MORE ABOUT RADIATION

ARAFURA
RARE EARTHS LIMITED

Nolans Project

The Nolans Project targets valuable amounts of rare earths locked inside apatite-rich rock. Rare earths are found throughout the natural environment and often occur with radioactive elements thorium and uranium.

The high concentration of rare earths in the Nolans orebody means that the amount of thorium and uranium there is higher than for average rocks. As a result, the rock is slightly radioactive. That is how the orebody was found – when aerial surveys picked up the radiation signal.

The Nolans orebody has relatively low levels of uranium, at 180 ppm (parts per million), and higher levels of thorium, at about 2,700 ppm. This is much lower than the concentration of thorium found in some high grade mineral sand mines, such as in Brazil and India.

The expected levels of radioactivity at the Nolans operation will be similar to those found at the Ranger Uranium Mine. But the radiation source at Nolans will be mainly thorium, rather than uranium.

Radiation can seem scary because you can't see or feel it, but it's really easy to measure with a Geiger counter or scintillometer. Some common questions about radiation will be answered in this information sheet.

What is radiation?

Put simply, radiation is energy moving through space. There is natural background radiation all around us: in the ground, the food we eat, the air we breathe and cosmic rays from space. This natural background radiation gives us a 'dose' of about 2 or 3 millisieverts per year (mSv/yr).

'Man-made' radiation is also part of our everyday life. It is used in x-rays, organ scans, smoke detectors, industrial gauges and in the sterilisation of medical equipment and certain food packaging.

The common types of radiation are:

- Alpha particles (α), which can't penetrate the skin, but can be hazardous if inhaled in high concentrations
- Beta particles (ß), which can penetrate a centimetre or so into the body, but are blocked by a thin sheet of metal
- Gamma rays (γ), which can go right through the body and require thicker materials to stop them, but aren't harmful at low levels.
- Neutron rays (n), which are highly penetrating and require materials like concrete or water to be effectively shielded.

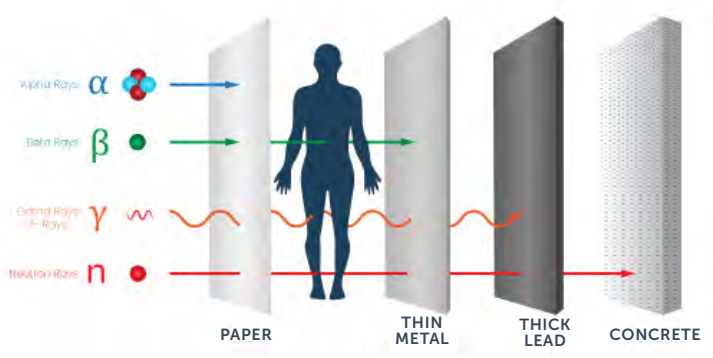
What is thorium and uranium?

Thorium and uranium are elements that are naturally occurring and radioactive. They are present in low concentrations nearly everywhere in nature. This includes in rocks, soils, water, plants and animals, as well as humans. The average amount of thorium in rocks and soils is 11 ppm.

Uranium is in ordinary soil at about 3 ppm, up to 50 ppm in some granites and generally above 1,000 ppm in uranium ores. These amounts vary depending on the geology of the region. In some places the levels are much higher.

Background radiation occurs all around us and is easily measured and controlled. In fact, radiation risks to those working and living near a mine are very low.

Types of radiation



How is radiation measured?

Radiation is easy to measure. Different types of equipment are used to measure the different types of radiation. For example, to measure gamma radiation, you use a Geiger counter.

For people, the amount of radiation that interacts with your body is called exposure. The impact that radiation has on you is called a dose. Radiation doses are measured in sieverts (Sv) and one thousandth of a sievert is known as a millisievert (mSv). Radiation workers usually get doses of several thousandths of a sievert in a year.

Portable radiation detection instrument

Radiation dosage information

REGULATORY DOSE LIMITS

Radiation dose limits are set at an international level and adopted by countries around the world. The limits are for doses from the workplace and don't include medical doses, or natural background radiation.

Public Limit	1 mSv/yr
Worker Limit	20 mSv/yr

DOSE COMPARISONS

Workers

Australian uranium, rare earth & mineral sands miners	1 to 5 mSv/yr

Other radiation workers

(e.g. radiographers, commercial flight crews)	1 to 5 mSv/yr

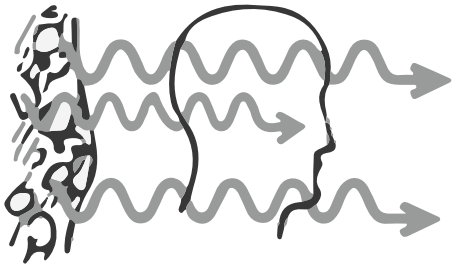
Medical doses

CAT-scan	10 to 20 mSv
Heart stress test	12 mSv
Other nuclear medicine scans	5 mSv

How do you get a dose?

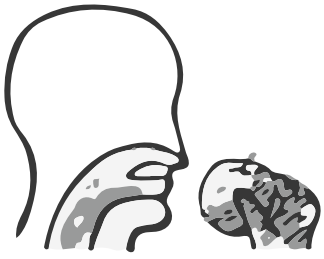
There are three pathways to get a dose:

1. Gamma radiation 'shine'



2. Breathing in radioactive dust

3. Eating radioactive dust



How do you control radiation doses?

GAMMA SHINE

This depends on:

- size of source
- distance from source
- concentration (ore grade)

It can be controlled by:

- time - reducing the time spent near the source
- distance - increasing the distance from the source
- shielding - shielding the source (if needed)

BREATHING IN DUST

This is controlled by preventing or minimising the production of dust (by using methods such as water sprays), and by wearing dust masks as a precautionary measure.

EATING DUST

This is controlled by:

- personal cleanliness - washing your hands and face before meals
- workplace cleanliness - regularly cleaning work areas and crib rooms.

Safety

At a mine site, radiation is just one of many industrial hazards that must be managed. The main workplace risks are ordinary industrial accidents, such as slips, trips and falls, vehicle accidents and chemical incidents, or industrial hearing loss.

Chronic (ongoing, long duration) high doses of radiation well above those expected at Nolans are known to result in an increased chance of cancer, so Arafura will continue to manage, monitor and minimise all workplace risks including the radiation risk. The radiation management issues at Nolans will be very similar to those of mineral sand mines, which have operated safely in Australia since the 1930s.

Arafura takes radiation management very seriously. The company has monitored and recorded the levels of radiation experienced by workers during all major exploration campaigns at Nolans for the past 15 years. This has allowed Arafura to develop specific radiation safety rules based on real measurements.

Arafura has flown aerial surveys to determine zones of higher radioactivity and continues to monitor the general area around Nolans.

Arafura's radiation measurements confirm its workers' doses are well below the regulatory limit and in line with other radiation workers.

How is the environment protected?

The potential issue of radioactive dust settling on vegetation or in the water catchments surrounding the Nolans operation is controlled by preventing or minimising the production of dust. Environmental monitoring and experience at other mine sites demonstrates that dust particles containing radioactive minerals are typically confined to an area of a few hundred metres from the mine or dust source.

On those parts of the Nolans site where radiation dust may accumulate from mining operations, all rainwater that falls and runs off those areas will be caught in dams and monitored. This water will then be recycled through the operation's process plants or released to the natural environment after monitoring.

The release of radioactive material off the Nolans site will also be minimised by washing dirty vehicles, equipment and contaminated clothing and boots before leaving the site. Arafura has completed baseline studies to establish the natural background levels within and around the mine site and this monitoring will continue during the life of the mining and processing operations.

What about radon gas?

Radon is a naturally-occurring radioactive gas present in the air that comes from uranium and thorium. It does not require active control except in enclosed spaces, such as in underground mines, where it can build up.

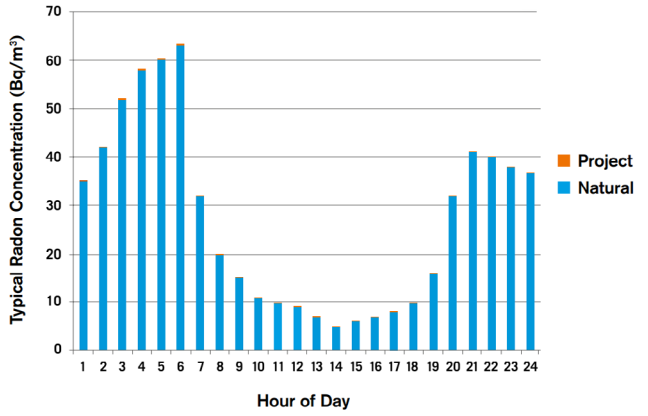
The concentration of radon outdoors depends on a couple of factors:

- rock properties (for example uranium and thorium content, porosity and moisture content), which affect the release of radon from the material
- weather conditions (for example wind and temperature), which affect how fast radon disperses into the atmosphere.

Radon concentration outdoors normally follows a daily pattern, peaking early in the morning when weather conditions tend to be cooler and calmer, then dropping during the afternoon when air mixing increases because of the hotter air and wind. These concentrations vary naturally by factors of 10 to 100. The additional radon resulting from a mining process is very small compared with the natural daily variations.

Measurements at other mines have found the level of extra radon as a result of operations is not much above natural background levels.

As you can see in the graph below, radon added by mining is a fraction of the natural daily variation.



Workers in PPE during sampling operations at the Nolans site

What about tailings?

The chemical processes used by Arafura to recover the rare earths at Nolans will separate the uranium and thorium, removing it from the rare earth and phosphoric acid products, before its final disposal in tailings storage facilities. The amount of uranium and thorium in tailings will be similar to that in the Nolans orebody.

During the life of the operation, tailings will be managed to minimise dust and exposure to radiation. The way in which tailings are managed at mine sites is standard. They are pumped to storage dams so they are typically about 60% water and 40% solids. Because they are fine-grained material, the tailings stay moist for a long time which limits the chance of dust blowing off the surface.

When the mine closes, the tailings will be covered with a layer of rock, which will prevent erosion and provide a barrier to shield against the low levels of radiation.

How is radiation regulated?

Because there is uranium and thorium in the orebody, radiation must be monitored and controlled at Nolans. Arafura is bound by the same standards that apply to uranium mines (and other radiation workplaces) in Australia, and throughout the world.

In the Northern Territory, radiation in mining is regulated by the Department of Industry, Tourism and Trade, the Department of Health, and NT WorkSafe. Companies must submit and have approved by the regulator a Radiation Management Plan to the regulator before starting exploration, mining or processing operations, showing how radiation will be managed and controlled.

Key messages

Radiation is everywhere in nature and has been studied and used for over a century.

Radiation is **easily measured and controlled.**

Doses to workers are very low - a small fraction of the regulatory limit.

Doses to people living near rare earths, mineral sands or uranium mines are **much smaller than doses** from natural background radiation.

Regulation is strict and based on sound and robust scientific data.

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