



**Australian Radiation Protection and
Nuclear Safety Agency**

**SAFETY EVALUATION REPORT
ON ANSTO APPLICATION
FOR LICENCE TO PREPARE A SITE FOR
THE REPLACEMENT RESEARCH REACTOR
(Application No. F0001)**

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**REGULATORY BRANCH, ARPANSA
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1. INTRODUCTION

1.1 Background

Commonwealth departments and agencies that undertake activities involving radiation sources or controlled facilities must comply with the requirements of the *Australian Radiation Protection and Nuclear Safety Act (1998)* (the Act) and the Australian Radiation Protection and Nuclear Safety Regulations 1999 (the Regulations). Under the Act, Commonwealth entities wishing to prepare a site, construct, possess and control, operate, or decommission, dispose or abandon a facility such as a nuclear research reactor must hold an appropriate licence. The facility licence authorising such a conduct would be issued by the Chief Executive Officer (CEO) of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA).

In accordance with the requirements of the Act, the Australian Nuclear Science and Technology Organisation (ANSTO) submitted an application dated 13 April 1999 for a facility licence to prepare a site for the Replacement Research Reactor. As required by the Regulations, the CEO ARPANSA published a notice in the *Government Gazette* and in newspapers notifying of the receipt of the application and of his intention to make a decision on the application. As the application relates to a nuclear installation, the CEO also invited submissions from the public about the application.

It is important to note that the ARPANSA review is not a site selection process. The role of ARPANSA is to confirm that the applicant has demonstrated that the site selected for the Replacement Research Reactor is suitable, with regard to the safety of future operations of the facility, and to make recommendations to the CEO ARPANSA on a decision on the application. Further licences would be required for any subsequent stages of the facility (construction, possession, operation, decommissioning and abandonment). Issuing of these licences would also be subject to a review of each application against safety standards and analysis of public submissions.

1.2 Legislative Requirements for Review of Applications

Section 32(3) of the Act makes the following requirement on the CEO in relation to applications for licence:

In deciding whether to issue a licence under subsection (1), the CEO must take into account the matters (if any) specified in the regulations, and must also take into account international best practice in relation to radiation protection and nuclear safety.

Regulation 41(3) specifies that in making a decision on an application for licence, the CEO must take into account the following matters:

- (a) *whether the application includes the information asked for by the CEO; and*
- (b) *whether the information establishes that the proposed conduct can be carried out with without undue risk to the health and safety of people, and the environment; and*

- (c) *whether the applicant has shown that there is a net benefit from carrying out the conduct relating to the controlled facility; and*
- (d) *whether the applicant has shown that the magnitude of individual doses, the number of people exposed, and the likelihood that exposure will happen, are as low as reasonably achievable, having regard to economic and social factors; and*
- (e) *whether the applicant has shown a capacity for complying with these regulations and the licence conditions that would be imposed under Section 35 of the Act; and*
- (f) *whether the application has been signed by an office holder of the applicant, or a person authorised by an office holder of the applicant; and*
- (g) *if the application is for a facility licence for a nuclear installation – the content of any submissions made by members of the public about the application.*

The information that may be requested by the CEO to be submitted with the application is listed in Part 1 of Schedule 3 of the Regulations. In addition to descriptive elements and various control plans in relation to siting applications, Schedule 3 refers to:

A detailed site evaluation establishing the suitability of the site.

The characteristics of the site, including the extent to which the site may be affected by natural and man-made events.

Any environmental impact statement requested or required by a Government agency, and the outcome of the environmental assessment.

1.3 Process of Review

The information provided by ANSTO with the application to establish the suitability of the site and describe the site characteristics was reviewed by ARPANSA staff against the ARPANSA Draft Safety Assessment Principles for Controlled Facilities (April 1999) (the principles) and ARPANSA Draft Criteria for the Siting of Controlled Facilities¹ (April 1999) (the siting criteria). These principles and siting criteria are based on international standards and recommendations, particularly those of the International Atomic Energy Agency (IAEA), and the contemporary practices in the nuclear industries of developed countries. The IAEA documents have been developed by consensus of member countries and represent the distillation of best practice of their cumulative nuclear experience.

¹ The 'ARPANSA Draft Safety Assessment Principles for Controlled Facilities' and the 'ARPANSA Draft Criteria for the Siting of Controlled Facilities' are based on documents of the Nuclear Safety Bureau, which preceded ARPANSA in the role of overseeing the safety of ANSTO's nuclear reactors. These documents at this stage remain in draft form. They will be finalised after consultation with the Nuclear Safety Committee established under the ARPANS Act. The draft principles and criteria are available from ARPANSA and can be accessed on the world wide web at www.arpansa.gov.au.

In drawing on IAEA standards and the experience of nuclear regulators around the world, ARPANSA developed safety principles and siting criteria that reflect international best practice for nuclear and radiation regulation. Reviewing the licence application against these principles and siting criteria therefore ensures that a recommendation on the licence decision may be made that takes account of international best practice.

In addition to reviewing the application, ARPANSA reviewed the public submissions made in response to the invitation by the CEO for comments on the application. All issues raised in the submissions related to the review of the application were taken into account in the review. Responses to other issues raised in the public submissions are also included in this report.

1.4 Format of the Safety Evaluation Report

This Safety Evaluation Report (SER) is a complete review of the application for licence to prepare a site for the Replacement Research Reactor and the public submissions on the application. In addition, the report includes the conclusions of the staff of ARPANSA on the issues to be taken into account by the CEO in making a decision on the application, and the staff's recommendation to the CEO on that decision.

The results of reviews by ARPANSA staff of the plans and arrangements for managing safety, the suitability of the site, the site characteristics, the environmental assessment process previously undertaken for the project and the public submissions received on the application are summarised in the body of the report. The report first describes the general information provided in the application (chapter 2) and then assesses the range of plans and arrangements for managing safety (chapter 3).

The objective of the site assessment is to demonstrate that the site is amenable to the construction and operation of a reactor facility while providing adequate protection to the health and safety of people and the environment. There are two aspects to be addressed:

- the first is to demonstrate that the site can provide acceptable radiological protection during normal operation and in the event of severe accidents. This is achieved largely through evaluation of a 'Reference Accident', which is reviewed in chapter 4;
- the second is to demonstrate that the natural characteristics of the site and man-induced phenomena can be accommodated safely in the design bases of the reactor facility. This is reviewed in chapter 5.

Detailed reviews of the site licence application against the principles and the criteria are described in a separate document to this report (ARPANSA September 1999). Conditions of licence to prepare the site that arise from the reviews, and advisory notices on issues that would require consideration during reviews of any future applications regarding the replacement research reactor, are identified at each part of the review. The report goes on to consider previous environmental assessments in chapter 6 (and Appendix A) and issues raised through public submissions in chapter 7 (and Appendices B, C and D).

Conclusions on the results of all the reviews based on the issues that the CEO is required to take into account in making a decision, and recommendations on the decision including a summary of the recommended licence conditions and advisory notices appear in chapter 8. A glossary of terms and acronyms used in the report and the main references quoted are given in chapters 9 and 10.

2. GENERAL INFORMATION ON THE APPLICATION

This section of the report summarises general information provided in the licence application. Detailed review of this information is not necessary.

2.1 Applicant Information

The applicant for the facility licence to prepare a site for the Replacement Research Reactor is Professor Helen Garnett, Executive Director, Australian Nuclear Science and Technology Organisation (ANSTO). The person nominated to be in effective control of the project is Mr Garry Seaborne, Project Manager, Replacement Research Reactor Project, ANSTO.

ANSTO operates laboratories and other facilities, including the 10MW research reactor HIFAR, at the Lucas Heights Science and Technology Centre on New Illawarra Road, Lucas Heights, south west of Sydney.

2.2 Description of the Purpose of the Facility

The intended purposes of the Replacement Research Reactor facility are specified in the licence application to be as follows:

- *Maintain and enhance health care benefits provided to the community and ensure security of supply, through local production, of the quantities and range of diagnostic and therapeutic radiopharmaceuticals needed to satisfy the requirements of Australia's medical professionals over the next 40 to 50 years.*
- *Maintain Australia's nuclear technical expertise in order to provide sound advice to Government in support of nuclear policy issues of strategic national interest and international obligations in this area.*
- *Provide a neutron beam research facility which will not only meet Australia's own scientific and industrial needs, but will also be a regional centre of excellence. Research undertaken using this facility will have broad application to investigations in a wide spectrum of scientific and industrial fields, including the life sciences and medicine, environmental science, chemistry, materials science, and engineering science.*
- *Provide research, and research training, facilities and programs to enhance the educational opportunities available to Australia's scientists and engineers.*
- *Provide industrial radioisotopes and facilities for neutron activation analysis, irradiation of materials, and neutron radiography to service the needs of agriculture and industry, particularly in the electronics, environmental, resource and minerals processing industries.*

2.3 Description of the Facility and the Site

ANSTO provided the following general information on the project.

The proposed replacement research reactor would:

- *be a pool type, in which the core of the reactor is at the bottom of a pool of water at least eight metres deep;*
- *have a maximum thermal power of 20 megawatts;*
- *use low-enriched-uranium fuel;*
- *produce a higher neutron flux than HIFAR;*
- *have a flexible irradiation facility arrangement;*
- *provide neutron beams with a wide range of energies, and which are cleaner and of higher intensity than those from HIFAR, for use in research activities; and*
- *include isotope and other irradiation facilities that would have a greater capacity than those in HIFAR and be designed to meet current and future needs.*

Associated buildings and support facilities for the reactor would include:

- *the building enclosing the reactor;*
- *a pond within the building for temporary storage of up to nine years of arisings of spent fuel;*
- *a storage vault for fresh fuel;*
- *a discharge stack for gaseous emissions;*
- *cooling towers and a pumphouse for the secondary cooling system;*
- *an office block and workshop space situated within the reactor facility; and*
- *a beam hall immediately adjacent to, and communicating with, the reactor building to be used for research activities.*

The reactor facility would be built on land owned by ANSTO at the western end of the Lucas Heights Science and Technology Centre adjacent to HIFAR. The proposed site for the reactor facility is within the existing perimeter fence and covers an area of approximately four hectares. ANSTO intends to maintain the buffer zone of 1.6 kilometres, centred on the existing HIFAR facility, within which land-use restrictions apply and residential development is excluded. The distance from the replacement reactor to the nearest residence (in the easterly direction, in Engadine) would then be approximately 1.8 kilometres.

The buffer zone is an important part of the site characteristics in terms of 'defence in depth' and it would be appropriate that conditions of licence require agreement of the CEO before the size or use of the buffer zone could be changed.

2.4 Conclusion

Subject to the following licence condition, the general information provided in the application for licence is adequate at the siting stage.

Recommended Licence Condition

The Licensee shall ensure that there are no changes to the boundaries or use of land within the Buffer Zone unless the CEO ARPANSA has approved such change in his absolute discretion.

3. PLANS AND ARRANGEMENTS FOR MANAGING SAFETY

Section 3 of the ANSTO application to prepare a site for the Replacement Research Reactor describes a series of Facility Management Plans that would form the basis for managing construction, operation and decommissioning of the facility to ensure the health and safety of people, and protection of the environment.

At the siting stage, it is not necessary for an applicant to describe in detail the plans for achieving safety at later stages in the life of the facility, but the capacity to develop and implement acceptable plans must be demonstrated. The review of the application assessed whether ANSTO has demonstrated this capacity, against ARPANSA's expectations for the information submitted with the application (April 1999) and the principles. The results of the review are summarised in this section.

3.1 The Arrangements for Maintaining Effective Control of the Facility

3.1.1 Expectations and Principles

In applying for a facility licence, the applicant must nominate a person or position that would control the conduct for which a licence is sought, and demonstrate how the nominee would maintain that control. The nominee must have appropriate responsibility, with adequate authority and control of sufficient material, human and financial resources to ensure safety of the facility.

ARPANSA's Safety Assessment Principle 3 is applicable to the review of this part of ANSTO's application.

3.1.2 Results of Review

The application includes a Project Management Plan (Section 3.1) that describes the organisational arrangements for the replacement reactor and responsibilities of key personnel. The responsibility for specifying the safety requirements and ensuring that licensing requirements for the project are satisfied is set out in the plan. This includes advising the project manager on safety and licensing requirements and ensuring that the reactor facility would satisfy these requirements at all stages throughout its design, construction and commissioning. While not stated explicitly, the safety and licensing requirements also impact on the siting stage of the project.

3.1.3 Conclusion

The Project Management Plan is adequate at the siting stage for maintaining effective control of the facility.

3.2 The Safety Management Plan for the Controlled Facility

3.2.1 Expectations and Principles

The applicant must describe the administrative arrangements for managing the safety of the facility to ensure the health and safety of people and the protection of the environment. At the siting stage this information includes:

- the structure and description of the applicant's organisation, as it relates to the safety of the proposed facility, including responsibilities and reporting requirements; and
- a quality system covering all activities associated with the facility that may have an influence on the safe operation of the facility.

Safety Assessment Principles 1, 4(a), 5(a), 5(c), 6, 13, 14 and 41 are applicable to this review.

3.2.2 Results of Review

The application includes a Safety Management Plan (Section 3.2) for the replacement reactor that would provide a safety management framework consistent with the ANSTO Safety Directives for existing operations. The arrangements provided in this plan cover responsibilities, lines of authority and the quality assurance (QA) arrangements for the reactor facility. The level of detail provided is considered to be adequate for the siting stage.

Section 3.7 of the application indicates a commitment to a quality assurance program for the reactor. No mention is made in Section 3.7 of siting, tendering, procurement, design, construction and commissioning. A position of Quality Assurance Manager is shown in the Project Management Plan (Section 3.1). QA would be, of course, required at all stages of the project. The additional licence condition and advisory notice that would ensure that an adequate QA system is in place during preparation of the site and all subsequent stages of the project are listed below.

3.2.3 Conclusion

In principle, the policy, strategies and actions described by ANSTO would be able to deliver an acceptable Safety Management Plan for the replacement reactor. Subject to the recommended licence conditions and advisory notice below, the detail provided in the licence application is considered to be adequate for the siting stage of licensing. However, detailed review and acceptance of the finalised plan, by ARPANSA, would be required prior to construction and operating licences being issued.

Recommended Licence Conditions

The Licensee shall ensure that ANSTO and vendor/contractor quality assurance systems for preparing the Site are clearly specified and have recognised quality practices accreditation.

The Licensee shall ensure that it complies with any quality assurance systems specified in the condition above and that such compliance can be readily verified by audit.

Recommended Advisory Notice

In any application for a Licence under the Act to construct, operate, have possession or control of, or decommission, dispose of or abandon the Replacement Research Reactor Facility the Licensee should ensure that ANSTO and vendor/contractor quality assurance systems for the tendering, design, procurement, construction, commissioning, operation or decommissioning of the Replacement Research Reactor Facility are clearly specified and have recognised practices' accreditation for each of the stages relevant to the application.

In any application for a Licence under the Act to construct, operate, have possession or control of, or decommission, dispose of or abandon the Replacement Research Reactor Facility the Licensee should ensure that they comply with any quality assurance systems specified in the above Advisory Note and that such compliance can be readily verified by audit.

3.3 The Radiation Protection Plan for the Facility

3.3.1 Expectations and Principles

The Regulations require, as a condition of licence, that licence holders ensure that all conducts at facilities are in accordance with the NHMRC *Recommendations for limiting Exposure to ionizing radiation* [NOHSC:3022 (1995)] and the *National standard for limiting occupational exposure to ionizing radiation* [NOHSC:1013 (1995)]. The arrangements to ensure compliance with the recommendations and standard during possession and control, operation or decommissioning of a facility should be set out in a radiation safety manual and in specific operating procedures. The objective is to ensure that radiation doses to workers and the public are as low as reasonably achievable (ALARA) below dose constraints, and less than the limits recommended by the NHMRC.

The arrangements should also cover the appointment of radiation safety officers and a radiation safety committee, recording of radiation exposures, transport of radioactive materials, and investigation and reporting of incidents and accidents involving radiation.

Safety Assessment Principles 18 and 57 to 62 are applicable to this review in so far as ANSTO must demonstrate the capacity to satisfy those principles during any construction, operation or decommissioning of the reactor facility.

3.3.2 Results of Review

The Radiation Protection Plan for the replacement reactor is described in Section 3.3 of the application. The plan describes the international, national and ANSTO standards for radiation protection that would be met by arrangements for radiation protection based on existing ANSTO arrangements.

The NHMRC based the recommendations for the management of radiation doses in Australia on those of the International Commission on Radiological Protection (ICRP Report 60, 1991). As a precaution, these bodies assume that all exposures to ionising radiation carry some risk of harm to health, and this risk increases with increased exposure. Consequently, practices that lead to an increased exposure to radiation must be justified to ensure their

overall benefits outweigh the additional risk due to the increased exposure, and radiation doses arising from such exposures must be within limits. In addition, radiation protection must be optimised, so that exposure of individuals from each source of radiation, and the number of people exposed, is kept as low as reasonably achievable, economic and social factors being taken into account.

ARPANSA requires radiation doses arising from existing and future research reactors to be less than the limits recommended by the NHMRC and to be kept as low as reasonably achievable.

Dose Limits

Dose limits represent the upper bound of risks from radiation exposure deemed acceptable by comparison to other risks to which people are commonly exposed. In line with ICRP Publication 60, the NHMRC's recommended radiation dose limit for total exposure of the public is 1 mSv² (1000 microSv) per year. For occupational exposures, which occur as a result of a person's employment, the dose limit is 20 mSv per year averaged over five consecutive years and not exceeding 50 mSv in any one year. These limits were adopted in the international Basic Safety Standards developed jointly by the IAEA, the World Health Organisation, the International Labour Organisation and other international organisations (IAEA 1996).

Dose Constraints

The NHMRC recommends a dose constraint for the public be chosen for each radiation source to ensure no individuals would exceed the dose limit when additional exposures from other sources are added. ANSTO's dose constraint for reactors, which has been agreed by ARPANSA, is 100 microSv per year for members of the public. This is one-tenth of the NHMRC recommended dose limit and is in line with worldwide practice. For occupational exposures, the dose constraint corresponds to the dose that may be applied in similar, well-managed practices. ANSTO has adopted 15 mSv per year as a constraint on occupational doses.

ALARA (As Low As Reasonably Achievable)

Radiation protection is considered to be optimised when the level of protection needed to further decrease radiation exposure cannot be achieved without an unreasonable social or economic cost. The upper bound for optimisation is the dose constraint. Exposures may be reduced to a level where the associated risk is broadly acceptable to the general population without additional protection. At radiation doses below this level, called the ALARA objective, it is not considered necessary to demonstrate that the ALARA principle has been satisfied. In the Environmental Impact Statements (1998) (EIS), prepared under the *Environment Protection (Impact of Proposals) Act 1974*, ANSTO committed to meet an ALARA objective for the public of 10 microSv per year, which is 1 per cent of the NHMRC limit. For comparison, this is about 0.5 per cent of the dose a person receives from naturally occurring background radiation. For occupational exposures ANSTO's ALARA objective is 2 mSv per year.

² Sv sievert unit of effective radiation dose, is a measure of the 'risk' associated with exposure to all types of ionising radiation

mSv millisievert one thousandth of a sievert

microSv microsievert one millionth of a sievert

The approach to management of radiation protection, outlined above, has been commonly adopted around the world and is written into the ARPANS legislation. ARPANSA is satisfied that the proposed replacement reactor would be able to comply with the dose limits and constraints and meet the ALARA objective, outlined above. This will ensure that any risks to public health from radiation exposure due to the replacement reactor would be negligible and acceptably low.

The application states that the health physics operational procedures, instructions and staffing arrangements would take into account the parallel operation of HIFAR and the replacement reactor during the commissioning period. This period of dual operation would be required to not be based on temporary arrangements, and would have to be adequately resourced, as noted in Recommendations 19 and 20 of the Environment Australia review of the EIS. The ARPANSA assessments of the applications for licence to operate the replacement reactor and HIFAR and to decommission HIFAR, relevant to the overlap period, would take into account details of the adequacy of resources.

3.3.3 Conclusion

The arrangements provided in the licence application, referring to the standards to be applied to the project, are adequate for the siting stage of licensing. In principle, the policy, strategies and actions described by ANSTO would be able to deliver an acceptable Radiation Protection Plan for the replacement reactor. The existing plans for the HIFAR reactor give confidence in the capacity of ANSTO to develop an adequate plan for the replacement reactor. The operational provisions to ensure that radiation exposures are as low as reasonably achievable and that all doses are within the dose constraints would be assessed in detail when a Final Safety Analysis Report is submitted with any application for a licence to operate the replacement reactor.

3.4 The Radioactive Waste Management Plan for the Controlled Facility

3.4.1 Expectations and Principles

The applicant must provide arrangements to protect the health and safety of people and to protect the environment from hazards arising from the handling, treatment, storage, discharge and disposal of any radioactive waste expected to arise from the controlled facility. ARPANSA expects the arrangements to address appropriate codes and standards; the physical, chemical and radiological characteristics of the waste; methods of minimising the volumes and activities of radioactive wastes generated; the treatment, storage, disposal and discharges of radioactive wastes; and the control, monitoring, recording and reporting of wastes.

ARPANSA Safety Assessment Principle 73 is applicable to this section of the review.

3.4.2 Results of Review

Section 3.4 of the siting application describes the Australian and international standards that would be implemented in the finalised Waste Management Plan for the project, and elements of the plan. Radioactive wastes are also discussed in Chapter 10 of the Draft and Supplementary EIS (1998, 1999). Features that would be considered in detailed plant design and the Preliminary Safety Analysis Report are described.

The treatment, storage, disposal and discharges of radioactive wastes arising from the operation of the replacement reactor and associated activities would be integrated into the waste management arrangements for the site as a whole. ANSTO has developed a policy for the management of radioactive wastes generated and accumulated from operations at the Lucas Heights Science and Technology Centre. This policy, associated strategies and action plans for implementation are described in references to the licence application. ANSTO has stated its commitment to ensuring all discharges and consequent radiation exposures are within limits and are ALARA. ANSTO has also committed itself to bringing the treatment, storage and disposal of radioactive wastes into accordance with international best practice.

As a process separate from this licence application, ARPANSA is reviewing operations of the site as a whole to develop authorisations for gaseous and liquid radioactive discharges. That review is examining reactor operations, radioisotope production and other site operations in order to authorise notification and correction levels for radioactive discharges on a site-wide basis. These levels would ensure that radiation doses to the public will be as low as reasonably achievable below dose constraints chosen to be a small fraction of the annual dose limit recommended by the National Health and Medical Research Council of Australia. The replacement reactor will be included, as part of the site analysis, during ARPANSA's review of any future application for an operating licence.

Additionally, ANSTO has lodged separate licence applications for the operation of existing radioactive waste management facilities and for the storage and handling of spent nuclear fuel. ARPANSA will invite public comment on these applications and will take any comments into account in deciding whether to issue licences for operation of these facilities.

Recommendations 7, 8, 9 and 10 of the Environment Australia review of the EIS, related to minimising waste production, emissions and consequent radiation doses to the public, are relevant to the reviews and licence applications described above. These must be addressed to ARPANSA's satisfaction, and would form the basis of recommended conditions of licence for the replacement reactor and other ANSTO facilities.

The Commonwealth Government is putting in place a national strategy for the long-term management of Australia's radioactive waste including wastes resulting from ANSTO's present and future research reactors and radiopharmaceutical operations. The Department of Industry, Science and Resources has carriage of site selection and construction of a facility for shallow ground burial of low level and short-lived intermediate level radioactive wastes, and the above ground storage for Australia's long lived intermediate level radioactive (category S) wastes. The Phase 3 report on the 'National Radioactive Waste Repository Site Selection Study' was released by the Minister for Industry Science and Resources, during July 1999.

This national radioactive waste facility would be the subject of an EIS process and separate licensing by ARPANSA under the respective legislation. In principle, the proposed national radioactive waste repository should be able to satisfy ARPANSA's siting requirements. Nevertheless, a detailed safety case for site suitability must be made for the particular site and design chosen for the repository.

The Australian Government decided in 1997 that part of an appropriate management strategy for the HIFAR spent fuel involved shipping it overseas and storing the resulting long-lived

intermediate level reprocessing wastes in Australia in a form suitable for acceptance into a national storage facility (Minister for Science, 3 September 1997). A budget was allocated for this purpose. Spent fuel will be shipped to France for reprocessing, under a contract ANSTO entered into with the French company, COGEMA, in January 1999. Shipments of spent fuel will be completed by 2004, reprocessing and the eventual return of the intermediate level waste to Australia in a single shipment will be achieved by around 2015. Spent fuel of United States origin will be returned to the US with no wastes to be returned to Australia.

ANSTO's arrangements with COGEMA also provide for the reprocessing of spent fuel from the replacement research reactor. These matters have been covered in the DEIS and its Supplement, both of which formed part of the siting licence application. ARPANSA accepts the proposed strategy as being appropriate and reasonably assured. It is acceptable for the site licence application for the replacement research reactor. However, considerably more detail would be required to demonstrate viability of the strategy to ARPANSA, in any application for a licence to construct the facility.

Contingency plans describing alternative strategies for disposal of radioactive waste and spent nuclear fuel will also be required with the application for licence to construct the replacement reactor. A licence to operate the reactor would not be issued by ARPANSA without there being clear and definite means available for the ultimate disposal of radioactive waste and spent nuclear fuel. Recommendations 26 and 27 arising from Environment Australia's review of the EIS are relevant to this issue.

The Regulations require, as a condition of licence to operate the reactor, that all transport of radioactive waste and spent nuclear fuel from the proposed site to the storage or disposal sites be in compliance with the IAEA regulations for the safe transport of radioactive materials, as adopted in Australia as codes of practice (1990). These regulations ensure that a high level of safety of transport is provided through the packaging of radioactive materials, procedures for transport and emergency arrangements.

3.4.3 Conclusion

In principle, the policy, strategies and actions described by ANSTO would be able to deliver an acceptable Radioactive Waste Management Plan for the replacement reactor. The detail provided in the licence application is adequate for the siting stage of licensing. However, detailed review and acceptance of the finalised plan, including contingency arrangements, would be required for any construction or operating licences for the reactor to be issued.

3.5 Strategies for the Ultimate Decommissioning of the Controlled Facility

3.5.1 Expectations and Principles

The applicant must provide strategies for the ultimate decommissioning of the controlled facility that demonstrate that the decommissioning of the facility and eventual abandonment of the site could be carried out safely. Although detailed arrangements for decommissioning activities need not be provided until the decommissioning licence is sought, consideration must be given to requirements for decommissioning at all stages throughout the life of the reactor facility. ARPANSA expects the design and operation of the plant to facilitate ease of decommissioning, to minimise the volume and activity of radioactive wastes generated, and

to minimise the radiation exposures to people and the environment during ultimate decommissioning.

ARPANSA Safety Assessment Principles 42, 43, 44, 67 and 68 are applicable to this section of the review.

3.5.2 Results of the Review

The strategy for ultimate decommissioning is described in Section 3.8 of the application. The design, construction, operation and decommissioning of the replacement reactor would have to ensure that during decommissioning radiation exposures are as low as reasonably achievable, and associated radioactive wastes would be minimised.

3.5.3 Conclusion

In principle, the policy, strategies and actions described by ANSTO would be able to deliver an acceptable Decommissioning Plan for the replacement reactor. The detail provided in the ANSTO licence application is adequate for the siting stage of licensing of the project. The operational provisions to ensure an effective decommissioning strategy would be assessed in detail when a Final Safety Analysis Report is submitted with any application for licence to operate the replacement reactor.

3.6 The Security Plan for the Controlled Facility

3.6.1 Expectations and Principles

The applicant must provide arrangements for security of a controlled facility that include arrangements to prevent sabotage, theft of controlled materials or unauthorised use of the facility. The arrangements should include administrative and physical controls and barriers and any requirements of the Australian Safeguards and Non-proliferation Office.

ARPANSA Safety Assessment Principle 4(c) is applicable to this section of the review.

3.6.2 Results of Review

Section 3.5 of the application describes the international, national and ANSTO standards that would be met by the arrangements for security and safeguards, and the strategy for meeting these standards. The level of threat used for designing protection would be determined in consultation with the Australian Safeguards and Non-proliferation Office and the Australian intelligence community.

3.6.3 Conclusion

In principle, the policy, strategies and actions described by ANSTO would be able to deliver an acceptable Security Plan for the replacement reactor. The detail provided in the licence application is adequate for the siting stage of licensing. The design and operational provisions to ensure an effective security plan would be assessed in detail in Preliminary and Final Safety Analysis Reports submitted with any respective applications for licences to construct or operate the replacement reactor.

3.7 The Emergency Plan for the Controlled Facility.

3.7.1 Expectations and Principles

The applicant must provide emergency arrangements for all foreseeable emergencies at the facility, such as dispersion of controlled materials, overexposure of operators, or theft or loss of controlled material. ARPANSA expects the emergency arrangements to be based on the results of analyses of accidents including accidents beyond the design basis of the facility, including the Reference Accident. The plans should be both flexible and extendible, and identify responsibilities of both the operating organisation and the external combat agencies for implementing actions.

Safety Assessment Principle 122 is applicable to this section of the review.

3.7.2 Results of Review

Section 3.6 of the licence application describes the existing plans for emergencies at the Lucas Heights Science and Technology Centre having on-site consequences and those having off-site consequences. These plans would provide the basis for protecting people from accidents and incidents involving the replacement reactor. The application also describes the process that would be followed in identifying the specific hazards at the replacement reactor for which plans and procedures would be developed, and lists the content of the plans. These plans would include development of procedures to minimise the damage and consequences of accidents and post accident recovery procedures.

3.7.3 Conclusion

In principle, the policy, strategies and actions described by ANSTO would be able to deliver an acceptable Emergency Plan for the replacement reactor. The detail provided in the licence application is adequate for the siting stage of licensing. Further information would be provided in a Preliminary Safety Analysis Report with any application for a construction licence. The operational provisions to ensure an effective emergency plan, including training of staff and exercises of the arrangements to demonstrate a satisfactory state of preparedness, would be assessed in detail when a Final Safety Analysis Report is submitted with any application for licence to operate the replacement reactor. The existing emergency plans provide a satisfactory basis for developing emergency arrangements for the replacement reactor.

4. REFERENCE ACCIDENT ASSESSMENT

The use of a Reference Accident allows the radiological suitability of a site for a proposed reactor to be assessed at the conceptual planning stage, largely independently of the detailed design and before the detailed design of the facility is known. It involves the identification of a severe hypothetical accident, beyond the design bases of the reactor facility, and assessing its radiological consequences against criteria intended to protect individuals, society and the environment. The Reference Accident must be proposed by the licence applicant and agreed by ARPANSA.

This approach is commonly used within the nuclear industry for assessing the radiological suitability of nuclear reactor sites and is used by ARPANSA in assessing the suitability of Australian ports for use by visiting nuclear powered warships (VSP(N) August 1999). The basis for the approach can be seen as being consistent with practice in other industries – for example, the requirements of the NSW Department of Urban Affairs and Planning for hazardous industries (June 1992) and international practice (IAEA 1998).

Section 6 of the ANSTO licence application describes the assessment of the consequences of a hypothetical Reference Accident, in order to demonstrate that the proposed site would provide protection to the appropriate level. The assessment is described in detail in Appendix C to the licence application. Additional information was provided in the Draft Environmental Impact Statement (DEIS) and the Supplement (SEIS).

ARPANSA's review of the Reference Accident submission and referenced documentation against its draft Safety Assessment Principles and siting criteria is summarised below. The review is described in detail in a separate ARPANSA report (ARPANSA September 1999).

4.1 Selection of the Reference Accident

4.1.1 Principles and siting criteria

ARPANSA has based its approach to safety and siting of nuclear installations on the internationally accepted strategy of 'defence in depth' for achieving safety in nuclear plants. This involves the use of layers of protection that are independent and different, so that a loss of safety at any level is compensated by the protection provided by the next layer. The levels of safety are as follows:

- Level 1: the prevention of failures by high quality, conservative design;
- Level 2: the provision controls to maintain normal operations and detect failures;
- Level 3: the implementation of engineered safety features and procedures to protect against anticipated events;
- Level 4: the implementation of accident management provisions to mitigate the progress of accidents; and
- Level 5: the provision siting and emergency actions to mitigate the consequences of severe accidents.

ARPANSA's principles require that the siting of a controlled facility provide a layer of defence in depth of public safety which is, as far as practicable, independent of the design of the facility or controls on its operation.

The natural and man-induced characteristics of the site must be amenable to constructing, operating and decommissioning the replacement reactor without imposing unacceptable risks on the health and safety of people and the environment. The site characteristics are important in establishing the site-related bases for the design of a safe reactor, and to determining the radiological impact of the facility on the surrounding population and the environment. Accordingly, the characteristics of the proposed site must be well understood and analysed conservatively, to identify the characteristics important to safety.

In assessing the radiological suitability of the proposed site for the replacement reactor, ARPANSA requires that the consequences of a hypothetical severe accident, called the Reference Accident, be compared to siting criteria. ARPANSA's siting criteria require that, following the Reference Accident:

- the implementation of emergency actions to protect individual members of the public would be feasible for the greatest distance necessary to protect individuals as recommended in Radiation Health Series (RHS) No. 32, Intervention in Emergency Situations Involving Radiation Exposure (1990), published by the National Health and Medical Research Council (NHMRC) of Australia;
- the health consequences to the exposed population determined from the sum of effective doses to individuals, which takes into account fatal and non-fatal cancers and other health effects, would be acceptable; and
- there would be no need for long-term restrictions on use of affected land, determined from the limits on contamination levels recommended by the NHMRC in RHS No. 32.

The Reference Accident selected for the siting assessment of the replacement reactor is a very severe accident at the facility, the consequences of which would be extremely unlikely to be exceeded. This allows radiological siting considerations to be examined largely independently of the detailed design. Before any construction of the facility, ARPANSA would require that the siting assessment be reviewed to ensure the expected frequency of the Reference Accident chosen is small enough so that it need not be considered in the design of the facility. Additionally, validity of the assumptions made in defining and assessing the Reference Accident would have to be demonstrated for the particular design of reactor to be constructed.

In general terms, the Reference Accident should assume the failure or gross degradation in the performance of multiple levels of defence in depth leading to a release of radioactive material and dispersion in the environment under prevailing meteorological conditions. This includes the assumed failure of operational and control systems at defence in depth levels 1 and 2, failure of safety systems at level 3, and reduced credit for accident management measures at level 4. The radiological consequences of the accident should be determined using conservative assumptions. The Reference Accident, therefore, represents an upper bound risk to the surrounding population for the purposes of assessing the radiological suitability of a site and for emergency planning purposes.

Safety Assessment Principles 2 (defence in depth), 17 (living safety case), 25 (risks from a single accident), 28 (frequency and consequences of accidents), 55 (inherent characteristics), and 118 (Reference Accident, failures and conservative assumptions) and Siting Criterion 4 describe the general characteristics of a Reference Accident for assessing the radiological suitability of a site.

4.1.2 Results of Review

Choice of Accident

The licence application and Section 11.3 of the Supplementary EIS provide detailed information on the process used to screen potential causes of accidents in order to select the Reference Accident for assessing site suitability, and the assumptions made in assessing its consequences. ANSTO screened a comprehensive cross section of accident scenarios including loss of coolant, loss of coolant flow, insertion of excess reactivity, loss of electrical power supplies, internal and external events, fuel handling and human errors.

The Reference Accident chosen by ANSTO is a hypothetical reactivity insertion accident, and is described in Appendix C of the licence application. In summary, the Reference Accident is based on the following assumptions:

- an unplanned addition of excess reactivity to the reactor core, leading to a rapid increase in reactor power;
- some unspecified failure of the reactor control system so that the increase in power is not terminated;
- rapid increase of fuel temperature resulting in 25% of the fuel melting;
- release of radioactive materials from the fuel into the pool water;
- retention of some radioactive materials in the pool, with releases from the water into the reactor building;
- normal ventilation at two air changes per hour continuing for two minutes after release radioactive materials, then a degraded leak rate from the building of 3 % volume per day; and
- very stable meteorological conditions that minimise the dispersion of airborne radioactive materials and maximising consequent radiation doses, commencing at the time of the accident.

Accidents that are anticipated and provided for by the design of a facility are called design-basis accidents. Typically a reactivity insertion would be such a design-basis accident, and the design would ensure that there would be no fuel damage. For the purposes of the site evaluation, the hypothetical reactivity insertion accident chosen for the Reference Accident was arbitrarily assumed to be beyond the design basis, with significant fuel damage and degradation of those barriers that prevent the release of fission products. In addition, atmospheric conditions were assumed at the time of the accident that would minimise the dispersion of airborne radioactive materials and consequently increase radiation doses.

ARPANSA is satisfied that the choice of the Reference Accident is appropriate for assessing the radiological suitability of the proposed site. In agreeing with this selection, the agency accepts the argument that, in principle, a large loss of coolant accident that could drain the reactor pool can be excluded from consideration on the basis of high quality design of the reactor pool and its penetrations. It should be possible for the reactor to be designed so that even a severe earthquake that may occur once every 10,000 years or more, would not damage the pool or the adjoining structures to the extent that water could leak away faster than it could be replenished from the supplies available. ARPANSA would require this to be confirmed for the detailed design of the reactor as part of any application for a licence to construct the replacement reactor.

The Preliminary Safety Analysis Report (PSAR), which would be submitted with any application for a licence to construct the replacement reactor, would be required to

demonstrate that the design of the reactor effectively excludes failures that could lead to large loss of coolant accidents. A PSAR is a detailed analysis of a design that assesses the impact of a range of accidents, and describes how the design would prevent accidents or mitigate their consequences. For the replacement reactor, this would include demonstrating, with high confidence, a low probability of failure of structures, systems and components that could lead to a fast loss of coolant accident.

More generally, the PSAR would have to demonstrate that the assumptions made in analysing the radiological consequences of the Reference Accident in the licence application would be achieved in practice for the particular design of reactor chosen. As noted by Environment Australia in its recommendations on the approval of the project, the assumptions used in deriving the Reference Accident effectively constitute design parameters for the proposed reactor, and would have to be incorporated in the final design to the satisfaction of ARPANSA. This would be assessed in the agency's review of any PSAR for the reactor. In particular, the design would have to take account of any safety implications of the proposed spent fuel store and the need for a fire suppression system in the containment building and a drencher system for the cooling towers, as noted in the Environment Australia recommendations.

ARPANSA agrees with the recommendation of Environment Australia that any PSAR for the reactor be subject to an independent peer review. The peer review would be in addition to that of ARPANSA. These recommendations, and the recommendation requiring that agreement to any major design changes be sought from the Minister for the Environment and Heritage prior to design finalisation, are reflected in the recommended advisory notice below.

Frequency and Severity of the Reference Accident

Although the DEIS quotes a frequency of 10^{-6} per year for the Reference Accident, no frequency of occurrence is quoted in the licence application. The Safety Assessment Principles do not include any frequency criteria for the Reference Accident, but it is expected that the frequency would be well below the criterion of the one in ten thousand years for the total frequency of all accidents. Given the conservative assumptions on which the Reference Accident is based, ARPANSA is satisfied that the frequency of the accident is sufficiently low and the accident represents a suitable bounding case for the siting assessment.

The assumed failures of plant and procedures in selecting and analysing the Reference Accident ensure that it is of sufficient severity to assess the site as the last level of defence in depth. This is consistent with Principles 2 and 17.

ARPANSA would require that any PSAR the frequency and radiological consequences of all potential accidents or classes of accidents against the safety limits and objectives in its Safety Assessment Principles (Principles 27 and 28). This analysis should include accidents initiated by plant failures and man-made and naturally occurring external events, and should confirm that the Reference Accident has been selected appropriately in that its consequences are very unlikely to be exceeded.

Conservatism of analyses

Although Principle 11 allows for realistic assessment of the consequences of beyond-design-basis accidents, in view of the lack of detailed design knowledge at the siting stage, it is appropriate that the Reference Accident be based on conservative assumptions (Principle 118). A comprehensive assessment of design-basis and beyond-design-basis accidents is

expected at the detailed design stage, in the PSAR submitted in support of any application for a licence to construct the replacement reactor.

A useful summary of the Reference Accident assumptions is found in Appendix C of the application and Table 11.1 of the SEIS. This is presented in support of ANSTO's argument that the assumptions and parameter values used in estimating fission product release fractions and source term for the consequence estimates, have been chosen with adequate conservatism. Consistent with Principle 55, the Reference Accident gives credit for some inherent features of the pool type reactor, e.g. retention of fission products in the pool water during accidents, which is a major safety advantage of a pool design.

It is considered that the Reference Accident used in the licence application is based on acceptably conservative assumptions.

4.1.3 Conclusion

The Reference Accident selected by ANSTO to evaluate the suitability of the proposed site for the replacement reactor is acceptable. This should be confirmed in the any application to construct the reactor, as described in the following advisory notice recommended to be attached to the licence.

Recommended Advisory Notice

In any application for a Licence under the Act to construct the Replacement Research Reactor Facility, the Licensee should ensure that:

- (a) the assumptions used in deriving the Reference Accident described in the licence application are accounted for in the final design of the proposed reactor, and that this is demonstrated in the Preliminary Safety Analysis Report for the reactor;**
- (b) the final design of the proposed reactor effectively excludes the failures of structures, systems and components to rule out fast loss of coolant as a credible accident, including for earthquakes of lower frequency than the design-basis earthquake, and that this is demonstrated in the Preliminary Safety Analysis Report for the reactor;**
- (c) prior agreement is sought from the Minister for the Environment and Heritage and the CEO ARPANSA to any major design changes such that the Reference Accident described in the licence application may no longer be valid.**
- (d) the safety implications of an inter-linked store for spent fuel elements and the need for a drencher system for the cooling tower are assessed in detail in the Preliminary Safety Analysis Report;**
- (e) the final design of the Replacement Research Reactor Facility includes a fire suppression system; and**
- (f) the Preliminary Safety Analysis Report is subject to independent peer review.**

4.2 Consequences of the Reference Accident

4.2.1 Principles and Siting Criteria

The assessment of radiological consequences of the Reference Accident takes into account, to the extent that information is available at the time of the assessment, all direct and indirect pathways by which radioactive material released by the accident could reach and affect

people and the environment. The assessment determines radiation doses to people and contamination levels to the environment.

The radiation doses to people following the Reference Accident must be such that emergency intervention to avoid unacceptable radiation doses to individuals would be feasible at any location around the site. Emergency response following a radiation accident is based on a number of interventions designed to avoid radiological hazards. These interventions also carry some expense and risk to those individuals, which varies with the type of intervention and environmental factors specific to the accident.

The decision on which countermeasure to impose, and the timing of the intervention, should be based on ensuring that the intervention does more good than harm, and that this net benefit is optimised. The 1990 NHMRC publication 'Intervention in Emergency Situations Involving Radiation Exposure' provides recommended values of intervention levels, which are doses averted by each type of intervention, at which there is likely to be a net benefit from the intervention. The feasibility of countermeasures around a controlled facility must be established for the lowest NHMRC intervention level recommended for short-term countermeasures such as sheltering and evacuation, and medium and long-term countermeasures such as restrictions on food supplies and decontamination.

The health consequences to the population arising from the Reference Accident are measured by the collective effective dose to the potentially most exposed population following the accident. This measure of health detriment to the population takes into account life shortening and the incidence of non-fatal cancers, as well as incidence of long-term cancer fatalities. The collective effective dose is calculated making no allowance for the avoidance of individual doses by short-term countermeasures. However, individual doses that could be readily averted by medium and long-term countermeasures may be excluded in the calculation.

Radiation doses to the public following a severe accident at a research reactor may cover a very wide range of values, as doses could be calculated for large distances from the source, using values that are diminishingly small. To ensure that there is some limit to the extent of the calculation of collective effective dose and that the result is a meaningful representation of societal risk, individual doses below some value should be excluded from the calculation of collective effective dose. The choice of this value must be justified, and may be derived from the extent of the population around the site, or based on a level of individual dose that is considered to be acceptably small in the circumstances.

The maximum calculated effective collective effective dose that would arise from the Reference Accident, calculated as described above, must be less than 200 man.Sv. This criterion is consistent with that used in Australia in the assessment of ports for visits by nuclear powered warships (VSP(N) 1999). The risk basis for this maximum collective effective dose is similar to the risk basis inherent in the publication of the NSW Department of Urban Affairs and Planning for the Multi-Level Risk Assessment of hazardous industries (1997).

Other long-term effects of a nuclear accident are considered in the siting criteria by requiring that long term restrictions on the use of land would not be needed to protect the public, following such an accident. This criterion was set in recognition of experience of severe accidents where extensive areas of land were contaminated to the extent that they are considered unsafe to farm or inhabit.

Safety Assessment Principles 30, 117, 119 and 120, and Siting Criterion 5 describe the determination of consequences of the Reference Accident. The criteria described above are included in Safety Assessment Principle 119 and Siting Criteria 6 and 7. The need for analyses of the impacts of accidents in the PSAR is covered by Principles 18 and 20.

4.2.2 Results of Review

The determination of consequences of the Reference Accident is described in Section 4 of Appendix C to ANSTO's siting licence application. This is a deterministic assessment of consequences, consistent with Principle 30, based on the Reference Accident reviewed above. The assessment was performed early in the planning for the facility to determine the suitability of the site, as described in Principle 117.

Computer Code

The computer code used by ANSTO to calculate the radiological consequences of the Reference Accident, "PC-COSYMA", is well validated and widely used around the world for this purpose. Use of this code is acceptable to ARPANSA. ARPANSA independently calculated the consequences of the Reference Accident using PC-COSYMA and its own code "ACCIDENT". The doses obtained by ARPANSA are similar to those calculated by ANSTO in its siting licence submission, with any differences readily explained by the use of different critical groups, different cloud models and dose conversion factors.

Feasibility of Emergency Response

The radiation doses that could arise from the Reference Accident were calculated for an individual at the edge of the buffer zone, which is 1.6 km from the origin of the release. The application calculates an effective dose of 0.86 mSv at 1.6 km for the 4 periods of release calculated. The thyroid dose at this distance, which is the largest single organ dose, is 1.6 mSv. These doses are less than the lowest intervention levels at which any emergency actions would be considered, based on the NHMRC recommended lower levels of 5 mSv effective doses and 50 mSv single organ dose. As noted above, ARPANSA accepts the doses calculated in ANSTO's submission and, therefore, is satisfied that no emergency intervention for members of the public outside the buffer zone would be necessary following the Reference Accident.

Notwithstanding the above result, ARPANSA reviewed the emergency arrangements submitted with the licence application against the criterion for feasibility of emergency response. These arrangements fit into the on-site ANSTO emergency plans and off-site local, district and State disaster plans (DISPLANs), arrangements that have been in place at the site for some years. In the application, ANSTO briefly described the relationship between the existing site arrangements and specific emergency arrangements for the replacement reactor. There is no clear statement in the application of the extent to which the siting of the replacement reactor impacts on the existing arrangements for emergency planning, their flexibility and extendability. These details would need to be completed to the satisfaction of ARPANSA before any licence for operation of the reactor would be issued.

ARPANSA is satisfied that it would be feasible to develop and implement emergency arrangements to adequately protect people and the environment following the Reference Accident.

Collective Effective Doses

The collective effective dose estimates are presented in section 4.5.2 of Appendix C to the licence application. Table 4.3 gives the projected 2011 population used to calculate a collective effective dose from doses to individuals. Consistent with Principle 120, no allowance is made for short-term countermeasures and individual doses of less than 10 microSv are not included. This cut-off dose is considered to be appropriate, as it is equivalent to a dose considered by the IAEA to be below regulatory concern (IAEA 1996). For these conditions, the calculated maximum population dose that could arise from the Reference Accident is 6.2 man.Sv, compared to the criterion of 200 man.Sv.

While ARPANSA agrees that 10 microSv is a reasonable cut-off for calculating population doses from the Reference Accident, some reviewers of the DEIS commented that the collective effective dose calculation did not include the Sydney CBD and daytime transients, as the cut-off dose is reached 25 km from the proposed site. In light of this, and to ensure that there is no 'cliff-edge' effect where consideration of a wider area leads to a sharp increase in consequences, the SEIS included a calculation of the collective effective dose to a distance of 50 km from the proposed site. The maximum collective effective dose calculated for these conditions is 22.6 man.Sv, which is still well below the criterion of 200 man.Sv.

ARPANSA considers that the calculated collective effective dose to the most exposed population that could result from the Reference Accident meets the relevant criterion, and that the calculated radiological impact of the Reference Accident on the population is acceptable.

Land Contamination

Section 4.5.3 of the Reference Accident submission describes the evaluation of long-term land contamination. The analyses of the Reference Accident in the DEIS and SEIS show that the contamination of land surrounding the proposed site would produce a maximum direct radiation dose of 0.1 mSv at the boundary of the buffer zone in the first year, and very much lower doses in subsequent years. The Reference Accident submission in the licence application provides similar results. The NHMRC recommends that intermediate term relocation of people be considered where effective doses exceed 50 mSv, and permanent relocation be considered where dose rates exceed the long-term public effective dose limit of 1 mSv per year (NHMRC 1990).

Some reviewers of the DEIS raised concerns on the impact of iodine-131 contamination following the Reference Accident. However, ARPANSA is satisfied that the calculated quantity of radioactive fission products released from the containment building (source term) includes a sufficient quantity of iodine-131, and that the environmental impact of a release of this source term has not been underestimated in the licence application. In the DEIS and SEIS, the calculated ground contamination levels at 0.4 km and 1.6 km due to iodine-131 are 0.4% and 0.1% respectively of the NHMRC recommended level derived from the intervention levels described above. The ANSTO siting licence application gives similar results, with an estimate, at 1.6 km, for the iodine-131 concentration at 0.07 % of the derived intervention level. There is reasonable agreement between the estimates in the two submissions, and both values are very much less than that in the NHMRC recommendations.

ARPANSA considers that there would be no long-term disruption to land use following the Reference Accident.

Hazard Category

The analysis of the Reference Accident, described in this section, is considered by ARPANSA to be an acceptable analysis of the safety of the proposed replacement reactor at the siting licence stage of the project. It is consistent with ARPANSA Safety Assessment Principle 18. However, the licence application does not include an analysis of the hazard category of the proposed facility, as described in Principle 20. Although the submission concludes that there would be no significant off-site consequences following the Reference Accident, the potential for such consequences should not be excluded before the safety review of any completed design of the reactor in a PSAR, to verify the assumptions in the present assessment. Therefore, ARPANSA would consider the replacement reactor to have a hazard category of F3 (potentially having significant off-site consequences) at the siting licence stage, subject to the hazard category for the facility being reviewed in any PSAR for the reactor.

4.2.3 Conclusion

The analysis described in the siting licence application provides an acceptable determination of the consequences of the Reference Accident for the proposed replacement reactor and meets all of the relevant ARPANSA siting criteria. Subject to the conditions of licence relevant to the Reference Accident, the proposed site would provide an acceptable level of radiological safety for the replacement research reactor.

5. SITE CHARACTERISTICS

The objective of the review of the site characteristics is to describe those characteristics that would influence the facility's safety and the potential impacts of normal operation and accidents on people and the environment, and to identify the design bases that would take account of these characteristics. The site characteristics are described in Section 5 and Appendix B of the siting licence application, and were reviewed against the relevant principles and siting criteria.

5.1 Radiological Baseline

5.1.1 Principles and Criteria

Before any work may be commenced on the proposed replacement reactor, it is important that the radiological baseline of the site be established. This information would be used during the construction, operation and decommissioning of the facility to assess impacts of these activities on the environment and ultimately, the effectiveness of decommissioning activities.

Safety Assessment Principle 43 and Siting Criterion 3 are applicable to this review.

5.1.2 Results of Review

The licence application describes the baseline radiological surveys of the proposed site. The historical baseline radioactivity measurements for the Lucas Heights Science and Technology Centre, from environmental monitoring of the site over the past 40 years, are described, together with specific studies undertaken for the replacement reactor site that include information on radionuclide concentrations in soil and groundwater.

There is a need for the baseline data provided in the licence application and the DEIS to be expanded to cover the entire Lucas Heights Science and Technology Centre and the buffer zone around the proposed site. This was reflected in the comments of the NSB and other reviewers of the DEIS, and is Recommendation 12 of the Environment Australia review of the proposal. ANSTO has undertaken to comply with the Environment Australia recommendation.

5.1.3 Conclusion

Subject to the following condition of licence, the licence application provides an acceptable radiological baseline of the site for the proposed replacement reactor.

Recommended Licence Condition

The Licensee shall establish a radiological characterisation of the Site for the Replacement Research Reactor Facility and a radiological characterisation of the Buffer Zone to provide a fundamental basis for ongoing radiological monitoring programs and the detection of radiological trends over time.

5.2 Site Characteristics and Related Design Bases

5.2.1 Principles and Siting Criteria

The licence application should describe characteristics of the proposed site that would influence the design of the facility or the radiological impact of operations or accidents. These include natural characteristics such as topography, meteorology, seismology and hydrology, and man-made characteristics such as population distributions, land and water use, supply of essential services, other hazardous industries and existing facilities on or near the proposed site.

Where a site characteristic could impact on the safety of the proposed facility, the licence application should identify the frequency and severity of events, so that this information may be used when establishing the external events that are to be taken into account in the design of the facility. While the design bases will be considered in detail as part of the design stage of the project, it is important that any design-basis external events that may result in design problems for a proposed facility be identified early in the project, at the siting stage.

There is also a need to establish a monitoring program that would ensure that the siting assessment and other safety analyses are revised to take account of any changes in the site characteristics or interpretation of their impact on the facility. The site related design bases would also be required to be monitored.

Siting Assessment Principles 26, 27 and 54 and Siting Criteria 1, 2, 8, 9 and 10 to 15 are applicable to this review.

5.2.2 Results of Review

The characteristics of the proposed site and the frequency and severity of the characteristics that would impact on the design of the research reactor are summarised in the licence application. Detailed information has been referenced in the DEIS. In general, all of the relevant site characteristics have been described, but further work is needed in some cases to expand the descriptions or the frequency and severity of events.

Section 3 of Appendix B of the licence application addresses site-related design bases. The submission identifies three external events that need to be part of the design-basis: earthquakes; a small aircraft crash; and high winds.

Topography

The geography of the site is described in the licence application, and references the DEIS for a description of the site topography. There is no clear statement of important features such as the on-site and off-site topography that could affect dispersion and diffusion; including valleys, hills, other buildings, stacks etc. A description of this site information is needed to support the dispersion analysis of airborne releases during normal operations and accidents.

Ecology

The application refers to the DEIS for a description of the ecology of the area surrounding the proposed site. A description of the surrounding vegetation is recommended, as the distribution of plant types is a major factor in hazard mapping (such as fire potential and

radioactive, or pollution distribution). It is also basic to determining and managing wildlife habitat.

Meteorology

The basis of the wind speed values chosen for the design of structures, components and systems important to safety is the value with a return period of 10,000 years within 100 km of the site. The design basis chosen for high winds is considered to be satisfactory.

In the licence application, lightning strikes are considered to have equal or less damage potential than the events for which the replacement reactor is to be designed. ARPANSA consider that frequent lightning strikes can be expected at the proposed site, and that more attention is needed to address the effects of severe lightning strikes on structures, systems, components and electrical services important to safety. In some countries the level of lightning protection is given detailed design attention and the relevant international standards and guidelines should be considered.

Bushfires

Bushfires are a moderately frequent occurrence around the proposed site. The IAEA review of the DEIS noted that the frequency of bushfires is once every 5 years. Large bushfires have a frequency of the order of 1 in every 10 years. ANSTO considers that the incidence of bushfires near the Lucas Heights Science and Technology Centre site does not present any unique effects for consideration in the design and operation of the replacement reactor, and that the effects of an off-site transport accident would bound the effects of a bushfire.

While ARPANSA accepts that a major bushfire would not be a direct threat to the reactor or cause a reactor accident, it could impact on reactor operation and the supply of off-site services such as water and electricity. The latter may require interim dependence on on-site or standby supplies, for example, for decay heat removal. It is expected that accommodation would be made for these situations in any reactor design or operation. Additionally, bushfires could impact on the on-site and off-site emergency planning arrangements for site evacuation.

The licence application states that bushfire events have equal or less damage potential than the events for which the replacement reactor is to be designed, and are bounded by an aircraft crash event. Furthermore, the effects of an aircraft crash bound the effects of bushfires in terms of high temperature debris, and any effects imposed by a bushfire on the reactor and associated buildings are bounded by the effects of an off-site transport accident. The impact of a bushfire on essential services should be examined in the PSAR required with any application to construct the replacement reactor.

Seismology

The licence application describes the seismology of the proposed site. The site is located on a sandstone plateau in the Sydney Basin, which is currently considered to lie in a low intensity seismic zone. ANSTO states that while there are a number of geological features in the Sydney Basin indicative of past earthquake activity, no seismically active geological structures have been identified, and there are no major faults within 35 km of Lucas Heights Science and Technology Centre. The licence application states that earthquakes with a return period of 10,000 years at the proposed site have been estimated to be in the range of magnitude 5.75 to 6.25 on the Richter scale, with an epicentre about 15-20 km distant. ANSTO's best estimate for horizontal ground accelerations associated with the 10,000 year

return period earthquake is 0.17 g, with an uncertainty of 0.06 g. These results are consistent with those of an independent analysis commissioned by ARPANSA.

However, the probabilistic safety assessment of HIFAR included an assessment of the frequency of damage to the reactor core resulting from seismic events. This study recommended reassessment of the seismic hazard at the site, taking account of the uncertainties in the models applied and parameter values used in the models. Subsequently, the Department of Industry Science and Resources engaged a consultant to perform further work reviewing the seismic information applicable to the site, update the hazard curve in the light of the best available data, and employ current international thinking regarding uncertainty of seismic events. This additional seismic study should be completed and its results included in the PSAR required with any application for a licence to construct the replacement research reactor.

To determine the seismic design basis, a 10,000-year return period earthquake was chosen for the Safe Shutdown Earthquake, which is consistent with world practice for new power reactors. A conservative estimate of 0.23 g peak horizontal ground acceleration has been chosen. This value must be confirmed as an upper bound value for use as a design basis following the completion of the additional work described above.

The licence application does not describe the seismic design bases of the Experimental Guide Hall. In addition, off-site electrical power supplies and water supply from the on-site water tower are vulnerable to failure under some seismic conditions and should be taken into account in determining the design basis. International experience shows that such failures can occur at ground accelerations much lower than the proposed reactor design-basis of 0.23 g.

Ground Water

Reference is made in the licence application to extensive studies of ground water hydrology by Coffey Partners (1998) and others. The ground water hydrology is important for both the existing site nuclear facilities and any replacement reactor, and was a significant issue in the DEIS. Review of the licence application by a consultant to ARPANSA found that the ground water table in the Woronora Ramp is largely a subdued replica of the surface topography. However, there may be a short pathway for shallow seated ground water and surface water run-off under heavy precipitation conditions from the proposed site resulting in flow to the Melinga Molong Creek. The ARPANSA consultant recommended that this possibility be examined by ANSTO to determine whether a short pathway exists, perhaps by a controlled radioactive tracer study.

In its review of the project, Environment Australia also noted the need for ground water monitoring as part of the Environment Management Plan to ensure coverage of contaminants from the site overall and aquifer flows downstream of the proposed replacement reactor. This recommendation is reflected in the recommended licence conditions below.

The licence application does not address design bases related to groundwater. ANSTO has undertaken to conduct further investigation of groundwater to characterise possible additional mitigation measures, prior to applying for a licence to construct the replacement reactor. Such investigations are particularly important for the design of wet and dry spent fuel storage tanks, as raised in reviews of the DEIS.

Surface Water

The licence application does not include an estimate of the frequency and severity of external flooding and stormwater events, but indicates that these events would be considered in any PSAR. Although the likelihood of flooding of the proposed site is low, the frequency and severity of flooding should be estimated to allow specification of the design bases for external flooding. This should take account of the stormwater control plan to be developed during the design stage, as recommended by Environment Australia

An external design-basis event for possible improvement of stormwater provisions has not been determined. The application mentions that the existing stormwater bunds are of small capacity and allow overflow in heavy rain periods. The NSB raised some concerns with the limited capacity of the stormwater bunds in its review of the DEIS. Environment Australia also raised the need for a stormwater control plan to be prepared at the design stage.

ARPANSA considers that the uncontrolled release of liquid from the site through stormwater bund overflow needs to be addressed. There should be a clear design capacity for these bunds based on historical rainfall, and a retention capability based on, say a one in ten year storm.

Demography

The licence application describes the demography around the site, and gives information on present and projected populations, but no information is given on the location of hospitals, schools etc. The eating habits of the population are mentioned as being described in the DEIS. The presence of special needs groups is not addressed. A comparison of the population estimates in the licence application, the SEIS, and an independent ARPANSA estimate for the most populated sector (NNE) indicated considerable differences in the estimates of the populations within the area segments. These may be explained by differences in the methods used, but the differences should be resolved in any PSAR for the reactor, along with a consideration of any special needs groups.

Land Use

The present use of land around the site is described in the licence application, but projected uses are not included. The DEIS and SEIS give some additional information on future land use, and indicate that future land use proposals, within the 1.6 km buffer zone, would be subject to ANSTO approval in accordance with a range of environmental and safety criteria. Some reference is made to the extent of farming in the area surrounding the site, but detailed description of food production and processing within 15 km should be presented. This information would be necessary for future assessment of radiation doses arising from radiation discharges from the proposed replacement reactor.

Water Supply

The licence application describes the existing water supply at the Lucas Heights Science and Technology Centre, which consists of supply pipelines, storage facilities, pump systems, and a site distribution system. The capacity of the existing water supply system is sufficient to meet the operational requirements of the replacement reactor, and any additional demands during construction. The submission identifies the need for additional water supply during any period of dual operation of replacement reactor and HIFAR, which can be accommodated by the reservoir capacity.

However, the ARPANSA consultant on seismic hazards drew attention to the outcome of a seismic review of the elevated water reservoir at the Lucas Heights Science and Technology

Centre, performed in the 1980s. The report, by Horoschun (1985) of the Department of Housing and Construction, recommended that the tower be reinforced and the quality of the foundation conditions investigated. ARPANSA considers that this work should be completed to ensure the continuity of the water supply to the ultimate heat sink during any operation of the replacement reactor.

Electrical Supply

The licence application does not give a conservative determination of any external design-basis event relating to electricity supply during the period of dual operation of the replacement reactor and HIFAR. Environment Australia recommended that the impact of loss of off-site electricity or water supply for fire-fighting purposes be considered in the PSAR, and that if risks are significant, on-site power provisions for water pumps are to be provided to the satisfaction of ARPANSA.

Sewerage Services

Waste water and sewerage services are described in the licence application. The infrastructure includes delay tanks for collection of liquid wastes from buildings and pipework to the low-level liquid and trade waste treatment facilities. As recommended by Environment Australia in its review of the SEIS, ANSTO must undertake further assessment and analysis to ensure that all possible exposure pathways and future processes at the Cronulla Sewage Treatment Plant are taken into account.

Other Facilities

The licence application states that an industrial accident occurring at the Lucas Heights Science and Technology Centre outside the proposed replacement reactor building that could significantly damage the reactor or its safety systems is extremely unlikely. Few operations on site have sufficient stored energy to penetrate the expected design of the reactor building; none have the energy and proximity to cause an accident at the reactor facility and the containment building.

The application mentions a proposed overlap period of six months for dual operation of the replacement reactor and HIFAR. Both reactors could be operated and maintained within their respective licences to ensure that safety is maintained during this overlap period. However, ARPANSA considers it prudent to anticipate that the overlap in operation could exceed six months. ARPANSA agrees with the recommendation of Environment Australia that specific approval of the CEO, ARPANSA be required for dual operation for any period longer than six months.

Nearby facilities and industry are described in the licence application. Reference is made to a communications tower within 100 m of the proposed site for the replacement reactor. During construction of this communication tower the NSB was assured it could only receive and not transmit, and thus there was no possibility of interference with reactor electrical equipment inside the HIFAR steel containment building. This assurance should be checked for the replacement reactor, particularly as the tower is much closer to the proposed site, and the proposed reactor containment building may be concrete.

Aircraft Impact

The licence application describes air transportation in the vicinity of the Lucas Heights Science and Technology Centre and the flight prohibitions over the site. The application also

identifies potential hazards that could arise from impact by civil and military aircraft, and is based on recent work undertaken for the HIFAR probabilistic safety analysis.

The estimation of the probability of aircraft crashes does not explicitly mention the crash of a military aircraft that is believed to have occurred within the Holsworthy Military area, a few kilometres from the Lucas Heights Science and Technology Centre site, in the 1960s-70s. It is not evident whether this crash statistic has been taken into account in the consultant's report (PLG 1998) from which aircraft crash frequencies have been estimated.

The estimated low probability of an aircraft crashing onto the replacement reactor facility would not require the design of the reactor to withstand aircraft crashes. Nevertheless, in the application ANSTO has committed to including the impact of a light aircraft as a design-basis accident, so that that the reactor would be designed to be safely shutdown in such an event.

The design-basis chosen for aircraft impact is considered to be satisfactory, by ARPANSA.

Sabotage

The physical protection and access control systems would require the approval of the Director General, Australian Safeguards and Non-Proliferation Office (ASNO). The level of threat for designing protection would be determined in consultation with the ASNO and the Australian intelligence community. No facilities (e.g. tall buildings, mines or equipment/security barriers that might be shared with other facilities) were identified which might impair the development of security arrangements and measures, or enhance the opportunity for sabotage.

Although no design basis for an external sabotage event that may lead to an accident is described in the application, the frequencies and severities of sabotage scenarios and related design bases would be addressed by ASNO and included in any PSAR for the reactor.

Monitoring Site Characteristics

The licence application states ANSTO's commitment to ongoing site evaluation during the life of the research reactor. The application addresses future use of the land within the 1.6 km buffer zone that is currently leased to Waste Service NSW, and states that the actual populations from the census scheduled for 2001 would be presented in any PSAR for the reactor.

Changes in the knowledge, understanding and interpretation of site characteristics, and regulatory changes, that could impact on the siting assessment, would be required to be addressed in any PSAR and maintained current in any Final Safety Analysis Report (FSAR) throughout any future life of the replacement reactor facility. Ongoing monitoring of site characteristics was also recommended by Environment Australia in its approval of the project.

The choice of design bases for the replacement reactor that are dependent on the man-made and natural characteristics of the site would be required to be justified to ARPANSA. This would include a process for review of the design bases of the facility in response to any changes in the site characteristics, through ongoing review and upgrading of any FSAR and appropriate approvals.

5.2.3 Conclusion

Subject to the following licence conditions, the licence application provides an acceptable description of the characteristics of the site and the site-related design bases for the proposed replacement reactor. These design bases should be taken into account in any PSAR for the reactor, as noted in the recommended advisory note below.

Recommended Licence Conditions

The Licensee shall ensure that:

- (a) a review of the topography and food production farming within 15 km of the Site is performed to confirm the likely impact of radioactive discharges from the Replacement Research Reactor Facility, and submitted to the CEO ARPANSA as soon as is reasonably practicable;**
- (b) the population distribution estimates submitted with the Application are confirmed, and that any special needs groups within 5 km of the Site are identified, and submitted to the CEO ARPANSA as soon as is reasonably practicable;**
- (c) an investigation of ground water direction and flow rate at the Site under heavy precipitation conditions is performed, and the results submitted to the CEO ARPANSA as soon as is reasonably practicable;**
- (d) the severity of local flooding at the Site is estimated having regard to the stormwater control plan recommended by Environment Australia in the Environment Assessment Report and be documented in the Preliminary Safety Analysis Report;**
- (e) the additional analysis of seismic hazards at the Site arising from the HIFAR Probabilistic Safety Assessment to describe uncertainties in the seismic characteristics of the Site and confirm the conservative upper bound value for use as a design basis for the Replacement Research Reactor Facility, is completed and submitted to the CEO ARPANSA as soon as is reasonable practicable together with documentation detailing the resolution of any issues raised by the analysis;**
- (f) design bases for seismic events are determined for the Experimental Guide Hall;**
- (g) seismic upgrading work to the Lucas Heights Science and Technology Centre water tower as recommended in the Horoschun report in 1985 be completed as soon as is reasonably practicable;**
- (h) further assessment and analysis is completed as soon as is reasonably practicable to ensure that all possible exposure pathways for radiological doses for people and future events at the Cronulla Sewage Treatment Plant are taken into account in determining radiation doses arising from liquid discharges.**

The Licensee shall confirm that the communication tower located near the Site will not be capable of transmitting radiation that could interfere with the electrical equipment of the Replacement Research Reactor Facility;

The Licensee shall ensure that the Preliminary Safety Analysis Report for the Replacement Research Reactor Facility includes provision for ongoing monitoring and audit of the frequency and severity of external events to ensure that assessed risks to the replacement reactor remain valid and acceptable, taking into account new developments in the vicinity of the reactor over time.

The Licensee shall ensure that the design bases for the Replacement Research Reactor Facility take account of:

- (a) interruptions to off-site and on-site water and off-site electrical power supplies due to seismic events;**
- (b) lightning strikes;**
- (c) ground water leakage into spent fuel stores;**
- (d) intense precipitation events;**
- (e) loss of off-site electrical supplies impacting on water supply and fire-fighting capability;**
- (f) interruptions to electrical supplies during parallel operation of the proposed reactor and HIFAR;**
- (g) sabotage events, and**
- (h) the impact of bushfires on the Replacement Research Reactor Facility, its essential services and emergency planning arrangements.**

Recommended Advisory Notice

Any Preliminary Safety Analysis Report submitted should address the matters raised in the condition above.

5.3 Impact of Site Characteristics on Anticipated Radiation Doses

5.3.1 Principles and Siting Criteria

As far as can be done at the siting stage, the radiological impact of the facility during operational states and anticipated occurrences should be assessed using the information on site characteristics described above. The assessment should include consideration of all direct and indirect exposure pathways, for all anticipated operational activities at the facility, including the handling, interim and permanent storage, transportation and disposal of new and spent nuclear fuel, radioactive and fissile materials, and radioactive waste.

Siting Criteria 16 and 17 are applicable to this review.

5.3.2 Results of Review

The replacement reactor siting licence application includes no examination of the anticipated radiation doses arising from operations of the replacement reactor and anticipated operational occurrences. Section 2.10 of Appendix B to the application refers to the DEIS and SEIS for information on gaseous emissions, surface water, ground water, and soil contamination. The licence application describes the historical radiological impact from routine discharges from the Lucas Heights Science and Technology Centre. It states that the main environmental pathway contributing to dose is external radiation from airborne releases, which comprise more than 80% of the total effective doses to members of the public from ANSTO's operations. It also states that liquid discharges make a negligible contribution to public dose.

The licence application states that there are no identified site characteristics that would adversely effect potential transfer pathways of radiological releases to humans. Such a statement on radiological impact should be based on some evaluation that has concluded there are no adverse site characteristics. In the past there was some concern, that due to the

local topography, there could be enhanced concentration of radionuclides in the Woronora Valley, and this needs to be resolved.

The issue of changes that might occur to the Sewage Plant at Cronulla was raised in the NSB review of the DEIS submitted to Environment Australia, and the ARPANSA review of the SEIS. The IAEA peer review of the DEIS noted that the sewer discharges are not evaluated in terms of public doses from exposure pathways such as fish ingestion, ingestion of seawater and external exposure from swimming. The NSB also commented on the need to include pathways for sewage workers at the Cronulla treatment plant. The IAEA peer review also pointed out that there may be future impacts on exposure pathways if there is any re-use of sewage water or sludge.

Appendix A of the licence application references environmental management systems. ARPANSA supports ANSTO's proposal to develop an environmental management system that is consistent with ISO 14000. In the longer term it is important that all operational areas meet the appropriate QA standards, and this would be part of the conditions for the licence to operate the replacement reactor. Such standards would ensure that radiation protection arrangements take account of any changes to the site characteristics.

5.3.3 Conclusion

The impacts of the site characteristics on radiation doses that would arise from operation of the proposed replacement reactor should be confirmed in any PSAR for the proposed replacement research reactor, as described in the recommended advisory notice below.

Recommended Advisory Notice

Any Preliminary Safety Analysis Report submitted should confirm that the Site and its characteristics do not adversely affect exposure pathways for radiological doses to people, and that any impacts on doses of changes to the site characteristics are monitored.

6. PREVIOUS ENVIRONMENTAL ASSESSMENTS

6.1 Environmental Impact Statement Process

The environmental impact statement process for the replacement reactor project, implemented under the *Environmental Protection (Impact of Proposals) Act 1974*, covered the conceptual stage of the project. It concluded when the Minister for the Environment and Heritage advised the Minister for Industry, Science and Resources that there were no environmental reasons why the project should not proceed (30 March 1999). The Minister also provided recommendations considered necessary for protection of the environment and on the environmental acceptability of the proposal. Some of the recommendations involved work that would be required to be completed to the satisfaction of ARPANSA during any future licensing of the replacement reactor.

Regulation of the safety of the replacement reactor project through licensing under the *ARPANS Act 1998* is independent of, and additional to, the EIS process under the *Environmental Protection (Impact of Proposals) Act 1974*, and continues after completion of the EIS process. ANSTO must comply with the requirements of both processes. Each of these processes requires considerable consultation with the public and other stakeholders.

With the application for licence to prepare a site for the replacement reactor, ANSTO included the DEIS, the SEIS and the Environment Australia's evaluation of the complete EIS. The NSB provided detailed comments on the DEIS to Environment Australia, and these were addressed in the SEIS and the EA Environment Assessment Report.

6.2 Review of Environment Assessment Report

Environment Australia concluded that, subject to a number of recommendations, there are no environmental reasons, including on safety, health, hazard or risk grounds, to prevent construction of the replacement reactor at the proposed site. Environment Australia's report and conclusions have been taken into account by ARPANSA in preparing this safety evaluation report of the siting licence application. Links between the respective reports have been identified. The main issues for ARPANSA flowing from Environment Australia's report are discussed below.

Aspects of Proposal

The Environment Assessment Report gives a concise summary of the proposal; the main points of interest to ARPANSA are:

- the 1.6 km buffer zone is to be retained;
- low enriched uranium is to be used rather than the highly enriched uranium fuel used in HIFAR, thus lowering non-proliferation concerns;
- HIFAR to be shutdown after the replacement reactor is operational sometime after 2005; and
- improved safety features of a pool reactor, in particular the protection against some severe accidents such as loss of coolant accidents.

Environmental Aspects

The areas of environmental impact that are of interest to ARPANSA are those associated with hazards and risks, operational emissions, and nuclear or radioactive waste. These have been

described in detail in chapters 10 and 11 of the DEIS and SEIS and have been reviewed by ARPANSA.

Environment Australia accepted the replacement reactor Reference Accident described in the DEIS and SEIS as representing a bounding, or worst, case for accidental radiological releases from the site. This would only be true once HIFAR is shutdown since the consequences of the HIFAR Reference Accident are greater than those of the replacement reactor. EA also accept that the ARPANSA siting requirements could be met, and that there are no credible circumstances in which emergency counter measures are needed beyond 1.6 km. EA concluded that 'hazards and risks associated with the replacement reactor have been adequately examined and do not pose a constraint to its siting'.

Environment Australia considers that there should be no increase in radioactive discharges from the Lucas Heights Science and Technology Centre during any operation of the replacement reactor, despite proposed increases in radioisotope production. ANSTO has made a commitment to radiation doses to individual being less than 0.01 mSv per year at 1.6 km from all site airborne discharges.

Environment Australia refers to the legacy of historical nuclear and radioactive waste stored on site. The main issue they discuss is the arrangements for the National Radioactive Waste Repository, and the recognition that the current radioactive waste is in storage, and does not constitute a permanent disposal route for long lived waste.

Conclusions

Environment Australia concluded that there are no environmental reasons, including safety, health, hazard or risk grounds to prevent construction of the replacement reactor at Lucas Heights Science and Technology Centre, subject to implementation of their recommendations which are also attached as Appendix A to this report. ARPANSA will take account of these recommendations when reviewing any future applications for licence for the replacement reactor and when reviewing the applications for licence for other facilities at the Lucas Heights Science and Technology Centre.

6.3 Implementation of EA Recommendations

Many of the 29 recommendations of the EA report involve radiation protection or nuclear safety, and are relevant to the review of the application for a licence to prepare a site for the replacement reactor, or any future licence applications. Others are relevant to the licensing of ANSTO's existing radioisotope production facilities. It is the intention of ARPANSA to implement Environment Australia's recommendations wherever they are relevant to the agency's regulation of any replacement research reactor or other ANSTO facilities. The relevant recommendations are attached as Appendix A, which also shows where such recommendations have been addressed in this report, or to which conduct the recommendations will be applicable.

7. PUBLIC CONSULTATION

7.1 Public notice about the licence application

Regulation 40 required the CEO, ARPANSA to advertise receipt of the site licence application for the replacement research reactor, and to invite submissions. The public was advised of the application and submissions were invited in the following ways:

- a notice published in the Commonwealth Gazette on 28 April 1999;
- on the ARPANSA Internet site from 28 April 1999;
- an advertisement in the Australian on 29 April 1999;
- an advertisement in the St George and Sutherland Shire Leader on 4 May 1999; and
- an advertisement in the Express on 30 April 1999.

Copies of the siting licence application submitted by ANSTO were made available to the public, along with advice as to how and when submissions could be made. Information was made available as follows:

- on the ARPANSA website;
- at the Sutherland Shire Council Library;
- at the ARPANSA office in Victoria; and
- at the ARPANSA office in Miranda.

The material was also forwarded to the Sutherland Shire Council and the Sutherland Shire Environment Centre.

7.2 Summary of public submissions

In making a decision on the licence application, Regulation 41(g) requires the CEO, ARPANSA to take into any submissions received from the public about the application.

Seventy-three submissions were received and analysed by ARPANSA. These are listed in Appendix B. The issues raised in the submissions are summarised in Appendix C together with an indication of where each issue is addressed in this Safety Evaluation Report.

Five of the submissions were a form letter (A), and a further forty-seven were a second form letter (B), expressing general opposition to the granting of a licence to prepare a site for the replacement reactor at Lucas Heights. Reasons for the opposition were stated as dissatisfaction with the EIS process, the need for a remote site and a view that the chosen site was selected as the easiest option. It was stated that public opinion is against the project, and recommendations of the Research Reactor Review (1993) have not been met. A lack of proof that low levels of radiation dose above background are not harmful, was also quoted, together with the unavailability of insurance cover for nuclear accidents and the need for long-term waste plans for radioisotope production.

A joint submission from Friends of the Earth, Australia (FOE), and the Australian Conservation Foundation (ACF) mainly addressed issues relating to the management of radioactive wastes arising from operation of the proposed replacement reactor and anticipated increases in radioisotope production. Some of these issues were also raised by the Brisbane Anti-Nuclear Collective and Greenpeace Australia, together with issues about liability in case of an accident, decommissioning and dose limit recommendations of the International

Commission on Radiological Protection, Greenpeace and a several other submissions expressed the opinion that road and sea transport of spent fuel and radioactive wastes were not acceptably safe.

Sutherland Shire Council drew attention to a number of matters related to the detailed design of the plant, site characteristics, the Reference Accident and interactions between ARPANSA and ANSTO in relation to technical details of safety in the tender process.

The Australian and New Zealand Association of Physicians in Nuclear Medicine (Inc.) argued that there is a lack of alternatives to the use of reactor produced radiopharmaceuticals in medicine, that the EIS process demonstrated that the proposed site is suitable and that alternative sites would lead to increased costs of isotopes. The Australian Nuclear Association similarly supported the replacement reactor and proposed site. Dr Jim Green argued that alternative sources of medical radioisotopes are available.

ARPANSA's review of issues raised in public submissions is presented in Appendix D.

7.3 Conclusions

ARPANSA has considered the public submissions addressing ANSTO's application to prepare a site for the replacement reactor. The issues raised have been noted and those relevant to the application have been addressed in the body of this report. The review has resulted in a number of recommended conditions of licence, some of which also flow from the EIS process.

Some of the issues are outside the scope of ARPANSA's present review of the siting application. Those relating to subsequent stages of the replacement reactor project would be considered by ARPANSA in reviewing any licence applications for the construction, operation or decommissioning of the reactor. Others, including the management of ANSTO's existing radioactive wastes at the Lucas Heights Science and Technology Centre, are being, or will be, dealt with through other licence applications already lodged by ANSTO in August 1999. Similarly, the proposed low level radioactive waste repository would be the subject of separate licensing actions.

Some of the issues raised, such as the need for the replacement reactor, relate to Government policy and are outside the scope of the present review, although comments on these issues have been included in Appendix D.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The ANSTO application for a facility licence to prepare a site for the replacement research reactor was reviewed by officers of ARPANSA against the requirements of the legislation and the agency's Safety Assessment Principles and siting criteria. In addition, the CEO ARPANSA published a notice in the *Government Gazette* (28 April 1999) and in newspapers notifying of the receipt of the application and of his intention to make a decision on the application, and invited submissions from the public about the application. These submissions have also been reviewed to ensure that all issues raised by the public relating to the application were addressed in the review.

The *Australian Radiation Protection and Nuclear Safety Act (1998)* requires that in making a decision on an application for licence, the CEO takes account of international best practice. As the ARPANSA Safety Assessment Principles and siting criteria are based on the recommendations of international radiation protection and nuclear safety organisations and regulatory practice around the world, the ARPANSA review of the application was a comparison of the siting licence application with international best practice. The following conclusions on the issues listed in the ARPANSA Regulations are based on the results of the review.

(a) Whether the application includes the information asked for by the CEO.

The application included the general details of the applicant, the purpose of the proposed facility and a description of the facility, and the plans and arrangements for managing the facility to ensure the health and safety of people and to protect the environment. Specific information relating to the proposed siting of the replacement reactor, being a detailed evaluation of the suitability of the site, the characteristics of the site, and the environmental impact statements and results of the assessment of the statements, was also submitted. All the applicable information listed in Schedule 3 Part 1 of the Regulations was submitted.

Much of the detailed information reviewed by ARPANSA was provided by reference to the environmental impact statements (DEIS and SEIS). As noted throughout the review, some of this information varied from that provided to the NSB at earlier stages of the project, and some effort was taken in the review to ensure that these differences could be explained. None of these differences resulted in any change to the overall results of the assessment, but the researching and cross-checking of the information considerably extended the time required for the review.

(b) Whether the information establishes that the proposed conduct can be carried out without undue risk to the health and safety of people, and to the environment.

Preparing the site for the replacement reactor would not, in itself, involve any radiological risks. However, the ability of the site to provide a layer of defence in depth against severe accidents, and the impact of the site on the safety of the reactor, must be considered at this stage of the project. Therefore, much of the information submitted is relevant to future conducts at the facility. The review sought to confirm that, for routine operations or accidents, ANSTO had demonstrated that any future operation or decommissioning of the

reactor could be carried out without undue risk to the health and safety of people, and the environment.

The ability of the site to provide a layer of defence in depth against accidents was reviewed by considering the consequences of a severe hypothetical accident at the proposed facility. As there is no detailed design for the replacement reactor, a Reference Accident relating to a design having the general attributes of the replacement reactor was considered. ARPANSA considers that the hypothetical Reference Accident chosen for assessing the proposed site for the replacement reactor is of sufficient severity and low probability, subject to assumptions on the design of the reactor being confirmed in the application for licence to construct the reactor.

The consequences of the Reference Accident were compared to ARPANSA siting criteria relating to the feasibility of emergency intervention, the collective radiation dose to the largest population exposed to more than negligible levels of radiation, and the contamination of land following the accident. The proposed site meets all these siting criteria.

Safety during operation and decommissioning of the reactor would be assured through the design of the facility and implementation of the plans and arrangements for safety. The design would be required to take account of the site characteristic that may impact on safety. Subject to the conditions of licence recommended in Section 8.2, the site-related design bases for the replacement research reactor are considered to be satisfactory. The detailed design would be assessed with any application for licence to construct the reactor.

The plans and arrangements for safety would be assessed in detail with any application to operate the replacement reactor. ARPANSA considers that, in principle, and subject to the recommended conditions of licence, the policies and strategies for safety submitted by ANSTO in their siting licence application would provide for acceptable plans and arrangements to be made for the replacement reactor.

Subject to the conditions of licence, it is concluded that the siting of the replacement reactor could be carried out without undue risk to the health and safety of people, and to the environment. ARPANSA consider that, in principle, ANSTO would be able to carry out future conducts at the reactor without undue risks, but this would be subject to the reviews of any applications for licence for each conduct.

(c) Whether the applicant has shown that there is a net benefit from carrying out the conduct related to the controlled facility.

In the context of the ARPANSA licensing process, the net benefit of the proposed conduct is assessed in radiation protection terms. There is no radiological risk associated with preparing the site for the replacement reactor, but the risks and benefits of any future operation of the reactor have been considered in principle.

The benefits of the project - notably the continued production of medical and industrial radioisotopes and the expanded opportunities for scientific research using neutron beams - are described by ANSTO in the environmental impact statements. ARPANSA concludes that these benefits exceed the detriment that may arise from the exposures of people to radiation likely to flow from any properly managed project for construction or operation of the replacement reactor. This view depends on there being no undue risks arising from the

project, as discussed in (b) above, and that the consequent radiation doses would be acceptably small, as discussed in (d) below.

(d) Whether the applicant has shown that the magnitude of individual doses, the number of people exposed, and the likelihood that exposure will happen, are as low as reasonably achievable, having regard to economic and social factors.

It is concluded that ANSTO's strategies and policies for radiation protection and radioactive waste management at the replacement reactor, would be able to provide adequate plans and arrangements to ensure acceptably low radiation doses during any operation or decommissioning of the reactor. These plans and arrangements would be required to be completed and submitted for review and agreement by ARPANSA, before any licence to operate the reactor would be granted.

(e) Whether the applicant has shown a capacity for complying with these Regulations and the licence conditions that would be imposed under section 35 of the Act.

The Project Management Plan and Safety Management Plan for the replacement reactor were reviewed by ARPANSA, and it is concluded that the arrangements for managing the proposed facility are sufficient to ensure that the legislative requirements for siting the reactor and future conducts can be met by ANSTO.

(f) Whether the application has been signed by an office holder of the applicant, or a person authorised by an office holder of the applicant.

The application was signed by the applicant, Prof Helen Garnet, Executive Director, ANSTO, who is the appropriate office holder.

(g) If the application is for a facility licence for a nuclear installation – the content of any submissions made by members of the public about the application.

As required by the Regulations, the CEO, ARPANSA advised of his intention to make a decision and invited submissions from the public on the application. The seventy-three submission received by ARPANSA were reviewed to ensure that the issues raised relating to the safety of the siting of the replacement reactor were addressed in the licence application. It is concluded that all the applicable issues have been satisfactorily addressed in the application, subject to the conditions of licence recommended in Section 8.2.

8.2 Recommendations

It is recommended that the CEO issue a facility licence authorising the Applicant to prepare a site for the construction of the Replacement Research Reactor, subject to:

- the applicable conditions of licence of the ARPANS Act 1998 (section 39);
- the ARPANS Regulations 1999, Division 4; and
- the following additional conditions:

1. The Licensee may only prepare the Site authorised under the Licence, and must not construct, possess, control, operate or decommission the Replacement Research Reactor Facility (unless licensed or properly authorised by the CEO ARPANSA under the Act) or

- otherwise engage in conduct which is prohibited under the Act, the Regulations or any further regulations made under the Act.
2. The site to be prepared by the Licensee under the Licence will only be used for the kind or category of controlled facility described in the Application.
 3. The Licensee shall ensure that ANSTO and vendor/contractor quality assurance systems for preparing the Site are clearly specified and have recognised quality practices accreditation.
 4. The Licensee shall ensure that it complies with any quality assurance systems specified in condition 3 above and that such compliance can be readily verified by audit.
 5. The Licensee shall ensure that there are no changes to the boundaries or use of land within the Buffer Zone unless the CEO ARPANSA has approved such change in his absolute discretion.
 6. The Licensee shall establish a radiological characterisation of the Site for the Replacement Research Reactor Facility and a radiological characterisation of the Buffer Zone to provide a fundamental basis for ongoing radiological monitoring programs and the detection of radiological trends over time.
 7. The Licensee shall ensure that:
 - (a) a review of the topography and food production farming within 15 km of the Site is performed to confirm the likely impact of radioactive discharges from the Replacement Research Reactor Facility, and submitted to the CEO ARPANSA as soon as is reasonably practicable;
 - (b) the population distribution estimates submitted with the Application are confirmed, and that any special needs groups within 5 km of the Site are identified, and submitted to the CEO ARPANSA as soon as is reasonably practicable;
 - (c) an investigation of ground water direction and flow rate at the Site under heavy precipitation conditions is performed, and the results submitted to the CEO ARPANSA as soon as is reasonably practicable;
 - (d) the severity of local flooding at the Site is estimated having regard to the stormwater control plan recommended by Environment Australia in the Environment Assessment Report and be documented in the Preliminary Safety Analysis Report;
 - (e) the additional analysis of seismic hazards at the Site arising from the HIFAR Probabilistic Safety Assessment to describe uncertainties in the seismic characteristics of the Site and confirm the conservative upper bound value for use as a design basis for the Replacement Research Reactor Facility, is completed and submitted to the CEO ARPANSA as soon as is reasonable practicable together with documentation detailing the resolution of any issues raised by the analysis;
 - (f) design bases for seismic events are determined for the Experimental Guide Hall;
 - (g) seismic upgrading work to the Lucas Heights Science and Technology Centre water tower as recommended in the Horoschun report in 1985 be completed as soon as is reasonably practicable;
 - (h) further assessment and analysis is completed as soon as is reasonably practicable to ensure that all possible exposure pathways for radiological doses for people and future events at the Cronulla Sewage Treatment Plant are taken into account in determining radiation doses arising from liquid discharges;

8. The Licensee shall confirm that the communication tower located near the Site will not be capable of transmitting radiation that could interfere with the electrical equipment of the Replacement Research Reactor Facility;
9. The Licensee shall ensure that the Preliminary Safety Analysis Report for the Replacement Research Reactor Facility includes provision for ongoing monitoring and audit of the frequency and severity of external events to ensure that assessed risks to the replacement reactor remain valid and acceptable, taking into account new developments in the vicinity of the reactor over time.
10. The Licensee shall ensure that the design bases for the Replacement Research Reactor Facility take account of:
 - (a) interruptions to off-site and on-site water and off-site electrical power supplies due to seismic events;
 - (b) lightning strikes;
 - (c) ground water leakage into spent fuel stores;
 - (d) intense precipitation events;
 - (e) loss of off-site electrical supplies impacting on water supply and fire-fighting capability;
 - (f) interruptions to electrical supplies during parallel operation of the proposed reactor and HIFAR;
 - (g) sabotage events, and
 - (h) the impact of bushfires on the Replacement Research Reactor Facility, its essential services and emergency planning arrangements.
11. The Licensee shall report to the CEO ARPANSA within three months of the date of issue of this Licence, for agreement, on the program and schedule for arrangements to ensure compliance with the conditions of this Licence, and every three months thereafter on the progress for implementation.

It is also recommended that the following advisory notes be attached to the licence.

1. When any further application under the Act for a Licence is made with respect to the Replacement Research Reactor Facility, the Licensee should annex and incorporate all documentation and supporting documentation referred to, or relied upon in support of the application for a Licence.
2. Any Application by the Licensee to CEO ARPANSA for a licence under the Act to construct the Replacement Research Reactor Facility should be accompanied by the Preliminary Safety Analysis Report.
3. Any Preliminary Safety Analysis Report submitted pursuant to 2 above should confirm that the Site and its characteristics do not adversely affect exposure pathways for radiological doses to people, and that any impacts on doses of changes to the site characteristics are monitored.
4. Any Preliminary Safety Analysis Report submitted pursuant to note 2 above, should also address the matters raised in Condition 10 above.

5. The Licensee should only apply for a facility licence under the Act to construct, have possession or control of, operate or decommission, dispose of or abandon the Replacement Research Reactor authorised to have a site prepared for it under this Licence if:
 - (a) it is the Replacement Research Reactor Facility detailed in the Application and will be, or is, operated only for the following purposes:
 - (i) production of diagnostic and therapeutic radiopharmaceuticals;
 - (ii) maintenance of Australia's nuclear technical expertise;
 - (iii) provision of a neutron beam research facility;
 - (iv) provision of research, and research training, facilities and programs; and
 - (v) provision of industrial radioisotopes and facilities for neutron activation analysis, irradiation of materials, and neutron radiography; and
 - (b) the Replacement Research Reactor:
 - (i) is a pool type research reactor, in which the core of the reactor is at the bottom of a pool of water at least eight metres deep;
 - (ii) has a maximum thermal power of 20 megawatts; and
 - (iii) uses low-enriched-uranium fuel.
6. In any application for a Licence under the Act to construct, operate, have possession or control of, or decommission, dispose of or abandon the Replacement Research Reactor Facility the Licensee should ensure that ANSTO and vendor/contractor quality assurance systems for the tendering, design, procurement, construction, commissioning, operation or decommissioning of the Replacement Research Reactor Facility are clearly specified and have recognised practices' accreditation for each of the stages relevant to the application.
7. In any application for a Licence under the Act to construct, operate, have possession or control of, or decommission, dispose of or abandon the Replacement Research Reactor Facility the Licensee should ensure that they comply with any quality assurance systems specified in Advisory Note 6 and that such compliance can be readily verified by audit.
8. In any application for a Licence under the Act to construct the Replacement Research Reactor Facility the Licensee should ensure that:
 - (a) the assumptions used in deriving the Reference Accident described in the licence application are accounted for in the final design of the proposed reactor, and that this is demonstrated in the Preliminary Safety Analysis Report for the reactor;
 - (b) the final design of the proposed reactor effectively excludes the failures of structures, systems and components to rule out fast loss of coolant as a credible accident, including for earthquakes of lower frequency than the design-basis earthquake, and that this is demonstrated in the Preliminary Safety Analysis Report for the reactor;
 - (c) prior agreement is sought from the Minister for the Environment and Heritage and the CEO ARPANSA to any major design changes such that the Reference Accident described in the licence application may no longer be valid.
 - (d) the safety implications of an inter-linked store for spent fuel elements and the need for a drencher system for the cooling tower are assessed in detail in the Preliminary Safety Analysis Report;

- (e) the final design of the Replacement Research Reactor Facility includes a fire suppression system; and
- (f) the Preliminary Safety Analysis Report is subject to independent peer review.

9. GLOSSARY OF TERMS AND ACRONYMS

ALARA - The process by which radiation exposures are kept 'as low as reasonably achievable', taking into account economic and social factors.

ANSTO - Australian Nuclear Science and Technology Organisation; a body corporate established by the Australian Nuclear Science and Technology Organisation Act 1987.

applicant - The organisation that applies for formal granting of a licence or authorisation to perform specified activities relating to a controlled facility.

ARPANS Act - the Act - *Australian Radiation Protection and Nuclear Safety Act 1998*, an Act to regulate activities of Commonwealth entities involving radiation, and for related purposes.

ARPANSA - Australian Radiation Protection and Nuclear Safety Agency, referenced in the *ARPANS Act*.

ASNO - Australian Safeguards and non-Proliferation Office.

beyond-design-basis accident - An accident that is not a design-basis accident. These might lead to more severe consequences than design-basis accidents, including release of nuclear materials to the environment, but because of their lower frequency of occurrence than design-basis accidents, do not result in unacceptable risk.

beyond-design-basis analysis - An analysis which determines the measures of defence in depth that are required to accommodate beyond-design-basis accidents. It may use deterministic and probabilistic methods.

buffer zone - An offsite public access control zone which is referenced in the emergency plan. This is an area around the site where generally there may be no public residences and that may be evacuated and where public access may be restricted in an emergency response situation.

CEO - The Chief Executive Officer of ARPANSA.

collective effective dose - A measure of the total radiation exposure of a group of people which is obtained by summing their individual effective doses.

controlled facility - means (a) a nuclear installation, or (b) a prescribed radiation facility.

controlled material - any natural or artificial material, whether in solid or liquid form, or in the form of a gas or vapour, which emits ionising radiation spontaneously.

defence in depth - The application of more than a single protective measure for a given safety objective such that the objective is achieved even if one of the protective measures fails. Defence in depth is implemented in the form of a hierarchical deployment of different diverse levels of equipment and procedures, so that a single failure, whether by equipment failure or

human action, at one level of defence, and even combinations of failures at more than one level of defence, would not propagate to jeopardise defence in depth at subsequent levels.

design-basis accident - The class of accident which is accommodated within the design of the facility - an accident that the facility with its safety systems is designed to accommodate. The design for such accidents addresses internal and external initiating events that may cause the facility to operate outside its domain of operational states. There should be no need for off-site countermeasures following a design-basis accident.

design-basis analysis - An analysis using predominantly deterministic methods which determines the safety systems and other provisions that are required to accommodate design-basis accidents.

design bases - Design parameters, operational limits and conditions, safety system settings and other quantities that are established by design-basis analyses as the basis for the design.

design-bases, site-related - Design bases that result solely from consideration of the external events that are characteristic of the particular site. Examples are: aircraft crash, bushfires, nearby industrial and military activities.

DISPLAN - The ANSTO Emergency Plan, and local, district and State disaster plans.

dose constraint - An upper level of dose that bounds the optimisation of protection for each radiation source. The constraint is used prospectively during optimisation of protection to allow for doses that might be received by individuals from other sources, and to promote good practice. Dose constraints for each source are chosen by the operating organisation and agreed with the regulatory body, and must be no greater than the relevant dose limit.

effective dose - The weighted sum of all the equivalent doses in all the tissues and organs of the body. The weighting ensures that the detriment is equal whether or not the whole body is irradiated uniformly.

EIS - Environmental Impact Statement.

Environment Australia (EA) – Commonwealth Department of Environment and Heritage.

Environment Assessment Report - The report produced by Environment Australia in response to the EIS.

event, initiating - The first event in a sequence. Initiating events are typically categorised by the area in which they occur. In the case of nuclear reactors, examples are: loss of electrical power supply; insertion of reactivity; loss of coolant; an equipment failure; internal events; external events; and human error.

event, postulated initiating - An initiating event that is postulated for the purposes of a safety analysis and design to lead to an anticipated operational occurrence or an accident condition.

Experimental Guide Hall - That part of the proposed replacement nuclear research reactor building that houses the neutron guides that are used for experiments.

fission product release fraction - The fraction of each fission product radionuclide that is released from the fuel of a nuclear reactor to a specified space (for example, to the containment building or the environment).

hazard category - The classification of a controlled facility according to categories that are agreed with the regulatory body, based on the unmitigated release of available hazardous material.

Category F1: Facilities having potential for significant consequences limited to within the facility.

Category F2: Facilities having potential for significant consequences limited to the site of the facility.

Category F3: Facilities having potential for significant consequences off-site.

HIFAR - High Flux Australian Reactor; a 40 year-old nuclear research reactor located at the Lucas Heights Science and Technology Centre and operated by ANSTO.

IAEA - International Atomic Energy Agency. Headquarters located in Vienna, Austria.

ICRP - International Commission on Radiological Protection.

international best practice - practice that predominantly conforms with guidelines and standards issued by international radiation protection and nuclear safety organisations (such as the IAEA, ICRP) and that is regularly subjected to peer or other critical review at an international level or forum.

intervention level - The level of avertable dose at or above which a specific protective action or remedial action is taken in an emergency exposure or chronic exposure situation.

licence - facility licence - a licence issued under section 32 of the *ARPANS Act* authorising any of the following conducts:

- (a) prepare a site for a controlled facility;
- (b) construct a controlled facility;
- (c) have possession or control of a controlled facility;
- (d) operate a controlled facility; or
- (e) decommission, dispose of or abandon a controlled facility.

NHMRC - National Health and Medical Research Council of Australia. The *ARPANS Regulations* require, as conditions of licence, that licence holders ensure that all conducts at facilities are in accordance with the NHMRC publications 'Recommendations for Limiting Exposure to Ionizing Radiation' and 'National Standards for Limiting Occupational Exposure to Ionizing Radiation'.

nuclear installation - any of:

- (a) a nuclear reactor for research or production of nuclear materials;
- (b) a plant for storing fuel for use in a nuclear reactor;
- (c) a nuclear waste storage or disposal facility; or
- (d) a facility for production of radioisotopes,

as defined in the *ARPANS Act*.

prescribed radiation facility - a facility or installation that is prescribed by the ARPANS regulations for the purposes of this definition.

Reference Accident - A hypothetical beyond-design-basis accident based on a conservative, deterministic model, which is used for assessing: siting, accident management, and emergency planning. It depends on the type of controlled facility and in general terms, assumes degraded performance of one or more safety systems that leads to a release of radioactive material and an increased leak rate of radioactive material from a confinement or containment system, together with assumptions about prevailing meteorological conditions.

RRR - Replacement nuclear research reactor that is intended to replace the HIFAR reactor.

safety analysis report (SAR) - A document submitted to the regulatory body by the operating organisation as part of its safety case for a licence or an authorisation for a controlled facility. The SAR is a living document that is updated during all stages in the life of the controlled facility.

safety analysis report, preliminary (PSAR) - The version of the SAR that is first submitted to the regulatory body with an application for a licence to construct a controlled facility.

safety analysis report, final (FSAR) - The updated version of the SAR that is submitted to the regulatory body with an application for a licence to operate a controlled facility.

safe shutdown earthquake - The earthquake design parameters or characteristics with a specified return frequency for which the controlled facility is designed to safely shut down.

SAPs - 'Safety Assessment Principles for Controlled Facilities', ARPANSA document. This document is the basis for the ARPANSA approach to the regulatory assessment of controlled facilities; whilst it does not record all the criteria that the agency uses in its regulatory assessment, it records the principles on which ARPANSA places most importance, priority and focus.

SER - safety evaluation report. These document ARPANSA's regulatory assessment of a submission from an applicant, including an application for a licence.

source term - An expression used to denote information about the actual or potential release of radioactive material from a given source, most commonly in the case of an accident. This may include information about the radionuclides present, and the composition, quantity, rate and mode of release of the material.

10. REFERENCES

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APPENDIX A

IMPLEMENTATION OF ENVIRONMENT AUSTRALIA RECOMMENDATIONS

ID	Recommendations	Section of SER or Applicable Conduct
1	The construction and operation of the proposed reactor at the Lucas Heights Science and Technology Centre (LHSTC) must be in accordance with the undertakings and commitments provided by the Australian Nuclear Science and Technology Organisation (ANSTO) in the Final Environmental Impact Statement (<i>Replacement Nuclear Research Reactor</i> , 1997/98, Volumes 1, 2 and 3), and as summarised in Chapter 18 of Volume 3. If there is conflict between the ANSTO undertakings and the recommendations below, the recommendations will take precedence.	Construction of RRR Operation of RRR
5	A Stormwater Control Plan must be developed during the design stage to ensure that the site system is constructed to current best practice and in accordance with NSW EPA guidelines. The plan will also consider options for containment of one-off larger volume spills, such as fire fighting foams. The plan must be prepared to the satisfaction of the Department of the Environment and Heritage.	SER Section 5.2
7	Radioactive gaseous emissions discharged via stacks from buildings associated with radiopharmaceutical production (primarily Buildings 23 and 54) must not increase above existing levels regardless of any future production increases. This requirement should be recognised by ARPANSA as part of its licensing of emissions from radiopharmaceutical facilities at the LHSTC. The objective of this approach is to ensure implementation of existing and emergent technologies to further contain or reduce emissions	Operation of radioisotope production facilities
8	ANSTO, in consultation with ARPANSA, should re-examine the issue of coordination and timing of processes which give rise to gaseous emissions from stacks with a view to minimising the impacts of radioactive gaseous discharges, to the extent practicable	Operation of RRR and other facilities at LHSTC that produce airborne radioactive discharges
9	A review of the method of molybdenum-99 production process must be undertaken by ANSTO, in consultation with ARPANSA, to investigate means whereby the isotope can be produced and isolated with decreased releases of subsidiary radioactive waste products. This should be completed to the satisfaction of ARPANSA.	Operation of radioisotope production facilities
10	A high priority must be given to the review and licensing of radioactive waste discharges to sewer by ANSTO. As part of this, ANSTO should be required to undertake further assessment and analysis to ensure that all possible exposure pathways and future events at the Cronulla Sewage Treatment Plant are taken into account. Monitoring and assessment of individual discharges within the LHSTC is also desirable, to enable understanding of the various sources and their relative contributions. This assessment must be prepared to the satisfaction of ARPANSA and prior to reactor operations commencing.	SER Section 5.2 and operation of other facilities at LHSTC that produce liquid radioactive discharges
11	As part of the groundwater monitoring program, ANSTO or its contractors must establish bores at appropriate locations in the LHSTC and the buffer zone to ensure coverage of contaminants from the site overall and aquifer flows downstream of the proposed reactor. The locations and monitoring regimes must be agreed with ARPANSA.	SER Section 5.2
12	ANSTO must consult with ARPANSA with a view to establishing a radiological site characterisation, or 'footprint', for the reactor site and LHSTC/buffer zone in general. The objective of this characterisation is to provide a fundamental basis for ongoing radiological monitoring programs and the detection of radiological trends over time. The current radiological monitoring should be reviewed on the basis of the site characterisation. The characterisation and monitoring review must be completed prior to commissioning of the proposed reactor.	SER Section 5.1 Construction of RRR

ID	Recommendations	Section of SER or Applicable Conduct
13	The Preliminary Safety Analysis Report (PSAR), to be prepared at the detailed design stage, must be subject to independent peer review to the satisfaction of ARPANSA.	SER Section 4.1
14	The assumptions used in deriving the Reference Accident effectively constitute design parameters for the proposed reactor and must be incorporated in the final design to the satisfaction of ARPANSA. In the event of changes, such that the Reference Accident examined may no longer be valid, agreement to any major design changes must be sought from the Minister for the Environment and Heritage prior to design finalisation.	SER Section 4.1
15	The PSAR must demonstrate that the design of reactor components (eg reactor pool, beam tube penetrations) effectively excludes the failure of these components for earthquakes of lower frequency than the design-basis earthquake, to rule out a fast loss of coolant accident as a credible incident. This will need to be demonstrated to the satisfaction of ARPANSA.	SER Section 4.1
16	The consequences resulting from loss of off-site electricity for water supply and fire fighting purposes must be examined as part of the PSAR. If risks are significant, on-site power provisions for water pumps should be provided to the satisfaction of ARPANSA.	SER Section 5.3
17	The safety implications of an inter-linked store for spent fuel elements must be assessed in detail in the PSAR, to the satisfaction of ARPANSA.	SER Section 4.1
18	The final design of the reactor should include a fixed and possibly automatic fire suppression system within the containment building, to the satisfaction of ARPANSA. The PSAR should also examine the need for a drencher system for the cooling towers.	SER Section 4.1
19	The risk of a common mode failure involving both HIFAR and the replacement reactor during the commissioning period, and resourcing requirements to ensure adequate infrastructure and staffing safety, must be addressed as part of the PSAR to the satisfaction of the ARPANSA. The results of the PSAR analysis should also be reflected in emergency plans.	Construction of RRR
20	In the event of dual operation occurring for a longer period than six months, ANSTO must obtain separate approval and authorisation from ARPANSA. This authorisation should specify safety, infrastructure and occupational requirements to ensure that doses are minimised during any extended commissioning period.	Operation of RRR
21	The Safety Analysis Report for the reactor must include provision for ongoing monitoring and audit of the frequency and severity of external events to ensure that assessed risks to the replacement reactor remain valid and acceptable, taking into account new developments in the vicinity of the reactor over time.	SER Section 5.2
22	Existing emergency plans and arrangements must be updated and subject to independent review at the detailed design stage and prior to the proposed reactor becoming operational. This must be completed to the satisfaction of ARPANSA. The independent review of the plans should include opportunities for input by relevant State emergency agencies and the general public.	Construction of RRR
23	The emergency management plan must also include a specific plan aimed at facilitating community understanding of credible hazards and risks from the reactor, mitigation measures, emergency arrangements and implications for the community. The plan should consider the best combination of media to achieve the above objectives. The plan must be prepared to the satisfaction of the Minister for the Environment and Heritage, in consultation with the Minister for Industry, Science and Resources and the Minister for Health, prior to the reactor being commissioned.	Construction of RRR
24	ANSTO must develop a specific program for ongoing community consultation and dissemination of information during the design, construction and commissioning phases of the reactor, to the satisfaction of the Minister for the Environment and Heritage.	SER Section 6.3 Construction of RRR Operation of RRR

ID	Recommendations	Section of SER or Applicable Conduct
26	Reactor construction should not be authorised until arrangements for the management of spent fuel rods from the replacement reactor have been demonstrated to the satisfaction of ARPANSA and the Minister for the Environment and Heritage.	Construction of RRR
28	ANSTO must continue, as a high priority, to review and upgrade its environmental management systems (EMS) to achieve ISO 14000 standards. The EMS should be certified by a suitably accredited independent body and be in place prior to the replacement reactor being commissioned.	Operation of RRR

APPENDIX B LIST OF PUBLIC SUBMISSIONS

Full Name	City, State	Sub. No.
Agius, Rita	Menai NSW	14
Agius, Ray	Menai NSW	15
Australian and New Zealand Association of Physicians and Nuclear Medicine Inc	Balmain NSW	43
Australian Nuclear Association Inc. Attn: Dr Clarence James Hardy	Peakhurst NSW	37
Bamforth, Gavin	Beverly Park NSW	58
Benson, Betty	Como NSW	18
Bradford, Margaret	Engadine NSW	10
Bradford, Sonya	Loftus NSW	16
Brittain, G	Arncliffe NSW	48
Cavanough, Simon	Leichardt NSW	59
Clark, Anna	Canterbury VIC	66
Claybourn, Jane	Caringbah NSW	39
Colella, Shirley	Maianbar NSW	44
Collins, Tim	Highgate Hill QLD	30
Crofts, Joan	Engadine NSW	20
Day, Anna	Bangalow NSW	25
Dingle Wall, Sally	Dover Heights NSW	53
Dixon, Roy	Menai NSW	35
Dixon, Lorraine	Menai NSW	65
EnuFF Lismore Attn: Isabella Whyte	Lismore NSW	42
Franks, Edith	Bangalow NSW	11
Franks, John	Bangalow NSW	26
Friends of the Earth Brisbane Anti Nuclear Collective Attn: Sybil MacLure	West End QLD	41
Friends of the Earth, Australia and The Australian Conservation Foundation Attn: Bruce Thompson	Adelaide SA	40
Giannotis, Luke	Rosebay NSW	52
Giles, Marion	Hamilton NSW	3
Giles, Zeny	New Lambton NSW	27
Giles, JR	New Lambton NSW	28
Gordon, Robin	Bangor NSW	73
Green, Jim	Chippendale NSW	36
Greenpeace Australia Ltd. Attn: Benedict Southworth Campaigns Manager	Sydney NSW	38
Grenenger, John	Como NSW	17
Harant, Gerry	Blackburn VIC	1
Helps, K	Bangalow NSW	5
Herter, Janine	Surry Hills NSW	56
Ho, Bok	Enmore NSW	47
Howden, J	Glenarie NSW	57
Jones, Keely	Turrumurra NSW	50
Klieber, Frank	Kirrawee NSW	33

Full Name	City, State	Sub. No.
Kupa Piti Kungka Tjuta Aboriginal Corp. (K.P.K.T.A.C) Attn: Emily Austin, Chairperson	Coober Pedy SA	64
Lawler, LM	Barden Ridge NSW	68
MacLure, Sybil	Highgate Hill QLD	31
McGregor, Don	Bonnet Bay NSW	23
McGregor, Mary	Bonnet Bay NSW	24
McLoughlin, Tom	Bondi Beach NSW	46
Morton, Tash	Mt Nebo QLD	29
Neave, J	Bronte NSW	61
Newcastle University	Callaghan NSW	72
Nicholson, Elke	Hamilton NSW	2
Pryor, S	Pimlico QLD	51
Psaltis, Marion	Barden Ridge NSW	6
Purchase, L	Cronulla NSW	34
Reude, Luke	S Brisbane QLD	45
Rice, Heather	Sutherland NSW	19
Roche, Roz	Miranda NSW	60
Roff, Pamela		4
Schnelboegl, Hans-Peter	Lismore NSW	71
Shavit, Gil	Bondi NSW	63
Sherman, Ondine	Bronte NSW	55
Storek, S	Engadine NSW	7
Newcastle University Students Association Attn: Hugh McCallum and Julie Power Environmental Officers	Newcastle NSW	
Sutherland Shire Environmental Centre Attn: Michael Priceman	Sutherland NSW	69
Sutherland Shire Council Attn: Dr Garry Smith	Sutherland NSW	70
Tehira, Anna	Erskineville NSW	62
Toogood, Lawrence & Rosemary	Mt Barker SA	12
Tregoning, Kim	Caringbah NSW	13
Tulloch, KS	Engadine NSW	21
Urause, N	Cronulla NSW	32
van Bree, James	Wahroonga NSW	49
Ward, Lyn	Cronulla NSW	9
Watson, Renelle	Glebe NSW	54
Weber, RM	Engadine NSW	22
Wolff, Ronald	Coorabell NSW	67
Zeibots, Ruth	Bangor NSW	8

APPENDIX C

SUMMARY OF ISSUES RAISED IN PUBLIC SUBMISSIONS

Issues	Submission Numbers	SER Section
General		
Concern on previous incidents and lack of information from ANSTO	2, 3, 4, 33	D1
ANSTO staffing and morale issues	69	D1
Safety issues raised by ex-ANSTO staff	10	D1
Due process not followed in approval of project	2, 3, 4, 27, 28	D4
Public opinion against the project	5, 6, 7, 9, 13, 14, 17, 18, 20,21, 23, 25, 26, 30, 31, 32, 33, 38, 39, 42, 44, 45- 63, 65, 66, 68, 69, 71, 73	D2
Public unable to reference international practices	69	D4
Need to consider cumulative impact of whole site	2, 3, 4	3.6
Facility management plan does not contain enough detail	69	3.2
Issues raised by 1993 review have been addressed	43	D4
Risk from dual operation HIFAR and replacement reactor	70	3.3, 5.2
Insurance cover for nuclear accidents not available	5, 6, 7, 10, 12, 13, 14, 17, 18, 20, 21, 23, 25, 26, 29, 30, 31, 32, 33, 34, 38, 39, 42, 44, 45-63, 65, 66, 67, 69	D1
Need for a reactor		
Case for project not proven/justified	10, 11, 67, 69, 71, 72	D2
Alternatives preferable/available	10, 11, 33, 36, 38, 67	D2
Reduced use/decline in nuclear industry	20, 38, 72	D2
Lack of alternatives	43, 69	D2
Project is justified in terms of need and costs	37	D2
Project is not in the public interest	41	D2
Site Selection		
Site Selection process was inadequate/lack of public consultation	1, 3, 4, 5, 7, 11, 33, 35, 41, 42, 44	D3
Proposed site not suitable/need for more remote location	5, 6, 7, 8, 9, 11, 13, 14, 17, 18, 20, 21, 23, 25, 26, 29, 30, 31, 32, 33, 34, 39, 41,45-63, 65, 66, 68, 73	D3
Lucas Heights chosen as site as easiest option	5, 6, 7, 13, 14, 17, 18, 20, 21, 23, 25, 26, 29, 30, 31, 32, 33, 39, 45-63, 65, 66, 68, 73	D3
Lucas Heights chosen because of lack of public acceptance elsewhere	42	D3
Other sites would lead to increased cost of isotopes, and problems for production - need to avoid long travel times	43	D3
Licensing Process		
Inquiry needed rather than 'approvals'	1, 2, 3, 4, 27, 28, 38, 72	D4
ARPANSA not an effective regulator/independence of staff questioned	1, 36, 71	D4
Possible input from ARPANSA advisory committees	69	D4
Application for construction to be a public process	70	D4
Approval has been given to project before Licence issued	17, 35	D4
More time needed for public comment process	34, 35, 69, 71	D4
Existing ANSTO operations should be licensed before RRR	35, 36, 40, 69	D4
Lack of regulatory control of ANSTO until licence issued	69	D4
Site licence needed for project tender process	37	D4

Issues	Submission Numbers	SER Section
EIS Process		
EIS process was biased towards ANSTO	2, 3, 4, 13, 27, 28, 72	D5
EIS for whole ANSTO site needed	2, 3, 4, 27, 28	D5
Project approved by Minister for Environment after EIS/site suitable	37, 43	D5
DEIS does not follow principles of ecologically sustainable development	41	D5
Lack of Public access to EIS documents	2, 3, 4	D5
ANSTO can meet conditions of environmental approval	37	D5
ARPANSA to ensure promises on safety in application and EIS met	70	D5
Issues raised in environmental assessment, concerning	70	
• groundwater investigation;		5.2
• spent fuel strategy;		3.4
• discharges and environmental pollution breaches; and		3.4
• future use of buffer zone		5.2
Radiation Protection		
Hazards of ionising radiation	10	3.4
Any dose above background level unacceptable	5, 6, 7, 13, 14, 17, 18, 20, 21, 23, 25, 26, 29, 30, 31, 32, 33, 39, 45-63, 65, 66, 68, 73	3.4
Public should decide if increased radiation levels are acceptable	44	3.4
ALARA standard not valid for Government mandate to protect people	67, 69	3.4
All effects of radiation should be considered	69	3.4
ICRP 'Permissible' radiation levels set arbitrarily	41	3.4
Consequences of accidents	12, 69, 33	4.2
Health Issues		
Need for studies of health effects of previous reactor operations – no studies to date.	10, 14, 34, 35, 42, 44, 67	D7
Cancer council study of thyroid cancer incidence	42	D7
Requirement for 'no undue effect' on human health is not appropriate - application should establish that operations would have no adverse effects on public health and the environment	67	D7
Concerns for safety of residents	44	D7
Reference Accident		
Likelihood of accidents,	9, 12, 33, 67	4.1
Need to consider 'worst case but credible' accident/military attack, Y2K problems	2, 3, 4, 71	4.1
Military and security threats	19, 33, 42, 69, 71	3.6, 5.2
Threat of bushfires	15, 24, 33, 35, 42, 65	5.2
Details of Reference Accident not available for public	2, 3, 4, 27, 28	D5
Health consequences of meltdown	34	4.2
Confirm that all events including those raised by Minister for the environment have been considered	70	4.1

Issues	Submission Numbers	SER Section
Issues on reference accident study concerning;	70	
• land contamination criteria		4.2
• reliance on human intervention to fully prevent serious accidents;		4.1
• approach to pool penetrations;		4.1
• fuel melt in air;		4.1
• beam tube failure during seismic events;		4.1
• detection and reversal of pool leakage;		4.1
• implementation of emergency ventilation;		4.1
• source term;		4.1
• consideration of all potential accidents		4.1
• 'chugging' of boiling water to release radioactivity;		4.1
• assumptions should be closely reviewed and verified by ARPANSA;		4.1
• use of NHMRC intervention levels; and		4.2
• potential for contamination of land.		4.2
Emergency Arrangements		
Details of DISPLANs not publicly available - problems with public information brochure evacuations of the area	69, 72	3.6
Information courses to local teachers was not effective	69	3.6
Local community not prepared for emergency response, especially at schools	6, 15, 16, 19, 22, 24, 33, 69, 22	3.6
Site Characteristics		
Site characteristics review superficial and not peer reviewed - issues concern; contamination of Woronora Dam; updates to seismology reports; liquid discharges; elimination of fast drain accidents; sabotage; seismic safe shutdown; and aircraft impact	70	5.2
Lucas Heights is geologically unstable	9	5.2
Increased population around site since 1955	42	5.2
Buffer zone larger than usual	43	5.2
Need for base line studies of surrounding area	2, 3, 4	5.1
Design		
Need for detailed design before siting approval	2, 3, 4, 27, 28, 69	D10
When will details of design be required?	70	D10
Confirm that engineering standards for reactor design exist, and that current work seismic analysis for the site is being taken into account and transferred to applications	70	5.2
Expect fundamental protection so that release of radioactivity in an accident prevented	70	D10
Design must prevent fast drain accidents	70	D10, 5.2
Ability to safely decommission the replacement reactor	38	3.5
Waste Management		
Need for long term waste plans	5, 6, 10, 16, 18, 21, 23, 25, 26, 29, 30, 31, 32, 33, 35, 39, 40, 42, 45-63, 65, 66, 73	3.4
Need for existing waste at Lucas Heights to be identified	40	D4
Waste will increase corresponding to increase in radioisotope production	40	3.4
All waste should be in above ground dry stores on-site	40	3.4
Fuel conditioning or processing not mentioned- these could be done under reactor licence	69	D4
Use of waste as a source of weapons material	67	D4

Issues	Submission Numbers	SER Section
Radioactive waste policy out of date	69	3.4
No consideration of solidification of Mo99 waste	69	D4
No proven safe management of radioactive discharges - increased ingestion of radioactive materials	41	3.4
Discharge of I-131 to the environment	8, 34	3.4
Issues relating to proposed LLW repository – alternatives?	40, 64, 67, 69	D4
RRR should be assessed in conjunction with LLW repository proposal	40, 44	D4
Safety of storage of waste at Lucas Heights site and transport of waste and spent fuel	6, 15, 16, 19, 22, 24, 38, 40	3.4
Problems with COGEMA reprocessing of spent fuel	38, 40, 69, 71	3.4
Problems of long term disposal of HLW	40	3.4

APPENDIX D REVIEW OF PUBLIC SUBMISSIONS

D1. General issues raised in submissions

General issues commented upon in several submissions included the history of incidents, purported cover-ups and lack of information provided by ANSTO, and a number of staffing issues, including morale. These safety culture matters are not specific to the replacement reactor and will be addressed in the context of ARPANSA's review of applications for operating licences for the previously unlicensed existing facilities at Lucas Heights Science and Technology Centre. These applications were lodged by ANSTO on 5 August, under the *ARPANS Act 1998*.

The duration and risks associated with the dual operation of HIFAR and the replacement reactor during its commissioning, was raised by the Sutherland Shire Council. ARPANSA notes concern over this issue and requires it to be addressed by ANSTO in the PSAR that would accompany any application for a licence to construct the replacement reactor. This requirement also flows from Condition 19 of the Minister for the Environment following the EIS process.

Greenpeace expressed the view that insufficient detail was provided in the licence application on provisions for decommissioning the replacement reactor at the end of its life. Strategies for the ultimate decommissioning of the replacement reactor are discussed in section 3.5 of this report.

A large proportion of submissions, including the form letters, pointed out that commercial insurance against losses resulting from an reactor accident is not available to the public. The Sutherland Shire Environment Centre expressed the view that that this is perhaps the most important issue as far as the community is concerned. The main issues relate to the lack of Australian legislation to channel absolute liability to a single entity, with compensation provided without the necessity to prove fault, resulting in the need to pursue compensation through common law.

This policy issue falls outside the scope of ARPANSA's technical review of the suitability of the Lucas Heights Science and Technology Centre as a site for the replacement reactor, discussed in this Safety Evaluation Report. However, it is noted that the issue was examined in the EIS process. Environment Australia's assessment report examines aspects of international conventions, liability for transport accidents and Australia's position.

D2. Need for a replacement reactor

Many submissions argued that the case for a replacement reactor has not been established by ANSTO, that the project's costs outweigh its benefits and that viable alternatives are available for the production of radioisotopes. Some also stated that the international nuclear industry is in decline and the use of research reactors is diminishing. Over half of the submissions stated that public opinion is against the project and, one submission expressed the view that the project is not in the public interest. Two submissions argued that no proven alternatives are available, and one that the project is justified in terms of necessity and costs.

These are policy issues and the Government has made a decision that a replacement research reactor is needed to meet Australia's future needs in relation to health and nuclear medicine; nuclear research for science and industry, education, industrial applications of nuclear technology, and the national interest. These arguments have been covered in the EIS process.

D3. Site selection

Several submissions addressed the site selection process and considered that there had been a lack of community consultation. Neither selection of the site, nor approval of the selection process, were part of ARPANSA's role under its enabling legislation. In deciding whether to issue a siting licence under the legislation, the CEO, ARPANSA is required to determine if the particular site proposed in the licence application is suitable for the replacement research reactor. ARPANSA has evaluated the information provided in ANSTO's application to see if the proposed site, at the Lucas Heights Science and Technology Centre, could provide adequate radiological protection of the health and safety of people the environment. This siting evaluation report addresses that process.

A number of submissions stated that Lucas Heights is not a suitable site for the replacement reactor because it is too close to residential areas, that it was chosen as the easiest option and that a more remote location is needed. ANSTO's licence application assesses the suitability of Lucas Heights in relation to the surrounding population against ARPANSA's radiological criteria for both normal operations and accident conditions. In developing these criteria, ARPANSA has drawn from IAEA recommendations and international practice. They were chosen to ensure that radiological risks to the health and safety of individuals, and the population as a whole, are insignificantly small by comparison to other risks routinely accepted in every day life. The criteria are in line with those for the siting of hazardous industries, set by such agencies as the NSW Department of Urban Affairs and Planning, and are discussed in greater detail in sections 1.3 and 4 of this report.

D4. Licensing Process

A number of submissions expressed the view that the replacement reactor proposal should be the subject of a public inquiry. Three submissions concluded that the Minister for Environment had "approved" the construction of the replacement reactor following the EIS process, and before an (ARPANSA) licence was issued. One submission argued that this rendered ARPANSA an ineffective regulator.

The decision-making process is set out in legislation and includes both an EIS process and a safety licensing process. Regulation of the safety of the replacement reactor project, through licensing under the *ARPANS Act 1998*, is independent of, and additional to, the EIS process under the *Environmental Protection (Impact of proposals) Act 1974*, and continues after completion of the EIS process. ANSTO must comply with the requirements of both processes.

Under the *ARPANS Act 1998*, the replacement reactor project is prohibited from proceeding without ANSTO gaining the necessary licences from ARPANSA. Regulatory control by ARPANSA would be ongoing and encompass licensing of each successive stage throughout the reactor's life. This would require demonstration by ANSTO of all aspects of radiation protection and nuclear safety in order to gain licence authorisation for siting, construction,

operation and decommissioning. This approach to licensing mirrors that of nuclear regulators overseas.

One submission commented that former ANSTO employees should be precluded from all ARPANSA operations relating to ANSTO. The implication is that real or perceived conflicts of interest exist. Clearly, ANSTO is a major source of the expertise needed both to operate and regulate research reactors, and it is the case that a number of ex-ANSTO staff in ARPANSA worked on this evaluation and will take part in subsequent processes. In so doing, they are bound by the provisions of the ARPANS Act. This evaluation of the ANSTO siting licence application is a public document for which the CEO of ARPANSA will be accountable to the Government and the Parliament.

It was pointed out in several submissions that presently there is a lack of regulatory control over ANSTO's existing operations, until licences are issued for these facilities. It was argued that the existing facilities should be licensed before the replacement reactor is considered. In accordance with the *ARPANS (Consequential Amendments) Act 1998*, ANSTO lodged licence applications for all radiation facilities and sources at the Lucas Heights Science and Technology Centre, on 5 August 1999. These include ANSTO's reactors, fuel storage and handling, waste management and radioisotope production facilities. ARPANSA will shortly announce a plan and schedule for reviewing these applications, setting out its priorities, and will invite comment on the program. Public comment will also be invited on the licence application for each of the existing nuclear installations. Until such time as the licences are issued, the CEO, ARPANSA has the powers of the former Nuclear Safety Bureau to monitor and review the safety of these facilities. It is anticipated that licensing of these facilities will be well advanced or completed before any application is lodged to construct the replacement research reactor.

D5. EIS process

The EIS process, under the *Environmental Protection (Impact of Proposals) Act 1974*, covered the conceptual stage of the project. It concluded when the Minister for the Environment and Heritage provided to ANSTO's Minister, recommendations considered necessary for protection of the environment and on the environmental acceptability of the proposal. ANSTO's Minister accepted these recommendations, some of which must be completed to the satisfaction of ARPANSA during future licensing processes. These recommendations are discussed in section 6 of this report and included as recommended conditions of licence.

Under ARPANS Regulation 39, the Environmental Impact Statement and the outcome of the environmental assessment must be submitted to ARPANSA with an application for a licence to prepare a site for a controlled facility. The siting application for the replacement research reactor includes, by reference, the Draft Environmental Impact Statement (DEIS), the Supplement to the draft statement (SEIS), and Environment Australia's Environment Assessment Report. The NSB reviewed the DEIS, and provided detailed comments to Environment Australia, and these were considered in the SEIS and Environment Australia's Environment Assessment Report. In evaluating the siting licence application against ARPANSA's Safety Assessment Principles (SAPs) and the Siting Guideline, ARPANSA has reviewed each of the referenced EIS documents and conclusions are documented in section 6 of this report.

A number of submissions commented on the EIS process, some stating that it was biased towards ANSTO, that an EIS is needed for the ANSTO site as a whole, that it did not follow the principles of sustainable development and there had been a lack of access to EIS documents. However, the Environment Assessment Report by Environment Australia concluded that the requirements of the *Environment Protection Act 1994* had been met in regard to the replacement reactor proposal.

One submission argued that the EIS demonstrated that the proposed site at Lucas Heights is suitable, and another was of the opinion that ANSTO would be able to meet the conditions of the Minister for the Environment.

Sutherland Shire Council commented that ARPANSA must ensure that ANSTO fulfils the commitments given in the EIS process and in the Site Licence application. ARPANSA is aware of these commitments and will monitor and report on ANSTO's progress in addressing those commitments relevant to radiological health and safety against conditions attached to successive licences to prepare the site, construct, operate and decommission the replacement reactor.

In summary, the EIS process is separate from and additional to the ARPANSA safety licensing process. However, information contained in the EIS documentation is referenced in the site licence application and has been reviewed by ARPANSA. Additionally, recommendations flowing from the EIS process must be satisfied by ANSTO to the satisfaction of ARPANSA.

D6. Radiation doses to the public

Submissions from the Sutherland Shire Environment Centre and ENUFF expressed the view that the ALARA process of 'optimisation' is not an acceptable basis for radiation protection of the public. Form letter B stated that any radiation dose above background is unacceptable. The Brisbane collective of the Friends of the Earth argued that the radiation dose limits recommended by the International Commission on Radiation Protection (ICRP) are arbitrarily set. One submission commented that the public should decide if increased levels of radiation are acceptable.

The ANSTO arrangements for radiation protection for workers and members of the public are reviewed in Section 3.4 of this report, and are considered to be adequate at the siting stage of the replacement research reactor project.

D7. Health issues

Concerns over health effects of previous reactor operations by ANSTO and the proposed replacement reactor were raised in a number of submissions. These submissions generally stated that no studies have been undertaken into the effects of operations on the health of the surrounding population. One stated that this should be done before licensing of the replacement reactor proceeds and should include examination of anecdotal evidence of cancer clusters.

A number of independent studies were conducted into the effects of ANSTO's operations on the health of the surrounding community for the 1993 Research Reactor Review (McKinnon).

These studies were carried out by Sir Richard Doll (Cancer Studies Unit, Oxford University), Dr P Lancaster (Australian Institute of Health and Welfare, Sydney University) and Associate Professor R Taylor (Head, NSW Central Cancer Registry and Cancer Epidemiology Research Unit, NSW Cancer Council). These studies were reported by the Review (Future Reactions 1993) and generally concluded that:

- the health of Sutherland Shire residents is not affected by emissions from reactor operations at Lucas Heights;
- the incidence of cancer in Sutherland Shire is normal; and
- the health of people in the Sutherland Shire is normal and compares with Warringah shire and the rest of NSW.

Taylor (1998) conducted a more recent study using data from the NSW Central Cancer Registry, NSW Cancer Council and NSW Health Department (1972 – 95) to examine the differences between the Sutherland and Warringah Shires and trends in the occurrence of leukaemia, lymphoma and all cancers. The study found no substantial or significant health differences.

ANSTO has argued that further studies would not add new information about the health impacts resulting from operations at Lucas Heights.

ARPANSA has no reason to disagree with the conclusions drawn from the various studies of available evidence and accepted by the Research Reactor Review and Environment Australia (Environment Assessment Report 1999).

The submission from ENUFF (Lismore) stated that a recent study by the NSW Cancer Council revealed that women in southern Sydney have a higher rate of thyroid cancer than the NSW average. Subsequently, People Against a Nuclear Reactor called for a cessation of ANSTO's iodine releases and a delay to the plans for the replacement reactor until the cause of the increase in the incidence of thyroid cancer in the Sutherland Shire has been established.

A NSW Cancer Council publication (1999), *Cancer Maps for New South Wales: Variation by Local Government Area, 1991-1995*, described the pattern of occurrence of thyroid cancers in Sydney as follows:

“Rates for both males and females were high in central Sydney. These high rates continued south west of the Sydney Statistical Division for females, and north west of the Sydney Statistical Division for males. Rates were low throughout the remainder of the State for females and average for males. This pattern appears to correspond reasonably well with the pattern of distribution for people of non-English speaking backgrounds.”

Discussions between ARPANSA and Cancer Council officers have confirmed that, within statistical variance, the Council has found no evidence or causal link to associate thyroid cancer prevalence with routine ANSTO iodine discharges, nor with other single specific causes. However, the Council noted that the pattern might be linked to dietary intake, related to ethnic background and socio-economic status.

Based on this evidence ARPANSA can see no reason to be concerned with any relationship between ANSTO's current iodine releases and the incidence of thyroid cancer in southern Sydney. However, it should be noted that, in response to EIS Condition 7, ANSTO is committed to introducing existing and emerging technologies to further contain or reduce

gaseous radioactive emissions from radioisotope production. ANSTO will action this commitment as part of its licence application for operation of the radiopharmaceutical facilities.

In apparent reference to Regulation 41(3)(b), it was submitted by ENUFF that the “no undue effect’ is an inappropriate standard against which risks to health posed by siting the replacement reactor at Lucas Heights. ARPANSA is satisfied that:

- ANSTO’s achievement of their commitment to meeting an ALARA objective of 10 microSv per year, by limiting routine radioactive emissions to the environment; and
- the replacement reactor satisfying ARPANSA’s Safety Assessment Principles in relation to accident consequences and frequencies,

would provide sufficient demonstration that the project can be carried forward without undue risk to the health and safety of people, and the environment. ARPANSA will address this issue in setting discharge authorisations for airborne discharges for the Lucas Heights Science and Technology Centre site as a whole, and in reviewing any application for a licence to construct or operate the replacement reactor facility.

D8. Emergency Arrangements

Ten submissions raised issues related to the existing emergency arrangements at the Lucas Heights Science and Technology Centre, in particular about the availability and dissemination of information on the plans and supporting arrangements, especially at schools.

ANSTO’s emergency plans are reviewed in section 3.6 of this report. ARPANSA concludes that the existing plans provide a satisfactory basis for developing emergency arrangements for the replacement reactor.

Conditions 22 and 23 of the Minister for the Environment, flowing from the EIS process, are relevant to the community concerns about ANSTO’s emergency arrangements. Condition 22 requires updating and independent review of the existing emergency plan and arrangements during the detailed design of the reactor and prior to the proposed reactor becoming operational, to the satisfaction of ARPANSA. State emergency agencies and the public should have opportunities for input to the independent review. To address public concerns about the emergency arrangements, Condition 23 requires ANSTO to develop a specific plan to facilitate public understanding of the hazards and risks from the reactor, the emergency arrangements and their implications for the community. The plan must satisfy the Minister for Environment, in consultation with the Ministers for Science and Health, prior to commissioning of the replacement reactor. ARPANSA will monitor ANSTO’s implementation of commitments to address these conditions.

D9. Reactor accidents

Several submissions drew attention to the fact that accidents have occurred in power and research reactors. Three submissions considered that the ‘worst case, but credible’ accident should form the basis for the Reference Accident, while others expressed the view that military attack, sabotage, bushfires and Y2K problems might result in higher risks. Those external events that could lead to accidents are evaluated in Section 5 of this report, along with the design bases that ensure these events would be taken into account in the design of the reactor.

The likelihood and consequences of military attack are difficult to quantify and, in line with general practice for hazardous industries in Australia and internationally, it is considered to be sufficiently improbable that it does not need to be part of the design bases for such facilities. Nevertheless, as discussed in sections 3.6 and 5.2.2 of this report, the prevention of sabotage by hostile forces would be included in the design of the reactor facility. ARPANSA accepts this approach to military attack and sabotage.

In assessing the suitability of the proposed site for the replacement reactor, ARPANSA requires that the radiological consequences of a hypothetical severe accident (the Reference Accident) be compared to siting criteria. The ability of the site to provide an additional layer of protection for the public from the radiological effects of accidents, is taken into account by assessing the feasibility of emergency actions to protect individuals, the risk to the exposed population and the impact on the environment.

The Sutherland Shire Council and other submissions raised a number of issues about the choice of the Reference Accident and the assumptions used in its analysis. In selecting the Reference Accident for the replacement reactor, ANSTO has considered the spectrum of possible initiating events, and assumed the failure or gross degradation in multiple layers of defence-in-depth. The accident selected is a very severe accident at the facility, the consequences of which would be extremely unlikely to be exceeded. It represents a bounding case for the purposes of site assessment and planning emergency arrangements. This allows radiological siting considerations to be examined largely independently of the detailed design. ARPANSA is satisfied that an appropriate Reference Accident was selected for evaluating radiological suitability of the site. The evaluation of the Reference Accident is described in more detail on Section 4 of this report.

Nevertheless, ARPANSA requires ANSTO to submit a Preliminary Safety Analysis Report (PSAR) for the particular reactor design, as part of any application for a licence to construct the facility. ARPANSA expects any such PSAR to assess the frequency and radiological consequences of all potential accidents or classes of accidents against the safety limits and objectives in its Safety Assessment Principles. This includes accidents initiated by plant failures as well as man-made and naturally occurring external events. ANSTO is further required to justify the claims and assumptions used in the analyses, in relations to detailed design of the reactor proposal.

This process would ensure that the risks to individuals from all accidents at the replacement reactor, including those beyond the basis of the design of the plant, will be acceptably low. It would also ensure that the risks are consistent with the objectives of the NSW Department of Urban Affairs and Planning, and international agencies, for total accidents that result in public fatalities in non-nuclear industries.

D10. Design issues

Six submissions suggested that the detailed design should be available before a licence to prepare a site is granted. The Sutherland Shire Council asked when detailed design details will be required by ARPANSA.

The generic characteristics of the design of the proposed reactor are already known. The use of broad design parameters and conservative assumptions in selecting the Reference Accident

and analysing its radiological consequences, allows the radiological suitability of the site to be examined before the detailed design is known. The validity of these assumptions must be demonstrated in the PSAR submitted with any application by ANSTO for a construction licence, when the detailed design of the plant is known. This is discussed further in sections 4.1 of this report.

The Council also requested confirmation that engineering standards are available for design of the replacement reactor and that work currently being undertaken on seismicity of the site will be taken into account and transferred to the licence applications.

ARPANSA is very conscious of the importance of ensuring that a comprehensive, compatible and cohesive set of standards must be employed in any design or construction of the replacement reactor. ANSTO and prospective tenderers are aware that ARPANSA would pay particular attention to this aspect in assessing any applications for construction or operating licence. Seismic considerations are discussed in section 5.2 of this report.

It was stated as an expectation of the Council, that fundamental protection be built into the design of the plant, so that the release of radioactivity during an accident is prevented. As discussed in section 1.3, this is also an expectation of ARPANSA which is manifest through its requirement to embody the philosophy of defence in depth in the design of the reactor plant.

Of particular concern to Sutherland Shire Council was the elimination of the fast loss of coolant accident from consideration as the Reference Accident and how this would be achieved in the plant design. Any PSAR would be required to demonstrate, to the CEO's satisfaction, that the particular reactor design chosen by ANSTO will achieve a level of safety set out in ARPANSA's "Draft Safety Assessment Principles for Controlled Facilities". This includes demonstrating, to a high level of confidence, a low probability of failure of structures, systems and components that could lead to a fast loss of coolant accident. That is, ANSTO must demonstrate in any application for a construction licence that the assumptions made in analysing the radiological consequences of the Reference Accident in the application for a site licence would be achieved in practice for the particular reactor design chosen.

ARPANSA considers that it would be feasible for the replacement reactor to be designed so that the assumptions made in analysing the consequences of the Reference Accident are incorporated in the design.

One submission questioned the ability to safely decommissioning the replacement reactor. ARPANSA's expectations in this regard are discussed in section 3.5 of this report.

D11. Radioactive wastes

A number of submissions, including that of the Friends of the Earth and the Australian Conservation Foundation, raised concerns about the management and disposal of radioactive wastes generated by ANSTO operations and the need to consider the cumulative impact of the entire site operations. Concerns included the storage and discharges of radioactive wastes at Lucas Heights, including from radioisotope production facilities, issues associated with the proposed national low level radioactive waste repository and co-located store for long-lived intermediate level wastes, and reliance on reprocessing of spent reactor fuel by the French

company COGEMA. ANSTO's waste management plan for the replacement reactor is reviewed in Section 3.4 of this report.