



Department of **Energy, Mines,
Industry Regulation and Safety**



Managing naturally occurring radioactive material (NORM) in mining and mineral processing

NORM-II Radiation management plans

Incorporating the appointment of radiation safety officers

March 2024

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Foreword

This Guide provides practical advice on how to comply with the requirements of the *Work Health and Safety Act 2020* (WHS Act) and the *Work Health and Safety (Mines) Regulations 2022* (WHS Mines Regulations).

The work health and safety (WHS) legislative framework takes a risk-based approach to minimising harm arising from exposure to workplace hazards, including the ionising radiation emitted from naturally occurring radioactive materials (NORM).

This Guide is intended to provide mine operators with information to develop and implement a radiation management plan (RMP) that meets legislative requirements and minimises the potential exposure of mine workers, and members of the public (critical groups) from naturally occurring radionuclides (NORs) in Western Australia.

Specifically, this Guide reflects the provisions of Part 10.2, Division 3, Subdivision 3B – Radiation in mines of the WHS Mines Regulations.

This Guide replaces the following:

- *NORM 1 Applying the system of radiation protection to mining operations: Guideline, Appendix B* (content on Radiation Safety Officer requirements)
- *NORM 2.1 Preparation of a radiation management plan – exploration: Guideline*
- *NORM 2.2 Preparation of a radiation management plan – mining and processing: Guideline.*

National uniformity

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) *National directory for radiation protection* (2nd Edition, 2021) (NDRP) provides an agreed regulatory framework for radiation safety across the Australian Commonwealth, states and territory jurisdictions.

The NDRP requires radiation protection legislation in the jurisdictions to be consistent with the applicable requirements of the International Atomic Energy Agency's (IAEA) *Governmental, legal and regulatory framework for safety: General safety requirements* (Rev.1, 2016) (GSR Part 1).

The WHS Mines Regulations reflect the regulatory framework outlined in the NDRP. This includes adoption of the ARPANSA *Radiation Protection Series 9 – Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing* (2005) (RPS-9). Should discrepancies arise between expectations of the regulator and those outlined in RPS-9, directions issued by the regulator have precedence in Western Australia.

How to use this Guide

References to the WHS Act and WHS Mines Regulations are included for convenience and are not to be relied on in place of the full text. Current versions of the Western Australian WHS legislation are available on www.legislation.wa.gov.au.

The words 'must', 'requires' or 'mandatory' indicate a legal requirement exists that must be complied with. The word 'should' indicates a recommended course of action, while 'may' is used to indicate an optional course of action.

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1 Introduction

WHS Mines Regulations r. 5B

Meaning of mining operations

WHS Mines Regulations r. 641K

Meaning of radioactive material

WHS Mines Regulations r. 641L

Application of subdivision

WHS Mines Regulations pt. 11.2

Exemptions

All exploration, mining and mineral processing operations in Western Australia that use or handle naturally occurring radioactive material (NORM) may come within the scope of the WHS Mines Regulations r. 641L.

This Guide provides mine operators with information to develop a detailed radiation management plan (RMP) with:

- identification of potential sources of radioactive materials on mining (including exploration) operations
- implementation of control measures to minimise radiation exposures to workers, members of the community and the environment
- methods deployed to verify and confirm the effectiveness of controls via a robust monitoring program.

1.1 Radioactive material

WHS Mines Regulations r. 641K states that material is **radioactive material** if the regulator designates it, in writing, to be radioactive material. The regulator may designate material to be radioactive material if it has an activity concentration that exceeds 1 Becquerel per gram (Bqg^{-1}), and:

- exhibits radioactivity
- emits ionising radiation, or particles
- contains radionuclides of natural origin; naturally occurring radionuclides (NORs).

The most significant NORs in the Western Australian mining industry are members of the decay series of:

- thorium-232 (^{232}Th)
- uranium-235 (^{235}U)
- uranium-238 (^{238}U)

The activity concentration criteria can be met by a single NOR or a combination of the contributions from two or more NORs.

If secular equilibrium is assumed among all members of the ^{232}Th , ^{238}U or ^{235}U decay series only the activity concentration of the head-of-chain is considered.

However, if secular equilibrium has been disturbed, then in accordance with WHS Mines Regulations r. 641K(2), the regulator requires the activity concentration of each radionuclide in a decay series to be evaluated against the 1 Bqg^{-1} criteria.

Secular equilibrium describes a situation where the activity of radioactive progeny resulting from the decay of a long-lived radionuclide equals that of the parent radionuclide.

While potassium-40 (^{40}K) and rubidium-87 (^{87}Rb) are significant NORs, the contribution to dose arising from ^{40}K and ^{87}Rb is insignificant when compared to those from the ^{232}Th , ^{238}U and ^{235}U decay series, and can be overlooked for the purposes of RMPs submitted.

1.2 Relevant mines

The WHS Mines Regulations, Part 10.2, Division 3, Subdivision 3B applies to 'relevant mines' as defined in WHS Mines Regulations r. 641L.

There are two conditions, both of which must be met in order for a mining operation to be deemed a relevant mine:

- minerals or radioactive materials with an **activity concentration** of 1 Bqg^{-1} or more are mined or are present at the mine, and
- **annual doses** of radiation from the mining operations are likely to exceed either
 - 1 millisievert (mSv) for workers
 - 0.5 mSv for members of the public at, or in the vicinity of, the mine.

1.3 Mining operations that do not meet the relevant mine criteria and exemptions

A mining operation that meets neither of the conditions to be deemed as a relevant mine will not be subject to the requirement of WHS Mines Regulations, Part 10.2, Division 3, Subdivision 3B until such time as either one or both conditions are met.

There will be occasions where the activity concentration condition is met, but the estimates of annual dose approaches, but does not exceed, the annual dose conditions for either the worker, critical group or member of the public.

In underground mining operations where radon has accumulated, it is feasible that the worker dose condition may be met, but not the activity concentration. In these circumstances, and in accordance with WHS Mines Regulations r. 690, the mine operator may apply to the regulator for an exemption from all, or specified parts of, WHS Mines Regulations, Part 10.2, Division 3, Subdivision 3B.

The Mine operator has a duty to demonstrate, with verifiable data, that the mine does not meet the criteria of a relevant mine. The regulator will consider the criteria as outlined in RPS-9 clause 3.5 and WHS Mines Regulations r. 685 before providing an exemption. The regulator may:

- impose conditions on the exemption under WHS Mines Regulations r. 691
- apply the condition that the mine operator must provide the regulator with regular updates to confirm conditions on the mine have not changed, and the criteria of a relevant mine are not met or exceeded.

The mine operator must comply with the conditions of the exemption.

An application for an exemption can be refused, and an exemption may be amended or cancelled. WHS Mines Regulations r. 676 lists reviewable decisions.

1.4 Relationship with other legislative requirements

Some processing plants are not classified as mining operations and are regulated by different legislation.

However, if the activity concentration of waste materials increases above the 1 Bqg^{-1} criteria, as a result of mineral processing operations, the WHS Mines Regulations cover the disposal of these radioactive wastes if it occurs at a mining operation.

The licence for the processing site is issued by the Department of Water and Environmental Regulation and may contain specific conditions for discharges and contaminated sites.

If irradiating apparatus such as x-ray fluorescence instruments or density gauges are in use on a mining operation, the instrument licensing and its use will fall within the remit of the *Radiation Safety Act 1975* (Radiation Safety Act). The Radiological Council of Western Australia may require a separate, specific radiation management plan (SRMP).

A reference to the SRMP for irradiating apparatus should be made in the health management plan for the mining operation.

Refer to section 2.8 of this Guide for information on reporting incidents involving irradiating apparatus to the regulator.

The RMP should cross reference the SRMP and other applicable legislation.

2 General guidance

WHS Act s. 17

Management of risks

WHS Act s. 19

Primary duty of care

WHS Mines Regulations ch. 10 pt. 10.2 div. 1 sub-div. 2

Mine safety management system

WHS Mines Regulations r. 641M

Pre-operational monitoring program

WHS Mines Regulations r. 641N

Radiation management plan

WHS Mines Regulations r. 641O

Radiation waste management plan

WHS Mines Regulations r. 641Q

Assessment of doses

2.1 Duties

The mine operator and any other person conducting a business or undertaking (PCBU) at the mining operation have a duty under the WHS laws to ensure, so far as is reasonably practicable, the health and safety of workers, others and members of the public, and the protection of the environment at all stages in the design, planning, construction, operation, decommissioning and closure of a mining operation.

RPS-9 clause 3.4.3 outlines the 'stages of mining operations' and should be read in conjunction with the definition of mining operations provided in WHS Mines Regulations r. 5B.

Each mine operator and PCBU, through each stage of a mining operation that meets the relevant mine criteria, are to ensure adequate measures are taken to control the exposure of workers, members of the public and the environment to radiation arising from NORs in the lithology (rock formations), hydrogeology (groundwater), ore being mined and processed, products, residues or wastes.

The RMP, as required under WHS Mines Regulations r. 641N, includes requirements for a plan to discharge radioactive wastes. WHS Mines Regulations r. 641O requires a radioactive waste management plan (RWMP).

2.2 Pre-operational monitoring program

WHS Mines Regulations r. 641M, requires the development of a pre-operational monitoring program that evaluates radiation levels and predicts potential doses at the mine.

Before mining operations commence at a site, the pre-operational monitoring program must:

- be submitted to the regulator by the mine operator
- provide the regulator with the results of the program
- be approved by the regulator.

The pre-operational monitoring program establishes the baseline radiological parameters to be met by the mine operator when seeking relinquishment of the mining lease. The pre-operational monitoring program may also be used to determine the background radiation exposure of members of the public before mining operations commenced. As such, the mine operator should maintain these records for the life of the mine until relinquishment is granted and be in a form that can be retrieved.

A pre-operational monitoring program should be formulated before significant exploration operations commence that may distribute radioactive material into the environment. The same, or better, monitoring program should be used for the rehabilitation stage of the mining operation. Requests for relinquishment should include pre-operational monitoring data and comparable post rehabilitation data.

It is recommended that mine operators and PCBUs consult with the regulator to develop an appropriate, bespoke pre-operational monitoring program. Once the proposed pre-operational monitoring program is deemed appropriate, it will be approved by the regulator.

2.3 RMP: regulatory requirements

The mine operator of a relevant mine is to have an approved RMP in place before each stage of mining operations commence. The RMP must comply with RPS-9, and include:

- a plan for monitoring workers' radiation exposure under clause 2.7.2(b)
- a plan for discharges of radioactive waste under clause 2.8 (refer to [section 2.8](#) of this Guide)
- the incidents that the mine operator will report to the regulator.

2.4 RMP to be part of the mine safety management system

The RMP is part of the mine safety management system (MSMS) for the mine under WHS Mines Regulations r. 622(d) and r. 641N(4).

This inclusion ensures that radiation protection is integrated into the overall hazard and risk management of the mining operation.

2.5 RMP to be approved before mining operations commence

The mine operator of a relevant mine must ensure that a new stage of a mining operation does not commence unless:

- an RMP has been submitted to the regulator
- the regulator has approved the RMP.

Before the RMP is approved, the regulator may allow peripheral activities that do not disturb the mineral-bearing lithology, such as installing fence lines or constructing access roads or airstrips.

Exploration drilling activities to identify radioactive minerals should be allowed to progress without an RMP. However, once the exploration activity encounters radioactive mineralisation that identifies the operation as a relevant mine then an RMP will be required.

2.6 Alignment with RPS-9

An RMP must incorporate the requirements of RPS-9 clause 2.7.2 and clause 3.8. This aligns the WHS Mines Regulations with ARPANSA's radiation regulatory framework and minimises duplication with conditions of the Radiation Safety Act.

WHS Mines Regulations r. 641Q(1)(c) requires the assessment of doses to be carried out in accordance with a procedure approved by the regulator. The [NORM-V Dose assessment: Guide \(NORM-V\)](#) has been declared an approved procedure by the regulator under WHS Mines Regulations r. 641Q(2). All dose assessments should be made in accordance with NORM-V, effectively rendering clause 3.8.1(d) of RPS-9 redundant.

Section 4 contains further information on the requirements of RPS-9 clause 2.7.2.

2.7 Plan for discharges of radioactive waste

The [ARPANSA Management of naturally occurring radiative materials \(NORM\): Safety guide RPS-15](#) covers 'waste rock, process tailings, and products containing elevated concentrations of naturally occurring radionuclides' (p. 4); states the 'processing of NORM materials gives rise to products, wastes and residues'; and further defines residues as materials that have the 'potential for utilisation' (p. 29).

The RMP must include a plan for the discharge of radioactive waste. This should correlate with the RWMP required by WHS Mines Regulations r. 641O. The RMP should detail the temporary storage of residues, including proposed periods of storage, and justify why the residues should not be construed as wastes.

2.8 Incidents to be notified to the regulator

The mine operator of a relevant mine must notify the regulator of:

- notifications, reports and records prescribed in WHS Mines Regulations r. 641Y
- incidents and accidents defined by RPS-9.

WHS Mines Regulations r. 641N(2)(a)(iii) requires that the RMP identifies and documents the types of notifications, reports and records that will be reported to the regulator. The RMP must also identify and document accidents and incidents that will be reported to the regulator.

An accident is defined by RPS-9 (p.40) as:

An unintended event which causes, or has the potential to cause, employees or members of the public to be exposed to radiation from which the individual doses or collective doses received do not lie within the range of variation which is acceptable for normal operation. An accident may result from human error, equipment failure or other mishap; it may require emergency action to save life or to safeguard health, property or the environment. An accident requires investigation of its causes and consequences and, possibly, corrective action within the program for control of radiation, and it may require remedial action to mitigate the consequences.

RPS-9 (p. 43) defines an incident as:

An event which causes, or has the potential to cause, abnormal exposure of employees or members of the public and which requires investigation of its causes and consequences. Such an event may require corrective action within the program for control of radiation but is not of such scale as to be classified as an accident.

Inadvertent exposure to radiation is a dangerous incident under section 37 of the WHS Act and must be reported to the regulator.

The incorrect use, loss or theft of irradiating apparatus used on a mining operation may expose persons to radiation and if applicable, should be considered for inclusion as a notifiable incident to the regulator in the RMP. Should such an event occur it may constitute a dangerous incident.

2.9 Review of the RMP

An RMP that has been approved by the regulator in writing, forms part of the MSMS for the mining operation. The RMP must be reviewed and submitted by the mining operator to the regulator at least every three years.

An earlier review is triggered if there is a change in the radiation risk profile of the relevant mine, such as:

- the annual radiation report indicates that conditions are not controlled
- significant changes occur to any part of the mining operations resulting in changes to the estimated dose to workers or members of the public
- a change to the appointed radiation safety officer (RSO) for the mining operation. The appointment of an RSO is covered in more detail in section 5 and Appendix 10 of this Guide.

More information about triggers for review can be found in the [Mine safety management system: Code of practice](#).

3 Risk-based radiation management plans

The underpinning principles of a risk-based RMP are: the radiation exposure of a mining operation is defined and quantified where possible; and the measures to control and minimise the risks of exposure to radiation are identified and documented so that implementation and effectiveness can be verified.

The IAEA's GSR part 1, establishes the responsibilities and functions of regulatory bodies in chapter 4. The performance of regulatory functions should correspond with the radiation risks associated with the mining operation, and outlines a graded approach, where:

Safety is optimized [*sic*], the balance between operational benefits and potential consequences for people and the environment being taken into account (GSR part 1, clause 4.3(a), p. 18).

As a result, the complexity, depth and scope of the RMP for a mining operation, including for exploration projects, follow the graded approach that correspond with the radiation risks associated with the activities proposed to be conducted on the site.

Some exploration and mining operations encounter NORs in concentrations that are elevated, but do not meet the 1 Bqg⁻¹ criteria, so may not be considered relevant mines, such as:

- mineral exploration operations where the lithology is not initially expected to be classified as radioactive, that is, not be above 1 Bqg⁻¹, for example exploration for heavy mineral sands, rare earths, phosphate or lithium
- underground mines, where exposure of workers may arise from the inhalation of isotopes of radon and radon progeny. There is potential for this exposure in all underground mines, independent of the mineral or material being mined.

The regulator may:

- exempt mining operations with a low radiation risk from some requirements of WHS Mines Regulations, Subdivision 3B – Radiation in mines, where appropriate (see section 1.3)
- scrutinise mining operations with high radiation risks before and after approvals or authorisations are granted.

Processing operations or underground mines may require data collection and assessment to demonstrate that the operation does not meet the criteria specified in WHS Mines Regulations r. 641L and is not a relevant mine. The regulator can require the mine operator to supply this information in accordance with the WHS Act s. 155.

An RMP is not required if the assessment indicates that:

- it is very unlikely that any radioactive materials will be encountered at **any part** of the mining operation
- the exposures of workers and the members of the public are expected to be significantly below the relevant mine criteria, and
- the generation of wastes is minimised resulting in undetectable exposure measurements and negligible impacts on the environment.

A commitment to periodically review and assess the concentrations of NORs, the potential exposure pathways and doses to workers and critical groups and the impacts upon the environment should be included in the RMP.

A critical group is defined in RPS-9 as a 'group of members of the public comprising individuals who are relatively homogenous with regard to age, diet, and those behavioural characteristics that affect the doses received and who receive the highest radiation doses from a particular practice'.

Greenfield exploration operations

Greenfield operations are potential sites that have not been previously developed.

The *Mining Act 1978* requires proponents for exploration operations to submit a [programme of work](#) (PoW) for environmental approval before exploration activities commence. If the exploration activities encounter lithology that contains NORs, proponents must indicate the occurrence.

The WHS Mines Regulations require the prospective mine operator to [notify the regulator before exploration operations commence](#). The exploration operation notification (EON) should contain information on the likelihood of NORs at the site and be submitted with a risk assessment.

When the regulator has received the EON and risk assessment, discussions relating to the requirements to submit an RMP may commence.

Risk assessments included in an EON for activities associated with greenfield exploration, such as ground surveying, collection of rock-chip samples, shallow augering, or where there is minimal ground disturbance, should indicate the steps the exploration manager proposes to use to ensure risks to workers (including third parties that may analyse samples that potentially contain NORs) and the environment are as low as reasonably achievable.

Generally, and with the exception of exploration for uranium-bearing lithology, a greenfield exploration operation will not require an RMP or appointment of an RSO. However, as exploration activities progress, a point may be reached where the exploration becomes 'advanced' and meets the criteria of a very low radiation exposure risk operation as outlined in Section 3.1, and an RMP and the appointment of an RSO may be required.

Graded risk-based approach for relevant mines

The graded approach adopted by the regulator has the following five tiers:

- Tier 1: Very low radiation exposure risk.
- Tier 2: Low radiation exposure risk.
- Tier 3: Restricted radiation exposure risk.
- Tier 4: Moderate radiation exposure risk.
- Tier 5: Elevated radiation exposure risk.

At every tier, the RMP needs to satisfy the regulator that the proposed operating principles are sufficient, and that the RMP application:

- demonstrates the safety of the exploration or mining operation, and that radiation safety is optimised
- is accurate, based upon appropriate, statistically valid data, and shows compliance with regulatory requirements
- provides sufficient evidence that radiation protection, and assumptions used have been proven through testing or experience
- documents ways the radiation risks associated with normal operation is as low as reasonably achievable
- identifies all anticipated incidents and accidents including those with a very low probability of occurrence, before activities commence, and throughout the lifetime of the operation.

3.1 Tier 1: Very low radiation exposure risk operations

Advanced exploration operations

During advanced exploration operations, it is likely that geochemical analyses are complete, information about the lithology composition and mineral characteristics has been assessed and plans to evaluate the potential resource are under development.

If exploration operations commence in a mineral deposit that includes high-grade minerals, and the risk assessment indicates the risk level exceeds the tier 1 operation criteria, then a complex RMP is to be submitted.

When the concentration of the NORs thorium and uranium in the lithology and mineral characteristics are assessed, if any results meet the definition of radioactive material under WHS Mines Regulations r. 641K, a tier 1 RMP, as outlined in section 4.2, should be submitted to the regulator for consideration for approval.

If drilling, bulk sampling or costeaning activities are proposed, the RMP should include a plan to monitor potential worker radiation exposure. This includes the inhalation of dust that contains NORs during drilling, exposure to gamma rays from bulk samples, or the potential for internal doses from radon and radon progeny in excavations deeper than three metres.

The tier 1 RMP should include a commitment to return the disturbed area of the operation to pre-existing radiological conditions, including the disposal of samples returned to the site.

An RSO must be appointed for an advanced exploration operation as outlined in section 5.4.

Brownfields exploration

Brownfield exploration refers to activities conducted on leases on which existing mining operations occur to evaluate the potential for further development. The RMP for the mining operation should include brownfield exploration activities.

In the event that an RMP has not been previously submitted and approved, the requirements of section 3.1 apply, and an RSO must be appointed as outlined in section 5.3.

Exploration operations that progress to mine development

WHS Mines Regulations r. 675UC

Information about commencement of non-exploration mining operations

If exploration operations transition to development of a mining operation, WHS Mines Regulations r. 675UC(2) requires a [Notice of information about non-exploration mining operation form](#) (MON-2) to be submitted to the regulator no later than 45 days before mining operations commence.

The risk of encountering NORs is to be indicated on the MON-2 in Part E: Information about the management of risk.

Concentrations of NORs can increase as a result of mining and mineral processing activities and may differ significantly from those in the untreated lithology.

Additional assessments of radiation exposure risks will be necessary through each stage of the mining operation to develop a formal RMP.

3.2 Tier 2: Low radiation exposure risk operations

A low radiation exposure risk operation is one in which:

- secular equilibrium of the thorium and uranium decay series has been preserved
- radioactive materials are encountered in products, at one or more of the mining, mineral processing, or residue and waste management operations
- radiation doses are generally less than the relevant mine criteria, but a worst-case exposure scenario indicates annual doses to
 - one or more cohorts of workers can approach 2 mSv, or
 - critical groups exceed 0.5 mSv.

The contents of an RMP for low radiation risk exposure mining operations are outlined in section 4.3.

An RSO (restricted) is to be appointed for a low radiation exposure risk mining operation as is outlined in section 5.5.

3.3 Tier 3: Restricted radiation exposure risk operations

A restricted radiation exposure risk operation is one in which secular equilibrium of the thorium and uranium decay series **has been disturbed** and distinct practises of the mining operations have the potential to concentrate NORs such that:

- radioactive materials are known to be present in specific sections of the mining operation
- radiation doses to workers are less than the relevant mine criteria, but a worst-case exposure scenario indicates that workers involved in the distinct practise may receive an annual dose that exceeds 1 mSv.

Examples of distinct practises include water treatment and reverse osmosis plants, accumulation of radionuclides in waste streams, and deposition of radioactive scale inside processing vessels.

The parts of the mining operation in which radioactive materials are not present may be subject to an exemption. As outlined in section 1.3, the onus is on the mine operator to demonstrate that Part 10.2, Division 3, Subdivision 3B should not apply. Exemptions are covered in [section 1.3](#).

The RMP requirements for a restricted radiation exposure risk operation are outlined in [section 4.4](#).

The RMP for a restricted radiation exposure risk mining operation will be limited to the specific section(s) of the mining operation affected by the distinct practise, and will not apply to sections of the mining operation where radioactive materials are not present.

An RSO (restricted) is to be appointed for a restricted radiation exposure risk mining operation as outlined in [section 5.5](#).

If radioactive materials that are not related to a distinct practise are present in the mining operation, a more complex RMP and the appointment of an RSO (relevant mine) will be required.

3.4 Tier 4: Moderate radiation exposure risk operations

A moderate radiation exposure risk operation is one in which radioactive materials are encountered in products or at one or more of the mining, mineral processing, or residue and waste management operations, and either:

- annual radiation doses to most workers are generally less than 2 mSv, but a worst-case exposure scenario indicates annual doses to
 - one or more cohorts of workers approaching 5 mSv, or
 - critical groups exceeding 0.5 mSv
- bulk residues or wastes generated by the mining operations do not exceed an activity concentration of 10 Bqg⁻¹.

It is important that the state of secular equilibrium of the thorium and uranium decay series for all products and at each stage of the mining, mineral processing, or residue and waste management operation is stated, and has been considered in the dose assessment process.

The contents of an RMP for moderate radiation risk exposure mining operations are outlined in section 4.5.

3.5 Tier 5: Elevated radiation exposure risk mining operations

An elevated radiation exposure risk operation is one in which radioactive materials are encountered in products or at one or more of the mining, mineral processing, or residue and waste management operations, and the:

- annual radiation doses to most of the workforce are generally less than 5 mSv, but a worst-case exposure scenario indicates annual doses to
 - one or more cohorts of workers can exceed 5 mSv, or
 - critical groups approach or exceed 1 mSv, and
- bulk residues or wastes generated by the mining operations exceed an activity concentration of 10 Bqg⁻¹.

The contents of an RMP for elevated radiation risk exposure mining operations are outlined in section 4.6.

3.6 Decision matrix

The radiation risk-based decision matrix is provided in Appendix 3 to assist in decision making to determine the appropriate tier of RMP.

4 Detail required in the radiation management plan

WHS Mines Regulations r. 641N

Radiation management plan

WHS Mines Regulations r. 641O

Radioactive waste management plan

The level of detail required in an RMP depends on the activity concentration of the NORs, the identified or estimated risk of potential radiation exposures or impact on the environment of radioactive waste materials, and the expected difficulty of controlling exposures.

For example, an RMP for a greenfield exploration project is not expected to be as detailed as one for a mining and mineral processing operation.

As outlined in section 2.1, a separate RWMP that complies with RPS-9 clause 2.8.2 should supplement the RMP:

- tier 4 and tier 5 radiation risk exposure operations require the submission and approval of an applicable RWMP
- lower tier operations may require the submission and approval of an RWMP, as directed by the regulator.

The RMP should be a controlled document, with a unique reference number relevant to the operation.

4.1 Common details required in all RMPs

Regardless of the radiation exposure risk associated with an exploration or mining operation, all RMPs should comply with the regulatory requirements outlined in section 2.3, and should include

- a cover sheet with the:
 - document title
 - date of submission to the regulator
 - name of the company and operation
 - Safety Regulation System (SRS) site group reference
 - EON or MON-2 reference number for the operation
 - previous RMP that the current submission replaces, if applicable
 - revision history of the document
 - signed endorsement by the exploration manager or site senior executive on behalf of the mine operator and the person who compiled the RMP, which is usually the appointed RSO
- a table of contents
- name and address of the mine operator
- name, title and email address of the company representative
- the scope of the RMP, including the
 - reference of the applicable lease(s), tenement(s) or other land title(s)
 - project location, including the shire and distance to the nearest town and critical group
 - specific operations and facilities described in the document, for example exploration, surface mining, underground mining, mineral processing, smelting, refining or waste disposal
- brief history of ownership of the site, lease or tenement
- a statement including the sources of radiation exposure, and the proposed risk level being addressed (tier 1 to tier 5, see section 3), the proponent forecasts, and the basis for the judgement
- if the RMP is not an initial submission, a summary of the geometric mean and maximum external, internal and total doses, by similar exposure group, for the period since the most recently approved RMP. In the unlikely event that the monitoring results are not log-normally distributed, the arithmetic mean is to be reported instead of the geometric mean.

Initial RMP submission

If the RMP is the first to be submitted for a specific mining operation, it should also include commitments to:

- conduct a baseline monitoring program, and provide the required information to the regulator before mining operations commence
- develop and submit an RWMP to the regulator for approval
- review the radiation exposure risk as the results of the annual monitoring plan become available.

4.2 Details required in an advanced exploration RMP (tier 1)

The RMP for a tier 1 operation should include the:

- details as listed in section 4.1
- expected duration and nature of the exploration operations
- size of the workforce and the anticipated periods of exposure
- appointment of an RSO (exploration)
- average and maximum concentration of NORs encountered to date on the site, lease or tenement
- commitment to perform a baseline gamma survey including the name and type of survey instrument, and its calibration details and to provide the results to the regulator
- estimate of average and maximum worker external doses from gamma radiation exposure
- methods used to minimise worker exposure to gamma radiation
- commitment to inform third party analytical laboratories that samples from the exploration operation may contain NORs
- commitment to return the gamma radiation levels at the site(s) of exploration activities to baseline levels.

If drilling or costeaning activities are scheduled to occur, the RMP should estimate the:

- average and maximum internal doses arising from inhalation of dust at concentrations of 0.5 milligram per cubic metre (mg/m^3), 1 mg/m^3 , 3 mg/m^3 and 5 mg/m^3 .
- internal dose from radon, thoron and their progeny from costeaning operations and sample storage areas
- effective dose arising from the applicable exposure pathways.

The radiological risk assessment can be based upon time and motion studies rather than personal sampling conducted on workers.

If the exploration period will extend past six months, the RMP should consider the allocation of personal monitors for gamma exposure to the potentially exposed workers.

4.3 Details required in a low radiation exposure risk mining RMP (tier 2)

The RMP for a tier 2 operation should include:

- the details listed in section 4.1
- the nature of the mining operations, for example, dredging, open pit, underground, processing plants, tailings storage
- the size of the workforce, the allocation of workers to similar exposure groups, and the average and maximum annual working hours
- identification of the cohorts of workers most likely to receive the maximum radiation dose
- the appointment of an RSO (restricted)
- the average and maximum concentration of NORs encountered in applicable products or the mining, mineral processing, or residue and waste management operations
- a radionuclide by mass balance for the inputs, products, residues and waste streams associated with the mining operations
- data verifying the secular equilibrium of the NORs has been maintained
- estimates of the average and maximum worker effective doses from applicable pathways for each similar exposure group that include
 - a summary of the contribution from each exposure pathway
 - a statement as to how the doses were calculated
- the details of the annual monitoring program with sufficient samples to make a statistically valid estimate of the doses received by the most exposed cohorts of workers. The monitoring program should show sufficient monitoring to verify the effectiveness of exposure controls, and to make evidence-based estimates of doses to the remainder of the workforce, based upon time and motion studies, and include
 - detail of the equipment to be used and the minimum detection levels of the equipment
 - a commitment to comply with the manufacturer's instructions and applicable Australian Standards
 - identify and verify the credentials of third parties that will analyse samples collected
- methods used to minimise worker radiation exposures, including
 - identification of supervised and controlled areas
 - a commitment to train workers and contractors required to perform tasks in supervised or controlled areas
 - site inductions that include measures workers and others can implement to minimise their radiation exposures
- identification of critical groups, their location in relation to the mining operations and the potential annual effective doses, including the contribution from each exposure pathway.

4.4 Details required in a restricted radiation exposure risk mining RMP (tier 3)

The RMP for a tier 3 operation is to include:

- the details listed in section 4.1
- the nature of the mining operation
- the distinct practises that require the submission of the RMP
- data that verifies secular equilibrium of the NORs has been disturbed
- a radionuclide by mass balance for each distinct practise
- identification and concentrations of the radionuclides that are the most likely source of exposure, and the potential behaviour in the environment in case of planned or accidental release
- exposure pathways noting if inhalation or ingestion are potential sources of exposure, the applicable dose coefficients are to be cited – refer to NORM-V
- demographics of the cohort of workers involved in the distinct practises, for example, the number of workers, estimated hours of exposure, applicable similar exposure group
- appointment of an RSO (restricted)
- an annual monitoring program designed to ensure, or verify that, doses received by the most exposed cohorts of workers in each distinct practise are as low as reasonably achievable
- methods to ensure that the doses to workers conducting the distinct practise, and others are minimised, including
 - identification of the physical and operational areas in which the distinct practises occur
 - provision of training to workers and contractors required to perform tasks in the distinct practise
 - site inductions with measures workers and others can implement to minimise their radiation exposures
 - safe work procedures describing specific measures associated with the management of the radiological hazards.

If disposal of potentially contaminated items of plant, equipment or wastes is proposed, a separate RMP addressing the removal, clearance levels, storage, transport and disposal of the materials must also be submitted to the regulator for approval. This will have the format and content of a tier 4 or tier 5 RMP, dependent on the radiation exposure risk of the disposal process.

4.5 Details required in a moderate radiation exposure risk mining RMP (tier 4)

An RMP for a tier 4 operation is to include:

- the details listed in sections 4.1 and 4.3
- a radionuclide by mass balance that clearly identifies the radiological properties of the various streams of inputs, intermediate and final products, residues and wastes
- a marked-up diagram, map or aerial photograph of the mining operation that identifies areas with potential for elevated exposure, using the radionuclide by mass or volume balance
- identification of parts of the mining operation designated as supervised or controlled areas
- identification of the cohort of workers that potentially receive annual effective doses greater than 5 mSv and personal identification of any worker whose annual exposure may exceed 10 mSv
- the appointment of an RSO (relevant mine)
 - if a new appointment is proposed, supply candidate credentials and the details of the predecessor in an appendix
 - if the candidate has been previously approved by the regulator, supply a copy of the formal approval issued by the regulator in an appendix
- an annual monitoring program, with the requirements of section 4.3 expanded to ensure sufficient personal monitoring data is collected on all designated workers (workers with potential exposures greater than 5 mSv), to support a statistically valid estimate of personal doses
- a communication strategy to advise designated workers that their potential dose places them into the designated worker category and the methods they can use to minimise their exposure
- details of the equipment used in the monitoring program, including calibration status, and method of calibration
- identification of any areas of the mining operation in which secular equilibrium has potentially been disturbed
- a commitment to apply a dose assessment procedure approved by the regulator as per WHS Mines Regulations r. 641Q(2)
- the dose conversion factors applied to the calculation of internal dose arising from inhalation of dust, including
 - for any areas in which secular equilibrium has been disturbed
 - the input parameters to the derivation of the dose conversion factors
- the dose coefficient for inhalation of isotopes of radon and their progeny, including the equilibrium factor used
- a monitoring program to calculate potential doses to critical groups, and if required, exposure controls to ensure compliance with the annual public dose limit
- links to the RWMP
- details about the induction and training course in radiation protection and exposure minimisation provided to workers, contractors and other people at the mining operation
- an overview, as per RPS-9 clause 3.8.1(f), of the systems used for record keeping, implementation and evaluation of exposure controls, calculation of doses, and reporting to workers and the regulator
- a commitment to verifying the effectiveness of the implementation in an appendix.

As in section 4.4, if the disposal of potentially contaminated items of plant, equipment and wastes is proposed, a separate RMP specifically addressing the removal, clearance levels, storage, transport and disposal of the materials must be submitted to the regulator for approval.

4.6 Details required in an elevated radiation exposure risk mining RMP (tier 5)

An RMP for a tier 5 operation should include:

- all details outlined in sections 4.1, 4.3 and 4.5
- an annual monitoring program that meets the requirements of section 4.5 and provides expanded details on how sufficient personal monitoring data is collected for each worker with potential exposures of 3–5 mSv. This data will support a statistically valid estimate of personal doses and allow for trend analysis and intervention to ensure doses remain as low as reasonably achievable
- identification of workers whose annual effective dose will potentially exceed 10 mSv, and the details of the personal monitoring program to effectively assess the dose
- detailed procedures designed to ensure workers whose doses potentially exceed 5 mSv are maintained as low as reasonably achievable
- evidence of the application of the hierarchy of control to minimise exposures to workers, especially those with the potential to exceed an annual effective dose of 5 mSv. For further information on the hierarchy of control, refer to the [*How to manage work health and safety risks: Code of practice*](#)
- evidence of the application of best practicable technology in the design of plant and equipment, and controls to maintain exposures to as low as reasonably achievable
- nomination of levels which, if exceeded, will trigger an investigation into a source of exposure or reported dose
- use of instantaneous readout detection equipment in areas of the mine with the potential for elevated radiation exposures.

5 Radiation safety officers

WHS Mines Regulations r. 641N

Radiation management plan

WHS Mines Regulations r. 675ZZK

Regulator may approve courses for particular statutory positions

WHS Mines Regulations Sch. 26 cl. 1

Radiation safety officers

The WHS Mines Regulations, Schedule 26 clause 1 requires that an RSO must be appointed for a mine to which Part 10.2, Division 3 Subdivision 3B applies.

The functions of an RSO include:

- advising the site senior executive or exploration manager of precautions to be taken to control the radiation doses people at the mine receive
- monitoring the sources of radiation exposure
- assessing doses of radiation received by people because of the mining operations carried out at the time.

An RMP will only be approved by the regulator if a suitably qualified, experienced and competent RSO is appointed. If the RSO for a site changes, the relevant sections of the RMP must be resubmitted to the regulator for approval.

RPS-9 clause 2.7.2(a) further states that the RMP must include 'demonstrated access to appropriate professional expertise in radiation protection'. RPS-9 clause 2.10.1(d) provides more information and requires the mine operator to:

ensure that appropriate expertise in the fields of radiation protection and radioactive waste management is available, and appoint a Radiation Safety Officer who has qualifications and experience acceptable to the relevant regulatory authority.

5.1 Appropriate expertise

The mine operator must ensure that appropriate expertise in radiation protection is available and appoint an RSO who has qualifications and experience acceptable to the regulator.

The appropriate expertise will be different for each exploration, mining or mineral processing operation, according to the scale of the operation and accompanying risks of radiation exposure. Appendix 10 has further information on appropriate expertise.

This approach is reflected in RPS-9 clause 3.10.1 which states:

The operator has the responsibility to appoint an appropriately qualified radiation safety officer (RSO). The requirements will change depending on the scale of the operation and concomitant risks of radiation exposure. Normally, an RSO is expected to have a degree in physical sciences or equivalent and some years of experience in radiation protection, preferably in the mining industry. The RSO is responsible for advising the operator on all matters relating to radiation protection of employees, members of the public and the environment, and for implementing the RMP.

5.2 A risk-based approach

The appropriate expertise required for an RSO will depend on the radiation exposure risk as outlined in section 3.

Three categories of RSOs apply to Western Australian mining operations:

- RSO (exploration)
- RSO (restricted)
- RSO (relevant mine).

A person is eligible to be an RSO if they:

- have an undergraduate degree in science, technology, engineering or mathematics
- meet the eligibility requirements for a mine air quality officer
- successfully complete a course about radiation protection from naturally-occurring radioactive material that the regulator considers suitable
- work for at least 12 months under the supervision of an RSO
- successfully complete an approved WHS risk management unit for RSOs
- passes an applicable WHS legislation examination for RSOs.

Each category related to radiation protection activities has additional requirements, as outlined in the following sections.

5.3 Conditions of appointment

The appointment of RSOs depends on the radiation exposure risk profile of a specific advanced exploration or mining operation.

It is a requirement that the mine operator, site senior executive or exploration manager nominates the appropriate RSO in the RMP. However, if the radiation exposure risk profile of the operation changes the RMP must be revised, and a review of the nominated RSO will occur as a result.

Approval as the RSO at one mining operation will not constitute approval at another mining operation.

The person appointed to an RSO role should attain the necessary licences as required under the Radiation Safety Act. Approval under the WHS Mines Regulations, Part 10.2, Division 3, Subdivision 3B does not necessarily constitute approval under the Radiation Safety Act.

If the RSO appointment is rescinded for any reason, the site senior executive or exploration manager and the appointed individual performing the RSO role must advise the regulator as soon as practicable.

5.4 Radiation safety officer (exploration)

The role of RSO (exploration) applies to those advanced exploration operations which present tier 1 (very low) radiation exposure potential as outlined in section 3.

The conditions on tier 1 advanced exploration operations are such that if radioactive materials are encountered, exposure periods are often of relatively short duration and doses are unlikely to exceed the 1 mSv criteria of a relevant mine.

The RSO verifies and implements simple dose minimisation controls such as the application of shielding, time and distance, and the effective use of dust controls.

Monitoring of exposure to external gamma radiation is expected, however estimates of internal dose are encouraged, but not mandated, unless directed by the regulator. If a direction is issued by the regulator, specialist assistance may be required for the collection and analysis of applicable representative samples.

To be considered for appointment as an RSO (exploration), the candidate must have:

- an undergraduate degree in science, technology, engineering, mathematics, geology, geophysics or earth science, and
- successful completion of an approved course for RSOs (exploration), and
- completed a course involving the appropriate use of hand-held instruments to measure dose rates from electromagnetic radiation for example, a course on irradiating apparatus.

An approved RSO (relevant mine) or RSO (restricted) may be considered for the role of RSO (exploration) if they meet the above criteria.

5.5 Radiation safety officer (restricted)

The role of RSO (restricted) applies to those mining operations which present tier 2 or tier 3 (low or restricted) radiation exposure potential as outlined in section 3.

The radiological conditions on a tier 2 or tier 3 mining operation may potentially meet the relevant mine criteria. The RSO (restricted) verifies, implements and validates the effectiveness of radiation exposure controls.

Dose assessments conducted will be based upon similar exposure groups and will apply default parameters for the assessment of internal doses.

To be considered for appointment as an RSO (restricted), the candidate must have:

- an undergraduate degree in science, technology, engineering, or mathematics; or occupational hygiene, or similar; with a curriculum that includes a significant component of hazard and risk management
- a relevant licence for use of radioactive substances issued by an appropriate authority. In WA this is the Western Australian Radiological Council
- attainment of the competencies of a mine air quality officer
- successful completion of an approved course for RSO (restricted)
- completed a professional development program in radiation protection in mining supervised and authenticated by an RSO (relevant mine).

Where an RSO (restricted) has been appointed, the RMP must nominate an appropriate person to provide the mining operation with specialist radiation protection. It is highly recommended that the appropriate person is, or is eligible for appointment as, an RSO (relevant mine).

5.6 Radiation safety officer (relevant mine)

WHS Mines Regulations Sch. 26 cl. 1
Radiation safety officers

The role of RSO (relevant mine) applies to mining operations which present tier 4 or tier 5 (moderate to elevated) radiation exposure potential as outlined in section 3.

As stated previously, WHS Mines Regulations, Schedule 26 clause 1 requires an RSO to be appointed for a relevant mine.

While the RSO (relevant mine) is able to fulfil the requirements of an RSO for any of the five tiers in the risk-based approach, the following criteria refer specifically to moderate and elevated radiation exposure risk mining operations (tier 4 and tier 5).

The functions of an appointed RSO (relevant mine) involve:

- advising the site senior executive or exploration manager of precautions to be taken to control the radiation doses people receive at the mine
- monitoring sources of radiation exposure
- assessing doses of radiation received by people (workers and members of the public) because of mining operations carried out at the mine.

To be considered for appointment as an RSO (relevant mine), the candidate must have:

- an undergraduate degree in science, technology, engineering or mathematics
- met the eligibility requirements for a mine air quality officer
- successfully completed a course about radiation protection from naturally-occurring radioactive material that is approved by the regulator
- worked for at least 12 months under the supervision of an RSO
- successfully completed an approved WHS risk management unit for RSOs
- passed an applicable legislation examination for RSOs.

5.7 Appointment of part time radiation safety officer

Details of the time allocated to fulfil the radiation protection duties should be included in the RMP. The allocation may be expressed as a percentage of full-time work, hours or days per month, or another measure that officially commits time and resources to the mining and mineral processing operation.

The time taken to fulfil the functions of the RSO role depends on the radiation exposure risk of the mining or exploration operation.

Tiers 1, 2 and 3 radiation exposure risk mining or advanced exploration operations may not warrant the appointment of a full-time RSO.

However, as the radiation exposure risk of the mining operation increases, the time commitment of the RSO will increase. A tier 5 mining operation with an elevated radiation exposure risk is more likely to fully engage a full-time RSO (relevant mine).

5.8 Appointment of a contracted radiation safety officer

WHS Act s. 26A

Duty of persons conducting businesses or undertakings that provide services relating to work health and safety

In some circumstances it may not be reasonably practicable for a tier 1, 2, 3 or 4 advanced exploration or mining operation to employ the requisite RSO as a member of its permanent workforce.

In these cases, it may be appropriate for the regulator to approve the appointment of an appropriately qualified, skilled and experienced person from outside the organisation to provide the services under contract.

The mine operator, the site senior executive or exploration manager responsible for the appointment of the RSO should be conscious of their key functions, including:

advising the operator on all matters relating to radiation protection of employees, members of the public and the environment, and for implementing the radiation management plan (RPS-9, clause 3.10.1).

The contract arrangement should allow the RSO to put the RMP into effect, and perform the relevant functions as outlined in WHS Mines Regulations, Schedule 26 cl. 1.

In practical terms the mine operator should:

- make the contracted RSO directly accountable to the site senior executive or exploration manager (whichever is applicable)
- allocate sufficient time and resources to the contract RSO to enable the evaluation and effectiveness of the measures to control radiation exposures, monitor sources of exposure and assess the doses
- assess the contract RSO's development, implementation, revision and verification of the effectiveness of the RMP and any supporting procedures, such as:
 - induction training
 - safe working procedures
 - methods for collecting and analysing samples and recording the results
 - assessment of doses to workers and members of the public
- ensure annual radiation reports are prepared and submitted as required by the regulator
- comply with Part 10.2, Division 3, Subdivision 3B.

The RMP should include details of the proposed time allocated to fulfil the radiation protection duties by the contracted RSO. This time commitment should provide the regulator with confidence that the RMP will be effectively implemented.

When considering an RMP that proposes the appointment of a contracted RSO, the regulator will evaluate the radiation exposure risk profile of the advanced exploration or mining operation and whether the time proposed to be allocated in the contract is sufficient to put the RMP into effect, while also being able to perform the relevant functions as outlined in Schedule 26 clause 1(2).

Appointment of contracted radiation safety officers to relevant mines

The regulator will not approve an external contractor to the role RSO (relevant mine) for a tier 5 mining operation unless exceptional circumstances apply, such as the need for an interim appointment of less than three months and the unforeseen absence of the approved RSO (relevant mine).

An external contractor may be appointed as an RSO (relevant mine) to a tier 4 mining operation. However, if any worker's annual dose is reported as exceeding 4 mSv, or an annual dose to a member of the public exceeds 0.5 mSv in the three-year period covered by the current version of the RMP, a review of the appointment will be conducted by the regulator. If the review confirms that the 95th percentile of annual dose to workers exceeds 4 mSv, or annual dose to a member of the public exceeds 0.5 mSv, the appointment may be revoked at the expiry of the three-year period, or at the direction of the regulator.

An external contractor may be appointed to a maximum of two tier 4 mining operations simultaneously.

Conditions on the appointment of contracted radiation protection personnel

External contractors appointed to the RSO roles are to be appointed individually, and not as a representative of a company. The individual external contractor appointed to the statutory position implements the RMP, and performs the relevant functions of an RSO.

The external contractor may engage third party service providers to collect samples or conduct analyses.

The external contractor may be appointed simultaneously in a radiation protection role for up to four mining operations, as defined by the site group status in the Safety Regulation System (SRS), and:

- appointments are limited to two tier 4 mining operations
- each nomination for appointment is to be included in an operation specific RMP submitted to the regulator for approval
- each proposal for appointment will be considered on its own merits. A prior appointment to a radiation protection role as outlined in this document is persuasive to an additional appointment, but does not bind the regulator.

PCBUs that provide a service relating to work health and safety, such as an individual RSO appointed as an external contractor or the PCBU for a business that represents a contractor, must ensure that the WHS service is provided so that relevant use will not put the health and safety of people at the workplace at risk. As such, the provisions of the WHS Act section 26A apply to the services provided.

All correspondence, including RMPs and annual reports, between the external contractor and the regulator must be authorised in writing by the site senior executive or exploration manager.

Appendix 1 Glossary and acronyms

The following terms are defined for the purposes of this Guide.

Key terms	Meaning
As low as reasonably achievable	An adopted practice should ensure radiation risks of individual doses, number of people exposed, and the likelihood of incurring exposures are all kept as low as reasonably achievable.
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency.
Control measure	In relation to a risk to health and safety, a measure to eliminate or minimise the risk.
Critical group	Defined in RPS-9 as 'a group of members of the public comprising individuals who are relatively homogenous with regard to age, diet, and those behavioural characteristics that affect the doses received and who receive the highest radiation doses from a particular practice'.
Designated worker	A worker that works, or may work, under conditions so that the effective dose of radiation the worker receives may exceed 5 millisievert per year.
Distinct practise(s)	<p>Distinct practises of mining operations have the potential to concentrate NORs such that:</p> <ul style="list-style-type: none"> radioactive materials are present in known and specific sections of the mining operation, and radiation doses to the majority of the workforce are less than the relevant mine criteria, but a worst-case exposure scenario indicates that workers involved in the distinct practise may receive an annual dose that exceeds 1 mSv. <p>Examples of distinct practises include water treatment and reverse osmosis plants, accumulation of radionuclides in waste streams, and deposition of radioactive scale inside processing vessels.</p>
EON	<p>Exploration operation notification.</p> <p>The notification used by the prospective mine operator to notify the regulator before exploration operations commence.</p>
Exploration manager	A person appointed under r. 675ZM.
GSR Part 1	International Atomic Energy Agency's (IAEA) <i>Governmental, legal and regulatory framework for safety: General safety requirements</i> (Rev.1, 2016).
Hazard	A situation or thing that has the potential to harm a person. Hazards at work may include: noisy machinery, a moving forklift, chemicals, electricity, working at heights, a repetitive job, bullying and violence at the workplace.
IAEA	International Atomic Energy Agency.
MON-2	Mining operational notice 2 – Notice of information about non-exploration mining operations.

Key terms	Meaning
May	'May' indicates an optional course of action.
Mine	A place at which mining operations are carried out.
Mine air quality officer	A person appointed to the statutory position set out in Schedule 26 clause 4.
Mining operations	Any method of working by which the earth or any rock structure, coal seam, stone, fluid, or mineral bearing substance is disturbed, removed, washed, sifted, crushed, leached, roasted, floated, distilled, evaporated, smelted, refined, sintered, pelletised, or dealt with for the purpose of obtaining any mineral or rock from it for commercial purposes or for subsequent use in industry, whether it has been previously disturbed or not; and includes exploration operations and developmental and construction work associated with opening up or operating a mine – see WHS Mines Regulations r. 5B for full definition and exclusions.
Mine operator	A person (including a partnership, syndicate or other association of persons) who: <ul style="list-style-type: none"> in relation to a mine where only exploration operations are being carried out, has overall control and supervision of the exploration operations at the mine and the exploration manager appointed for those operations otherwise is the proprietor, lessee, or occupier of a mine and who has overall control and supervision of the mine and mining operations at the mine.
MSMS	Mine safety management system.
Must	'Must' indicates a legal requirement exists that must be complied with.
NDRP	The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) <i>National directory for radiation protection</i> (2nd Edition, 2021).
NOR	Naturally occurring radionuclides.
NORM	Naturally occurring radioactive material.
Person conducting a business or undertaking (PCBU)	A PCBU is an umbrella concept, which intends to capture all types of working arrangements or relationships. A PCBU includes a: <ul style="list-style-type: none"> company unincorporated body or association WHS service provider sole trader or self-employed person. A reference to a PCBU in the WHS Mines Regulations is deemed to be a reference to a mine operator where it is relevant. Individuals who are in a partnership that is conducting a business will individually and collectively be a PCBU. A volunteer association (defined under the WHS Act) or elected members of a local authority will not be a PCBU.

Key terms	Meaning
RSO	Radiation safety officer.
RMP	Radiation management plan.
RPS-9	ARPANSA <i>Radiation Protection Series 9 - Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing</i> (2005).
RWMP	Radioactive waste management plan.
Radioactive material	Materials that have an activity concentration that exceeds 1 Becquerel per gram (Bqg ⁻¹), and: <ul style="list-style-type: none"> • exhibit radioactivity • emit ionising radiation particles • contain NORs.
Regulator	WorkSafe Commissioner.
Relevant mine	A mine is a relevant mine if minerals or radioactive materials with an activity concentration criteria of 1 Bqg ⁻¹ or more are mined at the mine, and annual doses of radiation from the mining operations are likely to exceed either: <ul style="list-style-type: none"> • 1 millisievert (mSv) for workers • 0.5 mSv for members of the public at, or in the vicinity of the mine.
Risk	The possibility harm (death, injury or illness) might occur when exposed to a hazard.
SRS	Safety Regulation System.
Secular equilibrium	Secular equilibrium describes a situation where the activity of radioactive progeny resulting from the decay of a long-lived radionuclide equals that of the parent radionuclide.
Should	'Should' indicates a recommended course of action.
Similar exposure group	A cohort of workers with similar expected exposure profiles to NORs. A similar exposure group can be defined based on duties, hazards to which the workers are exposed, the duration and concentration of exposure and controls in place to manage hazards.

Key terms	Meaning
Statutory positions	<p>Schedule 26 of the WHS Mines Regulations provides the requirement for the following statutory positions, where applicable:</p> <ul style="list-style-type: none"> • radiation safety officers • noise officers • statutory supervisors • mine air quality officers • electrical supervisors • high voltage operators • underground managers • underground supervisors • underground ventilation officers • authorised mine surveyors (underground & quarry operation) • winding engine drivers • quarry managers.
Worker	<p>Any person who carries out work for a PCBU, including work as an employee, contractor or subcontractor (or their employee), self-employed person, outworker, apprentice or trainee, work experience student, employee of a labour hire company placed with a 'host employer' or a volunteer.</p>
Workplace	<p>Any place where work is carried out for a business or undertaking and includes any place where a worker goes, or is likely to be, while at work. This may include offices, factories, shops, construction sites, vehicles, ships, aircraft or other mobile structures on land or water.</p>

Appendix 2 Developing an RMP

The information and checklists in the following appendices can assist to determine which tier of RMP applies to an exploration or mining operation, the relevant details to be included, and the skills and experience required to be an RSO for the operation.

In order to expedite the review process by regulator, submit the checklist and record the relevant page number within the RMP.

Ensure that where a combination of checklists are required, all relevant details have been completed.

Please note that additional site-specific issues may need to be included in the RMP. These will be considered on an as-needs basis by the regulator.

Appendix 3 Decision matrix

Tier	Descriptor	Annual Dose Range (mSv)		Secular equilibrium	Conditions	Typical activities
		Geometric mean	Worst case			
-	Greenfields exploration	< 0.5	< 1.0	Assumed intact	Mineral sands, tantalite rare earths or uranium exploration	<ul style="list-style-type: none"> • Rock chipping • Small volume field samples
1	Very low risk	< 1	~ 1	Assumed intact	<ul style="list-style-type: none"> • Radioactive materials may be encountered, but unlikely • Risk assessment attached to EON • Commitment to periodic review of NOR concentrations 	<ul style="list-style-type: none"> • Brownfield exploration if RMP not required on established operations • Wet gravity concentration • Ports shipping < 10 Bqg⁻¹ minerals
2	Low risk	< 1	1-2	Assumed intact	<ul style="list-style-type: none"> • Relevant mine criteria met, but majority of doses are less than, but may approach 1 mSv 	<ul style="list-style-type: none"> • Advanced exploration • Hard rock spodumene mining • Lithium processing • Garnet milling • Metallurgical laboratories • Ports shipping > 10 Bqg⁻¹ minerals
3	Restricted	< 1	1-2	Disturbed	<ul style="list-style-type: none"> • Relevant mine criteria met as a result of distinct practises • Majority of doses are less than, but may approach 1 mSv 	<ul style="list-style-type: none"> • Reverse osmosis plants • Underground mines with radium-contaminated steel parts • Mineral 'finishing' plants • Steel components in acid leach circuits

Tier	Descriptor	Annual Dose Range (mSv)		Secular equilibrium	Conditions	Typical activities
		Geometric mean	Worst case			
4	Moderate risk	< 2	1–5	Confirmed intact or disturbed	<ul style="list-style-type: none"> • Relevant mine criteria met • Bulk residues < 10 Bqg⁻¹ • Wastes < 10 Bqg⁻¹ 	<ul style="list-style-type: none"> • Mineral sands plants with low monazite content • Tantalum extraction • Ports shipping enhanced radionuclide minerals (e.g. zircon, monazite, xenotime) • In-situ uranium leaching • Zircon processing • Synthetic rutile production • Underground mines with radium-enriched waters (radon exposure)
5	Elevated risk	< 5	> 5	Confirmed intact or disturbed	<ul style="list-style-type: none"> • Relevant mine criteria met • Bulk residues > 10 Bqg⁻¹ • Wastes > 10 Bqg⁻¹ 	<ul style="list-style-type: none"> • Monazite or xenotime production • Rare earth separation • Uranium mining and processing

Appendix 4 Checklist for common elements and initial RMP submissions

Common elements

Information required	Completed	Page #
1. A cover sheet that includes the:		
• document title		
• date of submission to the regulator		
• name of the company and the operation		
• SRS site group reference		
• EON or MON-2 reference number for the operation		
• previous RMP the current submission replaces (if applicable)		
• revision history of the document		
• signed endorsement by exploration manager or site senior executive and the person (nominally the RSO) who compiled the RMP		
2. A table of contents		
3. The name and address of the mine operator, and name and email address of the company representative for forwarding of correspondence		
4. Scope of the radiation management plan, including the:		
• reference of the applicable lease(s), tenement(s) or other land title(s)		
• location of the project, including the shire and distance to the nearest town and critical group		
• specific operations and facilities described in the document; for example, exploration, surface mining, underground mining, mineral processing, smelting, refining or waste disposal		
5. A brief history of the ownership of the site (e.g. lease, tenement)		
6. A statement including the sources of radiation exposure, and the risk level (tier 1 to tier 5 – see Section 3), the proponent forecasts, and the basis for the judgement		
7. A summary of the geometric mean and maximum external, internal and total doses, by similar exposure group, for the period since the most recent approved RMP. If the monitoring results are not log-normally distributed, the arithmetic mean is to be reported		
8. If an initial RMP submission, the RMP should include:		
• Conduct a baseline monitoring program, and providing the required information to the regulator before mining operations commence		
• Develop and submit an appropriate RWMP to the regulator for approval		
• Review the radiation exposure risk as the results of the annual monitoring plan become available		

Appendix 5 Checklist for an advanced exploration RMP (tier 1)

These requirements are in addition to Appendix 4.

Information required	Completed	Page #
1. The expected duration and nature of the exploration operations		
2. The size of the workforce, and the anticipated periods of exposure		
3. The appointment of an RSO (exploration)		
4. The average and maximum concentration of NORs encountered (to date) on the site (e.g. lease, tenement)		
5. A commitment to perform a baseline gamma survey (including the name and type of survey instrument) and provide the results to the regulator		
6. An estimate of average and maximum worker external doses from gamma radiation		
7. Methods deployed to minimise worker exposure to gamma radiation		
8. A commitment to ensuring that third party analytical laboratories are informed that samples from the exploration operation may contain NORs		
9. A commitment to return the gamma radiation levels at the site(s) of exploration activities to baseline levels		
If drilling or costeaning activities are scheduled to occur, the RMP should also include:		
10. An estimate of average and maximum internal dose arising from inhalation of dust at concentrations of 0.5 mg/m ³ , 1 mg/m ³ , 3mg/m ³ and 5 mg/m ³		
11. An estimate of internal dose from radon, thoron and their progeny from costeaning operations and sample storage areas		
12. An estimate of effective dose arising from the applicable exposure pathways		

Appendix 6 Checklist for a low radiation exposure risk mining RMP (tier 2)

These requirements are in addition to Appendix 4.

Information required	Completed	Page #
1. The nature of the mining operation/s (e.g. dredging, open pit, underground, processing plants, tailings storage)		
2. The size of the workforce, the allocation to similar exposure groups, and the average and maximum annual working hours		
3. Identification of the cohort(s) of workers most likely to receive the maximum radiation dose		
4. Appointment of an RSO (restricted)		
5. The average and maximum concentration of NORs encountered in the products or mining, mineral processing, or residue and waste management operations (as applicable)		
6. A radionuclide by mass balance for the inputs, products, residues and waste streams associated with the mining operations		
7. Data that verifies that secular equilibrium of the NORs has been maintained		
8. Estimates of the average and maximum worker effective doses from applicable pathways for each similar exposure group. The estimates to include:		
• a summary of the contribution from each exposure pathway		
• a statement as to how the doses were calculated		
9. An annual monitoring program that includes sufficient representative personal samples to make a statistically valid estimate of the doses received by the most exposed cohort(s) of workers; supplemented by sufficient monitoring to make evidence-based estimates of doses to the remainder of the workforce, based on time and motion studies, and		
• details of the equipment to be used, and the minimum detection levels of the equipment where applicable		
• a commitment to comply with the manufacturer's instructions and any applicable Australian Standards		
• identify any third party that will analyse samples collected in the monitoring plan, and verify their credentials to provide the service		
10. Methods used to minimise worker radiation exposures, including:		
• identification of supervised and controlled areas		
• a commitment to train workers and contractors required to perform tasks in supervised or controlled areas		
• site inductions that include measures workers and others can implement to minimise their radiation exposures		
11. An estimate of effective dose arising from the applicable exposure pathways		

Appendix 7 Checklist for a restricted radiation exposure risk mining RMP (tier 3)

These requirements are in addition to Appendix 4.

Information required	Completed	Page #
1. The nature of the mining operations		
2. The distinct practises that require the submission of the RMP		
3. Data that verifies secular equilibrium of the NORs has been disturbed		
4. A radionuclide by mass balance for each distinct practise		
5. Identification of the radionuclide(s) that are the most likely source of exposure and their concentration		
6. Exposure pathways (if inhalation or ingestion are potential sources of exposure, cite the applicable dose coefficients)		
7. Demographics of the cohort of workers involved in the distinct practises (e.g. number of workers, estimated hours of exposure, applicable similar exposure group)		
8. Appointment of an RSO (restricted)		
9. An annual monitoring program designed to ensure doses received by the most exposed cohorts of workers in each distinct practise are as low as reasonably achievable		
10. Methods to ensure that the doses to workers conducting the distinct practise, and others, are minimised, including:		
<ul style="list-style-type: none"> • identify the areas in which the distinct practise occurs 		
<ul style="list-style-type: none"> • provide training to workers and contractors required to perform tasks in the distinct practise(s) 		
<ul style="list-style-type: none"> • site inductions that include measures workers and others can implement to minimise their radiation exposures 		
<ul style="list-style-type: none"> • specific safe work procedures describing all measures associated with the management of the radiological hazards 		

Appendix 8 Checklist for a moderate radiation exposure risk mining RMP (tier 4)

These requirements are in addition to Appendix 4.

Information required	Completed	Page #
1. A radionuclide-by-mass balance that clearly identifies the radiological properties of the various streams of inputs, intermediate and final products, residues and wastes		
2. A marked-up diagram, map or aerial photograph of the mining operation that identifies areas with potential for elevated exposure, using the radionuclide by mass (or volume) balance		
3. Identification of any parts of the mining operation that are designated as supervised or controlled areas		
4. Identification of the cohort of workers that may potentially receive annual effective doses greater than 5 mSv and personal identification of any worker whose annual exposure may exceed 10 mSv		
5. Appointment of an RSO (relevant mine):		
<ul style="list-style-type: none"> if a new appointment is proposed, supply the candidate's credentials in an appendix 		
<ul style="list-style-type: none"> if the candidate has been previously approved by the regulator, supply a copy of the formal approval issued by the regulator (or their predecessor) in the appendix 		
6. An annual monitoring program, with the requirements of Section 4.3 expanded to ensure sufficient personal monitoring data is collected on all designated workers (workers with potential exposures greater than 5 mSv), to support a statistically valid estimate of personal doses		
7. A communication strategy to advise all designated workers:		
<ul style="list-style-type: none"> that their potential dose places them into the designated worker category 		
<ul style="list-style-type: none"> of the methods they can use to minimise their exposure 		
8. Details of the equipment used in the monitoring program, including calibration status, and method of calibration		
9. Identification of any areas of the mining operation (if any) in which secular equilibrium has potentially been disturbed		
10. A commitment to apply a dose assessment procedure approved by the regulator as per WHS Mines Regulations r. 641Q(2)		
11. The dose conversion factors applied to the calculation of internal dose arising from inhalation of dust, including:		
<ul style="list-style-type: none"> for any areas in which secular equilibrium has been disturbed 		
<ul style="list-style-type: none"> the input parameters to the derivation of the dose conversion factors 		

Information required	Completed	Page #
12. The dose coefficient for inhalation of isotopes of radon and their progeny, including the equilibrium factor used		
13. A monitoring program to calculate potential doses to critical groups, and if required, exposure controls to assure compliance with the annual public dose limit		
14. Links to the RWMP for the operation		
15. Details about the induction and training course in radiation protection and exposure minimisation provided to the workforce (including contractors) and other people at the mining operation		
16. An overview of the system used for record keeping, implementation and evaluation of exposure controls, calculation of doses, and reporting to workers and the regulator		
17. A commitment to verifying the effectiveness of the implementation of the RMP		
18. An appendix listing the commitments made in the RMP		

Appendix 9 Checklist for an elevated radiation exposure risk mining RMP (tier 5)

These requirements are in addition to Appendix 4.

Information required	Completed	Page #
1. An annual monitoring program that meets the requirements of section 4.5, expanded to ensure sufficient personal monitoring data is collected on all workers with potential exposures of 3 - 5 mSv to support a statistically valid estimate of personal doses, and allow for trend analysis and intervention to ensure doses remain as low as reasonably achievable		
2. Identification of all workers whose annual effective dose will potentially exceed 10 mSv, and the details of the personal monitoring program to effectively assess their dose		
3. Detailed procedures designed to ensure workers whose doses potentially exceed 5 mSv are maintained as low as reasonably achievable		
4. Evidence of the application of the hierarchy of control to minimise exposures to workers, especially those with the potential to exceed an annual effective dose of 5 mSv		
5. Evidence of the application of best practicable technology in the design of plant and equipment, and controls to maintain exposures as low as reasonably achievable		
6. Nomination of investigation levels which, if exceeded, will trigger an investigation into a source of exposure or reported dose		
7. Use of instantaneous readout detection equipment in areas of the mine with the potential for elevated radiation exposures		

Appendix 10 Radiation safety officer (RSO) requirements

The RMP should describe the management and reporting structure for the particular site, and the duties and qualifications of relevant workers and, in particular, the RSOs performing radiation protection duties.

The RMP should also include a clear commitment to provide adequate staff with appropriate qualifications and experience, and availability to collect the data required to perform dose assessments, evaluate exposure controls and advise the site senior executive or exploration manager on all aspects of radiation protection on the site.

Qualifications

A prerequisite to formal approval as an RSO for a mining or minerals processing operation that uses or handles NORM is (as a minimum) the successful completion of an undergraduate degree in a relevant technical discipline that has, at its core, physics, chemistry, mathematics, environmental science or engineering.

To perform the complex calculations required to compile dose assessments, the RSO should have a firm grasp of advanced mathematical principles. As an exploration operation may have a reduced requirement for high level mathematics, it is not always necessary for the RSO to be able to perform all the calculations expected of an RSO (relevant mine). This reduced requirement is entirely dependent on the hazard and risk profile of the exploration operation.

All categories of RSO are required to successfully complete a course about radiation protection from naturally occurring radioactive material that is approved by the regulator under WHS Mines Regulations r. 675ZZK(1)(a).

Because internal dose from long-lived alpha emitting radionuclides in dust is an important exposure pathway, the RSO (relevant mine) must have attained the pre-requisite criteria to be appointed as a mine air quality officer.

It is advisable that the individual attends and successfully completes a fixed radiation gauge training course and initially becomes the RSO for fixed gauges.

Experience

There are two principle aspects of experience, which an RSO must possess. These are technical experience and relevant background.

Technical experience

An RSO should be thoroughly conversant with the various radiation monitoring and recording techniques approved by the regulator, as well as with the appropriate reporting protocols.

As per WHS Mines Regulations, Schedule 26 clause 1(3)(d), a nominee for the role of RSO (relevant mine) must have 12 months of practical experience in radiation protection activities under the direct supervision of an existing approved RSO (relevant mine). Although not mandatory, it is deemed best practice for the mine operator to nominate the candidate for appointment, and provide a learning and development program to the regulator.

For potential new RSOs with exceptional qualifications or experience in radiation safety, the supervision period may be revised to less than 12 months if the appointment is to be made to a tier 1, 2 or 3 operation.

In other circumstances, particularly if the nominee is to be appointed as an RSO (relevant mine) at a tier 5 operation, the supervision period may be extended beyond the 12-month period nominated in WHS Mines Regulations Schedule 26 clause 1(3)(d).

Relevant background

Protection of workers, public and the environment from potentially harmful effects of ionising radiation requires an understanding of many disciplines.

In the case of mining and mineral processing in Western Australia, technical areas such as physics, metallurgy and process control are required for the theoretical planning and implementation phase of the RMP.

Once operations commence, a skill set in occupational hygiene complemented by general understanding of other relevant disciplines is considered ideal for the monitoring, data analysis and reporting of radiation monitoring data.

It is highly recommended that the RSO has previous employment history or experience in an exploration, mining or processing environment.

Legislative framework(s)

It is expected that all categories of RSO are conversant with all Western Australian legislation, and national documents that are cited in, or influence, the State's legislative framework for radiation safety in mining and mineral processing operations.

Where applicable, the RSO should also be able to demonstrate familiarity with international publications, especially those from the International Commission for Radiological Protection and IAEA that are cited in, or influence the Australian radiation protection legislative framework.

Approved or authorised RSO's from jurisdictions outside Western Australia are required to demonstrate that they are conversant with the Western Australian framework and methodologies enshrined in the series of NORM guides.

Continuous professional development

It is strongly recommended that an RSO (relevant mine) commits to continuously update their skills and knowledge, for example, as:

- regulatory documents, including applicable national and international guides, are reviewed and amended
- new radiation monitoring equipment becomes available
- new monitoring methods are proposed and implemented
- dose conversion factors for assessments of internal radiation exposures change based on the latest research
- new software for assessment of radiological impact on the environment becomes available and is updated.

Appropriate resources

The RMP should also list the resources required to implement the sampling and monitoring program, including the:

- make and model of sampling and monitoring equipment
- calibration methods, frequency, and traceability to a primary standard
- maintenance and replacement schedule
- examples of warning signs used on site and their locations.

Appendix 11 Information for radiation safety officers appointed under the *Mines Safety and Inspection Act 1994*

Under the former Mines Safety and Inspection Regulations 1995, specifically r. 16.9(2), radiation safety officers were required to have qualifications and experience satisfactory to the State mining engineer.

If candidates nominated for the role of RSO met the criteria as listed in Appendix B of NORM Guideline 1, they were approved by the State mining engineer.

New and updated titles

The title RSO (exploration) was inferred in the previous approval process, but was not widely applied. Inclusion of the term formalises recognition of the title.

The title RSO (restricted) is an addition to the previous approval process, and reflects the risk-based approach.

Under the *Mines Safety and Inspection Act 1994* and regulations, a candidate who met the criteria outlined in Appendix B of *NORM Guideline 1: Applying the system of radiation protection to mining operations*, and received approval from the State mining engineer in accordance with regulation 16.9 was deemed as an RSO (NORM). The title RSO (relevant mine) replaces the title RSO (NORM).

Appendix 12 References

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) *National directory for radiation protection* (2nd Edition, 2021) (NDRP)

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) *Radiation Protection Series 9 - Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing* (2005) (RPS-9)

International Atomic Energy Agency (IAEA) *Governmental, legal and regulatory framework for safety: General safety requirements* (Rev.1, 2016) (GSR Part 1)

International Atomic Energy Agency (IAEA) *Radiation protection and safety of radiation sources: International basic safety standards* (GSR Part 3)

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