	1.9E+06	3.6E+03	5.6E+01	2.0E+05	3.3E+02	2.2E+02	6.0E+02
		HG	8.8E+04	2.4E+01	1.3E+02	9.7E+05	2.4E+01	1.5E+04	7.8E+02	7.8E-01	5.8E+00	7.8E-01	2.4E+01	1.3E+04	2.4E+02	5.4E+05	1.1E+03	2.2E+01	2.0E+05	3.3E+02	9.9E+01	1.4E+02
		MG	2.8E+05	2.5E+01	1.8E+02	1.6E+06	3.6E+01	3.3E+04	8.9E+02	8.9E-01	8.3E+01	8.9E-01	4.3E+01	1.5E+04	2.5E+01	1.4E+06	4.1E+03	6.4E+01	2.3E+05	3.8E+02	2.5E+02	5.8E+02
		LG	1.7E+05	2.7E+01	2.8E+02	1.6E+06	2.7E+01	1.4E+04	8.9E+02	8.9E-01	1.5E+01	8.9E-01	4.1E+01	1.5E+04	2.7E+01	7.9E+05	2.4E+03	6.4E+01	2.3E+05	3.8E+02	2.5E+02	5.5E+02
		Waste	1.7E+05	8.3E+01	1.4E+02	1.6E+06	2.4E+01	6.5E+04	4.9E+02	8.9E-01	0.0E+00	8.9E-01	4.7E+01	1.5E+04	2.4E+01	1.0E+06	1.9E+03	6.4E+01	2.3E+05	2.4E+02	2.5E+02	6.3E+02
1000	24	**VHG**	2.5E+05	7.3E+01	2.1E+02	2.2E+06	3.0E+01	1.3E+05	9.4E+02	9.4E-01	5.6E+02	9.4E-01	5.8E+01	1.6E+04	3.8E+01	3.5E+06	4.3E+03	6.7E+01	2.4E+05	3.9E+02	2.6E+02	7.2E+02
		HG	1.1E+05	2.9E+01	1.5E+02	1.2E+06	2.9E+01	1.8E+04	9.4E+02	9.4E-01	6.9E+00	9.4E-01	2.9E+01	1.6E+04	2.9E+02	6.4E+05	1.3E+03	2.7E+01	2.4E+05	3.9E+02	1.2E+02	1.7E+02
		MG	3.0E+05	2.7E+01	1.9E+02	1.7E+06	3.8E+01	3.6E+04	9.6E+02	9.6E-01	9.0E+01	9.6E-01	4.7E+01	1.6E+04	2.7E+01	3.7E+06	4.4E+03	6.9E+01	2.5E+05	4.0E+02	2.7E+02	6.2E+02
		LG	1.8E+05	2.9E+01	3.0E+02	1.7E+06	2.9E+01	1.5E+04	9.6E+02	9.6E-01	1.7E+01	9.6E-01	4.4E+01	1.6E+04	2.9E+01	8.7E+05	2.6E+03	6.9E+01	2.5E+05	4.0E+02	2.7E+02	5.9E+02
		Waste	1.8E+05	8.9E+01	1.5E+02	1.7E+06	2.6E+01	7.0E+04	5.2E+02	9.6E-01	0.0E+00	9.6E-01	5.1E+01	1.6E+04	2.6E+01	1.1E+06	2.0E+03	6.9E+01	2.5E+05	2.6E+02	2.7E+02	6.8E+02
1000	48	**VHG**	2.4E+05	7.2E+01	2.1E+02	2.2E+06	3.0E+01	1.2E+05	1.1E+03	1.1E+00	5.5E+02	1.1E+00	5.7E+01	1.9E+04	3.7E+01	3.5E+06	5.2E+03	8.1E+01	2.9E+05	4.7E+02	3.2E+02	7.0E+02
		HG	1.0E+05	2.8E+01	1.5E+02	1.1E+06	2.8E+01	1.8E+04	1.1E+03	1.1E+00	6.8E+00	1.1E+00	2.8E+01	1.9E+04	2.8E+02	6.3E+05	1.3E+03	2.6E+01	2.9E+05	4.7E+02	1.2E+02	1.6E+02
		MG	3.0E+05	2.7E+01	1.9E+02	1.7E+06	3.8E+01	3.6E+04	1.2E+03	1.2E+00	8.9E+01	1.2E+00	4.6E+01	2.0E+04	2.7E+01	3.6E+06	5.4E+03	8.4E+01	3.0E+05	4.9E+02	3.3E+02	6.1E+02
		LG	1.8E+05	2.9E+01	3.0E+02	1.7E+06	2.9E+01	1.5E+04	1.0E+03	1.2E+00	1.6E+01	1.2E+00	4.4E+01	2.0E+04	2.9E+01	8.6E+05	2.5E+03	8.4E+01	3.0E+05	4.9E+02	3.3E+02	5.9E+02
		Waste	1.8E+05	8.8E+01	1.5E+02	1.7E+06	2.6E+01	6.9E+04	5.2E+02	1.2E+00	0.0E+00	1.2E+00	5.1E+01	2.0E+04	2.6E+01	1.1E+06	2.0E+03	8.4E+01	3.0E+05	2.5E+02	3.3E+02	6.7E+02
1000	72	**VHG**	2.3E+05	6.9E+01	2.0E+02	2.1E+06	2.9E+01	1.2E+05	1.1E+03	1.1E+00	5.3E+02	1.1E+00	5.4E+01	2.0E+04	3.5E+01	3.3E+06	5.3E+03	8.3E+01	3.0E+05	4.8E+02	3.2E+02	6.8E+02
		HG	9.9E+04	2.7E+01	1.4E+02	1.1E+06	2.7E+01	1.7E+04	1.1E+03	1.1E+00	6.5E+00	1.1E+00	2.7E+01	2.0E+04	2.7E+02	6.0E+05	1.2E+03	2.5E+01	3.0E+05	4.8E+02	1.1E+02	1.6E+02
		MG	2.9E+05	2.6E+01	1.9E+02	1.6E+06	3.7E+01	3.5E+04	1.2E+03	1.2E+00	8.7E+01	1.2E+00	4.5E+01	2.1E+04	2.6E+01	3.6E+06	5.6E+03	8.8E+01	3.2E+05	5.1E+02	3.4E+02	6.0E+02
		LG	1.7E+05	2.8E+01	2.9E+02	1.7E+06	2.8E+01	1.5E+04	1.0E+03	1.2E+00	1.6E+01	1.2E+00	4.3E+01	2.1E+04	2.8E+01	8.5E+05	2.5E+03	8.8E+01	3.2E+05	5.1E+02	3.4E+02	5.8E+02
		Waste	1.8E+05	8.7E+01	1.5E+02	1.6E+06	2.6E+01	6.8E+04	5.1E+02	1.2E+00	0.0E+00	1.2E+00	5.0E+01	2.1E+04	2.6E+01	1.1E+06	1.9E+03	8.8E+01	3.2E+05	2.5E+02	3.4E+02	6.6E+02

Appendix 2: Roads and Hardstand Solute Release Rates

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 5 years
Event Duartion 1 hrs

Solute Loadings mg/m2

Processing Year	TDS	K	Na	Ca	Mg	SO4	S	HC03	Cl	Nitrate	F	Silica_diss	B	U	V	Al	As	Ba	Cd	Cr	Co	Cu	Fe	Li	Mn	Mo	Ni	Pb	Se	Sr	Zn
		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
-2	1357415	46195	362373	7832	33811	241852	80529	14540	563998	4019	120	314	1111	13	0.64	0.02	0.69	8.58	0.04	3.94	0.62	0.77	6	1.9	15.9	19.09	0.70	0.07	3.10	645	1.8
-1	1555041	53305	413429	7832	39678	275810	91846	14831	651166	4701	126	314	1225	14	0.64	0.02	0.72	9.19	0.04	4.32	0.67	0.80	5	1.9	17.5	20.90	0.69	0.06	3.26	699	1.4
1	2551759	89777	646736	7832	79489	428098	142693	13071	1129632	11824	141	314	1405	16	0.64	0.02	0.27	10.14	0.05	4.37	0.74	0.64	3	0.7	27.7	20.09	0.15	0.06	2.03	661	0.4
2	2965081	101549	737192	7832	94400	493237	164417	13325	1330825	19797	146	314	1405	9	0.50	0.02	0.16	10.14	0.05	5.72	0.74	0.57	3	0.3	27.7	18.19	0.12	0.06	1.79	564	0.4
3	2556392	89292	626151	7832	83298	425221	141791	17625	1147118	15768	172	314	1405	6	0.55	0.02	0.12	10.14	0.05	3.01	0.74	0.37	3	0.4	27.7	10.71	0.12	0.06	1.23	341	0.3
4	2384965	83207	583891	7832	77744	396372	132172	17107	1069652	14811	165	314	1314	6	0.56	0.02	0.11	9.66	0.05	2.81	0.70	0.37	4	0.4	26.1	10.01	0.14	0.06	1.18	324	0.7
5	2138165	42189	538167	7832	86925	364902	121635	19711	951597	2491	34	314	1426	30	0.64	0.02	2.98	9.85	0.05	0.84	0.75	1.81	30	3.4	190.4	9.47	3.21	0.36	5.51	609	44.6
6	1127042	32312	283210	7832	40908	189654	63243	15848	488904	3499	103	314	822	15	0.64	0.02	0.76	5.55	0.03	0.58	0.48	0.66	12	1.5	47.6	6.16	0.91	0.24	2.26	289	10.8
7	724854	17633	182157	7832	28047	121403	40490	13677	310405	1928	84	314	552	13	0.64	0.02	0.73	3.97	0.02	0.29	0.36	0.63	12	1.4	42.1	4.92	0.91	0.28	2.06	239	11.1
8	923704	18205	228412	7832	37605	155140	51721	14195	407140	2013	60	314	623	16	0.64	0.02	1.25	5.74	0.03	0.38	0.41	0.91	18	1.7	81.8	4.64	1.51	0.25	2.55	289	20.5
9	770667	22364	204328	7832	27307	126959	42326	13530	321501	3055	77	314	722	16	0.64	0.02	0.41	3.62	0.02	0.23	0.48	0.62	16	1.8	15.2	3.91	0.57	0.09	2.18	283	8.3
10	1757594	56111	483187	7832	59940	295831	98629	18592	729725	4908	102	314	1748	30	0.61	0.02	0.63	3.09	0.03	0.41	0.93	0.94	20	3.4	0.4	9.06	0.54	0.06	4.63	594	8.1
11	1587752	44024	422177	7832	57238	264180	88076	17173	680624	3947	86	314	1396	30	0.64	0.02	0.95	4.88	0.03	0.45	0.92	1.15	28	3.4	41.9	8.03	1.30	0.22	4.12	542	16.5
12	1684850	41627	436505	7832	62378	272700	90926	16595	750056	3688	90	314	1326	30	0.64	0.02	1.02	6.51	0.03	0.51	1.28	1.58	48	4.3	64.8	8.77	2.20	0.48	4.17	615	23.7
13	1330404	34144	346406	7832	48760	215970	72009	15383	584321	3447	85	314	1091	30	0.64	0.02	0.78	5.40	0.02	0.40	0.98	1.22	36	3.3	45.3	6.90	1.58	0.34	3.39	488	17.7
14	1319481	34223	343815	7832	47932	212257	70774	15163	581821	3523	90	314	1088	30	0.64	0.02	0.65	5.33	0.02	0.38	1.06	1.25	39	3.5	38.7	6.98	1.60	0.37	3.33	499	17.0
15	1392747	36312	362770	7832	50039	220587	73557	15096	620571	3719	99	314	1143	30	0.64	0.02	0.50	5.49	0.02	0.39	1.27	1.40	48	4.0	32.5	7.61	1.80	0.47	3.42	552	17.3
16	1291253	33728	336698	7832	46713	207088	69051	15005	569489	3532	91	314	1070	30	0.64	0.02	0.59	5.23	0.02	0.37	1.06	1.23	39	3.5	35.2	6.88	1.57	0.37	3.25	494	16.4
17	1232894	31942	320837	7832	44799	198079	66046	14814	543092	3421	88	314	1017	30	0.64	0.02	0.61	5.18	0.02	0.36	1.00	1.18	37	3.3	36.5	6.52	1.51	0.35	3.13	469	16.1
18	834519	20606	213342	7832	30754	132351	44130	13120	368004	2870	79	314	671	22	0.64	0.02	0.46	4.74	0.02	0.27	0.72	0.91	29	2.4	31.2	4.40	1.19	0.27	2.20	333	13.3
19	1740020	39766	444464	7832	66024	281240	93772	16616	784375	3392	83	314	1280	30	0.64	0.02	1.28	7.49	0.03	0.57	1.32	1.75	52	4.4	88.5	8.93	2.63	0.56	4.27	629	28.7
20	1561558	39209	405996	7832	57813	255088	85050	16396	688214	3572	85	314	1254	30	0.64	0.02	1.03	6.03	0.03	0.48	1.08	1.39	39	3.7	60.8	7.99	1.89	0.38	3.94	556	21.5
21	1804077	57606	496137	7832	61527	303798	101286	18828	749177	4984	103	314	1793	30	0.61	0.02	0.65	3.09	0.03	0.42	0.95	0.96	20	3.5	0.4	9.30	0.55	0.06	4.75	609	8.2
22	1766925	45903	465285	7832	65876	298972	99667	18314	758773	3701	72	314	1477	30	0.64	0.02	1.52	5.81	0.04	0.55	0.80	1.23	23	3.2	76.8	8.49	1.59	0.18	4.63	556	22.4
23	1798650	49534	479217	7832	65564	304027	101355	18556	765803	4057	80	314	1578	30	0.64	0.02	1.31	5.13	0.03	0.52	0.85	1.17	22	3.3	57.8	8.81	1.33	0.15	4.71	576	18.9
24	1592437	50659	436902	7832	54374	267542	89198	17751	660942	4620	98	314	1581	30	0.62	0.02	0.58	3.12	0.03	0.37	0.86	0.88	19	3.2	1.4	8.21	0.52	0.06	4.22	543	7.9
25	1804077	57606	496137	7832	61527	303798	101286	18828	749177	4984	103	314	1793	30	0.61	0.02	0.65	3.09	0.03	0.42	0.95	0.96	20	3.5	0.4	9.30	0.55	0.06	4.75	609	8.2
26	1804077	57606	496137	7832	61527	303798	101286	18828	749177	4984	103	314	1793	30	0.61	0.02	0.65	3.09	0.03	0.42	0.95	0.96	20	3.5	0.4	9.30	0.55	0.06	4.75	609	8.2
27	1804077	57606	496137	7832	61527	303798	101286	18828	749177	4984	103	314	1793	30	0.61	0.02	0.65	3.09	0.03	0.42	0.95	0.96	20	3.5	0.4	9.30	0.55	0.06	4.75	609	8.2
28	1804077	57606	496137	7832	61527	303798	101286	18828	749177	4984	103	314	1793	30	0.61	0.02	0.65	3.09	0.03	0.42	0.95	0.96	20	3.5	0.4	9.30	0.55	0.06	4.75	609	8.2
29	1804077	57606	496137	7832	61527	303798	101286	18828	749177	4984	103	314	1793	30	0.61	0.02	0.65	3.09	0.03	0.42	0.95	0.96	20	3.5	0.4	9.30	0.55	0.06	4.75	609	8.2
30	1804077	57606	496137	7832	61527	303798	101286	18828	749177	4984	103	314	1793	30	0.61	0.02	0.65	3.09	0.03	0.42	0.95	0.96	20	3.5	0.4	9.30	0.55	0.06	4.75	609	8.2

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 5 years
Event Duartion 6 hrs

Solute Loadings mg/m2

Processing Year	TDS	K	Na	Ca	Mg	SO4	S	HC03	Cl	Nitrate	F	Silica_diss	B	U	V	Al	As	Ba	Cd	Cr	Co	Cu	Fe	Li	Mn	Mo	Ni	Pb	Se	Sr	Zn
		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
-2	365258	12363	96978	4006	9048	64724	21551	3891	150937	1075	32	160	297	3	0.33	0.01	0.19	2.30	0.01	1.05	0.17	0.21	2	0.5	4.3	5.11	0.19	0.02	0.83	173	0.5
-1	418147	14266	110642	4006	10619	73812	24580	3969	174265	1258	34	160	328	4	0.33	0.01	0.19	2.46	0.01	1.16	0.18	0.21	1	0.5	4.7	5.59	0.19	0.02	0.87	187	0.4
1	684889	24026	173080	4006	21273	114568	38188	3498	302312	3164	38	160	376	4	0.24	0.01	0.07	2.71	0.01	1.17	0.20	0.17	1	0.2	7.4	5.38	0.04	0.02	0.54	177	0.1
2	795502	27176	197287	4006	25263	132000	44001	3566	356156	5298	39	160	376	2	0.13	0.01	0.04	2.71	0.01	1.53	0.20	0.15	1	0.1	7.4	4.87	0.03	0.02	0.48	151	0.1
3	686128	23896	167571	4006	22292	113798	37946	4717	306992	4220	46	160	376	2	0.15	0.01	0.03	2.71	0.01	0.81	0.20	0.10	1	0.1	7.4	2.87	0.03	0.02	0.33	91	0.1
4	640251	22268	156261	4006	20806	106077	35372	4578	286261	3964	44	160	352	2	0.15	0.01	0.03	2.59	0.01	0.75	0.19	0.10	1	0.1	7.0	2.68	0.04	0.02	0.32	87	0.2
5	574204	11291	144024	4006	23263	97655	32552	5275	254667	667	9	160	382	10	0.33	0.01	0.80	2.64	0.01	0.23	0.20	0.48	8	0.9	51.0	2.54	0.86	0.10	1.47	163	11.9
6	303606	8647	75793	4006	10948	50755	16925	4241	130841	936	27	160	220	4	0.33	0.01	0.20	1.49	0.01	0.16	0.13	0.18	3	0.4	12.7	1.65	0.24	0.07	0.60	77	2.9
7	195946	4719	48749	3980	7506	32490	10836	3660	83071	516	23	160	148	3	0.30	0.01	0.19	1.06	0.01	0.08	0.10	0.17	3	0.4	11.3	1.32	0.24	0.08	0.55	64	3.0
8	249188	4872	61128	4006	10064	41519	13842	3799	108959	539	16	160	167	4	0.33	0.01	0.34	1.54	0.01	0.10	0.11	0.24	5	0.5	21.9	1.24	0.40	0.07	0.68	77	5.5
9	208232	5985	54682	4006	7308	33977	11327	3621	86040	818	21	160	193	4	0.20	0.01	0.11	0.97	0.01	0.06	0.13	0.17	4	0.5	4.1	1.05	0.15	0.02	0.58	76	2.2
10	472356	15016	129311	4006	16041	79170	26395	4976	195289	1313	27	160	468	10	0.16	0.01	0.17	0.83	0.01	0.11	0.25	0.25	5	0.9	0.1	2.42	0.14	0.02	1.24	159	2.2
11	426902	11782	112983	4006	15318	70700	23571	4596	182149	1056	23	160	374	9	0.29	0.01	0.26	1.31	0.01	0.12	0.25	0.31	7	0.9	11.2	2.15	0.35	0.06	1.10	145	4.4
12	452890	11140	116818	4006	16694	72980	24334	4441	200730	987	24	160	355	12	0.33	0.01	0.27	1.74	0.01	0.14	0.34	0.42	13	1.1	17.4	2.35	0.59	0.13	1.12	165	6.3
13	358030	9138	92705	4006	13049	57798	19271	4117	156376	922	23	160	292	9	0.28	0.01	0.21	1.44	0.01	0.11	0.26	0.33	10	0.9	12.1	1.85	0.42	0.09	0.91	131	4.7
14	355107	9159	92012	4006	12828	56804	18940	4058	155707	943	24	160	291	9	0.25	0.01	0.17	1.43	0.01	0.10	0.28	0.33	10	0.9	10.4	1.87	0.43	0.10	0.89	134	4.6
15	374716	9718	97085	4006	13391	59034	19685	4040	166077	995	26	160	306	11	0.21	0.01	0.13	1.47	0.01	0.10	0.34	0.37	13	1.1	8.7	2.04	0.48	0.13	0.92	148	4.6
16	347553	9026	90107	4006	12501	55421	18480	4016	152407	945	24	160	286	9	0.24	0.01	0.16	1.40	0.01	0.10	0.28	0.33	11	0.9	9.4	1.84	0.42	0.10	0.87	132	4.4
17	331934	8548	85862	4006	11989	53010	17675	3964	145342	916	24	160	272	9	0.24	0.01	0.16	1.39	0.01	0.10	0.27	0.32	10	0.9	9.8	1.75	0.40	0.09	0.84	126	4.3
18	225320	5515	57095	4006	8230	35420	11810	3511	98485	768	21	160	179	6	0.23	0.01	0.12	1.27	0.01	0.07	0.19	0.24	8	0.6	8.3	1.18	0.32	0.07	0.59	89	3.6
19	467655	10642	118948	4006	17669	75266	25095	4447	209915	908	22	160	343	12	0.33	0.01	0.34	2.00	0.01	0.15	0.35	0.47	14	1.2	23.7	2.39	0.70	0.15	1.14	168	7.7
20	419893	10493	108653	4006	15472	68267	22761	4388	184180	956	23	160	335	10	0.33	0.01	0.27	1.61	0.01	0.13	0.29	0.37	11	1.0	16.3	2.14	0.51	0.10	1.05	149	5.7
21	484796	15417	132776	4006	16466	81303	27106	5039	200495	1334	28	160	480	11	0.16	0.01	0.17	0.83	0.01	0.11	0.26	0.26	5	0.9	0.1	2.49	0.15	0.02	1.27	163	2.2
22	474852	12285	124520	4006	17630	80011	26673	4901	203063	991	19	160	395	9	0.33	0.01	0.41	1.55	0.01	0.15	0.21	0.33	6	0.9	20.5	2.27	0.42	0.05	1.24	149	6.0
23	483343	13256	128248	4006	17546	81364	27125	4966	204944	1086	21	160	422	10	0.33	0.01	0.35	1.37	0.01	0.14	0.23	0.31	6	0.9	15.5	2.36	0.36	0.04	1.26	154	5.1
24	428156	13557	116924	4006	14552	71600	23871	4751	176881	1236	26	160	423	9	0.16	0.01	0.16	0.84	0.01	0.10	0.23	0.24	5	0.8	0.4	2.20	0.14	0.02	1.13	145	2.1
25	484796	15417	132776	4006	16466	81303	27106	5039	200495	1334	28	160	480	11	0.16	0.01	0.17	0.83	0.01	0.11	0.26	0.26	5	0.9	0.1	2.49	0.15	0.02	1.27	163	2.2
26	484796	15417	132776	4006	16466	81303	27106	5039	200495	1334	28	160	480	11	0.16	0.01	0.17	0.83	0.01	0.11	0.26	0.26	5	0.9	0.1	2.49	0.15	0.02	1.27	163	2.2
27	484796	15417	132776	4006	16466	81303	27106	5039	200495	1334	28	160	480	11	0.16	0.01	0.17	0.83	0.01	0.11	0.26	0.26	5	0.9	0.1	2.49	0.15	0.02	1.27	163	2.2
28	484796	15417	132776	4006	16466	81303	27106	5039	200495	1334	28	160	480	11	0.16	0.01	0.17	0.83	0.01	0.11	0.26	0.26	5	0.9	0.1	2.49	0.15	0.02	1.27	163	2.2
29	484796	15417	132776	4006	16466	81303	27106	5039	200495	1334	28	160	480	11	0.16	0.01	0.17	0.83	0.01	0.11	0.26	0.26	5	0.9	0.1	2.49	0.15	0.02	1.27	163	2.2
30	484796	15417	132776	4006	16466	81303	27106	5039	200495	1334	28	160	480	11	0.16	0.01	0.17	0.83	0.01	0.11	0.26	0.26	5	0.9	0.1	2.49	0.15	0.02	1.27	163	2.2

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 5 years
Event Duartion 48 hrs

Solute Loadings mg/m2 **+++++NO RUNOFF++**++++

Processing Year	TDS	K	Na	Ca	Mg	SO4	S	HC03	Cl	Nitrate	F	Silica_diss	B	U	V	Al	As	Ba	Cd	Cr	Co	Cu	Fe	Li	Mn	Mo	Ni	Pb	Se	Sr	Zn
		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 5 years
Event Duartion 72 hrs

Solute Loadings mg/m2 **+++++NO RUNOFF++**++++

Processing Year	TDS	K	Na	Ca	Mg	SO4	S	HC03	Cl	Nitrate	F	Silica_diss	B	U	V	Al	As	Ba	Cd	Cr	Co	Cu	Fe	Li	Mn	Mo	Ni	Pb	Se	Sr	Zn
		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 20 years
Event Duartion 1 hrs

Solute Loadings mg/m2

Processing Year	TDS	K mg/m2	Na mg/m2	Ca mg/m2	Mg mg/m2	SO4 mg/m2	S mg/m2	HC03 mg/m2	Cl mg/m2	Nitrate mg/m2	F mg/m2	Silica_diss mg/m2	B mg/m2	U mg/m2	V mg/m2	Al mg/m2	As mg/m2	Ba mg/m2	Cd mg/m2	Cr mg/m2	Co mg/m2	Cu mg/m2	Fe mg/m2	Li mg/m2	Mn mg/m2	Mo mg/m2	Ni mg/m2	Pb mg/m2	Se mg/m2	Sr mg/m2	Zn mg/m2
-2	1831110	62153	487552	15139	45490	325397	108347	19563	758827	5407	161	606	1495	17	1 24	0.05	0.93	11.55	0 06	5 30	0.83	1.04	8	2.6	21.4	25.68	0 94	0 09	4.17	868	2 5
-1	2097005	71719	556245	15139	53385	371086	123573	19954	876106	6325	170	606	1648	19	1 24	0.05	0.97	12.36	0 06	5 81	0.90	1.08	7	2.6	23.5	28.12	0 93	0 09	4 39	940	1 9
1	3438032	120790	870146	15139	106948	575981	191985	17587	1519855	15908	189	606	1890	21	1.19	0.05	0.36	13.65	0 07	5 87	0.99	0.86	4	1.0	37.2	27.03	0 20	0 08	2.73	890	0 5
2	3994132	136628	991849	15139	127009	663622	221213	17928	1790549	26636	197	606	1890	12	0 67	0.05	0.22	13.65	0 07	7 69	0.99	0.77	4	0.4	37.2	24.48	0.17	0 08	2.41	759	0 5
3	3444265	120137	842450	15139	112073	572110	190772	23713	1543382	21215	231	606	1890	8	0.74	0.05	0.16	13.65	0 07	4 05	0.99	0.50	4	0.6	37.2	14.41	0.17	0 08	1 65	459	0 5
4	3213620	111950	785592	15139	104600	533296	177830	23016	1439155	19927	221	606	1768	8	0.75	0.05	0.15	13.00	0 06	3.78	0.94	0.50	5	0.6	35.1	13.46	0.19	0 08	1 59	435	0 9
5	2881572	56763	724072	15139	116952	490955	163653	26520	1280319	3351	45	606	1919	48	1 24	0.05	4.00	13.26	0 07	1.13	1.01	2.43	40	4.6	256.2	12.75	4 31	0.48	7.41	820	60.0
6	1521157	43474	381043	15139	55039	255168	85090	21322	657793	4707	138	606	1106	20	1 24	0.05	1.03	7.47	0 04	0.78	0.64	0.89	16	2.0	64.1	8.29	1 23	0 33	3 04	389	14.5
7	980036	23724	245082	15139	37736	163340	54476	18401	417632	2595	113	606	743	18	1 24	0.05	0.98	5.35	0 03	0 39	0.48	0.85	16	1.9	56.7	6.61	1 22	0 38	2.77	321	15.0
8	1247577	24494	307315	15139	50595	208732	69587	19099	547784	2709	80	606	838	21	1 24	0.05	1.69	7.72	0 04	0 51	0.55	1.22	24	2.4	110.0	6.24	2 03	0 33	3.43	389	27.6
9	1041674	30089	274911	15139	36740	170816	56947	18203	432561	4110	104	606	972	22	0 99	0.05	0.56	4.87	0 03	0 31	0.65	0.83	21	2.4	20.4	5.26	0.77	0.12	2 93	381	11.2
10	2369539	75494	650100	15139	80646	398023	132700	25015	981803	6603	137	606	2351	52	0 82	0.05	0.85	4.15	0 04	0 55	1.26	1.27	27	4.6	0.5	12.19	0.72	0 08	6 23	800	10.9
11	2141023	59232	568016	15139	77011	355438	118502	23106	915740	5310	116	606	1879	48	1 24	0.05	1.28	6.57	0 04	0 60	1.24	1.55	38	4.5	56.3	10.80	1.75	0 29	5 54	729	22.2
12	2271673	56007	587292	15139	83926	366902	122335	22328	1009157	4962	121	606	1784	58	1 24	0.05	1.38	8.76	0 04	0 69	1.72	2.13	64	5.7	87.2	11.80	2 96	0 65	5 61	828	31.9
13	1794773	45938	466070	15139	65603	290575	96883	20698	786171	4637	115	606	1468	45	1 24	0.05	1.05	7.26	0 03	0 54	1.32	1.64	48	4.5	60.9	9.28	2.13	0.45	4 56	657	23.9
14	1780079	46045	462583	15139	64490	285580	95222	20400	782807	4741	121	606	1463	47	1 24	0.05	0.88	7.17	0 03	0 52	1.42	1.68	53	4.7	52.1	9.39	2.16	0 50	4.48	672	22.9
15	1878661	48855	488086	15139	67325	296788	98967	20311	834943	5004	133	606	1538	55	1 08	0.05	0.67	7.39	0 03	0 52	1.71	1.88	65	5.4	43.7	10.24	2.42	0 63	4 61	743	23.3
16	1742099	45380	453008	15139	62850	278626	92904	20189	766215	4752	122	606	1440	47	1.19	0.05	0.80	7.03	0 03	0 50	1.43	1.66	53	4.7	47.4	9.25	2.11	0 50	4 38	665	22.0
17	1663578	42976	431667	15139	60274	266504	88861	19931	730699	4603	119	606	1369	44	1 22	0.05	0.82	6.97	0 03	0.49	1.34	1.59	50	4.4	49.1	8.77	2 03	0.47	4 21	632	21.7
18	1127583	27724	287040	15139	41378	178071	59374	17652	495128	3861	107	606	902	30	1.15	0.05	0.62	6.38	0 03	0 36	0.97	1.23	40	3.3	41.9	5.92	1 61	0 37	2 96	447	17.9
19	2345902	53503	598001	15139	88831	378393	126165	22356	1055332	4564	112	606	1722	58	1 24	0.05	1.72	10.07	0 04	0.76	1.77	2.35	70	5.9	119.0	12.01	3 54	0.75	5.74	846	38.6
20	2105784	52754	546244	15139	77785	343207	114430	22059	925952	4806	114	606	1687	52	1 24	0.05	1.38	8.11	0 04	0 64	1.46	1.87	53	5.0	81.8	10.75	2 54	0 51	5 30	748	28.9
21	2432081	77505	667524	15139	82781	408743	136274	25332	1007975	6706	139	606	2413	53	0 83	0.05	0.88	4.15	0 04	0 56	1.28	1.29	27	4.7	0.5	12.51	0.73	0 08	6 39	819	11.1
22	2382088	61760	626015	15139	88633	402249	134097	24641	1020886	4980	97	606	1988	46	1 24	0.05	2.04	7.81	0 05	0.74	1.07	1.66	31	4.3	103.3	11.43	2.13	0 24	6 22	749	30.2
23	2424775	66646	644760	15139	88213	409050	136367	24966	1030344	5458	108	606	2123	48	1 24	0.05	1.77	6.90	0 05	0.70	1.14	1.58	30	4.4	77.7	11.85	1.79	0 20	6 34	775	25.5
24	2147325	68159	587827	15139	73157	359962	120010	23883	889259	6216	133	606	2127	47	0 83	0.05	0.78	4.20	0 04	0 50	1.16	1.19	26	4.3	1.9	11.04	0.71	0 09	5 68	731	10.6
25	2432081	77505	667524	15139	82781	408743	136274	25332	1007975	6706	139	606	2413	53	0 83	0.05	0.88	4.15	0 04	0 56	1.28	1.29	27	4.7	0.5	12.51	0.73	0 08	6 39	819	11.1
26	2432081	77505	667524	15139	82781	408743	136274	25332	1007975	6706	139	606	2413	53	0 83	0.05	0.88	4.15	0 04	0 56	1.28	1.29	27	4.7	0.5	12.51	0.73	0 08	6 39	819	11.1
27	2432081	77505	667524	15139	82781	408743	136274	25332	1007975	6706	139	606	2413	53	0 83	0.05	0.88	4.15	0 04	0 56	1.28	1.29	27	4.7	0.5	12.51	0.73	0 08	6 39	819	11.1
28	2432081	77505	667524	15139	82781	408743	136274	25332	1007975	6706	139	606	2413	53	0 83	0.05	0.88	4.15	0 04	0 56	1.28	1.29	27	4.7	0.5	12.51	0.73	0 08	6 39	819	11.1
29	2432081	77505	667524	15139	82781	408743	136274	25332	1007975	6706	139	606	2413	53	0 83	0.05	0.88	4.15	0 04	0 56	1.28	1.29	27	4.7	0.5	12.51	0.73	0 08	6 39	819	11.1
30	2432081	77505	667524	15139	82781	408743	136274	25332	1007975	6706	139	606	2413	53	0 83	0.05	0.88	4.15	0 04	0 56	1.28	1.29	27	4.7	0.5	12.51	0.73	0 08	6 39	819	11.1

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 20 years
Event Duartion 6 hrs

Solute Loadings mg/m2

Processing Year	TDS	K mg/m2	Na mg/m2	Ca mg/m2	Mg mg/m2	SO4 mg/m2	S mg/m2	HC03 mg/m2	Cl mg/m2	Nitrate mg/m2	F mg/m2	Silica_diss mg/m2	B mg/m2	U mg/m2	V mg/m2	Al mg/m2	As mg/m2	Ba mg/m2	Cd mg/m2	Cr mg/m2	Co mg/m2	Cu mg/m2	Fe mg/m2	Li mg/m2	Mn mg/m2	Mo mg/m2	Ni mg/m2	Pb mg/m2	Se mg/m2	Sr mg/m2	Zn mg/m2
-2	1577923	53077	416353	26595	38847	277879	92525	16706	648014	4617	138	1065	1277	15	2.17	0.08	0.80	9.86	0 05	4 52	0.71	0.89	7	2.2	18.3	21.93	0 80	0 08	3 56	741	2.1
-1	1804989	61246	475015	26595	45589	316895	105527	17040	748166	5401	145	1065	1408	16	2.17	0.08	0.83	10.56	0 05	4 96	0.76	0.92	6	2.2	20.1	24.02	0 80	0 07	3.75	803	1 6
1	2950180	103151	743076	26595	91330	491869	163949	15019	1297906	13585	162	1065	1614	18	1 02	0.08	0.31	11.65	0 06	5 02	0.85	0.74	4	0.8	31.8	23.09	0.17	0 07	2 33	760	0.4
2	3425072	116676	847007	26595	108462	566712	188909	15310	1529070	22747	168	1065	1614	10	0 57	0.08	0.19	11.65	0 06	6 57	0.85	0.66	4	0.4	31.8	20.90	0.14	0 07	2 06	649	0.4
3	2955503	102593	719424	26595	95707	488563	162913	20250	1317997	18117	197	1065	1614	7	0 64	0.08	0.13	11.65	0 06	3.46	0.85	0.43	4	0.5	31.8	12.31	0.14	0 07	1.41	392	0.4
4	2758540	95601	670869	26595	89325	455417	151861	19655	1228991	17017	189	1065	1510	7	0 64	0.08	0.13	11.10	0 05	3 22	0.81	0.42	4	0.5	30.0	11.50	0.16	0 07	1 36	372	0.7
5	2474983	48474	618334	26595	99873	419259	139754	22647	1093351	2862	39	1065	1639	41	2.17	0.08	3.42	11.32	0 06	0 97	0.86	2.08	34	3.9	218.8	10.89	3 68	0.41	6 33	700	51.3
6	1310962	37126	325398	24324	47002	217905	72664	18209	561733	4020	118	1065	944	17	1.41	0.08	0.88	6.38	0 03	0 67	0.55	0.76	13	1.7	54.7	7.08	1 05	0 28	2 60	332	12.4
7	841625	20259	209292	17087	32225	139487	46521	15714	356644	2216	97	1065	635	15	1 28	0.08	0.84	4.56	0 02	0 33	0.41	0.72	14	1.6	48.4	5.65	1 04	0 32	2 36	274	12.8
8	1074374	20917	262437	21364	43206	178251	59425	16310	467790	2313	69	1065	715	18	1 82	0.08	1.44	6.60	0 03	0.43	0.47	1.04	20	2.0	94.0	5.33	1.73	0 28	2 93	332	23.5
9	895799	25695	234765	18625	31375	145871	48631	15545	369393	3510	88	1065	830	19	0 85	0.08	0.48	4.15	0 02	0 26	0.55	0.71	18	2.1	17.5	4.49	0 66	0.10	2 50	326	9 6
10	2037722	64469	555164	26595	68869	339899	113322	21362	838427	5639	117	1065	2008	44	0.70	0.08	0.73	3.55	0 03	0.47	1.07	1.08	23	4.0	0.4	10.41	0 62	0 07	5 32	683	9 3
11	1842577	50582	485067	26595	65765	303533	101197	19731	782012	4535	99	1065	1604	41	1 23	0.08	1.10	5.61	0 03	0 51	1.06	1.33	32	3.8	48.1	9.22	1 50	0 25	4.74	623	18.9
12	1954149	47828	501528	26595	71670	313322	104470	19067	861787	4238	103	1065	1523	51	1.42	0.08	1.18	7.48	0 03	0 59	1.47	1.82	55	4.9	74.5	10.07	2 53	0 55	4.79	707	27.2
13	1546891	39230	398008	26595	56023	248142	82735	17675	671364	3960	98	1065	1253	38	1.19	0.08	0.89	6.20	0 03	0.46	1.13	1.40	41	3.8	52.0	7.92	1 82	0 39	3 90	561	20.4
14	1534343	39321	395031	26595	55072	243876	81317	17421	668491	4048	103	1065	1250	40	1 07	0.08	0.75	6.12	0 03	0.44	1.22	1.43	45	4.0	44.5	8.02	1 84	0.43	3 83	574	19.5
15	1618530	41721	416810	26595	57493	253447	84515	17345	713014	4273	114	1065	1314	47	0 92	0.08	0.57	6.31	0 02	0.45	1.46	1.61	55	4.6	37.3	8.74	2 07	0 54	3 93	634	19.9
16	1501910	38753	386854	26595	53672	237937	79337	17240	654323	4058	105	1065	1230	40	1 01	0.08	0.68	6.01	0 03	0.43	1.22	1.42	45	4.0	40.5	7.90	1 80	0.43	3.74	568	18.8
17	1434778	36700	368630	26518	51472	227586	75885	17020	623993	3931	101	1065	1169	38	1 04	0.08	0.70	5.95	0 03	0.42	1.14	1.36	43	3.8	41.9	7.49	1.74	0.40	3 60	539	18.6
18	970115	23676	245123	19577	35335	152067	50703	15074	422823	3297	91	1065	770	25	0 99	0.08	0.53	5.45	0 02	0 31	0.83	1.05	34	2.8	35.8	5.06	1 37	0 31	2 53	382	15.3
19	2017540	45689	510673	26595	75859	323135	107741	19091	901219	3898	96	1065	1471	52	1.74	0.08	1.47	8.60	0 03	0 65	1.51	2.01	60	5.1	101.7	10.26	3 02	0 64	4 90	722	32.9
20	1812485	45050	466474	26595	66425	293087	97719	18838	790733	4104	97	1065	1440	44	1.41	0.08	1.18	6.93	0 03	0 55	1.25	1.60	45	4.3	69.9	9.18	2.17	0.44	4 53	639	24.7
21	2091131	66187	570043	26595	70692	349053	116374	21632	860778	5726	118	1065	2060	45	0.71	0.08	0.75	3.54	0 03	0.48	1.10	1.10	23	4.0	0.4	10.68	0 63	0 07	5.45	699	9 5
22	2048440	52741	534596	26595	75689	343507	114514	21042	871803	4253	83	1065	1697	39	1.78	0.08	1.74	6.67	0 04	0 63	0.92	1.42	27	3.7	88.2	9.76	1 82	0 21	5 32	639	25.8
23	2084893	56913	550604	26595	75331	349316	116453	21320	879880	4661	92	1065	1813	41	1 52	0.08	1.51	5.89	0 04	0 60	0.97	1.35	26	3.8	66.4	10.12	1 53	0.17	5.41	662	21.8
24	1847959	58205	501985	26595	62474	307396	102485	20395	759398	5309	113	1065	1817	40	0.71	0.08	0.67	3.59	0 03	0.43	0.99	1.01	22	3.6	1.7	9.43	0 60	0 07	4 85	624	9.1
25	2091131	66187	570043	26595	70692	349053	116374	21632	860778	5726	118	1065	2060	45	0.71	0.08	0.75	3.54	0 03	0.48	1.10	1.10	23	4.0	0.4	10.68	0 63	0 07	5.45	699	9 5
26	2091131	66187	570043	26595	70692	349053	116374	21632	860778	5726	118	1065	2060	45	0.71	0.08	0.75	3.54	0 03	0.48	1.10	1.10	23	4.0	0.4	10.68	0 63	0 07	5.45	699	9 5
27	2091131	66187	570043	26595	70692	349053	116374	21632	860778	5726	118	1065	2060	45	0.71	0.08	0.75	3.54	0 03	0.48	1.10	1.10	23	4.0	0.4	10.68	0 63	0 07	5.45	699	9 5
28	2091131	66187	570043	26595	70692	349053	116374	21632	860778	5726	118	1065	2060	45	0.71	0.08	0.75	3.54	0 03	0.48	1.10	1.10	23	4.0	0.4	10.68	0 63	0 07	5.45	699	9 5
29	2091131	66187	570043	26595	70692	349053	116374	21632	860778	5726	118	1065	2060	45	0.71	0.08	0.75	3.54	0 03	0.48	1.10	1.10	23	4.0	0.4	10.68	0 63	0 07	5.45	699	9 5
30	2091131	66187	570043	26595	70692	349053	116374	21632	860778	5726	118	1065	2060	45	0.71	0.08	0.75	3.54	0 03	0.48	1.10	1.10	23	4.0	0.4	10.68	0 63	0 07	5.45	699	9 5

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 20 years
Event Duartion 48 hrs

Solute Loadings mg/m2 **+++++NO RUNOFF+++++**

Processing Year	TDS	K	Na	Ca	Mg	SO4	S	HC03	Cl	Nitrate	F	Silica_diss	B	U	V	Al	As	Ba	Cd	Cr	Co	Cu	Fe	Li	Mn	Mo	Ni	Pb	Se	Sr	Zn
		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 20 years
Event Duartion 72 hrs

Solute Loadings mg/m2 **+++++NO RUNOFF+++++**

Processing Year	TDS	K	Na	Ca	Mg	SO4	S	HC03	Cl	Nitrate	F	Silica_diss	B	U	V	Al	As	Ba	Cd	Cr	Co	Cu	Fe	Li	Mn	Mo	Ni	Pb	Se	Sr	Zn
		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 00	0.00	0.00	0.00	0.00	0 00	0.00	0.00	0	0.0	0.0	0.00	0.00	0 00	0 00	0	0 0

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 100 years
Event Duartion 1 hrs

Solute Loadings mg/m2

Processing Year	TDS	K mg/m2	Na mg/m2	Ca mg/m2	Mg mg/m2	SO4 mg/m2	S mg/m2	HC03 mg/m2	Cl mg/m2	Nitrate mg/m2	F mg/m2	Silica_diss mg/m2	B mg/m2	U mg/m2	V mg/m2	Al mg/m2	As mg/m2	Ba mg/m2	Cd mg/m2	Cr mg/m2	Co mg/m2	Cu mg/m2	Fe mg/m2	Li mg/m2	Mn mg/m2	Mo mg/m2	Ni mg/m2	Pb mg/m2	Se mg/m2	Sr mg/m2	Zn mg/m2
-2	2099630	70902	556176	27641	51893	371198	123597	22317	865634	6168	184	1107	1706	20	2 26	0.08	1.06	13.17	0 06	6 04	0.95	1.18	9	2.9	24.4	29.30	1 07	0.10	4.76	990	2 8
-1	2402951	81814	634537	27641	60899	423317	140966	22762	999420	7215	194	1107	1880	22	2 26	0.08	1.11	14.10	0 07	6 63	1.02	1.23	7	3.0	26.8	32.08	1 06	0.10	5 00	1073	2 2
1	3932729	137791	992621	27641	122002	657052	219008	20062	1733778	18147	216	1107	2156	24	1 36	0.08	0.41	15.57	0 08	6.70	1.13	0.98	5	1.1	42.5	30.84	0 23	0 09	3.12	1015	0 6
2	4567102	155858	1131454	27641	144886	757029	252349	20452	2042572	30385	224	1107	2156	14	0.76	0.08	0.25	15.57	0 08	8.77	1.13	0.88	5	0.5	42.5	27.92	0.19	0 09	2.75	866	0 6
3	3939839	137047	961026	27641	127848	652636	217624	27051	1760616	24201	264	1107	2156	9	0 85	0.08	0.18	15.57	0 08	4 62	1.13	0.57	5	0.6	42.5	16.44	0.19	0 09	1 89	524	0 5
4	3676730	127707	896165	27641	119322	608359	202859	26256	1641720	22732	253	1107	2017	9	0 85	0.08	0.17	14.83	0 07	4 31	1.08	0.57	6	0.7	40.1	15.36	0 21	0.10	1 81	497	1 0
5	3297947	64753	825987	27641	133413	560058	186687	30252	1460527	3823	52	1107	2189	55	2 26	0.08	4.57	15.12	0 07	1 29	1.15	2.78	46	5.2	292.3	14.54	4 92	0 55	8.45	935	68.5
6	1746050	49593	434676	27641	62786	291084	97067	24324	750378	5370	158	1107	1261	23	1 88	0.08	1.17	8.52	0 04	0 89	0.73	1.01	18	2.2	73.1	9.46	1.40	0 37	3.47	444	16.5
7	1123949	27063	279578	22826	43048	186331	62144	20991	476414	2960	129	1107	848	20	1.72	0.08	1.12	6.10	0 03	0.45	0.55	0.97	18	2.7	64.6	7.54	1 39	0.43	3.16	366	17.1
8	1433963	27941	350570	27641	57716	238112	79382	21787	624886	3090	92	1107	955	24	2 26	0.08	1.92	8.81	0 04	0 58	0.63	1.39	27	2.7	125.5	7.12	2 31	0 38	3 91	444	31.4
9	1196317	34324	313606	24879	41911	194859	64962	20766	493445	4689	118	1107	1109	25	1.13	0.08	0.64	5.55	0 03	0 35	0.74	0.95	24	2.8	23.3	6.00	0 88	0.14	3 34	435	12.8
10	2713843	86120	741603	27641	91997	454046	151378	28536	1119994	7532	157	1107	2682	59	0 94	0.08	0.97	4.74	0 05	0 62	1.43	1.44	30	5.3	0.6	13.90	0 83	0.10	7.11	912	12.5
11	2453163	67569	647965	27641	87850	405467	135181	26358	1044632	6058	133	1107	2143	54	1 64	0.08	1.46	7.49	0 05	0 69	1.42	1.77	43	5.1	64.2	12.32	2 00	0 33	6 33	832	25.3
12	2602204	63890	669955	27641	95739	418545	139554	25470	1151198	5661	138	1107	2035	68	1 90	0.08	1.57	10.00	0 04	0.78	1.96	2.43	73	6.6	99.5	13.46	3 38	0.74	6.40	944	36.3
13	2058178	52404	531670	27641	74837	331474	110520	23611	896826	5290	131	1107	1674	51	1 59	0.08	1.19	8.29	0 04	0 61	1.50	1.87	55	5.1	69.5	10.59	2.43	0 52	5 20	749	27.2
14	2041416	52526	527693	27641	73567	325776	108625	23272	892988	5408	138	1107	1669	54	1.43	0.08	1.00	8.18	0 04	0 59	1.62	1.92	60	5.4	59.5	10.71	2.46	0 57	5.11	767	26.1
15	2153874	55732	556786	27641	76801	338561	112897	23169	952463	5709	152	1107	1755	63	1 23	0.08	0.76	8.43	0 03	0 60	1.95	2.15	74	6.2	49.9	11.68	2.77	0.72	5 26	847	26.6
16	1998090	51767	516769	27641	71696	317843	105981	23030	874062	5421	140	1107	1643	54	1 36	0.08	0.91	8.02	0 03	0 57	1.63	1.89	61	5.4	54.1	10.55	2.41	0 57	5 00	759	25.1
17	1908517	49025	492425	27641	68758	304016	101369	22736	833546	5251	135	1107	1562	50	1 39	0.08	0.94	7.95	0 03	0 56	1.53	1.81	57	5.1	56.0	10.01	2 32	0 54	4 80	721	24.8
18	1295590	31626	327441	26151	47202	203135	67731	20137	564818	4405	122	1107	1029	34	1 32	0.08	0.71	7.28	0 03	0.41	1.11	1.40	45	3.7	47.8	6.75	1 83	0.42	3 38	510	20.4
19	2686883	61033	682170	27641	101334	431653	143923	25503	1203872	5207	128	1107	1965	69	2 26	0.08	1.96	11.49	0 04	0 87	2.02	2.68	80	6.8	135.8	13.70	4 03	0 85	6 55	965	44.0
20	2412965	60179	623129	27641	88733	391514	130536	25164	1056282	5482	130	1107	1924	59	1 89	0.08	1.57	9.25	0 04	0.73	1.66	2.14	60	5.7	93.3	12.27	2 90	0 58	6 05	854	33.0
21	2785188	88414	761479	27641	94433	466275	155455	28897	1149850	7649	158	1107	2752	60	0 94	0.08	1.00	4.74	0 05	0 64	1.46	1.47	31	5.4	0.6	14.27	0 84	0.10	7 28	934	12.6
22	2728159	70453	714128	27641	101108	458867	152971	28109	1164578	5681	110	1107	2267	53	2 26	0.08	2.33	8.91	0 05	0 85	1.22	1.89	35	4.9	117.8	13.04	2.43	0 28	7.10	854	34.4
23	2776855	76026	735511	27641	100629	466625	155561	28480	1175368	6227	123	1107	2422	55	2 03	0.08	2.01	7.87	0 05	0 80	1.30	1.80	34	5.1	88.7	13.52	2 04	0 23	7 23	884	29.1
24	2460352	77752	670565	27641	83454	410628	136902	27245	1014424	7091	151	1107	2427	53	0 95	0.08	0.89	4.79	0 04	0 57	1.32	1.35	29	4.9	2.2	12.60	0 81	0.10	6.48	834	12.1
25	2785188	88414	761479	27641	94433	466275	155455	28897	1149850	7649	158	1107	2752	60	0 94	0.08	1.00	4.74	0 05	0 64	1.46	1.47	31	5.4	0.6	14.27	0 84	0.10	7 28	934	12.6
26	2785188	88414	761479	27641	94433	466275	155455	28897	1149850	7649	158	1107	2752	60	0 94	0.08	1.00	4.74	0 05	0 64	1.46	1.47	31	5.4	0.6	14.27	0 84	0.10	7 28	934	12.6
27	2785188	88414	761479	27641	94433	466275	155455	28897	1149850	7649	158	1107	2752	60	0 94	0.08	1.00	4.74	0 05	0 64	1.46	1.47	31	5.4	0.6	14.27	0 84	0.10	7 28	934	12.6
28	2785188	88414	761479	27641	94433	466275	155455	28897	1149850	7649	158	1107	2752	60	0 94	0.08	1.00	4.74	0 05	0 64	1.46	1.47	31	5.4	0.6	14.27	0 84	0.10	7 28	934	12.6
29	2785188	88414	761479	27641	94433	466275	155455	28897	1149850	7649	158	1107	2752	60	0 94	0.08	1.00	4.74	0 05	0 64	1.46	1.47	31	5.4	0.6	14.27	0 84	0.10	7 28	934	12.6
30	2785188	88414	761479	27641	94433	466275	155455	28897	1149850	7649	158	1107	2752	60	0 94	0.08	1.00	4.74	0 05	0 64	1.46	1.47	31	5.4	0.6	14.27	0 84	0.10	7 28	934	12.6

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 100 years
Event Duartion 6 hrs

Solute Loadings mg/m2

Processing Year	TDS	K mg/m2	Na mg/m2	Ca mg/m2	Mg mg/m2	SO4 mg/m2	S mg/m2	HC03 mg/m2	Cl mg/m2	Nitrate mg/m2	F mg/m2	Silica_diss mg/m2	B mg/m2	U mg/m2	V mg/m2	Al mg/m2	As mg/m2	Ba mg/m2	Cd mg/m2	Cr mg/m2	Co mg/m2	Cu mg/m2	Fe mg/m2	Li mg/m2	Mn mg/m2	Mo mg/m2	Ni mg/m2	Pb mg/m2	Se mg/m2	Sr mg/m2	Zn mg/m2
-2	2063362	68947	540847	47204	50463	360967	120191	21702	841776	5998	179	2349	1659	19	4 59	0.18	1.03	12.81	0 06	5 87	0.93	1.15	9	2.9	23.7	28.49	1 05	0.10	4 63	963	2.7
-1	2363740	79559	617049	52621	59221	411650	137081	22135	971875	7016	188	2349	1829	21	4.71	0.18	1.08	13.71	0 07	6.45	0.99	1.20	7	2.9	26.1	31.20	1 03	0.10	4 86	1043	2.1
1	3857380	133994	965264	58648	118639	638943	212972	19509	1685993	17647	210	2349	2097	23	1 32	0.18	0.40	15.14	0 07	6 52	1.10	0.96	5	1.1	41.3	29.99	0 23	0 09	3 03	987	0 6
2	4474269	151563	1100270	58648	140893	736164	245394	19888	1986277	29548	218	2349	2097	14	0.74	0.18	0.25	15.14	0 07	8 53	1.10	0.85	5	0.5	41.3	27.15	0.18	0 09	2 68	842	0 5
3	3864295	133270	934540	58648	124324	634648	211626	26305	1712092	23534	256	2349	2097	9	0 83	0.18	0.17	15.14	0 07	4 50	1.10	0.56	5	0.6	41.3	15.99	0.18	0 09	1 84	510	0 5
4	3608437	124187	871466	58648	116034	591592	197268	25532	1596472	22106	246	2349	1961	9	0 83	0.18	0.16	14.42	0 07	4.19	1.05	0.55	6	0.7	39.0	14.93	0 21	0 09	1.76	483	1 0
5	3238290	62968	803222	56842	129736	544622	181542	29419	1420274	3717	50	2349	2129	54	4.44	0.18	4.44	14.71	0 07	1 26	1.12	2.70	44	5.1	284.2	14.14	4.79	0 53	8 22	910	66.6
6	1703918	48227	422696	31597	61056	283061	94391	23653	729697	5222	153	2349	1226	23	1 83	0.18	1.14	8.29	0 04	0 87	0.71	0.98	17	2.2	71.1	9.20	1 36	0 36	3 37	432	16.1
7	1094245	26317	271872	22197	41861	181195	60431	20413	463284	2878	126	2349	825	19	1 67	0.18	1.09	5.93	0 03	0.43	0.54	0.94	18	2.1	62.9	7.34	1 36	0.42	3 07	356	16.6
8	1396587	27171	340908	27752	56125	231549	77194	21187	607663	3005	89	2349	929	23	2 36	0.18	1.87	8.57	0 04	0 56	0.61	1.35	26	2.6	122.1	6.93	2 25	0 37	3 80	432	30.6
9	1164618	33378	304962	24194	40756	189488	63172	20193	479845	4560	115	2349	1078	24	1.10	0.18	0.62	5.40	0 03	0 34	0.72	0.92	24	2.7	22.7	5.84	0 86	0.13	3 25	423	12.4
10	2660150	83746	721164	46710	89461	441532	147206	27749	1089126	7325	152	2349	2608	57	0 91	0.18	0.95	4.61	0 04	0 61	1.39	1.40	29	5.1	0.6	13.52	0 80	0 09	6 91	887	12.1
11	2402870	65706	630107	42925	85429	394292	131455	25631	1015841	5891	129	2349	2084	53	1 59	0.18	1.42	7.29	0 04	0 67	1.38	1.72	42	5.0	62.5	11.98	1 94	0 33	6.15	809	24.6
12	2549695	62129	651490	44817	93101	407009	135708	24768	1119470	5505	134	2349	1978	66	1 84	0.18	1.53	9.72	0 04	0.76	1.91	2.36	71	6.4	96.8	13.09	3 29	0.72	6 22	918	35.3
13	2012651	50960	517017	36806	72775	322339	107474	22960	872109	5144	127	2349	1628	50	1 55	0.18	1.16	8.06	0 04	0 60	1.46	1.82	54	5.0	67.6	10.29	2 36	0 50	5 06	729	26.5
14	1995952	51079	513149	36407	71539	316797	105631	22630	868377	5259	134	2349	1623	52	1 39	0.18	0.97	7.95	0 03	0 57	1.58	1.86	59	5.2	57.8	10.42	2 39	0 55	4 97	745	25.4
15	2106703	54196	541440	37799	74684	329230	109785	22531	926212	5551	148	2349	1706	61	1 20	0.18	0.74	8.20	0 03	0 58	1.90	2.09	72	6.0	48.5	11.35	2 69	0.70	5.11	824	25.8
16	1953132	50340	502527	35718	69720	309083	103060	22395	849972	5271	136	2349	1597	52	1 32	0.18	0.89	7.80	0 03	0.56	1.59	1.84	59	5.2	52.6	10.26	2 34	0 56	4 86	738	24.4
17	1864756	47674	478854	34447	66863	295637	98575	22110	810573	5106	132	2349	1519	49	1 36	0.18	0.91	7.73	0 03	0 54	1.49	1.76	55	4.9	54.5	9.73	2 25	0 52	4 67	701	24.1
18	1261155	30755	318417	25431	45901	197536	65864	19582	549251	4283	118	2349	1001	33	1 28	0.18	0.69	7.08	0 03	0.40	1.08	1.36	44	3.6	46.5	6.57	1.78	0.41	3 29	496	19.8
19	2633398	59351	663369	46175	98541	419756	139956	24800	1170692	5063	124	2349	1910	67	2 25	0.18	1.91	11.17	0 04	0 84	1.97	2.60	78	6.6	132.1	13.33	3 92	0 83	6 37	938	42.8
20	2363027	58520	605955	42172	86287	380724	126938	24471	1027170	5331	126	2349	1871	57	1 83	0.18	1.53	9.00	0 04	0.71	1.62	2.08	59	5.6	90.7	11.93	2 82	0 57	5 88	830	32.1
21	2730595	85978	740492	47776	91830	453424	151171	28101	1118159	7439	154	2349	2677	59	0 92	0.18	0.97	4.60	0 04	0 62	1.42	1.43	30	5.2	0.6	13.87	0 81	0 09	7 08	908	12.3
22	2674852	68512	694445	47489	98321	446220	148755	27334	1132481	5524	107	2349	2205	51	2 32	0.18	2.27	8.67	0 05	0 82	1.19	1.84	34	4.8	114.6	12.68	2 37	0 27	6 91	830	33.5
23	2722792	73931	715240	48076	97855	453764	151274	27695	1142973	6055	119	2349	2355	54	1 97	0.18	1.96	7.66	0 05	0.78	1.26	1.75	33	4.9	86.2	13.15	1 99	0 23	7 03	860	28.3
24	2409867	75609	652083	42932	81154	399310	133129	26494	986466	6896	147	2349	2360	52	0 92	0.18	0.87	4.66	0 04	0 56	1.28	1.32	28	4.7	2.2	12.25	0.78	0.10	6 30	811	11.8
25	2730595	85978	740492	47776	91830	453424	151171	28101	1118159	7439	154	2349	2677	59	0 92	0.18	0.97	4.60	0 04	0 62	1.42	1.43	30	5.2	0.6	13.87	0 81	0 09	7 08	908	12.3
26	2730595	85978	740492	47776	91830	453424	151171	28101	1118159	7439	154	2349	2677	59	0 92	0.18	0.97	4.60	0 04	0 62	1.42	1.43	30	5.2	0.6	13.87	0 81	0 09	7 08	908	12.3
27	2730595	85978	740492	47776	91830	453424	151171	28101	1118159	7439	154	2349	2677	59	0 92	0.18	0.97	4.60	0 04	0 62	1.42	1.43	30	5.2	0.6	13.87	0 81	0 09	7 08	908	12.3
28	2730595	85978	740492	47776	91830	453424	151171	28101	1118159	7439	154	2349	2677	59	0 92	0.18	0.97	4.60	0 04	0 62	1.42	1.43	30	5.2	0.6	13.87	0 81	0 09	7 08	908	12.3
29	2730595	85978	740492	47776	91830	453424	151171	28101	1118159	7439	154	2349	2677	59	0 92	0.18	0.97	4.60	0 04	0 62	1.42	1.43	30	5.2	0.6	13.87	0 81	0 09	7 08	908	12.3
30	2730595	85978	740492	47776	91830	453424	151171	28101	1118159	7439	154	2349	2677	59	0 92	0.18	0.97	4.60	0 04	0 62	1.42	1.43	30	5.2	0.6	13.87	0 81	0 09	7 08	908	12.3

Dust Suppresion Application Rate	1	L/m2/day
Event ARI	100	years
Event Duartion	48	hrs

Solute Loadings mg/m2

Processing Year	TDS	K mg/m2	Na mg/m2	Ca mg/m2	Mg mg/m2	SO4 mg/m2	S mg/m2	HC03 mg/m2	Cl mg/m2	Nitrate mg/m2	F mg/m2	Silica_diss mg/m2	B mg/m2	U mg/m2	V mg/m2	Al mg/m2	As mg/m2	Ba mg/m2	Cd mg/m2	Cr mg/m2	Co mg/m2	Cu mg/m2	Fe mg/m2	Li mg/m2	Mn mg/m2	Mo mg/m2	Ni mg/m2	Pb mg/m2	Se mg/m2	Sr mg/m2	Zn mg/m2
-2	1775794	59253	464801	40567	43368	310213	103291	18651	723418	5154	154	4569	1425	17	3 95	0.34	0.89	11.01	0 05	5 05	0.80	0.99	7	2.5	20.4	24.48	0 90	0 08	3 98	827	2.4
-1	2033936	68372	530289	45222	50894	353770	117807	19023	835224	6029	162	4569	1571	18	4 05	0.34	0.93	11.79	0 06	5 54	0.85	1.03	6	2.5	22.4	26.81	0 89	0 08	4.18	896	1 8
1	3330799	115153	829543	63637	101958	549104	183027	16766	1448934	15166	180	4569	1802	20	1.14	0.34	0.34	13.01	0 06	5 60	0.95	0.82	4	0.9	35.5	25.77	0.19	0 08	2 61	848	0 5
2	3866613	130252	945567	69300	121083	632656	210891	17092	1706996	25393	188	4569	1802	12	0 64	0.34	0.21	13.01	0 06	7 33	0.95	0.73	4	0.4	35.5	23.34	0.16	0 08	2 30	724	0 5
3	3329455	114531	803139	56351	106843	545414	181870	22607	1471363	20225	220	4569	1802	8	0.71	0.34	0.15	13.01	0 06	3 86	0.95	0.48	4	0.5	35.5	13.74	0.16	0 08	1 58	438	0.4
4	3106165	106726	748934	52943	99719	508411	169531	21942	1372000	18998	211	4569	1685	8	0.71	0.34	0.14	12.39	0 06	3 60	0.90	0.47	5	0.6	33.5	12.83	0.18	0 08	1 52	415	0 8
5	2784170	54114	690285	48850	111495	468045	156016	25282	1220576	3195	43	3219	1830	46	3 81	0.34	3.82	12.64	0 06	1 08	0.96	2.32	38	4.3	244.3	12.15	4.11	0.46	7 06	782	57.2
6	1466889	41446	363262	27155	52471	243261	81119	20327	627098	4488	132	4569	1054	19	1 57	0.34	0.98	7.12	0 04	0.74	0.61	0.84	15	1.9	61.1	7.90	1.17	0 31	2 90	371	13.8
7	942939	22617	233646	19076	35975	155718	51934	17543	398144	2474	108	4569	709	17	1.43	0.34	0.93	5.10	0 02	0 37	0.46	0.81	15	1.8	54.0	6.30	1.17	0 36	2 64	306	14.3
8	1202771	23351	292975	23850	48234	198992	66340	18208	522223	2582	77	4569	799	20	2 03	0.34	1.61	7.36	0 03	0.48	0.52	1.16	23	2.2	104.9	5.95	1 93	0 32	3 27	371	26.3
9	1003417	28685	262083	20792	35025	162845	54290	17354	412376	3919	99	4569	927	21	0 95	0.34	0.53	4.64	0 03	0 29	0.62	0.79	20	2.3	19.5	5.01	0.74	0.12	2.79	363	10.7
10	2288670	71971	619764	40143	76882	379450	126508	23847	935989	6295	131	4569	2242	49	0.79	0.34	0.81	3.96	0 04	0 52	1.20	1.21	25	4.4	0.5	11.62	0 69	0 08	5 94	762	10.4
11	2067565	56468	541510	36890	73417	338853	112972	22027	873009	5062	111	4569	1791	45	1 37	0.34	1.22	6.26	0 04	0 57	1.19	1.48	36	4.3	53.7	10.30	1 67	0 28	5 29	695	21.1
12	2193745	53394	559888	38515	80010	349781	116627	21286	962067	4731	115	4569	1700	56	1 58	0.34	1.31	8.35	0 04	0 65	1.64	2.03	61	5.5	83.2	11.25	2 82	0 62	5 35	789	30.4
13	1732213	43795	444322	31631	62542	277016	92362	19732	749486	4421	109	4569	1399	43	1 33	0.34	1.00	6.93	0 03	0 51	1.26	1.56	46	4.3	58.1	8.85	2 03	0.43	4 35	626	22.7
14	1717862	43897	440998	31288	61481	272254	90779	19448	746279	4519	115	4569	1395	45	1.19	0.34	0.84	6.83	0 03	0.49	1.36	1.60	50	4.5	49.7	8.95	2 06	0.48	4 27	641	21.8
15	1813041	46576	465311	32484	64183	282939	94349	19363	795982	4771	127	4569	1466	52	1 03	0.34	0.64	7.05	0 03	0 50	1.63	1.79	62	5.2	41.7	9.76	2 31	0 60	4 39	708	22.2
16	1681063	43262	431869	30696	59917	265624	88569	19246	730462	4530	117	4569	1373	45	1.13	0.34	0.76	6.71	0 03	0.48	1.36	1.58	51	4.5	45.2	8.82	2 01	0.48	4.17	634	21.0
17	1605113	40971	411524	29603	57462	254069	84715	19001	696602	4388	113	4569	1305	42	1.17	0.34	0.78	6.65	0 03	0.47	1.28	1.52	48	4.2	46.8	8.36	1 94	0.45	4 02	602	20.7
18	1086381	26431	273646	21855	39447	169762	56603	16829	472024	3681	102	4569	860	28	1.10	0.34	0.60	6.08	0 03	0 35	0.93	1.17	38	3.1	40.0	5.64	1 53	0 35	2 82	427	17.0
19	2265255	51006	570096	39682	84686	360736	120278	21313	1006087	4351	107	4145	1642	58	1 94	0.34	1.64	9.60	0 04	0.73	1.69	2.24	67	5.7	113.5	11.45	3 37	0.71	5.47	806	36.8
20	2033324	50292	520755	36242	74155	327192	109090	21030	882745	4582	109	4569	1608	49	1 58	0.34	1.32	7.73	0 04	0 61	1.39	1.79	51	4.8	78.0	10.25	2.42	0.49	5 06	713	27.6
21	2349210	73889	636375	41058	78918	389670	129915	24149	960940	6393	132	4569	2300	50	0.79	0.34	0.84	3.96	0 04	0 53	1.22	1.23	26	4.5	0.5	11.92	0.70	0 08	6 09	781	10.6
22	2301305	58878	596803	40812	84497	383479	127839	23491	973249	4748	92	4569	1895	44	1 99	0.34	1.95	7.45	0 05	0.71	1.02	1.58	30	4.1	98.4	10.89	2 03	0 23	5 93	714	28.7
23	2342504	63536	614673	41317	84096	389963	130004	23801	982265	5204	103	4569	2024	46	1 69	0.34	1.68	6.58	0 04	0 67	1.08	1.51	29	4.2	74.1	11.30	1.71	0.19	6 04	739	24.3
24	2073578	64978	560397	36895	69744	343165	114410	22768	847764	5926	126	4569	2028	45	0.79	0.34	0.75	4.01	0 04	0.48	1.10	1.13	24	4.1	1.9	10.53	0 67	0 08	5.41	697	10.1
25	2349210	73889	636375	41058	78918	389670	129915	24149	960940	6393	132	4569	2300	50	0.79	0.34	0.84	3.96	0 04	0 53	1.22	1.23	26	4.5	0.5	11.92	0.70	0 08	6 09	781	10.6
26	2349210	73889	636375	41058	78918	389670	129915	24149	960940	6393	132	4569	2300	50	0.79	0.34	0.84	3.96	0 04	0 53	1.22	1.23	26	4.5	0.5	11.92	0.70	0 08	6 09	781	10.6
27	2349210	73889	636375	41058	78918	389670	129915	24149	960940	6393	132	4569	2300	50	0.79	0.34	0.84	3.96	0 04	0 53	1.22	1.23	26	4.5	0.5	11.92	0.70	0 08	6 09	781	10.6
28	2349210	73889	636375	41058	78918	389670	129915	24149	960940	6393	132	4569	2300	50	0.79	0.34	0.84	3.96	0 04	0 53	1.22	1.23	26	4.5	0.5	11.92	0.70	0 08	6 09	781	10.6
29	2349210	73889	636375	41058	78918	389670	129915	24149	960940	6393	132	4569	2300	50	0.79	0.34	0.84	3.96	0 04	0 53	1.22	1.23	26	4.5	0.5	11.92	0.70	0 08	6 09	781	10.6
30	2349210	73889	636375	41058	78918	389670	129915	24149	960940	6393	132	4569	2300	50	0.79	0.34	0.84	3.96	0 04	0 53	1.22	1.23	26	4.5	0.5	11.92	0.70	0 08	6 09	781	10.6

Dust Suppresion Application Rate	1	L/m2/day
Event ARI	100	years
Event Duartion	72	hrs

Solute Loadings mg/m2

Processing Year	TDS	K mg/m2	Na mg/m2	Ca mg/m2	Mg mg/m2	SO4 mg/m2	S mg/m2	HC03 mg/m2	Cl mg/m2	Nitrate mg/m2	F mg/m2	Silica_diss mg/m2	B mg/m2	U mg/m2	V mg/m2	Al mg/m2	As mg/m2	Ba mg/m2	Cd mg/m2	Cr mg/m2	Co mg/m2	Cu mg/m2	Fe mg/m2	Li mg/m2	Mn mg/m2	Mo mg/m2	Ni mg/m2	Pb mg/m2	Se mg/m2	Sr mg/m2	Zn mg/m2
-2	1481684	49426	387716	33839	36175	258766	86161	15557	603443	4300	128	4207	1189	14	3 29	0.32	0.74	9.18	0 04	4 21	0.66	0.83	6	2.1	17.0	20.42	0.75	0 07	3 32	690	2 0
-1	1696974	57033	442343	37722	42453	295099	98269	15868	696707	5030	135	4167	1311	15	3 38	0.32	0.77	9.83	0 05	4 62	0.71	0.86	5	2.1	18.7	22.36	0.74	0 07	3.49	748	1 5
1	2778842	96056	691968	53083	85049	458038	152673	13986	1208636	12651	150	4250	1503	17	0 95	0.32	0.29	10.85	0 05	4 67	0.79	0.69	3	0.8	29.6	21.50	0.16	0 07	2.17	707	0.4
2	3225795	108651	788750	57807	101002	527733	175916	14257	1423900	21182	156	4250	1503	10	0 53	0.32	0.18	10.85	0 05	6.12	0.79	0.61	3	0.3	29.6	19.47	0.13	0 07	1 92	604	0.4
3	2777722	95537	669942	47005	89124	454960	151708	18857	1227345	16871	184	4250	1503	7	0 59	0.32	0.12	10.85	0 05	3 22	0.79	0.40	3	0.4	29.6	11.46	0.13	0 07	1 32	365	0.4
4	2591463	89026	624727	44162	83181	424094	141416	18303	1144461	15847	176	4250	1406	6	0 59	0.32	0.12	10.34	0 05	3 00	0.75	0.39	4	0.5	27.9	10.70	0.15	0 07	1 26	346	0.7
5	2322431	45140	575805	40748	93004	390423	130142	21089	1018150	2665	36	2685	1526	38	3.18	0.32	3.18	10.54	0 05	0 90	0.80	1.94	32	3.6	203.8	10.14	3.43	0 38	5 89	652	47.7
6	1224052	34572	303017	22651	43769	202918	67666	16956	523097	3743	110	4250	879	16	1 31	0.32	0.82	5.94	0 03	0 62	0.51	0.70	13	1.6	50.9	6.59	0 98	0 26	2.42	309	11.5
7	786996	18866	194897	15912	30009	129893	43321	14633	332114	2063	90	4250	591	14	1 20	0.32	0.78	4.25	0 02	0 31	0.38	0.67	13	1.5	45.1	5.26	0 97	0 30	2 20	255	11.9
8	1003513	19478	244387	19895	40234	165991	55338	15188	435615	2154	64	4027	666	17	1 69	0.32	1.34	6.14	0 03	0.40	0.44	0.97	19	1.9	87.5	4.96	1 61	0 26	2.72	309	21.9
9	837445	23928	218618	17344	29217	135838	45286	14476	343986	3269	82	4250	773	17	0.79	0.32	0.44	3.87	0 02	0 24	0.52	0.66	17	1.9	16.3	4.18	0 61	0.10	2 33	303	8 9
10	1909545	60035	516980	33485	64132	316520	105527	19892	780760	5251	109	4250	1870	41	0 66	0.32	0.68	3.30	0 03	0.44	1.00	1.01	21	3.7	0.4	9.69	0 58	0 07	4 95	636	8.7
11	1725109	47103	451704	30772	61241	282656	94236	18374	728225	4223	93	4250	1494	38	1.14	0.32	1.02	5.22	0 03	0.48	0.99	1.23	30	3.6	44.8	8.59	1 39	0 23	4.41	580	17.6
12	1829987	44539	467033	32128	66741	291772	97285	17756	802513	3946	96	3873	1418	47	1 32	0.32	1.10	6.97	0 03	0 55	1.37	1.70	51	4.6	69.4	9.38	2 36	0 52	4.46	658	25.3
13	1445373	36532	370633	26385	52170	231075	77045	16459	625188	3688	91	4250	1167	36	1.11	0.32	0.83	5.78	0 03	0.43	1.05	1.30	38	3.6	48.4	7.38	1 69	0 36	3 63	522	19.0
14	1433402	36617	367861	26099	51284	227102	75724	16223	622512	3770	96	4250	1164	38	1 00	0.32	0.70	5.70	0 02	0.41	1.13	1.34	42	3.7	41.4	7.47	1.72	0.40	3 56	534	18.2
15	1512781	38851	388142	27097	53539	236015	78702	16152	663973	3980	106	4234	1223	44	0 86	0.32	0.53	5.88	0 02	0.41	1.36	1.50	51	4.3	34.8	8.14	1 93	0 50	3 66	591	18.5
16	1402706	36087	360246	25605	49980	221572	73881	16055	609318	3779	97	4250	1145	37	0 94	0.32	0.63	5.59	0 02	0.40	1.14	1.32	42	3.7	37.7	7.36	1 68	0.40	3.48	529	17.5
17	1339352	34176	343275	24694	47932	211933	70665	15850	581075	3661	94	4250	1089	35	0 97	0.32	0.65	5.54	0 02	0 39	1.06	1.26	40	3.5	39.1	6.98	1 62	0 37	3 35	502	17.3
18	906649	22047	228263	18230	32905	141608	47216	14038	393741	3071	85	4250	717	24	0 92	0.32	0.50	5.07	0 02	0 29	0.77	0.98	31	2.6	33.4	4.71	1 28	0 29	2 36	356	14.2
19	1889575	42547	475549	33101	70641	300910	100330	17778	839233	3630	89	3458	1370	48	1 62	0.32	1.37	8.01	0 03	0 61	1.41	1.87	56	4.7	94.7	9.55	2 81	0 60	4 56	673	30.7
20	1696393	41951	434390	30232	61857	272929	90998	17542	736346	3822	91	4096	1341	41	1 31	0.32	1.10	6.45	0 03	0 51	1.16	1.49	42	4.0	65.1	8.55	2 02	0.41	4 22	595	23.0
21	1960045	61635	530836	34249	65830	325045	108369	20144	801573	5332	110	4250	1919	42	0 66	0.32	0.70	3.30	0 03	0.45	1.02	1.03	21	3.8	0.4	9.95	0 58	0 07	5 08	651	8 8
22	1920084	49114	497826	34044	70484	319881	106638	19595	811841	3960	77	4250	1581	37	1 66	0.32	1.62	6.21	0 04	0 59	0.85	1.32	25	3.4	82.1	9.09	1.70	0.19	4 95	595	24.0
23	1954451	52999	512733	34464	70149	325290	108444	19854	819362	4341	86	4250	1688	39	1.41	0.32	1.40	5.49	0 04	0 56	0.90	1.26	24	3.5	61.8	9.42	1.42	0.16	5 04	617	20.3
24	1730125	54202	467458	30776	58177	286253	95436	18992	707167	4943	105	4250	1692	37	0 66	0.32	0.62	3.34	0 03	0.40	0.92	0.94	20	3.4	1.5	8.78	0 56	0 07	4 52	581	8.4
25	1960045	61635	530836	34249	65830	325045	108369	20144	801573	5332	110	4250	1919	42	0 66	0.32	0.70	3.30	0 03	0.45	1.02	1.03	21	3.8	0.4	9.95	0 58	0 07	5 08	651	8 8
26	1960045	61635	530836	34249	65830	325045	108369	20144	801573	5332	110	4250	1919	42	0 66	0.32	0.70	3.30	0 03	0.45	1.02	1.03	21	3.8	0.4	9.95	0 58	0 07	5 08	651	8 8
27	1960045	61635	530836	34249	65830	325045	108369	20144	801573	5332	110	4250	1919	42	0 66	0.32	0.70	3.30	0 03	0.45	1.02	1.03	21	3.8	0.4	9.95	0 58	0 07	5 08	651	8 8
28	1960045	61635	530836	34249	65830	325045	108369	20144	801573	5332	110	4250	1919	42	0 66	0.32	0.70	3.30	0 03	0.45	1.02	1.03	21	3.8	0.4	9.95	0 58	0 07	5 08	651	8 8
29	1960045	61635	530836	34249	65830	325045	108369	20144	801573	5332	110	4250	1919	42	0 66	0.32	0.70	3.30	0 03	0.45	1.02	1.03	21	3.8	0.4	9.95	0 58	0 07	5 08	651	8 8
30	1960045	61635	530836	34249	65830	325045	108369	20144	801573	5332	110	4250	1919	42	0 66	0.32	0.70	3.30	0 03	0.45	1.02	1.03	21	3.8	0.4	9.95	0 58	0 07	5 08	651	8 8

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 1000 years
Event Duartion 48 hrs

Solute Loadings mg/m2

Processing Year	TDS	K	Na	Ca	Mg	SO4	S	HC03	Cl	Nitrate	F	Silica_diss	B	U	V	Al	As	Ba	Cd	Cr	Co	Cu	Fe	Li	Mn	Mo	Ni	Pb	Se	Sr	Zn
		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
-2	2055785	68577	537943	46951	50192	359029	119545	21585	837257	5965	178	5837	1650	19	4 57	0.54	1.03	12.74	0 06	5 84	0.92	1.15	8	2.8	23.6	28.34	1 04	0.10	4 60	958	2.7
-1	2354494	79131	613736	52338	58903	409440	136345	22016	966657	6978	187	5781	1819	21	4 68	0.54	1.07	13.64	0 07	6.41	0.99	1.19	7	2.9	26.0	31.03	1 03	0.10	4 84	1038	2.1
1	3856227	133274	960081	73651	118002	635512	211828	19405	1676941	17552	209	6576	2085	23	1 32	0.54	0.40	15.06	0 07	6.48	1.10	0.95	5	1.1	41.1	29.83	0 22	0 09	3 02	982	0 5
2	4476077	150749	1094363	80205	140136	732212	244077	19781	1975613	29389	217	6294	2085	14	0.74	0.54	0.24	15.06	0 07	8.49	1.10	0.85	5	0.5	41.1	27.01	0.18	0 09	2 66	838	0 5
3	3855328	132554	929522	65218	123656	631241	210490	26164	1702899	23408	255	7231	2085	9	0 82	0.54	0.17	15.06	0 07	4.47	1.10	0.55	5	0.6	41.1	15.90	0.18	0 09	1 83	507	0 5
4	3596900	123520	866787	61274	115411	588416	196209	25395	1587901	21987	244	7231	1951	9	0 82	0.54	0.16	14.34	0 07	4.17	1.04	0.55	6	0.7	38.8	14.85	0 20	0 09	1.75	480	1 0
5	3222293	62630	798909	56537	129040	541698	180567	29261	1412648	3697	50	3725	2117	53	4.41	0.54	4.42	14.63	0 07	1 25	1.11	2.69	44	5.0	282.7	14.07	4.76	0 53	8.18	905	66.2
6	1698807	47968	420426	31428	60728	281541	93884	23526	725779	5194	152	6374	1220	22	1 82	0.54	1.13	8.24	0 04	0 86	0.71	0.98	17	2.2	70.7	9.15	1 35	0 36	3 35	429	16.0
7	1092221	26176	270412	22077	41636	180222	60107	20303	460796	2863	125	6187	820	19	1 66	0.54	1.08	5.90	0 03	0.43	0.53	0.94	18	2.1	62.5	7.30	1 35	0.42	3 05	354	16.5
8	1392340	27025	339078	27603	55824	230306	76780	21073	604401	2988	89	5587	924	23	2 35	0.54	1.86	8.52	0 04	0 56	0.61	1.35	26	2.6	121.4	6.89	2 24	0 37	3.78	429	30.4
9	1163056	33199	303325	24064	40537	188471	62833	20085	477269	4535	114	7027	1073	24	1.10	0.54	0.62	5.37	0 03	0 34	0.72	0.92	23	2.7	22.5	5.80	0 85	0.13	3 23	421	12.3
10	2650763	83296	717292	46459	88981	439161	146415	27600	1083278	7285	152	7231	2594	57	0 91	0.54	0.94	4.58	0 04	0 60	1.39	1.40	29	5.1	0.6	13.45	0 80	0 09	6 87	882	12.1
11	2394071	65354	626723	42695	84970	392175	130750	25494	1010387	5859	128	6438	2073	53	1 58	0.54	1.42	7.25	0 04	0 67	1.37	1.71	42	5.0	62.1	11.92	1 93	0 32	6.12	805	24.4
12	2539044	61796	647993	44576	92601	404824	134980	24635	1113459	5475	134	5374	1968	65	1 83	0.54	1.52	9.67	0 04	0.76	1.90	2.35	71	6.3	96.3	13.02	3 27	0.72	6.19	914	35.1
13	2005516	50686	514241	36608	72384	320608	106897	22837	867426	5117	127	6006	1619	50	1 54	0.54	1.15	8.02	0 04	0 59	1.45	1.81	53	4.9	67.2	10.24	2 35	0 50	5 03	725	26.3
14	1988918	50804	510394	36211	71155	315097	105064	22509	863714	5231	133	6018	1615	52	1 38	0.54	0.97	7.91	0 03	0 57	1.57	1.85	58	5.2	57.5	10.36	2 38	0 55	4 94	741	25.2
15	2098931	53905	538533	37596	74283	327463	109196	22410	921239	5522	147	5875	1697	61	1.19	0.54	0.74	8.16	0 03	0 58	1.89	2.08	71	6.0	48.2	11.29	2 67	0.70	5 08	819	25.7
16	1946375	50070	499829	35526	69346	307423	102507	22275	845408	5243	135	6066	1589	52	1 31	0.54	0.88	7.76	0 03	0 55	1.58	1.83	59	5.2	52.3	10.21	2 33	0 55	4 83	734	24.3
17	1858501	47418	476283	34262	66504	294049	98046	21991	806221	5079	131	6093	1510	49	1 35	0.54	0.91	7.69	0 03	0 54	1.48	1.75	55	4.9	54.2	9.68	2 24	0 52	4 65	697	24.0
18	1258341	30590	316707	25294	45654	196476	65510	19477	546302	4260	118	6293	995	33	1 27	0.54	0.69	7.04	0 03	0.40	1.07	1.36	44	3.6	46.3	6.53	1.77	0.40	3 27	494	19.7
19	2621721	59032	659807	45927	98012	417502	139205	24667	1164407	5036	124	4797	1900	67	2 24	0.54	1.90	11.11	0 04	0 84	1.95	2.59	77	6.6	131.3	13.25	3 90	0 83	6 33	933	42.6
20	2353687	58206	602702	41946	85824	378679	126257	24339	1021655	5303	126	5683	1861	57	1 82	0.54	1.52	8.95	0 04	0.71	1.61	2.07	58	5.5	90.3	11.86	2 80	0 57	5 85	826	31.9
21	2720829	85516	736516	47519	91337	450989	150359	27950	1112156	7399	153	7231	2662	58	0 91	0.54	0.97	4.58	0 04	0 62	1.42	1.42	30	5.2	0.6	13.80	0 81	0 09	7 05	904	12.2
22	2664152	68144	690717	47234	97794	443824	147956	27188	1126401	5495	107	5997	2193	51	2 31	0.54	2.25	8.62	0 05	0 82	1.18	1.83	34	4.7	113.9	12.61	2 35	0 27	6 87	826	33.3
23	2712237	73534	711399	47818	97330	451328	150462	27546	1136837	6023	119	6400	2342	53	1 96	0.54	1.95	7.61	0 05	0.78	1.26	1.74	33	4.9	85.8	13.08	1 98	0 23	6 99	855	28.1
24	2401824	75203	648582	42701	80719	397166	132414	26351	981169	6859	146	7231	2347	52	0 91	0.54	0.86	4.64	0 04	0 56	1.28	1.31	28	4.7	2.1	12.19	0.78	0.10	6 26	806	11.7
25	2720829	85516	736516	47519	91337	450989	150359	27950	1112156	7399	153	7231	2662	58	0 91	0.54	0.97	4.58	0 04	0 62	1.42	1.42	30	5.2	0.6	13.80	0 81	0 09	7 05	904	12.2
26	2720829	85516	736516	47519	91337	450989	150359	27950	1112156	7399	153	7231	2662	58	0 91	0.54	0.97	4.58	0 04	0 62	1.42	1.42	30	5.2	0.6	13.80	0 81	0 09	7 05	904	12.2
27	2720829	85516	736516	47519	91337	450989	150359	27950	1112156	7399	153	7231	2662	58	0 91	0.54	0.97	4.58	0 04	0 62	1.42	1.42	30	5.2	0.6	13.80	0 81	0 09	7 05	904	12.2
28	2720829	85516	736516	47519	91337	450989	150359	27950	1112156	7399	153	7231	2662	58	0 91	0.54	0.97	4.58	0 04	0 62	1.42	1.42	30	5.2	0.6	13.80	0 81	0 09	7 05	904	12.2
29	2720829	85516	736516	47519	91337	450989	150359	27950	1112156	7399	153	7231	2662	58	0 91	0.54	0.97	4.58	0 04	0 62	1.42	1.42	30	5.2	0.6	13.80	0 81	0 09	7 05	904	12.2
30	2720829	85516	736516	47519	91337	450989	150359	27950	1112156	7399	153	7231	2662	58	0 91	0.54	0.97	4.58	0 04	0 62	1.42	1.42	30	5.2	0.6	13.80	0 81	0 09	7 05	904	12.2

Dust Suppresion Application Rate 1 L/m2/day
Event ARI 1000 years
Event Duartion 72 hrs

Solute Loadings mg/m2

Processing Year	TDS	K	Na	Ca	Mg	SO4	S	HC03	Cl	Nitrate	F	Silica_diss	B	U	V	Al	As	Ba	Cd	Cr	Co	Cu	Fe	Li	Mn	Mo	Ni	Pb	Se	Sr	Zn
		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
-2	1914227	63855	500901	43718	46736	334307	111314	20099	779605	5555	165	5435	1536	18	4 25	0.54	0.96	11.86	0 06	5.44	0.86	1.07	8	2.7	22.0	26.39	0 97	0 09	4 28	892	2 5
-1	2192367	73683	571475	48734	54847	381247	126957	20500	900094	6498	174	5383	1694	19	4 36	0.54	1.00	12.70	0 06	5 97	0.92	1.11	7	2.7	24.2	28.89	0 96	0 09	4 51	966	1 9
1	3590693	124097	893971	68580	109877	591752	197242	18068	1561469	16344	194	6123	1942	21	1 23	0.54	0.37	14.02	0 07	6 04	1.02	0.89	4	1.0	38.2	27.78	0 21	0 08	2 81	914	0 5
2	4167861	140369	1019007	74682	130487	681793	227270	18419	1839575	27366	202	5861	1942	13	0 69	0.54	0.23	14.02	0 07	7 90	1.02	0.79	4	0.4	38.2	25.15	0.17	0 08	2.48	780	0 5
3	3590005	123427	865516	60728	115142	587775	195996	24362	1585640	21796	238	6882	1942	9	0.76	0.54	0.16	14.02	0 07	4.16	1.02	0.51	4	0.6	38.2	14.81	0.17	0 08	1.70	472	0 5
4	3349350	115015	807101	57055	107464	547898	182699	23647	1478560	20473	227	6861	1816	8	0.77	0.54	0.15	13.35	0 06	3 88	0.97	0.51	5	0.6	36.1	13.83	0.19	0 09	1 63	447	0 9
5	3000411	58317	743898	52644	120154	504397	168134	27246	1315375	3443	47	3469	1972	50	4.11	0.54	4.11	13.62	0 07	1.17	1.03	2.50	41	4.7	263.2	13.10	4.43	0.49	7 61	842	61.7
6	1581830	44665	391476	29264	56546	262155	87420	21906	675803	4836	142	5935	1136	21	1 69	0.54	1.06	7.67	0 04	0 80	0.66	0.91	16	2.0	65.8	8.52	1 26	0 34	3.12	400	14.9
7	1017012	24373	251792	20557	38769	167812	55968	18905	429067	2666	116	5761	764	18	1 54	0.54	1.01	5.49	0 03	0.40	0.50	0.87	17	2.0	58.2	6.79	1 26	0 39	2 84	330	15.4
8	1296466	25164	315729	25702	51980	214448	71493	19622	562783	2783	83	5202	861	22	2.19	0.54	1.73	7.94	0 04	0 52	0.56	1.25	25	2.4	113.0	6.41	2 08	0 34	3 52	400	28.3
9	1082969	30913	282438	22407	37746	175493	58506	18702	444405	4223	106	6543	999	22	1 02	0.54	0.57	5.00	0 03	0 31	0.67	0.86	22	2.5	21.0	5.40	0.79	0.12	3 01	392	11.5
10	2468564	77561	667900	43260	82854	408921	136333	25700	1008685	6784	141	7062	2416	53	0 85	0.54	0.88	4.27	0 04	0 56	1.29	1.30	27	4.8	0.5	12.52	0.74	0 09	6.40	822	11.2
11	2229219	60853	583568	39755	79119	365171	121746	23738	940813	5456	120	5995	1930	49	1.47	0.54	1.32	6.75	0 04	0 62	1.28	1.59	39	4.6	57.8	11.10	1 80	0 30	5.70	749	22.8
12	2364209	57541	603373	41507	86224	376948	125685	22939	1036788	5098	124	5004	1832	61	1.71	0.54	1.41	9.00	0 04	0.70	1.77	2.19	66	5.9	89.6	12.12	3 04	0 67	5.76	851	32.7
13	1867419	47196	478831	34087	67400	298531	99536	21264	807697	4764	118	5593	1508	46	1.43	0.54	1.08	7.46	0 03	0 55	1.35	1.68	50	4.6	62.6	9.53	2.19	0.46	4 69	675	24.5
14	1851964	47306	475249	33718	66256	293399	97829	20959	804240	4870	124	5604	1503	49	1 29	0.54	0.90	7.37	0 03	0 53	1.46	1.73	54	4.8	53.5	9.65	2 22	0 51	4 60	690	23.5
15	1954402	50193	501450	35007	69168	304914	101677	20867	857804	5141	137	5470	1580	56	1.11	0.54	0.69	7.59	0 03	0 54	1.76	1.93	66	5.6	44.9	10.52	2.49	0 65	4.73	763	23.9
16	1812351	46622	465411	33080	64571	286255	95448	20741	787195	4882	126	5648	1479	48	1 22	0.54	0.82	7.23	0 03	0 51	1.47	1.71	55	4.8	48.7	9.51	2.17	0 52	4 50	683	22.6
17	1730528	44153	443487	31902	61925	273802	91294	20477	750706	4729	122	5673	1406	45	1 26	0.54	0.84	7.16	0 03	0 50	1.38	1.63	51	4.6	50.5	9.01	2 09	0.48	4 33	649	22.3
18	1171693	28483	294899	23552	42511	182947	60999	18136	508685	3967	109	5859	927	31	1.19	0.54	0.64	6.55	0 03	0 37	1.00	1.26	41	3.3	43.1	6.08	1 65	0 38	3 04	460	18.4
19	2441193	54968	614374	42764	91263	388754	129620	22968	1084227	4689	115	4467	1769	62	2 09	0.54	1.77	10.35	0 04	0.78	1.82	2.41	72	6.1	122.3	12.34	3 63	0.77	5 90	869	39.6
20	2191616	54198	561200	39057	79914	352604	117563	22663	951305	4937	117	5292	1733	53	1.70	0.54	1.42	8.33	0 04	0 66	1.50	1.93	54	5.2	84.0	11.05	2 61	0 53	5.45	769	29.7
21	2533817	79628	685801	44247	85048	419935	140005	26025	1035574	6889	142	7073	2479	54	0 85	0.54	0.90	4.26	0 04	0 58	1.32	1.32	28	4.9	0.5	12.85	0.75	0 09	6 56	841	11.4
22	2480702	63451	643155	43982	91060	413263	137768	25315	1048839	5116	99	5584	2042	47	2.15	0.54	2.10	8.03	0 05	0.76	1.10	1.71	32	4.4	106.1	11.74	2.19	0 25	6.40	769	31.0
23	2525477	68471	662414	44525	90628	420250	140101	25649	1058556	5608	111	5960	2181	50	1 83	0.54	1.81	7.09	0 05	0.72	1.17	1.62	31	4.6	79.9	12.17	1 84	0 21	6 51	797	26.2
24	2236707	70025	603922	39761	75160	369818	123296	24537	913608	6387	136	7003	2186	48	0 85	0.54	0.80	4.32	0 04	0 52	1.19	1.22	26	4.4	2.0	11.35	0.73	0 09	5 83	751	10.9
25	2533817	79628	685801	44247	85048	419935	140005	26025	1035574	6889	142	7073	2479	54	0 85	0.54	0.90	4.26	0 04	0 58	1.32	1.32	28	4.9	0.5	12.85	0.75	0 09	6 56	841	11.4
26	2533817	79628	685801	44247	85048	419935	140005	26025	1035574	6889	142	7073	2479	54	0 85	0.54	0.90	4.26	0 04	0 58	1.32	1.32	28	4.9	0.5	12.85	0.75	0 09	6 56	841	11.4
27	2533817	79628	685801	44247	85048	419935	140005	26025	1035574	6889	142	7073	2479	54	0 85	0.54	0.90	4.26	0 04	0 58	1.32	1.32	28	4.9	0.5	12.85	0.75	0 09	6 56	841	11.4
28	2533817	79628	685801	44247	85048	419935	140005	26025	1035574	6889	142	7073	2479	54	0 85	0.54	0.90	4.26	0 04	0 58	1.32	1.32	28	4.9	0.5	12.85	0.75	0 09	6 56	841	11.4
29	2533817	79628	685801	44247	85048	419935	140005	26025	1035574	6889	142	7073	2479	54	0 85	0.54	0.90	4.26	0 04	0 58	1.32	1.32	28	4.9	0.5	12.85	0.75	0 09	6 56	841	11.4
30	2533817	79628	685801	44247	85048	419935	140005	26025	1035574	6889	142	7073	2479	54	0 85	0.54	0.90	4.26	0 04	0 58	1.32	1.32	28	4.9	0.5	12.85	0.75	0 09	6 56	841	11.4

Development of Tailings and Mine Waste Source Terms for the Proposed Yeelirrie Mine

APPENDIX C

Geochemical Modelling Input and Output files

Geochemical models:

Equilibrated geochemical results were obtained using the React subroutine of the program Geochemist's WorkBench (Bethke, 2007).

C1. SysCAD model

SysCAD_Output_React
Initial Conditions: T = 63°C, pH = 9.5, SysCAD model output
Output Summary:
Final Temperature: 25°C
Final pH: 9.43
Ionic Strength: 1.54
Minerals in System: brucite ($Mg(OH)_2$, calcium vanadate ($Ca_2V_2O_7$), carnotite ($K_2(UO_2)_2(VO_4)_2).3H_2O$), celestite ($SrSO_4$), strontianite ($SrCO_3$)

Table C1. Final Equilibrated Dissolved Elemental Concentrations from the SysCAD Model

Constituent	Concentration (mg/L)
Calcium	240
Chlorine	46,935
Magnesium	639.0
Potassium	1,840
Sodium	33,256
Strontium	32.0
Sulfur (as SO_4^{2-})	12,246
Uranium	$4.52x10^{-10}$
Vanadium	47

C2. Mean Aged Tailings

Not balancing charge on chloride introduces about a 1-2% difference in the final porewater concentrations.

Table C.2a Mean Aged Tailings slurries: Input and Output parameters

Parameter	Input	Output
Step #	Xi = 0.0000	Xi = 0.0000
Temperature	25.0 C	25.0 C
Pressure	1.013 bars	1.013 bars
pH	10.000	10.000
log fO2	-36.358	-17.853

Parameter	Input	Output
Eh	0.1000 volts	0.3737 volts
pe	1.6905	6.3170
Ionic strength	2.222123	2.220979
Charge imbalance	-0.370338 eq/kg (-11.92% error)	-0.370374 eq/kg (-11.92% error)
Activity of water	0.980492	0.980491
Solvent mass	1.0000 kg	1.0000 kg
Solution mass	1.1402 kg	1.1401 kg
Mineral mass	0.00000 kg	0.00011121 kg
Solution density	1.073 g/cm3	1.073 g/cm3
Solution viscosity	0.010 poise	0.010 poise
Chlorinity	0.607127 molal	0.607129 molal
Dissolved solids	122987 mg/kg sol'n	122906 mg/kg sol'n
Hardness	40.14 mg/kg sol'n as CaCO3	1.04 mg/kg sol'n as CaCO3
carbonate	40.14 mg/kg sol'n as CaCO3	1.04 mg/kg sol'n as CaCO3
non-carbonate	0.00 mg/kg sol'n as CaCO3	0.00 mg/kg sol'n as CaCO3
Carbonate alkalinity	74217.38 mg/kg sol'n as CaCO3	74192.34 mg/kg sol'n as CaCO3
Water type	Na-CO3	Na-CO3
Bulk volume	1.06e+03 cm3	1.06e+03 cm3
Fluid volume	1.06e+03 cm3	1.06e+03 cm3
Mineral volume	0.000 cm3	0.0319 cm3
Inert volume	0.000 cm3	0.000 cm3
Porosity	100. %	100. %
Permeability	98.7 cm2	98.6 cm2

Table C.2b Final Equilibrated Dissolved Elemental Concentrations from the Mean Aged Tailings slurries

Constituent	Concentration (mg/kg)
Calcium	9.85×10^{-27}
Chlorine	18,888
Magnesium	0.253
Potassium	1537
Sodium	40,500
Strontium	0.00024
Sulfur (as SO_4^{2-})	8,789
Uranium	54.0
Vanadium	46.7

C3. Sensitivity Model runs

Input for the Sensitivity Runs for pH and Eh were the 90th percentile values of the aged tailings porewater concentrations.

Table C.3a Mean Aged Tailings slurries: Input and Output parameters

Parameter	Input	Output
Step #	0	100
Temperature	25.0 C	25.0 C
Pressure	1.013 bars	1.013 bars
pH	10.000	9.998
log fO2	-32.982	-53.277
Eh	0.1500 volts	-0.1500 volts
pe	2.5357	-2.5357
Ionic strength	2.146854	2.144672
Activity of water	0.975082	0.975080
Solvent mass	1.0000 kg	0.99999 kg
Solution mass	1.1373 kg	1.1371 kg
Mineral mass	0.00000 kg	0.00020429 kg
Solution density	1.072 g/cm3	1.072 g/cm3
Solution viscosity	0.010 poise	0.010 poise
Chlorinity	0.778073 molal	0.778080 molal
Dissolved solids	120751 mg/kg sol'n	120601 mg/kg sol'n
Hardness	70.60 mg/kg sol'n as CaCO3	1.11 mg/kg sol'n as CaCO3
carbonate	70.60 mg/kg sol'n as CaCO3	1.11 mg/kg sol'n as CaCO3
non-carbonate	0.00 mg/kg sol'n as CaCO3	0.00 mg/kg sol'n as CaCO3
Carbonate alkalinity	50513.79 mg/kg sol'n as CaCO3	50484.18 mg/kg sol'n as CaCO3
Water type	Na-Cl	Na-Cl
Bulk volume	1.06e+03 cm3	1.06e+03 cm3
Fluid volume	1.06e+03 cm3	1.06e+03 cm3
Mineral volume	0.000 cm3	0.0792 cm3
Inert volume	0.000 cm3	0.000 cm3
Porosity	100. %	100. %
Permeability	98.7 cm2	98.4 cm2

Table C.3b Mean Aged Tailings slurries: Final Concentrations

Constituent	Concentration (mg/kg)
Calcium	1.21×10^{-28}
Chlorine	24,260
Magnesium	0.271
Potassium	161
Sodium	44,160
Strontium	0.000266
Sulfur (as SO_4^{2-})	13,715
Uranium	102.6
Vanadium	73.52

Evaporation:

Evaporation was modelled using both the Pitzer equations and B-dot equations in order to verify the applicability of the B-dot equations in the saline environment around Yeelirrie. Using both formulations, tailings pore water was evaporated and the minerals

Table C.4a Evaporation: Input and Output parameters

Parameter	Input	Output
Step #	0	100
Temperature	63.0 C	25.0 C
Pressure	1.013 bars	1.013 bars
pH	9.500	9.667
Ionic strength	1.619502	3.949203
Activity of water	0.989338	0.964802
Solvent mass	1.0000 kg	0.30001 kg
Solution mass	1.1012 kg	0.39736 kg
Mineral mass	0.00000 kg	0.0038594 kg
Solution density	1.033 g/cm3	1.160 g/cm3
Solution viscosity	0.005 poise	0.010 poise
Chlorinity	0.334679 molal	1.115548 molal
Dissolved solids	91913 mg/kg sol'n	244978 mg/kg sol'n
Hardness	3641.53 mg/kg sol'n as CaCO3	0.90 mg/kg sol'n as CaCO3
carbonate	3641.53 mg/kg sol'n as CaCO3	0.90 mg/kg sol'n as CaCO3
non-carbonate	0.00 mg/kg sol'n as CaCO3	0.00 mg/kg sol'n as CaCO3
Carbonate alkalinity	45909.08 mg/kg sol'n as CaCO3	121101.99 mg/kg sol'n as CaCO3
Water type	Na-CO3	Na-Cl
Bulk volume	1.07e+03 cm3	344. cm3
Fluid volume	1.07e+03 cm3	342. cm3
Mineral volume	0.000 cm3	1.29 cm3
Inert volume	0.000 cm3	0.000 cm3
Porosity	100. %	99.6 %
Permeability	98.7 cm2	86.7 cm2
Mass reacted	0 g	-700 g

Table C.4b Evaporation: Final Porewater Concentrations

Constituent	Concentration (mg/kg)
Calcium	5.1 x 10^{-28}
Chlorine	92,598
Magnesium	0.30
Potassium	6339
Sodium	166,718

Constituent	Concentration
Strontium	2.7×10^{-4}
Sulfur (as SO_4^{2-})	48,645
Uranium	391.5
Vanadium	281

Groundwater Mixing:

In a post closure environment the ground water will recover to approximately its pre-mining level. It is estimate that the new water level will be about 5 m below the pre-mining ground surface, which will intersect a significant portion of the tailings mass. As a result it is important to understand the influence that groundwater will have when mixed with tailings porewaters and solids.

Using Geochemist's workbench tailings porewater was mixed with various ratios of Yeelirrie groundwater. The tailings porewater was equilibrated and then mixed (in steps) with groundwater. Geochemical equilibration occurred throughout. Several runs were made using chloride and sodium to charge balance the resulting solutions. In all the scenarios the trends observed were consistent but the program corrections made in response to the charge balancing requirements were not acceptable. In the end, the no-charge balancing scenarios are shown. These results show trends consistent with the other scenarios that were run. In the four mixing ratios, the charge balance errors ranged from 3 to 10 percent.

A table of results is shown in Table C.5. In all the scenarios there is a consistent trend of pH decreasing and calcium increasing in agreement with the composition and pH of groundwater in the Yeelirrie area. Various COCs, including arsenic, selenium, molybdenum and vanadium decrease in response to the mixing. The long term fate of most COCs is predicted to improve as a result of mixing with Yeelirrie groundwater. For those metals that are predicted to increase, such as copper and nickel, the initial concentration is quite low so that the final concentration is in the microgram per litre range.

Table C.5 Evaporation: Input and Output parameters

Tailings Constituent	1:1 (mg/L)	10:1 (mg/L)	25:1 (mg/L)	100:1 (mg/L)	Trend
pH	9.98	9.57	7.08	6.46	decrease

Tailings Constituent	1:1 (mg/L)	10:1 (mg/L)	25:1 (mg/L)	100:1 (mg/L)	Trend
Br^-	56.49	37.02	38.03	34.91	decrease
Ca^{++}	0.0043	0.0074	0.0076	2.78	increase
Cl^-	15308	9954	10225	9370	decrease
F^-	5.84	2.31	2.37	1.88	decrease
K^+	1106	561	577	498	decrease
Si	5.97	0.92	0.95	2.54	
Na^+	25603	8533	8765	6467	decrease
SO_4^{2-}	2198	1226	1259	1115	decrease
U	8.79E-12	1.75E-14	1.80E-14	2.56E-18	decrease
Mg	0.31	0.61	0.63	265.6	increase
Al	1.45E-05	2.47E-04	2.53E-04	4.06E-04	increase
As	2.3015	0.4031	0.4141	0.1685	decrease
Ba	1.39E-06	4.34E-06	4.46E-06	3.43E-04	increase
B	24.58	13.12	13.48	11.80	decrease
Cr	0.5469	0.1047	0.1075	0.0502	decrease
Cu	1.05E-04	2.51E-04	2.58E-04	2.52E-02	increase
Fe	2.38E-07	1.22E-07	1.25E-07	1.58E-08	
Mo	1.12	0.29	0.29	0.18	decrease
Ni	2.84E-05	1.19E-04	1.23E-04	2.93E-02	increase
Se	0.27036338	0.0876	0.089981	0.06544	decrease
Sr	2.96E-04	7.08E-04	7.27E-04	3.54E-01	increase
V	26.63	4.74	4.87	2.03	decrease
Zn	0.0019	0.0115	0.0118	0.1041	

Development of Tailings and Mine Waste Source Terms for the Proposed Yeelirrie Mine

APPENDIX D

Stockpile Solute Loadings – Upper bound

Table D1a. Summary of Estimated Solute Loadings for Selected Rain Events
for the Upper Bound Case (ARI = 5 years)

Duration	Stockpile	Al	As	Ca	Cl	K	Mg	Mo
(hrs)		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
1	UHG hs	7.28E+00	7.31E+02	7.43E+03	1.48E+07	3.32E+06	1.97E+06	1.72E+03
	UHG ls	7.28E+00	5.29E+02	7.43E+03	1.07E+07	2.40E+06	1.42E+06	1.24E+03
	VHG hs	7.28E+00	1.08E+03	7.43E+03	2.19E+07	4.90E+06	2.90E+06	2.53E+03
	VHG ls	7.28E+00	9.06E+02	7.43E+03	1.84E+07	4.11E+06	2.44E+06	2.12E+03
	HG hs	7.28E+00	4.78E+02	7.43E+03	6.29E+06	1.37E+06	1.44E+06	2.07E+03
	HG ls	7.28E+00	3.35E+02	7.43E+03	4.41E+06	9.57E+05	1.01E+06	1.45E+03
	MG hs	8.77E+00	4.06E+02	8.95E+03	2.03E+07	3.74E+06	3.34E+06	2.13E+03
	MG ls	8.77E+00	6.22E+02	8.95E+03	3.11E+07	5.73E+06	5.12E+06	3.26E+03
	LG	8.77E+00	8.45E+02	8.95E+03	2.45E+07	4.26E+06	2.46E+06	4.13E+03
	Waste	8.77E+00	6.04E+08	8.95E+03	4.45E+13	6.64E+12	8.46E+05	3.20E+09
6	UHG hs	7.82E+00	7.86E+02	7.98E+03	1.60E+07	3.57E+06	2.11E+06	1.84E+03
	UHG ls	7.82E+00	5.68E+02	7.98E+03	1.15E+07	2.58E+06	1.53E+06	1.33E+03
	VHG hs	7.82E+00	1.16E+03	7.98E+03	2.35E+07	5.26E+06	3.12E+06	2.72E+03
	VHG ls	7.82E+00	9.73E+02	7.98E+03	1.98E+07	4.42E+06	2.62E+06	2.28E+03
	HG hs	7.82E+00	5.14E+02	7.98E+03	6.76E+06	1.47E+06	1.54E+06	2.22E+03
	HG ls	7.82E+00	3.60E+02	7.98E+03	4.74E+06	1.03E+06	1.08E+06	1.56E+03
	MG hs	1.38E+01	3.35E+02	1.41E+04	1.68E+07	3.09E+06	2.76E+06	1.76E+03
	MG ls	1.38E+01	5.14E+02	1.41E+04	2.57E+07	4.73E+06	4.23E+06	2.69E+03
	LG	1.38E+01	6.98E+02	1.41E+04	2.03E+07	3.52E+06	2.03E+06	3.41E+03
	Waste	1.38E+01	4.99E+08	1.41E+04	3.68E+13	5.49E+12	6.49E+05	2.65E+09
48	UHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	UHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG hs	4.08E+00	4.65E+01	4.16E+03	2.32E+06	4.29E+05	3.83E+05	2.44E+02
	MG ls	4.08E+00	7.13E+01	4.16E+03	3.56E+06	6.57E+05	5.87E+05	3.73E+02
	LG	4.08E+00	9.68E+01	4.16E+03	2.81E+06	4.88E+05	2.82E+05	4.73E+02
	Waste	4.08E+00	6.92E+07	4.16E+03	5.10E+12	7.61E+11	8.46E+04	3.67E+08
72	UHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	UHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	LG	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Waste	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table D1b. Summary of Estimated Solute Loadings for Selected Rain Events
for the Upper Bound Case (ARI = 5 years)

Duration	Stockpile	Na	Sr	Se	U	V	Ra-226
(hrs)		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
1	UHG hs	1.77E+07	2.46E+02	4.65E+02	2.25E+01	1.50E+01	4.49E+03
	UHG ls	1.28E+07	2.46E+02	3.36E+02	2.25E+01	1.50E+01	3.25E+03
	VHG hs	2.61E+07	2.46E+02	6.85E+02	2.25E+01	1.50E+01	6.62E+03
	VHG ls	2.19E+07	2.46E+02	5.76E+02	2.25E+01	1.50E+01	5.56E+03
	HG hs	1.59E+07	2.46E+02	3.97E+02	2.25E+01	1.50E+01	9.34E+01
	HG ls	1.11E+07	2.46E+02	2.78E+02	2.25E+01	1.50E+01	6.54E+01
	MG hs	1.85E+07	2.97E+02	5.12E+02	2.71E+01	1.81E+01	9.96E+02
	MG ls	2.83E+07	2.97E+02	7.85E+02	2.71E+01	1.81E+01	1.52E+03
	LG	2.40E+07	2.97E+02	6.03E+02	2.71E+01	1.81E+01	2.29E+02
	Waste	3.52E+13	2.97E+02	1.08E+09	2.71E+01	1.81E+01	0.00E+00
6	UHG hs	1.90E+07	2.65E+02	4.99E+02	2.42E+01	1.61E+01	4.82E+03
	UHG ls	1.38E+07	2.65E+02	3.61E+02	2.42E+01	1.61E+01	3.49E+03
	VHG hs	2.80E+07	2.65E+02	7.36E+02	2.42E+01	1.61E+01	7.11E+03
	VHG ls	2.36E+07	2.65E+02	6.19E+02	2.42E+01	1.61E+01	5.98E+03
	HG hs	1.71E+07	2.65E+02	4.26E+02	2.42E+01	1.61E+01	1.00E+02
	HG ls	1.20E+07	2.65E+02	2.99E+02	2.42E+01	1.61E+01	7.03E+01
	MG hs	1.53E+07	4.67E+02	4.23E+02	4.26E+01	2.84E+01	8.23E+02
	MG ls	2.34E+07	4.67E+02	6.48E+02	4.26E+01	2.84E+01	1.26E+03
	LG	1.98E+07	4.67E+02	4.99E+02	4.26E+01	2.84E+01	1.89E+02
	Waste	2.91E+13	4.67E+02	8.92E+08	4.26E+01	2.84E+01	0.00E+00
48	UHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	UHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG hs	2.12E+06	1.38E+02	5.87E+01	1.26E+01	8.40E+00	1.14E+02
	MG ls	3.25E+06	1.38E+02	8.99E+01	1.26E+01	8.40E+00	1.75E+02
	LG	2.75E+06	1.38E+02	6.92E+01	1.26E+01	8.40E+00	2.63E+01
	Waste	4.03E+12	1.38E+02	1.24E+08	1.26E+01	8.40E+00	0.00E+00
72	UHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	UHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	LG	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Waste	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table D2a. Summary of Estimated Solute Loadings for Selected Rain Events
for the Upper Bound Case (ARI = 20 years)

Duration	Stockpile	Al	As	Ca	Cl	K	Mg	Mo
(hrs)		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
1	UHG hs	1.30E+01	9.11E+02	1.33E+04	1.85E+07	4.14E+06	2.45E+06	2.14E+03
	UHG ls	1.30E+01	6.59E+02	1.33E+04	1.34E+07	2.99E+06	1.77E+06	1.55E+03
	VHG hs	1.30E+01	1.34E+03	1.33E+04	2.72E+07	6.10E+06	3.61E+06	3.15E+03
	VHG ls	1.30E+01	1.13E+03	1.33E+04	2.29E+07	5.12E+06	3.04E+06	2.65E+03
	HG hs	1.30E+01	5.96E+02	1.33E+04	7.83E+06	1.70E+06	1.79E+06	2.57E+03
	HG ls	1.30E+01	4.18E+02	1.33E+04	5.49E+06	1.19E+06	1.25E+06	1.80E+03
	MG hs	1.40E+01	4.52E+02	1.43E+04	2.26E+07	4.17E+06	3.73E+06	2.37E+03
	MG ls	1.40E+01	6.93E+02	1.43E+04	3.46E+07	6.38E+06	5.71E+06	3.63E+03
	LG	1.40E+01	9.41E+02	1.43E+04	2.73E+07	4.75E+06	2.74E+06	4.60E+03
	Waste	1.40E+01	6.73E+08	1.43E+04	4.96E+13	7.40E+12	8.45E+05	3.57E+09
6	UHG hs	2.40E+01	8.20E+02	2.45E+04	1.66E+07	3.72E+06	2.21E+06	1.92E+03
	UHG ls	2.40E+01	5.93E+02	2.45E+04	1.20E+07	2.69E+06	1.60E+06	1.39E+03
	VHG hs	2.40E+01	1.21E+03	2.45E+04	2.45E+07	5.49E+06	3.25E+06	2.83E+03
	VHG ls	2.40E+01	1.02E+03	2.45E+04	2.06E+07	4.61E+06	2.73E+06	2.38E+03
	HG hs	2.40E+01	5.36E+02	2.45E+04	7.05E+06	1.53E+06	1.61E+06	2.32E+03
	HG ls	2.40E+01	3.76E+02	2.45E+04	4.94E+06	1.07E+06	1.13E+06	1.62E+03
	MG hs	2.74E+01	4.31E+02	2.80E+04	2.15E+07	3.97E+06	3.55E+06	2.26E+03
	MG ls	2.74E+01	6.60E+02	2.80E+04	3.30E+07	6.08E+06	5.44E+06	3.46E+03
	LG	2.74E+01	8.97E+02	2.80E+04	2.60E+07	4.52E+06	2.61E+06	4.38E+03
	Waste	2.74E+01	6.41E+08	2.80E+04	4.72E+13	7.05E+12	7.59E+05	3.40E+09
48	UHG hs	2.92E+01	4.40E+02	2.98E+04	8.92E+06	2.00E+06	1.18E+06	1.03E+03
	UHG ls	2.92E+01	3.18E+02	2.98E+04	6.46E+06	1.44E+06	8.56E+05	7.46E+02
	VHG hs	2.92E+01	6.48E+02	2.98E+04	1.32E+07	2.94E+06	1.74E+06	1.52E+03
	VHG ls	2.92E+01	5.44E+02	2.98E+04	1.11E+07	2.47E+06	1.47E+06	1.28E+03
	HG hs	2.92E+01	2.88E+02	2.98E+04	3.78E+06	8.21E+05	8.63E+05	1.24E+03
	HG ls	2.92E+01	2.02E+02	2.98E+04	2.65E+06	5.75E+05	6.05E+05	8.71E+02
	MG hs	5.32E+01	3.69E+02	5.43E+04	1.84E+07	3.40E+06	3.04E+06	1.93E+03
	MG ls	5.32E+01	5.65E+02	5.43E+04	2.82E+07	5.21E+06	4.66E+06	2.96E+03
	LG	5.32E+01	7.68E+02	5.43E+04	2.23E+07	3.87E+06	2.24E+06	3.75E+03
	Waste	5.32E+01	5.49E+08	5.43E+04	4.04E+13	6.04E+12	6.50E+05	2.91E+09
72	UHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	UHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG hs	5.15E+01	3.21E+02	5.26E+04	1.60E+07	2.95E+06	2.64E+06	1.68E+03
	MG ls	5.15E+01	4.91E+02	5.26E+04	2.45E+07	4.52E+06	4.05E+06	2.57E+03
	LG	5.15E+01	6.67E+02	5.26E+04	1.94E+07	3.36E+06	1.94E+06	3.26E+03
	Waste	5.15E+01	4.77E+08	5.26E+04	3.51E+13	5.25E+12	5.64E+05	2.53E+09

Table D2b. Summary of Estimated Solute Loadings for Selected Rain Events for the Upper Bound Case (ARI = 20 years)

Duration	Stockpile	Na	Sr	Se	U	V	Ra-226
(hrs)		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
1	UHG hs	2.21E+07	4.39E+02	5.79E+02	4.01E+01	2.67E+01	5.59E+03
	UHG ls	1.60E+07	4.39E+02	4.19E+02	4.01E+01	2.67E+01	4.05E+03
	VHG hs	3.25E+07	4.39E+02	8.53E+02	4.01E+01	2.67E+01	8.24E+03
	VHG ls	2.73E+07	4.39E+02	7.17E+02	4.01E+01	2.67E+01	6.93E+03
	HG hs	1.98E+07	4.39E+02	4.94E+02	4.01E+01	2.67E+01	1.16E+02
	HG ls	1.39E+07	4.39E+02	3.46E+02	4.01E+01	2.67E+01	8.15E+01
	MG hs	2.06E+07	4.74E+02	5.71E+02	4.33E+01	2.88E+01	1.11E+03
	MG ls	3.16E+07	4.74E+02	8.74E+02	4.33E+01	2.88E+01	1.70E+03
	LG	2.68E+07	4.74E+02	6.72E+02	4.33E+01	2.88E+01	2.55E+02
	Waste	3.92E+13	4.74E+02	1.20E+09	4.33E+01	2.88E+01	0.00E+00
6	UHG hs	1.98E+07	8.12E+02	5.21E+02	7.41E+01	4.94E+01	5.03E+03
	UHG ls	1.44E+07	8.12E+02	3.77E+02	7.41E+01	4.94E+01	3.64E+03
	VHG hs	2.93E+07	8.12E+02	7.68E+02	7.41E+01	4.94E+01	7.42E+03
	VHG ls	2.46E+07	8.12E+02	6.45E+02	7.41E+01	4.94E+01	6.23E+03
	HG hs	1.78E+07	8.12E+02	4.45E+02	7.41E+01	4.94E+01	1.05E+02
	HG ls	1.25E+07	8.12E+02	3.12E+02	7.41E+01	4.94E+01	7.34E+01
	MG hs	1.96E+07	9.27E+02	5.44E+02	8.46E+01	5.64E+01	1.06E+03
	MG ls	3.01E+07	9.27E+02	8.33E+02	8.46E+01	5.64E+01	1.62E+03
	LG	2.55E+07	9.27E+02	6.41E+02	8.46E+01	5.64E+01	2.43E+02
	Waste	3.73E+13	9.27E+02	1.15E+09	8.46E+01	5.64E+01	0.00E+00
48	UHG hs	1.06E+07	9.87E+02	2.79E+02	9.01E+01	6.01E+01	2.70E+03
	UHG ls	7.70E+06	9.87E+02	2.02E+02	9.01E+01	6.01E+01	1.95E+03
	VHG hs	1.57E+07	9.87E+02	4.12E+02	9.01E+01	6.01E+01	3.98E+03
	VHG ls	1.32E+07	9.87E+02	3.46E+02	9.01E+01	6.01E+01	3.34E+03
	HG hs	9.56E+06	9.87E+02	2.39E+02	9.01E+01	6.01E+01	5.61E+01
	HG ls	6.70E+06	9.87E+02	1.67E+02	9.01E+01	6.01E+01	3.93E+01
	MG hs	1.68E+07	1.80E+03	4.66E+02	1.64E+02	1.09E+02	9.05E+02
	MG ls	2.57E+07	1.80E+03	7.13E+02	1.64E+02	1.09E+02	1.39E+03
	LG	2.18E+07	1.80E+03	5.49E+02	1.64E+02	1.09E+02	2.08E+02
	Waste	3.20E+13	1.80E+03	9.81E+08	1.64E+02	1.09E+02	0.00E+00
72	UHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	UHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	VHG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG hs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HG ls	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MG hs	1.46E+07	1.74E+03	4.05E+02	1.59E+02	1.06E+02	7.86E+02
	MG ls	2.24E+07	1.74E+03	6.20E+02	1.59E+02	1.06E+02	1.20E+03
	LG	1.90E+07	1.74E+03	4.77E+02	1.59E+02	1.06E+02	1.81E+02
	Waste	2.78E+13	1.74E+03	8.53E+08	1.59E+02	1.06E+02	0.00E+00

Table D3a. Summary of Estimated Solute Loadings for Selected Rain Events
for the Upper Bound Case (ARI = 100 years)

Duration	Stockpile	Al	As	Ca	Cl	K	Mg	Mo
(hrs)		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
1	UHG hs	2.31E+01	1.01E+03	2.35E+04	2.05E+07	4.59E+06	2.72E+06	2.37E+03
	UHG ls	2.31E+01	7.31E+02	2.35E+04	1.48E+07	3.32E+06	1.97E+06	1.71E+03
	VHG hs	2.31E+01	1.49E+03	2.35E+04	3.02E+07	6.76E+06	4.01E+06	3.49E+03
	VHG ls	2.31E+01	1.25E+03	2.35E+04	2.54E+07	5.68E+06	3.37E+06	2.94E+03
	HG hs	2.31E+01	6.61E+02	2.35E+04	8.69E+06	1.89E+06	1.98E+06	2.85E+03
	HG ls	2.31E+01	4.63E+02	2.35E+04	6.09E+06	1.32E+06	1.39E+06	2.00E+03
	MG hs	2.37E+01	4.78E+02	2.42E+04	2.39E+07	4.40E+06	3.93E+06	2.50E+03
	MG ls	2.37E+01	7.31E+02	2.42E+04	3.65E+07	6.74E+06	6.03E+06	3.83E+03
	LG	2.37E+01	9.94E+02	2.42E+04	2.88E+07	5.01E+06	2.90E+06	4.86E+03
	Waste	2.37E+01	7.10E+08	2.42E+04	5.24E+13	7.81E+12	0.00E+00	3.77E+09
6	UHG hs	4.92E+01	9.91E+02	5.02E+04	2.01E+07	4.50E+06	2.67E+06	2.32E+03
	UHG ls	4.92E+01	7.17E+02	5.02E+04	1.45E+07	3.26E+06	1.93E+06	1.68E+03
	VHG hs	4.92E+01	1.46E+03	5.02E+04	2.96E+07	6.63E+06	3.93E+06	3.43E+03
	VHG ls	4.92E+01	1.23E+03	5.02E+04	2.49E+07	5.57E+06	3.30E+06	2.88E+03
	HG hs	4.92E+01	6.48E+02	5.02E+04	8.52E+06	1.85E+06	1.94E+06	2.80E+03
	HG ls	4.92E+01	4.54E+02	5.02E+04	5.97E+06	1.30E+06	1.36E+06	1.96E+03
	MG hs	5.11E+01	4.73E+02	5.21E+04	2.36E+07	4.36E+06	3.89E+06	2.48E+03
	MG ls	5.11E+01	7.24E+02	5.21E+04	3.62E+07	6.67E+06	5.96E+06	3.79E+03
	LG	5.11E+01	9.84E+02	5.21E+04	2.85E+07	4.96E+06	2.87E+06	4.81E+03
	Waste	5.11E+01	7.03E+08	5.21E+04	5.18E+13	7.73E+12	0.00E+00	3.73E+09
48	UHG hs	1.02E+02	9.10E+02	1.05E+05	1.85E+07	4.13E+06	2.45E+06	2.13E+03
	UHG ls	1.02E+02	6.58E+02	1.05E+05	1.34E+07	2.99E+06	1.77E+06	1.54E+03
	VHG hs	1.02E+02	1.34E+03	1.05E+05	2.72E+07	6.09E+06	3.61E+06	3.15E+03
	VHG ls	1.02E+02	1.13E+03	1.05E+05	2.29E+07	5.12E+06	3.03E+06	2.64E+03
	HG hs	1.02E+02	5.95E+02	1.05E+05	7.83E+06	1.70E+06	1.79E+06	2.57E+03
	HG ls	1.02E+02	4.17E+02	1.05E+05	5.49E+06	1.19E+06	1.25E+06	1.80E+03
	MG hs	1.12E+02	4.57E+02	1.14E+05	2.28E+07	4.21E+06	3.76E+06	2.39E+03
	MG ls	1.12E+02	6.99E+02	1.14E+05	3.49E+07	6.44E+06	5.76E+06	3.66E+03
	LG	1.12E+02	9.50E+02	1.14E+05	2.76E+07	4.79E+06	2.77E+06	4.64E+03
	Waste	1.12E+02	6.79E+08	1.14E+05	5.00E+13	7.47E+12	0.00E+00	3.60E+09
72	UHG hs	1.06E+02	8.46E+02	1.09E+05	1.72E+07	3.84E+06	2.28E+06	1.98E+03
	UHG ls	1.06E+02	6.12E+02	1.09E+05	1.24E+07	2.78E+06	1.65E+06	1.44E+03
	VHG hs	1.06E+02	1.25E+03	1.09E+05	2.53E+07	5.66E+06	3.36E+06	2.92E+03
	VHG ls	1.06E+02	1.05E+03	1.09E+05	2.13E+07	4.76E+06	2.82E+06	2.46E+03
	HG hs	1.06E+02	5.53E+02	1.09E+05	7.28E+06	1.58E+06	1.66E+06	2.39E+03
	HG ls	1.06E+02	3.88E+02	1.09E+05	5.10E+06	1.11E+06	1.16E+06	1.67E+03
	MG hs	1.21E+02	4.45E+02	1.24E+05	2.23E+07	4.10E+06	3.67E+06	2.33E+03
	MG ls	1.21E+02	6.82E+02	1.24E+05	3.41E+07	6.29E+06	5.62E+06	3.57E+03
	LG	1.21E+02	9.27E+02	1.24E+05	2.69E+07	4.67E+06	2.70E+06	4.53E+03
	Waste	1.21E+02	6.63E+08	1.24E+05	4.88E+13	7.29E+12	0.00E+00	3.51E+09

Table D3b. Summary of Estimated Solute Loadings for Selected Rain Events for the Upper Bound Case (ARI = 100 years)

Duration	Stockpile	Na	Sr	Se	U	V	Ra-226
(hrs)		mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
1	UHG hs	2.45E+07	7.80E+02	6.42E+02	7.12E+01	4.75E+01	6.20E+03
	UHG ls	1.77E+07	7.80E+02	4.64E+02	7.12E+01	4.75E+01	4.49E+03
	VHG hs	3.61E+07	7.80E+02	9.46E+02	7.12E+01	4.75E+01	9.14E+03
	VHG ls	3.03E+07	7.80E+02	7.95E+02	7.12E+01	4.75E+01	7.68E+03
	HG hs	2.20E+07	7.80E+02	5.48E+02	7.12E+01	4.75E+01	1.29E+02
	HG ls	1.54E+07	7.80E+02	3.84E+02	7.12E+01	4.75E+01	9.04E+01
	MG hs	2.18E+07	8.00E+02	6.03E+02	7.31E+01	4.87E+01	1.17E+03
	MG ls	3.33E+07	8.00E+02	9.23E+02	7.31E+01	4.87E+01	1.79E+03
	LG	2.83E+07	8.00E+02	7.10E+02	7.31E+01	4.87E+01	2.70E+02
	Waste	4.14E+13	8.00E+02	1.27E+09	7.31E+01	4.87E+01	0.00E+00
6	UHG hs	2.40E+07	1.67E+03	6.30E+02	1.52E+02	1.01E+02	6.08E+03
	UHG ls	1.74E+07	1.67E+03	4.55E+02	1.52E+02	1.01E+02	4.40E+03
	VHG hs	3.54E+07	1.67E+03	9.28E+02	1.52E+02	1.01E+02	8.97E+03
	VHG ls	2.97E+07	1.67E+03	7.80E+02	1.52E+02	1.01E+02	7.53E+03
	HG hs	2.15E+07	1.67E+03	5.38E+02	1.52E+02	1.01E+02	1.27E+02
	HG ls	1.51E+07	1.67E+03	3.77E+02	1.52E+02	1.01E+02	8.87E+01
	MG hs	2.15E+07	1.73E+03	5.97E+02	1.58E+02	1.05E+02	1.16E+03
	MG ls	3.30E+07	1.73E+03	9.13E+02	1.58E+02	1.05E+02	1.78E+03
	LG	2.80E+07	1.73E+03	7.03E+02	1.58E+02	1.05E+02	2.67E+02
	Waste	4.09E+13	1.73E+03	1.26E+09	1.58E+02	1.05E+02	0.00E+00
48	UHG hs	2.20E+07	3.46E+03	5.78E+02	3.16E+02	2.11E+02	5.59E+03
	UHG ls	1.59E+07	3.46E+03	4.18E+02	3.16E+02	2.11E+02	4.04E+03
	VHG hs	3.25E+07	3.46E+03	8.52E+02	3.16E+02	2.11E+02	8.23E+03
	VHG ls	2.73E+07	3.46E+03	7.16E+02	3.16E+02	2.11E+02	6.92E+03
	HG hs	1.98E+07	3.46E+03	4.94E+02	3.16E+02	2.11E+02	1.16E+02
	HG ls	1.39E+07	3.46E+03	3.46E+02	3.16E+02	2.11E+02	8.14E+01
	MG hs	2.08E+07	3.77E+03	5.76E+02	3.45E+02	2.30E+02	1.12E+03
	MG ls	3.18E+07	3.77E+03	8.82E+02	3.45E+02	2.30E+02	1.71E+03
	LG	2.70E+07	3.77E+03	6.79E+02	3.45E+02	2.30E+02	2.58E+02
	Waste	3.95E+13	3.77E+03	1.21E+09	3.45E+02	2.30E+02	0.00E+00
72	UHG hs	2.05E+07	3.60E+03	5.37E+02	3.28E+02	2.19E+02	5.19E+03
	UHG ls	1.48E+07	3.60E+03	3.89E+02	3.28E+02	2.19E+02	3.76E+03
	VHG hs	3.02E+07	3.60E+03	7.92E+02	3.28E+02	2.19E+02	7.65E+03
	VHG ls	2.54E+07	3.60E+03	6.66E+02	3.28E+02	2.19E+02	6.43E+03
	HG hs	1.84E+07	3.60E+03	4.59E+02	3.28E+02	2.19E+02	1.08E+02
	HG ls	1.29E+07	3.60E+03	3.22E+02	3.28E+02	2.19E+02	7.57E+01
	MG hs	2.03E+07	4.11E+03	5.62E+02	3.75E+02	2.50E+02	1.09E+03
	MG ls	3.11E+07	4.11E+03	8.61E+02	3.75E+02	2.50E+02	1.67E+03
	LG	2.64E+07	4.11E+03	6.62E+02	3.75E+02	2.50E+02	2.52E+02
	Waste	3.86E+13	4.11E+03	1.18E+09	3.75E+02	2.50E+02	0.00E+00