internal report **284**

Radiation surveys of El Sherana camp site and Sleisbeck pit and waste rock piles

S Tims

B Ryan

May 1998

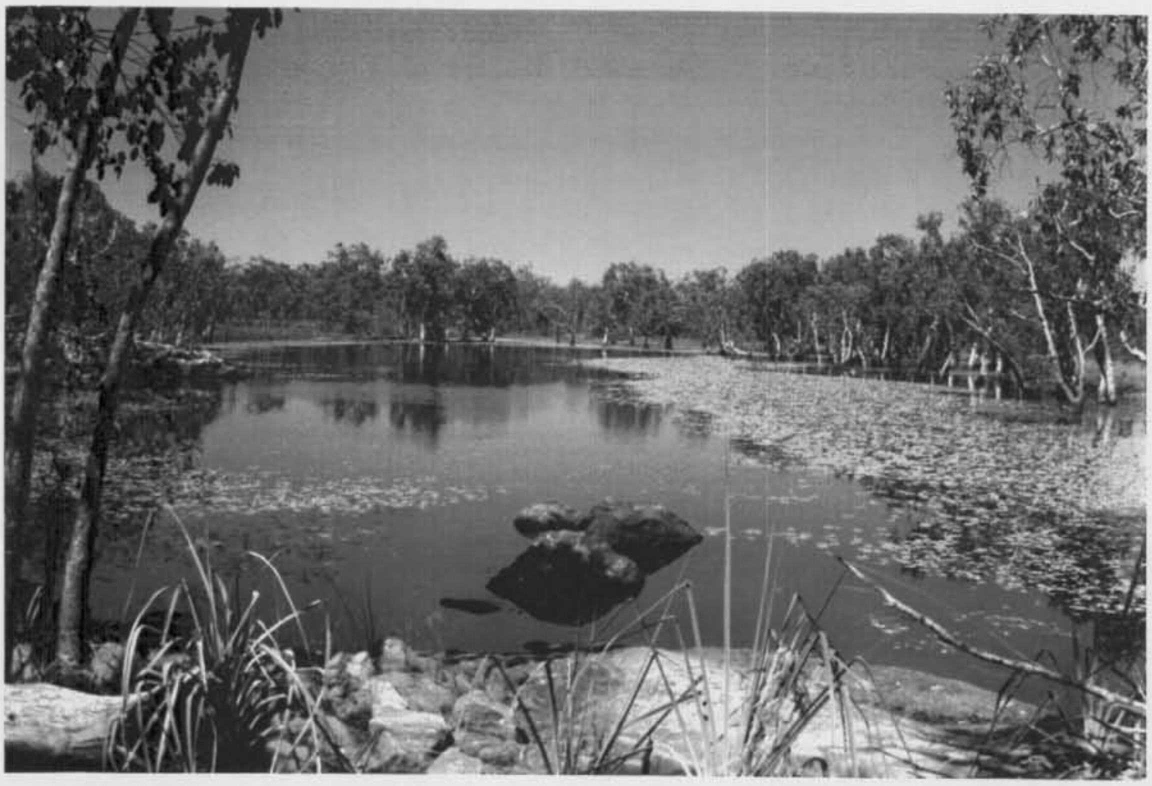
supervising scientist

γ Radiation surveys of El Sherana camp site and Sleisbeck pit and waste rock piles

S. Tims and B. Ryan

Environmental Research Institute of the Supervising Scientist (***eriss***)

Jabiru, NT 0886 (Australia)



Supervising Scientist for the Alligator Rivers Region

Internal Report 284

File Reference: JE-52-208

MAY 1998

eriss

ENVIRONMENTAL RESEARCH INSTITUTE OF THE SUPERVISING SCIENTIST

γ Radiation Surveys of El Sherana camp site and Sleisbeck pit and waste rock piles

S. Tims and B. Ryan

Environmental Research Institute of the Supervising Scientist, Jabiru, NT 0886

1 Introduction

The open cut El Sherana mine was the biggest producer of uranium in the South Alligator river valley, with 39,000 tonnes of high grade ore mined and processed at the Moline mill. The mill camp site is located on the road to Coronation Hill. It has a frontage of approximately 50m, and consists of several houses, storage sheds and plant buildings. The camp site was surveyed by technical staff of the Environmental Research Institute of the Supervising Scientist (***eriss***), during visits to the area in June and July 1992. These measurements were a part of the ***eriss*** contribution to the hazard reduction exercises carried out at a number of abandoned mine sites in Kakadu. The measurements at El Sherana camp involved gamma dose rate surveys of two contaminated areas of soil, and also of two contaminated concrete blocks, both before and after the hazard reduction work.

Approximately 35 km south-east of the El Sherana site lies the abandoned Sleisbeck mine. Sleisbeck is located in the Katherine valley, within Stage III of Kakadu National Park, and can be accessed via a 40 km rough track from Coronation Hill through the old Gimbat Pastoral Lease. Although the access road to Sleisbeck is sign posted with regard to the hazard in the area, there is no other obvious indication of a hazard at the site. In 1957, 637 tonnes of medium grade ore was mined and transported to Rum Jungle for treatment. A considerable quantity of low grade ore was also mined, stock piled on the site and later removed.

The old mine workings at Sleisbeck were surveyed for radiological hazard by the technical staff of the Environmental Research Institute of the Supervising Scientist, on the 17 May 1990. The workings consist of an open pit approximately 100 m x 30 m in dimensions, and 3 dump areas. The survey involved external gamma radiation measurements and collection of soil, water and plant samples for radionuclide analysis. The results of the water sample analysis are presented in Tables 1 and 2. The high-resolution gamma spectroscopy analysis results for the plant and soil samples are given in Tables 3 and 4, respectively.

In a to letter Senator Robert Hill, dated the 8th May 1997, Mr. M. Sherwood raised concerns about the safety of the El Sherana and Sleisbeck sites. Subsequently Parks Australia requested "... assistance and advice regarding the danger the radioactive material (at the El Sherana camp and Sleisbeck pit) may pose to staff or visitors to those sites ...". In response to this request a radiological survey in and around the storage sheds at El Sherana was carried out on 27th May 1997 by technical staff at ***eriss***. Additional surveys of the Sleisbeck overburden dump, pit and pit wall areas were also made on the 28th May 1997. The objective of this report is to provide current data on the radiological hazards present in these areas. This was done with a view to providing Parks Australia and UMARB (then OSS) with some of the information required to make a preliminary risk assessment of the sites.

2 Experimental Details

Gamma radiation levels were recorded on Mini Instrument Type 6-80 Environmental radiation meters with external high-sensitivity, compensated Geiger Muller tubes. The tubes have a sensitivity of approximately 18 counts per second for a dose rate of 1 $\mu Gy{\cdot}h^{-1}$. The calibration for each tube is based on gamma rays arising from the decay of ^{226}Ra and its progeny. These are the same isotopes that provide the bulk of the radiation dose from uranium ore, and consequently are well suited to dose assessment at uranium mine sites. Except where noted, the tubes were mounted in the horizontal position, 1m above ground height. The tubes are known to operate reliably under the severe climatic conditions present in the region. The associated meters provide output in the form of total number of counts for a given time period, and a common analogue meter which provides output in $\mu Gy{\cdot}h^{-1}$. Count periods of 600 s duration were used for each recording, except for measurements in the pit at Sleisbeck as noted below. Repeat measurements were also performed at each site. The statistical error on each measurement was never > 2.5%, and was typically 1.3%

El Sherana camp Area

Several storage area buildings at El Sherana camp have considerable fire and termite damage and, except for the hammer-drill sample shed, all appeared to be unstable at a level that was considered to be unsafe to enter. Measurements of the gamma dose rate were therefore limited to the entrance and/or perimeters of these buildings. Consequently the dose rates reported here are expected to be lower than would be found at locations closer to the core material and/or to the centre of the structure concerned.

The main core shed has racks of core material stored at one end of the shed. Recordings were made at the entrance of this building, approximately 2 m from the racks, which are within an area ~7 m x ~12 m x ~2.5 m (w x d x h). Other sites investigated included what was believed to be the hammer-drill sample storage shed, which contained ~80 sample crates, and 2 sample sheds which contained stored drill hole material.

The hammer-drill sample shed provided easy access between the rows of crates, each of which held ~1 m^3 of material. There are 4 rows of crates, typically stacked 3 crates high by 6-7 crates long, with approximately 1.5 m between each row. Gamma activity was recorded at the centre of this shed, and also along the individual rows of crates within the shed.

One sample shed (shed 1) has no side walls, and ~50 sample crates are visible from outside the structure. Measurements were made ~2 m from the perimeter of this shed. The crates in this shed were stored ~0.5 m apart and were not stacked upon one another. The second sample shed (shed 2) contained bags of waste material with a total volume of ~5 m^3.

Sleisbeck mine site

A 5 m high wall with exposed uranium mineralisation is located on the eastern side of the pit, which retains water through out the year. The exposed uranium mineralisation is largely confined to a small (~1.5 m x 4 m) hollow in the wall, and can be reasonably accessed only by boat from the water side. Recordings were made ~5 m from the pit entrance and along the pit walls. Measurements made along the pit walls were made with the detector tubes mounted vertically, ~1 m from the face of the wall. On the western side of the pit, where the wall activity was similar to the local background levels, measurements were made ~1 m above the water surface.

There are three major dumps approximately 100 m to the western side of the pit, which appear to contain overburden and low grade uranium ore. These dumps are ~0.5 m high and are spread over an area ~20 m x ~80 m. Recordings were also made of the dose rate levels present immediately above these dumps.

3 Discussion

A contribution of 0.07 $\mu Gy \cdot h^{-1}$, corresponding to the estimated cosmic ray background for the area, has been subtracted from the dose rate values from the 1997 work. This estimate was taken from the work of Marten (1992). The absorbed dose rates reported in Tables 5 and 6 can be used to provide an approximate upper limit on the direct gamma component of the whole body effective dose rate viz:

$$\text{Effective dose } (mSv \cdot y^{-1}) \lesssim 8.76 \times \text{Absorbed dose } (\mu Gy \cdot h^{-1}) \qquad (1)$$

The actual dose received will be somewhat less than this effective dose because the physical dose received by many of the important bodily tissues and organs will be reduced though attenuation from interceding parts of the body. In addition, and perhaps more importantly, equation (1) assumes that exposure will be continuous at the relevant absorbed dose level for the course of an entire year. It is unlikely that the exposure level would be continuous for such an extended period of time because the physical size of the area(s) with significant gamma activity is relatively small.

Except for the pit water sample, the preliminary studies reported here make no investigation of the expected radiation dose received from pathways other than direct gamma exposure. As such, the dose rate estimates reported here possibly form a lower limit to the actual expected dose rate. A more detailed investigation would require information on the proposed usage of the area(s) in question. This would allow the most significant pathway(s) to be identified and determine the level of any additional investigation necessary. Two pathways possibly worthy of further investigation arise from animals that drink directly from the pit, and the drainage pathway for the pit and dump region.

The original 1990 survey found that animal activity was distinctly noticeable around the pit, indicating that the water was used by marsupials. Human consumption of animals that drink from the pit could provide an additional pathway for radiation exposure to the individuals concerned. It is perhaps worth noting that the pit itself may not be crucial as a water supply, as there is a natural water body within a few kilometres of the pit. A full analysis of the drainage pathway(s) from the pit and/or dump regions is outside the scope of this report, however it is plausible that drainage could be into this water body. Evidence that some local plant and animal species, such as water lily, fish, turtle and mussels, internally accumulate selected uranium series radionuclides from their environment can be found in the literature (for example, Johnston (1987), Martin et al. (1995)). Consequently drainage into the water body could provide an additional radiation dose pathway. The significance of the dose received from the consumption of plants and/or animals such as those noted above should therefore be subject to further investigation.

El Sherana camp Area

Results for the four locations surveyed are given in Table 5. The 1990 surveys recorded the natural terrestrial gamma dose rate background for the El Sherana area as being of the order 0.1 $\mu Gy \cdot h^{-1}$. Hence the dose rate is above the natural background level for the main core shed and slightly above the natural background for the hammer-drill sample storage shed. The core shed, and sample sheds 1 & 2 are expected to give higher readings closer to the stored material.

If the reasonable assumption is made that the dose rate levels reported here are to within a factor of 3 of those typically found within the structures described, then the hazard of exposure at the site is not considered to be small. On site, the public dose limit of 1 $mSv \cdot y^{-1}$ for mining and milling of radioactive ores could be approached after an occupancy period of only a few weeks.

Sleisbeck mine site

Only external gamma radiation measurements were taken in the 1997 survey, and the results for this survey are listed in Table 6.

The gamma radiation dose rate in the over burden dump area is typically <1 $\mu Gy \cdot h^{-1}$ (1990 survey), slightly above the natural background rate for the region, which is ~0.2-0.5 $\mu Gy \cdot h^{-1}$. The two low grade ore dumps alongside the over burden give readings that are somewhat higher, typically ~1-2 $\mu Gy \cdot h^{-1}$; however there are some small, isolated regions present on these dumps which produce recordings of up to 10 $\mu Gy \cdot h^{-1}$.

The highest gamma dose rate found at the site was in the hollow part of the vertical wall on the eastern side of the pit, with recordings between 40 and 50 $\mu Gy \cdot h^{-1}$. Accordingly, count periods of 100 s duration were used at this part of the wall. The dose rate at the surface of the pit water is ~1-2 $\mu Gy \cdot h^{-1}$ and a pit water sample collected in the 1990 survey was mildly radioactive.

Except for the pit access area, application of equation (1) shows that continuous exposure at any of the locations reported in Table 6 will lead to effective dose rates that exceed the public dose limit for the mining and milling of radioactive ores. In particular the pit wall displays regions where just the gamma component contribution to the effective dose rate could be over 300 times the public limit. The average for the waste rock stockpiles is also significant, at more than 26 times the public limit. As noted above the actual dose received from these sites is most likely considerably less than this, however both of these sites are considered to constitute a significant radiological hazard in their current state.

At present the Australian drinking water guidelines (NHMRC (1996)) provide guideline values for the maximum concentrations of ^{238}U and ^{226}Ra that can be present in drinking water without posing any significant health risk to the consumer. In addition the guidelines note that:

> "If one or more radionuclide is present, the total annual dose from all radionuclides in drinking water, excluding the dose from potassium-40, should be calculated, and should not exceed 0.1 mSv."

It would not be unreasonable to expect that the major contributors to the total dose received by consuming water from the Sleisbeck pit would come from members of the uranium series decay chains. In particular the dominant contributors are most likely ^{226}Ra, ^{230}Th, ^{210}Pb, ^{210}Po and $^{234,238}U$. Smaller, but significant contributions could also be expected from ^{235}U

and ^{227}Ac. The total dose received from ingesting these radioisotopes (by drinking the water) is presently accepted as being proportional to the amount of water consumed. Using the ingestion dose coefficients of ICRP (1996) the total effective dose arising from the radioisotope concentrations listed in table 1 is 0.19 $\mu Sv \cdot l^{-1}$ of water consumed. If it is assumed that the concentration ratios for $^{234}U/^{238}U$, $^{235}U/^{238}U$, $^{227}Ac/^{226}Ra$ and $^{210}Po/^{210}Pb$ are 2.0, 0.05, 0.05 and 1.0 respectively, then the above figure increases to 0.28 $\mu Sv \cdot l^{-1}$.

It should be noted that the total dose received is greater for children than it is for adults, and for a 5 year old child the above figures increase to 0.39 and 0.63 $\mu Sv \cdot l^{-1}$. At these dose rates an adult would need to consume >380 litres per year of pit water to exceed the 0.1 mSv guideline dose. The corresponding figure for a 5 year old child is >250 litres per year. As such the risk of exposure from consuming pit water is considered to be small, especially in comparison with the direct gamma radiation dose that could be received from the surrounding waste rock stockpiles, or indeed as natural gamma radiation background from the area.

The NHMRC also give specific guideline concentration values for ^{238}U and ^{226}Ra. These are 250 $mBq \cdot l^{-1}$ for ^{238}U and 500 $mBq \cdot l^{-1}$ for ^{226}Ra. As can be seen from Table 1 the ^{238}U concentration clearly exceeds the guideline value. However, for the reasons pointed out by Qureshi and Martin (1996), these values should not be viewed as an absolute upper limit that should never be exceeded. Indeed, as stated by the NHMRC (1996):

> "Should this level be exceeded, further evaluation would be required to assess what action, if any, can be taken to reduce the dose. In some circumstances, such as in small remote communities where the water supply contains naturally-occurring isotopes, and there is no practical alternative to existing water supplies, there may be no alternative but to accept a dose which exceeds the guideline value, and the slight increase in risk this entails. Advice should be sought from the relevant health authority in such circumstances."

The pit and old mine workings area is unlikely to lead to substantial impact on any anthropogenic activities carried out at locations adequately removed from the region. The proposed safari camp, which would be located several hundred metres east of the pit and dump area, could be considered to be adequately removed from the area.

On site the exposure hazard is larger than is the case for the El Sherana camp. Occupancy of the site would again be limited to several weeks per year in order to remain below the public dose limit of 1 $mSv \cdot y^{-1}$.

The suggestion by Mr. Sherwood to backfill the pit with the low grade ore from the dump areas is almost certainly the best way to minimise the risk of exposure. However, this hazard could be significantly reduced if the access to the exposed mineralisation wall is restricted. This could be achieved by the erection of a wire fence and warning signs on the top of the wall around the pit. In addition the over burden and low grade ore, which are in small heaps previously truck dumped outside the entrance of the open cut, could also be ploughed and mixed. This would to reduce the radiological hazard that arises from the presence of the relatively higher radioactive spots. In the event that significant earthworks are used to reduce the radiological hazard at any of the sites, a further radiological survey should be made to ensure the effectiveness of the repairs.

4 References

ICRP (1996). *Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 5, Compilation of Ingestion and Inhalation Dose Coefficients.* ICRP publication 72. Annals of the ICRP vol 26 No. 1 1996.

Johnston, A. (1987). *Radiation exposure of members of the public resulting from operation of the Ranger uranium mine.* Technical Memorandum 20, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra.

Marten, R. (1992). External gamma dose rate survey of the Ranger land application plot in: *Proceedings of the workshop on land application of effluent water from uranium mines in the Alligator Rivers Region, Jabiru 11-13 September 1991.* Supervising Scientist for the Alligator Rivers Region, AGPS Canberra.

Martin, P., Hancock, G. J., Johnston, A. and Murray, A. S. (1995) *Bioaccumulation of radionuclides in traditional Aboriginal foods from the Magela and Cooper Creek systems.* Research Report 11, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra.

NHMRC (1996). *Australian drinking water guidelines.* National Health and Medical Research Council and Agriculture and Resource Management Council of Australia and New Zealand.

Qureshi, H. and Martin, P. (1996). *An assessment of the source of naturally occurring high concentrations of radium in groundwater of the Daly Basin.* NT power and water authority Report No. 73/1996D.

5 Acknowledgments

A number of people have helped with the preparation of this report. The authors would particularly like to thank Professor Riaz Akber of the Queensland University of Technology and Mr. Paul Martin of ***eriss*** for their suggestions and improvements to the text..In addition we would also like to thank ***eriss*** ex-staff members John Pfitzner and Gary Hancock for the initial sample collection and analysis of the data reported in this study.

Table 1. Radionuclide concentrations of composite water sample from Sleisbeck Mine Pit, collected on 17th May 1990. All results are in ($mBq \cdot l^{-1}$) ± 1 standard deviation.

Location	^{238}U	^{230}Th	^{226}Ra	^{210}Pb
Mine Pit	340 ± 38	295 ± 13	329.8 ± 4.9	31.5 ± 7.6

Table 2. ICPMS qualitative scan of a composite water sample from Sleisbeck Mine Pit, collected on 17th May 1990.

Sample Identification			
Element	**Sleisbeck Pit sample Blank Corrected (ppb)**	**Element**	**Sleisbeck Pit sample Blank Corrected (ppb)**
Mg	8600	Fe	140
Al	74	Ni	0.4
Sc	2	Cu	1
TI	4.8	Ga	<0.1
V	4.6	As	0.7
Cr	<0.5	Br	<0.01
Mn	19	U	<50

Table 3. Radionuclide concentrations of plant samples from Sleisbeck Mine, collected on the 17th May 1990. All results are in ($Bq \cdot kg^{-1}$ dry weight) ± 1 standard deviation.

Species	^{238}U	^{226}Ra	^{210}Pb
Terminalia	8.6 ± 4.7	89.4 ± 0.8	21.5 ± 1.7
Buchania seedling leaves	----	546.8 ± 4.1	17.4 ± 4.6
Eucal. latifolia leaves	20 ± 10	200.3 ± 1.8	10.9 ± 2.3
Acacia hegimasta leaves	21 ± 10	27.4 ± 1.2	20.7 ± 3.5
Erythrophleum leaves	----	13.3 ± 1.8	36.6 ± 6.0

Table 4. Radionuclide concentrations of soil samples from Sleisbeck Mine pit, collected on 17th May 1990. All results are in (Bq·kg^{-1} dry weight) ± 1 standard deviation.

Location	^{238}U	^{230}Th	^{226}Ra	^{210}Pb
NW-end *	2707 ± 82	3041 ± 262	3084 ± 21	2504 ± 38
E-end *	1255 ± 50	1463 ± 168	1566 ± 11	1171 ± 21
S-end *	845 ± 36	559 ± 119	1176 ± 9	768 ± 15
W-end, near access	878 ± 37	1131 ± 126	1094 ± 8	738 ± 16
W-end, middle	3292 ± 80	3419 ± 244	3462 ± 23	2868 ± 40
W-end, NW edge	2344 ± 63	2990 ± 204	2400 ± 16	1960 ± 30
NW-mid	119 ± 18	130 ± 71	156.7 ± 2.4	155.6 ± 7.6
E-end	2539 ± 67	3131 ± 210	2814 ± 19	2180 ± 32
E-end^{+}	18152 ± 217	18735 ± 559	12297 ± 75	12277 ± 136

Note: * Grab samples obtained from pit edge 0.5 m below water surface.

$^{+}$ Selected rock material at high dose rate (10 μGy·h^{-1}) point.

All other samples are dry surface grab samples from pit edge.

Table 5. Terrestrial gamma dose rates at El Sherana, May 1997.

Location	Coordinates	Counts·s^{-1}	Dose Rate (μGy·hr^{-1})
Main core Shed	S 13° 30.587' E 132° 30.707'	7.9	~0.38
Hammer-drill Shed	S 13° 30.755' E 132° 30.692'	5.1	~0.21
Sample shed 1	S 13° 30.743' E 132° 30.695'	3.4	~0.11
Sample shed 2	S 13° 30.614' E 132° 31.287'	2.7	~0.07

Table 6. Terrestrial gamma dose rate at Sleisbeck mine site, May 1997.

Location	Coordinates	Counts·s^{-1}	Dose Rate (μGy·hr^{-1})
Access area to pit (~5 m from the water)	S 13° 46.823' E 132° 49.550'	5.7	~0.28
Pit wall hot spot (~1 m from the wall)	S 13° 46.826' E 132° 49.540'	585.6	~38
Waste rock stockpile site 1	S 13° 46.864' E 132° 49.516'	19.0	~1.0
Waste rock stockpile site 2	S 13° 46.844' E 132° 49.502'	12.7	~0.6
Waste rock stockpile site 3	S 13° 46.839' E 132° 49.453'	134.6	~9
Waste rock stockpile site 4	S 13° 46.835' E 132° 49.456'	23.9	~1.4