



Memorandum

To: Greencoast Environmental Rehabilitation

From: [REDACTED]

Date: 2 March 2018

Subject: An assessment of potential radioactivity associated with the Crescent Head ilmenite stockpile

Dear James,

The following is a theoretical assessment of potential radioactivity associated with the Crescent Head ilmenite stockpile against the NSW Radiation Control Action 1990 and Radiation Control Regulation 2013, and the proposed measures for management and handling of any radioactive material.

The following information was received from Greencoast Environmental Rehabilitation Pty Ltd (GER):

- Background Information for Calytrix (GER)
- Original Assay Certificates (ALS Minerals)
- Gamma Radiation Survey (Pandanus Solutions)

Additional information was provided in further email correspondence between Calytrix and GER. This document is the final version of the assessment incorporating the results of gamma radiation surveys carried out at the site and in its vicinity in February 2018. The conclusions and recommendations made in this document are based on information provided by GER.

Background Information

Greencoast Environmental Rehabilitation (GER) holds Exploration License 8085. EL 8050 covers an abandoned pile of ilmenite tailings located approximately one kilometre south of the township of Crescent Head, NSW, on the eastern side of Point Plomer Road.

The stockpile contains approximately 100,000 tonnes of low-grade ilmenite and is approximately 230m long x 130m wide with a maximum stockpile height above 4.15 meters above natural ground. GER are seeking approval to remove the ilmenite stockpile to natural ground level and rehabilitate the site.

Laboratory Analysis of Ilmenite Samples

GER have collected representative ilmenite samples on a grid approximately 25m x 25m over the stockpile, consisting of 8 sampling lines perpendicular to the long axis of the stockpile. A total of 19 samples were collected including 14 auger holes and 5 surface samples, across the 8 sampling lines. The samples were composited to provide a single representative sample for each sampling lines. The 8 ilmenite samples were sent to ALS Laboratory in Brisbane for analyses including uranium and thorium (ALS is a NATA accredited analytical facility). The results of the analysis for radioactivity content (uranium and thorium) are summarised below:

- Uranium: range <0.01% to <0.03%
- Thorium: range <0.002% to 0.005%

In accordance with radiation safety regulations in the State of New South Wales (2013), where both thorium and uranium are potentially present in a material, it may potentially be classified as "radioactive ore" in accordance with regulation 4 -

4 Definition of “radioactive ore”

For the purposes of the definition of radioactive ore in section 4 (1) of the Act, the prescribed concentrations of uranium and thorium are:

...

(c) in the case of an ore that contains both uranium and thorium, a percentage by weight of uranium and thorium such that the expression:

$$\frac{U}{0.02} + \frac{Th}{0.05} \text{ is equal to, or greater than, one.}$$

Where:

U represents the percentage by weight of uranium.

Th represents the percentage by weight of thorium.

All uranium results were reported by ALS as below the laboratory detection limit, therefore requiring assumed values to be used in the calculation of averages. When the calculation is performed using assumed values obtained for the ilmenite located at the site, the result is 0.76. Therefore, the ilmenite material located at the site is *not* classified as ‘radioactive ore’ and it is unlikely that any specific radiation protection measures are required in the process of dealing with the material.

However, as uranium results were reported as below the laboratory detection limit, in December 2017 Calytrix Consulting recommended GER complete an additional gamma radiation field survey, both on the stockpile itself and in its vicinity (to establish the background radiation levels).

Gamma Radiation Survey

A field survey was been carried out by Pandanus Solutions in February 2018 using a RadEye B20-ER Survey Meter from ADM Nuclear Technologies. The instrument was calibrated prior to use. Readings were taken one meter above ground level on the stockpile, from off-stockpile (background), as well as from the nearby township of Crescent Head. Readings on the stockpile were taken on roughly 20m distances, with locations dependent on thickness of vegetation overgrowth. The survey results are summarised in Table 1 below, and illustrated in Figures 1 and 2. Results are tabulated in Appendix 1.

Table 1. Gamma Radiation Survey Summary Results

Location Description	Number of measurements	Gamma radiation level (µSv/hour)	
		Range	Average
Ilmenite stockpile	55	0.10 - 2.13	0.27±0.30
Background	20	0.08 - 0.26	0.14±0.05
Crescent Head township	2	0.11 - 0.80	0.46±0.49

The survey results summarised in Table 1 confirm that the ilmenite material located at the Crescent Head site contains very low concentrations of thorium and uranium, and no specific radiation protection measures would be required in the process of dealing with the material during its removal.



Figure 1. Overview of Crescent Head stockpile site and background field gamma readings ($\mu\text{Sv}/\text{hour}$), with approximate stockpile outline shown in yellow.



Figure 2. Detail view of Crescent Head ilmenite stockpile and background field gamma readings ($\mu\text{Sv}/\text{hour}$), with approximate stockpile outline shown in yellow.

Conclusions & Recommendations

As stated above, the ilmenite material located at the Crescent Head site is not classified as 'radioactive ore' in NSW and it is unlikely that any specific radiation protection measures are required in the process of dealing with the material during its removal.

However, the material should not be used in any situations where it can come into long term contact with the general public. For example, it should not be used as a landfill or in other construction activities.

Additionally, because several point locations on the stockpile exhibit levels of gamma radiation that are significantly higher than the background values, the following approach is recommended during remediation of the site:

1. Point locations where gamma radiation levels are 0.72, 0.87 and 2.13 $\mu\text{Sv}/\text{hour}$ are signposted and dealt with in the first instance, by blending with low gamma level material to produce a gamma radiation level preferably no higher than 0.3 $\mu\text{Sv}/\text{hour}$. If practicable, it is also recommended to deal with point locations showing 0.50, 0.50 and 0.66 $\mu\text{Sv}/\text{hour}$ at the same time and in the same manner.
2. A gamma radiation meter should be used to take regular readings from the stockpile during removal. If any elevated values are encountered the same blending approach should be adopted as in Point One above. A gamma radiation meter may be purchased or hired by GER and kept on-site during the remediation works for this purpose.
3. After all ilmenite has been removed - but *prior to* placement of any topsoil or cover material, it is recommended that a second detailed gamma radiation survey be conducted. This survey is to be done to establish that all ilmenite material has been successfully removed, and to estimate the required thickness of topsoil cover required, in event any residual areas show elevated levels of gamma radiation.

Please let me know if any additional information will be required.



The report has been prepared by Calytrix Consulting Pty Ltd (Australia) for the sole use by, and is confidential to the Greencoast Environmental Rehabilitation (GER) for the objective of the radiation protection assessment for a specific project described above.

This report does not constitute and should not be interpreted as legal advice in respect of the GER potential occupational health and safety and environmental liabilities.

The report is based on the information provided and Calytrix Consulting Pty Ltd has taken every effort to ensure that the information contained in this document is correct and that estimates, conclusions, and recommendations are reasonably established and based on sound scientific judgement.

Some information included in this report is based on the information provided by the GER personnel. It is assumed that all information provided by the GER is true and correct.

In preparing this report Calytrix Consulting has obtained and reviewed information from other sources. To the extent that it was relied on to prepare this report, Calytrix Consulting assumes that this information is correct and complete. Calytrix Consulting is not responsible for the quality or content of information from these sources.

Appendix 1 Field Survey Results

GPS COORDINATE SOUTH	GPS COORDINATE EAST	RADIATION METER READING (μSv per hour)	LOCATION DESCRIPTION
31° 12'01.0"S	152° 58'02.7"E	0.10	Stockpile
31° 12'00.6"S	152° 58'05.0"E	0.11	Stockpile
31° 11'59.9"S	152° 58'04.6"E	0.11	Stockpile
31° 11'57.8"S	152° 58'03.8"E	0.12	Stockpile
31° 12'01.3"S	152° 58'01.5"E	0.12	Stockpile
31° 12'00.4"S	152° 58'04.3"E	0.12	Stockpile
31° 12'00.6"S	152° 58'05.6"E	0.12	Stockpile
31° 11'57.1"S	152° 58'04.4"E	0.13	Stockpile
31° 11'59.2"S	152° 58'02.9"E	0.13	Stockpile
31° 12'00.6"S	152° 58'02.1"E	0.13	Stockpile
31° 12'00.2"S	152° 58'03.6"E	0.13	Stockpile
31° 11'58.4"S	152° 58'03.2"E	0.14	Stockpile
31° 12'01.7"S	152° 58'04.6"E	0.14	Stockpile
31° 12'02.1"S	152° 58'06.4"E	0.14	Stockpile
31° 12'03.9"S	152° 58'04.8"E	0.14	Stockpile
31° 11'56.3"S	152° 58'04.5"E	0.15	Stockpile
31° 11'59.9"S	152° 58'02.4"E	0.15	Stockpile
31° 11'58.9"S	152° 58'07.1E	0.15	Stockpile
31° 12'01.3"S	152° 58'07.1"E	0.15	Stockpile
31° 12'00.1"S	152° 58'05.4"E	0.15	Stockpile
31° 11'57.8"S	152° 58'05.7"E	0.15	Stockpile
31° 12'02.4"S	152° 58'06.3"E	0.16	Stockpile
31° 11'59.1"S	152° 58'07.0"E	0.16	Stockpile
31° 12'02.8"S	152° 58'06.9"E	0.16	Stockpile
31° 11'59.1"S	152° 58'04.9"E	0.16	Stockpile
31° 11'57.3"S	152° 58'05.8"E	0.17	Stockpile
31° 11'58.6"S	152° 58'05.7"E	0.17	Stockpile
31° 11'59.1"S	152° 58'07.2"E	0.17	Stockpile
31° 11'58.2"S	152° 58'07.0"E	0.17	Stockpile
31° 11'58.3"S	152° 58'05.8"E	0.18	Stockpile

GPS COORDINATE SOUTH	GPS COORDINATE EAST	RADIATION METER READING (μ Sv per hour)	LOCATION DESCRIPTION
31° 11'58.7"S	152° 58'06.3"E	0.18	Stockpile
31° 12'02.1"S	152° 58'05.3"E	0.21	Stockpile
31° 12'00.6"S	152° 58'06.2"E	0.21	Stockpile
31° 12'03.0"S	152° 58'05.4"E	0.22	Stockpile
31° 12'00.1"S	152° 58'03.9"E	0.22	Stockpile
31° 11'59.6"S	152° 58'06.1"E	0.22	Stockpile
31° 12'02.7"S	152° 58'08.4"E	0.23	Stockpile
31° 11'59.5"S	152° 58'03.9"E	0.24	Stockpile
31° 12'01.9"S	152° 58'08.5"E	0.25	Stockpile
31° 12'02.3"S	152° 58'04.1"E	0.26	Stockpile
31° 11'59.9"S	152° 58'06.6"E	0.27	Stockpile
31° 11'58.9"S	152° 58'04.4"E	0.28	Stockpile
31° 12'00.4"S	152° 58'07.4"E	0.29	Stockpile
31° 11'58.9"S	152° 58'04.3"E	0.31	Stockpile
31° 12'00.8"S	152° 58'08.4"E	0.32	Stockpile
31° 11'58.3"S	152° 58'04.8"E	0.33	Stockpile
31° 12'01.2"S	152° 58'03.8"E	0.36	Stockpile
31° 12'04.0"S	152° 58'08.8"E	0.42	Stockpile
31° 12'00.9"S	152° 58'06.3"E	0.44	Stockpile
31° 12'03.1"S	152° 58'08.4"E	0.50	Stockpile
31° 11'57.4"S	152° 58'05.2"E	0.50	Stockpile
31° 12'02.2"S	152° 58'04.1"E	0.66	Stockpile
31° 12'01.0"S	152° 58'07.0"E	0.72	Stockpile
31° 12'03.6"S	152° 58'04.9"E	0.87	Stockpile
31° 12'01.1"S	152° 58'07.8"E	2.13	Stockpile
31° 11'53.4"S	152° 58'06.2"E	0.08	Off-Stockpile
31° 12'01.3"S	152° 58'21.0E	0.08	Off-Stockpile
31° 12'01.9"S	152° 58'02.4"E	0.10	Off-Stockpile
31° 11'55.3"S	152° 58'03.9"E	0.10	Off-Stockpile
31° 11'59.5"S	152° 58'01.1"E	0.10	Off-Stockpile
31° 12'02.1"S	152° 57'59.7"E	0.12	Off-Stockpile
31° 11'54.8"S	152° 58'05.1"E	0.12	Off-Stockpile

GPS COORDINATE SOUTH	GPS COORDINATE EAST	RADIATION METER READING (μSv per hour)	LOCATION DESCRIPTION
31° 12' 01.0"S	152° 58' 00.1"E	0.12	Off-Stockpile
31° 12' 03.0"S	152° 58' 01.1"E	0.12	Off-Stockpile
31° 11' 56.6"S	152° 58' 16.1"E	0.14	Off-Stockpile
31° 11' 51.8"S	152° 58' 10.2"E	0.14	Off-Stockpile
31° 11' 57.9"S	152° 58' 01.7"E	0.14	Off-Stockpile
31° 12' 03.7"S	152° 58' 02.8"E	0.14	Off-Stockpile
31° 11' 56.4"S	152° 58' 02.6"E	0.15	Off-Stockpile
31° 12' 02.7"S	152° 58' 03.5"E	0.17	Off-Stockpile
31° 12' 05.1"S	152° 58' 04.6"E	0.17	Off-Stockpile
31° 12' 05.5"S	152° 58' 06.3"E	0.17	Off-Stockpile
31° 11' 55.5"S	152° 58' 08.5"E	0.17	Off-Stockpile
31° 12' 04.8"S	152° 58' 07.6"E	0.23	Off-Stockpile
31° 11' 57.7"S	152° 58' 10.8"E	0.26	Off-Stockpile
31° 11' 22.2"S	152° 58' 38.6"E	0.11	Crescent Head Town
31° 11' 35.5"S	152° 58' 45.9"E	0.80	Crescent Head Town