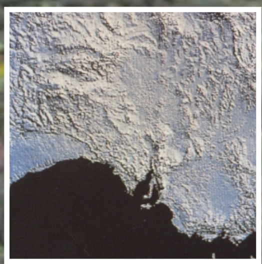
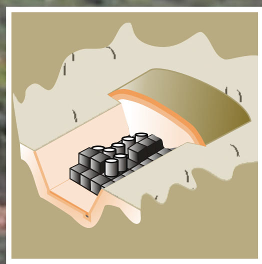
COMMONWEALTH DEPARTMENT OF EDUCATION SCIENCE & TRAINING

NATIONAL RADIOACTIVE WASTE REPOSITORY DRAFT EIS

SUMMARY



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Department of Education, Science and Training

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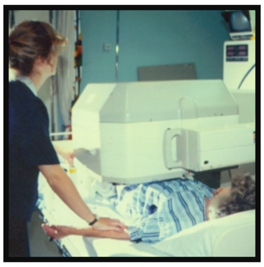
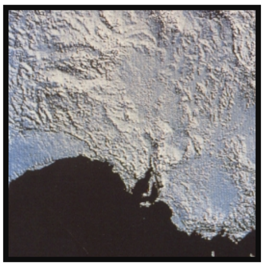
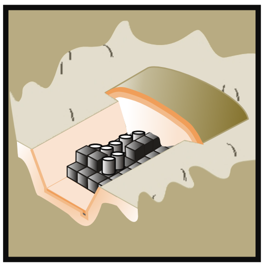
MAIN REPORT



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This environmental impact statement (EIS) has been prepared by PPK Environment & Infrastructure (PPK) on behalf of Department of Education, Science & Training (the Client). In preparing this EIS, PPK has relied upon and presumed accurate certain information provided by the Client, specialist subconsultants, certain State and Commonwealth government agencies and others identified herein. No warranty or guarantee, whether expressed or implied, is made with respect to the information reported or to the findings, observations or conclusions expressed in this EIS. Such information, findings, observations and conclusions are based solely on information in existence at the time of the investigation.

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How to Make a Submission

An important objective of the environmental impact statement (EIS) process is to ensure that all relevant information has been collected and assessed so that the Commonwealth Government can make an informed decision on the proposal. Making a submission is a way for the community to provide information to the proponent and the decision makers about the proposal. Interested persons, groups and authorities are encouraged to make a submission on this Draft EIS.

Viewing or Obtaining a Copy of the Repository EIS

The Draft EIS will be available for public review from the date published in press advertisements, which will also include the closing date for submissions and the locations of exhibition points.

The Draft EIS and Summary will also be available on the Department of Education, Science and Training's website: www.dest.gov.au/radwaste

What Can be Included in a Submission?

A submission can comment on any aspect of the proposal. It may provide information, options or suggestions on the material contained in the Draft EIS or may also identify errors or omissions. Comments may be made on general issues or specific items; they may cover related facts or topics that should be considered and may include suggestions on how to improve the proposal.

It is helpful if you can:

- provide your comments in point form so that the issues raised are clear to the reader
- refer each point to the appropriate sections of the Draft EIS
- include your name, address and date
- ensure that the submission is as clear as possible if hand written.

All submissions will be treated as public documents unless confidentiality is requested.

Contact Details

Submissions can be made by letter/fax/e-mail and should be sent to:

- Radioactive Waste Repository EIS
  Department of Education, Science and Training (Location 742)
  GPO Box 9880 CANBERRA CITY ACT 2601
- Facsimile: 02 6240 9184
- Email: repository@dest.gov.au

What Happens Next?

A supplement will be prepared taking into account and responding to the content of the public submissions received. It will be a public document. Together, the Draft EIS and Supplement will make up the Final EIS.

After receiving the Final EIS, Environment Australia will prepare its advice to the Minister for the Environment and Heritage taking into account the contents of the Final EIS and any additional documents relevant to the assessment. The Minister for the Environment and Heritage will then determine whether to give his approval for the proposal to proceed and, if so, set conditions under which it may do so.

Introduction

Most Australians benefit either directly or indirectly from the medical, industrial and scientific use of radioactive materials. This use produces a small amount of radioactive waste, including low level and short-lived intermediate level radioactive waste such as lightly contaminated soil, plastic, paper, laboratory equipment, smoke detectors, exit signs and gauges.

This waste is temporarily stored at more than 100 urban and rural locations around Australia, much of it in buildings that were neither designed nor located for the long-term storage of radioactive material and that are nearing or have reached capacity.

Storage locations include hospitals, research institutions, and industry and government stores. Storing such waste in many locations in non-purpose built facilities potentially poses greater risk to the environment and people than disposing of the material in a national, purpose-built repository where the material can be safely managed and monitored.

The objectives of the national repository are to:

- strengthen Australia's radioactive waste management arrangements by promoting the safe and environmentally sound management of low level and short-lived intermediate level radioactive waste
- provide safe containment of these wastes until the radioactivity has decayed to background levels.

To meet these objectives, it is proposed to construct a national near-surface repository at either the preferred site on the Woomera Prohibited Area (WPA) or either of the two nearby alternative sites.

The facility is not intended for the disposal of radioactive ores from mining. A national store for long-lived intermediate level waste will not be co-located with the national repository, and would be subject to a separate environmental assessment process.

The Proposed Site

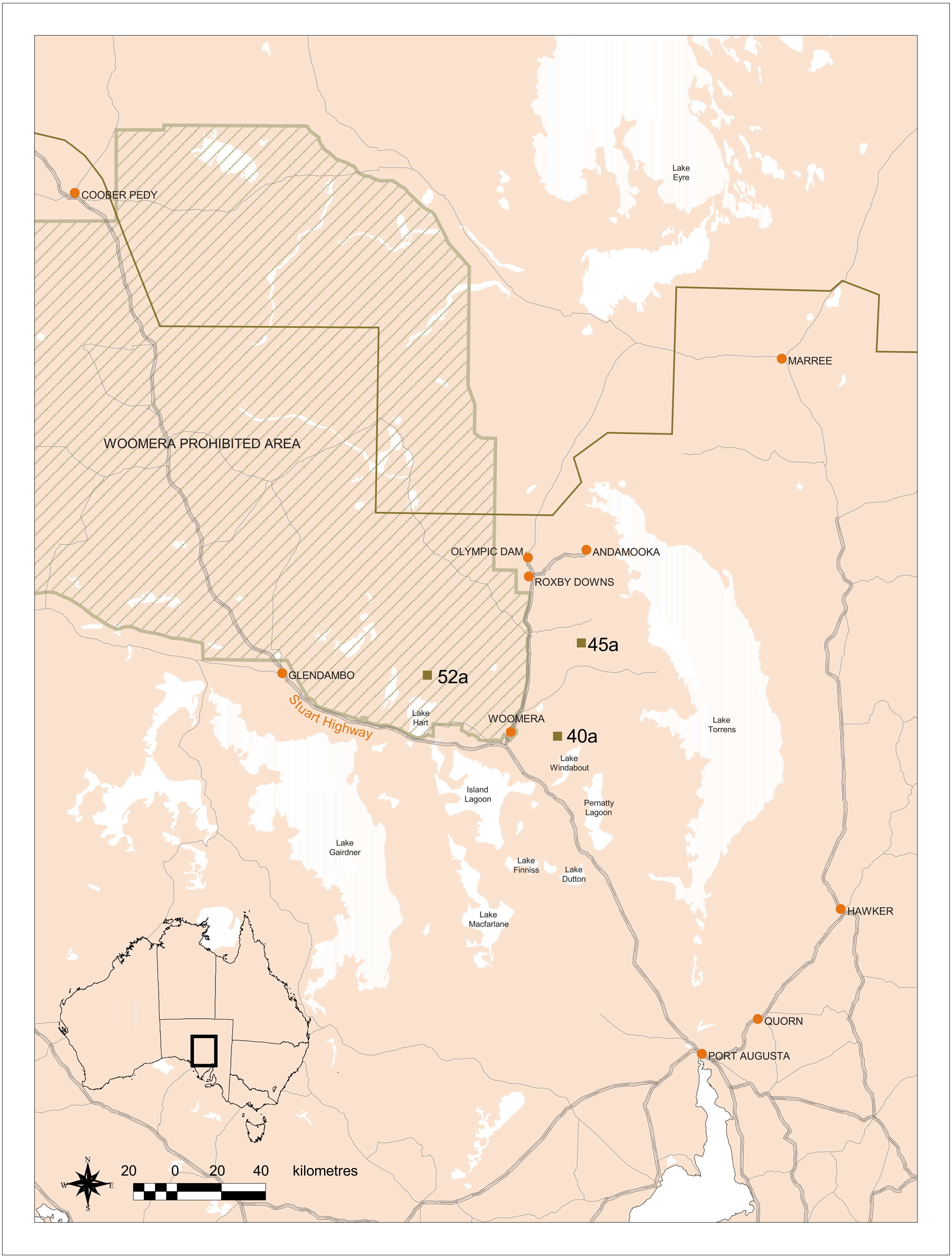
One preferred and two alternative sites have been selected for the national repository, following an extensive site selection process. All three sites are located in northern South Australia in a region known as central–north South Australia, approximately 400 km north of Adelaide, between the townships of Woomera and Roxby Downs (Figure 1). The sites are located in stony desert country with sparse saltbush. The extensive site selection process described below identified the preferred and alternative sites.

Site 52a, within the WPA, remains the preferred site following the environmental assessment process. However the alternative Sites 40a and 45a are acceptable sites subject to the implementation of certain additional management procedures.

The Environment Protection and Biodiversity Act

A principal object of the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is to ensure that matters potentially significantly affecting the environment are fully examined and taken into account in decisions made by the Commonwealth Government. Under the Act, an action requires approval from the Minister of Environment and Heritage if it has, will have or is likely to have a significant impact on a matter of national environmental significance.

Matters of national environmental significance are defined under the Act as: World Heritage properties, Ramsar wetlands of international importance, listed threatened species or communities, migratory species protected under international agreements, nuclear actions, or the Commonwealth marine environment. In addition, the Act provides that certain actions taken by the Commonwealth and actions affecting Commonwealth land also require approval under the Act.



Potential repository sites

Towns

Dog fence

Roads

Woomera prohibited area

Salt lakes

Sealed roads

FIGURE 1
Study area and site locations, central-north South Australia

The national repository was determined to require the approval of the Minister for the Environment and Heritage under the EPBC Act, and the proponent (the Department of Education, Science and Training) was requested to prepare an environmental impact statement (EIS) to assist in the decision-making process. Guidelines were prepared by Environment Australia outlining the requirements for the EIS. Figure 2 shows the overall Commonwealth referral, assessment and approval process.

Project Need and Justification

Along with the benefits Australians receive from the medical, research and industrial uses of radioactivity, comes the responsibility for the safe management and disposal of radioactive waste.

Australia's low level and short-lived intermediate level radioactive waste is temporarily stored at more than 100 locations across urban and rural Australia, largely in buildings that were neither designed nor located for the long-term storage of radioactive material.

In order to reduce the cumulative risks of managing numerous waste storage areas, a national near-surface repository is proposed for the disposal of Australian low level and short-lived intermediate level waste. A national repository represents the safest and most effective option for Australia to manage this type of waste, particularly as the ongoing generation of waste is expected to be relatively small, and therefore technically and economically does not justify the establishment of separate facilities on a state-by-state basis.

Concerns about the possibility of acts of terrorism involving nuclear and radioactive materials have also assumed greater international prominence in the wake of the events of 11 September 2001 in New York City and Washington DC.

A purpose built facility would ensure that management and maintenance complies with Commonwealth government policy and legislation, and is in accordance with international practice and obligations.

FIGURE 2
An overview of the referral, assessment and approval process

Radiation, Radioactive Waste and Waste Management

Radiation

Radiation is the emission and propagation of waves or sub-atomic particles. There are two types of radiation: ionising radiation, so called because it has sufficient energy to 'ionise' matter that it hits, and non-ionising radiation. Ionising radiation includes X-rays and the radiation that comes from radioactive elements, and it has the ability to break the bonds that bind electrons to atoms, thus causing ionisation of the matter through which it passes and damage to living tissue. Non-ionising radiation includes light, heat and radar. The type of radiation associated with radioactive waste is ionising radiation.

Radioactivity

All matter is made up of atoms, some of which are unstable because they have excess energy. Radioactivity is the term used to describe the breakdown of unstable atoms and the associated release of energy, which is in the form of sub-atomic particles or electromagnetic waves. Over time, radioactive material is completely broken down, stable atoms are formed and there is no further release of energy or radiation. The time taken for this decay process is measured in terms of an atom's half-life. One half-life is the time for half of the radioactive atoms to decay to stable atoms. After two half-lives, one quarter of the original radioactive atoms remain. Some radioactive substances have half-lives of less than a second; others have half-lives of thousands and even billions of years.

Radioactivity is a natural part of our Earth and the universe. Naturally occurring radioactive materials are present in the soil and rocks; the floors and walls of our homes, schools and offices; and our food and drink. The radiation from these natural radioactive sources is called background radiation; the amount of background radiation we receive depends on where we live and the types of activities that we are involved in. The higher we are above sea level, the more we are exposed to radioactivity from cosmic radiation. Some soils and rocks, for example granites, are naturally more radioactive than others, and, if we live in areas where these occur, our exposure to background radiation is increased. Some activities, for example air travel and certain medical treatments, increase our exposure to radiation.

The energy emitted from unstable atoms can be released in four forms: alpha (α) particles, beta (β) particles, gamma (γ) radiation and neutrons. Alpha particles are atomic nuclei, and can only travel a few centimetres in air; a sheet of paper or a layer of skin can stop them. Beta particles, which are electrons or positrons, can travel metres in the air and several millimetres into the human body. They can be stopped by a small thickness of light material such as aluminium or plastic sheeting. Gamma rays are very energetic electromagnetic radiation and can pass through the human body. A thick barrier of lead, concrete or water will stop gamma rays. Neutrons are sub-atomic particles that have no electrical charge. On Earth, they are rarely encountered outside the core of a nuclear reactor. A thick barrier of lead, concrete or water can stop them. Figure 3 shows the penetrating power of the various forms of radiation.

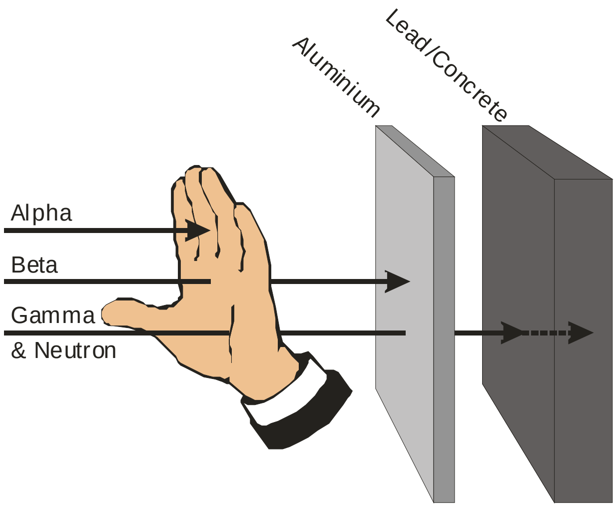


FIGURE 3
Penetrating power of radiation forms

Radiation Doses and Effects

A radiation dose is the measure of how much energy is absorbed when radiation hits body tissue. The different types of radiation (alpha, beta and gamma) have different penetrating power and carry different levels of energy, and therefore have different effects on humans.

Alpha radiation cannot penetrate skin; beta radiation will penetrate skin but will not penetrate far into human tissue (it is often referred to as a ‘skin dose’). Thus the effects of alpha and beta radiation are of most significance if radioactive material is taken into the body by inhalation of contaminated dust, or by ingestion of contaminated food or drink. Gamma radiation penetrates most matter and so may be of health significance for both internal and external radiation sources.

The energy that radiation deposits in the body has the ability to break the bonds between atoms. In most cases, these bond breaks do not matter to the functioning of the body, and are either repaired or occur in places where they do no harm. If the break occurs in molecules that control the way a cell works, the cell can stop working, start working in a destructive way that can lead to cancer, or die.

Uses of Radioactivity in Australia

During the past 100 years, radioactive materials have come to be used in a wide range of beneficial medical, industrial, agricultural and environmental applications, including:

- diagnosis and treatment of diseases
- sterilisation of medical supplies and of personal care products
- tracking of pollution
- industrial process monitoring and control, and agricultural monitoring and pest control
- life-saving devices such as smoke detectors.

For most people one of the most important uses of radioactive material is for medical purposes. For example, in 1997–98 alone, some 347,000 patient doses of radiopharmaceuticals were produced by the Lucas Heights research reactor for medical procedures such as cancer diagnosis and treatment, and Australian Nuclear Science and Technology Organisation (ANSTO) estimates that in 2000–01 there were about 525,000 people in Australia who underwent a nuclear medicine procedure for the treatment of medical conditions such as cancer.

Radioactive Waste Classification

Radioactive waste is often broadly categorised as low, intermediate or high level waste. It can also be classified as short-lived or long-lived, depending on the concentration of radionuclides present and the type of radiation emitted.

Low Level Waste

Low level waste contains low levels of short-lived beta and gamma emitting radionuclides and normally very low levels of alpha emitters. Special shielding is not normally required for transport and handling of this material. It includes items such as wrapping materials and discarded protective clothing, and laboratory plant and equipment.

Intermediate Level Waste

Intermediate level waste contains significant levels of beta and gamma emitting radionuclides and could also contain significant levels of alpha emitters. This waste sometimes requires shielding during handling and transport.

Short-lived radioactive materials have a half-life of 30 years or less, and typically include gauges and sealed sources used in industry and medicine, and small items of contaminated equipment.

Long-lived intermediate level waste (often referred to as ‘intermediate level waste’) generally contains radionuclides that have a half-life of more than 30 years. In Australia, this waste consists of historical waste from mineral sand processing, disused sealed sources and industrial gauges, reactor components, irradiated fuel cladding and conditioned waste from the processing of spent fuel. Long-lived intermediate level waste would not be disposed of in the national repository.

High Level Waste

High level waste contains high levels of beta and gamma radiation emitters and significant levels of alpha emitters. It also generates a significant amount of heat (about the same as an electric kettle). Nuclear power reactors generate high level waste. No high level waste is generated in Australia.

Regulatory Framework

Australia's radioactive waste is managed in accordance with national regulatory requirements and, where applicable, internationally accepted procedures and practices.

International Organisations and Conventions

Australia is an active member of international organisations involved in encouraging the safe use and management of radioactive materials. The International Atomic Energy Agency, of which Australia is a member, has developed a series of Radiation and Waste Safety Standards that are followed by most countries including Australia. The standards identify the basic principles for the regulatory, safety and technical requirements for radioactive waste repositories.

Australia's Regulatory Framework

Each of the states and territories has its own legislation to regulate the use of radioactive materials. In the case of the Commonwealth, in 1999 the *Australian Radiation Protection and Nuclear Safety Act 1998* (ARPANS Act) established the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), which regulates the Commonwealth's use of radioactive materials and provides advice on the use and management of radioactive substances. Specifically, ARPANSA is responsible for:

- promoting uniformity of radiation protection and nuclear safety policy and practices across Australia
- providing advice to government and the community on radiation protection and nuclear safety
- undertaking research and providing services for radiation protection, nuclear safety and medical exposure to radiation
- regulating all Commonwealth entities (including departments, agencies and bodies corporate) involved in radiation or nuclear activities or dealings.

Approvals and Licences

Approval is required under the ARPANS Act for each stage of the repository project including siting, construction, operation and decommissioning. Assessment of the licence approval would be subject to the evaluation of detailed plans and arrangements for protection and safety, including the:

- safety management plan
- radiation protection plan
- radioactive waste management plan
- strategies for the decommissioning, disposal or abandoning of the facilities and/or the site
- security plan
- emergency plan for the controlled facility.

The regulatory branch of ARPANSA would review the monitoring results from the repository regularly to ensure its safety and compliance with licence conditions.

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.

Inventory of Existing Waste

Australia has accumulated about 3700 m^3 of radioactive waste from over 40 years of research, medical and industrial uses of radioactive material. Of this total 2010 m^3 is slightly contaminated soil stored near Woomera, which arose from Commonwealth Scientific and Industrial Research Organisation (CSIRO) research into the processing of radioactive ores during the 1950s and 1960s. Another major component is 1320 m^3 of ANSTO operational waste, including clothing, paper and glassware, stored at Lucas Heights near Sydney. The Department of Defence (Defence) has 210 m^3, including contaminated soils from land remediation, sealed sources, gauges, electron tubes and other equipment, 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, industrial activities and other 'small users', and is distributed throughout the country.

Figure 4 shows waste typical of this last category.

A summary of existing waste is provided in Table 1. Of the total inventory of 3700 m^3, 2228 m^3 (60%) is held in South Australia and, of that, 2010 m^3 is contaminated soil stored at Woomera.

TABLE 1 Summary of inventory of low level and short-lived intermediate level waste by state

State	Estimated volume
South Australia	2,228 $m^{3(1)}$
Victoria	33 m^3
New South Wales	1,335 m^3
Queensland	45 m^3
Tasmania	15 m^3
Australian Capital Territory	8 m^3
Northern Territory	16 m^3
Western Australia	All historical and current waste in WA is disposed of at the Mount Walton East facility
Total	3,700 m^3

(1) includes 2010 m^3 of contaminated soil stored near Woomera

Future Waste Generation

Recycling of disused sources of radioactive materials used in medicine, industry or research is now extensively practised, and consequently estimated future waste quantities are relatively small. It is expected that about 40 m^3 of routine low level and short-lived intermediate level waste (conditioned volume) will be generated per year in the future, plus there will be other volumes from reactor decommissioning. Table 2 summarises estimated future low level and short-lived intermediate level waste arisings.

Compared with the amounts of similar wastes disposed of in countries with nuclear power programs, the accumulated and expected future amounts of this waste are quite small. For example, the Centre de la Manche repository in France accepted about 525,000 m^3 of radioactive waste from 1969 to 1994.

The repository would be designed to take about 10,000 m^3 of low level and short-lived intermediate level waste (although the limit would be set in terms of total activity of various radionuclide groups).

FIGURE 4
Existing waste

TABLE 2 Summary of estimated future low level and short-lived intermediate level waste arisings

Location 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	500–2,500 m^3
Lucas Heights replacement research reactor decommissioning	Expected to be similar to HIFAR

Waste Acceptance Criteria

Waste acceptance criteria (WAC) are the set of requirements that must be met before radioactive waste can be accepted for disposal at the repository. The criteria 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.

WAC would be developed for the facility before operations begin.

The Site Selection Process

Site Selection Criteria

In 1992 the National Health and Medical Research Council (NHMRC) released the *Code of practice for the near-surface disposal of radioactive waste in Australia (1992)* (NHMRC 1992 Code). The code includes 13 criteria designed to ensure that the selected site has characteristics that will facilitate appropriate isolation of waste and the long-term stability of the site. The criteria take into account a broad range of social, technical and environmental criteria, including:

- rainfall, potential for flooding and site drainage
- depth to the watertable, and fluctuations in the height of the watertable; suitability of groundwater for other purposes
- geology, geochemical and geotechnical factors
- seismic and volcanic activity
- population density and projected population growth
- potential of the land for other uses, or significant natural resources
- access for transport
- ecological, cultural or historical significance
- land tenure.

The Site Selection Process

The site selection process was undertaken in three phases. The first phase began in 1992 and involved the development of a methodology for site selection. The methodology used a geographic information system called ASSESS to compare a range of geographic factors with the 13 site selection criteria defined in the NHMRC 1992 Code.

The second phase of the process applied the site selection methodology to identify eight broad regions of Australia likely to contain suitable sites (Figure 5). The Great Artesian Basin and the Murray–Darling Basin, being major water resources, were excluded from the search. The central–north region of South Australia was selected as the preferred region. The third phase used the same selection criteria on a smaller scale to identify suitable sites within the central–north region, at which a more detailed drilling program was undertaken.

Description of Repository Facility

A preliminary design layout and an outline of operational concepts is presented below. The details of this concept plan will be further refined during the detail design phase of the project, which will be undertaken before the ARPANSA licensing process.

Design Basis

A multi-barrier approach would be used for the national repository, including physical containment provided by some, or all, of the following:

- the conditioned waste packages
- the waste form
- the trench/borehole design
- the host rocks, arid environment, and groundwater and surface water characteristics of the site.

Operational Usage and Institutional Control Periods

The operating life of the repository is expected to be approximately 50 years, after which there would be a review of operations. The low generation rate of radioactive waste in Australia means that once the existing waste has been disposed of, disposal campaigns would be separated by extended periods (2–5 years) of no disposal. At the end of each disposal campaign, the disposal structure (trench or borehole) would be closed and securely contained to prevent intrusion and minimise the ingress of rainwater.

The institutional control period (once the facility has ceased operations) would be 200 years. At the end of the institutional control period the radioactivity in the disposed waste would have decayed to low enough levels to allow unrestricted land uses.

Repository Layout

The repository would be on a site measuring 1.5 x 1.5 km, with the waste buried in the central 100 x 100 m part of the site in trenches or boreholes (Figure 6).

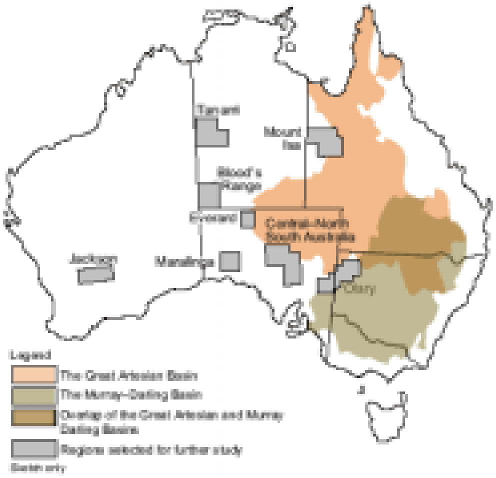


FIGURE 5
Eight regions selected for further study

Trench and Borehole Design

The repository would be designed to meet the licence requirements of ARPANSA, and the performance criteria and safety requirements of the NHMRC 1992 Code. The facility would contain a number of disposal trenches and boreholes, designed and sized to account for the different waste types and the quantities received during operational campaigns.

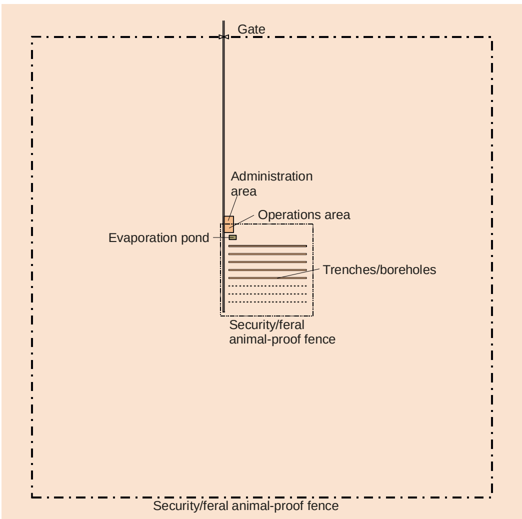


FIGURE 6
Indicative site plan

The trenches are expected to be about 12 m wide at the base to enable adequate construction equipment access and crane reach during unloading operations. Figure 7 shows an indicative design of the trench disposal method. The depth to the base would vary depending upon which site is chosen but is expected to be about 15–20 m below ground level. The sides of the trench would be battered to prevent collapse. The trenches would be ramped at one end to allow access by heavy machinery.

Boreholes would be approximately 2 m in diameter and 15–20 m deep, depending upon the final site chosen. Figure 8 shows an indicative design based on that used for the Mount Walton East repository in Western Australia.

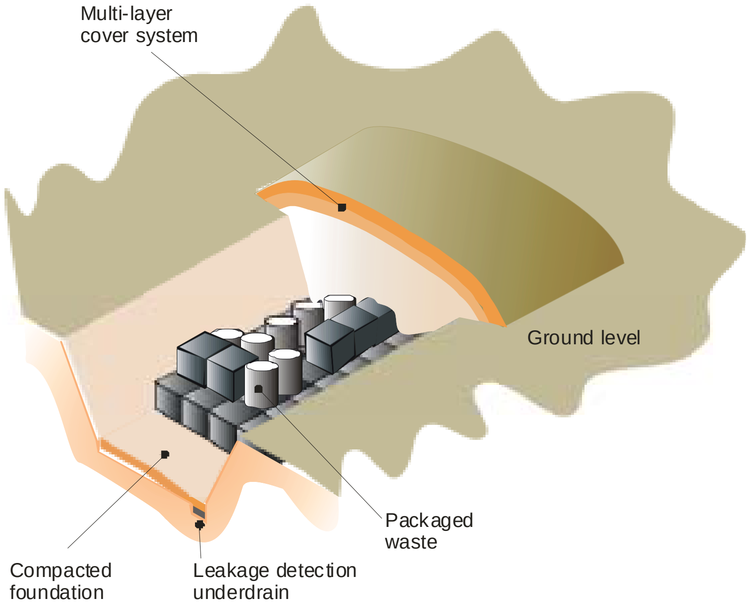


FIGURE 7
Indicative trench design

A suitable cover would be placed over the buried waste to limit infiltration of rainwater, discourage entry of animals, plant roots and humans, and inhibit erosion.

The NHMRC 1992 Code requires a 2 m depth of cover for Category A waste and a 5 m cover for Category B waste. For this repository a 5 m cover is proposed for all waste to limit the potential for escape of any radon generated by the waste.

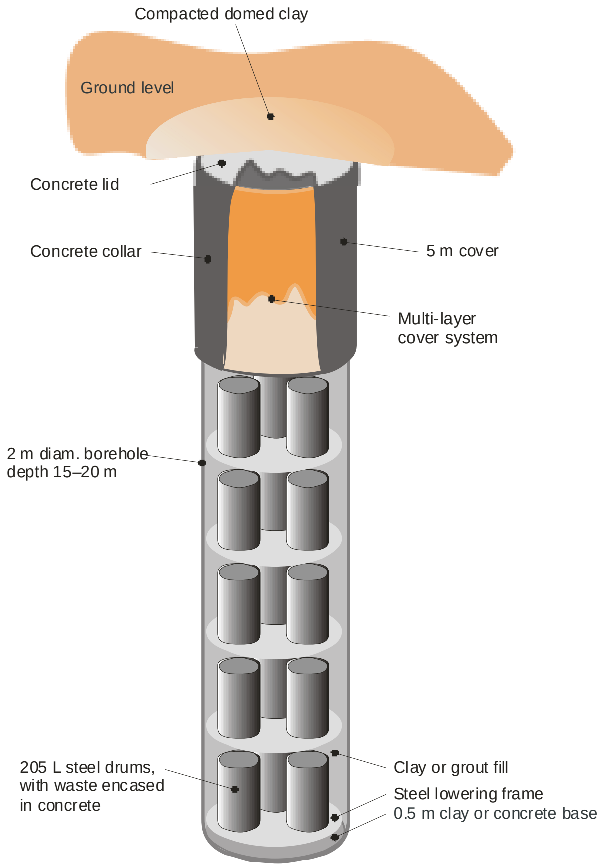


FIGURE 8
Indicative borehole design

Site Support Facilities

The extent of facilities at the site would largely be determined by the facility operator and would depend on a range of factors including the agreed nature of the packaging of arriving waste and the frequency of disposal operations.

The key features of the facilities (Figure 9) to be constructed are expected to include:

- **operations building** — containing facilities for waste receipt, holding, conditioning and retrieval, and a small laboratory for checking incoming waste
- **decontamination/washdown area** — for plant and equipment
- **office and associated facilities** — including administration, emergency services (first aid, health physics, fire), truck lay-by/check-in area, car park, change facilities (including showers)
- **health physics facility** — including clothing store, laundry, male/female showers, and equipment to monitor workers and for radiological surveillance of groundwater and other environmental monitoring
- **services compound** — including electricity, potable water and sanitation, and communication including portable power generators and a small workshop.

Description of Construction Works

The construction work program and first disposal campaign would begin after satisfactory completion of the EIS and ARPANSA licensing processes, including preparation of the detailed design and operating procedures and their approval by ARPANSA. A Commonwealth tender selection process would be used to let the construction works and the operation of the repository.

The initial construction would be expected to take two months, and would involve two main aspects:

- construction of buildings and infrastructure
- excavation of trenches and/or boreholes.

The specific design of the buildings, including preferred materials and colours, would form part of the detailed design process. It is expected that the office facilities would be portable buildings, and operational and storage sheds simple steel and corrugated iron buildings. All construction wastes other than spoil would be required by construction contracts to be removed from site. Spoil would be retained as backfill and for use in construction activities on site.

Description of Operations at the Repository

The main activities associated with operations at the repository would include:

- implementing criteria for acceptance of radioactive waste for disposal at the facility
- implementing a waste recording, documentation and quality assurance system
- planning and preparing waste for disposal
- designing and excavating trenches and boreholes
- transporting radioactive waste to disposal site
- receiving and checking consignment quantities on arrival
- accepting and checking radioactive waste for disposal
- providing short-term storage on site pending disposal

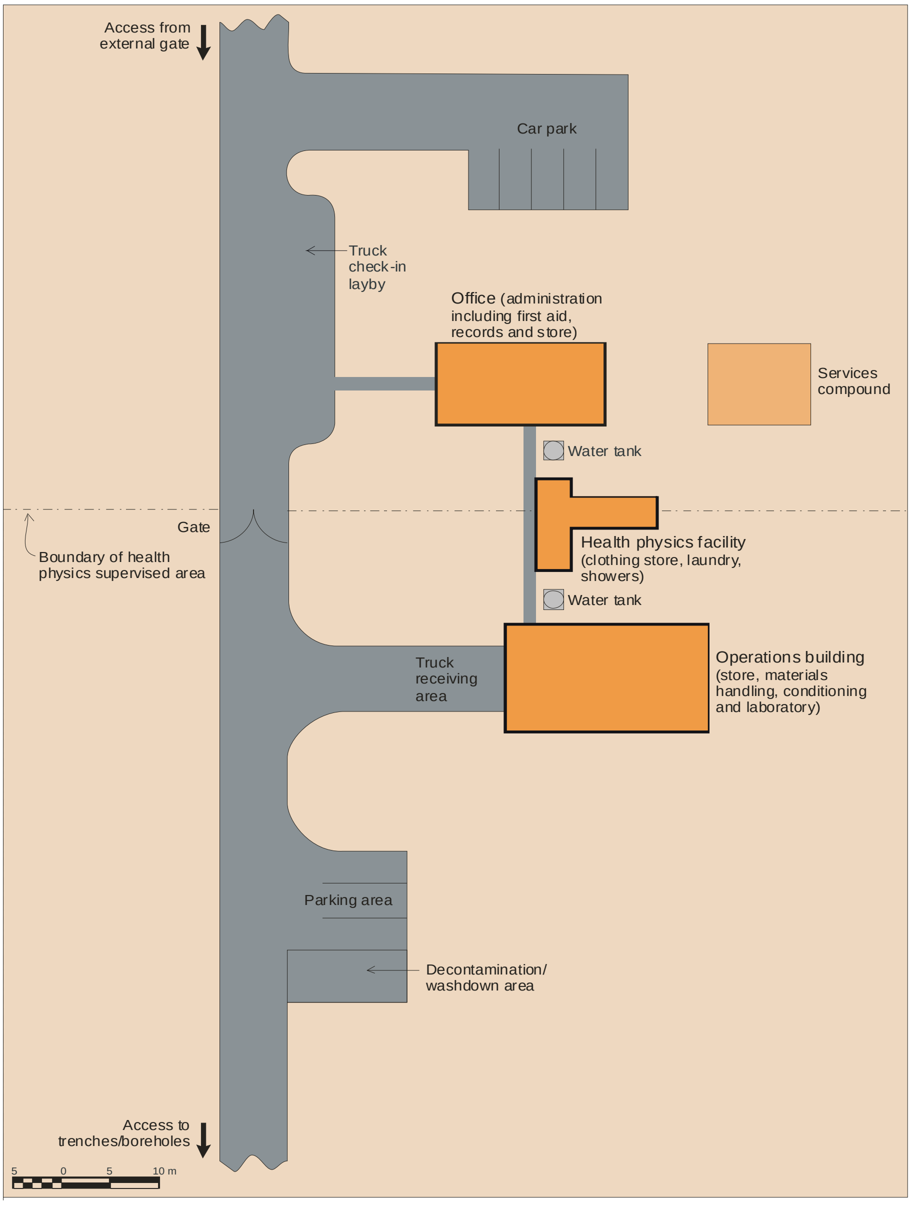


FIGURE 9
Indicative layout administrative and operations area

- responding to contamination or damaged packages
- implementing a site security system
- administering procedures for arrival of personnel and visitors on site, and for movement around the site and associated record keeping
- responding to incidents or accidents
- closing the facility between campaigns
- managing work methods for waste disposal operations, including safety procedures
- monitoring environmental radiation
- capping trench and boreholes
- rehabilitating trench surrounds
- close-out reporting.

The workforce during campaigns would number up to 10 personnel, including an operations manager, health physicist, and operational and security personnel.

The timing of construction and disposal operations at Site 52a would be scheduled so as not to conflict with other uses of the WPA.

Waste holders would be required to arrange disposal of waste at the repository with the facility operator. Details of the waste would be provided to ensure that it is suitable for disposal at the repository and meets the WAC.

Waste packages made of concrete, steel or other suitable material would be placed in layers in the trench by either a crane or a forklift. For borehole disposal a light mobile crane would be used. The location of all packages would be recorded. The waste packages would be designed with adequate strength to enable stacking, and packages would be packed tightly to minimise voids.

Security and Health Safety

A security fence would be constructed around the 1.5 x 1.5 km buffer zone to prevent unauthorised human intrusion and to exclude grazing animals. A security presence would be in place during the initial and subsequent campaigns to ensure the safety of personnel. The site would be monitored for any potential breaches in security between campaigns.

The repository would have a health physics program that would govern all work at the site involving radioactive material. The procedures would cover the conditions for entry to areas where there are radioactive substances, precautions to be taken when working in those areas and the process for decontamination of personnel and equipment.

There would be a variety of general hazards potentially associated with operations at the facility: operational hazards such as excavation, heavy machinery, slip/trip/fall hazards and manual handling, and environmental factors such as lightning, bushfire, noise, heat stress, snakebites and remote locations (access and communication). Appropriate procedures would be developed to address these issues.

Receipt, Recording and Retrieval of Disposed Wastes

All waste packages for disposal would have a unique engraved or raised marking to indicate the batch of waste to which they belong. This would allow a detailed inventory to be kept of all the waste disposed of at the site. Any markings on the package would be designed for longevity and would provide sufficient information to allow identification of the complete contents of the package on reference to the inventory.

Surveillance Periods

During the surveillance periods between disposal campaigns, security would be maintained and environmental monitoring of the site undertaken.

Decommissioning/Closure Phase

The NHMRC 1992 Code contains detailed guidelines for the closure of the disposal facility. Disposal operations at the facility would cease when the authorised disposal space was filled or the authorised limit on total site radioactivity was reached. The estimated initial operational life of the national repository is 50 years, after which time there would be an operational review.

Ownership and Operation

The national repository would be owned by the Commonwealth and regulated by the Commonwealth's independent regulator, ARPANSA. Operations would be undertaken by private contractors, whose performance would be overseen by the responsible Commonwealth department.

Financial Arrangements

Commonwealth policy requires that there would be a charge for disposal of waste in the national repository. Charges would be set to encourage waste minimisation and disposal when no other option, such as recycling, exists. Disposal charges would also be set to encourage waste producers to use the facility, rather than continue to store waste in non-purpose built accommodation or dispose of waste in an inappropriate manner.

Transport of Waste to the Repository

The transport of radioactive substances within Australia routinely takes place for a variety of commercial and industrial applications. Over the past 40 years there have been no accidents in which there has been a significant radiological release harmful to the environment or public health. Shipments of such substances are strictly governed by relevant Australian and international regulations and codes that define how waste should be packaged, which warning signs must be placed on vehicles, and which instructions must be provided to carriers for safe operating procedures.

Transport Modes and Routes

It is expected that the waste material will be transported to the repository by road, as this provides a safe, flexible, secure and cost-effective mode of transport, considering:

- the location of waste at over 100 sites around Australia
- most sites have only small quantities of waste, thus requiring some load consolidation
- trucks have flexible load capacity to facilitate load consolidation at intermediate storage locations

- the need to maintain continuous chain of custody of material during transport.

Although rail offers an inherently lower risk of accidents en route, its main disadvantages relative to road transport include additional handling, more inefficient transport arrangements for the relatively small volumes of material and, in particular, the security of chain of custody when compared with road transport.

Water-borne transport is generally not relevant to the proposed national repository, apart from the specific case of Tasmania from where a small amount of waste would need to be shipped to the mainland. Airborne transport would only be considered where it is a practical alternative, for example possibly for the small quantities of waste from Tasmania.

Possible road routes to the national repository have been identified. Route alternatives were defined between each state and territory and the repository in a hierarchical approach, which sought to maximise the use of national highways, supplemented with state highways. Other secondary roads were only selected where a connection between highways was needed. This approach was designed to reduce the impacts of truck movements on communities along each route.

Figure 10 illustrates the proposed routes to the repository. Where feasible, at least two route alternatives have been defined for each state or territory.

Frequency of Shipments

The total national volume of accumulated waste to be shipped to the repository is low, with conditioned waste estimated to be in the order of 1690 m^3, excluding that already at Woomera. Assuming that this material is packed in 205 L drums, with these drums then being double stacked into standard 6 m shipping containers for transport, the total number of shipments needed to clear the accumulated waste backlog is estimated to be 171 truckloads. This represents a very small number of truck movements over the road network.

Shipments of future waste are also expected to be very low, equivalent to about five 6 m shipping container loads per year nationally. More shipments would be needed to transport decommissioning wastes from ANSTO's research reactors. In practice, transport would be expected to be only for disposal campaigns, which are expected to be every 2–5 years after the initial campaign.

Community Consultation

Communities at selected locations along the proposed route network were consulted through a series of group discussions to seek their views on the transport issues. Representatives in Port Augusta (SA), Mildura (Vic), Broken Hill and Dubbo (NSW) were involved in the process.

The discussions revealed:

- a general low level of knowledge of the repository proposal and the shipments of waste
- concerns about the shipments, mostly over possible accidents and how such accidents might be treated, together with reservations about the potential frequency of shipments.

Generally, the community groups became less concerned about the proposal when key aspects of the transport proposals were outlined to them, in particular that:

- the low levels of accumulated waste nationally meant infrequent shipment
- radioactive materials are shipped daily and routinely in Australia, with an excellent safety record
- packaged waste must conform to codes, and would be designed to prevent dispersal or leakages of radioactive material during accidents
- the waste being transported would be solid and not able to spill in an accident.

Overall, the groups accepted the need for accumulated waste to be transported to a suitable location, and that the transport impacts and associated risks were low. There was a range of responses to the issue of transport of radioactive waste, from people being uninterested, through those who saw that the waste needed to be transported to a suitable location, to those who expressed reluctant acceptance as long as the material was transported safely. Others were more cautious in their response. The Port Augusta group accepted that the transport of radioactive materials, in the form of uranium oxide ore from Olympic Dam to Adelaide, already occurs through the city safely on a regular basis.

FIGURE 10
Principal potential transport routes

Transport Safety

A review of international transport experience confirmed a low likelihood of incidental exposure to radioactive materials as a result of shipments by road. The incidence of accidents has been historically low over a long period. Stringent controls and procedures placed on shipments internationally are largely responsible for this excellent safety record.

The potential for accidents involving trucks carrying waste to the repository was quantified, considering the individual transport routes, numbers of truck movements, historical accident rates and traffic conditions prevailing on the routes. Table 3 summarises the estimates of accidents involving trucks carrying waste. The rate of less than one expected accident when transporting the total accumulated waste inventory indicates a very low accident likelihood.

TABLE 3 Estimates of truck accidents involving trucks carrying waste

Source of waste	Volume of waste (m^3)	No. of waste shipments(1)	Total distance travelled (km)(2)	No. of accidents (in 1 year)(3)
SA/Adelaide (4)	218	22	490	0.004
NT/Darwin	16	2	2,600	0.002
Qld/Brisbane	45	5	2,100	0.011
NSW/Sydney(5)	1,355	136	1,580	0.208
Victoria/Melbourne	33	4	1,290	0.006
Tasmania/Hobart	15	2	1,610	0.003
Total	**1,682**	**171**		**0.234**

(1) Based on 10 m^3 per truck
(2) Rounded
(3) Calculated as a function of the number of truck movements, cumulative distance travelled on each route and the respective route accident rates
(4) Excludes waste material currently stored at Woomera
(5) Includes waste material from the ACT

In the unlikely event of an accident, the solid waste form and multiple packaging for sealed sources (an inner shielded container, the 205 L drum, and finally the 6 m ISO standard container) would help to ensure that radioactive material was not widely distributed around the accident site.

Additional analysis of truck accident potential on the national highway in Port Augusta, which forms a focus of all shipments to the repository except those from Darwin, demonstrated minimal risk.

Emergency Services

All states and territories have in place emergency response plans in case of accidents or incidents involving radioactive (or other hazardous) materials. In most emergency cases, the police, ambulance, fire services and state emergency services are the first responders. In addition, the Commonwealth can provide additional assistance if required.

The state and territory teams have the required level of training, and the protective clothing and equipment, needed to identify the nature of the hazard, and to retrieve material. Resources are located in various country centres around each state, enabling rapid responses to incidents at relatively short notice.

Physical Environment

The preferred and two alternative sites for the national radioactive waste repository are located in the Stuart Shelf geological province, to the west of Lake Torrens in South Australia. This province comprises incomplete sequences of flat-lying marine sediments of the Adelaide Geosyncline, overlying the northeastern part of the Archean Gawler Craton. The northern extension of the shelf is overlain by sediments of the Jurassic/Cretaceous Eromanga Basin, and a thin veneer of younger sediments or in situ deposits (e.g. silcrete or calcrete), which are commonly encountered at the landscape surface.

The Eromanga Basin is the largest and most central of the three depressions that together make up the Great Artesian Basin (the other two, the Carpentaria and Surat Basins, are in Queensland, and Queensland and New South Wales). Eromanga Basin sediments are absent from Sites 40a and 45a, and, where present at

Site 52a, are interpreted to be an outlier of the Eromanga Basin. Hydrogeologically the Eromanga Basin sediments, where present in the study area, are part of the Stuart Shelf aquifer system, and there is no known or suspected hydraulic connection of this part of the Eromanga Basin with the Great Artesian Basin aquifers. Figure 11 shows the general geology and the hydrogeological relationships of the region in cross-section. The overall groundwater movement in the area is towards Lake Torrens.

The preferred and two alternative sites have undergone extensive study including drilling investigations in the previous phases of the repository site selection process (see above), as well as further investigation as part of the environmental assessment process. These investigations included a series of hydrological model simulations to assess the potential infiltration of rainwater through various capping and base lining systems, and also modelling of the movement of water through the unsaturated zone of soil and rock between the ground surface and the watertable in the project area.

The various capping and base lining systems included a low permeability clay barrier layer in the cap, low permeability liner at the base of the repository, a homogeneous earthfill cap and a composite barrier layer in the cap (incorporating a geomembrane and low permeability compacted clay).

The assessment indicated rainwater infiltration to be minimal for all cases examined, with the least infiltration through a composite lining system located at the base of the cover layer. The alternative design proposals would be investigated further in the design phase. The benefits or otherwise of installing a coarse cobble layer (rock material from the excavations) as an additional deterrent to burrowing animals would also be assessed.

It was found that the installation of a compacted clay liner at the base of the repository did not significantly alter the percolation rate through the repository. Nevertheless, it is proposed to compact the base of the repository and grade the finished surface to a sump to collect any free water and direct it to a sampling well.

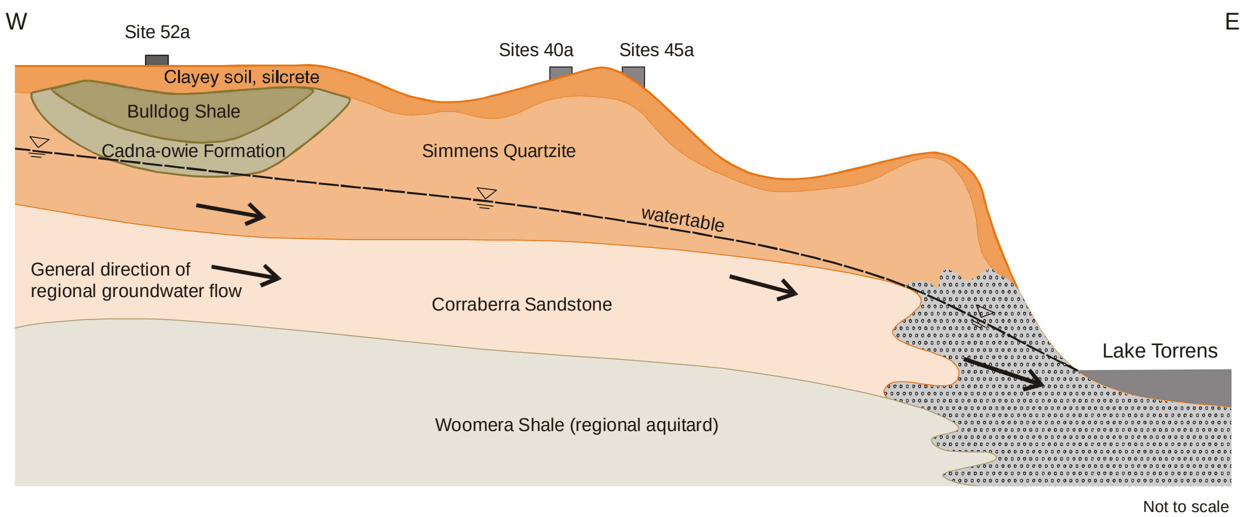


FIGURE 11
Schematic hydrogeological section

The modelling of the movement of water through the unsaturated zone of soil and rock between the ground surface and the watertable in the project area has suggested a transit time in the order of 60,000 years in the presence of vegetation and 6000 years in the absence of vegetation. These residence times are very long compared to the half-lives of typical radionuclides contained in wastes (maximum 30 years).

The adsorption and retardation characteristics of soil and rock samples were also investigated. The majority of radionuclides that would be present in buried waste adsorb to a greater or lesser degree on the surfaces of soil and rock particles, which further slows their movement relative to the already slow movement of water through the unsaturated zone towards the watertable.

The movement of three selected radionuclides through the unsaturated zone was further modelled for Site 52a. Simulations were completed for solute transport from the base of the waste repository during rain and storm periods for up to 100 years.

The modelling results indicate that the amount of solutes originating from the repository reaching the watertable under the conservative scenario of continual low-level seepage for 100 years would be so low as to be, to all practical extents, undetectable. Even if 100% of rainfall and stormwater were to penetrate the repository the amount of solutes reaching the watertable would not be detectable. The natural arid climatic regime of the study region, together with the design and construction of the repository, would provide considerable additional protection for the watertable.

Biological Environment

Flora

The Arcoona Tableland is primarily a treeless plain dominated by low chenopod shrubland. The region has had a long history of grazing by native, domestic and feral herbivores, as well as being subject to the operations and infrastructure of sheep and cattle stations, and the construction and operation of Woomera Rocket Range.

Following a detailed literature review, the field survey for this project was undertaken during August 2001 and coincided with above-average field conditions. Classification of the data collected showed that the vegetation communities of the three sites were relatively homogenous. At lower levels of dissimilarity, minor differences were present (based on slightly different floristic groups). All vegetation communities were in relatively good condition. Figure 12 is a photograph of typical flora at Site 52a.

There are no vegetation communities with recognised conservation status at any of the three sites or on the Arcoona Tableland generally. Seven plant species from the Arcoona Tableland have recognised State or national conservation status but none were recorded during the field survey. The two species with a national conservation status, Koch's saltbush (*Atriplex kochiana*) and Arcoona slipper-plant (*Embadium stagnense*) were not recorded during the field survey and are not expected to occur at any of the potential repository sites. *Brachycome eriogana* and *Sclerolaena holtiana* (Holt's bindyi) were not recorded during the August 2001 survey but could occur at any of the three potential repository sites.

FIGURE 12
Site 52a

Eight per cent of the species recorded during the field survey were identified as being introduced. This figure is slightly lower than the overall figure recorded on the Arcoona Tableland. The low incidence of introduced species is possibly a result of the relatively undisturbed condition of the study sites. Control of introduced species and prevention of the introduction of new species would be a key land management issue at the selected site.

Qualitative vegetation assessments were undertaken along access roads to all three potential sites. Access to Site 52a would cause the fewest environmental problems, while access to Sites 40a and 45a would cause the greatest problems. However, impacts to the biological environment of these latter sites would be minimal if access roads were upgraded within the existing disturbed corridor and using existing materials from this corridor.

Fauna

Results of the field surveys in August and October 2001 reflected exceptional seasonal conditions following well-above-average rainfall during late May and early June.

Canegrass swamp, gilgai and low open chenopod shrubland, the three major habitats that make up the Arcoona Tableland, were assessed. The results of the fauna survey indicated that a diversity of vertebrate and invertebrate species typical of the Arcoona Tableland are present at all three sites. All sites exhibited slight differences in species diversity and abundance.

Site 52a had the greatest faunal diversity (57 species of vertebrates, 8 genera of ants and 17 taxa of spiders), but the lowest mammal diversity, richness and abundance, with two species of small mammals compared to four at the other two sites. Site 45a contained the highest diversity of vertebrates. The assessment recorded 12 reptile species at Site 40a and 13 at each of Sites 45a and 52a. These totals probably underestimate the species diversity and abundance of reptiles in the project area. Figure 13 shows the central bearded dragon, which was found at all three sites. The most abundant mammal species captured for all sites was the striped-faced dunnart (Figure 14); this is consistent with other recent findings for the region. In comparison, the fat-tailed dunnart was the least trapped species; however, this species is widespread within the region. Low bat diversity and abundance (4 species) at each site is consistent with previous surveys in the area. Bird diversity was greatest at Sites 45a and 52a.

FIGURE 13
Central bearded dragon

European settlement and the introduction of stock and pest species such as European rabbit, red fox and feral cat have changed the assemblage of native species in the Australian arid zone. There are eight introduced mammal species and three species of introduced birds recorded in the region. All contribute to the decline of native species. Providing that suitable management actions are undertaken, key threatening processes would not increase as a result of construction and operation of the waste repository.

Five threatened animal species were recorded within the project area. Of these, the most significant is the plains rat, which is listed as vulnerable under the EPBC Act. It is present at Sites 40a and 45a. The other four species are vagrant or nomadic bird species including Peregrine falcon and Australian bustard. A number of other bird and reptile species are of regional significance and may be of future taxonomic and conservation significance. The project's main impacts on the biological environment would be associated with construction. These potentially adverse environmental impacts can be managed or minimised through careful planning and monitoring. Impacts of vegetation clearance on the vegetation communities and habitats would be limited: the area to be cleared is very small in relation to the large distribution of the vegetation communities across the Arcoona Tableland. Development of stock, pest animal and kangaroo-proof fencing around the preferred site and elimination of pest species from within the fenced area would probably make a very useful ecological exclosure and reference area.

FIGURE 14
Striped-faced dunnart

Land Use and Activity

The nature of human activity since European settlement at the three sites and in the region has been assessed, particularly for land use and activity, demographics and landscape character. Visual impact, site suitability and the potential for land use conflict now and in the future, have been assessed for the proposed facility.

The proposed facility is considered to be relatively minor in terms of its physical components and infrastructure (e.g. buildings, equipment, roads) particularly when compared to other land uses in the region (e.g. Olympic Dam). Similarly, over the life of the facility, the level of activity that it is likely to generate is considered to be relatively low.

The 100 x 100 m disposal area would be enclosed in a 1.5 x 1.5 km site, which would provide an extensive buffer and separate the operation from potentially incompatible land uses now and in the future. Security fencing would prevent unauthorised intrusion into the repository site.

The South Australian Government's Draft Planning Strategy for the region fundamentally acknowledges the existing land use activities but new land use activities are not specifically envisaged. Mining, defence and aerospace activities (including their support industries) are considered the key areas for potential economic growth and future development. Tourism (based on adventure, four-wheel drive, heritage and Aboriginal culture themes) is also considered a potential growth area. The strategic emphasis for rangeland grazing is one of adjusting practices to achieve a greater level of sustainability.

The location of the repository within the Woomera Instrumented Range (WIR) presents a small risk that a missile fired at a target within the WIR, most particularly at the Range E target, could strike the repository site. Smaller, low velocity projectiles can be expected to fragment on impact, with limited ground penetration, and damage only surface features or structures. However, larger or higher velocity weapons may strike with sufficient kinetic energy to penetrate the 5 m soil cover of the waste.

An assessment of the risk of such an occurrence — using US Department of Defense methodology, which considers 'the management of environmental, safety and health mishap risks encountered during the development, test, production, use and disposal of government systems, subsystems, equipment and facilities' — concluded that the mishap probability is Remote, the mishap severity is Marginal and the risk category is Medium, which is the second lowest risk category presented by the relevant standard. Risk mitigation measures would reduce the risk to a risk category of Low.

For land use and activity, Site 52a is considered to be the preferred site with respect to land use and activity for the following main reasons:

- Access to the WPA is already restricted, which would assist in addressing the potential for unauthorised intrusion.
- The visual impact of the proposed facility, its buildings and infrastructure, is considered to be minimal given that the landscape within the WPA is already characterised by a range of buildings, towers and other infrastructure.

Developing the facility at Site 40a or 45a would raise some concerns about the:

- need to upgrade road access, which may also improve public access to sensitive and fragile environments
- introduction of a new visual element and land use into predominantly pastoral areas.

The management of peak traffic generation during the construction stage would be important to avoid conflict with local peak traffic times. Sensitive design of permanent structures at the facility would minimise the visual impact and the proposed buffer is likely to minimise potential conflict with adjacent land uses. The timing of construction and disposal activities could be scheduled so as not to coincide with other uses of the WPA.

Cultural Heritage

Aboriginal

Results of the Work Area Clearance Surveys

The relevant Aboriginal groups have cleared the preferred site and two alternatives, and the access to them, for all works associated with the construction and operation of a waste repository. Certain conditions have been placed on these clearances. In undertaking their clearance work, all groups were concerned principally with ensuring that areas that were of cultural, social or spiritual significance to them were not adversely impacted to an unacceptable degree. Archaeological materials and sites were generally treated more peripherally.

No archaeological constraints to any of the three proposed repository areas were identified during the work area clearances. Part of the access track to Site 40a had extensive but sparse scatters of archaeological material and it was recommended that management strategies be formulated to minimise damage to and interference with this material.

Geomorphological Assessment

In order to provide more detailed information for planning and design purposes, a geomorphological assessment was made of the terrain of the three sites and their potential access routes. This assessment was undertaken to ensure that there are no landforms of high archaeological potential such as sand dunes, major water-holding claypans and canegrass swamps and creeks, or major rock outcrops that would be affected by the proposed development. It was confirmed that none of the three potential sites has archaeological constraints.

Sites 40a and 45a have extremely low background scatters of stone artefacts and their archaeological potential is low to negligible. Site 52a has a few quartzite flaking floors which can be avoided by the proposed activities of the repository, and a widespread background scatter of artefacts. Extensive but sparse scatters of stone artefacts associated with creeks were confirmed along parts of the access track to Site 40a. Sparse scatters of stone artefacts occur in the dunefield section of the access track to Site 45a.

Management Requirements

The Work Area Clearance Report prepared by the Antakirinja, Barngala and Kokotha claimant groups made specific recommendations on access to each of the three potential repository sites.

The proponent has noted these conditions and the proposals for accessing these three repository sites during the construction and operation phases incorporate commitments to use the existing access roads and tracks cleared by the various groups and, in the case of Site 40a, the potential new access track route defined by the Antakirinja, Barngala and Kokotha claimant groups.

Provided these conditions are adhered to, there should be no risks to cultural heritage sites and values of the land. The quartzite knapping floors at Site 52a are located away from proposed construction and operations areas and would be protected in accordance with management measures presented in the repository's environmental management and monitoring plan (EMMP). If the access road to Site 45a through the dunefield section requires road works with the potential to affect archaeological sites, then archaeological investigations and monitoring would be undertaken in accordance with the requirements of the EMMP.

European Heritage

Early Exploration

Edward John Eyre (1839) and John Horrocks (1846) reported that the region was desolate, which deterred initial development. Explorers in this area in the 1850s generally used a route immediately west of Lake Torrens. These explorers included BH Babbage (1853, 1858), Swinden (1857), Warburton (1858) and John McDouall Stuart (three major expeditions).

Pastoral Expansion and Historical Land Use

Pastoral activities began in South Australia in the 1830s, with licences issued to those wishing to use land for pastoralism. In 1851 the government introduced 14-year pastoral leases for Crown Land, which increased security for pastoralists. The definition and expansion of cropping and pastoral lands was considerably influenced by Goyder. By 1864 the northern edge of the pastoral expansion extended to the shores of Lake Eyre. Since the 1880s there have been many changes in the ownership and boundaries of pastoral leases in the area.

The development of the pastoral industry for sheep was aided by the construction of the dog fence (Figure 1) which extends from western Queensland to the Head of the Bight in South Australia. Pastoralism is the dominant land use in the region, with sheep grazing remaining the major pastoral activity on the Arcoona Tableland.

The first South Australian Pastoral Act was introduced in 1893. The *Pastoral Land Management and Conservation Act 1989* and the *Soil Conservation and Land Care Act 1989*, established a legislative framework to manage the pastoral lands. All of the project area is within the Kingoonya Soil Conservation District and is covered by the Soil Conservation Plan for the district.

Woomera Prohibited Area

Following World War II Great Britain sought to develop a facility for weapons research and testing. A 480,000 km^2 area north of Adelaide was chosen and the Long Range Weapons Organisation was established in 1947 as a joint venture between the British and Australian governments to undertake the firing, observation and recovery of long-range weapons.

Facilities developed for the rocket range included airfields, road and water reticulation networks, telecommunications, launch facilities, and a 132 kV transmission line and water supply pipeline. Personnel were accommodated in a purpose-built town, Woomera.

Eight of the nine independent and subsidiary live firing ranges initially established had closed by 1957. Resources were then concentrated on one main range, Range E, a world class facility for weapons testing.

Many short and long range weapons and research vehicles were completed and tested at the WPA, with the first missile launched almost two years after the establishment of the joint venture. During the 1960s, and subsequently, the functions of the WPA became less focused on weapons, and began to include research on a wide range of subjects, including satellite launches and deep space research.

The prohibited area now comprises a much smaller portion (127,800 km^2) of the original WPA.

Site 52a is located in WPA, approximately 10 km west-southwest of the Range E range head. Sites 40a and 45a are to the east of the eastern edge of the WPA.

Items of Heritage Value

No items of European heritage value for the project area are listed on the Australian Heritage Places Index. John Henry Davies' grave and the Philip Ponds Homestead are sign-posted as sites of local interest along the Woomera to Roxby Downs road.

Radiation

The existing background radiation at the sites has been evaluated from a series of measurements of radionuclide concentrations in the soil (both surface and underground), air, groundwater, plants and animals. All of these measurements indicate that the levels observed are typical of the region. There are no unusually high values of either naturally occurring radionuclides (e.g. uranium or thorium) or artificial radionuclides (e.g. caesium-137 from weapons testing). The natural background radiation would be the baseline against which the environmental monitoring program of the repository would be judged.

Initial construction of the repository trench would require that the excavation workers be exposed to the natural levels of radiation at the site. The radiological impact for this work has been assessed and found to be very low, at about 20 μSv, which is a very small addition to the average background radiation exposure in Australia of 2 mSv/yr. Should subsequent excavation be required at the site for future disposal campaigns in a trench adjacent to that where waste had previously been disposed, there would be an additional risk that construction workers might inadvertently expose the previously buried wastes. However, appropriate design and management controls would mitigate this risk. The construction of a borehole would result in lower levels of exposure to radiation than the construction of a trench.

During operation of the repository, radioactive waste would be brought to the site in an approved waste form and using approved waste packages. The packages would be assayed in accordance with a validation program to confirm compliance with the WAC. The waste would then be disposed of in the trench. There would be no operation at the site that involved the opening of these packages or the direct handling of radioactive materials. There would therefore be no routine radioactive discharges from the site.

All operations at the site would be conducted under a radiological protection regime consistent with the regulatory requirements and worker exposures would be as low as reasonably achievable (ALARA) and within the relevant dose constraints. There would be facilities at the site for the repackaging of waste, and some conditioning, if required.

Various potential accident scenarios in the operational/closure phase of the repository have been considered in some detail. One is the potential radiological impact resulting from a missile or aircraft crashing into the site from the nearby Woomera testing range. The assessment shows that the highest radiation exposures would be to a recovery team which, unaware of the fact that the repository had been hit, began their operations without taking any precautions and without any radiation protection supervision. The potential doses in such a case are of the order of a few mSv, which is well within the annual dose limit for a classified radiation worker (20 mSv per year averaged over 5 years).

After the wastes have been disposed of, and the trenches (or boreholes) capped, the repository area would be monitored and access controlled for a 200-year institutional period. During this period any release of radioactivity from the site would be detected and remediated if required.

In future years, when the repository site is no longer under institutional control and the waste form and waste packages have degraded, radioactivity could be released to the environment through a number of pathways. This aspect of the repository lifecycle has been considered in some detail. The potential pathways by which radionuclides may be released to the environment are discussed. The radiological impacts from such releases have been assessed. The scenarios and release pathways considered include:

- radioactive gaseous discharges and exposures to people living in dwellings over the repository site
- releases to groundwater through infiltration of rainwater and dissolution of the waste
- the effects of drilling and examination of borehole cores
- bulk excavation at the site
- the effects of building a road that runs across the repository
- the effects of archaeological digging at the site
- the longer term effects arising from exposure to excavated materials
- the effects of a rocket crash from the nearby Woomera test site
- the effects of an aircraft crash onto the repository site

- the effects of a transition to a wetter climate state
- the effects of a gross erosional event
- the effects of site flooding in the wetter climate state
- the effects of consuming contaminated waters obtained from a well drilled through the wastes
- the recovery of some of the more active sources or artefacts disposed of in the repository from the excavated materials.

The radionuclides that contribute most to radiation exposure in these scenarios are americium-241, caesium-137 (for source recovery only) and uranium-238 and its daughters, radium-226 and polonium-210. The inventory used for these assessments was based on the amount of radioactive waste identified as suitable for surface disposal using generic assumptions at the present time and assumptions about future arisings. The most significant postulated scenarios in terms of exposure are those of gas migration into a dwelling built on the repository site and recovery of the more active sources from the waste.

The conclusion from these assessments is that the risks are very low, and within the risk target value, for all of the scenarios other than major climate changes and gross erosional events. Where these major changes have been assumed to occur, the risks are only slightly higher than the risk target. However, computer modelling by CSIRO indicates that a transition to a wetter climate in the Woomera area is unlikely to occur in the next 10,000 years.

The total radionuclide inventory (both for bulk material and for individual sources), that would be acceptable for disposal at the repository would be determined by the Commonwealth's independent regulator, ARPANSA. ARPANSA would take into account the exact location of the site, the detailed repository design and the acceptance and verification of the scenarios and assumptions used in the risk assessments.

The radiation assessments are equally applicable to all three of the candidate sites. Overall it has been shown that the risks which might arise in future years, when the site is no longer under institutional control, are acceptably low and are in accordance with the NHMRC 1992 Code.

Environmental Management and Monitoring

An EMMP is required for operations at the national repository, covering both general environmental issues and the specific legislative requirements for radiation and near surface repositories. Development of the EMMP would take into account issues and responses raised in the EIS process, as well as formal regulatory requirements.

The general aims of the EMMP would be to establish:

- management processes and procedures that would ensure environmental impacts are minimised during construction, operation, surveillance and decommissioning
- ongoing monitoring (Figure 15) and reporting processes to evaluate any impacts of the operation on the surrounding environment
- audit processes for checking the implementation and effectiveness of management and monitoring systems.

FIGURE 15
Radiation monitoring

Proposed management and monitoring strategies broadly address the following areas:

- physical environment (Figure 16)
  - surface water runoff, soil erosion and siltation of watercourses
  - dust generation
  - noise
  - release of pollutants to soil, surface water or groundwater

- biological
  - potential for introduction of weeds
  - damage/removal of native vegetation
  - threatened species
  - off-road driving
  - loss of fauna
  - loss of habitat
  - increased competition for resources
  - pest species
- radiation
- land use planning conflicts
- consultation with Aboriginal groups.

FIGURE 16
Nevada test site repository, USA

Conclusions

Conclusions of the Assessment Process

1. A national repository is required to dispose of Australia's accumulated and expected future low level and short-lived intermediate level radioactive waste. Without a national repository, radioactive waste would continue to be stored in over 100 sites around Australia largely in facilities that were not purpose built. This poses potential public health and safety risks, including possible theft or misuse by terrorists. Alternatively, each state and territory would need to establish its own repository for a very small quantity of waste, which would be an inefficient and unnecessary use of resources.

2. The investigation process has been comprehensive and the consultation process extensive, extending over a total period of some 10 years.

3. The regulatory process in place is in accordance with accepted international practice, and the approval and licensing process is both comprehensive and rigorous.

4. The design of the proposed repository is in accordance with applicable national standards and codes of practice, as well as accepted international practice.

5. Transport of waste to the proposed repository would be in accordance with relevant Australian and international regulations and codes. The proposed mode of transport, principally by truck, is the preferred means of transport. The risk of an accident during transport is low. The solid waste would be packaged in accordance with the relevant codes and regulations. The waste would be confined by three levels of containment and, in the event of an accident, the package could simply be removed from the scene.

6. Hydrological model simulations indicated rainwater infiltration was minimal for all cases examined, with the least infiltration experienced using a composite lining system located at the base of the cover layer. The modelling of the movement of water through the unsaturated zone of soil and rock between the ground surface and the watertable in the project area has suggested a transit time in the order of 60,000 years in the presence of vegetation and 6000 years in the absence of vegetation. These residence times are very long compared to the half-lives of key radionuclides in typical wastes (e.g. caesium-137, 30 years).

7. Additional modelling of the movement of three selected radionuclides through the unsaturated zone undertaken for Site 52a has indicated that the amount of solutes originating from the repository reaching the watertable under the modelled, conservative scenario of continual low-level seepage for 100 years would be so low as to be, to all practical extent, undetectable at the watertable. The same conclusion is reached for Sites 40a and 45a, which have a deeper watertable, thus compensating for the absence of low-permeability shale. The natural arid climatic regime of the study region, together with the design and

construction of the repository, would provide considerable additional protection for the watertable.

8. The preferred and two alternative potential repository sites lie within the Arcoona Tableland, which has been recognised as a distinct land system, the Arcoona land system. Site 52a would have the least potential biological impact; in particular as only minimal road construction works would be required. However Sites 40a and 45a are acceptable subject to implementation of suitable management procedures.

9. The proposed repository is consistent with the existing land use. The existing use includes the storage of radioactive waste, and presently over half the current inventory of waste (2010 m^3 of slightly contaminated soil compared with the total of 3700 m^3 requiring disposal) is stored within the WPA. A risk assessment using US Department of Defense methodology concluded that the risk associated with the use of the WIR was Medium, the second lowest category, and that risk mitigation measures could reduce the risk to a risk category of Low. The timing of construction and disposal activities could be scheduled so as not to coincide with other uses of the WPA.

10. No archaeological constraints with any of the three proposed repository areas were identified during the work area clearances. All sites had a low background scatter of stone artefacts. The quartzite flaking floors identified on Site 52a would be avoided. Part of the access tracks to Sites 40a and 45a have scatters of archaeological material and it was recommended that management strategies be formulated to minimise damage to and interference with this material.

11. No items of European heritage value for the project area are listed on the Australian Heritage Places Index. No impact on items of European heritage is predicted.

12. Overall, it has been shown that the radiation risks during construction and operation, and those that might arise in future years when the site is no longer under institutional control, are acceptably low and are in accordance with the NHMRC 1992 Code.

13. An EMMP would be prepared for both construction and operations at the repository, covering the general environmental issues and also the specific legislative requirements in relation to radiation and near surface repositories. Development of the EMMP would take into account issues and responses raised in the EIS process, as well as formal regulatory requirements.

Comparison of Sites

A comparison of the individual sites is also provided in order to determine if the preferred site as identified following the previous phases of the site selection process remains the preferred site after the environmental assessment process.

The key advantages and disadvantages of the preferred and two alternative sites are summarised in Table 4.

TABLE 4 Advantages and disadvantages of the preferred and two alternative sites

Potential issue	Site 52a (preferred)	Site 40a (alternative)	Site 45a (alternative)
Construction	Need to coordinate with Defence use of WPA	Access road upgrade required prior to works (see below)	Access road upgrade required prior to works (see below)
Operation	Need to coordinate with Defence use of WPA	No significant issue identified	No significant issue identified
Access roads from Woomera	Good access using existing roads; 1.5 km requires minor upgrade	Requires 35.5 km of road upgrade construction through sensitive environment	Requires 12.5 km of road upgrade construction
Transport of waste to site	No significant issue identified; approx half the waste is presently 10 km from Site 52a	No significant issue identified	No significant issue identified
Geology	No significant issue identified; mud and siltstones on site provide better fill and cover characteristics than Sites 40a and 45a	No significant issue identified; may require blasting during construction	No significant issue identified; may require blasting during construction
Hydrology and hydrogeology	Presence of shale provides lower permeability material for trench base; favourable surface drainage features	Greatest depth to groundwater; large canegrass swamp near the site	Depth to groundwater intermediate compared with other two sites; favourable surface drainage features
Biology	No significant issue identified; this site has least biological impact	No significant issue identified; 35.5 km of road upgrade construction required	Site has high biodiversity; 12.5 km of road upgrade construction required
Land use (including activities on WPA)	Limited impact on WPA activities and pastoral usage	Limited impact on pastoral usage	Limited impact on pastoral usage
Heritage	Two knapping floors to be avoided on the site	Potential archaeological sites to be avoided during access road upgrade	Potential archaeological sites to be avoided during access road upgrade
Radiation	No significant issue identified	No significant issue identified	No significant issue identified
Security	Good; in Commonwealth protected area (WPA)	Requires more security measures than 52a	Requires more security measures than with 52a

Site 52a, within the WPA, remains the preferred site following the environmental assessment process. It has good existing access and superior security compared with the two alternative sites. The presence of shale provides the availability of lower permeability material for the trench base, and it has favourable surface drainage features. Its main disadvantage compared with the two alternative sites is its potential impact on activities within the WPA. However, the assessment has indicated that any such impacts can be managed.

The alternative Sites 40a and 45a remain as acceptable sites subject to the implementation of certain additional management procedures. These procedures relate to site security, and to construction and operational management to protect possible archaeological sites along the access road to Site 40a, and to protect biodiversity at Site 45a.

Site 45a has a significantly shorter length of required road construction than Site 40a; also the required road construction for Site 40a passes through areas of greater environmental and heritage sensitivity than for 45a. Site 45a has a higher biodiversity than Site 40a in terms of vertebrates and birds, although the footprint of the repository is small. Overall, of the alternative sites, Site 45a would be preferred over 40a, but both remain acceptable alternatives.