UraniumSA

Appendix 4

Draft Radioactive Waste Management Plan

Retention Lease Proposal

On

Mineral Claim 4280

for a

Uranium In-situ Recovery Field Trial

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Mullaquana Project

Uranium In-situ Recovery Field Trial

Draft Radioactive Waste Management Plan

DRAFT

Prepared for

UraniumSA Limited

by

On Site Technology Pty Ltd

Version 2

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1 Introduction

A detailed description of the Mullaqauna uranium project including the geological, hydrological and environmental setting is provided in the Mining and Rehabilitation Plan (MARP) and the Radiation Management Plan (RMP) provided in support of the Retention Lease Application for the In-situ Recovery Field Trial (ISR-FT).

The Mullaquana project ISR-FT is intended to provide “proof of process” of the metallurgical and bench scale tests that have been undertaken for the project. The trials are intended to provide a practical demonstration of the proposed In Situ Recovery (ISR) method of mining the Blackbush uranium ore body.

A secondary but equally important outcome from the ISR-FT will be the collection of process, process control, occupational and environmental data as confirmation of the baseline and modelled data provided in various documents as part of the MARP. This data will be used to refine and improve the proposed mining approach and to confirm (or calibrate) models used to estimate the occupational and environmental impacts of the project.

The ISR-FT will produce low level radioactive waste (LLRW) and the purpose of this Radioactive Waste Management Plan (RWMP) is to describe the proposed method of treating and disposing of the waste. The RWMP is prepared to address the regulatory requirements of the Mining Code[1]).

2 Regulatory Framework

The regulatory framework for the handling, processing and disposal of LLRW from IRS operations in South Australia structured around the:

- *Radiation Protection and Control Act 1982* (SA)
- *Environmental Protection Act 1993* (SA)

These Acts are supported by a number of regulations, guidelines and policies which detail the acceptable approach, expected outcomes and regulatory limitations on the handling and disposal of LLRW in general and waste resulting from ISR in particular. These documents include:

- *Radiation Protection and Control (Ionising Radiation) Regulations 2000*
- *Environmental Protection (Water Quality) Policy 2003*
- National Directory for Radiation Protection
- Code of Practice on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing
- Australia’s In Situ Uranium Mining Best Practice Guide
- Guidelines for miners: tailings and tailings storage facilities in South Australia
- Classification of Radioactive Waste
- Predisposal Management of Radioactive Waste
- Code of Practice for Near Surface Disposal of Radioactive Waste in Australia

3 Justification of Waste Classification

In formulating a RWMP the first step is to classify the waste as either radioactive or non-radioactive. This is generally based on the activity of the waste in question.

The current regulatory definition of radioactive material (i.e. that material to which the Radiation Protection and Control Act applies) is a specific activity of greater than 37 kBq/kg[2)]. However, the National Directory[3)] sets an exemption limit below which *"regulatory control is not required".* For uranium (U^{238}) contaminated waste this limit is 5 kBq/kg based on U^{238} and U^{234} being in approximate equilibrium. For radium the limit is 10 kBq/kg. This discrepancy between State regulations and Commonwealth guidelines is temporary and the State limits will be brought into line with the National Directory when the Radiation and Control (Ionising Radiation) Regulations 2000 are next reviewed.

For the purposes of this RWMP, the lower National Directory exemption limit of 5 kBq/kg for uranium (as U^{238}) and 10 kBq/kg for radium will be used to classify waste as radioactive. This approach is consistent with industry best practice and will accommodate the State regulatory situation as it will be at some time in the future. Although the precise time frame is not known it will certainly be within the "institutional control" period of the proposed LLRW repository.

The next step is the classification of the radioactive waste.

The Classification of Radioactive Waste safety guide defines two categories of LLRW, these are "Low Level Waste" (LLW) suitable for near surface disposal and "very Low Level Waste" (VLLW) suitable for landfill disposal.

The ISR Best Practice Guide[4)] (in section 4.3.3) suggests that;

> *"solid radioactive residues generated on an operational ISR mine site are classified a low level radioactive waste (LLRW)"*

Although the ISR-FT to be undertaken on the retention lease is not strictly speaking "mining" (at this stage no mining lease application has been made for the Blackbush deposit) it is considered that the application of various mining codes and definitions is consistent with both the regulatory framework and current industry best practice.

4 General Waste Classification

The process to be used for waste classification for the ISR-FT is detailed in Tables 1 to 3. The process can be summarised as follows.

Waste will be classified into four broad categories, these are:

1. Domestic waste including office waste, sewerage, ablution waste and general waste. These will be disposed via licensed waste removal contractors or, in the case of sewerage at the Nonowie office via the septic system.
2. Laboratory waste will be classified into radioactive and non radioactive waste as described in Table 1. Non radioactive waste will be disposed via licensed contractors. Radioactive waste (classified on the basis of the National Directory exemption limits) will be stored on site pending the completion of the ISR-FT.
3. Waste from spillages will be processed by recovery of the spilled material where practical. Recovered material will be disposed according to the process outlined in Table 2. Contaminated soil resulting from spillage will be classified according to radiological status (based on the National Directory exemption limits) and chemical contamination status (based on the SA-EPA

waste fill guideline). After classification waste will be either removed by licensed contractors, placed in the evaporation dam or (if radioactive) stored pending completion of the ISR-FT.

4. Process plant waste will be treated in the same way as laboratory waste as detailed in Table 3. The exceptions will be process liquors and calcium bleed solution that will be returned to the aquifer via the disposal wells and radon which will be vented to the atmosphere.

The evaporation dam will be designed and constructed in accordance with Minerals Regulatory Guideline MG5 “Guidelines for miners: tailings and tailings storage facilities in South Australia” version 1.4, September 2009 and current SA-EPA guidelines. The evaporation dam will not be used for the storage or disposal of LLRW.

In general, ISR uranium mines produce solid LLRW primarily through the production of calcium scale or sludge. The Mullaquana ISR-FT project is being designed to avoid production of this LLRW waste by using a process bleed stream to control calcium in the circulating leach solution. This bleed (estimated to be approximately 20% of the circulating leach liquor) will be disposed via a disposal well into a barren section of the mineralised aquifer that has been flushed with sea water. This approach will dispose of the calcium liquid waste with minimal risk of disposal well blockage because the “in aquifer” chemistry will be identical (except for the uranium content) to that existing at the extraction wells.

The estimated radium content (based on bench trials conducted by UraniumSA) of the calcium bleed will be 60 Bq/l and will not be classified as radioactive.

This approach is consistent with the aims of ISR best practice in that:

1. The production of solid LLRW (requiring disposal in a LLRW repository) is avoided or at least minimised
2. The extracted radioactive material (except for the uranium) is returned to the aquifer from which it was extracted.

There will be a number of contingencies in place to accommodate potential problems with the proposed calcium disposal system. These are:

Contingency 1

In the event that the disposal well becomes temporarily blocked, the calcium waste stream will be diverted for temporary storage in an evaporation dam until the disposal well is cleared. After the disposal well is cleared, disposal will continue.

Contingency 2

In the event that the disposal well can not be cleared or the disposal well option is not viable for other reasons. Evaporation from the dam will be used as the liquid disposal method and the resultant solid waste will be disposed as tailings. Based on UraniumSA bench trials and extrapolation of data (for example ore grade and expected uranium concentration in extracted liquid) from other ISR uranium mines in South Australia the evaporated waste is not expected to be radioactive.

Contingency 3

In the event that the solid waste resulting from implementation of contingency 2 would be radioactive the waste stream would be treated with barium chloride to remove the radium prior to disposal in the evaporation dam. This process would result in a small quantity (currently estimated at about 100kg per trial pattern) of LLRW that would be immobilised in cement and disposed in the bottom of the well arrays (that is, the well interval that intersects the mineralised zone) as part of the well closure and decommissioning program. The remaining bulk evaporated waste would not be radioactive and would be disposed as per contingency 2.

The proposed calcium waste stream disposal system and the various contingencies are shown in Figure 1. Based on the current understanding of the chemistry of the trial the implementation of the contingency plans is not anticipated. The need to implement contingency 3 is not considered likely because bench trials conducted by UraniumSA indicate the radium activity of any evaporated calcium bleed will be approximately 2 kBq/kg, well below the National Directory exemption limit of 10 kBq/kg.

Low level radioactive wastes generated by other parts of the ISR-FT plant are expected to be relatively small quantities and will be securely stored on site during the ISR-FT. After completion of the ISR-FT if the project is to progress to the mining phase the waste will continue to be stored pending the establishment of a Low Level Radioactive Waste repository as part of the mining process. If the project is to be would up, the LLRW will be disposed in a small LLRW repository to be established within the retention lease area. This repository will be constructed and decommissioned in accordance with the “Code of Practice for the Near-Surface Disposal of Radioactive Waste in Australia” and “Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing”.

The option of off-site disposal of low level radioactive waste will be re-investigated at that time dependant on the prevailing regulatory framework, the status of any proposed national or state repository and the quantity of LLRW generated.

At the completion of the ISR-FT the evaporation dam (containing non radioactive waste) will either be maintained (and potentially expanded) if the project progresses to the mining phase or capped and closed if the project is would up.

Source	Waste Material	Disposal Method	Sorting Criteria
Laboratory waste	Spilled and Used Reagents	Segregation and storage, removal by licensed contractor (Violia or transpacific)	Hazards index
	Surplus Samples	Return to aquifer via disposal well	
	PPE and Laboratory Consumables	Radioactive waste stored on site pending disposal Non radioactive waste removed as industrial waste by licensed contractor	National Directory exemption levels

Table 1: Classification of Laboratory Waste

Source	Waste Material	Disposal Method	Sorting Criteria
Fuel or chemicals	Recovery when practical	Removal by licensed contractor (violia or transpacific)	
	Excise contaminated soil	Removal by licensed contractor (violia or transpacific)	Above sa-epa waste fill criteria
		Dispose in tailings storage facility	Less than SA-EPA waste fill criteria
Yellowcake	Recovery when practical	Store with yellowcake product pending removal at trial completion	Visually clean yellowcake
	Excised contaminated soil	Store with radioactive waste pending trial completion	Uranium content above national directory exemption limit
		Dispose in tailings storage facility	Uranium content less than National Directory exemption limit
Leach or Process Liquors	Recovery when practical	Return to aquifer via disposal well	Visually free of settled solids
	Excised contaminated soil	Store with radioactive waste pending trial completion	Activity greater than National Directory Exemption Limit
		Dispose in tailings storage facility	Activity less than National Directory Exemption Limit

Table 2: Classification of Waste from Spillage

Source	Waste Material	Disposal Method	Sorting Criteria
Plant Waste	PPE	Store with radioactive waste pending trial completion	Activity greater than National Directory Exemption Limit
		Non radioactive waste removed as industrial waste by licensed contractor	Activity less than National Directory Exemption Limit
	Consumables	Store with radioactive waste pending trial completion	Activity greater than National Directory Exemption Limit
		Non radioactive waste removed as industrial waste by licensed contractor	Activity less than National Directory Exemption Limit
	Equipment	Store with radioactive waste pending trial completion	Activity greater than National Directory Exemption Limit
		Non radioactive waste removed as industrial waste by licensed contractor	Activity less than National Directory Exemption Limit
	Calcium Scale	Store with radioactive waste pending trial completion	Activity greater than National Directory Exemption Limit
		Dispose in tailings storage facility	Activity less than National Directory Exemption Limit
	Radon and Radon Daughters	Extraction from plant area and atmospheric dispersal	As per monitoring program
	Process Liquors	Return to aquifer via disposal well	

Table 3: Classification of Plant Waste

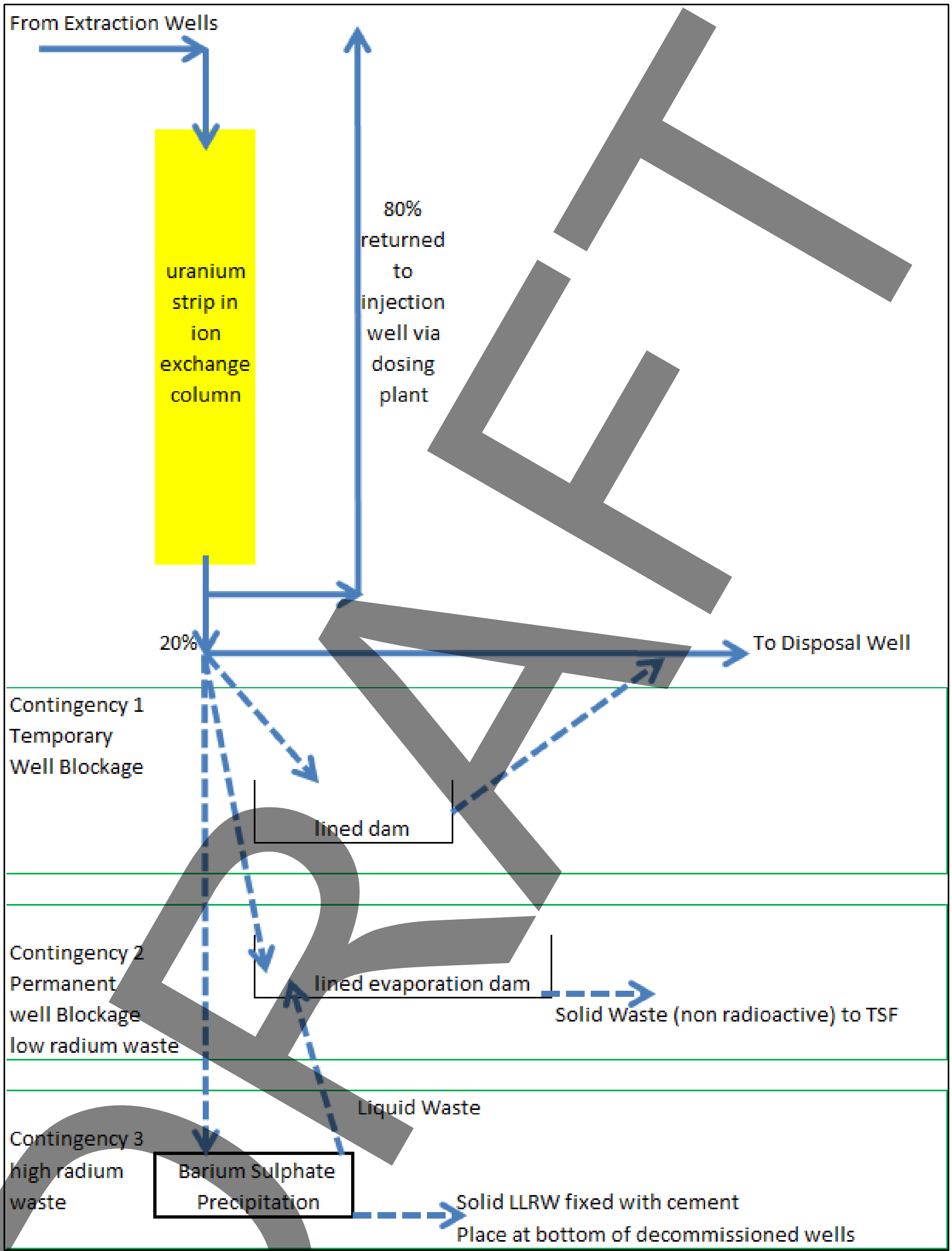

Figure 1: Calcium Waste Disposal Flow Sheet

5 Options Considered for LLRW Disposal

5.1 Solid Waste

With respect to solid waste two disposal options were considered based on the ISR Best Practice Guide (section 4.3.3) which suggests that:

> *"These* (LLRWs) *may be disposed of in a purpose built on-site LLRW disposal facility, or disposed off-site if approval by the regulatory authority."*

In the case of the proposed Mullquana ISR-FT, the proponent (UraniumSA Ltd) has been informed by the regulator that[5]):

> *"At this stage, the EPA does not consider offsite transport and disposal of radioactive waste a viable option for this project."*

Based on these factors two approached have been adopted, the first is to minimise (through process options and waste screening) the amount of LLRW generated and the second is to dispose of solid LLRW in an on-site repository. The LLRW repository will be designed in accordance with the:

1. Code of Practice for the Near Surface Disposal of Radioactive Waste in Australia[6])
2. Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing [7])
3. Guidelines for miners: tailings and tailings storage facilities in South Australia[8])

It is noted that the near surface disposal code specifically excludes waste from operating mines from it's scope (section 1.2), however, this code has been referenced by the State regulator (SA-EPA) as being appropriate for the Mullaquana ISR-FT. A significant departure from the code is that the Mullaquana LLRW repository will not accept any waste from off site. This is in consistent with the current South Australian regulatory framework and industry best practice.

The yellowcake produced during the ISR-FT will not be sold. However, at the end of the ISR-FT it will be transferred to a current uranium producer for inclusion in their product stream. This transfer will be undertaken in accordance with the requirements of the Code of Practice for the Safe Transport of Radioactive Materials[9]) and under the jurisdictional control of the Australian Safeguards and non Proliferation Office. Therefore, for the purposes of this RWMP, yellowcake product is not considered a waste.

5.2 Liquid Waste

LLRW in liquid form will be generated as part of the uranium recovery process during the leach trial. Such waste may include;

- Surplus laboratory samples
- Groundwater
- Raffinate bleed (calcium bleed), Eluate and other process liquors
- Liquids recovered from solid waste or product

Consistent with option 2 (section 4.4.3) of the ISR best practice guide these liquid wastes will be disposed to the mineralized aquifer through disposal wells. This approach is considered appropriate for the following reasons;

1. The radiological status of these waste streams will be similar to the ground water already in the aquifer.
2. Any chemical differences between the existing groundwater and the LLRW liquids will be neutralised by the natural attenuation discussed in the MARP
3. There is no current or identified future use for the hyper-saline water in this aquifer
4. The LLRW liquids will be isolated from the hydrological environment and biosphere by the well rehabilitation described in the MARP
5. This practice is consistent with current industry best practice

The use of option 3 (section 4.4.3) of the ISR best practice guide, that is, surface evaporation may be used (as a contingency as discussed in section 4) for liquid waste associated with the calcium bleed waste stream. This solid waste produced by the evaporation of the calcium bleed will not be radioactive and will be disposed with other non radioactive tailings material.

5.3 Gaseous Waste

The yellowcake product to be generated during the ISR-FT will be wet (up to 50% moisture) and will be packaged without drying. Therefore there will be no gaseous emissions from drying or packaging operations.

Radon gas will be released from the extracted water when it is brought to the surface and processed. This radon will be extracted and vented to the atmosphere for dispersal by wind. As detailed in the RMP the environmental and occupational impact of this radon and the associated daughter products will be monitored during the leach trials.

Based on industry knowledge and current practice at operating ISR uranium mines the need for more rigorous engineering control of radon and radon daughters is not warranted. The need for additional measures is considered unlikely because atmospheric dispersion modelling with fairly conservative inputs suggest that, even without active ventilation, radon levels are unlikely to be of occupational or environmental significance. This is consistent with the situation at currently operating ISR uranium mines. Data to be collected as part of the monitoring program detailed in the RMP will be used to confirm these modelled predictions.

However, if the extraction and venting system implemented for the Mullaquana ISR-FT project prove inadequate, engineering controls will be considered, these may include;

1. Increased ventilation rate
2. Increased release height
3. Filtration with charcoal filters

Option 3 would be considered only as a last resort because this would involve a potentially significant increase in gamma (whole body) exposure to workers involved in handling and maintaining the filters.

6 Discussion of Waste Streams

6.1 Laboratory Waste

LLRW produced by the site laboratory is expected to be of low volume and low activity. It is anticipated that the ISR-FT will generate less than a few hundred kg of laboratory LLRW.

Radiological screening of all laboratory waste will ensure that LLRW is not bulked up by non radioactive waste. The waste will be consolidated, compacted and stored in a lined 205 litre steel drum.

This waste will be securely stored pending the completion of the ISR-FT.

6.2 Waste From Spillage

Solid LLRW from spillage during the ISR-FT will be classified and minimised as shown in Figure 2.

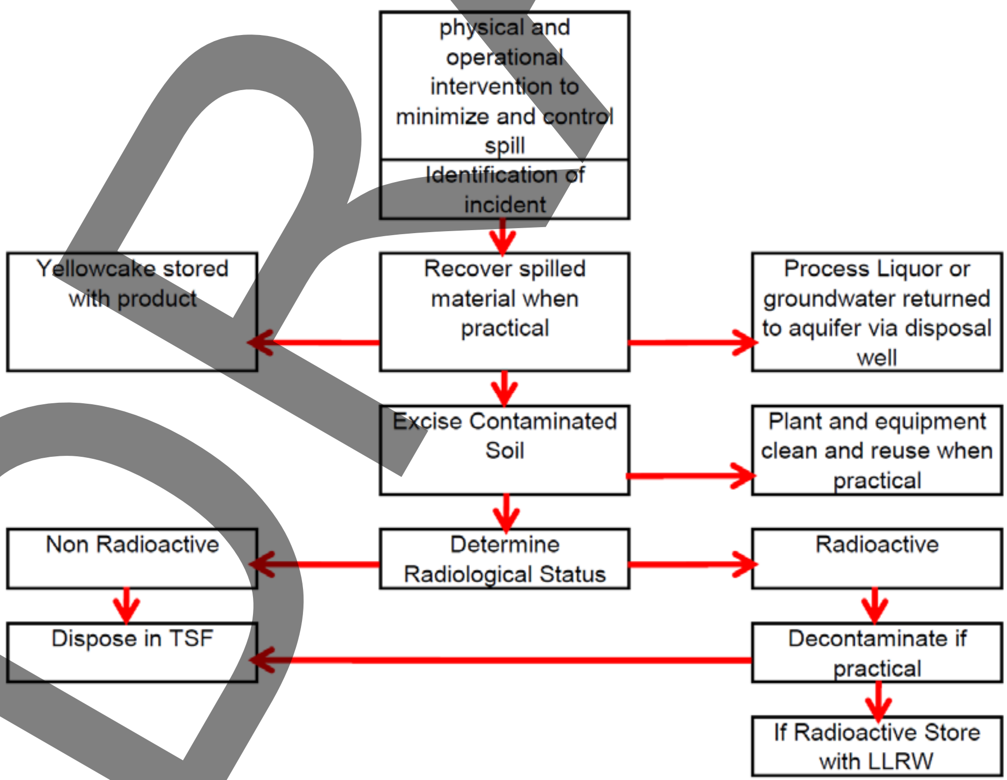

Figure 2: Treatment and Classification of Spilled Material

6.3 Solid Waste in Evaporation Dam

Under contingency 2 and 3 for the disposal of the calcium bleed the solid waste from the evaporation dam has been classified as non radioactive. This classification is based on the following. This information is subject to confirmation after the ISR-FT commences. It is anticipated that this confirmation will be completed within a sufficiently short time frame to prevent the accumulation of large (and problematic) amounts of LLRW.

Uranium in calcium bleed	2 mg/l	based on design parameters
Ra^{226} in calcium bleed	60 Bq/l	estimated from bench trials
Th^{230} in calcium bleed	1.1 Bq/l	based on similar ISR operations
TDS in calcium bleed	34 g/l	based on design parameters

These values provide a summed activity ratio (based on the National Directory procedure) of 0.3 which is less than the exemption value of 1. This justifies the classification of the evaporation dam residue as being non radioactive.

Under contingency 3, radium will be removed by precipitation with barium chloride. Bench tests undertaken by On Site Technology Pty Ltd indicate that approximately 80% of the radium from the calcium bleed can be removed by this process. The resultant barium sulphate precipitate would be a relatively small volume (perhaps 100kg per pattern) of LLRW.

It is anticipated that, in the unlikely event that this contingency is implemented, the barium sulphate waste will be stabilised with cement and placed in the bottom of the injection and extraction wells prior to decommissioning.

The liquid waste from the barium chloride treatment would not be radioactive and placed in the evaporation dam as per contingency 2.

This approach should be viable for radium levels (in the calcium bleed) of up to 1500 Bq/l which is 25 times higher than the levels expected for the Mullaquana ISR-FT calcium bleed.

6.4 Contaminated Equipment and Infrastructure

There is the possibility that plant and equipment used for the ISR-FT will become contaminated with radioactive materials.

In the case of high value equipment (for example filters, pumps valves etc) the approach will be to decontaminate the equipment when practical to do so. The residue resulting from any cleaning or decontamination action will be treated as waste.

For low value items (for example plastic pipe) or where decontamination is not practical the item itself will be treated as waste and if classified as LLRW will be stored pending completion of the ISR-FT.

In all cases the criteria for classification as LLRW will be:

For surface alpha activity	0.4 Bq/cm^2
For bulk items	The National Directory exemption limit

Items or waste with activity less than these criteria will be classified as non radioactive and disposed as industrial waste through licensed contractors.

7 References

1 Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing

ARPANSA Radiation Protection Series rps9

August 2005

2 Radiation Protection and Control Act (1982) and Radiation Protection and Control (Ionising Radiation) Regulations 2000

South Australian Government

3 National Directory for Radiation Protection

Radiation Protection Series Publication # 6

ARPANSA, August 2004

4 Australia's In Situ Recovery Uranium Mining Best Practice Guide:

Groundwaters, Residues and Radiation Protection

Commonwealth of Australia, 2010

5 Communication with SA-EPA dated 29th April 2011

Reference MI/02/017

6 Code of Practice for the Near Surface Disposal of Radioactive Waste in Australia

Radiation Health Series No 35

ARPANSA 1992

7 Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing

ARPANSA Radiation Protection Series rps9

August 2005

8 Guidelines for miners: tailings and tailings storage facilities in South Australia

PIRSA publication MG5

Version 1.4, September 2009

9 Code of Practice for the Safe Transport of Radioactive Materials
Radiation Protection Series No 2
ARPANSA 2008