# HONEYMOON PROJECT

# PROPOSED

# RADIATION MANAGEMENT PLAN

## Radiation Protection and Control Act 1982
## Licence to Mine or Mill

| DATE | VERSION/REVISION | APPROVED |
|---|---|---|
| May 2006 | Draft – for submission with licence application | Brian Lancaster |

## CONTENTS

# 1 INTRODUCTION

This Radiation Management Plan has been prepared as supporting documentation for an application under the Radiation Protection and Control Act 1983 for a Licence to Mine or Mill Radioactive Ores for the Honeymoon Uranium Project. The document has also been designed to meet the requirements of the expected primary licence condition: compliance with the Code of Practice and Safety Guide on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005). A final RMP will be submitted to the EPA for approval prior to authorisation for construction of the plant and wellfield.

The Honeymoon project is expected to have a life of at least six years and may extend to ten years. It is anticipated that this document will be modified in conjunction with the EPA as the project progresses and more is learned about the effectiveness of the radiation management plans.

This Plan is one of several documents required by the regulatory authorities. To avoid duplication the proposed Honeymoon operations are only briefly described in this document. A fuller description is available in the Licence application, the proposed Radioactive Waste Management Plan and the Mining and Rehabilitation Program.

## 2 THE PROCESS

Uranium is proposed to be mined at Honeymoon using the acid in-situ leach process (ISL). ISL enables extraction of uranium from suitable underground deposits without the physical disturbance inherent in conventional open-pit or underground mining operations. As a result, radon emissions are lower than in conventional mining operations and exposure to radioactive ores is almost eliminated

For ISL mining, patterns of vertical wells will be drilled into the Honeymoon deposit to allow leach solution to be injected into and recovered from the sands of the ore zone. Initially, natural ground water, which contains both radium and radon, will be withdrawn from the ore zone via wells designated as production wells and pumped to the process plant. At the plant, the pH will be adjusted to approximately 2.5 with sulphuric acid and oxidants such sodium chlorate added to form a leach solution that will be recirculated to the ore zone via other wells designated as injection wells (Fig 1).

In the ore zone, the leach solution will dissolve uranium, radium and other ore body components from between the sand grains, leaving the sand intact. The resultant pregnant solution will be drawn to production wells and pumped out to the process plant where the uranium will be recovered by solvent extraction to produce yellowcake. The radium will remain in the depleted (barren) leach solution. Approximately 1% of the barren solution will be sent to a pond to be disposed of. The remainder will be reconditioned by adding more leaching agent and oxidant and recirculated to wellfield.

In the solvent extraction stage of the process, organic solvents will be mixed with the pregnant solution to extract the uranium. The organic solvents will then be separated from the barren leach solution and contacted with an aqueous sodium carbonate solution. The uranium will transfer to the sodium carbonate solution. The resulting depleted organic solvents will be recycled to extract additional uranium (Fig 2).

Uranium will be precipitated from the sodium carbonate solution by the addition of hydrogen peroxide. The precipitated yellowcake will be dewatered, dried, packaged in steel drums and stored before being shipped off site.

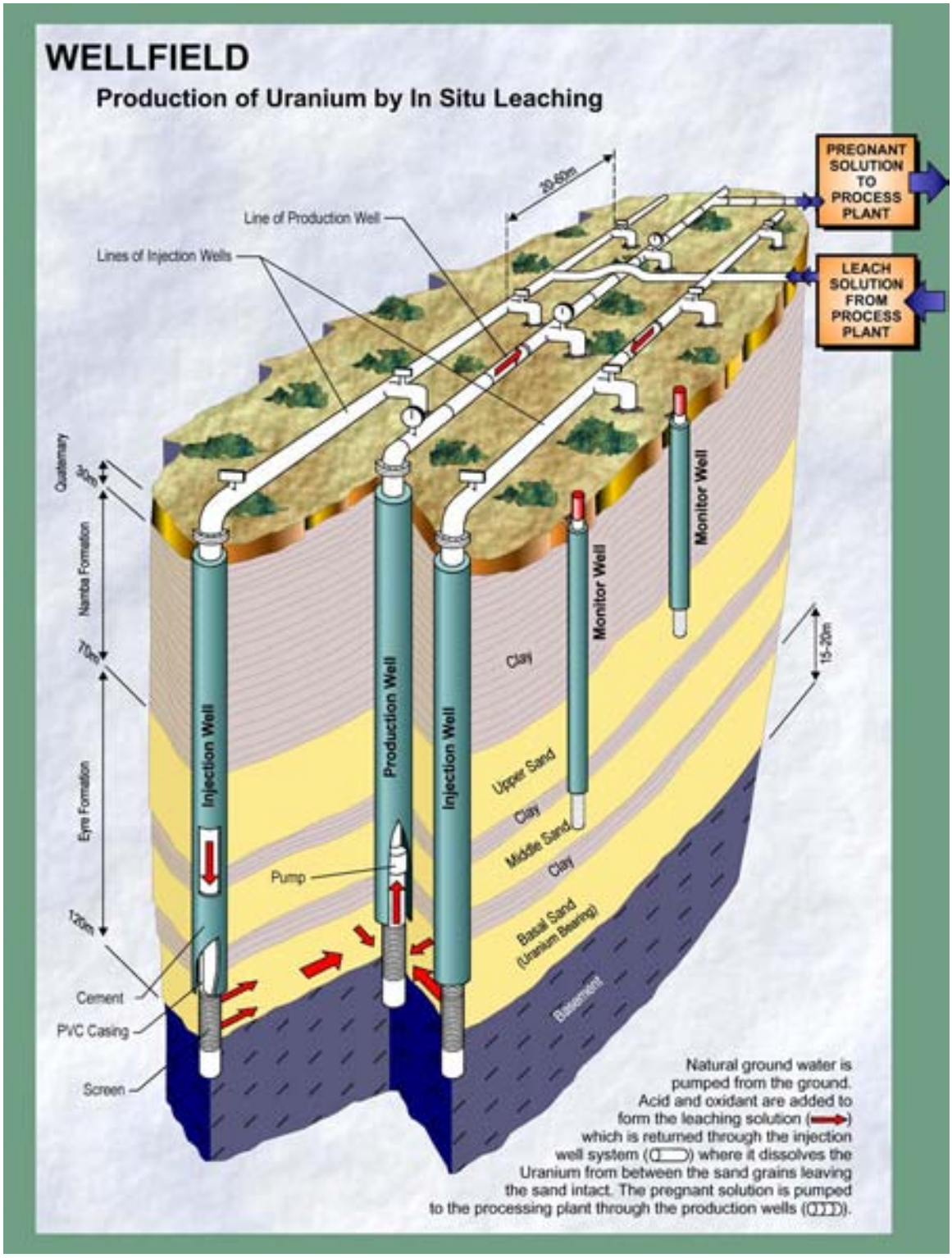


**Figure 1 Schematic of Wellfield Operation**

# 3 SOURCES OF EXPOSURE

Employees of the Honeymoon Project may be exposed to radiation that arises from radon decay products in the air, from process solutions containing radium within pipes and vessels, and from airborne dusts. The expected radiation levels and doses are discussed in section 5.

## 3.1 Radon and radon daughters in air

The major source of radon in air will be the pregnant leach solutions derived from the underground ore body. These solutions will contain dissolved radon some of which will be released to the air in process equipment located in or adjacent to the process plant. Further radon will be released from the solutions that are sent to ponds for disposal (see section 3.5.1 of the RWMP)

## 3.2 Gamma radiation

There will be sources of gamma radiation associated with pipes, tanks, ponds and other process equipment which contain significant quantities of solutions containing radium.

Uranium that has recently been separated from radium is not a significant source of gamma radiation. Drummed product will be stored away from occupied work areas. Consequently the product storage areas will not be a major source of gamma exposure

## 3.3 Dusts

In the drying and packing area where the product will be dried and packed into 200 litre drums there will be the risk that uranium-containing dusts will be inhaled. The dusts may arise from the handling of the dried material or from the resuspension of product deposited on the floors.

Radioactive dusts may also arise from dried spillage.

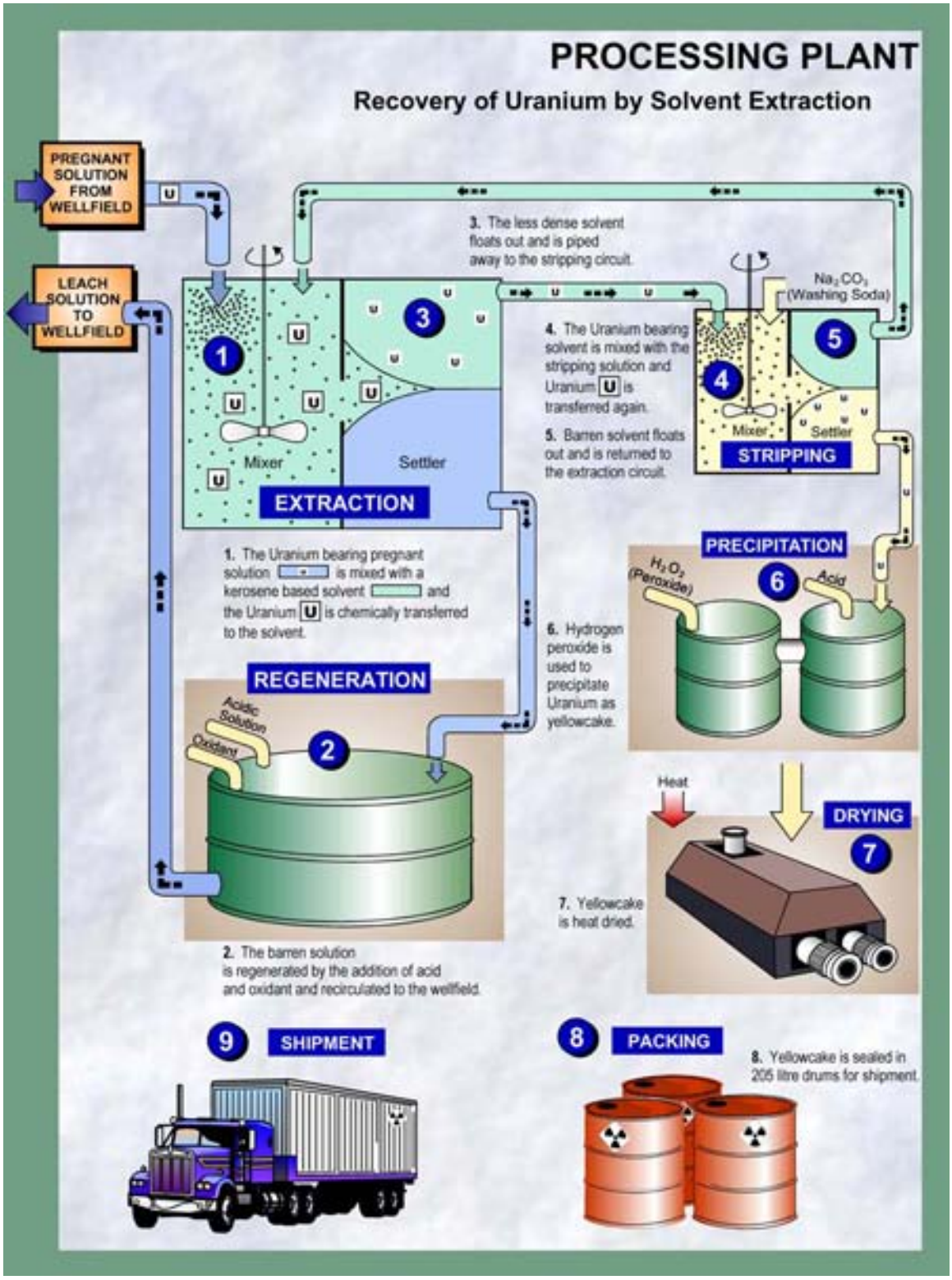


**Figure 2 Schematic of Plant Operation**

# 4 CONTROL MEASURES

Control measures will include the provision of physical (engineering) controls as described in sections 4.1 and 4.2 below, and administrative or procedural controls (section 4.3).

## 4.1 Radon Control

The majority of the radon that is released by the leach solutions will be released in agitated tanks adjacent to the plant boundary. This radon will be collected by mechanical ventilators and vented to a stack that will exhaust the radon approximately 10 metres above ground level. Other tanks in the processing plant that may release significant amounts of radon will be similarly vented. Venting in this way will minimise the exposure of employees in the plant.

With the exception of the drying and packaging area the plant building will be constructed with open sides and roof ventilators. This will provide natural ventilation that will prevent any accumulation of radon within the building.

## 4.2 Dusts

The drying and packaging areas will be enclosed. Drying and packaging equipment will operate under negative pressure to restrict the release of dried product into workplace air. The design of the building and its ventilation system will keep uranium product concentrations in the atmosphere at low levels. Operators in the area will wear appropriate respiratory protection to further reduce their exposure to dusts.

The plant will be designed to facilitate clean-up of spillage to prevent it drying and becoming a dust source.

## 4.3 Administrative/Procedural Controls

- Supervised/Controlled areas

  Access to areas of the plant and wellfield where significant radiation doses may be encountered will be managed. This management will include the use of supervised and/or controlled areas. Access to such areas will be restricted to those who have been appropriately trained in the radiation hazards that may be encountered in those areas, and the control measures required.

- Change Room/showers

  Workers in designated areas will be required to shower and change their clothing at the end of each shift. Appropriate change rooms and shower facilities will be provided.

- Investigation, Action and Reporting Levels

A system of Investigation, Action and Reporting levels will be established for responding to radiation monitoring results that are above the normally expected range. The system will apply to monitoring of gamma radiation, dusts and radon decay products, and will include details of the responses to be made in each case.

- Work Permit System

A system to control radiation exposures in non-routine operations where significant radiation exposures may arise, such as vessel entry, maintenance of the yellowcake drying or packing equipment etc will be established. The system will require "Work Permits" for such operations, which will specify the operation(s) to which they apply, and any control or monitoring requirements.

- Housekeeping

Housekeeping in the plant will be a priority continually enforced by the management and emphasized during staff induction and training. Regular plant wash down procedures will be incorporated into the plant operators' schedules to minimize surface contamination. Regular inspections of the plant buildings will be made by the RSO. Unforeseen spillage within the plant area will be promptly washed down to sumps and the sumps pumped out to the solids retention pond.

# 5 DOSE ESTIMATES

Dose estimates have been based on published data from the EIS, on data from other similar projects and on information derived during the operation of the demonstration plant at Honeymoon. The demonstration plant operated for approximately one year producing 30 tonnes of yellowcake, with flowrates of from 6L/s to 25L/s. The production plant will produce an average of 400 t/a product from a flow rate of around 150-200L/s. This represents an increase in scale by a factor of approximately 10. As noted below however, doses are not expected to scale linearly by this amount. The production plant will be much more open, with workers typically further from radiation sources than in the demonstration plant. Self absorption means that dose rates at the surface of gamma ray sources such as liquor tanks will be largely independent of the size of the tank, and independent of the flow through it. In addition, by its nature a pilot operation is more liable to mishaps such as spills than a routinely operating production plant.

The workforce in the plant is expected to be approximately 17. The full time workforce in the wellfield is expected to be approximately 11, but this will routinely be increased by contract drilling teams. There are also expected to be approximately 11 maintenance workers, and 12 management, technical and administrative employees. Contractors will be required to follow the same radiological control procedures as employees, and their radiation exposures will be assessed in the same manner.

## 5.1 Radon Decay Products

Plant

Monitoring in the demonstration plant during operation gave an average RnDP concentration of 0.08µJ/$m^3$ (Southern Cross Resources 2000) representing an annual dose of approximately 0.2mSv. The monitored concentration is within range of measured natural background measured at the site. Scaling by a factor of 10 gives an annual dose of 2mSv. For the reasons outlined above this scaling is expected to lead to an overestimate.

Wellfield

Radon decay product concentrations in the wellfield are expected to be less than those in the plant. There will be no significant sources of radon apart from transient releases during airlifting and similar operations.

## 5.2 Dusts

Plant

The drying and packaging process being used in the proposed plant will be similar to those used at in situ leach operations such as Christensen Ranch, in the USA. The maximum airborne uranium product dust exposure measured at the Christensen Ranch operation in 1994 (Cogema 1996) was less than 0.5 mSv for a production rate of 400 t/y of yellowcake. Although the Honeymoon Project will be using a dryer which produces a lower emission level than the Cogema plant, the exposure from the Cogema operation has been used as a worst case emission in the calculations for the proposed operations at Honeymoon.

Doses outside of the dryer/packing area can be estimated from demonstration plant monitoring, which gave an average activity concentration of long-lived alpha radiation in dust of 0.008 Bq/$m^3$. As no product packing operations were undertaken at the demonstration plant these monitoring results reflect dust generated from dried spills, and includes a contribution from natural background.

The annual dose received from the inhalation of long-lived alpha radiation in dust by the most exposed work group at the demonstration plant was less than 0.04 mSv. Scaling this dose by a factor of 10 leads to an annual dose estimate of 0.4mSv for the most exposed group.

Wellfield

Doses to drillers and wellfield operators are expected to be very small. There are no significant sources of radioactive dusts in the wellfield. Drilling is wet, and does not generate significant dust. Drilling sludge pits will be filled in before the contents dry out. Areas contaminated by spillage of liquor may become contaminated, but as the liquor soaks into the ground the effective grade of the layer of surface soil liable to dusting will be low.

### 5.3 Gamma radiation

Plant

The assessment of individual worker doses at the demonstration plant used the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) thermo-luminescent dosimeter (TLD) monitoring service. The average dose received, across all workers extrapolated for one year, was 0.12 mSv. The average for the most exposed work group was 0.22 mSv/y (Southern Cross Resources 2000). Doses in the production plant are expected to be similar. As noted above, doses at the surface of tanks etc are not expected to increase significantly, and the more open nature of the production plant will result in workers generally being further from sources. In addition, one of the most significant gamma sources in the demonstration plant, the pregnant liquor sand filters, is not expected to be required in the production plant as sediment will settle out in the ponds. However for a conservative estimate an increase of a factor of 2 is assumed giving a mean dose to the most exposed group of 0.5mSv/y.

Wellfield

Doses to drillers and wellfield operators are expected to be less than those of plant operators. The only significant gamma sources in the wellfield area will be small amounts of ore cuttings in the drill sludge pits. There will be no liquor tanks or similar gamma sources.

### 5.4 Total Dose

The total annual dose to plant operators is thus estimated to be approximately 2mSv from inhalation of radon decay products, approximately 0.5 from inhalation of dusts (either from product drying/packing, or from general plant spillage) and 0.5mSv from gamma exposure, for a total dose of 3mSv/y. This is expected to be a very conservative over estimate. Wellfield operators and drillers are expected to have significantly lower doses. The estimated plant dose is higher than that reported for the hydrometallurgical plant at Olympic Dam (Kinhill Engineers 1997) and for the Beverley ISL mine operated by Heathgate Resources Pty Ltd (CSIRO 2004), reflecting the conservative nature of the estimates. The dose estimates are well below the annual occupational dose limit of 20mSv (ARPANSA 2005).

# 6 MONITORING

Doses to employees will be assessed from the results of both personal and area monitoring as appropriate. Dose conversion factors recommended in the Code (ARPANSA 2005) will be used. Records of all monitoring results and dose assessments will be maintained.

## 6.1 Monitoring Equipment

External personal doses will be measured using thermo-luminescent dosimeters (TLDs). Radiation monitors – alpha/beta counters, external gamma monitors, surface contamination monitors – will be used for radiation protection monitoring. Concentrations of airborne contaminants (radioactive dusts and radon decay products) will be measured using portable sampling pumps (2-5L/min) and alpha drawer assemblies.

## 6.2 Calibration

All radiation monitoring equipment will be calibrated on-site using certified radiation calibration sources or by an appropriate independent body.

Radon/radon daughter monitors will be calibrated annually by an appropriate independent body.

External gamma monitors will be calibrated annually by an appropriate independent body and check calibrated against each other monthly by comparing their readings in the same radiation field.

Alpha counters will be calibrated weekly using a certified alpha radiation calibration source.

Surface contamination monitors will be calibrated weekly using certified alpha and beta calibration sources.

## 6.3 Monitoring

Radon Daughter Monitoring

| Area | Method | Frequency | Comment |
|---|---|---|---|
| Plant -<br><br>Four locations | Grab Sample | Weekly | The average PAEC will be obtained for the area and the personal dose calculated. |
| Confined spaces where radon is present | Grab Sample | Before entry | Vessels potentially containing radon/radium will be ventilated and the PAEC monitored before entry |

Radon Monitoring

| Area | Method | Frequency | Comment |
|---|---|---|---|
| North of plant | Nuclear Track Film | Quarterly | |
| South of plant | Nuclear Track Film | Quarterly | |
| East of plant | Nuclear Track Film | Quarterly | |
| West of plant | Nuclear Track Film | Quarterly | |
| East Side of Solids Retention Ponds | Nuclear Track Film | Quarterly | |

Gamma Radiation Monitoring

| Area/Personnel | Method | Frequency | Comment |
|---|---|---|---|
| Employees | TLD | Quarterly | |
| Contractors including drill rig operators | TLD or gamma monitor | Quarterly or per contract | RSO to determine the assessment to be made |
| Product storage | Gamma monitor survey | Monthly | |
| Leach solution pipes-wellfield and plant | Gamma monitor survey | Monthly | Will indicate scale build up |
| Plant – near process equipment | Gamma monitor survey | Monthly | Doserate to be read and recorded |
| Laboratory, Office/ Admin, Control Room, Change Rm/Laundry | Gamma monitor survey | Monthly | Doserate to be read and recorded |
| Wellfield control centres | Gamma monitor survey | Monthly | Doserate to be read and recorded |
| LSA area | Gamma monitor survey | Monthly | Doserate to be read and recorded |
| LLW disposal site | TLD | When operated | |
| Ponds - perimeter | Gamma monitor | Monthly | Dose to be read and recorded |

Dust monitoring

| Area | Method | Frequency | Comment |
|---|---|---|---|
| Drying and packaging | Personal dust sampling | During packaging | Alpha activity in air estimated |
| Plant building – various locations | Low flow rate Personal or static sampling | Weekly | Alpha activity in air estimated |
| Laboratory | Personal dust sampling | Weekly | Alpha activity in air estimated |
| Control room | Personal dust sampling | Weekly | Alpha activity in air estimated |
| Workshop | Personal dust sampling | Weekly | Alpha activity in air estimated |
| LLW disposal site | Personal dust sampling | When site being filled/closed | |
| LSA storage area | Personal/Medium flow air sampler | /When in operation | Alpha activity in air estimated |
| Wellfield control centers | Personal dust sampling | Monthly | Alpha activity in air estimated |
| Drill rigs various | Personal dust sampling | Monthly | When operating |
| Drying plant stack | Isokinetic sampling | Quarterly | |

Surface Contamination Monitoring

| Area | Method | Frequency | Comment |
|---|---|---|---|
| Skin and clothing | Hand held surface alpha/beta monitor | Before entering designated clean areas and before leaving the controlled area | If skin contamination above 4k Bq/$m^2$ washing required |
| Tools and equipment leaving controlled area | Hand held surface alpha/beta monitor | Equipment which has been in contact with radioactive material | Limit for release to be specified |
| Plant & Wellfield areas -as determined by RSO | Hand held surface alpha/beta monitor | As determined by RSO | House keeping check |
| Plant area | Survey | Monthly | Various locations |
| Offices, control room, laboratory, crib room, change room, workshops | Survey | Monthly | |
| Wellfield control centers | Survey | Monthly | |

# 7 EDUCATION AND TRAINING

A Radiation Safety Manual has been prepared for the Honeymoon site. The manual is under continual review and will be updated for use in the commercial operations at Honeymoon. The manual will form the basis for radiation safety training programs. A Radiation Safety Booklet that will summarise all radiation safety aspects of the operation will be prepared and issued to all employees and contractors working at the Honeymoon site.

## 7.1 Management

All line managers will be required to attend a radiation safety training program run by an appropriately qualified independent consultant before taking up their management position. All line managers will be required to attend an annual radiation safety training program run by an appropriately qualified independent consultant.

## 7.2 Employees

All new employees will attend a compulsory induction-training course before they commence their duties. This course will address all radiation protection issues relevant to the Honeymoon operation and will include job specific training. Every employee will attend an annual re-induction course in radiation protection.

Operators will be required to follow standard operating procedures. Routine staff training programs will emphasise the need to follow these procedures. The procedures will be structured to ensure that employee exposure to radiation is minimized.

All employees and contractors will receive a copy of the Radiation Safety Booklet. They will be required to read the booklet and comply with its rules and procedures.

# 8 AUDIT AND REPORTING PLAN

## 8.1 Audit

Each year Southern Cross Resources will audit its monitoring programs against the RMP requirements. The results will be reported to the EPA and PIRSA as part of the Honeymoon Project Annual Environment Report. Every three years an audit will be run by independent auditors.

## 8.2 Quarterly Report

Results of monitoring conducted under this program will be reported quarterly at the first ISL Operators meeting following the end of each quarter. Copies will be presented at the meeting to representatives of the EPA, PIRSA, and Department of Administrative and Information Services – SafeWork SA. The reports will include:

- Workplace radiation monitoring
- Dose estimation
- Designated employee list
- Incidents

## 8.3 Annual Report

Results of monitoring for each calendar year will be presented in summary as part of the Honeymoon Project Annual Environment Report. Copies of this report will be submitted to the Director – Radiation Protection Division (EPA) and to Chief Inspector of Mines (PIRSA) no later than 30 April the following year. The format will be similar to that of the Quarterly reports.

## 8.4 Incident Reports

All radiological incidents and resulting doses received will be promptly reported in writing to the EPA. The report will detail:

- The cause of the incident
- The consequences of the incident
- Steps taken to remedy the situation

If the incident has led to the significant contamination of an employee the EPA will be immediately consulted for advice on medical management.

## 8.5 Records

The records of all employee related monitoring programs will maintained on-site by the Radiation Safety Officer. Copies will be lodged in the Southern Cross Resources offices in Adelaide.

## 9 PERSONNEL AND RESOURCES

The Honeymoon project will employ an appropriately qualified Radiation Safety Officer (RSO) along with support staff for sampling and monitoring. . Appropriate equipment, laboratory and other facilities will be provided for the RSO.

The RSO's responsibilities will extend into the environmental management and OH&S areas. The RSO will be a member of all site safety committees and environmental management committees.

## 10 QUALITY ASSURANCE

The RSO will be required to document all site safety procedure procedures and record all monitoring data. The RSO will operate a quality assurance program that pursues continuous improvement and compliance with the ALARA principle. Procedures, data records and outcomes will be reviewed, assessed and audited to achieve this end.

## 11 REFERENCES


ARPANSA, 2005: Code of Practice and Safety Guide Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing, AGPS, 2005

Cogema Mining Inc, 1996: Application for renewal of source licence to United States Nuclear Regulatory Commission, Source Material Licence No SUA 1341.

CSIRO: Taylor, G. et al. 2004: Review of Environmental Impacts of the Acid In-Situ Leach Uranium Mining Process. CSIRO Land and Water Client Report.

Kinhill Engineers Pty Ltd, 1997: Olympic Dam Expansion Project – Environmental Impact Statement

Southern Cross Resources Australia Pty Ltd, 2000: Honeymoon Uranium Project – Environmental Impact Statement.

Southern Cross Resources Australia Pty Ltd, 2005: Honeymoon Project Mining and Rehabilitation Program

Southern Cross Resources Australia Pty Ltd, 2005: Honeymoon Project Radioactive Waste Management Plan