



Radiation

— 04 —

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

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ARAFURA
RESOURCES LIMITED

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Workers in protective equipment during drilling at the Nolans Mine Site

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 here 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 gamma radiation and airborne radioactive dust at the Nolans Mine 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 ARE THORIUM AND URANIUM?

Thorium and uranium are metals which are naturally 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.

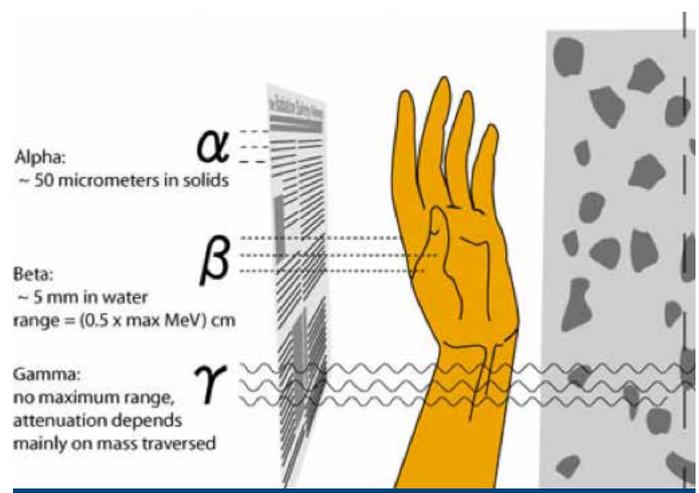
WHAT IS RADIATION?

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 stuffs.

The common types of radiation are:

- ▶ alpha particles (α), which can't penetrate the skin, but can be dangerous to the lungs. Alpha emitting dust should not be inhaled
- ▶ beta particles (β), 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.



Penetrating abilities of common radiation types



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 humans, the amount of radiation received is called a 'dose', which is a measure of the radiation intensity and amount you absorb over a period of time (exposure). 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

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 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

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 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. We have monitored and recorded the levels of radiation experienced by workers during all major exploration campaigns at Nolans for the past 10 years. This has allowed Arafura to develop specific radiation safety rules based on real measurements.

We have flown aerial surveys to determine zones of higher radioactivity and continue to monitor the general area around Nolans.

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

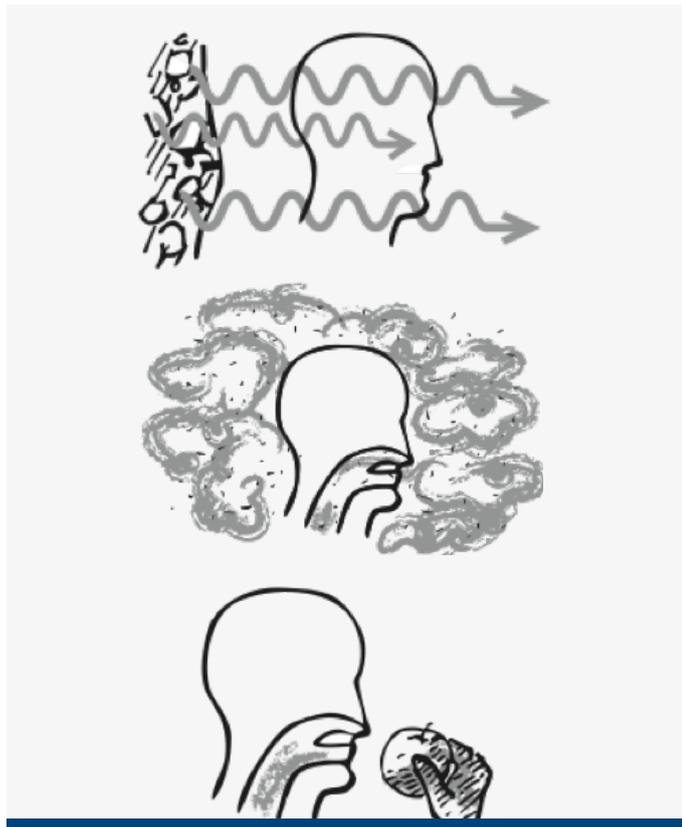


Workers in protective equipment during sampling operations at the Nolans Mine Site

HOW DO YOU GET A DOSE?

There are three pathways to get a dose:

- ▶ gamma radiation 'shine'
- ▶ breathing in radioactive dust
- ▶ eating radioactive dust



Dose pathways: gamma shine, breathing in and 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.

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 radioactive dust may have accumulated, all rainwater that falls within and runs off those areas will be caught and monitored. This water will then be recycled through our processing plants or released to the natural environment after monitoring.



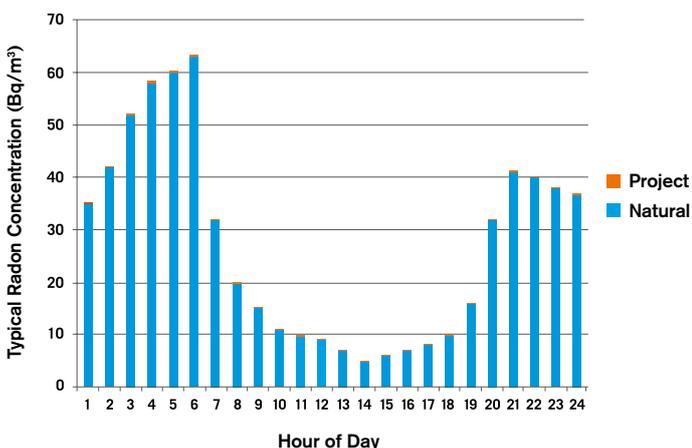
The release of radioactive material off the Nolans site will also be minimised by washing dirty vehicles, equipment and contaminated clothing and boots before leaving our site. Arafura has completed baseline studies to establish the natural background levels within and around the mine site and this monitoring 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. It does not require active control except in enclosed spaces, such as in underground mines, where it is known to 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 added by mining is a fraction of the natural daily variation

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. Outdoor radon 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 escaping into the air is not much above natural background levels.

WHAT ABOUT TAILINGS?

The chemical processes used by Arafura to recover the rare earths at Nolans will concentrate the uranium and thorium, removing it from the rare earth product, before its final disposal in tailings storage facilities.

During the life of the operation, tailings will be managed to minimise dust and exposure to radiation. How tailings are managed at mine sites is pretty standard. They are pumped to storage dams so they are typically about 50% water and 50% 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 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 Mines and Energy, the Department of Health, and NT WorkSafe. Companies must submit a Radiation Management Plan to the regulator before starting exploration, mining or processing operations, showing how radiation will be managed and controlled.



Workers in protective equipment during sampling operations at the Nolans Mine Site

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 a rare earths, mineral sands or uranium mine are much smaller than doses from natural background radiation
- ▶ Regulation is strict and based on sound and robust scientific data.

MORE INFORMATION

These issues and others have been addressed in greater detail in our Environmental Impact Statement, which has to satisfy the Northern Territory and Australian governments that Arafura understands and can manage all potential impacts and risks.

We are happy to come and talk to community groups in Central Australia and there are some useful references below.

Radiation Workers' Handbook

www.aurar.gov.au/file_upload/files/resources/uranium/3.1D_Download_Radiation_Workers_Handbook_1862009.pdf

Minerals Council of Australia

www.minerals.org.au or go to http://bit.ly/mca_uranium for a new publication on the uranium industry in Australia

World Nuclear Association

www.world-nuclear.org

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)

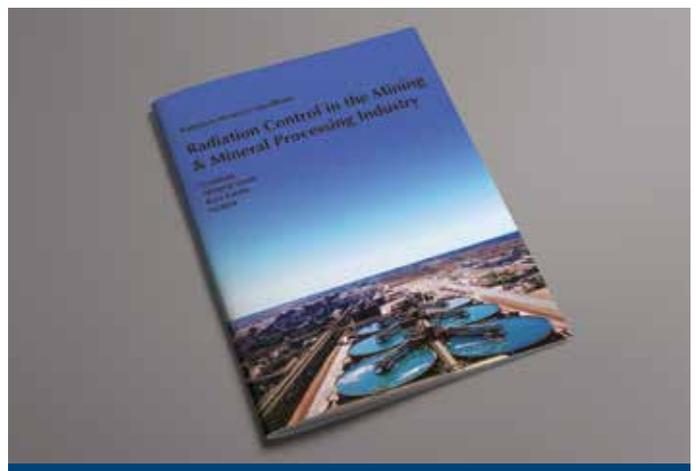
www.arpansa.gov.au

Australian Nuclear Science and Technology Organisation (ANSTO)

www.ansto.gov.au

US Environmental Protection Agency

www.epa.gov/radiation/understand



Radiation Workers' Handbook