Chapter 4
Radioactive Waste to be Held in the Repository

One of the key inputs to the design and management of the repository is to accurately define and quantify the types and volumes of low level and short-lived intermediate level radioactive waste to be disposed of at the facility.

This chapter provides:

- an overview of the existing inventory of low level and short-lived intermediate level waste
- estimates of potential future low level and short-lived intermediate level waste generation
- an outline of proposed waste acceptance criteria for waste to be disposed of at the repository.

4.1 Inventory of Existing Waste

Australia has accumulated about 3700 m^3 of low level and short-lived intermediate level radioactive waste from over 100 years of research, medical and industrial use of radioactive material. This is the conditioned volume requiring disposal. The approximate volumes are given below:

- 2010 m^3 of slightly contaminated soil from research by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) into ore processing, which is currently stored in drums near Woomera
- 1320 m^3 of operational waste from Australian Nuclear Science and Technology Organisation (ANSTO) operations at Lucas Heights near Sydney
- 210 m^3 of contaminated soil, sealed radioactive sources and other equipment held by the Department of Defence
- 160 m^3 (allowing for conditioning) of sealed radioactive sources used in gauges, smoke detectors, medical equipment and luminous signs stored at numerous locations around Australia, including in government stores, research institutions and industry stores.

The 2010 m^3 of slightly contaminated soil stored near Woomera arose from CSIRO research into the processing of radioactive ores during the 1950s and 1960s. This material is located at Woomera close to Site 52a, and is contained in some 9726 drums of 207 L capacity. It is low level waste ready for transport and disposal without further conditioning.

The 1320 m^3 of ANSTO operational waste, including clothing, paper and glassware, is stored at Lucas Heights near Sydney, and is in a conditioned form ready for disposal. It comprises packed waste of about 5000 drums of 205 L capacity and 400 drums of 300 L capacity, and unpacked waste of approximately 250 further drums of 205 L capacity.

The 210 m^3 of Department of Defence waste, which consists of contaminated soils from land remediation, sealed sources, gauges, electron tubes, equipment (watches and compass parts) and some aircraft ballast, is held at a number of locations around the country.

The remaining waste (approximately 160 m^3 conditioned volume) comprises spent sealed sources and miscellaneous laboratory waste from hospitals, universities, industry (including factories) and other ‘small’ waste producers and holders, and is distributed throughout the country. Figure 4.1 illustrates an example of such waste.

FIGURE 4.1
Existing waste

A summary of existing waste by state is provided in Table 4.1. The total inventory is 3700 m^3 (60%) is held in South Australia. Of the 2228 m^3, 2010 m^3 is contaminated soil stored at Woomera. See Appendix B for more detailed inventory of key radionuclides.

4.2 Future Waste Generation

Recycling of disused sources or radioactive materials used in medicine, industry or research is now extensively practised, and estimated future waste arisings are therefore relatively small.

It is expected that about 40 m^3 of low level and short-lived intermediate level waste will be generated in the future in Australia on an annual basis. Of this, about 30 m^3 (conditioned) is expected to be generated each year by ANSTO through routine operational activities. Other waste producers are expected to generate up to approximately 10 m^3/yr in conditioned form ready for disposal.

Table 4.2 summarises estimated routine future arisings of low level and short-lived intermediate level radioactive waste, and also notes the waste volume which would be generated from the decommissioning of the High Flux Australian Reactor (HIFAR), and from the replacement research reactor. There are various decommissioning options possible for HIFAR, and the amount of low level and short-lived intermediate level waste generated would vary from 500 to 2500 m^3 depending on the option chosen.

Option 1 involves immediate dismantling of HIFAR to a new site after its decommissioning, which would generate about 2500 m^3 of low level and short-lived intermediate waste. Option 2 involves the removal of fuel and heavy water, followed by care and maintenance for approximately 30 years, then entombment of the remaining structure in concrete. This option would involve the generation of 500 m^3 of low level waste. Option 3 would involve the removal of fuel and heavy water, followed by care and maintenance for up to 120 years, then dismantling to a new site, and would generate 2000 m^3 of low level and short-lived intermediate waste (PPK Environment & Infrastructure 1998).

ANSTO's preferred HIFAR decommissioning strategy is either Option 2 or 3 (PPK Environment & Infrastructure 1998). The amount of low level and short-lived intermediate level radioactive waste generated from the decommissioning of the replacement research reactor is likely to be within the range of volumes for the decommissioning of HIFAR.

TABLE 4.1 Summary of inventory of low level and short-lived intermediate level waste by state (approximate conditioned volumes for disposal)

State	Locations	Estimated volume[(1)]
South Australia	Adelaide and regional hospitals, universities and other research organisations, private companies and some government departments Locations include: Adelaide CBD and surrounding suburbs, including Salisbury; Mt Gambier, Woomera, Olympic Dam, Port Pirie, Whyalla and Loxton Includes 2010 m^3 of slightly contaminated soil stored near Woomera from CSIRO research into the processing of radioactive ores during the 1950s and 1960s	2228 m^3
Victoria	Melbourne and regional hospitals, universities and other research organisations, private companies and some government departments Locations include: Melbourne CBD and surrounding suburbs, including Clayton; Geelong, Sale and Wodonga	33 m^3
New South Wales	Sydney and regional hospitals, universities and other research organisations, private companies and some government departments Locations include: Sydney CBD and surrounding suburbs including Lidcombe, Liverpool, Menai (Lucas Heights), North Ryde; Griffith, Wollongong and Armidale Includes 1320 m^3 of ANSTO material stored at Lucas Heights near Sydney	1355 m^3
Queensland	Brisbane and regional hospitals, universities and other research organisations, private companies and some government departments Locations include: Brisbane CBD and surrounds, Esk, Mt Isa, Rockhampton and Townsville	45 m^3
Tasmania	Hobart, Launceston and regional hospitals, universities and other research organisations, private companies and some government departments Locations include: Hobart CBD, surrounding suburbs and regional areas	15 m^3
Australian Capital Territory	Hospitals, universities and other research organisations, private companies and some government departments Locations include: Canberra CBD, surrounding suburbs and regional areas	8 m^3
Northern Territory	Hospitals, universities and other research organisations, private companies and some government departments Locations include: Darwin CBD, surrounding suburbs and regional areas	16 m^3
Western Australia	Low level and short-lived intermediate level waste in WA is disposed at the intractable waste disposal facility (IWDF), Mount Walton East	
TOTAL		3700 m^3

(1) Further information on the waste inventory is provided in Appendix B. This information includes estimates of the total concentrations of key radionuclides that are expected to be disposed of in the repository.

TABLE 4.2 Summary of future low level and short-lived intermediate level waste arisings

Locations and nature of waste	Estimated volume when packaged / conditioned
ANSTO (HIFAR and replacement research reactor)	30 m^3/yr
Nationwide, other sources	Up to 10 m^3/yr
Moata Research Reactor (shut down in 1995)	55 m^3
Lucas Heights HIFAR research reactor decommissioning	500–2500 m^3
Lucas Heights replacement research reactor decommissioning	Amount expected similar to HIFAR

About 55 m^3 (100 tonnes) of low-level radioactive waste will also be generated from ANSTO's 100 kW Moata research reactor, which was shut down in May 1995, and the fuel, cooling system and electric systems were removed. A decommissioning plan has been prepared and agreed to by the regulator (ARPANSA). The timing of dismantling the reactor has not yet been decided.

The repository would be designed to take about 10,000 m^3 of low level and short-lived intermediate level radioactive waste (although the limit would be set for total activity for various radionuclide groups). The estimated initial operational life of the repository is 50 years, after which time there would be an operational review. The finalised volume and total activity would be in accordance with ARPANSA approvals (Section 3.3).

4.3 Waste Acceptance Criteria

4.3.1 Waste Acceptance Criteria General Factors

A key feature influencing the performance and safety of the repository would be the nature of the wastes that are accepted for disposal at the site. Waste acceptance criteria (WAC) are the set of requirements that must be met before radioactive waste can be accepted for disposal at a repository. It is accepted international practice to establish such criteria for the acceptable of waste at disposal facilities. Factors that influence WAC can be associated with a number of areas of waste management, in particular:

- transport
- operations and handling at the disposal facility
- post-closure safety assessment.

WAC Scope

WAC commonly include:

- general conditions for the acceptance of waste
- those materials excluded or treated prior to disposal
- conditions for the preparation of different types of waste
- acceptability of waste containers
- requirements for delivery of waste to the repository
- quality assurance requirements
- information required by the site operator from the consignor.

The WAC define the specific requirements to be met by a consignor for a radioactive waste package to be accepted for transport and disposal at the repository. The WAC address the characteristics of both the package and the waste, and other key issues such as documentation, procedures to be used by the consignor, authorisations and demonstrations of conformity.

The WAC also incorporate the requirements for packaging, labelling and transport of the waste following accepted international practice (as described in International Atomic Energy Agency (IAEA) Waste Safety Standards Committee documents and others, such as IAEA-TECDOC-1097 (International Atomic Energy Agency 1999), and are covered by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) 2001 *Code of practice for the safe transport of radioactive material* (ARPANSA 2001 Code), described in Section 3.2. Therefore, the WAC establish the acceptable standards for radioactive waste packaging through processing, transport, storage and disposal.

The WAC are developed from applicable national and international regulations and guidelines, which cover the safe management of radioactive waste at all stages. A safety assessment of the complete waste management system, from production to final disposal and post-closure, is also used in determining the criteria, especially those quantitative aspects.

To meet regulatory and safety requirements, constraints are imposed on both the waste packages and the components of the waste packages, taking account of implications on the waste inventory and the ultimate wasteform for disposal at the repository. Within these constraints it is then possible to define specifications for acceptable waste and waste packages and hence the WAC.

Although safety considerations are of primary importance in establishing WAC, non-safety-related elements that may affect the acceptability of a waste package at a disposal facility also need to be taken into account. Considerations may include, for example, compatibility with package handling equipment at the site and the need to provide a disposal record.

The detailed WAC for any consignment may be derived from a combination of factors, including transport package restrictions and/or limitations imposed by handling equipment at the disposal site. Compliance of the waste package with the WAC would be determined by a range of methods, including records of the waste characteristics and information obtained during the design and production of the waste package. The generation and management of these records of waste characteristics is covered by quality assurance and quality control arrangements, which may include waste records, waste assays, the recording of key plant and process information, and post-production testing.

Radionuclide Activity Factors

WAC would be applicable to each individual waste package. Restrictions may also be placed on individual radionuclides within a particular package (or group of packages from a waste supplier, constituting a consignment) in order to determine the appropriate disposal strategy for the package within the repository.

Activity concentration limits for each type of radionuclide accepted into the facility would be derived from a full assessment of the risks posed by radioactivity reaching the biosphere. For example, exposure scenarios due to inadvertent intrusion after the period of institutional control would be used as an input into determining the maximum acceptable total concentration of longer-lived isotopes. The risk from possible groundwater leaching would be considered throughout the lifetime of the facility.

Activity limits would be derived from a detailed pathway analysis, looking at normal operational and accident conditions.

4.3.2 Proposed Waste Acceptance Criteria

Proposed WAC are being developed for the national repository. Aspects of the proposed criteria (which will be further refined) are summarised below.

Conditions of Acceptance

A number of general conditions of acceptance of waste have been developed, including:

- Only low level and short-lived intermediate level waste (see Sections 2.3.1 and 2.3.2) will be accepted.
- Waste will require a current certificate or letter of authorisation issued by the appropriate government department (State/Territory/Commonwealth radiation safety regulator) before it will be accepted for disposal.
- Waste generated outside of Australia will not be accepted.
- Category S (long-lived intermediate level waste) material will not be accepted.

Materials to be Excluded or Treated Prior to Disposal

In addition, a number of criteria have been developed that relate to materials that need to be excluded or treated prior to disposal. Key factors include:

- Liquid waste would not be accepted. There would be a limit on the moisture content of solids.
- Wastes that may enhance the migration of particular radionuclides or heavy metals should be treated to reduce the possible long-term effects of leaching by water.
- No PCBs or PCB-contaminated items would be accepted.
- Oils and corrosive materials would not be accepted.
- Waste should not contain or be capable of generating gaseous materials in quantities that may result in the release of harmful vapours or fumes, or build-up of pressure.
- If compressed gases are present in the material, they must be appropriately treated so that they do not release fumes or build up pressure. The would only be disposed of if appropriately treated.
- Highly flammable materials, as defined in the *Australian code for the transport of dangerous goods by road and rail* (ADG Code; Advisory Committee on the Transport of Dangerous Goods 1998) would not be accepted, and flammable and non-flammable material would be separated and packed accordingly.
- Waste containing pyrophoric material would be processed to render it inert and approval of such processing confirmed by site operator prior to dispatching.
- Waste should not contain any explosive materials as defined in the ADG 1998 Code.
- Waste should be free of biological material or treated to destroy any relevant micro-organisms.
- No radioactive waste containing toxic, pathogenic or infectious material would be accepted unless appropriately treated or conditioned in accordance with relevant guidelines.
- Putrescible materials in waste should be excluded as far as practicable and should not exceed 1% of the primary containment weight.
- Radioactive waste material containing hazardous chemicals/agents would only be accepted if the radiological hazard clearly exceeds the toxic chemical/agent hazards, (other than covered by previous points).

Radioactivity Limits

Limits on radionuclide content would apply for the acceptance of waste for disposal, in accordance with criteria specified in the National Health and Medical Research Council (NHMRC) 1992 *Code of practice for near-surface disposal of radioactive waste in Australia* (NHMRC 1992 Code), or as subsequently modified by ARPANSA under any facility licence.

- Radioactivity concentrations for Category A, B and C (see Section 2.3) waste packages shall not exceed the predetermined values for each radionuclide group, as authorised by ARPANSA, based on site-specific risk scenarios of an annual effective dose of 1 mSv being received by a member of the public from the presence of the waste (NHMRC 1992 Code).
- The activity concentration for Category A and B wastes shall be calculated by averaging the activity over the whole conditioned package or container, while Category C bulk waste activity may be averaged over the volume of the disposal structure.
- The activity concentration of radionuclides in waste packages containing a mixture of radionuclides shall not exceed the maximum value as calculated using the summation rule.
- Waste packages containing radionuclides within two or more inner packages shall be classified and labelled according to the most restrictive classification.

Waste Packaging

The proposed waste package for general application is a standard industrial 205 L drum made of mild steel with a lid held on by a band secured with a bolt. These drums are not hermetically sealed, and have limited shielding properties, but are suitable for most low level and short-lived intermediate level radioactive waste. Packages other than the standard 205 L industrial drum may also be used, with the approval of ARPANSA and the facility operator (see Section 3.3).

Where contents are of higher total activity, and thus require more radiation shielding they would be placed inside 205 L steel drums together with a cementitious grout mixture. Where

contents are of higher specific activity, for example sealed sources, they would be placed inside 205 L drums that have concrete shielding and separate inner containers.

The principal transport method is proposed to be by trucks. Standard 6 m International Organization for Standardization (ISO) containers, with the 205 L drums stacked inside using appropriate packing for stability, may be used. Transport methods would be in compliance with the requirements of the ARPANSA 2001 Code and any other conditions imposed by ARPANSA licensing.

Preparation of Category A, B and C Waste for Disposal

Category A, B and C wastes shall be conditioned so as to comply with packaging and container conditions (as set out in the ARPANSA 2001 Code and any ARPANSA licensing requirements). Category A wastes (low concentrations, short half lives) may need minimal treatment and may be placed directly into disposal trenches. Waste containing radium (Category B) would not be accepted unless it complied with established activity concentration limits.

Transport Packages

The following waste acceptance criteria would relate to transport packages:

- Waste would only be accepted inside transport packages approved by the site operator and properly labelled in accordance with applicable transport regulations.
- The external non-fixed contamination levels on transport packages arriving at the repository must not exceed 4 Bq/cm^2 beta/gamma and 0.4 Bq/cm^2 alpha averaged over 300 cm^2.
- External dose rates must comply with applicable transport regulations, and packages not be left un-vented for more than 30 days prior to delivery to site.

Waste Containers

The following limitations would be applicable to acceptance of waste containers within transport packages:

- A maximum dimension of any waste container would be imposed and the containers and metal drums should not weigh more than limits set by the site operator.
- All individual containers within a transport package must be appropriately and clearly labelled to enable traceability to point of origin.
- The site operator must be satisfied with the qualification of all waste container design, manufacture, filling and handling to meet all specifications for waste acceptance and disposal.
- The external non-fixed contamination levels on waste containers arriving at the repository must not exceed 4 Bq/cm^2 beta/gamma and 0.4 Bq/cm^2 alpha averaged over 300 cm^2.
- External dose rates must comply with applicable health physics regulations for the safe handling of the containers.
- The placement of all waste containers inside transport packages must be such as to allow easy retrieval.

Delivery of Waste to the Repository

The repository would only be open for receipt of waste at a certain specified interval for the initial campaign, and subsequent campaigns (every 2–5 years). The following criteria have been set for the delivery of waste to the repository:

- A minimum notice period will be applicable for any potential waste delivery to the site and no waste will be accepted without prior consent from the site operator.
- Waste will only be accepted during normal operating hours, unless specific arrangements have been made with the site operator.

- Delivery personnel will at all times abide by the site rules when on site.
- Empty containers will be returned to customers within a set time from delivery.

Quality Assurance

A quality assurance (QA) system for acceptance of waste would be put in place and strong adherence to the following aspects of this system would be enforced:

- Customers would implement a suitable quality assurance system for effective management of low level and short-lived intermediate level waste up to the time of acceptance at the repository, including arrangements for periodic review. This customer QA plan would require the site operator's approval prior to delivery.
- All waste shall be accompanied by a valid waste description document as approved by the site operator. The following information would be provided by waste producers:
  - the waste identifier (number and name) and consignor code
  - a description of the process generating the waste
  - estimated arisings from the waste producer in terms of activity, volume, mass and timescale
  - whether the waste is a new arising or has been identified in previous Australian radioactive waste inventory estimates
  - physical and chemical composition
  - the non-radiological hazardous waste components
  - type of conditioning and stabilisation undertaken
  - consolidation undertaken
  - method of assessment of radioactivity content
  - radionuclide composition
  - waste category.
- Acceptance of waste would be subject to waste receipt monitoring, which may include testing and inspection of each consignment or samples of consignments before conditioning and transport and after delivery. Non-conforming waste would be appropriately managed at the repository site, and the customer charged a cost penalty, and could be subject to an investigation with potential restrictions on further deliveries.