Peer Review of Radiological Assessment conducted by IHC Mining titled, “Radioactivity of BJV Material Tested Project 2019”.

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1. Introduction

At the request of the West Coast Regional Council, The Institute of Environmental Science and Research Ltd (ESR) reviewed a radiological assessment conducted by IHC Mining, titled, “Radioactivity of BJV Material Tested Project 2019”.

This report summarises the findings of our review.

2. Background

Naturally occurring radioactive materials (NORMs) are materials that contain radioactive elements and emit ionizing radiation. These materials are present in the Earth's crust and have been since the planet's formation. These naturally occurring radioactive materials are ubiquitous in the environment, including soil, rocks, building materials, and water. Exposure to NORMs is a part of everyday life.

Many NORMs are part of natural decay chains that start at radioactive Uranium or Thorium, which have extremely long half-lives and decay to other isotopes and eventually to a stable isotope of Lead. In a decay chain, the parent isotope will decay and generate daughter and grand-daughter isotopes. When a decay chain reaches its so-called radioactive equilibrium, all isotopes are present at roughly the same activity. If left undisturbed the naturally occurring radioactive decay chains approach radioactive equilibrium.

Processing operations, especially those involving chemical separation, may disturb the radioactive equilibrium to some degree, and separate the elements of a decay chain according to their chemical and physical properties. This can lead to a build-up of certain elements either in the product, by-product, or the waste. In some cases, this could lead to concentrations of NORMs that warrant control and mitigation measures to protect people and the environment from radiological hazards.

To determine whether the radiological risk needs to be managed, it is advisable to understand and monitor the behaviour of NORMs throughout the processing.

3. Review of IHC Mining Assessment

3.1 Radioactivity Testing

The report "Radioactivity of BJV Material Tested PROJECT 2019 Barrytown Feasibility Study" makes reference to test results from x-ray fluorescence. X-ray fluorescence (XRF) can determine the elemental composition of a sample, however not its isotopic composition.

Many different radioactive isotopes may exist for each element. These isotopes have different half-lives and decay characteristics. Hence it is important to identify those isotopes directly. By limiting the testing to elemental analysis, assumptions need to be made in order to deduct isotopic activity values.

In the report, the assumption is made that the longest-lived isotopes U-238 and Th-232 constitute all uranium and thorium as identified by XRF. For undisturbed NORMs, this is a valid approach, as >99% of all uranium, (similarly thorium) will be present in its longest-lived species. This is not necessarily the case for processed samples, in which the radioactive equilibrium may have been disturbed.

The report further calculates a combined activity concentration for Uranium and Thorium. This is not necessary when comparing against regulatory thresholds, as the thresholds are stated per isotope. Since such a calculation is performed in the report, we note that it neglects the contribution of all daughter isotopes. Even though the radioactive daughters are insignificant in terms of number of atoms, their much shorter half lives will lead to higher specific activities.

As an example, the specific activity of U-238 is indeed 12.4 kBq/g, the specific activity of natural Uranium (a mix of U-238, U-234, U-235), however, is around 25.5 kBq/g. The specific activity of the entire U-238 chain will be higher. The implicit assumption that only one isotope, the one with the longest half-life, is present in the sample leads to an incorrect result. As regulatory thresholds are defined separately for different isotopes, the calculated total activity concentration is not relevant.

The analytical test report does not state the uncertainties and their coverage factors. Also, importantly, the limit of detection is not stated.. Several samples have been reported as containing zero ppm of Uranium, which is highly unlikely. The instrument or the measurement technique may not have been sensitive enough, in which case a detection limit should have been reported.

In conclusion, we believe that there are shortcomings in the choice of the analytical method and the reporting of the results.

3.2 Review of IHC Mining conclusions.

As discussed above there are limitations with the analytical technique used for this assessment. We are also not able to comment on how representative the samples are of the processes, products and by-products of the proposed operations as we have had no involvement in the sampling programme. Therefore, our review of the stated conclusions in the IHC Mining report, are based only on the activity concentrations reported.

For the stated activity concentrations for the high-grade product (0.66 Bq/g natural uranium and thorium), average grade (< 0.45 Bq/g) and tailings (<0.14 Bq/g); we agree that the radiological risks associated with such materials are very low and that the Radiation Safety Act 2016 and the IAEA Transport Regulations (IAEA SSR-6) do not apply.

Schedule 2 of the Radiation Safety Act 2016 (the Act) lists and defines “acceptable levels” for individual radionuclides. The provisions of the Act do not apply to material that contains radionuclides below the “acceptable levels”. As the “acceptable levels” for the relevant uranium and thorium radionuclides are 10 Bq/g, the stated activity concentrations are well below the threshold of what is considered as radioactive material in the Act and therefore the provisions of the Act do not apply.

Transport of radioactive materials must be in accordance with the IAEA Regulations for the Safe Transport of Radioactive Material (IAEA SSR-6). These regulations are implemented in New Zealand through the Office of Radiation Safety Code ORS C6, Code of Practice for the Safe Transport of Radioactive Material and the modal regulations, including the Land Transport Dangerous Goods Rule (2005). Paragraph 107 of the IAEA regulations states, “these Regulations do not apply to any of the following: (f) Natural material and ores containing naturally occurring radionuclides, which may have been processed, provided the activity concentration of the material does not exceed 10 times the values specified in Table 2.”. The values quoted in Table 2 for uranium and thorium are1 Bq/g and therefore the exempt activity concentrations for these products can be interpreted as 10 Bq/g applying paragraph 107 (f) and therefore the stated activity concentrations are well below the threshold for application of the IAEA Transport Regulations.

The New Zealand radiation safety legislation makes use of mandatory Codes of Practice to prescribe more detailed requirements specific to the different types of radiation sources and their uses. There is no specific Code that deals with NORMs in mining and mineral processing.

IAEA Safety Standards Series No. RS-G-1.7 (IAEA 2004), Application of the Concepts of Exclusion, Exemption and Clearance, sets exclusion levels for naturally occurring radioactivity in bulk materials at 1 Bq/g head-of-chain activity for the uranium and thorium decay chain radionuclides. The activity concentration of 1 Bq/g is currently the internationally-accepted level for naturally occurring materials containing uranium or thorium, below which a potential source of radiation exposure, such as an ore or mineral concentrate, could be considered inherently safe.

This IAEA Safety Standard also states that naturally occurring materials of higher activity concentrations may also be assessed, on a case-by-case basis, as inherently safe by the relevant regulatory authority (for example, if the source radionuclides are insoluble or immobile). IAEA suggest that regulators should apply a graded approach and apply regulatory controls commensurate with the radiological risk.

As the stated concentrations in the IHC Mining assessment are < 1 Bq/g, the products would be considered inherently safe.

4. Conclusions and Recommendations

1. Elemental analysis, such as X-ray fluorescence spectroscopy, or in-situ tests, such as dose rate monitoring, may guide decision making processes but should not be used to quantify isotopic activities. It is recommended that analytical tests that are isotope specific, for example gamma and/or alpha spectrometry, are carried out, to quantify and evaluate activity concentrations for comparison against regulatory requirements and international guidelines.

2. For the stated activity concentrations in the test report, the radiological risks associated with these levels are minimal and not of regulatory concern. However, there is not enough information in the report to be satisfied that the results of these samples are accurate enough or that enough sampling and assessment has been done to draw this conclusion. It is recommended that following additional sampling and testing using radionuclide analytical techniques (recommendation 1) the radiological risks are re-evaluated with a more comprehensive assessment.

3. Once the site is commissioned, it is recommended that an ongoing radiological monitoring and reporting programme is put in place to ensure the basis for any regulatory decisions (such as, whether controls and mitigations are warranted or not) remains valid.

CONFLICTS OF INTEREST (PERCEIVED OR ACTUAL)

ESR provides technical advice and services (including regulatory inspections) for the Office of Radiation Safety (Ministry of Health).

ESR provides radiological monitoring services including radionuclide assessment.

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