A RADIOACTIVE WASTE REPOSITORY FOR AUSTRALIA

Site Selection Study - Phase 3

Regional Assessment

A PUBLIC DISCUSSION PAPER

ISBN 0 642 28162 9

The contents of this paper and those of Phases 1 and 2 can be accessed via the Internet at:
http://www.nric.gov.au/nric/projects/assess/radwaste.html

Copies available from:

Information Officer
National Radioactive Waste Repository Project
Department of Primary Industries and Energy
GPO Box 858
Canberra ACT 2601

Telephone: Toll-free: 1800 682 704
Fax: 02 6272 4178
Email: Repository@dpie.gov.au
Internet: http://www.nric.gov.au/nric/projects/assess/radwaste.html

Preferred way to cite this publication:
Bureau of Resource Sciences (1997) A radioactive waste repository for Australia: Site selection study - Phase 3: Regional assessment: A public discussion paper. Bureau of Resource Sciences, Canberra.

The Bureau of Resource Sciences is a professionally independent scientific bureau within the Department of Primary Industries and Energy (DPIE). Its mission is to provide first-class scientific research and advice to enable DPIE to achieve its vision-rising national prosperity and quality of life through competitive and sustainable mining, agricultural, fisheries, forest, energy and processing industries.

FOREWORD

The Commonwealth Government considers that a national repository is needed for disposal of Australia's small inventory of low-level and short-lived intermediate-level radioactive waste and that management of this waste should not be left to future generations. This waste is generated from the medical, research and industrial use of radionuclides in Australia and consists of lightly contaminated soil, paper, plastics, glassware and protective clothing, luminous watches and exit signs, and industrial gauges.

Near-surface disposal, in properly sited, designed and operated facilities, in accordance with international guidelines, is recognised as an appropriate method of management for low-level and short-lived intermediate-level radioactive waste, and has been safely practised in a number of countries for over 30 years. Radioactive waste will be disposed of in a national repository in accordance with the National Health and Medical Research Council's 1992 *Code of Practice for the Near-surface Disposal of Radioactive Waste in Australia*, and international guidelines.

Continuing concern by some local communities regarding the temporary storage of radioactive waste in their vicinity and the inadequate capacity of some existing storage facilities prompted the Commonwealth, in 1992, to commence an Australia-wide search for a suitable national repository site.

Phase 1 of the National Repository Siting Study involved developing a methodology for selecting a suitable site using a Geographic Information System.

The Phase 1 public discussion paper, released in October 1992, explained the proposed site selection process and the methodology. The paper was widely circulated for comment by the public and interest groups, and a follow-up report, published in August 1993, summarised and responded to comment received on the Phase 1 study.

In Phase 2, the Phase 1 methodology was reapplied, taking into account public comment on the Phase 1 report. Based on public comment and new analysis, the Phase 2 study identified eight broad regions in Australia that are likely to contain suitable sites. The Phase 2 public discussion paper was released in July 1994. A report responding to public comment on this discussion paper was published in November 1995.

Phase 3 of the study will involve the detailed field investigaton of the preferred region to identify a suitable site.

The Government is strongly committed to effective consultation throughout Phase 3 of the search for a national radioactive waste repository. This paper has been prepared by the National Resource Information Centre of the Bureau of Resource Sciences for public discussion.

Persons or organisations wishing to comment on the paper are invited to make written submissions by 30 March 1998 to:

Information Officer
National Radioactive Waste Repository Project
Department of Primary Industries and Energy
GPO Box 858
Canberra ACT 2601

Telephone: Toll free number 1800 682 704
Fax: 02 6272 4178
Email: Repository@dpie.gov.au

Peter O'Brien
Executive Director
November 1997

CONTENTS

SUMMARY

This Paper reports the results of investigations in Phase 3 of the National Repository Siting Study to identify a suitable site for disposal of Australia's low-level and short-lived intermediate-level radioactive wastes.

Eight regions likely to contain suitable repository sites were identified in Phase 2 of the study, which was based on the methodology developed in Phase 1 and on public comment.

Given the high cost of conducting field surveys in every region it was necessary to select a single (preferred) region for more detailed field investigation. The Billa Kalina region contains the largest area of high suitability with respect to the National Health and Medical Research Council (NHMRC) selection criteria, on the basis of available data. It is, therefore, the preferred region for further study.

The Paper also outlines, for public comment, a proposed approach to field investigations and community consultation. A suitable site within the Billa Kalina region will be identified on the basis of detailed field investigations and community consultation.

INTRODUCTION

AUSTRALIA'S RADIOACTIVE WASTE

The volume of Australia's radioactive waste is small compared with that of nuclear power generating countries. Less than 60 cubic metres of waste is generated per year. This does not include waste from mining and milling of radioactive ores, which is generally disposed of locally at the mine site, in accordance with national codes of practice and State and Territory regulations. Over the past 40 years less than 3500 cubic metres of low-level and short-lived intermediate-level radioactive waste and 200 to 300 cubic metres of intermediate-level radioactive waste (Category S waste) has been produced in Australia by the medical, research and industrial use of radionuclides. High-level waste has not been produced as a result of these activities.

Information on the typical uses of radioisotopes in Australia and the ways that radioactive waste is ultimately derived is provided in Appendix 1.

Radioactive waste is currently stored at numerous sites around Australia, generally in temporary Commonwealth and State storage facilities. Small amounts of waste are also held by hospitals, industry and research institutions. Australia's first purpose-built radioactive waste disposal facility commenced operation in Western Australia in 1992; it only accepts waste produced within Western Australia.

Current temporary storage arrangements for radioactive waste are not ideal as there is a potential risk to the health of present and future generations and to the environment. The waste is potentially subject to vandalism, accidents, abandonment, the vagaries of climate and degradation of packaging. Workers responsible for the continued monitoring and maintenance of temporary waste stores may also be exposed to radiation. Many small generators of radioactive waste, such as hospitals and universities, are not equipped to manage its long-term storage in a satisfactory manner. For these reasons a national repository is required.

A national repository will promote the safe and environmentally sound management of radioactive waste, by enabling control of radioactive waste to be coordinated nationally, encouraging waste minimisation through charging users for disposal services, and by providing for safe containment of the waste until its radioactivity has decayed to such low levels that institutional control becomes unnecessary.

Australia's radioactive waste can be divided into two broad categories based on disposal requirements:

1. Low-level and short-lived intermediate-level radioactive waste that can be disposed of by near-surface disposal.

2. Long-lived intermediate-level radioactive waste (Category S waste) that requires geological disposal.

Low-level and short-lived intermediate-level radioactive waste

Australia's low-level and short-lived intermediate-level radioactive waste includes lightly contaminated plastics, paper, laboratory glassware, protective clothing and laboratory equipment, mainly stemming from the production of radiopharmaceuticals and radioisotopes for medical applications and research. Some waste is also a legacy of the past use of radioisotopes in consumer items such as radium-painted luminous watch faces, compasses and instrument dials, industrial smoke detectors and emergency night illumination devices.

Approximately 2000 cubic metres of Australia's radioactive waste is soil that is lightly contaminated with radioactive residues now in interim storage near Woomera, South Australia. This waste resulted from research into processing radioactive ores during the 1950s and 1960s at the former CSIRO laboratory site at Fisherman's Bend in Victoria.

The scientific consensus and international experience is that this waste can be safely packaged and disposed of in properly sited, designed and operated near-surface facilities. Such facilities contain the waste until its radioactivity decays naturally to insignificant levels or the remaining activity is low enough for control to be unnecessary. This decay will take from 100 to 300 years. Institutional control over the national repository site will be maintained until the need for control is no longer necessary.

Long-lived intermediate-level radioactive waste (Category S)

Category S waste is not suitable for near-surface disposal. This waste must be stored until a geological disposal facility is established.

The amount of Category S waste in Australia is very small; however, the volume of Category S waste increases significantly when it is packaged for long-term storage or disposal. It currently consists mainly of sealed radium sources and some of the waste from the production of radiopharmaceuticals. Additional Category S waste is expected from the treatment of Australia's used research reactor fuel.

The Government has decided to send UK origin spent fuel to Dounreay (Scotland) for reprocessing. The volume of equivalent waste expected to return to Australia is approximately 250 cubic metres (500 drums). This will be solid cemented waste in 500-litre drums.

The small quantity of Category S waste produced by Australia cannot presently justify the cost of constructing a geological disposal facility. Geological disposal of low-level waste with Category S radioactive waste would be expensive, though less so if an existing facility and infrastructure such as an abandoned mine site or worked-out areas of an active mine could be used.

HISTORY

Over the past ten years stringent international standards have been developed for the management of radioactive waste. These standards have been adopted by Australia through its development of national codes of practice. The codes and international standards are promulgated in Commonwealth, State and Territory regulations.

In 1991 the Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency published an *International Collective Opinion*, which confirmed that safety assessment methods are available today that can evaluate adequately the potential long-term radiological impacts of a carefully designed radioactive waste disposal system on humans and the environment.

Australia actively participated in negotiations on the recently adopted international Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. The objective of the Joint Convention is to encourage the safe and environmentally appropriate management of radioactive waste. The Convention is expected to strengthen internationally agreed safety standards and codes by requiring parties to have regard to them in domestic legislation. The Convention also requires parties to report on their radioactive waste management arrangements and inventories.

In 1985 the Commonwealth/State Consultative Committee (C/SCC) on Radioactive Waste Management recommended a national program to identify potentially suitable sites for a national near-surface radioactive waste repository. The C/SCC reported that most of Australia's radioactive waste is suitable for near-surface disposal at specially selected sites. Studies were undertaken by State and Territory authorities to identify potentially suitable regions using international guidelines.

These studies, presented in 1986, showed that in most States and the Northern Territory there were a number of regions that were likely to contain suitable repository sites. The C/SCC recommended that 'prospective host governments advise the Commonwealth on what basis they would proceed to detailed investigation of possible locations, and that appropriate arrangements be made to enable at least one of those governments to proceed'.

Although all governments supported the concept of a national repository, only the Northern Territory Government initially expressed interest in hosting one. In 1988 the Northern Territory Government agreed to a Commonwealth-funded feasibility study of a repository in the Northern Territory, which was completed in 1989. However, in May 1991 the Northern Territory Government advised the Commonwealth of its decision not to host the repository. Political rather than technical considerations appear to have caused the failure of the C/SCC siting process.

Continuing concern by some local communities regarding the temporary storage of radioactive waste in their vicinity and the inadequate capacity of some existing storage facilities prompted the Commonwealth, in 1992, to commence an Australia-wide search for a suitable national repository site.

The National Repository Study

The National Health and Medical Research Council's *Code of Practice for the Near-surface Disposal of Radioactive Waste in Australia* (1992) was developed from International Atomic Energy Agency (IAEA) criteria. The purpose of the Code is to provide a basis for near-surface disposal of solid radioactive waste in a way that ensures there is no unacceptable risk or detriment to humans, other living things or the environment at present, and that future risks or detriment will not exceed those currently accepted.

Underpinning the site selection criteria set out in the Code is the importance of natural site characteristics in providing an effective barrier to the dispersal of radionuclides from the waste, and to human intrusion. The criteria emphasise factors such as suitable geology and groundwater characteristics, arid climate, and remoteness from population centres.

Phase 1 of the National Repository Siting Study involved developing a methodology for selecting a suitable site using a Geographic Information System (GIS) to apply the site selection criteria as set out in the Code.

The Phase 1 public discussion paper, released in October 1992 (NRIC 1992), explained the proposed site selection process and the GIS-based methodology. The paper was widely circulated for comment by the public and interest groups, and a follow-up report, published in August 1993 (DPIE 1993), summarised and responded to comment received on the Phase 1 study.

In Phase 2, the Phase 1 methodology was reapplied, taking into account public comment on the Phase 1 report. Based on public comment and new analysis, the Phase 2 study identified eight broad regions in Australia that are likely to contain suitable sites. The Phase 2 public discussion paper was released in July 1994 (NRIC 1994). A report responding to public comment on this discussion paper was published in November 1995 (DPIE 1995).

Senate Select Committee and the Government's response

In May 1995 a Senate Select Committee on the Dangers of Radioactive Waste was established to investigate radioactive waste management issues in Australia. The Committee's terms of reference included reference to the process to establish a national near-surface radioactive waste repository.

The Commonwealth Government's repository siting study was postponed until it could take into account the Committee's findings. The Committee's report *No Time to Waste* was tabled in Parliament on 30 April 1996.

The key recommendation from the Senate Select Committee relating to the future of the national radioactive waste repository siting study was:

> ***Recommendation 17:***
> *The Committee recommends a national above ground storage facility be established which has the capacity to take low, intermediate and high-level radioactive waste.* (Paragraph 7.18).

The Government's response was:

> *In recommending a single facility, the Committee seems to confound the particular and exclusive requirements for safe storage of the various categories of radioactive waste. Nevertheless, the Government accepts in principle the recommendation of a storage facility for long-lived intermediate-level waste (Category S waste) which is not suitable for near-surface disposal. This would include waste to be returned from reprocessing of Australian research reactor fuel at Dounreay (Scotland). Establishment of such a facility will be raised in the Commonwealth/State Consultative Committee on Radioactive Waste Management to assess the extent of State and Territory support for the proposal.*
>
> *For low-level and short-lived intermediate-level radioactive waste, international standards and practice clearly indicate that near-surface disposal is appropriate rather than storage as recommended by the Committee. Accordingly, the Government intends to proceed with the study commenced by our predecessors to identify a disposal site for low-level and short-lived intermediate-level radioactive waste. The study will also consider the proposal that this repository be co-located with an above ground storage facility for long-lived intermediate-level waste in order to secure the benefits of shared infrastructure.*

In recommending above-ground storage of all categories of radioactive waste (Recommendation 17 and Paragraphs 6.47 and 6.57), the Senate Committee has given considerable weight to the hope that technology will be developed for destruction of radioactive materials. Transmutation may eventually be possible in the context of high-level actinide wastes from the reprocessing of spent nuclear power reactor fuel. However, it is unrealistic to expect this technique to be applied to low-level wastes. In any case, transmutation still results in some radioactive tails being produced.

There is also evidence in the Committee's report of confusion between 'disposal' and 'storage' of radioactive waste. For example the Committee contends that: 'The international nuclear community has been unable to come up with an answer on how to dispose of radioactive waste other than that classified as exempt'. This is patently incorrect. Many near-surface disposal facilities for low-level and short-lived intermediate-level wastes are operating overseas at present as acknowledged by the Committee (Paragraphs 6.69, 6.73, 6.74). One is currently operating in Western Australia.

Unnecessary storage of radioactive waste rather than disposal imposes an unnecessary burden of management on future generations. The International Atomic Energy Agency's Safety Fundamentals include the principle: 'Radioactive waste shall be managed in such a way that will not impose undue burdens on future generations.' Safe disposal of radioactive waste is the management approach that best satisfies this fundamental principle.

THE REPOSITORY PROPOSAL

The Commonwealth Government is seeking a repository site with excellent natural characteristics for the retention of radioactive materials. An area of 2.25 square kilometres is required for the national repository site, including a large buffer zone where access is controlled and conditions monitored.

Before any radioactive material is taken on to the site, a comprehensive baseline monitoring program will be instituted. Monitoring will continue during operations and over the control period.

Site infrastructure would include a near-surface disposal facility for low-level and short-lived intermediate-level waste, facilities for receipt, handling and short-term storage of waste, amenities for staff required during disposal operations, an access road from the nearest highway or railhead and security fences.

The site may also include facilities for packaging the waste for disposal. Options for waste packaging facilities are: on site; at a separate designated facility; or at individual regional facilities.

In its response to the Senate Select Committee's report the Government agreed to consider possible co-location of a Category S waste store with a near-surface disposal facility, an option that would provide benefits due to the shared infrastructure. The Phase 1 Discussion Paper (NRIC 1992) also indicated that a national near-surface repository could provide interim on-site surface storage facilities for waste not considered suitable for near-surface disposal. The appropriateness of storage of Category S waste at a near-surface disposal facility would, however, depend on the site selected and, in particular, appropriate site security arrangements.

A Category S store would require a purpose-built shielded facility designed to minimise radiation exposure to workers and the environment.

WASTE ACCEPTANCE CRITERIA

Radioactive waste will be accepted and disposed of at the national near-surface repository site in accordance with the NHMRC *Code of Practice for the Near-Surface Disposal of Radioactive Waste in Australia (1992)* and the IAEA guidelines on siting, design, construction, operation and closure of near-surface repositories.

Radioactive waste presented for disposal will need to meet activity concentration limits derived on the basis of recommendations in the NHMRC's Code. Activity concentration limits may vary depending on the institutional control period chosen by the appropriate authority. The Code requires that the institutional control period should be 'not less than 100 years' (Section 2.6.2). These limits will ensure only waste with very low concentrations of long-lived radionuclides will be accepted for disposal.

Based on evaluation of exposures that might result from release of radionuclides into the environment and on the anticipated mixture of radioisotopes, a limit on total radionuclide activity for the proposed disposal facility will be established.

The repository will receive a wide variety of waste, ranging from lightly contaminated soil to short-lived intermediate-level sources. The repository design will allow a range of containers to be used for different types of waste, for example 200-litre drums for very-low-level waste, and engineered concrete canisters or other modular containers or structures that meet containment and structural requirements, for short-lived intermediate-level waste.

The Code also specifies physical, biological and chemical requirements for the waste. For example, the waste is not to contain corrosive or reactive materials. Only solid waste containing or contaminated with radioactive materials will be accepted at the repository. Non-radioactive or liquid waste will not be accepted.

Design of the repository

An engineered shallow trench repository for the disposal of low-level and short-lived intermediate-level waste is proposed. The design will depend on factors such as the surrounding land use, accessibility to transport, amount and types of radioactive waste for disposal, climate, geology and operational arrangements. The institutional control period includes time after the site has been closed for which land use limitations can be imposed. The final design of the repository will depend on the site selected, the need for any additional barriers, and on public comment.

The near-surface disposal structure is expected to occupy an area of less than 100 metres by 100 metres (about the area of a soccer field) and would be less than 20 metres deep.

A suitably engineered cover will be placed over the buried waste to limit infiltration of rainwater, discourage human intrusion or intrusion by animals or plant roots, and inhibit erosion. The cover will be designed to ensure that only a very small fraction of rainwater, if any, falling on the repository will percolate down to the depth of the buried waste. Nearly all rainwater will run off the cover or be evaporated back to the atmosphere.

Regulatory control

Arrangements for regulatory control of the national radioactive waste repository will depend on whether it is sited on State or Commonwealth land. If it is on Commonwealth land then the expectation is that the repository will be regulated by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), a statutory authority to be established to regulate radiation-related Commonwealth activities. The establishment and operation of the repository will satisfy relevant radiological and environmental regulations, and a monitoring program will be established to ensure continued compliance with the regulations.

Operation and management

The operation and management of the repository will be determined following consultations with relevant parties. Responsibility for site management and security arrangements may include State Government, Commonwealth Government, private operator control or a combination of these.

Closure and post-operational monitoring

The NHMRC's Code of Practice has detailed guidelines for closure of the disposal facility. Disposal operations at the facility will cease when the authorised disposal space is filled or the limit on total site radioactivity is reached.

Prior to construction of the repository, plans for decommissioning the facility and rehabilitating the site will be prepared and submitted to the appropriate authority for approval. These plans will be reviewed regularly and resubmitted for approval. Prior to closure detailed decommissioning plans will be submitted.

During the repository operation and control period public access will be controlled and arrangements for site rehabilitation work and maintenance will be in place.

Land use after the control period

At the end of the established institutional control period no further control of the repository site will be necessary because the radioactive materials will have decayed to safe levels. In the unlikely event of human intrusion on the waste after this period, it would not result in significant human exposure or environmental impact above the prescribed radiological dose limits.

User-pays principle

The cost of establishing the repository and operating it will be recovered through a user-pays system for disposal, which will also encourage waste minimisation practices among waste producers. It is proposed that the user-charging policy will:

- reflect the true cost of disposal;
- enable recovery of the disposal facility establishment costs;
- cover operating costs during the lifetime of the facility and post-closure activities; and
- involve a charging regime that acts as an incentive for users to adopt waste minimisation practices but does not encourage illicit disposal or abandonment of radioactive waste.

A user charge is expected to be based on the volume and type of radionuclide and total package radioactivity.

Storage of Category S radioactive waste would also operate on a user-pays basis consistent with the principles outlined above.

Transport of waste

Transport of radioactive waste to the national repository will be infrequent, perhaps once a year, when sufficient waste has accumulated at interim stores around the country to make a transfer to the repository viable. It is expected that interim storage facilities will be required as central collection points for waste pending transport to the disposal facility.

Radioactive waste will be transported to the national repository in strict compliance with the national *Code of Practice for the Safe Transport of Radioactive Substances 1990* (Transport Code) (DASETT 1990) and relevant Commonwealth/State/Territory regulations. The preferred transport route for waste consignments will be determined in consultation with the appropriate State authorities.

The purpose of the Transport Code is to establish safety standards that provide acceptable levels of control of the radiation hazards to people, property and the environment associated with the transport of radioactive materials. It covers all operations and conditions associated with and involved in the movement of radioactive material. These include the design, fabrication and maintenance of packaging, and the preparation, consigning, handling, carriage, storage in transit and receipt at the final destination of packages. It also includes normal and accident conditions encountered in carriage and in storage during transit.

Transport of radioactive material has been practised with a high level of safety internationally and within Australia for many years. The risks involved with the transport of radioactive waste are less than with other hazardous cargoes that are routinely transported on our roads, such as flammable and corrosive substances.

SELECTION OF THE PREFERRED REGION

The public discussion paper *A Radioactive Waste Repository for Australia: Methods for Choosing the Right Site* (NRIC 1992) described a method for selecting a suitable site to dispose of Australia's low-level and short-lived intermediate-level radioactive waste, satisfying the site selection criteria set out in the National Health and Medical Research Council's *Code of Practice for Near-surface Disposal of Radioactive Waste in Australia.* The discussion paper provided examples of how a computer-based information storage and assessment system could be used to apply the NHMRC's site selection criteria over all of Australia to identify potentially suitable areas for the near-surface disposal of the radioactive waste.

A second discussion paper, *A Radioactive Waste Repository for Australia: Site Selection Study - Phase 2* (NRIC 1994), described the reapplication of that method with the inclusion of suggestions made following the Phase 1 report. Eight broad regions were identified by the system and public comment as highly likely to contain suitable repository sites.

This section describes the method used to identify and then compare the eight regions, and outlines each region's qualities for hosting a repository site of approximately 225 hectares (2.25 square kilometres). Assessments were made in two ways:

1. By a comparative description of each region against the selection criteria.

2. By mapping each region's numerical suitability ratings from the computer-based information system developed for this work (now called ASSESS - A System for Selecting Suitable Sites).

ASSESS

ASSESS is a computer-based software suite using geographic information to apply site selection criteria to indicate areas where low-level and short-lived intermediate-level radioactive waste could be disposed of in Australia. The system was first applied in a review for all of Australia (NRIC 1992). Following public consultation on Phase 1, ASSESS was reorganised to include updated information and was used to test several different treatments or interpretations of the information (scenarios).

Site selection criteria

The study initially reviewed all of Australia using continental-scale information. The site selection process applied all thirteen NHMRC criteria covering both biophysical and socio-economic considerations. The criteria are divided into two groups: those important for radiological protection, and other, non-radiological factors.

Selection criteria important for radiological protection were:

- **Criterion a:** The facility site should be located in an area of low rainfall, should be free from flooding and have good surface drainage features, and generally be stable with respect to its geomorphology.
- **Criterion b:** The water table in the area should be at a sufficient depth below the planned disposal structures to ensure that groundwater is unlikely to rise to within five metres of the waste, and the hydrogeological setting should be such that large fluctuations in water table are unlikely.
- **Criterion c:** The geological structure and hydrogeological conditions should permit modelling of groundwater gradients and movement, and enable prediction of radionuclide migration times and patterns.
- **Criterion d:** The disposal site should be located away from any known or anticipated seismic, tectonic or volcanic activity that could compromise the stability of the disposal structures and the integrity of the waste.
- **Criterion e:** The site should be in an area of low population density and in which the projected population growth or prospects for future development are also very low.
- **Criterion f:** The groundwater in the region of the site that may be affected by the presence of a facility ideally should not be suitable for human consumption, pastoral or agricultural use.
- **Criterion g:** The site should have suitable geochemical and geotechnical properties to inhibit migration of radionuclides and to facilitate repository operations.

Selection criteria for non-radiological factors were:

- **Criterion h:** The site for the facility should be located in a region that has no known significant natural resources, including potentially valuable mineral deposits, and that has little or no potential for agriculture or outdoor recreational use.
- **Criterion i:** The site should have reasonable access for the transport of materials and equipment during construction and operation, and for the transport of waste to the site.
- **Criterion j:** The site should not be in an area that has special environmental attraction or appeal, that is of notable ecological significance, or that is the known habitat of rare fauna or flora.
- **Criterion k:** The site should not be located in an area of special cultural or historical significance.
- **Criterion l:** The site should not be located in reserves containing regional services such as electricity, gas, oil or water mains.
- **Criterion m:** The site should not be located in an area where land ownership rights or control could compromise retention of long-term control over the facility.

Figure 1: The eight Phase 2 regions. No areas were considered within the Murray-Darling Basin or the Great Artesian Basin because of their important water and agricultural resources (Criteria f and h).

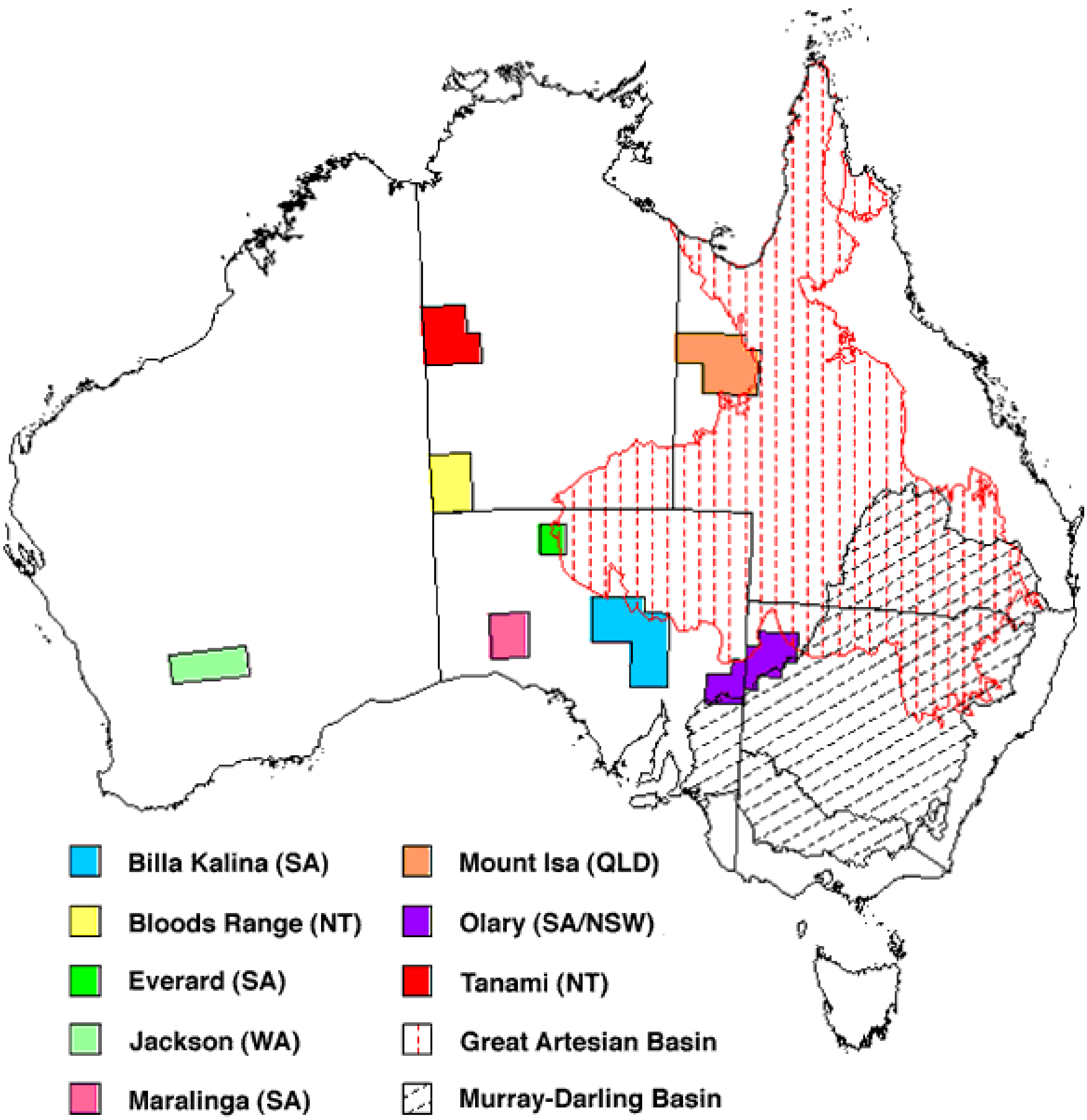
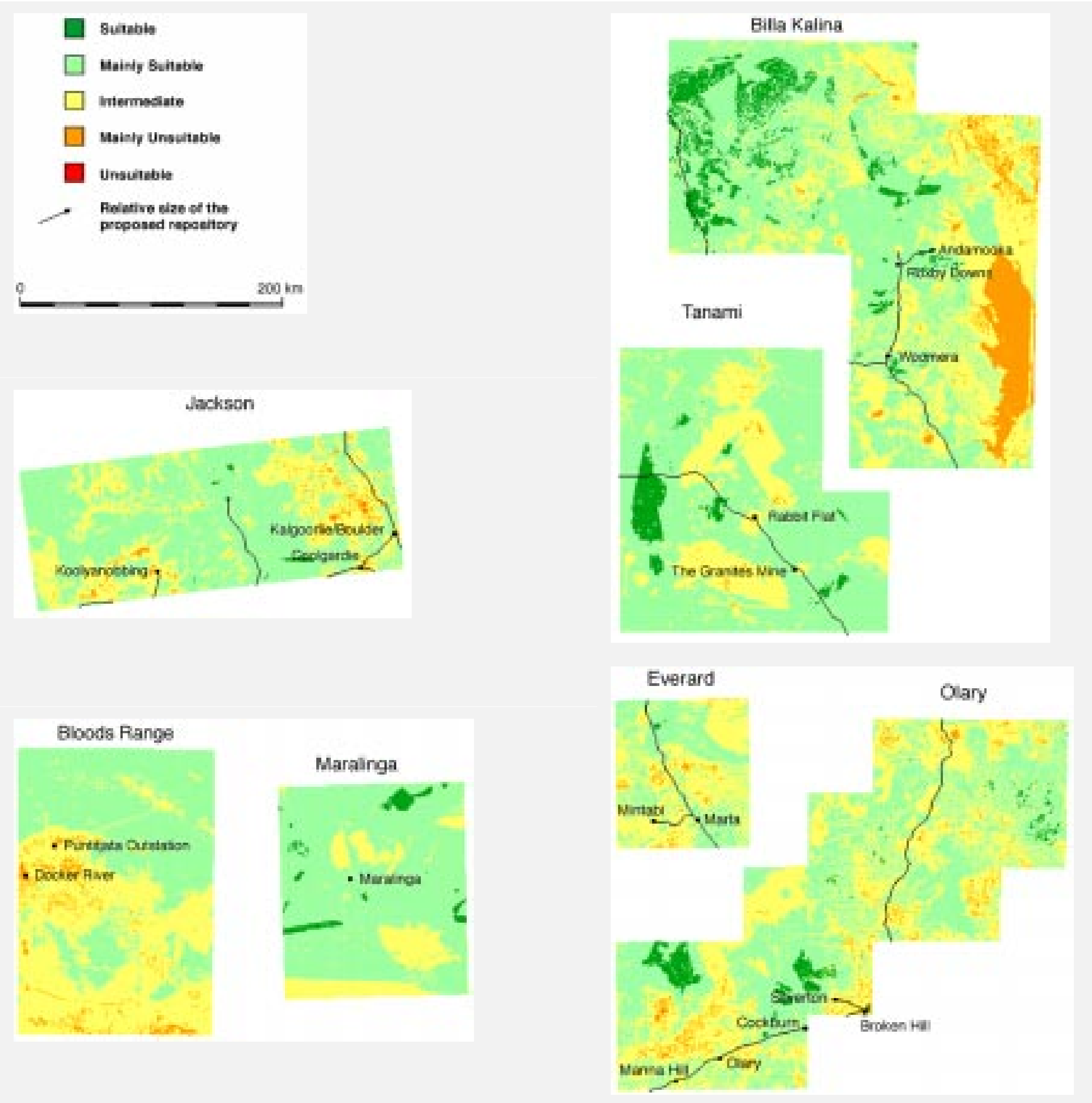


Figure 2: Mapped distribution of suitability for the eight regions using all information layers.



There is no stated preference or weighting of the criteria except for a statement that, 'A potential site may not necessarily comply with all of these criteria. However, there should be compensating factors in the design of the facility to overcome any deficiency in the physical characteristics of the site' (NHMRC 1992).

In Phase 1 all of Australia was assessed against the selection criteria using computer-based geographic data layers. For some criteria it was apparent that detailed, site-specific investigation would be needed to confirm suitability. For the Australia-wide assessment against the criteria information was collected describing:

Bedrock geology
Surficial geology
Vegetation typeLakes, rivers, streams, swamps
Hydrogeology
Groundwater quality
Water balance (meteorological dryness)
Topographic relief
Soil properties
Regolith
Fault lines (major)
Earthquake hazard
Populated places (cities, towns, homesteads)
Land tenure
Roads and railways
National estate (registered areas and sites)
Plants (rare or threatened)

Specialists in areas including geology, hydrogeology, seismology, ecology, meteorology and soils were asked to review the information against the selection criteria and to rate the suitability of different areas throughout Australia. The rating system assigned numbers to areas to represent relative suitability as:

1 = suitable
2 = mainly suitable
3 = intermediate or indeterminate
4 = mainly unsuitable
5 = unsuitable

Using ASSESS many layers of the rated information were added together, with the lowest summed areas being rated as suitable and the highest summed areas as unsuitable. From this process a relative suitability map for all of Australia could be made. ASSESS allowed for the suitability ratings to be changed and for only some data layers to be used. In this way the sensitivity of a suitability map to alternative interpretations or the use of different information could be tested.

Selection of the eight regions

After the receipt of public comment on the Phase 1 discussion paper, ASSESS was reapplied at the continental level using refined and updated information. Results obtained from many different ASSESS scenarios indicated that several broad regions of Australia appeared consistently likely to contain highly suitable repository sites. Areas that remained suitable in many scenarios became the focus for selecting smaller regions for more detailed assessment. In addition, public and broader scientific involvement suggested that other areas should also be considered either because of their likely technical suitability or because of a perceived compatible land use such as existing contaminated areas. Five regions were chosen based on ASSESS and three were identified by consultation.

The five regions identified by ASSESS were:

Billa Kalina, SA
Bloods Range, NT
Everard, SA
Olary, SA and NSW
Tanami, NT

The three regions identified by consultation were

Jackson, WA
Maralinga, SA
Mount Isa, Qld

In order to define a boundary for the collection of regional scale information for each region, standard metric map sheet areas (1:100 000 and 1:250 000 scales) containing the potentially suitable areas were identified (Figure 1). The boundaries represent a practical and convenient way of focusing upon more detailed information for each region. This does not necessarily indicate the limits of potential suitability.

Assessment of the eight regions

For this assessment, digital data for each region were assembled at a regional scale (1:250 000). The datasets were: geology; faults; surface water features; groundwater - its standing level, supply rates and quality; land ownership; and transport infrastructure. Fewer data layers were used than in the continental assessment because information was not available at the more detailed scale. The results of the eight regional assessments were presented in the Phase 2 public discussion paper (NRIC 1994).

After the release of the Phase 2 paper more detailed regional datasets and two new datasets became available. The new datasets were: proximity to populated places, and location of mineral resources. These were incorporated in ASSESS and the region assessments were re-done.

All eight regions are likely to contain suitable repository sites; however, some have larger areas of potential suitability than others. Given the high cost of conducting field surveys in every region it was necessary to select a single (preferred) region for more detailed field investigation. The aim was to select the region with the largest areas of high suitability.

In order to establish the region that best satisfied the requirements two styles of assessment were used - one a descriptive comparison against the selection criteria, and the other based on ASSESS. The descriptive comparison provides a understanding of the suitability features of each region against the selection criteria, but it cannot provide a combined map showing the areas of high suitability for all the criteria. The ASSESS method provides an analytical synthesis of the suitability ratings and maps the distribution of combined suitability for all criteria.

Descriptive comparison

The issues raised by each selection criterion and the geographic information used to compare the regions are described below. For some criteria, such as the climate characteristics or the surface drainage setting, comparative assessments can be made between the regions as a whole. Other criteria deal with locally varying conditions and need to be described individually and compared with other regions in semi-quantitative terms.

Criterion a: *The facility site should be located in an area of low rainfall, should be free from flooding and have good surface drainage features, and generally be stable with respect to its geomorphology.*

In considering rainfall it is important to review not only the yearly amount of rainfall received in an area but also its variability, intensity and distribution through the seasons. The *Climate* volume of the *Atlas of Australian Resources* provides a broad overview of rainfall characteristics, and a relative assessment of suitability is made here for each region.

Other factors are also important, such as the rates of rainfall run-off, infiltration and evapo-transpiration. These involve considerations such as geomorphology, soils, drainage systems and the vegetation cover. For many of these factors the Australia-wide assessments provided an initial representation of the important features.

In the Australia-wide consideration of suitability, ASSESS incorporated the ratio of annual evaporation over precipitation as a broad indicator of dryness. The more detailed aspects of surface water and its movement were reappraised for each region during the Phase 2 study and again after receiving public comment. Regional-scale data for surface drainage and local topography were used to indicate areas with good surface drainage, stable geomorphology and those parts of the regions that are free from flooding.

The consideration of stable geomorphology was assessed using a combination of regolith terrain, landscape descriptions and the topographical relief. At the continental scale, areas of moderate to low relief with an ancient history of deep weathering and slow erosional processes were rated as suitable. In contrast, areas that were steep and prone to rapid erosion, or areas that were low-lying or flat and prone to flooding or waterlogging, were rated as unsuitable. These areas included depositional landscapes where water- or wind-deposited sedimentation has occurred in recent geological time or where deposition is occurring at present.

All the regions, with the exception of Mount Isa, have a median annual rainfall of less than 300 mm. Of these, Billa Kalina, Everard and Maralinga have the highest suitability with median rainfall less than 200 mm. In the Mount Isa, Tanami and Bloods Range regions the rainfall intensity (Pilgrim 1987) is higher, leading to these regions being less suitable than the other regions. The variability of rainfall is highest in the Bloods Range and Everard regions.

Areas with good surface drainage that are free from flooding were assessed using a combination of a digital elevation model (DEM), regional watercourses and the general geomorphological setting and history (regolith terrains). Suitable areas are topographically raised above surrounding areas, have a mild slope and a clearly defined and interconnected surface drainage (creek line) pattern. The presence of deeply weathered soil and rock was used as an indicator of geomorphological stability.

The Billa Kalina, Jackson and Olary regions contain the largest areas of suitability with regard to Criterion a.

Criterion b: *The water table in the area should be at a sufficient depth below the planned disposal structures to ensure that groundwater is unlikely to rise to within five metres of the waste, and the hydrogeological setting should be such that large fluctuations in water table are unlikely.*

Criterion c: *The geological structure and hydrogeological conditions should permit modelling of groundwater gradients and movement, and enable prediction of radionuclide migration times and patterns.*

Criterion g: *The site should have suitable geochemical and geotechnical properties to inhibit migration of radionuclides and to facilitate repository operations.*

In the Australia-wide overview of Phase 1, all parts of Australia were categorised according to productivity and areal extent of their groundwater system. Three broad categories were used for suitability rating:

1. Areally extensive and highly productive groundwater system (unsuitable)
2. Areally extensive but of generally low to moderate productivity (intermediate/indeterminate)
3. Local and with generally low productivity (suitable)

As a refinement for the regional analysis of Phase 2, water bore records were used to give site-specific indications of the standing water level, water quality and the supply rate throughout the regions. The amount and quality of information available for the different regions varied widely, with some having good distribution and intensity of data and others that were very poor. As a consequence, only broad indications of groundwater characteristics were obtained, but this was still useful in gauging the range of conditions that might occur. A preferred region is one where there are large areas that contain deep aquifers, with poor water quality (highly saline) and very low supply rates.

The modelling of the geological and hydrogeological conditions to predict radionuclide migration times and patterns is easier in areas with a simple geological structure. These occur where the materials have a simple internal structure such as in layer-cake sedimentary sequences, or where intense, deep weathering has obliterated former, more complex structures. Another benefit exists if the materials are fine-grained (clay and silt) as these can be more reactive and may entrain or retard radionuclide movement.

At the continental level, bedrock geology, fault lines and fracture systems, regolith landscapes and relative topographic relief were used to assist the assessment of relative suitability. At the regional level, a more detailed review was made of the geological materials and structures.

A regional scale interpretation of groundwater conditions was possible for Billa Kalina, Mount Isa and Olary regions because sufficiently detailed water bore information could be obtained. Billa Kalina and Olary have areas with deep, low production and saline groundwater systems. The Mount Isa region is similar, but the water quality is generally good.

In the other regions the information is too sparse for a region-based interpretation so defining suitable areas based on groundwater characteristics becomes difficult.

The near-surface rock types and their properties vary widely within and between the regions. Most typically, the more suitable, topographically elevated areas are gently sloping rock outcrops with a thin cover of sediment, with flatter areas and plains covered by alluvium (water-washed) or aeolian (wind-blown) material. Deeply weathered soil and rock with relatively simple internal structure was sought in these areas. They occur extensively in the Billa Kalina, Jackson and Olary regions, occur to a lesser extent in the Mount Isa and Everard regions and are limited in occurrence in the Bloods Range, Tanami and Maralinga regions.

Favourable geochemical and geotechnical properties were indicated in different ways in the various regions. Suitable areas in the Jackson region are commonly over old, crystalline basement, in deeply weathered granites of the Yilgarn Block. Here the clayey weathering products form a hydrologically restrictive environment with a clay chemistry that could bind up or restrict the movement of radionuclides. In the Billa Kalina region there also occur deeply weathered materials in Mesozoic-age sediments such as the Bulldog Shale. This shale has a layer-cake internal structure with labile (reactive) silt and clay composition that provides suitably restrictive hydrological properties.

The favourable settings in the other regions are commonly Tertiary and Quaternary pediments and plains of weathered, sedimentary clays and sand. For example, in the Mount Isa, Olary and Everard regions the sediments overlie suitable, weathered pre-Cambrian or Archaean basement.

The bedrock of the Maralinga region is dominated by limestone and carbonate-rich sediments. There is evidence of extensive, cave-like openings (dolines) where groundwater has weathered away the rock and would make hydrological modelling difficult.

The Billa Kalina, Jackson and Olary regions contain the largest areas of suitability with regard to the criteria.

Criterion d: *The disposal site should be located away from any known or anticipated seismic, tectonic or volcanic activity that could compromise the stability of the disposal structures and the integrity of the waste.*

In Australia, the youngest volcanic rocks occur in western Victoria, southeastern South Australia and far-northeastern Queensland. These range from about two thousand to a few million years old and are closely associated with continental-style volcanic arc sequences of the Tasman Tectonic Belt of eastern Australia. The rest of Australia is dominated by ancient and comparatively tectonically stable continental crust or by very thick sequences of sediments in large, depositional basins.

Any area with a high seismic activity by Australian standards, or close to faults or fracture systems (of any age) or close to geologically young volcanics is rated unsuitable.

All the identified regions are in low risk areas with respect to this criterion.

Criterion e: *The site should be in an area of low population density and in which the projected population growth or prospects for future development are also very low.*

Criterion f: *The groundwater in the region of the site that may be affected by the presence of a facility ideally should not be suitable for human consumption, pastoral or agricultural use.*

Criterion h: *The site for the facility should be located in a region that has no known significant natural resources, including potentially valuable mineral deposits, and that has little or no potential for agriculture or outdoor recreational use.*

In the arid parts of Australia, where several of the selection criteria are best satisfied, the projected population growth or prospects for future development can be reasonably confined to those areas where there is scope for tourism, mining operations or intensive agriculture.

The areas that generally attract tourist interest have either aesthetic, historical or cultural significance (Criteria j and k), or are part of the 'Outback' and the attraction is one of travelling through its remoteness. A variety of information was used to assess these considerations including: areas listed on the Register of the National Estate (heritage areas), nature conservation reserves, towns, homesteads and related infrastructure.

The known and potential economic mineral deposits were reviewed both at the national and the regional scales using the Bureau of Resource Science's mineral location and mineral resource datasets. This information provides a general representation of the mineral occurrences in the regions, but a more detailed investigation of a preferred region's mineral potential will be done before a site is chosen. Ongoing exploration will assist in identifying areas of no economic interest, and detailed site investigations will provide further information. For these reasons, at this stage, presence or absence of economic mineral resources has not been used as a determinant of a region's suitability.

In arid and semi-arid lands the typical agricultural activity is rangeland grazing, with low stocking density. However, where adequate groundwater exists the prospect of intensive crop production could emerge; this could include saline water where desalinisation could be employed. For this reason areas with low production, deep and poor quality groundwater systems were rated as suitable because their use for intensive agriculture is unlikely.

High suitability was indicated where the groundwater was at least 50 metres below the surface and where water production was less than 0.5 litres per second. Groundwater with a salt content in excess of 14 000 parts per million was considered as unfit for pastoral or agricultural use.

Where the drilled depth of a water bore and the measured standing water level are similar this can indicate that the aquifers are unconfined (unpressured). If the standing water level is also deep (>50 m) it is unlikely that the water will rise close to any near-surface disposal facility.

The quality and quantity of water bore information varied within and between the regions; however, the Billa Kalina and Olary regions indicated large suitable areas. Mount Isa has generally high quality groundwater, unsuitable with regard to Criterion f. The other regions indicated some deficiencies in one or more of the considerations, but more detailed information would be required for confirmation.

Criterion i: *The site should have reasonable access for the transport of materials and equipment during construction and operation, and for the transport of waste to the site.*

The major road and rail networks were incorporated in the continental and regional analyses. The initial consideration was an area's distance from the transport route. The dataset has since been updated to include road quality.

Highest suitability is assigned to areas within 10 kilometres of a well formed major road or a rail line and lowest suitability to areas with poor quality access, such as more than 100 kilometres from a road.

Transport access is a limiting factor for the Bloods Range and Tanami regions. All other regions have at least one major highway and a railway line passing through them. The transport distance from the main temporary stores (eastern seaboard) was not analysed. However, the Billa Kalina, Everard, Maralinga and Olary regions are closest to the main sources of waste production.

Criterion j: *The site should not be in an area that has special environmental attraction or appeal, that is of notable ecological significance, or that is the known habitat of rare fauna or flora.*

Criterion k: *The site should not be located in an area of special cultural or historical significance.*

The national and regional assessments identified lands with a nature conservation status and the Register of the National Estate indicated areas of heritage importance. All of the regions have large areas that are outside these currently identified natural or cultural heritage areas.

A site-specific survey during the next phase will form part of an environmental assessment for the selected site. This survey will put the repository site in its regional context. The small size of the site should also allow it to be located to avoid special or peculiar environmental and ecological conditions and areas of special Aboriginal or European cultural significance.

Criterion l: *The site should not be located in reserves containing regional services such as electricity, gas, oil or water mains.*

If a site is chosen in the vicinity of an easement for regional services such as electricity, gas, oil and water mains it will be located at a reasonable distance from the easement.

Criterion m: *The site should not be located in an area where land ownership rights or control could compromise retention of long-term control over the facility.*

This criterion was not used as a determinant of region suitability because the choice of any site will include negotiation with the current land owner and others with a direct interest in the land.

There will be detailed consultation with the current owner, lessee or custodian leading to the identification of a preferred site. Public consultation and participation has been sought since 1992 and the communities with a direct interest in the preferred region will be consulted. All regions are expected to have sites where the long-term control of the facility can be maintained.

The descriptive analysis indicates that the Billa Kalina and Olary regions have the largest areas of suitability.

Analytical comparison

Following public comment on the Phase 2 discussion paper, new analyses of suitability were made for each of the eight regions. As described in the Phase 1 and Phase 2 reports, the datasets used to assess site suitability were sampled into grid squares (cells) to give an identical alignment of cells between themes; for example, geology or surface drainage features.

Each region had a suite of ten datasets for analysis in ASSESS. These were: geology; faults; surface water features, groundwater standing level, supply rates and quality; land ownership category; transport infrastructure; and two new datasets, proximity to populated places and mineral resource deposits.

Each cell in each dataset had attached to it a suitability rating ranging from suitable to unsuitable. These ratings could be interactively modified in ASSESS to test the sensitivity of alternative treatments of the data. The results of combining all the themes for each region are shown in Figure 2 (pages 8-9). Those cells rated 'suitable' are coloured dark green whereas the 'unsuitable' cells are coloured red. Intermediate categories are shaded in colours between the red and green spectrum.

The Billa Kalina region shows the largest areas of suitability. Due to the use of map sheet boundaries, this region includes Lake Torrens in the south-east, an area that is not suitable for a repository. The Everard, Jackson, Olary, and Tanami regions also have areas of high suitability but these are less extensive than in the Billa Kalina region. Other treatments of the data also support this conclusion.

Table 1: Summary of conclusions from the descriptive comparison of the eight regions

Criteria	Billa Kalina	Bloods Range	Everard	Jackson	Maralinga	Mount Isa	Olary	Tanami
a	⌖			⌖			⌖	
b, c and g	⌖			⌖			⌖	
d	⌖	⌖	⌖	⌖	⌖	⌖	⌖	⌖
e, f and h	⌖						⌖	
i	⌖		⌖		⌖		⌖	
j and k	⌖	⌖	⌖	⌖	⌖	⌖	⌖	⌖
l	⌖	⌖	⌖	⌖	⌖	⌖	⌖	⌖
m	⌖	⌖	⌖	⌖	⌖	⌖	⌖	⌖

⌖ **indicates that the region has large areas of suitability with respect to a criterion.**

The preferred region

The outcome of the descriptive and analytical comparison of the eight regions is that the *Billa Kalina* region is to be preferred and is recommended for investigation to identify a suitable repository site. Although other regions are likely to contain suitable sites, this region contains the largest areas of relative suitability with respect to the NHMRC selection criteria and on the basis of available data.

PHASE 3: IDENTIFICATION OF A PREFERRED SITE AND SITE ASSESSMENT

Timing of phase 3 activities

Ongoing Community consultation

1997

- Preliminary field reconnaissance surveys in preferred region

1998

- Detailed regional assessment and field investigations
- Data assessment

1999

- Detailed investigations in prospective area(s)
- Identification of a preferred site
- Commence environmental and safety assessment

2000

- Proposed repository construction

Community consultation

The Government is strongly committed to effective consultation with State, regional and local governments, communities and interested parties throughout Phase 3 of the search for a national radioactive waste repository.

Public consultation to date has involved the release of public discussion papers on Phases 1 and 2 of the siting study. In addition, reports have been prepared summarising and responding to public comment on the Phase 1 and 2 discussion papers. All of these reports have been widely circulated to groups and individuals that have expressed an interest in the proposal.

The Phase 1 and 2 reports were advertised in metropolitan and national newspapers. In addition, the Phase 2 report was advertised in regional newspapers within the eight identified regions.

Members of the study team have been available to provide information, record people's concerns and answer questions on the proposal and its progress, through the National Radioactive Waste Repository Project Information Office. This Office was established within the Department of Primary Industries and Energy at the commencement of the Project and will continue to operate throughout Phase 3.

Consultation in the identified region

The community consultation program for Phase 3 is principally focused on the identified region, and plans to involve the widest possible range of stakeholders. These include individuals and community groups as well as government bodies and industry. In short, everyone whose interests are potentially affected by the proposal.

Consultation with the broader Australian community will continue through circulation of reports and the provision of opportunity for comment. Broader community views and advice will continue to be taken into account in decision-making processes.

- The goals of the community consultation program are to:
- promote early and open discussion on issues;
- identify stakeholders and their interests and concerns;
- involve stakeholders in the decision-making processes;
- provide information to stakeholders and the wider community to allow people to become informed and draw their own conclusions on issues.

This Public Discussion Paper has been provided to the State Government and appropriate Local Governments and to all identified regional interest groups. Public comments are requested by 30 April 1998.

Accompanying the paper is a media release by the Minister for Resources and Energy. An advertisement containing contact information has been placed in local papers in the region and regional papers in South Australia, as well as national papers (Appendix 2). Groups and individuals that have expressed an interest in the study to date have been forwarded a copy of the paper.

A regional information office has been established in Port Augusta, to facilitate early dissemination of information, record people's concerns and provide answers to people's questions. The regional information office will continue to operate for as long as is required following the public release of this report.

A video on the proposal is available for viewing at the regional information office and copies will be provided to regional interest groups.

Consultative committees

Initially two key consultative committees will be formed. The State Government will be asked to assist in the formation of an Inter-Governmental Liaison Committee (IGLC) consisting of representatives of relevant State agencies, as well as relevant Commonwealth officers.

An Interim Regional Consultative Committee (RCC) will also be established, with membership reflecting a cross-section of regional interests. Representation will include local authorities, local industry and business representatives, local interest groups and relevant Commonwealth agencies. This committee will operate until a preferred site is identified.

Once a preferred site is identified, on the basis of detailed field investigations and community consultation, the emphasis will shift to liaison with the immediate community. A local Community Liaison Committee (CLC) will be established, to represent local interests around the site. It is likely that some members of the RCC will also be members of the CLC. This will provide continuity and will allow for wider regional interests to continue to be represented.

Consultative committee meetings are expected to facilitate sharing of information on all matters concerning the national repository project. They will meet regularly, approximately three-monthly or more often if necessary. It is essential that, through this process, community representatives are informed of progress with siting investigations and are provided with opportunities to request information and express community views on the proposal.

Advice from regional interests, obtained through the RCC, will be a key element in locating a preferred site within the region. Emphasis will be placed on the exchange of information on those aspects relevant to siting the facility.

All matters relating to the repository, including the community consultation process, repository design and management, radiation safety, the impact of untoward events such as flood and earthquake, long-term custody of the site, transport, and impacts on the local environment will be discussed by the consultative committees as the study progresses.

Field investigations

All field investigations and surveys will apply the *Code of Ethics* and the *Code for Consultants* for field geologists (AusIMM 1989a, 1989b) and will be planned and undertaken to minimise any environmental impacts. Appropriate authorities, including State and Commonwealth environment protection, water resource, mineral resource and natural heritage agencies, will be consulted.

The techniques for field survey are typical of those used by many exploration and survey companies when undertaking geotechnical and environmental assessments. Activities typically require fewer than six workers for any stage.

Reconnaissance open-hole drilling will be required, which is expected to amount to fewer than fifty drill holes over a widely distributed area in or near the Billa Kalina region. Most of the drill holes will be concentrated in smaller areas of the region that local knowledge and ASSESS indicate to be highly prospective. Open-hole drilling is expected to range in depth from a few tens of metres to less than 150 metres, varying in diameter from about 200 millimetres near the surface to 125 millimetres at depth. Drill holes are usually cased or collared to prevent hole failure near the surface, using PVC pressure pipe or retrievable steel bore casing.

When the preferred site is identified, additional open-hole and wire-line core drilling will be necessary to obtain rock samples for chemical and geotechnical analysis. These holes will number fewer than twenty, with depths ranging from about 50 metres to less than 250 metres. Drill core diameter may range from about 85 millimetres to a minimum of 45 millimetres. This type of core drilling requires the use of lubricating circulation mud, which can be prepared in an above-ground holding tank or a shallow excavated ditch.

Many of the drill holes will be left open to allow testing and monitoring; however, those that are no longer needed will be filled using a concrete slurry and dirt from the drill hole.

Test trenches are dug using a backhoe or an excavator to expose a continuous cross-sectional view of the near-surface conditions. The trench provides access so that the sub-surface structures can be mapped and measured, and rock chip and soil samples (typically of about 1 to 5 kilograms weight) can be collected. Depending on the equipment and the ground conditions, the trenches are approximately 1 metre wide, 1 to 4 metres deep and tens to less than a hundred metres long. Once surveyed, the trenches are back-filled and the surface level and appearance is restored.

Down-hole geophysical logging equipment is mainly truck- or trailer-mounted. Geophysical recording probes are lowered by cable down a drill hole to record a variety of geophysical properties. Some probes require the hole to be filled with water, which is usually supplied from a water truck. Surface-based geophysical survey equipment is compact and is typically used from a small trailer or light truck. Apart from vehicle movement, neither geophysical technique substantially disturbs the ground surface.

Airborne geophysical surveys can be a very cost-effective means of defining other geophysical characteristics. The magnetic field and the levels of naturally emitted ground radiation from potassium, thorium and uranium are routinely collected from a specially fitted light aircraft flying at low altitude. This baseline data will be used for comparison with monitoring once the repository is commissioned. A radiological survey will determine the existing natural levels of background radiation at the site.

Biological surveys, including flora and fauna, will be undertaken at the identified site to provide data for assessing the environmental impact of establishing the repository. This survey will enable the presence or absence of rare or endangered species to be identified.

Environmental impact analysis and safety assessment

The results of field investigations involving identification of the preferred site, reasons for its selection and the specific details of the repository design, construction and operation will form the basis of consideration of the proposal under the *Environmental Protection (Impact of Proposals) Act 1974.*

In accordance with the NHMRC *Code of Practice for Near-surface Disposal of Radioactive Waste in Australia* (1992) and IAEA guidelines, a detailed analysis of the design and operation of the facility, and an assessment of the projected long-term integrity of the site after closure, will be submitted to the appropriate authority for consideration.

A safety assessment will be undertaken to identify possible pathways through which radionuclides might be released into the environment during operation and following closure and to estimate potential for radiological doses. It will specify measures for maximising protection of the environment and human health. These will include ensuring that no off-site releases of radioactivity, or inadvertent intrusion at the site, after institutional control has ceased will lead to a radiation dose in excess of prescribed national dose limits.

The annual dose limit for exposure of members of the public recommended by the NHMRC and the ICRP is

1 mSv. To put the 1 mSv dose limit into context, on average Australians receive 2 mSv a year from all natural background radiation. Natural sources include radon gas in the air, cosmic rays, terrestrial radiation, food and drink. The average individual dose from medical procedures, such as X-rays, is about 1 mSv per year.

Next Steps

Several new activities will commence after the release of this Discussion Paper. All the activities are important and many of the activities will be done simultaneously. The next steps are as follows:

- receive, review and respond to public comments on this Discussion Paper;
- undertake discussions between State and Commonwealth authorities and local communities on siting, construction and operation of a national repository;
- undertake detailed regional assessment and field investigations;
- develop an operational plan for the repository including the administration, regulation, security and site infrastructure of the repository;
- further develop the repository design;
- identify a preferred repository site for detailed environmental and safety assessment taking account of consultations with the State Government and local communities, in particular local landholders.

The Commonwealth Government is committed to progressing the establishment of national repository for Australia's low and short-lived intermediate-level radioactive waste in consultation with the Australian community. In parallel with the systematic search for a national repository site, the study team has and will continue to consider any potentially suitable areas within or outside the eight identified regions, that are volunteered by State Governments or local communities.

BIBLIOGRAPHY

AusIMM (1989a) 'Code for consultants', in Berkman, D. A. (Compiler), Monograph 9, *Field Geologists Manual*, The Australian Institute of Mining and Metallurgy, Parkville, Victoria.

AusIMM (1989b) 'Code of ethics', in Berkman, D. A. (Compiler), Monograph 9, *Field Geologists Manual*, The Australian Institute of Mining and Metallurgy, Parkville, Victoria.

Commonwealth Government of Australia (1996) Government Response to the Report of the Senate Select Committee on the Dangers of Radioactive Waste 'No Time to Waste' (unpublished).

Department of Primary Industries and Energy (DPIE) (1993) *National Radioactive Waste Repository Site Selection Study: Phase 1.* DPIE, Canberra.

Department of Primary Industries and Energy (DPIE) (1995) *National Radioactive Waste Repository Site Selection Study Phase 2: A Report on Public Comment.* DPIE, Canberra.

Department of the Arts, Sport, the Environment, Tourism and Territories (DASETT) (1990) *Code of Practice for the Safe Transport of Radioactive Substances*, DASETT, Canberra.

Division of National Mapping (NATMAP) (1986) *Climate Atlas of Australian Resources*, Third Series, Vol 4, NATMAP, Canberra.

International Atomic Energy Agency (IAEA) (1984) *Safety Analysis Methodologies for Radioactive Waste Repositories in Shallow Ground*, Safety Series No. 64, IAEA, Vienna.

International Atomic Energy Agency (IAEA) (1990) *Regulations for the Safe Transport of Radioactive Material*, Safety Series No. 6, 1985 edition (as amended 1990) , IAEA, Vienna.

International Atomic Energy Agency (IAEA) (1994) *Siting of Near-surface Disposal Facilities*, Safety Series No 111 3-3-1, IAEA, Vienna.

International Atomic Energy Agency (IAEA) (1995a) *Safety Fundamentals: The Principles of Radioactive Waste Management*, Safety Series No. 111-F, IAEA, Vienna.

International Atomic Energy Agency (IAEA) (1995b) *Safety Standard: Establishing a National System for Radioactive Waste Management*, Safety Series No. 111-S-1, IAEA, Vienna.

International Commission on Radiological Protection (ICRP) (1990) *Recommendations of the ICRP*, Publication 60 (1991). ICRP, Oxfordshire, UK.

National Health and Medical Research Council (NHMRC) (1985) *Code of Practice for the Disposal of Radioactive Waste by the User*, NHMRC, Melbourne.

National Health and Medical Research Council (NHMRC) (1992) *Code of Practice for the Near-Surface Disposal of Radioactive Waste in Australia*, Radiation Health Series No. 35, NHMRC, Melbourne.

National Health and Medical Research Council and the National Occupational Health and Safety Commission (NHMRC & NOHSC) (1995) *Recommendations for Limiting Exposure to Ionising Radiation (Guidance note [NOHSC: 3022 (1995)]) and National Standard for Limiting Occupational Exposure to Ionizing Radiation [NOHSC;1013(1995)]*, Radiation Health Series 39, NHMRC, Melbourne.

National Resource Information Centre (NRIC) (1992) *A Radioactive Waste Repository for Australia: Methods for Choosing the Right Site*, A Discussion Paper. Bureau of Rural Resources, Canberra.

National Resource Information Centre (NRIC) (1994) *A Radioactive Waste Repository for Australia: Site Selection Study-Phase 2 Discussion Paper*. Bureau of Rural Resources, Canberra.

Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (1991) *Disposal of Radioactive Waste: Can Long-Term Safety be Evaluated?* A Collective Opinion of the Radioactive Waste Management Committee OECD NEA, International Radioactive Waste Management Advisory Committee International Atomic Energy Agency (IAEA) endorsed by the Experts for the Community Plan of Action in the Field of Radioactive Waste Management Commission of the European Communities, OECD, Paris.

Pilgrim, D. H. (ed.) (1987) *Australian Rainfall and Runoff-A Guide to Flood Estimation, Volume 2.* Institution of Engineers, Australia, Canberra.

Senate Select Committee on the Dangers of Radioactive Waste (1996), *No Time to Waste*, Senate Printing Unit, Canberra.

GLOSSARY OF TERMS

activity concentration
The concentration of a radioactive substance in any particular material expressed in terms of the activity of the radionuclide in becquerels (Bq) per kilogram of the material.

Bq
Becquerels. Radiological unit of measure.

buffer zone
A zone of restricted access, which is controlled by the operator, between the operational site boundary and any structure within the facility, to ensure that there is a sufficient distance between the facility and any area accessible to members of the public.

category A waste
Waste containing short-lived radionuclides (half-lives of around 30 years or less), mainly emitting beta or gamma radiation. Long-lived radionuclides emitting alpha radiation are present at very low concentrations. Under the NHMRC's 1992 *Code of Practice for the Near-surface Disposal of Radioactive Waste in Australia*, category A waste requires at least 2 metres of cover.

category B waste
Waste emitting considerably higher levels of beta or gamma radiation than category A waste, but still at relatively low levels. Under the NHMRC's 1992 *Code of Practice for the Near-surface Disposal of Radioactive Waste in Australia*, category B waste requires at least 5 metres of cover.

category C waste
Bulk waste of similar activity concentration to category B waste.

category S waste
Waste with activity concentrations greater than in categories A, B or C.

disposal
Placement of radioactive waste in a purpose-built facility in a manner such that there is no intention of retrieval.

disposal site
That area of land used for the disposal of the waste consisting of a disposal facility and a surrounding buffer zone.

disposal structure
A trench, bore hole or other form of excavation together with any engineered structure, that is designed to contain the radioactive waste; it may be constructed from natural as well as manufactured materials.

engineered barrier
A feature made or altered by humans that delays or prevents radionuclide migration from the waste or the disposal structure into its surroundings; it may be part of the waste package or part of the disposal structure.

environmental management plan
A document that sets out a system of management based on social, economic and environmental aims within which the decision-making process takes place.

geographic information system (GIS)
A geographic information system is a computer-based suite of software and hardware used to organise and manage spatial information.

high-level waste (HLW)
Waste containing high levels of beta and gamma radiation emitters and significant levels of alpha emitters, and generating significant amounts of heat (>2 kW/m3). It typically arises from the reprocessing of spent fuel elements from nuclear power generation. Such waste requires careful handling, substantial shielding, provision for dissipation of heat generated by the decay of fission products, and long-term immobilisation and isolation from the biosphere. HLW is not generated in Australia.

IAEA
The International Atomic Energy Agency, an autonomous intergovernmental organisation founded in 1957 in accordance with a decision of the General Assembly of the United Nations. Its statutory mandate is 'to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world and to ensure, so far is as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose'. Its activities include harmonisation of principles and standards for the safe management and disposal of radioactive waste, advisory services, assistance missions to Member States, and the coordination of research and development and special projects that have regional or global interest.

institutional control
The control of a former waste disposal site by the appropriate authority in order to restrict access to, and use of, the site and to ensure an ongoing knowledge that the site has been used for the disposal of radioactive waste.

interim storage
Storage of radioactive materials such that: (1) isolation, monitoring, environmental protection and human control are provided; and (2) subsequent action involving treatment, transport and disposal or reprocessing (fuel) is expected.

intermediate-level waste (ILW)
Waste containing significant levels of beta and gamma emitting radionuclides that could also contain significant levels of alpha emitters. It consists of chemical process residues, decayed sealed sources and industrial gauges, reactor components, irradiated fuel cladding, ion-exchange resins and filters (e.g. as a result of reactor operation). This waste requires special shielding during handling and transport. Disposal options for short-lived ILW are similar to those for low-level waste.

intrusion
The process, accidental or intentional, by which living organisms, including humans, may come in contact with disposed or stored waste.

long-lived waste
Waste that will not decay to an acceptable level in a period of time during which administrative controls can be expected to last (see short-lived waste).

low-level waste (LLW)
Waste containing low levels of beta and gamma emitting radionuclides and normally very low levels of alpha emitting radionuclides. Special shielding is not normally required for handling and transport of it.
It includes items such as wrapping material and discarded protective clothing and laboratory plant and equipment. Disposal in near-surface structures is commonly practised overseas. In some cases, the level of radioactivity is below the limit that regulations set as radioactive material. Indeed some of the LLW arising at ANSTO and elsewhere in Australia is suitable for disposal at authorised municipal landfill sites under the NHMRC *Code of Practice for the Disposal of Radioactive Waste by the User* (1985).

monitoring
The methodology and practice of measuring levels of radioactivity either in environmental samples or en route to the environment. Examples include groundwater monitoring and personnel monitoring.

mSv, millisievert
Equivalent to one-thousandth of a sievert.

NHMRC
The National Health and Medical Research Council. Its principal function is to advise the Australian community on matters relating to the achievement and maintenance of high standards of individual and public health through appropriate legislation, administration and practices, and to encourage health and medical research to achieve those standards.

near-surface disposal (as defined in this paper)
Disposal of radioactive waste, with or without engineered barriers, below the ground surface, where the final protective covering is a few metres thick.

radioactive waste
Waste materials that contain radioactive substances for which no further use is envisaged.

radioactive waste management
All activities, administrative and operational, that are involved in the handling, treatment, conditioning, transportation, storage and disposal of waste.

regolith
The layer rock or blanket or unconsolidated rocky debris of any thickness that overlies bedrock and forms the surface of the land.

reprocessing, fuel
Recovery of fissile and fertile material from irradiated nuclear fuel by chemical separation from fission products and other radionuclides; selected fission products may also be recovered.

risk
For the purpose of radiation protection, the probability that a given individual will incur any given deleterious stochastic effect as a result of radiation exposure.

short-lived waste
Waste that will decay to a level that is considered to be insignificant from a radiological point of view, in a time period during which administrative controls can be expected to last. Such waste can be determined by radiological assessment of the disposal system chosen.

short-lived nuclide
For waste management purposes, a radioactive isotope with a half-life shorter than about 30 years, e.g. 137Cs, 90Sr, 85Kr, 3H.

sievert, Sv
The unit of equivalent dose. Equivalent dose is a measure of the energy absorbed per unit mass in organs and tissues of the human body, from ionising radiation, which takes into account the type of radiation involved.

spent fuel
Irradiated fuel units not intended for further reactor service.

storage
The emplacement of waste in a facility with the intent and in such a manner that it can be retrieved at a later time.

waste conditioning
The process that converts the waste into an acceptable concentration and stable form for packaging, transport and disposal. The process may involve solidification of the waste and/or encapsulation in a stable matrix such as concrete.

waste minimisation
The establishment of practices in all stages of the production, processing and use of radioactive materials to minimise the quantity of waste generated, including its radioactivity.

waste packaging
The processes that are carried out to change the characteristics of the waste to produce a safe and convenient form of storage or disposal. This may involve operations such as solidification, incineration or compaction to minimise the waste volume.

GLOSSARY OF ABBREVIATIONS

ANSTO Australian Nuclear Science and Technology Organisation

ASSESS A System for Selecting Suitable Sites

C/SCC Commonwealth/State Consultative Committee on Radioactive Waste Management

CLC Community Liaison Committee

DEM digital elevation model

EMP Environment Management Plan

GIS Geographic Information System

IAEA International Atomic Energy Agency

ICRP International Commission on Radiological Protection

IGLC Inter-Governmental Liaison Committee

NHMRC National Health and Medical Research Council

NRIC National Resource Information Centre

OECD Organisation for Economic Co-operation and Development

PVC polyvinyl chloride

RCC Regional Consultative Committee

UK United Kingdom

APPENDIX 1: USE OF RADIOISOTOPES

Radioisotopes are the radioactive variants of a chemical element. Radioisotopes have two properties that make them especially useful for scientific, medical, forensic and industrial applications:

- their emissions are easily detectable and can penetrate solid materials
- many radioisotopes have a short half-life and decay to stable non-radioactive elements

Pharmaceuticals containing a radioisotope are known as radiopharmaceuticals, and are essential in diagnosing and treating some serious illnesses. Radiopharmaceuticals can be injected into the body, inhaled or taken orally to enable diagnosis of medical conditions and imaging of body organs. For example, thallium-201 is used for diagnosis of heart conditions and technetium-99m is used for imaging studies.

Radiation from radioisotopes also has a very important role in the treatment of serious disease. For example, cobalt-60, iodine-131 and iridium-192 are used in cancer therapy.

Sterilisation of medical products and instruments using gamma rays from a cobalt-60 source provides many benefits. Medical syringes, dressings, surgical gloves, heart valves and surgical instruments can be sterilised *after* packaging, and heat-sensitive items such as powders and ointments, and biological preparations such as tissue grafts, can be sterilised by radiation.

In modern industry, radioisotopes are used for industrial radiography, process control, checking oil and gas pipeline integrity, gauging thicknesses in manufacturing processes, and analysis of materials. Radiation and radioisotopes are used to improve food crops, control insect pests and preserve food. Radioisotopes are used as tracers to measure environmental processes including monitoring the movement of silt, water and pollutants.

There are currently no alternatives to many uses of radionuclides in medicine, industry and research, uses that are widely accepted and relied upon. However, the production and use of radioisotopes does generate some radioactive waste that must be properly managed.

Appendix 2: ADVERTISEMENT REQUESTING PUBLIC COMMENT

A RADIOACTIVE WASTE REPOSITORY FOR AUSTRALIA:
SITE SELECTION STUDY - PHASE 3 REGIONAL ASSESSMENT

A Discussion Paper on Phase 3 of a project to identify a suitable site for a national near-surface repository for Australia's low-level and short-lived intermediate-level radioactive waste is available for public comment.

The Paper, entitled 'A Radioactive Waste Repository for Australia: Site Selection Study - Phase 3 Regional Assessment', has been prepared by the Bureau of Resource Sciences. It describes the methodology used to select the preferred region for field investigation, the Billa Kalina region in South Australia, in order to identify a suitable repository site.

The Billa Kalina region covers an area of approximately 67,000 square kilometres, with its northern edge extending from 20 kilometres east of Coober Pedy to 10 kilometres west of Marree (excluding Lake Eyre), and its souther edge extending from 50 kilometres northwest of Tarcoola, to 40 kilometres west of Hawker. It includes the townships of Woomera, Andamooka and Olympic Dam Village.

Persons or organisations wishing to comment on the paper are invited to make written submissions by 30 April 1998 to:

The Information Officer
National Radioactive Waste Repository Project
Department of Primary Industries and Energy
PO Box 858
CANBERRA ACT 2601

Telephone Tollfree 1800 682 704
Facsimile 02 6272 4178

Email Repository@dpie.gov.au

Internet http://www.nric.gov.au/nric/projects/assess/radwaste.html

Copies of the paper can be obtained from the Information Officer.

PROPOSED DISTRIBUTION OF THE ADVERTISEMENT

Major daily newspapers

Adelaide Advertiser
Australian Financial Review
Northern Territory News
Sydney Morning Herald
The Age (Melbourne)
The Australian
The Canberra Times
The Courier Mail (Brisbane)
The Mercury (Hobart)
The West Australian

Rural press

Countryman (WA)
Country Life (Qld)
Stock Journal (SA)
The Land (NSW)
The Weekly Times (Vic)

Regional papers SA

Streaky Bay West Coast Sentinel
Port Lincoln Times
Port Pirie Flinders News
Port Pirie Recorder
Renmark Murray Pioneer
Port Augusta Transcontinental
Whyalla News
Cleve Eyre Peninsula Tribune
Coober Pedy Times

Local papers

Media release distributed to:

Specialist weeklies/monthlies
Wire services
Radio stations
TV Science and Health Editor