

Australian Government

Australian Radiation Protection and Nuclear Safety Agency



Radiological hazard assessment of the ARPANSA Yallambie site

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Why perform a hazard assessment?



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Hazard assessment

A hazard assessment should be performed to provide a basis for a graded approach in preparedness and response for a nuclear or radiological emergency.

- 3.1.18. Hazards should be identified and potential consequences of an emergency should be assessed to provide a basis for establishing arrangements for preparedness and response for a nuclear or radiological emergency. These arrangements should be commensurate with the hazards identified and the potential consequences of an emergency.
- 3.1.19. For the purposes of these safety requirements, assessed hazards are grouped in accordance with the emergency preparedness categories shown in Table 3

Categories



Emergency preparedness categories

Category	Description	
II	Facilities, such as some types of research reactors and nuclear reactors used to provide power for the propulsion of vessels (e.g. ships and submarines), for which on-site events are postulated that could give rise to doses to people off-site that would warrant urgent protective actions or early protective actions and other response actions to achieve the goals of emergency response in accordance with international standards, or for which such events have occurred in similar facilities. Category II (as opposed to category I) does not include facilities for which on-site events (including those not considered in the design) are postulated that could give rise to severe tissue reactions off-site, or for which such events have occurred in similar facilities.	EPC II: Potent which trigger actions off-sit Table B.2;
	Facilities, such as industrial irradiation facilities or some hospitals, for which on-site events are postulated that could warrant protective actions and other response actions on-site to achieve the goals of emergency response in accordance with international standards, or for which such events have occurred in similar facilities. Category III (as opposed to category II) does not include facilities for which events are postulated that could warrant urgent protective actions or early protective actions off-site, or for which such events have occurred in similar facilities.	EPC III: Poten less than thos would trigger actions off-sit Table B.2

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Summary table of criteria used for urgent and early protective actions

Phase	Protective Action	Output	Criteria	RPS G-3 Reference
Urgent	Evacuation	Total Effective Dose	50 mSv	RPS G-3 Part 1
Urgent	Sheltering	Total Effective Dose	10 mSv	Table B.2
Early	Temporarily relocate	Total ground concentration	Alphas: 50,000 Bq m ⁻² Betas or Gammas: 1,000,000 Bq m ⁻²	
Early	Restrict consumption of non-essential food, milk and water	Total ground concentration	Alphas: 100 Bq m ⁻² Betas: 1,000 Bq m ⁻² Gammas: 10,000 Bq m ⁻²	RPS G-3 Part 2 Table A.2

ARPANSA onsite and offsite area

With site boundary buffers used during assessment



Reference incident

- The reference incident chosen is based on sources undergoing thermal stress from an undisclosed initiating event (intentional or unintentional).
- Assumptions:
 - the release to the environment occurs in a 1-hour period
 - once radionuclides are released they are respirable
 - the release occurs at ground level.

Airborne release fraction for sealed and unsealed sources

Source type	Airborne release fraction	Description	Reference in US DOE Handbook
Sealed	0.6 %	Sealed encapsulation is compromised exposing the solid source (powder) to thermal stress.	4.4.1
Unsealed	10 %	Vigorous burning organic fire that burns to complete dryness over aqueous solution.	3.3.7

Airborne release fractions were taken from the United States Department of Energy Handbook for Nonreactor Facilities (US DOE 2013).

An 80% level of retention is included in the scenario due to the hold-up of radionuclides to the atmosphere through the building structure (ANSTO 2017).

Summary of modelled scenarios

Location	Description	Total sealed activity (MBq)	Total unsealed activity (MBq)	Highest security category source	Release Incident (1 hour release)
Room 115	Neutron Research and Measurement	1.5E+04	0.0E+00	4	0.6% release of sealed sources, 80% building retention factor (Category 3 sources not included in Reference Scenario)
Room 118	Teletherapy and Cobalt	3.5E+04	0.0E+00	4	0.6% release of sealed sources, 80% building retention factor (Sources contained in heavily shielded and fireproof containers and sources within safe are not included in assessment)
Room 135	Waste Store	1.4E+05	1.1E+02	4	0.6% release of sealed sources, 10% release of unsealed sources 80% building retention factor
Room 137	RSO Strong room	1.3E+05	9.3E+01	4	0.6% release of sealed sources, 10% release of unsealed sources 80% building retention factor
Room 327a	Radioisotope Laboratory	3.5E+04	3.0E+02	4	0.6% release of sealed sources, 10% release of unsealed sources 80% building retention factor
Room 352a	Radium Waste Room	7.1E+01	1.1E+03	5	 0.6% release of sealed sources, 10% release of unsealed sources 80% building retention factor (Unlikely that thermal stress will result in release of sources - release has been included for screening purposes)

Summary of modelled scenarios (cont.)

Room	Description	Included in reference Incident?
115	Neutron research and measurement	 3 sealed Cat 3 sources (2 x AmBe & 1 x Am-241) not included in Reference Incident (secured in heavily shielded containers) 2 sealed Cat 4 sources (AmBe & Cs-137) in minimal housing included
118	Teletherapy and Cobalt Laboratory	 2 large Teletherapy sources (Co-60 & Cs-137) not included in Reference Incident (housed within heavily shielded and fireproof containers) Various Cat 5 sources housed in safe are not included in Incident 5 source Cs-137 set (2 x Cat 4, 3 x Cat 5) in portable shielding will be included in Incident 1 x Co-60 source & 6 x Sr-90 Cat 5 sources included in the Reference Incident
327a	Radioisotope Laboratory (RIL room)	• 1 x sealed Cat 4 Am-241, and several sealed and unsealed Cat 5

Summary of modelled scenarios (cont.)

Room	Description	Included in Reference Incident?
135	Radioactive Waste Store	• 1 x Cs-137 & 1 x Ra-226 sealed Cat 4 and multiple sealed and unsealed sources designated at security category 5. All sources included in the Reference Incident.
137	Radiation Safety Officer Strong room	 Contains sealed Am-241, Cs-137 and Ra-226 Cat 4 sources and multiple sealed and unsealed Cat 5 sources, all of which have been included in the Reference Incident.
352a	Radium Waste Store	 Radium waste. Combination of sealed and unsealed category 5 and below material. Has been included in Reference incident for completeness and for screening purposes. It is unlikely that Thermal Stress to this room would result in a release.

Atmospheric dispersion modelling

- ARGOS decision support tool used for simulations
- Used BOM gridded weather data (~1.5x1.5km resolution)
- ARGOS batch run feature used allows a user to produce many different simulation outputs where each simulation has a different release time. Release time intervals or distributions are selected by the user
- Simulations were run at 25 hour intervals from 01 July 21 – 30 June 22 to provide a variety of different weather conditions representative of seasonal changes and day/night cycles



Analysis methodology – spatial method

This method provides a spatial map of consequences indicative of site and prevailing weather conditions





Analysis methodology – REPPIR method

- This method provides a conservative measure of the impact of varying weather on predicted consequences
- For each simulation output, calculate the maximum consequence at pre-selected distances
- Calculate the mean and 95th percentile of maximum consequence for each distance
- 95th percentile would be used as an input for emergency planning considerations



Exposure pathways considered

- The major exposure pathways for off-site receptors were identified as inhalation, cloudshine, and groundshine.
 - Inhalation dose: Using ICRP119 (ICRP 2012) dose coefficients;
 - External Gamma Plume shine dose: Using ICRP144 (ICRP 2020) dose coefficients;
 - External Gamma deposition dose: Using ICRP144 (ICRP 2020) dose coefficients;
- The inhalation pathway due to resuspension was not considered in this assessment as it was determined to contribute a negligible fraction of the dose.
- The ingestion pathway was considered separately to other dose pathways as it was determined to contribute a negligible fraction of the total effective dose.
- Total ground concentrations of gamma, beta, and alpha radionuclides were compared to levels defined in RPS G-3 (ARPANSA 2019b) where restrictions may be placed on consumption of nonessential local produce and rainwater to determine whether off-site monitoring of residential local produce and rainwater is required as part of emergency planning.

Results – 95th percentile of maximum value

	95 th pe	rcentile of	the Maxim	num value f	Protective action	Criteria							
	Tot	tal Effective	Dose 7 Days	(Sv)	Ground Concentration Bq/m2			Evacuation	50 mSv (5E-02 Sv)				
95 th								Sheltering	10 mSv (1E-02 Sv)				
of maximum value	Adult	1 year old	5 year old	10 year old	Alpha	ar Alpha	Beta	Beta	Beta	na Beta	Gamma	Temporarily	Alphas: 50,000 Bq m ⁻² (1E+04)
Room 115 Onsite	1.56E-03	5.96E-04	7.44E-04	1.02E-03	1.50E+01	0.00E+00	3.07E+00	relocate	(1E+06)				
Room 115 Offsite	7.25E-04	2.77E-04	3.46E-04	4.76E-04	8.03E+00	0.00E+00	1.64E+00	Restrict	Alphas: 100 Bg m ⁻² (1F+02)				
Room 118 Onsite	3.46E-07	1.30E-07	1.39E-07	2.25E-07	0.00E+00	1.54E+00	2.39E+01	consumption of non-essential	Betas: 1,000 Bq m ⁻² (1E+03)				
Room 118 Offsite	1.61E-07	6.06E-08	6.44E-08	1.04E-07	0.00E+00	8.27E-01	1.28E+01	food, milk and water	Gammas: 10,000 Bq m- ² (1E+04)				
Room 135 Onsite	3.05E-04	2.28E-04	2.36E-04	2.97E-04	6.23E+01	2.14E-02	8.03E+01						
Room 135 Offsite	1.42E-04	1.06E-04	1.10E-04	1.38E-04	3.34E+01	1.15E-02	4.30E+01						

Results – 95th percentile of maximum value (cont.)

	95 th pe	rcentile of	the Maxim	ium value f	Protective Action	Criteria			
	Total Effective Dose 7 Days (Sv)					Ground Concentration Bq/m2		Evacuation	50 mSv (5E-02 Sv)
95 th								Sheltering	10 mSv (1E-02 Sv)
percentile of maximum value	Adult	1 year old	5 year old	10 year old	Alpha	Beta	Gamma	Temporarily	Alphas: 50,000 Bq m ⁻² (1E+04)
Room 137 Onsite	3.04E-03	1.24E-03	1.51E-03	2.07E-03	7.17E+01	4.78E-02	5.93E+01	relocate	(1E+06)
Room 137 Offsite	1.41E-03	5.76E-04	7.04E-04	9.60E-04	3.84E+01	2.56E-02	3.18E+01	Restrict	Alphas: 100 Bg m ⁻² (1E+02)
Room 327a Onsite	5.31E-03	2.03E-03	2.54E-03	3.49E-03	5.22E+01	3.50E-01	2.59E+00	consumption of non-essential	Betas: 1,000 Bq m ⁻² (1E+03)
Room 327a Offsite	2.47E-03	9.44E-04	1.18E-03	1.62E-03	2.80E+01	1.87E-01	1.39E+00	food, milk and water	Gammas: 10,000 Bq m- ² (1E+04)
Room 352a Onsite	5.68E-05	4.28E-05	4.41E-05	5.55E-05	1.17E+01	0.00E+00	8.81E+00		
Room 352a Offsite	2.64E-05	1.99E-05	2.05E-05	2.58E-05	6.29E+00	0.00E+00	4.72E+00		

Results – 95th percentile of maximum value (cont.)

Room 327a REPPIR 95 th percentile value											
		Total Effective D	Ground	nd Concentration Bq/m2							
Distance	Adult	1 year old	5 year old	10 year old	Alpha	Beta	Gamma				
50m	2.47E-03	9.44E-04	1.18E-03	1.62E-03	2.80E+01	1.87E-01	1.39E+00				
100m	1.18E-03	4.51E-04	5.63E-04	7.75E-04	1.34E+01	9.00E-02	6.67E-01				
200m	6.14E-04	2.35E-04	2.93E-04	4.03E-04	6.59E+00	4.42E-02	3.27E-01				
350m	3.41E-04	1.30E-04	1.63E-04	2.24E-04	3.82E+00	2.56E-02	1.90E-01				
500m	2.33E-04	8.90E-05	1.11E-04	1.53E-04	2.54E+00	1.70E-02	1.26E-01				
750m	1.57E-04	6.01E-05	7.50E-05	1.03E-04	1.74E+00	1.17E-02	8.66E-02				
1km	1.08E-04	4.13E-05	5.15E-05	7.09E-05	1.30E+00	8.68E-03	6.43E-02				
1.5km	6.69E-05	2.56E-05	3.19E-05	4.39E-05	8.06E-01	5.40E-03	4.00E-02				
2km	4.13E-05	1.58E-05	1.97E-05	2.72E-05	5.71E-01	3.83E-03	2.84E-02				

Room 327a. 95th percentile of maximum value from each simulation at set distances from the edge of the site boundary.

Spatial outputs



Room 327a 95th Percentile Total Effective Dose 7 days Adult (Sv)



Room 327a 95th Percentile Alpha Ground Concentration (Bq/m²)

Conclusion

- Neither the criteria for Urgent nor Early actions has been exceeded for the off-site locations.
- The Yallambie site can be classified as an EPC III site.
- The room with the highest predicted off-site dose is Room 327a followed by rooms 115 and 137
- It may be prudent to undertake some follow-up monitoring (e.g ground and personal monitoring),out to approximately 100m – the distance at which the predicted dose is within an order of magnitude (ie, above 1 mSv), of the Sheltering urgent action.

Conclusion

- Predictions for ground concentrations were shown to be below the criteria for Early actions. They were many orders of magnitude below the criteria for temporary relocation.
- Predicted concentrations were well below the OIL criteria for the Beta and Gamma grouping nuclides for restriction of local produce.
- Some rooms containing an alpha source were within an order of magnitude of the restriction of local produce criteria.
- It may be prudent to undertake sampling/monitoring out to distances that are within an order of magnitude of the criteria.
 - Results show that a distance between 100 200m from the site boundary would be sufficient for room 327a. For Room 137 a distance of 200m would be sufficient.
- Spatial outputs indicates that the weather conditions which may lead to higher consequences are to the East and South of the site. If monitoring/detectors were to be setup on site, positioning a detector to the East of the building may provide the optimal location based on the plume pattern.

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Thank you

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