ANNUAL OCCUPATIONAL RADIATION MONITORING REPORT

LM7 License

BEVERLEY, BEVERLEY NORTH AND FOUR MILE MINERAL LEASES

Occupational Monitoring Program

Annual Report - 2016
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1 EXECUTIVE SUMMARY

1.1 Introduction
This report has been prepared in accordance with the requirements of the Heathgate Resources Pty Ltd (Heathgate) Radiation Management Plan v4.0 (2016) required as part of the LM7, License to Carry out Mining or Mineral Processing.

1.2 Occupational Radiation Monitoring
Radon decay products monitoring carried out in the plants and wellfields showed that the concentrations remained low during the year.

Area monitoring conducted at the plant supervised, wellfield and office areas showed that Long Lived Alpha Activity in dust remained consistently low.

Gamma dose rates throughout the plant and wellfield remained consistent with previous years’ monitoring results.

Alpha surface contamination in the plant and wellfield areas remained consistent with previous years’ monitoring results. Regular pressure cleaning helped minimise surface contamination levels in these areas.

1.3 Occupational Dose Estimation
Doses to employees and contractors at the Beverley, Beverley North and Four Mile Mines remained low during the year.

There were a total of 311 employees and contractors at the Beverley, Beverley North and Four Mile Mines during 2016.

The average worker dose of 0.37 mSv was less than the annual effective dose limit of 1 mSv to members of the public, as stipulated in the South Australian Radiation Protection and Control (Ionising Radiation) Regulations 2015. The maximum dose for the year was 2.63 mSv, also well below the worker dose limit of 20 mSv/yr\(^1\).

1.4 Adequacy and Effectiveness of Equipment and Procedures
Reviews of policies, procedures and equipment installed to manage radiation doses to ensure that doses to employees remain as low as reasonably achievable (ALARA) for 2016 included:

- An amended Radiation Management Plan (RMP) and Radioactive Waste Management Plan (RWMP), approved by the South Australian Environmental Protection Authority (EPA) in June 2016.
- A review of the radiation monitoring program and subsequent revised radiation monitoring program. This revised monitoring program was approved by the EPA in June 2016.
- New radiation monitoring equipment and respiratory protection devices were sourced to assist in Radiation Work Permit procedures.
- Preventive maintenance of Drier system and Ion Exchange Columns were carried out.

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\(^1\) Averaged over a period of 5 consecutive years, or a maximum of 50 mSv/yr in any one year.
2 INTRODUCTION

This report is prepared in accordance with the requirements of the Beverley, Beverley North and Four Mile Radiation Management Plan (RMP), License to Carry out Mining or Mineral Processing (LM7) under the Radiation Protection and Control Act, 1982. It provides a summary of all monitoring conducted during the calendar year 2016, previously reported in the quarterly Occupational Radiation Monitoring Reports.

The RMP’s document the strategies developed by Heathgate for the:

- Identification of potential radiation sources
- Monitoring of radiation exposures
- Assessment of employee dose
- Management of radiation exposures to ensure compliance with the ALARA principle.

The objective of a RMP is to assist Heathgate to fulfil its statutory requirements detailed in the Code of Practice on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005) and to comply with the relevant State and Commonwealth legislation.

The main radiation issues considered by the RMP and reported in this document are:

- Radon decay products inhalation
- Long lived alpha activity in dust inhalation
- Gamma dose external exposure
- Alpha contamination of surfaces
- Calculation of employee radiation dose
- Compliance with the ALARA principle.

2.1 HGR Management Personnel

Heathgate personnel, who are currently responsible for radiation management at the Beverley site, are as follows:

- President – Craig Bartels
- Operations Manager — Simon Tildesley
- Production Managers — Chris Every and Chris Heinrich
- Regulatory and Compliance Manager – Andrea Marsland-Smith
- Chief Environment and Radiation Advisor – Kelly Pelgrim
- Senior Health, Safety, Security and Environment Advisor — Sankaran Kutty.

The statutory position of Radiation Safety Officer is held by Sankaran Kutty, whose contact details are provided below:

Sankaran Kutty – Senior HSSE Advisor
Heathgate Resources
Suite 1, Level 7, 25 Grenfell St
Adelaide SA 5000
Adelaide Office: Ph: 08 8110 0500 Fax: 08 8212 5559
Beverley Site: Ph: 08 8413 2238 Fax: 08 8648 4628
2.2 **Summary of Process Activities and Changes**

A current map of the three mining tenements for Beverley, Beverley North and Four Mile and associated mining activity during 2016 is provided in Figure 2-2 and Figure 2-1. No wellfields within the Beverley ML were operated in 2016, however, water management activities were undertaken in the central, south and east wellfields. Actively mined wellfields during 2016 were within the Beverley North Pepegoona wellfields, and the Four Mile East and North East wellfields (see Figure 2-2 and Figure 2-1). The processing of uranium continued to be undertaken at the satellite plants within Beverley North, and the main Beverley Plant.

A number of modifications were made to processes during the year which had an impact on occupational exposures:

- Regular preventive maintenance was carried out in the Drier that helped to minimize LLA dust concentrations in the controlled area.

- Inspections and preventive maintenance of all Ion Exchange Columns at Beverley Pepegoona and Pannikan plants were carried out. This resulted in better efficiency of the columns, minimised breakdowns and thus helped to reduce occupational dose from confined space entries.

- A new dust extractor unit was purchased for use inside the Ion Exchange columns. This dust extractor helped to remove dust particulates inside the columns and thus minimized radiation dose.

![Figure 2-1: Map showing the wellfields mined in the Four Mile ML during 2016](image-url)
Figure 2-2: Map showing the wellfields mined in the Beverley North ML during 2016
3 OCCUPATIONAL RADIATION MONITORING

The occupational radiation monitoring conducted throughout the year included the measurement of radiation levels at the Beverley Process Plant, Process Plant Offices, Wellfields, Weather Tower, Camp, Beverley North Satellite Plants and Wellfields and Four Mile Wellfields. The frequency of monitoring was conducted according to the Radiation Management Plans. This monitoring included the following:

- Radon Decay Products area monitoring
- Long Lived Alpha Activity (LLAA) in dust personal and area monitoring
- Area gamma radiation surveys
- Alpha surface contamination monitoring.

3.1 Radon Decay Products

The Potential Alpha Energy Concentration (PAEC) of radon decay products was measured throughout the plants and wellfield areas. Monitoring was conducted according to the approved Standard Operating Procedure (SOP)².

The average and maximum concentrations measured at various locations throughout the year are given in Table 3-1. Trends of annual averages since commencement of operations are presented in Figure 3-1.

Radon Decay Products monitoring throughout the site showed PAEC to remain consistently low. Average concentrations across the site remain well below the internal investigation level of 2 μJm⁻³.

<table>
<thead>
<tr>
<th>Location</th>
<th>PAEC (μJm⁻³)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Max</td>
<td>Number 12 Hours Samples</td>
</tr>
<tr>
<td>Drilling</td>
<td>0.03</td>
<td>0.13</td>
<td>3</td>
</tr>
<tr>
<td>Environmental</td>
<td>0.07</td>
<td>0.38</td>
<td>8</td>
</tr>
<tr>
<td>Other</td>
<td>0.06</td>
<td>0.39</td>
<td>4</td>
</tr>
<tr>
<td>Plant Clean</td>
<td>0.04</td>
<td>0.26</td>
<td>16</td>
</tr>
<tr>
<td>Plant Controlled</td>
<td>0.08</td>
<td>0.51</td>
<td>12</td>
</tr>
<tr>
<td>Plant Supervised</td>
<td>0.06</td>
<td>1.85</td>
<td>92</td>
</tr>
<tr>
<td>Wellfield</td>
<td>0.04</td>
<td>0.16</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 3-1: Radon Decay Product PAEC in the Plant and Wellfield - 2016

² Routine Radon Decay Products Area Monitoring Using ERDM, Standard Operating Procedure RAD 02, Heathgate, October 2014
3.2 Long Lived Alpha Activity

Long Lived Alpha Activity (LLAA) sampling was conducted throughout the Plant controlled, supervised and clean areas and in the Wellfield. Monitoring was conducted according to the approved SOP\(^3\) and frequencies. Details of the average, maximum and minimum
concentrations at locations around the site, in the controlled area and for personal monitoring of operators are given in Table 3-3, Table 3-4 and Table 3-5 respectively. Trends of annual averages since commencement of operations are presented in Figure 3-2, Figure 3-3 and Figure 3-4.

Long Lived Alpha Activity in dust monitoring conducted in the Plant, Wellfield and other areas of the site remain low. The dust management programs detailed in the radiation management plan are thus considered sufficient to ensure doses via this pathway remain as low as reasonably achievable.

Table 3-3: LLAA Concentrations from Dust at the Plant and Wellfield - 2016

<table>
<thead>
<tr>
<th>Location</th>
<th>LLAA (Bqm⁻³)</th>
<th>Average</th>
<th>Max</th>
<th>Min</th>
<th>Std Dev</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental</td>
<td></td>
<td>0.02</td>
<td>0.08</td>
<td>0.00</td>
<td>0.03</td>
<td>8</td>
</tr>
<tr>
<td>Beverley FLT</td>
<td></td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>0.01</td>
<td>0.05</td>
<td>0.00</td>
<td>0.02</td>
<td>6</td>
</tr>
<tr>
<td>Plant Clean</td>
<td></td>
<td>0.01</td>
<td>0.15</td>
<td>0.00</td>
<td>0.02</td>
<td>74</td>
</tr>
<tr>
<td>Plant Supervised</td>
<td></td>
<td>0.02</td>
<td>0.12</td>
<td>0.00</td>
<td>0.02</td>
<td>182</td>
</tr>
<tr>
<td>Wellfield</td>
<td></td>
<td>0.01</td>
<td>0.09</td>
<td>0.00</td>
<td>0.02</td>
<td>22</td>
</tr>
</tbody>
</table>

The average and maximum dust concentrations in all the above areas remained low.

Table 3-4: LLAA Concentrations from Dust in the Controlled Area - 2016

<table>
<thead>
<tr>
<th>Location</th>
<th>LLAA (Bqm⁻³)</th>
<th>Average</th>
<th>Max</th>
<th>Min</th>
<th>Std Dev</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drier</td>
<td></td>
<td>2.24</td>
<td>13.83</td>
<td>0.00</td>
<td>2.68</td>
<td>127</td>
</tr>
<tr>
<td>Drier security room</td>
<td></td>
<td>0.02</td>
<td>0.09</td>
<td>0.00</td>
<td>0.02</td>
<td>46</td>
</tr>
<tr>
<td>Packing room</td>
<td></td>
<td>1.19</td>
<td>5.68</td>
<td>0.01</td>
<td>1.22</td>
<td>43</td>
</tr>
<tr>
<td>Packing Warehouse</td>
<td></td>
<td>0.02</td>
<td>0.08</td>
<td>0.00</td>
<td>0.02</td>
<td>47</td>
</tr>
</tbody>
</table>

Table 3-5: LLAA Concentrations from Personal Monitoring of Work - 2016

<table>
<thead>
<tr>
<th>Type</th>
<th>LLAA (Bqm⁻³)</th>
<th>Average</th>
<th>Max</th>
<th>Min</th>
<th>Std Dev</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drier Operator</td>
<td></td>
<td>0.51</td>
<td>5.69</td>
<td>0.00</td>
<td>1.01</td>
<td>72</td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td>0.05</td>
<td>1.79</td>
<td>0.00</td>
<td>0.19</td>
<td>98</td>
</tr>
<tr>
<td>Plant</td>
<td></td>
<td>0.05</td>
<td>0.32</td>
<td>0.00</td>
<td>0.07</td>
<td>48</td>
</tr>
<tr>
<td>Wellfield</td>
<td></td>
<td>0.03</td>
<td>0.06</td>
<td>0.00</td>
<td>0.02</td>
<td>0.14</td>
</tr>
<tr>
<td>Cleaner</td>
<td></td>
<td>0.02</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>2</td>
</tr>
</tbody>
</table>

4Airstream Helmets worn by these operators have a Protection Factor (PF) of 10, this is has not been taken into account but would reduce concentration by 10 times.
Figure 3-2: LLAA Concentration in Dust Monitoring Trends - Supervised and Office Areas

Figure 3-3: LLAA Concentration in Dust Monitoring Trends - Controlled Areas
Figure 3-4: LLAA Concentration in Dust Monitoring Trends - Personal Monitoring

(Investigation Level – 0.4 Bq/m³)
3.3 **External Gamma Dose Rate**

3.3.1 **Area Gamma Dose Rate Surveys**

External gamma dose rate surveys were conducted throughout all work areas in the Plant and Wellfield. Monitoring was conducted according to the approved SOP\(^5\).

Details of the average, maximum and minimum dose rates at each location during 2016 are given in Table 3-6. Trends in annual average dose rates since commencement of operations are presented in Figure 3-5.

Average gamma dose rates remained consistent throughout the year.

<table>
<thead>
<tr>
<th>Location</th>
<th>Gamma Dose Rate (µSv/h)</th>
<th>Average</th>
<th>Max</th>
<th>Min</th>
<th>Std Dev</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling</td>
<td></td>
<td>0.38</td>
<td>2.50</td>
<td>0.02</td>
<td>0.56</td>
<td>36</td>
</tr>
<tr>
<td>Plant Clean</td>
<td></td>
<td>0.22</td>
<td>1.40</td>
<td>0.02</td>
<td>0.22</td>
<td>55</td>
</tr>
<tr>
<td>Plant Controlled</td>
<td></td>
<td>1.89</td>
<td>8.00</td>
<td>0.15</td>
<td>2.12</td>
<td>27</td>
</tr>
<tr>
<td>Plant Supervised</td>
<td></td>
<td>1.56</td>
<td>11.00</td>
<td>0.04</td>
<td>2.20</td>
<td>64</td>
</tr>
<tr>
<td>Wellfield</td>
<td></td>
<td>2.46</td>
<td>15.00</td>
<td>0.03</td>
<td>2.46</td>
<td>110</td>
</tr>
</tbody>
</table>

![Figure 3-5: Gamma Dose Rate Monitoring Trend](image_url)

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\(^5\) Routine Gamma Dose rate Survey, Standard Operating Procedure RAD 01, Heathgate, October 2014
3.3.2 Thermoluminescent Dosimeter Results

Thermoluminescent Dosimeter (TLD) badges are issued to all permanent staff and long term contractors at the Beverley Site. They are also issued to temporary contractors who may be undertaking work in areas of higher than usual gamma dose rates.

Details of the average, maximum and minimum gamma dose on TLD badges for each workgroup are given in Table 3-7. Trends in annual average gamma doses since commencement of operations are presented in Figure 3-6. These average results are hourly weighted for each workgroup then allocated as an hourly dose rate to personnel who have either lost their badges or have not yet been issued with a badge. The final gamma dose statistics, including allocated doses, are presented in Figure 5-1.

Average TLD badge doses for 2016 remained consistently low.

<table>
<thead>
<tr>
<th>Work Group</th>
<th>Gamma Dose (mSv)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Max</td>
</tr>
<tr>
<td>Production</td>
<td>0.29</td>
<td>1.33</td>
</tr>
<tr>
<td>Maintenance</td>
<td>0.25</td>
<td>1.14</td>
</tr>
<tr>
<td>Geology &amp; Drilling</td>
<td>0.02</td>
<td>0.20</td>
</tr>
<tr>
<td>Projects</td>
<td>0.09</td>
<td>0.39</td>
</tr>
<tr>
<td>Other</td>
<td>0.05</td>
<td>0.11</td>
</tr>
<tr>
<td>Contractors</td>
<td>0.08</td>
<td>0.25</td>
</tr>
</tbody>
</table>

* Production Personnel – Plant and Wellfield Operators, laboratory staff and supervisors
  Geology & Drilling – Drillers, geologists and support staff
  Others – Environment, Safety, Radiation and other office based staff
  Contractors – All site contractors with exception of drillers
  Projects – Construction personnel.

![Figure 3-6: Annual Average TLD Badge Dose Trends](image-url)
3.4 Alpha Surface Contamination

Alpha surface contamination surveys were conducted in the Crib Rooms, Control Rooms, Offices, Change Rooms, Plants and Wellfields. Monitoring was conducted according to the approved SOP\(^6\).

Details of the contamination monitoring conducted in the Plant, Wellfield and Clean Areas for 2016 are given in Table 3-8. Trends in annual average surface contamination values are presented in Figure 3-7.

Regular pressure cleaning is conducted in the plant supervised and controlled areas to reduce the surface contamination levels.

Table 3-8: Alpha Surface Contamination Survey Results for Plant and Wellfield - 2016

<table>
<thead>
<tr>
<th>Location</th>
<th>Alpha Surface Contamination (Bq/cm(^2))</th>
<th>Average</th>
<th>Max</th>
<th>Min</th>
<th>Std Dev</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling</td>
<td></td>
<td>0.09</td>
<td>2.00</td>
<td>0.01</td>
<td>0.26</td>
<td>163</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>0.02</td>
<td>0.73</td>
<td>0.00</td>
<td>0.08</td>
<td>150</td>
</tr>
<tr>
<td>Plant Clean</td>
<td></td>
<td>0.08</td>
<td>2.13</td>
<td>0.00</td>
<td>0.21</td>
<td>284</td>
</tr>
<tr>
<td>Plant Controlled</td>
<td></td>
<td>2.44</td>
<td>26.67</td>
<td>0.00</td>
<td>4.11</td>
<td>351</td>
</tr>
<tr>
<td>Plant Supervised</td>
<td></td>
<td>1.68</td>
<td>26.67</td>
<td>0.00</td>
<td>2.89</td>
<td>303</td>
</tr>
<tr>
<td>Wellfield</td>
<td></td>
<td>0.60</td>
<td>4.00</td>
<td>0.01</td>
<td>0.63</td>
<td>191</td>
</tr>
</tbody>
</table>

Figure 3-7: Average Alpha Surface Contamination Trends

---

\(^6\) Alpha Surface Contamination Monitoring, Standard Operating Procedure RAD 07, Heathgate, October 2014
4 OCCUPATIONAL DOSE ESTIMATION

This chapter presents the results of annual occupational dose calculations for 2016. Dose assessment methodology is presented in Appendix 1 and is based on the 1994 *ICRP 68* and 1996 *IAEA Safety Series 115* methodology.

5 DOSE ASSESSMENT

During the year, there were a total of 311 employees and contractors working at the Beverley and Beverley North Sites. The total effective dose descriptive statistics for these employees are given in Table 5-1. Trends of the average and maximum dose since commencement of operations are presented in Figure 5-1.

Table 5-1: Total Effective Dose Statistics - 2016

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Dose (mSv)</td>
<td>0.37</td>
</tr>
<tr>
<td>Maximum Dose (mSv)</td>
<td>2.63</td>
</tr>
<tr>
<td>Minimum Dose (mSv)</td>
<td>0.00</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.38</td>
</tr>
<tr>
<td>Number of Employees</td>
<td>311</td>
</tr>
<tr>
<td>Dose limit (mSv)</td>
<td>20</td>
</tr>
</tbody>
</table>

Employees and contractors were assigned to various work groups based on their major tasks. The average and maximum effective doses to each of these work groups from each of the exposure pathways are presented in Table 5-2: Average and Maximum Effective Dose for Exposure Pathways by Work Group and the average is presented in Figure 5-2.

Doses to employees at the Beverley, Beverley North and Four Mile sites remained consistently low and below all applicable limits.
Table 5-2: Average and Maximum Effective Dose for Exposure Pathways by Work Group - 2016

<table>
<thead>
<tr>
<th>Work Group *</th>
<th>LLA (mSv) Average</th>
<th>LLA (mSv) Max</th>
<th>RnD (mSv) Average</th>
<th>RnD (mSv) Max</th>
<th>Gamma (mSv) Average</th>
<th>Gamma (mSv) Max</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>0.26</td>
<td>1.65</td>
<td>0.13</td>
<td>0.19</td>
<td>0.29</td>
<td>1.33</td>
<td>80</td>
</tr>
<tr>
<td>Maintenance</td>
<td>0.12</td>
<td>0.26</td>
<td>0.11</td>
<td>0.19</td>
<td>0.25</td>
<td>1.14</td>
<td>47</td>
</tr>
<tr>
<td>Geology &amp; Drilling</td>
<td>0.06</td>
<td>0.19</td>
<td>0.10</td>
<td>0.22</td>
<td>0.02</td>
<td>0.20</td>
<td>118</td>
</tr>
<tr>
<td>Projects</td>
<td>0.11</td>
<td>0.19</td>
<td>0.11</td>
<td>0.17</td>
<td>0.09</td>
<td>0.39</td>
<td>311</td>
</tr>
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<td>Other</td>
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<tr>
<td>Contractors</td>
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<td>0.12</td>
<td>0.23</td>
<td>0.08</td>
<td>0.25</td>
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* Production – Plant and Wellfield operators, laboratory staff and supervisors
  Geology & Drilling – Drillers, geologists and support staff
  Others – Environment, Safety, Radiation and other office based staff
  Contractors – All site contractors with exception of drillers
  Projects – Construction personnel

Figure 5-2: Average Total Effective Dose to each Workgroup from each Pathway - 2016
6 ADEQUACY AND EFFECTIVENESS OF EQUIPMENT AND PROCEDURES

The average and maximum doses received by workers at the Beverley, Beverley North and Four Mile sites during the year remained well below the statutory limits. The average dose received by employees and contractors is lower than the statutory limit for members of the public.

Although dose rates to the majority of employees remain very low, the effectiveness of engineering and administrative radiation controls are continuously reviewed to ensure that doses to employees remain As Low As Reasonably Achievable (ALARA). During 2016 a number of improvements to Heathgate’s radiation management system were identified and improvements undertaken, the section below details these key activities.

Management Systems/Procedures

A review of environmental and occupational radiation monitoring across the Beverley, Beverley North and Four Mile operations was conducted during 2015-2016. Following this review, an amended radiation monitoring program was submitted to the South Australian Environmental Protection Authority (EPA) in May 2016, and approved in June 2016. Revisions focused on removing monitoring sites where mining operations had concluded, and reducing monitoring where significant monitoring periods (>16 years) had demonstrated low to no actual risk.

In conjunction with request to amend the radiation monitoring requirements across all three Heathgate operated tenements, a request was made to combine the LM4 License to mine or undertake mineral processing of a prescribed radioactive substance for Beverley and Beverley North, with the LM7 licensee for the Four Mile ML. The change involved merging the Radiation Management Plans (RMP) and Radioactive Waste Management Plans (RWMP) for the Beverley, Beverley North and Four Mile ML’s. This change was approved in June 2016.

Revised procedures and new monitoring equipment was introduced during 2016 to improve the way confined space entries are carried out. This helps to minimise the associated radiation exposure.

Training

External specialist radiation safety training was undertaken to support personnel obtaining a ‘license to operate ionizing radiation apparatus’ and a ‘license to use or handle a radioactive substance’. Additional personnel are now licensed to use portable XRF units, logging tools and laboratory XRF equipment. Additional HSE personnel are now licensed to use or handle radioactive substances, and have been trained internally to undertake radiation monitoring and management activities, to support the site radiation safety officers.

Several sessions of worker radiation safety training was provided to impart radiation safety knowledge to permanent, contract and casual employees. Updated the radiation safety training program. In addition, employee safety meetings and everyday morning tool box meetings were used as a platform to discuss the radiation safety issues and implement corrective actions when required. Supervisors Safety Meetings were also used to discuss radiation safety related items and to implement corrective actions.

Equipment

New equipment was purchased during 2016 to support the monitoring program set out in the approved Radiation Management Plan, which included:

- Three new continuous radon daughter monitors
- An additional gamma survey meter
- Confined space monitoring devices

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<td>31 March 2017</td>
<td>S. Kutty</td>
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7 CONCLUSIONS

The results of the LM7 Radiation Monitoring Program have shown that no employee was exposed to unacceptable levels of radiation during 2016.

Doses received by employees and contractors working at the Beverley, Beverley North and Four Mile sites remain well below all statutory limits. The Radiation Management Plan and associated site procedures like the Radiation Work Permit systems have also been reviewed and updated to ensure doses are kept As Low As Reasonably Achievable.

8 REFERENCES

2. Code of Practice on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005), ARPANSA (RPS 9)
3. IAEA Safety Series No. 115, Basic Safety Standards for the Protection Against Ionizing Radiation and for the Safety of Radiation Sources, IAEA, 1996
APPENDIX 1

Occupational Dose Assessment Methodology
METHOD

Total effective dose was calculated as the sum of the three exposure pathways as detailed in the Code of Practice on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing, 2005.

- Inhalation of Long Lived Alpha Activity in Dust
- Inhalation of Radon Decay Products
- External exposure to Gamma Radiation.

Inhalation of Long Lived Alpha Activity in Dust.

The effective dose due to the inhalation of Long Lived Alpha Activity (LLAA) in Dusts has been calculated from the following equation.

\[ E_{LLAA} = [LLAA] \cdot DCF \cdot BR \cdot IT \]

Where:
- \( E_{LLAA} \) = Effective dose due to inhalation of LLAA (mSv)
- \([LLAA]\) = Average Concentration of LLAA (Bqm\(^{-3}\))
- \( DCF \) = Dose conversion factor (mSv/Bq)
- \( BR \) = Breathing Rate (1.2 m\(^3\)/h\(^{-1}\))
- \( IT \) = Inhalation Time (h).

The dose conversion factor used for the Beverley Uranium Mine is 0.0019 mSv/Bq, obtained from IAEA Safety Series 115 \(^3\) using the default AMAD of 5 mm and a solubility class of M.

Doses for workgroups other than Geology and Drilling, Contractors and HSSE/Admin are calculated monthly from the average of all personal dust monitoring conducted during the month for each workgroup and the hours spent by each employee in that workgroup. Time information was taken from the “In Flight” database where the onsite working time of all employees is recorded. No allowance for any respiratory protection that may have been worn has been made. The lack of this allowance for respiratory protection factor gives a slight overestimate in the drier operator dose, however the majority of their shift is spent in clean areas where no respirator is worn and the dust sample is still being collected. This method was considered the closest estimate obtainable.

Dose to the Geology and Drilling workgroup is taken from the average of area dust monitoring in the wellfield and drilling areas for the months and hours worked. Time information is obtained from the “In Flight” database.

Dose to the Contractors and HSSE/Admin workgroups is taken from the average of all area monitoring conducted around site for the month. Area sampling conducted in the Drier and packaging areas is divided by the respiratory protection factor 10 before being averaged since these areas require the compulsory wearing of an airstream helmet. Hours are obtained from the “In Flight” database.
Inhalation of Radon Decay Products

The committed effective dose due to the inhalation of radon decay products (RnD) has been calculated from the following equation.

\[ E_{RnD} = PAEC \cdot DCF \cdot IT \]

Where:
- \(E_{RnD}\) = Effective dose due to inhalation of RnD (mSv)
- PAEC = Average Potential Alpha Energy Concentration (\(\mu\)Jm\(^{-3}\))
- DCF = Dose conversion factor (0.0014 mSv/\(\mu\)Jm\(^{-3}\)/h)
- IT = Inhalation Time (h).

Doses were calculated monthly from the average PAEC in each work area and the time spent by each employee in that area.

External Exposure to Gamma Radiation

The external exposure to gamma radiation is monitored using Thermoluminescent Dosimeter (TLD) badges supplied by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Badges are issued to all employees and longer-term contractors for a period of three months. Any short-term contractors or employees who lose their badges are assigned a pro-rata dose based on their work group average and total hours.

Badges are worn close to the employee’s body for the duration of the shift and stored on a control board at all other times.