TORO ENERGY LIMITED

Non-Human Biota Assessment

Wiluna Uranium project

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1 Introduction

Toro Energy intends to extend the approved Wiluna Uranium Project to include the Lake Maitland and Millipede deposits. A previous ERICA assessment was carried out across the Centipede and Lake Way deposits as part of EPA assessment 1819 (Crouch, 2012). This Assessment will look at the potential impacts for mining a standalone Lake Maitland deposit, as well as the combined impact from mining at Millpede and Centipede deposits, which are a geological extension of the same ore body.

The Lake Maitland and Millipede ore bodies are shallow, low grade uranium deposits. Each would be mined using open cut methods with surface miners to cut benches into the ore body. No drill and blast would be required. Ore from Millipede would be trucked and stockpiled at the ROM pad located within the mining lease.

The Lake Maitland deposit is located some 105 km to the south east of the Centipede and Millipede deposits, and was originally going to be a standalone operation when owned by Mega Uranium. In November 2013 Toro acquired the Lake Maitland Project and decided to add it into the Wiluna Uranium Project and process the ore at a central processing plant. Ore from this deposit would be trucked along a purpose built haul road in covered trucks to the ROM pad at Centipede/Millipede.

This report concerns the potential radiological effects of the proposed operations on non-human biota (NHB) in the terrestrial environment. It is concerned only with the dispersion of radionuclides into the atmosphere through airborne pathways.

2 The ERICA Tool

The ERICA assessment tool (Environmental Risk from Ionising Contaminants) was developed under the European Commission to provide a method of assessing the impact of radiological contaminants on the natural environment (Brown 2008, Larson 2008). The tool contains two major data sources. The first, the database FREDERICA, contains information on the effects of radiation exposure on populations, and includes data on four main “endpoints”: morbidity, mortality, reproduction and mutation (Copplestone et al, 2008). The second is a collection of databases that allows estimation of the radiation doses that would accrue to biota from radiological contaminants in their environment.

The International Commission on Radiological Protection has recommended that environmental radiological effects should be assessed on a series of “reference organisms”, and these are incorporated into the ERICA tool (ICRP, 2008).

The starting point for an ERICA assessment is the radionuclide concentrations of the medium in which the reference organisms are living, in this case soil. This allows the external dose rate for the organisms to be derived, and in addition “concentration factors” from the ERICA database are used to calculate the radionuclide concentrations in the organisms to be calculated, and hence the internal dose rates.

The assessment process can be carried out in three “tiers”. Tier 1 is a simple highly conservative assessment, designed to easily identify situations which can be considered of negligible radiological concern. Tier 2 is used where a Tier 1 assessment indicates that there may be organisms at risk, and

allows the use of more realistic and less conservative parameters to allow the estimation of dose rates to the organisms. These dose rates are then assessed against a screening dose rate to determine if there is a likelihood that populations are likely to suffer harm. Tier 3 is not a screening tier but is designed to provide guidance on further investigations that may be required to adequately determine if there is any risk of radiological harm.

The screening level is the radiation dose rate below which no effects would be observed and the ERICA default level is set at 10 µGy/h (ARPANSA 2010).

This dose rate (described as the "predicted no-effect dose rate", PNEDR) was derived from the dose estimated to give a 10% effect (ie to one of the end points noted above) to 5% of the species present by applying a safety factor of 5. This screening rate is thus expected to protect the most radiosensitive organisms likely to be present in an environment (Garnier-Laplace et al, 2008). The ERICA tool allows other screening dose rates to be adopted. For example several organisations have suggested that no measureable effects would be observed for dose rates of 40 µGy/h (terrestrial animals) and 400 µGy/h (terrestrial plants) (UNSCEAR 1996, US Dept of Energy 2002, IAEA 1992). The ERICA tool presents the results as the dose rates to the organisms, and also in terms of the "Risk Quotient": the ratio of the dose rate to the screening rate. Dose rates and risk quotients are presented both for the "expected value" (RQ_{Expt}) and a "conservative value" (RQ_{Cons}). The default conservative value is three times higher than the expected value and represents the value at which there is only a 5% chance that the calculated dose rate exceeds the screening level. This then represents a further level of conservatism.

The results of an ERICA assessment can then be described in terms of three dose rate bands (Brown et al, 2008):

- RQ_{Expt} > 1 (ie expected dose rate > 1)
  Screening dose is exceeded. Further assessment needed.
- RQ_{Cons} > 1 but RQ_{Exp} < 1 (ie expected dose rate 3.3 – 10 µGy/h)
  Substantial probability that screening dose rate is exceeded. Assessment should be reviewed.
- $RQ_{Cons)}$ <1 (ie expected dose rate <3.3 µGy/h)
  Low probability that screening dose rate will be exceeded. Environmental risk is arguably negligible.

A disadvantage of the ERIICA tool in the past has been the limited information available on Australian fauna. Traditionally the roles of deer and rat have been used as analogues for kangaroos and small marsupials because of their similar diets and sizes. In 2014 ARPANSA published a report that established some parameters that could be used to create Australian organisms within the programme. In this study those values have been used to create more realistic Australian organisms including a Kangaroo, a mulgara, a mouse and a goanna.

The latest version of the ERICA software was released in November 2014 and the ERICA software package has been endorsed for use in Australia by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2010).

3 Environmental Radionuclide Concentrations

The main pathway of significance in this assessment is dispersion of Project generated radioactive dust.

Atmospheric dispersion modelling has been conducted for the Project, and as part of this dust deposition contours have been calculated (Air Assessments, 2014). The maximum monthly dust deposition rate is shown for the Centipede and Millipede deposits in Figure 1. The contours on the map represent the modelled monthly dust deposition in grams per square meter per month. Figure 2 shows the same information for Lake Maitland.

These two plots do not include dust generated from ore haulage between the two mine sites and the processing plant. This haulage would be along roads which are surfaced with materials that are not mineralised and thus have radionuclide concentrations typical of normal soils from the area. Fugitive dust emissions from haul trucks would be eliminated for two reasons. Firstly ore when mined would still be wet which acts as a natural dust suppressant. Secondly, on the haul road from Lake Maitland to the processing plant trucks would be covered to prevent dust escaping. Consequently it is expected that there would be no dust containing radionuclides released during transport and therefore no radionuclide releases to the surrounding areas.

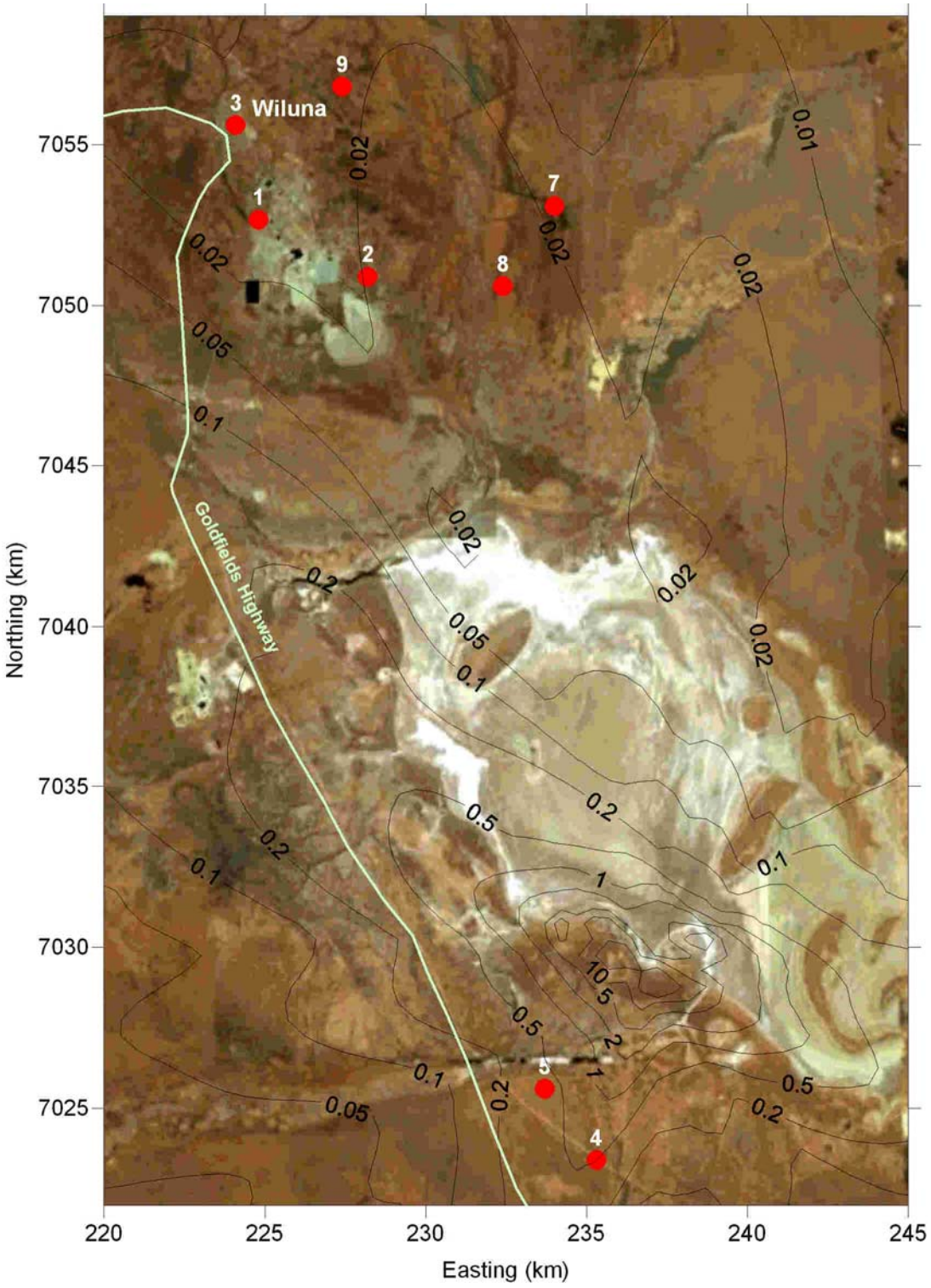

Figure 1 Maximum Monthly Dust Deposition Rate at Centipede and Millipede

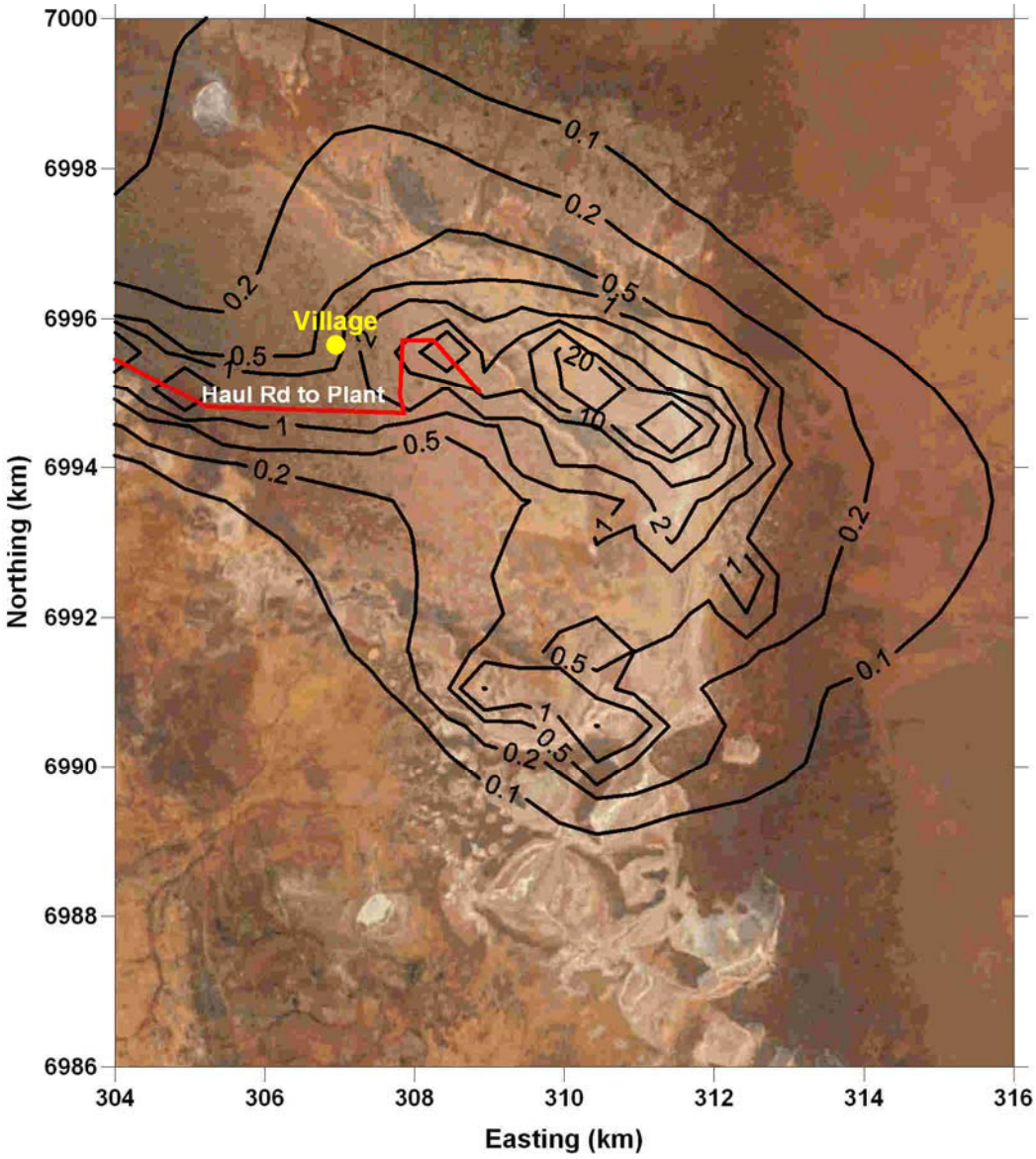

Figure 2 Maximum Monthly Dust Deposition Rate at the Lake Maitland Project

3.1 Estimated Radionuclide increase arising from Dust Deposition

Dust deposition across the Project would be an unavoidable consequence of mining and it is likely that a local increase in soil radionuclide concentrations would be seen as a result of the Project. For the purpose of this assessment Toro wishes to assess what impact the Project would have outside the mining area and has therefore done this ERICA modelling using a dust deposition contour that represents likely dust deposition at the edge of the Project. For this reason a dust deposition of 1g/m2/month has been used at Centipede and Millipede. The same level has been used at Millipede, although the modelling suggests the likely dust deposition at the edge of the mining lease to be far lower.

After depositing on the soil surface, dust would mix with the soil through a combination of physical, chemical and biological processes. For the purposes of this assessment, it was assumed that the mixing depth was 10 mm, which is consistent with measurements in SE Australia and in grasslands (Kaste et al, 2007). The soil density was assumed to be 1.5 t/m^3.

At the Centipede/Millipede processing plant dust is expected to be generated at approximately 1g/m^2/month. This would result in 216g/m^2 of dust being deposited over the life of the processing plant. Lake Maitland has a six year mine life and so over the 72 months of operation it is expected that 72g of dust would be deposited. The mass of uranium deposited in each scenario is 0.043g and 0.0144g. (Note that this has been derived by multiplying the "grade", 200ppm, ie; (200 / $10^{6)}$ x 216 = 0.043g of U).

The major isotope in naturally occurring uranium is U^{238}. To calculate the increase in soil activity the mass of uranium was multiplied by the specific activity of U^{238}which is 12,400Bq/g.

Therefore, the deposition of U^{238} is 533.2 and 179 Bq/m^2 respectively for the Project's life. There is 15kg of soil in 1m^2 (and 10mm deep) - therefore the change in radionuclide concentration is 35.5Bq/kg and 12Bq/kg.

4 Assessment

4.1 Tier 1

Two Tier 1 ERICA assessments were carried out using soil radionuclide concentrations of 35.5Bq/kg and 12Bq/kg for each of the radionuclides in the U^{238} decay series. The rationale behind using this number was to assess how the soil radionuclide concentration would change at the edge of the mining lease. Toro has committed in the Closure and Rehabilitation Plan to return disturbed areas to as close to pre mining levels as possible, and so high impact areas inside the mining lease would be rehabilitated at closure. Inside the mining lease it is likely the majority of vegetation would be cleared, and most fauna would move out of the area due to other impacts. For this reason the impact of additional radionuclide soil concentrations in these areas has been disregarded. A terrestrial ecosystem was chosen because there are no marine or freshwater ecosystems that would be impacted by airborne dust. The results of the Tier 1 assessments are presented in Tables 1 and 2 below.

Table 1 Tier 1 Assessment Results for the Processing Plant Site (35.5 Bq/kg)

Isotopes	Risk Quotient (unitless)	Limiting Reference Organism
Pb-210	0.00916	Lichen & Bryophytes
Po-210	1.41	Lichen & Bryophytes
Ra-226	0.157	Lichen & Bryophytes
Th-230	0.0218	Lichen & Bryophytes
Th-234	0.00022	Grasses and Herbs
U-234	0.0213	Lichen & Bryophytes

U-238	0.0235	Lichen & Bryophytes
Sum of Risk Quotients	1.64	

Table 2 Tier 1 Assessment Results for the Lake Maitland Site (12Bq/kg)

Isotopes	Risk Quotient (unitless)	Limiting Reference Organism
Pb-210	0.0031	Lichen & Bryophytes
Po-210	0.476	Lichen & Bryophytes
Ra-226	0.0529	Lichen & Bryophytes
Th-230	0.00737	Lichen & Bryophytes
Th-234	0.000075	Grasses and Herbs
U-234	0.0072	Lichen & Bryophytes
U-238	0.00793	Lichen & Bryophytes
Sum of Risk Quotients	0.555	

At Lake Maitland there are no values that exceed the screening level, while at Centipede and Millipede the risk quotients for Po-210 value exceed the screening levels. This supports the previous assessment done for the Centipede and Lake Way Project (Crouch, 2012).

For this reason it was not necessary to perform a Tier 2 assessment at Centipede / Millipede. The results of this assessment are presented in the next section.

5 Discussion

The Tier 1 assessment is designed to be simple and conservative and enable the user to exit the assessment after the Tier 1 assessment, provided no organisms exceed the predefined screening criterion (ARPANSA, 2010). The results of the Tier 1 assessment show that under the worst conditions, only one isotope leads to an exceedance of the screening value, and in that case only for lichens and bryophytes.

After taking into account the published literature on the radiosensitivity of lichen and bryophytes, the risk of radiological harm was assessed as 'negligible' for each reference organism.

6 References

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