ESKOM

PROPOSED PEBBLE BED MODULAR REACTOR

FINAL ENVIRONMENTAL IMPACT REPORT FOR THE PROPOSED PEBBLE BED MODULAR REACTOR (PBMR) DEMONSTRATION PLANT AT THE ESKOM KOEBERG NUCLEAR POWER STATION SITE IN THE WESTERN CAPE, SOUTH AFRICA

OCTOBER 2002

(REV 03)

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0046
In terms of the Environment Conservation Act (Act 73 of 1989), Eskom, South Africa’s national utility for electricity supply, submitted an application to establish and operate a 110MegaWatt (MWe) electricity class demonstration module Pebble Bed Modular Reactor (PBMR) on the site of the Eskom Koeberg Nuclear Power Station in the Western Cape.

The purpose of the proposed Plant is to assess the techno-economic viability of the technology for South African and international application for electricity generation and other commercial applications.

The Plant forms part of a suite of feasible technologies to optimise electricity supply and demand for future sustainable and affordable electricity management and to support economic growth. Since many of these technologies are new to the South African market demonstration plants will first be established to thoroughly understand the techno-economic characteristics of such technology(ies).

The introduction of these technologies forms part of Eskom’s Integrated Strategic Electricity Programme- (ISEP) which will ultimately inform the National Integrated Resource Planning Process (IRPP) as described in the National Energy Policy White Paper.

The Plant consists of a combination of two well established and tested technologies which have been combined and adapted through a modular South African design. These two technologies are the so-called “pebble bed modular reactor” which is based on a nuclear design with helium cooling and a Brayton cycle gas turbine which is helium driven.

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1 The Executive Summary has been translated into Afrikaans, Xhosa, Zulu and Sesotho
2 Hereafter referred to as the Plant.
3 The White Paper on National Energy Policy provides the definition and rationale for a demonstration project.
4 Eskom has identified various supply side (electricity generation) and demand side (electricity use) technologies to complement (broaden) the current energy mix. Supply technologies include amongst others the PBMR, Fluidised Bed which will use discard coal, Wind, Solar thermal and Biomass. Demand technologies include, amongst other, energy efficient devices for households, commerce and industry, preferential tariffs, load shifting, etc.
Its modular design, size and output position the technology package for commercial manufacturing and flexible integration into the energy mix.

The designers of the Plant state the following advantages:

- It has a high thermal efficiency (42%).
- The construction time frame is about 24 months.
- The building dimensions are 60m long and 37m wide and 60m high with about 24m above ground.
- It has a high availability (limited maintenance) and reliability.
- The design of the reactor and material features of the nuclear fuel coatings make the technology radiologically safe.
- The capital investment to provide for electricity growth or replacement of old generation plants is more affordable than for large coal fired stations.
- It can be utilised for base load, mid merit or peak demand electricity supply.
- It can rapidly change load rating from low levels (e.g. 50MWe) to peaking level (110MWe plus). This is referred to as the ramping capability of the Plant.

The global history of PBMR Technology, safety aspects and management of radiological waste(s) especially High Level Waste is dealt with in the Environmental Impact Report (EIR) and supplemented with international experience as summarised by Kugeler et. al. (Annexure 16a and b).

The manufacture of nuclear fuel for the Plant as well as the associated transport of nuclear materials forms part of a separate Environmental Impact Assessment (EIA) application by the South African Nuclear Energy Corporation (NECSA). It is proposed that Fuel manufacture will be done on the Pelindaba campus that is located to the west of Pretoria in North West Province. The Transport of imported Uranium oxide is proposed to be by road via the N3 highway from Durban Harbour (preferred harbour of import) to Pelindaba. The manufactured fuel will follow the N1 highway down to the PBMR demonstration module at the Koeberg Nuclear Power Station Site.

The Uranium oxide will be sourced from Russia and transported to South Africa by sea. This part of the transport falls outside the scope of this EIR.

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5 Electricity output ranges from 110MW to 130MW – hence the description of an 110MW class Plant. The output of the Plant is sufficient to provide electricity for about 30 000 homes.
OVERALL GOVERNANCE

The overall project (the Plant, fuel manufacture and transport) is governed by various Acts, Regulations, Treaties and Policies under the jurisdiction of various government departments, listed hereunder, namely:

**ACTS**

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<tr>
<th>No of Act</th>
<th>No and Date:</th>
<th>Departments</th>
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<tbody>
<tr>
<td>The Constitution of South Africa</td>
<td>Act 108 of 1996</td>
<td>Office of the State President</td>
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<tr>
<td>Environment Conservation Act</td>
<td>Act 73 of 1989</td>
<td>Environmental Affairs and Tourism</td>
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<td>National Environmental Management Act</td>
<td>Act 107 of 1998</td>
<td>Environmental Affairs and Tourism</td>
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<tr>
<td>Atmospheric Pollution Prevention Act</td>
<td>Act 45 of 1965</td>
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<td>Electricity Act</td>
<td>Act 41 of 1987</td>
<td>Public Enterprises</td>
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<td>Hazardous Substances Act</td>
<td>Ac 15 of 1973</td>
<td>Labour and Industry</td>
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<td>National Heritage Resources Act</td>
<td>Act 25 of 1999</td>
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<td>National Nuclear Regulator Act</td>
<td>Act 47 of 1999</td>
<td>Minerals and Energy</td>
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<td>National Roads Traffic Act</td>
<td>Act 94 of 1996</td>
<td>Transport</td>
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<td>National Water Act</td>
<td>Act 36 of 1998</td>
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<td>National Nuclear Energy Act</td>
<td>Act 46 of 1999</td>
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<td>Physical Planning Act</td>
<td>Act 135 of 1991</td>
<td>Land Affairs</td>
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<td>Promotion of Access to Information Act</td>
<td>Act 2 of 2000</td>
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<td>Seashore Act</td>
<td>Act 21 of 1935</td>
<td>Environmental Affairs and Tourism</td>
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**REGULATIONS:**

- The EIA Regulations contained in government notice 1183 of 5 September 1997 as amended.
National Road Traffic Regulations as published in the Government Gazette of 17 March 2000

Regulations for the safe transport of radioactive material (IAEA No. TS-R-1 (ST-1 revised))

TREATIES:

South Africa, as a responsible member of the world community, has become a signatory to a variety of international agreements, dealing with issues such as marine conservation and pollution, the atmosphere, fauna and flora, Antartica, whaling and the conservation of wetlands. These conventions place specific environmental impact management requirements and obligations on the South African Government in complying to the aims and objections of these conventions. In cases where the proposed undertaking of an identified activity may influence or affect compliance with these conventions or is likely to have a significant detrimental effect across South Africa’s international boundaries, special procedures and EIA requirements may be required.

Bonn Convention (Convention of Migratory Species of Wild Animals) (extracted from the DEAT EIA Guideline of April 1989)

South Africa acceded to the Bonn Convention in December 1991. The convention was a response to the need for nations to co-operate in the conservation of animals that migrate across their borders. These include terrestrial animals, reptiles, marine species and birds. Special attention is paid to endangered species. No direct application to the proposed PBMR project.

CITES (Convention on Trade in Endangered Species of Wild Fauna and Flora) (extracted from the DEAT EIA Guideline of April 1989)

The main objectives of this convention are the protection of endangered species, the economic utilisation of species, monitoring the status of species and control of illegal trade. No direct application to the proposed PBMR project.

Convention on Biological Diversity (CBD) (extracted from the DEAT EIA Guideline of April 1989)

The aim is to effect international co-operation in the conservation of biological diversity and to promote the sustainable use of living natural resources world-wide. No direct application to the proposed PBMR project, however the protection of biological diversity within the affected areas of the PBMR demonstration module and fuel plant will be undertaken through the construction EMP and operational environmental surveillance programmes and general operating practices.

South Africa is a founder member of the IWC and has a proud record regarding conservation and research for whale management. No direct application to the proposed PBMR project.


South Africa became a signatory in January 1990. The protocol is aimed at ensuring measures to protect the ozone layer. No direct application to the proposed PBMR project.


South Africa became party to the convention in May 1994. The main objectives of the convention are the reduction of the production of hazardous waste and the restriction of transboundary movement and disposal of such waste. This has application to the proposed PBMR project and are factored into the requirements of the National Nuclear Regulator with regard to the waste generated by the proposed Plant.

Framework Convention on Climate Change (FCCC) (extracted from the DEAT EIA Guideline of April 1989)

The convention addresses the threat of global climate change by urging governments to reduce the sources of greenhouse gases. Although no obligations to the reduction of greenhouse gases rests on South Africa as a developing nation, it is of relevance to the proposed PBMR project in that it was noted at the 18th World Energy Congress (October 2001) that for electricity generation “the most effective means currently in use to reduce CO₂ emissions are nuclear power and hydroelectric power” and that “they should continue to play an important role in electricity generation.”

World Heritage Convention (extracted from the DEATEIA Guideline of April 1989)

Convention concerning the protection of the world cultural and natural heritage. This has application to the proposed PBMR project. It needs to be noted that the Koeberg Nuclear Power Station is in proximity to Robin Island a recognised world heritage site and that Eskom has established a nature reserve on its surrounding land. The Koeberg nature Reserve has been declared a private nature reserve and a natural heritage site. The siting of the PBMR demonstration module and the EMP requirements take this into account in terms of the Emergency Planning Procedures.
Convention on Desertification (extracted from the DEAT EIA Guideline of April 1989)

Convention to combat desertification in those countries experiencing serious drought and/or desertification, particularly in Africa. No direct application to the proposed PBMR project. However, the siting of the PBMR demonstration module allows the use of sea water for the indirect cooling requirements, therefore conserving fresh water resources.

National Nuclear Non-proliferation Treaty enacted by the Nuclear Energy Act.

This Treaty makes provision for the international regulation of nuclear and other materials or precursory materials that may be employed for the manufacture, harbouring and use of devices or weapons of mass destruction. The PBMR thus have application to the non-proliferation of nuclear weapons.

This has specific and implied meaning for the use of such materials (including nuclear material) for commercial application since they must be declared and fully accounted for at national and international level.

The Minister of Minerals and Energy functions as the national governor for the implementation of this Treaty, and Safeguards Agreement.

The proposed PBMR has definitive application in terms of the Treaty and is dealt with in more detail in the Executive Summary and EIR (Chapter 4.2.3).

POLICIES:


The Western Cape’s White Paper on “Preparing the Western Cape for the Knowledge Economy of the 21st Century” which sets out the Western Cape’s vision and policy on inter alia sustainable development.

The different authorities that administer these Acts/Regulation/Treaties/Policies each have their own unique processes for approval and governance, which presents the applicants (Eskom/Necsa) and the participating public (Interested and Affected Parties) with a very diverse compliance framework.

The environmental authorisation process (i.e. the EIA) is only one of these process(es) and not an all embracing or final approval process. Approval by one authority does not automatically entail approval by another authority.

To ensure diligent governance, the government has decided that the National Cabinet in addition to other compliance requirement will jointly decide on the progressive development of the project, to provide the public with additional assurance.
The more important government approval processes that must be met before the proposed activity can be undertaken are mentioned below.

**ENVIRONMENTAL GOVERNANCE**

The Department of Environmental Affairs and Tourism (DEAT) is the competent environmental authority for the Environmental Impact Assessment for the proposed Plant, fuel manufacture and associated transport of nuclear materials.

The DEAT discharges this function in close co-operation with other affected national authorities and provincial environmental authorities of the Western Cape, North West and in liaison with the Free State, Gauteng, Kwa-Zulu Natal and Northern Cape. The key national stakeholders were consulted by the DEAT via the Interdepartmental Co-ordination Committee (IDCC) under the auspices of the Department of Minerals and Energy.

These coordinating activities are discharged in terms of the National Environmental Management Act (Act No. 107 of 1998).

The Consultant engaged the other relevant state bodies (e.g. provincial/local authorities) as well as Interested and Affected Parties (I & APs) through the public participation process(es) for the EIA.

The EIA process was formally initiated in April 2000 and during 2001 the draft and final Scoping Reports were prepared and submitted for public comment and authority review and acceptance. On the 14 December 2001 the DEAT accepted the Scoping Report and instructed the consultants to proceed with the EIA phase.

The DEAT appointed a Review Panel to assist them with the evaluation of the Scoping Reports (draft and final) as well as Environmental Impact Reports (draft and final) and report their conclusions and recommendations to the Director General of the DEAT. The appointment and finalisation of the Review Panel falls outside of the competence of the EIA Consortium.

**RADIOLOGICAL (NUCLEAR) SAFETY GOVERNANCE**

The radiological design (Safety Case) and safety features (Safety Analysis Report) of the Plant are prepared by Eskom and the PBMR (Pty) Ltd and submitted for evaluation to the National Nuclear Regulator (NNR), which, if satisfied, will grant the necessary nuclear licences for the phased implementation of the Plant. This means that the applicant (Eskom) needs to obtain various progressive nuclear licences i.e. a site preparation, a construction licence and an operational licence. The decommissioning and dismantling phase of the Plant is integrated into the various earlier licence requirements, but will also be specifically dealt with by this authority at that stage.
The NNR is an autonomous statutory body and which governs the radiological safety/health of the public and the environment according to national radiological safety legislation (the NNR Act, Act 47 of 1999). The South African radiological safety/health and environmental standards are also based on the standards and norms of the International Atomic Energy Agency (IAEA).

The environmental assessment procedure is a separate governance process, with different time scales to that for the nuclear licensing and the statutory jurisdiction of the NNR for the assessment of radiological impacts is acknowledged in the EIR.

In addition to the above legislation the Minister of Minerals and Energy must also provide written approval for the transport and disposal of nuclear materials/waste in terms of the Nuclear Energy Act (Act 46 of 1999). This provides a multiple system of checks and balances, to safeguard the public and the environment against particularly radiological damage.

❖ OTHER GOVERNANCE PROVISIONS

Further to the governance on national level, various acts, regulations and ordinances on provincial and local authority level will have bearing on the proposed Plant. These relate mainly to land use planning, service provision and economic development.

PUBLIC PARTICIPATION PROCESS

During the Scoping Phase some 2 600 Interested and Affected Parties (I & APs) were registered and engaged in the process through information dissemination (Notifications in the media, Information Document (Vol I) and Background Information Documents), public meetings, focus group meetings, interviews, capacity building workshops, open days and the publishing of the Scoping Report for comment.

The subjects/issues and impacts of key significance were highlighted in the Scoping Report and served as the Terms of Reference (ToR) for the formulation of the Plan of Study (PoS) for the EIA which is attached as Annexure 1.

For the EIA Phase extensive Issue Based Consultations were conducted with a broad range of stakeholders. Public meetings were furthermore held in seven centres in and around Cape Town, Durban, Johannesburg and Pelindaba to discuss the conclusions and recommendations of the draft EIR report.

The public meetings, and the availability and review period of the draft EIR were widely published in the media and communicated to I & APs.
A review period of 60 days, (4 June 2002 to 4 August 2002) was provided to I & APs, to provide comment on the draft EIR. Requests for further extension of the review time were received and in consultation with the DEAT, extension was granted until the 4th September 2002.

Availability of the final EIR was again communicated individually to registered I & APs and published in the national and regional printed media.

The final EIR contains a comprehensive issues/comments register that was compiled from comments provided by I & APs, with responses from the EIA Consortium.

Chapter 6 and Annexure 10 of the final EIR provides detail of the public participation process and the Issues Register.

### KEY ISSUES AND IMPACTS

The key issues and impacts that served as the basis of the EIR studies are subdivided into the following main categories, namely:

- Issues of a policy (strategic) and/or legal nature.
- Impacts which relate to the technical, biophysical, social and economic environment.

#### POLICY/LEGAL ISSUES

- **White Paper on a National Energy Policy (Annexure 2 provides the executive summary)**

  The White Paper is quite clear on its intent that the option of nuclear energy for commercial application, while open, will only be pursued with caution.

  The government has exercised this intent by introducing various checks and balances on the whole development process for the PBMR, from a procedural technical, economic and environmental point of view. To this end an Expert Review Panel was appointed by the Department of Minerals and Energy to assess the adequacy of information of the Detailed Feasibility and Design Studies; an EIA is being conducted to fulfil the requirements of the Environment Conservation Act (Act 73 of 1989) and the National Environmental Management Act (Act 107 of 1998); co-investors were secured to assist with the financing of the detailed feasibility and design studies and to gauge international acceptance and markets; the safety assessment of the design for licensing through the NNR, and ultimately the joint decision process of the Cabinet on the desirability to progress to follow-on phases.

  The operation of the PBMR Plant, if approved, will inform the Integrated Resource Planning Process (IRPP) as prescribed in the Energy White Paper. Informing the IRPP will be further facilitated through demonstration plants for other technologies (e.g. wind,
wind, solar thermal and biomass) which is in the process of being implemented by Eskom and Independent Power Producers (IPPs) in close succession with the Plant. Ultimately the real time techno-economic information obtained from these demonstration plants will facilitate decisions on future energy options and mixes.

Western Cape Policy on Energy

The Western Cape policy titled “Preparing the Western Cape for the Knowledge Economy of the 21st Century” deals with energy on page 50. The energy section reads that the energy objectives is aligned “with the National Government’s 1998 White Paper on the Energy Policy of the Republic of South Africa of cost effective, sustainable and environmentally friendly energy policy for the province ……” The policy further states that it will “support(ing) and take(ing) full advantage, in particular, of the economic and environmental opportunities presented by the distribution of natural gas by the proposed long-distance pipeline from the Namibian Kudu gas field to transform the energy of the Western Cape from Coal-based and nuclear power to thermally efficient and clean gas-fired power”. A footnote is added: “the prospects of a large natural gas field off the West Coast in the Northern Cape could, if realised, further expand the possibilities for cleaner and more efficient gas-fired power stations in South Africa in general, and the Western Cape in particular”.

This does not appear to be in conflict with national policy. This provincial policy is furthermore an “activity” as defined by Section 1 of NEMA and must comply with the principles and provisions of that Act.

While the draft EIR reported an “apparent conflict between the Western Cape’s and National policy on energy” the above extracts indicate otherwise. However, interpretation of the Western Cape’s policy by various provincial and local authorities clearly demonstrate a concern with the establishment of further nuclear power generation on the Koeberg Site or the extension of the operational life of the existing Koeberg N.P.S.

The EIA Consortium maintains that interpretation of the policy and its implementation requires resolve at an institutional and authority level. Such resolve, however, does not constitute a pre-requisite for a “Record of Decision” (RoD) by the DEAT or a fatal flaw to the proposed activities.

Alternatives in terms of Energy and Technology

Both the EIA regulations and the Energy Policy White Paper stipulate the consideration of alternatives (e.g. energy, technology, etc.).
While the proposed demonstration Plant will be linked to the national grid, this application is, not a commercial application for nuclear based power generation, but for the establishment of a demonstration Plant\(^6\) to inform on the techno-economics of the specific plant. In turn, this will inform the IRPP of government and Eskom’s ISEP with accurate information and the study of alternatives. Once this stage has been reached (probable in the years 2006 – 2008) more informed decisions can be made on commercial energy mixes for electricity supply and management.

**Radiological Waste Management and Final Disposal**

A draft National Radioactive Waste Management Policy (NRWMP) was issued by the DME in 2001 for public comment (Annexure 4).

This draft Policy is strategic in nature and sets out the principles and scope for the management of radiological waste(s) generated by the various sectors of the economy e.g. the mining sector, medical sector, food sector and electricity supply sector.

The draft Policy is currently under review by the DME and it is understood that it will be re-issued in late 2002 for comment.

Once this Policy is in place, more directive policies for the various economic sectors and types (classes) of radiological waste (i.e. low, intermediate and high level) may be formulated and issued.

While low level (LLW) and intermediate level (ILW) radiological waste(s) are well guided by policy, and, final deposition facilities with sufficient capacity for these wastes exist, there is a real need to accelerate the establishment of a Policy and facility(ies) (repository) for the long term management and disposal of long lived radioactive waste i.e. high level radioactive wastes (HLW).

The absence of a HLW repository is not seen as a prerequisite for a RoD by the DEAT or a fatal flaw to the proposed activity.

**Treaty on the Non-Proliferation of Nuclear Weapons and Materials of Mass Destruction**

Much confusion exists in the public domain about the scope of the Nuclear Non-Proliferation Treaty. Some members of public interpret/perceive the Treaty to intend

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\(^6\) Various other technologies are in this phase of development (e.g. wind, solar thermal and biomass) and due for EA application, within Eskom’s portfolio of new development project conducted in terms of its ISEP.
the total absence of the use of nuclear materials, processes, technology etc. within national boundaries.

This Treaty makes provision for the international regulation of nuclear and other materials or precursory materials that may be employed for the manufacture, harbouring and use of devices or weapons of mass destruction.

It thus has application to the non-proliferation of nuclear weapons as well as specific and implied meaning for the use of such materials for commercial application, since they must be declared and fully accounted for at national and international level. In this regard the Minister of Minerals and Energy functions as the national governor for the implementation of this Treaty, and Safeguards Agreement.

The implementation of the Safeguards Agreement require that Subsidiary Agreements be established for the various nuclear facilities that are under safeguards. For example, a Subsidiary Agreement exists (and has always existed) for Koeberg Units 1 and 2. A Subsidiary Agreement existed for the previous BEVA plant where accounting to gram quantities of uranium was required. Similar Subsidiary Agreements would have to be developed and signed for the PBMR Fuel Manufacturing Plant as well as for the proposed Demonstration Plant. The design and mode of operation of the respective proposed facilities will form part of the negotiations with the International Atomic Energy Agency (IAEA) in developing the Subsidiary Agreements.

It is quite clear that the proposed Plant and associated fuel manufacture facilities have a direct bearing on the Government’s obligations in terms of this Treaty and the Pelindaba Treaty. Government will discharge their duties accordingly.

In addition, South Africa was instrumental in the formulation of the Pelindaba Treaty or the African Nuclear Weapon-Free Zone Treaty. It should be noted that this Treaty is about keeping Africa free of Nuclear Weapons. It promotes co-operation in the peaceful uses of nuclear energy and recognises the right for countries to develop research on, the production of and use of nuclear energy.

The Treaty states that parties to the Treaty are determined to promote regional co-operation for the development and practical application of nuclear energy for peaceful purposes, in the interests of sustainable social and economic development of the African continent.
• **Epidemiological Studies**

  
  - **Radiologically Induced Cancers due to Commercial Nuclear Plants**

    During the Scoping Phase of this EIA the issue was raised that real time health risk or epidemiological studies should/must be conducted as part of the detailed studies to inform this EIR.

    Established national and international standards require very strict radiological surveillance of staff and the environmental media (air, water, soil and wildlife). The undertaking of prior epidemiological studies on the public is not stipulated in South African legislation, nor is it part of any international standard set for nuclear power station facilities.

    The National Nuclear Regulator Act (Act 47 of 1999) provides for the regulation of nuclear activities and to exercises the regulatory control and assurance on the health/safety of workers, property and the environment.

    The accepted approach to this study (PoS as approved by DEAT) was to review and be guided by international literature on the subject. (Annexure 3 provides papers from international research on the subject), to the accepted approach to this study (PoS as approved by the DEAT) was to review and be guided by international literature on the subject of epidemiological studies on cancer included health effects due to low level radiation releases (operational releases) from nuclear plant (Annexure 3 provides papers from international research on the subject), to decide on the desirability of such studies prior to, or during the operation of the proposed Plant.

    Much international epidemiological research is being (and has been) conducted on the subject, with opposing conclusions on the relationship between cancer incidence and radiation releases from commercial nuclear installations.

    However one of the primary aims of such research is to determined the safe levels (release standards) for the release of radioactive substances from nuclear installations, to safeguard the health of persons and the environment. The International Commission for Radiological Protection (ICRP) is the international body that advises on such standards and have progressively reduced radiological discharge and exposure levels.

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7 Epidemiological studies involve those studies on human health resulting from environmental stressors (man-made or natural activities) which may or will influence the well being of mankind.
Over time very strict international standards have been established to which South Africa subscribes and which is reflected in the Fundamental Safety Criteria of the NNR.

By nature these epidemiological studies are complex, needs to extend over at least 15 to 20 years, the population must be stable (i.e. low influx or exit from the population, and preferably start before the commissioning of a commercial nuclear plant to provide meaningful results.

Epidemiological study and health monitoring of the public for the proposed Plan is not recommended or required, provided that the recommendations as contained in this EIR and the NNR's conditions are met. Assurance that the practices carried out conform to requirement, must be demonstrated on an ongoing basis through operational and environmental monitoring programmes (as detailed in the EMP, Chapter 8), health monitoring of employees and conformance to the legal requirements as administered by the NNR and in terms of the Occupational Health and Safety Act (Act No. 85 of 1993).

• **HIV and AIDS**

The seriousness of HIV/AIDS is a real concern on international and national level every effort must be made to restrain and curb the epidemic phase of this disease.

Eskom has established a comprehensive policy, practices and support programme to address the disease in a positive, informed and non-discriminatory manner, with the co-operation of all employees.

The main features of the policy entails the following:

- Education and Information (workers, co-workers and immediate family)
- Confidentiality
- Testing (voluntary and anonymous)
- Non-discrimination
- Prophylaxes

The policy will be applied during the construction phase of the proposed plant and be maintained during the life cycle of the Plant.
Radiological Safety

Of specific concern to the authority(ies) and the public is the issue of radiological safety to man, property and the environment.

This EIR reports on the safety features related to the design and operation of the Plant as well as that of radiological waste management whether gaseous, liquid or solid. The EIR confirms conformance to the fundamental safety criteria laid down by the National Nuclear Regulator (NNR) (Chapter 4.20.5).

PROJECT ISSUES AND IMPACTS

Introduction

For the purposes of the EIR, the impacts/issues/concerns which were studied and addressed are divided into four main groups, namely:

- Social impacts [Safety, Health, Skills, Institutional capacity etc.; and
- Economic aspects [Land-use, Economics of, and, markets for the Technology both locally and internationally.
- Biophysical or sensitivity aspects;
- Technical or suitability aspects;

Social Aspects

The following social studies were undertaken:

- A project specific Social Impact Assessment (SIA).
- Safety and Security impacts (Radiological aspects will be evaluated by the NNR, that will inform the overall decision making for this proposed development).
- Potential impact on health by means of a literature study on the epidemiology of radiologically induced health incidence.
- Institutional capacity impacts, i.e. the NNR, Department of Minerals and Energy (DME), Departments of Health, Transport, Water Affairs and Forestry and Metropolitan Councils.
- Legal impacts including financial provisions for decommissioning, radiological waste management and 3rd party liability.
EXECUTIVE SUMMARY

- **Economic Aspects**
  - Impact(s) on spatial planning from a local and sub-regional point of view.
  - Impact on tourism in the Western Cape sub-region around Koeberg.
  - Impact on supply-side management based on the assumption that the Plant proves viable.
  - Life cycle costing of the proposed Plant.

- **Biophysical Aspects**
  The biophysical aspects considered included the following:
  - Marine fauna and flora and the effect of the additional thermal outflow on sea life.
  - Terrestrial fauna and flora and the effect of the proposed Plant on such life.
  - Archaeological/Palaeontological characteristics of the proposed Plant location.
  - Sensory assessment(s) i.e. noise and visual:
  - Waste impacts, i.e. gaseous, liquid and solid (types, quantities and management).

- **Technical Aspects**
  The technical aspects considered encompassed the following subjects, namely:
  - Verification of the geotectonics of the Koeberg site to determine the maximum credible earthquake and evaluate the adequacy of the proposed Plant design.
  - Verification of the groundwater characteristics of the site both qualitatively and quantitatively and evaluate the adequacy of the proposed Plant design.
  - Marine (Oceanographic) characteristics of the environment to determine the effect of thermal outflows, and evaluate the adequacy of the proposed Plant design.
  - Climate (Meteorological) characteristics of the Koeberg site and region to determine (model) operational/worst case emission dispersion.
  - Population distribution (demographics) up to 80 kilometres from the proposed plant and public exposure risks.
EXECUTIVE SUMMARY

- Infrastructure e.g. roads, harbours, telecommunication, medical and emergency services, water supply, sewage facilities, housing and associated infrastructure.

**ASSESSMENT OF IMPACTS AND CUMULATIVE EFFECTS**

The potential impacts for the proposed Plant were assessed for the full life cycle of the proposed Plant and for significance by employing the Significance Rating Methodology as specified by the DEAT8.

A panel was established to rate and rank the various impacts/issues/concerns.

The Panel consisted of the following members, namely:

Mr O Graupner - Poltech (Division of IRCA Technical Services)
Mrs A Haasbroek - Poltech (Division of IRCA Technical Services)
Mr W Schlechter - Netrisk (Division of IRCA)
Mr F Mellet - Netrisk (Division of IRCA)
Mr J de Villiers - Netrisk (Division of IRCA)
Mr W Lombaard - Poltech (Division of IRCA Technical Services)
Mrs K Botes - Interdesign Landscape Architects (Pty) Ltd
Dr D de Waal - Afrosearch
Mrs H van Graan - Nuclear Consulting International
Mr N Andersen - Andersen Geological Consulting
Dr M Levin - Africon (Pty) Ltd
Mr G Erasmus - Ledwaba Erasmus Associates
Mr P van Wyk - J Paul van Wyk Urban Economist and Town Planners

Technical information and explanation was provided by representatives from Eskom, Necsa and PBMR (Pty) Ltd.

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During the EIA phase possible links between impacts were considered and assessed, i.e. cumulative, linked and induced impacts.

Annexure 20 provides the CV’s of consultants that participated in the EIA.

A Risk Assessment Methodology termed “SWIFT” was also employed to determine the residual risk of the proposed Plant on the environment and the public. The findings of this assessment are reported in the EIR, Annexure 13.

MITIGATION OF SIGNIFICANT IMPACTS

An Environmental Management Plan (EMP), which describes mitigation measures for the management of the proposed Plant’s construction and operational/maintenance impacts is included in the EIR.

Through design, provision has been made to minimise the impacts of decommissioning/dismantling (i.e. materials employed, layout, etc).

A more detailed EIA will be conducted prior to Plant closure to define and assess the impacts and prescribed mitigation measures.

PUBLIC PARTICIPATION DURING THE EIA PHASE

- Issue Based Consultation

  Issue based consultation was conducted with identified I & APs which included:

- Authorities (National/Provincial/Local)
- Professionals persons
- NGOs/CBOs
- Neighbours to the Koeberg Site
- Institutions
- Labour Unions (COSATU & NUM)

  These consultations focused on project and site specific issues that informed the Information Document (Vol II) and the Social Impact Assessment. The availability of the draft EIR was notified to I & APs direct and through media releases (advertisements in the daily press and on radio).
Public Meetings

Seven public meetings were held between 16 and 30 May 2002, to provide feedback on the draft EIR. I & APs were given the opportunity to provide input on the draft EIR from 4 June to 4 August 2002. Extension of the review period to 4 September 2002, was provided to a number of I & APs on request and in conjunction with the DEAT.

The Public Meetings were held in the following areas:

- **Gauteng:** Hartbeespoort, Johannesburg, Atteridgeville
- **Kwazulu-Natal:** Durban
- **Western Cape:** Atlantis, Milnerton, Cape Town

Minutes were taken at all public meetings and circulated for comment before finalisation.

In addition a presentation on the findings, conclusions and recommendations of the draft EIR was made to the Western Cape Cabinet at their request. At the request of the Atlantis community, a further meeting was held in Atlantis on 1 August 2002.

Information Dissemination

Registered I & APs received (either by post, fax or e-mail) notifications on progress with the project, consultation sessions, public events, information availability and the availability of the EIR:

- The draft and final scoping reports, including the Background Information Documents and Information Document (volume 1), on the Website (http://www.pebble-bed.co.za) and CD.
- An information booklet, briefly explaining the different energy sources and technologies with emphasis on nuclear and the PBMR demonstration plant. This booklet titled “Planning for the Future Electricity Needs of South Africa” was produced by Eskom and is available in several South African languages.
- An Information Document (volume 2) was compiled that addressed relevant questions and requests for information.
- The Plan of Study for the EIA of the proposed Plant (Web site http://www.pebble-bed.co.za).
EXECUTIVE SUMMARY

❖ A public version of the DFR in electronic format

❖ The draft EIR in hard copy on CD and on web site (as above)

 AVAILABILITY OF THE (FINAL) EIR

The final EIR is available in hard copy, CD and on the website (http://www.pebble-bed.co.za). Hard copies of the document were distributed to public libraries and venues throughout the study area.

The Executive Summary of the project’s scope, main findings and recommendations (EMP) was translated into Afrikaans, Zulu, Xhosa and Sesotho and is available in hard copy and on the web site (http://www.pebble-bed.co.za).

 TIME FRAME FOR THE EIA PHASE

For the purpose of the EIA phase the following milestones were established, namely:

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 2001 – end January 2002</td>
<td>Formulation and acceptance of the PoS for EIA</td>
</tr>
<tr>
<td>February 2002</td>
<td>Formulate preliminary EIR/EMP</td>
</tr>
<tr>
<td>Start February - end April 2002</td>
<td>Complete studies and produce SIA Report</td>
</tr>
<tr>
<td>End April – end May 2002</td>
<td>Integrate specialist studies into draft EIR/EMP, reproduce and distribute</td>
</tr>
<tr>
<td>4 June -4 September 2002</td>
<td>90 day review by I &amp; APs, Authorities and DEAT review panel</td>
</tr>
<tr>
<td>4 September – end October 2002</td>
<td>Consolidate comments and update EIR/EMP</td>
</tr>
<tr>
<td>October 2002</td>
<td>Submit final EIR/EMP to DEAT for RoD and to I &amp; APs for information</td>
</tr>
</tbody>
</table>

 CONCLUSIONS OF THE EIR

❖ POLICY/STRATEGIC ISSUES AND IMPACTS

❖ The introduction of the PBMR technology, through a demonstration plant potentially represents a positive impact from different strategic points of view, namely:

❖ The techno-economic information from proposed Plant will inform the Integrated Resource Planning Process (PPP) as identified by the National Energy Policy to provide strategic guidance on the future use of the technology.

❖ The broadening of the energy mix for electricity supply, provided that the techno-economics are demonstrated.
From a radiological perspective the Plant’s design and operational features with regard to the safety and health of the worker, the public and the environment, are very conservative and within the prescribed limits of national legislation and international standards. The NNR will also evaluate the adequacy of these designs and operational procedures, as prepared by Eskom through the submission of a Safety Case and a Safety Analysis Report.

The Western Cape policy titled “Preparing the Western Cape for the Knowledge Economy of the 21st Century” deals with energy on page 50. The energy section reads that the energy objectives is aligned “with the National Governments 1998 White Paper on the Energy Policy of the Republic of South Africa of cost effective, sustainable and environmentally friendly energy policy for the province …..” The policy further states that it will “support(ing) and take(ing) full advantage, in particular, of the economic and environmental opportunities presented by the distribution of natural gas by the proposed long-distance pipeline from the Namibian Kudu gas field to transform the energy of the Western Cape from Coal-based and nuclear power to thermally efficient and clean gas-fired power”. A foot note is added: “the prospects of a large natural gas field off the West Coast in the Northern Cape could, if realised, further expand the possibilities for cleaner and more efficient gas-fired power stations in South Africa in general, and the Western Cape in particular”.

The energy policy of the Western Cape is therefore in synchronisation with the national policy.

While the draft EIR reported an “apparent conflict between the Western Cape’s and National policy on energy” the above extracts indicate otherwise. However, interpretation of the Western Cape’s policy by various provincial and local authorities clearly demonstrate a concern with the establishment of further nuclear power generation on the Koeberg Site, or the extension of the operational life of the existing Koeberg N.P.S. These concerns centres mainly around radiologically waste management and the absence of national policy on the subject, spatial planning restrictions, emergency procedures and capacity of local/provincial institutions, the potential for negative impact on tourism and potential epidemiological impacts.

The EIA Consortium maintains that interpretation of the Energy Policies and its implementation requires clarification and discussions. Such clarification, however, does not constitute a pre-requisite for a “Record of Decision” (RoD) by the DEAT.

The single most pressing issue is the need for a national policy on management of radiological waste, particularly the management and deposition of Radioactive High Level Waste (HLW). Strategic and sectoral guidance by national government needs to be
be accelerated and implemented. This does not represent a fatal flaw.

.getProjectRelatedIssues

Whilst potentially the most significant impact, no radiological impacts exceeding the standards stipulated by the NNR have been found, provisional to:

- Nuclear Licensing approval by the NNR
- Implementation of NNR approved General Operating Rules (GOR)
- Implementation of an Environmental Surveillance Programme (ESP).

The construction phase represents the stage which potentially holds the significant adverse impacts, namely:

- Temporary concentration, with limited influx, of construction workers with resultant traffic, services and resource requirement. This is largely off-set with better income and local spending, though of a limited duration. On a regional and national scale, component manufactures will further off-set adverse impacts.

- Changes to the aesthetic (visual) character that will manifest and become acceptable over time.

- Generation of construction waste(s) and spoil that respectively must be re-used, recycled or disposed of at approved disposal facilities (waste) and contoured, reshaped and rehabilitated (spoil material).

All of the adverse construction impacts can be successfully managed within acceptable levels, provided that a Construction EMP is implemented and monitored.

No significant adverse non-radiological impacts incapable of adequate mitigation were identified for the operations/maintenance phase. However, the implementation and monitoring of an operational EMP remains a prerequisite.

These include the following:

- Open and concerted communication with the City of Cape Town and other local provincial and national authorities on radiological surveillance programme design and results. While Eskom is commended on its current programmes, circumstances have changed such that a renewed focus is required.

- Diligent application of Eskom's HIV/AIDS policy and practices.

- Diligent support of the national goals on the training, development and retention of science and engineering skills.
• Continued support to the Disaster Management System and facilities of the Cape Unicity and Tygerberg Hospital.

• The design of the proposed Plant makes provision for simplified and streamlined decommissioning and dismantling from a radiological point of view.

• A Social Impact Assessment (SIA) was conducted by Afrosearch in accordance with International Association of Impacts Assessment (IAIA) principles and DEAT requirements. The SIA Report (Annexure 11) provides the findings of the in-depth assessment of the social impacts, including a rating of impacts and measures for mitigation through the enhancement of positive impacts and the amelioration of negative impacts.

The following impact themes were assessed in respect of the construction, operation and decommissioning stages of the project:

❖ Population impacts referring to acute or transient changes in the demographic composition (age; gender; racial/ethnic composition) of the population. Two specific aspects were considered in this regard, namely potential changes commensurate with the introduction of people dissimilar in demographic profile in the first instance and the inflow of temporary workers to the PBMR site in the second instance.

❖ Planning, institutional, infrastructure and services impacts. This theme related to projected impacts on Local and/or Metropolitan Government in terms of impacts on planning, the provision of off-site emergency response planning as well as an evaluation of needs related to infrastructure and services.

❖ Individual, community and family level impacts related to impacts on daily movement patterns, visual and aesthetic impacts as well as potential pollution related intrusion.

❖ Socio-economic impacts related to employment creation (focusing on the construction phase), changes in employment equity, direct and indirect socio-economic impacts resulting from the construction of the proposed PBMR demonstration module as well as property values in the primary impact area.

❖ Community health, safety and security impacts, including an evaluation of the psychosocial stressors involved in health perception and the nocebo effect.

❖ Management of waste and specifically nuclear waste.
Impacts on places of cultural, historical and archaeological significance (based on inputs received from I&APs and gathered during the baselines study).

Attitude formation, interest group activity and social mobilisation (the behavioural expression element of attitudes).

Throughout the Scoping and Impact Assessment processes it was clear that an essential and extremely important component of the impacts identified related to, or linked to, with risk assessment and perceptions regarding risk. The degree to which the proposed PBMR development is perceived on a continuum from “dread risk” to “no risk” has differed significantly from group to group, depending on the basic point of departure of the group. Based on this, a contextual foundation was provided for the impact assessment through an evaluation of factors involved in the development of risk perception as well as the implications of this for the rating of impacts and for the development of mitigatory mechanisms.

Based on the impact assessment, the following specific conclusions and recommendations are made, inter alia. That:

- The absence of a coherent national nuclear energy policy and particularly the absence of a national policy regarding the disposal of nuclear waste is both a major factor contributing to the “dread risk perception” experienced by the affected society and a substantive environmental hazard in its own right. The failure to finalise the development of such a policy (with due cognisance of the process that has been initiated to develop a Radioactive Waste Management Policy) may be constituted as a breach of the environmental duty of care borne by the national government in terms of Section 28 of the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA) and of the principles as contained in Section 2 of NEMA. For this reason the national government is urged to ensure that, at minimum, the development of an effective radioactive waste management policy is regarded as of the utmost importance and fast-tracked, with full cognisance of the need to follow due process.

- Risk perception and negative psycho-social sequelae of nuclear related “dread risk perception” is frequently attenuated and tempered by the provision of neutral, reliable, responsible, un-biased information dissemination and risk communication. While there is a limited public perception that neither NECSA nor Eskom will, necessarily, provide neutral information and risk communication, it is also perceived that anti-nuclear lobbies will not necessarily engage in the provision of neutral information and risk communication either. For this reason it is seen as an urgent imperative that an organisation such as the African Commission on Nuclear Energy (AFCONE), formed to oversee compliance in respect of the Organisation of African Unity’s Treaty of
Unity’s Treaty of Pelindaba, be formally requested to extend its activities under Article 12 of the Treaty to educate and inform the public of the real risks and issues related to “the peaceful use of nuclear energy for the betterment of society”.

- It is vital that the Tygerberg Hospital’s ability to cope with nuclear incidents and disaster is upgraded and maintained, in line with the World Health Organisation’s (WHO) REMPAN programme, aimed at promoting regional competence to deal with nuclear incidents and disasters. It is, therefore, seen as an absolute requirement that NECSA and Eskom ensure that Tygerberg Hospital has this competence.

- The importance of establishing risk communication and risk management as a “two-way” process that includes mechanisms to address legitimate concerns has been stressed at various stages in the SIA Report. Some guidelines regarding the promotion of effective risk communication include ensuring that:
  - A senior person at Eskom is appointed to communicate with the public.
  - There is a thorough understanding and acceptance of community concern and sensitivity about secrecy and that information is provided freely and involves the public from the outset.
  - Every attempt is made to, first and foremost, earn trust and credibility.
  - No mixed messages are given and ensuring that all information has been checked and double-checked for accuracy.
  - The truth is told at all times even where this involves “bad news”, instead of attempting to salvage the situation later.
  - Attention is paid to community outrage factors and concerns. This will require that it be accepted that response to risk is more complex than the provision of scientific data and linear response to facts and that information should be provided so as to meet the requirements of people.
  - Wherever practicable, the help of organisations that have credibility in communicating with communities is enlisted.

- The Melkbosstrand Residents Ratepayers Association, the Transport and Roads Division of the City of Cape Town, as well as other I&APs have raised concerns about existing emergency plans (including evacuation plans) for Koeberg as well as the proposed PBMR. In this regard, the CCT states that it sees the existing Koeberg evacuation plan as requiring re-evaluation and being “totally inefficient ... (as) it will take approximately 19 hours to evacuate, which is much too long. This plan should also address the additional PBMR and the result of both reactors being faulty or the
faulty or the effect of the one on the other” (p.5: Annexure D: Comments from service delivery units).

From an Economic point of view the demonstration Plant will:

- Provide some 1400 local jobs over the construction period
- Provide some 40 permanent jobs
- Place capital expenditure emphasis on local content, where possible.
- Support and promote the national goals on Science and Technology.
- Not place additional spatial restrictions on the development of Cape Unicity area of jurisdiction.
- Have limited transient negative impact on tourism that may be offset by business visitor influx to the proposed Plant.
- Employ international practices and norms to accumulate sufficient segregate funds for the decommissioning and dismantling of the Plant and the disposal and long term management of HLW.

CUMULATIVE IMPACT

- The cumulative impacts of the proposed PBMR Plant are largely in association with the Koeberg NPS. These effects and impacts will fit into the footprint of Koeberg.
- HLW, as is the case with Koeberg NPS, will be managed on site for the life of the Proposed Plant to allow sufficient thermal cooling and radiological decay of the mother products. This has specific implications in terms of safety measures, security measures, and non-proliferation protocols.
- Radiological discharges (gaseous, liquid and solid) will fit into the Annual Authorised Discharge quantities (AADQ) for Koeberg. The NNR will decide on the emergency planning exclusion and evacuation zones. It is however the opinion of the consultants that the current requirements for Koeberg NPS will not be affected.
- During Construction traffic volumes and patterns will be affected by commuters, material/equipment supplies and abnormal loads. Import of abnormal items will be routed via Saldanha harbour.
- The only linked impact of the proposed demonstration module PBMR, and, the fuel Plant proposed to be established at Pelindaba, is the cumulative low and intermediate level radioactive waste to be transported to and disposed of at, Vaalputs. The Vaalputs
Vaalputs. The Vaalputs repository has sufficient capacity to receive the LLW & ILW for the full life cycle of the PBMR Plant in addition to the radioactive waste load(s) from other sources e.g. Koeberg N.P.S. The relatively low quantities of material to be generated render this linked impact insignificant.

**RECOMMENDATIONS**

The EIA Consortium identified no significant environmental risk(s) or adverse impact(s) in part or on the whole that cannot be adequately managed and mitigated over the life of the Plant.

- It is therefore recommended that the Department of Environmental Affairs and Tourism authorize the proposed activity provided that:
  - The proposed activity is licensed by the NNR.
  - The Environmental Management Plan is implemented.
  - Financial provision is made for decommissioning and the long-term management and storage of radioactive waste in particular HLW.

- Furthermore, it is recommended that:
  - The DME accelerate the establishment of National Radioactive Waste Management Policy.
  - An information process is established by government to objectively inform the public on nuclear matters.

**LIST OF ABBREVIATIONS AND ACRONYMS**

<table>
<thead>
<tr>
<th>ACRONYM</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>AADQ</td>
<td>Annual Authorised Discharge Quantities (applicable to normal operations only) – annual limit on amount of activity discharged)</td>
</tr>
<tr>
<td>ALARA Principle</td>
<td>As Low As Reasonably Achievable</td>
</tr>
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<td>AVR</td>
<td>Arbeitsgemeinschaft Versuchsreaktor</td>
</tr>
<tr>
<td>BH</td>
<td>Borehole</td>
</tr>
<tr>
<td>BID</td>
<td>Background Information Document</td>
</tr>
<tr>
<td>BISO</td>
<td>Buffer isotropic pyrolytic carbon</td>
</tr>
<tr>
<td>BNFL</td>
<td>British Nuclear Fuels Limited</td>
</tr>
<tr>
<td>BOD</td>
<td>Basis of Design</td>
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<tr>
<td>Bq</td>
<td>Becquerel Unit of Radio-activity</td>
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<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
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<tr>
<td>Critical Mass</td>
<td>The amount of radioactive material needed to sustain a nuclear</td>
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<tr>
<td>ACRONYM</td>
<td>DESCRIPTION</td>
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<tr>
<td>chain reaction</td>
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<tr>
<td>DACE (NW)</td>
<td>Department of Agriculture, Conservation and Environment (North West Province)</td>
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<tr>
<td>DACEL(G)</td>
<td>Department of Agriculture, Conservation, Environment and Land Affairs of the Gauteng Provincial Administration</td>
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<tr>
<td>DEAT</td>
<td>Department of Environmental Affairs and Tourism</td>
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<tr>
<td>DFR</td>
<td>Detailed Feasibility Report</td>
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<td>DFS</td>
<td>Detailed Feasibility Study</td>
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<tr>
<td>DM&amp;E</td>
<td>Department of Minerals and Energy</td>
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<tr>
<td>Dose</td>
<td>A term used in radiation protection linked to risk assessment and monitoring of exposure. (Sometimes used interchangeably with “exposure”) See Sv</td>
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<tr>
<td>DOE</td>
<td>U.S. Department of Energy</td>
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<tr>
<td>ECA</td>
<td>Environment Conservation Act (Act 73 of 1989)</td>
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<tr>
<td>EIA</td>
<td>Environmental Impact Assessment (as provided for in the Environment Conservation Act (Act 73 of 1989)</td>
</tr>
<tr>
<td>EIR</td>
<td>Environmental Impact Report (the second phase of an Environmental Impact Assessment)</td>
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<tr>
<td>EMP</td>
<td>Environmental Management Plan</td>
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<tr>
<td>EPZ</td>
<td>Emergency Planning Zone</td>
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<tr>
<td>FY</td>
<td>Fiscal Year</td>
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<tr>
<td>HEPA</td>
<td>High Efficiency Particulate Absolute (Filter)</td>
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<tr>
<td>HVAC</td>
<td>Heating, Ventilation and Air-conditioning</td>
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<tr>
<td>HTR</td>
<td>High Temperature Reactor</td>
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<tr>
<td>HTGR</td>
<td>High Temperature gas-cooled reactor</td>
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<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
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<tr>
<td>ICRP</td>
<td>International Commission on Radiological Protection</td>
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<tr>
<td>I&amp;APs</td>
<td>Interested and Affected Parties (the words stakeholders and I&amp;APs are used interchangeably)</td>
</tr>
<tr>
<td>IEP</td>
<td>Integrated Energy Policy</td>
</tr>
<tr>
<td>ISEP</td>
<td>Integrated Strategic Electricity Programme (Eskom’s programme to manage)</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Organisation</td>
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<tr>
<td>LEU</td>
<td>Low Enriched Uranium</td>
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<tr>
<td>LWR</td>
<td>Light Water Reactor</td>
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<tr>
<td>ULW(L)-SL</td>
<td>Low and Intermediate Level Waste (low dose rate) - Short Lived</td>
</tr>
<tr>
<td>ULW(L)-LL</td>
<td>Low and Intermediate Level Waste (low dose rate) - Long Lived</td>
</tr>
<tr>
<td>MHTGR</td>
<td>Modular High-Temperature Gas Reactor</td>
</tr>
<tr>
<td>mSv</td>
<td>Millisieverts - metric measure of radiation dose, one thousandth of a Sv</td>
</tr>
<tr>
<td>MWe</td>
<td>MegaWatt of electrical power</td>
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<tr>
<td>ACRONYM</td>
<td>DESCRIPTION</td>
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<td>-----------------------------------------------------------------------------</td>
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<tr>
<td>NECSA</td>
<td>South African Nuclear Energy Corporation</td>
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<td>NNR</td>
<td>National Nuclear Regulator</td>
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<tr>
<td>NUKEM</td>
<td>A German Fuel Production Company</td>
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<tr>
<td>NPT</td>
<td>Non-proliferation treaty</td>
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<tr>
<td>OBE</td>
<td>Operating Basis Earthquake</td>
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<tr>
<td>PBMR</td>
<td>Pebble Bed Modular Reactor</td>
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<tr>
<td>PWR</td>
<td>Pressurised Water Reactor</td>
</tr>
<tr>
<td>PGA</td>
<td>Peak Ground Acceleration</td>
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<tr>
<td>PoS</td>
<td>Plan of Study</td>
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<td>PPP</td>
<td>Public Participation Process</td>
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<tr>
<td>PRA</td>
<td>Probabilistic Risk Assessment</td>
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<td>ROD</td>
<td>Record of Decision</td>
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<tr>
<td>QA</td>
<td>Quality Assurance</td>
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<tr>
<td>QC</td>
<td>Quality Control</td>
</tr>
<tr>
<td>SABRE-Gen</td>
<td>South African Bulk Renewable Energy Generation Programme</td>
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<tr>
<td>SAHRA</td>
<td>South African Heritage Resources Agency</td>
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<tr>
<td>SAR</td>
<td>Safety Analysis Report (A part of the Nuclear Licensing Process)</td>
</tr>
<tr>
<td>SIA</td>
<td>Social Impact Assessment</td>
</tr>
<tr>
<td>SiC</td>
<td>Silicon Carbide</td>
</tr>
<tr>
<td>SNF</td>
<td>Spent Nuclear Fuel</td>
</tr>
<tr>
<td>SSE</td>
<td>Safe Shutdown Earthquake</td>
</tr>
<tr>
<td>Sv</td>
<td>Sievert (dose unit)</td>
</tr>
<tr>
<td>SWIFT</td>
<td>Structured What If Tool</td>
</tr>
<tr>
<td>TRISO</td>
<td>Oxide fuel particle coated with layers of a low-density buffer inner pyrocarbon, silicon carbide, and outer pyrocarbon.</td>
</tr>
<tr>
<td>TEEL-0</td>
<td>The threshold concentration below which most people will experience no appreciable risk of health effects</td>
</tr>
<tr>
<td>TEEL-1</td>
<td>The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odour.</td>
</tr>
<tr>
<td>TEEL-2</td>
<td>The maximum concentration hazardous substance in air below which it is believed nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.</td>
</tr>
<tr>
<td>TEEL-3</td>
<td>The maximum concentration hazardous substance in air below which it is believed nearly all individuals could be exposed without experiencing or developing life-threatening health effects.</td>
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<tr>
<td>TSLCC</td>
<td>Total System Life Cycle Cost</td>
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<tr>
<td>TSPA</td>
<td>Total System Performance Assessment</td>
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<tr>
<td>ACRONYM</td>
<td>DESCRIPTION</td>
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<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>µSv</td>
<td>Microsieverts (dose unit) (one millionth part of a Sievert)</td>
</tr>
<tr>
<td>UO₂</td>
<td>Uranium Oxide</td>
</tr>
<tr>
<td>WP</td>
<td>Waste Package</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY ................................................................................................................................. 1

1. INTRODUCTION ........................................................................................................................................ 1

1.1 NEED FOR THE PBMR DEMONSTRATION MODULE (THE PLANT) ......................................................... 1
1.2 PURPOSE OF THE ENVIRONMENTAL IMPACT REPORT ................................................................................ 2
1.3 MAJOR MILESTONES OF THE SCOPING PHASE ....................................................................................... 3
1.4 CONCLUSIONS OF THE SCOPING PHASE ................................................................................................. 5
1.5 GOVERNANCE OF THE EIA AND OTHER APPROVAL REQUIREMENTS ..................................................... 5

1.5.1 ACTS ......................................................................................................................................................... 5
1.5.2 REGULATIONS: ....................................................................................................................................... 6
1.5.3 TREATIES/CONVENTIONS: ...................................................................................................................... 6
1.5.4 POLICIES: ............................................................................................................................................... 9
1.5.5 ENVIRONMENTAL AND RADIOLOGICAL GOVERNANCE ..................................................................... 10

1.6 PUBLIC PARTICIPATION DURING THE EIR ............................................................................................ 10

2. THE PROPOSED ACTIVITY ......................................................................................................................... 12

SECTION 1: DESCRIPTION OF THE PROPOSED ACTIVITY ............................................................................. 12

2.1 THE PREFERRED SITE AND ALTERNATIVES ............................................................................................ 12

2.2 DESCRIPTION OF THE ACTIVITY ............................................................................................................. 14

2.2.1 BACKGROUND ....................................................................................................................................... 14
2.2.2 TECHNICAL SPECIFICATIONS OF THE PBMR ...................................................................................... 14
2.2.3 DESIGN FEATURES OF THE PBMR ......................................................................................................... 15
2.2.4 PBMR BUILDING FACILITIES ............................................................................................................... 17
2.2.5 PBMR OPERATING PRINCIPLE .............................................................................................................. 17
2.2.6 PBMR FUEL ............................................................................................................................................ 19

2.2.7 SAFETY AND RELATED ASPECTS OF THE DEMONSTRATION MODULE PBMR .................................. 20

2.2.8 BASIC LICENSING REQUIREMENT FOR THE PBMR ............................................................................. 21
2.2.9 SAFETY ARRANGEMENTS OF THE PBMR .......................................................................................... 23
2.2.10 SECURITY ............................................................................................................................................. 27
2.2.11 GRAPHITE FIRE ................................................................................................................................. 30

2.2.12 SOLID WASTE MANAGEMENT, SPENT FUEL AND NUCLEAR WASTE ................................................. 31

SECTION 2: ASPECTS OF THE PROPOSED ACTIVITY .................................................................................... 38

2.3 INTRODUCTION ......................................................................................................................................... 38

2.4 SUPPLEMENTARY INFORMATION ON INPUTS AND OUTPUTS OF THE PROPOSED ACTIVITY ................. 38

2.4.1 INPUT DATA ............................................................................................................................................ 38

2.4.2 OUTPUT DATA ...................................................................................................................................... 41

2.5 INPUT/OUTPUT TABLES FOR THE VARIOUS LIFE CYCLE PHASES .......................................................... 43
SECTION 2: ECONOMIC ASPECTS ................................................................. 147

4.4 IMPACTS ON SPATIAL PLANNING ................................................................. 147
  4.4.1 INTRODUCTION .................................................................................. 147
  4.4.2 LAND-USE RIGHTS ........................................................................ 147
  4.4.3 SPATIAL PLANNING IMPLICATIONS ............................................... 147
  4.4.4 ASSESSMENT OF IMPACT(S) ............................................................ 148
  4.4.5 CONCLUSION .................................................................................. 148

4.5 IMPACT ON TOURISM .............................................................................. 149
  4.5.1 INTRODUCTION ................................................................................ 149
  4.5.2 STRUCTURE OF REPORT ................................................................. 152
  4.5.3 METHODOLOGY ............................................................................. 152
  4.5.4 MAIN FINDINGS ............................................................................. 155
  4.5.5 SURVEY RESULTS .......................................................................... 155
  4.5.6 CONCLUSION .................................................................................. 169

4.6 IMPACT ON SUPPLY SIDE MANAGEMENT ........................................... 190
  4.6.1 INTRODUCTION ................................................................................ 190
  4.6.2 IMPACT ON THE PROPOSED PLANT ON SUPPLY SIDE MANAGEMENT .......... 190
  4.6.3 DEMAND SIDE MANAGEMENT ....................................................... 190
  4.6.4 THE DSM ROLLOUT PLAN FOR 2002 ............................................. 191
  4.6.5 CONCLUSION .................................................................................. 192

4.7 REPORT ON ECONOMICAL POTENTIAL, MARKETS AND EMPLOYMENT .......... 193
  4.7.1 INTRODUCTION ................................................................................ 193
  4.7.2 THE DEMONSTRATION MODULE PBMR ...................................... 193
  4.7.3 VARIOUS ORDER SCENARIOS ....................................................... 194
  4.7.4 WITHDRAWAL OF EXELON ............................................................ 194
  4.7.5 POTENTIAL CONTRIBUTION TO NATIONAL SCIENCE AND TECHNOLOGY GOALS ........ 195
  4.7.6 CONCLUSION .................................................................................. 199

4.8 LIFE CYCLE COSTING .............................................................................. 201
  4.8.1 INTRODUCTION ................................................................................ 201
  4.8.2 THE KOEBERG NPS CASE ............................................................... 201
  4.8.3 FINANCIAL PROVISIONS FOR THE PROPOSED PBMR ............... 202
  4.8.4 COMPARATIVE INFORMATION ....................................................... 203
  4.8.5 OVERALL CONCLUSION ................................................................. 205

SECTION 3: BIOPHYSICAL ASPECTS ................................................................. 206

4.9 EFFECTS OF THERMAL OUTFLOWS ON MARINE FAUNA AND FLORA .......... 206
  4.9.1 INTRODUCTION ................................................................................ 206
  4.9.2 MARINE ECOLOGY ......................................................................... 206
  4.9.3 BASELINE ECOLOGICAL REPORT ................................................. 206
  4.9.4 FINAL ECOLOGICAL REPORT ......................................................... 208

4.10 IMPACT OF THE PROPOSED PBMR PLANT ON TERRESTRIAL FAUNA AND FLORA ....... 211
  4.10.1 INTRODUCTION .............................................................................. 211
  4.10.2 DISCUSSION .................................................................................. 211
  4.10.3 DUNE REGIMES ............................................................................ 211
EIR FOR DEMONSTRATION MODULE PBMR

4.16.6 ISOTOPE HYDROLOGY .................................................................................................................. 304
4.16.7 IMPACT OF THE PBMR PLANT .................................................................................................. 308
4.16.8 EMP .............................................................................................................................................. 311
4.17 METEOROLOGICAL CHARACTERISTICS OF THE KOEBERG SITE AND SUB-REGION .......... 314
4.17.1 INTRODUCTION .............................................................................................................................. 314
4.17.2 CLIMATIC DATA ANALYSIS FOR KOEBERG SITE AND SUB-REGION ........................................... 314
4.17.3 DISCUSSION .................................................................................................................................. 314
4.17.4 CONCLUSIONS ............................................................................................................................... 321
4.18 ASSESSMENT OF THE OCEANOGRAPHY OF THE KOEBERG ENVIRONMENT AND COOLING WATER SUPPLY ........................................................................................................................... 322
4.18.1 INTRODUCTION ................................................................................................................................ 322
4.18.2 PARAMETERS REVIEWED .............................................................................................................. 322
4.18.3 FLOODING FROM THE SEA ............................................................................................................ 323
4.18.4 AVAILABILITY OF COOLING WATER AND AN ALTERNATIVE HEAT SINK ................................. 325
4.18.5 SEA TEMPERATURES ..................................................................................................................... 327
4.18.6 CONCLUSION ................................................................................................................................. 328
4.18.7 REFERENCES ................................................................................................................................. 328
4.19 EVALUATION OF THE EFFECT OF ADDITIONAL COOLING WATER DISCHARGE INTO THE ATLANTIC OCEAN AT KOEBERG NUCLEAR POWER STATION .................................................................................................................. 331
4.19.1 EXECUTIVE SUMMARY ................................................................................................................ 331
4.19.2 INTRODUCTION .............................................................................................................................. 332
4.19.3 ASSUMPTIONS: ............................................................................................................................... 332
4.19.4 WARM WATER PLUME .................................................................................................................. 333
4.19.5 PLUME TEMPERATURE RISE AND ASSOCIATED RISK .................................................................. 336
4.19.6 POLLUTION DILUTION POTENTIAL ............................................................................................... 338
4.19.7 POTENTIAL MARINE IMPACT ...................................................................................................... 338
4.19.8 CONCLUSION ................................................................................................................................. 340
4.19.9 RECOMMENDATIONS .................................................................................................................... 341
4.19.10 REFERENCES ............................................................................................................................... 341
4.20 POPULATION DISTRIBUTION (DEMOGRAPHICS) AROUND KOEBERG AND IMPACT OF THE PROPOSED PBMR PLANT ON EMERGENCY RESPONSE PLANNING ................................................................................................................. 342
4.20.1 INTRODUCTION .............................................................................................................................. 342
4.20.2 THE 1996 POPULATION DISTRIBUTION DATA AROUND KOEBERG ........................................... 343
4.20.3 REFERENCES ................................................................................................................................. 344
4.20.4 ADJUSTED CENSUS FIGURES 2001 AND 2006 ............................................................................ 348
4.20.5 ASSESSMENT OF PUBLIC RISK (CONFIDENTIAL REPORT DOC NO 001929-207 SEC 6: PBMR 2001 REV 08 SECTION 6, CHAPTERS 0, 1, 2, AND 3, ANNEXURE 23) ......................................................... 348
4.20.6 CONCLUSION ................................................................................................................................. 349
4.21 INFRASTRUCTURE STATUS AND CAPABILITY OF THE KOEBERG SUB-REGION ................. 350
4.21.1 INTRODUCTION .............................................................................................................................. 350
4.21.2 DISCUSSION .................................................................................................................................. 350
4.21.3 CONCLUSION ................................................................................................................................. 351
4.21.4 REFERENCES ................................................................................................................................. 351
SECTION 5: CUMULATIVE IMPACTS ........................................................................................................ 352
4.22 CUMULATIVE IMPACTS ..................................................................................................................... 352
ENVIRONMENTAL MANAGEMENT PLAN ............................................................................................................. 396

8.1 INTRODUCTION .............................................................................................................................................. 396
8.2 SCOPE .............................................................................................................................................................. 396
  8.2.1 PURPOSE .................................................................................................................................................. 396
  8.2.2 APPLICABILITY ......................................................................................................................................... 396
  8.2.3 ACCOUNTABILITY AND RESPONSIBILITY ............................................................................................ 396
  8.2.4 AUTHORITY REPORTING ........................................................................................................................ 397
8.3 NORMATIVE REFERENCES ............................................................................................................................. 397
  8.3.1 DEFINITIONS ........................................................................................................................................... 397
  8.3.2 ABBREVIATIONS ...................................................................................................................................... 398
8.4 GENERAL EMP SPECIFICATIONS DURING CONSTRUCTION .......................................................................... 399
  8.4.1 AIR QUALITY ............................................................................................................................................ 399
  8.4.2 WATER QUALITY ................................................................................................................................. 400
  8.4.3 WASTE MANAGEMENT ........................................................................................................................ 402
  8.4.4 VEHICLE/EQUIPMENT MANAGEMENT .............................................................................................. 403
  8.4.5 LAND MANAGEMENT .......................................................................................................................... 404
  8.4.6 GENERAL ............................................................................................................................................... 405
  8.4.7 SOCIAL ISSUES ....................................................................................................................................... 407
  8.4.8 VISUAL ................................................................................................................................................... 412
  8.4.9 RADIATION ENVIRONMENTAL SURVEILLANCE ............................................................................. 412
8.5 EMP SPECIFICATIONS DURING OPERATION ............................................................................................... 413
  8.5.1 GENERAL OPERATING PRACTICES ..................................................................................................... 413
  8.5.2 QUALITY MANAGEMENT PROGRAMMES ............................................................................................ 415
  8.5.3 CONDUCT OF OPERATIONS ................................................................................................................ 417
  8.5.4 OPERATING TECHNICAL SPECIFICATIONS ...................................................................................... 420
  8.5.5 CONDUCT OF MAINTENANCE .............................................................................................................. 420
  8.5.6 RADIATION PROTECTION PROGRAMME ............................................................................................ 422
  8.5.7 EMERGENCY PLAN .............................................................................................................................. 423
  8.5.8 SITE NUCLEAR SECURITY ..................................................................................................................... 424
  8.5.9 NUCLEAR MATERIALS SAFEGUARDS .................................................................................................. 424
  8.5.10 WASTE MANAGEMENT .................................................................................................................... 425
  8.5.11 FIRE PROTECTION ............................................................................................................................. 425
  8.5.12 ENVIRONMENTAL SURVEILLANCE PROGRAMME ........................................................................... 426
  8.5.13 NUCLEAR PUBLIC AWARENESS ......................................................................................................... 431
  8.5.14 SOCIAL ................................................................................................................................................ 432
  8.5.15 HYDROLOGY ......................................................................................................................................... 432
  8.5.16 LAND MANAGEMENT ......................................................................................................................... 433
  8.5.17 ENVIRONMENTAL MANAGEMENT PLAN .......................................................................................... 433
8.6 REFERENCES .................................................................................................................................................. 433
FIGURES

FIGURE 1: KOEBERG SITE AND APPROXIMATE LOCATION OF THE PBMR ........................................................... 13
FIGURE 2: SCHEMATIC LAYOUT OF THE DEMONSTRATION MODULE PBMR ........................................................... 19
FIGURE 3: SCHEMATIC ILLUSTRATION OF A FUEL SPHERE...................................................................................... 20
FIGURE 4: RADIATION RELEASE AT KOEBERG NUCLEAR POWER STATION ........................................................... 133
FIGURE 5: MODEL USED TO ASSESS PERCEPTIONS ............................................................................................. 153
FIGURE 6: TOURISM INSTITUTIONS CONTACTED AND INTERVIEWED ........................................................... 154
FIGURE 7: PBMR BUSINESS CASE ......................................................................................................................... 196
FIGURE 8: MEASURING POINT ............................................................................................................................... 217
FIGURE 9: MEASURING POINT ............................................................................................................................... 218
FIGURE 10: MAIN STRUCTURAL MAP OF KOEBERG .............................................................................................. 265
FIGURE 11: LOCALITY MAP SHOWING THE TILT AXIS AND SHELF-BREAK .................................................................... 271
FIGURE 12: A COMPARISON OF THE TWO ATTENUATION RELATIONSHIPS AT AN EPICENTRAL DISTANCE OF 7 KM. ............................................................................................................................... ........................................ 278
FIGURE 13: SIMPLIFIED TECTONIC MAP OF THE WESTERN CAPE. (MODIFIED AFTER RANSOME AND DE WIT, 1992). SHOWING APPROXIMATE DOMAIN AND SUB DOMAIN BOUNDARIES BY DASHED LINES; MAJOR FAULTS ARE Delineated BY SOLID LINES AND FOLD AXES ARE SHOWN BY DOT/DASH LINES........ 280
FIGURE 14: PRESENT-DAY CONFIGURATION OF THE PENINSULA (PMP) AND QUOIN POINT (QPMP) MICRO PLATES. (MODIFIED AFTER RANSOME AND DE WIT, 1992) ....................................................................................... 281
FIGURE 15: LOCALITIES OF GROUNDWATER SAMPLES ......................................................................................... 301
FIGURE 16: GROUNDWATER DRAW DOWN CONTOURS .......................................................................................... 302
FIGURE 17: GROUNDWATER SALINITY LEVELS..................................................................................................... 303
FIGURE 18: WIND ROSE JANUARY ......................................................................................................................... 315
FIGURE 19 WIND ROSE FEBRUARY ....................................................................................................................... 315
FIGURE 20: WIND ROSE MARCH ............................................................................................................................ 316
FIGURE 21 WIND ROSE APRIL ............................................................................................................................... .. 316
FIGURE 22 WIND ROSE MAY ............................................................................................................................... .. 317
FIGURE 23 WIND ROSE JUNE ............................................................................................................................... .. 317
FIGURE 24 WIND ROSE JULY ............................................................................................................................... .. 318
FIGURE 25 WIND ROSE AUGUST ............................................................................................................................ 318
FIGURE 26 WIND ROSE SEPTEMBER ...................................................................................................................... 319
FIGURE 27 WIND ROSE OCTOBER .......................................................................................................................... 319
FIGURE 28 WIND ROSE NOVEMBER ...................................................................................................................... 320
FIGURE 29 WIND ROSE DECEMBER ....................................................................................................................... 320
FIGURE 30: TOTAL POPULATION WITHIN EACH 5 KM DISTANCE BAND AROUND KOEBERG UP TO 50 KM (22.5 DEGREE RADIAL GRID) .................................................................................................................. 347
FIGURE 31: PUBLIC PARTICIPATION TIMEFRAMES FOR THE EIA PHASE ................................................................ 377
TABLES

TABLE 1: NNR LICENSING REQUIREMENTS FOR THE PBMR .......................................................... 22
TABLE 2: DESIGN ESTIMATE ANNUAL RELEASE RATES OF GASEOUS RADIO NUCLIDES ............... 33
TABLE 3: ESTIMATED RADIOACTIVE SOLID AND LIQUID WASTE PRODUCED IN THE PBMR PLANT .................................................. 37
TABLE 4: VOLUME OF EXTERNAL SERVICE WATER REQUIRED DURING NORMAL OPERATION .......... 39
TABLE 5: AVERAGE SEWERAGE EFFLUENT .................................................................................. 42
TABLE 6: AVERAGE VOLUME OF GARBAGE REMOVAL .................................................................. 42
TABLE 7: CONSTRUCTION PHASE: INPUT/OUTPUT PARAMETERS (DURATION ABOUT 24 MONTHS) .......... 44
TABLE 8: COMMISSIONING PHASE INPUT/OUTPUT PARAMETERS (DURATION ± 6 MONTHS) ............ 45
TABLE 9: OPERATIONAL PHASE INPUT/OUTPUT PARAMETERS (DURATION 40 YEARS) ...................... 46
TABLE 10: DECOMMISSIONING PHASE: INPUT/OUTPUT PARAMETERS (DURATION ABOUT 1 YEAR) .......... 47
TABLE 11: DISMANTLING PHASE: INPUT/OUTPUT PARAMETERS (DURATION 1 – 2 YEARS) ............. 48
TABLE 12: CONSTRUCTION PHASE: INPUT/OUTPUT RELATED IMPACTS (DURATION 24 MONTHS) ............ 50
TABLE 13: COMMISSIONING PHASE: INPUT/OUTPUT RELATED IMPACTS (DURATION ±6 MONTHS) ......... 51
TABLE 14: OPERATIONAL PHASE: INPUT/OUTPUT RELATED IMPACTS (DURATION ± 40 YEARS) .......... 52
TABLE 15: DECOMMISSIONING PHASE: INPUT/OUTPUT RELATED IMPACTS (DURATION ABOUT 1 YEAR) ............. 53
TABLE 16: DISMANTLING PHASE: INPUT/OUTPUT RELATED IMPACTS (DURATION 1 – 2 YEARS) .......... 54
TABLE 17: INSTITUTIONAL CAPACITY RELATED TO THE SERVICES PROVISION ................................................. 141
TABLE 18: SUMMARY OF FINDINGS – TOURIST SURVEY (KOEBERG) ......................................................... 157
TABLE 19: SUMMARY OF FINDINGS – TOURISM ESTABLISHMENT SURVEY (KOEBERG) .............. 160
TABLE 20: SUMMARY OF FINDINGS – TOURIST SURVEY (PELINDABA) ..................................................... 164
TABLE 21: SUMMARY OF FINDINGS – TOURISM ESTABLISHMENT SURVEY (PELINDABA) ............ 167
TABLE 22: RSA LOCAL CONTENT TARGETS ......................................................................................... 194
TABLE 23: IMPACT OF PBMR ON SA ECONOMY .................................................................................. 197
TABLE 24: ECONOMICS OF DIFFERENT ELECTRICITY PRODUCTION OPTIONS .......................................................... 204
TABLE 25: SOUND LEVELS IN THE VICINITY OF KOEBERG POWER STATION ........................................... 216
TABLE 26: TEMPERATURES AND WIND SPEEDS AT SOME LOCATIONS AROUND KOEBERG POWER STATION. 29 SEPTEMBER 1999 AND 13 OCTOBER 1999 ........................................................................................................... 219
TABLE 27: CATEGORIES OF OBSERVERS .............................................................................................. 231
TABLE 28: PERCEPTIONS OF OBSERVERS ............................................................................................ 232
TABLE 29: CHARACTER OF VIEWING POINTS ....................................................................................... 235
TABLE 30: SIGNIFICANCE ASSESSMENT OF IDENTIFIED VISUAL IMPACTS OF THE EXISTING KOEBERG STRUCTURES .................................................................................................................. 238
TABLE 31: SIGNIFICANCE ASSESSMENT OF IDENTIFIED VISUAL IMPACTS OF THE PROPOSED PBMR (NORTHERN SITE), SEEN IN RELATION TO THE EXISTING KOEBERG STRUCTURES ......................... 239
TABLE 32: SIGNIFICANCE ASSESSMENT OF IDENTIFIED VISUAL IMPACTS OF THE PROPOSED PBMR (SOUTHERN SITE), SEEN IN RELATION TO THE EXISTING KOEBERG STRUCTURES ......................... 240
TABLE 33: SIGNIFICANCE ASSESSMENT OF IDENTIFIED VISUAL IMPACTS OF THE PROPOSED NEW STRUCTURES (NORTHERN SITE), SEEN AS A STAND-ALONE STRUCTURE ........................................... 241
TABLE 34: SIGNIFICANCE ASSESSMENT OF IDENTIFIED VISUAL IMPACTS OF THE PROPOSED STRUCTURES ............................................................................................................................... 242
TABLE 35: VISUAL IMPACT OF ACTIVITIES OF ALTERNATIVE SITES .......................................................... 243
TABLE 36: RADIOACTIVE RELEASES IN LIQUID EFFLUENTS AND ACTIVITY CONCENTRATIONS AT THE POINT OF RELEASE ........................................................................................................... 250
TABLE 37: EFFECT OF THE ESTIMATED LIQUID RELEASE ON THE KOEBERG AADQ .......................................................... 251
TABLE 38: ESTIMATED RADIOACTIVE SOLID AND LIQUID WASTE PRODUCED IN THE PBMR PLANT ........................................... 252
TABLE 39: DESIGN ESTIMATE ANNUAL RELEASE RATES OF GASEOUS RADIO NUCLIDES ..................................................... 254
TABLE 40: ANNUAL EMISSION VIA THE EXHAUST CHIMNEY FOR THE PBMR CAUSED BY PRIMARY COOLANT LEAKAGE .................................................................................................................................................. 255
TABLE 41: ANNUAL EMISSION OF RADIOACTIVE MATERIAL TOGETHER WITH EXPELLED AIR FROM THE REACTOR CAVITY ........................................................................................................................................ 257
TABLE 42: GASEOUS RADIOACTIVE MATERIALS RELEASED ANNUALLY .................................................................................. 258
TABLE 43: GEOLOGICAL FORMATIONS ..................................................................................................................................... 264
TABLE 44: PARTICLE MOTION ANALYSIS .......................................................................................................................... 275
TABLE 45: RESULTS OF THE CHEMICAL AND ENVIRONMENTAL ANALYSIS ON THE BOREHOLEs SAMPLED SEPTEMBER 1999 .................................................................................................................................................. 306
TABLE 46: SUMMARY OF EXTREME VALUES ........................................................................................................................... 324
TABLE 47: MAXIMUM TEMPERATURE INCREASE IN DEGREES CELSIUS .................................................................................. 337
TABLE 48: MAXIMUM TEMPERATURE INCREASE IN DEGREES CELSIUS .................................................................................. 338
TABLE 49: POPULATION DISTRIBUTION RELATIVE TO KOEBERG POWER STATION (22.5 DEGREE RADIAL GRID) 344
TABLE 50: TOTAL POPULATION WITHIN EACH 5 KM DISTANCE BAND AROUND KOEBERG (22.5 DEGREE RADIAL GRID) ........................................................................................................................................ 345
TABLE 51: KOEBERG CUMULATIVE POPULATION DATA UP TO 50 KM (22.5 DEGREE SECTORS) .................................................. 345
TABLE 52: LIST OF FOCUS GROUP MEETINGS HELD FOR THE EIA PHASE ........................................................................ 379
TABLE 53: LIST OF FOCUS GROUP MEETINGS HELD FOR THE EIA PHASE ........................................................................ 379
TABLE 54: NOTIFICATION OF PUBLIC MEETINGS FOR THE EIA PHASE ........................................................................ 380
TABLE 55: NOTIFICATION OF PUBLIC MEETINGS FOR THE EIA PHASE ........................................................................ 382
TABLE 56: VENUES WHERE DRAFT ENVIRONMENTAL IMPACT REPORTS WERE AVAILABLE FOR COMMENT ........................................ 383
TABLE 57: DURATION OF PRE-OPERATIONAL SAMPLING PROGRAMME ........................................................................ 413
TABLE 58: OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMME .................................................. 427
TABLE 59: OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMME: FOOTNOTES ........................................ 430

**BOX**

BOX 1: THE “ALARA” PRINCIPLES ............................................................................................................................................. 22

**ANNEXURES**

ANNEXURE 1: Plan of Study

ANNEXURE 2: Executive Summary National Energy White Paper

ANNEXURE 3: Epidemiology Studies

ANNEXURE 4: National Radioactive Waste Management Policy

ANNEXURE 5: Meteorology
ANNEXURE 6: Oceanography
ANNEXURE 7: Demography
ANNEXURE 8: Terramare Demographic Document
ANNEXURE 9: Infrastructure
ANNEXURE 10: Issues Register
ANNEXURE 11: Social Impact Assessment
ANNEXURE 12: Significance Rating Methodology
ANNEXURE 13: SWIFT Risk Assessment Results
ANNEXURE 14: Information Document Volume II
ANNEXURE 15: Pelindaba Site Study
ANNEXURE 16A: Review of Current Nuclear Reactor Types
ANNEXURE 16B: BMR - Early History and Experience Else Where
ANNEXURE 17: General Operating Rules
ANNEXURE 18: Safety Case Support Programme
ANNEXURE 20: CV’s of Consultants
ANNEXURE 21: Copy of Advertisements
ANNEXURE 22: Media Cover
ANNEXURE 23: SAR Rev 1: Section 6 Chapters 0, 1, 2 and 3
1. INTRODUCTION

1.1 NEED FOR THE PBMR DEMONSTRATION MODULE (THE PLANT)

Eskom plans to broaden (diversify) the primary energy mix for the supply of electricity, for both the addition of future generation capacity (anticipated between 2005 and 2007) as well as the replacement of existing power stations (around 2020).

This diversification will take cognisance of the following considerations:

- To reduce over the longer term, the dominant rate of coal in the generation mix from the current level of 90% to 50% in the future.
- To provide a better geographical spread of generating stations as well as cost effective off grid (stand alone) generation installations for remote supply.
- To maintain and improve cost effectiveness, social acceptability and environmental suitability of generation options.

In terms of Eskom’s Integrated Strategic Electricity Plan (ISEP) various supply and demand technologies are under investigation for techno-economic evaluation. Some of the supply side technologies include:

- The Pebble Bed Modular Reactor (PBMR)
- Renewables such as Wind, Solar thermal and Biomass Technologies
- Fluidised Bed Combustion Technology based on discard coal
For the final stage of feasibility assessment, demonstration plants are proposed to be established to fully test the techno-economics9 of the plant(s) under South African conditions. The proposed demonstration module 110MWe class PBMR is now in this phase of development together with wind and solar.

The results of the PBMR will inform Eskom’s ISEP as well as government’s Integrated Resource Plan and Programme (IRPP), as will other demonstration plants for wind and solar thermal.

The developers of the PBMR plant, together with their co-investors i.e. Eskom, the Industrial Development Corporation (IDC) and British Nuclear Fuel Limited (BNFL), state that there is significant scope for the international application of this technology. The stated commercial potential of the PBMR for global application, although outside the scope of this EIA, is addressed to some degree within the EIR.

From the outset it needs to be emphasised that the justification for the proposed Plant is to test the techno-economics and to inform future decisions on energy technology applications for electricity generation. The proposed Plant will be linked to the national transmission grid (i.e. electricity generated by the Plant will be sold commercially to recover the investment cost and to enable demonstration) and will remain a demonstration plant for its full life cycle (i.e. 40 years although the first 5 to 6 years will be more important in terms of deciding on its techno-economic performance). The rationale for the prolonged period of demonstration is to obtain and assess the techno-economic information on maintenance and refurbishment of continued operation as well as materials behaviour. This information will be incorporated into the design optimisation process, provided that the Plant proves viable.

1.2 PURPOSE OF THE ENVIRONMENTAL IMPACT REPORT

This EIR primarily addresses, assesses and evaluates the issues and impacts related to the proposed Plant as defined within the Plan of Study for the EIA which was accepted by the DEAT in early March 2002 (see Annexure 1 for a copy of the PoS for EIA). The EIR forms part of the overall Environment Impact Assessment (EIA) that is mandatory in terms of the Environmental Conservation Act (Act No. 73 of 1989) and the National Environmental Management Act (Act No. 107 of 1999).

The Report also pays attention to strategic issues, namely policy imperatives, international treaties, radiological safety and health issues including HIV/AIDS.

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9 The White Paper on a National Energy Policy for South Africa provides a definition for a demonstration plant.
The complete range of issues and impacts covered in the EIR, were defined through the Scoping process which started in April 2000 and terminated in December 2001 when the Scoping Report was accepted by DEAT. For a record of this process the reader is referred to the Scoping Report and Annexures that are available on the website: http://www.pebble-bed.co.za. (The major milestones of the Scoping Phase of the EIA are listed below).

The EIR furthermore reports on the significance of identified issues/impacts and recommended mitigating measures to reduce the risk of adverse impacts and enhance beneficial aspects/impacts. These mitigating measures are incorporated in the Environmental Management Plan (EMP) which details the construction and operation/maintenance phases of the proposed Plant.

This EIR also incorporates a Social Impact Assessment (SIA), to more fully inform and understand the socio-cultural and economic perceptions of the public about the proposed Plant, together with recommendations for mitigation.

1.3 MAJOR MILESTONES OF THE SCOPING PHASE

The milestones of the Scoping Phase are summarised below:

- Completion, submission and acceptance of the application for the proposed Plant by the Department of Environmental Affairs and Tourism (DEAT) in June 2000.

- Completion and acceptance by the DEAT of the Plan of Study (PoS) for Scoping for the proposed Plant in January 2001. Alternative sites that were considered for investigation included the Thyspunt site located near Cape St Francis in the Eastern Cape Province; Bantamsklip site near Hermanus in the Southern Cape region of the Western Cape Province and Koeberg near Blaauwbergstrand in the Western Cape.

- Announcement of the proposed Plant in the print media (national, regional and local newspapers) and electronic media (radio).

- Registration of I & APs and public consultations to disseminate information and register public issues, concerns and/or suggestions.

- A Background Information Document (BID) as well as an Information Document (Volume I) were distributed for public information. Both documents were available in hard copy and electronically (compact disc and web site).

- Capacity Building Workshops were held in the Cape Town, Pelindaba, Johannesburg and Durban areas between November 2000 and January 2001. These workshops informed interest groups on various topics and issues including the proposed development; nuclear related issues, especially safety and alternative
alternative energies/technologies. Opportunities were provided to NGOs to present alternative viewpoints.

- Consultation was conducted via open days, public meetings, focus group meetings (individuals or organisations with a common interest) and personal interviews

  A broad range of interest groups were covered including:

  - Government at national, provincial & local level
  - Professional institutions and persons
  - NGOs and CBOs
  - Commerce and Industry
  - Local communities

  In all, about 2600 I & APs were registered on a national basis.

- A comprehensive Issues Report was compiled that contained the name of the person/organisation, the nature of the issue and comment on the issue from the EIA Consortium as provided from various sources.

- Compilation and issue of the Draft Scoping Report for public review in March 2001. The Report was distributed in hard copy (public libraries) and electronically (CD & website). This report was also reviewed by the Review Panel established by the DEAT. The Panel consisted of international and national members.

- A number of conclusions and recommendations were made by the Review Panel. The most important being that the NECSA Pelindaba Campus in the North West Province, must also be scoped and assessed as an alternative site for the proposed Plant (See Annexure 15 for the Report on the Investigation of Pelindaba as an alternative site).

- Compilation and submission of the final Scoping Report for DEATs' consideration and acceptance in October 2001. The Report was available to the public (hard copy and electronically) and was also reviewed by the DEAT, the provincial environmental authorities and the Review Panel.

- Acceptance of the Scoping Report by the DEAT in mid December 2001 and an instruction to proceed with the EIA phase through the submission of a Plan of Study (PoS) for the EIA (Annexure 1). No appeal against the acceptance of the Scoping Report was received from any party.
1.4 CONCLUSIONS OF THE SCOPING PHASE

The conclusion of the scoping phase were:

✦ That the Eskom Koeberg NPS site is the preferred (recommended) site for the proposed Plant due to its inherent characteristics and developed infrastructure.

✦ That the Pelindaba Campus, while feasible, will carry a substantial cost penalty to equalise the site with that of Koeberg. The cost penalty is based on infrastructure enhancement and design realignment, without providing any advantages other than the elimination of fuel transport for the demonstration Plant. However, it would have lengthened the transport of low and intermediate level nuclear waste to the Vaalputs repository near Springbok in the Northern Province (See Annexure 15).

✦ That the alternative sites i.e. Thyspunt and Bantamsklip, should not be considered for the purposes of a demonstration Plant due to their greenfield’s nature (these sites have no infrastructure and require development from a greenfields level).

✦ That an EIA should be conducted for the proposed Plant on the Eskom Koeberg site based on the scope of work as defined in the approved PoS for EIA for the Plant (Annexure 1).

1.5 GOVERNANCE OF THE EIA AND OTHER APPROVAL REQUIREMENTS

The proposed Plant and Fuel Manufacture and associated transport of nuclear materials is governed by various Acts, Regulations, Treaties and Policies which are listed hereunder:

1.5.1 Acts

<table>
<thead>
<tr>
<th>Name of Act</th>
<th>No and Date:</th>
<th>Departments</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Constitution of South Africa</td>
<td>Act 108 of 1996</td>
<td>Office of the State President</td>
</tr>
<tr>
<td>Environment Conservation Act</td>
<td>Act 73 of 1989</td>
<td>Environmental Affairs and Tourism</td>
</tr>
<tr>
<td>National Environmental Management Act</td>
<td>Act 107 of 1998</td>
<td>Environmental Affairs and Tourism</td>
</tr>
<tr>
<td>Atmospheric Pollution Prevention Act</td>
<td>Act 45 of 1965</td>
<td>Environmental Affairs and Tourism</td>
</tr>
<tr>
<td>Electricity Act</td>
<td>Act 41 of 1987</td>
<td>Public Enterprises</td>
</tr>
<tr>
<td>Name of Act</td>
<td>No and Date:</td>
<td>Departments</td>
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<tr>
<td>Hazardous Substances Act</td>
<td>Ac 15 of 1973</td>
<td>Labour and Industry</td>
</tr>
<tr>
<td>National Heritage Resources Act</td>
<td>Act 25 of 1999</td>
<td>SA Heritage Resources Agency</td>
</tr>
<tr>
<td>National Nuclear Regulator Act</td>
<td>Act 47 of 1999</td>
<td>Minerals and Energy</td>
</tr>
<tr>
<td>National Roads Traffic Act</td>
<td>Act 94 of 1996</td>
<td>Transport</td>
</tr>
<tr>
<td>National Water Act</td>
<td>Act 36 of 1998</td>
<td>Water Affairs and Forestry</td>
</tr>
<tr>
<td>National Nuclear Energy Act</td>
<td>Act 46 of 1999</td>
<td>Mineral and Energy</td>
</tr>
<tr>
<td>Physical Planning Act</td>
<td>Act 135 of 1991</td>
<td>Land Affairs</td>
</tr>
<tr>
<td>Promotion of Access to Information Act</td>
<td>Act 2 of 2000</td>
<td>-</td>
</tr>
<tr>
<td>Seashore Act</td>
<td>Act 21 of 1935</td>
<td>Environmental Affairs and Tourism</td>
</tr>
</tbody>
</table>

Further to the national statutes (acts and regulations) a number of provincial and local authority regulations/ordinances must be satisfied, particularly those related to land-use planning, economics and service provision.

1.5.2 Regulations:

- National Road Traffic Regulations as published in the Government Gazette of 17 March 2000
- Regulations for the safe transport of radioactive material (IAEA No. TS-R-1 (ST-1 revised))

1.5.3 Treaties/Conventions:

South Africa, as a responsible member of the world community, has become a signatory to a variety of international agreements, dealing with issues such as marine conservation and pollution, the atmosphere, fauna and flora, Antartica, whaling and the conservation of wetlands. These conventions place specific environmental impact management requirements and obligation on the South African Government in complying to the aims and objections of these conventions. In cases where the
where the proposed undertaking of an identified activity may influence or affect compliance with these conventions or is likely to have a significant detrimental effect across South Africa’s international boundaries, special procedures and EIA requirements may be required.

✦ Bonn Convention (Convention of Migratory Species of Wild Animals) (extracted from the DEAT EIA Guideline of April 1989)

South Africa acceded to the Bonn Convention in December 1991. The convention was a response to the need for nations to co-operate in the conservation of animals that migrate across their borders. These include terrestrial animals, reptiles, marine species and birds. Special attention is paid to endangered species. No direct application to the proposed PBMR project.

✦ CITES (Convention on Trade in Endangered Species of Wild Fauna and Flora) (extracted from the DEAT EIA Guideline of April 1989)

The main objectives of this convention are the protection of endangered species, the economic utilisation of species, monitoring the status of species and control of illegal trade. No direct application to the proposed PBMR project.

✦ Convention on Biological Diversity (CBD) (extracted from the DEAT EIA Guideline of April 1989)

The aim is to effect international co-operation in the conservation of biological diversity and to promote the sustainable use of living natural resources worldwide. No direct application to the proposed PBMR project, however the protection of biological diversity within the affected areas of the PBMR demonstration module and fuel plant will be undertaken through the construction EMP and operational environmental surveillance programmes and general operating practices.


South Africa is a founder member of the IWC and has a proud record regarding conservation and research for whale management. No direct application to the proposed PBMR project.

South Africa became a signatory in January 1990. The protocol is aimed at ensuring measures to protect the ozone layer. No direct application to the proposed PBMR project.

**Basel Convention (Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposals)** (extracted from the DEAT EIA Guideline of April 1989)

South Africa became party to the convention in May 1994. The main objectives of the convention are the reduction of the production of hazardous waste and the restriction of transboundary movement and disposal of such waste. This has application to the proposed PBMR project and are factored into the requirements of the National Nuclear Regulator with regard to the waste generated by the proposed Plant.

**Framework Convention on Climate Change (FCCC)** (extracted from the DEAT EIA Guideline of April 1989)

The convention addresses the threat of global climate change by urging governments to reduce the sources of greenhouse gases. Although no obligations to the reduction of greenhouse gases rests on South Africa as a developing nation, it is of relevance to the proposed PBMR project in that it was noted at the 18th World Energy Congress (October 2001) that for electricity generation “the most effective means currently in use to reduce CO₂ emissions are nuclear power and hydroelectric power” and that “they should continue to play an important role in electricity generation.”

**World Heritage Convention** (extracted from the DEAT EIA Guideline of April 1989)

Convention concerning the protection of the world cultural and natural heritage. This has application to the proposed PBMR project. It needs to be noted that the Koeberg Nuclear Power Station is in proximity to Robin Island a recognised world heritage site and that Eskom has established a nature reserve on its surrounding land. The Koeberg nature Reserve has been declared a private nature reserve and a natural heritage site. The siting of the PBMR demonstration module and the EMP requirements take this into account in terms of the Emergency Planning Procedures.

**Convention on Desertification** (extracted from the DEAT EIA Guideline of April 1989)

Convention to combat desertification in those countries experiencing serious drought and/ or desertification, particularly in Africa. No direct application to the proposed PBMR project. However, the siting of the PBMR demonstration module
allows the use of sea water for the indirect cooling requirements, therefore conserving fresh water resources.

National Nuclear Non-proliferation Treaty enacted by the Nuclear Energy Act.

This Treaty makes provision for the international regulation of nuclear and other materials or precursory materials that may be employed for the manufacture, harbouring and use of devices or weapons of mass destruction. The PBMR thus have application to the non-proliferation of nuclear weapons.

This has specific and implied meaning for the use of such materials (including nuclear material) for commercial application since they must be declared and fully accounted for at national and international level.

The Minister of Minerals and Energy functions as the national governor for the implementation of this Treaty, and Safeguards Agreement.

The proposed PBMR has definitive application in terms of the Treaty and is dealt with in more detail in the Executive Summary and EIR (Chapter 4.2.3).

1.5.4 Policies:


- The Western Cape’s White Paper on “Preparing the Western Cape for the Knowledge Economy of the 21st Century” which sets out the Western Cape’s vision and policy on inter alia sustainable development.


The different authorities that administer these Acts/Regulation/Treaties/Policies each have their own unique processes for approval and governance.

The environmental authorisation process (i.e. the EIA) is only one of these process(es) and not an all embracing or final approval process. Approval by one authority does not automatically entail approval by another authority.

To ensure diligent governance, the government has decided that the National Cabinet will in addition to the other compliance processes, jointly decide on the progressive development of the project, to provide the public with additional assurance.
1.5.5 Environmental and Radiological Governance

The national Department of Environmental Affairs and Tourism (DEAT) is the competent lead authority for the approval of the EIA. Their function is discharged in close cooperation with the relevant provincial environmental authorities, the Department of Minerals and Energy (DM&E) including the National Nuclear Regulator (NNR) and the Department of Transport. The EIA Consortium Consultants engaged the other authorities (national, provincial and local) and Interested and Affected Parties (I & APs) through the EIA’s participation process.

The NNR functions in terms of the Nuclear Regulator Act (Act No. 47 of 1991) and serves as the approval authority for the nuclear licence related to the radiological safety/health and the protection of the public, property and the environment.

The applicant (Eskom) has also prepared and submitted a Safety Case and Safety Analysis Reports to the NNR for evaluation. Once satisfied, the NNR will issue a licence. Licensing is a staged process, involving site preparation, a construction licence, commissioning licence and an operation/maintenance licence for the Plant.

The radiological safety standards applied by the NNR conform to the international standards established by the International Atomic Energy Agency (IAEA) and inform this EIR.

The Minister for Mineral and Energy, in terms of the Nuclear Energy Act (Act No. 46 of 1999), furthermore regulates the use and transportation of nuclear materials and waste.

Additionally the National Cabinet has established decision milestones to consider and approve consecutive stages of the project.

The above main approval processes are independent of one another, therefore providing various checks and balances on governance for public assurance.

1.6 Public Participation During the EIR

The engagement of the public (I & APs) during the EIR phase is dealt with in detail in Chapter 6. Extensive Issue Based Consultation (IBC) and a SIA formed an integral part of this process and special attention was given to engage the disadvantaged and illiterate sectors of society.

Information was furthermore disseminated via the Information Document II (Annexure 14) which supplemented the existing BIDs and Information Document (see website http://www.pebble-bed.co.za) and the Information Booklet titled “Planning for the Future Electricity Needs of South Africa” was published by Eskom in several African
African languages. During the review period of the draft EIR, a public version of the DFR was made available to I & APs on request.

Public meetings were conducted in seven centres around Cape Town, Pelindaba, Durban and Johannesburg, before the release of the draft EIR, to inform the public of the Reports’ content and conclusions.

The draft EIRs were available for public review and comment from 4 June to 4 August 2002. (Hard copies in 36 libraries and electronically on CD and on website (www.pebble-bed.co.za)). An extension of review time until 4 September 2002 was granted to a number of I & APs at their request and in consultation with the DEAT. The final Report is again published for public information on website (as above), Compact Disc (CD 50 copies) and distributed in hard copy to public libraries in the main centres i.e. Cape Town, Pelindaba area, Durban and Bloemfontein. Registered I & APs were individually notified on the publication of the final EIRs.

The time frames for the final EIAs are as follows:

<table>
<thead>
<tr>
<th>Event</th>
<th>Time Frame</th>
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<tbody>
<tr>
<td>Publish draft EIR for public review/comment</td>
<td>4 June – 4 September 2002</td>
</tr>
<tr>
<td>Publish final EIR</td>
<td>November 2002</td>
</tr>
<tr>
<td>Provide Record of Decision (RoD) by the DEAT</td>
<td>on receipt of RoD from DEAT</td>
</tr>
</tbody>
</table>
2. THE PROPOSED ACTIVITY

SECTION 1: DESCRIPTION OF THE PROPOSED ACTIVITY

2.1 THE PREFERRED SITE AND ALTERNATIVES

For the purpose of this EIA the defined impacts of the proposed PBMR demonstration plant are comprehensively described and assessed for the Koeberg NPS site and environment, while the Pelindaba Campus alternative is reported on as required by the DEAT.

اسلوب The Eskom Koeberg Nuclear Power Station Site

The proposed Plant will be located some 400m south east of the Koeberg Nuclear Power Station (KNPS), along the Atlantic Ocean and just outside Koeberg's inner security fence. Figure 1 provides a map indicating the Koeberg Site and approximate locality of the PBMR.

The technical, biophysical, social and economic parameters of the site and sub-region are provided in Chapter 4: Assessment of Impacts on the Affected Environment.

اسلوب The NECSA Pelindaba Campus as an Alternative Site

An investigation was conducted of the Pelindaba Campus (North West Province) to assess the suitability of the site for the establishment of the proposed demonstration module PBMR.

Annexure 15 provides the details and conclusions of the investigation conducted by Eskom and the PBMR (Pty) Ltd.

The main conclusion was that whilst the site is feasible, it will incur a significant cost penalty due to the need for the upgrading of infrastructure. The EIA Consultants furthermore hold the opinion that the use of the site will present complex legal issues in terms of ownership and continued liabilities (i.e. safety, security, governance, etc.).

Based on these conclusions and legal implications it is the recommendation of the Consultants that the Pelindaba site not be considered for the establishment of the proposed demonstration Plant.

The advantages of the Pelindaba alternative, of not having to transport the manufactured fuel for the extended distance to Koeberg, is off-set by the need to transport LLW & ILW from Pelindaba to Vaalputs in the Northern Cape Province.
Figure 1: Koeberg Site and approximate location of the PBMR
2.2 DESCRIPTION OF THE ACTIVITY

Note: This chapter contains a description of the proposed Plant in terms of its technical, design, safety and security features.

2.2.1 BACKGROUND

The Demonstration Module Pebble Bed Modular Reactor (PBMR) is an advanced South African designed reactor based on the German high temperature nuclear reactor technology. The PBMR uses helium gas as coolant and low enriched uranium as its energy source (fuel). Helium is a stable and chemically inert gas.

The PBMR uses a direct gas turbine cycle to convert the (from nuclear fission) heat into electricity without a secondary steam cycle. A turbine extracts heat from the closed cycle. The turbine drives a generator that produces electricity. Heat from nuclear fission in the reactor is transferred to the coolant gas. The turbine removes heat from the closed cycle. The turbine drives the generator that produces approximately 130 MW of electricity. The cycle has two sets of turbo compressors, each on a single shaft, and one regenerative heat exchanger which enables greater efficiency, but do not increase or decrease the overall energy level of the closed cycle. Two water-cooled heat exchangers remove heat from the cycle.

The stated advantages of the PBMR are its radiological safety (or so-called inherent safety), high thermal efficiency and limited production of waste.

2.2.2 TECHNICAL SPECIFICATIONS OF THE PBMR

The assessment of impact was conducted for a PBMR Module with the following specifications:

| Reactor Pressure Vessel       | Forged steel vessel with: |
|                              | Inner diameter : 6.2m     |
|                              | Height : 22.0m            |
|                              | With a wall thickness of between 120mm to 220mm. |
| Thermal Output               | 302MW                     |
| Graphite Reflector           | Diameter of 3.7m and effective height of 9.5m |
| Coolant Gas                 | Helium. The gas leaves the last turbine at 530°C and pressure of 26 bar, where after it is cooled and recompressed to 85bar and reheated to 500°C. |
| Power Conversion Unit (PCU)  | 120MWe nominal output     |
| Building                     | The PBMR building will be 60m long, 37m wide and 60m high of which 24m will be above ground. |
Fuel

Low Enriched Uranium (LEU) (i.e. up to 10% enriched.

Fuel spheres is based on the triple coated (Triso) kernels (0.9mm diameter) containing in total 9g of uranium and compressed into a graphite sphere (195g) with an overall diameter of 6.0cm and weight of 204g.

Fuel requirements

About 425 new fuel spheres per day. Initial load of 330 000 spheres. Annual replacement is about 130 000 spheres. Fuel spheres will pass through the core 6 times where after it will be stored in spent fuel storage tanks located next to the reactor in the basement of the building.

Cooling Water Outflow (seawater)

1.7m³/s at a delta temperature of 40°C.

2.2.3 Design Features of the PBMR

The PBMR reactor core is designed for the low enriched uranium Triple-coated Isotropic (TRISO) fuel element which was developed for High Temperature Gas Cooled Reactor (HTGR) in Germany from 1969 to 1988. The German design is supported by a large database consisting of test data from irradiation tests in materials testing reactors and data obtained from a large number of tests on fuel elements irradiated in the Arbeitsgemeinschaft Versuchsreaktor (AVR) under operating conditions. This fuel is the key element for the safety and environmental aspects of the HTGR, and is now used exclusively in all modular HTGR designs.

The reactor is based on the German AVR, Thorium High Temperature Reactor (THTR), High Temperature Module Reactor (HTR-Modul) and High Temperature Reactor (HTR) - 100 designs. The basic design and the operating experience of these plants have been used in the design of the PBMR. Annexure 16 provides detail on the design and operating experience of PBMR (HTR) on a global basis.

The most innovative part of the power plant design is the integration of the reactor and the Power Conversion Unit (PCU).

The power turbine design is based on conventional gas turbine technology.

The specialised gas cycle pipe design is based on the proven THTR-300 and HTR-Modul hot pipe technology. The design of the fuel handling and storage system is based partly on the THTR-300 reactor, in that the PBMR reactor also has a multi-pass continuous fuelling. Some aspects of the system are, unique to the PBMR design.

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10 PBMR Demo Plant Detail Feasibility Report Doc No. 009838-160 Rev 1
The consequence of an accident with the PBMR is much lower than with the traditional nuclear power reactors (LWRs). When the fuel of an operating LWR is not immersed in water or has insufficient cooling, the fuel and fuel cladding will melt and the fuel and its fission products will pass to the coolant, increasing the likelihood of fission product release. This position is however, negated in the PBMR fuel design as detailed in the Report.

Without coolant, the PBMR design is such that sufficient heat is removed by passive heat rejection to maintain the fuel within an acceptable temperature range. Heat passes from the core to the walls of the reactor cavity concrete without active components. The simplicity of not requiring the movement of pumps, valves and electrical generators simplifies the design, reduces the number of components necessary to respond to an accident, and increases safety. During normal operation, unacceptable increase in power is prevented by the negative reactivity coefficient, a passive characteristic of the fuel. The negative temperature coefficient ensures that a temperature increase will result in a power decrease. Thus preventing an excessive fuel temperature with the potential of fission product release (Annexure 16 provides further information on these aspects).

When PBMR fuel is without helium cooling, the fuel will not increase to temperatures that can result in significant fission product release. The fuel, which is designed to prevent release of radioactive fission products up to very high temperatures, i.e. 1600°C plus is central to the safety objective of the PBMR. Equivalent fuel has been tested and significant releases occur only at temperatures exceeding 2000°C (See Annexure 16) Ensuring that there can be no credible circumstances in which these temperatures could be reached, therefore ensure that radioactive release cannot reach significant levels. For normal and accident conditions without cooling, the fuel and fission products will be retained within the series of protective boundaries around the uranium kernels in the matrix of the fuel spheres.

These design features enables the PBMR to be located closer to areas of high population, since it ensures the protection of both the workers and the general public against high levels of radiation.

The Helium which is used as the coolant gas, combined with the high-temperature integrity of the fuel and structural graphite, allows the use of a high coolant temperature (900°C) yielding higher thermal efficiencies. These high temperatures justify the use of a closed cycle gas turbine without a secondary steam cycle.

A number of key safety design features, described below, enable the required levels of safety to be achieved with a greatly simplified design, construction and operation compared, for example, with current LWR. In particular:
The small normal operational excess reactivity made possible by continuous fuelling and de-fuelling.

The radio nuclide retention capability of the fuel pebbles which contain coated fuel particles and fission products, even at high temperature.

The large negative temperature coefficient of reactivity of the core which prevents excessive temperature increases.

The inert nature and neutron transparency of helium, used as reactor coolant and working medium (“fluid”), which minimises the consequence of a coolant release.

The large passive heat removal capability of the reactor design, which prevents excessive fuel temperature if the normal method of heat removal is gone.

Because the PBMR uses an inert stable gas for cooling, instead of water, the accidents and the consequence of accidents associated with water cooling have been eliminated. A single state gas, instead of a coolant with two physical states (gas and liquid), significantly reduces the number of accidents, which can occur.

2.2.4 PBMR BUILDING FACILITIES

The demonstration module PBMR will consist of a single building (referred to as a Module), covering an area of some 2220m² (60 x 37m), which means that about four modules could fit on a soccer field. The height of the building will be 60m, of which 24m will be above ground level. The part of the building that will be visible above ground is equivalent to an eight-storey building. In addition to the Module the PBMR facility will consist of cooling water structures linked to that of Koeberg NPS and site services.

The reactor, power conversion unit (PCU) and spent fuel storage tanks will be located on a “nuclear island”, specifically designed to cope with seismic events. These components are protected within a citadel of 2 meter reinforced concrete. All of these structures together with the turbines, etc. are housed within the PBMR building which is constructed of 1 meter thick reinforced concrete to form the outer shell.

2.2.5 PBMR OPERATING PRINCIPLE

The plant reactor consists of a vertical steel pressure vessel, with a 6.2m inner diameter...
diameter and 22m height. The fuel pebbles are housed inside a graphite block structure, which reflect neutrons back into the fuel. Control rods, which absorb neutrons, are located in and can be moved into or out of the graphite blocks to control reactivity and power generation. Please refer to Figure 2 for a schematic layout of the PBMR nuclear reactor.

The reactor operator increases reactivity and power from the control room by removing the control rods from the graphite block reflector. The heat that is generated by the nuclear reaction is transferred to the reactor coolant, helium. Helium coolant enters the reactor vessel at a temperature of about 500 ºC and a maximum operating pressure of 85 bar. The helium cools the hot fuel spheres, and leaves the reactor vessel at a temperature of 900 ºC. The helium then passes through the high and low-pressure turbo units, through the power turbine that in turn drives the generator. A regenerative heat exchanger, recuperator, removes and adds heat. Energy is removed from the cycle by the pre- and inter-cooler. The low and high-pressure compressors add energy to the cycle that was previously removed by the turbines. The helium gas is returned to the core at 530 ºC. The intercooler and pre-cooler are cooled by a secondary closed water cycle which again is cooled by a tertiary sea water cooling system.

The reactor is loaded with over 440 000 spheres, three quarters of which are fuel spheres and one quarter which are graphite spheres. The graphite spheres slow down (moderate) the neutrons. The fuel and graphite spheres are continually being added to the core from the top and removed from the bottom.

For normal routine power operation, heat removal and power levels are controlled by varying helium pressure and density. The temperature remains constant.

The helium inventory and pressure is controlled by compressors, and high/low pressure holding tanks. The use of helium, rather than water as the primary coolant, allows high operating temperatures to be achieved.

This means that the plant is more efficient (efficiency increases with temperature),
2.2.6 **PBMR Fuel**

(More information on the proven characteristics of the fuel is provided in Annexure 16). The Uranium fuel is contained inside spheres, each of which is about the size of a tennis ball (60mm diameter). The Uranium is in the form of very small granules or kernels (about the size of a grain of sugar), each of which is surrounded with four layers of special ceramic and carbon coatings. These coatings ensure that radioactive material that results from the nuclear reaction is locked inside the kernel. About 15000 of these very small-coated kernels (particles) are embedded in graphite, all of which is enclosed in a Uranium free shell of graphite. Please refer to Figure 3 for a schematic illustration of a fuel sphere.

Fuel spheres are continually added to the reactor from the top and removed from the bottom. The removed spheres are monitored to determine fuel consumed. If the Uranium in the sphere has been used up sufficiently, the sphere is sent to the spent fuel storage system which has a dry helium blanket. If the sphere has sufficient fuel, it is then reloaded into the core and recirculated.

A fuel sphere passes through the core about 6 times before being discharged to the spent fuel storage system. The spent fuel storage tanks are in a secured area inside the reactor building below ground level.

The peak temperature that could be reached in the fuel under the most extreme foreseen conditions is 1600 °C. This means that the plant cannot experience thermal fuel damage. As a further safety measure, the fuel is designed to retain its density up...
to temperatures of over 1700 ºC, and, will maintain its integrity at a sustained temperature of 2000 ºC.

The fuel will be manufactured by NECSA in the BEVA buildings, which is located at Pelindaba in the North West Province. The BEVA buildings, previously used and licensed to manufacture Koeberg’s nuclear fuel, conform to radiological process requirements. The manufactured fuel spheres will be transported by road from the Pelindaba plant to the PBMR demonstration unit at Koeberg. The manufactured and transport of the fuel will be done in accordance with NNR and international safety standards to ensure public safety (a separate EIR has been compiled for the fuel manufacture and transport of associated nuclear materials). The fresh fuel, which emits low levels of radioactivity, will be transport to the PBMR site by road and in purpose designed containers, in accordance with NNR and international safety standards.

**Figure 3: Schematic Illustration of a Fuel Sphere**

2.2.7 SAFETY AND RELATED ASPECTS OF THE DEMONSTRATION MODULE PBMR

The South African nuclear industry adheres to and maintains very high standards of safety by conforming to the requirements of the National Nuclear Regulator (NNR). South African regulations are based on international standards and norms established by the International Atomic Energy Agency (IAEA). The philosophical basis for the safety standards set down by the NNR, for the licensing of nuclear installations or activity(ies) involving radioactive materials, is presented in a set of fundamental principles referred to as the “fundamental safety standard”. The applicant must demonstrate that the proposed nuclear installation or activity under consideration,
consideration, will comply with these requirements. Compliance with safety standards and regulations, protects the general public and site workers.

### 2.2.8 Basic Licensing Requirement for the PBMR

The licensing process requires the licensee to present a safety case and support programmes to the National Nuclear Regulator, i.e. a structured and documented presentation of information, analyses and intellectual argument to demonstrate that the proposed design will comply with the safety standards.

The “Basic Licensing Requirements for the PBMR” describes the fundamental safety standards (FSS) prescribed by the National Nuclear Regulator and provides insight into their basis and establishment. The requirement presents the derived standards in terms of design and operational principles and in terms of quantitative risk criteria, both of which the design must comply with. The FSS also describes the processes that the licensee (Eskom) must undertake, to demonstrate compliance with the standards.

The following principles form the basis of the fundamental safety standards:

- The risk presented by a nuclear plant/activity shall not increase significantly the total risks to which the population is exposed;
- The nuclear risk are less than those associated with other major industrial enterprises;
- Allowance shall be made for possible demands for more stringent safety standards in the future;
- The safe design of the reactor shall be demonstrated by analysis and testing;
- Good nuclear safety design practice;
- Internationally recognised design and operational rules are followed; and
- Compliance with the risk and radiation dose limitation criteria.

Quantitative risk criteria have been derived from studies on risks associated with a broad range of human activities.

This requires a high level of confidence that the risk to society from the PBMR will be very low. However, the operator of the plant (Eskom) will be required to go even further to reduce risk by demonstrating the concept of ALARA (see Box 1). ALARA involves selecting design and operational features that provide further optimised levels of safety and involves the use of a range of techniques.
Box 1: The “ALARA” principles

With regard to good nuclear safety design practice, of prime consideration are the principles of defence-in-depth and of ensuring that risks and radiation doses to members of the public and workers will be maintained As Low As Reasonable Achievable (ALARA) below the stipulated radiation dose limits.

The licensing process requirements are summarised in Table 1 below. This requires the applicant to identify all events that will be associated with a number of conditions, namely:

- with the normal operation of the reactor (referred to as Category A events);
- those events associated with the design which could reasonably be anticipated to be possible and which may give rise to accidental exposure of workers or members of the public (referred to as Category B events), and
- any other events that can be identified with very low probability of occurrence or complex events of equally small likelihood that could give rise to accidental exposure (referred to as Category C events).

The applicant is required to identify the events and to justify their selection and classification. The adequacy of these proposals are evaluated against prevailing national and internationally endorsed standards. These events form the basis for the design, procedures and emergency planning.

The applicant must furthermore demonstrate that the PBMR can respond to these events/accidents and the operator must demonstrate the means to recognise and respond to these accidents/events or incidents. Accident management procedures, that minimise the consequences of any accident, ensure that the public and workers are protected.

Table 1: NNR Licensing requirements for the PBMR

<table>
<thead>
<tr>
<th>Event frequency</th>
<th>Safety requirements</th>
<th>Safety criteria</th>
</tr>
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<tbody>
<tr>
<td>CATEGORY A</td>
<td></td>
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<tr>
<td>Category A events (or combinations of events) are those which lead to exposure and which could occur with a frequency of more than one in one hundred years ($\geq 10^{-2}$ y$^{-1}$). Such events are treated as part of normal operation.</td>
<td>The design shall ensure that under anticipated conditions of normal operation, there shall be no radiation hazard to the workforce and members of the public. Normal operation includes: exposures resulting from minor mishaps and misjudgements in operation, maintenance and decommissioning.</td>
<td>The individual radiation dose limit shall be: 20 mSv.y$^{-1}$ to plant personnel, and 250 µSv.y$^{-1}$ to members of the public.</td>
</tr>
<tr>
<td>Event frequency</td>
<td>Safety requirements</td>
<td>Safety criteria</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>CATEGORY B</td>
<td>The design shall be such to prevent and mitigate potential equipment failure or withstand externally or internally originating events that could give rise to plant damage, leading to radiation hazards to plant personnel and members of the public in excess of the safety criteria. The analysis performed to demonstrate compliance with this requirement shall be conservative. In addition, radiation doses and risks associated with these events shall be kept ALARA and the principle of defence-in-depth shall be applied.</td>
<td>The individual radiation dose limit shall be: 500 mSv per event or combination of events to plant personnel, and 50 mSv per event or combination of events to members of the public.</td>
</tr>
<tr>
<td>CATEGORY C</td>
<td>The design shall be demonstrated to respect the risk criteria for plant personnel and members of the public. The analysis performed to demonstrate compliance with this requirement may use best-estimate data, provided it is supported by an appropriate uncertainty analysis. The analysis must also demonstrate a bias against large accidents. In addition, radiation doses and risks associated with these events shall be kept ALARA and the principle of defence-in-depth shall be applied.</td>
<td>Limitation of risk to the values set by the risk criteria. Plant personnel: 5 x 10^{-5}.y^{-1} peak individual risk, and 10^{-5}.y^{-1} average risk Members of the public: 5 x 10^{-6}.y^{-1} peak individual risk, and 10^{-6}.y^{-1} average population risk per site.</td>
</tr>
</tbody>
</table>

### 2.2.9 SAFETY ARRANGEMENTS OF THE PBMR

The various safety arrangements to demonstrate response and recognition of category A, B and C events are described hereunder, namely:

- **Radiological Safety**

  The Final Safety Design Philosophy (FSDP) must ensure that the fuel will retain its integrity to contain radioactive fission products under normal and accident conditions and thereby assure radiological safety. This is achieved by relying on
fuel whose performance has been demonstrated under simulated normal and accident conditions\textsuperscript{12}.

To ensure that the fuel integrity is maintained, the plant design for operating and accident conditions provides for the following:

- Sufficient heat removal capability such that fuel temperatures will remain in the proven safe region;
- Limited chemical reaction and physical deterioration of the fuel; and
- Adequate measures to control reactivity and power.\textsuperscript{13}

\textbf{Safety Analyses}

Appropriate analysis must demonstrate that the design objectives have been met with adequate margins. The design has been systematically analysed to ensure that all normal and abnormal conditions have been identified and considered. When the design or operation of the plant is modified, this analysis is updated for design changes and reviewed periodically.\textsuperscript{14}

\textbf{Probabilistic Risk Assessment (PRA)}

The PRA provides a systematic analysis to identify and quantify all risks that the Plant imposes to the general public and the worker and thus assess compliance to NNR regulatory risk criteria.

Demonstration that regulatory risk criteria are met, was achieved through focus on the challenges to fuel integrity. Other Systems, Structures and Components (SSCs) act as further barriers or obstacles to the release of fission products, and were modeled in the PRA. This approach provides a measure of the levels of defence-in-depth that exist in the design and operation of the PBMR and provided a means for the optimisation of the design and operating programmes.\textsuperscript{15}

The comprehensive Probabilistic Risk Assessment (PRA) on the design and operation of the Plant, confirms that the PBMR meet NNR regulatory risk criteria as is reflected in Annexure 23.
Defence-in-Depth

Defence-in-Depth ensures that various independent barriers are established between the public and the radioactive material. These barriers may be physical or administrative, to ensure the safety of workers and the public.\(^\text{16}\)

ALARA

The design ensures that the dose that might be received by the operators, workers and the public as well as releases to the environment in normal operations and accident conditions, not only meets all regulatory limits but is also As Low As Reasonably Achievable (ALARA).\(^\text{17}\)

Radiation Protection Programme (RPP) for Normal Operation

The Radiation Protection Programme controls access to areas where radiation and/or radioactive contamination may be present. This is accompanied by a radiation protection monitoring programme to ensure that no worker will receive undue exposure to radiation and that only authorized radiation workers are allowed to work in controlled areas. A comprehensive plan protects personnel from excess exposure during maintenance activities.

The principle of ALARA is also embodied in the Radiation Protection Programme which specifies Radiation Protection (RP) limits and conditions. The operating procedures include measures to control the release of radiological materials (gaseous, liquid or solid) to minimise the radiological exposure to the plant personnel, general public and environment.\(^\text{18}\)

Test and Commissioning Programme

The objective of the Test and Commissioning Programme is to demonstrate that all Systems, Structures and Components (SSC) as well as materials will perform as designed. This programme ensures that any of the SSC and the Plant will operate safely in normal and accident conditions.

A pre start up commissioning programme will as far as possible test sub-system and systems components, prior to fuel loading.

\(^\text{16}\) SAR Rev 1, Chapter 1
\(^\text{17}\) SAR Rev 1, Chapter 1
\(^\text{18}\) SAR Rev 1, Chapter 1
Due to the specific design features of the PBMR, which exploit natural physical phenomena, the test and commissioning programme will ensure that the physical phenomena that have a unique application to the safety of the PBMR design, are adequately demonstrated on the module. Assurance is therefore provided that the assumptions made during design and analysis are valid.

**Operating Procedures**

The documentation in place to support the safe operation of the PBMR will be in the form of General Operating Rules (GOR). The GOR are interface documents between the PBMR plant design and the actual operating practices. They prescribe the operating rules, which ensures that the Plant stays within the envelope of its design bases, in any operating state, (normal or abnormal) and ensures that the main assumptions in the safety assessment, remain valid.

Annexure 17 authored by the PBMR (Pty) Ltd, provides more information on the GOR.

Adherence to the Plant operating procedures ensures that during normal operation, the plant remains within a domain of the design and licensing basis. Operating Technical Specifications (OTS) define the technical rules and regulatory requirements to be observed, in order to maintain the Plant within the licensing basis. They are developed to ensure that the assumptions in the design and analysis remain valid.

**Maintenance Programme**

A Maintenance Programme is developed to ensure that all the equipment required for the operation of the plant, remain available and reliable. The Programme includes appropriate control, monitoring and management systems, using preventive, predictive and corrective maintenance. The technical basis for the programme is founded on the Safety Case.

Assurance that there are adequate means to monitor the plant, and detect when the Plant is outside of its normal operating envelope, is obtained by establishing an appropriate test and surveillance programme.

An Emergency Plan, appropriate to the level of the nuclear hazard that the PBMR poses under abnormal or accident conditions, is established and prescribes the level of preparation required both on and off site.

**Support Programmes for the Safety Case**
Annexure 18 provides a summary of the support programmes for the Safety Case. This report was prepared by PBMR (Pty) Ltd and provides an explanation of how, and when the key principles of the Safety Case will be met in the licensing plan.

2.2.10 Security

**Access Control**

Site access control is enforced by means of a security fence, site access control, Plant access control, and restricting entry to designated security access points, where permits will be issued. Lock out systems and camera surveillance forms part of the security systems.

The proposed demonstration module PBMR will be located between the inner and outer security fence system on the existing Koeberg Site. In the longer term it is considered that the PBMR plant will function under similar security arrangements to existing Light Water Reactors (LWRs). To this end there is provision for on-shift security guards. The key differences between the PBMR and a standard LWR is that due to the physical layout there are less access points to enter the plant, with no external systems which are safety grade (i.e. systems which ensure the safe operation of the Plant). Therefore, given the 1m+ outer wall the only method of damaging the plant is to gain physical access, through the limited access points.

Prior to the loading of the nuclear fuel, further safety measures will be implemented. These are provided for in terms of the recommendations contained in this EIR and will further be addressed in the NNR Licensing process.

Before any nuclear fuel is brought onto site, it will be assured that adequate safety and security plans are in place and that the physical barriers such as fences, grates, doors, walls or ceilings are installed and functional, to deter and deny unauthorized access to the facility.

The following systems will be operational:

- Physical security systems.
- Nuclear fuel storage facilities.
- All safety-critical equipment interfaces.
- Material control and accountability areas.
- Non-interruptible power supplies.
Area monitoring systems such as lighting and communication.

Security surveillance, assessment, detection and alarm systems.

Vital areas and vital equipment.

Material access areas.

Safety and security interfaces.

Adequate safety and security personnel to continuously operate and monitor surveillance and assessment equipment.

Critical plant areas such as computer security areas are contained within clearly defined perimeter barriers and the means of access is limited to entry portals, which are controlled.

**AIRCRAFT CRASH AND TERRORIST ATTACK**

PBMR has investigated the events of an aircraft crash [Civil aircraft = Cessna 210; Military aircraft = German KTA (F4 Phantom @ 227km/hr) and Commercial aircraft = Boeing 777] or terrorist attack for inclusion in the design basis and produced a methodology to mitigate the release of radioactive material into the environment. The nuclear regulatory bodies will furthermore produce a design basis for such extreme events towards the end of 2002 and this methodology will then be expanded to provide for any additional design requirements.

The adequacy of these measurements are judged from a nuclear safety point of view, irrespective the potential economic damage to the plant caused by sabotage or aircraft impact and subsequent aviation fuel fire to ensure that the structural integrity of the Reactor Pressure Vessel and its fuel inventory are maintained during and after the event.

The double barrier, reinforced concrete structure surrounding the Reactor Cavity, together with the encasement of the fuel spheres within the Reactor Pressure Vessel and the Core Barrel ensure that the principle of Defence in Depth, is applied. A further level of protection is provided by the containment of the radioactive fuel elements within the fuel spheres.

The module building, which comprises the entire structure that houses the power plant and its ancillary systems, is designed to withstand significant external forces such as aircraft impacts and tornadoes. It is also highly resistant to explosions from potential saboteurs. The thickness of the reinforced concrete roof and walls (above ground level) of this structure is 1m.

Within the module building, is the reinforced concrete containment or citadel that
that encloses the Reactor Pressure Vessel (RPV) and the Power Conversion Unit (PCU). The thickness of the walls surrounding the RPV is 2.2 m. The PCU comprises the high- and low-pressure turbo-units, power turbine generator, a recuperator and coolers.

The citadel is a vented containment which is normally closed to the external environment and operates at lower than atmospheric pressure. It is similar in design and function as the secondary containment structures for Boiling Water Reactors. Any increase in pressure within the containment due to a range of breaches in the primary pressure boundary, is relieved by venting to atmosphere. Small leaks can be vented by means of the heating, ventilating and air conditioning (HVAC) system.

Medium to large leaks or breaks are vented through a dedicated pressure relief shaft to atmosphere. The design of the pressure relief shaft is such that quick acting valves close to protect the HVAC system. In addition, a rupture panel in the depressurisation route opens at a pre-determined pressure, thereby allowing the gas to escape to atmosphere.

After release of the excess pressure, the shaft is closed automatically by a damper mechanism. A manual back-up closure mechanism is provided should this damper fail to operate. After closure of the pressure relief shaft, the building integrity is restored and the HVAC is allowed to resume the conditioning of the environment inside the containment and return it to a sub-atmospheric pressure.

Any radioactive release that occurs during the venting of the high-pressure helium would be significantly below the levels allowed by regulations. This is because the amount of radioactivity that could be released is equal to the amount in the helium system at the time of the release. The amount of radioactivity in the helium is continuously monitored during plant operation and limited by the plant operating license.

If these limits were to be approached, the plant would be required to shutdown before they were exceeded. Unlike a light water reactor which continues to build up pressure due to the generation of steam after it is shutdown and thus provides a driving force for the release of further radioactivity, the PBMR does not continue to build up pressure after the helium has been released. This means that there is no driving force for the release of radioactivity after the initial pressure release.

Once the pressure in the Citadel is relieved and the vent closed again, there would be no significant pressure build-up within the building and no further releases.
2.2.11 Graphite Fire

- **Likelihood**

  A free flow of air through the reactor is needed for a self-sustaining fire to occur. This requires the vessel head to be breached as well as a breach at the bottom of the structure and a failure of the citadel (to allow air in). The design target is such that no event can lead to this level of damage.

  What can occur is a graphite corrosion event caused by a single hole in the primary circuit leading to a mixing of air and helium. Under these conditions (given a breach in the citadel), there can be a steady influx of air into the core at a rate that cannot sustain a “fire”. The high temperature of the core from nuclear decay heat can, however, result in corrosion of the graphite at a slow rate (less than 1% per day at current estimates).

  Due to the helium expansion resulting from core heat-up, it will take more than two days before air can physically enter the core.

- **Consequence**

  If the air ingress event occurs, it forms a corrosion front at the point where the graphite exceeds the oxidation temperature of graphite (about 700 degrees C), which is a long way from the point of the core where the temperature of the fuel causes damage to uncovered SiC particles (1200+ degrees C). Under these conditions, it is expected that the upper limit for core radioactive release is ~10e-6 per day, once the condition stabilizes after about 1-2 days. This would be a very limited release.

- **Response**

  An air ingress event (and any associated release) can be terminated by any of the following actions:

  - Closing up the breach in the primary circuit
  - Closing the citadel opening
  - Cooling the core below the temperature of concern

- **Safety view**

  The PBMR design standards in this area are sufficient and currently exceed those of previously operating High Temperature Gas Reactors. At the time of Chernobyl, there were HTGRs operating in both the US (Fort Saint Vrain) and
Germany (THTR and AVR) and in both countries the issue of air ingress was accepted not to have a significant impact.

 Experience

There have been a number of events in gas-graphite reactors (Wind scale, St Laurent, Wyfla, Chernobyl) where graphite fires have been implicated. The actual evidence to date indicates that there was no case of serious graphite corrosion except Chernobyl, where the fire was kept alight by asphalt from the roof flowing into the core.

2.2.12 Solid Waste Management, Spent Fuel and Nuclear Waste

A Waste Management Programme ensures that the generation of radioactive waste is minimised throughout the lifecycle of the plant. The Programme provides rules for the processing, conditioning, handling and storage of radioactive waste which limits the radiological doses to the plant personnel, the general public and the environment.

In addition to demonstrating that the reactor will be safe in terms of meeting good design and operational requirements and will comply with the risk and radiation dose criteria as described in Table 1, the applicant must also show that the radioactive waste arising from the operation and decommissioning of the reactor will be safely managed. All sources of waste must be identified and characterised. The design must provide for collecting and treating the wastes, for control over effluent discharge, and for safe storage of waste at the facility.

During the operational life of the plant no spent fuel needs to be removed from the site as the PBMR system has been designed to deal with nuclear waste with minimum risk to the worker. Sufficient tank storage for spent fuel spheres will be available for the 40-year life of the plant. After the plant has been decommissioned (permanently shut down), the spent fuel can remain on site. Longer storage allows for the residual heat generated by the fuel and radioactivity of the spent fuel, to decreased. The South African government is developing a national nuclear waste management policy and strategy that will determine the final disposition of radioactive High Level Waste (HLW) (Annexure 4). Should a HLW repository not be available after 80 years, the storage facility on site (or elsewhere) will have to be upgraded and refurbished to store and manage such fuel and other HLW for a further extended period (e.g. 40 years).

Extension of the Plant’s life beyond its 40 years of design life is not considered at this stage. However, should this become a consideration in later years, then such modification(s) as may be required, will become subject to a new application in terms of the Environment Conservation Act (Act No. 73 of 1989) and future amendments...
amendments thereto.

The PBMR requires infrequent maintenance, which ensures that the amount of low and intermediate waste produced is limited. The low and intermediate waste will be dealt with in the same manner as that from Koeberg. That is, it will be stored in steel drums that conform to international standards and disposed of at the National Radioactive Waste Repository Site at Vaalputs in the Northern Cape. Management of radioactive waste will be enforced on site by Eskom and nationally by the National Nuclear Regulator (NNR) which are based on International Atomic Energy Agency (IAEA) guidelines/standards.

There is no intention to reprocess the spent fuel, because of the very high burn-up of uranium in the fuel spheres (i.e. very little residual fuel) and the very high cost of reprocessing.

Management measures and controls will be implemented for the storage and handling of each waste stream, as described below.

- **Waste Management**

  The annual generation of each radioactive waste type and its radio nuclides content has been estimated for the operational period. Measures to control the generation of the waste, in terms of both volume and activity content have been considered through:

  - The selection of appropriate materials used for the construction of the facility.

  - The selection of appropriate waste management processes and equipment.

  - The selection of appropriate design features in the SSC\(^{19}\) and its layout in order to aid in the optimisation of waste generation during operation as well during decommissioning with the aim to return the site back to a greenfield state.

  The Waste Handling System (WHS) has been defined as one of the auxiliary systems that support the power generation process to handle and store all low- and medium-level radioactive waste generated during normal operation, maintenance activities, upset conditions and during the decommissioning period of the plant.

  The WHS\(^{20}\) consists of three subsystems, namely:

\(^{19}\) SSC = Systems, Structures and Components  
\(^{20}\) WHS = Waste Handling System
Gaseous waste handling system.

Solid waste storage and handling system.

Liquid waste storage and handling system.

Gaseous waste handling

The release of gaseous activity from the plant has been based on the loss of 0.1% of the volume of the primary helium containing systems per day. The concentration of activity in the gas was derived from values calculated for the HTR-Modul, which in turn was based on the AVR experience.

All releases are routed via the reactor building ventilation system and released at a height of 20 m above ground level and the dilution factors are specific to the design of the ventilation system.

Table 2 presents a conservative estimate of the annual gaseous radioactive release rates from the Module into the surrounding air.

<table>
<thead>
<tr>
<th>Radio nuclide</th>
<th>Annual Activity Release (Bq per year) per Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noble gases</td>
<td>$4.4 \times 10^{11}$</td>
</tr>
<tr>
<td>Argon 41</td>
<td>$8.0 \times 10^{12}$</td>
</tr>
<tr>
<td>Iodine 131</td>
<td>$1.5 \times 10^{7}$</td>
</tr>
<tr>
<td>Sum of long-lived aerosols (half-life &gt;10 d): Co-60, Ag-110m, Cs-134, Cs-137, Sr-90</td>
<td>$2.4 \times 10^{7}$</td>
</tr>
<tr>
<td>Tritium</td>
<td>$5.4 \times 10^{12}$</td>
</tr>
<tr>
<td>Carbon 14</td>
<td>$3.2 \times 10^{11}$</td>
</tr>
</tbody>
</table>

Any controlled or uncontrolled releases of gaseous or radioactive waste from within the building are handled by the HVAC system, whereby the extraction air system ensures that the gaseous waste is expelled to the atmosphere via the filtration system.

Solid waste handling and storage system

The solid waste generated during the normal operation, upset conditions and decommissioning of the plant will consist of:
- Clothing.
- Cleaning materials.
- Unserviceable contaminated and activated SSC.
Contaminated replaceable parts such as filters (compressible and non-compressible).

Residue from decontamination activities.

Residue from the analytical laboratory.

The annual volume of solid LLW and ILW produced by a single module, assuming a compaction ratio of 5:1, is estimated to be approximately 10 m$^3$ consisting of 50 x 210 litre drums which are qualified to IP-2 and approved to carry SCO-2 or LSA-2 radioactive material (as defined in IAEA Safety Series 6). Where the waste cannot be compacted or drummed in the 210-liter drums due to activity or dose rate or physical size, suitable containers will be used. The use of concrete containers is not envisaged.

The compacting press as well as the waste in the steel drums, accumulated over a period of three years, will be stored in a low-level waste store in the module building.

The cost per drum in South Africa is approximately US$75.00 (including labour for handling and compaction) and US$25.00 for transportation, which equates to US$15 000 per three-year period and US$200 000 over the 40 years of operations.

At the end of three years, the total volume will be shipped to the Vaalputs facility. All shipments will be required to comply with the IAEA guidelines and the NECSA acceptance criteria for storage at the Vaalputs facility under their control.

HLW will be retained and managed on site in purpose designed holding tanks. These tanks have sufficient capacity for the design life of the Plant (i.e. 40 years).

Liquid waste handling and storage system

Liquid waste generated during the operational activities of the plant will be drained or pumped, depending upon the origin of the liquid and the position of the collecting tanks, to a central collecting, chemical dosing and storage area in the module building.

The level of radioactivity, radioactive nuclide content and chemical composition of the liquid will be measured and treated (chemically and otherwise) in order to render the effluent suitable for discharge to the environment.

Only treated liquid releases will be diverted to the seawater discharge of the KNPS. The design will ensure that all releases to the environment are controlled.
and monitored. The impact on the KNPS releases will be minimal, i.e. they will not impact on Koeberg’s ability to comply with the Annual Authorized Discharge Quantities (AADQ).

Table 3 presents an estimate of the rate at which solid and liquid radioactive waste will be produced in the facility, and the handling procedures.
### Table 3: Estimated Radioactive Solid and Liquid Waste Produced in the PBMR Plant

<table>
<thead>
<tr>
<th>No.</th>
<th>Waste Type</th>
<th>Activity Level</th>
<th>Activity</th>
<th>Sources</th>
<th>Approach</th>
<th>Waste Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solid</td>
<td>Low</td>
<td>Not applicable</td>
<td>Health Physics (Maintenance activities and clothing, e.g. booties, gloves etc.)</td>
<td>Compacted, steel drummed and stored temporarily in module or service building. It will be transported to a permanent storage facility (Vaalputs) at 3 years intervals.</td>
<td>All solids total 50 x 210 litre drums per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
<td>Not applicable</td>
<td>Decontamination facility</td>
<td>Compacted, mixed with concrete, drummed and stored temporarily in module or services building. At 3 year intervals, it will be transported to a permanent storage facility at Vaalputs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liquid</td>
<td>Low</td>
<td>Active</td>
<td>Decontamination facility and laboratory.</td>
<td>Will be stored in purpose designed monitoring tanks before treatment and/or release to the environment.</td>
<td>480 m³ per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Possibly Active</td>
<td>Low</td>
<td>Showers (emergency and health physics) and washrooms</td>
<td></td>
<td>100 m³ per year</td>
</tr>
<tr>
<td></td>
<td>Liquid</td>
<td>Low</td>
<td>Possibly Active</td>
<td>Sump system</td>
<td>The main sources for the sump waste are the HICS, PLICS and HVAC systems.</td>
<td>Will be stored in purpose designed monitoring tanks before treatment and/or released to the environment.</td>
</tr>
</tbody>
</table>
SECTION 2: ASPECTS OF THE PROPOSED ACTIVITY

2.3 INTRODUCTION

To provide an overview of the life cycle impacts (potential and real) of the proposed Plant, inputs and outputs were developed for each life cycle phase. These are presented below in tables and text. The in- and output tables, in turn, were used to develop the impact tables for each of the life cycle phases.

2.4 SUPPLEMENTARY INFORMATION ON INPUTS AND OUTPUTS OF THE PROPOSED ACTIVITY²¹

2.4.1 INPUT DATA

❖ Nitrogen/Helium

❖ Nitrogen for installation and commissioning period

For the initial clean up and commissioning nitrogen gas rather than helium gas will be used due to the cost of helium gas.

Approximately 1 000 kg nitrogen is required for the initial clean up of the MPS²² and gas systems. For completion of the installation and commissioning period the demonstration module will require an additional 3 576 kg of nitrogen.

❖ Helium for normal operations

The expected helium loss during normal operations is specified as 0.1% of inventory per day. The inventory is approximately 7 290 kg and the helium loss is approximately 2 661 kg per year. The inventory loss is based on the THTR/HTR specification, although less inventory loss was experienced. Actual loss will be determined during operation.

❖ Helium for planned outages

During each sixth year planned outage, a helium loss of approximately 898 kg is expected. An additional 250 kg is required during the outage when the core reflector is replaced.

²¹ Source: PBMR (Pty) Ltd – DFR and SAR Rev 1
²² MPS = Main Power System
Graphite spheres

The central graphite column in the reactor will be replaced once in about 20 years of the plant's life. A total of 110,000 graphite spheres will be removed from the graphite storage tank to replace those in the central column. The spheres removed from the storage tank will have to be replaced to maintain the de-fuelling capability.

The usage of graphite spheres due to normal wear and maintenance activities is expected to be about 3,000 spheres over the life of the plant.

New Fuel Spheres

The Fresh Fuel Storage Area is designed to store six months' supply of fresh fuel, i.e. approximately 70,000 fresh fuel spheres.

The Spent Fuel Storage Area in the basement of the building will provide storage space for all the spent fuel produced during the lifetime of the reactor, which is 35 Full Power Years (FPY). This amounts to about $6.0 \times 10^6$ spent fuel spheres. The spent fuel spheres will be stored in 10 Spent Fuel Storage Tanks.

Only two of the 10 Spent Fuel Tanks will be in operation at any given time. Spent fuel is loaded in daily batches into the two tanks, until the tanks are full. Thereafter, the tanks will be sealed and the next pair of tanks is brought into operation. A total of about 425 spheres are loaded into the tanks per Full Power Day (FPD).

Demineralised water

The initial filling of the module's closed water circuits will be obtained from Koeberg and transported in tankers. Approximately 500 m³ of demineralised water will be required for the first fill.

For make-up water, decontamination and other cleaning processes, demineralised water at an average of 10 m³ per month is required.

Potable water system

During normal operation, the volume of potable water required per month is indicated in Table 4.

<table>
<thead>
<tr>
<th>Plant Configuration</th>
<th>Normal Operation Potable Water Consumption (m³/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Services &amp; auxiliary buildings + 1 module</td>
<td>200</td>
</tr>
</tbody>
</table>

During an outage about 50 m³ of water per day is required.
Foundation conditions

Ideally, any PBMR plant should be built on sound bedrock. In the case of this site, drilling results show that such bedrock exists at a depth of some 20 to 22 m below ground level. This is particularly appropriate for the PBMR, since the design of the plant is such that it ideally requires to be embedded to a depth of some 22 to 25 m.

The information regarding foundation conditions, was confirmed by information gathered during the construction of the Koeberg NPS.

Excavation conditions

Drilling results at the proposed site have shown that the local water table is some 5 m below ground level. Since the site is immediately adjacent to the Atlantic Ocean and about 8 meters above sea level, it must be assumed that during the excavation process, continuous dewatering of the area will be required via pumping. This dewatering will continue during construction, until such time as the building’s walls have reached ground level and backfilling of the excavation is completed. Thereafter the groundwater level will be left to resume normal levels.

Except for the bottom one or two meters of partially fractured rock the material to be excavated will be compacted sand.

No decisions have been made on methods of limiting water ingress to the excavation, or to the excavation methodology to be used. These are dependent on the evaluation of proposals to be received from civil engineering contractors and will be environmentally managed to acceptable levels in the EMP.

Site access

Access to the proposed site would be via the existing normal access routes to Eskom's KNPS, i.e. via the R27 Highway from the directions of either Cape Town or Saldanha Bay. Although a private Eskom owned road from Duynefontein to Koeberg exists, traversing through the Koeberg Nature Reserve, this route would be designated as off-limits to construction traffic, to and from the PBMR site.

Shipments of equipment of normal mass for the demonstration plant would be imported via Cape Town harbour. In the case of components of extreme mass, route studies have shown that several of the road bridges between Cape Town harbour and the proposed site could not handle these loads. It is therefore proposed that these abnormal components be imported via Saldanha Bay harbour and transported to site by road via the R27 Highway. Surveys of this route show that that there is only one highway bridge, which would not be capable of handling the loads. The bridge can be bypassed via a temporary road.
Availability of cooling water

It has been established that the cooling water supply for the demonstration plant will be taken from Koeberg’s cooling water pump house, and that the heated water from the demonstration plant will be routed into Koeberg’s thermal water discharge channel. This will result in PBMR not having to build new water intake and discharge structures, with a resultant considerable cost saving. Piping connections between the Plant and the Koeberg structures will, however, have to be provided.

Availability of labour

Skilled labour is readily available in surrounding towns such as Atlantis, some 25 km from the site. Unskilled labour is readily available from any number of the townships surrounding Cape Town. In both cases, the mass transporting of this labour to and from site by PBMR contractors will be essential.

Availability of local nuclear infrastructure

Being immediately adjacent to Eskom's KNPS, the proposed site of the demonstration Plant is ideal from a nuclear infrastructure point of view. Although it is planned that the demonstration plant will run independent of Koeberg, it will use some of Koeberg’s facilities, such as Radiation Medicine and to some extent, the decontamination facilities.

Impact on 400m exclusion zone

The PBMR requirement for a 400 m radius exclusion zone around the demonstration Plant will have no additional effect on adjacent land use, since the entire area defined by such a radius falls well within Koeberg’s existing and much larger exclusion zone.

Employment

During construction about 1 400 job opportunities will be created with emphasis on local recruitment. During operations about 40 permanent employees will be required to operate the proposed Plant.

2.4.2 OUTPUT DATA

Sewerage system

The sewerage requirements for the demonstration plant are catered for by the existing Koeberg sewerage reticulation system. The sewerage flow is estimated at 140 m³ per month.

The expected sewerage effluent is as indicated in Table 5.
Table 5: Average Sewerage Effluent

<table>
<thead>
<tr>
<th>Plant Configuration</th>
<th>Average Estimated Sewerage Effluent (m³/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Services &amp; auxiliary buildings + 1 module</td>
<td>140</td>
</tr>
</tbody>
</table>

Local authority garbage/refuse disposal

The average volume of garbage/refuse on site is as indicated in Table 6:

Table 6: Average Volume Of Garbage Removal

<table>
<thead>
<tr>
<th>Plant Configuration</th>
<th>Compacted Average Estimated (m³/month)</th>
<th>Non-compactated Average Estimated (m³/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Services &amp; auxiliary buildings + 1 module</td>
<td>3.6</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Ultimate heat sink

The demonstration plant’s ultimate heat sink system will be interfaced with the existing KNPS seawater basin. The seawater temperature at Koeberg is 18 °C (weighted maximum average).

For a constant heat load of 158 MW for the module, a main closed circuit water flow rate of 1 300 litres per second, a closed circuit heat exchanger inlet water temperature of 50 °C, and a closed circuit heat exchanger outlet temperature of 21 °C, sea water at a rate of 1 700 litres per second is required. The seawater outlet temperature is 40 °C at this rate.
2.5 INPUT/OUTPUT TABLES FOR THE VARIOUS LIFE CYCLE PHASES

Table 7 to Table 11 provide the inputs and outputs for the various life cycle phases. The inputs and outputs provided, represent the more important (significant) ones for the identification of impacts.
2.5.1 **Construction Phase: Input/Output Diagramme**

**Table 7:** Construction Phase: Input/Output Parameters (Duration About 24 Months)

The site for the proposed Plant is located on a previously disturbed area some 400 meters south east of Koeberg Nuclear Power Station. The site falls within the outer security fence of the Koeberg NPS. No pristine fynbos will be disturbed and proper access roads as well as security fencing and access control facilities exist:

<table>
<thead>
<tr>
<th>INPUT</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DIRECT</strong></td>
<td><strong>DIRECT</strong></td>
</tr>
<tr>
<td>- Construction Activities</td>
<td>- Spoil material</td>
</tr>
<tr>
<td>- Excavations</td>
<td>- Effluent</td>
</tr>
<tr>
<td>- Dewatering</td>
<td>- Dewatering</td>
</tr>
<tr>
<td></td>
<td>- Construction, and</td>
</tr>
<tr>
<td></td>
<td>- Sewage</td>
</tr>
<tr>
<td></td>
<td>- Waste</td>
</tr>
<tr>
<td></td>
<td>- Construction</td>
</tr>
<tr>
<td></td>
<td>- Domestic</td>
</tr>
</tbody>
</table>

- Building materials and construction machinery
- Capital
- Jobs
  - Construction
  - Component manufacture
- Plant and equipment
- Housing
- Professional, commercial and social services (e.g. medical, schools, banking, postal, telecoms, shops, potable water, emergency services, road etc.)
- Transmission upgrades

**CONSTRUCTION OF MODULE**

- Noise from construction activities
- Emissions/dust
- Stimulation of local/regional economy (temporary)
- Communicable disease
- Increased traffic
- Complete module
2.5.2 **COMMISSIONING PHASE: INPUT/OUTPUT DIAGRAMME**

**Table 8: Commissioning Phase Input/Output Parameters (Duration ± 6 Months)**

A two stages commissioning procedure will be followed, namely:

- **Cold Commissioning**: The Plant will be run without any nuclear fuel. This procedure will test the integrity and functionality of the various structures, system and components to the extent for positive non-power conditions.

- **Hot Commissioning**: The Plant is loaded with nuclear fuel and the nuclear reaction is initiated. Thereafter the Plant is monitored in various modes, to assess the systems, and components and techno-economics.

<table>
<thead>
<tr>
<th>INPUT</th>
<th>OUTPUT</th>
</tr>
</thead>
</table>
| **COLD COMMISSIONING** | **COMMISSIONING PHASE**  
Note: Plant is run without nuclear fuel |
| Nitrogen Gas | Emissions (Nitrogen) |
| Energy (Electricity) | Hot (Thermal) effluent |
| Sea Water (Cooling) | Domestic effluent |
| Potable Water | Solid waste (domestic) |
| Emissions (Nitrogen) | |
| Labour (skilled) | |

<table>
<thead>
<tr>
<th>INPUT</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HOT COMMISSIONING</strong></td>
<td></td>
</tr>
<tr>
<td>Helium Gas</td>
<td>Helium emissions</td>
</tr>
<tr>
<td>Energy (Nuclear fuel)</td>
<td>Radioactive emissions,</td>
</tr>
<tr>
<td>Graphite spheres</td>
<td>Effluent and solid waste</td>
</tr>
<tr>
<td>Sea Water</td>
<td>- Radiological</td>
</tr>
<tr>
<td>Potable Water</td>
<td>- Non-radiological</td>
</tr>
<tr>
<td>Labour</td>
<td>- Thermal</td>
</tr>
</tbody>
</table>
2.5.3 Operational Phase: Input/Output Diagramme

Table 9: Operational Phase Input/Output Parameters (Duration 40 Years)

The in- and outputs of this phase resembles that of the Hot Commissioning phase except for the quantum of in- and outputs

<table>
<thead>
<tr>
<th>INPUT</th>
<th>OPERATIONAL/Maintenance Phase</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear fuel</td>
<td></td>
<td>• Electricity (Sales)</td>
</tr>
<tr>
<td>Graphite spheres</td>
<td></td>
<td>• Spent fuel</td>
</tr>
<tr>
<td>Helium gas</td>
<td></td>
<td>• Emissions (helium)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Radioactive waste</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Gaseous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Liquid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Solid (filters, clothing)</td>
</tr>
<tr>
<td>Sea Water</td>
<td></td>
<td>• Domestic Waste</td>
</tr>
<tr>
<td>Potable Water</td>
<td></td>
<td>- Solid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Liquid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Redundant parts/Components</td>
</tr>
<tr>
<td>Labour</td>
<td></td>
<td>• Thermal Effluent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finance</td>
<td></td>
<td>• Data on radiological effects on staff and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>environment</td>
</tr>
<tr>
<td>Institutional Support</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.g. NNR, Eskom, local</td>
<td></td>
<td></td>
</tr>
<tr>
<td>authorities, contractors, provincial authorities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(schools, health, education, etc) professional services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replacement parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Non-Radiological</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Radiological (e.g. filters)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphite column of the reactor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring of Environment &amp; Staff</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.5.4 **DECOMMISSIONING PHASE: INPUT/OUTPUT DIAGRAMME**

**Table 10**: Decommissioning Phase : Input/Output Parameters (Duration About 1 Year)

- Reduced services are provided during the decommissioning phase
- Detailed plans and options are developed for the dismantling of the Plant

<table>
<thead>
<tr>
<th>INPUT</th>
<th>DECOMMISSIONING PHASE (about 1 year)</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling Water</td>
<td></td>
<td>• Spent fuel (final load out)</td>
</tr>
<tr>
<td>Environmental Monitoring</td>
<td></td>
<td>• Radiological waste - Solid</td>
</tr>
<tr>
<td>Labour</td>
<td></td>
<td>• (LLRW &amp; ILRW) - Liquid</td>
</tr>
<tr>
<td>- Security</td>
<td></td>
<td>• Data on environmental quality</td>
</tr>
<tr>
<td>- Professional</td>
<td></td>
<td>• Retrenchment/pensioned/re-employed staff</td>
</tr>
<tr>
<td>Finance</td>
<td></td>
<td>• Redundant equipment/components/parts</td>
</tr>
<tr>
<td>Energy (Electricity)</td>
<td></td>
<td>• Domestic waste</td>
</tr>
<tr>
<td>Replacement parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean-up of MPS &amp; Reactor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note**: The Design of the Plant is such that it can safely remain in idle state for a prolonged period while radioactive wastes decay

| LLRW | = Low Level Radioactive Waste |
| ILRW | = Intermediate Level Radioactive Waste |
2.5.5 **Dismantling Phase: Input/Output Diagramme**

**Table 11**: Dismantling Phase: Input/Output Parameters (Duration 1 – 2 Years)

- This phase will entail the removal of all equipment (radiological and non-radiological)
- Only essential equipment and services will remain in order to manage the security and safety of the spent fuel
- This phase resembles the Construction Phase in the reverse e.g. equipment is removed, irradiated parts are decontaminated and building structures are demolished as needed and disposed of.

<table>
<thead>
<tr>
<th>INPUT</th>
<th>Dismantling Phase</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td></td>
<td>Domestic Waste</td>
</tr>
<tr>
<td>Finance</td>
<td></td>
<td>Radiological (LLRW &amp; ILRW) and construction waste</td>
</tr>
<tr>
<td>Construction Activities</td>
<td></td>
<td>Dust and Noise</td>
</tr>
<tr>
<td>Construction Equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy (Electricity)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Monitoring</td>
<td></td>
<td>Data on environmental quality</td>
</tr>
</tbody>
</table>

Note: The spent fuel components can be maintained for a prolonged period after decommissioning, even if the final deposition High Level Radioactive Waste (HLRW) repository is not available.
SECTION 3: ANTICIPATED IMPACTS OF THE PROPOSED ACTIVITY

2.6 IMPACTS RELATED TO THE INPUT/OUTPUTS OF THE LIFE CYCLE PHASES

Section 2 summarise the inputs and outputs for each phase of the Plant’s life. The in- and output tables, in turn, were used to develop the impact tables, Table 12 to Table 16 for each of the life cycle phases.

These impacts are evaluated and assessed for their effects on the affected (receiving) environment in Chapter 4.
### Table 12: Construction Phase: Input/Output Related Impacts (Duration 24 Months)

<table>
<thead>
<tr>
<th>Input</th>
<th>Impact</th>
<th>Output</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>Stockpiling of spoil material</td>
<td>Displacement of fauna &amp; flora (f &amp; f)</td>
<td></td>
</tr>
<tr>
<td>The module</td>
<td>Surface disturbance and displacement of fauna and flora.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service trenches</td>
<td>Temporary displacement of fauna and flora (f &amp; f)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dewatering of excavation until Module construction has advanced to surface level</td>
<td>Temporary localised change in water table depth</td>
<td>Saline effluent released to the sea</td>
<td>Nil</td>
</tr>
<tr>
<td>Building materials supplied from commercial sources</td>
<td>Accelerated production at mines/supply sources</td>
<td>Increased traffic</td>
<td>Risk of accidents</td>
</tr>
<tr>
<td>Construction equipment</td>
<td>Capital expenditure, employment</td>
<td>Construction works</td>
<td>Temporary disruption of the biophysical environment</td>
</tr>
<tr>
<td></td>
<td>Energy expenditure</td>
<td></td>
<td>Construction waste &amp; Domestic waste</td>
</tr>
<tr>
<td></td>
<td>Noise, dust and emissions and maintenance waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital</td>
<td>Stimulation of economy on a local to international level</td>
<td>Completed module</td>
<td>Visual (aesthetics)</td>
</tr>
<tr>
<td>Employment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>Housing requirements</td>
<td>Temporary/Permanent stimulation of economy</td>
<td>Communicable disease.</td>
</tr>
<tr>
<td></td>
<td>Service requirements (materials, water sewage, telecoms, energy, schools, health etc.). Emergency Plan (EP) for Koeberg.</td>
<td>Improved levels of income</td>
<td>Capacity of service provides and facilities e.g. Authorities, professional and commercial capabilities</td>
</tr>
<tr>
<td>Component manufacturing</td>
<td>Localised construction activities</td>
<td>Change to Koeberg Emergency Plan</td>
<td></td>
</tr>
<tr>
<td>Transmission upgrades</td>
<td>Linkage to the national grid for supply and demand</td>
<td></td>
<td>Stimulation of the local/regional economy.</td>
</tr>
</tbody>
</table>


### Table 13: Commissioning Phase: Input/Output Related Impacts (Duration ±6 Months)

<table>
<thead>
<tr>
<th>Input</th>
<th>Impact</th>
<th>Output</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Commissioning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen gas</td>
<td>Nil</td>
<td>Assurance MPS integrity assurance</td>
<td>Nitrogen Helium emissions</td>
</tr>
<tr>
<td>Energy (Electricity)</td>
<td>Use of energy for non production</td>
<td>Operate the turbo compressor(s) and drive the helium cycle.</td>
<td>Nil</td>
</tr>
<tr>
<td>Sea water</td>
<td>Nil</td>
<td>Thermal sea water @1.7m/ s and a delta temp of ≤40°C</td>
<td>Hot water plume within the near shore marine environment that may affect the F &amp; F.</td>
</tr>
<tr>
<td>Potable water</td>
<td>Use of additional fresh water resource(s)</td>
<td>Water for human consumption and use; Water for the intermediate cooling cycle &amp; Demineralised water.</td>
<td>Effluent Domestic</td>
</tr>
<tr>
<td>Labour</td>
<td>Increased levels of permanent employment</td>
<td>Increase in income and stimulus to local economy</td>
<td>Increased demands on local services and facilities (professional, commercial and authority capacities)</td>
</tr>
<tr>
<td>Hot Commissioning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel spheres</td>
<td>Special safety and security measures for fissile material.</td>
<td>Heat that is employed to generate electricity.</td>
<td>Spent fuel that contains HLRW. Radioactive waste LLW &amp; ILW</td>
</tr>
<tr>
<td>Graphite</td>
<td>Nil</td>
<td>Moderation to the nuclear fission reaction</td>
<td>Radioactive waste LLW &amp; ILW</td>
</tr>
<tr>
<td>Helium Gas</td>
<td>International purchases of Helium gas.</td>
<td>Reactor coolant and turbine drive fluid</td>
<td>Helium emissions</td>
</tr>
<tr>
<td>Impacts 3, 4 &amp; 5 above</td>
<td></td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>Protective Clothing/Equipment Replacement parts</td>
<td>Nil</td>
<td>Radioactive Waste emissions, Effluents, Solid Wastes</td>
<td>Radioactive and inert wastes</td>
</tr>
</tbody>
</table>
**Table 14: Operational Phase: Input/Output Related Impacts (Duration ± 40 Years)**

<table>
<thead>
<tr>
<th><strong>Input</strong></th>
<th><strong>Impact</strong></th>
<th><strong>Output</strong></th>
<th><strong>Impact</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear fuel spheres</td>
<td>Safety (radiological) and security</td>
<td>Heat that is converted to produce electricity.</td>
<td>Spent fuel</td>
</tr>
<tr>
<td>Graphite</td>
<td>Nil</td>
<td>Moderation of the nuclear reaction</td>
<td>Radioactive waste</td>
</tr>
<tr>
<td>Helium Gas</td>
<td>Outflow of currency since it due to importation</td>
<td>Reactor coolant and medium to drive the turbine generator.</td>
<td>Gaseous emissions (Helium) Production of electricity</td>
</tr>
<tr>
<td>Sea water</td>
<td>Nil</td>
<td>Thermal sea water @ 1.7 m³/s at a delta temperature of 40°C.</td>
<td>Hot water plume in the near shore marine environment that may affect the fauna and flora</td>
</tr>
<tr>
<td>Potable water</td>
<td>Additional use of fresh water resources</td>
<td>Water for human consumption and use Water for the intermediate cooling cycle &amp; demineralised /decontamination water.</td>
<td>Domestic effluent Radioactive effluents</td>
</tr>
<tr>
<td>Labour</td>
<td>Increased levels of permanent employment</td>
<td>Increase in income and stimulus to local economy</td>
<td>Increased demands on local services and facilities (professional, commercial and authority capacities).</td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filters</td>
<td>Expenditure</td>
<td>Replaced filters will contain radioactive substances LLW &amp; ILW that require management and security</td>
<td></td>
</tr>
<tr>
<td>Replacement Parts</td>
<td>Expenditure</td>
<td>Scrap (radioactive and non-radioactive)</td>
<td></td>
</tr>
<tr>
<td>Environmental monitoring</td>
<td>Nil</td>
<td>Data on Environmental quality</td>
<td>Assurance on public/ environmental safety</td>
</tr>
</tbody>
</table>
Table 15: Decommissioning Phase: Input/Output Related Impacts (Duration About 1 Year)

<table>
<thead>
<tr>
<th>Input</th>
<th>Impact</th>
<th>Output Direct</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (Electricity)</td>
<td>Non productive use of energy</td>
<td>Operation of the cooling system for the spent fuel</td>
<td>Expenditure</td>
</tr>
<tr>
<td>Sea Water</td>
<td>Nil</td>
<td>Indirect cooling of the spent fuel storage area</td>
<td>Thermal outflows to the sea</td>
</tr>
<tr>
<td>Labour (reduced)</td>
<td>Employment loss</td>
<td>Retrenched/pensioned/redeployed staff</td>
<td>Local economics may/can suffer</td>
</tr>
<tr>
<td>Finance</td>
<td>Non productive expenditure</td>
<td>Safeguarding society against nuclear accidents</td>
<td>Assurance to public safety</td>
</tr>
<tr>
<td>Replacement parts</td>
<td>Expenditure</td>
<td>Securing the integrity of the Plant</td>
<td>Assurance to public safety &amp;</td>
</tr>
<tr>
<td>Environmental Monitoring</td>
<td>Nil</td>
<td>Securing environmental data on environment and</td>
<td>Assurance on public/ environmental safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td>human health</td>
<td></td>
</tr>
</tbody>
</table>
### Table 16: Dismantling Phase: Input/Output Related Impacts (Duration 1 – 2 Years)

<table>
<thead>
<tr>
<th>Input</th>
<th>Impact</th>
<th>Output</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>Non productive use of energy</td>
<td>Operation of coolant systems for the spent fuel storage area</td>
<td>Expenditure</td>
</tr>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Fuels</td>
<td>Expenditure</td>
<td>Operation of construction equipment</td>
<td>Emissions</td>
</tr>
<tr>
<td>Labour</td>
<td>Influx of people to the area</td>
<td>Temporary stimulation of the economy</td>
<td>Capacity of services</td>
</tr>
<tr>
<td>Construction equipment</td>
<td>Expenditure</td>
<td>Dismantling of equipment and building structures</td>
<td>Noise, dust, emissions, waste (non &amp; irradiated)</td>
</tr>
<tr>
<td>Sea water (cooling)</td>
<td>Nil</td>
<td>Indirect cooling of the spent fuel storage area</td>
<td>Thermal effluent</td>
</tr>
<tr>
<td>Potable Water</td>
<td>Natural Resource use</td>
<td>Water for: Human consumption and Decontamination</td>
<td>Effluent and Radioactive Liquid waste</td>
</tr>
<tr>
<td>Environmental Monitoring</td>
<td>Nil</td>
<td>Data on environmental quality</td>
<td>Assurance to public on environmental /human safety</td>
</tr>
<tr>
<td>Clean up of MPS and Reactor</td>
<td>Radioactive waste</td>
<td>Secured and safe Plant</td>
<td>LW, ILW and HLW</td>
</tr>
<tr>
<td></td>
<td>Non radioactive waste</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.7 INDUCED (INDIRECT) IMPACTS

As a result of the proposed plant various indirect impacts will result. These impacts are dealt with in Chapter 4 and relate mainly to:

2.7.1 INSTITUTIONAL CAPACITIES TO MANAGE/PROVIDE SERVICES TO THE PLANT DURING ITS LIFE CYCLE AND THEREAFTER.

The more important sectors are listed hereunder:

<table>
<thead>
<tr>
<th>National Nuclear Regulator</th>
<th>: Competent staff to ensure safety/licenceability of the Plant and radiological materials waste management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education Institutions</td>
<td>: Provision of skilled workforce</td>
</tr>
<tr>
<td>Other government authorities at national, regional and local level</td>
<td>: Competent staff to provide services</td>
</tr>
<tr>
<td>Emergency Response Services</td>
<td>: Competent staff</td>
</tr>
<tr>
<td>Koeberg and Local Authorities</td>
<td></td>
</tr>
<tr>
<td>PBMR (Pty) Ltd/Eskom</td>
<td>: Training of competent staff</td>
</tr>
</tbody>
</table>

2.7.2 NATURAL DISASTERS

A number of natural disasters which are discussed in Chapter 4 may affect the integrity of the Plant namely:

- Earthquake

- Tsunamis (abnormal wave heights that may flood the station)/Seiches (abnormal low tides and sea water levels).

- Abnormal rain events (may lead to flooding of the station).

2.7.3 MAN-MADE DISASTERS

- Sabotage

- Impact on the building that houses the reactor and spent fuel storage tanks. This may be caused by projectiles or a plane crash into the building.

2.8 CUMULATIVE IMPACTS

The proposed Plant will be established in close proximity to the existing Koeberg NPS.

The main cumulative impacts are mentioned below, namely:
During construction/dismantling:
- Traffic
- Water for construction and human consumption
- Domestic waste
- Radiological waste
- Housing and Services (health, schooling, municipal and emergency services)
- Employment and income
- Local/regional economic stimulation

During operation/maintenance:
- Radiological and non-radiological emissions, effluents and solid/wastes
- Thermal effluent
- Potable water
- Local/regional economic stimulation
- Emergency Services and disaster management

2.9 LINKED IMPACTS

The only linked impact of the proposed demonstration module PBMR and the Fuel Plant proposed to be established at Pelindaba is the cumulative low and intermediate level radioactive waste to be transported to and disposed of at Vaalputs. As discussed in chapter 4.14 and relative to Koeberg, low quantities of material will be generated by the proposed Plant. This renders this linked impact insignificant.
3. SUMMARY OF ANTICIPATED ISSUES AND IMPACTS AND APPROACH TO THE ASSESSMENT OF IMPACTS

3.1 INTRODUCTION

This chapter deals with the impacts/issues/concerns that were identified in Chapter 2 and raised via the public consultation process that will be dealt with in the EIR.

In general the issues/impacts can be divided into two classes, namely:

- Issues and impacts of a strategic/policy nature
- Issues and impacts of a project nature

3.2 ISSUES OF A STRATEGIC/POLICY NATURE

Issues of a policy/strategic nature were considered and reported on in the EIR. These issues are listed below:

- Alternatives in terms of Energy (Fuel) and Technology(ies) for Electricity Generation and Supply.
- Final Deposition and Management of High Level Radioactive Waste
- Non-proliferation of Nuclear Weapons
- Radiological Safety/Health/Environmental Issues
- Epidemiological Studies

3.3 ISSUES/IMPACTS OF A PROJECT NATURE

For the purpose of the EIA Study, the impact issues/concerns to be studied are divided into four main groups, namely:

- Social impacts [Safety, Health, Skills, Land-use, Institutional capacity etc.]; and

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23 Proposed scope of work for the Environmental Impact Report (EIR)
3.3.1 SOCIAL ASPECTS

The following social aspects were assessed:

- A project specific Social Impact Assessment (SIA). Work was done by Afrosearch based on international best practices.

The SIA serves to identify future consequences of a current or proposed action. It is a process that assesses or estimates, in advance, the social consequences or changes that are likely to emanate from the proposed development. Social impact assessment variables point to measurable change in human population, communities and social relationships resulting from the project.

- Safety and Security impacts (including radiological aspects for which the NNR review and acceptance will inform overall decision making for this proposed development). Information was supplied by Eskom and PBMR (Pty) Ltd.

- Impact on health by means of a literature study on the epidemiology of radiologically induced health incidence. International literature was reviewed.

- Life cycle costing. Based on work by Eskom and International literature.

- Institutional capacity impacts.

- Legal impacts including financial provisions for decommissioning, high level radiological waste management and third party liability. Work was conducted by Ledwaba Erasmus (Environment and Development Law Association).

3.3.2 ECONOMIC ASPECTS

- Impacts on spatial planning from a local and sub-regional point of view. Work was based on work conducted by Eskom and the Western Cape Provincial Administration.

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IAIA (2001), available on-line (http://www.pebble-bed.co.za)
Impact on tourism in the sub-region around Koeberg i.e. 50 kilometre radius. Based on investigations by Urban-Econ.

Impact on supply-side management based on the assumption that the plant proves viable. Based on info supplied by Eskom.

Economic potential, markets and employment. Based on work conducted by PBMR (Pty) Ltd.

3.3.3 BIOPHYSICAL ASPECTS

The biophysical aspects include the following:

- Marine fauna and flora and the effect of the additional thermal outflow on such marine life. Work was based on existing UCT research as reported in the KSSR.

- Terrestrial fauna and flora and the effect of the proposed plant on such life. Extracted from the Eskom KSSR information base.

- Archaeological/Palaeontological characteristics of the proposed plant location. Extracted from Eskom KSSR information base.

- Sensory impact assessment(s) e.g. noise and visuals:

  Noise

  The existing and anticipated noise was evaluated against the SABS Code of Practice 0103 as per the Environmental Noise Control Regulation of the Environment Conservation Act. Work was conducted by Poltech.

  Visual

  The visual impact assessment evaluated the visual/aesthetic sensitivity of the landscape and the surrounding environment to the proposed development. This was conducted by Interdesign Landscape Architects (Pty) Ltd.

- Radiological and non-radiological waste impacts, i.e. gaseous, liquid and solid (types, quantities and management). Based on the Detailed Feasibility Report Study (DFS) peer reviewed by the international panel appointed by the Department of Minerals and Energy (DM&E) and the Safety Analysis Report (SAR) prepared by Eskom.
3.3.4 TECHNICAL ASPECTS

The technical aspects encompass the following subjects, namely:

- Verification of the geotectonics of the Koeberg site to determine the maximum credible earthquake that can occur in order to assess the adequacy in terms of the intent of the design of the proposed plant for such events. The work was conducted according to CFR 100 EPA standard by Andersen Geological Consulting and reviewed by the Council for Geo-Science.

- Verification of the groundwater characteristics of the site both qualitatively and quantitatively to determine pathways and plant adequacy in terms of the intent of the design. The work was done by Dr M Levin (Africon) in conjunction with Wits University.

- Meso and micro meteorological characteristics of the Koeberg site and region to determine (model) operational emission dispersion. Work was done by Eskom based on KSSR information.

- Surrounding population density (demographics) up to 80 kilometres from the proposed plant. Work was done by Eskom and Terramare Environmental Data Systems based on NNR standards and census statistics for current/projected population statistics.

- Physico-chemical characteristics of the marine environment to determine the effect of thermal outflows, and adequacy in terms of the intent of the plant design. This work was done by Eskom based on the work of various specialists as contained in the Koeberg Site Safety Report (KSSR).

- Infrastructure e.g. roads, harbours, telecoms, medical and emergency services, water supply, sewage facilities, housing and associated facilities and transmission. Work was based on a review of data in the KSSR that was conducted by Poltech.

3.4 APPROACH TO THE ASSESSMENT OF IMPACTS

The above studies on impacts were assessed for the full life cycle of the proposed Plant and were evaluated for significance based on the Guideline Document (1989) of the Department of Environmental Affairs and Tourism entitled “Implementation of Sections 21, 22 and 26 of the Environmental Conservation Act (Act No 73 of 1989).” (See Annexure 20 for the CVs of Panel Members and Consultants that participated in the EIA).
A panel, consisting of the persons mentioned below, was established to rate and rank the various impacts/issues/concerns.

- Mr O Graupner - Poltech (Division of IRCA)
- Mr W Lombaard - Poltech (Division of IRCA)
- Mr W Schlechter - Netrisk (Division of IRCA)
- Mr F Mellet - Netrisk (Division of IRCA)
- Mr J de Villiers - Netrisk (Division of IRCA)
- Mrs A Haasbroek - Poltech (Division of IRCA)
- Mrs K Botes - Interdesign Landscape Architects
- Dr D de Waal - Afrosearch
- Mrs H van Graan - Nuclear Consulting International
- Mr N Andersen - Andersen Geological Consulting
- Dr M Levin - Africon (Pty) Ltd
- Mr G Erasmus - Ledwaba Erasmus Associates
- Mr P van Wyk - J Paul van Wyk Urban Economist and Town Planners

3.5 CUMULATIVE EFFECTS

During the EIA phase the more important indirect (induced), cumulative and linked impacts were considered, assessed and reported on in the EIR.

3.6 MITIGATION OF SIGNIFICANT IMPACTS

An EMP was prepared and is submitted as Chapter 8 of the EIR.
4. ASSESSMENT OF IMPACTS ON THE AFFECTED ENVIRONMENT

4.1 INTRODUCTION

This Chapter deals with the various anticipated impacts of the proposed Plant (as defined in Chapters 2 and 3) and their effects on the affected (receiving) environment/or Plant.25

The issues/impacts are dealt with in the same chronological order, as that provided in Chapter 3.

Each issue/impact is introduced through a self-contained extract report that contains an index, a description of the environment, an assessment following a life cycle approach as needed and conclusions/recommendations on the mitigation of impacts. A literature reference list is also provided in the sub-sections.

More detailed reports are available for the subjects that are covered in this Chapter. However, some of the information is commercially confidential, as stated under each subject heading.

4.2 ASSESSMENT OF IMPACT ON POLICY ISSUES

The project is governed by a number of policies and the governance on the projects does not lie with a single Department. This section aims to provide information on the policy issues and responsibilities at work in this project.

4.2.1 NATIONAL ENERGY POLICY WHITE PAPER AND ALTERNATIVES IN TERMS OF ENERGY (FUEL) AND TECHNOLOGY(IES) FOR ELECTRICITY GENERATION AND SUPPLY

In South Africa energy planning and control falls within the mandate of the Department of Minerals and Energy (DME). The Minister of Minerals and Energy is responsible for the governance of the energy industry.26

25 Effects on the proposed Plant relate to natural and/or man-made disasters.

The following are contained within the South Africa Energy Policy White Paper:

**Page 49 Nuclear:** Whilst it is unlikely that additional nuclear capacity will be required for a number of years, it would not be prudent to exclude nuclear power as a supply option. Decisions on the role of nuclear power, as with any other supply option, need to be taken within the context of an integrated resource planning process.

**Page 53 Oil and Gas:** Government will ensure the optimal and environmentally sustainable exploration and development of the country’s natural oil and gas resources to the benefit of all.

**Page 70 Coal:** Government will continue to investigate and encourage options for the utilization of coal discard streams and stockpiles and will promote appropriate options for the resultant energy and environmental benefits.

**Page 71 Renewables:** Government will provide focused support for the development, demonstration and implementation of renewable energy sources for both small and large-scale applications.

**Page 77 Energy Efficiency:** Government will promote energy efficiency awareness amongst industrial and commercial energy consumers and will encourage the use of energy-efficient practices by this sector.

**Page 92 International energy trade:** Government will facilitate active regional cooperation, including energy trade, information exchange, capacity building and the training of energy specialists.

**Page 75 Integrated Resource Planning:** The DME will ensure that an integrated resource planning approach is adopted for large investment decisions by energy suppliers and service providers. 28

**Conclusion**

Based on an assessment of the National Energy White Paper the conclusion is drawn that Government has discharged the objectives of the Policy through various checks and balances on the whole development process for the PBMR, from a procedural, technical, economic and environmental point of view, including public consultations and nuclear safety. To this end an Expert Review Panel was appointed by the Department of Minerals and Energy to assess the adequacy of information of the

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Detailed Feasibility and Design Studies; an EIA is being conducted to fulfil the requirements of the Environmental Conservation Act (Act No. 73 of 1989) and the National Environmental Management Act (Act No. 107 of 1998); co-investors were secured to assist with the financing of the detailed feasibility and design studies and to gauge international acceptance and markets; the safety assessment of the design for licensing through the NNR, and ultimately the joint decision process of the Cabinet on the desirability to progress to follow-on phases.

The PBMR Plant, if approved, will inform the Integrated Resource Planning Process (IRPP) as prescribed in the Energy White Paper. This is especially so since the demonstration plants for other technologies (e.g. wind, solar thermal and biomass) are implemented by Eskom and Independent Power Producers (IPPs) in close succession with the Plant.

Alternative in terms of Energy and Technology

Both the EIA regulations and the Energy Policy White Paper stipulate the consideration of alternatives (e.g. energy, technology, etc).

Conclusion

While the proposed PBMR Plant will be linked to the national transmission grid, this application is, however, not a commercial application for nuclear based power generation, but an application for the establishment of a demonstration Plant to inform on the techno-economics of the specific plant which, in turn, will inform the IRPP of government and Eskom’s ISEP. Once this stage has been reached (probable in the years 2006 – 2008) more informed decisions can be made on commercial energy mixes for electricity supply and management.

Western Cape Energy Policy

The Western Cape policy titled “Preparing the Western Cape for the Knowledge Economy of the 21st Century” deals with energy on page 50. The energy section reads that the energy objectives is aligned “with the National Government's 1998 White Paper on the Energy Policy of the Republic of South Africa of cost effective, sustainable and environmentally friendly energy policy for the province …….” The policy further states that it will “support(ing) and take(ing) full advantage, in particular, of the economic and environmental opportunities presented by the distribution of natural gas by the proposed long-distance pipeline from the Namibian Kudu gas field to transform the energy of the Western Cape from Coal-based and nuclear power to thermally efficient and clean gas-fired power”. A foot note is added: “the prospects of a large natural gas field off the West Coast in the Northern

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29 Various other technologies are in this phase of development (e.g. wind, solar thermal and biomass) and due for EIA application, within Eskom’s portfolio of new development project conducted in terms of its ISEP.
Northern Cape could, if realised, further expand the possibilities for cleaner and more efficient gas-fired power stations in South Africa in general, and the Western Cape in particular.

**Conclusion**

The above does not appear to be in conflict with national policy.

While the draft EIR reported an “apparent conflict between the Western Cape’s and National policy on energy” the above extracts indicate otherwise. However, interpretation of the Western Cape’s policy by various provincial and local authorities clearly demonstrate a concern with the establishment of further nuclear power generation on the Koeberg Site or the extension of the operational life of the existing Koeberg N.P.S.

The EIA Consortium maintains that interpretation of the policy and its implementation requires resolve at an institutional and authority level. Such resolve, however, does not constitute a pre-requisite for a “Record of Decision (RoD) by the DEAT.

### 4.2.2 Radiological Waste Management and Final Disposal of Radioactive Waste

Under the Nuclear Energy Act (Act No. 46 of 1999) the authority over radioactive waste and irradiated nuclear fuel vests in the Minister of Minerals and Energy. The Minister is also responsible for South Africa’s other institutional nuclear obligations for example the decommissioning and decontamination of past strategic nuclear facilities.30

The Department of Minerals and Energy (DME) has drafted, and issued for public comment, a radioactive waste management policy for South Africa. A working group has clarified the status of radioactive waste in South Africa. Work on establishing a strategy for radioactive waste management is progressing.31

The high-level radioactive material that will be generated by the PBMR is the spent nuclear fuel. The reactor fuel will remain inside the reactor for a period until the useful uranium has been “burnt up” in the fission process and then will be transferred to storage containers. Upon unloading from the reactor the fuel is highly radioactive and generates a certain amount of heat. As the radioactive fission products in the spent fuel decay, the fuel becomes less radioactive and generates less heat.

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The prevailing opinion internationally is that if spent nuclear fuel is to be disposed of, as radioactive waste, deep geological disposal is an appropriate disposal option. This means disposal some several hundred metres underground in a suitable geological matrix, which minimises the likelihood of ground water ingress into the repository and subsequent leaching and migration of radioactivity from the repository. Such repositories are under consideration/development in a number of countries (e.g. USA, Finland and Sweden).

A comprehensive safety assessment is required which will demonstrate the adequacy of the repository from an engineering and environmental perspective. This assessment will provide the necessary assurance that the facility will be safe in respect of preventing the migration of radioactivity from the repository in such a way that radiation dose limits will be respected (contained) both in the short and long term. This process will inevitably take a number of years to complete, probably twenty to thirty years. All interested and affected parties will have to be involved in the development process in order to establish the necessary level of public confidence. During this period the spent fuel will have to be safely stored in respect of containing the radioactive material and removing the heat generated. The storage containers will have to be demonstrated by engineering analysis the ability to fulfil these functions. At the same time, a considerable amount of radioactive decay will have taken place, which facilitates subsequent handling, transport, and management/disposal of the spent fuel.

In the process of developing a national radioactive waste management policy, which has already commenced, it will be necessary to ensure that arrangements are put into place which enable the process outlined above to take place. This means that a dedicated function will have to be established to carry out the necessary development work, with the necessary skills, technical resources and financial support. The process will also have to be subjected to close and ongoing scrutiny by the National Nuclear Regulator (NNR). The proposed PBMR meets the applicable standards.

In evaluating the proposals for the PBMR, the NNR will also carry out an in depth evaluation of the spent fuel handling and storage facilities to ensure that safe storage can be attained. The design of the spent fuel storage tanks for the PBMR provides for sufficient time to enable the development of an appropriate final disposal arrangement, for the HLW of the Plant.

**Conclusion**

The absence of final high level radiological waste disposal facilities at this stage, is not seen to be a prerequisite for the authorization of the PBMR.\(^{32}\)

\(^{32}\) National Nuclear Regulator, 2000.
Whilst the PBMR will generate some 760 tons of HLW, such waste will be safely contained and managed on site for the full operational life of the Plant and for a further 40 years thereafter to allow for radiological decay and thermal cooling.

The establishment of a HLW repository is clearly the responsibility of the DM & E and studies on disposal options and alternatives and authorisations (e.g. ECA & NEMA approvals) within their domain of accountability.

Except for the consideration of environmental risk and safety and accepting the principle of “Polluter Pays” the economic feasibility for the establishment of a final HLW repository is volume dependent (i.e. quantity of HLW) to negate financial burden on tax payers, (i.e. the capital and operational cost of the repository is shared by various HLW generators).

Annexures 16a and 16b provide information on HLW disposal and alternatives.

4.2.3 NON-PROLIFERATION OF NUCLEAR WEAPONS

Under the Nuclear Energy Act (Act No. 46 of 1999) the authority over institutional nuclear obligations including nuclear non-proliferation vests in the Minister of Minerals and Energy. The Nuclear Energy Act, (Act No. 46 of 1999), addresses the issue of non-proliferation of nuclear weapons.

The Nuclear Energy Act implements South Africa’s commitments with respect to the Treaty on the Non-Proliferation of Nuclear Weapons acceded to by the Republic on 10 July 1991 and the allied Safeguards Agreement that has been entered into between South Africa and the IAEA. The Minister of Minerals and Energy is accountable and responsible for all safeguards, but may delegate all or part of this function. Partial delegation, to NECSA, has been implemented.

The implementation of the Safeguards Agreement requires that Subsidiary Agreements be established for the various nuclear facilities that are under safeguards. For example, a Subsidiary Agreement exists (and has always existed) for Koeberg Units 1 and 2. A Subsidiary Agreement existed for the previous BEVA plant where accounting to gram quantities of uranium was required. Similar Subsidiary Agreements would have to be developed and signed, for the proposed PBMR Demonstration Plant as well as for the PBMR Fuel Manufacturing Plant. However the design and mode of operation of the respective facilities already forms part of liaison with the IAEA to develop the basis for the Subsidiary Agreements.

In addition, South Africa was instrumental in the formulation of the Pelindaba Treaty or the African Nuclear Weapon-Free Zone Treaty. It should be noted that this Treaty is about keeping Africa free of Nuclear Weapons. It promotes co-operation in the peaceful uses of nuclear energy and recognises the right of countries to develop research on, production of and use of nuclear energy.
The Treaty states that parties to the Treaty are determined to promote regional co-operation for the development and practical application of nuclear energy for peaceful purposes in the interests of sustainable social and economic development of the African continent.

**Conclusion**

The proposed PBMR demonstration plant has direct impact on the Non-Proliferation Treaty. The formalisation of Safeguards Agreements with the IAEA, however, provides for the diligent control on the governance of the fissile material, through strict inventory accounting and regular inspections by the NNR and representatives of the IAEA.

### 4.2.4 Radiological Safety/Health/Environmental Issues

The National Nuclear Regulator Act (Act 47 of 1999) provides for the regulation of nuclear activities. The National Nuclear Regulator (NNR) is established to exercise the set out legislated regulatory control and assurance. In terms of the National Nuclear Regulator Act the objectives of the NNR are to:

(a) provide for the protection of persons, property and the environment against nuclear damage through the establishment of safety standards and regulatory practices;

(b) exercise regulatory control related to safety over:
   (i) the siting, design, construction, operation, manufacture of component parts, and decontamination, decommissioning and closure of nuclear installations; and
   (ii) vessels propelled by nuclear power or having radioactive material on board which is capable of causing nuclear damage, through the granting of nuclear authorisations;

(c) exercise regulatory control over other actions, to which this Act applies, through the granting of nuclear authorisations;

(d) provide assurance of compliance with the conditions of nuclear authorisations through the implementation of a system of compliance inspections;

(e) fulfil national obligations in respect of international legal instruments concerning nuclear safety; and

(f) ensure that provisions for nuclear emergency planning are in place.
Conclusion

The proposed PBMR in terms of its design specifications, safety features, waste management practices and monitoring/surveillance/emergency programmes meets the standards set by the NNR and will need to be licensed by the NNR.

4.2.5 Epidemiological Studies

Cancer induced Health Effects due to Commercial Nuclear Plant Operations

The National Nuclear Regulator Act (Act 47 of 1999) provides for the regulation of nuclear activities. The NNR is established to exercise the set out legislated regulatory control and assurance. The purpose of the Act is to provide for the establishment of the NNR in order to regulate nuclear activities for its objects and functions, for the manner in which it is to be managed and for its staff matters; to provide for safety standards and regulatory practices for protection of persons, property and the environment against nuclear damage; and to provide for matters connected therewith.

The accepted approach to this study (PoS as approved by the DEAT) was to review and be guided by international literature on the subject of epidemiological studies on cancer included health effects due to low level radiation releases (operational releases) from nuclear plant (Annexure 3 provides papers from international research on the subject), to decide on the desirability of such studies prior to or during the operation of the proposed Plant.

Much international epidemiological research is being (and has been) conducted on the subject, with opposing conclusions on the relationship between cancer incidence and radiation releases from commercial nuclear installations.

However one of the primary aims of such research is to determine the safe levels (release standards) for the release of radioactive substances from nuclear installations, to safeguard the health of persons and the environment. The International Commission for Radiological Protection (ICRP) is the international body that advises on standards and have progressively reduced radiological discharge and exposure levels.

Over time very strict international standards have been established to which South Africa subscribes and which is reflected in the Fundamental Safety Criteria of the NNR.

By nature these epidemiological studies are complex, need to extend over at least 15 to 20 years, the population must be stable (i.e. low influx or exit from the population, and preferably start before the commissioning of a commercial nuclear plant to provide meaningful results.

Conclusion

Recommending such research before the establishment (or during the operation) of the PBMR within the footprint of Koeberg, will hold limited (if any) advantages.
Therefore based on the international experience, the role of the NNR and environmental monitoring/surveillance results at Koeberg NPS (for a period of 20 years), as reported in Chapter 4.3.3, an epidemiological study is not recommended. It is furthermore concluded that the practices carried out at the proposed PBMR facility, will provide for the protection of persons, property and the environment against nuclear damage. This shall be assured through the operational and environmental monitoring programmes, health monitoring of employees and conformance to the legal requirements as administered by the NNR which is prescribed by the EMP, for the proposed Plant and in terms of the Occupational Health and Safety Act (Act No 85 of 1993).

**HIV and AIDS**

Eskom has established a comprehensive wellness programme, intended to address the well being of individuals and groups. The programme consists of employee assistance, sports and recreation; managing the impact of HIV/AIDS, biokinetics, spiritual wellness, occupational health and medicine, travel medicine and health promotion. Health and wellness teams have been created to implement the total integration of services, information sharing and allocation of resources.

**Conclusion**

Regarding HIV/AIDS Eskom’s policy and practice will be applied as discussed in Chapter 4.3.3:

The key areas for the HIV/AIDS programme are focussed on education, communication, care and support, self-awareness and the management of associated risks. This will be used as the basis on which the specific programmes will be developed for the PBMR demonstration plant during construction and operational phases.

When implemented for the PBMR Plant it will ensure the required awareness and mitigation of the impacts of HIV/AIDS and treatment of infected persons.
4.3 ASSESSMENT ON PROJECT RELATED ISSUES AND THE AFFECTED ENVIRONMENT

SECTION 1: IMPACTS OF SOCIAL NATURE

4.3.1 SOCIAL IMPACT ASSESSMENT

Background

Afrosearch was appointed to undertake the social impact assessment (SIA) process for the proposed PBMR at Koeberg. Based on the issues identified during the Public Participation Process as well as the Scoping process, a number of broad categories of issues specifically related to the proposed development at Koeberg, were identified as requiring investigation, elucidation and detailed evaluation. In accordance with IAIA principles and DEAT requirements, the Assessment has focused on (but not been restricted to) the possible impacts identified by the affected public. The SIA Report provides the findings of the in-depth assessment of the social impacts, including a rating of impacts (based on nature, extent, duration, probability and intensity as required by the EIA Regulations) the significance thereof and measures for mitigation through the enhancement of positive impacts and the amelioration or reduction of negative impacts.

It had been clear throughout the Scoping and Impact Assessment processes that an essential and extremely important component of the impacts identified, related to or was linked in, with risk assessment and perceptions regarding risk. The degree to which the proposed PBMR development is perceived on a continuum from “dread risk” to “no risk” has differed significantly from group to group, depending on the basic point of departure of the group. Based on this, a contextual foundation was provided for the impact assessment through an evaluation of factors involved in the development of risk perception as well as the implications of this for the rating of impacts and for the development of mitigatory mechanisms.

The description of the relevant social impact assessment variables was preceded by an overview of demographic trends and indictors within the Greater Cape Metropolitan Council area. The SIA and discussion was presented in the form of assessment tables (evaluation framework) for each theme. The following impact themes were assessed in respect of the construction, operation and decommissioning stages of the project:

- Population impacts referring to acute or transient changes in the demographic composition (age; gender; racial/ethnic composition) of the population. Two
specific aspects were considered in this regard, namely potential changes commensurate with the introduction of people dissimilar in demographic profile in the first instance and the influx of temporary workers to the PBMR site in the second instance.

- Planning, institutional, infrastructure and services impacts. This theme related to projected impacts on Local and/or Metropolitan Government in terms of impacts on planning, the provision of off-site emergency response planning as well as an evaluation of needs related to infrastructure and services.

- Individual, community and family level impacts related to impacts on daily movement patterns, visual and aesthetic impacts as well as potential pollution related intrusion.

- Socio-economic impacts related to employment creation (focusing on the construction phase), changes in employment equity, direct and indirect socio-economic impacts resulting from the construction of the proposed PBMR demonstration module as well as property values in the primary impact area.

- Community health, safety and security impacts, including an evaluation of the psychosocial stressors involved in health perception and the nocebo effect.

- Management of waste and specifically nuclear waste.

- Impacts on places of cultural, historical and archaeological significance (based on inputs received from I&APs and gathered during the baselines study).

- Attitude formation, interest group activity and social mobilisation (the behavioural expression element of attitudes)

**Rating of Impacts and Mitigation Measures**

**Population Impacts**

Population change refers to acute or transient changes in the demographic composition (age; gender; racial/ethnic composition) of the population. Two specific aspects have been considered in this regard, namely potential changes commensurate with the introduction of people dissimilar in demographic profile in the first instance and the influx of temporary workers to the PBMR site in the second instance.

i. Introduction of People Dissimilar in Demographic Profile

a. Brief Description of Impact and Rating

This impact category refers to the potential introduction of significant numbers of people who are sufficiently dissimilar to the receiving population in terms of demographic profile, culture, values and norms to incur the risk of tension and or clashes.

The limited number of international employees entering the existing scenario will not alter the local demographic profile in any conspicuous and significant manner.
b. Proposed Mitigation Measures

While the contingent of international workers during construction and operation of the proposed BMR will not be large, it does serve as an opportunity for local service providers to extend their current client base. Allowing maximum equal offset opportunities for service providers will promote equity.

It is also suggested that Eskom require that staff bind themselves to a code of conduct aimed at ensuring that pro-social behaviour is maintained.

The availability of international specialists provides an opportunity for promoting the local in-house competence and expertise of South African workers. It is suggested that it be a requirement that international specialists provide mentoring where appropriate for South African specialists.

ii. Impact Commensurate with Inflow of Temporary Workers

a. Brief Description of Impact and Rating

This sub-impact category serves as a continuation of the main category related to Population Impacts and deals with the inflow of temporary workers to the site during construction/decommissioning as well as during operation.

The nature, extent and intensity of impacts is expected be influenced by a variety of factors. These include the number of workers coming into the area per day, the degree to which movement in and out of the area is controlled or not, potential non-compliance by contractors/workers with contractual and EMP provisions, which experience shows is not uncommon. In contrast, the proposed project offers the potential opportunity for gainful employment of a significant number of people over a period of 3 to 6 years.

b) Proposed Mitigation Measures

The conduct of contract workers would have to be specified in worker related management plans and employment contracts. It is suggested that a peer-group based incentive/fine scheme, which has been successfully used in other projects to achieve compliance, be introduced. This incentive scheme is described in more detail in the body of the document.

The SAP as well as local appropriate policing forums should be urged to ensure that baseline statistics are available regarding existing crime rates and should, proactively engage with Eskom in developing mechanisms for monitoring and the distribution of information to counter potential community perceptions that there are perceived
changes in the crime rate directly as a result of construction workers being in the immediate area (see below);

Care should be taken that persons with possible criminal intent are not in a position to use increased activity during the construction phase as a ‘cover’ or platform to launch opportunistic criminal activities; and

Meetings should be arranged with residents’ associations, community policing fora, as well as the local police personnel to discuss contractors’ plans, procedures, schedules and possible difficulties and safety and security concerns. Experience in other projects has shown that members of the community readily attribute crimes committed to the presence of construction workers, particularly where there are significant pre-existing levels of crime. This perception is entrenched by the actions of workers who may enter private properties to access taps or to ask domestic workers for water. Proactive discussions between the contractor(s) and project proponents have been found to be effective in addressing concerns and putting possible preventative measures in place. Despite being simple, cheap and effective, a measure such as compelling workers to wear identification badges at all times is often not instituted or enforced by contractors— to the discontent of local residents who find it impossible to separate workers from possible criminal ‘elements’.

As far as possible, the movement of construction workers should be confined to the work site to avoid any potential for impact from this variable in proximate residential areas.

Public Health and Safety

a) Brief Description of Impact and Rating

Public Health and Safety impacts during construction as well as operation are explored under this variable.

Based on the findings of the impact assessment as well as the findings set out in the study entitled “Response to the Issue of Health Monitoring and an Epidemiological Study for the Proposed PBMR Demonstration Module” it is believed that the impact on health from the proposed PBMR demonstration module can be well contained. The assurance (from Eskom) that the public is at no significant risk to radioactivity as a result of its nuclear facilities is deemed realistic and achievable.

No deterministic (effective) or latent (stochastic) effects would manifest from normal operation related activities. In addition, the degree of impact from Event Categories A to C is such that the impacts and footprint of the proposed PBMR will not extend beyond those for Koeberg.
Within the context of a Category A Event, Intensity is rated as low, although effects are essentially zero in terms of public exposure limit. While occupational health/safety falls outside the scope of the SIA, it is noted that effects on workers would be below 50mSv.

Impact from a Category B Event (or combinations of A and B events) would not extend beyond the 400m-boundary area, the health impact would be rated as moderate on-site, despite the fact that radiation levels would be below 50mSv (public dose limit). The rating of moderate is based on the potential psychological health impact intensity.

Impacts from Category C Events (or combinations of A, B and C events) would be limited locally on-site, potential on-site health impacts are rated as high, based on the principle that this is an event category of low frequency but potentially high in respect of the potential consequences for workers and visitors on-site.

b) Proposed Mitigation Measures

Health and Safety Management Plans should be developed in respect of construction worker safety.

The development of an integrated on- and off-site Emergency Response Plan for Koeberg and the proposed PBMR demonstration module should include mechanisms for communicating potential risk, health and safety information to affected communities as part of a pro-active risk communication strategy (discussed in greater detail in the section dealing with emergency response).

It is acknowledged that a proportion of the public have little faith in the ability of regulatory mechanisms or Eskom’s assurances that members of the public are at no significant risk to radioactivity. For this reason, Eskom’s visible compliance with the measures for ensuring that the public is at no significant risk is deemed to be of utmost importance. It is required that such compliance is made ‘visible’ to surrounding communities on a participative basis through the development of a community-based environmental indicators project. If possible, such an activity should interface with the CMC initiative to develop indicators/proxy indicators to assess quality of life of communities (‘Levels of Living’ initiative) as well as the research and reporting initiatives to assess the ‘State of the Environment’ in the CMA. It is suggested that Eskom, in partnership with relevant local authorities, volunteer community members and an organisation such as the NGO Group for Environmental Monitoring (GEM) identify realistic, reasonable and appropriate indicators (e.g. monitoring of radiation levels, etc.) and implement a process for ongoing and systematic monitoring and evaluation of compliance.
The promotion of an understanding of radiation, radiation exposure and nuclear power-related activities is seen as a central requirement in initiatives to reduce the levels of fear and anxiety emanating from perceptions about nuclear-related risks. The development of an honest, transparent and comprehensive awareness creation campaign for the dissemination of information about energy generation and nuclear and other technologies (as currently being investigated by Eskom) is seen as a fundamental requirement for Eskom. However, it is necessary to take due cognisance of the degree of public distrust and that there is a need to ensure that the dissemination of information should not be perceived as a “public relations” or “marketing” exercise. For this reason it is seen as an urgent imperative that an organisation such as the African Commission on Nuclear Energy (AFCONE), formed to oversee compliance in respect of the Organisation of African Unity’s Treaty of Pelindaba, be formally requested to extend its activities (under Article 12 of the Treaty) to educate and inform the public of the real risks and issues related to “the peaceful use of nuclear energy for the betterment of society”.

Under existing agreed mitigation measures in respect of the Koeberg Plant, the Tygerberg Hospital has developed regional competency to deal with radiation incidents and the routine and emergency support for radiation exposed individuals. It is deemed vital that the Tygerberg Hospital’s ability to cope with nuclear incidents and disaster is upgraded and maintained, in line with the World Health Organisation’s (WHO) REMPAN programme, aimed at promoting regional competence to deal with nuclear incidents and disasters. It is, therefore, seen as an absolute requirement that NECSA and Eskom ensure that Tygerberg Hospital has this competence.

Planning, Land Use, Infrastructure and Services Impacts

i. Local/Metropolitan Government Planning Impacts

a) Brief Description of Impact and Rating

This variable relates to projected impacts on local and/or Metropolitan Government as a result of planning impacts, including the need for maintaining an emergency response system, as well as allied ramifications in respect of the need for housing, infrastructure and services are concerned.

Although a rating of low has been set in respect of this particular variable, this rating may need to be changed to moderate at a later juncture.

b) Mitigation
Traffic congestion
The off-site movement of construction vehicles should, as far as is possible, be limited to off-peak periods in order to avoid exacerbating the existing congestion of roads. Additional mechanisms for mitigation of traffic congestion have been provided in the section dealing with impacts related to daily movement patterns.

If possible, metropolitan traffic planning should assess the feasibility of developing stronger links to the north by means of upgrading the Vissershoeck Road and future R300, to allow traffic to be accommodated to the north rather than the south.

Existing zoning of the Koeberg site as an agricultural area
While no specific suggestion can be made for mitigation of this impact component, the historic nature of the activities on-site appears to contra-indicate a reasonable refusal of a re-zoning application. However, such refusal appears technically feasible. Given the time and financial implications that will result from a re-zoning refusal, it is suggested that in-depth discussions be initiated with the CMC in this regard and that such discussions be firmly based on legal requirements that may be set.

Spatial planning and land-use
While not deemed to be the responsibility of the project proponent and therefore not an inherent component of the PBMR mitigation plan, it is suggested that the City of Cape Town (CoCT) enter into discussions with the Blaauwberg substructure to negotiate a partial lifting of the existing restrictions adopted in their Spatial Development Framework.

An additional mechanism is related to the potential for the negotiation of a decrease in the existing exclusion zone. However, it is not clear whether this will be considered, given that existing emergency planning zones apply to Koeberg specifically, which is a different class of nuclear reactor with a different exclusion zone.

ii. Emergency Planning

a) Brief Description of Impact and Rating

Discussion in respect of this variable relates to factors, concerns and issues in respect of existing and future emergency planning. It investigates issues related to the provision of off-site management and services in respect of accidents, emergency services and disaster response procedures. Emergency services are currently the responsibility of the CMC (until July 2002) and the provincial government (subsequent to this date). As the need for emergency response is specifically related to a crisis that may range from “mild” accident to “worst case” scenario, three event categories (A, B & C as explained in the discussion hereunder) have been included as part of the impact rating. In
rating. In addition, the discussion includes the description of impacts in respect of a “worst case” scenario for the PBMR.

It is noted that, irrespective of event category, the onus is on the project proponent to keep radiation doses and risks ALARA (As Low as Reasonably Achievable), below laid down radiation limits and applying the principle of defence-in-depth. The rating in respect of this impact category, specifically as it relates to off-site emergency service requirements, is low as a result of the fact that even a situation described as “very severe and recoverable” would be some 10 000 times less than that requiring any off-site emergency actions.

In terms of on-site emergency response requirements, impact from a Category A Event is rated as low although effects are essentially zero in terms of the impact. Impacts from Category B Events are also rated as low, offering potential on-site sequelae. Impacts from Category C Events are rated as moderate as a result of the potential requirements such an event may pose on the facilities at the Tygerberg Hospital and requirements for on-site emergency services to deal with any potential sequelae from such an event.

b) Proposed Mitigation Measures

Currently a duty is placed on the Council in terms of the Civil Protection Act to be responsible for all off-site emergency planning and protective actions throughout the PBMR’s full life cycle. Despite the fact that none of the described events set out in categories A to C would require off-site emergency response, the fact that such services are being centralised to provincial level will need to be taken into consideration in the development of off-site emergency response plans and the interface between off-site and on-site emergency response systems.

In terms of mitigation it would be necessary to (1) clarify whether existing emergency plans for Koeberg require any overview and adaptation and would apply to the PBMR; (2) clarify issues regarding evacuation specifically for Koeberg; and (3) rehearse emergency plans – specifically for Koeberg - in association with the local emergency services and community organisations.

Individual, Community and Family Level Impacts

This impact category relates to projected impacts on daily movement patterns that may result from activities during the construction/decommissioning as well as operational phases of the proposed PBMR demonstration module and includes direct intrusion impacts from photic, noise and air pollution.

i. Impact on Daily Movement Patterns

a) Brief Description of Impact and Rating
This variable relates to projected impacts on living patterns specifically in terms of routine daily movement patterns.

Unless specific measures are introduced to mitigate daily movement patterns during construction, impacts will be negative with a moderate to high significance. However, impacts are expected to respond to mitigation.

While the impact from daily movement patterns associated with operation will be definite and long-term, the limited extent thereof allows movement related impacts to be rated low in intensity and significance.

b) Proposed Mitigation Measures

- **Construction**
  Agreements will need to be put in place to ensure that contractors, sub-contractors and suppliers will adhere to measures related to ensuring that:

  - construction related vehicle use is limited to off-peak periods only.
  - there is an avoidance of busy routes, intersections, residential areas and roads leading past schools (e.g. access road via Melkbosstrand).
  - strict adherence to speed limits are enforced.

While not essential, it is believed that it would be advantageous to ensure that a monitoring function will be implemented in respect of the above. The Environmental Officer could fulfil this role, although community involvement in monitoring is desirable. It is further suggested that a toll-free complaint service be initiated and that the access number for this service is sign-posted at key impact sites, for use by the public. Co-operation with local traffic law enforcement agencies would be important to ensure compliance with traffic legislation.

ii. Air/Dust Pollution and Radioactive Particles

a) Brief Description of Impact and Rating

This sub-impact category refers to the generation of Air/Dust pollution and radioactive particles during construction and operation of the proposed PBMR.

Given the specific safety systems and design, as well as the fact that the proponent has indicated that releases into the atmosphere will be kept within the limits of all legal requirements, the definite rating for air pollution is set against a low impact probability.

b) Proposed Mitigation Measures
The filter system and design are expected to control impacts, unless the reactor is decimated in its entirety due to a catastrophic accident.

iii. Light Intrusion

a) Brief Description of Impact and Rating

This sub-impact category refers to the impacts of lights used during the construction phase as well during the operation phase.

Light intrusion from these sources is likely to be low in intensity, although the possibility exists of a cumulative effect together with the lighting of the KNPS. Such impacts are rated as moderate in intensity, long-term in duration and moderate in significance (potential cumulative impact), with a definite probability rating.

b) Proposed Mitigation Measures

The site demarcated for the proposed PBMR is recessed and surrounded by dunes in the direction of Melkbosstrand. This is likely to attenuate direct light intrusion, although the reflective glow from the KNPS and PBMR would be visible from the R27 and Robben Island, inter alia. The positioning of mast lights should be done taking due cognisance of potential impacts on the surrounding residential areas.

iv. Noise Intrusion

a) Brief Description of Impact and Rating

This sub-impact category looks at how noise during the construction and operational phase may affect people.

While noise will occur during construction as well as operation, a low rating has been assigned to impacts in respect of this variable.

b) Proposed Mitigation Measures

- Construction

Where possible, intrusive construction activity should be limited to daylight hours.
Ensure that all machinery is in good order notably as far as silencers are concerned and that all vehicles and equipment comply with generally accepted noise levels.

Any high impact activity that may be required should only be undertaken after adjacent landowners have been timeously informed of the nature of such activities, the purpose thereof as well as the timing of such activities.
v. Visual and Aesthetic Impacts

a) Brief Description of Impact and Rating

This sub-impact category takes a look at any adverse visual and aesthetic impact the proposed PBMR might have on the surrounding environment.

Based on the physical characteristics of the PBMR, a long-term, moderate intensity, negative rating is allotted. The visual and aesthetic impacts are also relevant from a tourism perspective and a specialist study, with separate recommendations, has been conducted by Urban Econ (Cape Town) in this regard.

b) Proposed Mitigation Measures

Where possible and justifiable, design and landscaping related mitigation is required to limit visual and adverse aesthetic impact.

Community/Institutional Arrangements

This impact category focuses on the attitudes (positive and negative) towards the project as well as interest group activity and social mobilisation that has resulted or may result from negative perceptions and attitudes. It is stressed that this variable focuses exclusively on the attitudes of I&APs, who have registered for inclusion in the public participation process. As such it does not serve to provide a representative picture about perceptions and attitudes of the general population.

i. Attitude Formation For and Against the Proposed PBMR

a) Brief Description of Impact and Rating

This sub-category examines people’s attitudes towards the proposed PBMR and how they are derived.

A negative rating in terms of significance, intensity, duration and extent of attitude formation has been allocated, based on factors such as the nature of objections against the proposed development, the degree of persistence and the duration of the negative attitude towards the idea of nuclear technology.

b) Proposed Mitigation Measures

Based on the inter-related nature of this, and the next impact variable related to interest group activity and mobilisation, the mitigation measures that are recommended are the same for both and provided at the end of the next section.
ii. Interest Group Activity and Social Mobilisation

a) Brief Description of Impact and Rating

This variable assesses interest group activity and social mobilization as indicators of whether a project is deemed socially desirable or acceptable by the members of the community registered on the I&AP database.

A negative rating in terms of significance, intensity, duration and extent of interest group activity and social mobilization has been allocated, based on factors such as the nature of objections against the proposed development, the degree of persistence and the duration of the negative attitude towards the idea of nuclear technology.

b) Proposed Mitigation Measures

The absence of a finalised coherent national nuclear energy policy and particularly the absence of a national policy regarding the disposal of nuclear waste is both a major factor contributing to the “dread risk perception” experienced by the affected society and a substantive environmental hazard in its own right. The failure to finalise the development of such a policy (with due cognisance of the process that has been initiated to develop a Radioactive Waste Management Policy) may be constituted as a breach of the duty of care borne by the national government in terms of Section 28 of the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA) and comply with the principles as contained in Section 2 of NEMA. For this reason the national government is urged to ensure that, at minimum, the development of an effective radioactive waste management policy is finalised as a matter of the utmost importance and fast-tracked, with full cognisance of the need to follow due process.

Risk perception and negative psycho-social sequelae of nuclear related “dread risk perception” is frequently attenuated and tempered by the provision of neutral, reliable, responsible, un-biased information dissemination and risk communication. While there is a limited public perception that neither NECSA nor Eskom will, necessarily, provide neutral information and risk communication, it is also perceived that anti-nuclear lobbies will not necessarily engage in the provision of neutral information and risk communication either. For this reason it is seen as an urgent imperative that an organisation such as the African Commission on Nuclear Energy (AFCONE), formed to oversee compliance in respect of the Organisation of African Unity’s Treaty of Pelindaba, be formally requested to extend its activities under Article 12 of the Treaty to educate and inform the public of the real risks and issues related to “the peaceful use of nuclear energy for the betterment of society”.

Hattingh and Seelinger (February 2002, p.14) state: “With the scenario of a fledgling civilian nuclear industry being established in South Africa, the temptation may be to
promote and protect the industry from effective public scrutiny, thereby blocking the ability of the public to influence development and regulatory decisions in this regard. This should be avoided at all costs. Since nuclear-based energy generation has become such a sensitive issue, the ability of the public to participate and influence the process of decision-making should rather be actively promoted and developed”.

Risks communication, with specific emphasis on the PBMR, providing information that demonstrate adherence to international best practice guidelines.

Total community involvement and monitoring during construction; commissioning; operation and decommissioning, including waste disposal and management and regulatory issues.

Socio-economic Impacts

This section deals with some aspects related to employment creation (focusing on the construction phase), changes in employment equity, direct and indirect socio-economic impacts resulting from the construction of the proposed PBMR demonstration module as well as property values in the primary impact area.

i. Employment Creation

a) Brief Description of Impact and Rating

This variable relates to projected impacts specifically in terms of the creation of employment.

Based on increases in both the level of employment and in real earnings, the retention and training of nuclear expertise in South Africa (particularly as this relates to requirements for decommissioning related expertise) and the professional and other positions required during operation, including engineers, human resource practitioners, financial experts and designers, amongst others, impacts in respect of this variable is rated as high with a positive valence.

b) Proposed Mitigation Measures

The following specific measures are suggested to maximise the benefits related to employment creation:

Eskom should, as far as is practicable, make the appointment of local labour for construction activities a priority issue.
The number of persons required, as well as the specific skills required in respect of each worker should be specified as soon as possible. An employment/skills registration agency or ‘labour desk’ should be put in place to identify prospective candidates who would meet the job specifications. Such an agency/desk would have to take responsibility for accurate information dissemination at community level. Experience has shown that formalising this process through such an agency avoids duplication, misrepresentation, confusion and unrealistic expectations. It is also important to clarify project time frames and when candidates from local communities are anticipated to be required.

Eskom could provide further information to local businesses and structures like the tourist and business forum regarding direct business opportunities associated with the project.

It is common practice for local informal vendors (notably women providing cooked food) to enter construction areas, given the new business opportunity provided by the construction workers. Due to requirements for security, it is believed that the PBMR construction site will not readily lend itself to this practice. It may be possible to allow this practice through the allocation of a designated area where vendors could ply their trade.

A skills development programme should be introduced whereby international employees train and mentor South African staff members to ensure transference of skills.

ii. Employment Equity and Inequity

a) Brief Description of Impact and Rating

This variable, falling under financial and socio-economic impacts, relates to employment equity and inequity. The concepts employment equity and inequity refer to the extent to which historic discriminatory laws and practices have resulted in disparities in education, employment, occupation and income within the national labour market and practices that may, intentionally or unintentionally serve to prevent equal opportunities for specific disadvantaged individuals and groups.

In an evaluation of the potential for this variable to result in employment related inequity, a low probability, intensity and significance rating seems warranted.

b) Mitigation

The contract and tender documentation in respect of the work to be undertaken during the construction phase will need to ensure that affirmable procurement practices as well as mechanisms for the active promotion of employment equity are in place.
It may be prudent to put in place standardised communication and dispute resolution procedures in respect of employment creation and training. The above would have to be standardised in the form of contract provisions, specifying input (skills development; job-creation plans) and output key performance indicators (actual evidence that local contractors & labour is being used).

It is recommended that an information programme on power generation and nuclear technology within the broader sciences and maths framework be developed. The development of a bursary fund to allow promising scholars from previously disadvantaged communities to complete higher education (secondary and tertiary) and gain access to mentoring programmes would serve to directly contribute to the promotion of equity.

iii. Property Values

a) Brief Description of Impact and Rating

This variable relates to projected impacts that the development of the proposed PBMR demonstration module may have on property values.

It is not anticipated that the proposed PBMR would have a marked deleterious effect on property values during normal operation and that other factors (such as interest rates and economic factors) appear to play a significantly more important role.

b) Proposed Mitigation Measures

Proactive steps in the re-evaluation and updating of existing emergency and evacuation plans (in respect of Koeberg) as well as the implementation of any specific required actions and/or measures flowing from this will assist in ensuring that property values are not affected negatively.

iv. Direct and Indirect Socio-Economic Impacts

a) Brief Description of Impact and Rating

Purely from a construction point of view, there are three major channels through which construction may impact on the economy. These are through Direct Impacts (related to direct expenditure on producers leading to increased activity in the construction industry; Indirect Impacts (related to an increased demand for materials and services); and induced impacts (related to increases in the flow of income and expenditure resulting from direct and indirect impacts).

This section deals with some components of direct and indirect impacts that would result from the proposed PBMR demonstration module.
A high significance rating is allotted, given the cash injection into the South African economy and specific sectors (e.g. material; civils; labour support costs). The high (as opposed to very high) intensity rating serves to account for the fact that only 48% of the material & equipment costs will be spent on South African made products for the Demonstration Plant.

iteurWaste Management
a) Brief Description of Impact and Rating

This assessment focuses on the social impacts related to high and low level nuclear waste rather than municipal wastes, the latter which will be handled by the CCT.

Rating of the impact took the financial and institutional, health and moral burden of waste management into consideration. For this reason ratings are high. It is noted that all indications are that the current waste management processes will be of a high standard, with high levels of process security.

The public is however, not sufficiently informed or involved in the monitoring and evaluation processes. This exacerbates perceptions of fear and risk.

b) Proposed Mitigation Measures

The need to ensure that the finalisation of the Radioactive Waste Management Policy is fast-tracked has already been noted and is stressed within the context of this impact category.

It is necessary to initiate a visible culture of safety in terms of the application of nuclear technology offering risk, while a complex social construct, is deemed to involve the measurable adherence to duty of care, regulatory requirements and pro-active management of safety and prevention. There is no doubt that the nuclear weapons industry, with its track record of secrecy, military security and pervasive threat of countries at war has served as a strong basis for the development of anti-nuclear heuristics. This will need to be addressed on a consistent, honest and transparent basis through risk communication as well as the introduction of mechanisms that allow ‘visible gate keeping’, through participative monitoring and evaluation programmes as well as the introduction of reporting requirements that are available as well as accessible to communities.

Additional key requirements relate to the need to ensure: (1) continual training, supervision and management of personal who will be required to look after and effectively protect waste storage; (2) sound policies and strategies regarding nuclear power generation and waste management as well as (3) effective and efficient financial and institutional arrangements.
While an EIA process is aimed at the evaluation of impacts of a discreet event such as the proposed activities related to the proposed PBMR demonstration module, the need for ensuring that a Strategic Environmental Assessment (SEA) is in place prior to further implementation of the PBMR technology (if proved feasible) is deemed essential. SEAs address the investigation of all alternatives and impacts relevant to sustainability and cumulative environmental impacts at both a policy as well as planning levels. Such an assessment should provide a framework for the assessments of specific future projects within the context of policy and multi-regional development decisions.

- **Impacts on Known Cultural, Historical and Archaeological Resources**

  a) **Brief Description of Impact and Rating**

  The following assessment focuses on cultural, historical and archaeological resources and has been exclusively based on inputs received from I&APs and information gathered during the baselines study.

  The site that has been selected for the development of the proposed PBMR demonstration module is already disturbed to a significant extent. However, during excavations for the Koeberg reactor, some artefacts were found at some depth from the surface. It is probable that the site for the PBMR will show the same tendency. In view of this, a moderate rating has been allocated in respect of status, duration, intensity, probability and significance.

  b) **Proposed Mitigation Measures**

  Excavations will need to be handled with the necessary care to ensure that any artefacts that may be found are not damaged or destroyed. Where artefacts are found, they will need to be handled according to standard conventions for palaeontological and archaeological remains.

  In addition, any further plans to develop in the area will require archaeological impact assessments as part of an EIA process.\(^{33}\)

- **Conclusions and Recommendations**

  Based on the impact assessment, a number of general conclusions (dealing with the entire process) as well as following specific conclusions (dealing with the PBMR demonstration module) conclusions are made.

\(^{33}\) Source: PBMR Scoping Report.
General Conclusions

No social impact related fatal flaws were found.

The EIA process has been characterised by high levels of mobilisation against the proposed PBMR demonstration module as well as the fuel plant and associated transport actions. In many instances levels of mobilisation appear to have been based on a strong anti-nuclear sentiment. In addition high levels of fear and “dread” regarding perceptions about the potential risk attached to the short- medium- and long-term storage and management of high as well as low level wastes and pollution as well as the potential impacts on health. This perception of “dread risk” is often deliberately or inadvertently escalated by biased information dissemination.

Because of the severe negative psychological impact that can result from the deliberate dissemination of biased information, including the potential for triggering occurrences of the Nocebo Effect, all role-players are perceived to have a moral obligation to communicate honestly.

The public participation, scoping and impact assessment processes have identified both positive and negative perceptions regarding the proposed project. In general, mobilisation against the proposed project appears to be a crystallisation of pre-existing strong anti-nuclear feelings. In general:

- Anti project perceptions have, most frequently, been characterised by:
  - A strong anti nuclear bias.
  - Mistrust of the institutions involved in the nuclear industry.
  - Fears that quality of life will be affected negatively.
  - High levels of perceived risk and fear, mostly as a result of health and safety concerns.

- Pro project perceptions have, most frequently, centred around:
  - A high regard for the historic safe track record of nuclear activities in South Africa.
  - An emphasis on the duty of care.
  - Concerns about issues such as global warming.
  - Strong perceptions on the potential for ensuring the efficacy of mitigation, control and management processes.
Responses that show a strong leaning to logic (as opposed to emotion) and a pragmatic acceptance of statistical and calculated risk assessment based on historic real risk.

At times the project proponents are “too positive” and show a low understanding of the extent of the perceived risk attributed to nuclear technology and nuclear power generation. These two factors together promote the perception that there is a sanguine disregard of legitimate concerns.

A general tendency has been identified where solutions and actions are sought from the inappropriate role-player. An example of this is the requirement voiced by an I&AP that Eskom ensure and provide assurance that no aircraft will fly into the proposed PBMR demonstration module. While it is Eskom’s responsibility to ensure that design criteria are such that the module can withstand such an onslaught, it clearly has no control over civil aviation regulations or activities related thereto.

Specific Conclusions Regarding the Proposed PBMR Demonstration Module

The following conclusions are drawn regarding the intensity of social impacts as well as the development of attitudes and mobilisation against the project, specifically in so far as it relates to the proposed establishment of the PBMR demonstration module:

The proposal for the development of demonstration module for a nuclear technology-based energy generation process is seen as perpetuating the “nuclear” agenda.

The siting of the proposed PBMR demonstration module at Koeberg (irrespective of the fact that it will have a significantly smaller ‘footprint’) is seen as a perpetuation of Koeberg as a nuclear site.

There is a perception that the current emergency and evacuation response systems are dated and/or inefficient. There is a related problem in that the current emergency services, presently performed by the CMC, are being centralized to provincial level. Significant personnel loss is reported with a concomitant deleterious impact on emergency service delivery.

Significant concern has been expressed about the storage and management of both high as well as low level wastes at the site as well as in respect of transportation of waste.

There are strong fears and concerns about radiation related health and safety as well as the potential impacts that would result should a “worst case” scenario be encountered.
The existing Koeberg Plant and the required and imposed exclusion zones are seen to have had a significant deleterious impact on the ability of the CCT to plan, develop and grow Cape Town in a 'rational' manner. Proposals for additional new activities on site have served to bring these feelings to the fore and to escalate them.

**Recommendations**

Based on the impact assessment, the following specific conclusions and recommendations are made, inter alia. That

- The absence of a coherent national nuclear energy policy and particularly the absence of a national policy regarding the disposal of nuclear waste is both a major factor contributing to the "dread risk perception" experienced by the affected society and a substantive environmental hazard in its own right. The failure to finalise the development of such a policy (with due cognisance of the process that has been initiated to develop a Radioactive Waste Management Policy) may be constituted as a breach of the duty of care borne by the national government in terms of Section 28 of the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA) and of the principles as contained in Section 2 of NEMA. For this reason the national government is urged to ensure that, at minimum, the finalisation of an effective radioactive waste management policy is regarded as of the utmost importance and fast-tracked, with full cognisance of the need to follow due process.

- Risk perception and negative psycho-social sequelae of nuclear related "dread risk perception" is frequently attenuated and tempered by the provision of neutral, reliable, responsible, un-biased information dissemination and risk communication. While there is a limited public perception that neither NECSA nor Eskom will necessarily, provide neutral information and risk communication, it is also perceived that anti-nuclear lobbies will not necessarily engage in the provision of neutral information and risk communication either. For this reason it is seen as an urgent imperative that an organisation such as the African Commission on Nuclear Energy (AFCONE), formed to oversee compliance in respect of the Organisation of African Unity's Treaty of Pelindaba, be formally requested to extend its activities under Article 12 of the Treaty to educate and inform the public of the real risks and issues related to "the peaceful use of nuclear energy for the betterment of society".

- It is vital that the Tygerberg Hospital's ability to cope with nuclear incidents and disaster is maintained, in line with the World Health Organisation's (WHO) REMPAN programme, aimed at promoting regional competence to deal with nuclear incidents and disasters. It is, therefore, seen as an absolute requirement that
NECSA and Eskom continue to ensure that Tygerberg Hospital maintains this competence.

- Decision-makers and the proponents of nuclear technology should avoid ..."the temptation to promote the new generation nuclear industry by protecting it from effective public scrutiny...".\(^{34}\) Not only is scrutiny necessary, this should be extended to participative scrutiny involving communities, authorities and interest groups in the ongoing monitoring of key activities against set indicators. Activities aimed at promoting and ensuring duty of care and adherence to regulatory requirements also termed ‘gate-keeping’ activities should be visible and accessible to all.

- There is an ethical obligation on operators and managers of nuclear processes to inform the potentially affected public of how much risk they are being exposed to by the activities. It is also their responsibility to ensure that those potentially affected understand the risk they (or future generations) could be exposed to.\(^{35}\)

- Attention should be paid to community outrage factors and concerns. This will require that it be accepted that response to risk is more complex than the provision of scientific data and linear response to facts and that information should be provided so as to meet the requirements of people. It is important that nuclear proponents, should familiarise themselves with the content of the socio-economic debate about nuclear technology, in an effort to understand where fears and concerns come from and why these fears and concerns are often perceived valid.\(^{36}\)

- Clear indications should be provided about the requirements, duties, obligations and responsibilities of all role players involved in nuclear energy generation, including the NNR, government at national, provincial and local level as well as role player such as NECSA and Eskom. There appears to be a tendency for (at least perceptually) not acknowledging that there must be an alignment between the responsibilities placed on an organisation or institution and the level of authority it may have.

- Risk communication and risk management should be established as a "two-way" process that includes mechanisms to address legitimate concerns as has been

\(^{34}\) Hattingh and Seeliger, 2002

\(^{35}\) Hattingh and Seeliger, 2002

\(^{36}\) Hattingh and Seeliger, 2002
stressed at various stages in the SIA Report and future public inputs. In this regard it is proposed that Eskom extends its efforts regarding communication with the surrounding and potentially affected communities and involve them in transparent and open monitoring and evaluation processes. In this regard, the formation of a monitoring and evaluation committee for the proposed PBMR demonstration module is strongly recommended. Some guidelines regarding the promotion of effective risk communication include ensuring that:

- A senior person at Eskom is appointed to communicate with the public.

- There is a thorough understanding and acceptance of community concern and sensitivity about secrecy and that information is provided freely and involves the public from the outset.

- Every attempt is made to, first and foremost, earn trust and credibility.

- No mixed messages are given and ensuring that all information has been checked and double-checked for accuracy.

- The truth is told at all times even where this involves “bad news”, instead of attempting to salvage the situation later.

- Attention is paid to community outrage factors and concerns. This will require that it be accepted that response to risk is more complex than the provision of scientific data and linear response to facts and that information should be provided so as to meet the requirements of people.

- Wherever practicable, the help of organisations that have credibility in communicating with communities is enlisted.

DEAT give serious consideration to the establishment of a Strategic Environmental Assessment (SEA) process to address the investigation of all alternatives and impacts relevant to energy generation and the sustainability and cumulative environmental impacts thereof at policy as well as planning levels. Such an assessment should provide a framework for the assessments of specific future projects within the context of policy and multi-regional development decisions. The work by, especially the European Commission in respect of their ExternE Programme provides a basis for including a sound and tested basis for factors relating to comparative risk assessments related to energy options.

All mitigation measures should be reflected in the EMP and implemented accordingly.
4.3.2 PLANT RADIOLOGICAL SAFETY AND SECURITY IMPACT ASSESSMENT

Introduction

The PBMR (Pty) Ltd on behalf of Eskom has prepared a comprehensive Safety Analysis Report (Rev 1) as well as a Detailed Feasibility Report (Doc No. 009838-160 Rev 1) on Radiological Safety. Extracts from these reports are presented below. Sections 6.0, 6.1, 6.2 and 6.3 of the SAR (Rev 1) are contained in Annexure 23.

Safeguards

An agreement has been entered into between the government of South Africa and the IAEA for the application of safeguards as provided for in the Treaty on the Non-proliferation of Nuclear Weapons. Any nuclear facility constructed in South Africa must fall within the ambit of this agreement. The South African government has enacted the Nuclear Energy Act 131/1993 to implement its commitments and obligations in the agreement.

Within the government, the Minister of Mineral and Energy Affairs who is responsible for the implementation of the act, has delegated part of this responsibility to NECSA.

The implementation of the Safeguards Agreement requires that Subsidiary Arrangements have to be developed and agreed with IAEA for each of the nuclear facilities, which are under safeguards. For the PBMR project this means that such Subsidiary Arrangements have to be concluded for the demonstration plant and fuel manufacturing plant.

The import of enriched uranium for the project will also require an import permit to be obtained from DME, as stipulated in the Nuclear Energy Act. Such a contract can only be concluded as and when the project is authorised to proceed.

Conclusion

The proposed PBMR will impact on the Treaty. However, the establishment of the required Subsidiary Safeguards Agreements will ensure adequate control through precise accounting of the nuclear materials inventory as well as reporting to and inspection(s) thereof by the NNR and IAEA.

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37 PBMR Demo Plant DFR, Doc No. 009838-160 Rev 1
Radiological Safety

The Final Safety Design Philosophy (FSDP) is based on the premise that the fuel will retain its integrity to contain radioactive fission products under normal and accident conditions and thereby assure radiological safety. This is achieved by relying on fuel whose performance has been demonstrated under simulated normal and accident conditions, and whose integrity will not be compromised even under accident conditions.\(^{38}\)

To ensure that the fuel integrity is maintained, the plant design for operating and accident conditions provide for the following:

- Sufficient heat removal capability such that fuel temperatures will remain in the proven safe region;
- Limited chemical and other physical attack on the fuel; and
- Adequate measures to control reactivity and to ensure the shut down of the reactor.\(^{39}\)

Safety Analyses

Appropriate analysis demonstrates that the Fundamental Safety Design Philosophy (FSDP) and NNR standards have been met with adequate margins. The design has been systematically analysed to ensure that all normal and abnormal conditions have been identified and considered. This analysis is updated with any changes to the design during the life of the plant and reviewed periodically.\(^{40}\)

Probabilistic Risk Assessment

A comprehensive Probabilistic Risk Assessment (PRA) demonstrates that the PBMR design meets regulatory risk criteria. See Annexure 23.

The PRA of the PBMR design provides a systematic analysis to identify and quantify all risks that the plant imposes to the general public and the environment and thus demonstrates compliance to regulatory risk criteria. The calculations of consequence are undertaken with best estimate assumptions and uncertainties.

The PRA also identifies what measures may be taken to further enhance safety.

\(^{38}\) SAR Rev 1, Chapter 1
\(^{39}\) SAR Rev 1, Chapter 1
\(^{40}\) SAR Rev 1, Chapter 1
Compliance with regulatory risk criteria focuses on the challenges to fuel integrity, despite the large conservatism associated with this approach. However the status of Systems, Structures and Components which will act as further barriers to prevent the release of fission products is modelled in the PRA. The level of safety/risk is quantified and provides a measure of the levels of defence-in-depth that exist in the design and operation of the PBMR and provides a tool for further optimisation.\(^{41}\) Chapter 4.20.5 provides the results of the PRA for a category C event as defined by the Fundamental Safety Criteria of the NNR.

**Defence-in-Depth**

The design is such that any single failure of an element of the safety case does not invalidate the Fundamental Safety Design Philosophy. This is achieved by applying the Defence-in-Depth principle.\(^{42}\) If one barrier fails, other barriers prevent the undesirable consequence of the failure.

**Alara**

The design ensures that for all pathways, any dose received by the operators and public, and releases to the environment in normal operations, as well as risks from accident conditions, not only meets all regulatory limits and constraints, but is also As Low As Reasonably Achievable (ALARA).\(^{43}\)

**Radiation Protection Programme for Normal Operation**

The principle of ALARA is embodied in all operating Support Programmes. In particular a Radiation Protection Programme specifies Radiation Protection (RP) limits and measures to limited personnel dose, and includes operating procedures to control the release of radiological effluent and the generation of solid radioactive waste from the normal operation of the plant. It minimizes, the radiological exposure to the plant personnel, general public and environment to As Low As Reasonably Achievable (ALARA).\(^{44}\)

**Test and Commissioning Programme**

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\(^{41}\) SAR Rev 1, Chapter 1  
\(^{42}\) SAR Rev 1, Chapter 1  
\(^{43}\) SAR Rev 1, Chapter 1  
\(^{44}\) SAR Rev 1, Chapter 1
An extensive Test and Commissioning Programme will be conducted to demonstrate the performance of all Systems, Structures and Components (SSC) and materials especially those which are important to safety. This programme, which is supported by an appropriate testing and qualification programme for SSC, ensures that any physical phenomena that have an application to the safety of the PBMR design, are adequately demonstrated on the first module.

A pre start up commissioning programme will allow for sub-system, system and complete plant test before any fuel is loaded into the core.

The documentation in place to support the safety operation of the PBMR is in the form of General Operating Rules (GOR) (Annexure 17). The GOR are interface documents between the PBMR plant design and the actual operating practices. They prescribe the operating rules, which ensures that the plant stays within the envelope of its design bases in any operating state, normal or abnormal, and ensures that the main assumptions in the safety assessment remain valid.

Adherence to the plant operating procedures ensures that during normal operation the plant remains within a domain of plant states that have been proven safe, with an appropriate safety margin, by means of safety analysis, computer modelling, systems validation and commissioning tests. Operating Technical Specifications (OTS) define the technical rules to be observed in order to maintain the plant within this domain. They are developed on the basis of the design studies and identify limits on continued operation and the required corrective actions, should these limits be exceeded.

A Radiation Protection Programme provides for controlled access to areas where radiation and/or radioactive contamination may be present. This is accompanied by a radiation protection monitoring programme to ensure that no worker will receive an undue exposure to radiation and that only authorized radiation workers are allowed to work in controlled areas. A comprehensive plan protects personnel from excess exposure during maintenance activities.

A Waste Management Programme ensures that the generation of radioactive waste is minimized throughout the lifecycle of the plant. Management of the processing, conditioning, handling and storage of radioactive waste limits the radiological doses to the plant personnel and general public, and the radiological impact on the environment.

The PBMR design ensures that the generation of process (non-spent fuel) waste during plant operation is limited. Where radioactive waste is generated (ventilation filters, maintenance arisings, etc), adequate facilities are included in the module for storage. This reduces the need for frequent handling and transport of radioactive waste outside
the module. Appropriate conditioning and processing of the waste minimises the required storage volume.

Provisions are made for the disposal of low and intermediate level operational waste in the licensed off-site repository.

The design of the PBMR includes a facility inside the module to store all the spent fuel generated over the planned life. This storage system will provide a long-term storage for fuel after the end of the operational life of the PBMR. It is planned that the fuel will be transferred directly from the PBMR to final disposal when appropriate in accordance with national policy.

The design of the PBMR takes into consideration the volume and type of waste generated in decommissioning the plant. Design features are included to minimise this waste.\textsuperscript{45}

A Maintenance Programme is developed to keep all the functions required for plant operation available and reliable. The Programme includes appropriate control, monitoring and management systems, using preventive, predictive and corrective maintenance. The technical basis for the programme is founded on PBMR Fundamental Safety Design Philosophy.

Assurance that there are adequate means to monitor the plant, and detect when the plant is outside of its normal operating envelope is obtained by establishing and following appropriate Test and Surveillance Programmes. Periodic tests, re-qualification tests and surveillance tests demonstrate plant line-up and system function readiness under the conditions provided for in the design, and provide confidence that plant and systems will perform the functions within the required levels of performance, in accordance with the design studies. These test programmes contain the frequency and success criteria for individual component testing, as well as reference to the test bases, test rules, standards and codes, system performance studies, etc.

Plant condition monitoring programmes ensure that any deterioration of particularly safety important equipment is detected before equipment degrades beyond an acceptable limit. Plant condition monitoring (which includes In-service Inspection (ISI)) provides an assessment and an assurance of the plant condition and minimum required performance levels. This monitoring validates the assumptions in the design studies and monitors plant degradation and precursors to equipment failure.

\textsuperscript{45} SAR Rev 1, Chapter 1
An Emergency Plan appropriate to the level of nuclear hazard posed by the PBMR under abnormal or accident conditions will be in place and lays down the level of preparation required both on and off the power station site. If the PBMR is on a common site with another facility (nuclear or non-nuclear), then the site emergency plan must consider all on-site facilities, using a consistent technical bases for determining the extent of the emergency plan measures.\textsuperscript{46}

\textbullet\hspace{0.5em} Radiological

The Radiation Protection Programme and Waste Management Programme will be consistent with the basic licensing requirements for the PBMR, as described in the NNR Licensing Guide, LG-1037, and will ensure compliance with the fundamental safety requirements relating to a system, to safeguard personnel and the public against radiological hazards for normal operation, based on the following principles and objectives:

\begin{itemize}
  \item All exposures of site personnel and the general public shall be kept As Low As Reasonably Achievable (ALARA), taking into account the resulting Total Effective Dose Equivalent (TEDE).
  \item The dose to individuals shall not exceed the effective and equivalent dose limits detailed in the SAR. To achieve this, radiological protection and radioactive waste management programmes shall be established to control occupational, public, potential, chronic and emergency exposures.
  \item The defence-in-depth concept shall be applied in the operational radiological protection and the radioactive waste management programmes.
\end{itemize}

The component layout has not yet been fully finalised, hence equipment location cannot be quoted, and only the major components are referenced.\textsuperscript{47}

The high retention of radiologically significant fission products by the coated fuel particles has been studied extensively in the German fuel development programme. The high degree of safety and the low source term of the PBMR are a consequence of this ability of the coated fuel particles to retain fission products, even at high temperatures.

\textsuperscript{46} SAR Rev 1, Chapter 1
\textsuperscript{47} SAR Rev 1, Chapter 6.3
For the purposes of identifying radiation fields and designing the radiation protection programme for the PBMR, the following nuclear systems have been considered as the main sources of radiation:

- reactor and Power Conversion Unit (PCU);
- fuel handling equipment;
- primary coolant-conveying systems; and
- water-carrying systems.

The strongest radiation field is that around the reactor during operation. It determines the design of the shielding around the reactor and the PCU. Apart from gamma radiation, neutron radiation is also significant. After reactor shutdown, only gamma radiation needs be considered in shielding design. The same applies to all non-fuel-containing systems for all operating states.

The sources of all other radiation fields also originate from the reactor. They are products either of nuclear fission in the fuel, or of activation in the radiation field of the reactor.

Other radiation fields are primarily caused by:

- Fission products - in the fuel elements and as contaminants in the primary coolant.

- Activation products - in the structural material and systems surrounding the reactor core.

Nearly 100% of the total quantity of fission products is retained in the fuel elements, which form the main radiation source in the fuel handling equipment. The main components of the fuel handling equipment are located around the upper part of the reactor vessel.

The noble fission product gases and highly volatile fission products constitute the basis of the primary coolant activity. These fission products primarily originate from the small fraction of failed particles caused by manufacturing and irradiation-induced defects. The main activity-carrying components of the helium purification system are the dust removal filters, the molecular sieves, and the helium storage tanks. They are housed in the reactor building.

The Active Cooling System (ACS) will contain radioactivity during operation. As the Reactor Cavity Cooling System (RCCS) is located in the radiation field of the reactor,
radioactive isotopes are produced by activation of the water and any impurities present in it, and by activation of the structural materials followed by corrosion. This then causes a radiation field in areas where this cooling water is located. Any leaks or deposition from this system will cause areas of contamination.

The design of the PBMR power plant is based on the following principles intended to keep radiation exposure of the operating personnel as low as reasonably achievable:

- There is a clear division between different radiation areas.
- Plant equipment and shielding facilities are designed and installed in such a way as to maintain occupational radiation exposure of personnel as low as reasonably achievable and also below statutory limits.
- The following measures are taken for this purpose:

Various barriers, such as the pyrocarbon and silicon carbide coatings of fuel (so-called TRISO coating), the graphite structure of the fuel element and the primary gas envelope prevent uncontrolled releases of radioactive materials to plant areas.

Fission product release from the fuel is very low because of:

- the smaller number of fuel particles in silicon carbide layers having manufacturing defects;
- the low irradiation-induced fraction of particle failure in normal operation;
- negligible fission product diffusion through intact silicon carbide layers; and
- retention of solids in the graphite matrix.

The resulting primary coolant activity is very low.

The following facilities are also employed to limit radioactivity:

- Systems for extraction of radioactive materials from the primary coolant and for storage of these materials.
- Where possible, design of plant equipment is such to avoid accumulation of solids. Where this is not possible, facilities for removal of such will be available.

Further radiation protection measures are taken during plant design:
Shielding is, where possible, designed such that movement is not required.

Shielding inside the controlled area is designed such that the dose rates in compartments containing radiation sources are not significantly affected by radiation from adjacent compartments.

Shielding is designed to minimize streaming of high levels of radiation.
Shielding of compartments, which do not contain radiation sources, is based on necessary accessibility of the compartment.

Shielding of the controlled area to the outside, during normal operation and anticipated operational occurrences ensures safe adherence to the limits for non-radiation workers on the rest of the power plant site, and safe adherence to the dose limits for the public off-site.

The physical layout of the controlled area is selected in such a way that compartment configuration meets radiological protection requirements wherever possible.

No compartment is to be entered through compartments in which local dose rates are expected to be higher than in the target compartment itself.

Entrances are equipped with doors or traps where necessary for radiation protection reasons.

Wall penetrations, e.g. for ventilation, cables and pipes, are positioned and designed such that radiation passing through them does not govern the design dose rates in adjacent compartments.

At selected locations in the controlled area, the local dose rate is monitored by means of stationary or area-dedicated portable measuring instruments.

Shielding is such as to allow access to control rooms for the maintenance of a safe plant state.48

The Radiological Protection (RP) Organization

The radiation protection organisation will be established in order to identify responsibilities for the implementation of the various programmes embraced under the radiation protection programme. The radiation protection organisation will comprise an adequate number of suitably qualified and experienced personnel to ensure the effectiveness of the individual programmes such that the objectives of the radiological protection programme are attained. The PBMR site operational management will ensure that the radiation protection organisation is equipped with sufficient resources in order to be able to achieve this.49

48 SAR Rev 1, Chapter 7.5
49 SAR Rev 1, Chapter 7.5
Functional Specification for the RP Organization

The structure of the RP organisation will be described by an organogram, with the definition of responsibilities for the implementation of each part of this programme.

Notifications

In the event of a change to the RP organisation the necessary notifications to the regulatory authority will be identified and implemented. 50

The Establishment of Dose Limits

Dose limits will be established by the appropriate regulatory authority, and therefore there is no section relating to notifications in this regard. Dose or collective dose targets are established by the operator, and may be subject to notification to the regulatory authority, should they be changed. The following dose limits shall apply to the operation and decommissioning of the PBMR. 51

Occupational Exposure

The occupational exposure of any worker at the PBMR shall be so controlled that the following dose limits are not exceeded:

- an effective dose of 20 mSv per year averaged over five consecutive years;
- an effective dose of 50 mSv in any single year;
- an equivalent dose to the lens of the eye of 150 mSv in a year; and
- an equivalent dose to the extremities (hands and feet) of 500 mSv in a year.

The working conditions of a pregnant worker, after the declaration of the pregnancy, should be such as to limit the additional equivalent dose to the conceptus (foetus) to 1 mSv during the remainder of the pregnancy. 52

Non-radiation Workers and Visitors to the Site

The estimated average doses to non-radiation workers, and the dose to visitors to the PBMR site, will not exceed 1 mSv in a year. 53

50 SAR Rev 1, Chapter 7.5
51 SAR Rev 1, Chapter 7.5
52 SAR Rev 1, Chapter 7.5
53 SAR Rev 1, Chapter 7.5
Public Exposure

The estimated average doses to the critical groups of members of the public shall not exceed the following limits;

- an effective dose of 250 µSv in a year;
- an equivalent dose to the lens of the eye of 15 mSv in a year; and
- an equivalent dose to the skin of 50 mSv in a year. 54

ALARA Considerations

Although the dose limits have been established, all doses to occupationally exposed workers and to members of the public shall be kept ALARA below these limits.

As an aid in achieving this, an ALARA objective will be defined for annual individual effective dose, and the average effective dose to the collective workforce. 55

Notifications

Any necessary notifications to the regulatory authority, in the event of a change to the ALARA targets, will be identified. 56

The Operational Radiation Protection Programme

The operational radiation protection programme is intended to ensure the protection of the occupationally exposed workforce, by ensuring that personnel exposed to ionising radiation are subject to a strategy of controls, which will ensure that compliance with the dose limits and the ALARA principle can be achieved. The operational radiation protection programme comprises the following facets. 57

a) The Designation of Areas

Areas within the PBMR site will be designated according to radiological hazard. The basic principles that will be followed for designation of areas are as follows. 58
(i) Controlled areas

A controlled area is an area in which specific protective measures or safety provisions are, or could be, required for:

- controlling normal exposures or preventing the spread of contamination during normal working conditions; and
- preventing or limiting the extent of potential exposures.

In practice, a controlled area is established around areas where there is a potential for surface or airborne contamination to exist, or where the integrated annual equivalent dose to any worker is likely to exceed approximately 6 mSv. To minimise the hazards to individuals working in these areas, and to prevent the spread of contamination, access to these areas are strictly controlled. ⁵⁹

(ii) Supervised areas

A supervised area is any area not already designated as a controlled area, but where occupational exposure conditions need to be kept under review, even though specific protection measures and safety provisions are not normally required.

In practice, a supervised area is established in areas where there is no potential for surface or airborne contamination to exist, or where the integrated annual equivalent dose to any worker is likely be greater than 1 mSv per year, but less than 5 mSv per year for an occupancy of 2 000 h per year. ⁶⁰

Classification of areas within controlled areas according to ambient dose equivalent rate

Further classification of areas within the controlled area aids in identifying where access restriction must be imposed. All areas within controlled areas will be further classified into a strategy of zoning based upon ambient dose equivalent rate. This definition of each area in terms of this zoning strategy will take into account the need for access as a result of In-service Inspection (ISI), maintenance, surveillance, etc. and the need for compliance with the annual effective dose limit for occupationally exposed workers. The conditions, within which allowance may be given for hotspots exceeding the zone classification, will be given. ⁶¹

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⁵⁹ SAR Rev 1, Chapter 7.5
⁶⁰ SAR Rev 1, Chapter 7.5
⁶¹ SAR Rev 1, Chapter 7.5
Classification of areas within controlled areas according to surface and airborne contamination

Areas with loose surface and/or airborne contamination may exist inside controlled zones. These areas will be designated and appropriately demarcated where the surface and airborne contamination levels warrant such a division. The level of surface or airborne contamination at which a surface or airborne contamination zone is declared, will be defined and justified on the basis of the nature of the source term.\textsuperscript{62}

Access and Exit Control

Access to controlled areas will be regulated by the Radiation Protection Group. Certain requirements will exist before an individual may enter a radiation zone. The requirements for entry and egress will be stipulated, and will include reference to following aspects:

- Review of the qualification of personnel for work involving radiation.
- Review of individual exposure history prior to entry.
- Issue of direct reading and legal dosimetry appropriate for the working and radiation environment, and any bioassay requirements for personnel once the work has been completed.
- Specification of the reason for entry including a description, the location and duration of the work and the number of individuals involved.
- Specification of the radiological conditions in the area being visited and any necessity for further radiological surveillance.
- Specification of protective clothing.
- Specification of any radiological controls necessary during the entry including hold-points in any work to be performed.
- A system to validate authority for access to the controlled zone.
- A system to ensure that personnel egress has been noted for purposes of personnel accountability.
- The personnel surveillance requirements for exit from controlled areas, including radiological criteria.

\textsuperscript{62} SAR Rev 1, Chapter 7.5
The radiological criteria for removal of material from controlled areas. 63

Categories of Personnel Entering the PBMR Site

Persons entering the PBMR site may do so for various reasons, and may need to access different areas. Therefore a classification scheme will be necessary in order to aid in access restriction to hazardous areas, ensuring that only personnel who are suitably qualified, are able to enter controlled areas. 64

The categories of persons that may enter the PBMR site are as follows:

(1) Persons qualified for radiation work

This may include two sub-categories:

- Persons qualified for radiation work in the host country.
- Persons qualified for radiation work in another country, but requiring access to the PBMR-controlled zone in the host country. 65

(2) Persons not qualified for radiation work

This may include three sub-categories:

- Persons who are not qualified for radiation work, who do not require access to controlled zones, but have responsibilities on the PBMR site (non-radiation workers).
- Persons who are not qualified for radiation work, who do not normally have responsibilities on the PBMR site, but who sometimes require access to the controlled area.

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63 SAR Rev 1, Chapter 7.5
64 SAR Rev 1, Chapter 7.5
65 SAR Rev 1, Chapter 7.5
Persons who are not qualified for radiation work, who do not require access to controlled zones, and do not normally have responsibilities on the PBMR site (visitors).

The qualifications and limitations to the activities appropriate to each of these categories of personnel will be described. 66

Radiological Surveillance

Radiological surveillance will be required for a number of purposes. 67

Routine radiological surveillance

Routine radiological surveillance is required in order to continually monitor and record the radiological conditions in all parts of the module - both inside and outside the controlled area. Such monitoring is implemented as a matter of routine, and is not applicable to surveillance during the performance of work. The information is used for trending and characterising areas in terms of radiological hazard due to external radiation, airborne contamination and surface contamination, and as a means to confirm that the original radiological zoning is adequate, to identify any changes in radiological status, and to investigate any anomalies.

The location, frequency and type of monitoring to be implemented must be specified and justified in terms of the predicted radiological hazard and the potential for change, type of work activities to be performed in the area, and the expected occupancy of the area. The action levels at which some action would be implemented upon exceeding the level, will be defined as well as the action required, and both will be justified.

The database for the recording of surveillance results will be described. 68

Task-related surveillance

Task-related surveillance will be required for defined tasks - usually those performed inside the controlled area, which have potential radiological hazards associated with them. Following a pre-task review, the required strategy of radiological surveillance is

66 SAR Rev 1, Chapter 7.5
67 SAR Rev 1, Chapter 7.5
68 SAR Rev 1, Chapter 7.5
recommended, which includes the type, location and frequency. It will also include action levels at which some action would be implemented upon exceeding the level.

The location, frequency and type of monitoring to be implemented will be specified and justified in terms of the predicted radiological hazard, and the potential for change considering the type of work activity being performed. The action levels at which some action would be implemented upon exceeding the level, will be defined as well as the action required, and both will be justified.

The database for the recording of surveillance results associated with each task will be described. 69

Shield verification surveillance

Post start-up shielding tests are necessary to confirm that the performance of shielding is as predicted in the design analyses. The source term used in the design analysis will dictate the predicted level of external dose. Similarly, in order to make a meaningful comparison of the measured radiation levels against those which have been predicted, it must be ensured that the same source term is available. A programme of shield verification measurements will be constructed, which identifies the location, type of survey measurement, type of survey instrument, the point in time at which the measurement should be made (taking into account the operational status of the plant), and the expected measurement result based upon the design analysis. The point in time at which the measurement will be made is important, since sufficient time must be allowed for some radiation sources to develop. Therefore, the timing of measurements will be justified on this basis. Tests will also be conducted when previously tested shielding has been modified. Testing of shield wall penetrations will also be performed to verify that the degree of radiation streaming is within design limits.

The action to be taken in the event that the measured level exceeds the predicted level will be specified and justified. 70

The Administrative System for the Specification of Radiological Work Control

An administrative system of work control shall be described, which allows an individual access to the controlled area for work purposes, and which specifies all radiological safety requirements, which are applicable to the particular task.

69 SAR Rev 1, Chapter 7.5
70 SAR Rev 1, Chapter 7.5
This system will allow for the following:

- The qualification of personnel for work involving radiation.

- Specification of direct reading and legal dosimetry appropriate for the working and radiation environment, and any bioassay requirements for personnel once the work has been completed.

- The reason for entry including a description, the location and duration of the work, and the number of individuals involved.

- Specification of the radiological conditions in the area being visited, and any necessity for further or continuing radiological surveillance.

- Specification of protective clothing.

- Specification of any radiological controls necessary during the entry, including hold-points in any work to be performed.

- Specification as to what level of ALARA review has been attributed to the task.

- Specification of ALARA review comments. 71

The Radiation Dosimetry Programme

To ensure compliance with annual dose limits and ALARA objectives, a Radiation Dosimetry programme will be implemented that will enable the measurement and subsequent control of the personal dose equivalent quantities due to external radiation fields and the committed effective dose due to intakes of radio nuclides. The Radiation Dosimetry programme therefore has an External Dosimetry Programme component and an Internal Dosimetry Programme component. 72

The external dosimetry programme

Only dosimetric devices as approved by the regulatory authority shall be used as legal dosimeters. Other dosimeters may be used to complement the monitoring of the personal dose equivalent quantities that a radiation worker may receive.

Arrangements will be made for the issue and the collection of dosimetric devices.

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71 SAR Rev 1, Chapter 7.5
72 SAR Rev 1, Chapter 7.5
Controls will be established to ensure that personnel entering controlled zones are in possession of an approved legal dosimeter(s) (including extremity dosimeters and neutron dosimeters), depending on the exposure circumstances.

Arrangements will be made to ensure that doses received by personnel in radiation zones, as indicated by direct reading dosimeters, are recorded upon exit from the controlled zone. This will be done as part of the dose tracking system.

An investigation level will be established for unplanned exposures.

The external dosimetry programme will make reference to the following:

- The justification for the use of a dosimeter as a legal dosimeter, including reference to the personal dose equivalent quantities measured, and the strategy of performance tests required to satisfy regulatory requirements.
- The operational calibration and quality control test strategy, including the conversion factors used to determine the personal dose equivalent quantities of interest from the primary quantity used in calibration. \(^{73}\)

The internal dosimetry programme

Facilities will be available to perform the necessary analyses for the estimation of committed effective dose from intakes of the radio nuclides of importance as dictated by the nature of the source term. With regard to analytical facilities, the internal dosimetry programme shall address the following:

- The nature of the source term and the different types of analytical facility necessary for the estimation of the intake.
- The requirements in terms of sensitivity of each type of analytical equipment.
- The requirements in terms of quality control checks and calibrations for each type of analytical equipment.
- The establishment of investigation levels.

With regard to operational procedures, the internal dosimetry programme shall address the following:

- The frequency of routine bioassay for occupationally exposed workers.
- The circumstances where special bioassay measurements are required.

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\(^{73}\) SAR Rev 1, Chapter 7.5
The methodology used to determine intake from circumstances where the time at which the intake has occurred is not known, and the methodology used to determine the committed effective dose.  74

The Respiratory Protection Programme

The respiratory protection programme supports the operational radiation protection programme by ensuring the availability of suitable respiratory protection equipment, as and when required.  75

Respiratory protection programme considerations

The use of respiratory protection will be governed by the following guidelines:

- In routine operations, the use of respiratory protection as a substitute for engineered controls will be minimized.
- During emergencies, which may involve entering unknown atmospheres, sufficient respiratory devices of the pressure-demand Self-contained Breathing Apparatus will be provided.
- Consideration will be given to ALARA when prescribing respiratory protection, which could lengthen working times, cause physical and psychological stress, and impair communication.

In addition to this, the following aspects of the respiratory protection programme will be described:

- Guidelines for acceptable practice relating to the use of prescription glasses, contact lenses, presence of facial hair, dentures, and protective headgear with respiratory protection.
- The selection methodology for respiratory protection appropriate to foreseen circumstances, taking into account the airborne contaminant type, the nature of the sorbent or filter, and any other factors which could influence the effectiveness of the protection.
- The training programme to ensure that personnel receive the necessary training in the use of respiratory protection provided, and to include the necessity for fit-testing, where appropriate.

74 SAR Rev 1, Chapter 7.5
75 SAR Rev 1, Chapter 7.5
The medical screening of personnel to ensure that any contra-indications to the wearing of respiratory protection are identified.

The maintenance programme for respiratory protection equipment, to include reference to storage locations, inventory checks, accountancy procedures, maintenance practices, decontamination and cleaning, and inspection and testing of new equipment.  

Training Programmes

Training is necessary for occupationally exposed workers who are routinely exposed to ionising radiation as part of the ALARA commitment. The provision of re-qualification courses enables the feedback of operational experience to improve radiation work practices in any areas found to be weak.

The provision of other training courses is also necessary, for instance, visitors to the site need be less detailed and focused on more general practices such as what to do in the event of an emergency.

For all types of training courses provided, the following will be described:

- the course name, target audience, training objective and the course content;
  and
- any requirements for persons to re-qualify.

Procedures, Records, Reports and Notifications for all Programmes Comprising the Operational Radiation Protection Programme

All aspects of the programmes comprising the operational radiation protection programme shall be described by procedure.

The necessary records and their period of retention for all aspects of the programmes comprising the operational radiation protection programme will be described.

The necessary reports to the regulatory authority, and their frequency of submission for all aspects of the programmes comprising the operational radiation protection programme, will be described.

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76 SAR Rev 1, Chapter 7.5
77 SAR Rev 1, Chapter 7.5
The necessary notifications to the regulatory authority, and the conditions under which they will be made for all aspects of the programmes comprising the operational radiation protection programme, will be described. 78

Radiological Effluent Management Programme

Studies of the migration of activity from the fuel to the systems of the module and to the discharge points, will aid in the estimation of conservative release quantities. These will be used by the regulatory authority, in conjunction with dose conversion factors, to determine the acceptability of the estimated releases, and to consolidate authorised discharge quantities. The radiological effluent management programme has been established in order to ensure compliance with the discharge authorisation given by the regulatory authority, and thereby provide protection to members of the public. The radiological effluent management programme comprises aspects relating to installed radiation monitoring, sampling and analysis and accountancy of releases. 79

Installed Radiation Monitoring

In terms of monitoring of airborne and liquid radiological releases, the following will be addressed:

- A description of each type of monitoring provided, and the radio nuclides that each is capable of detecting, together with a justification that all significant radio nuclides in the source term have been addressed.
- The sensitivity of each monitor, and a justification for the acceptability of this sensitivity.
- A description of how the information provided by the monitoring instrumentation will be used to determine the quantity released, and at what frequency this is performed.
- A specification and justification of any alarm/trip set points that may be applicable, and any associated automatic isolation functions that may be activated.

78 SAR Rev 1, Chapter 7.5
79 SAR Rev 1, Chapter 7.5
A description of any automatic isolation functions associated with the monitoring systems provided.

A description of the type and frequency of all quality assurance checks applicable to the monitoring system, including calibration.\(^{80}\)

**Sampling and Analysis Procedures**

In terms of sampling and analysis as a means of monitoring of airborne and liquid radiological releases, the following will be addressed:

- A description of each type of monitoring provided, and the radio nuclides that each is capable of detecting, together with a justification that all significant radio nuclides in the source term have been addressed.
- The sensitivity of each monitoring method, and a justification for the acceptability of this sensitivity.
- A description of how the information provided by the monitoring method will be used to determine the quantity released.
- Specification of an investigation level of activity in effluent from considerations of the expected levels of activity.
- A description of the type and frequency of all quality assurance checks applicable to the instrumentation used as part of the monitoring method, including calibration.\(^{81}\)

**Administrative Controls**

The method of radio nuclide accountancy will be described.

The authorisation procedure for the discharge of batch releases will be described.\(^{82}\)

**The Radioactive Waste Management Programme**

The radiological waste management programme is established in order to ensure the correct management of radioactive waste with a view to the protection of the

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\(^{80}\) SAR Rev 1, Chapter 7.5  
\(^{81}\) SAR Rev 1, Chapter 7.5  
\(^{82}\) SAR Rev 1, Chapter 7.5
occupationally exposed workforce and members of the public. In order to achieve this, the radiological waste management programme has various requirements: 83

Requirements of the Radioactive Waste Management Programme

The following requirements of the radioactive waste management programme will be detailed:

- The identification of all sources of radioactive wastes.
- Methodologies to determine the radio nuclide-specific content as either the level of surface contamination and/or volumetric contamination.
- Methodology for the classification of all radioactive wastes according to the radio nuclide(s), volumetric activity concentration or level of surface contamination (fixed and non-fixed) and origin.
- How each class of waste will be processed and packaged to satisfy the requirements of the regulations for the safe transport of radioactive materials.
- The locations to be used for radioactive material storage.
- An accounting system which details the contents of all packages, and where the package is stored or was disposed of. 84

Receipt, Disposal and Transport of Radioactive Material

In order for the PBMR site to receive material contaminated with radio nuclides, the necessary authorisation will be obtained from the appropriate regulatory authority.

For disposal of radioactive waste, the packaging requirements of the appropriate regulatory authority will be described for all relevant categories of radioactive waste.

Radioactive waste and material contaminated with radio nuclides will be packaged for transport according to the requirements of the regulations for the safe transport of radioactive materials. 85

83 SAR Rev 1, Chapter 7.5
84 SAR Rev 1, Chapter 7.5
85 SAR Rev 1, Chapter 7.5
The ALARA Programme

The operational management of the PBMR is committed to an ALARA programme with the objective of maintaining all doses ALARA. This includes doses to both the operationally exposed workers and members of the public.

ALARA Objective

In order to aid in the assessment of the success of the ALARA programme, quantifiable ALARA objectives will be defined for:

- The annual individual effective dose to occupationally exposed workers, and the annual average dose to the occupationally exposed workforce.
- The annual individual effective dose to the average member of the critical group.

Features of the ALARA Programme

The ALARA programme comprises a number of features, which collectively contribute to keeping all individual and collective doses, to both the occupationally exposed workforce and members of the public, ALARA.

Training

An ALARA training programme will be compiled which will include courses structured and aimed at specific levels in the organisational matrix, to include personnel who are involved in activities that bear influence on dose uptake, and who would include:

- persons qualifying for radiation work (radiation workers);
- maintenance personnel;
- engineers involved in design and review; and
- management.

Important operational aspects, such as dose tracking by task and the extent of the supervisor’s and individual workers’ responsibilities to ensure the successful implementation of ALARA, will be emphasised.

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86 SAR Rev 1, Chapter 7.5  
87 SAR Rev 1, Chapter 7.5  
88 SAR Rev 1, Chapter 7.5
Procedures review

ALARA requirements will be incorporated into procedures by a system of formal administrative procedure review. This system will include a method for identifying the relevant procedures.

The review of the way in which tasks are performed in a formal ALARA review environment, will aid in identifying and correcting any work practices which are not consistent with the ALARA principle. 89

Design review

The integration of ALARA design reviews into the engineering design cycle for those system and operational modifications which are likely to affect radiation exposure patterns to the occupationally exposed workforce, and to members of the public, will be described. 90

Operational work-planning and control

Work tasks, which will be conducted in radiation zones, will be planned to ensure that radiation exposure is minimised in the execution of the tasks by procedure review and pre-task review. The extent of formal planning will be commensurate with the radiological hazard associated with individual tasks. With regard to the ALARA programme, the following will be described:

- The method by which the ALARA review of tasks be integrated into normal work planning.
- Criteria for determining the extent of formal ALARA input to tasks, based upon the predicted doses.
- The system of dose tracking.
- The system for documenting ALARA input to pre-task review, post-task analyses, and retrieval of such documentation. 91

Procedures, Records, Reports and Notifications

All aspects of the ALARA programme will be described by procedure.

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89 SAR Rev 1, Chapter 7.5
90 SAR Rev 1, Chapter 7.5
91 SAR Rev 1, Chapter 7.5
The necessary records and their period of retention for all aspects of the ALARA programme will be described.

The necessary reports to the regulatory authority, and their frequency of submission for the ALARA programme, will be described.

The necessary notifications to the regulatory authority, and the conditions under which they will be made for the ALARA programme, will be described. 92

Radiological Instrumentation Programme

The radiological instrumentation programme supports the operational radiation protection programme, effluent management programme and the emergency preparedness programme in achieving their objectives by the provision of suitable instrumentation capable of measuring the quantities of interest with sufficient accuracy and reliability.

The radiological instrumentation programme comprises aspects relating to installed radiation monitoring systems, portable radiological surveillance instrumentation, non-portable radiological surveillance instrumentation and analytical instrumentation. 93

Installed Radiation Monitoring Systems (IRSs)

This equipment relates to all installed monitoring equipment, with the exception of portal contamination monitors. It includes equipment used in sample collection, but does not include requirements relating to the analysis of samples – these requirements are provided for in the section on analytical equipment.

With regard to installed radiation monitoring equipment, the following will be addressed:

- The purpose of each type of monitor, to include a reference to any engineered systems with which they may be associated.
- A justification for the choice of the type of monitor to fulfil the stated purpose, with reference to the radiation source and type of radiation emitted.

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92 SAR Rev 1, Chapter 7.5
93 SAR Rev 1, Chapter 7.5
A technical description of the monitor, to include the location of readouts, whether alarm/trip set points are relevant, and any associated automatic isolation functions.

The sensitivity of each monitor, and a justification for the acceptability of this sensitivity.

A description of the necessary periodic tests to be conducted such as source tests, calibration, visual checks, etc.

Technical justification for the selection of any relevant alarm/trip set points.

Technical report indicating the position (location) and a photograph of IRSs in the PBMR, within a reasonable period after start-up of the Plant.

With regard to installed equipment to be used for the purposes of sample collection, the following will be addressed:

The purpose of each type of equipment, to include a reference to any engineered systems with which they may be associated.

A technical description of the equipment, to include the location of any readouts, whether any alarms are relevant, and any associated automatic isolation functions.

A description of the necessary periodic tests to be conducted, such as operability tests, visual checks, etc. 94

Portable Radiological Surveillance Instrumentation

Portable radiological surveillance instrumentation refers to all instrumentation used for radiological surveillance purposes, which is not installed and includes ambient dose rate monitors, surface contamination monitors, and airborne contamination monitors. With regard to portable radiological surveillance instrumentation, the following will be addressed:

The purpose of each type of monitor, with specific reference to the type electromagnetic shielding and energy of radiation which is expected as justification for the choice of the type of monitor to fulfil the stated purpose.

94 SAR Rev 1, Chapter 7.5
• A technical description of the monitor with photograph and location in the PBMR, to make reference to any alarms provided and to include the sensitivity of each monitor.

• A description of the necessary periodic tests to be conducted, such as source tests, calibration, etc. and the circumstances where instruments must be submitted for re-calibration.

• Any relevant requirements for secondary standard instruments which may be used for calibration purposes.

• Any requirements on reference sources which are used for calibrations.  

- Non-portable Radiological Surveillance Instrumentation

Non-portable radiological surveillance instrumentation includes non-portable-contamination monitors, including portal monitors and any other non-portable monitoring equipment such as laundry or special tools monitoring. In this regard, the following will be addressed:

• The purpose of each type of monitor with specific reference to the type and energy of radiation which is expected as justification for the choice of the type of monitor to fulfil the stated purpose.

• A technical description of the monitor, with photograph and location within the PBMR, reference to any alarms provided to include the sensitivity of each monitor.

• A description of the necessary periodic tests to be conducted, such as source tests, calibration, etc. and the circumstances where instruments must be submitted for re-calibration.

• Any requirements on reference sources which are used for calibrations.  

- Analytical Instrumentation

Analytical instrumentation includes all non-portable instrumentation used for the determination of either total or radio nuclide specific activity, or surface contamination situated in a laboratory environment. In this regard, the following will be addressed:

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95 SAR Rev 1, Chapter 7.5
96 SAR Rev 1, Chapter 7.5
The purpose of each type of monitor, with specific reference to the type and energy of radiation which is expected to be monitored for, or analysed as justification for the choice of the type of monitor to fulfil the stated purpose.

- A technical description of the analytical method, to include the sensitivity of the method.

- A description of the necessary periodic tests to be conducted, such as source tests, calibration, etc.

- Any requirements on reference sources which are used for calibrations. 97

Procedures, Records, Reports and Notifications

All aspects of the radiological instrumentation programme will be described by procedure.

The necessary records and their period of retention for all aspects of the radiological instrumentation programme will be described.

The necessary reports to the regulatory authority, and their frequency of submission for the radiological instrumentation programme, will be described.

The necessary notifications to the regulatory authority, and the conditions under which they will be made for the radiological instrumentation programme, will be described. 98

The Environmental Monitoring Programme

The environmental monitoring programme is complementary to the radiological effluent management programme in ensuring that the risk to members of the public as a result of radiological discharges remains acceptable. The programmes will be conducted as part of the existing KNPS programme by the Environmental Services Laboratory. The purpose of the environmental monitoring programme is to:

- Assess the adequacy of controls on the release of radioactive effluent to the environment.

- Aid in the assessment of the level of exposure of the public resulting from the release of radioactive effluent to the environment.

97 SAR Rev 1, Chapter 7.5
98 SAR Rev 1, Chapter 7.5
Detect any long-term changes or trends in the environment, and to detect any previously unidentified concentration mechanisms of activity that may exist.

The following will be addressed by the environmental monitoring programme:

- Details of the land-use census and its frequency of review.
- Details of the survey of dietary habits of the public around the PBMR site, and its frequency of review.
- Details of the meteorological programme established in order to measure and document atmospheric dispersion conditions, and used to evaluate environmental impact of releases.
- Details of the environmental media sampled, the frequency of sampling, the radio nuclides analysed for, and the type of analysis to be used, together with the justification for the completeness of the programme.
- Details of the reporting levels associated with each radio nuclide in each environmental medium with the justification.
- Details of the calibration and periodic test requirements of analytical instrumentation associated with the environmental monitoring programme. 99

Procedures, Records, Reports and Notifications

All aspects of the environmental surveillance programme will be described by procedure.

The necessary records and their period of retention for all aspects of the environmental surveillance programme will be described.

The necessary reports to the regulatory authority, and their frequency of submission for the environmental surveillance programme, will be described.

The necessary notifications to the regulatory authority, and the conditions under which they will be made for the environmental surveillance programme, will be described. 100

Nuclear Emergency Preparedness Programme

A programme of nuclear emergency preparedness will be implemented, in addition to the designed and engineered features to prevent accidents, consistent with the

99 SAR Rev 1, Chapter 7.5
100 SAR Rev1, Chapter 7.5
principle of accident mitigation. The following features of the nuclear emergency preparedness programme will be described:

- An analysis of all foreseeable accidents, in order to predict the likelihood and the consequence of each, taking into account local environmental conditions, in order to select the appropriate scale of formal emergency planning, and the justification for the selection of the emergency planning zone radii.
- The emergency response organization and responsibilities for each phase of the emergency.
- Emergency response facilities available.
- The methodology used for the recognition of an event as one which is a precursor to an accident, and criteria to escalate the emergency classification.
- The principles and methodology for decision-making making during each phase of the emergency, including the definition of appropriate reference levels.
- Criteria for the termination of an emergency.
- Programme of training and exercises for the entire emergency preparedness organization, in order to maintain the effectiveness of emergency response.
- The inventory, location and periodic testing programme for equipment used in the emergency preparedness programme.  

Procedures, Records, Reports and Notifications

All aspects of the nuclear emergency preparedness programme will be described by procedure.

The necessary records and their period of retention for all aspects of the nuclear emergency preparedness programme will be described.

The necessary reports to the regulatory authority, and their frequency of submission for the nuclear emergency preparedness programme, will be described.

The necessary notifications to the regulatory authority, and the conditions under which they will be made for the nuclear emergency preparedness programme, will be described.  

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101 SAR Rev 1, Chapter 7.5

102 SAR Rev 1, Chapter 7.5
Assessment and Review Programme

In order to ensure the effectiveness of the radiation protection programme, a programme of technical assessment and review will be implemented. The programme will operate on two levels:

- A quality assurance programme of audits to ensure that the various aspects of each of the programmes are covered by procedure, and that all aspects are being conducted according to the procedure.
- A higher-level technical assessment to ensure that the programmes are meeting the stated objective.
- The programme of QA audits and technical assessments will be described. ¹⁰³

Procedures, records, reports and notifications

All aspects of the technical assessment and review programme will be described by procedure.

The necessary records and their period of retention for all aspects of the technical assessment and review programme will be described.

The necessary reports to the regulatory authority, and their frequency of submission for the technical assessment and review programme, will be described.

The necessary notifications to the regulatory authority, and the conditions under which they will be made for the technical assessment and review programme, will be described. ¹⁰⁴

References


¹⁰³ SAR Rev 1, Chapter 7.5
¹⁰⁴ SAR Rev 1, Chapter 7.5


7. Calibration of Radiation Protection Monitoring Instruments. Safety Reports Series No. 16, IAEA, 2000.\textsuperscript{105}

\section*{Security}

The security features have been discussed in Chapter 2 of the Report.

\section*{Conclusion}

\begin{itemize}
  \item The safety design of the proposed Plant, Test and Commissioning Programme, General Operating Rules and Radiological Protection Programme will conform to the safety criteria stipulated by the NNR and international practices/norms and will ensure the safety of the public, property and the environment.
  \item The security features of the Plant in terms of design, access control and surveillance will protect the Plant against security threats. Should security be breached the design of the Plant will protect the public against radiological exposures in excess of stipulated exposure criteria of the NNR.
\end{itemize}

\subsection*{4.3.3 Impacts on Health}

\section*{Introduction}

The purpose of this Chapter is two fold, namely:

\begin{itemize}
  \item To present the outcome of a desk top review of international literature on public health effects of radiation associated with commercial nuclear facilities and the need for public health monitoring and epidemiological studies in relation to the proposed project.
  \item To provide and overview of Eskom's Policy and Practices on HIV/AIDS.
\end{itemize}

\textsuperscript{105} SAR Rev 1, Chapter 7.5
i. CANCER INDUCED HEALTH IMPACTS DUE TO THE OPERATION OF NUCLEAR POWER PLANTS

The prime concern over radiation protection has been the protection of deoxyribonucleic acid (DNA) from damage in living organisms, especially humans. The biological effects of radiation are dependent on the amount of exposure. Very high exposures can damage and kill a sufficient number of human cells to destroy organs and cause a breakdown in vital body functions, leading to severe disability or death within a short time. Their effects are well documented. On the other hand, very low level radiation related health effects for individuals cannot be identified, as they would occur principally as cancers late in life. As exposure decreases, the likelihood of radiation induced cancer death or other morbidity effects is assumed to decrease linearly, reaching zero only at zero exposure above the background. Some scientists are critical of this type of extrapolation, assuming that a natural threshold exists for radiation effects, with very small incremental doses above a significantly larger natural background exposure posing no risk at all.

The accepted approach to this study (PoS as approved by the DEAT) was to review and be guided by international literature on the subject of epidemiological studies on cancer included health effects due to low level radiation releases (operational releases) from nuclear plant (Annexure 3 provides papers from international research on the subject), to decide on the desirability of such studies prior to or during the operation of the proposed Plant.

Much international epidemiological research is being (and has been) conducted on the subject, with opposing conclusions on the relationship between cancer incidence and radiation releases from commercial nuclear installations.

However one of the primary aims of such research is to determine the safe levels (release standards) for the release of radioactive substances from nuclear installations, to safeguard the health of persons and the environment. The International Commission for Radiological Protection (ICRP) is the international body that advises on standards and have progressively reduced radiological discharge and exposure levels.

Over time very strict international standards have been established to which South Africa subscribes and which is reflected in the Fundamental Safety Criteria of the NNR.

By nature these epidemiological studies are complex, needs to extend over at least 15 to 20 years, the population must be stable (i.e. low influx or exit from the population, and preferably start before the commissioning of a commercial nuclear plant to provide meaningful results.
OVERVIEW OF LITERATURE

Widely accepted investigations, such as the comprehensive 1990 National Institutes of Health (NIH) study of some one million cancer deaths in people living near nuclear power plants in the USA, demonstrate no correlation between cancer deaths and plant operations. Investigations carried out in Canada, France, Japan and the United Kingdom support the NIH results. A number of widely publicized studies reporting a linkage of radiation from nuclear power activities to occupational or public health consequences, such as the Sellafield occupational exposure study published in 1990 have been shown to be incorrect. 106

The Nuclear Regulatory Commission (NRC) in the USA recently issued a report that supports previous studies that claim of a link between Strontium-90 and cancer are unsubstantiated by sound science. In its report, the NRC stated that "there is little reason to believe that airborne emissions from any civilian nuclear power plant are contributing to childhood cancer in populations living near these plants."

The request from the New Jersey authorities centered on an article published in the International Journal of Health Services, "Strontium-90 in deciduous teeth as a factor in early childhood cancer." Jay Gould, a co-founder of the anti-nuclear Radiation and Public Health Project (RPHP) organisation, authored the article. RPHP is an anti-nuclear citizens group based in Manhattan that has a long-range goal of closing down nuclear power plants in the United States. The group claims that Strontium-90 shows up in teeth of infants and is directly responsible for an increase in breast cancer rates on Long Island.

The NRC's review of the issue clearly explains how Strontium-90 is a major by-product of Cold War aboveground nuclear weapons testing conducted by the United States and the Soviet Union. The two countries signed the Nuclear Test Ban Treaty in 1963, effectively ending aboveground testing. Much of the Strontium-90 remaining in the environment is directly linked to the weapons testing and little Strontium-90 is produced at the nation's nuclear power plants. In fact, any Strontium-90 releases are so small as to be undetectable when compared to amounts already in the environment. A general consensus of the scientific community is that it is misleading and reckless to equate the mere presence of a radioactive isotope, many of which are produced naturally by the environment and the human body, with adverse health effects.

The NRC substantiates its case by citing studies done by the National Institutes of Health's

Health's National Cancer Institute, the Agency for Toxic Substances and Disease Registry and an epidemiology study conducted in Suffolk County in New York that dispute the RPHP's report. Other studies including one from the American Cancer Institute's New Jersey Division in 1997 and a report from the United Nation's Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) released in the fall of 2000, further support the NRC's review. In fact, the UNSCEAR definitively reported that radiation emanating from nuclear power plants is "one twelve-thousandth of natural background radiation." 107

ASSURANCE THROUGH MONITORING

One aspect in providing assurance that the practices carried out at a nuclear facility provides for protection against nuclear damage is through monitoring.

- Eskom’s Statement on Radiological Monitoring
  
  In order to provide the public with assurance regarding radiation and health effects, Eskom states the following commitment, namely:

  “To demonstrate, through the environmental monitoring programme, that discharges of radioactivity from an Eskom nuclear facility, results in no significant risk to members of the public, in accordance with international standards.”

- Radiological Monitoring programme at Koeberg NPS

  Environmental monitoring for radioactivity started two years before Koeberg NPS began to operate. This was undertaken to provide the baseline data for the subsequent evaluation of the impact of operations on the environment surrounding Koeberg. Environmental monitoring has been constantly conducted over the 18 years of Koeberg’s operation, with no significant changes in radiation levels having been detected. No changes in the environment, as a result of operational radiation releases from Koeberg has been detected either. The monitoring, under the control and inspection of the National Nuclear Regulator (NNR), is based on international standards and is undertaken to demonstrate that discharges of radioactivity from Koeberg result in no significant health risk to members of the public, staff or the environment.

  The NNR Annual Report for 2001/2002 provides the following statements:

Public Exposure

“Various gaseous and liquid effluents are produced during the process of nuclear power generation. These effluents are treated by dedicated clean-up systems, which remove most of the radioactivity from the effluents prior to discharge into the environment. However, it is inevitable during the operation of any nuclear power station that small amounts of radioactivity will be released into the environment. Public exposure is controlled within strictly defined limits by the implementation of a radiological effluent management programme, which ensures that the discharges of radioactivity from Koeberg results in no significant risk to members of the public. A key feature of this programme is the control of radioactivity in effluent discharges within Annual Authorised Discharge Quantities (AADQ). In addition to the continuous monitoring of radioactivity in effluent, radiological surveillance of the environment is also carried out. In this way, independent and strict control on public exposure to radioactive releases is maintained.

Radioactivity in liquid and gaseous effluent discharges from Koeberg during 2001 contributed a total dose of 0.65 microSieverts to the hypothetically most exposed group. The dose as a result of gaseous and liquid discharges was 0.29 microSieverts and 0.36 microSieverts respectively, which is well within the prescribed limit of 250 microSieverts per annum.

It is evident from the above that the annual dose arising from Koeberg’s effluent discharges has been consistently low at less than 1% of the prescribed dose limit”.

Environmental Surveillance

“The Koeberg Environmental Surveillance Programme, involving sampling and analysis of representative environmental media, is performed in order to verify that effective control has been maintained over effluent discharges.

The small amounts of radioactivity released from Koeberg could not be identified in either surface water inland or in seawater. Sensitive gamma spectrometric measurements of biological materials, soil and air samples, vegetation and food did not reveal any contamination of the environment, although very small
although very small quantities of 110mAg and 58Co originating from Koeberg’s operation, were found in some samples.

As a demonstration of the sensitivity of the equipment, natural radioactivity is routinely measured in the majority of samples in which none of the effluent activities are evident. Very small amounts of characteristic activities in Koeberg effluent could be identified in sewage sludge, while reportable activities of 131I, originating from the therapeutic or diagnostic medical treatment of local residents, were detected on various occasions in Melkbosstrand sewage sludge.

A widespread network of Environmental Thermo-Luminescent Dosimeters (LTDs) around Koeberg monitors the external exposure to active gaseous effluents from Koeberg. As in previous years, there were no indications of external radiation above normal background levels, whether close to the power station or further afield. The environmental surveillance programme confirmed adequate control over effluent discharges in the period under review”.

- A wide range of environmental media (terrestrial & marine) within a 16km radius from the Koeberg Nuclear Power Station is continually sampled and analysed to detect any variations in radioactivity. This is undertaken in terms of the Power Station’s Nuclear License requirements which also prescribe the medical (and psychological) surveillance of all personnel with potential occupational exposure to ionising radiation, with the record keeping of exposure levels. During the operation period of Koeberg no deterministic or stochastic health effects have been recorded as a result of its operation. This monitoring however, excludes health monitoring of the public.

- Results of Koeberg Radiological Releases (refer to Figure 4 below)
The proposed environmental monitoring programme for the PBMR demonstration module

The environmental monitoring programme is complementary to the radiological management programme in ensuring that the risk to members of the public remains acceptable. The purpose of the environmental monitoring programme is to:

- Assess the adequacy of controls on the release of radioactive effluent/emission to the environment.
- Aid in the assessment of the level of exposure of the public resulting from the release of radioactive effluent/emissions to the environment.
- Detect any long-term changes or trends in the environment, and to detect any previously unidentified concentration mechanisms of activity that may exist.

The following will be addressed by the environmental monitoring programme:

- Details of the land-use census and its frequency of review.
- Details of the survey of dietary habits of the public around the PBMR site, and its frequency of review.
Details of the meteorological programme established in order to measure and document atmospheric dispersion conditions, and used to evaluate environmental impact of releases.

Details of the environmental media sampled, the frequency of sampling, the radio nuclides analysed for, and the type of analysis to be used, together with the justification for the completeness of the programme.

Details of the reporting levels associated with each radio nuclide in each environmental medium with the justification.

Details of the calibration and periodic test requirements of analytical instrumentation associated with the environmental monitoring programme.  

Procedures, Records, Report and Notifications

All aspects of the environmental surveillance programme will be described by procedure.

The necessary records and their period of retention for all aspects of the environmental surveillance programme will be described.

The necessary reports to the regulatory authority, and their frequency of submission for the environmental surveillance programme, will be described.

The necessary notifications to the regulatory authority, and the conditions under which they will be made for the environmental surveillance programme, are described. 

Detail of the Environmental Surveillance Programme is provided in Chapter 8 of the EMP.

MEDICAL SUPPORT

For the demonstration plant, no additional cost is envisaged for infrastructure at the existing emergency support facility currently provided at the Tygerberg Hospital to the KNPS. It must be recorded that Eskom is making a contribution towards the maintenance of this facility.

110 SAR Rev 1, Chapter 7.5
111 SAR Rev 1, Chapter 7.5
For generic plants, the capacity and location of the hospital are influenced by various factors. The technical factors are typically the number of modules per site, number of personnel on site, population density, etc.

These factors and the perceived risk inherent to the PBMR design will determine characteristics such as road distance to the hospital and the minimum facilities required at the hospital.¹¹²

**Conclusion**

- International research literature reveal opposing evidence of a correlation between commercial nuclear facilities and radiation induced cancers. Such research is ongoing, and must be accepted as “State of the Art” for South African purposes.

- Health monitoring of members of the public is not recommended or required provided that assurance is continually given to the NNR that persons, property and the environment are at no significant risk due to radioactivity, as a result of the operation of Koeberg NPS or the proposed Plant.

- Assurance that the practices carried out provide for the protection of persons, property and the environment against nuclear damage, must continue through environmental monitoring programmes, health monitoring of employees and conformance to the legal requirements of the National Nuclear Regulator (NNR). In terms of the proposed PBMR demonstration module a comprehensive radiological discharge management programme must be implemented, including:

  - a safety analysis to demonstrate that the proposed effluent/emission discharges will result in public exposures below the dose limit and that the discharges have been optimised to give public doses as low as is reasonably achievable (ALARA);

  - Licensed operating procedures which are constantly reviewed;

  - monitoring of discharges to ensure compliance with the regulatory authorisation; and

  - an environmental surveillance programme to ensure the detection of any bio-accumulation mechanisms for radioactivity, which have not been taken into account in the safety assessment.

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¹¹² DFR, Document No. 009838-160 Rev 2
ii. ESKOM POLICY AND PRACTICES ON HIV/AIDS IN THE WORKPLACE

Introduction

HIV (Human Immunodeficiency Virus), the modes of transmission of which are presently known to be through blood inoculation, unprotected sexual intercourse and from an infected mother to her unborn child, attacks the body’s immune system, leaving the carrier increasingly vulnerable to opportunistic infections and malignant tumours.

HIV infection is at present incurable with an eight to twelve year mean time from infection to AIDS (acquired immune deficiency syndrome), with fatal consequences following one to three years later.

The mode of transmission of HIV precludes real risk of infection to employees in the workplace, with the exception of healthcare workers who might become exposed to body fluids in the course of their duties and in the management of medical emergencies.

Statement of Intent

Eskom recognises the seriousness and implications of HIV infection and AIDS for the individual, his/her family, for Eskom, its employees as well as co-workers of infected/affected individuals.

Eskom is committed to addressing HIV and AIDS in a positive, supportive and non-discriminatory manner, with the informed support and co-operation of all employees, in terms of the principles outlined in this practice document.

Practice

Education and information

All Eskom employees and their immediate families are informed and educated through ongoing health education programmes.

Education and information programmes are developed in co-operation with all appropriate stakeholders and always involve participation of the target population and the utilisation of community-based organisations where possible and available.

Education and information programmes have the objectives of:

a) Imparting a basic knowledge of the disease and information on prevention of the disease
b) Eliminating discrimination against persons with HIV and AIDS through dispelling any ignorance and myths about the disease and its mode of transmission

c) Information on the rights of, and services available to, infected employees

d) Protection of persons potentially exposed to HIV in the pursuance of their duties.

Confidentiality

Persons with HIV or AIDS have the right to confidentiality and privacy concerning their health and HIV status.

Healthcare professionals maintain absolute confidentiality of all records relating to the personal health and HIV status of employees, which may by law never be disclosed to any other person without the written consent of the employee and, after death, without the consent of his/her family or partner, except in cases involving a clear threat to or disregard of an identifiable individual’s life interests.

The occupational health practitioner is accountable for the supervision, maintenance, confidentiality and security of employees’ personal medical files.

Potential hazard Health-care workers who may work under increased risk of infection are informed of specific precautionary measures to be taken and are provided with appropriate protective devices. Employees at an increased risk of infection due to the geographic situation of their work-site (areas of high HIV incidence) are informed of protective measures to be taken and reassured as to the availability of health-care facilities and services. Procedures for casualty evacuation in the event of life-threatening injuries or disease are in place.

Health services In-house counselling services are available for all employees with HIV and AIDS. Where this is not physically or practically possible the employee is encouraged to participate in counselling services provided by external organisations.

Testing

Voluntary anonymous incidence monitoring:

(a) Epidemiological regional incidence monitoring of HIV infection may be undertaken with employee participation invited on a voluntary, anonymous and unlinked basis to identify areas for strategic preventative education and information programme planning and to assess the efficacy of existing health programmes.

(b) Anonymity will at all times be assured and preserved.
Confidential testing on request:

(a) Voluntary, confidential HIV antibody testing with pre- and post-test counselling is available to all employees.

(b) Employees are confidentially notified of an HIV positive result and assured of access and availability of continuing support and health services.

(c) No employee in service can be instructed to undergo testing for HIV at management request.

Pre-employment selection criteria:

(a) Eskom notes that general mandatory pre-employment blood screening tests for HIV may achieve only limited effective and functional preventative effect, and is declared unacceptable by the World Health Organisation (WHO), International Labour Organisation (ILO), political, trade union and employee groups. Compulsory HIV testing will not be the basis for pre-employment testing or a ground for refusing to employ any person.

(b) Selection criteria for prospective applicants for positions determined to involve an identified high risk to the health and safety of the applicant, the health and safety of fellow workers or the safety of the process they control, may in particular circumstances include appropriate screening test. The international guidelines of prior counselling, informed consent, support and confidentiality will be applied.

Non-discrimination:

(a) Eskom is committed to fair, sound and non-discriminatory employment practices.

(b) Employees who develop, disclose, or are diagnosed HIV or AIDS positive will not be prejudiced, victimised or discriminated against on account of their medical condition.

(c) The positive HIV status or AIDS does not by itself justify termination of employment, demotion, transfer or discrimination in employment. The compulsory conditions of service, including pension fund, medical aid, stated benefits, sick leave, housing, training and development will continue as with any other employee, as amended from time to time.
Co-workers:

(a) All employees receive educational and informational briefing on HIV and AIDS, and the realities, misconceptions and circumstances of working with infected and affected employees.

(b) Where for reasons outside Eskom’s control, co-workers become reluctant, unwilling or resist working with an affected colleague, they will be counselled and cautioned that their attitude in appropriate circumstances is unwarranted, unreasonable and not medically or scientifically justified, in an effort to alleviate their fears and concerns.

Consequences of illness Employees who develop, disclose, or are diagnosed with HIV or AIDS are evaluated against their duties, their continued ability to perform or undertake them, the position of co-workers, and Eskom’s statutory duty to provide, maintain and ensure a safe working environment and the safe execution of the processes employees control.

Eskom’s ill-health retirement provisions and the conditions of service apply to all employees affected by HIV or AIDS, against the stated criteria.

Prophylactic devices:

(a) A programme on the social marketing of condoms exists whereby condoms are readily available to all employees.

(b) Dispensary units are in inconspicuous areas in male/female ablution facilities and/or within the Business Unit’s medical centre.

Review

This policy will be regularly reviewed to accord and reflect medical, academic, occupational and employment learning and developments, within the field and in Eskom.

Conclusion

Eskom has the required HIV/AIDS prevention and management practices in place to assist with the prevention of the disease; to support individuals that have been positively identified as well as co-workers that require support. These practices will apply to the PBMR (Pty) Ltd and all construction personnel employed during construction of the proposed Plant.
4.3.4 IMPACT ON INSTITUTIONAL CAPACITY

INTRODUCTION

The assurance and maintenance of competent and resourced institutions, to provide governance, administration and services for the establishment and sustained operation of the proposed Plant, was assessed on an organisational level.

The more important institutions considered were:

- The National Nuclear Regulator (NNR)
- The Department of Minerals & Energy
- The South African Nuclear Energy Corporation, Ltd (NECSA)
- The Department of Environmental Affairs and Tourisms
- The Department of Health (Tygerberg Hospital) Western Cape Province Government (Various Departments)
- The City of Cape Town (Emergency Service Structure(s))
- The PBMR (Pty) Ltd and Eskom
- Educational institutions

DISCUSSION

The assessment of institution considered two main criteria, namely:

- The nature of the services/functions to be provided and or performed, and,
- The capacity of competent staff and resources (financial, equipment, etc)

NATURE OF SERVICES

For the purpose of this EIR, it was decide to focus onto the main issues involved and not to conduct in-depth analysis on the full scope of institutional structures, functions or budgets. These were:

- Radiological safety
- Emergency services
## INSTITUTIONAL CAPACITY

Table 17 provides high level information on the capacity of institutions related to the nature of the services provided.

**Table 17: Institutional Capacity Related To The Services Provision**

<table>
<thead>
<tr>
<th>Institutional</th>
<th>Service(s) provided</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>The National Nuclear Regulator</td>
<td>Licensing of nuclear installations Auditing of licence in terms of conformance to licence requirements Regular assessment of emergency plans, structures, system(s), procedures and demonstration of competence of licensee.</td>
<td>Competent staff exist to address the proposed PBMR application. Services provided on a Commercial basis (i.e. Applicant pays for the service).</td>
</tr>
<tr>
<td>The Department of Minerals and Energy (DM &amp; E) including the Minister</td>
<td>Assurance of Safeguards Subsidiary Agreements with the IAEA for the proposed Plant.</td>
<td>A dedicated section of NECSA performs this task as a non-commercial service.</td>
</tr>
<tr>
<td></td>
<td>Provision of Disposal site/facilities for Radioactive Waste (Low level and intermediate level = LLW &amp; ILW)</td>
<td>Vaalputs Radiological Disposal site management by NECSA with competent staff Commercial service</td>
</tr>
<tr>
<td></td>
<td>Authorisation of Transport of Nuclear Material(s)</td>
<td>Minister for DM&amp;E in a personal capacity.</td>
</tr>
<tr>
<td>NECSA</td>
<td>Manufacture of fuel for the PBMR</td>
<td>Dedicated Department with competent staff exist and will be further augmented should the project be authorised. Commercial Service</td>
</tr>
<tr>
<td>Institutional</td>
<td>Service(s) provided</td>
<td>Capacity</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Department of Environmental Affairs</td>
<td>Safeguards Agreements (see DM&amp;E above)</td>
<td>-</td>
</tr>
<tr>
<td>Department of Health</td>
<td>Authorisation of EIA Applications for listed activities</td>
<td>Dedicated Department with competent staff exist</td>
</tr>
<tr>
<td>Medical Care at Tygerberg Hospital for assessment and treatment of patients with radiation exposure.</td>
<td>Commercial Service Adequate facilities and medical staff exist.</td>
<td></td>
</tr>
<tr>
<td>Western Cape Province – Various Departments</td>
<td>Spatial Planning Frameworks Provision of regional infrastructure and services (e.g. roads, water, etc)</td>
<td>Adequate and competent staff exist.</td>
</tr>
<tr>
<td>City of Cape Town (previously the Cape Metropolitan Council)</td>
<td>Authorisation of Zoning Applications Emergency Services through the various local authorities.</td>
<td>Sufficient capacity and competent staff exist City and Local Government funded</td>
</tr>
<tr>
<td>Eskom and PBMR (Pty) Ltd</td>
<td>The full complement of radiological incident emergency and training services and centres exist</td>
<td>Sufficient competent staff exist, which is Eskom funded.</td>
</tr>
<tr>
<td>Educational Institutions</td>
<td>Academic and technical education Engineering sciences Physical sciences Medicine Chemical sciences Management/administration sciences</td>
<td>Various Technicons and Universities with the required competent staff exist.</td>
</tr>
</tbody>
</table>

**CONCLUSION**

The institutional capacity(ies) to provide governance administration and services in relation to the proposed Plant exist. It appears that the required competent staff also exist.

Resourcing does not present a problem since most of the services are provided on a commercial basic for which the user (Eskom) must pay (i.e. no burdens on the tax/rate payer).
4.3.5 Legal Impacts and Financial Provision (decommissioning and 3rd Party Liability)

Introduction

Within the South African framework for environmental governance the legal impacts of proposed activities that may significantly impact on the environment are statutorily covered by the “Duty of Care” imposed by Section 28 of the National Environmental Management Act, (Act 107 of 1998) (NEMA) read together with the principles contained in Section 2 of that Act. These provisions must be read within the context provided by Section 24 of the Constitution of the Republic of South Africa, (Act 108 of 1996) which entrenches every person’s right to an environment that is not harmful to their health or well-being.

In lay terms the legal impacts of an activity identified in terms of Section 21 of the Environment Conservation Act, (Act 73 of 1989) have, for purposes of this assessment been defined as being: “future civil liabilities that may arise from the proposed activity”.

In view thereof that the legal impacts of the proposed activity are statutorily determined, this assessment will deal with:

- Who is liable?
- For what are they liable?
- Mitigation/management.
- Recommendations.

Who is liable?

All liability arising from an activity which has caused, causes or may cause significant pollution or degradation of the environment is statutorily determined by the “Duty of Care” imposed on all persons by Section 28 of NEMA read together with the principles contained in Section 2 of NEMA and particularly Section 2(4)(p) of NEMA.

In terms of Section 28(1) the Duty of Care is imposed on “every person who has caused, causes or may cause” significant pollution or degradation of the environment to take “reasonable measure to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment”.

In terms of Section 28(2) of NEMA the Duty of Care is specifically stated to include (but is not limited to) an owner of land or premises, a person in control of land or premises, or a person who has the right to use the land or premises on or in which any activity is undertaken or a situation exists which causes, has caused or is likely to cause significant
pollution or degradation of the environment. The effect of this provision is to establish vicarious liability extending beyond the site of pollution/degradation to the owners and management of institutions that cause significant pollution or degradation of the environment.

Section 2(4)(e) entrenches the principle of life-cycle responsibility, with the result that the liability of persons and organisations that survives their own mobility away from an activity and the Duty of Care imposed by Section 28 of NEMA, extends to all present and past persons who fall within the ambit of Section 28(2) of NEMA.

In addition to the private liability established by these provisions, the State, as custodian of the environment bears overall responsibility to respect, promote and fulfil the social, economic and environmental rights of everyone.

For what are they liable?

Section 2(4)(p) of NEMA provides that the “costs of remedying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects must be paid for by those responsible for harming the environment. While Section 2(4)(p) of NEMA only refers to liability for remedying pollution and adverse health effects, the same principle applies to negative impacts on well-being in terms of Section 24 of the Constitution.

In terms of Section 28(3)(f) of NEMA the reasonable measures referred to in Section 28(1) of that Act, include the duty to “remedy the effects of the pollution or degradation”

In the context of the present application this means that the following categories of legal impacts occur and must be considered:

- Potential impacts
  - 3rd Party liability for negative impacts on health and/or well-being;
  - Costs of remedying/minimising/mitigating pollution or degradation of the environment.

[Note: The likelihood of these impacts occurring and their severity if they do occur are the subject of the overall Environmental Impact Assessment (EIA) being undertaken, as is the framework for prevention and mitigation. The purpose of this section is, consequently, to identify legal impacts and make recommendations on how they should be mitigated or managed.

- Inevitable impacts
  - Decommissioning costs;
High-level radiological waste management.

[Note: As is evident from the content of the EIA and feasibility frameworks for the proposed activity, the costs of decommissioning and high level radiological waste management form an integral part of the financial planning of the overall project].

Mitigation or management of impacts

Possible impacts

The following must be borne in mind when considering these impacts:

➢ The recommendations that flow from the substantive EIA are aimed at avoiding, minimising and mitigating these impacts;

➢ The risk that these impacts may occur can never be assumed not to exist and they must be managed from a legal impact assessment perspective as if they will occur;

➢ The legal remedies envisaged by Section 2(4)(p) of NEMA ultimately sound in money.

Managing these impacts entails ensuring that the applicant has the capacity and financial means to discharge the duty of care imposed by Section 28 of NEMA.

Inevitable consequences

The following must be borne in mind when considering these impacts:

➢ The recommendations that flow from the substantive EIA are aimed at avoiding, minimising and mitigating these impacts;

➢ They will occur in the life-cycle of the proposed activity;

➢ The management of these impacts is only partly within the control of the applicant. Much of the responsibility for the management of these impacts rests with the national government of the Republic of South Africa especially in respect of establishing a comprehensive nuclear waste policy and facilities for the final disposal of nuclear waste.

Managing these impacts entails ensuring that the applicant has the capacity and financial means to discharge the Duty of Care imposed by Section 28 of NEMA and ensuring, in so far as it falls within the ability of the applicant, that the national government establishes a comprehensive nuclear waste policy and facilities for the final disposal of nuclear waste within a reasonable timeframe.
Recommendations

Subject to compliance with the recommendations that flow from the substantive EIA, and the following recommendations, the legal impacts of the proposed activity do not constitute grounds for refusing authorisation of the proposed activity in terms of section 22 of the Environment Conservation Act, 1989.

It is recommended that:

- The applicant must establish to the satisfaction of the authority and maintain for the life-cycle of the project and such extended period as the authority may decide, appropriate financial provision for the satisfaction of 3rd party claims that may emanate from the proposed activity;

- The applicant must establish to the satisfaction of the authority and maintain for the life-cycle of the project and such extended period as the authority may decide, appropriate financial provision for remedying any pollution or degradation of the environment that may emanate from the proposed activity;

- The applicant must establish to the satisfaction of the authority and maintain for the life-cycle of the project appropriate provision for the costs of decommissioning the proposed activity;

- The national government of the republic of South Africa must be directed in terms of Section 28(4) of NEMA to (within a reasonable period (possibly 5 years)), formulate a comprehensive policy on the management of nuclear waste and to establish appropriate facilities for the final disposal of high level radioactive waste as part of the Duty of Care it bears in terms of section 28 of NEMA. For purposes of this recommendation, this subsection must be seen as notice in terms of section 28(12) of NEMA to the Director General of the Department of Environmental Affairs and Tourism to issue such a directive and to respond in writing thereto to the EIA Consortium within 30 days of issue of a Record of Decision (RoD) in respect of the proposed activity (whether it be positive or negative).
4.4 IMPACTS ON SPATIAL PLANNING

4.4.1 INTRODUCTION

Eskom acquired the Koeberg NPS site and surrounding properties namely the farms Duinefontein and Klein Duynefontein in the mid 70s, following extensive feasibility studies to establish a nuclear power station in the Western Cape. The decision to establish a nuclear power station was motivated by the need for the replacement/augmentation of generating capacity in the Cape (about 2000 MWe) and to improve reliability of supply, which was hampered by long distance transmission from the coal stations in the Mpumalanga province. The cost of coal transport to the Western Cape the land required for the disposal of pulverised flue ash and the adverse meteorological conditions in the coastal area for plume dispersion are some of the more important considerations which mitigated against the establishment of a coal fired power station in the Western Cape.

4.4.2 LAND-USE RIGHTS

In terms of the Guide Plans for the Cape and West Coast Region which were established under the Physical Planning Act, Eskom was granted the rights to use the property for nuclear power generation purposes. The current Framework Development Plan for the Blaauwberg sub-region still recognise and demarcate the land for this purpose.

The land use zoning of the property is for agriculture use and the applicant will have to ensure that the necessary land use rezoning and use right, to undertake the proposed activity be obtained from the Cape Provincial Authority in terms of the applicable land-use Ordinance for the Cape Province.

4.4.3 SPATIAL PLANNING IMPLICATIONS

According to the City of Cape Town and Provincial Planning Departments the north-south development axis from Cape Town to Atlantis along the West Coast, presents the only remaining land that is available for especially urban development. The emergency planning zones and regulation of population density around Koeberg NPS, according to the authority planners, results in sub optimal urban land-use and increases the cost of service provision for such urban development.
The addition of the proposed Plant, the extension of the Koeberg NPS sites life, and pending the emergency zone restriction imposed by the NNR, are considered by the said authorities as potentially aggravating conditions for future spatial planning along the West Coast development axis.

4.4.4 ASSESSMENT OF IMPACT(S)

In view of the conclusions of the PRA for a category C event, as defined by the Fundamental Safety Criteria (Table 1, Chapter 2) of the NNR, the proposed Plant will require an exclusion zone of 400 meters and will, consequently not impact on Spatial Planning beyond this distance.

Pending the decision by the NNR, the need for an emergency planning zone around the proposed Plant, may also not be required. This however does not negate the need for emergency planning procedures for the proposed Plant.

4.4.5 CONCLUSION

- In addition to environmental authorisation and nuclear licensing, the Applicant will have to ensure that the required land use rezoning and rights are obtained, to undertake the proposed activity.

- The proposed Plant will not hold additional spatial planning impact, subject to the approval and licensing requirements of the NNR.
4.5 IMPACT ON TOURISM

4.5.1 INTRODUCTION

THE CONSULTANT

Urban Econ was appointed by the EIA Consortium to conduct a survey on tourists and tourism operators, to determine what effect the proposed PBMR Plant, fuel manufacture and associated transport of nuclear materials may pose to the tourism industry.

BACKGROUND

Coal-fired power stations generate about 90% of South Africa's electricity, with one large nuclear power station (Koeberg - Cape Town) generating another 5%. The rest of the supply (5%) is generated by hydro-electric and pumped storage schemes.

It is estimated that the future demand for electricity in South Africa will exceed current supply levels between the years 2005 and 2010. This estimation is based on a moderate growth of 2.8% per annum (p.a.). In the longer term (i.e. 2020 and beyond), the existing coal fired power stations will start to come to the end of their economic productive lives. The potential for hydro electricity to satisfy this estimated shortfall can be considered marginal as there are not enough suitable sites in South Africa. Similarly, it would appear as if South Africa’s natural gas resources are also too limited to provide a viable option. This implies that the only options available would be coal fired and / or nuclear power.

In the case of the coal fired option, this can only be achieved if the capacity of the existing stations are increased, and / or new stations are developed. In order to assess the potential of the nuclear option more accurately, Eskom has initiated an investigation of a particular nuclear technology, namely Pebble Bed Modular Reactor (PBMR). Prototype PBMR reactors have been build in the United States (US) and Germany between the late 1960’s and early 1980’s. Eskom has been investigating the PBMR option as part of its Integrated Electricity Planning Process since 1993. The overall objectives of these investigations were to establish whether PBMR could become part of Eskom’s expansion planning and what specific advantages it would bring over other options. The results of these investigations confirmed that PBMR should be considered as a possible option for future South African electricity supply.

Since the technology had not been previously commercialised, there is a need to demonstrate the techno-economic viability on a full scale demonstration plant. In 1995, Eskom commissioned a pre-feasibility study, followed by a techno-economic study in 1997. In 1998, the project has progressed to the point at which it had entered the full
the full scale engineering design phase. In 2000, a PBMR company was formed between Eskom, the Industrial Development Corporation (IDC), British Nuclear Fuels plc and the United States utility Exelon Corporation\textsuperscript{113}, to build and market PBMR-based power plants. The intention is to build and operate a single module to serve as a demonstration plant and to launch a platform for local and international sales. The proposed project will essentially involve the following:

i. The manufacturing of nuclear fuel at the existing BEVA buildings at Pelindaba.

ii. The transportation of the nuclear fuel from Pelindaba to Koeberg.

iii. The generation of energy at a new plant that is to be built next to the existing Koeberg power plant.

The first phase of the project was given the go-ahead by the South African Government in April 2000. It involves undertaking a detailed feasibility study, an environmental impact study (EIA) and a public participation process. The next phase, which will involve the physical construction of the demonstration module, is subject to the successful completion of the first phase and the issuing of a construction licence by the South African National Nuclear Regulator.

This particular study forms part of the first phase of the project, and the objective is to determine and assess the possible effects of the establishment of the PBMR plant on the local economy through the tourism industry.

\section*{Problem Definition}

Society at large has certain perceptions about nuclear technology with regard to the dangers associated with radiation. From a tourism perspective, these perceptions may influence the decision and willingness to visit and spend time in an area that has a nuclear plant.

The tourism industry is one of the main drivers of the local economies of both the Pelindaba and Koeberg areas. As such, it is important to determine and assess these perceptions in terms of the degree to which they may influence the decisions of potential tourists to visit any of the two areas. Ultimately, the impact on the tourism industry will also be reflected in the local and regional economies in terms of criteria such as employment and the Gross Geographic Product (GGP).

\textsuperscript{113} Exelon has since withdrawn from the partnership and expressed their intention to become a vendor of the technology only. Exelon will effectively withdraw after the Detailed Feasibility Phase and not participate in the development and construction of the proposed Plant.
PURPOSE OF THIS STUDY

The purpose of this study can be defined as follows:

To determine and assess the current perceptions within the tourism industry (both demand and supply) on nuclear technology, with specific reference to the use of PBMR technology at the Koeberg and Pelindaba plants.

THE STUDY AREA

The area comprises those areas that can be considered to fall within the “tourism catchment areas” of Koeberg and Pelindaba. For the purposes of this study, these two study areas were defined to include the following:

i. Koeberg:
   - Blaauwberg
   - Cape Town Central
   - Tygerberg
   - Helderberg
   - Oostenberg
   - South-Peninsula
   - Yzerfontein

ii. Pelindaba:
   - Pretoria
   - Johannesburg
   - Beestekraal
   - Hartebeesfontein
   - Kosmos
   - Meerhof
   - Melodie
   - Schoemansville
   - Hartebeespoort
   - Scheerpoort
4.5.2 Structure of Report

The structure of this report is as follows:

- **Section Two**
  The section presents:
  - the approach followed
  - the survey (questionnaires)

- **Section Three**
  The section presents a summary of the findings of the survey.

- **Section Four**
  The section presents the context in which the findings have to be interpreted, as well as the final conclusions.

4.5.3 Methodology

- **Approach**

  The focus of the study involves a particular industry in the economy (i.e. the tourism industry) and the impact it may have on the local economy. From this perspective, the most effective approach to conduct the study would be the "demand and supply" approach.

  The demand side can be described in terms of measurements such as the number of tourists visiting a certain area and the money spent. The supply side can be described in terms of measurements such as overnight accommodation, places of interest, restaurants, etc.

  The impact of the proposed nuclear plant will initially be on the demand side of the model, as it may impact on the propensity or willingness of tourists to visit the area. Ultimately, and depending on the degree and scale of such an impact, it might also affect the supply-side. Some of the existing tourist establishments might have to close down as a result of a decrease in the demand levels, or more establishments might open, in reaction to an increase in the demand.

  Another element that may impact on the demand side refers to people working at the new plant. The survey that was conducted at local establishments, particularly those near Koeberg, have indicated that a notable component of their clientele comprised of
of engineers and technicians working at Koeberg. As an indication, the survey showed that 10% of people staying at the tourism establishments near Koeberg, were businessmen, with the corresponding figure at Pelindaba being 17%. This is an average percentage, and is much higher at those establishments that are located in close proximity of the plant. However, per definition, this element cannot be considered as part of the tourism industry, but should be included as a component of the broader definition of “visitors”. For the purposes of this study, the definitions of these two terms are as follow:

| i. Tourist: | Any person visiting and staying in an area for reasons such as being on holiday, recreation / sport, visiting friends and relatives, etc. |
| ii. Visitor: | Any person, including tourists, that visit and stay in an area. As such, this category can include people visiting and staying in an area for business reasons. |

The focus of this study is therefore on the point of interaction between demand and supply. This approach is graphically illustrated in Figure 5.

**Figure 5:** Model used to assess perceptions

**Local tourism industry**

**DEMAND:**
- Number of tourists
- Profile of tourists
- Preferences of tourists
- Spending power and patterns of tourists

**SUPPLY:**
- Number of tourist facilities
- Type of tourist facilities

The project impact on the demand by changing the propensity or willingness of tourists to visit the area.

A change in the propensity and willingness of tourists to visit the area impact on the feasibility of the establishments which may result in more opening or some of the existing having to close.

**NUCLEAR TECHNOLOGY:**
The main elements of PBMR technology:
- The PBMR plant at Koeberg
- The manufacturing of nuclear fuel at Pelindaba
- The transportation of nuclear fuel from Pelindaba to Koeberg.
The SURVEY

A structured survey was conducted that involved both the demand and supply sides.

On the supply side, a two pronged approach was followed. The one leg involved discussions with some of the main stakeholders in the local tourism industry, whereas the second leg involved a survey at specific tourism establishments that included B&B’s, hotels and self-catering facilities. Annexure’s 1 and 2 provide a list of the institutions contacted and the particular establishments surveyed in the Koeberg and Pelindaba study areas.

Figure 6 presents perspective on the various tourism institutions contacted and interviewed. Annexure 3 provides the questionnaire used in the survey of the tourism establishments.

The demand side involved a survey amongst the tourists that visited the two study areas. Annexure 4 presents the questionnaire used in the tourist survey.

Figure 6: Tourism institutions contacted and interviewed
The supply side

The questionnaire (Refer to Annexure 3) comprised of three sections, of which the first gave a general perspective on the establishments in terms of the size (capacity), the origin of the visitors and the degree of seasonal fluctuation. The second section concentrated on the perceptions of the owner regarding nuclear technology and the degree to which the existing nuclear plants may have had an impact on the attractiveness of the two areas from a tourism perspective. The third section focussed specifically on the proposed PBMR project to determine if the owner was aware of it or not, and his / her perception on the possible impact it may have on the local tourism industry.

The demand side

The questionnaire (Refer to Annexure 4) established the profile of the tourist, as well as the knowledge and perception of the tourist on nuclear energy. Secondly, the questionnaire established an indication of whether the presence of a nuclear plant will effect his / her (tourist) decision to visit the area.

4.5.4 MAIN FINDINGS

INTRODUCTION

The purpose with this section is to provide a broad perspective of the results of the survey.

4.5.5 SURVEY RESULTS

CAPE TOWN: Tourist survey

a) Summary of survey results

a.1) Origin

The tourism industry is very seasonal, with the peak season being from January to March. The majority of the tourists during this peak period is from overseas, mainly Europe (55%).

a.2) Duration of stay

86% of the tourists indicated that they are staying for 3 days and longer, with only 14% staying for less than 3 days.
a.3) Purpose of visit

68% of the tourists are here for holiday, 11% for business and 21% for other reasons (presumably visiting friends and relatives).

a.4) Frequency of visits

Most of the tourists have visited Cape Town before (59%).

a.5) Most appealing characteristic

The majority of the tourists (41%) consider the natural views and scenic beauty as being most appealing character of Cape Town, followed by the local culture (28%), climate (17%) and nature (14%).

a.6) Perception on nuclear technology

The majority (55%) has a negative perception about nuclear technology, with only 21% viewing it in a positive light, and 21% being indifferent.

a.7) Awareness of the PBMR project

Only 31% of the tourists were aware of the PBMR project.

a.8) Effect on decision

All (100%) of those who are aware of the PBMR, indicated that it had no effect on their decision to visit Cape Town.

a.9) Impact on decision to visit again

By far the majority (93%) indicated that they would visit Cape Town again, even after they have become aware of the PBMR project. Only 7% indicated that there is a possibility that they may not visit Cape Town again.

a.10) Most significant implication of the development

44% indicated that they would consider the danger of radiation as presenting the most significant implication, followed by the visual disturbance of the building (30%) and the possible impact on ecology (19%).
Table 18 presents a summary of the results of the survey.

**Table 18: Summary of findings – tourist survey (Koeberg)**

<table>
<thead>
<tr>
<th>Question 1: Where are you visiting from?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
</tr>
<tr>
<td>55%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 2: How long is your stay?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Day</td>
</tr>
<tr>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 3: What is the purpose of your visit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business</td>
</tr>
<tr>
<td>11%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 4: Where are you currently residing?</th>
</tr>
</thead>
<tbody>
<tr>
<td>B&amp;B/G.H</td>
</tr>
<tr>
<td>31%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 5: Have you visited here before?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>59%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 6: What is the most appealing characteristic of this area?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Views</td>
</tr>
<tr>
<td>41%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 7: What are your perceptions on nuclear technology?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
</tr>
<tr>
<td>21%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 8: Are you aware of the proposed PBMR development?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>31%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 9: If yes, did it in any way effect your decision to visit the area?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 10: Now that you are aware of the PBMR development, would you again visit the area?</th>
</tr>
</thead>
</table>
Question 11: What element of the proposed development will have the most significant impact on local tourism?

<table>
<thead>
<tr>
<th>Element</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>30%</td>
<td>44%</td>
</tr>
<tr>
<td>Radiation</td>
<td>19%</td>
<td>7%</td>
</tr>
<tr>
<td>Ecology</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>Other</td>
<td>30%</td>
<td>44%</td>
</tr>
</tbody>
</table>

b) Interpretation of survey results

Although most respondents had negative perceptions on nuclear technology and the Koeberg plant (those who were informed about it), it had no effect on their decision to visit Cape Town. 59% of the respondents had visited Cape Town before and 93% indicated that they would visit Cape Town again, even after being informed about Koeberg and the proposed PBMR. The most common reason given was that many of the respondents were from countries that have nuclear power plants, such as Germany and the United States. As such, they are familiar with and used to living with nuclear technology and do not consider it as a significant, direct danger.

CONCLUSION #1

The presence of a nuclear plant does not have a significant impact on the decision of tourists to visit Cape Town.

CAPE TOWN: Tourist establishment survey

c) Summary of survey results

c.1) Ratio between domestic and overseas tourists

About 60% of clientele are from overseas. This relative high ratio can be ascribed to the fact that the survey was done in March, which falls in the peak season. Surveys done by the Western Cape Tourism Board also found that the majority of tourists during the summer months are from overseas. During the winter months, the situation is reversed with the majority of the tourists then being local (Western Cape) and from other provinces in South Africa. On average, the survey indicated that the majority of the visitors were from overseas. In the case of Pelindaba, it is the other way around (refer paragraph g.1).

c.2) Profile of visitors

27% of the tourists are businessmen, 28% are families and 12% are retired couples.

c.3) Seasonal fluctuation of business
The majority of the establishments (93%) indicated that their businesses were not strongly seasonal. This could be attributed to the fact that foreign tourists occupy the establishment during the summer, with domestic tourists visiting the area during winter. In addition to the domestic tourists, it was indicated that people employed at the plant accounted for a percentage of occupation during the winter, particularly at those establishments located near the plant. These two factors even out significant fluctuations.

c.4) Age of establishment

Only 7% of the establishments existed before the construction of Koeberg. As such, it is difficult to ascertain from this source if the development of Koeberg had a notable effect on the local tourism industry.

c.5) Perception of nuclear technology

46% is positive about nuclear technology, with only 30% being negative and 24% being indifferent. The main reasons why the owners are positive include:

- They trust the professionals at Koeberg
- It is a cheap and clean energy source


c.6) Possible implications for the tourism industry

The majority (75%) are of the opinion that the existence of Koeberg does not have a negative effect on the local tourism industry.

c.7) Possible perceptions of tourists towards nuclear technology and Koeberg

Only 13% are of the opinion that tourists have a negative perception of nuclear technology and the Koeberg plant, while 7% are of the opinion that tourists have a positive perception. 43% are of the opinion that tourists are indifferent.

c.8) Effect of Koeberg on decisions to visit the area

Only 7% are of the opinion that the existence of Koeberg has an effect on the decisions of tourists to visit the area, whereas 66% are of the opinion that Koeberg has no effect.

c.9) Effect of Koeberg on the local tourism industry

20% are of the opinion that Koeberg had a positive effect on the local tourism industry, 27% indicated that it has a negative effect and 53% are not sure. The main reason for the positive effect can be attributed to the fact that a percentage of their clientele comprises of people who are employed at Koeberg. However, referring to the
paragraph c.4 above, it has to be taken into account that only 7% of establishments existed before the development of Koeberg. As such, the findings of this particular question has to be interpreted with care.

c.10) Awareness of PBMR

51% of the operators are aware of the PBMR project, of which 64% has learnt about it through the printed media.

c.11) Opinion on impact of the PBMR project in the local tourism industry.

Nearly half (59%) of operators are of the opinion that the PBMR project will not have a negative effect on the local tourism industry, with 32% being unsure. Only 9% are of the opinion that the project will have a negative effect.

Table 19 presents a summary of the findings.

Table 19: Summary of findings - tourism establishment survey (Koeberg)

| Question 1: How long have you managed the facility? |
|---------------------------------|-------------|-------------|-------------|
| 0-2 Years                       | 3-5 Years   | 6-10 Years  | 10<         |
| 14%                            | 49%         | 27%         | 11%         |

| Question 2: How many people can you accommodate? |
|---------------------------------|-------------|-------------|-------------|
| 0                               | 1-2 People  | 3-5 People  | 6-10 People | 10< People |
| 17%                            | 3%          | 10%         | 12%         | 58%        |

| Question 3: What is the ratio between domestic and foreign visitors p.a? |
|---------------------------------|-------------|
| %Domestic                       | %Foreign    |
| 40%                             | 60%         |

| Question 4: What is the profile of your visitors p/a? |
|---------------------------------|-------------|-------------|-------------|-------------|
| %Business                       | %Families   | %Retired    | %Backpacker | %Other      |
| 27%                             | 28%         | 12%         | 10%         | 23%         |

| Question 5: Is your business strongly seasonally linked? |
|---------------------------------|-------------|
| Yes                             | No          |
| 7%                              | 93%         |

| Question 6: What time of the year is your peak season? |
|---------------------------------|-------------|-------------|-------------|-------------|
| Sept-Dec                        | Jan-March   | April-Aug   | Whole Year  |
| 24%                             | 57%         | 0%          | 20%         |

<p>| Question 7: Did your business exist before Koeberg? |</p>
<table>
<thead>
<tr>
<th>Question 8: What is your perceptions on nuclear technology with regard to safety and its impact on the environment?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
</tr>
<tr>
<td>46%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 9: Do you think Koeberg had a negative effect on the local tourism industry?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 10: What are the general perceptions of tourist regarding nuclear technology and Koeberg plant?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
</tr>
<tr>
<td>7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 11: Do you think Koeberg plant had an effect on tourists’ decision to visit the area?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 12: What element of the plant has the most significant negative impact on the local tourism industry?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
</tr>
<tr>
<td>1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 13: Has Koeberg had any positive effect on the local tourism industry?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>20%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 14: Are you aware of the proposed PBMR?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>51%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 15: How did you obtain information about it?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printed Media</td>
</tr>
<tr>
<td>64%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 16: Do you think the establishment of the PBMR will have a negative effect on the local tourism industry?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>9%</td>
</tr>
</tbody>
</table>
d) Interpretation of findings

Nearly half (46%) of the owners have a positive perception on nuclear technology, 24% are indifferent and 30% have negative perceptions. Most of those who have a positive perception state that they trust the professionals working at Koeberg. Some respondents are also of the opinion that technological advancement is inevitable, and that nuclear technology is cleaner and cheaper than other alternatives.

75% of the respondents agreed that the Koeberg power plant has had no negative impact on the local tourism industry. In fact, 20% felt that the plant had a positive impact on the local tourism industry because of the spin-offs that it caused and the contribution this had made to the local economy.

66% of respondents were of the opinion that Koeberg had not affected the tourists' decision to visit Cape Town, while 7% felt that it did.

CONCLUSION #2

The development of the PBMR can be beneficial to the local tourism industry as some of the people that will be employed at the plant will stay at local establishments.

 PEINDABA: Tourist survey

e) Summary of survey results

e.2) Origin

By far the majority (63%) of the tourists come from Europe. This high percentage can be ascribed to the fact that the survey was conducted in March, which falls in the peak season. The situation is reversed during the winter months, when the majority of tourists are domestic. On average, the survey has indicated that the majority of the visitors are from South Africa, which is the opposite for Cape Town, where the majority of visitors are from overseas.

e.2) Duration of stay

57% stay for 3 days and longer, 26% for 3 days and 18% for less than 3 days.

e.3) Purpose of visit
The majority (74%) are on holiday, and 17% are businessmen.

e.4) Frequency of visits

57% have indicated that it is the first time that they have visited the area.

e.5) Most appealing characteristic

36% finds nature to be the most appealing character of the area, followed by the climate (27%) and then the views (23%).

e.7) Perception on nuclear technology

Nearly half (50%) have negative perceptions about nuclear power, 32% are indifferent and 18% positive.

e.8) Awareness of the PBMR project

By far the majority (91%) are not aware of the project.

e.9) Effect on decision

Of those that did know, the majority (91%) said that it did not influence their decision to visit the area.

e.10) Impact on decision to visit again

By far the majority (70%) said that it would have no effect on their decision to visit the area again.

e.11) Most significant implication of the development

40% felt that the most significant impact on the local tourism industry is the visual impact of the plant, followed by the danger of radiation (35%).

Table 20 presents a summary of the findings.
Table 20: Summary of findings – tourist survey (Pelindaba)

<table>
<thead>
<tr>
<th>Question 1: Where are you visiting from?</th>
<th>Europe</th>
<th>America</th>
<th>South Africa</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>62%</td>
<td>4%</td>
<td>17%</td>
<td>17%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 2: How long is your stay?</th>
<th>1 Day</th>
<th>2 Days</th>
<th>3 Days</th>
<th>Longer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9%</td>
<td>9%</td>
<td>26%</td>
<td>57%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 3: What is the purpose of your visit?</th>
<th>Business</th>
<th>Holiday</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17%</td>
<td>74%</td>
<td>9%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 4: Where are you currently residing?</th>
<th>B&amp;B/G.H</th>
<th>Self-Cat</th>
<th>Hotel</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>61%</td>
<td>13%</td>
<td>4%</td>
<td>22%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 5: Have you visited here before?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>43%</td>
<td>57%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 6: What is the most appealing characteristic of this area?</th>
<th>Views</th>
<th>Nature</th>
<th>Climate</th>
<th>Culture</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22%</td>
<td>36%</td>
<td>27%</td>
<td>9%</td>
<td>5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 7: What are your perceptions on nuclear technology?</th>
<th>Positive</th>
<th>Negative</th>
<th>Indifferent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18%</td>
<td>50%</td>
<td>32%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 8: Are you aware of the proposed PBMR development?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9%</td>
<td>91%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 9: If yes, did it in any way effect your decision to visit the area?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9%</td>
<td>91%</td>
</tr>
</tbody>
</table>
**Question 10:** Now that you are aware of the PBMR development, would you again visit the area?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>70%</td>
<td>30%</td>
</tr>
</tbody>
</table>

**Question 11:** What element of the proposed development will have the most significant impact on local tourism?

<table>
<thead>
<tr>
<th>Visual</th>
<th>Radiation</th>
<th>Ecology</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>40%</td>
<td>35%</td>
<td>20%</td>
<td>5%</td>
</tr>
</tbody>
</table>

f) Interpretation of the findings

Although half (50%) of the tourists have negative perceptions about nuclear technology, the majority (70%) would again visit the area even if the PBMR project is implemented.

**CONCLUSION #3**

The majority of tourists will visit the Pelindaba area again, even if the PBMR project is implemented.

» **PELINDABA: Tourism Supply**

<table>
<thead>
<tr>
<th>g) Summary of survey results</th>
</tr>
</thead>
<tbody>
<tr>
<td>g.1) Ratio between domestic and overseas tourists</td>
</tr>
</tbody>
</table>

The majority (65%) of the tourists are from South Africa.

<table>
<thead>
<tr>
<th>g.2) Profile of visitors</th>
</tr>
</thead>
</table>

A large percentage (46%) of the tourists are retired people, 13% are businessmen and 13% families.

<table>
<thead>
<tr>
<th>g.3) Seasonal fluctuation of business</th>
</tr>
</thead>
</table>

81% indicated that the tourism industry is not strongly seasonally orientated, with the peak season being September to March. However, similar to Cape Town, there is a change in the origin profile of the tourists with the majority in the peak season being from overseas, with the profile being reversed in the winter months.

On average, it would appear that the tourism establishments receive more domestic tourists than overseas tourists (refer paragraph g1 above).
g.4) Age of establishment

The majority (76%) of the establishments were developed after Pelindaba was built.

g.5) Perception of nuclear technology

The majority (60%) has a negative perception about nuclear technology, 15% are indifferent and 25% positive.

---

g.6) Possible implications for the tourism industry

The respondents were nearly split on the question of whether the Pelindaba plant has had an effect on the local tourism industry. 35% were of the opinion that it had no effect, 30% were of the opinion that it's had a negative effect, and 35% were not sure.

---

g.7) Possible perceptions of tourists towards nuclear technology and Pelindaba

Half (50%) of respondents were of the opinion that tourists have a negative perception about nuclear technology.

---

g.8) Effect of Pelindaba on decisions to visit the area

Nearly half (45%) of respondents were of the opinion that the existence of the Pelindaba plant had no effect on the decision of tourists to visit the area, 15% percent said that it has and 35% were not sure.

---

g.9) Effect of Pelindaba on the local tourism industry

30% of the respondents were of the opinion that the plant has had a negative effect on the local tourism industry, 35% were not sure, whereas only 19% were of the opinion that it had a positive effect.

---

g.10) Awareness of PBMR

By far the majority (71%) were aware of the PBMR project, of which 69% learnt about it through the printed media.

---

g.11) Opinion of PBMR impact on the local tourism industry.

38% of the respondents were of the opinion that the project will have a negative effect, 14% did not think that it would, whereas 48% were not sure.
Table 21 presents a summary of the findings.

**Table 21: Summary of findings – tourism establishment survey (Pelindaba)**

<table>
<thead>
<tr>
<th>Question 1: How long have you managed the facility?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2 Years</td>
</tr>
<tr>
<td>24%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 2: How many people can you accommodate?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 People</td>
</tr>
<tr>
<td>9%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 3: What is the ratio between domestic and foreign visitors p/a?</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Domestic</td>
</tr>
<tr>
<td>65%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 4: What is the profile of your visitors p/a?</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Business</td>
</tr>
<tr>
<td>13%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 5: Is your business strongly seasonally linked?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>19%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 6: What time of the year is your peak season?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept-Dec</td>
</tr>
<tr>
<td>43%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 7: Did your business exist before Pelindaba?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>24%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 8: What is your perceptions on nuclear technology with regard to safety and its impact on the environment?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
</tr>
<tr>
<td>25%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 9: Do you think Pelindaba had a negative effect on the local tourism industry?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>30%</td>
</tr>
</tbody>
</table>
Question 10: What are the general perceptions of tourists regarding nuclear technology and Pelindaba plant?

<table>
<thead>
<tr>
<th></th>
<th>Positive</th>
<th>Negative</th>
<th>Indifferent</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15%</td>
<td>53%</td>
<td>28%</td>
<td>21%</td>
</tr>
</tbody>
</table>

Question 11: Do you think Pelindaba plant had an effect on tourists' decision to visit the area?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15%</td>
<td>45%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Question 12: What element of the plant has the most significant negative impact on the local tourism industry?

<table>
<thead>
<tr>
<th></th>
<th>Visual</th>
<th>Ecology</th>
<th>Radiation</th>
<th>None</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>19%</td>
<td>29%</td>
<td>29%</td>
<td>10%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Question 13: Has Pelindaba had any positive effect on the local tourism industry?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Not Sure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>19%</td>
<td>43%</td>
<td>38%</td>
</tr>
</tbody>
</table>

Question 14: Are you aware of the proposed PBMR?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>71%</td>
<td>29%</td>
</tr>
</tbody>
</table>

Question 15: How did you obtain information about it?

<table>
<thead>
<tr>
<th></th>
<th>Printed Media</th>
<th>Radio</th>
<th>T.V</th>
<th>Discussions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>69%</td>
<td>6%</td>
<td>6%</td>
<td>19%</td>
</tr>
</tbody>
</table>

Question 16: Do you think the establishment of the PBMR will have a negative effect on the local tourism industry?

<table>
<thead>
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<tr>
<td></td>
<td>38%</td>
<td>14%</td>
<td>48%</td>
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h) Interpretation of findings

Similar to the reaction in Koeberg, nearly half (48%) of the operators have a negative perception about nuclear technology. However, nearly half of the operators (43%) were also of the opinion that the existence of Pelindaba had no effect on the decision of tourists to visit the area. 38% were of the opinion that the PBMR project will have a negative effect on the local tourism industry, whereas nearly half of the respondents (48%) were not sure.
CONCLUSION #4

Pelindaba had little effect on the local tourism industry.

4.5.6 Conclusion

Introduction

The purpose of this section is to present the findings of the survey in their context, and to present a final conclusion.

Context of the Findings

The results of the survey, as summarised in Section 3, appears to indicate that a percentage of the tourists may reconsider to visit these two areas again if the PBMR project is implemented. In the case of Koeberg, 7% have indicated that they may not visit the area again, with the corresponding figure for Pelindaba being a much higher 30%. However, these results have to be interpreted in context, and the following considerations need to be taken into account:

i. The survey did not capture the full spectrum of visitors, but focussed largely on those that stayed in the establishments that are less expensive such as B&B’s and self-catering facilities. The reason for this is because the hotel groups were not willing to allow surveys to be done on their clientele. As such, the high-income category tourists could not be included in the survey. Most of the tourists who resided in hotels in and around the Cape Town CBD and Waterfront, are far from the Koeberg power plant. It can therefore be assumed that this group would in all probability be much less concerned about the existence of a nuclear plant. As such, this grouping would have decreased the percentage of tourists that may not return due to the existence of a nuclear plant.

ii. A one-page background document was attached to the questionnaire to provide the basic information on the PBMR. However, it was found that tourists did not have time to study the background documentation, and as such did not have a good understanding of what the project entailed. Their reaction may thus have tended to be more negative, based on the connotation on nuclear technology and their perceptions of past accidents, such as the disaster that occurred at Chernobyl. The high percentage of visitors in the Pelindaba area that indicated that they might consider not to visit the area again should the PBMR project be implemented, could therefore be considered as an over-count.

iii. The study did not consider the positive effects that the construction and operation of the plant will have on the local economy. As an indication of the significance of such a contribution, the proposed phase 2 development at Arabella Golf Estate could be used
used as an example. It was calculated that the investment of R431 750 000 would generate an additional R97 850 000 to the GGP. This is a once off injection into the economy. The construction of the PBMR plant would have a similar effect on the local economy. Besides this once-off effect, the operation of the plant, and the sale of the electricity generated would also have an ongoing impact on the local economy. As an indication of the significance of this, the sector “Water and Electricity” (which include the sale of electricity), contributed 2.1% towards the GGP of Malmesbury\textsuperscript{114} in 1980. In 2000, the contribution of this sector increased to 22%. The annual growth rate achieved in this sector for the period 1990 to 2000 was about 6.3%. This growth can only be attributed to the effect of Koeberg. As such, the effect of the initial capital investment and the operational cost may cancel and even exceed the “loss” that may occur because of fewer tourists visiting the area.

iv. Some of the people employed at the nuclear plant would stay at the local tourism establishments. In discussions with the owners of the local B&B’s, it was stated that many of the engineers and technicians from overseas stay at the local establishments. This category of visitors is an important source of clientele, particularly for those establishments that are located near to the plants.

\section*{CONCLUSIONS}

The survey seems to suggest that the development of the PBMR project will have a negative effect on the economy via the tourism industry, as fewer people may visit the area. However, this result has to be interpreted in context of the considerations listed in paragraph 4.2 above. Even in the event of a decrease in the number of visitors to the area, this should not have a dramatic negative effect on the economy for the following reasons:

i. The reduction in the number of people visiting the two areas will in all probability only occur in the short term, as people will in time “get used to” the existence of the plant. Secondly, the annual overall growth of the local tourism industry (i.e. the annual growth in the number of visitors) should cancel this decrease.

ii. Some of the engineers and technicians employed at or visiting the plant, stay at the local tourism establishments as they offer affordable rates and are closely located to the plant. This source of visitors could off-set the “loss” of the others.

\textsuperscript{114} The official economic statistics is presented according to the magisterial districts, and Koeberg falls in the Malmesbury Magisterial District.
It can therefore be concluded, that the possible negative effect implied by less tourists visiting the area, may only last for the short term, and may be cancelled out by workers staying at the local establishments.

**CONCLUSION #5**

The possible negative effect implied by less tourists will probably only last for the short term. In the medium to longer term, this could be cancelled out by employees staying at local establishments.

The study only focussed on the “negative” element of the possibility that fewer tourists may visit the area. However, there are a number of positive impacts that also need to be taken into consideration, one of the most important of which the injection into the local economy caused by the construction and operation of the plants. Depending on the value of the construction, the operational costs, and the value of the electricity sold, the total spin-offs would probably generate a net benefit to the local and regional economies.

**CONCLUSION #6**

The direct and indirect spin-offs to the local and regional economies through the initial construction and operation phases in addition to electricity sales, should cancel out any negative effects of fewer tourists to the area. This could then result in a net benefit to the local and regional economies.

**CONCLUSION #7**

Summary:

It can be concluded that the establishment of the PBMR plant at Koeberg, and the manufacturing of the nuclear fuel at Pelindaba could in the short term have a negative effect on the local economy as fewer tourists may be willing to stay at the local establishments. However, this effect will only apply to the short term. In the medium to longer term, the total effect of the PBMR on the local economy of both areas will be positive.
## ANNEXURE 1

### 10. Stakeholders contacted - Koeberg study area

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11. Stakeholders contacted - Pelindaba study area

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<td>Die Oude Pastorie</td>
</tr>
<tr>
<td></td>
<td>Dodona</td>
</tr>
<tr>
<td></td>
<td>Enchanted Valley Lodge</td>
</tr>
<tr>
<td></td>
<td>Glen Afric Country Lodge</td>
</tr>
<tr>
<td></td>
<td>Heron's Nest</td>
</tr>
<tr>
<td></td>
<td>Highlander Resorts</td>
</tr>
<tr>
<td></td>
<td>Holmley Lodge</td>
</tr>
<tr>
<td></td>
<td>Leopard Lodge</td>
</tr>
<tr>
<td></td>
<td>Magaliespark</td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td>Paradise Village</td>
<td></td>
</tr>
<tr>
<td>River Bend Cottage</td>
<td></td>
</tr>
<tr>
<td>Vergenoeg Nature Reserve</td>
<td></td>
</tr>
</tbody>
</table>
ANNEXURE 3

PBMR: Tourism Impact Study

February - March 2002

To whom it may concern:

This questionnaire forms part of a Tourism Impact Study regarding the proposed Pebble Bed Reactor (PBMR) that is to be built at the Koeberg site. The purpose of the study, is to assess the current perceptions within the tourism industry on nuclear technology, with specific reference to the use of PBMR technology at Koeberg and Pelindaba.

1. The study will be conducted in Blaauwberg and surrounding areas, i.e. the immediate vicinity of Koeberg nuclear plant.

2. The study will also be conducted in the areas within the immediate vicinity of the Pelindaba nuclear plant.

For the success of this study, it is of the utmost importance that the respondents answer all questions as accurately as possible. Please note that you will remain completely anonymous and that the response to this questionnaire will be analysed for statistical purposes only. You may contact Urban-Econ for further information.

Thank You.

Miss. L. Liesing               Mr. D.W. Visser
for Urban-Econ                 for Urban-Econ
Cell. 083 4262142              Cell. 082 3350554
Tel. (021) 426 0272
Fax. (021) 426 0271
For Administration Purposes (Please complete)

Date: 
Name of correspondent: 
Contact number of correspondent: 
Name of field worker: 
Number of questionnaire: 

PBMR: Tourism Impact Perception Survey

INSTRUCTIONS:
Please answer all the questions as accurately as possible.
Mark with an "X" blocks.

The business/ facility

Question 1  How long have you owned/managed this facility?

0-2years
3-5years
6-10years
Longer

Question 2  How many people can you accommodate overnight?

0
1-2
3-5
6-10
10 and more

Question 3  What is the ratio between local and foreign visitors per annum?

<table>
<thead>
<tr>
<th>Domestic/local</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>
Question 4  What is the profile of the tourist/visitors that you accommodate? Please indicate in % where applicable.

<table>
<thead>
<tr>
<th>Profile</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>High profile business people</td>
<td></td>
</tr>
<tr>
<td>Families</td>
<td></td>
</tr>
<tr>
<td>Retired people</td>
<td></td>
</tr>
<tr>
<td>Backpackers</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

Question 5  Is your business strongly seasonally linked?

<table>
<thead>
<tr>
<th>Seasonality</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

Question 6  What time of the year is the peak season?

<table>
<thead>
<tr>
<th>Season</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept - Dec.</td>
<td></td>
</tr>
<tr>
<td>Jan.-March</td>
<td></td>
</tr>
<tr>
<td>Jun-Aug.</td>
<td></td>
</tr>
<tr>
<td>The whole year</td>
<td></td>
</tr>
</tbody>
</table>

Question 7  Did your business exist before the development of Koeberg / Pelindaba?

<table>
<thead>
<tr>
<th>Existence</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

**Perceptions**

Question 8  What are your perceptions about nuclear technology, with regards to safety and its impact on the environment?

<table>
<thead>
<tr>
<th>Perception</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td></td>
</tr>
<tr>
<td>Indifferent</td>
<td></td>
</tr>
<tr>
<td>Explain</td>
<td></td>
</tr>
</tbody>
</table>
Question 9  Do you think the development of Koeberg / Pelindaba had a negative effect on the local tourism industry?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yes</strong></td>
<td></td>
</tr>
<tr>
<td><strong>No</strong></td>
<td></td>
</tr>
<tr>
<td>Not sure</td>
<td></td>
</tr>
<tr>
<td>Explain</td>
<td></td>
</tr>
</tbody>
</table>

Question 10  In your opinion, what are the general perceptions of tourists regarding nuclear technology and the Koeberg/Pelindaba?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Negative</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Indifferent</strong></td>
<td></td>
</tr>
<tr>
<td>Not sure</td>
<td></td>
</tr>
<tr>
<td>Explain</td>
<td></td>
</tr>
</tbody>
</table>

Question 11  Do you think that the existence of the Koeberg/Pelindaba plant has had any effect on the decision of tourists to visit the area?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yes</strong></td>
<td></td>
</tr>
<tr>
<td><strong>No</strong></td>
<td></td>
</tr>
<tr>
<td>Not sure</td>
<td></td>
</tr>
</tbody>
</table>

Question 12  What element of Koeberg / Pelindaba has, in your opinion, the most significant (negative) impact on the tourism local industry?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Visual</strong></td>
<td></td>
</tr>
<tr>
<td>Possible impact on the ecology</td>
<td></td>
</tr>
<tr>
<td>Perception of radiation</td>
<td></td>
</tr>
<tr>
<td>None of the above</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Explain</td>
<td></td>
</tr>
</tbody>
</table>
Question 13 Has Koeberg/ Pelindaba had any positive impact on the local tourism industry?

<table>
<thead>
<tr>
<th>Yes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Not sure</td>
<td></td>
</tr>
<tr>
<td>Explain</td>
<td></td>
</tr>
</tbody>
</table>

Knowledge and perception on PBMR

Question 14 Are you aware of the PBMR that is possibly to be build at Koeberg?

<table>
<thead>
<tr>
<th>Yes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Question 15 How did you obtain information about PBMR?

| Printed media |                  |
|               |                  |
| Radio         |                  |
| T.V.          |                  |
| Discussions   |                  |

Question 16 Do you think the establishment of the PBMR will (in future) have a negative effect on the local tourism industry?

<table>
<thead>
<tr>
<th>Yes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Not sure</td>
<td></td>
</tr>
<tr>
<td>Explain</td>
<td></td>
</tr>
</tbody>
</table>
ANNEXURE 4

PEBBLE BED MODULAR REACTOR PROJECT:

TOURISM IMPACT ASSESSMENT

To whom it may concern:

Eskom, which is the largest provider of electricity in South Africa, is in the process to conduct detailed feasibility studies and an environmental impact assessment (EIA) on a demonstration model for a Pebble Bed Modular Reactor (PBMR), which is to be located near to the existing nuclear plant at Koeberg. One element of this impact assessment is to gain an informed perspective on the possible impact that such a development may have on the economy through the tourism industry. This questionnaire forms part of a survey conducted in the local tourism industry to determine perceptions and opinions about the use of nuclear technology to generate electricity. It will be to the long-term benefit of the economy, the tourism industry and the local community if this survey reflects the actual views and perceptions. The view and perceptions of the individual tourist, both domestic and international, represents the key to this survey.

It would therefore be appreciated if you complete this questionnaire as accurately as possible.

Please note that you will remain completely anonymous and that responses in this survey will be used for statistical purposes only.

Should you have any further questions, please do not hesitate to contact De Wit Visser or Lizell Liesing at any of the contact numbers or addresses provided below.

Your co-operation is much appreciated.

Contact persons for more detail:

De Wit Visser
Or
Lizell Liesing
Urban-Econ
Tel: 021 – 426 0272
Fax: 021 426 0271
E-mail: uedevectn@adept.co.za
PBMR: Tourism Impact Perception Survey

INSTRUCTIONS:

Please answer all the questions as accurately as possible.

Please indicate your answer with an "X" in the appropriate block.

### The tourist

**Question 1**  Where are you visiting from?

<table>
<thead>
<tr>
<th>Country</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td></td>
</tr>
<tr>
<td>America</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

**Question 2**  How long is your stay in the Pretoria/Cape Town area?

Please indicate the duration.

<table>
<thead>
<tr>
<th>Duration</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Day</td>
<td></td>
</tr>
<tr>
<td>2 Days</td>
<td></td>
</tr>
<tr>
<td>3 Days</td>
<td></td>
</tr>
<tr>
<td>Longer</td>
<td></td>
</tr>
</tbody>
</table>

**Question 3**  For which purposes did you come to visit the Pretoria/Cape Town?

<table>
<thead>
<tr>
<th>Purpose</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Business</td>
<td></td>
</tr>
<tr>
<td>Holiday</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

**Question 4**  Where are you currently residing?

<table>
<thead>
<tr>
<th>Accommodation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B&amp;B/Guesthouse/Lodge</td>
<td></td>
</tr>
<tr>
<td>Self-Catering facility</td>
<td></td>
</tr>
<tr>
<td>Hotel</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

**Question 5**  Have you visited the Pretoria/Cape Town before?

<table>
<thead>
<tr>
<th>Answer</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>
Question 6  What is the most appealing characteristic of this area?

Panoramic Views
Nature Reserves/facilities
Climate
Culture/People
Other

Perceptions on nuclear energy

Question 7  What is your perception on nuclear energy?

Positive
Negative
Indifferent

Question 8  Are you aware of the proposal to manufacture nuclear fuel at Pelindaba?

Yes
No

Question 9  If yes, did it in any way effect your decision to visit the Pretoria/Cape Town?

Yes
No
Explain

Question 10  Now that you know about the proposed development, would you again visit and stay in Pretoria/Cape Town?

Yes
No
Explain
**Question 11** What element of the proposed development will have the most significant impact on the local tourism industry

<table>
<thead>
<tr>
<th>Visual impact</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception of radiation</td>
<td></td>
</tr>
<tr>
<td>Possible impact on ecology</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

**Explain**
4.6 IMPACT ON SUPPLY SIDE MANAGEMENT

4.6.1 INTRODUCTION

Eskom’s Integrated Strategic Electricity Plan (ISEP) provides for a dualistic approach to the supply and management of electricity, namely:

- A Supply Side Management approach, and
- A Demand Side Management approach

To diversify the national energy mix for the generation of electricity, a number of new technologies are under consideration for further development. These technologies, which were reported on within the Scoping phase of the proposed demonstration PBMR Plant, include:

- The PBMR nuclear technology which is in the Detail Feasibility Phase
- Renewables (wind and solar thermal) which also are in the feasibility phase (An EIA is currently conducted for the wind turbine plant while EIA work, in all probability, will start in 2002 for the solar thermal plant).
- Fluidised Bed Combustion that will use discard coal.
- Biomass, etc.

The objective of this work is not to replace currently used technologies, but to more fully understand their techno-economics. In turn, this will provide guidance on their feature use.

4.6.2 IMPACT ON THE PROPOSED PLANT ON SUPPLY SIDE MANAGEMENT

The proposed Plant will generate some 130MW electricity that represents 0.3% of Eskom’s installed nett (operational) capacity of 39810MW (nett capacity excludes the mothballed stations). The installed nominal capacity is 42011MW (Eskom 2001 Annual Report).

The contribution to overall capacity is therefore very limited. Although the Plant will be linked to the national transmission grid the purpose of the Plant at this stage is to demonstrate its techno-economic viability and is not intended to supplement overall generation output capacity.

4.6.3 DEMAND SIDE MANAGEMENT

The term “demand side management” (DSM) was first used in the United States in the early 80s to describe the “planning and implementation of utility activities designed to influence the time, pattern and/or amount of electricity demand in ways that would increase customer satisfaction, and co-incidentally produce desired changes in the
utility’s load shape” (Gellings 1989). DSM – as an alternative to system expansion as well as a tangible means of providing customers with a valuable service – was later adopted in the United Kingdom, Europe and Australia. Today, DSM associated initiatives are practiced worldwide, although not necessarily referred to as DSM programmes.

In South Africa, DSM is still a relatively new concept to most. While Eskom formally recognized DSM in 1992 when integrated electricity planning (IEP) was first introduced, the first DSM plan was only produced in 1994. In this plan, the role of DSM was established and a wide range of DSM opportunities and alternatives available to Eskom were identified (Ellman & Alberts 1999). Some municipalities and local service providers currently undertake activities seeking to “produce desired changes in the utility’s load shape”. Some of these activities can be classified as DSM initiatives, others not. The reason for this, generally, is that this latter group of activities tends to focus on achieving load impacts, and are not necessarily geared towards bringing about increased customer satisfaction. In the White Paper on Energy Policy, the South African government recognizes the importance and potential of energy efficiency, and commits itself to promoting the efficient use of energy in all demand sectors. It also commits itself to investigating the establishment of “appropriate institutional infrastructure and capacity for the implementation of energy efficiency strategies”. Currently, the Department of Minerals and Energy is starting to move in this direction.

Within the context of Eskom’s market oriented and customer driven philosophy, it is apparent that much is to be gained by a focused domestic electrification programme. On the one hand, it brings improved quality of life, comfort, convenience, safety, security, education and recreational opportunities. On the other hand it creates a multiplier effect in the domestic electrical appliance and electrical service industries, with multiple benefits to the economy and the labour market.

4.6.4 The DSM Rollout Plan for 2002

Residential Load Management

A goal of 49MW was set by ISEP for Residential Load Management for 2002 with a budget for R83m. To achieve this target in the Residential Load Management area, the overall strategy is to more effectively utilize existing load management systems for Supply Authorities. In areas where the relevant Supply Authority is not currently employing LM systems, but where significant megawatt reductions are foreseen, new LM systems will be introduced.

The first projects proposed for 2002 is for both the installation of a complete Load Management System for the Cape Town Unicity and the refurbishment of an existing
load management system for the Randburg section of Johannesburg City Power by the TSI Load Management Division of Eskom Enterprises.

An upgraded and functional Randburg load management system will deliver 17MWe controllable load. The Western Cape Unicity proposal is for the installation of a new load management system and access to 16,000 geysers to control 10MWe.

**Residential Energy Efficiency**

A goal of 36MWe was set by ISEP for Residential Energy Efficiency for 2002 with a budget of R57 m. To achieve this target in the Residential Load Management area for 2002, the overall strategy is to more effectively utilize the targets realized by BONESA, the company managing Eskom’s Efficient Lighting Initiative (ELI).

Other pilot projects are being pursued through Eskom Enterprises TSI, in the areas of geyser blankets and heat insulation initiatives.

**Industrial/Commercial Energy Efficiency**

Demand Side Management’s goal set by ISEP for the year 2002 on the Industrial Commercial Energy Efficiency (ICEE) sector is to reduce 95MWe from the Eskom electricity supply system demand peak with a budget of R208 million. The ICEE sector will initially focus on Eskom’s industrial sites and commercial buildings and then target the industry throughout South Africa in order to realize the forecasted 2002 MWe reduction required.

**4.6.5 CONCLUSION**

- Eskom is employing a responsible and rational approach to the management of electricity (supply and demand) and the concomitant use of natural and economic resources.

- The proposed Plant will have minimal impact on Eskom’s nominal or nett installed generating capacity.

- Eskom has set achievable targets for Demand Side Management which will facilitate the deferment of new generation plant and promote the more optimal use of available resources. The DSM objectives will furthermore provide downstream economic benefits through the improvement of quality of live and sales in the appliances sectors (provided that such appliances are locally manufactured).
4.7 REPORT ON ECONOMICAL POTENTIAL, MARKETS AND EMPLOYMENT

4.7.1 INTRODUCTION

While the Environmental Impact Assessment focuses on the proposed demonstration Plant, the potential macro economic benefits on the commercialisation of the PBMR technology were required to be reported on by the Review Panel. In this regard, the following is recorded:

- This EIA is limited to a single demonstration module PBMR,
- Any further related proposed activities will require separate assessment and authorisation,
- The strategic and commercial objectives of the applicants were deemed irrelevant to the EIA.

Two scenarios are addressed in this sub-chapter, namely:

- The demonstration Module PBMR
- Various subsequent order scenarios for the Plant as presented by the Applicant.

4.7.2 THE DEMONSTRATION MODULE PBMR

As indicated earlier in the Report the construction of the Plant will employ about 1 400 persons over a 24 month period (about an equal number will be required for decommissioning/dismantling).

For operational purposes 40 employees will be required ranging from professional to administrative staff. Most of these persons will be sourced from the nearby towns.

The above figures do not account for the manufacture of equipment for the Plant within South Africa. Given that about 48% (Table 22) will be local content, it is estimated that about 450 manufacturing employment opportunities will be created.

During establishment of the Plant (construction) this will provide economic benefit on a local, regional and national scale albeit of limited duration. During the operation of the Plant economic benefit will largely be of a local and sub-regional nature and limited in extent, due to limited staff numbers and infrequent maintenance requirements.
4.7.3 **VARIOUS ORDER SCENARIOS**

Figure 7 and Table 23 respectively provide a potential Business Case, based on Marketing Research by the PBMR (Pty) Ltd (which is classified confidential) and the potential economic impact for the Business Case.

From Table 23 it can be seen that about 54,500 jobs will be sustained, with a nett impact on the Balance of Payments (BoP) of some R97,600 million and an annual government income of R2,170 million over 26 years.

The above figures are based on a local content target as given in Table 22 and Figure 7.

<table>
<thead>
<tr>
<th>Sales Order Scenario</th>
<th>RSA Content Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstration plant</td>
<td>48%</td>
</tr>
<tr>
<td>Ten-module Eskom plant</td>
<td>69%</td>
</tr>
<tr>
<td>Less than 10 modules in a developing country</td>
<td>65%</td>
</tr>
<tr>
<td>More than 10 modules in a first-world country</td>
<td>43%</td>
</tr>
<tr>
<td>Less than 10 modules in a first-world country</td>
<td>54%</td>
</tr>
</tbody>
</table>

Table 22: RSA Local Content Targets

Should the above scenario realise it will place high pressure on educational institutions to produce the required number of qualified professional, technical, managerial and administrative employees.

4.7.4 **WITHDRAWAL OF EXELON**

Exelon’s withdrawal coincided with a change of leadership and a re-assessment of the utility’s core business. In announcing their withdrawal on 16 April 2002, Exelon issued the following statement: “This decision comes after a broad-based review of Exelon’s investments that was conducted to ensure a disciplined strategy focused on the fundamentals of generation, power marketing and distribution. Becoming a reactor supplier is no longer consistent with Exelon’s strategy.

“Exelon continues to believe that the PBMR technology has the potential to be viable and successful. Exelon’s economic and professional support has done a great deal to

---

115 PBMR Demo Plant DFR, Doc No. 009838-160 Rev 1
advance this technology’s development to the point where there is a defined path to the completion of the commercialisation of the technology. The project is now positioned for other companies with the appropriate expertise and core business experience to deliver the PBMR plants to power generators such as Exelon Generation”.

4.7.5 Potential Contribution to National Science and Technology Goals

Claire Bisseker (Financial Mail – 16 August 2002) wrote: “Each year SA stagnates at the bottom of the World Competitiveness rankings, our school children perform abysmally in international science and maths competitions and more of our best brains leave the country”.

The author further reports that “although South Africa’s total research expenditure is low by international standards, the amount allocated per researcher is comparable to that in several developed countries. This has enabled SA to retain pockets of world-class expertise despite its limited resources” and the report reminds one that “South Africans invented the CAT scan and the technology that underpins both the walkie-talkie and the palm pilot or that Eskom has developed a reactor that may become the next-generation nuclear power plant”.

PAGE 195
Figure 7: PBMR Business Case
## Impact of PBMR on SA Economy

<table>
<thead>
<tr>
<th></th>
<th>Reactor *</th>
<th>Fuel Plant **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Domestic Product [R millions]</td>
<td>7,600</td>
<td>925 (per year)</td>
</tr>
<tr>
<td>Jobs sustained</td>
<td>54,500</td>
<td>9,200 (average)</td>
</tr>
<tr>
<td>Total capital [R millions]</td>
<td>12,950</td>
<td>1,750</td>
</tr>
<tr>
<td>Impact on total household income [R millions]</td>
<td>5,290</td>
<td>690 (per year)</td>
</tr>
<tr>
<td>Impact on low income groups [R millions]</td>
<td>1,050</td>
<td>130 (19.8%)</td>
</tr>
<tr>
<td>Net impact on the Balance of Payments [R millions]</td>
<td>97,600</td>
<td>n/a</td>
</tr>
<tr>
<td>Total government income [R millions]</td>
<td>56,350</td>
<td>n/a</td>
</tr>
<tr>
<td>Average Government income over [R millions]</td>
<td>2,170</td>
<td>n/a (average)</td>
</tr>
<tr>
<td>Shadow price factor</td>
<td>0.9</td>
<td>n/a</td>
</tr>
</tbody>
</table>

2000 Rand Values  
* over 26 years  
** over 15 years

**Table 23:** Impact of PBMR on SA Economy
However, if the skills development and the technological base in the areas of science and technology is to increase, it needs to be linked to South Africa’s industrial strategy. Should the PBMR prove its techno-economic viability and becomes commercialised then it has the potential to significantly contribute towards the broader science and technology goals of the country. Unless there are careers in South Africa for scientists and technologists, they will leave the country.

To identify the extent to which the PBMR project and the commercialisation of the technology could contribute to the broader science and technology goals of South Africa, it is necessary to look at the role of the National Research Foundation (NRF).

The organisation was established in 1999 as a result of The NRF Act, and reports to the Minister of Arts, Culture Science and Technology.

As the government’s national agency responsible for promoting and supporting basic and applied research as well as innovation, the NRF invests in knowledge, people, products and infrastructure. The NRF provides services and grants to support research and postgraduate research training, vital to the development of South Africa. It is the NRF’s vision to be a key instrument in the creation of an innovative, knowledge-driven society where all citizens are empowered to contribute to a globally competitive and prosperous country.

The objective of the NRF is to support and promote research through funding, human resource development and the provision of the necessary research facilities, in order to facilitate the creation of knowledge, innovation and development in all fields of the natural and social sciences, humanities and technology. In so doing, it contributes to the improvement of the quality of life of all the people of the country.

Funding from the NRF is largely directed towards academic research, developing high-level human resources, and supporting the nation’s national research facilities. The NRF’s task is to advance research in all fields of the humanities, social and natural sciences, engineering, and technology; including indigenous knowledge. By forging strategic partnerships locally and internationally, it extends the resources that researchers need to foster and expand South Africa’s research capabilities and, ultimately, to improve the quality of life for all.

Other areas of its core business are to promote research capacity development (RCD), to unlock the creative potential of the research community and to establish equity and redress. The NRF fosters strategic partnerships and knowledge networks to make South Africa globally relevant and competitive. It provides research information and strategic advice.
Taking the role, mission and strategy of the NRF as highlighted above, the PBMR project in its broader context, is seen to be compatible. Through the University of the Witwatersrand a post graduate diploma has been developed and implemented successfully for the second year. This post graduate diploma provides an opportunity for postgraduates to gain competency in the field of nuclear engineering. The curriculum of this diploma covers a broad range of physical, nuclear, environmental and engineering sciences.

The make up of the students that have attended this accelerated post-graduate diploma to date is as follows:

- **First: 2001**

- **Second: 2002**

Given the employment profile of PBMR (Pty) Ltd, the NNR, Eskom and NECSA the project is already contributing towards the NRF’s and national goals of science and technology. However, it will become a significant initiator for the training and employment of scientists, technologists and engineers once the technology is commercialised and links to the commercial and industrials sector(s).

### 4.7.6 Conclusion

- The demonstration Plant will make a contribution to the local regional and national economy albeit to a limited extent. The project goes some way in fostering and supporting the national goals of science and technology in that it employs and retains essential skills within the country.

- The economic and commercial potential of the technology (as postulated by the applicant in Table 23) will create a meaningful multiple launch pad for manufacturing, manpower development, skills retentions, foreign investment and earnings (to mention some of the potential benefits) and propel the economy into
into higher levels of sustained performance.
4.8 LIFE CYCLE COSTING

4.8.1 INTRODUCTION

This sub-chapter provides information on financial provisions for the management and storage of radioactive waste, especially High Level Waste as well as the decommissioning of the proposed Plant.

The following aspects are addressed:

- The Koeberg NPS Case: Financial provisions and the effect on tax payers and future generations
- Financial provision for the PBMR
- Comparative information based on international studies

4.8.2 THE KOEBERG NPS CASE

By the end of 2001, Eskom had an accumulated provision of R 2.827 billion for decommissioning and rehabilitation\(^{116}\), of which R 1.451 billion is specifically for nuclear (Koeberg) decommissioning and waste management\(^{117}\). A provision is raised for the estimated decommissioning cost of nuclear power station (as with other power station plants within Eskom) and capitalised to the cost of the nuclear power station plant when it is commissioned. The estimated cost of decommissioning at the end of the productive life of the power station is based on engineering estimates and reports from independent experts\(^{118}\). A provision is similarly made, over the life of the power station, for the management of spent nuclear fuel assemblies and radioactive waste. The above-mentioned provision of R1.451 billion for Koeberg power station decommissioning and waste management will thus continue to increase each year, for the remainder of the life of the power station. The annual amount by which the provision is increased is based on the latest available cost information and is included in the operating expenditure. The payment dates of total expected future decommissioning costs related to Koeberg decommissioning and waste management are uncertain, but are

\(^{116}\) Eskom annual report 2001, page 78
\(^{117}\) Eskom annual report 2001, page 108
\(^{118}\) Eskom annual report 2001, page 87
are uncertain, but are currently expected between 2021 and 2050. The decommissioning provisions are kept in a segregate fund and are audited on an annual basis, including the compliance to the General Accepted Accounting Statement on provisions.

A similar practice will be applied to the proposed PBMR demonstration module.

CONCLUSION

From the above it is clear that significant financial provision has and will continue to the made for the decommissioning and rehabilitation of Koeberg as well as for the management of radioactive High Level Waste.

Of note is the fact that the funds are audited annually in compliance with General Accepted Accounting Practices and Statements and published in Eskom’s Annual Report. This provides transparency and assurance to the public, that no further financial burdens will be placed on the tax payer or future generations, to manage the mentioned activities.

4.8.3 Financial Provisions for the Proposed PBMR

Expenditure to Date

Due to the numerous request for financial figures by interested and affected parties (I & APs) and the range of figures quoted in the press and through the EIA process, update figures are provided below:

- Amount spent to date (July 2002) on the PBMR project = R684.2m
- Amount spent by Eskom to date (July 2002) of the PBMR project = R350.6m
- Expected amount to be spent in total to end of detailed feasibility stage (end 2002) on the PBMR project = R1,013.3m
- Expected amount to be spend by Eskom to end of detailed feasibility stage (end 2002) on the PRMB project = R460.6m
- The cost to build the PBMR demonstration module will probably be available on completion of the project business plan (year end 2002)

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119 Eskom annual report 2001, page 109
CONCLUSION

The ratio of Eskom’s contribution to overall expenditure to the end of the detail feasibility stage (end 2002) is about 45% which is somewhat disproportionate to their shareholding in the project (Eskom 30% and Black Empowerment 5%).

Financial Provision for the PBMR

In terms of the applicants “Duty of Care” to make financial provisions for decommissioning/rehabilitation and the management/storage of radioactive waste (especially HLW) the following rationale will be applied.

Current financial figures on the cost of the Plant, lies within the range of 2.8 to 3.4$c/KWh. This range provides for capital, operational, maintenance and decommissioning cost including long-term management of waste. The confidence limit that is placed on this figure is 70% plus, as reported by the financial staff of the PBMR (Pty) Ltd.

The following provisions are including into the figures:

- 1.5% of the Capital cost of the Plant is provided for decommissioning
- 1.5% of the fuel cost is provided for long term storage and management of spent fuel

A segregate account (fund) will be established, that will accumulate funds over the operational life of the Plant, to execute both of the applicants obligations. This approach as well as the percentage figures for financial provision is in line with international norms.

The early retirement of the Plant will be dealt with through other provision mechanisms.

CONCLUSION

The applicant intends to follow accepted international norms and practices to ensure that sufficient funds will be accumulated to discharge its obligations.

4.8.4 COMPARATIVE INFORMATION

PBMR is being developed as a competitive generating system compared to other new-built options both in South Africa and overseas. The specific cost of a coal-fired power station may vary depending on its proximity to a cheap coal source, as found in the Mpumalanga province. The PBMR design target is about US$1 million per MW of installed capacity, compared to US$900 000 per MW for a new coal-fired power station in South Africa. This more than compensates for the cost of coal away from the pit-head. It is
head. It is highly unlikely that the investors will proceed with this project if it is not competitive with other new-built options such as solar, hydro, wind, natural gas and biomass.

Clearly the price that electricity is sold at reflects the price to produce electricity. Therefore when Eskom builds a new power station (be it solar, wind, nuclear, coal, gas or hydro) the electricity price will reflect these capital expenditures. However, all of this is strictly controlled and regulated by the National Electricity Regulator (NER) to protect the consumer at the end of the day.

Comparative cost for electricity generation by other primary energy sources have been extracted from Kugeler et al (2001), Annexure 16a, page 3 and is presented hereunder:

<table>
<thead>
<tr>
<th>Primary Energy</th>
<th>Specific investment ($/k/We4)</th>
<th>Fuel costs (ct/k/Wh4)</th>
<th>Production costs of electricity (ct/kWhel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal (world market)</td>
<td>1000</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Natural gas</td>
<td>400</td>
<td>2</td>
<td>4.5</td>
</tr>
<tr>
<td>Wind power</td>
<td>1000</td>
<td>0</td>
<td>5 - 10</td>
</tr>
<tr>
<td>Photovoltaic (direct use)</td>
<td>7000</td>
<td>0</td>
<td>70</td>
</tr>
<tr>
<td>Photovoltaic (H2-storage)</td>
<td>7000+...</td>
<td>0</td>
<td>300</td>
</tr>
<tr>
<td>Nuclear (old plants)</td>
<td>600</td>
<td>0.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Nuclear (new plants)</td>
<td>1500</td>
<td>0.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Note: Based on cost in Germany (2000)

Bechtel SAIC Company (Annexure 19) conducted a comparative evaluation of PBMR and LWR (Koeberg type reactor) spent fuel disposal cost on the basis of equal energy generation of 1GWe-year. Results indicated that the PBMR disposal cost “could range from four (4) to ten (10) times that for the LWR disposal cost at equal electricity generation”.

However the PBMR appears to ......“have potential benefits in the areas of thermal management, source term and radio nuclide release rate but poses the challenge of increase volume for disposal....”. This increased volume causes the significant disposal cost penalty indicated above.
4.8.5 Overall Conclusion

The applicant (Eskom) has established the required mechanisms to ensure that the required financial provisions will be in place to discharge its “Duty of Care” in line with international practices.

- For bulk electricity generation the estimated cost of the PBMR is competitive compared to that of coal, natural gas and renewables.

- The disposal cost for PBMR spent fuel will carry a significant cost penalty compared to LWR (four to ten times higher due to increased volume and based on equal electricity generation). However increased safety benefits (i.e. thermal management, reduced source term and radio nuclide release rates) are evident.

- The consumer(s) is protected by the National Electricity Regulator in terms of the prices that will be passed onto them by the producer and/or supplier.
4.9 EFFECTS OF THERMAL OUTFLOWS ON MARINE FAUNA AND FLORA

4.9.1 INTRODUCTION

This chapter provides an overview of marine biological studies done by various specialists on different aspects of the Koeberg marine environment. It describes the environmental impact, ongoing monitoring programmes which are being followed and conclusions.

4.9.2 MARINE ECOLOGY

A report by B Currie and PA Cook of the University of Cape Town (Reference 1) describes the broad ecological characteristics of the intertidal and shallow sub-tidal marine environment in the vicinity of Duynefontein, with specific reference to the distribution of fauna according to the character of the coastline.

Further experimental work by Dr Cook on the possible effects of the thermal plume from Duynefontein, with particular reference to rock lobster, was undertaken on behalf of Eskom and a report published in 1978 (Reference 2).

During the construction phase of the Power Station, Dr Cook continued to do further research in order to establish a more detailed baseline and also to determine seasonal variations in population characteristics. He also studied possible differences in susceptibilities to temperature fluctuations during various stages in the life cycles of the dominant species.

Studies carried out by Dr Cook of UCT concentrated on three distinct periods, viz, the pre-operation phase (1981-1984), transitional phase (1985,1986), and the operational phase (1987-1989).

4.9.3 BASELINE ECOLOGICAL REPORT

The Baseline Ecological Report of 1984 (Reference 3) contains a vast quantity of environmental and ecological data as well as some preliminary findings which can be listed as follows:

- A possible decrease in specie diversity,
The white mussel, *Donax serra*, was identified as an indicator species.

It was suggested that the thermal pollution from Koeberg might result in a disruption of the breeding cycle of *Donax serra*.

The effects of entrainment on the suspended planktonic organisms, where the water is both heated and chlorinated as it passes through the plant, was not too serious as long as no ‘shock’ chlorinating took place.

At that stage there was no evidence of colonisation of opportunistic ‘warm water’ species.

Generally metal concentrations in both black and white mussels collected close to Koeberg had remained fairly constant.

In support of the studies carried out by Dr Cook, Eskom undertook to study the extent and volume of the ‘warm water plume’ and the results are described in the ‘Warm Water Plume Report’ by Rattey and Potgieter (Reference 5). This report describes the dissipation, path and extent of the warm plume. Salient features that were deduced from the interpretation of the plume studies are:

- The dispersion of the plume is governed by the volume of warm water discharged into the sea (subject to the power station status), the vertical mixing process of breaking waves, horizontal eddy diffusion and by the advection of ambient currents.

- Plume trajectory is in correspondence with the prevailing ambient currents which are primarily wind induced.

- The downward penetration of the warm water plume is limited by its buoyancy, especially outside the surf zone where bottom measurements showed ambient temperatures.

- The main impact area of the warm discharge appears to be along the beach to the south side of Koeberg, between the Outfall and the Ou Skip Rocks.

- The relatively small extent of the plume is unlikely to have a dramatic effect on the local marine environment. The effected area is unlikely to extend more than a kilometre or so from the Outfall channel, even in the worst conditions.

- No temperature increase in excess of two degrees above ambient was observed further than 1 km from the Outfall.
A further study was conducted by Rattey and Potgieter to investigate the dynamic variances of the ocean physics (Reference 6). The study describes the degradation and propagation of beaches, which could physically affect the monitoring program undertaken by Dr Cook, as well as to qualify the actual temperature increase at Ou Skip (the reference site for marine ecological impact studies) resulting from the warm plume created by Koeberg. The dynamic beach processes and changes and temperature influences can be described as:

- The interrelationships of the sandy shore process. The extent and configuration being dependant upon wave height and period, currents, the range of tides, the degree of exposure to winds and sediment source.

- Although there are seasonal variations of the seabed slope, as confirmed by previous studies, the most significant changes occur at localised positions on the beach due to cell circulation systems in the nearshore zone.

- The wave induced cell circulation is most apparent with rip currents which are strong narrow currents that flow seawards from the surf zone.

- The cell circulation system is dependent on complex wave incident and set-up conditions and can occur at any time of the year.

- The erosion/accretion cycle is of a short duration but is responsible for large amounts of sand being moved.

- It can be assumed that the beaches are in a constant state of dynamic equilibrium indicating little nett loss or gain in the sediment budget.

- Cogniscance must be taken of the fact that perturbations in faunal density and population could be affected by beach processes.

- The measurable influence of the warm pollution from Koeberg on the sea temperature at Ou Skip Rocks equals 0.62 ºC. If the long term non-operational differential is applied to the seasonal regimes, the positive temperature influence is 0.66 ºC during summer and 0.56 ºC during winter.

- Koeberg’s influence is well within the standard deviation of the natural temperature variation over a long period.

4.9.4 Final Ecological Report

In the final report by Dr PA Cook (Reference 4), which included the Marine Environmental Impact studies during the operational phase of the study, most of the
earlier predictions regarding the extent of the pollution impact were proved incorrect. The main findings can be summarised as:

- No reduction in the specie diversity index was recorded, in fact the index rose during the operational period.
- Overall community structure of beach animals was very variable from year to year, but the dominance of a few key species was maintained throughout the assessment period.
- The predicted colonisation of the area by opportunistic warm water species did not occur.
- The breeding cycle of the main indicator specie, Donax serra, appeared to be more influenced by seasonal marine variations, than by the released thermal water.
- Phytoplankton biomass was reduced by an average of about 53 % due to entrainment in the power station cooling system whilst zooplankton mortality averaged 22.3 %. Mortality of plankton during entrainment was not, however, considered to be detrimental to the marine environment because of the very localised area affected.
- The overall conclusion is that the Koeberg Nuclear Power Station has had very little detrimental effect on the ecology of the local sandy beaches.

**Ongoing Programme and Conclusion**

Since 1990 emphasis has been placed on Donax serra as being the indicator specie and most of the ongoing study has concentrated on this beach animal. In conjunction bi-annual total specie samples are being taken for identification and counting of the samples. The annual reports thus far indicate differences which have little overall biological significance (Reference 7).

**Effect of Thermal outflow from the proposed Plant on Marine Ecology**

With one PBMR unit operating, the total sea water volume used for one day will be approximately 150 thousand cubic meters. For Koeberg this volume exceeds 7 million m$^3$. For 10 PBMR’s the volume will increase to 1.5 million m$^3$. This water will be pumped and forced through filter systems and condensers. This huge volume of water contains vast numbers of planktonic organisms, all less than 3mm in size, which then get subjected to heat, physical stress, mechanical damage, pressure changes, turbulence as well as chlorination. This entrainment process poses a risk that the planktonic biomass might be reduced.
Utilising the pollution factors calculated for the different operating regimes, the reduction in phytoplankton biomass can be calculated. The average phytoplankton biomass reduction for Koeberg was calculated to be 53% by Cook from measurements made. He also found the reduction in zooplankton mortality to be 22% due to entrainment.

For a PBMR, the grid sizes of the marine filtration system and the physical process through the condensers units is taken to be the same as for Koeberg. Similar forces will exist in the PBMR cooling system for marine wildlife such as phytoplankton, thus the quoted reduction in biomass and mortality rates will apply.

In the entrainment process, only a very localised area and volume of the Atlantic Ocean is under consideration, thus the effect of biomass reduction and higher than normal plankton mortality is not deemed to be significantly detrimental to the marine environment.

**Conclusion**

In evaluating the effect that the additional warm water from one, up to ten, PBMR units will have on the warm water plume as well as the potential impact on the marine environment, a number of conclusions are made:

- The theoretical temperature rise at 1 kilometre falls well within the natural viability of the Atlantic Ocean and therefore poses a very low to insignificant risk to the marine environment.

- The plankton mortality and limited biomass reduction due to the entrainment process has an effect only on a very localised area of the Atlantic Ocean, thus the influence will be of a very low significance.

- It was found that no detrimental effect on the marine life around Koeberg could be proved, thus one PBMR will cause no settlement of opportunistic warm water species nor will it reduce the number of species found in the area.

It can be concluded with a high level of confidence, that the warmed water from one PBMR unit will have no detectable effect on the marine environment nor increase the size or temperature of the current warm plume in any significant way.

**References**

1. ESK 02 C; Koeberg Nature Reserve, Environmental Management Programme, 1996.

2. ESKPBAAD6; Eskom Environmental Management Policy, January 1996.
4.10 IMPACT OF THE PROPOSED PBMR PLANT ON TERRESTRIAL FAUNA AND FLORA

4.10.1 INTRODUCTION

The site for the proposed PBMR is located between the inner and outer security fence, and some 400 meters south east of the Koeberg NPS.

The proposed site was previously used as a construction yard area for the establishment of temporary contractor site offices and material/equipment lay down areas.

4.10.2 DISCUSSION

The area is still largely devoid of prominent fynbos species and is kept short for security purposes. Eskom has introduced free roaming Bontebok and Springbok, which through grazing, assist with the process of maintaining the vegetation in a short state.

Though a Plant survey was not conducted (in view of the status of the pioneering and sub climax vegetation) it is unlikely that rare or endangered plant species exist on the area.

4.10.3 DUNE REGIMES

Planting of marram grass to stabilize the dune area was completed in 1983 after a total of 152.75 ha was stabilised.

A stable and diverse plant community has taken over the stabilised dune area.

A total of 280.63 ha of dune area is still untouched and is being conserved with the minimum of disturbance. The stability of these dunes is regularly monitored.

4.10.4 LAND ECOSYSTEM

Eskom maintains the remaining land around the Nuclear Power Station as a nature reserve (2820 ha). In 1991 the area was proclaimed as the Koeberg Nature Reserve. The main vegetation types of the area include: Strandveld and Acid Sand Plain Fynbos. These form part of the Cape Floristic Kingdom which is the smallest floristic kingdom in the world, but which has the greatest diversity of plant species. An Environmental Management Plan has been compiled by a consultant (Reference 8), and the nature reserve is managed on these principles.
Conservation objectives that receive attention are:

- The alien eradication programme,
- Environmental education,
- Research and the improvement of visitors facilities on the hiking trails.

The reserve also offers an opportunity for the local community to gain income by cutting Rooikrans trees in a woodlot area to sell for firewood. This activity serves a dual purpose. It aids in removing the invasive alien species and supports ±50 - 100 people in receiving an income. The area owned by Eskom on the eastern side of the R27 is 90% infested by Port Jackson. Biological control methods were introduced into this area in 1991 by the Plant Protection Unit, as a long term solution to the problem.

Two hiking trails exist on the reserve, namely the Dikkop and the Grysbok trails. On average about 3 000 hikers walk these trails per year and the total is increasing on a yearly basis.

All roads and fences on the reserve are maintained and the entire fence line has been cleared to a width of ±10 m, (using a tractor-drawn bushcutter), to serve as a fire belt.

The Cape Metropolitan Council (CMC) and CSIR jointly manage an underground aquifer which is used to pump water to Atlantis for industrial and domestic use. Approximately 5 300 000 m³ water is drawn each year.

### 4.10.5 Conclusions

- The proposed Plant will have no significant impact on the existing fauna and flora on the site and provided that detailed rehabilitation procedures/plans are implemented, only temporary ecosystem disruption on a very limited scale, will be caused.

- The construction area needs to be fenced, to deny the antelope entry to the area.

- The exclusion zone area and remaining Eskom land is managed according to scientific method, thus preserving a valuable natural asset.

### References

2. Cook, PA; A Prediction of Some Possible Effects of Thermal Pollution on Marine Organisms on the West Coast of South Africa, with Particular Reference to the Rock Lobster, Jasus Lalandii, University of Cape Town 1978.


4. Cook, PA; Final Report, Marine Environmental Monitoring Programme, Koeberg Nuclear Power Station, Zoology Department, University of Cape Town, December 1989.


7. Cook, PA; Marine Environmental Reports, 1990 - 1996, Zoology Department, University of Cape Town.


4.11 ARCHAEOLOGICAL AND PALEONTOLOGICAL CHARACTERISTICS OF THE PROPOSED PLANT SITE

4.11.1 INTRODUCTION

During the development of the Koeberg site all archaeological and palaeontological sites of scientific value were identified, registered and recorded by the SA Museum. These sites are however in the eastern region of the Koeberg Reserve and remote from the proposed Plant site with proper fencing and access control.

The largest excavated sites are Duynefontein and Duynefontein 2, which are Middle to Later Stone Age Layers of the Die Kelders Cave 1. Ad hoc excavation work is still being carried out on these sites by the S. A. Museum and Universities.

These sites will not be affected by the construction, or operation of the proposed PBMR Plant.

During the excavation for the PBMR Plant building foundations (which will be some +22 meters deep over an area of about 60m x 40m = 2 400m²) palaeontological finds may be discovered. The construction EMP will however direct contractors on the procedures to follow in such event(s).

4.11.2 CONCLUSIONS

✦ The proposed Plant site and its development is free of any known archaeological material of scientific note. Construction and operation activities for the proposed Plant will also not affect the known sites.

✦ EMP construction procedures must be developed to direct contractors when palaeontological finds may be discovered during foundation excavations. The operators of excavation equipment must receive basic awareness training to identify such objects/materials.
4.12 NOISE IMPACT ASSESSMENT

4.12.1 PURPOSE

To reflect the results of a baseline survey with the aim to establish the impact on sound levels that the proposed pebble bed modular reactor may have on the environment as well as the community of the surrounding neighbourhoods.

4.12.2 INTRODUCTION

Sound is the sensation perceived by the human ear when a vibrating body causes rapid fluctuations in air pressure. Exposure to noise intensities above 85 dB(A) for eight hours has the potential to cause irreversible hearing damage.

However, noise may also be of such a nature where it causes annoyance or discomfort amongst employees or members of the community. The degree of annoyance largely depends on the frequency and noise of a high frequency is generally perceived as more annoying than noise of a low frequency. Although annoyance noise has few physiological effects on the body, it causes an increased irritability, fatigue and elevates the level of stress experienced by a person. Speech communication from one person to another and telephonic conversations may also be hampered.

4.12.3 RELEVANT STANDARDS

The Noise Control Regulations in terms of Section 25 of the Environmental Conservation Act No. 73 of 1989, prohibits any person to make, produce or cause a disturbing noise or allow it to be made by any person, machine, device or any apparatus or any combination thereof. In terms of the said noise control regulations, noise is regarded as disturbing if it is of a level that exceeds the zone sound level. If no zone sound level has been established, noise is classified as being of a disturbing nature when it exceeds the ambient sound level by 7 dB(A) or more. The ambient sound level in terms of the above legislation can be defined as the sound level recorded in the absence of the noise under investigation.

Noise levels at which annoyance may occur are also recommended in SABS 0103 of 1994 Code of Practice - "The measurement and rating of environmental noise with respect to annoyance and to speech communication".
4.12.4 RESULTS

Sound Levels

The results of sound level measurements are shown in Table 25.

Table 25: Sound Levels in the Vicinity of Koeberg Power Station
29 September 1999 and 3 October 1999.

<table>
<thead>
<tr>
<th>Measuring Point (See Figure 8 and 9)</th>
<th>Rating Level dB(A)</th>
<th>Recommended Rating Level for Ambient Noise dB(A), SABS 0103</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day Time</td>
<td>Night Time</td>
</tr>
<tr>
<td>Power Station Perimeter Fence - See Figure 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>59.4</td>
<td>61.5*</td>
</tr>
<tr>
<td>2.</td>
<td>56.6</td>
<td>53.0*</td>
</tr>
<tr>
<td>3.</td>
<td>51.8</td>
<td>49.5</td>
</tr>
<tr>
<td>4.</td>
<td>53.9</td>
<td>49.6</td>
</tr>
<tr>
<td>5.</td>
<td>55.5</td>
<td>46.9</td>
</tr>
<tr>
<td>6.</td>
<td>57.2</td>
<td>56.5*</td>
</tr>
<tr>
<td>7.</td>
<td>59.1</td>
<td>57.0*</td>
</tr>
<tr>
<td>Nature Reserve Perimeter Fence - See Figure 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>47.5*</td>
<td>47.4*</td>
</tr>
<tr>
<td>9.</td>
<td>47.3*</td>
<td>39.5*</td>
</tr>
<tr>
<td>10.</td>
<td>59.9*</td>
<td>59.4*</td>
</tr>
<tr>
<td>11.</td>
<td>60.3*</td>
<td>56.4*</td>
</tr>
<tr>
<td>12.</td>
<td>49.2*</td>
<td>39.9*</td>
</tr>
</tbody>
</table>

* Exceeds Recommended Rating Level for ambient noise (SABS 0103 of 1994)
Figure 8: Measuring Point

Legend:

- Measuring Point No.2
- Night time Rating Level
- Day Time Rating Level

All noise levels in dB(A)

1. 61.5
    - Night time: 59.4
    - Day time: 59.4

2. 53.0
    - Night time: 56.6
    - Day time: 56.6

3. 49.5
    - Night time: 51.8
    - Day time: 51.8

4. 49.6
    - Night time: 53.9
    - Day time: 53.9

5. 46.9
    - Night time: 49.6
    - Day time: 49.6

6. 56.5
    - Night time: 57.2
    - Day time: 57.2

7. 57.6
    - Night time: 59.1
    - Day time: 59.1

Power Station

Weather Station

Security

Inner Perimeter Fence

Outer Perimeter Fence

450m

200m

400m

600m

800m

200m
Figure 9: Measuring Point
Meteorological Conditions

Meteorological conditions that prevailed at the time of the survey are shown in Table 26.

**Table 26:** Temperatures and Wind speeds at Some Locations Around Koeberg Power Station. 29 September 1999 and 13 October 1999.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Wind Speed (m/s)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 September 1999, Wind Direction: East North East to East South East</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08h00</td>
<td>3.6</td>
<td>12.7</td>
</tr>
<tr>
<td>09h00</td>
<td>3.8</td>
<td>15.3</td>
</tr>
<tr>
<td>10h00</td>
<td>4.1</td>
<td>18.2</td>
</tr>
<tr>
<td>11h00</td>
<td>3.8</td>
<td>20.9</td>
</tr>
<tr>
<td>12h00</td>
<td>2.8</td>
<td>22.9</td>
</tr>
<tr>
<td>13 October 1999, Wind Direction: East South East to South South East</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20h00</td>
<td>1.5</td>
<td>21.6</td>
</tr>
<tr>
<td>21h00</td>
<td>1.9</td>
<td>20.1</td>
</tr>
<tr>
<td>22h00</td>
<td>2.2</td>
<td>19.0</td>
</tr>
<tr>
<td>23h00</td>
<td>1.7</td>
<td>18.2</td>
</tr>
<tr>
<td>24h00</td>
<td>1.8</td>
<td>18.1</td>
</tr>
</tbody>
</table>

4.12.5 Discussion Of Results

Sound level measurements were conducted at several locations next to the power station's outer perimeter fence as well as at points on the fence of the nature reserve. Readings were taken during both the day and at night in order to establish the influence of traffic and other activities in and around the power station.

Corrections for tonal character were made to readings obtained at measuring points no. 1, 2 and 7 as a humming sound emanating from the power station were clearly audible at these locations. Tonal character corrections are normally made when audible tones such as whistles, hums, music, etc. are present and are performed by adding 5 dB(A) to the reading obtained from the instrument.

Rating levels at the Power Station Perimeter Fence were evaluated against recommended ambient sound levels that fall in the "Urban districts with some workshops, with business premises and with main roads" category of SABS 0103 of 1994. Standards of the "Rural Districts" category was applied for rating levels at the Nature Reserve Perimeter Fence. Although the above category descriptions are not exactly the same as those in
the same as those in the mentioned SABS standard, they were found to be the most appropriate.

Rating levels recorded at the Power Station Perimeter Fence during the day time survey were all below the recommended sound levels stipulated in SABS 0103 of 1994. Night time readings at some locations however, did not conform to the relevant standards. See Table 25 and Table 26 Page 216. It has to be kept in mind that it was not only noise from the power station that was responsible for the non-conformances, but sound emanating from the sea’s wave action taking place along the coastline which also played a significant role.

Rating levels at the Nature Reserve Fence all exceeded the recommended standard. Most of the noise was generated by traffic, mainly from the West Coast Trunk Road as well as the sea’s wave action (to a lesser degree). No audible tones from the power stations were observed at any of the above measuring points.

4.12.6 CONCLUSION

Although rating levels exceeded the accepted norm at several measuring points, the power station's impact on the environment and surrounding communities can at present, be described as insignificant. It is thus of paramount importance to ensure that should the development of the proposed pebble bed modular reactor take place at the Koeberg site, noise levels be kept well under control, in order to prevent a noise annoyance problem from developing. This will be included in the EMP.
4.13 VISUAL IMPACT ASSESSMENT

4.13.1 PURPOSE

The purpose of this visual impact assessment is to:

✦ Provide an inventory of visual resources in terms of character, quality and scarcity.

✦ Evaluate the visual/aesthetic sensitivity of the landscape and the surrounding environment to the proposed development, in other words the visual impact of the development.

✦ Identify possible visual issues associated with the proposed structure, by briefly describing the impacts and their significance.

✦ Reflect all the information in a logical and systematic manner, in order to enable the Department Environmental Affairs and Tourism in co-operation with Provincial Government to assess the development proposal in the context of the Impact Report.

4.13.2 SCOPE OF WORK

ILA (Pty) Ltd was appointed as a sub-consultant of the EIA Consortium to conduct a visual impact assessment for the proposed establishment of a 110 MWe Class Pebble Bed Modular Reactor (PBMR) demonstration module at Koeberg. The scope of work entailed the necessary investigations and site visits to conduct a visual impact assessment as part of the Environmental Impact Assessment process.

For the purposes of this visual impact assessment two alternative positions for the erection of one Modular Reactor were investigated, namely:

✦ the northern section of the Koeberg site.

✦ For engineering reasons i.e. linkage with Koeberg NPS infrastructure, access etc, consideration of this position was discontinued.

✦ the southern section of the Koeberg site.

The study area was defined as all the surrounding areas from which the proposed Modular Reactor can be observed.
A comprehensive description of the visual quality of the landscape, development proposal, anticipated viewing points and a significance assessment for these viewing points is included in the report. Mitigatory measures are included in order to ensure the minimum visual impact on the surrounding landscape.

4.13.3 Approach and Methodology

The approach to the visual impact assessment was one of on-site and area investigation, to obtain an overview of the visual aspects related to the development site and the surrounding area. On site assessment of the environmental characteristics was supported by literature studies.

Visual impact assessments by nature are subjective and quantification is difficult, due to the fact that it is based on the judgment of the observer. For the purpose of this study it was attempted to follow an approach in which cultural- and physiological parameters were also taken into account, in order to obtain an objective, systemised result with established criteria for scenic value.

According to Oberholzer (1992), these criteria should conform to the following:

- be as objective as possible;
- include a full range of natural and cultural components;
- be applicable to the scale of the study area; and
- be replicable for the purpose of consistency.

The following steps should furthermore, be taken as part of the visual impact assessment process (Oberholzer (1992)):

- Observation, which implies the understanding the natural processes and the inter-relationships between these processes. Our perception of the environment primarily encompassed the visual senses, as well as the hearing-, smell- and tactile senses, and psychological experience. Humans primarily experience landscapes in a kinetic way, which results in a sequential experience.

These sensory, psychological and sequential experiences provide a feel and image of an area. This is defined as the “genius loci” or sense of place.

- Recording entails the description and classification of the area in a systematic way. Techniques, such as watersheds, landforms, soil types, vegetation cover, climate and scenic qualities, can been utilised for recording purposes.
Evaluation entails the interpretation and rating of the natural-, cultural- and visual resources of an area. In order to prevent subjectivity, ratings should be based on the perceptions of the community, tourists and trained observers.

4.13.4 Locality and Study Area

The proposed Pebble Bed Modular Reactor demonstration unit will be located within the parameters of the existing Koeberg Nuclear Power Station, which is situated on the farm Duynefontyn no 34, Malmesbury. The study area falls within the magisterial district of Malmesbury.

4.13.5 Description of the Existing Landscape Character

Elements such as the topography, landform, land use, man-made environment, vegetation and natural - or cultural features determine the landscape character. This section describes the landscape character.

TOPOGRAPHY AND LANDFORM

The northern and southern sections of the Koeberg site is generally flat with a modest fall towards the coast, with a series of primary, secondary and tertiary coastal dunes varying in height up to 10 metres and shifting sand to the north and south of the property.

The natural components, seen from a visual perspective, include the following:

- The landform of the immediately adjacent land is sand beaches and vegetated dunes which consists of strandveld fynbos.
- The existing landform is flat, with dunes.
- The configuration of the land-water edge is concave. A still water bay has been constructed approximately 800 metres into the Atlantic Ocean.

EXISTING LAND USE

Duynefontyn (Cape farm no. 34) belongs to Eskom, and measures some 1,257 ha in extent, stretching 4,4km along the coast and 3,5km inland. To the north the farm, Kleine Springfontyn no. 33, which also belongs to Eskom, borders the proposed site. This property measures 1,590 ha, stretching 3,6km along the coast and 3,75km inland.

Access to the site is provided from the West Coast Road (Provincial Trunk Road no. 77), which transects the property.
The Koeberg NPS itself consists of a main turbine building which is very large in scale and rectangular in form. Two circular silos pressure vessels which house the reactor units form part of this unit. The rectangular building is flat roofed and its exterior is white, whereas the silos are constructed of unpainted concrete. Numerous other flat-roofed buildings and warehouse-type structures make up the remainder of the complex. Most of the exteriors of these structures are either white or a shade of grey. There exists a strong overall horizontal design, which echoes the very flat, horizontal character of the surrounding landscape. The colours of the buildings and structures tend to blend in with the surroundings, particularly on an overcast day.

To the south of the Koeberg site, is the residential area, known as Duynefontyn. The Melkbosstrand urban strip, including Van Riebeeckstrand further to the south along the coast, dominates the land use within a 5km radius. The area to the east of the Koeberg site is largely uncultivated due to the presence of sandy soils with a low agricultural potential. Agricultural land use occurs further within the north-eastern to the east-south-eastern sectors.

The farms Duynefontyn and Kleine Springfontein were proclaimed as the Koeberg Private Nature Reserve in 1991. This reserve is open to the public.

The Atlantis industrial and residential areas are located approximately 12km to the northeast of the Koeberg site. The growth of the industrial area is relatively stagnant.

The area between Atlantis and the coastline has been identified for possible inclusion in the proposed West Coast Biosphere Reserve. The Koeberg Nature Reserve forms part of the West Coast Biosphere Reserve.

There are no major fishing activities within a 15 nautical mile (27km) radius from the proposed Pebble Bed site. The closest commercial activity in the Atlantic Ocean is found at Robbeneiland, approximately 15km south-southwest of the Koeberg site.

EXISTING INFRASTRUCTURE

According to Motloch (1991: p. 54), landscapes can functionally be seen as a set of interrelating ecological and human systems, which are powered by human physical needs and technological growth. Infrastructure supports a desired lifestyle and addresses the integration of ecological- and human needs. The “genius loci” (sense of place) is dependent upon the degree to which infrastructure systems integrate with other human and natural systems.

The major roads, from which the proposed Pebble Bed site is visible, include the following:
NORTH SOUTH TRAFFIC MOVEMENT:

- West Coast Road (Trunk road no. 77)
- The National N7 Road

EAST WEST TRAFFIC MOVEMENT:

- Otto du Plessis Drive, which runs along the coast from Table View to Melkbosstrand and links with the West Coast Road.
- Mamre-Darling Road
- Dassenberg Road, which connects the West Coast Road and Atlantis (east-west traffic movement)
- Philadelphia Road between the Mamre-Darling Road and the N7.
- The Brakfontein road, which connects the West Coast Road with the Mamre-Darling Road.
- Melkbosstrand road, which links the West Coast Road, The Mamre-Darling Road and the N7.

According to the Koeberg Site Safety Report, the West Coast Road (Trunk road no. 77) and the National Road N7 serve primarily as north-south and regional distributors, with the additional function of local rural access.

The West Coast Road is a dual carriageway and links the Cape Metropolitan Area with the northern West Coast areas, traversing the farm Duynefontyn at approximately 2.3km from the existing reactor buildings. Access to the Koeberg Nuclear Power Station is provided from this road. The average annual daily traffic volumes taken by the Provincial Roads Administration in 1993 and 1994 on the West Coast Road in both directions varied from approximately 8,100 vehicles at the Melkbosstrand Road intersection to approximately 6,700 vehicles at the Dassenberg road intersection. The volume of vehicles at the access point to Koeberg was approximately 7,000 vehicles per day.

During the above survey, approximately 10,100 vehicles were counted at the Mamre-Darling road intersection.

Shipping lanes are indicated in the KSSR. The shipping lanes are used for fishing purposes and not for tourists.
VEGETATION

The landscape character of the area directly adjacent to the proposed Pebble Bed Modular Reactor site is primarily natural, with suburban sections to the south and north, and an agricultural character to the east.

The vegetative cover of the Koeberg Nature Reserve consists of large tracts of Strandveld and Dune Veld. The vegetation primarily consists of indigenous pioneer plants covering the coastal dunes, reaching a maximum height of 1,500 to 2,000 metres, resulting in uninterrupted views with no screening capacity for the scale of the proposed structure.

Eskom has established Fynbos vegetation on the shifting sand dunes north of the existing structures, which has changed the original visual character of the landscape.

NATURAL AND CULTURAL FEATURES

Unique cultural features present in the regional area include Robbeneiland and Table Mountain.

The Koeberg Private Nature Reserve is a unique natural feature, which conserves a number of unique coastal landforms, wetlands and vegetation communities. Two hiking trails have been developed in the Reserve, which are open to the public.

Robbeneiland, which has been declared as a World Heritage Site, is located approximately 15km south south west from the proposed site, in the Atlantic Ocean.

4.13.6 DESCRIPTION OF THE PROPOSED STRUCTURE

This section briefly describes the position and the development characteristics of the proposed Pebble Bed Modular Reactor.

PROPOSED POSITIONS

The two alternatives for the proposed Pebble Bed Modular Reactor are not obtrusive, due to the fact that these sites are located adjacent to the existing structures on the site. The two alternative positions for the establishment of the Modular Reactor are discussed below:

- Alternative 1: the northern section of the Koeberg site (discontinued for engineering reasons).
- Alternative 2: the southern section of the Koeberg site.
DEVELOPMENT CHARACTERISTICS

The project will entail the construction, commissioning, operation/maintenance and decommissioning of a 110 MWe Class Pebble Bed Modular Reactor demonstration module electricity generating plant. The electricity generation plant will be enclosed in a specially designed/constructed concrete building with the following approximate dimensions; 60 metres long, 40 metres wide and about 60 metres high, of which 24 metres will be above the natural ground level.

The demonstration plant will make use of the existing infrastructure of Koeberg Power Station and modifications thereto, with the main components being as follows:

- Water supply. Both cooling water 1.7m³/s, and, raw water for the intermediate cooling cycle and domestic use on the station.
- Intake water stilling basin and thermal water outflow structures.
- Transmission network including power lines and substations.
- Sewage facilities.
- Roads.
- Residential areas.
- Emergency Plans.
- Environmental monitoring network(s).

The scale of the proposed building is described in Chapter 2.2.3.

CONSTRUCTION PHASE

Construction will entail major excavations and dewatering due to the shallow water table.

The construction time for the PBMR is approximately 36 months. The proposed time frame for construction is from the year 2004 to 2006.

4.13.7 OBSERVATION OF THE PROPOSED STRUCTURE

This section describes the existing theories with regard to the observation of elements in a landscape by humans. Thereafter the anticipated viewing points and type of observers are evaluated.
THEORIES

i. “GENIUS LOCI”

The landscape is usually experienced in a sensory, psychological and sequential sense, in order to provide a feel and image of place (“genius loci”).

A landscape is an integrated set of expressions, which responds to different influences. Each has its unique spirit of place, or “genius loci”. Each landscape has a distinct character, which makes an impression in the mind, an image that endures long after the eye has moved to other settings.

The visual quality of a coastal landscape is to a large extent the product of the topography, ocean and skyline. The construction and/or positioning of any structures that could alter the character of the landscape should be carefully designed and located.

According to Motloch (1991: p. 54), elements such as landform and topography, vegetation, climate, water, social history, physical location, human activities, the place’s meaning beyond its physical expression due to its historical significance, and the sensory experience, primarily visual, contribute towards the “genius loci” of a place. The loss of spirit of place or “placelessness” results from an inability to perceive or respond to this spirit as an interactive synthesis of the above elements.

ii. SENSORY EXPERIENCE

Our perception of the environment encompasses the visual, hearing, smell and tactile senses, together with the psychological experience. The major emphasis in planning and impact assessment is usually on the visual characteristics of the environment.

iii. PSYCHOLOGICAL EXPERIENCE

According to Laurie (1978, p.155), human psychological and social needs, behavioural patterns and the perception of the environment, differ according to variables such as age, social class, cultural background, past experience, motives and daily routine of the individual.

Behaviour results from the interaction of individuals with other individuals, in other words the social environment, and with the surrounding environment. In design there are two categories of human factors that should be considered, namely the physical and the inner condition.
The inner condition of the individual entails the following factors:

- Physiological, which is related to the body's biological mechanisms, and
- Psychological, which is related to previous experiences and basic needs.

The way in which the individual perceives the environment, as well as behavioural reactions, should therefore be taken into account with the planning and design of a structure. Another way in which the influence of the environment on behaviour can be seen, is in the way places/structures assume meaning, e.g. the symbolism of a church or nuclear power station such as Koeberg. This selection and attribution of meaning or symbolism to the environment, or the development of an emotional response to aspects of the environment, will vary according to the individual. This fact makes it difficult to produce universal rules with regard to perceptions and behaviour. What is seen by an individual is usually what he/ she wants to see, or what he/ she is looking for. The perception of the environment depends on the type of social- and economic group, e.g. low-, middle- or high-income groups or tourists.

Each person has a visual realm or cone of vision, which is approximately 60 degrees from the point of viewing for an average person with clear vision. This cone is 30 degrees to the left and 30 degrees to the right of the viewer, and 30 degrees above the horizontal. Any element viewed within this cone is observed as part of its surroundings. Furthermore a person with normal 20/20 vision can identify a human form at a distance of approximately 120 metres. A normal person with 20/20 vision can identify a person's face over a distance of 60 metres. This distance can be considered as the limit of intimate space. Intrusion into this intimate space can be considered to be the greatest visual impact.

Jacobs, Maertens and Blumenfeld (1999: p 278) came to the following conclusions, based on their work on physiological optics and experience:

- at a height: distance ratio of 1:1 or less, the object being viewed fills and dominates the frame of vision.
- at a height: distance ratio of 1:2, the object appears as a little world in itself, with the surroundings only dimly perceived as a background.
- at a height: distance ratio of 1:3 it still dominates the picture, but now its relation to its surroundings becomes equally important.
- at a height: distance ratio of 1:4 or less, the object is not seen as an individual element, but becomes part of its surroundings and speaks mainly through its silhouette.

For the purpose of this study, distances will be specified in km, due to the fact that most of the viewing points will fall in the category of a height: distance ratio of 1:4 or less.

According to the context theory, the average person becomes aware of a structure within his visual realm at the first viewing of the element. Thereafter the awareness fades, until the element is hardly noticed at all. The time period for the person to become accustomed to the structure depends on the following:

- the regularity at which the person views the structure,
- the speed at which the object is viewed, and
- the cultural background of the viewer.

The first two categories would eventually hardly notice the structure at all. Incremental development is less easily noticeable to regular passers-by. It would however be clearly noted by first-comers and tourists.

iv. SEQUENTIAL EXPERIENCE

The landscape is seldom experienced in a static way, but mainly in a kinetic way from foot or from moving cars. This constantly changing scene can be defined as sequential experience.

◆ ANTICIPATED VISUAL OBSERVATION OF THE PROPOSED REACTOR

This section of the report entails the interpretation of data with regard to the above description of the existing landscape, the proposed structure and the observers.

i. ANTICIPATED VIEWING POINTS

The following viewing points to the proposed alternatives for the modular reactor can be listed:

- Duynefontyn
- Van Riebeekstrand
- Melkbosstrand
- Table Mountain
- The Atlantic Ocean
Koeberg Private Nature Reserve & Visitors centre
Atlantis industrial area
Atlantis residential area
Robbeneland
Roads, which are listed in paragraph 4.1.3.5. (Existing infrastructure)

ii. CATEGORIES OF THE COMMUNITY, ANTICIPATED TO OBSERVE THE PROPOSED STRUCTURE

The categories of humans, who are expected to have visual access to the site, are set out in Table 27. (Categories of Observers).

Table 27: CATEGORIES OF OBSERVERS

<table>
<thead>
<tr>
<th>VIEWING POINTS</th>
<th>AGE (majority)</th>
<th>ACTIVITY</th>
<th>TOURISTS</th>
<th>LOCAL RESIDENTS</th>
<th>SOCIO-ECONOMIC LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>West Coast Road</td>
<td>adult</td>
<td>travel, sight-seeing</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>The National N7 Road</td>
<td>adult</td>
<td>travel, sight-seeing</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Otto du Plessis Drive</td>
<td>adult</td>
<td>travel</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Mamre-Darling Road</td>
<td>adult</td>
<td>travel</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Dassenberg Road</td>
<td>adult</td>
<td>travel</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Philadelphia Road</td>
<td>adult</td>
<td>travel</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Brakfontein road</td>
<td>adult</td>
<td>travel</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Melkbosstrand road</td>
<td>adult</td>
<td>travel</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Duynefontyn</td>
<td>varies</td>
<td>Live</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Van Riebeekstrand</td>
<td>varies</td>
<td>Live</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Melkbosstrand</td>
<td>varies</td>
<td>Live</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Table Mountain</td>
<td>varies</td>
<td>sight-seeing</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>The Atlantic Ocean</td>
<td>adult</td>
<td>work</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Koeberg Nature Reserve &amp; Visitors Centre</td>
<td>varies</td>
<td>sight-seeing</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
<tr>
<td>Atlantis Residential Area</td>
<td>varies</td>
<td>Live</td>
<td>♦</td>
<td>♦</td>
<td>♦ ♦ ♦</td>
</tr>
</tbody>
</table>
The perceived visual perceptions of observers from the different viewing points are set out in Table 28.

### Table 28: Perceptions of Observers

<table>
<thead>
<tr>
<th>Viewing Points</th>
<th>Awareness</th>
<th>Visual Distance (km)</th>
<th>Static/Kinetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Coast Road</td>
<td>High/daily routine</td>
<td>&lt;2</td>
<td>kinetic</td>
</tr>
<tr>
<td>The National N7 Road</td>
<td>High/daily routine</td>
<td>3 – 5</td>
<td></td>
</tr>
<tr>
<td>Otto du Plessis Drive</td>
<td>Daily routine</td>
<td>6-10</td>
<td></td>
</tr>
<tr>
<td>Mamre-Darling Road</td>
<td>Daily routine</td>
<td>11-15</td>
<td></td>
</tr>
<tr>
<td>Dassenberg Road</td>
<td>Daily routine</td>
<td>16-20</td>
<td></td>
</tr>
<tr>
<td>Philadelphia Road</td>
<td>Daily routine</td>
<td>&gt;30</td>
<td></td>
</tr>
<tr>
<td>Brakfontein Road</td>
<td>Daily routine</td>
<td>2</td>
<td>kinetic</td>
</tr>
<tr>
<td>Melkbosstrand road</td>
<td>Daily routine</td>
<td>3</td>
<td>kinetic</td>
</tr>
<tr>
<td>Duynefontyn</td>
<td>Daily routine</td>
<td>4</td>
<td>kinetic/Static</td>
</tr>
<tr>
<td>Van Riebeeckstrand</td>
<td>Daily routine</td>
<td>5</td>
<td>kinetic/Static</td>
</tr>
<tr>
<td>Melkbosstrand</td>
<td>Daily routine</td>
<td>6</td>
<td>kinetic/Static</td>
</tr>
<tr>
<td>Table Mountain</td>
<td>High</td>
<td>7</td>
<td>kinetic/Static</td>
</tr>
<tr>
<td>The Atlantic Ocean</td>
<td>Daily routine</td>
<td>8</td>
<td>kinetic</td>
</tr>
<tr>
<td>Koeberg Nature Reserve &amp; Visitor Centre</td>
<td>High</td>
<td>9</td>
<td>kinetic/Static</td>
</tr>
<tr>
<td>Atlantis Residentia Area</td>
<td>Daily routine</td>
<td>10</td>
<td>kinetic/Static</td>
</tr>
</tbody>
</table>
If the context theory is applied, tourists will clearly note the proposed structure from these roads. The awareness of regular viewers, who travel on the above roads regularly and at a speed, will become accustomed to the structure with time, until the element blends into the overall picture. The same principle would be applicable for people who work or stay in Duynefontyn, Van Riebeekstrand, Melkbosstrand and Atlantis, where observation fades with time.

According to Bentley (1996: p. 42) users, rather than designers, form images of layout, the designer merely arranges the physical layout itself to achieve legibility. Legibility can be defined as the quality that makes a place graspable, and that enables people to form clear, accurate images of a city/structure or new entity. Table Mountain and Robbeneiland are of natural-, historical- and cultural significance. These landmarks contribute to the legibility of Cape Town.

Researchers have explored the contents of these images, using techniques such as interviews, asking directions to places, and getting people to draw maps from memory. Certain types of physical features play a key role in the content of these shared images. Kevin Lynch, an American planner, grouped these features into five key elements, namely nodes, edges, paths, districts and landmarks. These key physical elements are illustrated below.

<table>
<thead>
<tr>
<th>VIEWING POINTS</th>
<th>AWARENESS</th>
<th>VISUAL DISTANCE (km)</th>
<th>STATIC/KINETIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantis Area</td>
<td>Industria Daily</td>
<td>&lt;2</td>
<td>kinetic/static</td>
</tr>
<tr>
<td>Robbeneiland</td>
<td>high</td>
<td>3 - 5, 6 - 10, 11 - 15</td>
<td>kinetic/static</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 - 20, &gt;30</td>
<td>kinetic/static</td>
</tr>
</tbody>
</table>

◆ = OBSERVERS WHO WILL BE AWARE OF THE NEW DEVELOPMENT
The most significant viewing points would be the Koeberg Private Nature Reserve, Table Mountain and Robben Island, due to the awareness and category of users, which mainly entails tourists. Table Mountain and Robben Island, however, are located at distances of 31 and 15 km respectively from the proposed structures, which implies that the proposed reactor will not be seen as an individual element, but becomes part of its surroundings and speaks mainly through its silhouette.
The character of the respective viewing points is rated in Table 29.

**Table 29: CHARACTER OF VIEWING POINTS**

<table>
<thead>
<tr>
<th>VIEWING POINTS</th>
<th>VISUAL EXPOSURE</th>
<th>IMPORTANT VISTAS VIEWPOINTS</th>
<th>CHARACTER</th>
<th>FEATURE/LANDMARK</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Coast Road</td>
<td>High</td>
<td>No</td>
<td>rural, agricultural</td>
<td>no</td>
</tr>
<tr>
<td>The National N7 Road</td>
<td>High</td>
<td>No</td>
<td>rural, agricultural</td>
<td>no</td>
</tr>
<tr>
<td>Otto du Plessis Drive</td>
<td>Low</td>
<td>No</td>
<td>rural, agricultural</td>
<td>no</td>
</tr>
<tr>
<td>Mamre-Darling Road</td>
<td>Low</td>
<td>No</td>
<td>rural, agricultural</td>
<td>no</td>
</tr>
<tr>
<td>Dassenberg Road</td>
<td>Low</td>
<td>No</td>
<td>rural, agricultural</td>
<td>no</td>
</tr>
<tr>
<td>Philadelphia Road</td>
<td>Low</td>
<td>No</td>
<td>rural, agricultural</td>
<td>no</td>
</tr>
<tr>
<td>Brakfontein road</td>
<td>Low</td>
<td>No</td>
<td>rural, agricultural</td>
<td>no</td>
</tr>
<tr>
<td>Melkbosstrand road</td>
<td>Low</td>
<td>No</td>
<td>rural, agricultural</td>
<td>no</td>
</tr>
<tr>
<td>Duynefontyn</td>
<td>High</td>
<td>No</td>
<td>suburban</td>
<td>no</td>
</tr>
<tr>
<td>Van Riebeeckstrand</td>
<td>High</td>
<td>No</td>
<td>suburban</td>
<td>no</td>
</tr>
<tr>
<td>Melkbosstrand</td>
<td>High</td>
<td>No</td>
<td>suburban</td>
<td>no</td>
</tr>
<tr>
<td>Table Mountain</td>
<td>Low</td>
<td>yes (tourism)</td>
<td>natural</td>
<td>yes</td>
</tr>
<tr>
<td>The Atlantic Ocean</td>
<td>Low</td>
<td>No</td>
<td>natural</td>
<td>yes</td>
</tr>
<tr>
<td>Koeberg Nature Reserve &amp; visitor centre</td>
<td>High</td>
<td>yes (tourism)</td>
<td>natural</td>
<td>yes</td>
</tr>
<tr>
<td>Atlantis residential area</td>
<td>Low</td>
<td>No</td>
<td>suburban</td>
<td>no</td>
</tr>
<tr>
<td>Atlantis industrial area</td>
<td>Low</td>
<td>No</td>
<td>suburban</td>
<td>no</td>
</tr>
<tr>
<td>Robbeneland</td>
<td>Low</td>
<td>yes (tourism)</td>
<td>natural, suburban</td>
<td>yes</td>
</tr>
</tbody>
</table>

4.13.8 ASSESSMENT OF VISUAL IMPACTS

**DESCRIPTION OF METHODOLOGY FOR ASSESSMENT OF SIGNIFICANCE**

The Department of Environmental Affairs and Tourism has published a guideline document on the implementation of sections 21, 22 and 26 of the Environment Conservation Act, 1989. The mentioned document states that the significance of

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120 The character of the landscape can be categorised as follows:
- **Urban**, namely highly intensive use of the land
- **Suburban**, namely more extensive use & smaller structures
- **Rural**, namely small structures mixed with open land
- **Agricultural**, namely extensive open land and scattered structures

121 Landmarks are point references which most people experience from outside.
impacts can be determined through a synthesis of the aspects produced in terms of the nature, duration, intensity, extent and probability of identified impacts.

Poltech (Pty) Ltd has developed a Significance Assessment Methodology in accordance with the above guidelines. In terms of the above methodology the significance of an impact is the product of a probability rating and a severity rating. This methodology has been adapted by ILA (Pty) Ltd for the purposes of visual impact assessments. A detailed description of the mentioned methodology can be found in Appendix 12.

4.13.9 Anticipated Visual Impacts

Utilising the information reflected in, Table 28 and Table 29 a significance assessment of each visual impact was performed according to the methodology described in Appendix 12. The results of the significance assessment for the existing Koeberg structures, the additional visual impact of the PBMR (northern site) and the additional impact of the PBMR (southern site) are depicted in Table 32 and Table 34 respectively.

From Table 35, it is clear that the most significant viewing points towards the existing Koeberg structures would be the N7, the West Coast road and the Koeberg Private Nature Reserve and the deck of the Visitors centre, due to the location there-of and the category of observers, namely tourists.

The visual impact of the northern site for the proposed PBMR, seen in relation to the existing Koeberg structures, would have a lower significance in comparison to the southern site, as indicated by Table 31 and Table 33. The visual impact of the northern site for the proposed PBMR, seen as a stand-alone structure, would have a lower significance in comparison to the southern site, as indicated by Table 31 and Table 33. From these tables it is clear that the anticipated visual impact of the proposed PBMR will be less significant than the impact of the existing Koeberg structures, due to the scale of the proposed structures.

4.13.10 Assessment of Alternative Sites for Modular Reactor in Terms of Associated Activities

The anticipated visual impacts for the two alternatives sites based on a subjective visual evaluation of the study area in terms of the associated activities, are indicated in Table 35.

For the purposes of this assessment, the following assumptions were made:

- that the existing intake water stilling basin will not be extended, and
that the existing residential facilities will not be extended with more than 20 houses for the purposes of the Proposed Pebble Bed Modular Reactor.

that the proposed structure would be viewed from the 3 viewing points with the highest significance rating according to Table 32, Table 34 and Table 35 namely the West Coast Road, the National N7 Road and the Koeberg Nature Reserve and deck of the Visitors Centre
<table>
<thead>
<tr>
<th>VIEWING POINTS</th>
<th>PROBABILITY RATING</th>
<th>EXTENT FACTOR</th>
<th>DURATION</th>
<th>SEVERITY FACTOR</th>
<th>SEVERITY RATING</th>
<th>SIGNIFICANCE RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Coast Road</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>15 medium</td>
</tr>
<tr>
<td>The National N7 Road</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>15 medium</td>
</tr>
<tr>
<td>Otto du Plessis Drive</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Mamre-Darling Road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Dassenberg Road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Philadelphia Road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Brakfontein road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Melkbosstrand road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Duynefontyn</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>10 medium</td>
</tr>
<tr>
<td>Van Riebeeckstrand</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>10 medium</td>
</tr>
<tr>
<td>Melkbosstrand</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>10 medium</td>
</tr>
<tr>
<td>Table Mountain</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>9 medium</td>
</tr>
<tr>
<td>The Atlantic Ocean</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Koeberg Nature Reserve &amp; visitors centre(deck)</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>15 medium</td>
</tr>
<tr>
<td>Atlantis residential area</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Atlantis industrial area</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Robben island</td>
<td>2</td>
<td>2</td>
<td>24</td>
<td>4</td>
<td>2 low</td>
<td>4 low</td>
</tr>
</tbody>
</table>

1. The Severity factor = Extent factor x Duration factor
2. Low Severity (Rating 2): Calculated values 2 to 4
   Medium Severity (Rating 3): Calculated values 5 to 8
   High Severity (Rating 4): Calculated values 9 to 12
   Very High Severity (Rating 5): Calculated values 13 to 16

1. The Significance rating = Severity rating x Probability Rating

High (Calculated significance rating 16 and more)
Medium (Calculated significance rating 7 to 15)
Low (Calculated significance rating 4 to 6)

Severity factors below 3 indicated no impact.
Table 31: SIGNIFICANCE ASSESSMENT OF IDENTIFIED VISUAL IMPACTS OF THE PROPOSED PBMR (NORTHERN SITE), SEEN IN RELATION TO THE EXISTING KOEBERG STRUCTURES

<table>
<thead>
<tr>
<th>VIEWING POINTS</th>
<th>PROBABILITY RATING</th>
<th>EXTENT FACTOR</th>
<th>DURATION</th>
<th>¹SEVERITY FACTOR</th>
<th>²SEVERITY RATING</th>
<th>³SIGNIFICANCE RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Coast Road</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>15 medium</td>
</tr>
<tr>
<td>The National N7 Road</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>15 medium</td>
</tr>
<tr>
<td>Otto du Plessis Drive</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>6 low</td>
</tr>
<tr>
<td>Mamre-Darling Road</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>6 low</td>
</tr>
<tr>
<td>Dassenberg Road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Philadelphia Road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Brakfontein road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Melkbosstrand road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Duyniewofyn</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Van Rebeeks Strand</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Melkbosstrand</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Table Mountain</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>3 medium</td>
<td>2 low</td>
</tr>
<tr>
<td>The Atlantic Ocean</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>6 low</td>
</tr>
<tr>
<td>Koeberg Nature Reserve &amp; visitors centre(deck)</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>15 medium</td>
</tr>
<tr>
<td>Atlantis residential area</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>6 low</td>
</tr>
<tr>
<td>Atlantis industrial area</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>6 low</td>
</tr>
<tr>
<td>Robben Island</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2 low</td>
<td>4 low</td>
</tr>
</tbody>
</table>

¹The Severity factor = Extent factor x Duration factor
²The Significance rating = Severity rating x Probability Rating
³Low Severity (Rating 2): Calculated values 2 to 4
Medium Severity (Rating 3): Calculated values 5 to 8
High Severity (Rating 4): Calculated values 9 to 12
Very High Severity (Rating 5): Calculated values 13 to 16
Severity factors below 3 indicated no impact
Table 32: SIGNIFICANCE ASSESSMENT OF IDENTIFIED VISUAL IMPACTS OF THE PROPOSED PBMR (SOUTHERN SITE), SEEN IN RELATION TO THE EXISTING KOEBERG STRUCTURES

<table>
<thead>
<tr>
<th>VIEWING POINTS</th>
<th>PROBABILITY RATING</th>
<th>EXTENT FACTOR</th>
<th>DURATION</th>
<th>²SEVERITY FACTOR</th>
<th>³SIGNIFICANCE RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Coast Road</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
</tr>
<tr>
<td>The National N7 Road</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
</tr>
<tr>
<td>Otto du Plessis Drive</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
</tr>
<tr>
<td>Mamre-Darling Road</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
</tr>
<tr>
<td>Dassenberg Road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
</tr>
<tr>
<td>Philadelphia Road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
</tr>
<tr>
<td>Brakfontein road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
</tr>
<tr>
<td>Melkbosstrand road</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
</tr>
<tr>
<td>Duynefontyn</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low, 10 medium</td>
</tr>
<tr>
<td>Van Rebeekstrand</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low, 10 medium</td>
</tr>
<tr>
<td>Melkbosstrand</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low, 10 medium</td>
</tr>
<tr>
<td>Table Mountain</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
</tr>
<tr>
<td>The Atlantic Ocean</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
</tr>
<tr>
<td>Koeberg Nature Reserve &amp; visitors centre (deck)</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium, 15 medium</td>
</tr>
<tr>
<td>Atlantis residential area</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
</tr>
<tr>
<td>Atlantis industrial area</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
</tr>
<tr>
<td>Robben Island</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2 low</td>
</tr>
</tbody>
</table>

¹The Severity factor = Extent factor x Duration factor

²The Significance rating = Severity rating x Probability Rating

³Low Severity (Rating 2): Calculated values 2 to 4
Medium Severity (Rating 3): Calculated values 5 to 8
High Severity (Rating 4): Calculated values 9 to 12
Very High Severity (Rating 5): Calculated values 13 to 16

Severity factors below 3 indicated no impact.

High (Calculated significance rating 16 and more)
Medium (Calculated significance rating 7 to 15)
Low (Calculated significance rating 4 to 6)
### Table 33: Significance Assessment of Identified Visual Impacts of the Proposed New Structures (Northern Site), Seen as a Stand-Alone Structure

<table>
<thead>
<tr>
<th>Viewing Points</th>
<th>Probability Rating</th>
<th>Extent Factor</th>
<th>Duration</th>
<th>²Severity Factor</th>
<th>³Severity Rating</th>
<th>³Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Coast Road</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>3 medium</td>
<td>12 medium</td>
</tr>
<tr>
<td>The National N7 Road</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>3 medium</td>
<td>12 medium</td>
</tr>
<tr>
<td>Otto du Plessis Drive</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Mamre-Darling Road</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Dassenberg Road</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Philadelphia Road</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Brakfontein road</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Melkbosstrand road</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Duynefontyn</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Van Riebeeckstrand</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>4 medium</td>
</tr>
<tr>
<td>Melkbosstrand</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>4 medium</td>
</tr>
<tr>
<td>Table Mountain</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>6 medium</td>
</tr>
<tr>
<td>The Atlantic Ocean</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Koeberg Nature Reserve &amp; visitors centre (deck)</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>15 medium</td>
</tr>
<tr>
<td>Atlantis residential area</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Atlantis industrial area</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Robben Island</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2 low</td>
<td>2 low</td>
</tr>
</tbody>
</table>

¹The Severity factor = Extent factor x Duration factor
²Low Severity (Rating 2): Calculated values 2 to 4
Medium Severity (Rating 3): Calculated values 5 to 8
High Severity (Rating 4): Calculated values 9 to 12
Very High Severity (Rating 5): Calculated values 13 to 16
Severity factors below 3 indicated no impact

²The Significance rating = Severity rating x Probability Rating

<table>
<thead>
<tr>
<th>High (Calculated significance rating 16 and more)</th>
<th>Medium (Calculated significance rating 7 to 15)</th>
<th>Low (Calculated significance rating 4 to 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Green</td>
<td>Yellow</td>
</tr>
</tbody>
</table>
**Table 34: SIGNIFICANCE ASSESSMENT OF IDENTIFIED VISUAL IMPACTS OF THE PROPOSED STRUCTURES (SOUTHERN SITE), SEEN AS A STAND-ALONE STRUCTURE**

<table>
<thead>
<tr>
<th>VIEWING POINTS</th>
<th>PROBABILITY RATING</th>
<th>EXTENT FACTOR</th>
<th>DURATION</th>
<th>¹SEVERITY FACTOR</th>
<th>²SEVERITY RATING</th>
<th>³SIGNIFICANCE RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Coast Road</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>3 medium</td>
<td>12 medium</td>
</tr>
<tr>
<td>The National N7 Road</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>3 medium</td>
<td>12 medium</td>
</tr>
<tr>
<td>Otto du Plessis Drive</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Mamre-Darling Road</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Dassenberg Road</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Philadelphia Road</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Brakfontein road</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Melkbosstrand road</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Duynefontyn</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>8 medium</td>
</tr>
<tr>
<td>Van Riebeeckstrand</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>10 medium</td>
</tr>
<tr>
<td>Melkbosstrand</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>10 medium</td>
</tr>
<tr>
<td>Table Mountain</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>6 medium</td>
</tr>
<tr>
<td>The Atlantic Ocean</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2 low</td>
<td>6 medium</td>
</tr>
<tr>
<td>Koeberg Nature Reserve &amp; visitors centre(deck)</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>3 medium</td>
<td>15 medium</td>
</tr>
<tr>
<td>Atlantis residential area</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>4 low</td>
</tr>
<tr>
<td>Atlantis industrial area</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>4 low</td>
</tr>
<tr>
<td>Robben Island</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2 low</td>
<td>2 low</td>
</tr>
</tbody>
</table>

¹The Severity factor = Extent factor x Duration factor = $2 \times 3 = 6$

²Low Severity (Rating 2): Calculated values 2 to 4
Medium Severity (Rating 3): Calculated values 5 to 8
High Severity (Rating 4): Calculated values 9 to 12
Very High Severity (Rating 5): Calculated values 13 to 16

²Low Severity (Rating 2): Calculated values 2 to 4
Medium Severity (Rating 3): Calculated values 5 to 8
High Severity (Rating 4): Calculated values 9 to 12
Very High Severity (Rating 5): Calculated values 13 to 16

³The Significance rating = Severity rating x Probability Rating

High (Calculated significance rating 16 and more)
Medium (Calculated significance rating 7 to 15)
Low (Calculated significance rating 4 to 6)

Severity factors below 3 indicated no impact
### Table 35: Visual Impact of Activities of Alternative Sites

<table>
<thead>
<tr>
<th>ACTIVITIES</th>
<th>WEST COAST ROAD</th>
<th>NATIONAL N7 ROAD</th>
<th>KOEBERG NATURE RESERVE AND DECK OF THE VISITORS CENTRE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alternative 1 (North)</td>
<td>Alternative 2 (South)</td>
<td>Alternative 1 (North)</td>
</tr>
<tr>
<td>Construction Phase</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modular Reactor unit</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Water supply</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Intake water stilling basin</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Transmission network</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Sewage facilities</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Roads</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Residential areas</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Operational Phase</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modular Reactor unit</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Water supply</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Intake water stilling basin</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Transmission network</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Sewage facilities</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Roads</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Residential areas</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>10</td>
<td>9</td>
</tr>
</tbody>
</table>

0: no significance
1: low significance
2: medium significance
3: high significance

¹ Viewed at a 2km distance from the proposed structure
² Viewed at a 12 km distance from the proposed structure
³ Viewed at a distance of less than 2km from the proposed structure
From the above table it can be derived that the visual impact of the proposed pebble bed modular reactor will be considerably higher during the construction phase of the development. Alternative 1 (northern site) will have a lower visual impact than alternative 2 (southern site) during the operational phase. However for engineering reasons consideration of this option was discontinued.

4.13.11 Mitigation Measures

- The form of the proposed structure, as well as the material finish, should relate well to the existing structures and the existing landscape. The colour of the sand and the existing vegetation, the typical patterns of light and shade, the horizon line and the spatial characteristics of the landscape will be reflected in the design of the structure.

- Trees which are endemic to the area, should be grouped along the roads with viewing points towards the proposed structure to simulate natural tree groups to screen the views towards the Modular Reactor, as well as the infrastructure (transmission network, roads, services) associated with the proposed development. Regular spacing and the placement trees in rows should be avoided, in order to simulate natural stands.

- The provision of large screen planting, endemic to the study area, outside the Koeberg site boundaries, should be considered to act as a screen for the adjacent residential townships.

4.13.12 Conclusion

It is the recommendation of ILA (PTY) Ltd, based on the above visual impact assessment, that the construction of the proposed Pebble Bed Modular Reactor be authorised, conditional to the above recommendations, for the design and construction phases of the proposed project, as its proposed Plant will have a negligible visual impact on the surrounding landscape.

The proposed PBMR would have a medium significant impact on the visual character of the surrounding environment from all the viewing points, in particular the adjacent townships and roads during the construction phase. During the operational phase, however, the visual impact will be less significant.

The proposed design is aesthetically acceptable, and it is recommended that the architectural style of the existing Koeberg structures is continued with the detail design of the PBMR.
4.13.13 ACKNOWLEDGEMENTS AND REFERENCES


Brown, Rodney. Van Riet & Louw Landscape Architects

Eskom: Koeberg Site Safety Report.


4.14 WASTE IMPACT ASSESSMENT FOR THE PROPOSED PLANT

4.14.1 INTRODUCTION

This Section provides more technical detail on radiological waste, that will be produced by the proposed Plant. Radioactivity concentrations for gaseous and liquid releases (as provided in Table 36, Table 37, Table 39, Table 40, Table 41 and Table 42) are based on a 268MWth core. For a 302 MWth core an approximate ratio of 302/268 (i.e. 1.127 rounded) can be applied. The 302 MWth core results are provided in Chapter 4.20.5 and falls within the NNR Fundamental Safety Criteria (Table 1) for a category c event.

Non-radiological (i.e. conventional) waste will be minimal during operation and will be dealt with, within the normal municipal waste streams and facilities, for which sufficient capacity exist (e.g. sewage, office waste, domestic waste, etc).

The evaluation and licensing of radiological waste discharge concentrations will also be undertaken by the NNR.

4.14.2 WASTE MANAGEMENT

Requirements for the management of radioactive waste in South Africa may be found in the Radioactive Waste Management Policy of South Africa presently published in Draft.

The annual generation of each radioactive waste type and its radio nuclides content has been estimated for the operational period of the proposed Plant. Measures to control the generation of the waste, in terms of both volume and activity content have been considered through:

- The selection of appropriate materials used for the construction of the facility.
- The selection of appropriate waste management processes and equipment.
- The selection of appropriate design features in the SSC and its layout in order to aid in the minimisation of waste generation during operation as well during decommissioning, with the aim to return the site back to a greenfield state.

The Waste Handling System (WHS) has been defined as one of the auxiliary systems that supports the power generation process to handle and store all low- and medium-level radioactive waste generated during normal operation, maintenance activities, upset conditions and during the decommissioning period of the plant.
The WHS consists of three subsystems, namely:

- **Solid waste storage and handling system**

  The solid waste handling and storage system is required to receive, process and temporarily store low- to medium-level radioactive solid waste produced for subsequent removal to a long-term storage/disposal facility.

- **Liquid waste storage and handling system**

  The liquid waste storage and handling system is required to collect and process radioactive liquid waste in order to ensure that the liquid discharged to the environment is within statutory and licensing limits for toxicity and radioactivity.

- **Gaseous radioactive waste handling**

  Any controlled or uncontrolled releases of gaseous emissions from within the building are handled by the HVAC system, whereby the extraction air system ensures that the gaseous waste is expelled to the atmosphere via the filtration system. \(^{122}\)

- **Solid waste handling and storage system**

  A distinction is made between radioactive Low Level Waste (LLW) and Intermediate Level Waste (ILW) and that of High Level Waste (spent fuel) based on their activity levels & safety.

  - **High Level Radioactive Solid Waste**

    About 20 tons of HLW (spent fuel) will be produced per year. Over the 35 year full power load life of the Plant this equates to 760 tons including the last load out of fuel spheres. This waste will be kept on site in purpose designed storage tanks in a helium environment. The storage tanks are located on the aseismic nuclear island and further protected by the citadel that is constructed around the reactor and PCU as described in Chapter 2 of this report.

    Additional capacity has been provided for in the spent fuel storage tanks, for the following contingencies, namely:

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\(^{122}\) PBMR Demo Plant DFR, Doc No. 009838-160 Rev 1
- A full reactor core load-out during the life of the proposed Plant.

- Broken fuel spheres, which based on the German experience with the AVR and THTR as well as the stringent quality assurance on fuel manufacture is estimated to be less than one percent (1%).

Large items (classified as HLW) will be stored in purpose designed storage casks and sufficient space has been provided for the storage of such casks within the HLW storage area that is located on the nuclear island (seismicity protected area). Such items will be generated during the refurbishment of the reactor, after 20 years of operation.

Should the life of the proposed Plant be extended beyond its 40 years of design life, additional storage facilities for HLW will have to be constructed assuming the non-availability of a HLW repository at that stage. For a number of reasons this is not foreseen, at this stage and is also highly unlikely.

The rationale for on site storage (or so-called intermediate storage) is to allow the thermal and radioactive cool down of the spent fuel spheres. The thermal heat that is generated during the decay process of the different radioactive isotopes within the fuel spheres, is dissipated through a purpose designed cooling water system. This system is linked to the main cooling water system of the Plant, that consists of a primary closed circuit of fresh water and a secondary once through system which employs sea water. In the event of coolant loss, natural convention cooling (cooling by air) will be employed.

Due to the different half-lives of the different isotopes, most of the radioactive decay will have taken place in the 40 years of on-site storage (some of the isotopes reach their half-lives within hours, others within days, months or years and only the very long lived isotopes such as Plutonium with a half-life of 24,000 years and others with half lives of millions of years remain. These materials are in minute quantity and encapsulated within the triple coated kernels).

After about 36 to 40 years the spent fuel can be more readily handled and managed (due to thermal cool down and radioactive decay). Hence the provision of 40 years storage after shutdown (decommissioning) of the proposed Plant.

The technology for the management, processing and final storage of HLW is dealt with by Kugeler et al (2001) in Annexure 16a (paragraph 11) and the cost of storage by a study conducted by Bechtel SAIC Company (2001), attached as Annexure 19.

- Low Level and Intermediate Level Radioactive Solid Waste

The radioactive solid LLW & ILW generated during the normal operation, upset conditions and decommissioning of the plant will consist of:
• Clothing.
• Cleaning materials.
• Unserviceable contaminated and activated SSC.
• Contaminated replaceable parts such as filters (compressible and non-compressible).
• Residue from decontamination activities.
• Residue from the analytical laboratory.

The annual volume of solid waste produced by a single module, assuming a compaction ratio of 5:1, is estimated to be approximately 10 m$^3$ consisting of 50 x 210 litre drums which are qualified to IP-2 and approved to carry SCO-2 or LSA-2 radioactive material (as defined in IAEA Safety Series 6). Where the waste cannot be compacted or drummed in the 210 litre drums due to activity or dose rate or physical size, suitable containers will be obtained. The use of concrete containers is not envisaged.

The compacting press as well as the waste in the steel drums, accumulated over a period of three years, will be installed and stored in a low-level waste store in the module building.

The cost per drum in South Africa is approximately US$75.00 (including labour for handling and compaction) and US$25.00 for transportation, which equates to US$15,000 per three-year period and US$200,000 over the 40 calendar years of operations.

At the end of three years, the total volume will be shipped to an off-site long-term storage facility. All shipments will be required to comply with the IAEA Transport guidelines and the NNR approved acceptance criteria for storage at the NECSA controlled radioactive waste storage facilities at Vaalputs, where sufficient storage space is available.

**Liquid waste handling and storage system**

Liquid waste generated during the operational activities of the plant will be drained or pumped, depending upon the origin of the liquid and the position of the collecting tanks, to a central collecting, chemical dosing and storage area in the module building.

\[123\] PBMR Demo Plant DFR, Doc No. 009838-160 Rev 1
The level of radioactivity, radioactive nuclide content and chemical composition of the liquid will be measured and treated in order to render it suitable for discharge to the environment.

Only treated liquid releases will be diverted to the sea water discharge Table 36 of the Koeberg Nuclear Power Station (KNPS). The design will ensure that all releases to the environment are controlled and monitored. The impact on the KNPS releases will be minimal Table 37, i.e. they will not impact on Koeberg’s ability to comply with the Annual Authorised Discharge Quantities (AADQ) as prescribed and authorised by the NNR.

Table -38 presents an estimate of the rate at which solid and liquid radioactive waste will be produced in the facility, and the handling procedures.\textsuperscript{124} Table -38 provide the nuclide mixture that was obtained from calculations of radioactive releases estimated for the German HTR-Modul, and considers possible fluctuations in the nuclide composition in a conservative manner. The activity values in the table were obtained by adjusting the HTR-Modul activities by multiplying the latter by the power ratio.\textsuperscript{125}

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Fraction of Nuclide Mixture (%)</th>
<th>Release Based on Nuclide Mixture (Bq p.a.)</th>
<th>Activity Concentrations\textsuperscript{1)} (Bq/m\textsuperscript{3})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-60</td>
<td>24.0</td>
<td>2.3 x 10\textsuperscript{9}</td>
<td>42.9</td>
</tr>
<tr>
<td>Sr-90</td>
<td>0.5</td>
<td>4.9 x 10\textsuperscript{7}</td>
<td>0.92</td>
</tr>
<tr>
<td>I-131</td>
<td>5.0</td>
<td>4.9 x 10\textsuperscript{9}</td>
<td>9.14</td>
</tr>
<tr>
<td>Cs-134</td>
<td>15.0</td>
<td>1.4 x 10\textsuperscript{9}</td>
<td>26</td>
</tr>
<tr>
<td>Cs-137</td>
<td>55.0</td>
<td>5.2 x 10\textsuperscript{9}</td>
<td>97</td>
</tr>
<tr>
<td>Ag-110m</td>
<td>0.5</td>
<td>4.9 x 10\textsuperscript{7}</td>
<td>0.91</td>
</tr>
<tr>
<td>Total mixture</td>
<td>100</td>
<td>9.5 x 10\textsuperscript{9}</td>
<td>177</td>
</tr>
<tr>
<td>H-3</td>
<td>100</td>
<td>4.3 x 10\textsuperscript{13}</td>
<td>802 000</td>
</tr>
</tbody>
</table>

Note: 1) Activity concentrations at the point of release for mixing with 1.7 m\textsuperscript{3}/s of average run-off of the discharge receiving cooling sea water.

Based on the PBMR open circuit flow rate of 6 120 m\textsuperscript{3}/h cooling water.

\textsuperscript{124} PBMR Demo Plant DFR, Doc No. 009838-160 Rev 1
\textsuperscript{125} SAR Rev 1, Chapter 6.3
\textsuperscript{126} SAR Rev 1, Chapter 6.3
Table 37 details the effect of the estimated liquid releases using the AADQ and Dose Conversion Factors calculated for the Koeberg site.\textsuperscript{127}

**Table 37: Effect of the Estimated Liquid Release on the Koeberg Aadq\textsuperscript{128}**

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Release Based on Nuclide Mixture (Bq p.a.)</th>
<th>Annual Dose Estimate to the Public (µSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-60</td>
<td>$2.3 \times 10^9$</td>
<td>$1.3 \times 10^2$</td>
</tr>
<tr>
<td>Sr-90</td>
<td>$4.9 \times 10^7$</td>
<td>$8.1 \times 10^5$</td>
</tr>
<tr>
<td>I-131</td>
<td>$4.9 \times 10^8$</td>
<td>$4.3 \times 10^4$</td>
</tr>
<tr>
<td>Cs-134</td>
<td>$1.4 \times 10^9$</td>
<td>$1.1 \times 10^3$</td>
</tr>
<tr>
<td>Cs-137</td>
<td>$5.2 \times 10^9$</td>
<td>$2.3 \times 10^2$</td>
</tr>
<tr>
<td>Ag-110m</td>
<td>$4.9 \times 10^7$</td>
<td>$3.7 \times 10^2$</td>
</tr>
<tr>
<td>H-3</td>
<td>$4.3 \times 10^{13}$</td>
<td>$3.0 \times 10^7$</td>
</tr>
<tr>
<td>Total Dose</td>
<td></td>
<td>$3.7 \times 10^2$</td>
</tr>
</tbody>
</table>

\textsuperscript{127} SAR Rev1, Chapter 6.3
\textsuperscript{128} SAR Rev 1, Chapter 6.3
### Table -38: Estimated Radioactive Solid and Liquid Waste Produced in the PBMR Plant

<table>
<thead>
<tr>
<th>No.</th>
<th>Waste Type</th>
<th>Activity Level</th>
<th>Activity</th>
<th>Sources</th>
<th>Approach</th>
<th>Waste Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solid</td>
<td>Low</td>
<td>Not applicable</td>
<td>Health Physics (Maintenance activities and clothing, e.g. booties, cloves etc.)</td>
<td>Compacted, steel drummed and stored temporally in module or USB. At a stage, it will be transported to a permanent storage facility.</td>
<td>All solids total 50 x 210 litre drums per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>Not applicable</td>
<td>Decontamination facility</td>
<td>Activated components/parts</td>
<td>Compacted, mixed with concrete, drummed and stored temporally in module or services building. At some stage, it will be transported to a permanent storage facility.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Filters from HVAC, decontamination facility and liquid waste storage and handling system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Liquid</td>
<td>Low</td>
<td>Active</td>
<td>Decontamination facility and laboratory: 480 m³ per year.</td>
<td>Will be stored in waste delay and/or monitoring tanks before treated and/or released to the environment.</td>
<td>Short-lived and long-lived waste will be considered in deciding on the number, size, treatment and/or final disposal of the waste.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Laundry: 500 m³ per year.</td>
<td></td>
<td>Transport regulations, taking into consideration the waste, will be considered when deciding on transporting the waste.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Criteria for release to the environment to be investigated.</td>
</tr>
<tr>
<td>No.</td>
<td>Waste Type</td>
<td>Activity Level</td>
<td>Activity</td>
<td>Sources</td>
<td>Approach</td>
<td>Waste Quantities</td>
</tr>
<tr>
<td>-----</td>
<td>------------</td>
<td>----------------</td>
<td>----------</td>
<td>---------</td>
<td>----------</td>
<td>------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Possibly Active</td>
<td>Showers (emergency and health physics) and washrooms:</td>
<td></td>
<td>Will be stored in waste delay and/or monitoring tanks before treated and/or released to the environment.</td>
<td>Short-lived and long-lived waste will be considered in deciding on the number, size, treatment and/or final disposal of the waste.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100 m$^3$ per year</td>
<td></td>
<td></td>
<td>Transport regulations, taking into consideration the activity of the waste will be considered when deciding on transporting the waste.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sump system: 365 m$^3$ per year</td>
<td></td>
<td></td>
<td>Criteria for release to the environment to be investigated.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The main sources for the sump waste are the HICS, PLICS and HVAC systems.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Gaseous waste handling

The release of gaseous activity from the plant has been based on the loss of 0.1% of the volume of the primary helium containing systems per day. The concentration of activity in the gas was derived from values calculated for the HTR-Modul, which in tum was based on the AVR experience.

All releases are routed via the reactor building ventilation system and released at a height of 20 m above ground level and the dilution factors are specific to the design of the ventilation system.

The radioactive emissions via the exhaust chimney consist of the following:

- Noble gas, iodine, C-14, H-3 and aerosol emissions caused by leaks in the primary cycle and the systems that contain primary coolant. To calculate the annual emission, a primary coolant leak rate of 0.1% per day and per Module, as well as a mean air exchange factor of 1 h⁻¹, were used.

- Iodine, C 14 and H3 emissions from the storage containers for radioactively contaminated helium. According to the design criteria, 15 regenerations per year are used.

Table 39 presents a conservative estimate of the annual gaseous radioactive waste design estimate release rates from the module into the surrounding air. It is expected that the actual releases will be much lower.

<table>
<thead>
<tr>
<th>Radio nuclide</th>
<th>Annual Activity Release (Bq per year per Module)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noble gases</td>
<td>4.4 x 10¹¹</td>
</tr>
<tr>
<td>Argon 41</td>
<td>8.0 x 10¹²</td>
</tr>
<tr>
<td>Iodine 131</td>
<td>1.5 x 10⁷</td>
</tr>
<tr>
<td>Sum of long-lived aerosols (half-life &gt;10 d):</td>
<td>2.4 x 10⁷</td>
</tr>
<tr>
<td>Co-60, Ag-110m, Cs-134, Cs-137, Sr-90</td>
<td></td>
</tr>
<tr>
<td>Tritium</td>
<td>5.4 x 10¹²</td>
</tr>
<tr>
<td>Carbon 14</td>
<td>3.2 x 10¹¹</td>
</tr>
</tbody>
</table>

i. Emission caused by primary coolant leaks

The primary coolant leak rate from the Peach Bottom nuclear plant was 1% of the inventory per day and from the AVR and Dragon reactors it was 0.2%. To achieve lower
leak rates, very high demands will be made on the impermeability of components and systems. Special attention will have to be given to this aspect during design of the components and systems.

By including reserves in the design of other components, it will also be possible to restrict the radioactive emissions to the design values, even if an unexpectedly high leak rate occurs.

To calculate the emission rates, it is assumed that the leaks occur inside the reactor building, and that the radioactive materials that are released will be removed at a rate corresponding to an air exchange of 1 h⁻¹ (as is usual in such buildings).

The annual emissions via the exhaust chimney caused by primary coolant leaks are shown in Table 40. It was assumed that 100% of the radioactive iodine was elemental. ¹²⁹

<table>
<thead>
<tr>
<th>Radio nuclide</th>
<th>Activity (Bq)</th>
<th>Design Value</th>
<th>Expected Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kr-83m</td>
<td></td>
<td>5.8 x 10⁹</td>
<td>1.7 x 10⁹</td>
</tr>
<tr>
<td>Kr-85m</td>
<td></td>
<td>2.1 x 10¹⁰</td>
<td>6.7 x 10⁹</td>
</tr>
<tr>
<td>Kr-85</td>
<td></td>
<td>1.3 x 10⁸</td>
<td>3.4 x 10⁷</td>
</tr>
<tr>
<td>Kr-87</td>
<td></td>
<td>1.9 x 10¹⁰</td>
<td>6.0 x 10⁹</td>
</tr>
<tr>
<td>Kr-88</td>
<td></td>
<td>4.7 x 10¹⁰</td>
<td>1.4 x 10¹⁰</td>
</tr>
<tr>
<td>Kr-89</td>
<td></td>
<td>8.0 x 10⁸</td>
<td>-</td>
</tr>
<tr>
<td>Kr-90</td>
<td></td>
<td>6.4 x 10⁷</td>
<td>2.0 x 10⁷</td>
</tr>
<tr>
<td>Xe-131m</td>
<td></td>
<td>5.0 x 10⁸</td>
<td>1.6 x 10⁸</td>
</tr>
<tr>
<td>Xe-133m</td>
<td></td>
<td>4.6 x 10⁸</td>
<td>1.3 x 10⁸</td>
</tr>
<tr>
<td>Xe-133</td>
<td></td>
<td>9.4 x 10¹⁰</td>
<td>2.8 x 10¹⁰</td>
</tr>
<tr>
<td>Xe-135m</td>
<td></td>
<td>1.9 x 10¹⁰</td>
<td>5.5 x 10⁸</td>
</tr>
<tr>
<td>Xe-135</td>
<td></td>
<td>5.4 x 10¹⁰</td>
<td>1.6 x 10¹⁰</td>
</tr>
<tr>
<td>Xe-137</td>
<td></td>
<td>1.7 x 10⁸</td>
<td>5.0 x 10⁸</td>
</tr>
<tr>
<td>Xe-138</td>
<td></td>
<td>9.4 x 10⁹</td>
<td>2.8 x 10⁹</td>
</tr>
<tr>
<td>Xe-139</td>
<td></td>
<td>1.0 x 10⁸</td>
<td>-</td>
</tr>
</tbody>
</table>

¹²⁹ SAR Rev 1, Chapter 6.3
¹³⁰ SAR Rev 1, Chapter 6.3
<table>
<thead>
<tr>
<th>Radio nuclide</th>
<th>Activity (Bq)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design Value</td>
<td>Expected Value</td>
<td></td>
</tr>
<tr>
<td>Total noble gases</td>
<td>2.6 x 10^{11}</td>
<td>7.9 x 10^{10}</td>
<td></td>
</tr>
<tr>
<td>I-131</td>
<td>1.4 x 10^{7}</td>
<td>1.6 x 10^{5}</td>
<td></td>
</tr>
<tr>
<td>I-132</td>
<td>1.5 x 10^{8}</td>
<td>1.7 x 10^{6}</td>
<td></td>
</tr>
<tr>
<td>I-133</td>
<td>8.7 x 10^{7}</td>
<td>1.0 x 10^{6}</td>
<td></td>
</tr>
<tr>
<td>I-134</td>
<td>2.5 x 10^{8}</td>
<td>3.1 x 10^{6}</td>
<td></td>
</tr>
<tr>
<td>I-135</td>
<td>1.5 x 10^{8}</td>
<td>1.7 x 10^{6}</td>
<td></td>
</tr>
<tr>
<td>Total iodine</td>
<td>6.5 x 10^{8}</td>
<td>7.4 x 10^{6}</td>
<td></td>
</tr>
<tr>
<td>Cs-134</td>
<td>1.1 x 10^{5}</td>
<td>2.4 x 10^{3}</td>
<td></td>
</tr>
<tr>
<td>Cs-137</td>
<td>2.3 x 10^{5}</td>
<td>5.1 x 10^{3}</td>
<td></td>
</tr>
<tr>
<td>Ag-110m</td>
<td>8.0 x 10^{3}</td>
<td>1.8 x 10^{2}</td>
<td></td>
</tr>
<tr>
<td>Sr-90</td>
<td>8.7 x 10^{3}</td>
<td>1.5 x 10^{1}</td>
<td></td>
</tr>
<tr>
<td>Total solids</td>
<td>3.4 x 10^{5}</td>
<td>7.4 x 10^{3}</td>
<td></td>
</tr>
<tr>
<td>Rb-88</td>
<td>2.8 x 10^{10}</td>
<td>4.6 x 10^{8}</td>
<td></td>
</tr>
<tr>
<td>Rb-89</td>
<td>3.4 x 10^{8}</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Rb-90</td>
<td>1.3 x 10^{9}</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Sr-89</td>
<td>3.2 x 10^{4}</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Cs-138</td>
<td>9.4 x 10^{6}</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Cs-139</td>
<td>1.9 x 10^{8}</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Ba-139</td>
<td>1.5 x 10^{7}</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total noble gas decay products</td>
<td>3.0 x 10^{10}</td>
<td>4.6 x 10^{8}</td>
<td></td>
</tr>
<tr>
<td>H-3</td>
<td>3.5 x 10^{12}</td>
<td>1.1 x 10^{11}</td>
<td></td>
</tr>
<tr>
<td>C-14</td>
<td>3.5 x 10^{12}</td>
<td>3.2 x 10^{11}</td>
<td></td>
</tr>
</tbody>
</table>

ii. Activity emissions in air from the reactor cavity

The activity emissions, which are removed via the exhaust chimney, are shown in Table 41. They are based on the activity inventory in the primary cavity and an air exchange factor of $\alpha = 1 \text{ d}^{-1}$.\textsuperscript{131}

\textsuperscript{131} SAR Rev1, Chapter 6.3
### Table 41: Annual Emission of Radioactive Material together with Expelled Air from the Reactor Cavity

<table>
<thead>
<tr>
<th>Radio nuclide</th>
<th>Activity (Bq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cr-51</td>
<td>1.5 x 10⁶</td>
</tr>
<tr>
<td>Mn-54</td>
<td>5.9 x 10⁵</td>
</tr>
<tr>
<td>Fe-59</td>
<td>3.8 x 10⁶</td>
</tr>
<tr>
<td>Co-58</td>
<td>5.0 x 10⁵</td>
</tr>
<tr>
<td>Co-60</td>
<td>9.4 x 10⁶</td>
</tr>
<tr>
<td>Ta-182</td>
<td>1.1 x 10⁷</td>
</tr>
<tr>
<td><strong>Total activation products</strong></td>
<td><strong>2.4 x 10⁷</strong></td>
</tr>
<tr>
<td>Ar-41</td>
<td>8.0 x 10¹²</td>
</tr>
</tbody>
</table>

iii. Expected release rates of gaseous effluents to the environment

The low activity inventory in the primary coolant results in the annual release due to primary coolant leaks being small. Iodine and aerosol-bound fission products are exclusively emitted into the environment via this route. The design value for a total annual iodine release is 6.5 x 10⁸ Bq, and for long-lived fission products, it is 3.4 x 10⁵ Bq in Table 40. The annual activity emission rate in the form of aerosol-bound fission products, which are formed by decay of short-lived noble gases, is 3.0 x 10¹⁰ Bq. Since the half-lives of these radio nuclides, with the exception of Sr-89, are shorter than eight days, they can be added to the noble gases, so that only Sr-89 with 3.2 x 10⁴ Bq/a must be taken into consideration, together with the long-lived aerosols.

Most of the activity in noble fission gases, H-3 and C-14 is emitted during regeneration of the helium purification plant from the storage containers for radioactively contaminated helium. Annual releases of 2.6 x 10¹¹ Bq for the noble fission gases, 3.5 x 10¹² Bq for tritium, and 3.5 x 10¹² Bq for C-14, must be reckoned with in the design scenario.

Expelled air from the reactor cavity (See Table 41) is responsible for the emission of Ar-41 and most of the aerosol activity. Annual releases of 8 x 10¹² Bq for Ar-41, and 2.4 x 10⁷ Bq for aerosols, must be reckoned with in the design scenario. Co-60 was selected as the representative nuclide for aerosol emissions.

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132 SAR Rev 1, Chapter 6.3  
133 SAR Rev 1, Chapter 6.3
In summary, it is important to consider the unfiltered emissions via the exhaust chimney given in Table 42. Filtered emissions will decrease the released activities.134

**Table 42:** Gaseous Radioactive Materials Released Annually135

<table>
<thead>
<tr>
<th>Radio nuclide</th>
<th>Activity Release (Bq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of noble fission gases1</td>
<td>2.6 x 10^{11}</td>
</tr>
<tr>
<td>Ar-414)</td>
<td>8.0 x 10^{12}</td>
</tr>
<tr>
<td>I-1314)</td>
<td>1.4 x 10^7</td>
</tr>
<tr>
<td>Total of all iodines (I-131 included)4)</td>
<td>6.5 x 10^8</td>
</tr>
<tr>
<td>Co-60 (Aerosol)</td>
<td>2.4 x 10^7</td>
</tr>
<tr>
<td>Ag-110m (Aerosol)</td>
<td>8.0 x 10^3</td>
</tr>
<tr>
<td>Cs-134 (Aerosol)</td>
<td>1.1 x 10^6</td>
</tr>
<tr>
<td>Cs-137 (Aerosol)</td>
<td>2.3 x 10^5</td>
</tr>
<tr>
<td>Sr-90 (Aerosol)</td>
<td>8.7 x 10^2</td>
</tr>
<tr>
<td>Sum of long lived aerosols5) (half-life &gt;10 d) :Co-60, Ag-110m, Cs-134, Cs-137, Sr-90</td>
<td>2.4 x 10^7</td>
</tr>
<tr>
<td>C-142)</td>
<td>3.5 x 10^{12}</td>
</tr>
<tr>
<td>Tritium3)</td>
<td>3.5 x 10^{12}</td>
</tr>
</tbody>
</table>

**Notes:**

1. Sum of released noble gas activity was calculated by multiplying the coolant activity by 0.1%/d x 365d
2. PBMR calculated value in.
3. PBMR calculated value in.
4. All other PBMR source terms calculated by multiplying the HTR Module source terms by the power ratio of 268 MW/200 MW x 0.5
5. Aerosol values obtained from and adjusted as in the previous note (4).

### 4.14.3 CONCLUSIONS

**Solid Radioactive Waste**

The volume of operational solid radioactive waste (LLW and ILW) are low i.e. about 2000 x 210 litre drums will be produced over the life of the proposed Plant. This volume excludes large unplanned replacement items of Low or Intermediate Level

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134 SAR Rev 1, Chapter 6.3
135 SAR Rev 1, Chapter 6.3
Waste that will require larger containers. Such LLW and ILW will be transported to and disposed of at the Vaalputs Repository where sufficient space and infrastructure exist to manage these wastes.

Spent fuel (HLW) will be kept on site and managed in accordance with international and national safety standards. Annexure 16 provides information on the interim storage of HLW (spend fuel), the rationale for interim storage on site and technology applications for final management and deposition.

- **Liquid Radioactive Waste**

  Effluent discharges conform to safety criteria specified by the NNR. The NNR will also evaluate and decide on the validity of the information as supplied by Eskom through the Safety Case and Safety Analysis Report (SAR). The concentrated radioactive waste residue will also be drummed and disposed of at the Vaalputs Repository.

  
  The effluent discharges from the proposed Plant will not affect the Koeberg operating license in terms of cumulative release or dose rates.

- **Gaseous Radioactive Waste**

  Emission concentrations conform to safety criteria stipulated by the NNR.

- **Diligent monitoring of the environmental media** (see Section 8.5.2 Environmental Surveillance Programme) will furthermore assure that the radiological exposure levels of the public, property and the environment are within accepted risk norms from such releases.
4.15 GEOLOGICAL, SEISMO-TECTONIC AND SEISMIC HAZARDS ASSESSMENT OF THE KOEBERG SITE

4.15.1 INTRODUCTION

- From an Earth Science point of view, the establishment of a nuclear facility requires an evaluation of the geology and seismo-tectonic characteristics of the site, whereafter a Seismic Hazard Assessment is performed. South Africa follows international guidelines, such as those given in 10 CFR 100 (see reference list) for the seismo-tectonic characterization, and a Parametric-Historic approach (Council for Geoscience) for the Seismic Hazard Assessment.

- The seismo-tectonic history of the Koeberg Site is assessed in the light of the current understanding of the subject which is a complex and all-embracing task. The various factors that could contribute towards the evaluation are reviewed and conclusions are drawn as to what impact each would have with respect to the Seismic Hazard Assessment of the Site.

- This report has been divided into three main sections, each of which covers one avenue of study which is then sub-divided into several topics. The following avenues of study and topics are addressed in extract and briefly discussed:
  
  - Semi-Regional and Site Geology
    - Basement and Cenozoic Geology
    - Structural Geology
    - Ancient Sea-levels and Crustal Warping
  - Seismo-tectonic Model
A brief introduction covering the reason for each avenue of study is first given, where-after the study is briefly discussed and then conclusions are drawn. The final conclusion summarises the total study.

4.15.2 Semi-Regional and Site Geology

General

The semi-regional and site specific geology of the Koeberg Site as well as the structural geology are summarized below. More detail can be obtained from the Koeberg Site Safety Report (KSSR, 1998) as well as from the Koeberg Site Geological Report by Andersen (1999). Although both of these reports are of a detailed nature, there are additions to the study which include a reappraisal of the structural/tectonic setting of the Site as well as a proposed new Seismo-tectonic model, that are reported here.

The reason for the geological, structural geological and seismo-tectonic studies is that they are a requirement of nuclear siting practices as prescribed by the Code of Federal Regulations, 10 CFR 100. This regulatory guide requires that investigations into surface faulting should include the following:-

- Determination of the lithologic, stratigraphic, hydrologic (not covered by this study) and structural geological conditions at the site and in the area surrounding the site, including its geological history;
- Evaluation of the tectonic structures underlying the site, whether buried or expressed at the surface with regard to their potential for causing surface displacement at or near the site (structural section);
- For faults greater than 1000 feet (300m) long, any part of which is within 5 miles (8km) of the site, determination of whether these faults are considered as capable faults (structural section);
Listing of all historically reported earthquakes that can reasonably be associated with capable faults greater that 1000 feet (300m) long, any part of which is within five miles (8km) of the site (this is part of the Seismic Hazard Assessment).

A fault shall be considered capable if (Serva, 1993):

(a) “It shows evidence of past movements of a recurring nature within such a period that it is reasonable to infer further movement at or near the surface can occur. In highly active areas where both historical and geological data consistently reveal short earthquake recurrence intervals, periods of the order of tens of thousands of years may be appropriate for the assessment of capability (upper Pleistocene – Holocene). In less active areas it is likely that much longer periods may be required.

It has a demonstrated structural relationship to a known capable fault such that movement of the one may cause movement on the other at or near the surface.

(c) The maximum potential earthquake associated with the seismogenic structure, to which the fault belongs, is sufficiently large and at such a depth that it is reasonable to infer that surface faulting can occur”.

Basement and Cenozoic Geology

The oldest rocks in the area are those of the Precambrian Malmesbury and Klipheuwel Groups. The former Group has been intruded by the Cape Granite Suite and the latter has an unconformable relationship with the granites. The Tygerberg Formation of the Malmesbury Group and the granite that intrudes the Malmesbury Group, comprises most of the bedrock on which the younger Quaternary sediments were deposited. Sandstones of the Table Mountain Group form the highland areas east of the coastal plains.

The Malmesbury Group consists predominantly of a marine sedimentary assemblage with a large lithological variation which have been deformed by two tectonic events.

The intrusion of the Cape Granites took place in two phases along northwest to southeast trending lines of weakness. The younger granites have been dated at 500 ±15 million years and the Malmesbury sediments have a minimum isotopic age of 600 million years.

The late Precambrian Malmesbury orogeny was followed by a period of erosion and planation, preceding the deposition of the Klipheuwel Group. These sediments are mainly arenaceous in character are unmetamorphosed and show little deformation.

There is a large depositional gap in the geological history over most of the south-western
western Cape Province due to the absence of the Cape Supergroup of sediments. It is possible that this Supergroup once overlay the area but has since been removed by tectonic uplift and subsequent planation.

Following the Cretaceous break-up of Gondwanaland (Dingle and Scrutton, 1974), the Late Precambrian rocks were exposed by erosion and subjected to tropical and subtropical weathering (Glass, 1977), probably in the Early Tertiary, which resulted in deeply weathered and highly leached bedrock, particularly along the coastal area (Rogers, 1980). On the published geological maps, the sandy surface material mapped in the Western Cape is described as ‘Tertiary to Recent’. Over the last couple of years, the stratigraphy of the Cenozoic sediments in the Western Cape is slowly being formalized. The South African Committee for Stratigraphy (SACS, 1980) has ratified some of the old names and proposed that the entire Western Cape Cenozoic succession be termed the Sandveld Group. The formations encountered between Cape Town and Eland’s Bay are the Miocene, fluviatile Elandsfontyn Formation, the Miocene, littoral Saldanha Formation, the Mio-Pliocene, phosphatic littoral and shallow-marine Varswater Formation, the Early Pleistocene, aeolian Springfontyn Formation, the Late Pleistocene, littoral Velddrif Formation, the Late Pleistocene, aeolian Langebaan Formation and the Holocene, aeolian Witzand Formation. At present SACS, (1980) has accepted but not yet approved all the formational names.

Rogers (1980), examined the sedimentary successions in three excavations made for the Koeberg Nuclear Power Station at Duynefontein No 34 and recognized the Varswater-(oldest), Springfontyn-, Milnerton- and Witzand (youngest) Members. These have since been upgraded to Formations and the Milnerton Member has been renamed the Velddrif Formation. The Geological formations are shown in Table 43.
Table 43: Geological Formations


<table>
<thead>
<tr>
<th>PERIOD</th>
<th>FORMATION</th>
<th>LITHOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>QUATERNARY</strong></td>
<td>*WITZAND FORMATION</td>
<td>HOLOCENE AND RECENTLY ACTIVE</td>
</tr>
<tr>
<td></td>
<td>AEOIAN PART OF 4-6 M PACKAGE</td>
<td>CALCAREOUS DUNE FIELDS AND CORDONS</td>
</tr>
<tr>
<td></td>
<td>*LANGEBAAN FORMATION</td>
<td>MID-LATE PLEISTOCENE</td>
</tr>
<tr>
<td></td>
<td>AEOLIAN PART OF 4-6 M PACKAGE</td>
<td>CALCAREOUS EOLIANITE WITH CALCRETIZED PALEOSOLS</td>
</tr>
<tr>
<td></td>
<td>*VELDDRIF FORMATION</td>
<td>PLEISTOCENE (EEMIAN) SHALLOW</td>
</tr>
<tr>
<td></td>
<td>MARINE PART OF 4-6 M PACKAGE</td>
<td>MARINE COQUINA, CALCARENITE SAND AND CONGLOMERATE</td>
</tr>
<tr>
<td></td>
<td>*SPRINGFONTYN FORMATION</td>
<td>PLEISTOCENE TO RECENT QUARTZSE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SAND DUNES, SILTS AND PEATS</td>
</tr>
<tr>
<td><strong>MIO-PLIOcene</strong></td>
<td>VARS WATER FORMATION</td>
<td>MIOCENE AND PLIOCENE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PHOSPHATIC LITTORAL AND SHALLOW MARINE SAND-STONES, CONGLOMERATES AND COQUINA.</td>
</tr>
<tr>
<td><strong>ORDOVICIAN AND LOWER CARBONIFEROUS</strong></td>
<td>TABLE MOUNTAIN GROUP</td>
<td>SANDSTONES AND SHALES</td>
</tr>
<tr>
<td><strong>CAMBRIAN</strong></td>
<td>PRE-CAPE</td>
<td>DOLERITE DYKES</td>
</tr>
<tr>
<td></td>
<td>KLIPEHUEL GROUP</td>
<td>CONGLOMERATE SHALES AND MUDSTONES</td>
</tr>
<tr>
<td><strong>LATE PRECAMBRIAN</strong></td>
<td>CAPE GRANITE SUITE</td>
<td>COARSE-GRAINED PORPHYRTIC GRANITE WITH HYBRID PORPHYRTIC VARIETIES</td>
</tr>
<tr>
<td></td>
<td>Darling Granite</td>
<td></td>
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<tr>
<td></td>
<td>MALMESBURY GROUP</td>
<td>GREYWACKE, SANDSTONE, MUDSTONE AND SHALE WITH METAMORPHOSED EQUivalENTS</td>
</tr>
<tr>
<td></td>
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<td>AND INTERBEDDED LAVAS AND TUFFS</td>
</tr>
</tbody>
</table>

* Accepted but not yet formally approved by the South African Committee for Stratigraphy (SACS,1980)
Figure 10: Main Structural Map of Koeberg
a) Discussion on the Site Geology

(i) The Koeberg Site lies within a Cenozoic Depocentre (Pether, et al., 2000), with the basement rocks along the coastline being at a depth of approximately 10 m below sea-level. The basement rocks can be seen to outcrop approximately 500 m to the south and 7000 m to the north of the Site. The thickness of the Cenozoic cover, depends on the surface and basement topography and varies from 10 to 50 m. This forms the Atlantis aquifer. (Bedrock contours of the Atlantis aquifer were supplied by the CSIR in Stellenbosch, October, 2000 Figure 10).

(ii) Of possible concern from a seismo-tectonic perspective, is whether this “Cenozoic Depocentre” is a fault-controlled graben and if so when did the faults last move or is Miocene crustal warping responsible for its formation. The Springfontyn Fault could be one such structure. The oldest sediments overlying the Malmesbury bedrock, and reported from the Koeberg excavation, belong to the Varswater Formation and have been assigned a Miocene age (~5 Ma, Pether et al., op cit.). This could imply that the “Graben” was formed by faulting that took place about 5 million years ago and that the faults therefore have no associated seismic risk. The crustal warping equally has no attendant seismic risk. The faulting is discussed in under structural geology section 2.3 and the crustal warping under ancient sea levels and crustal warping which follow hereunder.

Structural Geology

The major regional faults consist of (i) the Saldanha-Darling-Franschhoek (ii) the Piketberg-Wellington and (iii) the Milnerton-Cape Hangklip fault zone. The Saldanha-Darling-Franschhoek fault zone trends approximately NW-SE and lies 18 km east of Koeberg and the Piketberg-Wellington trends approximately NNW-SSE and lies 55 km to the east (KSSR, 1998).

A discontinuity, approximating the postulated Milnerton-Cape Hangklip fault zone is evident on the aeromagnetic imagery. This “fault” has a NNW-SSE strike, and passes through Milnerton and extends into the sea. There is unfortunately no aeromagnetic coverage of this part of the ocean, but if the fault were to be extended seaward it would pass approximately 8 km west of Koeberg Power Station. A sub-parallel fault cuts through Springfontyn se Punt and continues NNW to cut through the Poenskop peninsula 15 km to the NNW (See Figure 10).

These faults comprise a complex of sub-parallel shear systems which resulted in en-echelon zones of ductile deformation, brittle failure with associated breccia zones, and en-echelon crack arrays, cataclasis and mylonitization.
The fact that these fault systems are originally of pre-Cape age is supported by evidence of intrusion of late-stage phases of the Cape Granite Suite through the fault systems which have been truncated by pre-Cape erosion prior to the deposition of the Table Mountain Group in Silurian Times (Hartnady et al., 1974).

Post-Table Mountain Group movement is apparent and rejuvenation occurred along parts of the pre-existing fault zones.

Along the Saldanha-Franschhoek fault line, a major zone of faulting appears to be present between Klipheuwel and Mamre while a 50 km long fault continues from Mamre through Darling towards Langebaan.

This Klipheuwel-Darling fault zone, approaches to within 18 km of the site and clearly represents a major discontinuity of regional extent along which large granite stocks were intruded. Broad mylonite zones testify to intense cataclastic deformation along this major fault during Precambrian and post-Cambrian times.

The southern tip of the Koeberg Nuclear Power Station site is traversed by a magnetic anomaly which represents an early Cape aged fault along which a swarm of dolerite dykes was intruded. This trend of dyking is ubiquitous throughout the south western Cape and tend to occur in swarms. They clearly post-date the pre-Cape rocks and they are thought to belong to the so-called Western Province dolerites which pre-date the Jurassic Karoo dykes (Nell and Brink, 1944). The dykes have undergone various degrees of low-grade regional metamorphism and deformation – probably related to the Permo-Triassic Cape Orogeny (~240 Ma). The old fault planes are likely to have been annealed and as such are unlikely to constitute a seismic hazard.

An interpretation of a recently imaged regional aeromagnetic survey indicates that there are a large number of WSW-ENE trending faults that were previously undetected (Andersen, 1999). The reason for this is that the area is sand-covered and the detection of the faults has only been made possible by recent advances in the science of aeromagnetic image processing.

Of importance to the Koeberg site is the existence of the Springfontein Fault and the two faults straddling Springfontein se Punt (See Figure 10). The Springfontein Fault, which lies approximately 7 km to the north of Koeberg, is probably of a composite en echelon nature and strikes WSW-ENE. It can be measured in the beach outcrops but there is no expression on the aeromagnetic imagery. Several strong breccias were mapped showing randomly orientated greywacke fragments set in a coarse grained matrix of quartz and feldspar. There are also several strong E-W open fractures. This fault complex appears to control the boundary between the high basement to the north and the Cenozoic Depocentre (Atlantis Aquifer) to the south (Fig. 1). The bedrock contours indicate a difference in elevation of roughly 20 m between the northern and southern
southern sides of the strike extension of the measured fault line. The bedrock contours were supplied by the CSIR, Stellenbosch.

b) Discussion on the Structural Geology

(i) On a regional scale, faulting can be seen to have affected all the consolidated rocks of the region. It has however, been reasonably well established that two episodes of both compression and extension (i.e. 4 episodes) have alternated along the southern margins of Gondwana over a period of circa 600 million years since the late Precambrian. These episodes are: (a) the Pan-Gondwanean convergence circa 650±100 million years, (b) the late-Proterozoic to early Paleozoic extension circa 500±100 million years, (c) the late Paleozoic convergence circa 300±100 million years and (d) the mid to late Mesozoic extension circa 150±50 million years. Most of the faults in the South Western Cape would have been reactivated during these episodes.

(ii) Offshore surveys undertaken by Soekor north west of St Helena Bay and on the Agulhas Bank have established rifting on the continental shelf along NW trending fault zones that probably represent the seaward continuation of major fault zones identified onshore. In the offshore areas, lower Cretaceous sediments are displaced by NW and NNW trending faults. Hence the last documented movement along these faults occurred approximately 110 million years ago.

(iii) If Cretaceous faulting took place in the site area this is most likely to have occurred along old established lines of weakness such as the Klipheuwel-Darling-Saldanha fault zone. The many NNW and NE trending open fissures and tension gashes, found in the site area, may well date back to this last significant phase of brittle deformation.

(iv) The detailed geological mapping and evaluation of the bedrock exposed in the investigation for units 1 and 2 of the Koeberg Nuclear Power Station showed the ubiquitous presence of fossil lamillibranch (pholad) borings that penetrate up to 20 cm into the bedrock cutting both fault and joint planes. Of special significance is that no tectonic deformation of these borings, by faulting was observed during these studies. The minimum age of the faulting can thus be determined by dating these borings. The sediments directly overlying the bedrock have been classified as belonging to the Varswater Formation which has been dated as being of Mio-Pliocene (~5 million years) age. This would confirm that the faults in the excavation have not moved in the last 5 million years and therefore pose no seismic risk.

(v) The WSW trending Springfontein Fault that appears to control the boundary between the high basement to the north and the Cenozoic Depocentre (Atlantis Aquifer) to the south is the only feature that could pose a possible seismic risk. Although the rapid change in elevation from sea-level to about 20 m above sea-level along the projected strike of this fault, is reminiscent of a fault scarp, the breccias on the beach outcrop
outcrop don’t show the intense brecciation and mylonitization that would be expected of a seismically active fault.

Ancient Sea-Levels and Crustal Warping

c) Reason for the Study

The late Cenozoic history of the South African coastline is related to the history of sea level fluctuations. During the Pleistocene, the sea level fluctuated in sympathy with the repeated waxing and waning of northern hemisphere ice sheets, and palaeo-graphic studies show that coastal lowlands all over the world have been subjected to periods of alternating submergence and emergence. The resulting affect on the South African coastline was the formation of Raised Beach Terraces and High Strand-lines.

The reason for this study was to try and establish if there was a raised beach terrace of accurately determined age and elevation, that could be used as a time-stratigraphic marker horizon to determine if any vertical tectonic movement had taken place and when. This study was focussed on understanding crustal warping and attempting to compare beach terraces in the Koeberg area with those to the north of the Springfontyn Fault.

d) The Marine Terraces

Several lines of evidence prompt the conclusion that the Cape west coast was probably more unstable during the Cenozoic period that the Cape south coast (Tankard et al., 1982). The continental shelf-break, east of the Agulhas Arch is at a normal depth lying between 120 and 180 m (Dingle, 1973a). West of the Agulhas Arch the nature of the shelf break is variable (Fig. 2). West of the Cape Peninsula it has an average depth of 450 m, but west of the Orange River mouth it is at a depth of 200 m (Dingle, 1973b). This variation in depth of the west coast shelf break is attributed to differential warping of the continental margin. The effect of tilting on the on-shore deposits is maximized in the Saldanha area which is furthest removed from the hinge line. Here Tertiary beach terraces, that lie 5 m above sea-level are correlated with similar terraces at the Orange River mouth that lie 35 m above sea-level (Tankard, et al., 1982).

The Agulhas Arch is a NW-SE striking antiform (Dingle, 1973a) coinciding with the NNW structural trend of Late Precambrian origin. Early Tertiary intrusive dykes follow the same structural trends (Kröner, 1973). On the farm Dikdoorn on the Groen River an intrusive melilitic basalt has been dated at 38.5 million years old. In the Borgenfels area of Namibia phonolitic lavas of the Klinghardt volcanism have been dated at 35.7 million years old. Early Tertiary igneous intrusives are also encountered offshore on the Agulhas arch (Dingle and Gentle, 1972).
Tilting probably took place about an axis or ‘hinge line’ which tended to follow the NNW Precambrian structural lineament and continued from Oranjemund to the Agulhas Arch. This ‘hinge line’ has been named the Agulhas – Vredenburg Axis (de Wit, et al., 2000).

A maximum elevation of only ~35 m for the terminal Middle Miocene Prospect Hill marine gravel supports the concept of down warping of the southern part of the south western Cape during the Miocene (~22 to 5 million years ago) (Partridge and Maud, 1987).

Since the discovery of marine diamonds on the south-western coast, considerable attention has been focussed on the distribution and age of the beach terraces with which the diamond-rich sediments were associated. Between Port Nolloth and Oranjemund, there is a rapid decrease in elevation of the terrace levels, and they have all merged at a height of 9 to 10 metres above sea-level 50 km north of Oranjemund (Hallam, 1964). This is the elevation of the lower Pleistocene set of terraces in Namaqualand. There is therefore strong evidence for crustal movement to have taken place north of Oranjemund during the period Miocene- to lower Pleistocene (~5m to ~1m years ago), there is no evidence for movement in the late-Pleistocene to Holocene (~600 000 to present) (Dingle, Seisser and Newton, 1983). The convergence in the Oranjemund area can be accounted for by crustal upwarp in late Miocene and early Pliocene times (~5 million years ago), followed by a progressive subsidence to a position about 16 m below its late Miocene level by the beginning of the late Pleistocene (~600 000 years ago). These movements were of a greater magnitude to the north and diminish to the south.

A past high sea-level of about 6-8 m above that of the present is recorded at many places along the coast of southern Africa, south of Latitude 25° south (Hendey and Volman, 1986). It is represented by a variety of features and deposits that suggest that this sea-level event was one of the longer of the Quaternary high stands. The dating of this beach has been controversial. Corvinus (1983), assigned a Middle Pleistocene age (ca. 400 000 – 700 000 years old) and Early Pleistocene age (1.6 million to 600 000 years old) have been assigned to it or it is considered to consist of superimposed Pleistocene beaches of more than one age. Dale and McMillan (1999), don’t recognize the ‘6-8 m Beach’ but do recognize an ‘8-10 m Package’ which is extensively developed across the low-lying ground east of Saldanha town, also along the Hondeklipbaai-Kleinzee coast and north of Oranjemund on the west coast. To the south, the 8-10 m succession is preserved on the western and eastern margins of the Cape Peninsula and in the Cape Point Nature Reserve. Dale and McMillan (1999), date the ‘8-10 m Package’ as being Late Pleistocene in age (Latest Holsteinian-Earliest Saalian Forced Regressive System about 200 000 years old).
The ‘4 m Eemian Package’ (Dale and McMillan, 1999) occurs close to the present-day coastline and consists of marine calcarenite and aeolian units. The marine unit has been named the Velddrif Formation and the aeolian unit the Langebaan Formation. The unit extends as far north as Elands Bay and is also present south of the Modder River, at Koeberg Power Station, Rietvlei-Milnerton, Noordhoek beach and Swartklip on the northern shore of False Bay (Tankard, 1976; Rogers, 1980, 1983; Theron et al., 1992). It occurs on the northern shore of Saldanha Bay and the western shore of Langebaan Lagoon, where it is overlain by the late Pleistocene Langebaan Formation (Tankard, 1976; Rogers, 1983; Roberts and Berger, 1997). This constrains the age to the Eemian (117 000 years) when sea-level reached an elevation of +5 m. This age is confirmed by sea-level oxygen isotope curves at ~117 kyr (Roberts and Berger, 1997). The Velddrif Formation represents littoral sediments deposited during the Last Interglacial. It is defined on the basis of lithological, palaeontological and temporal criteria and is limited to a maximum storm beach height of ~7 m amsl.

Figure 11: Locality Map Showing the Tilt Axis and Shelf-Break

The Late Quaternary period covers a full glacial cycle from the Last Interglacial at about 120 000 years ago, through the Last Glacial Maximum 17 000 – 16 000 years ago, to the present interglacial conditions. The local sea-level curve has a Late Pleistocene minimum of ca. −130 m at about 17 000 years ago, to a mid-Holocene maximum of ca. +2 m about 5 000 years ago (Miller, D.E., 1990). Evidence for elevated sea-levels of about +2 m around 5 000 years ago have been described from numerous localities,
e) Conclusions with respect to Ancient Sea-Level and Crustal Warping

(i) The Cape west coast was probably more unstable during the Cenozoic period than the Cape south coast. The continental shelf break varies in depth from a normal 120 to 180 m east of Cape Agulhas to 450 m off the Cape Peninsula and to 200 m of the Orange River mouth. The tilting effect is also noted in the Tertiary beach terraces that are down warped from 35 m above sea-level at the Orange River mouth to 5 m above sea-level at Saldanha bay. This axis of tilting has been named the Saldanha-Vredenberg Axis.

(ii) The diamondiferous beach terraces north of Oranjemund have converged as a result of both upward and downward crustal movement that possibly ceased in the Late Pleistocene (~600 000 years ago).

(iii) The 6-8 m sea-level stand, which is recognized around the coastline of South Africa, has a controversial age which ranges from Early to Late Pleistocene (~1.2 million years to ~600 000 years old). A possible equivalent of this terrace (the 8-10 m package) is dated at 200 000 years old. The consistent distribution of this sea-level stand possibly indicates that tectonic movement of the Cape west coast had ceased by the Late Holsteinian-Earliest Saalian Forced Regressive System. About 200 000 years ago.

(iv) The Eemian global sea-level high stand attained a maximum elevation of ~5 m above present mean sea-level at about 120 000 years before present, leaving wave-cut terraces and beach deposits that may or may not be overlain by aeolianites. This unit is called the ‘4-6m Package’, with the 4-6 m range referring to the lower and upper limits of the marine terrace. The marine and aeolian parts of the package are called the Velddrif and Langebaan Formations respectively.

An attempt was made to locate the 4-6 m Package, just to the north of the Koeberg Power Station, in order to correlate the elevation with the 4-6 m Package at Langebaan. Deviations from the classic elevation above sea-level of the marine unit would then imply neotectonic activity, in the vertical sense, on the Springfontyn Fault, subsequent to its deposition some 120 000 years ago (Eemian).

The attempt failed as it was not possible to detect the marine unit from the drill core samples. The Langebaan Formation has been recorded in excavations on the Koeberg Site as well at many other locations both to the north and south of Koeberg (see 2.4.1 above). The elevation of the land-ward pinch-out, which would indicate the position of maximum transgression of this Formation, has not been determined at any of these sites. However at the Milnerton Lighthouse site, the top of the marine deposit is described as
being 2.5 m above the level of Low Water Spring Tide (Kensley, 1985). This was the position of the Formation where it had been exposed by storm wave action and no further land-ward excavation was undertaken to determine the limit of the marine deposit the base of which may achieve higher elevations (4m).

On the strength of the above discussion it is postulated that it is unlikely that major vertical fault displacement has occurred on the Springfontyn Fault in the past 117,000 years.

(v) A Mid-Holocene (5,000 year) +2 m sea-level also left recognizable terraces and deposits throughout the south western and southern Cape coast (Langebaan to Knysna). The consistent nature of these terraces could possibly also corroborate the notion that there has been no tectonic activity since at least the Eemian.

“The present state of our knowledge of the southern African sea-level curve is inadequate for evaluating any possible regional differences in sea-level history, differences that could be revealing about short-term local tectonics.

Detailed local sea-level change records are not going to be available from elevated beach deposits as the altitudinal resolution is too coarse. Such information will have to be sought from more sensitive indicators of sea-level change, such as lagoonal and estuarine deposits or prograded beach sequences in which the shore face facies can be recognized unequivocally”. (From Miller et al., 1993)

4.15.3 **THE SEISMO-TECTONIC MODEL**

Reasons for the Study

A Seismo-tectonic Model is an attempt to set up a regional structural framework within which a Tectonic Province can be characterized by a combination of parameters such as lithology, metamorphism, age, structure and tectonic boundaries, which differ significantly from adjacent areas. The model will also include seismically active structures, if identifiable and the orientation of the neotectonic stress field. The orientation of the major fault trends also plays a role as those faults sub-parallel to the ambient neotectonic stress field could be susceptible to reactivation and will require evaluation. Faults normal to the stress field would be “locked in” and therefore inactive. The orientation of the neotectonic stress field has been assessed and is discussed in Section 3.2.

If such a model can be formulated and is sustainable, then seismic events occurring outside the boundaries of the province are very unlikely to occur within, and the seismic energy can be attenuated from the boundary of the province to the site. This is also
applicable to major fault structures that by instrumental measurement are shown to be seismogenic.

Dames and Moore (1976) felt that there was reasonable justification, from a tectonic standpoint, to assume that the earthquakes in the south-western Cape area are associated with major structural discontinuities. They named the following three fault zones as being “seismically active”:

The postulated Piketberg-Bridgetown-Worcester fault zone approximately 70 km to the NE of the site.

The Saldanha-Darling-Franchhoek fault zone which at its closest approach is approximately 18 km from the site. The postulated Milnerton-Cape Hangklip fault zone which is observed not to approach closer than 8 km from the site. (The Council for Geoscience note that there is very poor direct evidence to indicate the existence of the Milnerton-Cape Hangklip fault zone, and hence are of the opinion that it poses no threat to the seismic hazard of the Koeberg NNP).

Based on these seismogenic structures, Dames and Moore (1976) then divided the area into three seismo-tectonic provinces, which are located between these structures. From west to east they are (i) the South-western Province, (ii) the Central Province, and (iii) the North-eastern Province. Dames and Moore (1976) postulated that while small earthquakes might be expected anywhere in the region, the larger events would be expected to be confined to the zones of major faulting.

Dames and Moore (1976), based their three seismogenic structures on historic earthquakes only, which makes the confirmation of the spatial association between these structures and the relevant events very difficult. Since the introduction of the South African National Seismological Network approximately 100 events have been recorded and located within 400 km of the Koeberg Site. Over a period of 26 years of measurement, only the events of the 23 December, 1974 (mag = 3.4) and 7 June, 1977 (mag = 5.5) show some correlation with the Piketberg-Wellington fault zone (Graham et al., 1999).

It is therefore recommended that the Dames and Moore (1976) model be modified and that it be reduced to incorporate the Peninsula Microplate only as explained below (Section 3.4). The eastern boundary of the microplate could possible coincide with the north-western extension of the Worcester Fault although the Piketberg-Bridgetown-Worcester fault may also be an active branch of this fault. The Saldanha-Darling-Franchhoek fault zone is considered to be inactive as it is roughly at right angles to the neotectonic stress field. (See Section 3.2 below).
Orientation of the Neotectonic Stress Field

It was necessary to determine the orientation of the neotectonic stress field in order to support the Peninsula Microplate Model and to ascertain if any of the faults in the vicinity of the Koeberg Site could be potentially “capable” of generating a seismic event. Two approaches were adopted, (i) a study of focal mechanism analyses carried out on the Ceres, 1969 seismic event, and (ii) a study of shear-wave splitting on recent events that had good signal characteristics.

Shear Wave Splitting

A shear wave splitting analysis was carried out by the Council for Geoscience (Graham, 1999) on ten events recorded by the Elim Seismological Station.

Table 44 gives the results of Particle Motion Analysis for the Elim Seismological Station. “BAZ” indicates the back-azimuth, “Angle” the polarization angle of the first - arriving shear wave in the Radial - Transverse horizontal plane and “Polarization” the geographical orientation of the first shear wave. The “quality of arrival” is given as a weight on a scale from 1 to 4.

<table>
<thead>
<tr>
<th>Event No</th>
<th>BAZ</th>
<th>Angle</th>
<th>Polarization</th>
<th>Angle Incidence</th>
<th>o</th>
<th>Quality of arrival *</th>
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</thead>
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<tr>
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<td>109°</td>
<td>33°</td>
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<td></td>
</tr>
<tr>
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<td>25°</td>
<td>110°</td>
<td>135°</td>
<td>35°</td>
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</tr>
<tr>
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<td>87°</td>
<td>65°</td>
<td>39°</td>
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<td></td>
</tr>
<tr>
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<td>216°</td>
<td>36°</td>
<td>?</td>
<td>2</td>
<td></td>
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</tbody>
</table>

The weighted average orientation of these events gives the orientation of the maximum principal stress field as 62°.
Focal Mechanism Analysis

Focal mechanism analyses carried out on the 29th September, 1969 (Ceres Earthquake) indicate that the Western Branch of the Worcester Fault has a NW - SE strike and its movement is left-lateral strike-slip. The maximum principal stress direction that caused the event is WNW and the nodal planes are almost vertical, with the minimum principal stress being horizontal (Fairhead and Girdler, 1971; Green and McGar, 1972).

These techniques confirmed that the orientation of the maximum horizontal stress field driving the movement of the Peninsula Microplate is WNW (focal mechanisms) and ENE-WSW (62° from shear wave splitting).

a) Conclusions with regard to the Neotectonic Stress Field

(i) The orientation of the maximum horizontal stress field driving the movement of the Peninsula Microplate is WNW (focal mechanisms) and ENE-WSW (62° from shear wave splitting).

(ii) In the light of the above results, it is therefore concluded that the major NNW- SSE trending faults (Saldaha-Darling-Franchhoek and others) are not seismogenic as their orientation is almost normal to the prevailing neotectonic stress field. However the ENE-WSW and E-W trending faults (such as the Springfontyn Fault) should be considered, in nuclear siting terms, to be potentially “capable” as they are sub-parallel to this stress field.

(iii) A fault would be considered “capable” if it had associated instrumentally recorded seismicity. However, the relocation of two historic seismic events in the vicinity of Koeberg, using modern software, shows the error ellipses to be so large that it is not possible to relate these events to any of the known faults (Kijko et al., 1999). A more extensive relocation exercise carried out by Smith (1999), commented on by Graham et al. (1999), who noted that of the approximately 100 events recorded over the past 26 years, only two show some correlation with the Piketberg-Wellington fault zone. None of the WSW-ENE trending faults described below (3.3) have any related seismicity over this time period.

(iv) The Springfontyn Fault (not recognized by the Council for Geoscience) lies within the granite intruded Peninsula Microplate. It could therefore be argued that this granite intruded plate could act as a buffer and the seismic energy release (resulting from ridge push) was more likely to take place on the eastern boundary of the Microplate rather than by moving the fault.
Structural Analysis, Fault Rupture Length and Peak Ground Acceleration (PGA)

Recent advances in the science of geophysical signal processing techniques have enabled higher resolution imagery to be made of older aeromagnetic surveys. In this study, the Cape Regional Aeromagnetic Survey was reprocessed and images of the Enhance Total Magnetic Intensity and the Fractal Gradient were produced. A structural-geological interpretation was then carried out on these images and numerous, previously unrecognised WSW-ENE trending faults were detected. Of importance to the Koeberg Site is the fault at Springfontyn se Punt (near Silverstroomstrand, 11 km to the north), which has a strong aeromagnetic signature; and the so-called Springfontyn Fault, which is visible in beach outcrop only and lies about 7 km to the north of Koeberg (Figure 10).

Of significance, from a nuclear site evaluation point of view, is that the strike direction of these faults is sub-parallel to the prevailing neotectonic stress field and as such they could be considered as being “capable”. Considering the orientation of the strain ellipse, derived from the shear-wave splitting study, faults lying parallel to the principal stress axis could be reactivated as normal faults, whereas those lying within 30° of this direction could be reactivated as strike-slip faults (Park, 1988).

Should these faults be reactivated, what is the Peak Ground Acceleration (PGA) that would be felt on site? In order to evaluate these possibilities, the regression curves of Atkinson and Boore (1997) and Toro et al., (1997), were used which empirically relate fault rupture length to maximum theoretical PGA. It must be noted that the theoretical results relating PGA to fault rupture length are only best estimates. It is infrequent that the largest possible earthquake has occurred along a specified fault during the known history of seismicity.

Curves were then generated showing the peak ground acceleration expected on site at an epicentral distance of 7 km (Springfontyn Fault) for a range of rupture lengths (Kijko et al., 1999).
The Koeberg Site Safety Report, (KSSR, 1998) defines the Safe Shutdown Earthquake (SSE) as an event with a local magnitude of 7.0 at a distance of 8 kilometres from the site. Using the attenuation equation developed (in KSSR, 1998), a peak ground acceleration of 0.3 g is obtained at site.

b) Conclusions with regard to Structural Analysis, Fault Rupture Length and Peak Ground Acceleration (PGA)

(i) The stress theory predicts that faults with a strike orientation lying close to the principal stress axis could be reactivated. This implies that the Springfontyn and other WNW trending faults are potentially capable

(ii) The Koeberg NPP has been designed for a Safe Shutdown Earthquake (SSE) with a PGA of 0.3 g (KSSR, 1998).

(iii) When considering the PGA versus fault rupture length relationships presented in Figure 12 above, a PGA of 0.3 g on site would require a fault rupture length of approximately 2.5 km (using the mean value). Field examination of the Springfontyn Fault exposure in the beach outcrops, gives no indication by way of breccia and mylonitization that recent movement of this magnitude has taken place. This fault therefore poses no threat to the Koeberg NPP.
The Microplate Tectonic Model

The Cape Fold Belt can be divided into three structural domains, namely the Western Branch, the Southern Branch and an intervening Syntaxial Domain. See Figure 11. The Western Branch is then subdivided into a Northern Subdomain and a Southern Subdomain.

The Southern Subdomain, within which the Koeberg Site falls, is underlain by the Precambrian Cape Granite batholith and in the Cape Peninsula by a thick succession of basal formations of the Cape Supergroup. Deformation in these cover sequences is relatively mild.

The Northern Subdomain is comprised of Late Precambrian metapelites of the Malmesbury Group which contain a distinct NW-striking fabric. The domain is characterized by open upright folds and monoclines in the Cape Supergroup which strike predominantly in a northerly direction. Slickensides developed along fold limbs are sub-horizontal demonstrating a north to NNE-transport direction.

Ransome and de Wit (1992) suggested that much of the Phanerozoic history (past 545 million years) of the Western Cape Fold Belt, is a direct consequence, not only of pre-existing Pan African basement structures but also of the formation of two semi-coherent microplates. These plates were formed by the intrusion of granitic material into a pelitic basement (Figure 13) and thereafter possibly acted as a tectonic buffer during subsequent deformation. They postulate that the largest microplate (Figure 14) underlies the Southern Subdomain of the Western Branch of the Cape Fold Belt and refer to this as the Peninsula Microplate. The second proposed microplate (called the Quoin Point Microplate) is situated within the south-western portion of the Southern Branch of the Cape Fold Belt and extends offshore to form part of the Agulhas Arch. The Koeberg Site lies within the Peninsula Microplate.
Studies done by Green and Bloch (1971), on the distribution of aftershocks after the Ceres Earthquake of 29th September, 1969, have delineated a zone of seismic activity which is coincident with the boundary between the Northern and Southern Domains. They have shown that these earthquakes are currently occurring at mid-crustal depths and are associated with left lateral displacement along sub-vertical NW-striking faults. This zone is the eastern margin of the Peninsula Microplate as defined above.
Figure 14: Present-Day Configuration of the Peninsula (PMP) and Quoin Point (QPMP) Micro Plates. (Modified After Ransome and De Wit, 1992).

Inset, the mid-Atlantic Ridge, is offset by a number of transform fracture zones, the most prominent of which is the Meteor Fracture Zone (MFZ). The westward migration of the Mid-Atlantic ridge (MOR), south of this transform currently places the western South African margin under compression. This transmitted stress is taken up by flexuring and strike-slip tectonics along the eastern boundary of the Peninsula Microplate. AFZ = Agulhas Falkland Fracture Zone. PMP = Peninsula Microplate. QPMP = Quoin Point Microplate.
This eastern margin of the Peninsula Microplate also coincides with a neotectonic axis of uplift. Although the mechanism of these “intraplate” earthquakes are not fully understood, Ransome and de Wit (1992) suggest that they may owe their origin to flexure of the Peninsula Microplate due to compression from the Mid-Atlantic-Ridge. This seismically active zone is also coincidental with a major right-lateral transform fault within the Mid-Atlantic-Ridge (the Meteor Fracture Zone). The western margin of South Africa is under compression and this transmitted stress is taken up by flexuring and strike-slip tectonics along the eastern boundary of the Peninsula Microplate.

c) Conclusions with respect to the Microplate Model

The following conclusions can be drawn with respect to the Microplate Model:

(i) The driving mechanism responsible for warping of the Cape West Coast is one of approximately west to east ridge-push being derived from the Meteor Fracture Zone on the Mid Atlantic Ridge. This is indicated by the shear wave splitting and focal mechanism studies.

(ii) The major north-northwest to south-southeast trending faults are considered to be aseismic with respect to the neotectonic compressional stress as they are almost normal to it and could only be reactivated as thrusts. This is most unlikely as the minimum horizontal stress orientation has been shown by the focal mechanism analyses to be horizontal and not vertical as would be required for thrusting. The mechanism for the generation of earthquakes at the Ceres Seismic Centre, on the eastern edge of the Peninsula Microplate is shown in Figure 14. The focal mechanism analysis of the 1969 Ceres earthquake showed that the event was triggered by left-lateral strike-slip motion on a north-west to south-east trending fault plane by east-west compression.

(iii) Neotectonic studies have delineated a zone of seismic activity which is coincident with the boundary between the Northern and Southern Domains. These earthquakes are currently occurring at mid-crustal depths and are associated with left lateral displacement along sub-vertical NW-striking faults. This zone is the eastern margin of the Peninsula Microplate as defined above.

(iv) It is postulated that the major earthquakes are most likely to occur on the eastern edge of the Peninsula Microplate. The granite will act as a resistant buffer transmitting the energy from the ridge push to this position causing left-lateral strike-slip motion on the western branch of the Worcester Fault and crustal warping. The Koeberg Power Station is situated about 70 km from the Microplate edge and therefore the attendant energy release from any such seismic event should be attenuated over this distance.

(v) In their Seismic Hazard Assessment, Stettler et al.,(1999), identify a “Cape Town Cluster” of earthquakes (amongst others) which is based purely on historical evidence.
They then calculate the seismic hazard at the Koeberg Site based on the epicentral distance of Cape Town to Koeberg i.e. 26.9 km. In the light of the Peninsula Microplate model it is considered justified to relocate all of these events to the “Ceres Cluster” near the eastern edge of the microplate (~70 km from Koeberg). This will result in a lower ground acceleration on site. (The Council for Geoscience consider that this is not justified due to the lack of information).

### 4.15.4 The Seismic Hazard Assessment

#### The Technique

The design basis earthquake to be used for the construction of a nuclear power plant may be calculated using either the probabilistic or deterministic methods, however both are generally used. Both methods are based on a seismo-tectonic model of the region which includes the site area. The seismo-tectonic approach is based on identification of seismogenic structures as well as tectonic or seismo-tectonic provinces. Once this has been done then the maximum potential earthquakes related to the structures and/or to the province can be evaluated (probabilistic), and finally these earthquakes’ effects are attenuated to the site (deterministic).

Earthquakes are assumed to occur at the closest approach of the seismogenic structure or seismo-tectonic province to the site when the deterministic approach is used. If the site is in a seismo-tectonic province, which is generally the case, the earthquake associated with this province is assumed to occur at, or close to, the site.

The PARAMETRIC-HISTORIC PROCEDURE for Probabilistic Seismic Hazard Analysis developed by the South African Council for Geoscience (Kijko and Graham, 1998, 1999), combines the best features of the “DEDUCTIVE”(Cornell, 1968), and “historic” procedures (Veneziano ET AL., 1984).

The approach permits the combination of historical and instrumental data. The historical part of the catalogue contains only the strongest events, whereas the complete part can be divided into several sub catalogues, each assumed complete above a specified threshold of magnitude. Uncertainty in the determination of magnitude is also taken into account. The maximum credible magnitude, (also known as the Safe Shutdown Earthquake, SSE), is of paramount importance.

A “Safe Shutdown Earthquake” (SSE), is defined as that earthquake which is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology. It is that earthquake which produces the maximum vibratory ground motion for which certain structures systems and components are designed to remain functional (10CFR100).
Seismic Hazard at the Koeberg Site

Dames and Moore (KSSR, 1998), in their deterministic study, recommended that the seismic source closest to Koeberg Site was the seaward extension of the postulated Milnerton-Cape Hangklip fault (8 km). After going through a probabilistic assessment, as well as using expert opinion, a decision was made that the maximum event size and the associated SSE should be considered as local magnitude 7, in conjunction with the attenuation relationship. The SSE was therefore defined as an event with a local magnitude of 7.0 at a distance of 8 km from the site. Using the attenuation equation, a peak ground acceleration of 0.3g was obtained for the Koeberg Site.

The Council for Geoscience (Stettler, et al., 1999), in their assessment of the seismic hazard of the Koeberg Site recognized four distinctive seismically active source zones, viz. the Worcester-Cango-Baviaanskloof (W-C/B) faults, the Ceres Seismicity Cluster, the Cape Town Seismicity Cluster and the background seismicity of the Cape Low Province. The SSE was calculated for each of these zones as well as the associated PGA at the Koeberg Site which are given in the table below.

<table>
<thead>
<tr>
<th>SOURCE ZONE</th>
<th>M max</th>
<th>PGA (g)</th>
<th>AVERAGE HYPOCENTRAL DISTANCE (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-C/B</td>
<td>5.79</td>
<td>0.02</td>
<td>206.5</td>
</tr>
<tr>
<td>Background</td>
<td>5.79</td>
<td>0.22</td>
<td>19.7</td>
</tr>
<tr>
<td>Cape Town Cluster</td>
<td>6.51</td>
<td>0.27</td>
<td>26.9</td>
</tr>
<tr>
<td>Ceres Cluster</td>
<td>6.73</td>
<td>0.12</td>
<td>66.0</td>
</tr>
</tbody>
</table>

The Ceres Seismicity Cluster had the highest SSE, but the largest PGA came from the Cape Town Cluster.

This seismic hazard analysis yielded a mean PGA of 0.27g for the Koeberg Site. The PGA has a return period of 1 000 000 years.

Conclusions with respect to the Seismic Hazard Assessment

(i) The Koeberg Nuclear Power Station has been designed to withstand a peak horizontal ground acceleration of 0.3g which would result from a Safe Shutdown Earthquake (SSE) with a local magnitude of 7.0 at a distance of 8 kilometres from the site. These were the recommendations made by Dames and Moore.

(ii) A more modern Seismic Hazard Assessment carried out by the Council for Geoscience, indicates that the SSE could arise from the Cape Town Cluster of historic seismic events. The maximum magnitude of the Event would be 6.51 at an average
hypocentral distance of 26.9 km and would result in a peak horizontal ground acceleration of 0.27g on site.

(iii) The Council for Geoscience have also calculated that the maximum magnitude resulting from background seismicity at an average hypocentral distance of 19.7 km would be 5.79 resulting in a peak horizontal ground acceleration at site of 0.22g.

(iv) The Ceres Seismic Cluster has the highest maximum magnitude of 6.73 but due to the hypocentral distance, this event would result in a peak ground acceleration of 0.12g on site.

(v) The Microplate Tectonic model gives the theoretical justification to relocate the Cape Town Seismic Centre to Ceres, thus reducing the attendant seismic hazard of this cluster. The reason for relocating the Cape Town Cluster is that all of these events were historically recorded prior to the advent of seismic instrumentation in South Africa by a population living in mainly the Cape Town area. The rural areas were sparsely populated and communication was minimal. (The Council for Geoscience feel that there is insufficient evidence to relocate the Cape Town Cluster).

4.15.5 Summary of the Main Conclusions

Geology

(i) The Koeberg Site lies within a Cenozoic Depocentre, with the basement rocks along the coastline being at a depth of approximately 10 m below sea-level. The eastern and northern part of this depocentre forms the Atlantis aquifer.

(ii) Of possible concern from a seismo-tectonic perspective, is whether this “Cenozoic Depocentre” is a fault-controlled graben and if so when did the faults last move or is Miocene crustal warping responsible for its formation. The Springfontyn Fault could be one such structure. The oldest sediments overlying the Malmesbury bedrock, and reported from the Koeberg excavation, belong to the Varswater Formation and have been assigned a Mio-Pliocene age (~5 Ma). This could imply that the “Graben” was formed by faulting that took place about 5 million years ago and that the faults therefore have no associated seismic risk.

Structural Geology

(i) On a regional scale, faulting can be seen to have affected all the consolidated rocks of the region. It has however, been reasonably well established that two episodes of both compression and extension (i.e. 4 episodes) have alternated along the southern margins of Gondwana over a period of circa 600 million years since the late Precambrian. Most of the faults in the South Western Cape would have been reactivated during these episodes the last of which occurred 150±50 million years ago.
(ii) Offshore surveys undertaken by Soekor north west of St. Helena Bay and on the Agulhas Bank have established rifting on the continental shelf along NW trending fault zones that probably represent the seaward continuation of major fault zones identified onshore. In the offshore areas, lower Cretaceous sediments are displaced by NW and NNW trending faults. Hence the last documented movement along these faults occurred approximately 110 million years ago.

(iii) If Cretaceous faulting took place in the site area this is most likely to have occurred along old established lines of weakness such as the Klipheuwel-Darling-Saldanha fault zone.

(iv) The detailed geological mapping and evaluation of the bedrock exposed in the investigation for units 1 and 2 of the Koeberg Nuclear Power Station showed fossil borings that penetrate up to 20 cm into the bedrock cutting both fault and joint planes which have not been displaced. The minimum age of the faulting would thus be Mio-Pliocene (~5 million years) which is the age of the overlying Varswater Formation.

(v) There is no evidence of surface faulting.

(vi) The WSW trending Springfontyn Fault (not recognized by the Council for Geoscience) that appears to control the boundary between the high basement to the north and the Cenozoic Depocentre (Atlantis Aquifer) to the south is the only feature that could pose a possible seismic risk. Although the bedrock contours indicate a possible fault scarp, the breccias in the beach outcrop don’t show the intense brecciation that would be expected of a seismically active fault.

Conclusions with respect to Ancient Sea-Level and Crustal Warping

(i) The Cape west coast was probably more unstable during the Cenozoic period than the Cape south coast. The tilting effect is also noted in the Tertiary beach terraces that are down warped from 35 m above sea-level at the Orange River mouth to 5 m above sea-level at Saldanha bay. This axis of tilting has been named the Saldanha-Vredenberg Axis.

(ii) The diamondiferous beach terraces north of Oranjemund have converged as a result of both upward and downward crustal movement that possibly ceased in the Late Pleistocene (~600,000 years ago).

(iii) The 6-8 m sea-level stand, which is recognized around the coastline of South Africa, possibly indicates that tectonic movement of the Cape west coast had ceased by the Latest Holsteinian-Earliest Saalian about 200,000 years ago.
(iv) The Eemian global sea-level high stand attained a maximum elevation of ~5 m above present mean sea-level at about 120,000 years before present, leaving wave-cut terraces and beach deposits which is called the ‘4-6m Package’. The marine part of the package is called the Velddrif Formation.

The Velddrif Formation occurs close to the present-day coastline and extends as far north as Elands Bay and is also present south of the Modder River, at Koeberg Power Station, Rietvlei-Milnerton, Noordhoek beach and Swartklip on the northern shore of False Bay. It occurs on the northern shore of Saldanha Bay and the western shore of Langebaan Lagoon. The Velddrif Formation represents littoral sediments deposited during the Last Interglacial. It is defined on the basis of lithological, palaeontological and temporal criteria and is limited to a maximum storm beach height of ~7 m amsl.

The elevation of the land-ward pinch-out, which would indicate the position of maximum transgression of this Formation has not been determined at any of these sites. However at the Milnerton Lighthouse site, the top of the marine deposit is described as being 2.5 m above the level of Low Water Spring Tide. This was the position of the Formation where it had been exposed by storm wave action and no further land-ward excavation was undertaken to determine the limit of the marine deposit the base of which may achieve higher elevations (4 m).

Due to the extensive distribution of the Velddrif Formation as described above it is postulated that it is unlikely that major vertical fault displacement (causing graben development) has occurred on the Springfontyn Fault in the past 117,000 years.

(vi) A Mid-Holocene (5,000 year) +2 m sea-level also left recognizable terraces and deposits throughout the southwestern and southern Cape coast (Langebaan to Knysna). The consistent nature of these terraces could possibly also corroborate the notion that there has been no tectonic activity since at least the Eemian.

Conclusions with respect to the Seismo-tectonic Model

a) The Neotectonic Stress Field

(i) The orientation of the maximum horizontal stress field driving the movement of the Peninsula Microplate is WNW (focal mechanisms) and ENE-WSW (62° from shear wave splitting). In the light of the above results, it is therefore concluded that the major NNW-SSE trending faults are not seismogenic as their orientation is almost normal to the prevailing neotectonic stress field. However the ENE-WSW and E-W trending faults (such as the Springfontyn Fault) should be considered, in nuclear siting terms, to be potentially “capable” as they are sub-parallel to this stress field. The Springfontyn Fault is composite, consisting of several, possibly en-echelon strike slip faults.
(ii) A fault would be considered “capable” if it had associated instrumentally recorded seismicity. None of the WSW-ENE trending faults have shown any seismicity over the past 26 years.

(iii) The Springfontyn Fault lies within the granite intruded Peninsula Microplate. It could therefore be argued that this granite intruded plate could act as a buffer and the seismic energy release (resulting from ridge push) was more likely to take place on the eastern boundary of the Microplate rather than by moving the fault.

Conclusions with regard to Structural Analysis, Fault Rupture Length and Peak Ground Acceleration (PGA)

The stress theory predicts that faults with a strike orientation lying close to the principal stress axis could be reactivated. This implies that the Springfontyn and other WNW trending faults are potentially capable.

(ii) The Koeberg NPS has been designed for a Safe Shutdown Earthquake (SSE) with a PGA of 0.3 g (KSSR, 1998) and the proposed plant for a SSE with a PGA of 0.49g (DFR).

(iii) When considering the PGA versus fault rupture length relationships, a PGA of 0.3g on site would require a fault rupture length of approximately 2.5 km. Field examination of the Springfontyn Fault exposure in the beach outcrops, gives no indication by way of breccia and mylonitization that recent movement of this magnitude has taken place. This fault therefore poses no threat to the Koeberg NPS or the proposed PBMR demonstration plant.

Conclusions with respect to the Microplate Model

(i) The driving mechanism responsible the warping of the Cape West Coast is one of approximately west to east ridge-push being derived from the Meteor Fracture Zone on the Mid Atlantic Ridge. This is shown by the shear wave splitting and focal mechanism studies. This mechanism is also responsible for generating the earthquakes at the Ceres Seismic Centre, on the eastern edge of the Peninsula Microplate. These earthquakes are currently occurring at mid-crustal depths and are associated with left lateral displacement along sub-vertical NW-striking faults.

(ii) The major NNW - SSE trending faults are considered to be aseismic with respect to the neotectonic compressional stress as they are almost normal to it.

(iii) It is postulated that the major earthquakes are most likely to occur on the eastern edge of the Peninsula Microplate. The granite will act as a resistant buffer transmitting the energy from the ridge push to this position causing left-lateral strike-slip motion on the western branch of the Worcester Fault.
(iv) In their Seismic Hazard Assessment, Stettler et al. (1999), identify a “Cape Town Cluster” of earthquakes and calculate the seismic hazard at the Koeberg Site based on the epicentral distance of Cape Town to Koeberg i.e. 26.9 km. In the light of the Peninsula Microplate model it is considered justified to relocate all of these events to the “Ceres Cluster” near the eastern edge of the microplate (~70 km from Koeberg). This will result in a lower ground acceleration on site.

Conclusions with respect to the Seismic Hazard Assessment

(i) The Koeberg Nuclear Power Station has been designed to withstand a peak horizontal ground acceleration of 0.3g which was recommended in earlier studies by Dames and Moore. The proposed Plant will be designed to withstand a PGA of 0.4g (DFR).

(ii) A more modern Seismic Hazard Assessment carried out by the Council for Geoscience, indicates a peak horizontal ground acceleration of 0.27g on site.

(iii) The Council for Geoscience have also calculated that the maximum magnitude resulting from background seismicity would result in a peak horizontal ground acceleration at site of 0.22g.

(iv) The Ceres Seismic Cluster has the highest maximum magnitude of 6.73 (Richter scale) but due to the hypocentral distance, this event would result in a peak ground acceleration of 0.12g on site.

(v) The Microplate Tectonic model gives the theoretical justification to relocate the Cape Town Seismic Centre to Ceres, thus reducing the attendant seismic hazard of this cluster. (The Council for Geoscience disagree with this postulation as they feel that there is insufficient historic evidence.)

(vi) The demonstration module PBMR has a design basis to withstand a peak horizontal ground acceleration (PHGA) of 0.4g which will be adequate to withstand the calculated PHGA of 0.3g. (PBMR Demo Plant DFR (2001))

(vii) During site excavation careful observations must be conducted by a competent geologist to confirm that bi-valve borings are not displaced and also to look for signs of liquefaction although it is anticipated that neither will be observed.
4.15.6 REFERENCES

10 CFR 100  United States Nuclear Regulatory Commission, RULES and REGULATIONS. Title 10, Chapter 1. CODE OF FEDERAL REGULATIONS. May 31, 1984.


PBMR Demo Plant DFR, Doc no. 009838-160 Rev 1 (confidential report)


4.16 HYDROLOGICAL & GEOHYDROLOGICAL ASSESSMENT OF THE KOEBERG SITE AND SUB-REGION

4.16.1 INTRODUCTION

The geohydrological setting of Koeberg was evaluated from all the existing information consisting of available reports prepared since site selection and construction. A hydrocensus was conducted to record all existing boreholes around Koeberg Nuclear Power Station (KNPS) and sample them for both chemistry as well as environmental isotopes. The objective of the investigation was:

- To compile a baseline document for future reference and provide baseline data for the proposed PBMR project.
- To evaluate the potential impact of releases on groundwater users.
- To recommend management/monitoring measures for consideration during design construction and operation of the proposed PBMR demo plant.

4.16.2 PHYSIOGRAPHY

The area of interest is located on the Cape West Coast approximately 30 km north of Cape Town in an area devoid of rivers, streams or any major drainage channels.

To the southeast of Koeberg there are two seasonal drainage channels. The Donkergat River flows into the Sout River, which flows into the sea at the “Ou Skip” caravan park in Melkbosstrand. Due to the high permeability of the unconsolidated sands no runoff occurs in the area. Water logging of limited areas of the ground occurs after intense periods of precipitation. However no flooding or stream flow occurs from adjacent properties. No dams or natural reservoirs exist in the area however several wetlands exist in the area. The wetlands are more prominent during the rainy season and some tend to shrink and dry up during the dry season.

4.16.3 SITE INVESTIGATIONS

The investigations were restricted to the KNPS property, which covers the farms Dujnefontyn and Kleine Springfontyn. The fieldwork conducted during September 1999, consist of locating and sampling existing boreholes drilled by CSIR (Fleisher, 1993), SRK (1995), Greef (1995) as well as wellpoints and construction monitoring boreholes at the KNPS site (Africon, 2000). The Aquarius Well Field was not in operation and boreholes were not accessible, however a sample was taken from the well field water. 18 Boreholes were located of which 17 could be sampled. Only 3 boreholes on the
Department of Water Affairs and Forestry Database are on the site. However, they were damaged, closed and not accessible for sampling. The locality and distribution of all these boreholes are shown on Figure 15.

At the sampling site, parameters such as temperature, electrical conductivity and pH as well as the depth of the water level below surface were recorded. Samples were taken for chemical analysis as well as for isotopic analysis. The chemical analysis was carried out by the CSIR, Stellenbosch, while the Schonland Research Centre, University of the Witwatersrand, carried out the isotope analysis.

Geology

The geology of the area is dealt with elsewhere in detail, by Andersen, as part of this project. However, very important is Andersen's structural map indicating the topography of the basement rocks underlying the sand and other recent formations. His map shows the basement topography, just north of KNPS, sloping from a height of more than 60 metres above mean sea level (mamsl) about 5 kilometres inland to 0 mamsl and even below mean sea level along the coast line. This sloping trend can be extrapolated through the Koeberg Site where bedrock elevations of between 8 and 12 metres below mean sea level are indicated.

The following description by Greef (1995) serves as background geological information to the geohydrology of the area. The bedrock of the area consists of shale, siltstone and greywacke beds of the Tygerberg Formation of the Malmesbury Group of sediments, which dip 60° to the west and are exposed on Blouberg Hill and along the coastline. Weathering has reduced the upper 20 metres of the bedrock to clay and soft shale, but this material becomes firmer and eventually grades down into very hard-indurated shale or hornstone. Fracture zones in this bedrock material are infilled by secondary quartz to form a honeycomb structure, which has a high degree of porosity, and permeability from which good supplies of water may be obtained.

In the Koeberg area the bedrock is covered by between 10 and 15 metres of unconsolidated sediments belonging to the Witzand Formation. The sediments consist of a thin layer of marine gravel at the base, covered by wind-blown sand, interlayered with some layers of hillwash and stream sediment which have been introduced from the east. The dunes to the north of the KNPS consist of recent windblown sand.

4.16.4 Regional Geohydrology

There is a vast age difference between the hard crystalline base rock formations and the overlying unconsolidated and semi-consolidated sedimentary rocks. The water-bearing properties of these rock types also differ and two different water-bearing formations or aquifers are distinguished namely, primary aquifer for the sedimentary rocks and
rocks and secondary aquifer for the crystalline rocks.

A primary aquifer or unconfined aquifer is one in which the water table serves as the upper surface of the zone of saturation. It is also known as a free, phreatic or non-artesian aquifer.

The water table undulates and changes in slope, depending upon areas of recharge and discharge, pumpage from wells and permeability of the strata. Rises and falls in the water table correspond to changes in the volume of water in storage within the aquifer.

A secondary aquifer and normally confined aquifer, also known as an artesian, sub-artesian or pressure aquifer occurs where ground water is confined under a pressure greater than atmospheric by overlying relatively impermeable strata. Rises and falls of water level in wells penetrating confined aquifers result primarily from changes in pressure rather than changes in storage.

PRIMARY AQUIFER

Occurrence

The Cenozoic sediments, which host this aquifer, are up to 50 m thick. These sediments are divided into the Varswater and Bredasdorp Formations each with widely varying properties. The aeolian Bredasdorp Formation consisting of the Springfontein, Mamre and Witzand Members, and is of particular interest as it represents the deposits from which most ground water is exploited (Murray et al, 1988).

Groundwater flow

The regional groundwater flow has been well studied in the Atlantis area but not in that detail in the Koeberg area. As far as could be established, few regional boreholes are available east and south of the Koeberg site to establish the regional flow pattern. In the Atlantis area the gradient of the groundwater is generally steep (on the average 1 in 58) in a south-westerly direction towards the coast. Due to the unconfined nature of the sediments recharge takes place over the entire area. Computer modeling has been carried out in the Atlantis and Witzands area to establish the impact of groundwater withdrawal on the regional pattern.

Groundwater Quality

Not much data is presently available on regional groundwater quality. According to Murray et al (1988) the groundwater quality in the Atlantis area varies from point to point largely because of variations in characteristics of the deposits and in natural recharge rates. The best water quality is in the barren dune area to the
dune area to the east of the West Coast Road. In other areas the water quality is more saline, which means that over-exploitation may lead to deterioration in quality. An area of higher salinity in the KNPS region is shown by the Department of Water Affairs and Forestry's published map of the regional groundwater quality.

- **Groundwater use**

  The groundwater from the Atlantis and Witzand well fields is used for domestic and industrial use at Atlantis.

- **Secondary Aquifer**

  - **Occurrence**

    The secondary aquifer occurs in the fractured, faulted and sheared crystalline or metamorphic basement rock underlying the Cenozoic sediments. In a large part of the area these rocks are either granite from the Cape Granite Suite or rocks of the Malmesbury Group. Very little is known about this aquifer as no exploitation of groundwater is undertaken due to the poor quality of the groundwater. During the initial excavations at the Koeberg site pressures in these structures were found to be artesian which may also have a leakage impact on withdrawal in the unconfined aquifer as was reported during Koeberg dewatering.

    **Groundwater quality.**

    Generally the water quality in the Malmesbury Group aquifers is poor and saline. Leakage from this aquifer into the overlying Cenozoic Sedimentary aquifer may cause deterioration in water quality. Little is known regarding recharge or the dynamics of this aquifer. As far as could be established there are no users of this groundwater in the area.

4.16.5 **SITE GEOHYDROLOGY**

The site geohydrology is documented in the Koeberg Site Safety Report. The studies on the KNPS were aimed at assessing the impact of dewatering and the impact of the groundwater on the cement structures. Other studies were aimed at water supply to the KNPS. The studies by SRK (1994), CSIR (Fleischer, 1992, 1993) and Greef (1995) would fall into this category.

At present the only site specific information consist of the geotechnical information by Jones and Wagener (2000). A geohydrological site evaluation on the guidelines of the IAEA (1984) fell outside the scope of this investigation and still need to be considered by PBMR.

- **Primary Aquifer**
Occurrence

The unconfined primary aquifer occurs in the unconsolidated sediments: viz marine, fluvial and aeolian sands with lenticular pedogenic horizons near the surface. The thickness of these sandy strata overlying the bedrock averages 20 m in the west and up to more than 30 m in the east. These thickness' are based on the reports of SRK (1994), the CSIR (1993) and the recent drilling on the proposed PBMR site by Jones & Wagener (2000).

The best description is from the Fleisher (1993) report describing the geometry and composition of the aquifer. The aquifer north of Koeberg is 6m thick and composed of mostly unconsolidated sands of various grain sizes, with occasional streaks of calcite. The lower part consists of pebbly sand grading down into gravels. The aquifer rests on a dark, clayey, silty sand formation, apparently of very low permeability.

In the KNPS site area the latest drilling indicated a profile consisting of sand at the top becoming organic rich with shell fragments below 7.5 m. Towards the base the quartz grains are sub-rounded. This aquifer rests on weathered bedrock consisting of impervious clay.

Groundwater flow

The groundwater levels measured varied between 0.4 m near KNPS to 16 m below surface in the north near Springfontein. Seventeen boreholes were measured and their localities are shown on Figure 1 and reported in Africon (2000). Fluctuations in the groundwater levels were observed by previous studies. However, it is not clear if the impact of the tidal and seasonal fluctuations was taken into account. The present impact of abstraction of water in the well fields to the north and north-east is expected to be insignificant. Groundwater simulations showed that seasonal rain variations will also not significantly affect groundwater flow or level in the Koeberg area. A range of permeability’s varying from $10^{-4}$ m/s in the overlying sands to a low of $10^{-8}$ m/s in the underlying marine sands were measured (KNP Site Safety Report REV 1, 1998). Recent investigations (Jones & Wagener, 2000) confirmed that permeabilities is less in the underlying marine sands.

The latest studies by Anderson show that in the area north of KNPS the topography of the basement underneath the sand and sediment cover slope towards the coastline. The few data points in the KNPS area indicate that this trend can be extrapolated south across the Koeberg Site. Rainwater percolating into the sand
into the sand and sediments will collect on this surface and flow towards the coast. The general flow of the groundwater is west to south westerly towards the sea.

Due to the unconfined nature of the sediments recharge takes place over the entire area and flows towards the coast. The only way in which groundwater can flow inland is if the flow is reversed by drawing down during pumping. Computer modeling has been carried out in the Atlantis and Witzands area by the CSIR to establish the impact of groundwater withdrawal on the regional pattern. The impact of abstraction from Koeberg production boreholes to the south of the Atlantis and Witzand well fields, has also been simulated by the CSIR (Du Toit et al, 1995). As shown in Figure 16, even at highest possible production rate the draw down contours do not reach Koeberg. It is therefore concluded that in the unlikely event of groundwater being contaminated at Koeberg, the contamination can never impact on the Witzand or Atlantis Aquifers.

The ingress of saltwater into this aquifer during construction is an indication that the drop in overlying pressure through dewatering can cause influx of saline water be it from the underlying aquifer or the ocean.

- **Groundwater Quality**

  Seventeen samples were collected during the first sampling exercise in September 1999, and the localities are shown in Figure 15 (Africon, 2000). The results of the chemical analyses are listed in Table 44. Three of the new boreholes on the proposed PBMR Site south of the KNPS, were collected during August 2000 and their chemical results are also shown Table 44. The chemical analyses confirmed the existing regional map Figure 17 published by the Department of Water Affairs and Forestry (DWAF), showing that KNPS is located in an area with groundwater salinity higher than 300 mg/l Chloride.

- **Groundwater use**

  Groundwater of the above quality is not considered suitable for domestic use according to the Department of Water Affairs and Forestry classification (Water Research Commission, 1999). However, groundwater is abstracted from ten boreholes at the Aquarius well field for use on the KNPS site. The groundwater from this well field is used for domestic and industrial as well as conjunctive use with surface water in the case of Koeberg.

  There are a number of well points on the Koeberg site and numerous at the Duinefontein township, used for gardening purposes.
Secondary Aquifer

The secondary aquifer on site was not studied in detail as only three boreholes in this aquifer were sampled. Little is known except that it contains saline water and under dewatering of the overlying sedimentary formations, influx of the saline water may occurred.

- Water levels

  The water levels measured in the three boreholes in this aquifer confirmed the confined nature of this aquifer as the water struck at depth rise to within about 4 m from surface. At the PBMR Site it was found that hydraulic continuity exist between the primary and the secondary aquifers. During dewatering of the overlying sedimentary aquifer influx can therefore be expected of saline water from this aquifer.

- Groundwater quality

  Two boreholes, KB17 and PO1 sampled groundwater from this secondary aquifer. Both samples show high salinity especially high sodium chloride values and extremely low sulphate values (almost depleted values). Alkalinity is also low and the impact of this water quality on cement is addressed in previous studies by KNPS (KNPS Safety Report, 1998).

- Groundwater flow

  Little data is available regarding the flow of groundwater in the secondary aquifer but it is expected that the flow is towards the sea.

- Groundwater Use

  Due to the high salinity the water is not used and there are no known groundwater users.
Figure 15: Localities of Groundwater Samples
**Figure 16**: Groundwater Draw Down Contours

![Groundwater Draw Down Contours Map](image-url)
Figure 17: Groundwater Salinity Levels
4.16.6 ISOTOPE HYDROLOGY

The environmental isotopes species employed in this study are the non-radioactive (or “stable”) isotopes Oxygen-18 (\(^{18}\)O) and Deuterium (\(^{2}\)H) and the radioactive isotope Tritium (\(^{3}\)H). These label the water molecule itself or the carbonate and bicarbonate ions in the groundwater.

Knowledge of the isotope ratios enable us to:

- Determine the origins and ages of different water bodies;
- Provide an estimate of the degree of mixing;
- Determine the location and proportion of water recharge; and
- Indicate the velocity of groundwater flow.

Stable isotope oxygen –18 (\(^{18}\)O) and deuterium (\(^{2}\)H)

Oxygen–18 (\(^{18}\)O) together with deuterium (\(^{2}\)H) are present in water in isotopic abundances of about \(^{18}\)O/\(^{16}\)O = 0.2% and \(^{2}\)H/\(^{1}\)H = 0.015% with respect to the common, lighter isotopes \(^{16}\)O and \(^{1}\)H respectively. In various combinations, these isotopes constitute water molecules, principally of masses 18, 19 and 20. In phase processes such as evaporation and condensation, the different vapour pressures of these molecules cause small changes in the isotopic abundances, the heavier isotopes tending to concentrate in the denser phase. These small changes can be expected as a fractional deviation from a standard called SMOW (standard mean ocean water), defined as:

\[
\delta = \left[ \left( \frac{R_s}{R_r} \right) - 1 \right] \times 1000 \text{ (‰)}
\]

where \(R_s\) and \(R_r\) are the ratios of the abundances of the rare (heavier) isotope to the more abundant (light) isotope for the sample and reference standard, respectively.

‰ = per mil or per 1000

Physical processes such as evaporation can change these \(\delta\) values from that in the original precipitation. The \(\delta\) values can therefore be diagnostic of water from different origins. However, the \(^{18}\)O and \(^{2}\)H values determined for directly recharged ground water do not differ considerably from that of rainwater.

The results of the stable isotope analyses are shown in Table 44. It can be said that in the dune area the Oxygen-18 values are well below \(-4.00\) \(\delta_{18}\)O‰ whereas outside the dunes where shallow groundwater occur, some evaporation is visible and values approach \(-2.00\) \(\delta_{18}\)O‰ and higher. These values probably represent mixed water. The deuterium values show a similar trend as the \(\delta^{18}\)O, confirming the evaporated nature of the shallow
the shallow well points.

Tritium (³H)

This isotope is formed in the upper atmosphere through nuclear reactions involving cosmic ray neutrons. Oxidised to water, mainly in the form ³H/¹H₂O, it reaches the surface of the earth as part of rain water, in which it is quasi-conservative. The isotopic ratio ³H/¹H is established by this natural source in continental environments and is about 3 x 10⁻¹⁸, or 3 TU (tritium units) in the Southern Hemisphere and of the order of 30 in the Northern Hemisphere. Tritium is radioactive with a half-life of 12.43 years. When rain water is isolated from the atmospheric source, i.e. no new tritium is added, the tritium content will decrease with this characteristic half-life.

The useful range of measurement of environmental tritium in geohydrological applications spans four to five half-lives. It is therefore measurable only in, and can act as an indicator of, very recently recharged ground water. Since the middle fifties the atmospheric source increased due to nuclear fallout. Since the middle sixties, rainwater tritium levels have declined, to reach about pre-bomb levels in non-industrialised areas at present. It is possible to identify the recharge period of recent groundwater by comparing its tritium content with those of present day rainfall. It is an accepted fact that ground water could be stratified, depending on the hydraulic properties of the aquifer. It is therefore possible to get mixtures between recent rainwater and old water with low or nil tritium.

The tritium values for all the samples taken are shown in Table 45. Zero to near zero values of naturally occurring tritium is recorded in boreholes in the secondary aquifer. These low values indicate less dynamic groundwater regimes and almost zero recharge to this aquifer.

Low tritium is also noted in the deeper boreholes in the primary aquifer in the Aquarius wellfield, indicating slower movement and recharge to these parts of the aquifer. The significant tritium (>1) values in the primary aquifer indicate a fairly dynamic system with turnaround times within a decade or two. This is in line with what one would suspect from an unconfined aquifer. However, stratification in age of the groundwater is suspected and the samples probably represent a mixture of water of various ages.

The Department of Water Affairs and Forestry (2000) is presently publishing a guideline document for radioactive dose calculation in water for domestic use. Tritium is not specifically addressed but reference is made to the Euratom Commission recommendation for tritium, which is 100 Bq/l. The highest value recorded during the present investigation is only about 5 Bq/l, which is well within this limit.
**Table 45**: Results of the chemical and environmental analysis on the boreholes sampled September 1999.

<table>
<thead>
<tr>
<th>SAMPLE ID:</th>
<th>KB 1</th>
<th>KB 2</th>
<th>KB 3</th>
<th>KB 4</th>
<th>KB 5</th>
<th>KB 6</th>
<th>KB 7</th>
<th>KB 8</th>
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<tr>
<td><strong>Potassium as K mg/1</strong></td>
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<td>2.</td>
<td>6.</td>
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<td>3.</td>
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<td>7.</td>
<td>3.</td>
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<td><strong>Sodium as Na mg/1</strong></td>
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<td>5</td>
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<td>8</td>
<td>21</td>
<td>41</td>
<td>9.</td>
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<td>9</td>
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<td>8.</td>
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<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>8.</td>
</tr>
<tr>
<td><strong>Sulphate as SO4 mg/1</strong></td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>9</td>
<td>11</td>
<td>8.</td>
</tr>
<tr>
<td><strong>Chloride as Cl mg/1</strong></td>
<td>25</td>
<td>5</td>
<td>25</td>
<td>24</td>
<td>11</td>
<td>38</td>
<td>71</td>
<td>13.</td>
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<tr>
<td><strong>Alkalinity as CaCO3 mg/1</strong></td>
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<td>22</td>
<td>19</td>
<td>21</td>
<td>17</td>
<td>21</td>
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<td>16.</td>
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<td>&lt;0,</td>
<td>&lt;0,</td>
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<td>0.1</td>
<td>0.1</td>
<td>&lt;0,</td>
<td>&lt;0,</td>
</tr>
<tr>
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<td>6</td>
<td>13</td>
<td>12</td>
<td>7</td>
<td>17</td>
<td>26</td>
<td>9.</td>
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<tr>
<td><strong>pH (Lab)</strong></td>
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<td>7.</td>
<td>7.</td>
<td>7.</td>
<td>7.</td>
<td>7.</td>
<td>7.</td>
<td>8.</td>
</tr>
<tr>
<td><strong>Total Dissolved Solids (Calc) mg/1</strong></td>
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<td>40</td>
<td>83</td>
<td>80</td>
<td>49</td>
<td>112</td>
<td>170</td>
<td>59.</td>
</tr>
<tr>
<td><strong>Hardness as CaCO3 mg/1</strong></td>
<td>47</td>
<td>20</td>
<td>28</td>
<td>30</td>
<td>20</td>
<td>39</td>
<td>41</td>
<td>24.</td>
</tr>
<tr>
<td><strong>δ 18O ‰</strong></td>
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<td>-1.8</td>
<td>-4.0</td>
<td>-4.0</td>
<td>-4.2</td>
<td>-3.4</td>
<td>-2.7</td>
<td>-4.1</td>
</tr>
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<td>2.5±0.</td>
<td>1.0±0.</td>
<td>0.2±0.</td>
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<td>KB 13</td>
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<tr>
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<td>2</td>
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<td>1</td>
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<td>Sodium as Na mg/</td>
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<td>25</td>
<td>36</td>
<td>3</td>
<td>9</td>
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<tr>
<td>Calcium as Ca mg/</td>
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<td>13</td>
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<td>9</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Magnesium as Mg mg/</td>
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<td>5</td>
<td>4</td>
<td>2.</td>
<td>8</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Sulphate as SO4 mg/</td>
<td>12</td>
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<td>34</td>
<td>14</td>
<td>2</td>
<td>4</td>
<td>14</td>
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</tr>
<tr>
<td>Chloride as Cl mg/</td>
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<td>26</td>
<td>60</td>
<td>3</td>
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<td>36</td>
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<tr>
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<td>19</td>
<td>4</td>
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<td>3</td>
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<tr>
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<tr>
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<tr>
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<td>123</td>
<td>140</td>
<td>154</td>
<td>16</td>
<td>57</td>
<td>121</td>
<td>234</td>
</tr>
<tr>
<td>Hardness as CaCO3 mg/</td>
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<td>38</td>
<td>66</td>
<td>39</td>
<td>6</td>
<td>15</td>
<td>29</td>
<td>49</td>
</tr>
<tr>
<td>δ 18O %</td>
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<td>-2.9</td>
<td>-3.3</td>
<td>-3.3</td>
<td>-4.1</td>
<td>-1.8</td>
<td>-2.1</td>
<td>-4.3</td>
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<tr>
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<td>42.5±1.</td>
<td>4.8±0.</td>
<td>2.6±0.</td>
<td>0.3±0.</td>
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</tbody>
</table>
(continue)

<table>
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<tr>
<th>SAMPLE ID:</th>
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<th>PO4</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sodium as Na mg/L</td>
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<td>37</td>
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</tr>
<tr>
<td>Calcium as Ca mg/L</td>
<td>6, 13</td>
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</tr>
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<td>Magnesium as Mg mg/L</td>
<td>3, 4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Sulphate as SO4 mg/L</td>
<td>2, 4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Chloride as Cl mg/L</td>
<td>98, 75</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Alkalinity as CaCO3 mg/L</td>
<td>5, 24</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Nitrate plus nitrite as N mg/L</td>
<td>&lt;0, &lt;0, &lt;0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity mS/m @25°C</td>
<td>30, 27</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>pH (Lab)</td>
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<td>8</td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids (Calc) mg/L</td>
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<td>175</td>
<td>174</td>
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<tr>
<td>Hardness as CaCO3 mg/L</td>
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<td>56</td>
</tr>
<tr>
<td>δ D ‰</td>
<td>-19, -19, -20</td>
<td></td>
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</tr>
<tr>
<td>δ 18O ‰</td>
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<td>-4.1</td>
<td></td>
</tr>
<tr>
<td>Tritium TU</td>
<td>0.1±0.</td>
<td>1.2±0.</td>
<td></td>
</tr>
</tbody>
</table>

**4.16.7 IMPACT OF THE PBMR PLANT**

Two scenarios are considered namely, under normal conditions and during an incidence. Only impact on the water environment is considered as atmospheric releases are considered elsewhere.

**UNDER NORMAL CONDITIONS**

Any possible release of radioactivity during normal operational conditions reaching the primary aquifer on site will flow towards the sea as previously explained. The quantification of releases from the PBMR is addressed elsewhere and this section only deals with the subsequent movement of any activity that is deposited into the groundwater. The movement of such activity will be restricted to the PBMR site in stagnant or faster flowing zones. At maximum it will follow the general groundwater flow which is west to south-westerly towards the sea. Monitoring boreholes installed before commissioning will detect any possible contamination of groundwater before it can impact on the groundwater used by residents for gardening to the south of the site.
UNDER INCIDENT CONDITIONS

Any activity reaching the groundwater will follow the general regional flow pattern, which is west to south-westerly. The levels and movement may be restricted by the design of the site and freedom of movement of groundwater around or through the site. Monitoring boreholes should be installed on and away from the site to monitor any impact on the groundwater used by residents for gardening to the south of the site. Details on movement of activity in the environment are addressed elsewhere.

It is concluded that the impact on the groundwater will be restricted to the site and within its boundaries. Any pollution contaminating the groundwater will eventually move out of the system to the ocean. Impact area(s) can be controlled and monitored until contamination levels have decreased to acceptable levels. No contamination will be drawn into the well fields to the northeast, from contaminated groundwater in the vicinity of the site as shown by the CSIR modeling.

AVAILABLE INFORMATION

The following maps, reports and publications were consulted:

- 1: 250 000 Geological Series map 3318 CAPE TOWN
- 1: 50 000 Topographical Sheet 3318C B MELKBOSSTRAND
- 1: 500 000 Hydrogeological Map Series 3317 CAPE TOWN
- Koeberg Site Safety Report REV 1, Chapters 9, 10 and 11. ESKOM dated 1998.
- Dames & Moore, The probability of the increase of the seawater to the area surrounding the foundations of Units 1 and 2 – Koeberg Power Station. ESCOM – July 1977.
4.16.8 EMP

In order to avoid or minimise any impact by the PMBR plant on the groundwater environment it is necessary to plan and program certain actions into the construction and operational phases of the PMBR project. This will allow early detection of any deviation from the norm and timely action can be taken to address the incident.

During construction

It is assumed that information regarding boreholes drilled to investigate the suitability of a proposed site will be archived for reference and as baseline data. These boreholes all lie within the construction zone and will probably not be preserved as monitoring boreholes. It is therefore necessary to make provision for the drilling and construction of boreholes for monitoring before construction of the facility commence. The locality of the boreholes will be determined by the site-specific geological and geohydrological information. This information should be obtained from a geohydrological investigation of the proposed site before construction.

Based on the Koeberg experience provision for at least six monitoring boreholes should be made. At least three boreholes should be placed upstream and three downstream. Two are to be drilled on the centreline (in the direction of flow) of the structure, the remaining boreholes are to be located adjacent to the structure but far enough to detect and monitor the pluming effect of any contamination. It will be necessary to drill at an upstream and downstream borehole locality, two boreholes, one monitoring the primary and one monitoring the secondary aquifer at that locality.

It is important to note that similar to the situation during Koeberg site de-watering, leaking of saline groundwater from the confined Malmesbury aquifer will impact on the quality of the primary aquifer in the vicinity of the excavations. It is important that this impact be closely monitored during and after construction. Observing the tritium isotope levels in the monitoring boreholes can monitor mixing of groundwater from the two aquifers. The primary aquifer display a rain water tritium signal whereas the secondary aquifer contains zero tritium. The mixing will fall in-between these values. Monitoring of the water levels (pressure levels) in the monitoring boreholes will also be an important indicator of mixing during construction.
The following actions are recommended during the construction phase:

- Care must be taken when drilling monitoring holes that no contamination of the primary aquifer occur therefore boreholes drilled into the secondary aquifer should be sealed off as leakage into the primary aquifer can cause flow and alter flow patterns in the primary aquifer.

- The impact on the primary aquifer by saline water intrusion before and after de-watering should be monitored monthly and recorded in order to understand future groundwater flow in the vicinity of the building structures. In this respect monitoring of water levels, water quality and tritium isotope levels will be important indicators. This can continue for several years after construction until the conditions return to that recorded before construction.

- The water level in the monitoring boreholes should be recorded weekly for at least one full hydrological cycle to establish the impact of the rainy and dry seasons on the water level.

- It is recommended that base line water quality and environmental isotope data is obtained from any new borehole drilled on or near the site. Base line data should be collected as soon as the boreholes are constructed and should continue at least two years before commissioning. Water sampling should be taken monthly for quality and stable isotopes. Tritium level in the monitoring boreholes as baseline data is absolutely vital and only need to be sampled annually.

- Water quality (at least EC) should be monitored weekly, through at least one hydrological cycle to establish the impact of the rainy season on the quality.

- At least one rainwater sample per season should be collected for environmental isotope analysis to serve as background value. Combined sample of a period of rainfall will be preferable. This should be taken in consultation with the isotopes laboratory.

- Monitoring of the most important indicators such as electrical conductivity (EC), pH temperature should be done on site while the normal macro chemical analysis and isotope analysis is done at the laboratories. Any parameter that is considered important in the future operation of the PMBR could be added to the list.

- During operation

The following actions are recommended during the operational phase of the project:

- For the first year monthly samples should be taken from the monitoring boreholes and any other point considered important, for water quality testing. Intervals can
be changed to quarterly after one year, however, should any anomalous values be obtained, sampling must be more frequent until the problem is solved.

- Environmental isotope analysis should be checked annually. Especially tritium should be done for the PBMR Site south of the KNPS as this isotope could be an early indicator of operational contamination.

- Water levels should be monitored monthly and if any anomalous values are recorded then the readings must be more frequently until the problem has been resolved.
4.17 METEOROLOGICAL CHARACTERISTICS OF THE KOEBERG SITE AND SUB-REGION

4.17.1 INTRODUCTION

The proposed Plant will be located some 400 meters southeast of Koeberg. The meteorological database, analysis and dispersion modeling capability of Koeberg is therefore of advantage to the proposed Plant.

This information is applied to model the dispersion of operational/accidental releases of radioactivity from the Plant to determine the dose risk to the public.

4.17.2 CLIMATIC DATA ANALYSIS FOR KOEBERG SITE AND SUB-REGION

The report prepared by Cape Weatherwise International (2001) Annexure 5 provides information on the following climatic conditions:

- Wind speed and direction
- Atmospheric Dispersion
- Temperature
- Precipitation
- Thunder and hail
- Snow and frost
- Fog

4.17.3 DISCUSSION

The seasonal wind frequency data indicates a predominance of southerly winds in summer while northerly winds dominate in winter. Emission plume dispersion modeling around Koeberg used models developed by Pasquill (1961) and modified by Gilford (1962). From these models the ratio of concentration of emission from a continuous sources (X) and the emission rate (Q) was calculated employing the Koeberg climatic data. (Wind rose data for January to December representing averages for 20 years, is provided in the attached Figure 18 to Figure 29.)
**Figure 18**: Wind Rose January

![Average Wind Rose - January 1980-2000 KOEBERG](image)

Radial scale = 0 to 20% in 5% intervals.

**Figure 19**: Wind Rose February

![Average Wind Rose - February 1980-2000 KOEBERG](image)

Radial scale = 0 to 20% in 5% intervals.
**Figure 20**: Wind Rose March

**Figure 21**: Wind Rose April

**Average Wind Rose - March 1980-2000 KOEBERG**

**Average Wind Rose - April 1980-2000 KOEBERG**

Radial scale = 0 to 20% in 5% intervals.
**Figure 22** Wind Rose May

![Average Wind Rose - May 1980-2000 KOEBERG](image)

Radial scale = 0 to 20% in 5% intervals.

**Figure 23** Wind Rose June

![Average Wind Rose - June 1980-2000 KOEBERG](image)

Radial scale = 0 to 20% in 5% intervals.
Figure 24 Wind Rose July

Average Wind Rose - July 1980-2000 KOEBERG

Radial scale = 0 to 20% in 5% intervals.

Figure 25 Wind Rose August

Average Wind Rose - August 1980-2000 KOEBERG

Radial scale = 0 to 20% in 5% intervals.
Figure 26 Wind Rose September

Average Wind Rose - September 1980-2000 KOEBERG

Radial scale = 0 to 20% in 5% intervals.

Figure 27 Wind Rose October

Average Wind Rose - October 1980-2000 KOEBERG

Radial scale = 0 to 20% in 5% intervals.
Based on a number of assumptions (as given in Annexure 5) the ratio (X/Q) was calculated to arrive at the averaged totals for each wind sector.
The sector with the highest X/Q values is the NE sector which corresponds to the cold air moving in from the sea (south westerly sea winds). This causes temperature inversions which limits vertical dispersion.

The sector with the lowest X/Q values correspond to winds from the southeast thus resulting in maximum dispersion both horizontally and vertically.

The X/Q values and diagrams derived there from, is used to position monitoring equipment to measure regular or continuous releases from the source (Plant). However for accidental releases or worst case scenarios such diagrams are inadequate.

For the purpose of accidental releases or accident events dynamic software models (programmes) are employed to determined the dispersion of the emission plume and to direct emergency procedures and responses.

These models (Dispersion Prediction Programmes) employ the actual weather conditions (wind direction, speed, temperature, etc), and radioactive release concentrations to predict plume behaviour to direct the emergency operations.

4.17.4 CONCLUSIONS

A well equipped meteorological weather station, back-up weather masts and equipment software with predictive dispersion capability and professional staff exist at Koeberg NPS to gather the required real time weather data.

A reliable database and analysis for climate/weather conditions exist at Koeberg to predict emissions dispersion under normal operation or to direct emergency operations in the event of an accident (Category A, B or C events as described by the NNRs' fundamental standards).

Dispersion prediction models (programmes) and developments in this field are continuously evaluated by Eskom to ensure reliability and accuracy of current practices.

The proposed PBMR will be linked into this system and will therefore have the required infrastructure for emergency planning and evacuation programmes/incidents.
4.18 ASSESSMENT OF THE OCEANOGRAPHY OF THE KOEBERG ENVIRONMENT AND COOLING WATER SUPPLY

4.18.1 INTRODUCTION

As the proposed Plant will link into the existing cooling water supply system and thermal outflow system and structures for Koeberg NPS, the Koeberg Site Safety Report (KSSR Chapter 8, 1997, Annexure 6) was consulted to assess the impact of flooding and assurance of cooling water supply on the proposed plant (individually and cumulatively). A report by Cape Weatherwise International (cc) (2002) was commissioned to assess the impact of thermal outflow collectively with that of the KNPS.

Oceanography (Physico-chemical) data and characteristics are relevant to the safety of the proposed Plant in so far as they have a bearing on the following:

- The possibility of flooding from the sea due to abnormal tides and tidal waves (Tsunamis)
- Assurance of cooling water supply that may be affected by extreme low water levels (seiche), blockage of sea water intake structures by sand, oil slicks, debris and fouling by marine fauna/flora.
- The design, operation and maintenance of cooling water supply at maximum sea temperature in correlation with thermal outflows.
- Effluent releases to the sea (thermal, radioactive and chemical)

4.18.2 PARAMETERS REVIEWED

The parameters which were studied by Eskom\textsuperscript{136} included the following:

- Tide heights (including storm surge)
- Tsunami risk
- Wave heights, period (duration), direction, set-up and run-up
- Currents (near- and off-shore as well as surface and subsurface)
- Correlation of wind and current

\textsuperscript{136} For the siting and design of the KNPS Eskom conducted a broad range of oceanographic studies and monitoring from 1969 onwards. The information is incorporated into the KSSR and Safety Analysis Report (SAR) and is kept current for nuclear licensing purposes.
Water temperature
- Chemical composition of sea water
- Sand in suspension and grain size
- Movement of the beach and sea bed
- Marine fouling
- Effect of thermal, radioactive and chemical effluents on marine organisms

4.18.3 Flooding From The Sea

Conditions that may jeopardise the proposed Plant are:

- Terrace height (elevation) of the Plant above Mean Sea Level (MSL),
- Extreme waves, tide levels, abnormal tidal waves (tsunamis) or extreme low tides (Seiches).

The wave data, tide levels and tsunamis are discussed below.

The basic oceanographic data was obtained from various studies (as given in reference 3 to 84 below) which cover the period January 1969 to December 1996. Table 46 gives a comparison of study figures by Watermeyer, Prestedge, Retief WPR (1997, Reference 98) with that from Watermeyer Halcrow and Partners (WHP, 1980).

Wave data analysed by Rossouw, (1989, Reference 94), was extrapolated to determine extreme values.

Return periods for extreme high water levels resulting from the combined effects of tide (including sea level rise), surge, wave run-up and wave set-up are given in Table 46.

Data on the likely incidence and size of tsunamis was calculated by Dames and Moore (1975, Reference 87) and Wijnberg (1988, Reference 95). A tsunami run-up of +4.0 m could, however, be envisaged (according to Wijnberg (1988), following a magnitude 7.8 seismic upheaval at the South Sandwich Islands. This tsunami would have a period of 45 minutes. In determining extreme water levels for licensing Watermeyer et al. (1977, Reference 98) combined the maximum credible tsunami run-up with the highest astronomical tidal level (HAT) to obtain a maximum flood level of +5.2 m MSL.

Extreme high water levels were obtained by combining probable maximum sea level rise by the year 2030 of 0.6 m from Prins (1986, Reference 97), with tide plus surge data from Wijnberg (1993, Reference 96), and wave run-up and wave set-up data from Rossouw (1989, Reference 94).

Conclusion

The above studies yielded the conclusion that a terrace level at +8.0 m MSL, is acceptable and that no wave wall is necessary. The KNPS and proposed Plants are both located at +8.0m above MSL terrace.
Table 46: Summary of Extreme Values

<table>
<thead>
<tr>
<th>Component</th>
<th>Units</th>
<th>WHP 1980</th>
<th>WPR 1997</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Best fit</td>
<td>Upper confidence limit</td>
</tr>
<tr>
<td>Return period 1 in 1 year</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Significant wave height</td>
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<td>Wave set-up</td>
<td>M</td>
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<tr>
<td>Wave run-up</td>
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<td>m MSL</td>
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<td>Low tide plus negative surge</td>
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</tr>
<tr>
<td>Intake water temperature</td>
<td></td>
<td>22.00</td>
<td>18.54</td>
</tr>
<tr>
<td>Return period 1 in 10 years</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Significant wave height</td>
<td>m</td>
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<td>11.00</td>
</tr>
<tr>
<td>Wave set-up</td>
<td>m</td>
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<td>1.61</td>
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<tr>
<td>Wave run-up</td>
<td>m</td>
<td>0.54</td>
<td>0.60</td>
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<tr>
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<td>High tide plus surge, set-up and run-up</td>
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<td>3.75</td>
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<tr>
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<td>m MSL</td>
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<td>-1.05</td>
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<tr>
<td>Intake water temperature</td>
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<td>19.96</td>
</tr>
<tr>
<td>Return period 1 in 100 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significant wave height</td>
<td>m</td>
<td>10.00</td>
<td>14.70</td>
</tr>
<tr>
<td>Wave set-up</td>
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<tr>
<td>Wave run-up</td>
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<td>0.59</td>
<td>0.70</td>
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<tr>
<td>Intake water temperature</td>
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<tr>
<td>Return period 1 in 1 000 000 years</td>
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<td></td>
<td></td>
</tr>
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<td>Wave run-up</td>
<td>m</td>
<td>0.70</td>
<td>1.13</td>
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</table>
## Component

<table>
<thead>
<tr>
<th>Component</th>
<th>Units</th>
<th>WHP 1980</th>
<th>WPR 1997</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Best fit Upper confidence limit</td>
<td>Best fit Upper confidence limit</td>
</tr>
<tr>
<td>High tide plus positive surge</td>
<td>m MSL</td>
<td>1.64 2.30</td>
<td>2.70 3.02</td>
</tr>
<tr>
<td>High tide plus surge, set-up and run-up</td>
<td>m MSL</td>
<td>4.47 7.59</td>
<td>5.95 6.97</td>
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<tr>
<td>Sea level rise to 2030</td>
<td>m</td>
<td></td>
<td>0.40 0.60</td>
</tr>
<tr>
<td>High tide plus surge, set-up and run-up</td>
<td>m MSL</td>
<td></td>
<td>6.35 7.57</td>
</tr>
<tr>
<td>Low tide plus negative surge</td>
<td>m MSL</td>
<td>-1.09 -1.53</td>
<td>-2.12 -2.17</td>
</tr>
<tr>
<td>Seiche amplitude</td>
<td>m</td>
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<td>-1.00 -1.00</td>
</tr>
<tr>
<td>Low tide plus negative surge and seiche</td>
<td>m MSL</td>
<td>-2.09 -2.53</td>
<td>-3.12 -3.17</td>
</tr>
<tr>
<td>Tsunami run-up</td>
<td></td>
<td>2.25 4.00</td>
<td></td>
</tr>
<tr>
<td>HAT</td>
<td></td>
<td></td>
<td>1.70</td>
</tr>
<tr>
<td>Tsunami run-up plus HAT</td>
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<td>5.20</td>
</tr>
<tr>
<td>Tsunami run-down</td>
<td></td>
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<td>-4.00</td>
</tr>
<tr>
<td>LAT</td>
<td></td>
<td></td>
<td>-0.81</td>
</tr>
<tr>
<td>Tsunami run-down plus LAT</td>
<td></td>
<td></td>
<td>-4.81</td>
</tr>
<tr>
<td>Intake water temperature</td>
<td></td>
<td>26.79 27.48</td>
<td></td>
</tr>
</tbody>
</table>

Confidence limits used for waves and water levels 68%

Confidence limits used for temperatures and water levels 95%

### 4.18.4 Availability of Cooling Water and an Alternative Heat Sink

Conditions which might jeopardise the security of the essential services cooling water supply are as follows:

- uncovering of intakes at extreme low water,
- damage to intake structure by waves or other means,
- silting up of basin entrance,
- blockage of intakes by sand, oil slicks, flotsam or marine life.

#### Exposure of Cooling Water Intakes

The minimum still water level due to extreme low tide, combined with extreme negative storm surge is given as -2.17 MSL by Watermeyer et al. (1997, Reference 98).

Short period (less than five minutes) oscillations within the basin, viz, short and long period waves may be superimposed upon this. Normal wave action (referred to as short period waves) will be minimal in
order to be consistent with the assumption of zero wave set-up used to obtain the above extreme low water level of -2.17 m MSL.

Studies of possible resonance of the basin volume to long period waves shared a strong correlation between seiche and larger offshore wave conditions. Larger waves cause increased set-up near the coast, which would raise water levels in the basin. Although the assumption of a lowered water level of 1 m due to seiche is considered to be very conservative, it was again applied. The minimum 1 in 10^6 year water level for low tide, plus negative surge and seiche, at the 68% confidence level, and ignoring possible sea level rise, is found to be -3.17 m MSL.

The maximum run-down due to the tsunami is expected to be -4 m below Sea Water Level (SWL). If this occurs at lowest astronomical tide (LAT) of -0.81 m MSL the extreme low water level could be -4.81 m MSL.

The Pump house is designed to accommodate a minimum short period water level of -2.50 m MSL under normal operating conditions. If the water level drops below this level there will be a reduction in pumping efficiency due to increased head difference across the pumps, and reduced area of flow through the screens. If the sea level drops below -3.5 m MSL, no water will reach the pumps.

In the event of extreme low water levels being so severe that the cooling water demand cannot be obtained from the sea, the necessary cooling will be provided by the application of an alternative heat sink for Koeberg NPS (This will not be required for the proposed PBMR that can be cooled by convection).

The basin arms are designed on “Zero Percent Damage” criteria by the USA Army CERC (1973, Reference 89) for the maximum possible wave heights which can exist in the depth of water found at the basin entrance. Damage to the south breakwaters due to wave action during the period up to 1996 has been assessed at 3.8%, which is less than the “zero percent damage” definition of 5% as determined by Watermeyer et al. (1997, Reference 98). Ongoing monitoring continues and if damage repair is carried out in the event that damage exceeds 5%, the risk to the structural integrity of the breakwaters will not be increased. Damage might be caused if a vessel collided with the breakwaters. However, it is considered that damage would not jeopardise the availability of water within the harbour. Warning lights have been erected on the harbour arms. Damage to the intake structure in the relatively still water within the harbour is considered to constitute a safety problem.

**SEDIMENTATION**

- General Accretion/Erosion

  Regular surveys have indicated that no long term erosion or accretion of the beach or seabed in the vicinity of the cooling water intake basin has occurred, except for minor erosion damage repair on the south side of the basin. A programme of ongoing surveys will continue.
Silting up of Basin Entrance

Since commissioning the cooling water system in 1982, regular surveys of the basin have been carried out and the rate of sedimentation in the basin monitored. The infill rate on average has been about 132 000 m³/a (Reference 98) and four main dredging contracts have been carried out to date to remove accumulated sediment from the settling basin.

Based on experience of the operation of the cooling water intake basin it is considered that the possibility of sediment blocking the entrance and preventing the inflow of cooling water is highly improbable.

Blockage of Cooling Water Intakes

The front wall of the pump house is such that water is drawn below a level of -3.7 m MSL. Nevertheless suitable coarse and fine screens prevent a complete blockage of the cooling water intakes by flotsam, fuel oil, as well as marine flora or fauna.

Chlorine which is produced by means of electrolysis is employed to defer sea growth of marine life on intake structures and pipelines.

The intakes of the Pump house were designed to minimise the possible ingress of sand. The cooling water intake basin is dredged to a depth of -7.5 m MSL for a distance of 75 m in front of the pump house, i.e., deeper than the remainder of the basin which is dredged to -6.0 m MSL. The level of the bottom of the opening to the intake is -5.2 m MSL. The floor of the pump house slopes towards the sea in the vicinity of the intakes to further minimise the possibility of sand moving along the floor towards the pump intakes.

An oil spill contingency plan exists. As part of this plan, an oil boom has been procured for deployment in front of the pump houses in the event of an oil spill entering the basin. This provides an additional safety measure to keep oil away from the intakes. There is an upper limit to conditions under which the oil boom is effective in restraining a floating oil slick. The depth of the intake of the pump house is below -3.75 m MSL, which also has the purpose of excluding floating oil.

A study into the possible effect of liquefaction of the slope adjacent to the pump houses, with respect to blocking the pump house intakes, led to the conclusion (Reference 98) that such a possibility was too remote to require further consideration.

4.18.5 Sea Temperatures

The results given below are based on an analysis of sea water temperatures recorded at the cooling water intake (1 January 1987 to 31 December 1994) and a review of the results of the mathematical model on which the Koeberg Site Safety Report was based.

The intake temperatures for various return periods obtained from the recorded temperatures are given in Table 46.
The original predicted intake temperatures were found to be conservative when compared to the results of the analysis of recorded data. The recorded data (95% confidence limit) gives the 1:100 year temperature as 21.73 °C when compared with the predicted temperature of 28.10 °C.

A considerably lower 1 in 1 year (95% confidence level) extreme value of 18.78 °C is obtained from the records compared with the previous “maximum annual intake temperature” of 22.0 °C. When extrapolated the present analysis gives the 1:10 year intake temperature as 20.29 °C and the 1:100 year intake temperature as 21.73 °C.

4.18.6 CONCLUSION

- An extensive data base exist on oceanographic conditions to predict and ensure the operational safety of the proposed Plant under normal and abnormal sea conditions or man made disasters (oil slicks).
- The convention cooling design features of the Plant, in the event of sea water cooling loss and its location above mean sea level (i.e. +8 meters) will protect the Plant against abnormal sea conditions (seiches and tsanomis) to ensure continued safety.
- The sea water cooling structure (i.e. stilling basin, intake structures and pump house) is sufficiently designed, constructed and operated to withstand normal or abnormal natural or man made disasters.
- The cooling water structure and equipment has sufficient capacity to cope with the additional requirements of the proposed PBMR Plant.

4.18.7 REFERENCES


86) ‘Preliminary Study into the Threat of an Oil Spill in the Vicinity of Koeberg Nuclear Power Station, the Resultant Form the Oil Pollution will take and the effectiveness of the Possible Remedial Actions’, D S F Mulligan, March 1980.


4.19 EVALUATION OF THE EFFECT OF ADDITIONAL COOLING WATER DISCHARGE INTO THE ATLANTIC OCEAN AT KOEBERG NUCLEAR POWER STATION

The attached report from Cape Weatherwise International provides a full assessment of the impact of the proposed Plant on thermal outflows, separately and in conjunction with the Koeberg NPS.

For theoretical purposes the thermal impact of 10 PBMR Modules were also assessed to determine immediate impact and conclusions drawn.

4.19.1 EXECUTIVE SUMMARY

In evaluating the effect of additional warm water discharge into the Atlantic Ocean at Koeberg Nuclear Power Station, consideration was given to the possible enlargement and temperature increase of the warm water plume as well as to the potential marine impact.

When calculating the increase in water temperature at discharge point (surf zone) due to one operational Pebble Bed Modular Reactor (PBMR) unit, the result is 0.73°C with one Koeberg unit operational and the rise will be 0.39°C when both units are running. The theoretical rise in plume temperature at a distance if 1-Km is 0.22°C with one Koeberg unit running and 0.12°C when both are running. The additional outflow from one PBMR unit will cause no change in the dissipation of the plume as the dynamic forces in the ocean govern this.

In assessing the potential marine impact of one PBMR, the additional entrainment of planktonic organisms is calculated to be 2%. The resultant higher mortality of plankton due to entrainment by the operation of one PBMR unit is not, however, considered to be detrimental to the marine environment because of the very localised area affected. For a theoretical 10 PBMR units the additional mortality due to entrainment equals 21%. The theoretical temperature rise along the beach to the south falls well within the natural variability of the temperatures along the Atlantic coast and therefore poses minimal risk to the marine environment.

The cooling water from one PBMR unit will have no detectable effect on the marine environment nor increase the warm water plume to a level where the potential risk increases.

When more than one unit is constructed and operational, detailed studies of the resultant warm plume will have to be undertaken to verify the extent and temperature of the plume. In addition, consideration must be given to upgrade the current marine impact study. Both these studies should be conducted when a 12% increase (6 PBMR units at 1.7m³/s each) of maximum Koeberg operational

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137 The projections for both Koeberg units running during the next ten years average 89% per year.
operational flow rate\textsuperscript{138} is reached.

4.19.2 INTRODUCTION

Koeberg Nuclear Power Station is situated on the west coast about 30 km north of Cape Town. One of the main reasons for siting the station on the Atlantic coast, is the relatively cold seawater, which is utilised as a condenser-cooling medium. The average sea water temperature is in the region of 13°C with the minimum below 10°C and the maximum exceeding 20°C on rare occasions. At full operation the station pumps just more than 80 cubic meters water per second through the condensers. This water is chlorinated at ± 1 part per million (ppm) before reaching the condensers where the water temperature increases at an average of about 10°C above ambient. Chlorination of the intake water prevents the settlement of young marine fouling organisms inside the plant. This water, warmed and chlorinated, is now returned to the sea into relatively shallow water via the outfall structure. The configuration of the outfall structure causes the water to be jetted in a south-westerly direction at a speed of between 2 and 3 m/s at the outlet of the outfall, depending on tide and sea swell conditions. As the water is more buoyant, a warm water plume is formed.

Studies have been conducted to assess the extent, dissipation and behaviour of this plume under different environmental conditions. In addition, the marine environmental impact of this warm plume has been and still is being researched.

This first focus of the evaluation is to determine the effect on the warm water plume by the additional warm water used by a Pebble Bed Modular Reactor (PBMR). Secondly, the impact on the marine environment is assessed.

A mathematical approach is used starting with the theoretical cooling requirement of one PBMR. The calculations are then continued to determine the possible effects of up to 10 PBMR units.

4.19.3 ASSUMPTIONS:

The basis for the evaluation is taken as:

- A discharge rate of 1.7 cubic meters per second per PBMR.
- A PBMR delta temperature of 40 degrees Celsius above ambient at discharge point.
- A delta temperature of 10 degrees Celsius above ambient is taken as the Koeberg warm water plume discharge temperature.

The following assumptions are made:

\textsuperscript{138} Maximum Koeberg operational flow equals 82m\textsuperscript{3}/s.
That the PBMR discharge point will converge with the existing Koeberg condenser cooling water discharge.

That the Chlorination concentration of the PBMR cooling water will be below 1 PPM at the condensers.

That no other pollutants are added to the warm water discharge.

That the seawater filtration system will have the same grid spectrum as the Koeberg filtration system.

That the PBMR condenser structures and apertures are in the same physical range as those of Koeberg.

That the discharge of the additional warm water from the first and additional PBMR units flows directly into the Koeberg condenser cooling water outfall channel.

A theoretical multi unit of 10 PBMRs was included to assess cumulative impact should more units be considered at the site.

### 4.19.4 Warm Water Plume

Rattey and Potgieter in “Warm Water Plume Report” adequately described the complex dynamic forces acting on the discharged warm water from Koeberg. In assessing the dissipation of a plume with increased volume, the governing factor of path, extent and dissipation of the plume remains unchanged. Only the worst case scenarios need be considered.

#### Worst Case Scenarios

In defining the worst case scenario, consideration of what the worst plume would be like, should be taken into account. In reality this would be the circumstance in which the least mixing of the warm plume with the Atlantic Ocean occurs. The temperature increase of the buoyant plume would be the highest above ambient at the point where it could have detrimental impact. Two such areas are evident. The first being at the end of the southern breakwater, where a potential re-circulation threat exists and the second on the beaches directly to the south of the Power Station, where higher seawater temperatures could impact on the marine environment.

The first worst case scenario will be the result of light easterly winds with relatively calm sea conditions which periodically occur after a high pressure cell has ridged over the interior. This will be typical just after a south-easterly wind condition. This condition occurs mostly in summer.

The second scenario that can be classified as worst case is the passage of a coastal low or the approach of a frontal system. In these cases, the wind will be from a northerly direction for a period of time, thus causing a southerly long shore current to become prevalent. This condition occurs mostly in winter. A more in depth description of these two conditions is thought to be prudent.

#### Worst Case Condition 1
Light easterly surface winds with little or no swell conditions:

The wind and swell condition that is associated with the slackening of a southeaster (and a typical summer wind regime), will result in a worst case plume. In this case the southeaster and even the light easterly conditions, cause an up-welling event that result in a sharp drop in sea surface temperatures. This is due to the warmer surface water being driven offshore and the colder water from the bottom being forced to the surface along the coast. The warm water plume will be restricted to a northerly direction, immediately adjacent to the southern breakwater and will have a steep isotherm gradient on the southern flank. This is as a result of the northerly surface current induced by the southeaster. This current has a greater force than the Koeberg ejected plume, that started in a south-westerly direction due to the construction configuration of the outfall structure. The northerly current induced by the wind is of a long shore nature but the physical barrier posed by the breakwater forces the plume in a north-westerly direction.

As Rattey and Potgieter\(^1\) determined, this condition results in a plume of 2 - 3°C above ambient at the northern tip of the southern breakwater, (Warm Water Plume survey no. 15 : 26 September 1986). This was for a plume with Koeberg running at full capacity, thus 82m\(^3\)/s.
Worst Case Condition 2

- Light northerly surface winds with little or no swell conditions:

  The warm water plume will move offshore in a south-westerly direction. This is directly against the wave direction and thus the prevailing turbulent forces. As tremendous turbulent forces exist even in small swell heights, dissipation occurs rapidly and no apparent demarcation of plume is observed. Horizontal eddy diffusion also adds in this mixing process. The surface current, being onshore, now tries to swing the plume around to force it on the beaches to the south of the outfall. As the plume is thus mostly parallel to the coast the main body of the plume remains in the turbulent surf zone. Mixing to a greater depth is therefore achieved and the warm plumes to the beaches to the south of the station are thus not as pronounced as in the case with the plumes jetting offshore adjacent to the breakwater. No clear demarcation of the horizontal isotherms can be observed due to the variability, extend and force of the turbulence available close to the shore. A person standing at an elevated position close to the surf zone can easily observe this turbulence.
4.19.5 Plume Temperature rise and associated Risk

To be able to assess and define the potential increase in the temperature of the discharged water, at discharge point as well as of the warm plume in the ocean, a mathematical approach is taken. This will enable the quantification of the associated risk.

The theoretical increase in temperature of the total discharged volume needs to be calculated taking the current Koeberg flow rate and temperature, and combining it with the planned PBMR flow rate and temperature.

This results in:

\[ PpT = \frac{(Kv(T) + Av(T))}{Tv} \]  \hspace{1cm} (1)
Where \( \text{PpT} \) = Potential Plume Temperature Increase and

\( \text{Kv(T)} \) = Koeberg effluent volume at Delta T

\( \text{Av(T)} \) = Additional effluent volume at Delta T

\( \text{Tv} \) = Total effluent volume

Applying (1) to the different operating criteria and the volumes and temperatures as defined in the Assumptions, the potential temperature increase for up to 10 PBMR units has been calculated. The conservative assumption that the Koeberg outlet temperature is 10°C above ambient was followed. Operating regimes are defined as A) Koeberg using 42m³/s, B) 62m³/s and C) 82m³/s of cooling water. The results of the calculations is given in Table 47.

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<th>Koeberg Operating Regime</th>
<th>Outfall Temperature increase per number of Pebble Bed Modular Reactors</th>
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<td>B</td>
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<tr>
<td>C</td>
<td>0.39</td>
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Table 47: Maximum Temperature increase in degrees Celsius.

Taking into consideration that the maximum expected plume temperature increase is 0.73°C or 7% at the outfall, with one additional unit operating, this increase will have no significance on the plume path, extend or dissipation. The fractional increase in buoyancy will not influence physical behaviour of the plume in the turbulent ocean.

Utilising the above data, the potential increase in temperature of the plume at 1-Km can now be calculated. The conservative approach is followed that the Koeberg warm plume is 10°C above ambient at outfall and 3°C above ambient at 1-Km distance from the outfall. To calculate the theoretical new plume temperature at 1-Km, we use (1) but add the Koeberg delta plume temperature at 1-Km.

\[
\text{PpT}_{(1-Km)} = \text{PpT} \left( \frac{\text{TK}}{\text{TK}_{(1-Km)}} \right)
\]

Where \( \text{TK} \) = Koeberg Outlet Temperature above ambient and

\( \text{TK}_{(1-Km)} \) = Koeberg Plume Temperature above ambient at 1-Km

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<th>Koeberg Operating Regime</th>
<th>Temperature at 1-Km increase per number of Pebble Bed Modular Reactors</th>
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4.19.6 Pollution Dilution Potential

A practical mathematical approach to the potential dilution of any additional pollution into the discharged water is taken.

For any dilution, the following will hold true:

\[ \frac{C_i}{C_f} \]

Where: \( C_i = \) Initial Effluent Concentration and 
\( C_f = \) Final Effluent Concentration, 
and the result will be the calculated dilution.

When the additional discharged water is taken, per assumptions, as 1.7 m\(^3\)/s per PBMR, and the different operating regimes of Koeberg with the associated cooling water discharge rates of 42 m\(^3\)/s, 62 m\(^3\)/s and 82 m\(^3\)/s we get dilution factors of:

- **A** (Koeberg cooling water discharge volume of 42 m\(^3\)/s) \( \frac{1.7}{42} = 0.040 \)
- **B** (Koeberg cooling water discharge volume of 62 m\(^3\)/s) \( \frac{1.7}{62} = 0.027 \)
- **C** (Koeberg cooling water discharge volume of 82 m\(^3\)/s) \( \frac{1.7}{82} = 0.021 \)

In the operation of a single PBMR unit, which will have 1.7 m\(^3\)/s of cooling water added to the Koeberg discharge, any impurities resulting from the operation, such as chlorination, need to be assessed utilising the above factors. As Koeberg chlorinates their cooling water at 1 part per million, chlorination might be a special case. For any other impurities, the above will hold.

In practical terms, the dilution of impurities from the PBMR will be a factor of approximately 25, 37 and 48 times for the different operating regimes (A, B and C) of Koeberg.

As the assumptions preclude any additional pollution, no calculation is done for any specific pollution but the above factors can be utilised for this purpose.

4.19.7 Potential Marine Impact

Various factors need to be taken into consideration to determine the potential marine impact of any additional pollution in the form of warm water as a result of any cooling process using seawater.

**Temperature**

Water temperature is a parameter that influences the physical ability of water to dissolve gasses that sustain marine macro fauna as well as micro fauna. Any increase in this temperature decreases the solubility of gasses over time therefore decreasing the capability of water to hold life giving dissolved...
oxygen. In addition, micro and macro organism metabolic rates are increased due to an increase in temperature. Due to the increase in metabolism, organism development is speeded up and consequently more dissolved oxygen is required to maintain existence. Changes in temperature can also effect the life cycles of various organisms as the mating and spawning of some are triggered by certain water temperature regimes. The overall effect of increased thermal pollution may therefore be a reduction in the number and species of marine fauna in the area.

Rattey and Potgieter\(^4\) determined that the natural standard deviation of surf zone temperature is in the order of 0.46°C on a daily basis. With Koeberg operational this increases to 0.62°C. One PBMR will add a conservative additional delta temperature of 0.12°C. The additional 0.16 for Koeberg and 0.12 for PBMR can also be described within the natural deviation.

It was found by Cook\(^2\) and in subsequent years by Cook\(^3\), that no detrimental effect on the marine life around Koeberg can be found due to the influence of the warm plume. The reports state that no settlement by opportunistic warm water species or a reduction of Species Diversity Index could be found.

**Entrainment Process**

With one PBMR unit operating, the total sea water volume used for one day will be approximately 150 thousand cubic meters. For Koeberg this volume exceeds 7 million m\(^3\). For 10 PBMR's the volume will increase to 1.5 million m\(^3\). This water will be pumped and forced through filter systems and condensers. This huge volume of water contains vast numbers of planktonic organisms, all less than 3mm in size, which then get subjected to heat, physical stress, mechanical damage, pressure changes, turbulence as well as chlorination. This entrainment process poses a risk that the planktonic biomass might be reduced.

Utilising the pollution factors calculated for the different operating regimes, the reduction in phytoplankton biomass can be calculated. The average phytoplankton biomass reduction for Koeberg was calculated to be 53% by Cook\(^3\) from measurements made. He also found the reduction in zooplankton mortality to be 22% due to entrainment.

For a PBMR, the grid sizes of the marine filtration system and the physical process through the condensers units is taken to be the same as for Koeberg. Similar forces in the PBMR cooling system to marine animals such as hytoplankton will exist, thus the quoted reduction in biomass and mortality rates will apply.

In the entrainment process, only a very localised area and volume of the Atlantic Ocean is under consideration, thus the effect of biomass reduction and higher than normal plankton mortality is not deemed to be significantly detrimental to the marine environment.
4.19.8 CONCLUSION

In evaluating the effect that the additional warm water from one, then up to ten, PBMR units will have on the warm water plume as well as the potential impact on the marine environment, a number of conclusions are made:

- With one PBMR, the maximum expected outfall temperature rise is 0.73 Degrees Celsius with only one Koeberg unit operational and 0.39 Degrees Celsius with both Koeberg units running.
- With ten PBMR's the maximum increase of temperature at outfall with both Koeberg units running is 2.82 Degrees Celsius.
- With one PBMR, the maximum expected temperature rise at a distance of one Kilometre is 0.22 Degrees Celsius with only one Koeberg unit operational and 0.12 Degrees Celsius with both Koeberg units running.
- With ten PBMR's the maximum expected temperature rise at a distance of one Kilometre is 0.85 Degrees Celsius with both Koeberg units running.
- The fractional increase in buoyancy to elevated temperature will not influence the physical behaviour of the plume in the turbulent ocean.
- The additional cooling water volume from a PBMR will not cause any changes in the dissipation of the Koeberg plume as the dynamic forces in the ocean governs this.
- The theoretical temperature rise at 1 Kilometre falls well within the natural variability of the Atlantic Ocean and therefore poses a very low to insignificant risk to the marine environment.
- The plankton mortality and limited biomass reduction due to the entrainment process has an effect only on a very localised area of the Atlantic Ocean, thus the influence will be of a very low significance.
- It was found that no detrimental effect on the marine life around Koeberg could be proved, thus one PBMR will cause no settlement of opportunistic warm water species nor will it reduce the number of species found in the area.

It can be concluded with a high level of confidence, that the warmed water from one PBMR unit will have no detectable effect on the marine environment nor increase the size or temperature of the current warm plume in any significant way.

### 4.19.9 Recommendations

Should more than one PBMR be considered, further studies should be considered:

- The discharge temperature of 40 degrees Celsius per PBMR will result in an increase of 2 Degrees Celsius at outfall with 5 additional units. The extend, dissipation and dilution of the resultant warm plume need to studied when this stage is reached.
- The mortality of phytoplankton at the higher stress temperatures needs to be studied.

### 4.19.10 References:


4.20 POPULATION DISTRIBUTION (DEMOGRAPHICS) AROUND KOEBERG AND IMPACT OF THE PROPOSED PBMR PLANT ON EMERGENCY RESPONSE PLANNING

4.20.1 INTRODUCTION

The subject of demographics relates to the spatial distribution of populations (inhabitants) within a given geographical area over time.

This subject is of particular relevance for spatial development as well as emergency planning and evacuation purposes around nuclear power stations.

The subject relates very closely with meteorological (climatic) conditions, infrastructure availability (i.e. road, telecommunications and medical facilities) and emergency response infrastructure (i.e. people and equipment). A specific requirement for the operating license of a nuclear station is the continued ability to demonstrate the capability to manage and implement the Emergency Plan under various scenarios.

This chapter describes the adjusted 1996\textsuperscript{139} population distribution within 50km of the Koeberg NPS as a base case (Appendix 7). These figures were updated for 2001 and projected to 2006 by “Teramare” Environmental Data Systems (Pty) Ltd (Appendix 8), which included the domestic (permanent) and transient populations (tourists) for the area.

For the purposes of emergency planning, the PBMR (Pty) Ltd (designers of the proposed Plant and Eskom) postulates that the exclusion zone around the proposed Plant will be 400 meters, with limited further need for population regulation beyond this sphere.

To support their statement preliminary Probabilistic Risk Assessments and accident consequence assessment were performed to determine public exposure risks for a Category C event as postulated by the Fundamental Safety Criteria of the NNR (See Table 1, Chapter 2). The approach and results are reported in this Chapter.

\textsuperscript{139} Sourced from the Demographic Information Bureau (DIB) of Maps and Data (Pty) Ltd. The adjusted figures for 1996 were calculated from the 1991 census results provided by the Department of Statistics and corrected by Dorrington (2000).
4.20.2 THE 1996 POPULATION DISTRIBUTION DATA AROUND KOEBERG

集中 Amer 4.20.2 Population Data

The population data, arranged in radial sectors around Koeberg NPS, is presented in various tables and figures. For the purpose of the EIR extracts are given. Table 49 shows the population figures in radial bands in the 22.5 degree radial grid. Table 50 presents total population within each 5 km distance band up to 50 km for the 22.5 degree radial grid. Since the 22.5 degree radial grid is important for emergency planning purposes the cumulative population data up to 50 km is presented in Table 51. Figure 30 shows the total population data within each 5 km distance band up to 50 km in the 22.5 degree radial grid. This data was obtained from Table 49.

Conclusion

Several conclusions can be drawn from the tables and graphs presented.

- The cumulative population per 22.5 degree sector shows a sharp spike around Atlantis between the distances 10 km and 25 km from Koeberg. The population of Atlantis according to this data is 52 084.
- For distances greater than this the population distribution is dominated by the population in and around Cape Town.
- Total current maximum population (excluding tourists) is about 3.8 million within the 80km radius from Koeberg NPS.
- Construction staff for the proposed Plant will impact on the domestic and transient population numbers especially in the 0 – 5km and 0 – 20km concentric sector around the Station. This aspect needs to be incorporated into the Emergency Response Plan for the Koeberg NPS and the proposed Plant and communicated with the relevant players (e.g. emergency teams and liaison committees) and become part of the Communication actions pursued by the Koeberg NPS.

140 Sourced from the Koeberg Site Safety Report (KSSR – Chapter 3, 1997)
4.20.3 **References**

Magugumela M. 1997: Population Distribution Data within 50 km of Koeberg. MWP-NSD report Number NSD-R97/009

**Table 49:** Population Distribution Relative to Koeberg Power Station
(22.5 Degree Radial Grid)

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Table 50: Total Population Within Each 5 Km Distance Band Around Koeberg (22.5 Degree Radial Grid)

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Table 51: Koeberg Cumulative Population Data Up To 50 Km (22.5 Degree Sectors)

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Figure 30: Total Population within each 5 km Distance Band around Koeberg up to 50 km (22.5 degree radial grid)
4.20.4 ADJUSTED CENSUS FIGURES 2001 AND 2006

Updated census information was generated through “Terramare” Environmental Data Systems (Pty) Ltd (Annexure 8). Their Report considered both domestic and transient populations (tourists) for the area for the periods 2001 and 2006 during the peak tourist season.

Two scenarios are described, namely:

i. Domestic Populations for 2001 and 2006 in 5km concentric circles around Koeberg NPS up to 80km and within 22.5 degree sectors around the KNPS. (See Annexure 8 Tables T-3-5 on page 39 and Figure 3-12 on page 74 and Table T-3-11 on page 64 and Figure F-3-18 on page 81) which reflect this information.

ii. Transient Populations (Tourist both domestic and international) for 2001 and 2006 up to 80km from the KNP are reflected in (Annexure 8 Table T-3-1 on page 18 and Table X on page 103).

4.20.5 ASSESSMENT OF PUBLIC RISK (CONFIDENTIAL REPORT DOC NO 001929-207 SEC 6: PBMR 2001 REV 08 SECTION 6, CHAPTERS 0, 1, 2, AND 3, ANNEXURE 23)

ACCOUNT

Preliminary assessments have been conducted to evaluate the public risk related to the operation of the PBMR Plant.

Various codes are used to calculate the radiation inventories, release rates and expected activity levels for Radioactive Materials (RM) in various parts of the Plant (reactor, coolant, primary cycle, MPS, etc.).

Probabilistic Risk Assessment methods are then employed to determine and assess the consequences of category A, B and C events (as stipulated by NNR Fundamental Safety Criteria) and the resultant risk to the public.

The PBMR (Pty) Ltd and Eskom have conducted these calculations and consequence assessments using the PC COSYMA Version 2.1. software.

A wide spectrum of events and frequency was considered, particularly those involving breach of the pressure boundary and which will result in public exposure and possible resultant late mortality or morbidity.

The peak and average population risk were determined for the population around the proposed PBMR Plant site (using the demographic data and meteorological conditions) from 400m up to +50km.

RESULTS

The results obtained provided the following values for category C events for a 268 Mwth core and estimated for a 302 MWth core.
The 268 and 302 designs are different due to, amongst other things, the solid central column resulting in lower operating temperatures for fuel. The higher power indicates an increase in fission product inventory by a factor 302/268 (1.127 rounded) as an approximation – ignoring the effect of lower operating temperatures since this would only affect the steady state activity in the MPS. Assuming that the latent release, which dominates in terms of dose, is also a factor of 302/268 higher by this margin. Therefore, the impact of the 302MW design can be calculated as a factor 302/268 higher than the risk figures calculated for the 268MW design.

It should be emphasised that:

- There is a very large margin between the estimated risk and the targets set by the NNR;
- The current assessment methods are known to be conservative and it is to be expected that the estimate will reduce in the future.

4.20.6 Conclusion

- The result of the preliminary analysis, based on conservative assumptions in consequence assessment modeling, confirms the compliance of the PBMR Plant (268 and 302MWth core) with the NNR safety criteria for the public.
- The analysis must be verified by the NNR as part of their licensing process to assure final acceptance of the results.
4.21 INFRASTRUCTURE STATUS AND CAPABILITY OF THE KOEBERG SUB-REGION

4.21.1 INTRODUCTION

The Koeberg Site Safety Report (1997) Annexure 9 and Safety Analysis Report (confidential) contain comprehensive information on the status and capability of infrastructure as well as civil facilities and industrial installations in the Koeberg sub-region. This information covers the following; namely:

- Transport networks with regard to air, rail, road and sea.
- The distribution of civil facilities including schools, day care centres, old age homes, hospitals, prisons and police stations.
- The extent and nature of industrial installations and other urban infrastructure which includes power stations, coal burning installations, telephone exchanges, water supplies, sewage works, shopping and recreation centres.

4.21.2 DISCUSSION

The above data is relevant to nuclear installation so far as the following is concerned:

- Provision of services to the installation, its employees and residential areas.
- The location of facilities, installations and infrastructure that may be impacted upon in the event of an emergency.
- The nature of installations and/or cargo that may pose a risk to the nuclear station(s).
- Co-ordinated liaison between the nuclear installation, the authorities (local/ provincial/national) and civil protection structures to ensure the following:
  - Regular updating of the emergency plans, services and the resourcing thereof.
  - Integrated consideration of sub-regional spatial development frameworks and development proposals.

A review of the information in the KSSR and SAR clearly points to a very comprehensive database, which demonstrates the following:

- Sufficient infrastructure, liaison structures and civil facilities exist to accommodate and furnish Koeberg and the proposed Plant and personnel with services, from both a operational point of view as well as for the construction of the proposed PBMR demonstration plant.
Industrial installations and transient cargo that may pose a risk to Koeberg and/or the proposed Plant are well recorded.

Civil facilities which may be impacted by emergency scenarios at the Koeberg Nuclear installation (and the proposed Plant) are identified and recorded.

Of vital importance is the NNRs consideration and decision on the content of an Emergency Plan for the proposed Plant given its radiological safe design, its fuel characteristics and postulated releases under a credible accident scenario.\(^{142}\)

4.21.3 CONCLUSION

Sufficient infrastructure exists in the sub-region to service the proposed Plant.

Liaison structures exist to facilitate the development, implementation and maintenance of a spatial development framework for the Blaauwbergstrand sub region. Such planning liaison structure also efficiently addresses development proposal that may impact on the proposed Plant or vice versa to mutual advantage.

The recommendations of the SIA on emergency planning/plans and its impact on affected parties (communities and authorities) must be implemented by Eskom.

4.21.4 REFERENCES


\(^{142}\) The releases of radioactive materials and radiation exposure, to the public are discussed under Chapter 4.20.5. of the EIR.
SECTION 5: CUMULATIVE IMPACTS

4.22 CUMULATIVE IMPACTS

4.22.1 INTRODUCTION

The proposed PBMR demonstration module will result in a number of indirect, cumulative and linked impacts that are dealt with separately for the construction and operational phases. The decommissioning/dismantling phase has not assessed separately since this phase largely replicates those impacts associated with the construction phase. The cumulative impacts that are discussed/assessed represent the more significant ones, rather than an exhaustive list of all such impacts.

4.22.2 CUMULATIVE IMPACTS ASSOCIATED WITH THE CONSTRUCTION DECOMMISSIONING/ DISMANTLING

✦ Traffic

During the peak of construction about 550 persons will be employed on site. While the majority of the construction work force will be from surrounding residential areas, this will create additional traffic on the main roads to and from the Koeberg NPS site. The main roads that will be affected are the Otto du Plessis Drive to M5 and N7. To alleviate this impact, Eskom will contractually require contractors to supply mass transport (e.g. busses, mini-busses etc) for commuters. Traffic associated with material/equipment supply (heavy and abnormal loads) represent the more significant impacts. These impacts can however be addressed (mitigated) through non-peak hour delivery agreements, to alleviated traffic congestion.

✦ A Residential Land, Accommodation and Services

Most of the work force will be sourced locally, that will result in a minimal (if any) need for additional residential development. Migrant labour with the aspiration of finding employment on the project, will present itself and may cause some friction with the resident population.

Services such as water provision, health, schooling, municipal and emergency services will largely be insignificantly affected, again because of the localised nature of the work force and the existing capacity of the services.

✦ Employment and Income

Although of a temporary nature (2 years) the project will provide some relief on unemployment. During the construction phase, employees/labour will however acquire marketable skills, which can be gainfully employed after the project. Given the multiplier effect of about \( \leq 2.0 \) for projects of this
nature, the project will hold positive benefit for the sub region by augmenting income levels and buying capacity.

**Economic Stimulation**

A number of economic sectors will be positively impacted by the project, namely the civil and building industry (sand, aggregate, cement, etc) the services industry (professional, technical services, accommodation, entertainment, etc) and the commercial industry.

About 15% of the Capital expenditure will accrue to the sub regional economy, which is regarded as significant given the resultant multiplier effect.

**Domestic Waste**

Capital intensive projects, by nature, cause significant volumes of waste. However, by implementing a diligent waste management strategy, that shall be contractually binding on contractions, such waste can be minimised, re-used, recycled to limit disposal quantities.

**Radiological Waste**

The various types of radiological waste that will result from decommissioning/decontamination and dismantling activities will range from LLW, ILW and HLW. These will be dealt with as part of the decommissioning phase management plan/strategy which must be licensed by the NNR.

Decontamination activities will however significantly reduce the volume of radioactive materials.

**4.22.3 Cumulative Impacts associated with the Operation/Maintenance Phase**

The following more important cumulative impacts are foreseen during the operational/maintenance phase.

- Radiological and non-radiological emissions, effluent and solid waste(s) and resultant impacts.
- Thermal effluent impacts
- Potable water impact
- Economic impacts
- Emergency services impacts

These are dealt with in the relevant Chapters as contained in the body of the EIR.

**4.22.4 Linked Impacts**

The only linked impact of the proposed demonstration module PBMR and the Fuel Plant proposed to be established at Pelindaba is the cumulative low and intermediate level radioactive waste to be transported to and disposed of at Vaalputs. As discussed in Chapter 4.14 and relative to Koeberg low
low quantities of material will be generated by the proposed Plant. This renders this linked impact significant.
5. SIGNIFICANCE RATING OF IMPACTS

5.1 INTRODUCTION

The chapter assesses the significance of impacts according to the Significance Rating Methodology as described in Annexure 16. The methodology conforms to the guidelines provided by the Department of Environmental Affairs and Tourism of 1989.

In addition to the Significance Rating Methodology a Risk Assessment was also conducted by employing the SWIFT Risk Assessment Method as per Annexure 17.

Assessment Panel

The significance assessment and the SWIFT Risk Assessment were conducted by a panel of professional persons as mentioned below.

Mr O Graupner - Poltech (Division of IRCA Technical Services)
Mrs A Haasbroek - Poltech (Division of IRCA Technical Services)
Mr W Schlechter - Netrisk (Division of IRCA)
Mr F Mellet - Netrisk (Division of IRCA)
Mr J de Villiers - Netrisk (Division of IRCA)
Mr W Lombaard - Poltech (Division of IRCA Technical Services)
Mrs K Botes - Interdesign Landscape Architects (Pty) Ltd
Dr D de Waal - Afrosearch
Mrs H van Graan - Nuclear Consulting International
Mr N Andersen - Andersen Geological Consulting
Dr M Levin - Africon (Pty) Ltd
Mr G Erasmus - Ledwaba Erasmus Associates
Mr P van Wyk - J Paul van Wyk Urban Economist and Town Planners

The CVs of Consultants that participated in the EIR are provided in Annexure 20.
5.2 SIGNIFICANCE RATING AND DISCUSSION OF THE PLANTS RELATED IMPACTS

5.2.1 IMPACTS OF A SOCIAL NATURE

i. Impacts on Security

 tụ Nature of the area and event

Chapter 4.3.2. provides an overview of the radiological safety programme as well as security measures for the proposed Plant.

Both safety and security are achieved through design, procedures, and monitoring to protect the worker and the public. Accident scenarios for a plane crash (including a Boeing 777) and other Category C events have been developed and assessed for public radiation exposure dose(s).

 tụ Significance Rating

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<tr>
<td>Security breach with internal sabotage</td>
<td>Local, Short term, High, Improbable</td>
<td>2 4 8 3 2 -6 Low</td>
</tr>
<tr>
<td>Safety event with release to the environment (Category C)</td>
<td>Local to subregional, Short term, High, Improbable</td>
<td>2 4 8 3 2 -6 Low</td>
</tr>
</tbody>
</table>

 tụ Conclusions

安全管理：安全管理采取了周到的现场访问控制，限制入侵。访问控制到建筑，结合摄像机监控和互锁系统，防止对建筑的重要组件的直接访问。前厅是管理部分，后端是建筑的重要部分。建筑结构（外壳和城堡）设计足够 sturdy to protect the Plant and assure radiological safety in the event of projectiles (sabotage) and aircraft crashes.

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ii. Impact on Health (Epidemiology)

✦ Nature of the issue

a. Radiologically Induced Cancers

Chapter 4.3.3. provides an overview of international literature on the correlation between radiological induced cancers/late fatalities and commercial nuclear facilities.

No credible correlation could however be established.

Eskom conducts extensive radiological/health monitoring programmes of workers, and, the environment for radiological build-up or contamination at Koeberg. A similar monitoring programme will also be followed for the proposed Plant as part of the NNRs licence conditions.

✦ Significance Rating

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation induced cancers and late fatalities</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

✦ Conclusions

The need for epidemiological studies of radiologically induced cancers of the public is not recommended, in view of international research conclusions and monitoring results from 20 years of Koeberg operational results.

✦ Mitigation

❖ NNR licence conditions must be adhered to

❖ HIV/AIDS in the Workplace

b. HIV/AIDS in the Workplace

The introduction of 1400 construction workers over the two year construction period may have consequences on the further communication of the disease.

However, most of the workers will be sourced from the Cape Town environment with the result that minimal new workers and thus potentially infected individuals will be introduced.

Despite local recruitment rigorous practices will have to be employed to minimise the spread or effect of the disease.

✦ Significance Rating

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>Duration</td>
<td>Intensity</td>
</tr>
<tr>
<td>--------------</td>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Local to sub-regional</td>
<td>Medium 3</td>
<td>High 4</td>
</tr>
</tbody>
</table>

**Conclusions**

While construction workers will largely be recruited from the local work environment (Cape Town sub-region) the spread of the disease remains a real concern with medium term effects.

**Mitigation**

A rigorous policy, practices and programmes must be implemented, maintained and revised to educate and support worker (construction as well as own employees) on HIV/AIDS. Eskom has committed itself to the implementation of such a policy and practices.

**iii. Impact on Institutional Capacity**

**Nature of the issue**

Chapter 4.3.4. provide information on Institutional Capacity.

No significant impact will result on institutional capacity due to establishment and operation of the proposed Plant.

**Mitigation**

However, definitive plans and programmes will have to be formulated and implemented to ensure timeous succession of key personnel such as nuclear operators, NNR inspection staff, radiation workers and medical staff.

**iv. Legal Impact and Financial Provision**

**Nature of the issue**

Chapter 4.3.5. provides an overview of the legal obligations of government and the applicant.

Attention is paid to:
The demonstration of Duty and Care in terms of the National Environmental Management Act (Act No. 107 of 1998) specifically for the finalisation of the National Radiological Waste Management Policy and the establishment of a repository for radioactive High Level Waste (HLW),

3rd Party Liability provision

Financial provision (Eskom) for decommissioning and the long term management of radiological waste specifically HLW.

Significance Rating

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>Duration</td>
<td>Intensity</td>
</tr>
<tr>
<td>-</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Conclusions

Except for the promulgation of Policy on the Management of Radioactive Waste, Government and the applicant are exercising their “Duty of Care” through various facilities (Vaalputs), structures (The NNR) acts and policies (Nuclear Energy Act, Act No. 46 of 1999; National Energy Policy White Paper) and management.

Mitigation

The Department of Minerals and Energy should accelerate and promulgated the National Policy on the Management of Radioactive Waste. The work on the establishment of a High Level Waste repository needs to commence inclusive of public participation.

Financial provision must be made by Eskom for 3rd party liability and the decommissioning of the Plant (at the end of life) and final storage/disposal of High Level Waste.
5.2.2 **Issues and Impacts of an Economic Nature**

i. **Impact on Spatial Planning (Land use, air use and sea use)**

*Nature of the area and event*

Chapter 4.4. of the Social Impact Assessment (Annexure 11 page 52) provides a comprehensive account of the projected spatial planning impacts related to Koeberg NPS and the proposed Plant.

*Significance Rating*

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extent</td>
<td>Duration</td>
</tr>
<tr>
<td>Impact of the proposed Plant on the Spatial Development Framework for the Blaauwbergstrand region</td>
<td>Sub regional</td>
<td>Long term</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>4</td>
</tr>
</tbody>
</table>

*Conclusions*

The proposed PBMR Plant will fit into the existing footprint for Koeberg without affecting the Annual Authorised Discharge Quantities.

The fears of some members of the planning authorities in the Western Cape provincial government or the City of Cape Town, is unwarranted, since the Plant will not imposed additional restrictions on development. Because of the inherent safety characteristics of the Plant, it may in the long term be beneficial to the sub region, in terms of more conservative emergency planning requirements.

*Mitigation*

Provided that the 400 meter exclusion zone is observed no further mitigation is required.

ii. **Impact on Tourism**

*Nature of the issue*

Chapter 4.5. describes the approach and results of the Tourism survey that was conducted for the proposed Plant.

The main findings were that:
The presence of a nuclear Plant (Koeberg) does not have significant impact the decisions of tourists to visit Cape Town.

Almost half (46%) of operators have a positive perception, 24% is indifferent and 30% have negative perceptions on nuclear technology.

66% of respondents hold the opinion that Koeberg has not affected tourists' decisions to visit Cape Town, while 7% felt that it did.

**Significance Rating**

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact on Tourism as a result of the establishment of the proposed Plant/Nuclear Technology</td>
<td>Regional: Short term, Duration: 2, Intensity: 1, Severity Rating: 2, Probability: Probable</td>
<td>-6 Low</td>
</tr>
</tbody>
</table>

**Conclusions**

- Reduction in tourism numbers will probably only occur in the short term.
- The annual growth of the tourism industry may cancel the decrease.
- Professionals visiting the Plant will probably stay at local guest houses, thus offsetting the above “loss”
- The direct and indirect spin offs to the local/regional economics through construction and operation maintenance will offset tourism “losses”.

**Mitigation**

A repeat of the tourism survey in year two of operation.

**ii. Impact on Supply Side (and Energy) Management**

**Nature of the issue**

Chapter 4.6. describes Eskom’s generation supply capacity and demand side objectives for 2002. While the proposed Plant will make a limited contribution to Eskom’s nett generation capacity, its purpose is to demonstrate its techno-economics. This will inform the National Energy Policy, which will then guide the future use of the technology. Eskom furthermore has set realistic targets for demand side management, which will be of mutual benefit to the user.

**Significance Rating**

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>
Conclusions

The proposed Plant will have a two fold positive impact on the environment. Firstly it will marginally contribute to generation capacity and secondly it will inform the IRPP, which will guide the future application of the technology.

Mitigation

Nil


Nature of the issue

Chapter 4.7. provides broad employment figures for the proposed Plant’s construction (1 400 temporary jobs) and operation (40 permanent jobs).

The construction workforce will largely be recruited from the local area where sufficient capacity and skills exists. Operational staff will be sourced from Koeberg and the South African market, as far as highly experienced professionals are concerned.

Significance Rating

<table>
<thead>
<tr>
<th>Event</th>
<th>National</th>
<th>Long term</th>
<th>Low</th>
<th>Highly probable</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment for</td>
<td>Local</td>
<td>Short term</td>
<td>Medium</td>
<td>Definite</td>
<td></td>
</tr>
<tr>
<td>Construction/Decommissioning</td>
<td>-</td>
<td>2</td>
<td>2 (4) 2</td>
<td>5</td>
<td>+10 Medium</td>
</tr>
<tr>
<td>Operation</td>
<td>Local</td>
<td>Long term</td>
<td>Low</td>
<td>Definite</td>
<td></td>
</tr>
<tr>
<td>Economic Potential</td>
<td>National</td>
<td>Long term</td>
<td>Medium</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Labour</td>
<td>-</td>
<td>4</td>
<td>1 (4) 2</td>
<td>5</td>
<td>+10 Medium</td>
</tr>
<tr>
<td>BoP</td>
<td>National</td>
<td>Long term</td>
<td>Medium</td>
<td>Probable*</td>
<td>+9 Medium</td>
</tr>
</tbody>
</table>

The proposed Plant (if approved) goes some way in retaining science and engineering skills and thereby support the national objective on science and technology. Under a commercialisation scenario these objectives will be further supported and the up and down stream economic benefits will be of a significant nature i.e. foreign investment and earning, skills training and retention as well as manufacturing.

Note: * = A rating of 3 is given since the information is based on market
information and not firm orders.

Conclusions

- Employment for the PBMR Plant will be sourced locally, with concomitant benefit to the sub region.
- If techno-economically viable the continued economic benefit will be significant
- Education Institutions will have to position themselves to produce the required competent employees, should the technology become commercialised.

Mitigation

a. PBMR Plant

- Vagrant labour must be controlled and discouraged
- Sub contracts must provide percentage preference for empowerment contractors
- Training and skilling of operational staff must consider empowerment opportunities.

b. Multi Orders for the Technology

- A number of programmes will have to be developed to ensure sustained performance, namely manufacture, educational, financial etc.

v. Life Cycle Costing

Nature of the issue

Chapter 4.8 gives account on how Eskom will make financial provision for the full “Life Cycle” of the proposed Plant. Allocations from sales on the capital portion and fuel cost will be placed in a fund to respectively finance the decommissioning and long term storage of spent fuel. This approach is in line with International practice and norms.

Significance Rating

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial provision to cover the Life Cycle Cost of the Plant</td>
<td>Extent Duration Intensity Severity Rating Probability</td>
<td>Local Long term Low (4) 2 5 +10 Medium</td>
</tr>
</tbody>
</table>

Conclusions
Assured mechanisms have been established to build the required segregate funds for decommissioning and long term spent fuel storage.

- **Mitigation**
  - The financial provisions must be evaluated and audited annually and evaluated for adequacy.
  - Audit results should be published annually to facilitate transparency and provide public assurance that no tax payer liabilities will ensue.

### 5.2.3 IMPACTS OF A BIOPHYSICAL NATURE

#### i. Effects of Thermal Outflows on Marine Life (Fauna & Flora)

- **Nature of the area and event**

Chapter 4.9. provides an overview of the research findings and conclusions of the effects of thermal outflows, entrainment and chlorine dosing on marine fauna and flora resulting from the proposed Plant and the Koeberg NPS thermal and effluent releases.

- **Significance Rating**

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of thermal outflow of 1.7 m³/s at 40°C to Marine Life</td>
<td>Extent: Local, Duration: Long term, Intensity: Low, Severity Rating: Improbable</td>
<td>Probability: Improbable, Rating: Low</td>
</tr>
</tbody>
</table>

- **Conclusions**

The net findings were that no directly attributable effect was expected. Since the proposed Plants thermal release will only increase the maximum net temperature of the thermal plume by 0.39°C at outflow volume of 83.7 m³/s (Koeberg 82.0 m³ and Plant 1.7 m³/s) no significant impact is foreseen or predicted due to the dynamic mixing in the coastal zone.

- **Mitigation**

No additional mitigation is required.

#### ii. Effects of the proposed Plant on Terrestrial Wildlife

- **Nature of the issue**

Chapter 4.10. provides a brief overview of the Plants' site, which will be located on an already disturbed area within the outer security boundary area of Koeberg NPS.
No significant impact is thus foreseen in terms of fauna and flora species.

Measurements of environmental media for radiological levels related to Koeberg emissions, indicate no build-up.

### Significance Rating

<table>
<thead>
<tr>
<th>Event</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Severity Rating</th>
<th>Probability</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of the Plant and impact on terrestrial wildlife</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>Local to subregional</td>
<td>Short</td>
<td>Low</td>
<td>Improbable</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>(2)</td>
<td>2</td>
<td></td>
<td>-4 Low</td>
</tr>
<tr>
<td>Operational</td>
<td>Local to subregional</td>
<td>Permanent</td>
<td>Low</td>
<td>Probable</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1</td>
<td>(4)</td>
<td>3</td>
<td></td>
<td>-6 Low</td>
</tr>
</tbody>
</table>

### Conclusions

The proposed Plant will not significantly affect the terrestrial fauna and flora of the site during construction or normal operation.

### Mitigation

The construction site must be fenced off, to prevent free roaming antelope from enter into the area.

### iii. Effect of the Plant on Archaeological/Paleontological Characteristics of the Koeberg environment

#### Nature of the area and event

Chapter 4.11. gives a brief description of the archaeological/palaeontological attributes of the Eskom Koeberg property.

Since none of the existing archaeological sites will be affected by the Plants’ proposed site, impacts will be insignificant. During excavation of the building foundations (below 22 meters) archaeological and palaeontological discoveries may be made.

### Significance Rating

<table>
<thead>
<tr>
<th>Event</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Severity Rating</th>
<th>Probability</th>
<th>Significance Rating</th>
</tr>
</thead>
</table>
Impact of Construction

Archaeological

- No impact

Palaeontological attributes of the area

- Local
- 1 year
- Low
- Probable
- 2
- 1
- (2) 2
- 3
- -6 Low

**Conclusions**

- Archaeological attributes will not be affected.

- Palaeontological discovery may be made. In such an event the relevant cultural historical authority will be notified.

**Mitigation**

Notification of the relevant authority(ies) South African Heritage Resources Agency, Cultural Historical Museum, etc) for investigation and further direction of construction work pending the value of the material(s).

**iv. Noise impacts from the proposed Plant**

**Nature of the issue**

Chapter 4.12. provides the result of a baseline survey on current ambient noise levels emanating from Koeberg NPS, wave action, the residential area of Duynefontein and traffic.

While some 50% of the recorded levels (day and night time) exceeded the prescribed limits these exceedances were related to traffic and wave action. Day time noise levels from the Koeberg NPS were within recommended Noise Level Ratings. The expected noise level rating of the proposed Plant is however not known.

**Significance Rating**

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Ambient Noise Levels on the Koeberg site (outer perimeter fence and Nature Reserve fence)</td>
<td>Local</td>
<td>Permanent</td>
</tr>
<tr>
<td>Extent</td>
<td>Duration</td>
<td>Intensity</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>(8) 3</td>
</tr>
</tbody>
</table>

**Conclusions**
Night time ambient noise levels are above Recommended Rating Levels.

Day time ambient noise levels are within Recommended Rating Levels closer to the Koeberg NPS.

All ambient noise levels (50 – 60dB(A)) are below the critical level of 85dB(A) which will after 8 hours of exposure, will cause permanent hearing impairment.

**Mitigation**

The proposed Plant building design must take cognisance of the noise factor and reduce noise levels as far as possible through acoustic design.

**v. Visual Impact from the proposed Plant**

**Nature of the issue**

Chapter 4.13. analyse the visual attributes of the area from various vantage points and distances for travellers and tourists.

Since the architecture and material finishes of the Plant building will harmonise with that of Koeberg NPS and the surrounding environment, and, given the relative size of the building compared to Koeberg NPS it is anticipated that the change in visual character will re-manifest over time (1 – 2 years after commissioning).

**Significance Rating**

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual impact of the proposed Plant combined with that of Koeberg NPS</td>
<td>Extent: Local to subregional, Duration: Permanent, Intensity: Medium, Severity Rating: Definite</td>
<td>Significance Rating: -15 High</td>
</tr>
</tbody>
</table>

**Conclusions**

The initial visual impact will be noticed but this will be of a temporary nature for the observer, until the new “landscape” has manifested.

The building design and finishing will blend with the existing structures and the environment.
Mitigation

Screening of the observation positions, with well planned and design indigenous tree/shrub vegetation screens.

**vi. Waste Impacts from the proposed Plant**

**Nature of the issue**

Chapter 4.14. provides data on the volumes of various wastes from the proposed PBMR Plant.

Conventional waste from construction (excavation spoil, seepage water, concrete, wood, metal, cables, glass etc) and operational activities will not cause significant environmental impact.

Radiological wastes/discharges from operation, maintenance and decommissioning however, will be carefully managed, monitored, shielded, stored and disposed of.

**Significance Rating**

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extent</td>
<td>Duration</td>
</tr>
<tr>
<td>Emissions</td>
<td>Local to sub regional</td>
<td>Long term</td>
</tr>
<tr>
<td>Normal and upset</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Effluent(s)</td>
<td>Local</td>
<td>Long term</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Solid Waste</td>
<td>Local</td>
<td>Long term</td>
</tr>
<tr>
<td>LLW &amp; ILW</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>HLW</td>
<td>Local</td>
<td>Permanent</td>
</tr>
<tr>
<td>* spent fuel &amp; reactor column</td>
<td>-</td>
<td>4</td>
</tr>
</tbody>
</table>

**Conclusions**

Conventional wastes will not have a significant impact on the environment.
Radiological waste will not have a significant impact on the environment provided that the safety procedures are adhered to and kept ALARA.

- **Mitigation**
  - Conventional waste: Waste must be separated, recycled and disposed of on registered landfill sites.
  - Radiological waste: Safety and Licence requirements must be adhered to as stipulated by the NNR. Full radiological inventory accounting must be conducted.

5.2.4 **TECHNICAL OR SUITABILITY IMPACTS (I.E. IMPACTS OF ENVIRONMENT ON THE PLANT)**

i. **Geotectonic Suitability of the Koeberg Site and Geological Province**

- **Nature of Event**
  
  Chapter 4.15. describes the geological and seismic characteristics of the site and sub region. The study concludes that the site is stable and that the maximum peak ground acceleration (PGA) for an earthquake will be 0.27g on the proposed site, based on historically measured and calculated data for the sub region.

  An event of this nature, although never experienced at Koeberg, is therefore probable, with a high intensity (natural or man-made function/process temporarily or permanently altered) but of limited duration (from a few seconds to days due to and after shock waves).

  This impact will affect the design and operational phases of the Plant.

- **Significance Rating**

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>Duration</td>
<td>Intensity</td>
</tr>
<tr>
<td>Earthquake event with a PGA of 0.27g horizontal acceleration (h.a.)</td>
<td>Local to sub regional</td>
<td>Less than a year</td>
</tr>
<tr>
<td>-</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

- **Conclusion**

  Since the Reactor and critical components will be located on aseismic bearings that can withstand a PGA of 0.4g no damage to such components will occur. In such an event the power station will be shut down and inspected for damage. Should the helium circuit be breached the helium gas containing radioactive gases and materials will be released to the reactor building compartment from where it will discharge through the HVAC system.

  The volume will be restricted to the escaped volume of the helium gas that has moved through the reactor till the isolation system becomes functional (i.e. on both the helium circuits and reactor building compartment).
Mitigation

Public exposure levels have been modelled and assessed by the applicant, as part of the Safety Analysis Report and will be evaluated by the NNR for licensing purposes.

The Safety Procedures and Programmes, as required by the NNR, must be implemented.

ii. Hydrological and Geohydrological Suitability of the Site

Nature of area or event

Chapter 4.16. provides a description of the hydrology of the site and sub region. During construction the excavations will be subjected to continuous seepage (due to a shallow water table, i.e. -5.0m) of a saline nature, which will be pumped out to the sea. The resultant impact will be of low environmental significance. During normal operation all radiologically contaminated effluent are isolated to specific systems, secured, shielded and treated. However in the event of an accidental release, the effluent will be restricted to the primary aquifer and movement will be towards the sea where it will be diluted.

An event of this nature is improbable (as demonstrated by design and monitoring data) with a medium intensity (some reversible process damage may have occurred) and of short duration (Detection will be rapid or may take some days where after clean-up and intensive monitoring will be done).

This issue will affect the design construction and operational phases of the Plant.

Significance Rating

<table>
<thead>
<tr>
<th>Event</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Severity Rating</th>
<th>Probability</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidental liquid effluent release to ground water due to natural/man-made events</td>
<td>Local</td>
<td>Less than a year</td>
<td>Medium</td>
<td>Improbable</td>
<td>-4 (low)</td>
<td></td>
</tr>
</tbody>
</table>

Conclusion

No boreholes or wells used for human or industrial consumption will be affected or compromised.

Mitigation

Monitoring of groundwater quality to establish a representative (about 2 years) pre-operational baseline database.

Establishment of permanent monitoring wells up and downstream from the Plant, that must be monitored on an approved regime (frequency) and for specific constituents (radiological and non-radiological parameters).
iii. Meteorological Conditions of the Koeberg Region

Nature of area or event

Chapter 4.17. provides a description of the meteorological (climate) conditions of the Koeberg region as well as equipment to continuously monitor weather conditions. While extreme climatic conditions (temperature, rainfall, wind and fog) will not impact on the Station, inversion conditions (air stability) can influence emissions dispersion and dilution and thus public exposure to such emissions. Emission dispersion is however dealt with under demographic impacts (Chapter 5.3.5).

During construction wind speed and direction (southerly) may present a nuisance impact since soft excavated material may blow onto the Koeberg Station. Such impact will largely be restricted to the site and it is unlikely that the public will or may be affected.

Climatic conditions will influence the design, construction and operational phases of the Plant.

Significance Rating

The combined effect of unfavourable climatic conditions and abnormal (category C event) radioactive releases are dealt with in Chapter 4.

Conclusion

The Koeberg weather station is sufficiently equipped (with back up) to provide data and analysis to the proposed Plant during normal and upset conditions.

Mitigation

Emission releases should consider climatic conditions and be effected only when sufficient dilution and dispersion can occur to limit human/environmental exposures.

iv. Oceanographic conditions around the Koeberg Site

Nature of area or event

Chapter 4.18. provides a description of the physical oceanographic conditions of the marine environment around Koeberg.

Adverse conditions (re-entrainment of the hot water plume and oil slicks) are monitored and contingency procedures are in place to deal with such eventualities.

This issue will impact the design and operational phases of the Plant. While both events have the same severity rating (duration x intensity) the natural extreme phenomena is improbable while the adverse conditions are probable.
Significance Rating

<table>
<thead>
<tr>
<th>Event</th>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extreme oceanographic conditions</td>
<td>Local to sub-regional</td>
<td>A few days (worst) 2</td>
<td>(8) 3</td>
</tr>
<tr>
<td>Adverse natural/man-made conditions (e.g. entrainment of thermal plume or oil slicks)</td>
<td>Local</td>
<td>Few days 2</td>
<td>High 4</td>
</tr>
</tbody>
</table>

Conclusion

It is concluded that the terrace height of the proposed Plant as well as the existing stilling basin and seawater intake structure for Koeberg is sufficiently located and designed to cope with extreme tidal waves (tsunamis) and extreme low tide conditions (Seiches). Sea water temperatures and the dynamic mixing (currents) of the sea water body are also such that thermal outflows from the proposed Plant, in addition to that of Koeberg, will be sufficiently dissipated.

Mitigation

The existing contingency procedures are sufficient to deal with the adverse conditions namely:

- Monitoring of the sea current and thermal plume movement conditions and surveillance on oil slicks and floating debris.
- Boom systems to close off the stilling basin to protect sea water intake equipment and the stations’ cooling systems against oil ingress.
- Shut down of the power stations and alternative cooling supply arrangements

vi. Thermal Discharge

Chapter 4.19 provides information on the projected temperature rise due to the additional outflow from the proposed Plant and concludes that the impact on marine life will be negligible. The largest impact will be on zoo- and phytoplankton but due to the localised nature of the impact and the dynamic characteristic of the Atlantic Ocean the impact is regarded as insignificant.
vii. Population Density (Demography) in the Koeberg sub region

Nature of the area and event

Chapter 4.20. provides information on the population distribution around Koeberg up to a plus 50km radius. The information is based on updated census figures for 2001 and 2006, which include both permanent and transient (tourism) populations.

Demographic information is relevant for the calculation of peak and average public exposure levels for various events (i.e. category A, B and C events) and emergency evacuation plans as may be required by the NNR.

The NNR will determine the exclusion zone distance for the PBMR as well as the evacuation zone for the Plant.

The Plants’ designers postulate that the evacuation zone for the proposed Plant will be 400 meters with no further emergency planning requirements beyond that distance. The NNR will also assess the motivation of the statement and if satisfied, will approve a licence.

The SAR evaluation should however, include consideration of the likelihood of simultaneous accidents at stations (i.e. Koeberg NPS and the proposed PBMR Plant) and the cumulative radiological impact of such an event(s).

Significance Rating

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extent</td>
<td>Duration</td>
</tr>
<tr>
<td>Category C event release to the environment under unstable climate conditions</td>
<td>Local</td>
<td>Short term</td>
</tr>
</tbody>
</table>

Conclusion

Worst case event exposure levels from the PBMR will be very low and it is expected that the PBMR Plant will not impact on the Koeberg NPS limits.

Mitigation

Radiation protection programmes and the ALARA principle must be implemented and regularly reviewed for conformance and/or improvement.

vii. Infrastructure Status (e.g. Roads, Harbours, Residential areas, Utilities and Services)
Nature of the area or event

Chapter 4.21. provides an overview of the status of the infrastructure in the Koeberg sub region. These relate to:

- Main, arterial, and service roads
- Cape Town harbour facilities
- Residential areas
- Schools, churches, hospitals and medical services
- Industries (particularly high risk industries e.g. petroleum storage)
- Fisheries industries, fishing grounds and sea routes
- Airports and flight zones and routes
- Agriculture and produce processing particularly milk products
- Communication, electricity and water infrastructure

The information serves a two fold function, namely:

- Capacity of infrastructure (social and physical) to provide service and accommodate the influx of persons and goods/equipment
- It forms the basis for emergency planning and must be read in conjunction with demography and climate conditions.

The largest impact on the capacity of infrastructure will be during the construction phase of about 24 months with a peak construction workforce of about 1 400 persons. Most of the construction workers will however be sourced locally with the result that the impact on housing will not be to critical. No temporary residential area for construction workers is planned for either. The more significant impact will be on traffic for the transport of material, equipment and people. Traffic and emergency services may have to be supplemented for this purpose, especially in and around the Koeberg area.

For the operational phase 40 employees will be required. In year 20 of the Plants’ operation a mayor maintenance program will be conducted which also involves the replacement of the reactor column. This programme will again cause the influx of maintenance workers. Decommissioning/dismantling will require a similar workforce to construction.

Significance Rating

<table>
<thead>
<tr>
<th>Event</th>
<th>Assessment Criteria</th>
<th>Significance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extent</td>
<td>Duration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Influx of people (about 1,400) for construction or dismantling

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Local to subregional</th>
<th>About years</th>
<th>Medium</th>
<th>Highly probable</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic - heavy vehicles and commuters for construction or dismantling</td>
<td>Local to subregional</td>
<td>About years</td>
<td>2</td>
<td>(4) 2</td>
<td>4</td>
</tr>
<tr>
<td>Upgrading of utility capacity (water and electricity)</td>
<td>Local to subregional</td>
<td>About years</td>
<td>4</td>
<td>(4) 2</td>
<td>5</td>
</tr>
</tbody>
</table>

**Conclusion**

- The sub regions infrastructure has the capacity to cope with the temporary supply of services.
- Traffic and emergency services will require supplementation during the construction phase.
- Water and electricity supply will require upgrading for construction and the operational phases.

**Mitigation**

Utility upgrades should be planned and conducted in close co-operation between Eskom and the Cape UniCity (CUC) to optimise long term benefit to the society.

The construction workforce must, as far as practicable, be sourced locally.

Traffic and emergency services capacities have to be supplemented during construction and such need must be planned and implemented in close co-operation between the project proponent (Eskom), the City of Cape Town and local authorities.
6. PUBLIC PARTICIPATION

6.1 INTRODUCTION

The aim of this chapter is two-fold:

- It provides a description of the public participation process conducted for both EIA phases (i.e. PBMR (Koeberg) as well as the other regarding the Fuel Manufacture and Transportation).

- It provides a list of issues recorded during the process (EIA Phase) and aims to clarify these issues by either providing a cross-reference to sections of the reports or supporting documentation where the issue was addressed. Alternatively, an answer is provided in the "Comment" section column. Where relevant, statements were recorded to give the reader a feel for the sentiments of I&APs.

6.2 METHODOLOGY, SCOPE AND PROCESS

For the EIA phase, a process comprising a number of tools were employed to achieve the aim of identifying and incorporating site-specific issues.

6.2.1 OVERVIEW OF THE PROCESS FOLLOWED

The approach towards any public participation process is dependent upon the details of the project, the reason being that each project has a particular geographic and technical nature and hence the public participation process should be structured accordingly. Where possible and within the required statutory frameworks, it is also desirable to structure such a process to address the process needs of the I&APs.
**Figure 31:** Public participation timeframes for the EIA phase

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submission of Scoping Reports (Plans of Study for EIA included)</td>
<td>17 October 2001</td>
</tr>
<tr>
<td>Reports accepted by the DEAT</td>
<td>14 December 2002</td>
</tr>
<tr>
<td>Send out information to I&amp;APs</td>
<td>07 to 14 February 2002</td>
</tr>
<tr>
<td>Plans of Study for EIA accepted</td>
<td>05 March 2002</td>
</tr>
<tr>
<td>Focus Group &amp; Individual Meetings</td>
<td>13 March to 25 April 2002</td>
</tr>
<tr>
<td>Finalise Information Document (Volume II)</td>
<td>17 April 2002</td>
</tr>
<tr>
<td>Advertise Public Meetings</td>
<td>28 April to 02 May 2002</td>
</tr>
<tr>
<td>Send out notices of Public Meetings and availability of Info Doc II</td>
<td>23 April to 03 May 2002</td>
</tr>
<tr>
<td>Hold Public Meetings</td>
<td>16 to 30 May 2002</td>
</tr>
<tr>
<td>Make Draft Environmental Impact Assessment Documents Available</td>
<td>04 June to 04 August 2002</td>
</tr>
<tr>
<td>Finalise Environmental Impact Report</td>
<td>After 04 August 2002</td>
</tr>
<tr>
<td>Submit Report to the relevant authority (DEAT)</td>
<td>End of September 2002</td>
</tr>
<tr>
<td>Receive Record of Decision (RoD)</td>
<td>Dependant on authority</td>
</tr>
<tr>
<td>Inform I&amp;APs and advertise in newspapers</td>
<td>Dependant on date of RoD</td>
</tr>
<tr>
<td>Appeal period</td>
<td>Thirty days after notification</td>
</tr>
</tbody>
</table>
6.3 TOOLS AND INPUTS

This section provides information on the various mechanisms employed during the public participation process. Details will also be provided on the advertising and notification procedures. The following tools and mechanisms were utilised:

- Continued registration of I&APs;
- Providing I&APs with information in the form of an Information Document (Volume I and II);
- Structured interviews in a focus group/individual format;
- Written submissions received from I&APs;
- Public Meetings; and
- Public Review of the Draft EI Rs.

6.3.1 IDENTIFICATION OF INTERESTED AND AFFECTED PARTIES

Through networking and advertisements, 2 817 I&APs are currently registered on a database. Afrosearch endeavoured to ensure that individuals/organisations from a 'vertical' (institutional) as well as a 'horizontal' (geographical) point of view are identified.

Geographically, Afrosearch focused on nearby landowners and the organisations that represent them. A 'vertical' approach was used to identify those institutions or individuals that might be affected by, or could make a contribution to the project, but who are not necessarily in its direct sphere of impact.

Periodically, registered I&APs' details are verified.

6.3.2 INFORMATION DOCUMENT (VOLUME 2)

**Note:** Refer to Annexure 14 for the Information Document (Volume II).

In April 2002, an Information Document (Volume 2) was compiled. This document is in a questions and answers format (as was the Information Document Volume 1). The objective was to supply information on frequently asked questions, under a number of main headings.

6.3.3 STRUCTURED FOCUS GROUP AND INDIVIDUAL INTERVIEWS AND MEETINGS

Focus group meetings are used as a valuable tool to obtain detailed information ranging from statistics and facts to emotive feedback from a sectoral perspective. For this process, a focus group meeting was defined as a meeting where I&APs, who share a common sectoral focus, were brought together to discuss the project and identify questions, concerns and issues. An individual meeting was a meeting where only one representative of a specific organisation was met with or if the individual...
individual had a particular function such as a mayor.

The focus group meetings were conducted as a formal meeting, which was chaired by a member of the EIA Consortium. Issues identified by I&APs were formally recorded. Records of issues raised were provided to participants for comment and correction. Issues identified were entered into the issues register.

Table 52: List of Focus Group Meetings held for the EIA phase

(Gauteng and North West Province)¹⁴³

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>ORGANISATIONS AND INDIVIDUALS INVITED</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-03-02</td>
<td>08:00</td>
<td>CSIR</td>
</tr>
<tr>
<td>13-03-02</td>
<td>11:00</td>
<td>Afrikaanse Handelsinstituut</td>
</tr>
<tr>
<td>13-03-02</td>
<td>14:00</td>
<td>National Government Departments</td>
</tr>
<tr>
<td>14-03-02</td>
<td>11:00</td>
<td>National Nuclear Regulator</td>
</tr>
<tr>
<td>14-03-02</td>
<td>14:00</td>
<td>Solar Centre (SOLCEN)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solar Energy Society of Southern Africa (SESSA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Duard Barnard and Associates</td>
</tr>
<tr>
<td>14-03-02</td>
<td>18:00</td>
<td>Pelindaba Surrounding Land Owners</td>
</tr>
<tr>
<td>15-03-02</td>
<td>11:00</td>
<td>SACOB</td>
</tr>
<tr>
<td>25-03-02</td>
<td>11:00</td>
<td>Brits Industrial Assoc</td>
</tr>
<tr>
<td></td>
<td></td>
<td>North West Chamber of Industries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>North West Chamber of Industries and Mines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brits Industrial Society</td>
</tr>
<tr>
<td>26-03-02</td>
<td>18:00</td>
<td>Community and Environment Based Organisation</td>
</tr>
<tr>
<td>27-03-02</td>
<td>11:00</td>
<td>Chamber of Mines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chemical and Allied Industries Association</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Business Council for Sustainable Development: South Africa (Formerly the Industrial Environmental Forum)</td>
</tr>
<tr>
<td>27-03-02</td>
<td>14:00</td>
<td>Onsite Businesses, Pelindaba</td>
</tr>
<tr>
<td>09-04-02</td>
<td>08:00</td>
<td>COSATU</td>
</tr>
<tr>
<td>10-04-02</td>
<td>18:00</td>
<td>Pelindaba Communication Forum</td>
</tr>
</tbody>
</table>

Table 53: List of Focus Group Meetings held for the EIA Phase

(Western Cape)¹⁴⁴

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>ORGANISATIONS AND INDIVIDUALS INVITED</th>
</tr>
</thead>
<tbody>
<tr>
<td>04-04-02</td>
<td>12:00</td>
<td>Blaauwberg Administration City of Cape Town</td>
</tr>
<tr>
<td>04-04-02</td>
<td>14:00</td>
<td>Energy Transformations CC</td>
</tr>
</tbody>
</table>

¹⁴³ A number of meetings were arranged, but due to cancellations, did not take place. These were:

The Independent Development Forum; DEAT Tourism; the SA Pool for the Insurance of Nuclear Risk; the Free Market Foundation, Human Rights Committee of SA and the Human Rights Institute of SA; Edward, Nathan and Friedman and Deneys Reits the Diepsloot Community Development Forum and the Dukasie Development Trust.

¹⁴⁴ Meetings that did not take place due to cancellation were the meetings with the Provincial Administration: Department Economic Affairs, Agriculture and Tourism and the National Union of Mineworkers (Western Cape).
### Public Meetings

The main objective of a public meeting during the EIA Phase is to give the public the opportunity to receive feedback on the findings of the specialist studies. Furthermore, public meetings are an important platform by which information assimilated during the consultation process can be verified. Presentations are made regarding the technical studies, the conclusions and the recommendations of the Consultants.

For the two projects, a series of public meetings were held in the Western Cape, Durban and the Pelindaba area. As indicated in Figure 31 the initial notification (newspaper and communication with registered I&APs) for the Public Meetings took place between 23 April and 03 May 2002. The dates of the Meetings were as follows:

- **Thursday 16 May 2002** at 18:30 (Hartbeeshof Service Centre, 125 Kuyper Street, Schoemansville);
- **Saturday 18 May 2002** at 10:00 (Mobolekwa Hall, C/o Sehloho & Sethole Street, Atteridgeville);
- **Tuesday 21 May 2002** at 18:30 (Ferndale Community Centre, C/o Harley Street & Surrey Avenue, Randburg);
- **Thursday 23 May 2002** at 18:30 (Durban Exhibition Centre (Hall 6) 11 Walnut Road, Durban);
- **Tuesday 28 May 2002** at 18:30 (Jan van Riebeeck High School, 129 Kloof Street, Cape Town);
- **Wednesday 29 May 2002** at 18:30 (Atlantis Secondary School, Palmer Avenue, Atlantis); and
- **Thursday 30 May 2002** at 18:30 (Jansen Hall, Jansen Street, Milnerton).

The following steps were taken to inform and remind I&APs and the public of the meetings: Table 54

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>05-04-02</td>
<td>09:00 Industrial and Petrochemical Consultants Mr. J. Walmsley</td>
</tr>
<tr>
<td></td>
<td>Institution of Nuclear Engineers: South African Branch</td>
</tr>
<tr>
<td>18-04-02</td>
<td>12:00 Local and Regional Trade and Industry</td>
</tr>
<tr>
<td>18-03-02</td>
<td>14:30 National Botanical Society</td>
</tr>
<tr>
<td>18-03-02</td>
<td>18:30 Land owners adjacent to Koeberg</td>
</tr>
<tr>
<td>19-03-02</td>
<td>17:30 National Energy Organisations</td>
</tr>
<tr>
<td>04-04-02</td>
<td>12:00 City of Cape Town: Blaauwberg Administration (SIA Interview)</td>
</tr>
<tr>
<td>05-04-02</td>
<td>09:00 Industrial and Petrochemical Consultants (SIA interview)</td>
</tr>
<tr>
<td>24-04-02</td>
<td>11:00 Provincial Administration – DECAS (Western Cape)</td>
</tr>
<tr>
<td>24-04-02</td>
<td>14:00 CMC: Planning and Environment – Environmental Management</td>
</tr>
<tr>
<td>25-04-02</td>
<td>08:30 University of Stellenbosch: Department of Medicine</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NATIONAL NEWSPAPERS</th>
<th>REGIONAL NEWSPAPERS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NATIONAL NEWSPAPERS</strong></td>
<td><strong>REGIONAL NEWSPAPERS</strong></td>
</tr>
<tr>
<td>The Sowetan 28-04-2002</td>
<td></td>
</tr>
</tbody>
</table>

**Table 54**: Notification of Public Meetings for the EIA Phase

PAGE 380
### Personal Invitations: 23 April to 03 May 2002

<table>
<thead>
<tr>
<th>Letters</th>
<th>Fax</th>
<th>E-mails</th>
<th>Telephonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>725</td>
<td>1 700</td>
<td>849</td>
<td>None</td>
</tr>
</tbody>
</table>

Letters to headmasters of schools in Atlantis, Mamre and Milnerton: 23

### Posters

<table>
<thead>
<tr>
<th>Alantis: 50</th>
<th>Cape Town: 50</th>
<th>Durban: 50</th>
<th>Hartbeespoort / Meerhof / Ifafi: 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milnerton: 50</td>
<td>Randburg: 50</td>
<td>Atteridgeville: 200</td>
<td></td>
</tr>
</tbody>
</table>

### Flyers

6 700 Flyers were distributed in Atteridgeville, Diepsloot, Hartbeespoort / Schoemansville, Pelindaba, Ifafi, Lanseria and Broederstroom.

The following steps were taken to inform members from disadvantaged communities of the Public Meetings:
Public Meetings were specifically arranged for Atteridgeville and Atlantis.

Formal and informal leaders in Atteridgeville, Diepsloot, Atlantis, Mamre, Khayelitsha and Langa were contacted and informed;

Street Posters were put up in Atteridgeville, Mamre and Atlantis and flyers were distributed.

Permission was obtained from the respective Departments of Education to distribute information to the schools. All schools in Atteridgeville (33) were informed of the Public Meetings on 24 April 2002 and those in Mamre, Atlantis (and Milnerton) (23) were informed of the Public Meetings on 13 May 2002.

The public libraries in Avon, Mamre, Khayelitsha (and Milnerton) were asked to display posters advertising the Public Meetings in an obvious place.

A Xhosa advertisement advertising the Public Meetings were placed in the City Vision in the Western Cape.

At the request of the attendants at the Public Meeting in Atlantis on 30 May 2002, an information meeting was arranged to inform residents and other interested parties of the proposed project and technology. This meeting took place on 01 August 2002 in the Hartebeeskraal Multi-purpose Centre. This meeting was arranged in close collaboration with Ms. Julia Mentor – CEO of the Centre.

The table below indicates the electronic and print media where press releases regarding the Public Meetings were sent. The radio, in particular, is regarded as a prime method of communicating to persons who live in disadvantaged communities.

**Table 55: Notification of Public Meetings for the EIA Phase**

<table>
<thead>
<tr>
<th>MEDIA PRESS RELEASES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication Xellence coordinated press releases inviting the public to the public meetings and informing them of the progress of the project</td>
<td></td>
</tr>
<tr>
<td><strong>NATIONAL</strong></td>
<td></td>
</tr>
<tr>
<td>Associated Press</td>
<td>Agence France Presse</td>
</tr>
<tr>
<td>Business News</td>
<td>Business Day</td>
</tr>
<tr>
<td>Citizen</td>
<td>City Vision</td>
</tr>
<tr>
<td>50/50</td>
<td>Freek Robinson</td>
</tr>
<tr>
<td>I-Net Bridge</td>
<td>Insig</td>
</tr>
<tr>
<td>Radio Lotus</td>
<td>RSG</td>
</tr>
<tr>
<td>SABC Radio</td>
<td>SABC TV</td>
</tr>
<tr>
<td>Saturday Star</td>
<td>702</td>
</tr>
<tr>
<td>Summit TV</td>
<td>Sunday Independent</td>
</tr>
<tr>
<td><strong>GAUTENG MEDIA</strong></td>
<td></td>
</tr>
<tr>
<td>Highveld</td>
<td>Jacaranda</td>
</tr>
<tr>
<td>Sunday Times (Gauteng)</td>
<td>Rapport (Gauteng)</td>
</tr>
</tbody>
</table>
6.3.5 Public Review of the Draft EIRs

Sixty days (06 June to 04 August 2002) has been allocated for comments on the reports to be sent to the PBMR EIA Consortium. During the review period for the draft EIRs, hard copies will be distributed for public review and comment in a number of publically accessible venues (33 countrywide) (see Table 56). A copy will also be available on the website (www.pebble-bed.co.za) and CD-Roms containing the draft EIRs and Supporting Documentation will be made available on request.

Table 56: Venues where Draft Environmental Impact Reports were available for comment.

<table>
<thead>
<tr>
<th>ATLANTIS (AVONDALE) LIBRARY</th>
<th>EMPANGENI LIBRARY</th>
<th>PAARL LIBRARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grovenor Street</td>
<td>C/o Commercial &amp; Union Streets</td>
<td>C/o Meul &amp; Main Streets</td>
</tr>
<tr>
<td>ATTERIDGEVILLE LIBRARY</td>
<td>ERMELO LIBRARY</td>
<td>PELINDABA (NECSA)</td>
</tr>
<tr>
<td>Mohlabat Street</td>
<td>C/o Church &amp; Taute Streets</td>
<td>Visitor’s Centre – Gate 2</td>
</tr>
<tr>
<td>BEAUFORT-WEST LIBRARY</td>
<td>HARRISMITH LIBRARY</td>
<td>PIET RETIEF LIBRARY</td>
</tr>
<tr>
<td>15 Church Street</td>
<td>C/o Murray &amp; Warden Streets</td>
<td>10 Retief Street</td>
</tr>
</tbody>
</table>
A copy of the report was also made available on the website (www.pebble-bed.co.za).

6.3.6 WRITTEN SUBMISSIONS RECEIVED FROM I&APS AND COMMENTS REGISTER

Letters/e-mails/faxes were received from I&APs informing the PBMR EIA Consortium of their comments on the Draft EIR. A copy of each communication, along with the response sent to the person/organization is kept on file for record purposes.

A register containing all the comments that were received since 01 June 2002 are included as the Comments Register.

6.3.7 ISSUES REGISTERS

Two issues registers were compiled to deal with the different aspects of the two projects. One register was used to record issues for the PBMR (Koeberg) and another for the two parts of the NECSA project (i.e. Fuel Manufacture and Transportation). The PBMR EIA Consortium endeavoured to provide an indication of where answers to, or explanations regarding the issues could be obtained in the EIR. The PBMR Issues Register can be found under Annexure 10.

6.3.8 MEDIA COVERAGE

Annexure 21 provides copy of the advertisements that were placed in terms of the regulations while Annexure 22 provide news print and medial analysis reports.
7. CONCLUSIONS

The conclusions of the EIR are dealt with in separate parts, namely:

- Policy/Strategic Issues and Impacts
- Project Related Issues and Impacts
- Projected Related Issues and Impacts
- Cumulative Issues and Impacts
- Linked Impacts

7.1 POLICY/STRATEGIC ISSUES AND IMPACTS THAT IS REPORTED ON

7.1.1 NATIONAL ENERGY POLICY WHITE PAPER

Government has pursued its obligations and objectives on the proposed Plant from a technical, economic and environmental point of view. To this end an Expert Review Panel was appointed by the Department of Minerals and Energy to assess the adequacy of information of the Detailed Feasibility and Design Studies; an EIA is being conducted to fulfil the requirements of the Environmental Conservation Act (Act 73 of 1989) and the National Environmental Management Act (Act 107 of 1998); co-investors were secured to assist with the financing of the detailed feasibility and design studies and to gauge international acceptance and markets; the safety assessment of the design for licensing through the NNR, and ultimately the joint decision process of the Cabinet on the desirability to progress to follow-on phases.

The PBMR Plant will:

- Inform the Integrated Resource Planning Process (IRPP) as stipulated in the Energy White Paper to provide guidance on the future use of the technology. This is especially so since demonstration plants for other technologies (e.g. wind, solar thermal and biomass) will be implemented by Eskom and Independent Power Producers (IPPs) in close succession with the Plant.

- Broaden the energy mix for electricity supply.

- Western Cape Policy on Energy and Spatial Development

  These policies form part of the Western Cape Province’s broad vision and policy on “Previous the Western Cape for the Knowledge Economy of the 21st Century.”

While the Energy Chapter of the Western Cape Policy is in synchronisation with the National Energy Policy White Paper (1998) there appears to be different interpretation of the former Policy’s intent by some Provincial and Local authorities in terms of the desirability of the PBMR.
This differences of interpretation and concerns of the Western Cape Authorities need to be discussed and clarified at an institutional and authority level.

- Alternatives in terms of Energy and Technology

Both the EIA regulations and the Energy Policy White Paper stipulate the consideration of alternatives (e.g. energy, technology, etc.). This application is, however, not a commercial one for nuclear based power generation, but for the establishment of a demonstration Plant\(^{145}\) to inform on the techno-economics of the specific plant which, in turn, will inform the IRPP of government, Eskom’s ISEP and the consideration of alternatives. Once this stage has been reached (probable in the years 2006 - 2008) more informed decisions can be made on commercial energy mixes for electricity supply and management.

### 7.1.2 Radiological Waste Management and Final Disposal

A draft National Radioactive Waste Management Policy (NRWMP) was issued by the DM&E in 2001 for public comment.

This draft Policy is strategic in nature and sets out the principles and scope for the management of radiological waste(s) generated by the various sectors of the economy e.g. the mining sector, medical sector, food sector and electricity supply sector.

The draft Policy is currently under review by the DM&E and it is understood that it will be re-issued in late 2002 for comment.

Once this Policy is in place, more directive policies for the various economic sectors and types (classes) of radiological waste (i.e. low, intermediate and high level) may be formulated and issued.

While low level (LLW) and intermediate level (ILW) radiological wastes are well guided by policy, and, final deposition facilities for these wastes exist, there is a real need to accelerate the establishment of a Policy and facility(ies) (repository) for the long term management and disposal of long lived radioactive waste i.e. high level radioactive wastes (HLW).

### 7.1.3 Treaty on the Non-Proliferation of Nuclear Weapons and Materials for Mass Destruction

Much confusion exists in the public domain about the scope of the Nuclear Non-Proliferation Treaty. Some members of public interpret/perceive the Treaty to intend the total absence of the use of nuclear materials, processes, technology etc. within national boundaries.

\(^{145}\) Various other technologies are in this phase of development (e.g. wind, solar thermal and biomass) and due for EIA application, within Eskom’s portfolio of new development project conducted in terms of its ISEP.
This Treaty makes provision for the international regulation of nuclear and other materials or precursory materials that may be employed for the manufacture, harbouring and use of devices or weapons of mass destruction.

It thus has application to the non-proliferation of nuclear weapons as well as specific and implied meaning for the use of such materials for commercial application, since they must be declared and fully accounted for at national and international level. In this regard the Minister of Minerals and Energy functions as the national governor for the implementation of this Treaty, and Safeguards Agreement.

The implementation of the Safeguards Agreement require that Subsidiary Agreements be established for the various nuclear facilities that are under safeguards. For example, a Subsidiary Agreement exists (and has always existed) for Koeberg Units 1 and 2. A Subsidiary Agreement existed for the previous BEVA plant where accounting to gram quantities of uranium was required. Similar Subsidiary Agreements would have to be developed and signed for the Fuel Manufacturing Plant as well as for the proposed PBMR Demonstration plant. The design and mode of operation of the respective proposed facilities will form part of the negotiations with the International Atomic Energy Agency (IAEA) in developing the Subsidiary Agreements.

It is quite clear that the proposed Plant and associated fuel manufacture facilities have a direct bearing on the Government’s obligations in terms of the Treaty and the Pelindaba Treaty. However, government is well aware of these obligations and will discharge their duties accordingly.

In addition, South Africa was instrumental in the formulation of the Pelindaba Treaty or the African Nuclear Weapon-Free Zone Treaty. It should be noted that this Treaty is about keeping Africa free of Nuclear Weapons. It promotes co-operation in the peaceful uses of nuclear energy and recognises the right for countries to develop research on, the production of and use of nuclear energy.

The Treaty states that parties to the Treaty are determined to promote regional co-operation for the development and practical application of nuclear energy for peaceful purposes, in the interests of sustainable social and economic development of the African continent.

7.1.4 Epidemiological Studies

During the Scoping Phase of this EIA the issue was raised that real time health risk or epidemiological studies should/must be conducted as part of the detailed studies to inform this EIR.

a. Radiologically induced Cancer(s) due to the operation of nuclear plants

146 Epidemiological studies involve those studies on human health resulting from environmental stressors (man-made or natural activities) which may or will influence the well being of mankind.
Established national and international standards require very strict radiological surveillance of staff and the environmental media (air, water, soil and wildlife). The undertaking of prior epidemiological studies on the public is not stipulated in South African legislation, nor is it part of any international standard set for nuclear power station facilities.

The National Nuclear Regulator Act (Act 47 of 1999) provides for the regulation of nuclear activities and to exercises the regulatory control and assurance on the health/safety of workers, property and the environment.

The accepted approach to this study (PoS as approved by the DEAT) was to review and be guided by international literature on the subject. (Annexure 3 provides papers from international research on the subject).

Based on this literature review, the role of the NNR and the radiological protection programme and the environmental monitoring/surveillance that will be implemented for the proposed Plant, epidemiological study and health monitoring of the public for the proposed Plan is not recommended or required. Assurance that the practices carried out conform to requirement must be demonstrated through operational and environmental monitoring programmes, health monitoring of employees and conformance to the legal requirements as administered by the NNR and in terms of the Occupational Health and Safety Act (Act No. 85 of 1993).

b. HIV/AIDS in the Workplace

Eskom has committed itself to the implementation of an HIV/AIDS Policy and Practices to educate and also support infected staff and co-workers. The policy will also be applied to contractors during the construction phase.

7.1.5 Radiological Safety

Of specific concern to the authority(ies) and the public is the issue of radiological safety to man and the environment.

This EIR reports on the safety features related to the design and operation of the Plant as well as that of radiological waste management whether gaseous, liquid or solid and confirms conformance to the fundamental safety criteria laid down by the National Nuclear Regulator (NNR).

7.2 PROJECT RELATED ISSUES AND IMPACTS THAT WERE ASSESSED

7.2.1 Construction Phase

- Temporary concentration, with limited influx, of construction workers with resultant traffic, services and resource requirement. This is largely off-set with better income and local spending, though of a limited duration. On a regional and national scale, component manufactures will further off-set adverse impact as well as the upgrading of some utilities i.e. water supply and electricity.
Changes to the aesthetic (visual) character that will manifest and become acceptable over time.

Generation of construction waste(s) and spoil respectively need to be sorted, recycled, re-used or disposed of at existing disposal facilities (waste) or re-used, contoured and rehabilitated (spoil).

All the adverse construction impacts can be successfully managed within acceptable levels, provided that a Construction EMP is implemented and monitored.

7.2.2 OPERATIONS/Maintenance Phase

No significant adverse non-radiological impacts incapable of adequate mitigation were identified for the operations/maintenance phase. However, the implementation and monitoring of an operational EMP remains a prerequisite.

These include the following:

- Open and concerted communication with the City of Cape Town and other local provincial and national authorities on radiological surveillance programme design and results. While Eskom is commended on its current programmes, circumstances have changed such that a renewed focus is required.

- Diligent application of Eskom’s HIV/AIDS policy and practices.

- Diligent support of the national goals on the training, development and retention of science and engineering skills.

- Continued support to the Disaster Management System and facilities of the Cape Unicity and Tygerberg Hospital.

7.2.3 DECOMMISSIONING AND Dismantling Phase

The design of the proposed Plant makes provision for simplified and streamlined decommissioning and dismantling from a radiological point of view.

7.2.4 Social Impact Assessment

A Social Impact Assessment was conducted by Afrosearch in accordance with IAIA principles and DEAT requirements. The SIA Report provides (Annexure 11) the findings of the in-depth assessment of the social impacts, including a rating of impacts and measures for mitigation through the enhancement of positive impacts and the amelioration of negative impacts.

The following impact themes were assessed in respect of the construction, operation and decommissioning stages of the project:
Population impacts referring to acute or transient changes in the demographic composition (age; gender; racial/ethnic composition) of the population. Two specific aspects were considered in this regard, namely potential changes commensurate with the introduction of people dissimilar in demographic profile in the first instance and the inflow of temporary workers to the PBMR site in the second instance.
Planning, institutional, infrastructure and services impacts. This theme related to projected impacts on Local and/or Metropolitan Government in terms of impacts on planning, the provision of off-site emergency response planning as well as an evaluation of needs related to infrastructure and services.

Individual, community and family level impacts related to impacts on daily movement patterns, visual and aesthetic impacts as well as potential pollution related intrusion.

Socio-economic impacts related to employment creation (focusing on the construction phase), changes in employment equity, direct and indirect socio-economic impacts resulting from the construction of the proposed PBMR demonstration module as well as property values in the primary impact area.

Community health, safety and security impacts, including an evaluation of the psychosocial stressors involved in health perception and the nocebo effect.

Management of waste and specifically nuclear waste.

Impacts on places of cultural, historical and archaeological significance (based on inputs received from I&APs and gathered during the baselines study).

Attitude formation, interest group activity and social mobilisation (the behavioural expression element of attitudes)

Throughout the Scoping and Impact Assessment processes it was clear that an essential and extremely important component of the impacts identified related to, or was linked in, with risk assessment and perceptions regarding risk. The degree to which the proposed PBMR development is perceived on a continuum from “dread risk” to “no risk” has differed significantly from group to group, depending on the basic point of departure of the group. Based on this, a contextual foundation was provided for the impact assessment through an evaluation of factors involved in the development of risk perception as well as the implications of this for the rating of impacts and for the development of mitigatory mechanisms.

Based on the impact assessment, the following specific conclusions and recommendations are made, inter alia, that:

- The absence of a coherent national nuclear energy policy and particularly the absence of a national policy regarding the disposal of nuclear waste is both a major factor contributing to the “dread risk perception” experienced by the affected society and a substantive environmental hazard in its own right. The failure to finalise the development of such a policy (with due cognisance of the process that has been initiated to develop a Radioactive Waste Management Policy) may be constituted as a breach of the duty of care borne by the national government in terms of Section 28 of the National Environmental Management Act, 1998 (Act
1998 (Act 107 of 1998) (NEMA) and of the principles as contained in Section 2 of NEMA. For this reason the national government is urged to ensure that, at minimum, the finalisation of an effective radioactive waste management policy is regarded as of the utmost importance and fast-tracked, with full cognisance of the need to follow due process.

- Risk perception and negative psycho-social sequelae of nuclear related “dread risk perception” is frequently attenuated and tempered by the provision of neutral, reliable, responsible, un-biased information dissemination and risk communication. While there is a limited public perception that neither NECSA nor Eskom will, necessarily, provide neutral information and risk communication, it is also perceived that anti-nuclear lobbies will not necessarily engage in the provision of neutral information and risk communication either. For this reason it is seen as an urgent imperative that an organisation such as the African Commission on Nuclear Energy (AFCONE), formed to oversee compliance in respect of the Organisation of African Unity’s Treaty of Pelindaba, be formally requested to extend its activities under Article 12 of the Treaty to educate and inform the public of the real risks and issues related to “the peaceful use of nuclear energy for the betterment of society”.

- It is vital that the Tygerberg Hospital’s ability to cope with nuclear incidents and disaster is maintained, in line with the World Health Organisation’s (WHO) REMPAN programme, aimed at promoting regional competence to deal with nuclear incidents and disasters. It is, therefore, seen as an absolute requirement that NECSA and Eskom continue to ensure that Tygerberg Hospital maintains this competence.

- The importance of establishing risk communication and risk management as a “two-way” process that includes mechanisms to address legitimate concerns has been stressed at various stages in the SIA Report. Some guidelines regarding the promotion of effective risk communication include ensuring that:
  - A senior person at Eskom is appointed to communicate with the public.
There is a thorough understanding and acceptance of community concern and sensitivity about secrecy and that information is provided freely and involves the public from the outset.

Every attempt is made to, first and foremost, earn trust and credibility.

No mixed messages are given and ensuring that all information has been checked and double-checked for accuracy.

The truth is told at all times even where this involves “bad news”, instead of attempting to salvage the situation later.

Attention is paid to community outrage factors and concerns. This will require that it be accepted that response to risk is more complex than the provision of scientific data and linear response to facts and that information should be provided so as to meet the requirements of people.

Wherever practicable, the help of organisations that have credibility in communicating with communities is enlisted.

- The Melkbosstrand Residents Ratepayers Association, the Transport and Roads Division of the City of Cape Town, as well as other I&APs have raised concerns about existing emergency plans (including evacuation plans) for Koeberg as well as the proposed PBMR. In this regard, the CCT states that it sees the existing Koeberg evacuation plan as requiring re-evaluation and being “totally inefficient ...(as) it will take approximately 19 hours to evacuate, which is much too long. This plan should also address the additional PBMR and the result of both reactors being faulty or the effect of the one on the other” (p.5: Annexure D: Comments from service delivery units).

### 7.2.5 Economics

- Provide some 1,400 local jobs over the construction period
- Provide some 40 permanent jobs
- Place capital expenditure preference on local content, where possible.
- Support and promote the national goals on Science and Technology.
- Not place additional spatial restrictions on the development of Cape Unicity area of jurisdiction.
- Have limited transient negative impact on tourism that may be offset by business visitor influx to the proposed Plant.
 Employ international practices and norms to accumulate sufficient segregate funds for the decommissioning and dismantling of the Plant and the disposal and long term management of HLW.

7.3 CUMULATIVE AND LINKED IMPACTS

The cumulative effects of the proposed PBMR Plant are largely in association with the Koeberg NPS. These effects and impacts will largely fit into the footprint of Koeberg.

HLW, as is the case with Koeberg NPS, will be managed on site for the life of the Proposed Plant to allow sufficient thermal cooling and radiological decay of the mother products. This has specific implications in terms of safety measures, security measures and non-proliferation protocols.

Radiological discharges (gaseous, liquid and solid) will fit into the Annual Authorised Discharge quantities (AADQ) for Koeberg. The NNR will decide on the emergency planning exclusion and evacuation zones. It is however the conclusion of the consultants that the current requirements for Koeberg NPS will not be affected.

During construction traffic volumes and patterns will be affected by commuters, material/equipment supplies and abnormal loads. Import of abnormal items will be routed via Saldanha harbour.

The only linked impact of the proposed demonstration module PBMR, and, the Fuel Plant proposed to be established at Pelindaba, is the cumulative low and intermediate level radioactive waste to be transported to and disposed of at, Vaalputs. The relatively low quantities of material to be generated render this linked impact insignificant.

7.4 RECOMMENDATIONS

The EIA Consortium identified no significant environmental risk(s) or adverse impact(s) in part or on the whole that can not be adequately managed and mitigated over the life of the Plant.

It is therefore recommended that the Department of Environmental Affairs and Tourism authorize the proposed activity provided that:

- The proposed activity is licensed by the NNR.
- The Environmental Management Plans for Construction and Operation/Maintenance are implemented
- Financial provisions are made for decommissioning and the long-term management and storage of radioactive waste in particular HLW.

Furthermore, it is recommended that:
• the DM&E accelerate the establishment of National Radioactive Waste Management Policy.

• An information process (centre) is established by government to objectively inform the public on nuclear matters.
8. ENVIRONMENTAL MANAGEMENT PLAN

8.1 INTRODUCTION

This environmental management plan (EMP) for the construction and operation/maintenance is developed to ensure that those activities of the PBMR demonstration module that have, or could have, a significant impact on the environment are appropriately controlled.

The EMP for Decommissioning will be developed at an appropriate stage during the operational phase of the project.

This EMP forms part of the final Environmental Impact Report (EIR) to be issued to the DEAT for a ROD and must be regarded as a dynamic document and a minimum requirements to be updated and detailed as the need arise. It is also available to I&APs for information purposes.

8.2 SCOPE

8.2.1 PURPOSE

The purpose of this document is to ensure that the final EMP requirements, as based on the findings and recommendations of the EIA, are included into all contracts and site specifications for the construction activities and operational/maintenance practices to take place for the PBMR demonstration module. The purpose of which shall be to ensure adequate management of activities that have or could have an impact on the environment.

8.2.2 APPLICABILITY

This specification is applicable to all construction and operational/maintenance activities associated with the PBMR demonstration module at the Eskom Koeberg Nuclear Power Station Site.

8.2.3 ACCOUNTABILITY AND RESPONSIBILITY

The implementation, review and updating of these EMPs, for the construction and operation/maintenance of the proposed Plant, remain the accountability of Eskom, even where parts thereof have been contracted out to a 3rd party.

Responsibility for the various EMP measures must be clearly stated in all contracts, work orders and job descriptions together with reporting lines, format and frequency.

The appointment of an Environmental Control Officer (ECO) to advise, co-ordinate and monitor the implementation of the EMP’s must be considered as integral to the successful implementation of the EMPs. Such person shall enjoy direct reporting to the Project Manager for the Construction Phase, and the Power Station Manager for the operations/maintenance phase.
8.2.4 Authority Reporting

The various recommendations provided in the EMPs must be monitored and audited for progress and compliance and reflected in an Annual Report to be submitted to the DEAT and other relevant authorities e.g. the NNR, Water Affairs and Forestry, Provincial Government and Local Authorities.

8.3 Normative References

The following documents contain provisions that, through reference in the text, constitute requirements of this procedure. All standards are subject to revision and parties to agreements are encouraged to apply the most recent revision of the documents listed below. Information on currently valid national and international documents will be available from various Eskom centres, namely the Information Centre at Megawatt Park, the Technology Standardisation Department and the Generation Client Office document control section.

PSE, PBMR Environmental Surveillance Programme.

ESKPBAAD6, Environmental Management Policy.

ESKADAAP8, Nuclear Sites Management Policy.

KSA-085: Koeberg Standard: Requirements for the Environmental Management System.

8.3.1 Definitions

- **Environment.** The surroundings within which humans exist and that are made up of:
  - the land, water and atmosphere of the earth;
  - micro-organisms, plant and animal life;
  - any part or combination of a) and b) and the interrelationships among and between them; and the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being. (National Environmental Management Act. No. 107 of 1998)

- **environmental issue:** Elements of an organization’s activities, products or services which can interact with the environment. (SABS ISO 14001)

- **environmental impact:** Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization’s activities, products or services. (SABS ISO 14001)

- **environmental impact assessment (EIA):** A systematic process which involves collecting, analysing, interpreting and communicating data that will reduce
negative impacts while enhancing positive impacts associated with new site-specific or area-specific activities, in advance of their implementation. (Department of Environmental Affairs and Tourism, 1998a; 1998c)

- environmental management plan (EMP): A plan that seeks to achieve a required end state of the environment and describes how activities, that could have a negative impact, will be managed and monitored and how impacted areas will be rehabilitated.

- mitigate: The implementation of practical measures to reduce adverse impacts or enhance beneficial impacts of an action.

- monitoring: An activity that ensures that the requirements of the Environmental Management Programme are met.

- site: the Koeberg Nuclear Power Station owner controlled area.

### 8.3.2 ABBREVIATIONS

- DEAT: Department of Environmental Affairs and Tourism
- ECO: Environmental Control Officer
- EIA: Environmental impact assessment
- EMP: Environmental Management Plan
- EMS: Environmental Management System
- GOR: General Operating Rules
- KNPS: Koeberg Nuclear Power Station
- NNR: National Nuclear Regulator
- OTS: Operating Technical Specifications
- PBMR: Pebble bed modular reactor
- PRA: Probabilistic Risk Assessment
- QA: Quality Assurance
- QC: Quality Control
- ROD: Record of decision (as issued by DEAT)
- SAR: Safety Analysis Report
8.4 GENERAL EMP SPECIFICATIONS DURING CONSTRUCTION

8.4.1 AIR QUALITY

- Excavated sand and areas cleared of vegetation/ compacted surfaces/ treated areas shall be managed so as not to cause sand/soil/dust movement (airborne dust).

- A dust control plan shall be developed and issued to Eskom for approval before implementation. Dust control should include (but not limited to): limiting vehicle speeds; minimise the width of haul roads; minimise the number of roads; apply water to haul roads with a spraying truck; rehabilitation and revegetation of disturbed areas including spoil disposal areas (only approved indigenous vegetation shall be used for this purpose); covering and maintaining appropriate freeboard in trucks transporting loose material; keeping top soil piles low, installation of wind breaks.

- In situations where fire breaks (temporary or permanent) fire breaks shall be constructed to prevent accidental fires spreading from the site as well as fires entering the site from adjacent land, these shall be constructed in accordance with the Veld and Forest Fires Act and in direct consultation and approval from Koeberg. Appropriate fire fighting equipment and trained staff must be available at all times.
Fumes (black smoke) emitted from vehicles and equipment/appliances shall be monitored and action taken to ensure vehicles are serviceable.

Burning of waste material shall be strictly prohibited.

8.4.2 WATER QUALITY

Provision shall be made for the drilling and construction of boreholes for monitoring before construction of the facility commence. The locality of the boreholes will be determined by the site-specific geological and geohydrological information. This information should be obtained from the detailed geohydrological investigation of the proposed site before construction. 147

Provision for at least six monitoring boreholes shall be made. At least three boreholes shall be placed upstream and three downstream. Two are to be drilled on the centre line (in the direction of groundwater flow) of the structure, the remaining boreholes are to be located adjacent to the structure but far enough to detect and monitor the pluming effect of any contamination. It will be necessary to establish two monitoring boreholes upstream and downstream of the locality, one monitoring the primary and one monitoring the secondary aquifer at that locality. 148

It is important to note that during site excavation and de-watering, leaking of saline groundwater through possible breach of the confined Malmesbury aquifer, will impact on the quality of the primary aquifer in the vicinity of the excavations. This potential impact must be closely monitored during and after construction. Monitoring of the tritium isotope levels in the boreholes will detect mixing of groundwater from the two aquifers. The primary aquifer displays a rain water tritium signal whereas the secondary confined Malmesbury aquifer contains zero tritium. The mixing will fall in-between these values. Monitoring of the water levels (pressure levels) in the monitoring boreholes will also be an important indicator of mixing during construction. 149

147 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
148 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
149 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
Care must be taken when drilling monitoring holes that no contamination of the primary aquifer occurs. Therefore boreholes drilled into the secondary aquifer should be sealed off, as leakage into the primary aquifer can cause flow and alter flow patterns in the primary aquifer.\(^{150}\)

The impact on the primary aquifer by saline water intrusion before and after de-watering should be monitored monthly and recorded in order to understand future groundwater flow in the vicinity of the building structures. In this respect monitoring of water levels, water quality and tritium isotope levels will be important indicators. Monitoring needs to continue for several years after construction, until the conditions return to that recorded before construction.\(^{151}\)

The water level in the monitoring boreholes should be recorded weekly for at least one full hydrological cycle to establish the impact of the rainy and dry seasons on the water level.\(^{152}\)

Eskom shall obtain base line water quality and environmental isotope data is obtained from any new borehole drilled on or near the site. Base line data should be collected as soon as the boreholes are constructed and should continue for at least two years prior to the Plant's critical (hot) commissioning. Water sampling should be taken monthly for quality and stable isotopes. Tritium level in the monitoring boreholes as baseline data is absolutely vital and only need to be sampled annually.\(^{153}\)

Water quality (at least electrical conductivity) shall be monitored weekly, through at least one hydrological cycle to establish the impact of the rainy season on the quality.\(^{154}\)

At least one rainwater sample per season should be collected for environmental isotope analysis to serve as background value. Combined samples of a period of rainfall will be preferable. This should be taken in consultation with the isotopes laboratory.\(^{155}\)

Monitoring of the most important indicators such as electrical conductivity (EC), pH, temperature shall be done on site while the normal macro chemical analysis and isotope analysis is done at accredited laboratories. Any parameter that is considered important in the future operation of the PMBR could be added to the list.\(^{156}\)

\(^{150}\) Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\(^{151}\) Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\(^{152}\) Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\(^{153}\) Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\(^{154}\) Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\(^{155}\) Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\(^{156}\) Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
Ground water quality monitoring system to be designed and installed during de-watering of the excavation.

The construction site sewerage system shall tie into the existing Koeberg sewerage system. If the existing Koeberg sewerage system is unable to cater for the PBMR, it shall be upgraded or alternatively a temporary sewerage treatment plant shall be installed on site.

In accordance with the requirements of the National Water Act surface and ground water shall not be polluted (oil, petrol, diesel, cleaning materials, herbicides, contaminated storm water etc.) under any circumstances.

On-site drainage shall be managed through gravity flow. Culverts and diversion berms must be designed to keep storm water flow away from the developed portions of the site.

All storm water, contaminated by the site and run off water from the activities from the site, shall be collected in on-site lined (impermeable) holding dams with sufficient capacity. Dams to be made secure to prevent unauthorised access by animals or man.

Silt traps shall be installed to ensure the retention of silt.

Oil/grease traps shall be installed at vehicle workshops to ensure the retention of oils and greases.

The de-watering effluent shall be discharged to the ocean. No discharge of de-watering effluent to off-site land or surface water bodies will be allowed. This water may be used as part of a dust control plan.

Storm water shall be managed to ensure that it does not become polluted. The un-polluted storm water run-off shall be routed to the existing discharge point at the CW outfall.

Chemical toilets shall be supplied for use by all construction site personnel. The toilet facilities shall be maintained for the duration of the activities on site.

8.4.3 Waste Management

Waste management programmes shall be implemented to ensure that waste is prevented, reduced, re-used, re-cycled, treated or disposed of. Dedicated and demarcated facilities shall be made available on site, to support the programme and to ensure that no waste is left on site and no littering takes place.
- All waste removed from the site shall be disposed of at a licensed waste site. Copies of documentary evidence of proper disposal of all waste shall be maintained.

- All hazardous substances at the site shall be adequately stored and accurately identified, recorded and labelled. All waste hazardous substances shall be disposed of at an appropriate licensed disposal site.

- During construction concrete dumping/washing shall be done in demarcated areas to ensure waste is collected, managed and as appropriate disposed of off-site to a registered landfill.

8.4.4 **Vehicle/Equipment Management**

- Vehicles, equipment and machines shall be operated and maintained in accordance with the following specifications:

  - Vehicle or machinery shall only be refuelled at a purposed designed and designated refuelling area on site.

  - No oil or lubricant changes or repairs shall be made on site other than at designated workshop areas.

  - Fuel, oils and lubricants shall be stored in secure areas, which shall be bunded and contain an impervious floor surface to ensure spills do not contaminate the ground nor water sources.

  - Preventative measures shall be taken to prevent the occurrence of oil leaks or fuel spills. Minor spills shall be immediately remedied.
Any major oil, chemical or fuel spill shall be immediately reported to the Protection Services at Koeberg who will institute appropriate action. All costs shall be borne by the party that has caused the incident.

8.4.5 Land Management

- The boundary of the construction site shall be agreed with Koeberg and fenced with a security / game fence complying with the Koeberg specifications.
- The construction site shall only be extended with the written approval of Eskom Generation.
- The boundary of the construction site shall be agreed with Eskom Generation and fenced with a security/game fence complying with the Eskom Generation specifications.
- Prior to commencement of excavation into natural soil profile, all top soil (upper 300mm of soil) shall be removed and stockpiled on a designated area. During back-filling the sub-soil shall be replaced first and followed by the replacement of the top soil.
- Sand/soil from the site shall not intrude on the Koeberg Nuclear Power Station Site.
- Both structural and non-structural (vegetation) erosion control measures shall be designed and implemented to prevent soil erosion from taking place.
- Excavated rock and soil, not used in the final back-filling or terracing around the PBMR demonstration module, shall be removed from the site as waste.
- Access to the site shall only be permissible via the West Coast road.
- No vehicles shall be allowed off road or outside of any demarcated construction site.
- Regular clean-up of access roads and their surroundings shall be undertaken.
- An effective wheel cleaning measure (grid or wash-down) shall be implemented to remove soil from vehicles to ensure roads outside of the site are not soiled.
- All services on the site allocated to the PBMR demonstration module shall be located and mapped.
- All wild game shall have the right-of-way.
Excavation barriers must comply with legal requirements.  

The construction site shall be landscaped and revegetated, to compliment the natural surrounding environment. An Eskom approved landscape plant for the site shall be developed and implemented. This shall cover the aesthetics of the site (screening of site using embankments, walls and/or vegetation) and rehabilitation. Only indigenous vegetation that is compatible with the surrounding vegetation shall be used. Approval from Koeberg shall be obtained for all vegetation to be introduced for rehabilitation and landscaping.

Weeds shall not be allowed to grow or spread. Invasive and alien plants shall be controlled (invasive plants and weeds shall be identified and controlled to prevent them from spreading).

Except within the construction site area the removal/collection of indigenous vegetation (plants, flowers, herbs, firewood etc.) and poaching must be strictly prohibited and enforced.

Except for guard dogs no domestic animals shall be kept on site.

Feeding of the wildlife on the Koeberg Nature Reserve must be prohibited.

The South African Museum (Cape Town) shall be allowed permanent access to the site during excavation to monitor any archaeological discoveries. In the event of a discovery, excavation work in that area shall be halted by the contractor until such time as instructions from Eskom have been issued to continue.

Graves, archaeological sites and sites of historical interest (as defined in the National Heritage Resources Act) in proximity to the construction site must be stipulated as off limits for unauthorised entry.

8.4.6 GENERAL

A formal Environmental Management System (EMS) shall be established and implemented prior to commencement of construction that must be continued and maintained during the operational phase. Formal environmental performance reporting shall be periodically performed as part of the EMS.

All services (water, electricity) shall be metered and monitored.

An independent Environmental Control Officer (ECO) shall be appointed by Eskom to monitor activities against the EMP and report on performance. A job profile for the ECO shall be developed as detailed in Chapter 8.2.3.

157 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\begin{itemize}
\item Environmental induction/awareness training shall be given to all staff coming onto site.
\item All construction staff shall attend an induction course. This shall include elements of the Koeberg General Employees Training (GET) course.
\item All construction site buildings shall be designed and built to ensure that they can be removed (including the foundations) after completion of the construction activities.
\item Fires and open flames shall only be permitted in demarcated areas.
\item Serviceable fire fighting equipment shall be made available on site.
\item A disaster response plan (fire, chemical, medical etc.) shall be developed.
\item Access to the South breakwater entrance and the southern emergency exit shall be kept open at all times.
\item The Eskom Generation site representative shall have access to the construction site at all times to monitor compliance to specific EMP requirements.
\item Compliance with Koeberg Nuclear Power Station Emergency Plan shall be established and be tested. Such testing shall be pre-planned in conjunction with the PBMR Construction/Site Manager and shall be subject to the PBMR demonstration module construction schedule.
\item Eskom Generation shall approve the construction site security plan. It must be noted that the proposed PBMR site is situated inside a land and air restricted zone, which has been registered as a National Key Point.
\item Eskom Generation shall approve excavation, when blasting is to take place, before commencement.
\item During excavation of the foundations formal inspections shall be performed to check and verify the findings of the Geotectonic Study(ies). In this respect the presence of Pholad (bi-valve) borings must be checked for any deformation/displacement and observation must be made for any signs of liquification. A competent geologist shall be employed to perform this function.
\item Where existing buildings at the Koeberg Nuclear Power Station site cannot be utilised and construction site buildings are constructed, these buildings shall be designed and built to ensure that they can be removed (including the foundations) after completion of the construction activities.
\item Eskom Generation shall identify existing and redundant resources on the site (e.g. concrete slabs) for re-use during the construction of the plant (i.e. crusher/base course).
\item Herbicide usage shall adhere to legal requirements, and shall only be applied subject to the approval of Eskom Generation.
\end{itemize}
Fences and gates shall not be damaged. Repairs to fences or gates shall be done immediately after damage has occurred.

The condition of gates, fences and locks shall be regularly monitored to ensure that they are secure (i.e. to prevent animals getting in as well as to prevent access to the site by unauthorized personnel). Gates shall always be kept closed or monitored.

Access roads and site land shall be monitored for deterioration and possible erosion. Soil erosion shall be prevented at all times. Pro-active measures shall be implemented to curb erosion and to rehabilitate eroded areas.

All animal fatalities due to the site activities shall be identified, and appropriate action shall be implemented to minimize or eliminate the problem. Wildlife interactions/mortalities shall be reported, recorded and investigated in compliance with the Koeberg site procedure. Remediation measures shall be followed-up to assess the effectiveness.

Surface preparation of materials, including solvent washing, acid pickling and blast cleaning and spray painting shall be performed in dedicated areas with precautions to prevent spillage of solvents or acids and to prevent escape of dust from the area.

A noise control plan shall be developed and implemented. This should include, amongst others: conformance to the South African Bureau of Standards recommended code of practice, SABS Code 0103: 1983; all equipment and vehicles fitted with serviceable exhaust silencers; screening of certain activities.\textsuperscript{158}

8.4.7 Social issues

While the contingent of international workers during construction and operation of the proposed PBMR will not be large, it does serve as an opportunity for local service providers to extend their current client base. Allowing for maximum equal offset opportunities for service providers, must be promoted.\textsuperscript{159}

The availability of international specialists provides an opportunity to promote knowledge/skills transfer to the local in-house competence and expertise of South African workers. It is recommended that it be a requirement that international specialists provide mentoring where appropriate for South African specialists.\textsuperscript{160}

\textsuperscript{158} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\textsuperscript{159} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\textsuperscript{160} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
It is recommended that staff bind themselves to a code of conduct aimed at ensuring that pro-social behaviour is maintained. 161

The conduct of contract workers would have to be specified in worker related management plans and employment contracts. It is suggested that a peer-group based incentive/fine scheme, which has been successfully used in other projects to achieve compliance, be introduced.162

Eskom should (as far as is practicable) make the appointment of local labour for construction activities a priority issue. 163

An employment/skills registration agency or ‘labour desk’ should be put in place to identify prospective candidates who would meet the job specifications. Such an agency/desk would have to take responsibility for accurate information dissemination at community level. Experience has shown that formalising this process through such an agency avoids duplication, misrepresentation, confusion and unrealistic expectations. The number of persons required, as well as the specific skills required in respect of each worker should be specified as soon as possible. It is also important to clarify project time frames and when candidates from local communities are anticipated to be required. 164. Informing local businesses and structures like the tourist and business forum regarding direct business opportunities associated with the project, is also strongly recommended. 165

It is common practice for local informal vendors (notably women providing cooked food) to enter construction areas, given the new business opportunity provided by the construction workers. Due to requirements for security, it is believed that the PBMR construction site will not readily lend itself to this practice. Nonetheless the possibility to allow this practice through the allocation of a designated area where vendors could ply their trade, must be considered by Eskom. 166

The contract and tender documentation in respect of the work to be undertaken during the construction phase will need to ensure that affirmable procurement practices as well as mechanisms for the active promotion of employment equity are put in place. Ensuring that local

161 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
162 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
163 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
164 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
165 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
166 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
workers will gain access to employment opportunities through optimisation measures such as the establishment of a labour desk, etc. are recommended.\textsuperscript{167}

- Standardised communication and dispute resolution procedures in respect of employment creation and training are advised. The needs to be standardised in the form of contract provisions, specifying input (skills development; job-creation plans) and output key performance indicators (actual evidence that local contractors & labour is being used).\textsuperscript{168}

- Construction staff for the PBMR demonstration module will impact on the transient population numbers especially in the 0 – 5km and 0 – 20km concentric sector around the Station. This aspect needs to be incorporated into the Emergency Response Plan for the Koeberg NPS and the proposed Plant and communicated with the relevant players (e.g. emergency teams and liaison committees) and become part of the Communication actions pursued by the Koeberg NPS.\textsuperscript{169}

- The development of an integrated on- and off-site Emergency Response Plan for Koeberg and the proposed PBMR demonstration module should include mechanisms for communicating potential risk, health and safety information to affected communities as part of a pro-active risk communication strategy.\textsuperscript{170}

- In terms of mitigation (if the PBMR is implemented), it would be necessary to (1) clarify whether existing emergency plans for Koeberg require any overview and adaptation and would apply to the PBMR; (2) clarify issues regarding evacuation specifically for Koeberg; and (3) rehearse emergency plans – specifically for Koeberg - in association with the local emergency services and community organisations.\textsuperscript{171}

- The SAP as well as local appropriate policing forums should be urged to ensure that baseline statistics are available regarding existing crime rates and should, proactively engage with Eskom in developing mechanisms for monitoring and the distribution of information to counter potential community perceptions that there are perceived changes in the crime rate directly as a result of construction workers being in the immediate area.\textsuperscript{172}

\textsuperscript{167} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\textsuperscript{168} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\textsuperscript{169} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\textsuperscript{170} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\textsuperscript{171} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\textsuperscript{172} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
Care should be taken that persons with possible criminal intent are not in a position to use the increased activity during the construction phase as a ‘cover’ or platform to launch opportunistic criminal activities.173

Meetings should be arranged with residents’ associations, community policing forums, as well as the local police personnel to discuss contractors’ plans, procedures, schedules and possible difficulties and safety and security concerns. Proactive discussions between the contractor(s) and project proponents have been found to be effective in addressing concerns and putting possible preventative measures in place.

As far as possible, the movement of construction workers should be confined to the work site to avoid any potential for impact or interference with proximate residential areas.174

Health and Safety Management Plans should be developed in respect of construction worker safety.175

The promotion of an understanding of radiation, radiation exposure and nuclear power-related activities is seen as a central requirement in initiatives to reduce the levels of fear and anxiety emanating from perceptions about nuclear-related risks. The development of an honest, transparent and comprehensive awareness creation campaign for the dissemination of information about energy generation and nuclear and other technologies (as currently being promoted by Eskom) is seen as an important requirement for Eskom.176

The development of an integrated on- and off-site Emergency Response Plan for Koeberg Nuclear Power Station and the proposed PBMR demonstration module should include mechanisms for communicating potential risk, health and safety information to affected communities as part of a pro-active risk communication strategy.177

Traffic congestion. The off-site movement of construction vehicles should, as far as is possible, be limited to off-peak periods in order to avoid exacerbating the existing congestion of roads.178

An effective risk communication strategy must be established. The following serve as guidelines that may be formulated and introduced prior to a crisis and implemented during a crisis.179,180

173 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
174 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
175 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
176 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
177 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
178 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
179 Adapted from Dewling, January, 1998.
180 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
Involve the most senior person at Eskom to communicate with the public.

Offer information on a pro-active and voluntary basis and involve the public from the outset.

Work first and foremost to earn trust and credibility.

Do not give mixed messages and ensure that all information has been checked and double-checked for accuracy.

Tell the truth at the outset, instead of attempting to salvage the situation later.

Provide substantive information that meets people’s needs and pays attention to community fears and concerns rather than only communicating “scientific data” thus acknowledging that response to risk is more complex than linear response to the facts.

Wherever practicable, enlist the help of organizations that have credibility in communicating with communities.

Be sensitive about the fact that people believe that nuclear related activities have been cloaked in secrecy for decades and that visible proof should be offered that international and national rules, agreements and regulations are being adhered to at all times.

While not essential, it is believed that it would be advantageous to ensure that a monitoring function will be implemented. The Environmental Officer could fulfil this role, although community involvement in monitoring is desirable. It is further suggested that a toll-free complaint service be initiated and that the access number for this service is sign-posted at key impacts sites, for use by the public. Co-operation with local traffic law enforcement agencies would be important to ensure compliance with traffic legislation.

It is recommended that an information programme on power generation and nuclear technology within the broader sciences and mathematics framework be developed. The development of a bursary fund to allow promising scholars from previously disadvantaged communities to complete higher education (secondary and tertiary) and gain access to mentoring programmes would serve to directly contribute to the promotion of equity.

Overnight accommodation inside the Koeberg owner controlled area shall not be allowed.

A plan of action shall be established with the neighbouring property owners and the relevant authorities in the case of an emergency (veld fire, oil spillage, water contamination, etc.).

All complaints received by Eskom or its contractors must be recorded and investigated in compliance with a procedure.

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181 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
182 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
An HIV/AIDS programme shall be implemented based on Eskom’s policy and practices. Eskom has established a comprehensive wellness programme, intended to address the well being of individuals and groups. The programme consists of employee assistance, sports and recreation; managing the impact of HIV/AIDS, biokinetics, spiritual wellness, occupational health and medicine, travel medicine and health promotion. Health and wellness teams have been created to implement the total integration of services, information sharing and allocation of resources. The key focus areas for HIV/AIDS remain education, communication, care and support, self-awareness and the management of associated risks.

Continuation of the Koeberg Liaison Forum and extension of the forum to include the PBMR demonstration module. This Forum should be made up of representatives of local groups from Atlantis, Melkbosstrand and Table View (surrounding communities to the Koeberg and site for the PBMR demonstration site). Meetings to continue to take place every quarter and cover events and issues relating to Nuclear, PBMR and Koeberg. In this regard it is proposed that Eskom extends its efforts regarding communication with the surrounding and potentially affected communities and involve them in transparent and open monitoring and evaluation processes. In this regard, the formation of a monitoring and evaluation committee for the proposed PBMR demonstration module is strongly recommended to be established under this forum.

8.4.8 Visual

Although the site for the proposed PBMR is recessed and surrounded by dunes in the direction of Melkbosstrand, illumination and reflective glow from the KNPS and PBMR would be visible from the R27 and Robben Island. The positioning of permanent mast lights should be done taking due cognisance of the potential impact on the surrounding residential areas.

The form of the proposed PBMR building, as well as the material finish, relates well to the existing structures and the landscape. This architecture should be adhered to for the detail design and construction of the proposed PBMR.

8.4.9 Radiation Environmental Surveillance

A radiological environmental surveillance programme shall be implemented prior to operation of the PBMR demonstration module.

The programme shall be done in terms of the Eskom Generation PBMR Client Office standard (PSE0001). This programme shall be for the monitoring of ionising radiation exposure, PBMR.

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183 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
184 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
185 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
186 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
employees and the environment in the vicinity of the PBMR demonstration module. The results of this programme will serve as a measure of exposure and safety of the public.

- The purpose of this radiological environmental surveillance programme shall be to ensure that the operation of the PBMR demonstration module does not result in unacceptable contamination of the environment and complies with regulatory discharge limits.
- The results on the monitoring results shall be reported to the National Nuclear regulator (NNR) and be made available to relevant authorities and communities through the established liaison/communication forums, on request.
- I&APs shall, on request, be afforded the opportunity to witness sampling.
- A pre-operational environmental surveillance programme shall be fully operational two years prior to the operation of the PBMR demonstration module.
- The duration of the pre-operational programme for specific environmental media, presented in Table 57 below, shall be followed.

<table>
<thead>
<tr>
<th>Six months</th>
<th>One year</th>
<th>Two years</th>
</tr>
</thead>
<tbody>
<tr>
<td>airborne iodine</td>
<td>airborne particulates</td>
<td>direct radiation</td>
</tr>
<tr>
<td>iodine in milk products</td>
<td>milk [remaining analysis]</td>
<td>fish and food</td>
</tr>
<tr>
<td>[while animals are in pasture]</td>
<td>surface water</td>
<td>invertebrates</td>
</tr>
<tr>
<td></td>
<td>ground water</td>
<td>sediment from shoreline</td>
</tr>
<tr>
<td></td>
<td>drinking water</td>
<td></td>
</tr>
</tbody>
</table>

Note: Table 57 tabulates the environmental sampling and monitoring programmes to be initiated at time intervals prior to the operation of the PBMR Demonstration Module. However, existing data may be used, if available, should the PBMR Demonstration Module be built at a nuclear site where an environmental sampling programme has been operational.

### 8.5 EMP SPECIFICATIONS DURING OPERATION

#### 8.5.1 GENERAL OPERATING PRACTICES

- The operation, maintenance and management of the PBMR demonstration module activities will be undertaken in terms of general operating rules (GOR) to ensure the plant is operated in accordance with its safety design basis and in terms of the nuclear licensing requirements.\(^{187}\)

- PBMR demonstration module plant operations shall be governed by clearly established rules, which, when followed, will guide operating personnel during normal operations and assist plant

\(^{187}\) SAR Rev 1, Section 7
personnel in coping with abnormal conditions. Conducting operations in accordance with these GOR will also promote the readiness of plant Structures, Systems and Components (SSC) to perform their respective safety functions in order to maintain the plant within its design envelope. In practice, this is achieved by complying with the prescribed operational limits and conditions, performing surveillance and monitoring activities, optimising the availability and reliability of plant equipment by performing appropriate predictive, preventive or corrective maintenance, and employing an emergency plan to properly respond to unexpected plant conditions. 188

- The programmes in place to support the safe and legal operation of the Pebble Bed Modular Reactor (PBMR) are known as General Operating Rules (GOR). The GOR prescribe the interface between the PBMR plant design and the actual operating practices. They establish a series of plant-specific rules of operation, compliance with which provides assurance that in any operating state – normal or abnormal – the plant stays within the envelope of its design bases. 189

- Any other rules that are not necessary to support safe plant operation, and operation within the plant licensing basis, do not constitute part of GOR, and are included in other documents (e.g. procedures to operate equipment that is not important for safety, etc.). A distinction is made between safe plant operation and operation within the licensing basis of the plant, to point out that certain licensing basis commitments may not relate directly to safe plant operation, but still constitute requirements to which the licensee is legally bound. 190

- The implementation of the GOR will ensure safety during plant operation, as follows: 191

**Prevention**

Adherence to the GOR ensures that during normal operation, the plant remains within a domain of plant states that have been proven by safety analysis, computer modelling, systems validation and commissioning tests. The Operating Technical Specifications (OTS) provide specific plant limits, SSC operability requirements and set points, which, when adhered to through plant operating procedures, prevent the plant from departing from the safe operating envelope defined in the plant design.

**Monitoring and Detection**

188 SAR Rev 1, Section 7
189 SAR Rev 1, Section 7
190 SAR Rev 1, Section 7
191 SAR Rev 1, Section 7
The implementation of this principle requires establishing and following surveillance test programmes, maintenance programmes, as well as components and systems re-qualification testing. The surveillance test programmes contain the frequency and success criteria for individual component testing, as well as reference to the test bases: test rules, national and international standards and codes, system performance studies, etc. This process of component monitoring provides confidence that equipment, required to support plant safety during incidents and abnormal conditions, is able to perform adequately upon demand.

The plant monitoring activities are designed to ensure that any deterioration of equipment that is important to safety is identified (i.e., no important equipment function could experience degradation beyond an acceptable limit that can remain unnoticed for longer than a predetermined period of time). This approach ensures that the probability of multiple failures in safety-important equipment is minimised.

Another objective of the plant monitoring programme is to ensure that all assumptions made in the Safety Analysis Report (SAR) event analyses, and concerning the status of equipment required to operate during abnormal plant conditions, remain valid during a transition from one operating mode to another.

**Actions to Control Incidents and Events**

This principle is implemented by the establishment and maintenance of a plan to deal properly with incidents and events which can occur during plant operations. Operating procedures for abnormal plant conditions are provided to assist operating personnel in controlling plant conditions and avoiding consequential events. If these procedures fail to promptly restore normal plant operations, an Emergency Plan is provided. This plant-specific Emergency Plan (which is one of the GOR), and associated response procedures, provide direction to plant and off-site support personnel to effectively deal with abnormal operating conditions, to ensure that appropriate actions are taken to prevent or limit the consequences of such occurrences. A set of incident response procedures is used in conjunction with Emergency Plan procedures to provide a structured means to maximise the degree to which the features provided by plant design may be utilised to mitigate the effects of events. In addition, this Emergency Plan provides appropriate means for effective communication with both plant personnel and local and national authorities (police, medical services, etc.) regarding event significance and required actions, should any become necessary.

**8.5.2 Quality Management Programmes**

Implementation of a Quality Management Programme ensures that confidence is maintained in meeting the plant safety requirements and performance objectives. The PBMR Quality Assurance (QA) programme will cover all aspects of the design, manufacturing, construction and operational phases to ensure that a high degree of quality is achieved throughout all stages of the plant lifetime. The QA Programme is based on the international standard on quality systems, ISO 9001 and will comply with
comply with National Nuclear Regulator (NNR) licensing requirements as contained in LD-1094 and the requirements of IAEA Code 50-C/CS-Q 1996. The requirements of ASME Standard NQA-1 will also provide input to the programme.

Prior to use, internationally recognised codes and standards shall be thoroughly evaluated to determine their applicability, accuracy and sufficiency. The applied codes and standards shall be supplemented or modified as necessary, to ensure that the necessary levels of quality are achieved.

Appropriate records of the design, fabrication, erection and testing of SSC important to safety shall be maintained throughout the life of the plant.

The QA programme will be based on consideration of the following:

- ensuring that each work group is responsible and accountable for the quality of its work;
- providing confidence through the QA Programme that safety-related SSC will perform their intended functions;
- performing Quality Assurance/Quality Control (QA/QC) functions during the full range of the plant lifetime;
ensuring independence of the organization performing checking functions from the organization responsible for performing the functions;

- including QA personnel in the formal review process associated with the generation of quality-related procedures;
- establishing criteria for determining QA Programme requirements;
- establishing qualification requirements for personnel performing QA and QC functions;
- sizing and training the QA staff commensurate with its duties and responsibilities; and
- establishing procedures for maintenance of ‘as-built’ documentation.

8.5.3 CONDUCT OF OPERATIONS

The Plant Operations Programme provides management standards and expectations from which detailed procedures and guidance are developed to ensure that the plant is operated safely, in accordance with plant design. Documents which support this GOR describe features such as the organisational structure, allocation of responsibilities and authorities, personnel staffing, training, and qualifications requirements.

Objectives

Operations requirements are put into place in order to:

- Establish requirements for professional conduct and good shift operating practices, which result in appropriate attention to plant conditions.
- Ensure that shift supervision maintains a broad perspective of operational conditions affecting safety as a matter of highest priority at all times.
- Require that maintenance and other non-operational personnel who will be making adjustments or changes to equipment with operations permission, notify the control room prior to beginning such work.

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192 SAR Rev 1, Section 7
Ensure that Maintenance, Chemistry, Radiation Protection, and technical programmes are supported for all operational states.

Ensure that training programmes provide operating personnel with the guidance and qualifications necessary to perform their mission in a safe, confident manner, including the ability to respond properly to abnormal conditions when they arise.

Approach

This GOR shall be implemented by establishing and maintaining:

- operational procedures and guidelines which are in compliance with regulatory requirements;
- administrative control programmes to handle configuration changes resulting from maintenance, modifications, and testing activities which include instructions for system alignments, verification of OTS compliance prior to plant operating mode changes, authorization prior to removing or restoring equipment to service, and identification and documentation of equipment deficiencies.

Operating procedures

Operating procedures shall be developed to direct the Operations staff in proper performance of significant operational duties.

As a minimum, operating procedures are established to control the following activities:

- plant start-up;
- plant shutdown;
- alternative shutdown method;
- reactor trip;
- alternative reactor trip; and
- Power Conversion Unit (PCU) trip.

Abnormal Plant Operations

A set of procedures is developed to direct the plant Operations staff during abnormal operating conditions. The general objectives and the control strategy implemented in the abnormal condition procedures are determined by the plant state, available equipment, and human interventions. These procedures will be state-based and event-based as appropriate, such that the operators are directed to perform appropriate actions which are based on the physical plant condition (e.g. temperatures, pressures, etc.), or knowledge of a particular malfunction (if available).

The PBMR design provides for plant operation within a broad range of conditions and for a variety of events. At any point in time, the plant conditions can be determined by parameters that are
displayed to the operator, e.g. pressure, temperature, mass flow rate, radioactive nuclide content, etc. Incident response procedures allow the operators, in conjunction with additional support staff which would be available in accordance with the Emergency Plan to effectively respond to abnormal conditions, minimising adverse consequences such as release of radioactivity to the plant or environment.

Administrative requirements are also established for evaluating industry design, construction and operating experience, to ensure that information related to plant safety is incorporated into plant operations through plant modifications, procedure changes, etc. in a timely manner.

Organizational structure and responsibilities

The Operations Programme documents provide a description of the plant organisation structure, define interfaces between different departments, and define reporting lines.

Management responsibilities

a. Management responsibilities are as follows:
   - to define and clearly express the requirements for safe plant operation;
   - to verify compliance of the equipment and operating practices with the requirements for safe operation;
   - to define the roles of plant departments with regard to nuclear and radiation safety;
   - to identify areas for improvement; and
   - to verify implementation of company policies to improve operational safety, including the support and management of plant staff.

   Plant workers' responsibilities

b. Plant workers' responsibilities are as follows:
   - to accept individual responsibility for the quality of assigned duties;
   - to implement the ‘Defence-in-depth’ and ‘As Low As Reasonably Achievable’ (ALARA) principles. These principles are applicable to both operating and maintenance activities, especially in unfamiliar situations such as special tests, application of temporary procedures, etc.;
   - to maintain the operability of equipment; and
to use experience feedback.

**Power plant staff qualifications**

The specific requirements for operating staff training and qualifications will be listed in one of the Operations Programme documents.

### 8.5.4 Operating Technical Specifications

This GOR establishes the limits to be observed for each operating mode, and specifies which systems are required to be available to ensure plant safety in all plant operating modes. The OTS comprise a critical set of requirements, which when followed, ensure that the plant remains within its safety design basis. Operating the plant in accordance with the OTS provides reasonable assurance that equipment which is required to be available in a given plant mode to assure plant safety, is, in fact, available. In case of non-compliance with its requirements, the OTS specifies the procedure to be followed, including the applicable limiting conditions of operation, fallback time, and plant fallback state.

The OTS include the following:

- Safety Limits for Operation (SLO).
- Limiting Safety Systems Settings (LSSS).
- Limiting Conditions for Operation (LCO).
- Surveillance Requirements (SR).
- Operating Modes and Standard States.
- Technical Bases, which describe the importance of the OTS requirements to plant safety.

### Verification and surveillance testing

The objective of the Verification and Surveillance Testing Programme is to establish monitoring of the PBMR conditions that is sufficient in scope and detail, to provide reasonable assurance that all assumptions in the overall PBMR Safety Case remain valid at all times. Carrying out surveillance testing on equipment important to safety, as directed by the OTS, constitutes an important part of the second level of defence, i.e. monitoring.

### 8.5.5 Conduct of Maintenance

**Objectives**

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193 SAR Rev 1, Section 7
The Maintenance Programme shall be established to ensure accomplishment of maintenance activities in accordance with a clear maintenance philosophy, employing sound principles, techniques, and quality practices. These activities shall be designed to consistently achieve high levels of safety, quality, reliability, and availability, while maintaining personnel radiation exposure ALARA.

**Approach**

- Maintain a training and qualification programme to provide the knowledge and skills needed to effectively perform maintenance activities. Establish a maintenance organization that is clearly defined and effectively implements its responsibilities.
- Maintain systems, components and equipment in condition to perform their intended functions for their design life.
- Ensure that maintenance is performed in a manner that maintains the integrity of the plant design basis.
- Provide for control and calibration of measuring and test equipment and appropriate controls for all maintenance tools, special tools, and equipment.
- Provide a programme that optimises the use of Predictive, Preventative and Corrective Maintenance to maximize equipment reliability in a cost-effective manner.
- Establish and maintain procedures, which provide technically accurate and complete instructions for the effective performance of maintenance activities while maintaining personnel radiation levels ALARA.
- Establish a programme for root cause analysis of failures and quality assurance/control issues.

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194 SAR Rev 1, Section 7
Provide the resources and work environment, which are conducive to the attainment of consistently high levels of safety and quality in maintenance.

8.5.6 Radiation Protection Programme

The Radiation Protection Programme includes Radiation Protection Limits and Conditions, application of ALARA, Procedures, Staffing Requirements, Administration, Training, and Personnel Qualification.

Objectives

The licensee shall be committed to effectively manage the radiation dose that the public, plant personnel and its contractors receive. These doses will be managed at levels that are ALARA.

The licensee shall:

- Manage the dose to the public by safe operation of the PBMR plant and effective implementation of the Radiation Protection Programme.
- Manage individual and collective doses from internal and external sources so that the assumed risks are consistent with applicable standards.
- Manage the production of Radwaste to levels ALARA.

Approach

This programme shall be implemented by establishing and maintaining:

- A trained, qualified staff with appropriate facilities and equipment.
- Procedures which are in compliance with regulatory requirements, and suitable given the PBMR plant design.
- Goals for key performance indicators and Radiation Protection performance, which shall be monitored and trended to identify and correct, if necessary, root causes of variances.

Control of release of radioactive substances

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195 SAR Rev 1, Section 7
A set of procedures is followed to ensure that during normal operation, all releases of radioactive substances are within the limits of the plant OTS. The procedures indicate the methodologies to determine the amount of the releases and the nuclide contents.

In order to keep releases of radioactive materials to unrestricted access areas during normal conditions ALARA, including anticipated operational transients, the following requirements are established:

- Operating procedures for the measurement and control of effluents shall be established and followed.
- Maintenance of the radioactive waste holding system should be carried out in accordance with authorized procedures.
- The quantities of each of the principal radio nuclides that can be released as solid, liquid, or gas, to unrestricted areas during plant operation (in normal, transient, and accident conditions), will be limited to the Authorized Annual Discharge Quantities (AADQ). Also, these releases should be limited to levels as low as practicable.

### 8.5.7 Emergency Plan

The Emergency Planning Programme is appropriate to the level of nuclear hazard the PBMR poses under abnormal conditions. It establishes an emergency plan, which prescribes the level of preparation required both on and off the power station site. If the PBMR is on a common site with another (nuclear or non-nuclear) facility, then the site emergency plan must consider all on-site facilities.

The PBMR emergency response plan shall meet the following requirements:

- The plan will be based on PBMR plant design, with a clear linkage back to plant accident analyses and the PRA.
- Primary responsibilities have been assigned for emergency response by the site staff.
- The emergency responsibilities of the various supporting organizations have been specifically established.

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196 SAR Rev 1, Section 7
On-shift staff responsibilities for emergency response are unambiguously defined, and adequate staffing is maintained at all times, to provide initial response to abnormal conditions in key functional areas.

A standard emergency classification and action level scheme is in use by all organizations involved in emergency response activities. The basis of this scheme includes PBMR plant system and effluent parameters.

Procedures and means have been established for the plant staff to notify external response organizations and the public of abnormal conditions. These include the content of initial and follow-up messages, and clear instructions to local authorities regarding any protective action recommendations (e.g. sheltering, evacuation etc.).

Adequate methods, systems, and equipment for assessing and monitoring actual or potential off-site consequences of a radiological emergency condition are in use.

Arrangements have been made for medical services for contaminated, or overexposed, injured individuals.

General plans have been developed for de-escalation from an emergency classification, including criteria for entry into the recovery phase.

Development of the detailed Emergency Plan will incorporate the requirements of as well as future NNR regulatory guidance, as applicable.

8.5.8 Site Nuclear Security 197

The plant shall be protected against potential and actual sabotage, vandalism, theft of Special Nuclear Materials, threats and any actions, which might compromise nuclear, or personnel safety. Procedures are to be established to provide for these objectives.

8.5.9 Nuclear Materials Safeguards 198

A nuclear materials safeguards programme shall be established to provide for the physical security of fissile, radioactive and other hazardous materials used and stored on site. This programme shall include a nuclear materials accountability system, which incorporates appropriate surveillance activities.

197 SAR Rev 1, Section 7
198 SAR Rev 1, Section 7
8.5.10 WASTE MANAGEMENT

A waste management programme and associated procedures will be developed to ensure the proper handling and disposition of radioactive waste in accordance with the requirements of 6.

8.5.11 FIRE PROTECTION

The licensee shall provide for the protection of the public, employees, and plant equipment from potential fire hazards associated with operation of the PBMR.

Objectives

- Ensure the programme complies with regulations issued by the National Nuclear Regulator (NNR) and other responsible local authorities and national bodies.
- Promote a high degree of fire prevention and safety awareness, including control of combustibles, ignition sources and plant housekeeping.
- Minimize the risk of a fire incident through proper training, fire protection system maintenance, and compliance with the fire protection programme.

Approach

This policy shall be implemented by establishing and maintaining:

- Programmes, procedures and training addressing fire protection, prevention and response to mitigate the consequences of a fire.
- Pre-fire strategy plans that ensure the capability to effectively react to potential fire incidents.
- An effective interface with national and local governments and organizations, including organizations which govern, support, regulate, insure, and audit plant activities.
- Fire protection systems, which have a high degree of availability and reliability to prevent damage to SSC important to safety.

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199 SAR Rev 1, Section 7
200 SAR Rev 1, Section 7
8.5.12 ENVIRONMENTAL SURVEILLANCE PROGRAMME

A radiological environmental surveillance programme shall be maintained in terms of the Eskom Generation PBMR Client Office standard (PSE0001). This programme shall be for the monitoring of ionising radiation exposure, PBMR employees and the environment in the vicinity of the PBMR demonstration module. The results of the programme shall serve as an indicator of public exposure to such radiation.

The purpose of this radiological environmental surveillance programme shall be to ensure that the operation of the PBMR demonstration module does not result in unacceptable contamination of the environment and complies with the regulatory release limits of the NNR.

The results on the monitoring results shall be reported to the National Nuclear regulator (NNR) and be MADE available to relevant authorities and communities through the establishment liaison/communication forums.

I&APs shall, on request, be afforded the opportunity to witness sampling.

An operational Eskom nuclear installation shall collect and analyse environmental samples as specified in Table 58 below as well as the associated footnotes specified in Table 59.

Eskom shall prepare a map listing for all the nuclear sampling sites and a sampling schedule.

If specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of automatic sampling equipment and other legitimate reasons, temporary deviations are permitted from the required sampling schedule in agreement with the Regulatory Authority (NNR). However in the event of sampling equipment malfunction, every effort should be made to apply corrective action before the end of the next sampling period. All deviations from the sampling schedule shall be documented in an annual audited report.

If milk samples become unavailable from any of the sample locations required by the programme, Eskom shall prepare and submit to the Regulator (NNR) a special report stating the cause of the unavailability of samples and the locations for obtaining replacement samples. The locations from which samples were unavailable may then be deleted from the programme, provided the locations from which the replacement samples were obtained are added to the programme as replacement locations unless no replacement location is available.

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201 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
### Table 58: Operational radiological environmental monitoring programme

<table>
<thead>
<tr>
<th>Exposure pathway and/or sample</th>
<th>Number of samples (a) and locations</th>
<th>Sampling and collection frequency (a)</th>
<th>Type, frequency and analysis</th>
</tr>
</thead>
</table>
| **Radio iodine and particulate** | Samples from five locations:  
Three samples from off-site locations [in different sectors of the highest calculated annual average ground level X/Q.  
One sample from the vicinity of a community having the highest calculated annual average ground level X/Q.  
One sample from a control location ±30 km distant and in the least prevalent wind direction. | Continuous sampler operation with sample collection weekly (e) | Radio iodine Canister: analyse weekly for I-131.  
Particulate Sampler: gamma isotopic activity following filter change (bc), |
| **Direct Radiation** | Forty stations with two or more dose meters or one instrument for measuring and recording dose rate continuously, to be placed as follows:  
an inner ring of stations in the general area of the site boundary and  
an outer ring in the 6 to 8 km range from the site with at least one station in each section of each ring [16 sectors x 2 rings = 32 stations],  
The balance of the stations, 8, should be placed in special interest areas such as population centres, nearby residences, schools and in two or three areas to serve as control stations, 15 to 30 km distant. | Monthly or quarterly  
Gamma exposure: analyse monthly or quarterly. | |
| **Sea Water** | One sample on each side of discharge within 500 m. | Composite sample over a one-month period from weekly grab sample | Gamma isotopic analysis: monthly.  
Composite for tritium analysis: quarterly |
<p>| <strong>Exposure pathway and/or sample</strong> | Number of samples (a) and locations | Sampling and collection frequency (a) | Type, frequency and analysis |
| <strong>Soil</strong> | Samples from four locations within 5 km and one from 30 km. | Annually | Gamma isotopic analysis |
| <strong>Drinking or surface fresh</strong> | One sample of each of the two nearest water supplies. If not used for drinking, surface fresh water shall be sampled weekly | | Composite for gamma isotopic analysis |</p>
<table>
<thead>
<tr>
<th>Exposure pathway and/or sample</th>
<th>Number of samples (a) and locations</th>
<th>Sampling and collection frequency (a)</th>
<th>Type, frequency and analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>water</strong>&lt;sup&gt;(g)&lt;/sup&gt;</td>
<td>sampled.</td>
<td>monthly composite</td>
<td>monthly.</td>
</tr>
<tr>
<td></td>
<td>One sample ±30 km distance for control</td>
<td>Monthly</td>
<td>Composite for tritium analysis: quarterly</td>
</tr>
<tr>
<td><strong>Sediment from shoreline</strong></td>
<td>One sample each side of discharge within 500 m at low tide.</td>
<td>Semi-annually</td>
<td>Gamma isotopic analysis semi-annually</td>
</tr>
<tr>
<td><strong>Exposure pathway and/or sample</strong></td>
<td><strong>Number of samples (a) and locations</strong></td>
<td><strong>Sampling and collection frequency (a)</strong></td>
<td><strong>Type and frequency and analysis</strong></td>
</tr>
<tr>
<td><strong>Milk</strong>&lt;sup&gt;(h)&lt;/sup&gt;</td>
<td>Samples from three locations within 5 km [nearest to the reactor] having the highest dose potential.</td>
<td>Semi-monthly</td>
<td>Gamma isotopic and I-131 analysis: semi-monthly when animals are on pasture; monthly at other times</td>
</tr>
<tr>
<td></td>
<td>If there are none, then one sample from milk producing animals in each of three areas between 5 to 8 km distant having the highest dose potential based on meteorological data.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>One sample from milk producing animals at a control location 15 to 30 km distant and in the least prevalent wind direction.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fish and Invertebrates</strong>&lt;sup&gt;(i)&lt;/sup&gt;</td>
<td>One sample of each commercially and recreationally important species in vicinity of discharge point influenced by plant discharges</td>
<td>Sample semi-annually.</td>
<td>Gamma isotopic analysis: On edible portions.</td>
</tr>
<tr>
<td></td>
<td>One sample of same species in areas not influenced by plant discharge.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Food products</strong>&lt;sup&gt;(i)&lt;/sup&gt;</td>
<td>One sample of each principal class of food products from the nearest area within 15 km of the reactor.</td>
<td>At time of harvest&lt;sup&gt;(i)&lt;/sup&gt;</td>
<td>Gamma isotopic analysis: On edible portions.</td>
</tr>
<tr>
<td><strong>Broad Leaf Vegetation</strong>&lt;sup&gt;(i)&lt;/sup&gt;</td>
<td>Three samples of broad leaf vegetation grown nearest off-site locations of highest calculated annual average ground level X/Q.</td>
<td>Monthly when available</td>
<td>Gamma isotopic analysis: On leaves.</td>
</tr>
<tr>
<td></td>
<td>One sample of each of the similar vegetation grown 15 to 30 km distant in the least prevalent direction.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sewage</strong>&lt;sup&gt;(l)&lt;/sup&gt;</td>
<td>Sample the off-site sewage system which receives sewage effluent from the station</td>
<td>Monthly sample</td>
<td>Gamma isotopic analysis of sludge: Monthly H-3 analysis of liquid:</td>
</tr>
<tr>
<td>Exposure pathway and/or sample</td>
<td>Number of samples (a) and locations</td>
<td>Sampling and collection frequency (a)</td>
<td>Type, frequency and analysis</td>
</tr>
<tr>
<td>-------------------------------</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Quarterly composite.</td>
</tr>
</tbody>
</table>
**Table 59: Operational radiological environmental monitoring programme: Footnotes**

**Footnote (a)**
The number, media, frequency and location of sampling may vary from site to site. It is recognised that, at times, it may not be possible or practical to obtain samples of the media of choice at the most desired location or time. In these instances suitable alternative media and locations may be chosen for the particular pathway in question and submitted for acceptance. Actual locations [distance and direction] from the site shall be provided.

**Footnote (b)**
If Cs-137 activity in air is detected, Sr-89 & 90 analysis shall be performed.

**Footnote (c)**
Gamma isotopic analysis means the identification and quantification of gamma-emitting radio nuclides that may be attributable to the effluents from the facility.

**Footnote (d)**
The purpose of this sample is to obtain background information. If it is not practical to establish control locations in accordance with the distance and wind direction criteria, other sites that provide valid background data may be substituted.

**Footnote (e)**
Canisters for the collection of radio iodine shall be carefully checked before operation in accordance with the quality assurance programme of the manufacturer.

**Footnote (f)**
One or more instrument(s), such as a pressurised ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to, integrating dose meters. For the purpose of this table, a thermo-luminescent dose meter may be considered to be one phosphor and two or more phosphors in a packet may be considered as two or more dose meters. The 40 stations are not an absolute number. This number may be reduced according to geographical limitations, for example, at an ocean site; some sectors will be over the sea so that the number of dose meters may be reduced accordingly.

**Footnote (g)**
Ground water samples shall be taken when this source is tapped for drinking or irrigation purposes in areas where the hydraulic gradient or recharge properties are suitable for contamination.

**Footnote (h)**
The dose shall be calculated for using the methodology prescribed by the National Nuclear Regulator and the actual parameters particular to the site.

**Footnote (i)**
If harvest occurs more than once a year, sampling shall be performed during each discrete harvest. If harvest occurs continuously, sampling shall be monthly. Attention shall be paid to including samples of tuberous and root food products if available.

**Footnote (k)**
If gamma isotopic analysis indicates Cs-137, an analysis for Sr-89 & 90 shall be performed.

**Footnote (l)**
The NNR shall be informed if the total gamma activity in sewage sludge at the Melkbos sewage works exceeds 100 Bq/kg or if the activity of any single nuclide exceeds 50 Bq/kg (both requirements exclude natural radioactivity).

> Environmental surveillance data relating to the Koeberg Nature Reserve and the Koeberg Weather Station shall be made available to I&APs on request and provided at the communication /liaison forum. This could include:
- Average monthly rainfall.
- Monthly mean and extreme wind statistics.
- Annual wildlife statistics.
- Wildlife management operational activities.
- Alien vegetation control statistics.
- Statistics of visitors to the Koeberg Nature Reserve and Koeberg Visitors Centre.

### 8.5.13 Nuclear Public Awareness

- A repeat of the tourism survey (as undertaken during the EIA) be undertaken in year two of operation.

- The Tygerberg Hospital’s ability to cope with nuclear incidents and disaster is maintained, in line with the World Health Organisation’s (WHO) REMPAN programme, aimed at promoting regional competence to deal with nuclear incidents and disasters.

- Continuation of the Koeberg Liaison Forum and extend the forum to include the PBMR demonstration module. This Forum should be made up of representatives of local groups from Atlantis, Melkbosstrand and Table View (surrounding communities to the Koeberg and site for the PBMR demonstration site). Meetings to continue to take place every quarter and cover events and issues relating to Nuclear, PBMR and Koeberg. In this regard it is proposed that Eskom extends its efforts regarding communication with the surrounding and potentially affected communities and involve them in transparent and open monitoring and evaluation processes. In this regard, the formation of a monitoring and evaluation committee for the proposed PBMR demonstration module is strongly recommended to be established under this forum.

- In this regard there is an ethical obligation on operators and managers of nuclear processes to inform the potentially affected public of how much risk they are being exposed to by the activities. It is also their responsibility to ensure that those potentially affected understand the risk they (or future generations) could be exposed to. The results of the radiological environmental surveillance monitoring be presented at Koeberg Liaison Forum and the results explained to the representatives. Eskom must apply greater attention to ensure they understand where the public’s fears and concerns come from and why these fears and concerns are often perceived valid.

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202 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
203 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
204 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
205 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
The establishment of a “two-way” risk communication and risk management process that includes mechanisms to address legitimate concerns. Guidelines regarding the promotion of effective risk communication include the following:

- A senior person at Eskom is selected to communicate with the public.
- There is a thorough understanding and acceptance of community concern and sensitivity about secrecy and that information is provided freely and involves the public from the outset.
- Every attempt is made to earn trust and credibility.
- No mixed messages are given and all information is thoroughly checked for accuracy.
- The truth is told at all times even where this involves “bad news”.
- Attention is paid to community outrage factors and concerns. This will require that it be accepted that response to risk is more complex than the provision of scientific data and linear response to facts and that information should be provided so as to meet the requirements of people.
- Wherever practicable, the help of organisations that have credibility in communicating with communities is enlisted.

The Nuclear Safety Oversight Committee (NSOC) shall provide assurance to Eskom’s stakeholders and the general public that nuclear safety at Eskom’s nuclear facilities exceeds compliance to minimum NNR and Eskom standards while emulating good practice.

**8.5.14 SOCIAL**

- Proactive steps in the re-evaluation and updating of existing emergency and evacuation plans (in respect of Koeberg) as well as the implementation of any specific required actions and/or measures flowing from this will assist in ensuring that property values are not affected negatively.

**8.5.15 HYDROLOGY**

- For the first year monthly groundwater samples should be taken from the monitoring boreholes and any other point considered important, for water quality testing. Intervals can be changed to quarterly after one year, however, should any anomalous values be obtained, sampling must be more frequent until the problem is solved.

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206 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)

207 Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
Environmental isotope analysis should be checked annually. Especially tritium should be done for boreholes south of the KNPS and PBMR sites, as this isotope could be an early indicator of operational contamination.\textsuperscript{208}

Borehole water levels should be monitored monthly and if any anomalous values are recorded then the readings must be more frequently until the cause has been identified and resolved.\textsuperscript{209}

8.5.16 LAND MANAGEMENT

The remaining Eskom land surrounding the Koeberg and PBMR nuclear power stations must continue to be managed according to scientific methods, thus preserving a valuable natural asset.\textsuperscript{210}

8.5.17 ENVIRONMENTAL MANAGEMENT PLAN

In terms of Eskom’s environmental management policy an environmental management system shall be implemented. The environmental management system shall be based on and comply with the SABS ISO 14001 standard, in terms of the Standards Act No. 29 of 1993. This environmental management programme shall be managed in terms of the environmental management system.

8.6 REFERENCES

- LD-1094 – Rev. 0, Quality Management Requirements for the Pebble Bed Modular Reactor.
- ASME NQA-1: Quality Assurance Requirements for Nuclear Facility Applications.
- Koeberg Safety Analysis Report, Part II, Chapter 5, Section 2.
- LG-1037 – Rev. 0, Basic Licensing Requirements for the Pebble Bed Modular Reactor.

\textsuperscript{208} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\textsuperscript{209} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)
\textsuperscript{210} Draft PBMR Demonstration EIR (Rev 3 dated October 2002)