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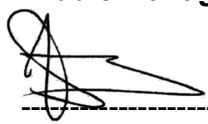
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EXECUTIVE SUMMARY

Eskom Holdings (SOC) Limited has applied, in accordance with the regulations R.927 (regulations on licensing of sites for new nuclear installations), for a nuclear installation site licence (NISL) for the Thyspunt site. The purpose of the NISL application is to licence Thyspunt as a nuclear site for a new nuclear installation(s).

This Public Information Document (PID) serves to provide members of the public with information on the analyses and assessments that support the Eskom NISL application.

Design details of the planned nuclear installation do not form part of the NISL application and will be addressed during the next licensing stage. However, to show compliance with NNR requirements, on among others, radiological dose and risk, a Plant Parameter Envelope (PPE) approach was followed. The PPE is used as input in assessing the potential impact on nuclear safety, environmental protection issues and plans for coping with nuclear emergencies independent of specific nuclear plant design. Since the Thyspunt Site Safety Report (TSSR) is based on site-specific data, the conclusions of the TSSR are definitive and are to be applied in support of subsequent nuclear installation licences as it provides a set of enveloping parameters on which the acceptability of a specific design for a particular site will be based. It must be noted that in the use of PPE approach, reference to a proposed facility, site, or project is not meant to be restrictive to the reactors as discussed, but rather encompasses any design bounded by the PPE.

SITE DESCRIPTION

The Thyspunt site is located on the South African south coast approximately 4 km east of Oyster Bay, 12 km west of St. Francis Bay and 17.3 km south of Humansdorp (distances measured from the site centroid to the nearest town boundary).

There are no highways that traverse the site. The main access road to the site is by an unsurfaced secondary road to Oyster Bay. An alternative route is via an unsurfaced branch road from the tarred R330 road from Humansdorp to St. Francis Bay.

The airfields in the region are predominantly small civil airfields and emergency landing strips located on farms. Most are unregistered facilities used for private purposes with no structures or buildings. The David Stuurman International Airport (DSIA)¹ (85 km east) is located outside the 80km radius of the site and is the nearest major airport to the site.

There are no military facilities within 80 km of the site.

There are no active railway lines in the site region.

The Gqeberha and Ngqura (Coega) harbours, located beyond 80 km from the site, are the largest commercial harbours in the broader region.

¹ David Stuurman International Airport formerly known as the Port Elizabeth International Airport

A small craft harbour at Cape St. Francis, located 13.9 km to the east, consists of a breakwater with an inside basin for commercial fishing vessels, with mooring at concrete jetties and a section with a slipway facility for small recreational vessels. There are currently no plans to expand the port.

SAFETY JUSTIFICATION

The Thyspunt site has been extensively investigated with regard to all the site characteristics that could have an impact on the safety of the proposed nuclear installation(s). In addition, the potential impact of radiological events under normal operational states (which includes Anticipated Operational Occurrences²) and in accident conditions was also evaluated.

Appropriate methods following international codes, standards and guides were adopted and applied throughout, for example, a state-of-the-art methodology, the senior seismic hazard analysis committee (SSHAC) Level 3 approach was followed to determine the seismic hazard for the site.

Based on the studies performed it is concluded that the natural and human-induced external events associated with the Thyspunt site does not preclude the site from the establishment of a nuclear installation. External events were either:

- Screened out unconditionally from being considered further as they would not pose a hazard on the design;
- Screened out conditionally on the basis that the status be confirmed when the specific design is selected; or
- Will be compensated for by means of:
 - Design features of the envisaged nuclear installation; or
 - Site protection measures.

In the evaluation of the site to determine its potential radiological impact on the region for normal operational states and accident conditions, appropriate estimates of expected or potential releases of radioactive material were derived, with account taken of the enveloping characteristics of proposed facilities to be constructed on the site and its safety features.

The direct and indirect pathways by which radioactive material could reach and affect people and the environment were investigated and evaluated, taking into account specific regional and site characteristics.

The cumulative radiological dose assessment indicates that the projected annual effective dose to the representative person associated with normal operation and minor occurrences is less than 0.1 millisievert per year. This confirms the annual dose is less than the NNR regulatory

² Anticipated Operational Occurrences are operational deviations from normal procedures that are expected to happen at least once during the lifetime of a facility. Due to proper design safeguards, these minor anomalies are contained safely and do not cause significant damage or lead to serious accidents.

public dose limit and site dose constraint values of 1 millisievert per year and 0.25 millisievert per year respectively.

The radiological dose assessment indicates that for the maximum planned site capacity of 33 000 MWth (10 000 MWe), the representative person's total annual effective dose associated with normal operation and minor occurrences is less than 0.2 millisievert per year. This value is well below the National Nuclear Regulator (NNR) public dose limit of 1 millisievert and the site dose constraint of 0.25 millisievert for compliance purposes. Therefore, the assessment concludes that the risk posed to the public and environment by the proposed new nuclear installation(s) at the Thyspunt site is as low as reasonably achievable (ALARA).

A screening radiological risk assessment was carried out for non-human biota assuming operational discharges from the New Nuclear Power Station (NNPS) using ERICA Tool. ERICA Tool is a software designed to demonstrate and evaluate the impact of radiation to the local ecosystem (plants and animals). The assessment shows that plants or animals assessed in the area would not be harmed from radiation. All species evaluated fall below the screening limit of 10 µGy/h, meaning there is no significant impact expected on animals or plants.

The Level 3 Probabilistic Safety Assessment study performed for the site concluded that the annual expected station risks due to reactor accidents and external hazard induced reactor accidents for a 6 unit EPR reactor installation or an 8 unit AP1000 reactor installation for the population within a 50 km radius around the site is 3.73×10^{-7} and 1.06×10^{-7} fatalities per year respectively. These are far below the NNR risk limits of 5.00×10^{-6} fatalities per year.

The assessment of emergency preparedness and response concluded that there are no significant impediments that could affect the feasibility of developing and implementing an emergency plan.

CONCLUSION

Detail on the analyses and assessments performed to assess the suitability of the Thyspunt site are documented in the Thyspunt Site Safety Report in compliance with regulation R927 [1]. The comprehensive nature of the studies and the diligence with which they were performed forms the justification for Eskom's NISL application. Care was taken to ensure that all hazards that could result in ionising radiation have been identified and that their associated radiological impact can be kept as low as reasonably achievable and within the regulatory limits. It can therefore be concluded that the site is suitable to locate a new nuclear installation(s) and that:

- The radiological dose and risk to the public will be acceptably low and within regulatory limits.
- No significant impediments to the development and the implementation of an emergency plan have been identified.
- All identified hazards were assessed and either screened out or can be dealt with in the nuclear installation(s) design.
- Adequate security measures can be put in place.

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ABBREVIATIONS AND ACRONYMS

Abbreviation / Acronym	Description
AADQ	Annual Allowable Discharge Quantity
AC	Alternating Current
AFE	Annual Frequency of Exceedance
ALARA	As Low As Reasonably Achievable
ASME	American Society of Mechanical Engineers
BLEVE	Boiling Liquid Expanding Vapour Explosion
CAA	Civil Aviation Authority
CED	Committed Effective Dose
CFR	Code of Federal Regulations
CGN	China General Nuclear Power Group
CGS	Council for Geoscience
CHRS	Containment Heat Removal System
CISF	Central Interim Storage Facility
CNNC	China National Nuclear Corporation
COL	Combined Licence
CP	Construction Permit
CPR	Chinese Pressurized Water Reactor
DSA	Deterministic Safety Analysis
DSIA	Dawid Stuurman International Airport
EA	Environmental Authorisation
ECC	Extended Continental Crust
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EP	Emergency Planning
EPD	Electronic Personal Dosimeter
EPR	European Pressurised Water Reactor
EPRI	Electric Power Research Institute
EPZ	Emergency Planning Zone
ESP	Early Site Permit
EUR	European Utility Requirements
EZ	Exclusion Zone
FAR	Federal Aviation Regulatory
GAL	Generic Action Level
GIL	Generic Intervention Level

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Abbreviation / Acronym	Description
GMC	Ground Motion Characterisation
GMPE	Ground Motion Prediction Equation
GMRS	Ground Motion Response Spectrum
GWh	Gigawatt hour
HLW	High Level Waste (Heat generating radioactive waste with high long- and short-lived radionuclide concentration)
HV	High Voltage
HVAC	Heat, Ventilation, and Air Conditioning
IAEA	International Atomic Energy Agency
I&C	Instrumentation and Control (System)
ICRP	International Commission on Radiological Protection
IDLH	Immediately Dangerous to Life or Health
IDP	Integrated Development Plan
ILW	Intermediate Level Waste
INSAG	International Nuclear Safety Advisory Group
IRP	Integrated Resource Plan
IRWST	In-Containment Refuelling Water Storage Tank
ISI	In-Service Inspection
ISO	International Organisation for Standardisation
IST	In-Service Testing
JPC	Joint Planning Committee
kA	Kiloampere
KNPS	Koeberg Nuclear Power Station
kV	Kilovolt
LCR	Licence Change Request
LFL	Lower Flammable Limit
LLW	Low Level Waste
LNT	Linear No-Threshold Model
LOCA	Loss of Coolant Accident
LOOP	Loss Of Offsite Power
LPZ	Long-Term Protective Action Zone
LRF	Large Release Fraction
LWR	Light Water Reactor
MeV	Mega electron Volts
MOX	Mixed Oxide
MPA	Marine Protected Area

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Abbreviation / Acronym	Description
mSv	Millisievert
MTU	Megaton of Uranium
MW	Megawatt
MWe	Megawatt (electrical)
MWh	Megawatt hour
MWth	Megawatt (thermal)
NECSA	The South African Nuclear Energy Corporation
NEMA	National Environmental Management Act
NIL	Nuclear Installation Licence
NISL	Nuclear Installation Site Licence
NKP	National Key Point
NM	Nautical Miles
NNPS	New Nuclear Power Station
NNR	National Nuclear Regulator
NNRA	National Nuclear Regulatory Act
NPP	Nuclear Power Plant
NPS	Nuclear Power Station
OSP	Operational Support Development Programme
OTS	Operating Technical Specifications
PID	Public Information Document
PP	Position Paper
PPE	Plant Parameter Envelope
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Assessment
PSHA	Probabilistic Seismic Hazard Analysis
PSM	Power Station Manager
PWR	Pressurised Water Reactor
QRA	Quantitative Risk Assessment
RAP	Reference Animal and Plant
RB	Reactor Building
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RD	Regulatory Documents
RF	Radio Frequency
RG	Regulatory Guide
RP	Radiation Protection

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Abbreviation / Acronym	Description
RPC	Radiation Protection Certificate
RPP	Radiation Protection Programme
SABS	South African Bureau of Standards
SAMSA	South African Maritime Safety Authority
SANS	South African National Standards
SAR	Safety Analysis Report
SAWS	South African Weather Service
SBO	Station Blackout
SC	Safety Case
SDF	Spatial Development Framework
SG	Steam Generator
SSA	State Security Agency
SSHAC	Senior Seismic Hazard Analysis Committee
SSR	Site Safety Report
STP	Sewerage Treatment Plant
TCA	Terminal Control Area
TEDE	Total Effective Dose Equivalent
TLD	Thermoluminescent Detector
TMI	Three Mile Island
TRITON	Transport Rigor Implemented with Time-Dependent Operation for Neutronic Depletion.
TSSR	Thyspunt Site Safety Report
UFP	Used Fuel Pool
UHRs	Uniform Hazard Response Spectra
USA	United States of America
USNRC	United States Nuclear Regulatory Commission
UV	Ultraviolet
VEGP	Vogtle Electric Generating Plant
W-C	Wolff-Chaikoff
WHO	World Health Organisation

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COMPOUND SYMBOLS

Compound	Description
KI	Potassium Iodide
KIO ₃	Potassium Iodate
NIS	Sodium-iodide symporter
CO ₂	Carbon dioxide
UO ₂	Uranium dioxide
μGy/h	Microgray per Hour
mSv	Millisievert

DEFINITIONS

Term	Definition
Burn-up	The total heat energy extracted per unit weight of fuel, preferably expressed in Megawatt-hour per kilogram of Uranium (MWh/kgU) or Megaton of uranium (MWD/MTU). (Note: MWh is thermal energy not electrical energy.)
Committed effective dose (CED)	The quantity $E(\tau)$ is defined as: $E(\tau) = \sum_T w_T \times H_T(\tau)$.....Eqn 1 Where: $H_T(\tau)$ is the committed equivalent dose to tissue or organ T over the integrated time τ that elapsed after an intake of radioactive substance. w_T is the tissue weighting factor for tissue or organ T. When τ is not specified it is taken to be 50 years for adults and the duration of intake for children to be 70 years.
Constraint	A prospective and source related value of individual dose (dose constraint) or of individual risk (risk constraint) that is used in planned exposure situations as a parameter for the optimization of protection and safety for the source, and that serves as a boundary in defining the range of options in optimization. - For occupational exposure, a constraint on individual dose to workers established and used by registrants and licensees to set the range of options in optimizing protection and safety for the source. - For public exposure, the dose constraint is a source related value established or approved by the government or the regulatory body, with account taken of the doses from planned operations of all sources under control. - The dose constraint for each particular source is intended, among other things, to ensure that the sum of doses from planned operations for all sources under control remains within the dose limit. - For medical exposure, the dose constraint is a source related value used in optimizing the protection of carers and comforters of patients undergoing radiological procedures, and the protection of volunteers subject to exposure as part of a programme of biomedical research.

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Term	Definition
	v) The risk constraint is a source related value that provides a basic level of protection for the individuals most at risk from a source. This risk is a function of the probability of an unintended event causing a dose and the probability of the detriment due to such a dose. Risk constraints correspond to dose constraints but apply to potential exposure.
Dose	A measure of the energy deposited by radiation in a target.
Effective dose	The quantity E, which defined as a summation of the tissue or organ equivalent doses, each multiplied by the appropriate tissue weighting factor: $E = \sum_T w_T \times H_T \dots \dots \dots \text{Eqn 2}$ Where: H_T is the equivalent dose in tissue or organ T and, w_T is the tissue weighting for tissue or organ T.
Enrichment	Any process that artificially increases the fraction of U-235 in a mixture of Uranium Isotopes to levels higher than what is found in nature, given that in nature U-238 constitutes about 99,274% and U-235 about 0,720%. There are other isotopes such as U-234 and U-236, but these only make up a small fraction e.g. U-234 only constitutes 0,005%. The balance is made up of U-232, U-233, and U-236.
Irradiated fuel	Nuclear fuel that has been exposed to neutron radiation in a nuclear reactor, but not necessarily to design burnup.
Nuclear fission	Nuclear fission occurs when a nucleus of an atom breaks into two or more nuclei.
Nuclear installation site licence (NISL)	A nuclear authorisation for a nuclear site that is earmarked for the siting, construction, and operation of one or multiple nuclear facilities. Individual nuclear licences are required for each nuclear facility being constructed on the nuclear site.
Passive Safety	The capability of a nuclear reactor or safety system to prevent or mitigate accidents through inherent design features and natural forces, without the need for external power, active components, or human intervention.
Probability	The likelihood of an event occurring.
Probabilistic risk assessment (PRA)	A qualitative and quantitative assessment of the risk associated with plant or facility operation and maintenance that is measured in terms of frequency of occurrence of risk metrics, such as release category frequency and its effects on the health of the public [also referred to as a probabilistic safety assessment (PSA) or quantitative risk assessment (QRA)].
Projected dose	The dose that would be expected to be received if planned protective actions were not taken.
Reference accident	A selected accident that envelops the set of accidents that can reasonably be foreseen in the safety analysis (refer to RG-0011).
Reference animal or plant (RAP)	A hypothetical entity with the assumed basic biological characteristics of a particular type of animal or plant (as described to the generality of the taxonomic level of family) with defined anatomical, physiological and life history properties. A RAP can be used for the purposes of relating exposure to dose and dose to effects, for that type of living organism.

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Term	Definition
Representative person	An individual, who will almost always be a hypothetical construct, receives a dose that is representative of the more highly exposed individuals in the population. The representative person is equivalent to, and replaces, the average number of the critical group.
Risk	Refers to the frequency and consequences of an event, as expressed by the “risk triplet” that answers the following three questions: • <i>What</i> can go wrong? • How <i>likely</i> is it? And • What are the <i>consequences</i> if it occurs?
Spent or used fuel	Nuclear fuel that has been irradiated in a nuclear reactor to the point where the fuel is no longer useful in sustaining a nuclear reaction. The fuel is removed from the reactor core and stored underwater in storage racks in spent fuel pools.
Stochastic effects	Those effects for which the probability of occurrence increases with dose, for which there is no threshold where they will occur.
Source term	The fractions defining the portion of the radionuclide inventory in the reactor at the start of an accident that is released to the environment. Also included in the source term are the initial elevation, energy, and timing of the release.

NORMATIVE/INFORMATIVE REFERENCES

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1. PURPOSE AND SCOPE

The purpose of this document is to provide members of the public with information regarding the nature of the nuclear installation site licence (NISL) application for the Thyspunt site. The document provides a broad overview of the project, a description of the hazards that could result from exposure to ionising radiation, high level detail on the technology type that could be located on the site, specific parameters considered in characterising the site, a description of the site and justification for its suitability, supporting safety case elements, an assessment of the feasibility of developing and implementing an emergency plan, information regarding waste management and decommissioning, a description of transport actions and provisions for safe transport of radioactive material.

A NISL application is limited to the evaluation of the suitability of a site for new nuclear installations and this is done in accordance with regulations on licensing of sites for new nuclear installations (Regulation R.927) [1]. The process makes provision for the applicant to request authorisation in the absence of a specific design selection by considering an envelope of nuclear installations that are most likely to be located at the site (also known as the Plant Parameter Envelope (PPE) approach). This approach is used to provide finality on siting issues upfront where a decision on a specific reactor design is still outstanding. As part of the application, compliance must be demonstrated to the National Nuclear Regulator (NNR) that the relevant siting factors have been appropriately characterised and assessed to address safety issues and that the dose and risk to the public from all nuclear installations will comply with the NNR criteria and be as low as reasonably achievable (ALARA).

Subsequent to a NISL, a nuclear installation licence (NIL) represents the primary authorisation for the construction, operation, maintenance, decontamination, and decommissioning of the nuclear installation based on a specific design. The associated PID for a specific NIL application will be developed once an application for an NIL is made.

This document is an update of the previous revision taking into account recent updates of information of the site and its environments.

2. BACKGROUND

Eskom has applied for an NISL in accordance with the nuclear energy policy of 2008 [6], which mandates Eskom to ensure that sites to build future nuclear plants on are available, secured, protected and authorised before development pressures makes them unsuitable or create major safety and emergency planning difficulties.

This NISL application is a precursor for an NIL to construct and operate a nuclear power station at the Thyspunt site. The NISL application (if granted), allows Eskom to initiate early site activities as contained in the position paper (PP-0009): Authorisation for Nuclear Installations [24].

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2.1 Similar Nuclear Siting Projects Worldwide

Siting of a nuclear installation is a crucial process since it can significantly affect the costs, public acceptance, and safety of the installation over its operating lifetime.

The nuclear siting process is a well-defined process. Various countries which have embarked on siting processes, take guidance from publications by the International Atomic Energy Agency (IAEA) such as IAEA's SSG-35 (*Site Survey and Selection*) [17], NG-T-3.7 (*Managing Siting Activities for Nuclear Power Plants*) [20], SSR-1 (*Site Evaluation for Nuclear Installations*) [19], the Electric Power Research Institute's (EPRI) siting guide [8] and the United States Nuclear Regulatory Commission's (USNRC) 10 CFR Part 100 [39]; 10 CFR Part 51 [40]; 10 CFR Part 52 [41], and others.

In terms of the IAEA [17], there are two processes relating to the safety considerations for the site of a nuclear installation, i.e. the siting process and the site evaluation process. Siting is the process surveying and selecting a suitable site for nuclear installation, whereas the site evaluation process is defined as the analysis of factors at a site that could affect the safety of a facility or activity on that site. Thus, evaluation continues throughout the operating lifetime of the installation, with appropriate components covered in the final safety analysis report to take into account changes in site characteristics, the availability of data and information, operational records, regulatory approaches, evaluation methodologies and safety standards.

According to the IAEA [17], "in most States, siting is a non-regulated activity and no licence is required". Site evaluation and preparation activities are generally defined and controlled by the nuclear safety regulator. In general, site evaluation factors in IAEA SSR-1 [19] are considered in all countries, though commonly through local interpretation. It is also a requirement to perform an environmental assessment to address the potential impact of the power station on the surrounding area and the impact of the site and the surrounding area on the power station.

In the United States of America, the site licence application occurs under the auspices of an early site permit (ESP) application. By issuing an ESP, the US Nuclear Regulatory Commission (NRC) approves one or more sites for a nuclear power facility, independent of an application for a construction permit or combined licence.

The ESP process is meant to resolve key site suitability issues well in advance of when a decision is made to build a nuclear power facility. Under 10 CFR 52 [41], an ESP can be issued separate from any other NRC licensing action. Such permits are valid for a period of ten to twenty years with provisions for renewal for an additional ten to twenty years. ESP licensing issues are resolved with finality during the ESP review process and are not re-examined in any subsequent licensing action involving the permitted site.

The purpose of an ESP application is to set aside a proposed site for future energy generation.

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An ESP process that encompasses a range of reactor designs enables companies to select the best design when a decision is made to proceed with a new plant. Through the use of the Plant Parameter Envelope (PPE) concept, the suitability of a site can be assessed based on a generalised plant description that encompasses the characteristics of several designs.

The NRC have issued ESPs for a number of sites, i.e. Clinton ESP site (2007) [50], Grand Gulf ESP site (2007) [51], North Anna ESP site (2007 and in 2013, a revised ESP Amendment) [52], Vogtle ESP site (2009) [53], PSEG ESP site (2016) [54] and the Clinch River ESP site (2019) [55].

In all these applications, except for the Vogtle ESP site, the specific reactors have not been selected. Technical information from various surrogate reactor designs was used to develop bounding parameters that are intended to envelop the proposed facility characterisation necessary to evaluate the suitability of the sites for future construction and operation of a nuclear power plant.

3. APPLICANT INFORMATION

The applicant's full name	Eskom Holdings SOC Limited
Physical address	Megawatt Park Maxwell Drive Sunninghill 2157
Company registration number	2002/015527/30
Date of incorporation	2002
Registered address	P.O. Box 1091, Johannesburg, 2000
The address of the proposed nuclear installation	The site is situated in the Eastern Cape between the towns of Humansdorp (north 17.3 km), St. Francis Bay (12 km east) and Oyster Bay (4 km west), bounded to the south by the Indian Ocean.
Details of any holding or subsidiary companies	Eskom Holdings SOC Limited is wholly owned by the state.
Details of any foreign involvement or control of nuclear installation by foreign corporations/governments	N/A

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4. PROJECT DESCRIPTION

4.1 Proposed Plant

Eskom has not made a decision yet on the specific design of the reactor to be located at the Thyspunt site, however, a pressurised water reactor (PWR) technology (refer Figure 1) was chosen in line with the Nuclear Energy Policy of South Africa [6] as the proposed reactor type to be used. A PWR uses light water as a coolant and moderator. Eskom has been using this type of a reactor safely for over 40 years at Koeberg Nuclear Power Station (KNPS) and is therefore familiar with this technology. The PWR technology used at KNPS was based on a design by Westinghouse of the USA and built by Framatome, a French company.

Eskom has also successfully undertaken the KNPS licence extension process, with Unit 1 authorised for long term operation in 2024 and Unit 2 in 2025 [31]. This achievement demonstrates the robustness, reliability, and long-term safety of the KNPS. The continued regulatory approval of KNPS operations reflects confidence in Eskom's ability to safely operate and maintain nuclear facilities in accordance with international standards.

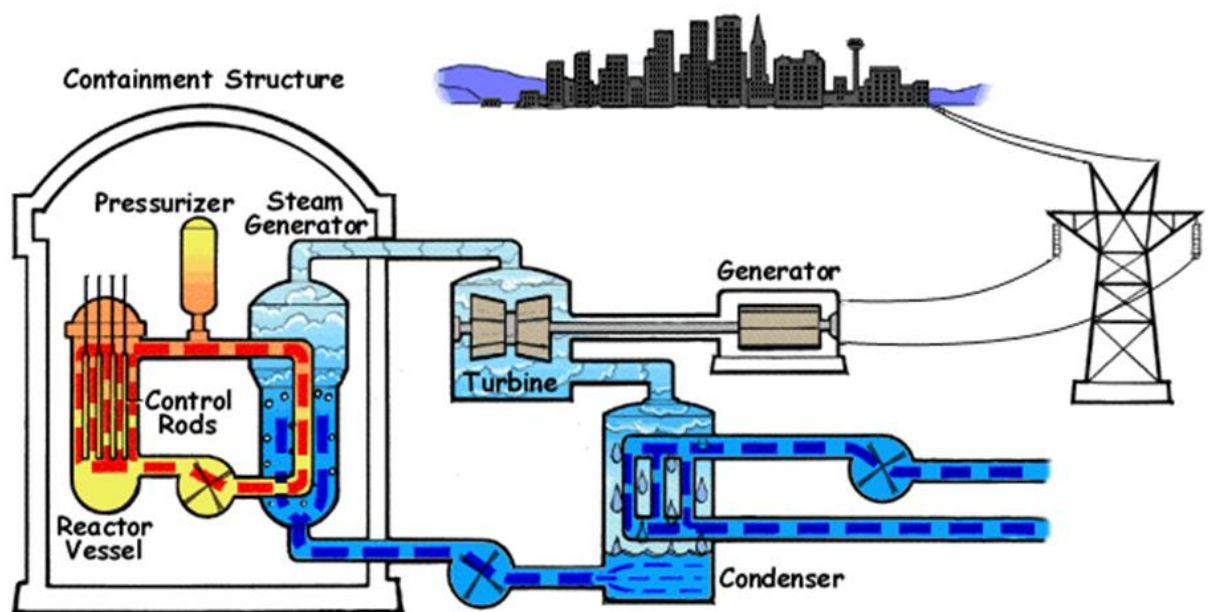


Figure 1: Typical pressurised water reactor schematic [42]

A typical PWR is made up of a three-loop system (Primary Loop, Secondary Loop and Tertiary Loop) in which the systems are separated from each other as shown in Figure 2 with minimal mixing between water of adjacent systems. The three-loop system provides redundancy, meaning that if one loop experiences a fault or must be isolated, the

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remaining loops can continue removing heat. In situations where one loop experiences a malfunction such as a pump failure or a leak, the design reduces the likelihood that the issue will affect the other loops.

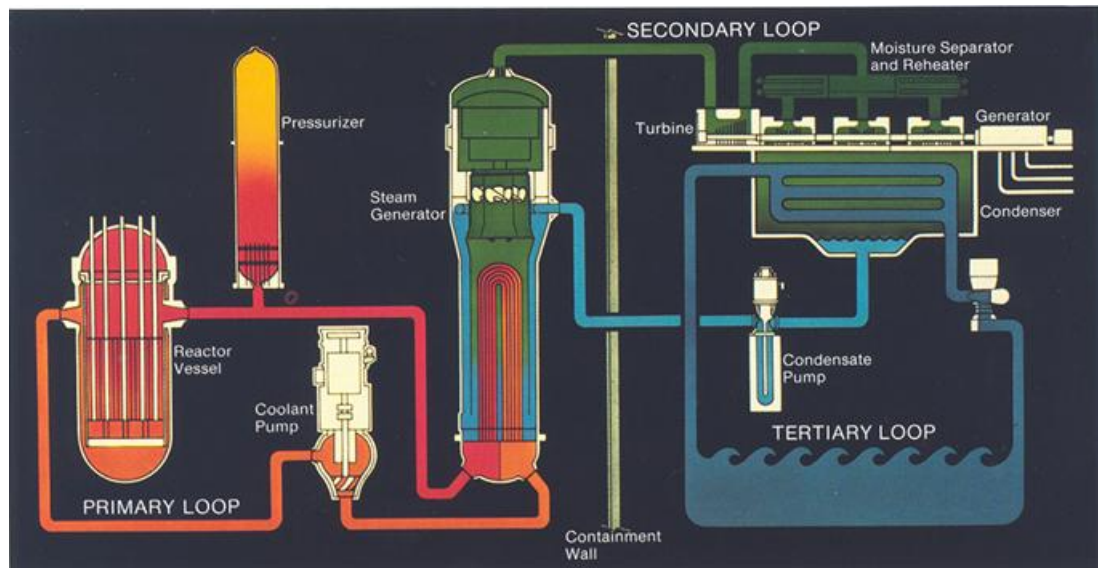


Figure 2: Configuration of the systems of the PWR [57]

Each reactor unit comprises a nuclear island, a turbine island, water intake and discharge structures and, in some cases, a cooling tower. The main parts of the nuclear island are:

- the reactor building (RB), also referred to as the containment. It contains the reactor and all the pressurised coolant loops as well as part of the loops and systems required for reactor operation and safety; is a leak tight, pressure retaining building that both retains radioactivity released by the core in the unlikely event of an accident and protects the reactor system from external events. During normal operation the RB is kept under a negative pressure. The primary system consists of three steam generators, three reactor coolant pumps, a pressuriser, and the reactor pressure vessel, which holds the nuclear fuel.
- The fuel building, which houses the facilities for storing and handling new fuel (before loading into the reactor) and used fuel (removed from the reactor). The fuel building also contains the equipment for the fuel pool cooling and purification system and the steam generator emergency feedwater system.
- The electrical equipment rooms, which contains all the means for controlling the unit (the control room and operations facilities, electric power supplies, and the instrumentation and control [I&C] system).
- A nuclear auxiliary building housing the auxiliary systems required for normal reactor operation and supporting safety systems. This building houses the equipment of the chemical and volume control system, the gaseous waste processing system, the reactor coolant effluent processing system, backup reactor safety systems, and the boron recycle system.

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- Two geographically separate buildings, each housing a diesel generator (emergency backup power supply).

Since detailed descriptions of the proposed plant are not yet available, salient features of the PWR design to be considered includes:

- A standardised design for the type of plant to expedite licensing, reduce capital cost, and reduce construction time.
- A simple and robust design, making the plant easier to operate and less vulnerable to operational upsets;
- High availability and longer operating life– typically in excess of 60 years;
- Reduced probability of core melt accidents;
- Higher containment integrity;
- Minimal effect on the environment;
- Higher burn-up to optimise fuel use and reduce the amount of waste;
- Burnable absorbers to extend fuel operating cycle; and
- Emergency Planning Zones complying with NNR requirements.

These features are characteristic of current PWR technologies (also known as Generation III and III+ designs).

4.2 Generation III / III+ PWR Designs

Generation III and III+ reactors have utilised industry experience over the past few decades, and several improvements have been incorporated in their designs. These designs incorporate improved fuel technology, have superior thermal efficiency, significantly enhanced safety systems (including passive nuclear safety) and have standardised designs for reduced maintenance. All reactor types meeting the above requirements would be considered should the nuclear procurement be given the go-ahead in future. Generation III and III+ designs currently understood to be in the market include (but are not limited to) the Westinghouse AP1000, Korean APR1400, Chinese HPR1000, Framatome's EPR, and Rosatom's VVER1000. Key differences between these plants and the Koeberg Nuclear Power Station are given in Table 1 and a brief description of each technology is given below.

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Table 1: Comparison of Key Characteristics of Known PWR Designs

Characteristic	Koeberg (reference)	AP1000	APR1400	HPR-1000	EPR	VVER1200
Developer	Framatome	Westinghouse/ Mitsubishi	Dosam (KHNP)	China General Nuclear Power Group (CGN) and China National Nuclear Corporation (CNNC)	Framatome	Rosatom (ASE)
Core thermal power (MWth)	2 775	3 400	3 983	3 160	4 250	3 200
NSS thermal power (MWth)	2 790	3 415	4 000	3180	4 500	3 212
Net electrical power output (MWe)	900	1 117	1 400	1 185	1 600 – 1 700	1 082
Plant efficiency (%)	32	35,6	35	~38%	37	34.5
Plant design life (years)	40	60	60	60	60	60
No of loops	3	2 hot legs/4 cold legs	4	3	4	4
Fuel assembly pin array	17x17	17x17 square	16x16 square	17x17 square	17x17 square	Hexagonal
No of fuel assemblies per core	157	157	241	177	241	163
Enrichment limits (%)	4,95	4,80	3,80	~4.45	5 or MOX	4,69

Characteristic	Koeberg (reference)	AP1000	APR1400	HPR-1000	EPR	VVER1200
No. of steam generators per reactor	3	2 with triangular pitch	2 with a triangular pitch	3	3 with a triangular pitch	4 corridor arrangem ent
Layout of steam generators	Vertical	Vertical	Vertical	Vertical	Vertical	Horizontal
Reactor coolant pumps	3	4	4	3	4	4

4.2.1 AP1000

The AP1000 is an advanced passive PWR designed by Westinghouse Electric Company. It is a larger version of the AP600 design which was reviewed and certified by the US NRC in 2005 with twelve AP1000s currently in operation or under construction. Four are in operation in China, two at Sanmen Nuclear Power Station and two at Haiyang Nuclear Power Plant. As of 2024, 6 more are under construction in China. A further two are in operation at the Vogtle Electric Generating Plant in the United States, with Vogtle 3 having come online in July 2023 and Vogtle 4 in April 2024 [44].

China is currently developing more advanced versions and owns their patent rights. Further builds in China will be based on the modified CAP1000 and CAP1400 designs and HPR1000 designs.

AP1000 is a two-loop plant with the reactor coolant system consisting of two heat transfer circuits, each with a steam generator, two reactor coolant pumps installed directly onto the steam generator, hence eliminating piping between pumps and the steam generator, a single hot leg and two cold legs for circulating reactor coolant. A simplified support structure for the primary systems reduces in-service inspections and improves accessibility for maintenance.

The AP1000 has a severe accident mitigation goal which is to ensure the continued functioning of the containment in the event of an accident that results in significant structural degradation of the reactor core. Reactor safety functions are achieved using passive processes only, no active pumps, no alternating current power, cooling water, heat, ventilation, and air conditioning (HVAC), and I&C.

Specific design features have been incorporated for the retention and stabilisation of the molten core inside the containment as well as for the mitigation of environmental effects that can compromise its fission product retention capability. These design features provide redundant and diverse mitigation of challenging phenomena in the unlikely event of a severe accident. These features include the reactor coolant automatic depressurisation system, the ability to flood the reactor vessel cavity, hydrogen igniters in the large dry containment, and the passive containment cooling system. These design features act to maintain reactor coolant system integrity, prevent containment over-pressurisation from hydrogen detonation or deflagration, and remove heat from the containment. These mitigation features maintain a very low potential for fission product release from the AP1000 containment.

The AP1000 is designed with environmental consideration as a priority. The safety of the public, power plant workers, and the impact to the environment has been addressed as follows:

- Operational releases have been minimised by design features.
- Aggressive goals for worker radiation exposure have been set and satisfied.
- Total radioactive waste volumes have been minimised.

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- Other hazardous waste (non-radioactive) has been minimised.

4.2.2 APR1400

The Advanced Power Reactor 1400 (APR1400) is an advanced pressurised water nuclear reactor designed by the Korea Electric Power Corporation (KEPCO) in 2002. The design is based on the experience that has been accumulated through the development, construction, and operation of the OPR1000, Optimum Power Reactor 1000 MWe, the first standard pressurised water reactor plant in Korea and also incorporates features from the US Combustion Engineering (C-E) System 80+ design. APR1400 has several advanced features such as direct vessel injection from the safety injection system, passive flow regulation device in the safety injection tank, in-containment refuelling water supply system, advanced safety depressurisation system, and systems for severe accident mitigation and management. Another design improvement is the advanced main control room, designed with the consideration of human factors engineering, with full-digital I&C systems [45].

Currently in South Korea there are four units in operation (Shin Kori units 3 and 4, Shin Hanul units 1 and 2), and 2 units in construction (Shin Kori units 5 and 6). Four units are completed and in commercial operation in the United Arab Emirates at Barakah [45].

4.2.3 Hualong One HPR1000

The Hualong one Nuclear Power Plant (NPP) is a generation III PWR developed jointly by the China General Nuclear Power Group (CGN) and the China National Nuclear Corporation (CNNC). The design is based on proven technologies from the CPR1000 design. The CPR1000 was a generation II reactor developed from technology from Framatome (AREVA). HPR1000's power output is 1100-1200 MWe and its primary circuit is composed of 3 loops.

HPR1000 is characterized by a high standard of safety based on active and passive safety systems, comprehensive severe accident prevention and mitigation measures, enhanced protection against external events and improved emergency response capability. The technology contains a number of major technological innovations, including an advanced reactor core design and a double shell containment. The core damage frequency and large release frequency is said to be one order of magnitude better than the utility requirements for third-generation technologies in the United States and Europe. In addition, the technology has high seismic resistance and is capable of resisting the impact of large commercial aircraft crash.

Currently 6 units of HPR1000 are operational in China, i.e. Unit 5 and 6 of Fuqing Nuclear Power Plant, Fangchenggang Unit 3, Changjiang Units 3 and 4, and Zhangzhou Unit 1. A further two units were put into commercial operation in Pakistan, i.e. Karachi Units K2 and K3. These units have shown good operational performance. Further units are under construction and/or planned [46].

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4.2.4 European Pressurised Reactor (EPR)

The EPR is a PWR designed by Framatome and EDF (France) and Siemens (Germany) with the first operational EPR unit commissioned in China (Taishan 1) in 2018. Taishan 2 started commercial operation in September 2019. The first EPR unit to start construction, at Olkiluoto in Finland, only started commercial operation in 2023. The second EPR unit to start construction at Flamanville in France only started commercial operation in 2024.

The EPR is a four-loop plant. Each loop is made up of a steam generator and a reactor coolant pump, all connected to the reactor. The entire primary system has only one pressuriser connected to the hot leg of the reactor as shown in Figure 3.

The EPR safety design is based primarily on deterministic analyses complemented by probabilistic analyses. The deterministic approach is based on the defence-in-depth concept, which comprises four levels, the objectives of which are:

- To compensate for potential human and component failures;
- To maintain the effectiveness of the barriers by averting damage to the plant and to the barriers themselves;
- To protect the public and the environment from harm in the event that these barriers are not fully effective.

Based on this, the top priority of the defence-in-depth principle is prevention of accidents, and if this fails, to limit their potential consequences and prevent any evolution to a more serious condition. It uses active safety systems (such as alternating current power) to protect the plant.

The overall mean large release fraction of radioactive materials released to the environment from a core damage event will be less than one in a million per year for a single reactor. Some of the most important safety features of the EPR as illustrated in Figure 4 [47].

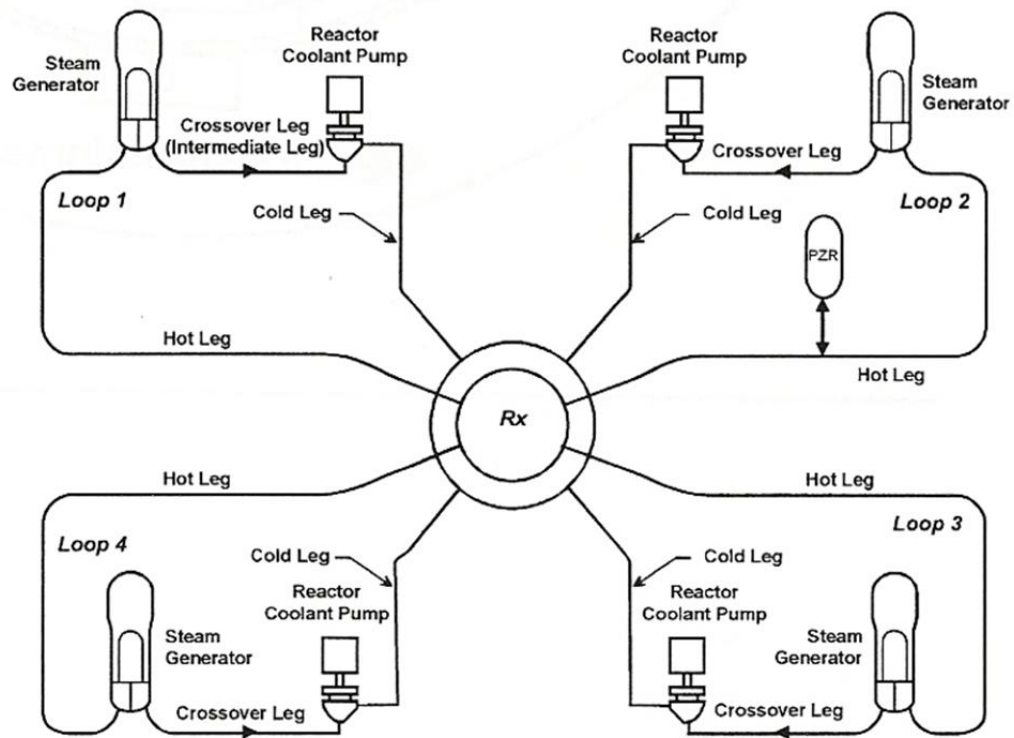


Figure 3: Illustration of generic arrangement of SSCs in a four-loop nuclear plant

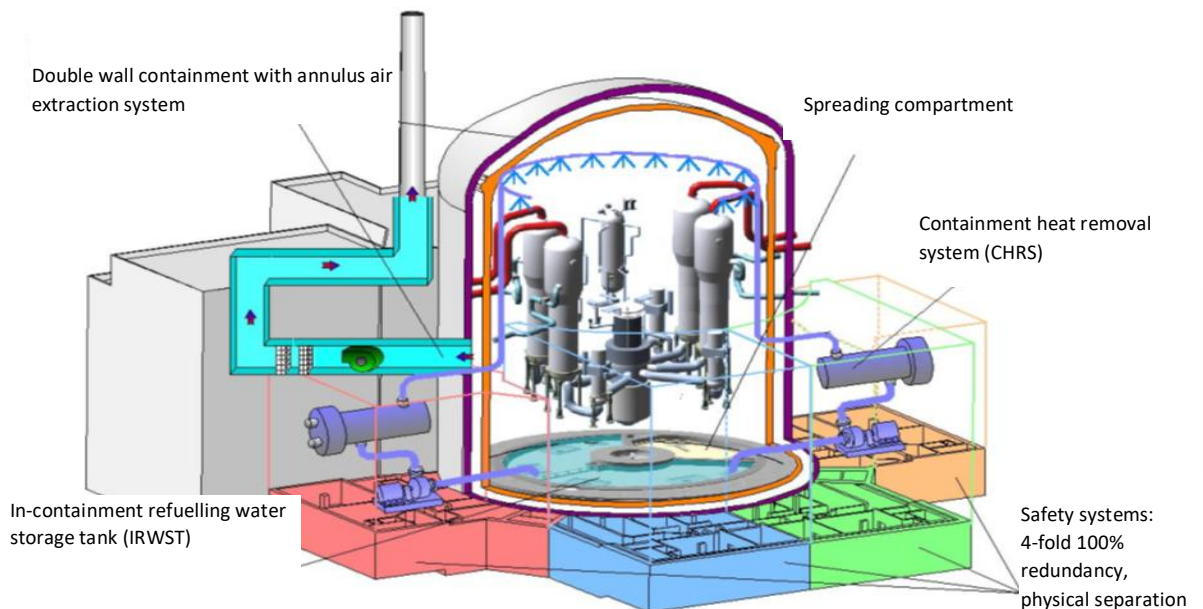


Figure 4: Main safety features of an EPR Power Reactor

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4.2.5 VVER1200

The VVER-1200 (AES-2006) is a standardized Russian nuclear power plant design that satisfies Generation III+ design features and strives to attain up-to-date safety and reliability characteristics with the optimization of construction costs. VVER stands for 'water-water energy reactor' (i.e. water-cooled water-moderated energy reactor). The first VVER-1200 reactor was installed at Novovoronezh II Unit 6 and brought online in August 2016. At present, another VVER-1200 unit is connected to the grid on the same site. There are plans to build the same design units at Leningrad II and in Belarus. Generation III+ reactors are currently under construction in the USA, France and other countries.

The main distinguishing features of the VVER compared to other PWRs are:

- Horizontal steam generators
- Hexagonal fuel assemblies
- No bottom penetrations in the pressure vessel
- High-capacity pressurisers providing a large reactor coolant inventory.

VVER combines reliability of time-proven engineering solutions with a set of active and passive safety systems compliant with post-Fukushima requirements.

A spent fuel pool inside the containment, inter-containment space ventilation filters, a core catcher with a sacrificial concrete layer, an unparalleled passive heat removal system, and other cutting-edge technologies incorporated into the VVER-1200 design undoubtedly make it a Generation III+ reactor. The emergency core cooling system also features advanced technologies, and one of them is cold boric acid stored under pressure in special tanks. In case of containment or pipeline rupture, valves open and boric acid is injected into the reactor core to stop the chain reaction and cool down the reactor. The emergency core cooling system combined with other systems guarantees an extreme degree of the reactor safety [48].

4.3 Electricity Generation from Nuclear Power Plants

4.3.1 Nuclear Fission

Nuclear power relies on low enriched uranium and/or mixed oxide (MOX) as a source of fuel to produce heat. The heat generated during nuclear reactions result from a process called 'fission'. Fission entails the splitting of nuclei of atoms by smaller particles, called neutrons. When a relatively large fissile atomic nucleus is struck by a neutron, it splits into two or more smaller nuclei as fission products and emits energy and neutrons in the process. Thereafter the free neutrons trigger further fission, and the fission process continues in a chain reaction. The splitting of the atoms and the subsequent release of energy is called nuclear fission (Figure 5).

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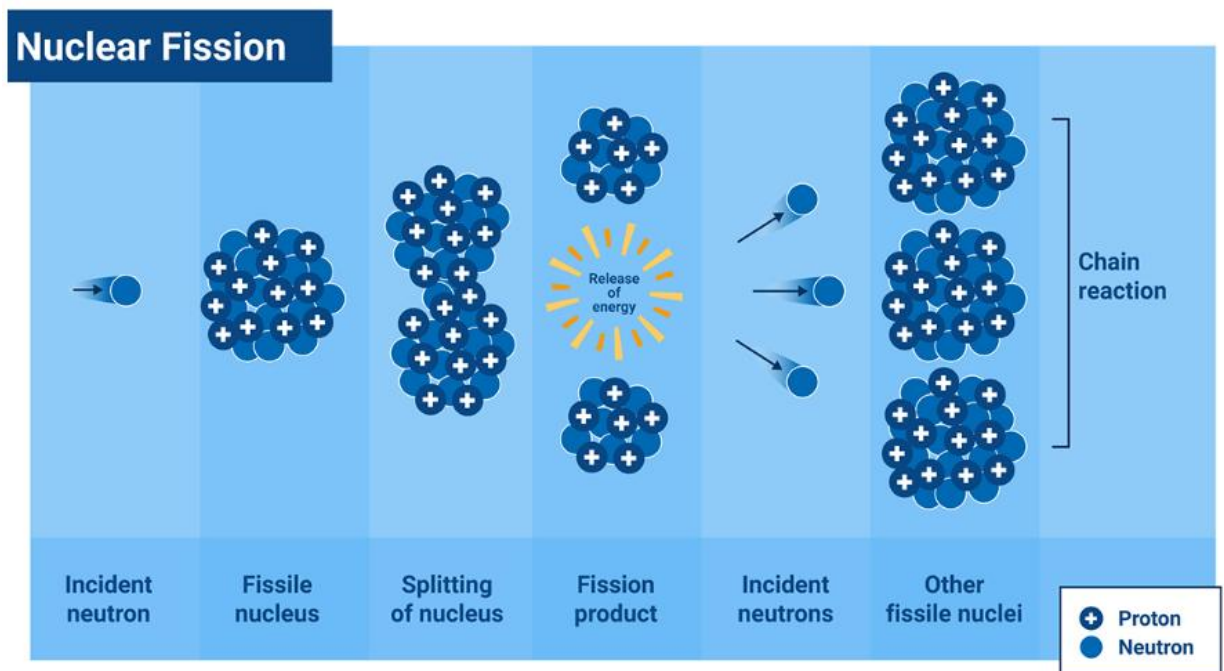


Figure 5: Nuclear fission reaction [43]

The fission process is carefully controlled by using boric acid dissolved in the primary system (reactor coolant) water and reactor control rods to ensure that design limits are not exceeded. The primary system water is circulated through the primary system to remove the heat energy from the reactor through the hot leg of the reactor and flows into the steam generator. In the steam generator, the primary circuit water is cooled as it transfers its heat to the secondary circuit. From the steam generator, the primary circuit water is then pumped back into the reactor core through the cold leg of the reactor by the reactor coolant pumps, where it is again heated up by the energy released from the nuclear fission process. Most pressurised water reactors have three primary circuit loops, that is, three steam generators and three primary pumps. One of the primary circuit loops has a pressuriser that maintains the primary system pressure high enough to prevent the water in the primary circuit from boiling, hence the name pressurised water reactor (Figure 6).

In the process, heat is transferred between the primary and the secondary systems. In the secondary side of the steam generator, the water is allowed to boil to be converted into steam. This steam is then used to drive the turbine, which drives the generator that generates (produces) electricity. After passing through the turbine, the steam is condensed into water in the condenser so that it can be pumped back to the steam generators, completing the secondary circuit. In the case of Koeberg, and as will be for Thyspunt, sea water is pumped through the condenser in the third, or tertiary, water circuit, and the residual heat extracted from the steam in the condenser is then transferred to the ocean.

The PWR technology generally operates using three separate water circuits: the primary, the secondary, and the tertiary systems. The purpose of separating the three systems is

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to ensure that the water from the primary system, which is radioactive and in a closed system, is completely isolated from the tertiary system by the secondary system, preventing any interaction between the primary system and the tertiary system, as the tertiary system is open to the environment.

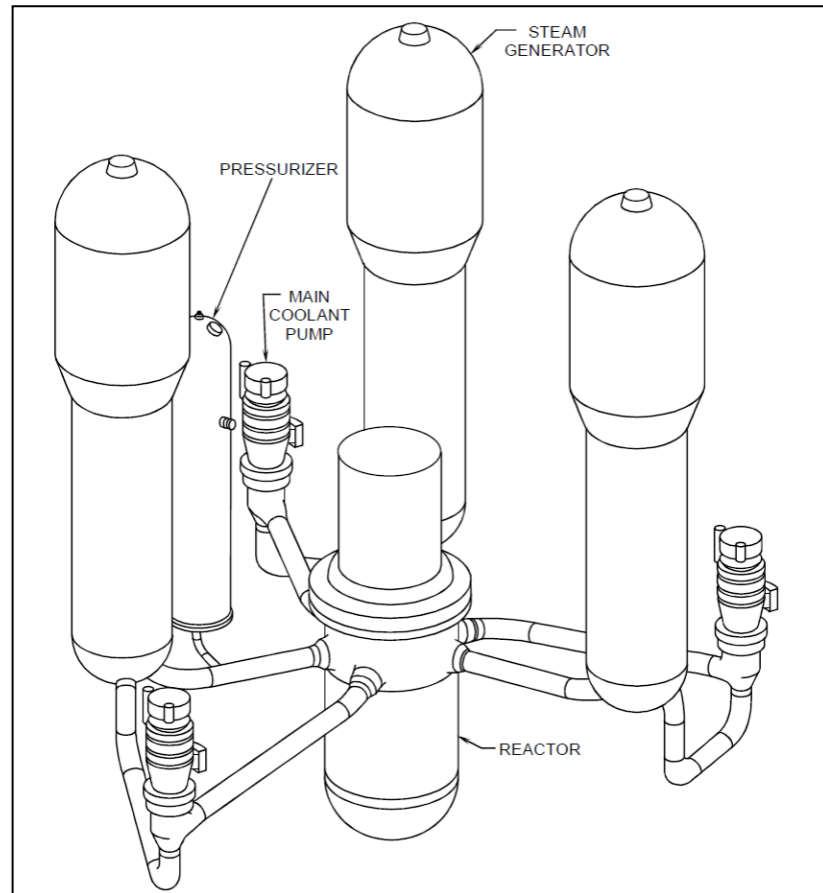


Figure 6: Illustration of generic arrangement of SSCs in a three-loop nuclear plant [58]

4.3.2 Radioactive Material Utilised

A nuclear reactor produces and controls the release of energy through a fission process (that is, splitting of atoms) using mainly uranium-235 (U-235) isotopes in the form of uranium dioxide (UO₂) pellets, as fuel. The UO₂ pellets are stacked in tubes to form fuel rods, which are loaded into the reactor core as fuel assemblies, illustrated in Figure 7. In the reactor core the U-235 isotope fissions or splits, producing heat in a continuous process called a chain reaction.

Water is used as a moderator to slow down the neutrons released from fission process so that they can cause more fission, whereas control rods and dissolved boron in the primary coolant are used to absorb neutrons to control the rate of reaction within the reactor core.

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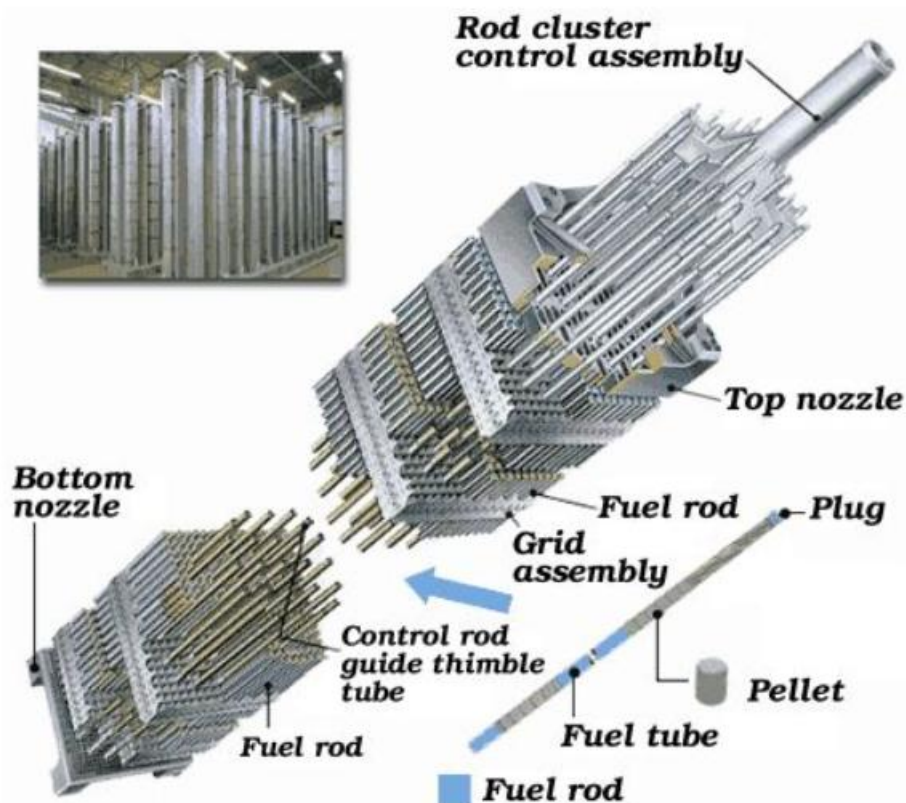


Figure 7: Illustration of a typical PWR fuel assembly, with the fuel rod, control rod and fuel pellet elements shown separately. (insert: photo of an unirradiated fuel pellet) [49]

The type of nuclear reactors that are most likely to be located at the Thyspunt site are designed to sustain an ongoing fission chain reaction of enriched uranium, contained in specially designed nuclear fuel assemblies.

As an example, AP1000 fuel assemblies are similar to other PWR fuel such as the 17x17 robust and 17x17 XL robust fuel assemblies, for which substantial operating experience exist. The 17x17 robust fuel assemblies have an active length of approximately 3.7 m and three intermediate flow mixing grids in the top mixing vane grid spans. The 17x17 XL robust fuel assemblies have an active fuel length of approximately 4.3 m with no immediate flow mixing grids. AP1000 fuel assemblies are the same as the 17x17 XL robust fuel assemblies and consist of 264 fuel rods in a 17x17 square array. The fuel rods consist of uranium, enriched to a maximum of 5 wt% U-235, in the form of cylindrical pellets of uranium dioxide, contained in ZIRLO™ tubing. The tubing is plugged and seal welded at the ends to encapsulate the fuel. Fuel rods are pressurized internally with helium during fabrication to reduce clad creep during operation and thereby prevent clad flattening. The fuel rods in the AP1000 fuel assemblies contain additional gas space below the fuel pellets, compared to previous fuel assembly designs, to allow for increased fission gas production due to high fuel burnups. Fuel rods may also contain burnable absorbers in the

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form of boride-coated fuel pellets or uranium oxide fuel pellets mixed with gadolinium oxide, or a combination, for reactivity control in the core.

The centre position in an AP1000 fuel assembly has a guide thimble that is reserved for in-core instrumentation. The remaining 24 positions in the fuel assembly have guide thimbles, joined to the top and bottom nozzles of the fuel assembly to provide the supporting structure for the fuel grids. The AP1000 fuel assemblies have three intermediate flow mixing grids in the top mixing vane grid.

A number of proven design features have been incorporated in the AP1000 fuel assembly design, such as low pressure drop intermediate grids, intermediate flow mixing grids, a reconstitutable Westinghouse integral nozzle, and extended burnup capability. The bottom nozzle is a debris filter bottom nozzle that minimizes the potential for fuel damage due to debris in the reactor coolant. The AP1000 fuel assembly design also includes a protective grid for enhanced debris resistance.

The EPR core can accommodate different fuel assembly designs such as the AFA 3GL or HTP type. The EPR fuel assembly has an active length of approximately 4,2 m and consists of 265 fuel rods that are arranged in a 17 × 17 matrix. The assembly also contains 24 guide thimbles which are used as locations for rod cluster control assemblies (RCCAs) and for in-core movable instrumentation.

The EPR fuel assembly rods are made of highly corrosion-resistant and low-growth M5TM alloy tubing. These rods contain UO₂ ceramic pellets, with an initial enrichment of less than or equal to 5 wt% U-235. The fuel rods are mechanically restrained axially and radially in the fuel assembly structure by eight M5TM intermediate grids and two end spacer grids. The pellets contain Gd₂O₃ as integral burnable poison in which the Gd concentration may vary between 2 wt% and 8 wt% to suppress high excess reactivity in the core. Depending on the amount of burnable poison required to meet the design or safety requirements, the number of Gd₂O₃ rods in the fuel assembly may be varied from 8 to 20.

For the fuel designs discussed here the concentration of fission products and heavy elements will increase during operation, to the point where it is no longer feasible to continue to use the fuel. When removed from a reactor, the used fuel will continue to emit both radiation and heat. Normal operating cycles are typically between 12 and 24 months. During a refuelling shutdown, one third of the fuel assemblies is replaced, that is, two thirds of the used fuel assemblies are reloaded along with one third of new (fresh) fuel assemblies.

From the reactor core, the used fuel assemblies are placed in a spent fuel pool to allow heat and the radiation to decrease to acceptable levels before they are transferred into dry spent fuel storage casks. In the spent fuel pool, the water provides shielding against radiation and absorbs the heat being emitted by the fuel. The used fuel assemblies are kept in spent fuel pools for at least 10 years to allow for cooling so that the spent fuel has very low energy left when transferred to the dry storage casks.

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4.4 Radiation and Radioactivity

4.4.1 Radiation in Everyday Life

The following text is taken from the IAEA fact sheet on radiation [56]:

Naturally occurring radioactive materials are present in the earth's crust, the floors and walls of our homes, schools, and offices, and in the food, we eat and drink. There are radioactive gases in the air we breathe. Our own bodies – muscles, bones, and tissue – contain naturally occurring radioactive elements.

We also receive exposure from man-made radiation (such as X-rays), radiation used to diagnose diseases and for cancer therapy. Fallout from nuclear explosives testing, and small quantities of radioactive materials released to the environment from coal and nuclear power plants, are also sources of radiation exposure to humans.

Radioactivity is the term used to describe disintegration of atoms. The atom can be characterised by the number of protons in the nucleus. Some natural elements are unstable. Therefore, their nuclei disintegrate or decay, thus releasing energy in the form of radiation. This physical phenomenon is called radioactivity. The radioactive decay is expressed in units called becquerels. One becquerel equals one disintegration per second.

The time that it takes for half the radionuclides to disintegrate or decay is called half-life. This differs for each radioelement, ranging from fractions of a second to billions of years. For example, the half-life of iodine-131 is eight days, but for uranium-238, which is present in varying amounts all over the world, it is 4.5 billion years. Potassium-40, the main source of radioactivity in our bodies, has a half-life of 1.42 billion years.

The term “radiation” is very broad and includes such things as light and radio waves (also referred to as non-ionising radiation). In the context of nuclear safety, this refers to ionising radiation, which means that because such radiation passes through matter, it can become electrically charged or ionised. In living tissues, the electrical ions produced by radiation can affect normal biological processes.

The common ionising radiations generally talked about are as follows:

- **Alpha (α) radiation** consists of heavy, positively charged particles emitted by atoms of elements such as uranium and radium. Alpha radiation can be stopped completely by a sheet of paper or by the thin surface layer of our skin (epidermis). However, if alpha-emitting materials are taken into the body by breathing, eating, or drinking, they can expose internal tissues directly and may, therefore, cause biological damage.
- **Beta (β) radiation** consists of electrons. They are more penetrating than alpha particles and can pass through 1-2 centimetres of water. In general, a sheet of aluminium a few millimetres thick will stop beta radiation.
- **Gamma (γ) rays** are electromagnetic radiation similar to X-rays, light, and radio waves. Gamma rays, depending on their energy, can pass right through the human body, but can be stopped by thick walls of concrete or lead.

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- **Neutrons** are uncharged particles and do not produce ionisation directly. However, their interaction with the atoms of matter can give rise to alpha, beta, gamma, or X-rays which then produce ionisation. Neutrons are penetrating and can be stopped only by thick masses of concrete, water, or paraffin.

To reduce the harmful effects of radiation, various shielding materials are used to protect the public from undue radiation exposure, depending on the type of radiation that shielding is required for as shown in Figure 8, adapted from [60]. Although the presence of radiation cannot be seen or felt, it can be detected and measured in the minutest quantities with quite simple radiation measuring instruments.

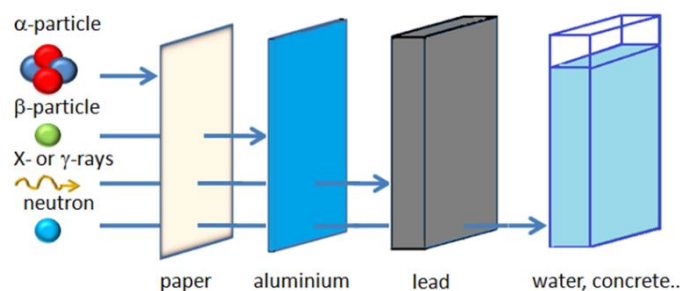


Figure 8: Types of ionising radiation together with their respective shielding materials

Hazards associated with radiation exposure depend on the type of radiation, duration over which it is delivered, and the amount of energy deposited in the material. Acute health effects such as skin burns, or acute radiation syndrome can occur when doses of radiation exceed certain levels. Low doses of ionising radiation can increase the risk of longer-term effects such as cancer. Known effects include direct damage to the cells (DNA strand in a chromosome), chromosomal mutation, genetic disorders, heritable effects, organ dysfunction, cancer, and in some instances, death.

4.4.2 Radiological Impact on the Public

Exposure can be categorised into occupational exposure (exposure of workers incurred as a result of their work), medical exposure (exposure of patients as part of their diagnosis or treatment), and public exposure (exposure of members of the public to radiation as a result of being exposed to all kinds of sources of radiation, man-made or natural).

Radiation exposure may be internal or external, and can be acquired through various exposure pathways, for example, inhalation, ingestion, or direct (refer to Figure 9). Internal exposure occurs when a radionuclide is inhaled, ingested, or when an individual is injected with tiny amounts of radioactive particles. External exposure may occur when an individual is exposed to a radiation field from an external source, for example, a person standing next to equipment or a component that emits radiation during normal operation.

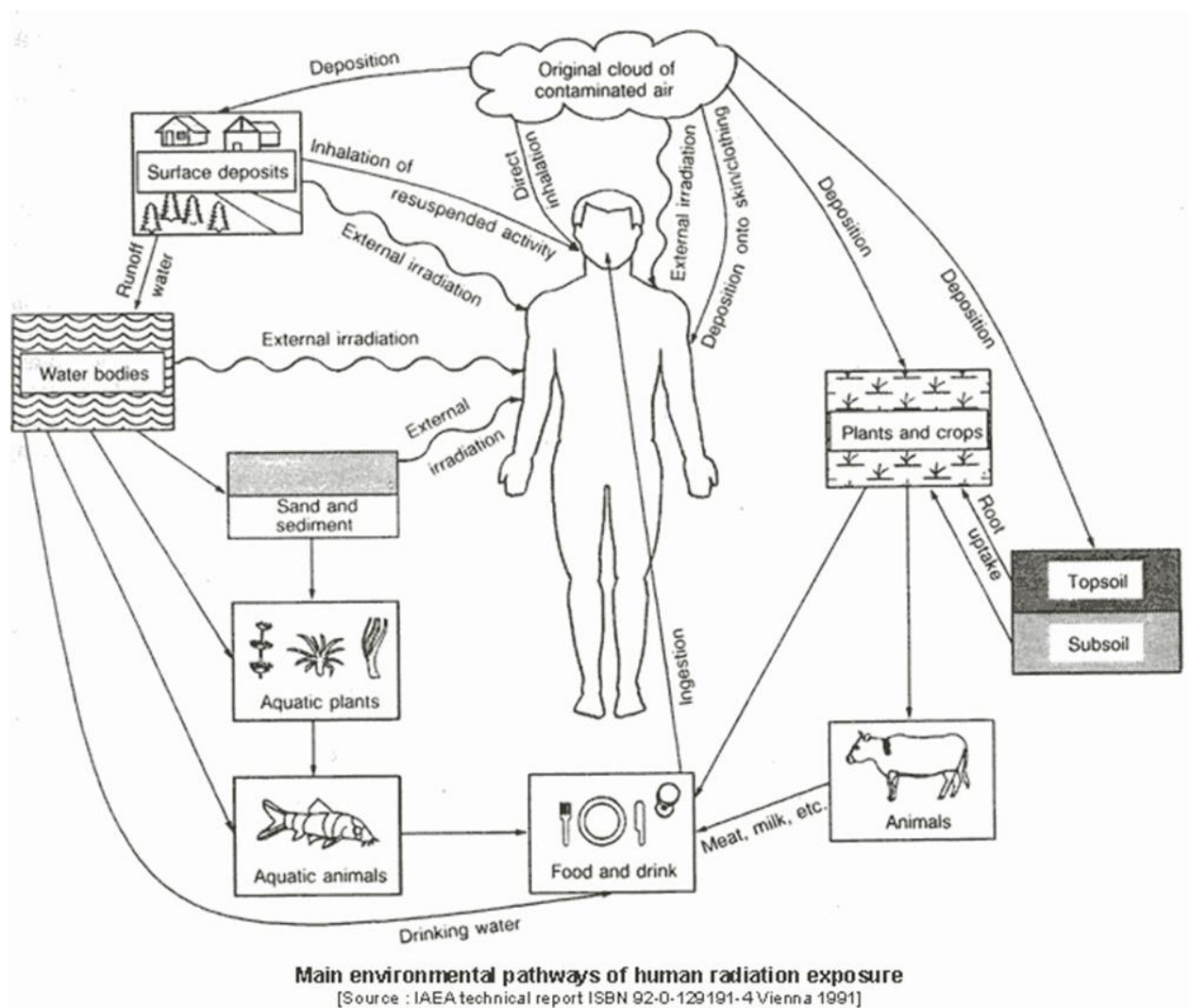


Figure 9: Exposure pathways [59]

The risk of public exposure as a result of the radiation released to the environment is controlled through the implementation of radiation protection (RP) at a nuclear power station or in industries that emit radiation. RP provides an appropriate level of protection from potential harmful effects of ionising radiation for both human and non-human biota (i.e. the reference animals and plants (RAPs)). For human beings, it is used to ensure that the risk of cancer and heritable effects is reduced to the extent reasonably achievable. For the environment, it is used to ensure that the impact on the environment is negligible so as to maintain biological diversity, conservation of species, and the health and status of natural habitats, communities, and ecosystems.

The International Commission on Radiation Protection (ICRP) outlines three fundamental principles: justification (any exposure must do more good than harm), optimisation (doses should be as low as reasonably achievable), and dose limitation (individual exposure should not exceed prescribed limits).

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For public exposure, radiation dose (annual effective dose) to members of the public is estimated by calculating the sum of the effective dose obtained within a period of one year from external exposure and the committed effective dose from radionuclides incorporated within that year. This is coupled by data obtained from effluent discharges, environmental measurements, and habit data and modelling.

For planned exposure situations, dose limits and site dose constraints are used as a measure of protection to the public. For emergency and existing exposure situations, the source related restriction is the application of reference levels used to implement protective measures and for non-human species, a screening value is used to quantify the environmental risk.

For public exposure, in planned exposure situations, a dose limit of 1 millisievert per year is applied. The NNR specifies the dose constraint of 0.25 millisievert per year for the representative person (previously referred to as the average member of the critical group) from an authorised action [4].

For each planned activity, it is expected that the dose to the public and the environment is assessed taking into account all exposure pathways. The work performed to assess the radiological impact on the public considers liquid discharges into the marine environment, marine dispersions (aquatic food ingestion, sea spray inhalation), sedimentation (external radiation), and airborne discharges taking into account dispersion (external radiation, plume inhalation) and deposition (external radiation, suspension, and terrestrial food) as reflected in Figure 9.

The radiological impact on the public and the environment is also assessed for emergency situations so that appropriate measures can be put in place to protect the public and the environment.

As part of its normal operations, a nuclear power station discharges both liquid and gaseous effluent to the environment under controlled and monitored conditions to ensure that the risk to the public is kept as low as reasonably achievable (ALARA) and within the regulatory limits. The liquid and gaseous releases are required to conform to the Annual Allowable Discharge Quantities (AADQs) limits, which complies with the annual effective dose constraint of 0.25 millisievert per year (also known as site dose constraint) to a member of the critical group within the exposed population as set out by the NNR in terms of the National Nuclear Regulator Act no. 47 of 1999 (NNRA) [36]. Prior to locating the proposed nuclear installation at the Thyspunt site, additional safety assessments will be performed to demonstrate adequate fulfilment of safety functions by the design of the nuclear installation, and assurance that the safety barriers designed to contain radioactive material will prevent any uncontrolled release that could expose the public or the environment under all plant operating conditions.

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The public dose as a result of KNPS radioactive effluent discharge for example, is shown in Figure 10 for the period 2003 to 2024.

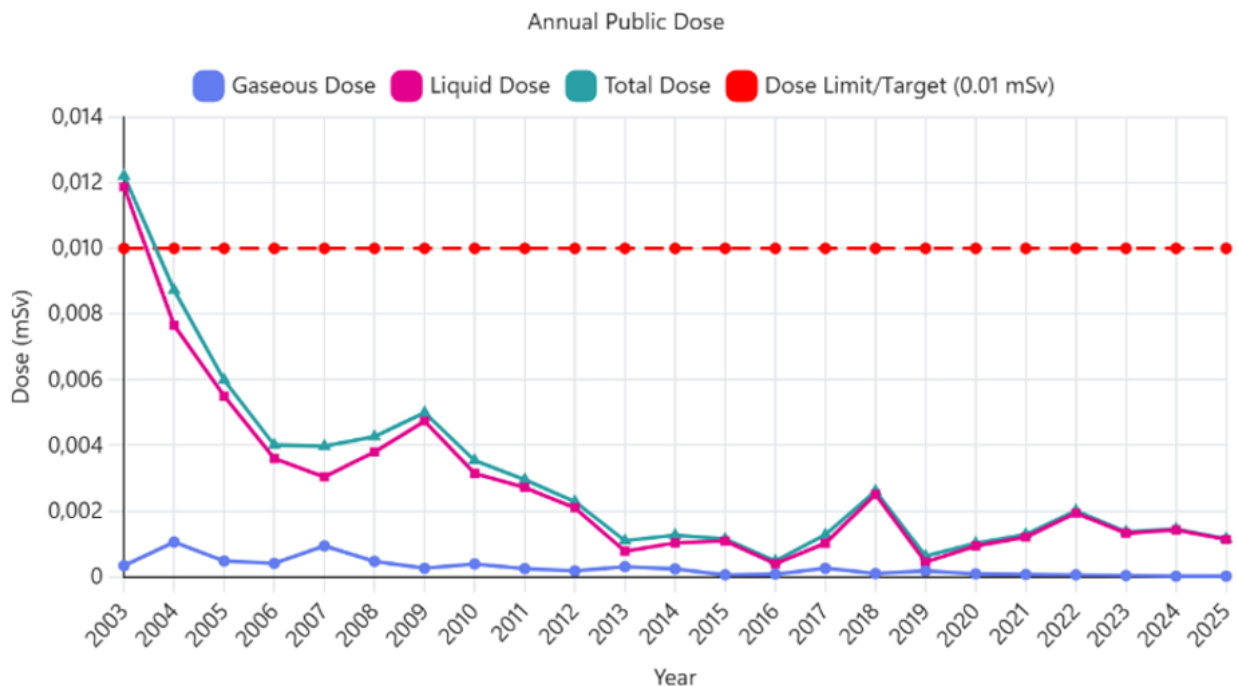


Figure 10: Public exposure as a result of Koeberg operation

The results show that the radiation dose is significantly lower than the 0.25 millisievert per year site dose constraint for radioactive effluent discharges.

For new nuclear installation(s) located at the Thyspunt site, a prospective radiological impact on the public and the environment considering a planned capacity of 9 900 to 13 200 MWth and an eventual total site capacity up to a maximum power of approximately 33 000 MWth of PWR GEN III technology was carried out based on conservative and enveloping discharges of airborne and liquid radioactivity during normal operation. The assessment includes Anticipated Operational Occurrences (AOO) also referred to as minor occurrences.

Design information of four representative Gen III technologies was used to construct radioactive source terms of operational discharges to the environment. Bounding source terms were derived for 33 000 MWth power operation and radioactivity build-up in the environment after 60 years of operation was included in the dose assessment. The dose assessment was based on conservative assumptions to demonstrate that regulatory criteria can be met. Once a specific nuclear installation(s) is selected, a detailed description of all systems of the nuclear installation and its layout on the site will be presented and the public dose re-assessed.

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The annual dose to a member of the public was calculated using the most recent habits data of people living and working in areas adjacent to the site where radiological exposure can occur through various exposure pathways involving food consumption, external radiation and inhalation of radioactivity discharged from the proposed nuclear installation(s).

The representative person total annual dose is estimated to be less than 0.2 millisievert per year. It can therefore be concluded that new nuclear installation(s) on site with a maximum generating capacity of 33 000 MWth will comply with the NNR regulatory dose constraint value of 0.25 millisievert per year and the dose limit of 1 millisievert per year for the site.

Studies have also been performed to determine the dose on non-human biota. The results of the radio-ecological screening assessment indicate no significant radiological impact on non-human species. None of the organisms assessed using the *ERICA* code, exceeded the screening value of 10 μ Gy/h.

4.4.3 Occupational Exposure to Radiation

Employees who are recruited to work for Eskom as radiation workers undergo extensive medical examination to determine whether they are fit to work in a radiation environment. Prior to working in the radiation zone, employees are trained and certified as radiation workers. This enables the employee to learn and understand the risk associated with exposure to high levels of radioactivity and be informed of measures that are in place to protect them. Radiation workers are issued with an electronic personal dosimeter (EPD) and the thermo-luminescent detector (TLD) indicated in Figure 11 and Figure 12 respectively. These instruments are worn to monitor their radiation exposure levels (radiation dose) when working in areas where they are exposed to radiation (referred to as controlled zones).

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Figure 11: Electronic personal dosimeter (EPD) [61]



Figure 12: Thermo-luminescent dosimeter (TLD) [62]

Radiation workers who perform work in a controlled zone are issued with personal protective equipment commensurate with the protection required for that contamination level and with dosimetry to measure their dose.

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To minimise the harmful effects of radiation when handling radiation sources the aspects of “time, distance, and shielding” that support the ALARA principle of radiation protection are applied. The ALARA principle is a radiation safety standard that emphasises keeping exposure to radiation as low as reasonably possible, even if the dose is already below legal limits. Its main goal is to protect workers and the public from unnecessary radiation while allowing nuclear operations to proceed safely.

The ALARA principle may be explained as follows:

- The less time (duration) one spends in the vicinity of a radiation source/radioactive material, the lower the dose received and, hence, the lower the potential health risks.
- The further the distance between radiation source and the person handling it, the lower the potential of health risks.
- The thicker the shielding material one uses for a given type of radiation, the better the protection is from the harmful effects of radiation.

For occupational exposure in planned exposure situations, the highest individual dose limit is 20 millisievert per year averaged over a period of five-years (100 millisievert in 5 years), with a provision that the effective dose does not exceed 50 millisievert in any single year. At Koeberg, that has been operating for longer than 40 years, the worker doses are within regulatory limits; for example, the maximum individual dose observed was 17 millisievert in 2011 (limit of 50 millisievert). Figure 13 provides the highest worker doses received over the period 2009 to 2025.

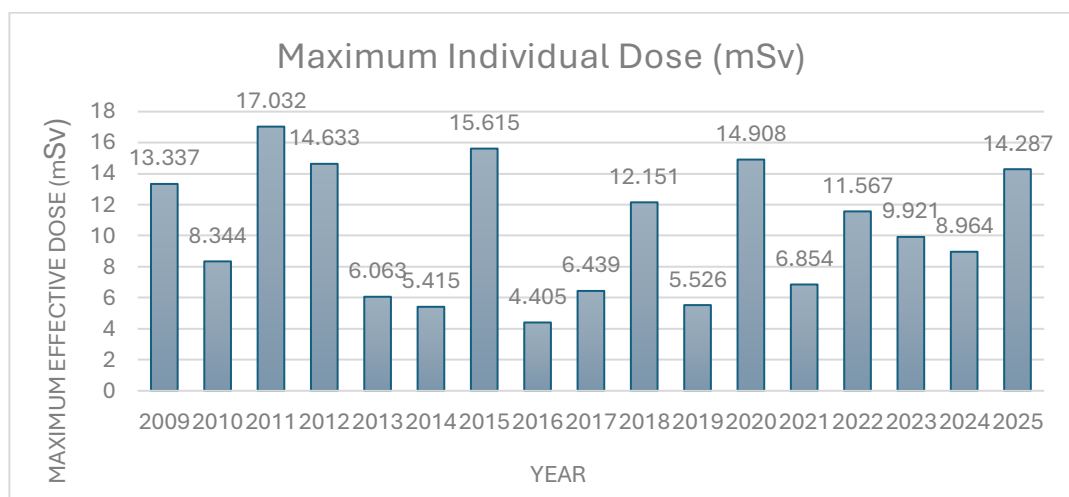


Figure 13: Highest worker dose received per annum at Koeberg

An ALARA target of 4 millisievert for example, is set at Koeberg for the average dose for workers. The target is much lower than the effective dose limit of 20 millisievert per year for workers averaged over five consecutive years. Koeberg, as an example, has

consistently met the dose target of 4 millisievert over the review period from 2009 to 2025, as shown Figure 14. The average dose is less than 1 millisievert per worker per year.

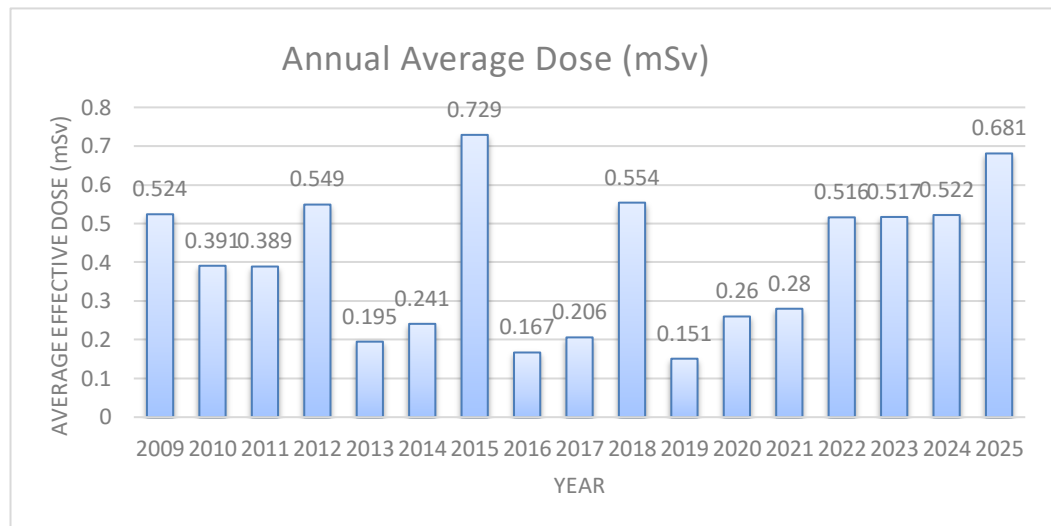


Figure 14: Average dose per worker per annum (mSv) at Koeberg

4.4.4 Radiological Risk

The NNR specifies principal safety criteria (risk limits) with which nuclear installation(s) must comply to. Principal safety criteria are limits on the annual risk to members of the public and workers due to exposure to radioactive material as a result of normal or accident conditions.

The NNR safety criteria is contained in Table 2 below.

Table 2: NNR Safety Criteria for Accident Conditions

NNR Criteria	
Peak Public Risk ³	5.00E-6 fatalities per year
Average Annual Public Risk ⁴	1.00E-8 fatalities per person per year
Peak Site Personnel Risk ⁵	5.00E-5 fatalities per year

³ The peak individual risk refers to the highest risk that a member of the public may be subjected to as a result of a nuclear accident.

⁴ The average public risk to an individual in the national population is defined as the number of annual fatalities divided by the total national population.

⁵ The peak and average worker risks are defined as the risks affecting on-site workers due to an accidental release, since all workers are exposed to this risk, it corresponds to the peak and average worker risks.

Average Site Personnel Risk	1.00E-5 Fatalities per person per year.
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As an example, Koeberg Nuclear Power Station has been in operation for more than 40 years. The power station has over the years demonstrated compliance with the principal safety criteria and kept the peak public risk at less than 3 per cent of the NNR criteria (approximately $1,17\text{E-}07$ fatalities per year) and the workers' peak site risk at less than 20 per cent of the NNR criteria (approximately $7,56\text{E-}06$ fatalities per year). To appreciate the concept, one may consider the risk of a fatality due to a motor vehicle accident (either as a driver, passenger, or pedestrian) in South Africa. The annual road safety report for South Africa for 2022 reported that 12 436 people died in 2022 due to road accidents [7]. Based on a population of 60 million people, the average risk is that 21 people for every 100 000 inhabitants (or $2,1\text{E-}04$ per year) will likely die in a road accident in South Africa every year. That means that a member of the public is more than 1 000 times more likely to die in a road accident than from nuclear accident conditions at Koeberg.

To determine the risk to the population and workers and to demonstrate compliance to probabilistic risk limits as contained in the Regulations on Safety Standard and Regulatory Practices (SSRP) [4], a Probabilistic Risk/Safety Assessment (PRA / PSA) for the Thyspunt site was performed using typical Generation III plant source terms and site-specific data. Probabilistic safety assessment is a quantitative systematic and structured methodology to identify and analyse potential risks in design and operations in order to develop solutions to mitigate their impact on the plant and the environment, including people [10].

The assessment was performed taking into consideration the population data, meteorological conditions of the site and external events important to the Thyspunt site. Probabilistic PC Cosyma calculations were performed to estimate the early and late fatalities per distance band for each Release Category (RC). Thereafter the early and late fatalities were summed to determine the total fatalities per distance band. The total fatalities per distance band were then multiplied with the associated RC's frequency, summed up for all distance bands of all the RCs and divided by the national population to obtain the average public risk.

The peak risk is obtained by multiplying the total number of fatalities at 2.25 km for each RC by the associated release frequency and dividing the sum over all RCs by the population at the site boundary.

The total risk for a multi-unit reactor site is estimated by multiplying the results with the number of units.

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The dose results, the number of fatalities and the consequences related to the operation were assessed against the NNR safety criteria. The AP1000 results show that the “Containment Bypass Failure” (BP) release category (RC) as the highest contributor to public risk, and therefore it was used to assess the mean individual 30-day effective dose. The effective dose for the RC-Bypass was calculated at 547 millisievert whilst the EPR effective dose was estimated at 94 millisievert for mean short term individual dose. The mean long-term individual doses to various organs as well as the effective doses calculated for a 50-year period after the accident shows the effective dose of 1010 millisievert for AP1000 and 199 millisievert for EPR.

The risk of fatalities and the consequences related to the operation of such a facility were then compared with the NNR safety criteria as outlined in RD-0024 (refer Table 3) [21].

Table 3: Annual risk assessment for the Thyspunt site due to newly proposed nuclear power plant

	AP 1000			EPR			
Risk Measure	Annual Risk Per Unit	Annual Risk (per Station)	% of NNR Criteria	Annual Risk Per Unit	Annual Risk (per Station)	% of NNR Criteria	NNR Criteria
Peak Public Risk	4.67 E-08	3.74E-07	7.5%	1.77E-08	1.06E-07	2.12%	5.00E-06
Average Public Risk	5.38E-12	4.28E-11	0.4%	4.43E-12	2.66E-11	0.27%	1.00E-08
Peak Site Personnel risk	9.10E-07	7.28E-06	14.6%	5.50E-07	3.3E-06	6.59%	5.00E-05
Average Site Personnel Risk	9.10E-07	7.28E-06	72.8%	5.5E-07	3.3E-06	32.97%	1.00E-05

From Table 3 it can be concluded that the Level 3 PSA study performed to determine if the safety criteria set by the NNR for risks to members of the public and site personnel arising from accidental releases from the potential reactors that could be located at the Thyspunt site, will be complied with and thus pose no undue risk to the public and the environment. This study is fit for purpose, in the current licensing stage. Once a decision is made on the design and technology to be located on the Thyspunt site, detailed PSA studies will be performed to assess the risk against the NNR criteria. This will only happen in the next licensing stage.

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5. SITE DESCRIPTION AND JUSTIFICATION

In accordance with local regulatory requirements, in particular RG-0011 (*Interim Guidance on the Siting of Nuclear Facilities*) [29] and Regulation R.927 (*Regulation on Licensing of Sites for New Nuclear Installations*) [1], an application for a nuclear site licence must consider the following aspects in the evaluation of the suitability of a site for a nuclear facility:

- a) Effects of external events occurring in the region of the particular site (natural and human induced);
- b) Characteristics of the site and its environment which could influence the transfer of released radioactive material to persons; and
- c) Population density and distribution, as well as other characteristics in relation to the possibility of implementing emergency measures and the need to evaluate risk to individuals and the population.

The site is deemed unsuitable if it has serious deficiencies that cannot be compensated for by means of:

- Design features;
- Site protection measures; or
- Administrative procedures.

A brief site description is provided below.

5.1 Thyspunt Site Description

The site is located on the south coast 4 km east of Oyster Bay, 12 km west of St. Francis Bay and 17.3 km south of Humansdorp (distances measured from the site centroid to nearest town boundary). The large urban areas of Gqeberha and Kariega⁶ are located partly within the 80 km radius of the site.

There are no highways that traverse the site. The N2 highway runs in an east-west direction approximately 22 km to the north of the site. A tarred feeder road leads to Humansdorp and then the main existing access route to the site is by an unsurfaced secondary road in moderate condition to Oyster Bay. An alternative route is via an unsurfaced branch road from the tarred R330 road from Humansdorp to St. Francis Bay.

There is significant and extensive agricultural activity in the area, with the closest being dairy pastures within 3 km and centre-pivot irrigated crops at a distance of 5 km from the site centroid. The site is situated between two rivers, the Krom River to the northeast and the Slang River to the west in quaternary catchment K80F. There are no rivers on the site

⁶ Formerly known as Uitenhage

itself but there are ecologically important wetlands and springs, the former in the vegetated and mobile dune area and the latter along the coast.

The site is bounded to the south by the Indian Ocean. The rocky shoreline is oriented almost west-northwest and east-southeast and comprises a wave-cut platform. The landform inland for a distance of approximately 3 km comprises a prominent dune field having crests trending east-northeast as a result of the prevailing winds. The coastal dune belt is vegetated while there is a narrow inland belt of non-vegetated, mobile dunes that extends from Oyster Bay towards St. Francis Bay. These dunes are labelled as shifting sand dunes.

The highest portion of the dune field is approximately 2 km from the coastline and has an average elevation of about 100 m, with high points of 111 m and 122 m. The undulating vegetated dunes between this zone and the coastline are approximately 70 to 80 m high, dropping to a terrace 20 m above the rocky shore. Further inland from the dune field the topography rises evenly to a low hill that has its long axis oriented northwest-southeast with a high point of 170 m. This elongated hill is about 6 km inland.

The airfields within the region are predominantly small civil airfields and emergency landing strips located on farms. Most are unregistered facilities used for private purposes with no structures or buildings. The nearest major airport to the site is David Stuurman International Airport, which is located 85 km to the east. Only one active commercial airport occurs within 16 km of the site, the St. Francis airfield (10.8 km east). The airfield has one grass runway 10/28, measuring 1 000 × 23 m. It operates daily and has no control tower but has landing lights and accommodates 20 hangers for storage and maintenance of small private planes. No aviation fuel or other hazardous chemicals are stored on this site. General aircraft, i.e. propeller type, helicopters, and Lear jets (< 5,7 t as defined by the ICAO) use this airfield and approximately 100 movements per year have been recorded. At present there are no plans for future extension of this airfield. There are no military facilities within 80 km of the site.

There are no active railway lines close to the site. A section of the Gqeberha–Avontuur Railway narrow gauge, non-electrified, railway line is located 21.3 km north of the site. Rail traffic consists of about three diesel-electric freight trains per week, hauling pulpwood from Assegaibosch to Gqeberha. The line is also used by the Apple Express, a local tourist train. No future development of the rail infrastructure is planned within 16 km of the site.

Gqeberha and Ngqura (Coega) harbours are the largest commercial harbours in the broader region and are located beyond 80 km from the site. The Port St. Francis small craft harbour is located 13.9 km to the east. It consists of a breakwater with an inside basin for commercial fishing vessels, with mooring at cement jetties, and a section (within the harbour) with a slipway facility for small recreational vessels. The maximum boat size that

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can be accommodated is 18 m, with a draft of no more than 3 m. Entry to the port is access-controlled and a harbour master is employed to manage the facility.

The site falls within the Fish-Tsitsikamma water management area. However, large quantities of water are imported from the upper Orange River water management area via the Sundays River. The various water storage and transfer systems that supply the local area and the Nelson Mandela Bay Municipality (NMBM) are called the Algoa water supply system. The NMBM supplies water to the population at Humansdorp and St. Francis Bay via the Churchill pipeline from the Churchill and Impofu (formerly Elandsjacht) dams with capacities of 26.3 and 32.1 million m³ respectively. This pipeline runs in an east-west direction to the south of the N2 freeway from these dams to Gqeberha, with an offshoot to St. Francis Bay linking up with the Humansdorp-St. Francis Bay tarred road (R330) just before the Krom River bridge. The local towns obtain a portion of their water supply from groundwater sources.

A 22 kV line passes 0.4 km to the north of the site, which can provide a supply of approximately 8 MVA. A new 66 kV line will be required from the St. Francis Bay substation to the site, and it is anticipated that this line will follow the planned eastern access road from St. Francis Bay to the site. A new 132 kV line needs to be provided from the Melkhout sub-station (approximately 3 km north of Humansdorp) to the HV yard across the dunes in order to provide 30 MVA to the site.

From a regional perspective, land use change in the site region is expected to be concentrated in and around existing settlements. Any significant growth that would occur would be concentrated in the NMBM and more specifically towards the Coega special economic zone. The agricultural and irrigation pattern is expected to remain constant. Coastal resort towns are expected to grow in keeping with tourism development in the region. Although some growth is expected to occur within the smaller settlements in the region, the focus is envisaged to be in coastal resort areas, where no significant industrial development, other than the nuclear installation at the site is planned for the future.

The Thyspunt Site Safety Report [10] provides a more detailed description of the Thyspunt site.

5.2 Proposed Building and Site Layout

The proposed power station complex as shown in Figure 15 will include inter alia the nuclear reactors and their auxiliaries such as:

During construction:

- A temporary spoil pipeline into the ocean for construction; and
- Laydown areas and other areas to be cleared during construction.

During operation:

- Reactor building

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- Nuclear auxiliary buildings
- Turbine halls;
- Used or spent fuel and nuclear fuel storage facilities;
- Hydrogen plant
- Diesel and gas turbine generators
- Waste handling and storage facilities;
- Waste water treatment works;
- Intake and outfall structures into the ocean required to obtain/release water used to cool the process;
- Desalinisation plant;
- 132 kV and 400 kV transmission and distribution lines from the power station to the high-voltage yard;
- Roads;
- 400 kV and 132 kV high-voltage yard (HV yard);
- Transmission lines between the power station and the HV yard (only at the Thyspunt site); and
- Other auxiliary service infrastructure (refer to Figure 16).

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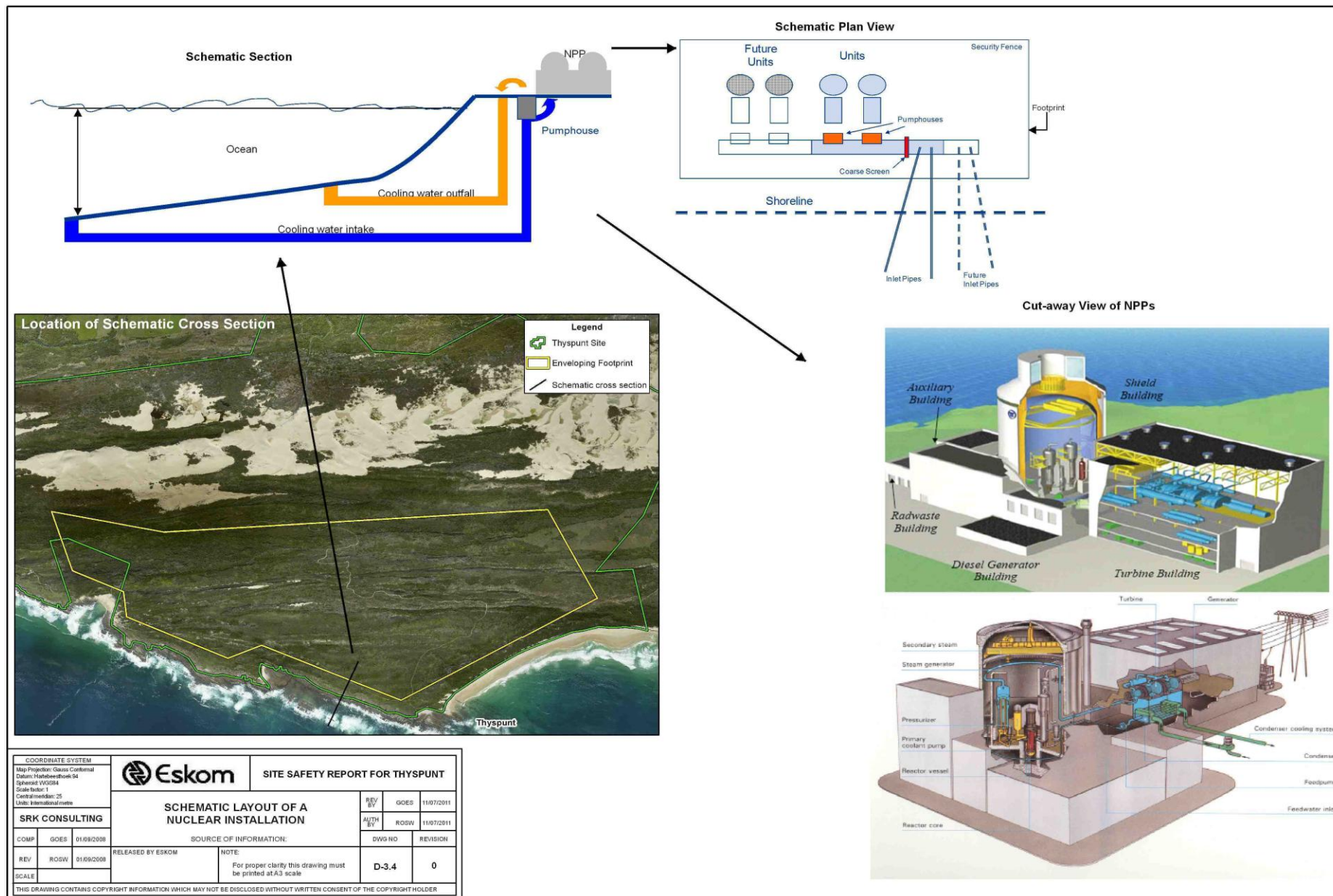


Figure 15: Schematic layout of nuclear installation

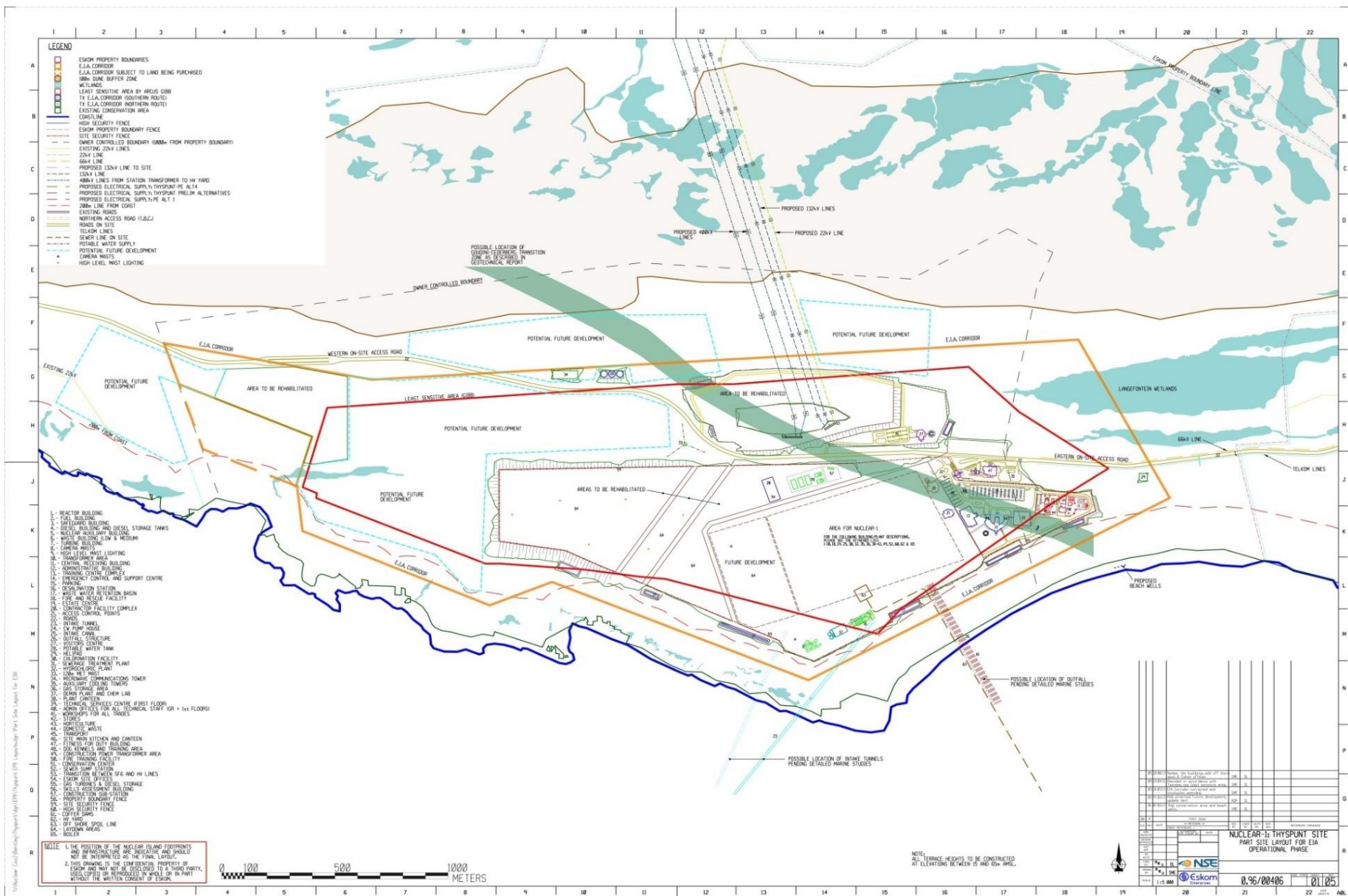


Figure 16: Thyspunt site layout

5.3 Site Justification

Detailed investigations were performed to confirm the suitability of the Thyspunt site, taking into account all factors relevant to the site (i.e. natural and human-induced external events, potential radiological impact to the public and the environment, feasibility of developing and implementing an emergency plan as well as security arrangements required for the site).

5.3.1 Evaluation of External events

Events external to a nuclear installation(s) which could challenge nuclear safety were identified and evaluated for the site. The two main categories of external events are:

- Events of natural origin, e.g. extreme weather-induced flooding of the site;
- Events of human-induced origin, e.g. accidental aircraft crashes.

The current regulatory requirements relevant for the evaluation of external events during site characterisation for new nuclear installations are stipulated in the following two documents:

- R.388 (*Safety Standards and Regulatory Practices*) [4]; and
- R.927 (*Regulations on Licensing of Sites for New Nuclear Installations*) [1].

The regulations in R.927 that make reference to external events are:

“4(2) The proposed nuclear installation design(s), and the characteristics specific to the site: New nuclear installation(s) must reflect through their design, construction and operation an acceptably low probability of postulated events that could result in release of quantities of radioactive material.”

“4(3) The site location and the engineered safety features of all nuclear installations, included as safety measures against the hazardous consequences of postulated events, must ensure an acceptably low risk of public exposure.”

“4(4) The site must be such that radiological doses and risks from normal operation and postulated events associated with all nuclear installations in the vicinity will be acceptably low.”

“4(5) Natural phenomena and potential man-made hazards must be appropriately accounted for in the design of the new nuclear installation(s), and that adequate emergency plans and nuclear security measures can be developed.”

“5(3) The characteristics of the site relevant to the design assessment, risk and dose calculations, including inter alia:

- a) external events;*
- b) meteorological data;*
- c) land use;*
- d) population demographics;*

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e) *regional development;*"

"5(4) A source term analysis that is representative of the overall potential hazards posed to the public and the environment owing to the new nuclear installation(s). A representative scope of internal and external events enveloping the new nuclear installation(s) must be taken into consideration."

5.3.2 Natural Hazards

Events are evaluated by analysis of available monitoring data for the site and determining event frequencies statistics. These statistics are return periods and annual probabilities of exceedance of parameter values characteristic of the event severity.

5.3.2.1 Geological hazards

Geological investigations for the Thyspunt site have been conducted for more than 25 years. These studies have included geological mapping, on- and offshore geophysical studies, geochronological analyses, geomorphic studies, paleoseismic studies, and geotechnical investigations.

These studies were conducted as part of early screening studies to evaluate multiple nuclear sites, specific studies conducted for the Thyspunt site, and geological investigations conducted specifically to address key issues of importance to seismic hazard analysis. Consistent with NNR guidance and international regulatory guidance and standards, the full range of methods and tools were applied, and the investigations included the recommended increasing levels of specificity ranging from the site region, site vicinity, and the site area to the site location. As is recommended in the existing regulatory guidance, the results of the investigations conducted for the site were integrated with studies conducted by a large number of investigators within the geological community and published in the professional literature.

The net result of integrating all the geological studies conducted with the interpretations offered by members of the community in technical publications is a strong, complete geological knowledge base for the site region, site vicinity, site area, and site location.

The on- and offshore regional geology and tectonics at the site are well understood. The shoreline and coastal plain at the site area and location represent an old and stable landscape. From an erosional point of view, the resistant rocks that establish this rugged coastline provide a stable base for the construction of nuclear installations. Significant changes in the geological environment are therefore extremely unlikely. Given the silica-rich (sandstones and siltstones) nature of the Palaeozoic-age bedrock underlying the site location, there is no risk of solution cavities forming beneath the site.

5.3.2.1.1 Slope Instability

The site and its vicinity were evaluated to determine the potential for slope instability (such as land and rockslides) that could affect the safety of the nuclear installation(s).

Slope instability is a phenomenon resulting from steep slopes, high groundwater, and/or vibratory ground motion but not related to surface faulting. Slope instability can result in landslides and general earth movements that could affect the safe operation of the nuclear installation. It could also hinder emergency response.

The site geotechnical profile consists of bedrock overlain by predominantly cohesionless Aeolian sands that range in thickness from 0 m at sea level to a maximum of 65 m under the dune peaks inland (about 700 m inland from the sea). There is also an intergranular aquifer found at (or near) surface at sea level and as deep as 60 m from surface under the dune peaks inland.

The described geotechnical profile indicates that while the overlying cohesionless Aeolian sands and variable groundwater levels require assessment for localised duneslope stability, these conditions do not pose a fundamental constraint to the site. Slope instability potential will be evaluated through geotechnical modelling of sand shear strength, groundwater behaviour, excavation geometry and seismic loading, and any identified risks will be mitigated through civil engineering design, consistent with regulatory requirements.

5.3.2.1.2 Collapse, Subsidence, or Uplift of the Site Surface

Geological maps and other appropriate information for the region were examined for the existence of natural features such as caverns, karstic formations, and human-made features such as mines, quarries, and wells. The potential for collapse, subsidence, or uplift of the site surface was evaluated.

The site is underlain by Table Mountain Group (TMG) sandstone dominated by the Skurweberg (near the sea) and the Goudini (further inland) formations. These formations do not possess any physical attributes that could result in the development of subsurface voids (e.g. caves) and karst features (which develop in limestone/dolomite). Extensive drilling programmes carried out on the site have not encountered any voids or karst features that could pose external hazards to the site.

The following features are considered hazardous to a nuclear installation:

- Indicators of potential cavities and susceptibility to ground collapse in the context of sinks, sink ponds, caves and caverns, sinking streams, historical ground subsidence, natural bridges, surface depressions, springs, rock types such as limestone, dolomite, gypsum, anhydrite, halite, terra rossa soils, lavas, weakly cemented clastic rocks, coal or ores; and non-conformities in soluble rocks;
- Zones of weakness or discontinuities in crystalline rocks.

Information gathered to date from historical and extensive intrusive investigations on site, indicate that no features that could be potentially hazardous to a nuclear installation are present on the site. In addition, as the nuclear installation is planned to be founded on (or

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in) bedrock, no subsidence, collapse, or uplift is anticipated at the site during the lifetime of the facility.

Mining activities within 16 km of the site were considered to identify the potential sources of human-induced events. The site evaluation concluded that there are no mining activities within the 16 km radius of the site that could affect surface stability.

A limited number of quarries, sand mines, and brickfields found in the site area are directly related to the construction industry and occur in areas close to existing towns where most new construction takes place.

Production boreholes/wells would have to be sited close to the nuclear installation to have any possible effects due to drawdown of groundwater levels based on yield testing carried out on the site.

The Southern Outeniqua Basin, outside of the site region, is highly rated for oil in the central and southern extent of the basin and more gas-prone towards the northern periphery. The Algoa Basin, also outside of the site region includes oil, while the Gamtoos Basin, located inside the site region is shown to be gas prone and the Pletmos Basin has proven gas resources. In the Southern Outeniqua Basin significant gas reserves have recently been confirmed through the drilling of the Brulpadda and Luiperd wells by *TotalEnergies*, *Main Street*, *Qatar Petroleum* and *CNR* [10]. Figure 17 indicates the relevant lease areas within the site region.

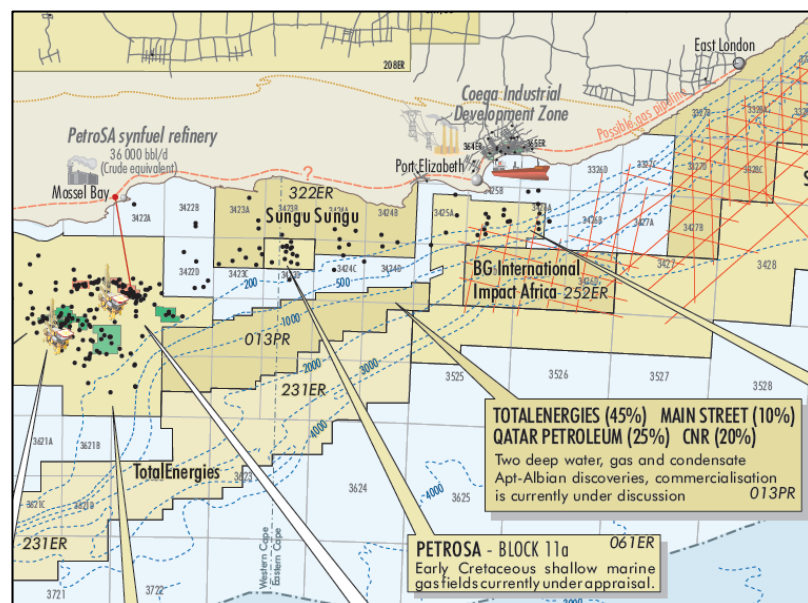


Figure 17: Petroleum exploration and production activities relative to the site region

There are currently two offshore exploration rights under application in the site region, namely Sungu Sungu where PetroSA is conducting an appraisal of Cretaceous shallow marine gas fields, and New Age Algoa/Rift Petroleum where the prospectivity evaluation of the synrift and post rift sequences is ongoing.

In addition, *TotalEnergies*, *Main Street*, *Qatar Petroleum* and *CNR* had production rights under application immediately to the south of the site region. The project was in its approval stage and was expected to start commercial operation by 2026, however, in July 2024, *Total Energies*, *Qatar Petroleum* and *CNR* gave notice to the joint venture partners that they were withdrawing from their interest. Main street retained their interest. The future extraction of this resource is therefore uncertain and will need to be monitored.

Based on the current information about the site and the region, no collapse, subsurface or uplift of the site surface, due to cavern and karst formations is expected to occur during the lifetime of the nuclear installation. The future extraction of gas resources needs to be monitored and assessed for its impact on the site when more information becomes available.

5.3.2.1.3 Soil Liquefaction

The liquefaction potential of the subsurface materials of the proposed site was evaluated by using parameters and values for the site-specific ground motion. The evaluation included the use of accepted methods of soil investigation and analytical methods to determine the hazards. Significant damage can occur to civil structures supported on soils that liquefy.

Current analysis indicates that liquefaction potential exists in isolated areas, but in general the site does not exhibit a high liquefaction risk.

The site is underlain by an intergranular aquifer dominated by poorly graded Aeolian sand that exhibits erratic soil consistency in places. Poorly consolidated soils in the upper soil horizons will exhibit liquefaction potential should these horizons become saturated in future for whatever reason.

Liquefaction risks will be dealt with in the design of the installation, e.g. through founding the plant basemat on bedrock.

5.3.2.1.4 Volcanism

Volcanic events can present significant hazards to a nuclear installation during its lifetime. As a general guide, volcanoes that have erupted during the last 10 000 years are usually considered active. Information on the assessment of the potential volcanism in the site region indicate that volcanism occurred in the region more than 10 million years ago which means that they can be considered inactive.

5.3.2.1.5 Behaviour of Foundation Materials

The geotechnical characteristics of the subsurface materials, including uncertainties, were investigated and a soil profile for the site in a form suitable for design purposes was determined. The stability of the foundation material under static and seismic loading was assessed. The groundwater regime and the chemical properties of the groundwater were also studied.

Extensive investigation of the site bedrock through field and laboratory investigations revealed that the site is underlain by hard quartzitic (sandstone dominated) Skurweberg formation rocks in the south and less hard (quartzitic sandstone dominated) Goudini formation rocks in the central and northern parts of the site.

These rocks have been extensively sheared and deformed due to past tectonic activity and the site itself is located on the southern limb of an anticline. The Table Mountain Group (TMG) rocks underlying the site dip at approximately 50° to the south. Being of sedimentary origin, it is apparent that the weathering profile of these rocks varies considerably across the site and this weathering is influenced by depositional characteristics and discontinuities in the deformed rocks.

The Skurweberg and Goudini formation rocks appear to have varying characteristics related to uniaxial compressive strength (UCS). In essence, the Skurweberg formation rocks tend to have a higher average UCS than the Goudini formation rocks. The distribution of UCS in the Skurweberg rocks envelops the distribution of UCS in the Goudini rocks.

Comparison of the general foundation soil characteristics requirements for a nuclear installation(s) and the currently available data for the site indicate no impediment to building the nuclear installation foundations on (or in) the site bedrock.

5.3.2.2 Probabilistic Seismic Hazard Analysis PSHA

The Thyspunt probabilistic seismic hazard analysis (PSHA) [9], which characterised the seismic hazard at the Thyspunt site, adhered to the requirements and followed methodologies recognised and approved by the United States Nuclear Regulatory Commission, since these were (and still are) widely considered to be the most stringent regulatory requirements worldwide. Thereby the PSHA also satisfied the requirements and standards of the IAEA and NNR. Thus, the Thyspunt PSHA was executed as a SSHAC Level 3 study, which refers to a detailed, formal process for conducting a PSHA.

Like all SSHAC studies, the Thyspunt PSHA had clearly defined roles for all participants, with the technical work conducted by a multi-disciplinary technical team. The responsibility for process and technical review was assigned to a highly qualified and experienced Participatory Peer Review Panel (PPRP), who had the ultimate responsibility to confirm whether the study captured, and adequately documented, the available data, models and methods.

The Thyspunt PSHA utilised an exhaustive project database, created compilation of all available data identified by the Technical Integrator (TI) Teams, assisted by suggestions

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from the PPRP, and included published papers, unpublished reports, maps recordings, catalogues, and other quantitative data. The SSHAC Level 3 process also made provision, through formal workshops, for the technical team to interact directly with members of the scientific community regarding information and specific models and interpretations relevant to the PSHA.

Additionally, a number of specialist studies were undertaken to collect additional data that contributed to better constraining the scientific models, thereby reducing the overall epistemic uncertainty. These included a number of studies focussed on large, regional Kango, Baviaanskloof, Coega and Kouga fault zones, and a marine terrace investigation focussed on Thyspunt and the surrounding region. These investigations utilised and added to offshore data and focused research on the Kango Fault previously commissioned by Eskom (and subsequently published in the scientific literature). The first, extensive investigation of historical (pre-instrumental) earthquake reports were undertaken for South Africa, to supplement the instrumental database of the earthquake catalogue. Geotechnical measurements, including non-invasive MASW (Multi-channel Analysis of Surface Waves) and PS suspension logging in 26 boreholes, were conducted at the Thyspunt site to assess the dynamic characteristics of the near-surface rock profile.

The seismic source model is a conceptual and mathematical representation of the physical characteristics of earthquake sources that are deemed capable of producing hazard-significant ground motions at the site. Two types of earthquake sources were considered in the Thyspunt PSHA; known geological faults and seismic source zones. The latter describe regions of the Earth's crust within which seismic activity can occur without being limited to specific known faults. The final source model included ten seismic sources, which included five source zones (Extended Continental Crust [ECC, the host zone], Syntaxis [SYN], Karoo [KAR], Namaqua [NAM], and Cedarville-Koffiefontein [CK]), and five fault sources, which included the Kango (KNG), Agulhas (AFZ), Gamtoos (GAM), Plettenberg (PLET), and Worcester (WOR) faults. Logic trees were developed to capture the characteristics of these sources. For seismic source zones these characteristics included the location and nature of their boundaries, a number of parameters related to maximum magnitudes, orientations of earthquake ruptures that can occur within each zone, and earthquake recurrence characteristics. For fault sources this included their seismogenic probability, style of faulting, three-dimensional geometry, characteristic magnitudes, slip rates, magnitude-frequency relationships, and earthquake recurrence rates. Additional characterisation was performed for the Kango fault, which was subject to considerable paleoseismic investigation.

For the GMC (ground motion characterization) model, the TI Team reviewed all available ground-motion prediction equations (GMPEs) and decided to adapt and adjust existing equations to match local conditions. In this hybrid-empirical approach stochastic parameters are used to apply host-to-target region adjustments to empirical GMPEs. Site response analyses were performed to develop amplification functions for the transfer of the bedrock motions at depth to the bedrock surface at the site.

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The hazard calculations were conducted using the nuclear-qualified software package FRISK88. Independent calculations for several logic-tree branches were performed externally as an independent check on the implementation of the seismic source and ground motion models. The basic output from the PSHA was hazard curves showing the annual frequency of exceedance (AFE) of different values of the spectral accelerations at these response periods. The hazard calculations were run for the 10 target oscillator periods identified previously and for a wide range of AFEs, producing separate hazard curves at the surface elevation as shown in the Figure 18 below.

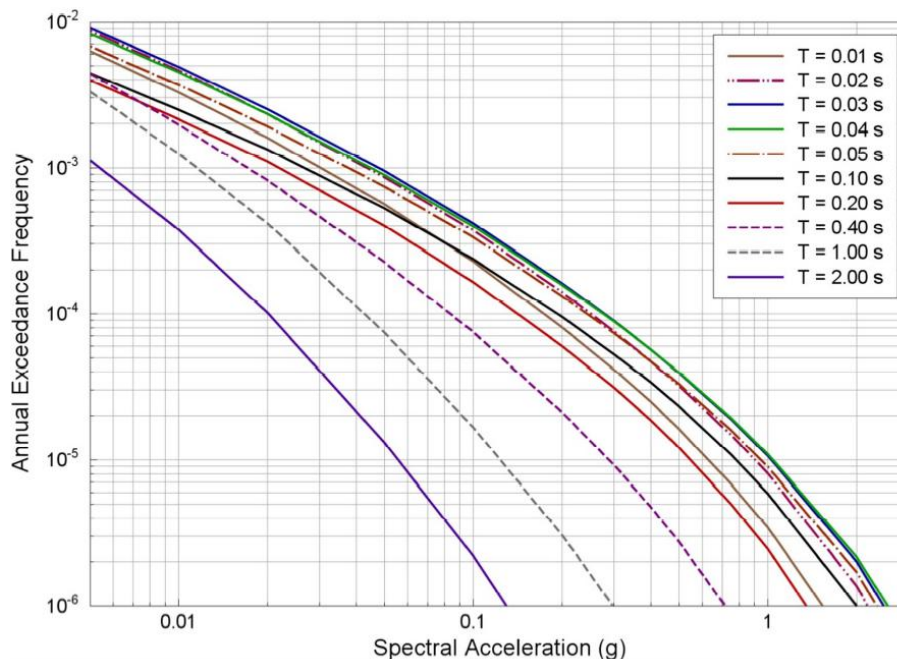


Figure 18: Mean Hazard Curves at the Surface Elevation

Disaggregation plots were produced for specific combinations of response period and AFE, to assess the impact of different combinations of earthquake magnitude, source-to site distance and ground-motion level (within the probabilistic distribution of accelerations predicted by ground-motion equations for a specific magnitude and distance).

From the seismic hazard curves, uniform hazard response spectra (UHRS) were constructed for various AFEs. Another output from the study was ratios of vertical-to-horizontal spectral ordinates that can be used to obtain vertical response spectra from the horizontal response spectra and is obtained by applying a modified version of the V/H ratios for hard rock sites in Central and Eastern United States presented in NUREG/CR-6728 (refer [9]).

When the resulting horizontal and vertical GMRS (ground motion response spectra) are compared with the standard AP1000 design spectra (see figure below), there is an appreciable margin between the Thyspunt GMRS and the AP1000 design spectrum. The design spectrum is exceeded only at short oscillator periods, reflecting the widely recognised inadequacy of the standard design spectra used for hard rock sites at the time, which should not become constant above frequencies as low as 40 Hz high oscillator

frequencies (from 25 Hz to just below 100 Hz), which is common phenomenon for hard rock sites (refer to Figure 19).

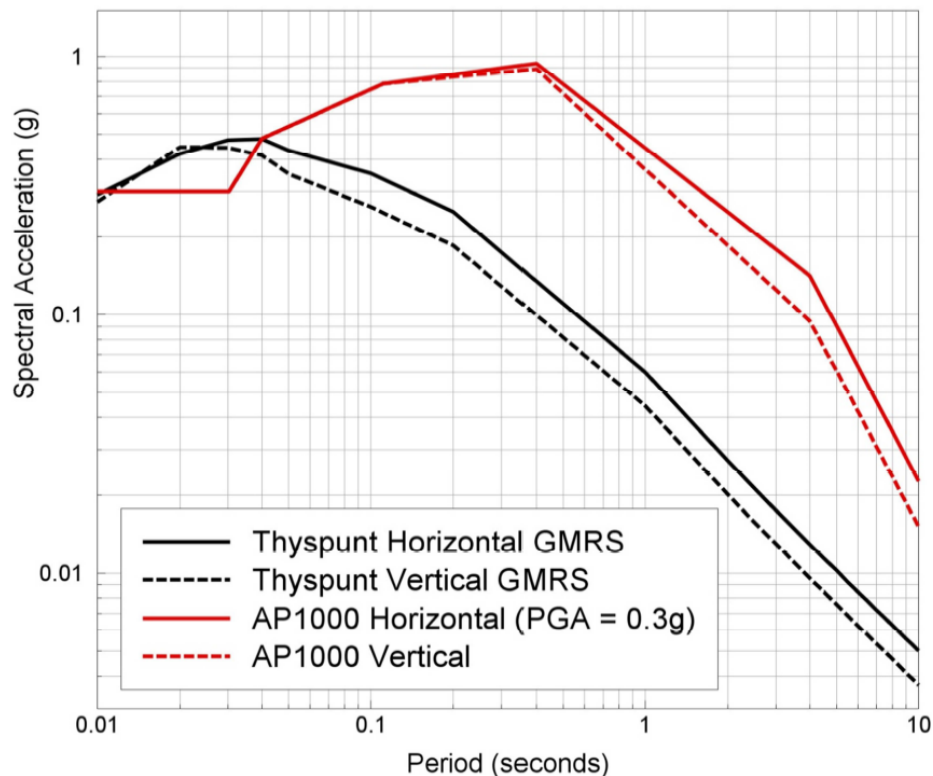


Figure 19: GMRS of Thyspunt compared with the AP1000 design spectrum

5.3.2.2.1 Mining-Induced Seismicity

South Africa experiences both natural (tectonic) and mining-induced earthquakes/seismicity. In terms of the scope of the seismic hazard assessment, the focus is exclusively on ground shaking resulting from natural earthquakes of tectonic origin. The ground motions from mining-related earthquakes attenuate much faster with distance than those from tectonic earthquakes (due to higher frequency content of the motions and shallower depth of the events), therefore these events are not expected to generate surface ground motions of engineering significance except in the immediate vicinity of the source.

In common with seismological agencies worldwide, events of purely anthropogenic origin such as mining induced events are identified by the Council for Geoscience (CGS) as part of their routine observation and recording of seismic activity. Due to the importance and volume of mining activities in South Africa, CGS also routinely identifies and separates mining-related events. Mining-related events are identified based on location and waveform aspect as part of the routine processing procedure of seismic data at the CGS and flagged by using a different fixed depth from that used for tectonic events, hence are straightforward to eliminate. The magnitude cut-off at $ML = 3.0$ would eliminate the vast majority of these events. Note that the occurrence of moderate-magnitude mining-related

events is primarily associated with deep mining activities (gold and platinum mines), which are concentrated in the northern and central part of the country, and largely fall outside the Thyspunt study region.

The motivation for the removal of anthropogenic (man-made) events from the earthquake catalogue was two-fold: firstly, such events follow different temporal patterns since they are caused by different processes from tectonic processes that lead to natural seismicity. Consequently, to include these events in the seismic source model would still require them to be identified and separated, and then for recurrence relationships to be derived specifically for these events. The second factor in the motivation to exclude these events from the catalogue and from the development of the seismic source model is the fact that they correspond to magnitude and distance combinations that are of no consequence to the estimate of seismic hazard at the Thyspunt site. Were there sources of mining-related earthquakes much closer to the site, then it would be necessary to include their contributions to the site hazard by developing seismic source models for such earthquake activity of anthropogenic origin. However, the Thyspunt site is very remote from the gold mining areas, and it is the nature of such earthquakes that they are spatially limited to the immediate vicinity of the anthropogenic activity, in this case deep gold mining. Since the largest events that can occur in relation to mining are limited to a little greater than the lower bound magnitude threshold of $M=5$ considered in the PSHA calculations (in accordance with USNRC Regulatory Guide 1.208), such events simply do not contribute to the site hazard.

Let's look at the $ML=5.5$ earthquake of 5 August 2014 near Orkney (considered to be mining related). This earthquake, which was associated with mining, the location is more than 800 km from the Thyspunt site. It is clear that an earthquake of magnitude 5.5 at more than 800 km from the site would have no influence at all on the shaking hazard at Thyspunt. This is confirmed by intensity observations from the earthquake that show at the southwest limit of the Free State, which is more than 400 km from Thyspunt, the intensity had already reduced to III or II (Figure 20), the latter being the absolute lower limit of human perceptibility corresponding to persons favourably positioned and at rest feeling the ground shaking.

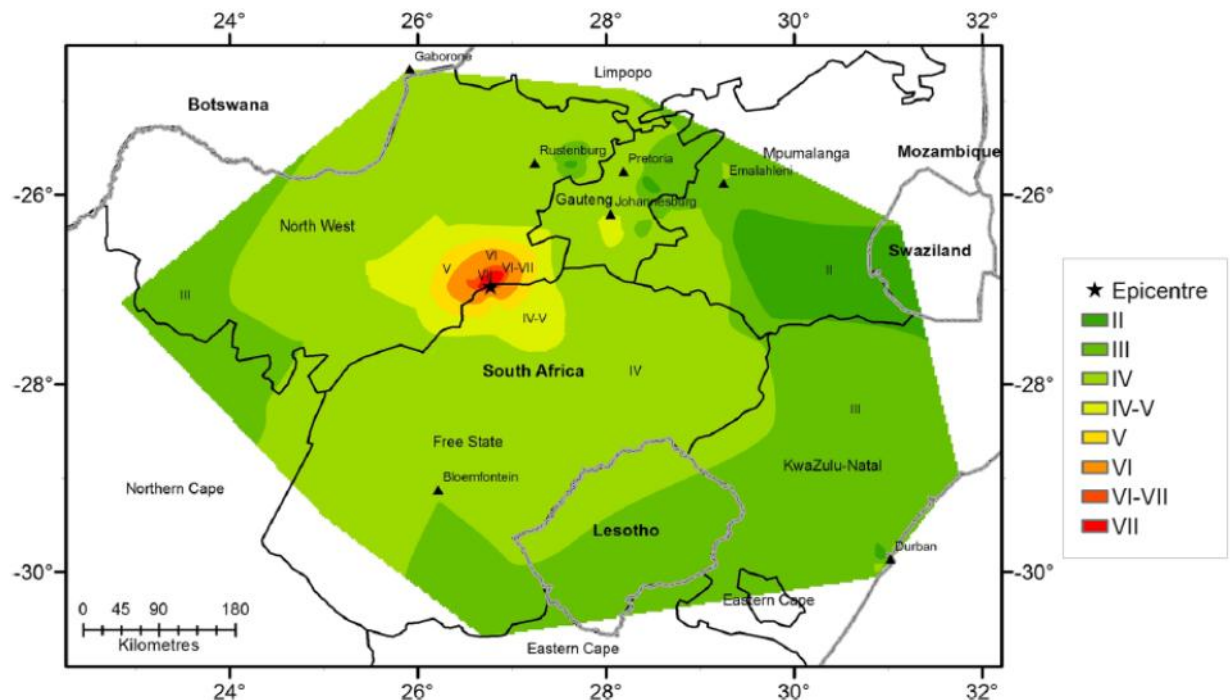


Figure 20: Iseismal map of the 2014 Orkney Earthquake [64]

Therefore, the mining induced events were excluded from the catalogue because it's not from tectonic origin and makes almost null contribution to the hazard estimates, simply by virtue of its separation from the site.

5.3.2.2.2 Surface faulting

The potential for surface faulting (i.e. the fault capability) was assessed for the site. The methods used and the investigations made were sufficiently detailed to determine that there is no capable fault on the site. The investigation indicates that there is no evidence for capable tectonic deformation at the site location and that the potential for tectonic deformation is negligible. This is based on the geological investigations which demonstrated that mapped faults within the site area are not capable faults. Bedrock mapping in the site vicinity found no evidence for surface faulting or deformation that would suggest capable faults in the site area. The basis for this conclusion is the absence of geomorphic features, indicative of Quaternary deformation.

5.3.2.3 Meteorological Events

The meteorological and climatological characteristics for the region around the site were investigated and evaluated in support of the identification of external events and potential hazards to the nuclear installation on the site. The atmospheric structure required for enabling atmospheric dispersion predictions necessary for the assessment of potential radiological impact on the public and the environment and the feasibility of emergency planning is also developed. In accordance with local and international recommendations, two main types of meteorological phenomena and events need to be evaluated in the site

evaluation stage, i.e. extreme values of meteorological hazard parameters and rare meteorological phenomena.

In order to evaluate their possible extreme values, the following meteorological phenomena were investigated: hurricane-force wind (including windblown dust storms), thunderstorms, precipitation (including hail), air temperature (dry bulb and wet bulb), atmospheric pressure, and storm surges. Uncertainties in the data and the potential effects of climate change were taken into account in this evaluation.

5.3.2.3.1 Meteorological measurement

On-site meteorological data has only been accumulated for a period of seven years. Data accumulated over longer periods are required for long-term statistical analysis. To allow the establishment of historical trends, the NNR and IAEA consider it acceptable to collect meteorological information from nearby weather stations. Since the conditions at Cape St. Francis most closely represent the meteorological conditions at the site, the site data was augmented by long-term meteorological data collected by a weather station of the South African Weather Service (SAWS) at Cape St. Francis, approximately 9.3 km east-southeast of the site at a height of 9 m above mean sea level (m amsl) (Figure 21). In addition to the meteorological observations at Cape St. Francis WS, long term rainfall data were sourced from the Humansdorp WS, approximately 17.3 km north-northeast of the site (109 m amsl). Albeit significantly further from the site, a fully automatic weather station with a long history of data is located at Gqeberha, approximately 85 km east-northeast of the site (60 m amsl).

The meteorological station on site is established at an altitude of 51 m amsl, which is approximately 730 m west of the current site centroid and about 760 m from the high tide mark. Parameters measured at this weather station include wind speed and direction at 9 m above ground level, dry-bulb temperature at 2 m and 8 m above ground level, solar radiation, relative humidity, atmospheric pressure, rainfall, visibility and lightning events.

An automatic data logger is used to record meteorological data. The data are stored as 10-minute averages in electronic format. The data is retrieved remotely via telephone dial-up modem or downloaded onsite, using a data transfer connection cable and personal computer.

Corrosivity of the local atmosphere was measured using the ISO Standard methodology. The ISO Standard 9223 [12] methodology uses the measured temperature and relative humidity from the local weather station together with the deposition rate of sulphur dioxide and airborne salinity to determine the corrosivity rate.

Meteorological measurement at higher levels will be initiated at least one year prior to the start of the nuclear installation construction.



Winter winds were most prevalent from the west with 19.63 per cent at Thyspunt weather station and 31.52 per cent at Cape St. Francis.

Spring winds were also mostly prevalent from the west with 21.89 per cent at Thyspunt weather station and 31.58 per cent at Cape St. Francis.

Autumn winds were also mostly prevalent from the west with 21.94 per cent at Thyspunt weather station and 35.87 per cent at Cape St. Francis (see Figure 23).

The highest hourly average and wind gusts recorded at the site during the 2008 – 2013 and 2017 - 2019 period is presented in Table 4 below. The highest gust recorded at the Thyspunt WS was 32.2 m/s (24 September 2019 at 7h00). The highest gust at the Cape St. Francis WS on the same day and hour was 31.6 m/s. The highest gust at the Cape St. Francis WS was significantly higher, i.e. 45.8 m/s (18 August 2020 at 13h15). Unfortunately, this was outside the monitoring campaign for the Thyspunt WS for a comparison.

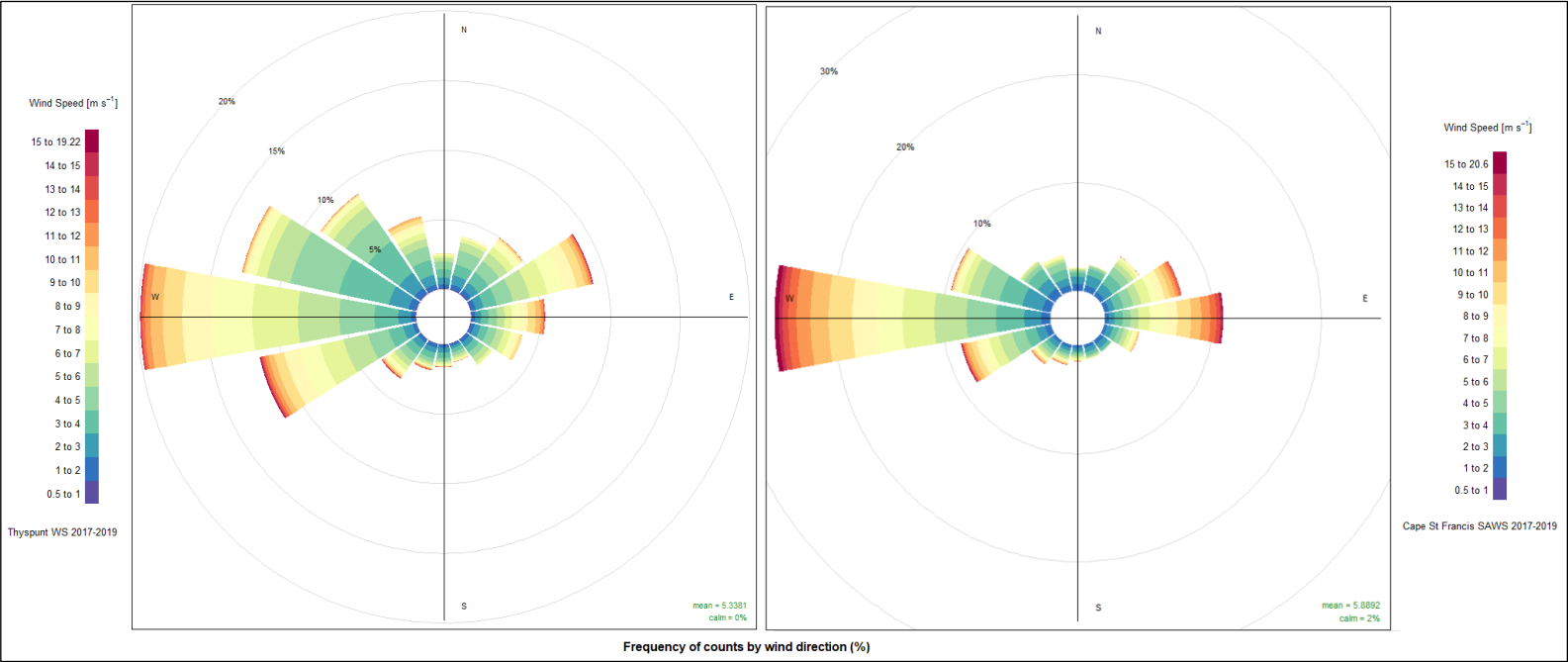


Figure 22: Comparison of SAWS Cape St. Francis WS and Thyspunt WS for 2017-2019 Period

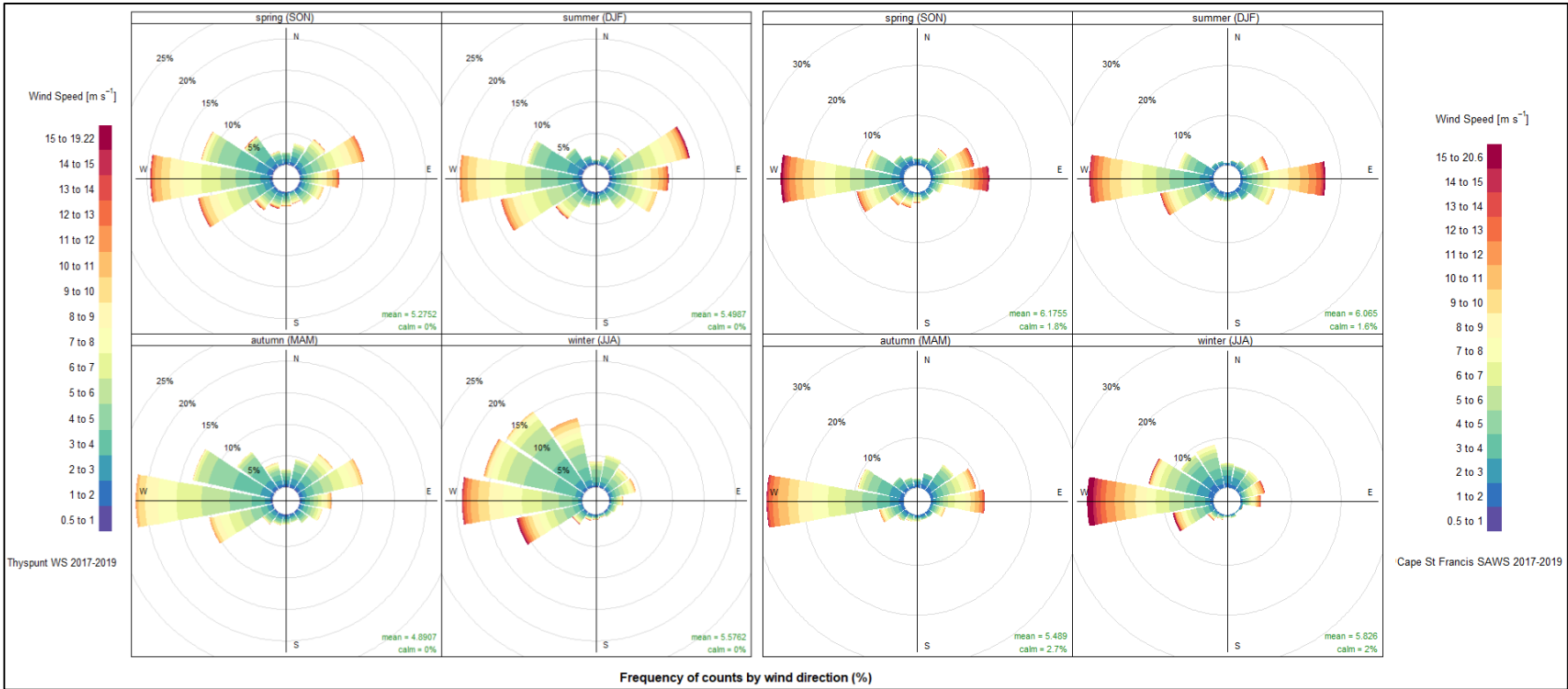


Figure 23: Comparison of Seasonal Wind Roses for Cape St. Francis WS and Thyspunt WS (2017 to 2019)

Table 4: Monthly Maximum Hourly Average and Wind Gusts (m/s) at Cape St. Francis and Thyspunt Weather Stations

Month	Cape St. Francis Weather Station		Thyspunt Weather Station	
	2004 – 2023		2008 – 2013 & 2017 – 2019	
	Max of Hour Average	Highest Gust	Max of Hour Average	Highest Gust
January	18.8	34.5	16.6	29.0
February	16.6	35.7	14.8	30.7
March	19.5	31.2	14.7	24.1
April	18.1	28.7	14.1	31.6
May	22.8	39.7	15.1	31.6
June	23.2	32.6	17.9	30.2
July	21.2	37.9	19.3	32.2
August	21.1	45.8	16.4	29.2
September	18.8	31.6	17.9	37.9
October	19.3	38.5	17.9	31.7
November	17.5	30.2	15.5	25.5
December	19.7	34.1	16.6	24.2
Annual	23.2	45.8	19.3	37.9

ii) Ambient air temperature

Temperature is a primary climatological parameter that is used as an index of the energy status of the environment.

The reference height for ambient temperature measurement is typically 2 m above ground level. The monitoring levels for air temperature at Thyspunt was initially only at 2 m (2009 – 2013), but from 2017 to 2019 a second temperature sensor was established at 8 m. The temperature sensor at the Cape St. Francis weather station is also located at 2 m above ground level.

Dry bulb air temperature observations at the Thyspunt WS (January 2008 to October 2013 and June 2017 to September 2019) recorded the following:

- average of the daily maximums: 20.8 °C (average of monthly ADMxT in Table 5);
- average of the daily minimums: 14.4 °C (average monthly ADMnT in Table 5);
- the months with the highest average daily maximum temperatures of 23.4 °C are January and February (highest monthly ADMxT in Table 5);
- the month with the lowest average daily minimum temperature of 18.4 °C is August (lowest monthly ADMxT in Table 5);
- the month with the highest average daily minimum temperature of 17.8 °C is January (in Table 5);

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- the month with the lowest average daily minimum temperature of 11.2 °C is August (lowest monthly ADMnT in Table 5);
- the annual average temperature is 17.3 °C (average of hourly average temperatures).

The lowest and highest hourly average temperatures recorded at the Thyspunt WS (2 m level) were 6.7 °C (August) and 38.2 °C (April). The extreme hourly temperatures at the Cape St. Francis WS (2 m level) were 4.9 °C (21 June 2018) and 38.5 °C (28 March 2022).

Table 5: Ambient Air-Dry Bulb Temperature [°C] at the Thyspunt WS (January 2008 to October 2013 and June 2017 to September 2019)

Month	Daily Average		95% Confidence Interval of Average	Daily Median	Percentiles		Maximums and Minimums						A#DDMxT		A#DDMnT	
	ADT	StdDev			25%	75%	MnADT	MxADT	TMn	TMx	ADMnT	ADMxT	>35.0	>30.0	<10.0	<5.0
1	20.5	1.3	±2.58	20.4	18.9	22.0	16.8	24.3	13.0	31.3	17.8	23.4	0.0	0.3	0.0	0.0
2	20.4	1.6	±3.04	20.3	18.7	21.8	16.0	26.4	13.5	32.4	17.6	23.4	0.0	0.9	0.0	0.0
3	19.8	1.7	±3.26	19.6	18.2	21.1	15.0	25.2	11.7	36.6	17.1	23.0	0.0	1.0	0.0	0.0
4	17.8	2.2	±4.35	17.7	15.8	19.4	11.7	25.3	8.3	38.2	14.8	21.3	0.3	0.9	0.1	0.0
5	17.0	2.4	±4.62	16.7	14.8	18.5	12.0	27.2	8.4	35.8	13.9	20.9	0.1	1.0	0.9	0.0
6	15.2	2.5	±4.98	14.8	12.7	16.9	10.0	24.7	7.1	31.2	11.8	19.1	0.0	0.4	5.1	0.0
7	15.1	3.0	±5.86	14.5	12.3	17.0	9.8	25.9	7.2	31.8	11.7	19.1	0.0	0.5	6.8	0.0
8	14.6	2.2	±4.35	14.3	12.3	16.4	9.8	22.6	6.7	31.3	11.2	18.4	0.0	0.3	8.3	0.0
9	15.4	2.2	±4.23	15.3	13.3	17.1	10.8	28.7	7.6	36.3	12.2	18.8	0.1	0.6	2.9	0.0
10	16.5	2.0	±3.98	16.2	14.7	17.9	12.9	25.9	9.4	34.7	13.6	19.5	0.0	0.7	0.4	0.0
11	17.3	1.6	±3.08	17.3	15.7	18.9	13.1	23.4	9.6	32.9	14.5	20.3	0.0	0.4	0.1	0.0
12	19.3	1.7	±3.30	19.1	17.6	20.9	15.7	23.6	11.2	34.0	16.5	22.1	0.0	0.3	0.0	0.0

ADT - Average daily temperature: average of the temperatures observed at 24 equidistant times in the course of a continuous 24-hour period (midnight to midnight).

StdDev – Standard deviation.

MnADT - Minimum of average daily temperature for a month: minimum of the average daily temperatures.

MxADT - Maximum of average daily temperature for a month: maximum of the average daily temperatures.

TMn - Minimum hourly temperature: minimum of the temperatures observed at 24 equidistant times in the course of a continuous 24-hour period.

TMx - Maximum hourly temperature: maximum of the temperatures observed at 24 equidistant times in the course of a continuous 24-hour period.

ADMxT - Average daily maximum temperature for a month: average of the daily maximum temperatures.

ADMnT - Average daily minimum temperature for a month: average of the daily minimum temperatures.

A#DDMxT - average number of days with maximum hourly temperature above.

A#DDMnT - average number of days with minimum hourly temperature below.

iii) Precipitation

Types of precipitation include hail, sleet, snow, rain, and drizzle. The formation of precipitation may occur at temperatures above or below freezing. Since the rainfall measurements are done automatically, it is not currently possible to determine the details of the type of precipitation. Instead, a constant precipitation type ('showers') most common to the area is used to evaluate the impact of precipitation on airborne concentrations of contaminants and on ground contamination.

No records could be obtained that quantified the occurrence of freezing precipitation at the site. However, given the relatively high wet-bulb temperatures recorded at the site (lowest of 3.5°C at the Thyspunt WS and 3.1°C at the Cape St. Francis WS), the likelihood of freezing precipitation is expected to be low.

The site receives rainfall throughout the year with wetter months typically from April to November and drier months from December to March. To supplement onsite monitoring data, reference and comparison to other weather stations in the vicinity is necessary. The Thyspunt WS data included six full years from 2008 to 2012 (2013 not full year) and 2018 (2017 and 2019 not full years). The mean annual precipitation (MAP) for this period was calculated to be 774.4 mm, which is higher than the observed MAP for the Cape St. Francis WS and the Humansdorp WS. Above average annual rainfall was observed during 2011 and 2012 at the Thyspunt WS, which skewed the average over the period.

Based on 146 years of observations at the SAWS Humansdorp WS (1878-2022), the MAP was estimated to be 678.8 mm. However, this site is approximately 17.3 km inland from Thyspunt and may not reflect identical rainfall conditions.

The Cape St. Francis WS is closer to Thyspunt (approximately 9.3 km east); however, this location is very close to the shoreline and may be influenced by this proximity. The combined rainfall data for the period 1881 to 2023 provides an MAP of 619.5 mm.

Monthly average, minimum and maximum rainfall results for Humansdorp, Cape St. Francis and Thyspunt are presented in Table 6. The monthly average rainfall totals for these three weather stations are also given graphically in Figure 24.

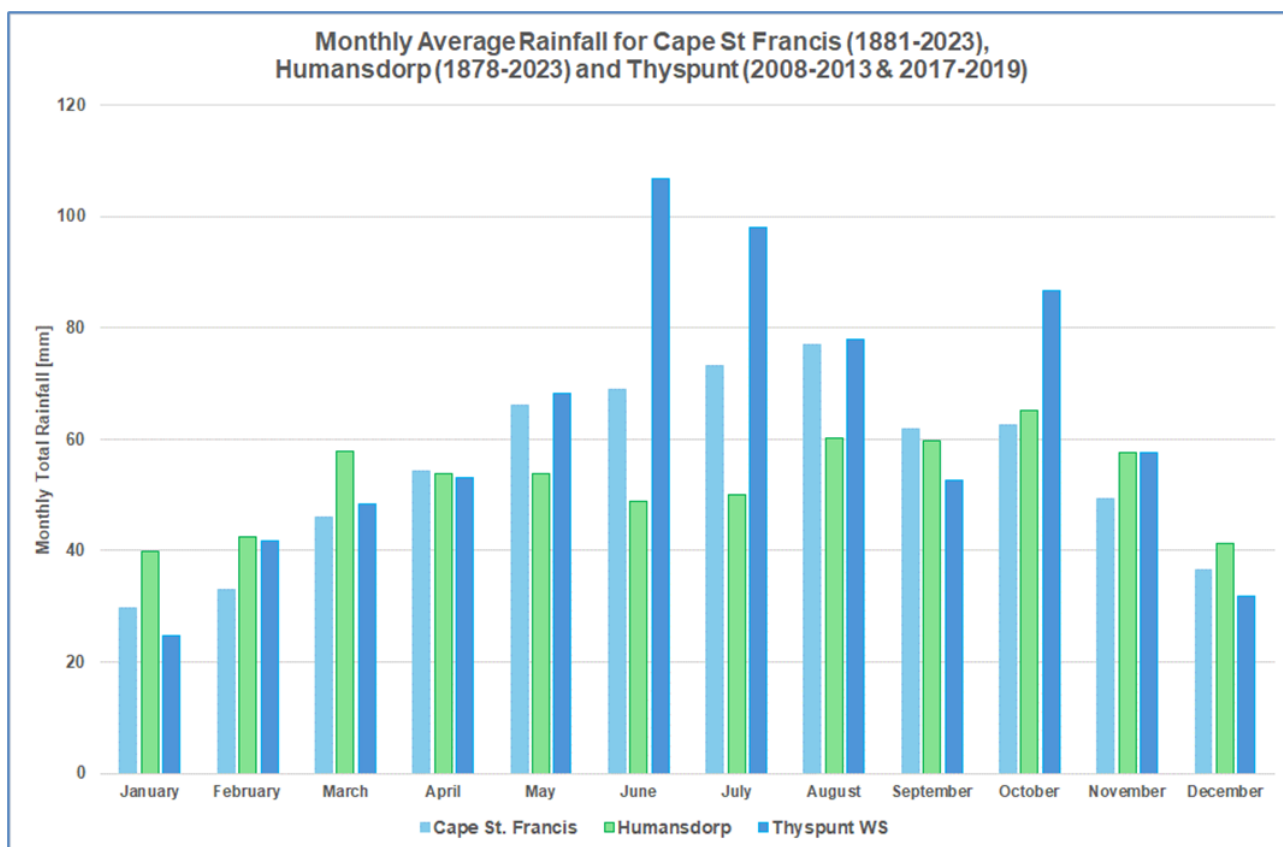


Figure 24: Monthly Rainfall Data at Cape St. Francis WS, Humansdorp WS and Thyspunt WS

Normal monthly rainfall is well distributed throughout the year with:

- The highest monthly averages of 106.7 mm and 98.0 mm occurring in June and July, respectively;
- The lowest monthly averages of 24.8 mm in January.

The highest monthly rainfall of 353.2 mm occurred in July, and the lowest monthly rainfall of 0.5 mm occurred in March.

The recorded maximum 24-hour rainfall at Cape St. Francis (old station) of 130 mm occurred on 27 May 1944. A new record high 24-hour rainfall of 157.8 mm was recorded on 5 March 2007 at the new SAWS station. The highest hourly rainfall observed at the Cape St. Francis WS was 37.4 mm (17 December 2022). The highest hourly rainfall at the site of 51.9 mm was recorded on 17 March 2011.

Table 6: Average, Highest and Lowest Monthly Rainfall for Cape St. Francis WS, Humansdorp WS and Thyspunt WS

Month	Average Monthly [mm]				Highest Monthly [mm]				Lowest Monthly [mm]			
	Cape St. Francis	Humansdorp	Thyspunt		Cape St. Francis	Humansdorp	Thyspunt		Cape St. Francis	Humansdorp	Thyspunt	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
January	31.1	21.1	39.9	24.8	104	70.2	176.1	48.2	0.0	4.4	2.8	11.0
February	34.1	25.7	42.5	41.8	188	49.4	217.0	77.3	3.0	7.4	1.8	18.6
March	45.6	49.2	57.9	48.4	257	173.4	250.3	169.7	1.0	0.4	1.4	0.5
April	55.5	46.3	53.7	53.2	173	104.4	193.3	101.3	1.0	8.2	2.3	7.9
May	67.7	55.2	53.8	68.3	251	209.2	261.2	245.5	0.1	7.0	0.5	20.7
June	69.4	66.2	48.8	106.7	215	212.2	270.2	199.7	0.0	15.8	0.8	29.2
July	72.3	78.8	50.0	98.0	198	224.2	238.3	353.2	6.0	2.4	4.9	10.8
August	76.1	82.7	60.2	77.8	185	213.0	465.0	192.4	0.0	9.4	0.3	10.5
September	64.7	43.7	59.8	52.6	366	121.2	341.5	122.4	3.4	11.2	6.0	1.1
October	64.2	52.5	65.1	86.8	209	167.6	487.7	208.6	7.0	8.4	2.4	34.4
November	50.4	41.5	57.7	57.6	188	117.2	263.5	121.6	1.0	3.8	4.8	23.4
December	37.3	32.4	41.4	31.9	176	138.0	244.3	81.0	4.0	0.4	2.5	6.5
Average	55.7	49.6	52.6	62.3	209	150.0	284.0	160.1	2.2	6.6	2.5	14.6
Highest	76.1	82.7	65.1	106.7	366	224.2	487.7	353.2	7.0	15.8	6.0	34.4
Lowest	31.1	21.1	39.9	24.8	104	49.4	176.1	48.2	0.0	0.4	0.3	0.5

Notes:

- (1) The statistics included 1881 to 2003
- (2) The statistics included the June 2004 to December 2023 data. Partial year for 2004 (15 June to 31 December) and subsequently excluded.
- (3) The statistics included the May 1878 to December 2023 data.
- (4) The statistics included the January 2008 to October 2013 and June 2017 to September 2019 data. Partial year for 2013 (1 January to 4 October). Partial year for 2017 (16 June to 31 December) and 2019 (1 January to 10 October).

iv) Droughts and Wet Years

The SAWS defines drought on the basis of two indices. The first index is based on the degree of dryness in comparison to normal or average amounts of rainfall for a particular area or place and the duration of the dry period. This is what is termed a meteorological drought, and the normal year would be calculated over a 30-year period.

Less than 75 per cent of normal rainfall is regarded as a severe meteorological drought but 80 percent of normal rainfall will cause crop and water shortages. A wet year has 25 per cent more rainfall than the normal year (i.e. 125 per cent).

Drought and wet years as observed at the Cape St. Francis WS during the period 1985 to 2023 are provided in Figure 25. During this period, six wet years (1992, 1993, 1996, 2011, 2012 and 2023) and seven drought years (1988, 1991, 2001, 2005, 2008, 2009 and 2017) were observed. Two years, 2007 and 2019 were on the cuff of being a wet and dry year, respectively. Since this index compares rainfall deficit in the current month with rainfall for the same month in the history of the station and does not consider the cumulative effect of rainfall deficit, the Standard Precipitation Index (SPI) has been introduced.

The SPI calculation is based on the distribution of rainfall over long time periods (preferably more than 50 years). SPI values above zero indicate wetter periods and values less than 0 indicate drier periods. A drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less.

During the 39-year historical period at the Cape St. Francis WS, five “extremely dry” years (1989, 2004, 2005, 2017 and 2018) were observed with two “extremely wet” years (1997 and 2012).

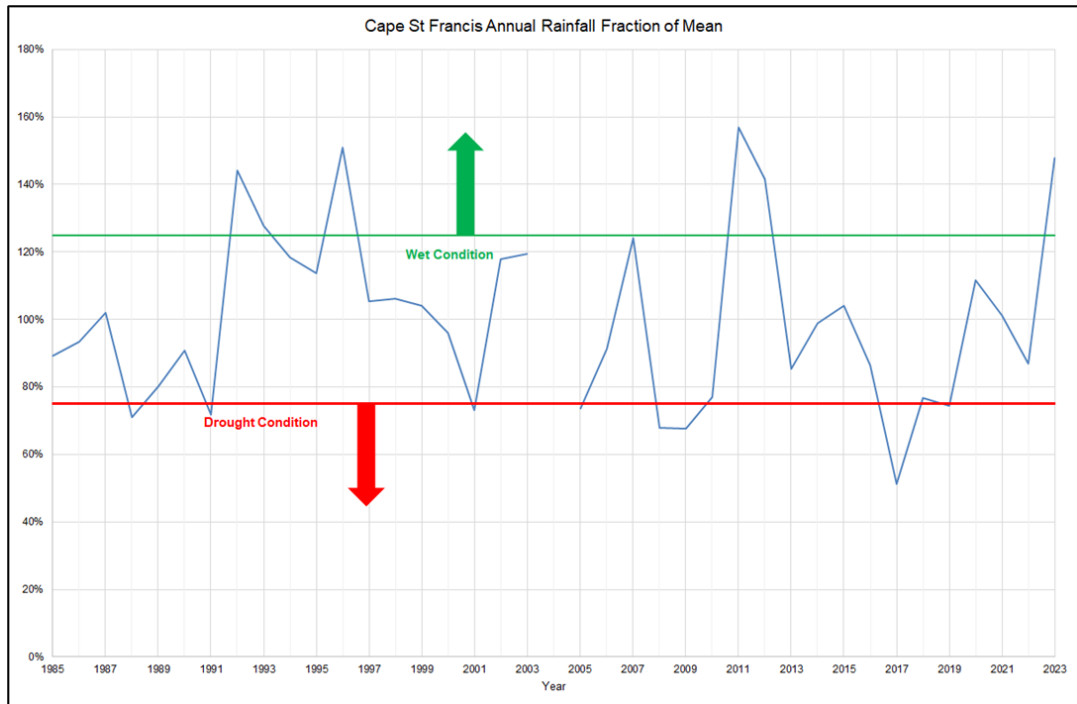


Figure 25: Dry and Wet Rainfall Periods Observed at Cape St. Francis WS

v) Thunder, Hail, Snow, and Fog

The SAWS climate data for Cape St. Francis (1881-1984) were used to determine the average number of days that thunder, hail, snow, and fog occur. The results of the data analysis are presented in Table 7.

Table 7: Average number of days with thunder, hail, snow, and fog at Cape St. Francis (1881-1984)

Month	Thunder	Hail	Snow	Fog
January	0.6	0.0	0.0	2.0
February	0.7	0.0	0.0	4.0
March	1.0	0.0	0.0	4.8
April	0.8	0.0	0.0	2.8
May	0.7	0.2	0.0	1.1
June	0.3	0.1	0.0	0.2
July	0.3	0.2	0.0	0.5
August	0.4	0.2	0.0	0.8
September	0.5	0.0	0.0	1.0
October	0.8	0.1	0.0	2.4
November	0.6	0.0	0.0	2.1
December	0.5	0.0	0.0	2.6
Annual	7.2	0.8	0.0	24.3

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vi) Atmospheric Moisture

Measurements of relative humidity were performed for the period January 2008 to October 2013 and June 2017 to September 2019 at the Thyspunt WS.

The annual average relative humidity recorded was 76.9 per cent at the Thyspunt WS and 79.0 per cent at the Cape St. Francis WS. The highest daily average relative humidity at the Thyspunt WS and Cape St. Francis WS was recorded during February at both sites, i.e. 83.5 per cent and 84.1 per cent, respectively. The highest daily maximum humidity values at the Cape St. Francis station also occurred in January and February, i.e. 84.4 per cent and 85.1 per cent respectively.

The lowest daily average relative humidity at the Thyspunt WS was during July (66.9 per cent) and during June at the Cape St. Francis WS (72.6 per cent). The annual average maximum and minimum relative humidity recorded at the Thyspunt WS were 99.9 per cent and 40.3 per cent respectively.

The annual average maximum and minimum relative humidity recorded at the Cape St. Francis station were 97.5 per cent and 46.1 per cent respectively.

vii) Atmospheric Stability

The southern and western coastal areas experience a persistent low-level subsidence inversion, termed the sub-escarpment layer, with its base at approximately 500 m and a depth of about 600 m. This layer is due to the predominance of the South Atlantic high-pressure (HP) system, and represents the boundary between the dry, subsided upper air and the moist influx of maritime air. The height above ground surface of this layer is related to the thickness of the sea breeze system and the intensity of subsidence in the upper air. The strength of inversion has been shown to vary between an average of 7°C in summer and 5.2°C in winter. The sub-escarpment inversion is stronger and occurs more frequently during the summer (51 per cent) due to the South Atlantic HP reaching its most easterly position during December.

Based on the temperature gradient between the 2 m and 8 m levels, it is estimated that surface inversions occurred for approximately 30 per cent over the year, with the most prevalent during winter months. As expected, summer occurrences are significantly lower ranging from 17 per cent in December to 18 per cent in March.

Using the sigma-theta method to calculate the atmospheric stability, the most prevalent atmospheric condition observed at the Thyspunt WS was observed to be slightly stable (stability class E), with 45.89 per cent and neutral (stability class D) with 40.67 per cent. The sigma-theta method is more suitable for stability classification at the Thyspunt WS.

viii) Corrosivity

a) Abrasive Effects by Sand and Dust

Since strong winds are evident at the site, large exposed sandy areas could be prone to the development of windblown dust. They occur when wind forces exceed the threshold value at which loose sand and dust are removed from a dry surface and become airborne. The term 'dust storm' is most often used when fine particles are blown long distances, whereas the term 'sandstorm' is more likely to be used when, in addition to fine particles obscuring visibility, a considerable amount of larger sand particles become airborne and are mobilised, but closer to the surface. The vegetation found on the site acts as a natural mitigation measure. Dust mobilisation occurs only for wind velocities higher than threshold value and is not linearly dependent on the wind friction and velocity.

According to the IAEA, the frequency of dust storms and sandstorms can be identified through hourly weather observations when visibility is 10 kilometres or less, the wind speed exceeds a threshold value (i.e. 7.5 m/s), and the relative humidity is below a threshold value (i.e. less than 70 per cent).

The Thyspunt WS data (January 2008 to September 2013 and September 2017 to March 2019), shows that the highest number of hours of windblown dust occurred during the summer months, with November experiencing the highest occurrence. The lowest dust conditions occurred during March.

The highest dust loading during the monitoring period occurred from 01h00 to 21h00 on 27 August 2018. The time integrated dust loading for this period was calculated to be 22.3 mg-h/m³. The average wind speed for the 21-hour period was 9.6 m/s which occurred from the southwest with maximum gusts up to 22.8 m/s.

Based on the observed frequency of dust events (Figure 26), June, August, September and November are the months most likely to experience dust storms, whereas March is the month least likely to experience dust storms. It is likely that the summer season will have between 7 and 10 days of dust events in total.

Figure 26 illustrates the average daily dust hours per month, whereas the dust loading maximum refers to a continuous stretch of strong winds and low relative humidity periods (i.e. consecutive hours). In other words, the dust loading is the total amount of dust generated in one event that continued for the period 01h00 to 21h00 on 27 August 2018. The total number of dust hours only reflects the hours when the wind speed and relative humidity exceed their respective thresholds, whereas the dust load is calculated using this condition and weighted inversely with the visibility

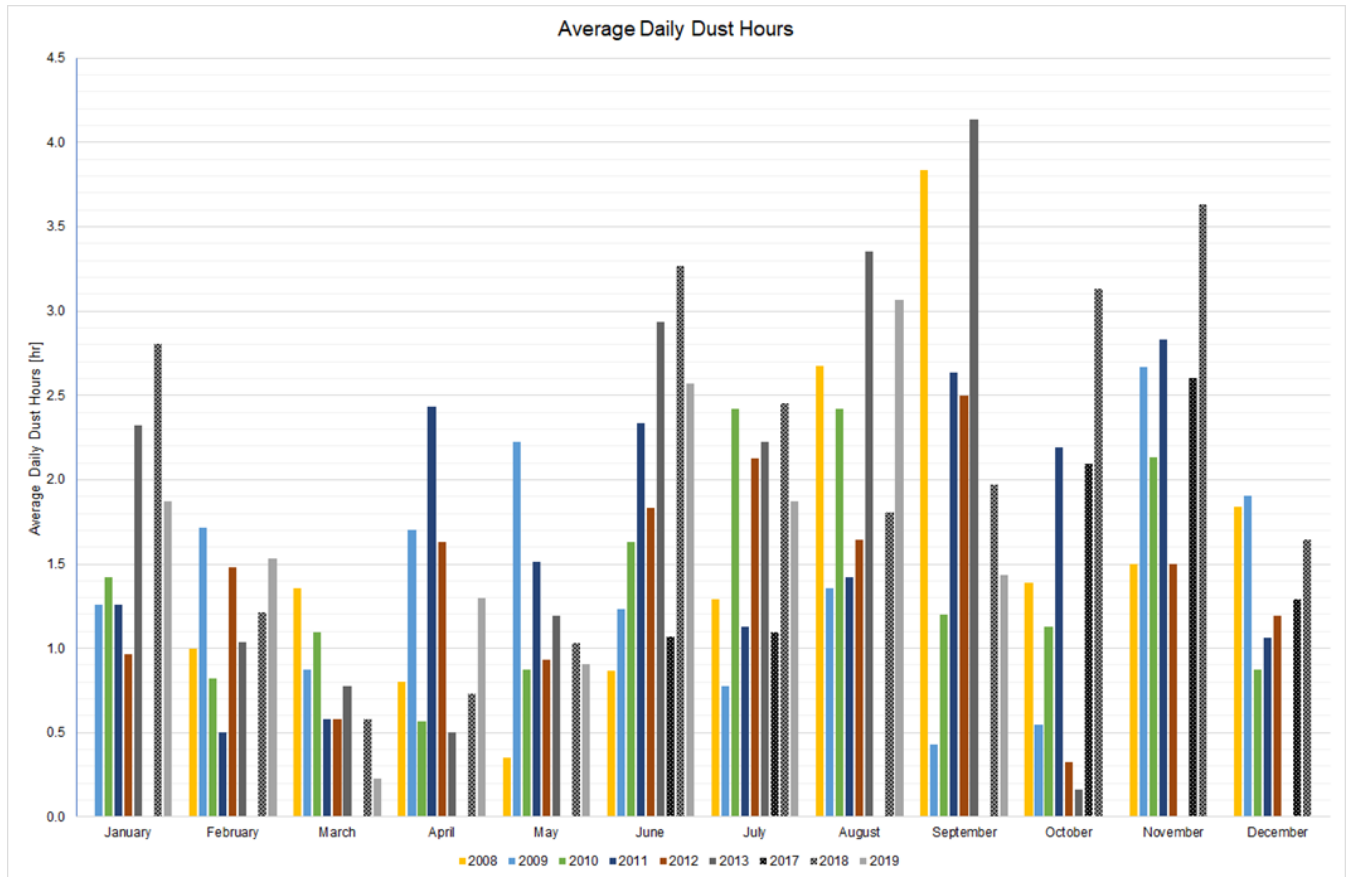


Figure 26: Average Durations (Hours) of Dust Conditions per Day Per Month

From Figure 26, the highest number of average daily hours per month was during September 2013, followed by September 2008. If we look at medians, November scores the highest, followed by September and August. The lowest is for March.

b) Freeze-Thaw

The possibility of freeze-thaw from frozen water in the pores of rocks or concrete building structures is not likely at the site since the lowest temperatures recorded was 4.9°C (Cape St. Francis WS) and 6.7°C (Thyspunt WS). Additionally, regarding the possibility of ice occurring in the sea surrounding the site, the lowest seawater temperature measured in all data sets is 7.9°C. On this basis ice is not anticipated to form in the sea at the site.

c) Atmospheric Corrosion

Marine atmospheric corrosion is primarily catalysed by moisture and oxygen but is accentuated by contaminants such as sulfur compounds and salt spray. The prediction of atmospheric corrosion rates therefore contains a term for 'time of wetness', which is a function of the ambient air temperature and relative humidity, and the quantity of pollutants in the air, specifically sulfur dioxide and sodium chloride. The ISO 9223 International Standard [12] specifies the key factors in

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the atmospheric corrosion of metals and alloys and provides the methods for determining these. As per the ISO 9223 International Standard the corrosion rates may also be estimated from a combination of the annual average temperature, relative humidity, and sulfur dioxide and chloride deposition rates.

A summary of the calculated corrosion rates for carbon steel, zinc, copper and aluminium is provided in Table 8 below.

Table 8: Calculated Corrosion Rate Values for Various Metals and Exposure Periods

Corrosivity	Metal	Corrosion Rate [µm/year]
Rate in 1 st year	Carbon steel	68.0 (50.6-81.6)
	Zinc	2.8 (2.2-3.4)
	Copper	1.8 (1.5-1.9)
	Aluminium	1.0 (0.7-1.2)
Average rate over 20 years	Carbon steel	8.8 - 11.1
	Zinc	1.3 - 1.6
	Copper	0.4 - 0.5
	Aluminium	0.3 - 0.4

According to ISO 9224:2012 [13], corrosion progresses rapidly during initial exposure before slowing down due to surface passivation:

- “Long-term outdoor exposure shows that the depth of pits grows relatively quickly in the first two years but undergoes little further growth in the subsequent years.”
- “The mass loss grows relatively quickly in the first two years. Due to the formation of the oxide layer, the surface is passivated and the uniform corrosion rates decrease to lower values.”

This clarifies why carbon steel exhibits an initial corrosion rate of 68 µm/year, while the long-term average drops to 8.8 – 11.1 µm/year over a 20-year period as presented in Table 8. The elevated early-life rate is a normal outcome of ISO-based atmospheric corrosion modelling, reflecting the well-understood rapid initial corrosion before surface passivation, rather than indicating any anomaly.

5.3.2.3.3 Severe and Rare Phenomena

Rare meteorological phenomena are defined as phenomena that occur infrequently. Thus, at any particular weather station, the instruments used for routine measurements would rarely register characteristics of these phenomena. Rare meteorological phenomena, which are highly complex, are usually scaled in terms of their intensity. These intensity values may be expressed in terms of either a qualitative characteristic such as damage or a quantitative physical parameter such as wind speed.

The paucity of detailed studies on severe storm and climate hazards at Thyspunt has made it difficult to analyse and synthesise information for the purposes of quantifying the frequency of occurrence. As a result, information from weather observations made by SAWS at Cape St. Francis was used. Although it is not possible to quantify an uncertainty in this approach, it is expected that similar weather patterns would be exhibited. This is expected because of the proximity of the site and the Cape St. Francis WS and because these locations are affected by the same synoptic scale systems.

i) Severe weather

The southern and southwestern coast of South Africa is subjected to large synoptic scale systems that drive the local weather conditions in any given area. These local weather conditions are normally characterised by low-level stratus clouds and not by towering convective storms that produce hail and thunder showers. Severe weather is more closely associated with severe wind conditions. Four main wind producing systems have been identified, namely coastal low buster, cut-off lows, shallow south-easterlies, and mid-latitude lows.

The site can potentially experience severe weather in the form of thunderstorms, hail, hurricane-force winds, and possibly tornadoes. Many of the severe storms occurring in the Eastern Cape are compound, producing various combinations of hail, wind, tornado, lightning, and flash flooding. Damaging winds associated with severe thunderstorms include tornadoes, downbursts (microbursts or microbursts)⁷, straight-line winds⁸, gust fronts, and derechos⁹. Historical records, covering a period of about 160 years of severe weather events in the region (radius of 100 km), lists 20 gale force or severe wind events and 3 tornadoes up to 2023. The same record also lists 6 severe rain and 32 flood events.

⁷ A downburst is created by an area of significantly rain-cooled air that, after hitting ground level, spreads out in all directions producing strong winds. Microbursts and macrobursts are downbursts at very small and larger scales, respectively. Most downbursts are less than 4 km in extent: these are called microbursts. Downbursts larger than 4 km in extent are sometimes called macrobursts.

⁸ Straight-line winds are common with the gust front of a thunderstorm or originate with a downburst from a thunderstorm. If these winds meet or exceed 93 km/h then the storm is classified as severe.

⁹ The term 'derecho' is used to describe larger scale straight-line winds advancing very quickly ahead of a well-organised, long-lasting squall line or a large-scale multiple cell storm.

ii) Tropical cyclones

The Thyspunt region is not on a hurricane (tropical cyclone) track or adjacent to a warm ocean. Therefore, it is not expected that the site will experience a cyclone, or at least there is a very low probability. Tropical cyclones are generated in areas where the ocean surface temperature is greater than 27°C and between latitudes 5°S to 30°S. The site is located at 33°S and is therefore not subjected to tropical cyclones.

iii) Tornadoes

A tornado is a violent rotating column of air extending from a thunderstorm.

Tornadoes in South Africa are typically associated with very hot air masses and severe thunderstorms. There have been six occurrences of tornadoes within a distance less than 100 km, whilst 11 occurred further than 200 km from the site. Six occurrences between 100 km and 200 km from the site, but no evidence of tornadoes could be found for the site and its surrounding area. On the basis of the available tornado occurrences an estimate of tornado frequency for the site was made by analysing the available tornado recordings. These included tornadoes witnessed up to a maximum distance of about 320 km from the site (KuGompo City¹⁰). Figure 27 depicts the tornado occurrences over the period 1905 to 2020.

The tornado frequency for EF0 to EF5 tornadoes and path width and length are given in Table 9 below.

¹⁰ Formerly known as East London

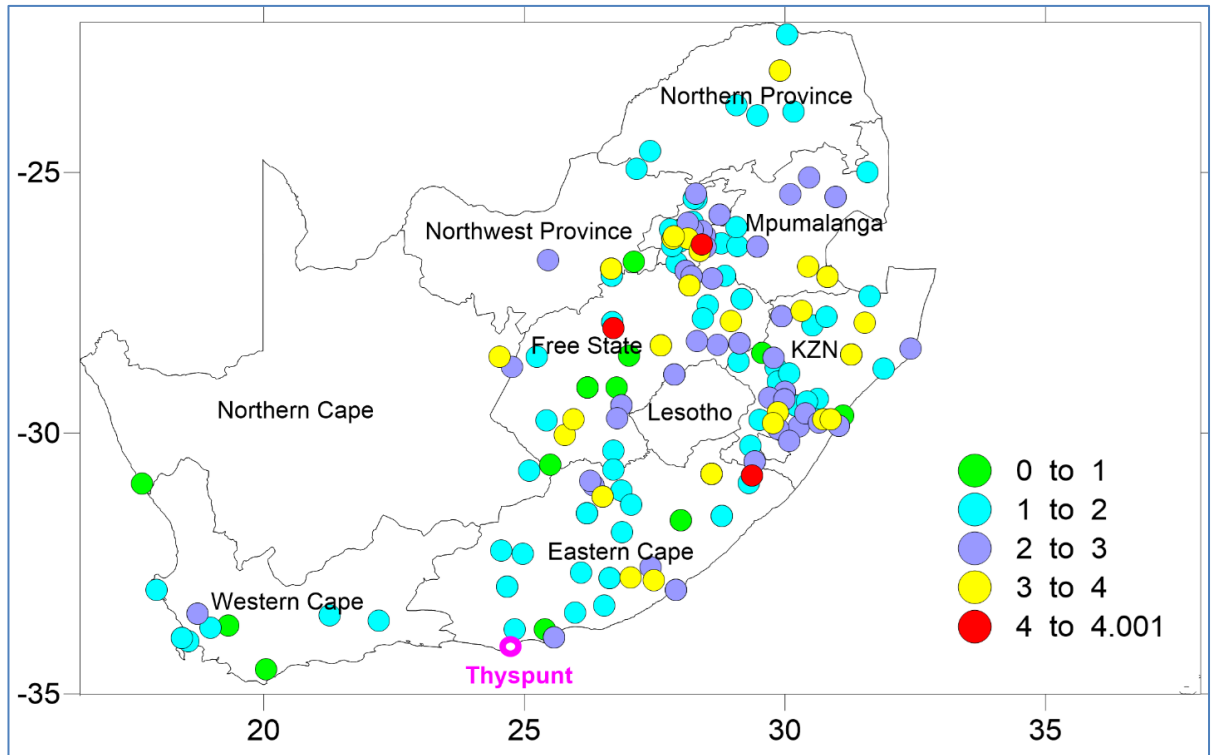


Figure 27: Occurrence of tornadoes for period from 1905 to 2020 [10]

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Table 9: Frequencies of Severity of Tornadoes and Path Width and Length

Tornadoes		Value			
Tornado Probability (EF – Enhanced Fujita Scale)	Based on 116-year database 1905 - 2020	All ⁽²⁾	6.8 x 10 ⁻⁶ per year per km ²		
		EF0	1.3 x 10 ⁻⁶ per year per km ²		
		EF1	2.1 x 10 ⁻⁶ per year per km ²		
		EF2	6.6 x 10 ⁻⁷ per year per km ²		
		EF3	<1.0 x 10 ⁻⁸ per year per km ²		
		EF4	<1.0 x 10 ⁻⁸ per year per km ²		
		EF5	<1.0 x 10 ⁻⁹ per year per km ²		
	Based on 25-year database 1996 – 2020 ⁽¹⁾	All ⁽²⁾	3.2 x 10 ⁻⁶ per year per km ²		
		EF0	4.0 x 10 ⁻⁵ per year per km ²		
		EF1	2.3 x 10 ⁻⁶ per year per km ²		
		EF2 ⁽³⁾	6.6 x 10 ⁻⁷ per year per km ²		
		EF3 ⁽³⁾	<1.0 x 10 ⁻⁸ per year per km ²		
		EF4 ⁽³⁾	<1.0 x 10 ⁻⁸ per year per km ²		
		EF5 ⁽³⁾	<1.0 x 10 ⁻⁹ per year per km ²		
10 ⁻⁷ per year wind speed:					
- maximum wind speed			75.0 m/s		
- maximum translational			15.0 m/s		
- maximum rotational			60.0 m/s		
Path Width [m]		Lower Quartile	Upper Quartile	Median	Average
EF0 tornado (40% to 64% probability)		22.9	68.6	45.7	54.9
EF1 tornado (36% to 48% probability)		68.6	182.9	91.4	163.8
EF2 tornado (0% to 4% probability)		137.2	402.3	228.6	344.1
EF3 tornado (0% to 4% probability)		339.5	1005.8	548.6	736.3
Path Length [km]					
EF0 tornado (40% to 64%)		0.29	2.7	0.8	2.27
EF1 tornado (36% to 48% probability)		1.77	9.33	4.4	7.1
EF2 tornado (0% to 4% probability)		4.53	19.25	10	14.3
EF3 tornado (0% to 4% probability)		12.38	36.34	23	29.1
Pressure drop for 10 ⁻⁷ per year wind speed		40 hPa			
Maximum rate of pressure drop for 10 ⁻⁷ per year wind speed		13 hPa/s			
Notes:					
(1) Tornado activity has increased since 1987 within an 80 km radius from the site. Whilst climate change may have contributed to increases in tornado frequencies, it may also simply be that the reporting of tornadoes has increased due to population spread as well as the associated damage to property.					
(2) The “All” tornado entry combines all frequencies from EF0 to EF4 in the table.					
(3) No tornadoes of magnitude higher than EF2 were observed during the 34 years of reporting and therefore assumed the same values as for the long-term analysis.					

iv) Lightning

Lightning data have been collected in the vicinity of the site, and the SAWS provided valid data for the period July 2007 to December 2008. The number of strikes recorded during this period was 211. The average number of strokes per flash was 5 with a maximum of 16. The area included in the observation was approximately 15.8 km by 15.9 km. The site therefore experiences less than 1 lightning flash per year per km². The highest peak cloud to ground current recorded during the period was 166 kA (kiloampere) with an average of 25 kA.

Lightning activities were also measured at the Thyspunt WS from June 2017 to October 2019. The average annual number of lightning strokes measured at the Thyspunt WS was 179 887 strokes. The number of flashes has been estimated assuming a minimum of 2.5 strokes per flash as the Upper Estimate (14 710 flashes), 25 strokes per flash as the Lower Estimate (1 765 flashes) and 13.75 strokes per flash (mid value) as the Middle Estimate (7 881 flashes)¹¹. The flash density for the monitoring period is therefore estimated to be between 0.4 and 3.3 flashes per km², with a mid-value of 1.8 flashes per km², which is slightly higher than the SAWS observations.

5.3.2.3.4 Other Extreme Meteorological Events

Extreme events such as tropical cyclones, ice and ice cover, blizzards, and drought are screened out because of the meteorological data presented above and the fact that the sea serves as a heat sink. Ice is not anticipated to form in the sea at the site.

5.3.2.4 Hydrological Events

The site region was assessed to determine the potential for flooding due to one or more natural causes that may affect the safety of the nuclear installation such as high tide, storm surge, seiche, and wind waves. All pertinent data, including historical data, both meteorological and hydrological, was collected and critically examined.

A suitable meteorological and hydrological model was developed with account taken of the limits on the accuracy and quantity of the data, the length of the historical period over which the data were accumulated, and all known past changes in relevant characteristics of the region.

The possible combinations of the effects of several causes were also examined. For example, the potential for flooding by a combination of high tide, wind effects on bodies of water, and wave actions were assessed and taken into account in the hazard model.

¹¹ A flash consists of one or perhaps as many as 25 return strokes (Rakov, 2007; Gill, 2009). International studies done on stroke multiplicity in cloud to ground (CG) lightning flashes found that the average negative stroke multiplicity is 4.6, 6.4, 3.4 and 4.5 for Florida, New Mexico, Sweden and Sri-Lanka respectively (Rakov & Huffines, 2003). Similar CG stroke multiplicity of 4.2 was found in South Africa by (Schonland, 1956) and 3.5 by (Malan, 1956) [10].

The hazards for the site due to flooding were derived from the model. The parameters used to characterise the hazards due to flooding included the height of the water, the height and period of the waves, the warning time for the flood, and the duration of the flood and flow conditions. Values for extreme high sea water levels and the annual probabilities of exceedance were identified which include the potential effects of climate change. Extreme low sea water levels were also analysed and quantified.

The potential for instability of the coastal area due to erosion or sedimentation was investigated.

The region was also investigated to determine the potential for tsunamis or seiches that could affect the safety of nuclear installation(s) on the site.

5.3.2.4.1 Flooding From The Sea

Flooding from the sea can occur due to:

Storm wave run-up combined with sea level rise, high tides, positive storm surge and wave set-up; and

- Tsunami run-up combined with sea level rise, high tides and positive storm surge.
- The results of the assessment of flooding from the sea show the following:
- The flooding hazard increases over time due to climate change which causes sea level rise and associated coastline recession, a rotated wave climate, and increases in storm wave height and storm surge.
- The best estimate maximum vertical run-up level in 2034 due to $1E-08\ y^{-1}$ storm is 13.3 m msl, increasing to 17.6 m msl in 2134.

Flooding from the sea is therefore identified as a significant hazard that will need to be taken into account in the design of the nuclear installation, i.e. the terrace will need to be positioned landward of the maximum flood lines, or protective structures such as revetments and wave walls will need to be placed in front of the terrace.

5.3.2.4.2 External flooding from other sources

Other flooding scenarios that have to be considered for a nuclear installation on the site are those that could induce a transient in water level at the site resulting in static effects (water weight) and dynamic loads on the nuclear installation. Operational experience from existing nuclear installations provides evidence for external flood-induced events in which the functionality of safety related equipment has been impaired. Most of these are related to insufficient measures for site protection, to poor maintenance of the drainage systems and to effects of ice on river sites. The provisions for such events are mostly design related.

5.3.2.4.3 Floods and waves caused by failure of water retaining structures

The hazards associated with the failure of water control structures (e.g. dams) were investigated. The risks from changes in the natural channel for rivers were also investigated. There are no significant dams or defined water courses situated within the quaternary catchment K80F which drain towards the Thyspunt site. There is a catchment divide

(Northern and Southern zone), and the Northern zone drains into the dunes and does not reach the enveloping footprint. The existing water bodies create natural storage areas which would not result in significant backup of headwater. There are no man-made embankments crossing the watercourse which could significantly increase the head of water and potentially breach during a storm event causing surges and damage to downstream infrastructure.

Due to the extensive inter-dune temporary ponding areas, low peak flows, and velocities, there is minimal erosion and damage potential which may impact on the safety of the nuclear installation. Any potential flooding due to sedimentation within a watercourse is negligible and will not affect the safety of the nuclear installation.

Hence, from a site safety perspective, the nuclear installation will not be located along any major watercourses which could potentially affect the site during an extreme external flood event. Due to the small contributing catchments, extreme flood levels are impacted by downstream still high-water levels rather than water levels generated by surface water run-off from the minor catchments.

5.3.2.5 External fires

External fires were investigated with appropriate considerations for the safety of the facility (e.g. access to the site, availability of power, ventilation, etc.) with special emphasis on the unavailability of power or any threat to operator action owing to the release of smoke and toxic gases. External fires are fires occurring outside the site boundary, e.g. forest/veld fires and oil spills at sea. Potential hazards are loss of off-site power (LOOP), forced isolation of a nuclear installation's ventilation, and the impact on control room habitability. Protection of the nuclear installation against fires is to be achieved by minimising the probability of a fire and providing barriers against external fires.

On-site fires are prevented with the establishment and management of fire breaks and alien vegetation eradication in accordance with an approved environmental management plan. Land use around the nuclear installation will be managed so that an external fire does not propagate toward the plant.

5.3.3 External Human-Induced Events

Human-induced events are considered accidental events (e.g. oil spills and hazardous material explosions). Potential stationary and mobile sources of human-induced hazards that were investigated are:

- The potential for aircraft crashes on the site, with account taken to the extent practicable of characteristics of future air traffic and aircraft.
- Activities in the region that involve the handling, processing, transport and storage of chemicals having a potential for explosions or for the production of gas clouds capable of deflagration or detonation.
- Facilities that may give rise to missiles of any type that could affect the safety of the nuclear installation(s).
- Potential sources (stationary and mobile) of hazards, including external fire.

The ultimate purpose of the investigation is to identify transportation, civil, industrial, and military facilities outside of the owner-controlled boundary that may affect the feasibility of implementing emergency plans or potentially hazardous activities that may pose a threat to the nuclear installation(s) on the site and to identify sources of external hazards inside and/or outside the owner-controlled boundary in order to ensure the safety of the nuclear installation(s) against external human-induced events.

5.3.3.1 Aircraft crashes

The NNR requires a design-specific assessment of the effects on the nuclear installation of the impact of a large commercial or military aircraft. A nuclear installation has to be designed to withstand the impact of a design-basis aircraft crash without the loss of any safety function. The potential for aircraft crashes on the site was assessed with account taken to the extent practicable, of characteristics of future air traffic and aircraft (both military and commercial). Double containment and layout of advanced nuclear installation designs to reduce aboveground vertical profiles offer advantages in the resistance to malevolent human-induced external events which cannot be probabilistically defined. Key relevant information on airports and airways can be summarised as follows:

- St. Francis airfield (10.8 km east) is the only airfield within 16 km of the site. The airfield has one grass runway 10/28, measuring approximately 1 000 x 12 m. The 10/28 refer to the magnetic orientation of each end of the runway where “10” means the runway is oriented at 100° magnetic and “28” means the opposite end is oriented at 280° magnetic. The runway is designed to accommodate Learjets, and does not accommodate routine, commercial, or public traffic. The airfield operates daily and has no control tower but contains landing lights and 20 hangers for storage and maintenance of small private planes. No aviation fuel is stored on site. The largest aircraft type the airfield can accommodate weights less than 5.7 t. No aircraft accidents have occurred

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at the airfield according to records kept by the Civil Aviation Authority (CAA) for the period 1998 to 2024. At present there are no plans for future extension of the airfield.

- The only airport outside the 16 km radius of any significance is DSIA (85 km east-northeast), which controls all domestic flights for the south-eastern region of South Africa. Two aircraft accidents have occurred at the airport in the period 2009 to 2023 according to records kept by the Civil Aviation Authority.

Aircraft movement operations at DSIA are significantly less than a screening distance value criterion of $1\,000 \times d^2$. The parameter d is the distance in kilometres from a large airport to a site. The risk analysis conducted indicates that the airport will experience future growth in air traffic, but this growth will be in the northerly direction of Johannesburg and Europe. The study indicates that an increase in flights to and from Cape Town would not influence frequencies calculated to determine risk as:

- DSIA is sufficiently far from the site to exclude airport related accidents; and
- In-flight crash frequencies are based on historical crash data over the South African mainland over the last 10 years. There is no indication that an increase in air traffic would result in a high crash zone having a higher crash frequency than for other parts of the country.

Airspace falls under the control of DSIA. The only major airport route in the vicinity of the site is for scheduled flights between DSIA and Cape Town. The analysis indicates that OKSET¹² needs to be further investigated for acceptability of distance from a flight path, as IAEA recommendations indicate a screening distance value of 4 km from the site for airways.

Crash frequencies were determined for airport and in-flight related operations. In-flight crashes per km² for the South African mainland were determined from historical aircraft accidents for the various sub-categories. Crash rates, based on the available data at the time of the risk analysis are summarised in Table 10.

Table 10: Total crash rate for the different aircraft categories for the Thyspunt site

Aviation Category			Annual Crash Rate (/y/km ²)			
			Mean	5%tile	50%tile	95%tile
Civil Aviation	Commercial Aviation		2.08E-07	4.91E-08	1.90E-07	4.07E-07
	General Aviation	Fixed-Wing	5.42E-06	3.66E-06	5.40E-06	7.25E-06
		Helicopters	1.75E-06	1.27E-06	1.73E-06	2.29E-06
Military Aviation		Large	1.09E-07	1.94E-08	9.18E-08	2.59E-07
		Small	1.64E-07	4.47E-08	1.46E-07	3.44E-07
		Helicopters	1.67E-04	1.74E-05	1.68E-04	3.18E-04

¹²OKSET refers to a marker beacon used by pilots when approaching the airport. It is a unique identifier related to the approach/holding pattern at PEIA, which forms part of the flight path to Cape Town and not an abbreviation.

It is important to note that aircraft crash is included as a standard event with specific load functions in the design basis of the reference nuclear installations (designs with known parameters used in analyses to assess compliance with regulatory requirements), irrespective of aircraft crash frequency considerations. The Westinghouse AP1000, Framatome EPR and China's HPR1000 reactors, have designs that are certified as being able to withstand the impact of a large commercial aircraft and include the following safety features:

- Performing the cooling function with reduced use of operator action;
- Intact containment (i) will not be perforated by the impact of a large commercial aircraft, and (ii) will maintain ultimate pressure capability, given the core damage event until effective mitigation strategies can be implemented. Effective mitigation strategies are those that provide, for an indefinite period, sufficient cooling to the damaged core or containment to limit temperature and pressure challenges below the ultimate pressure capability of the containment.
- Used fuel pool (UFP) integrity: The impact of a large commercial aircraft on the UFP wall or support structures would not result in leakage through the UFP liner below the required minimum water level of the pool.

5.3.3.2 Explosions and asphyxiant/corrosive/toxic gas releases

Activities in the region that involve the handling, processing, transport, and storage of chemicals and explosives having a potential for safety concerns, such as explosions and asphyxiant/toxic gas releases, were investigated. Consequences from external events involving hazardous substances would either damage nuclear installation structures, systems, and components or incapacitate operating personnel as a result of toxic gases, thermal radiation, and/or explosion overpressures. The limiting hazard parameter values where the consequences would be considered 'safe' and not pose a threat to life because of events, e.g. failures of structures, are given in Table 11¹³.

Table 11: Limiting values for external events associated with hazardous material

Hazard	Hazard Parameter	Screening Value
Pool fire	Thermal radiation (1)	2,9 kW/m ²
Jet fire	Thermal radiation	2,9 kW/m ²
Flash fire	Flammable limits	½ LFL (3)

¹³ (1) The screening value of 2.9 kW/m² has been adjusted for the maximum daily solar radiation value of 1.1 kW/m²

(2) BLEVE: Boiling Liquid Expanding Vapour Explosion

(3) LFL: Lower Flammable Limit

(4) IDLH: Immediately Dangerous to Life or Health IDLH) and refers to the maximum concentration to which a healthy person may be exposed to for 30 minutes and escape without suffering irreversible health effects or symptoms that impair escape (ranging from runny eyes that temporarily impair eyesight to a coma).

Hazard	Hazard Parameter	Screening Value
Boiling liquid expanding vapour explosion (BLEVE) (2)	Thermal radiation	2,9 kW/m ²
Explosion	Overpressure	2 kPa
Toxic cloud	Concentration	IDLH (4)

5.3.4 Assessment of Potential Impact of the Nuclear Facility in the Site Region

5.3.4.1 Demography (population growth and distribution)

The current and future population characteristics in the site region and vicinity were investigated in order to assist in assessing the potential effects of the proposed nuclear installation on the public in the region. The Ideal Dataset for the Demographic Universe by Environmental Systems Research Institute (ESRI) South Africa and IRL Consulting served as the baseline for alignment with the 2011 census data for the population distribution within the site region. Spatial development plans and frameworks have also been utilised to assist in the estimation of the projected population in the region (i.e. estimated growth rates and envisaged development nodes). Projections were made on the basis of population growth rates and plans for possible development in the region. The projected figures for the two categories of permanent population and temporary population were extrapolated separately according to the data available. Critical groups of the population with particular dietary habits and specific locations for particular types of activity in the region have also been considered.

Although the Ideal Data Set (2022 municipal data), based on the 2011 census data was used in the preparation of the population demographics in the TSSR, it compares well with the macro-level population statistics of the latest census (2022) data.

5.3.4.1.1 Current Population Distribution

i) Permanent population

a) Population

The analysis showed that a population of approximately 119 615 persons resided within 50 km of the site in 2022 (refer to Figure 28). The largest population concentrations are in west-northwest, north-northeast (highest), northeast and east from the site, coinciding with urban settlements within the Kouga and Koukamma municipalities. The main settlements are presented in Table 12.

b) Population Centres/Density

In accordance with international recommendations, population centres of about 25 000 should not be closer than approximately 6,5 km from the reactor site, as a density of approximately 200 persons per square kilometre within this distance would yield a population of approximately 25 000 persons (approximately 16 km for 100 000 persons, 35 km for 500 000 persons, and 50 km for 1 000 000 persons) (Figure 28). Based on the Ideal Dataset for the Demographic Universe and IRL Consulting including the 2011 census data, the site conforms to this guideline.

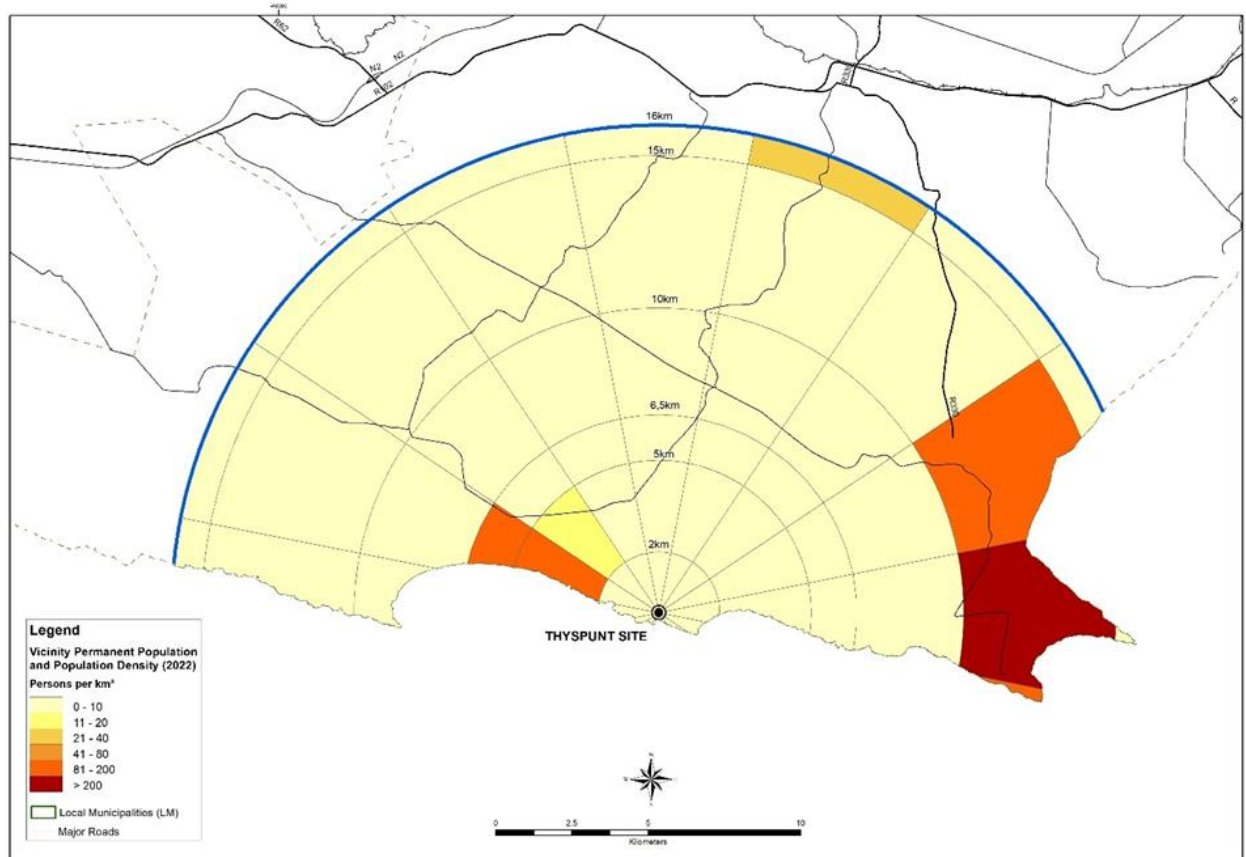


Figure 28: Vicinity population density (2022)

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Table 12: Main settlements within the 50 km zone (2022)

Settlement	Distance (km)	Direction	Number of Persons (2011)
Oyster Bay, Umzamowethu	3.5 to 5.5	W/NW	818
St. Francis Bay/ Cape St. Francis	10 to 15	E	6 513
Humansdorp/KwaNomzamo	17 to 26	N/NNE	28 990
Jeffreys Bay	24 to 29	NE	32 762
Hankey	38 to 46	NNE	13 882
Kareedouw	42.5 to 47.5	WNW	5 649
Patensie	47.5 to 50	N/NNE	6 071

5.3.4.1.2 Temporary population

Temporary or transient population groups that were analysed for the Thyspunt region are those members of the public who reside for a short period (days or weeks) in a location (such as a camping ground) that can be identified in advance. This does not include members of the public who may be travelling through the area. To this end, data on residential resorts, main recreational venues, main annual sporting and concert events, beaches, large shopping centres and main conference facilities were sourced by means of a desktop study and site surveys conducted in 2024. In addition, the number of beachgoers per beach stretch of coastline were recorded on 31 March 2018, i.e. during Easter weekend and again on 23 September 2024, i.e. during a national holiday via aerial surveys.

5.3.4.1.3 Tourist population

Datavision Marketing and Tourism Research Consultants undertook a study to, inter alia, estimate the total tourist population during 2024 on any single day during the peak season within the site region. The maximum daily averaged monthly peak season number on any given (peak month) day within 80 km from the site was estimated at 6 287 persons per day.

The maximum summative capacity of visitors residing within formal accommodation establishments was estimated between 7 606 and 7 856 visitors per day (averaged at 7 731 visitors). The high season for the region was established to be from November to April, with January and December being the two busiest peak months. The month of December was the busiest peak month.

The tourist population was estimated for 2024, in ten-year intervals from 2026 to 2126 and for 2130. As the tourism figures were not available per Enumerated Area, Small Areas or Sub-places, the total tourist population was distributed within each of the sectors around the nuclear installation(s) as a ratio of the permanent population in that sector. A tourist population ratio per permanent population of 0.0365 was applied to each sector for a specific year.

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The total number of tourists within the 50 km radius around the Thyspunt site on any one day in the peak month (i.e. December) was estimated (upper estimate) to be approximately:

- 4 524 tourists in 2024;
- 5 521 tourists in 2036;
- 8 734 tourists in 2096;
- 8 743 tourists in 2130.

5.3.4.1.4 Projected population distribution

i) Permanent population

a) Projected population

In accordance with the relevant regulations on the development of a nuclear installation, population projections need to be undertaken for the life expectancy of the installation. For this reason, population growth within the 50 km radius around the site was projected up to the year 2096.

The population projections within the 50 km radius around the nuclear installation(s) indicate, approximately:

- 123 970 persons in 2024 (refer to Figure 30);
- 156 010 persons in 2036;
- 245 320 persons in 2096;
- 245 034 persons by 2130 (refer to Figure 31).

On the basis of the abovementioned data, the total cumulative population distribution was estimated in ten-year intervals from 2024 to 2130 within 50 km from the nuclear installation(s). The total cumulative population estimates within the 50 km radius around the nuclear installation(s) indicate, inter alia, approximately:

- 128 490 persons in 2024 (refer to Figure 32);
- 161 523 persons in 2036;
- 254 042 persons in 2096;
- 253 772 persons by 2130 (Figure 33).

The total estimated cumulative population numbers in 2024, 2036, 2096 and 2130 with respect to various annuli within 50 km from the site centroid are as follows:

- 6.5 km Radius

Oyster Bay with a total cumulative population of approximately 872 persons in 2024, approximately 990 persons in 2036, approximately 1 221 persons in

2096, and approximately 1 187 persons in 2130, is the only settlement located within 6.5 km of the site.

The total cumulative population within the 6.5 km radius is estimated to be approximately 1 162 persons in 2024, 1 496 persons in 2036, 1 803 persons in 2096 and 1 730 persons by 2130.

- **16 km Radius**

The town of St. Francis Bay is the largest settlement within the 16 km radius and is estimated to have a total cumulative population of 6 632 persons in 2024, 8 571 persons in 2036, 12 875 persons in 2096 and 12 519 persons by 2130.

The total cumulative population within the 16 km radius is estimated to be 15 463 persons in 2024, 21 803 persons in 2036, 33 926 persons in 2096 and 33 628 persons by 2130.

- **35 km Radius**

The towns of Humansdorp/KwaNomzamo and Jeffreys Bay are the largest settlements within the 35 km radius. The population of Humansdorp/KwaNomzamo is estimated to be 38 594 persons in 2024, 50 149 persons in 2036, 94 899 persons in 2096 and 97 791 persons in 2130.

The cumulative population of Jeffreys Bay is estimated to be 35 344 persons in 2024, 44 782 persons in 2036, 69 239 persons in 2096, and 67 972 persons by 2130.

The total cumulative population within the 35 km radius is estimated to be 88 633 persons in 2024, 116 117 persons in 2036, 191 536 persons in 2096 and 192 058 persons by 2130.

- **50 km Radius**

The towns of Humansdorp/KwaNomzamo and Jeffreys Bay are the largest settlements within the 50 km radius. Other large settlements within the 50 km radius are Hankey, St. Francis Bay, Patensie and Kareedouw.

The total cumulative population of Hankey is estimated to be 14 937 persons in 2024, 17 875 persons in 2036, 27 824 persons in 2096 and 27 779 persons by 2130. The total cumulative population of Patensie is estimated to be 6 743 persons in 2024, 7 525 persons in 2036, 9 933 persons in 2096 and 9 659 persons by 2130.

The total cumulative population of Kareedouw is estimated to be 5 973 persons in 2024, 6 743 persons in 2036, 8 667 persons in 2096 and 8 587 persons by 2130.

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The total cumulative population within the 50 km radius is estimated to be 128 490 persons in 2024, 161 523 persons in 2036, 254 042 persons in 2096 and 253 772 persons by 2130.

It is not likely that a population centre of 25 000 or more persons would develop within 6,5 km of the site over the life of the nuclear installation. In view of the possibility that a nuclear installation may be constructed at the site, further expansion of Oyster Bay/Umzamawethu should nevertheless be restricted.

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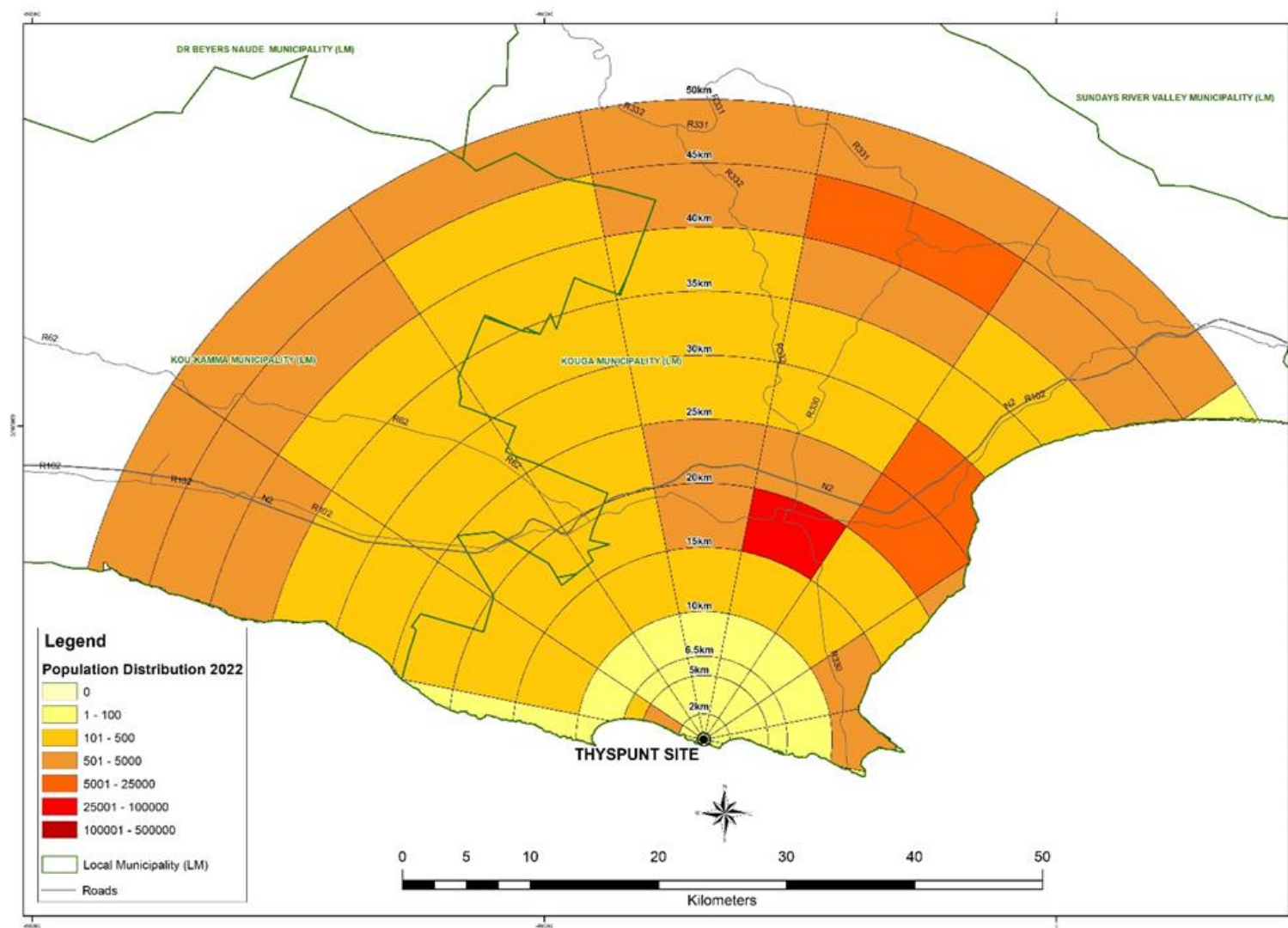


Figure 29: Population distribution within 5 km distance annuli around the Thyspunt site (22.5° radial grid) up to 50 km (2022)

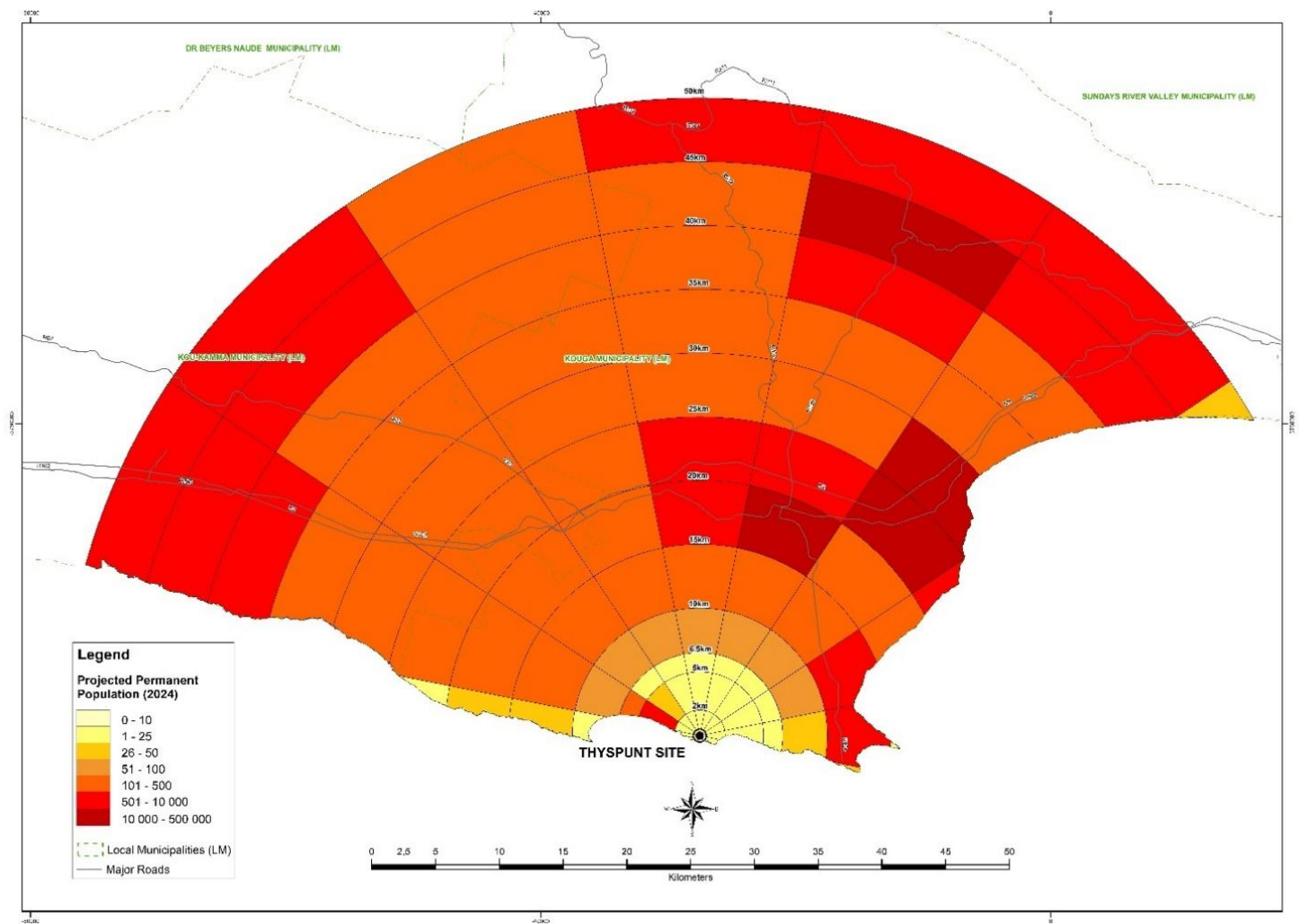


Figure 30: Projected permanent population within 5 km distance annuli around the Thyspunt site (22.5 degree radial grid) up to 50 km (2024)

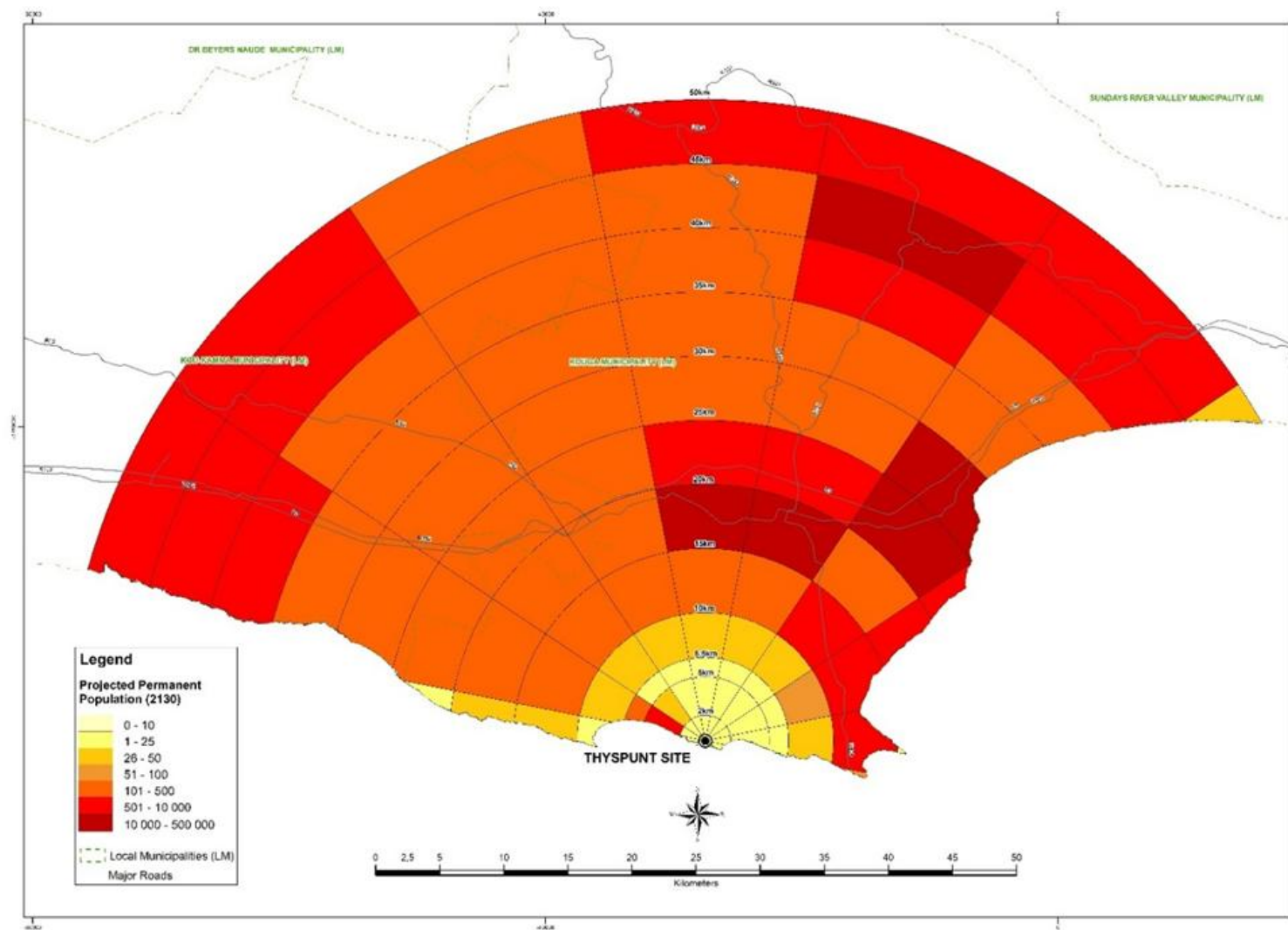


Figure 31: Projected permanent population within 5 km distance annuli around the Thyspunt site (22.5 degree radial grid) up to 50 km (2130)

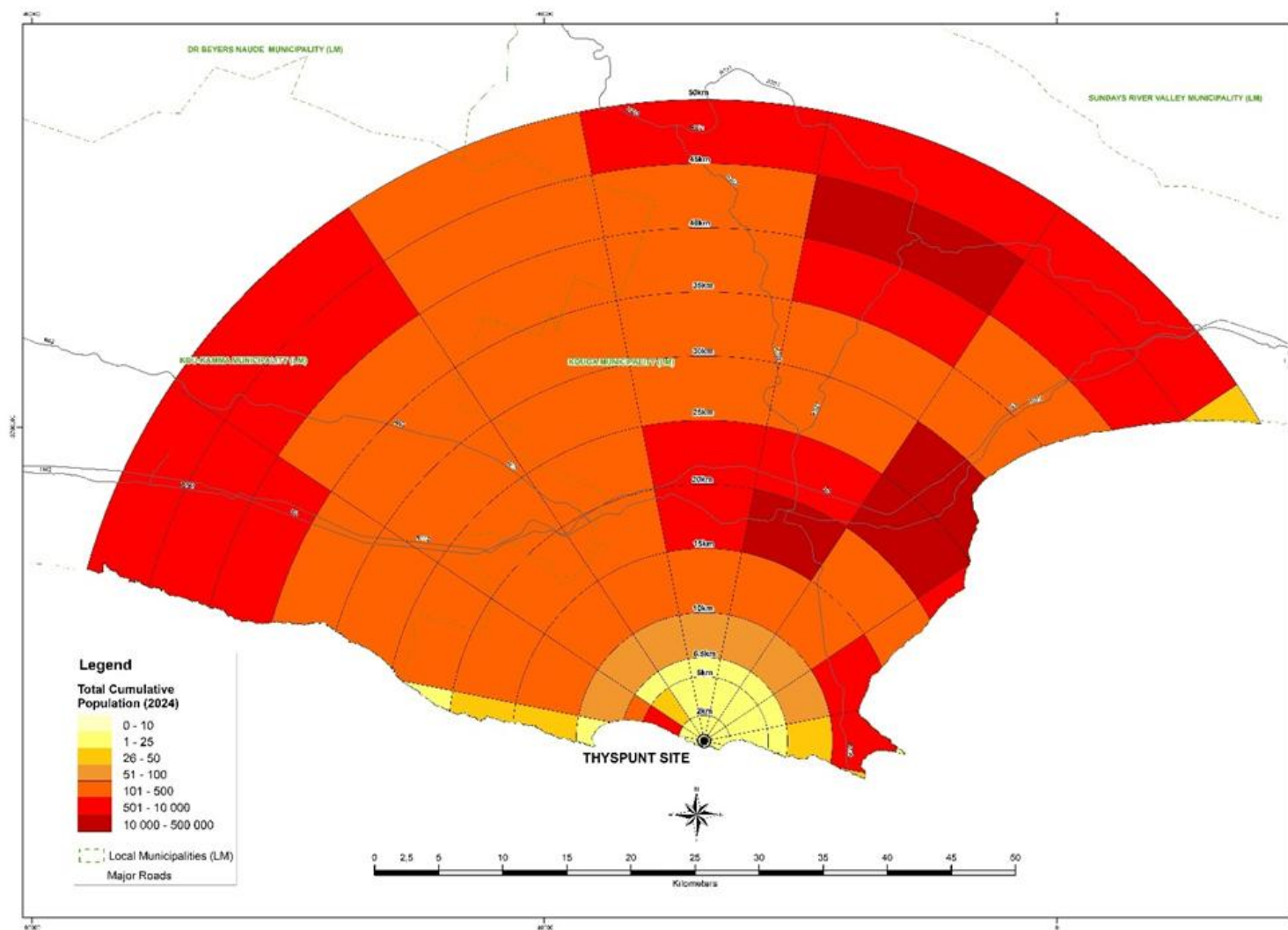


Figure 32: Total cumulative population within 5 km distance annuli around the Thyspunt site (22.5 degree radial grid) up to 50 km (2024)

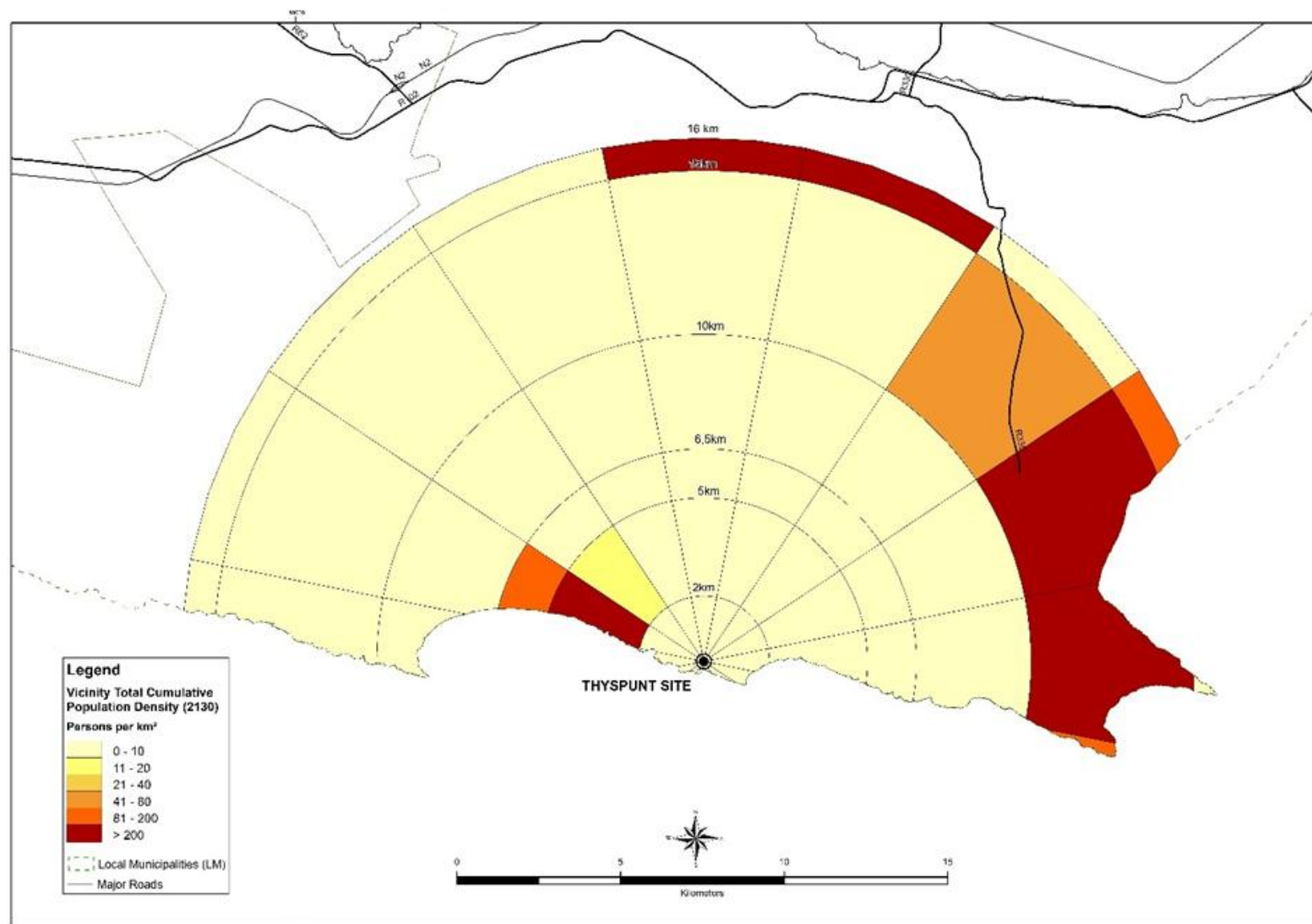


Figure 33: Total Cumulative Vicinity Population Density (2130)

5.3.4.2 Land And Water Use

The use of land and water was characterised in order to assess the potential effects of the potential nuclear installation in the region and in particular for purposes of preparing emergency plans. The investigation covered land and water bodies used by the population or that could serve as a habitat for organisms in the food chain.

The site region is characterised by predominantly natural areas (69.9 per cent). Agriculture makes up 24.0 per cent of the regional land cover. Very low levels of urban land cover are present (2.1 per cent), with relatively low industrial development.

Agriculture occurs throughout the site region, largely along rivers and in coastal plains. Cultivation of fruit and vegetable is concentrated around Hankey and Patensie, with large volumes of citrus being cultivated and exported from the region.

Significant dairy farming occurs in the coastal plains surrounding the site.

There are several coastal resort towns in the site vicinity. The urban settlement of Oyster Bay (including the associated informal settlement of Umzamowethu) is located less than 5 km to the west of the site, and Cape St. Francis and St. Francis Bay are situated 10.8 km to the east of the site, Paradise Beach (18 km east-northeast), Aston Bay (22 km east-northeast), Pellsrus (23 km east-northeast) and Gamtoos Mouth (41 km northeast). These coastal towns are important and well-established tourist destinations (refer Figure 34).

Other urban settlements within the 20 km radius of the site include Humansdorp (17.3 km north-northeast), the centre of the wider district's light industry and agricultural activities. Jeffreys Bay (25 km northeast) is a coastal resort town known for its beaches and surfing waves, including the world renown Super Tubes. It also caters to a wide array of other leisure activities, including scuba diving, skydiving and quad biking. Numerous smaller towns are spread throughout the rural area, including Clarkson (32 km west-northwest), Hankey (38 km north-northeast), Kareedouw (45 km northwest), Loerie (46 km north-northeast) and Patensie (49 km north-northeast).

The nearest city to the site is Gqeberha located approximately 80 km northeast (i.e. outside of the site region).

Limited expansion of towns within 16 km of the site is envisaged at local government level. The largest expected growth areas are planned at a strategic municipal level for Humansdorp and Jeffreys Bay urban settlements.

About 1.4 per cent of the region accommodates surface water resources. This water is used for irrigation and potable water supply within the site region. A large part thereof is transferred to the NMBM via the Algoa Water Supply System (AWSS). Groundwater is an important water resource for the coastal towns and in the southern part of the region. Towns that rely on groundwater resources for supplementary potable water (i.e. in addition to the water received via the AWSS), include Humansdorp, St. Francis Bay, Cape St. Francis, Oyster Bay, and Jeffreys Bay. The main aquifer utilised comprises of fractured sandstone of the Table Mountain Group Aquifer.

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Overall, the AWSS is in deficit as a result of over-allocation, and the slow implementation of interventions to diversify water supply and reduce water requirements.

The Kouga Local Municipality has effectively reached the limit of its allocations from the AWSS. Further growth in the municipality's water requirements should therefore be met by the development of new water resources by the Kouga Local Municipality (e.g. groundwater resources).

The coastal towns in the site vicinity experience seasonal fluctuations in water use as a result of a large number of second homes that are occupied over holiday periods, as well as large numbers of tourists that visit the site region during the Christmas and Easter holiday periods.

Water used for irrigation in agricultural land is obtained from rivers in the region and three large dams, namely the Kouga, Churchill, and Mpofu dams. Several smaller dams and groundwater extraction facilities are also used for irrigation.

The overall land use distribution in the site region is expected to remain relatively stable over the nuclear installation lifetime, particularly with respect to the urban settlements within the site vicinity.

Large parts of the site vicinity are indicated for conservation purposes. Given the importance of agriculture and ongoing conservation efforts, it can be expected that land use within the site vicinity will not experience significant changes in the foreseeable future. This takes into account the restrictions on urban development in the area. The Kouga Local Municipality Spatial Development Framework indicates that the future development needs in the region are to be directed toward protecting the agricultural and natural resources through the implementation of urban edges. Where major development proposals occur (e.g. the new industrial focussed development corridor along the R102 between Humansdorp and Jeffreys Bay), these occur outside of the 16 km zone.

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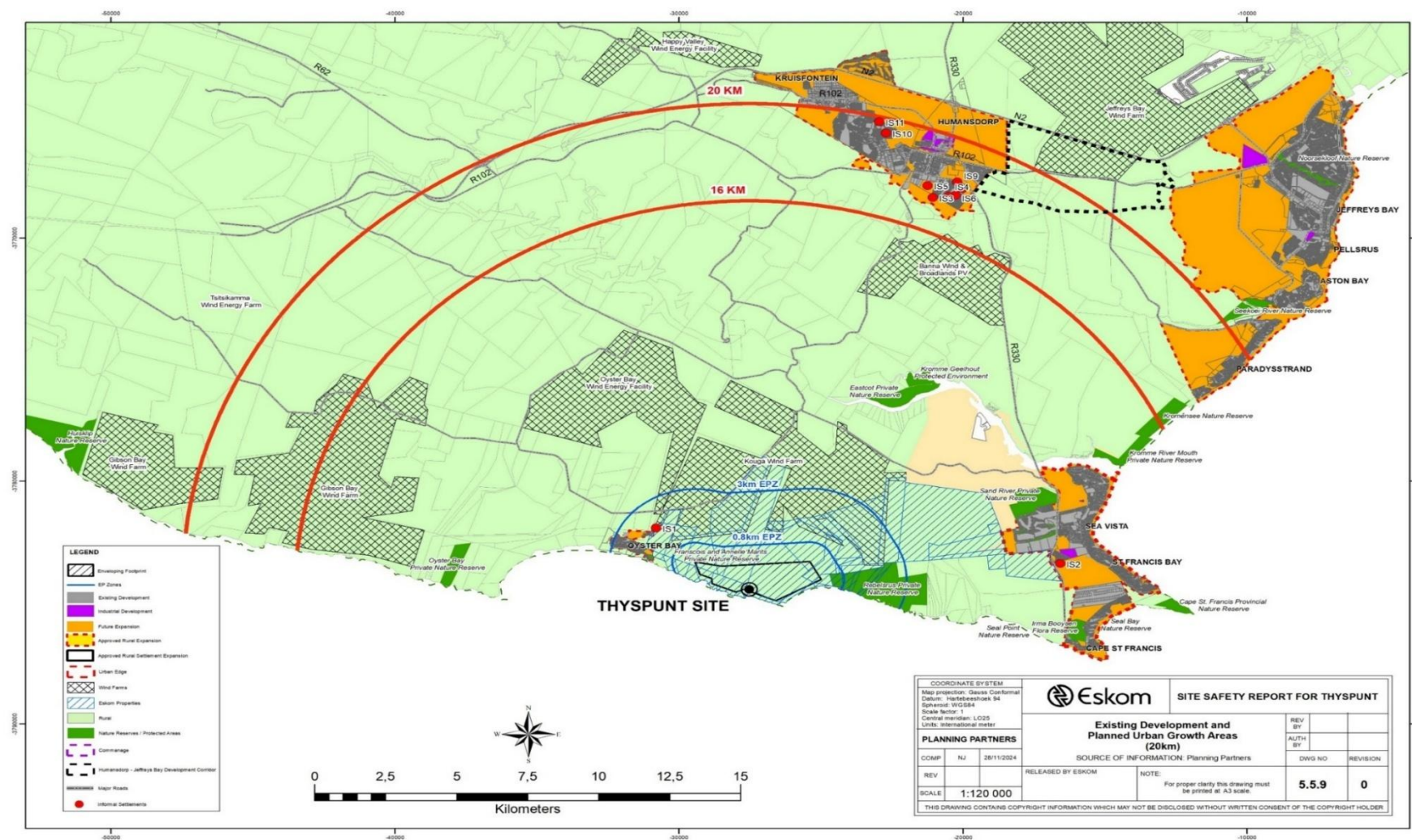


Figure 34: Existing development and planned urban growth areas (20 km)

5.3.4.3 Adjacent Sea use

The regional shoreline to the north of the site is characterised by exposed rocky shores, mixed shores and sandy shores. Land use along this coastline is predominantly conservation and rural, with the exception of the coastal towns of Oubosstrand (51.60 km west-northwest), Eersterivierstrand (49.74 km west-northwest) and Oyster Bay and Cape St. Francis, St. Francis Bay, Paradise Beach, Aston Bay, Marina Martinique (24.1 km east-northwest) and the larger Jeffreys Bay, Blue Horizon Bay (59.34 km east-northeast), Beach View (65.38 km east-northeast), Sea View (67.96 km east-northeast), Kini Bay (69.61 km north northeast) and Sardinia Bay (81.13 km east-northeast).

There are a number of Marine Protected Areas (MPAs) in the site region, i.e. Tsitsikamma MPA, Sardinia Bay MPA and Gqeberha Corals MPA.

The site falls within the Special Sea Area declared in terms of International Convention for the Prevention of Marine Pollution from Ships of 1973, as modified by the Protocol of 1978 (MARPOL), which is focussed on protection of the marine environment and resources from oil pollution. Control of the use of the sea and the seashore within the site region falls within the ambit of the Maritime Zones Act, 1995, the Sea Shore Act, 1935 and the Marine Living Resources Act, 1998.

The main activities associated with the maritime and coastal environment are linked to the characteristics of the coastline and include fishing, collection of food, recreational and tourist activities and processing of fish products.

Fishing activities include commercial fishing, small-scale fishing and recreational fishing. Fish species such as squid, south coast rock lobster, and fish are commercially harvested in the area. Recreational fishing is also popular and is practised from the accessible coastal sites and ski boats. The coastal region surrounding the site is a popular tourist destination and includes the coastal resort towns of Oyster Bay, St. Francis Bay, and Cape St. Francis. Recreational and tourism activities that occur along the coast include swimming, surfing, kite surfing, boating, sand boarding and recreational fishing (refer to Figure 35).

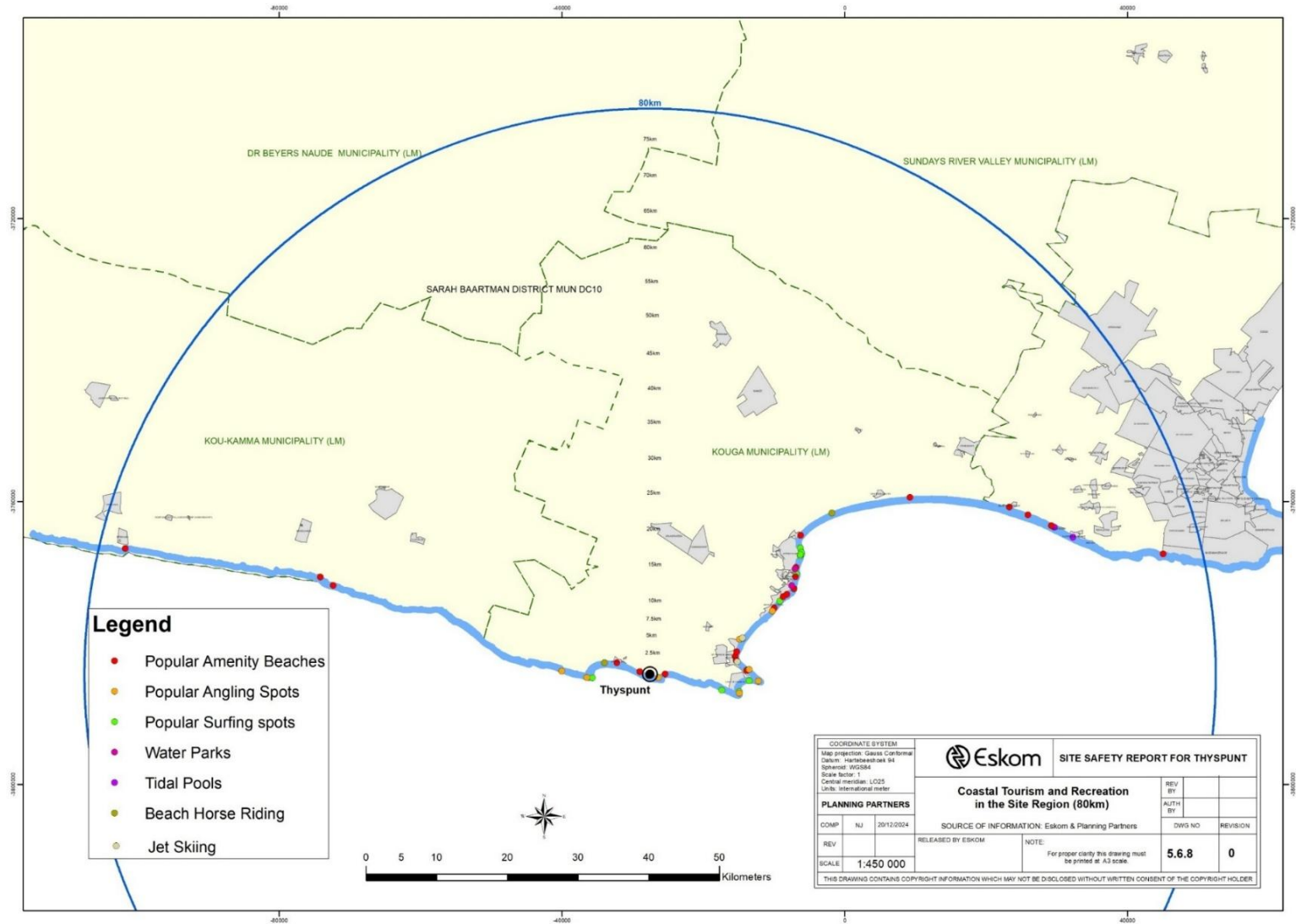


Figure 35: Coastal tourism and recreation (80 km)

5.3.4.4 Regional Development Plans

Various strategic plans and policies were compiled for the broader area within which the site is located. The Kouga Spatial Planning and Land Use Management By-Laws, 2015 [65] and the Koukamma Spatial Planning and Land Use Management By-Laws, 2016 [67] stipulate that a municipal spatial development framework must be drafted for the Kouga municipal area and the Koukamma municipal area, respectively.

The projected regional activities (which influence population distribution) are to a large extent determined by the control of land use and spatial planning. Future activities are therefore presented by discussing the strategic spatial planning strategies and policies adopted by the Kouga and Koukamma municipalities, i.e. the Kouga Spatial Development Framework, 2021 (Kouga SDF) [66] and the Koukamma Spatial Development Framework, 2023 (Koukamma SDF) [68].

a) Kouga Spatial Development Framework (2021) [66]

The site falls within the area of jurisdiction of the Kouga Local Municipality. The Kouga SDF [66] is a framework that seeks to influence the overall spatial distribution of current and future land use within the municipal area to give effect to the vision, goals and objectives of the Integrated Development Plan (IDP). Whereas the IDP is prepared for a five-year period, the SDF has a longer horizon of 30 years, thereby providing the long-term context for the IDP.

The purpose of the SDF is to ensure that future growth and development do not result in unsustainable, low-density settlement sprawl and the destruction of the ecosystem and agricultural resources and will perpetuate the spatial divisions of the past.

In accordance with the vision, the SDF sets aside a large portion of the area for the protection and management of natural areas and higher value agricultural land. Apart from non-consumptive activities and land uses associated with agricultural production and agricultural processing, significant changes to land use in non-urban area is therefore not foreseen.

The SDF proposes a hierarchy of settlements which range from old forestry stations to the primary urban settlements of Jeffreys Bay and Humansdorp. The settlements are connected by a comprehensive network of transportation routes which serve both a mobility and logistics function. These routes are also significant from a tourism perspective (refer to Figure 36 below).

The 'development triangle' of Jeffreys Bay, Humansdorp and St. Francis Bay where the highest pressure for development is experienced, and the secondary nodes of Hankey and Patensie, are identified for focussed investment in infrastructure and human settlement development. As the Gamtoos agricultural sector is expected to grow significantly, the need for human settlement and its associated facilities in the area will also grow. The SDF identifies Andrieskraal as

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a potential location for the establishment of a new rural settlement to address these needs.

Urban and rural edges are delineated around all settlements to protect valuable agricultural, natural and cultural resources and to enable development of sustainable settlements.

In support of a nodal strategy, existing primary, secondary and rural nodes should be strengthened through infill and higher-density development. Growth expansion and investment should be focussed on the primary nodes of Jeffreys Bay and Humansdorp. Secondary nodes such as Hankey, Patensie and St. Francis Bay should fulfil the functions of basic service delivery and ports to the rural hinterland. Limited growth and investment are proposed for rural nodes such as Loerie and Oyster Bay. The SDF states that the establishment of new rural nodes should be carefully considered. Andrieskraal is identified as a new rural node to accommodate some of the future growth in the Gamtoos Valley. Nodal development should support service delivery, compact urban form, and higher densities to ensure sustainability.

Regarding transportation routes, the SDF proposes that the existing network, with the N2 Freeway as the main corridor, be maintained and strengthened by means of upgrading and regular maintenance to ensure economic development and growth. The integrity of movement corridors should be protected with detailed assessment of access proposals during development applications.

A development corridor is proposed along the R102 Road and N2 Freeway between Jeffreys Bay and Humansdorp. This is intended to accommodate commercial, manufacturing, high tech industry and agricultural-related industries and distribution centres.

The SDF proposes a preliminary node framework plan for Oyster Bay (refer to Figure 37 below). The framework proposes limited opportunities for tourism and residential accommodation for farm labourers. A number of vacant sites are available for such development. According to the SDF, the rural character and low density should be retained, with an emphasis on the integration of Oyster Bay town and Umzamowethu. An urban edge is demarcated to exclude sensitive coastal and critical biodiversity areas, agricultural land and undevelopable land from development. Future residential development is subject to “confirmation from Eskom as per the Thyspunt policy”.

Regarding Thyspunt, the SDF states the following:

“The Thyspunt site, west of Cape St. Francis has been acquired by ESKOM for possible future power generation purposes. As a result, the Kouga Coast Sub-Regional Structure Plan was prepared based on the need to maintain the viability of the Thyspunt site for possible future nuclear power generation.

With respect to the Thyspunt site, the following land use principles apply:

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- *To ensure the viability of the Thyspunt site for future possible power generation, development of the surrounding areas must be carefully managed.*
- *Urban expansion of Oyster Bay and Umzamowethu, which falls within the 0 - 5 km zone should not be permitted.*
- *The provision of a small school (without a hostel) to cater for local children may be supported in Oyster Bay.*
- *Institutional land uses such as prisons, old age homes and hospitals that may result in the concentration of a resident population should not be developed within 16 km of the Thyspunt site, because of potential evacuation difficulties.*
- *No new food processing plants to be allowed to be developed within the 16 km.*
- *Agricultural activities to be monitored within 16 km.”*

A minor review of the SDF should be undertaken each year, while a substantial review/redraft should be undertaken every five years. These reviews should be aligned with the IDP and budget planning and approval process.

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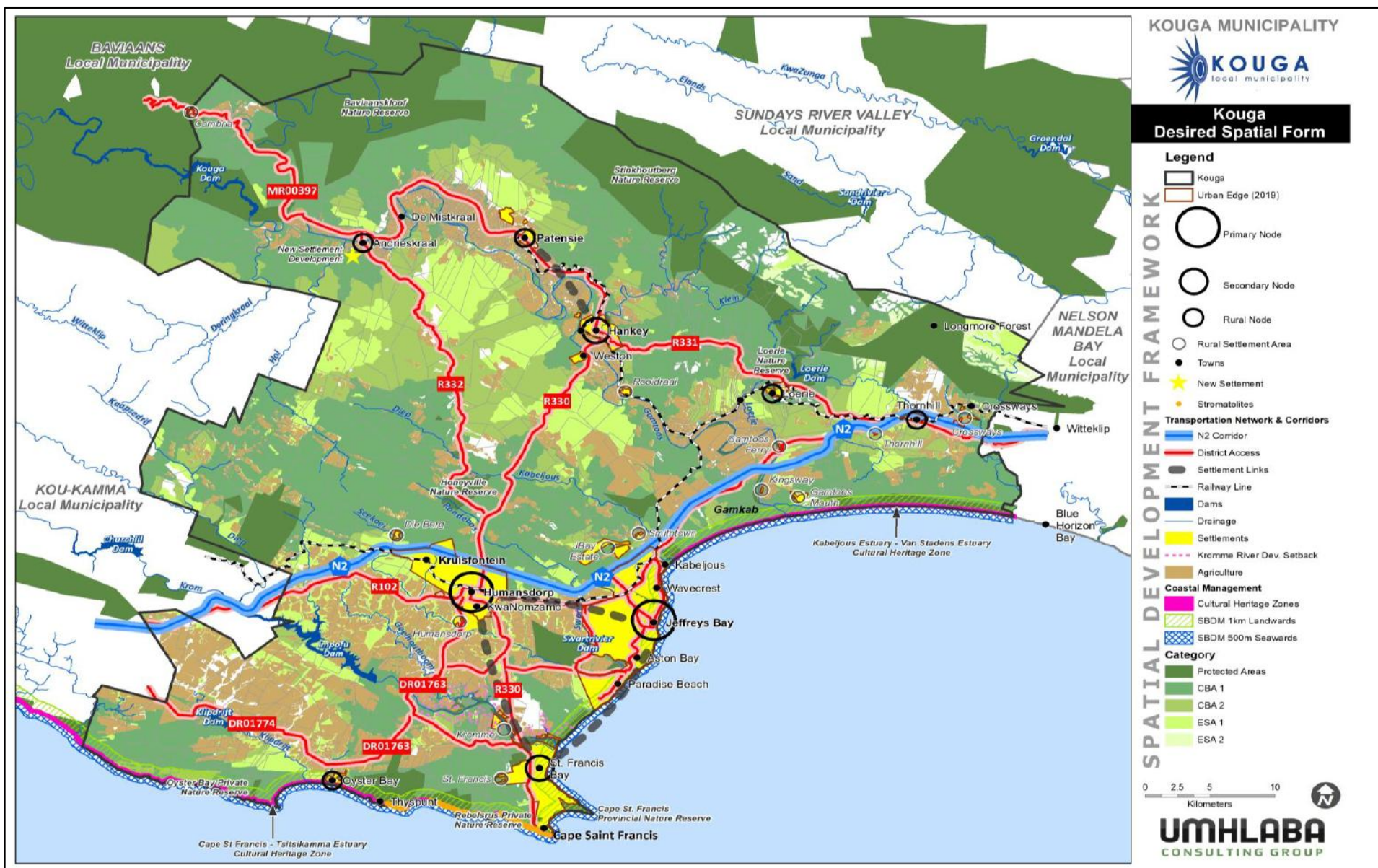


Figure 36: Kouga Spatial Development Framework

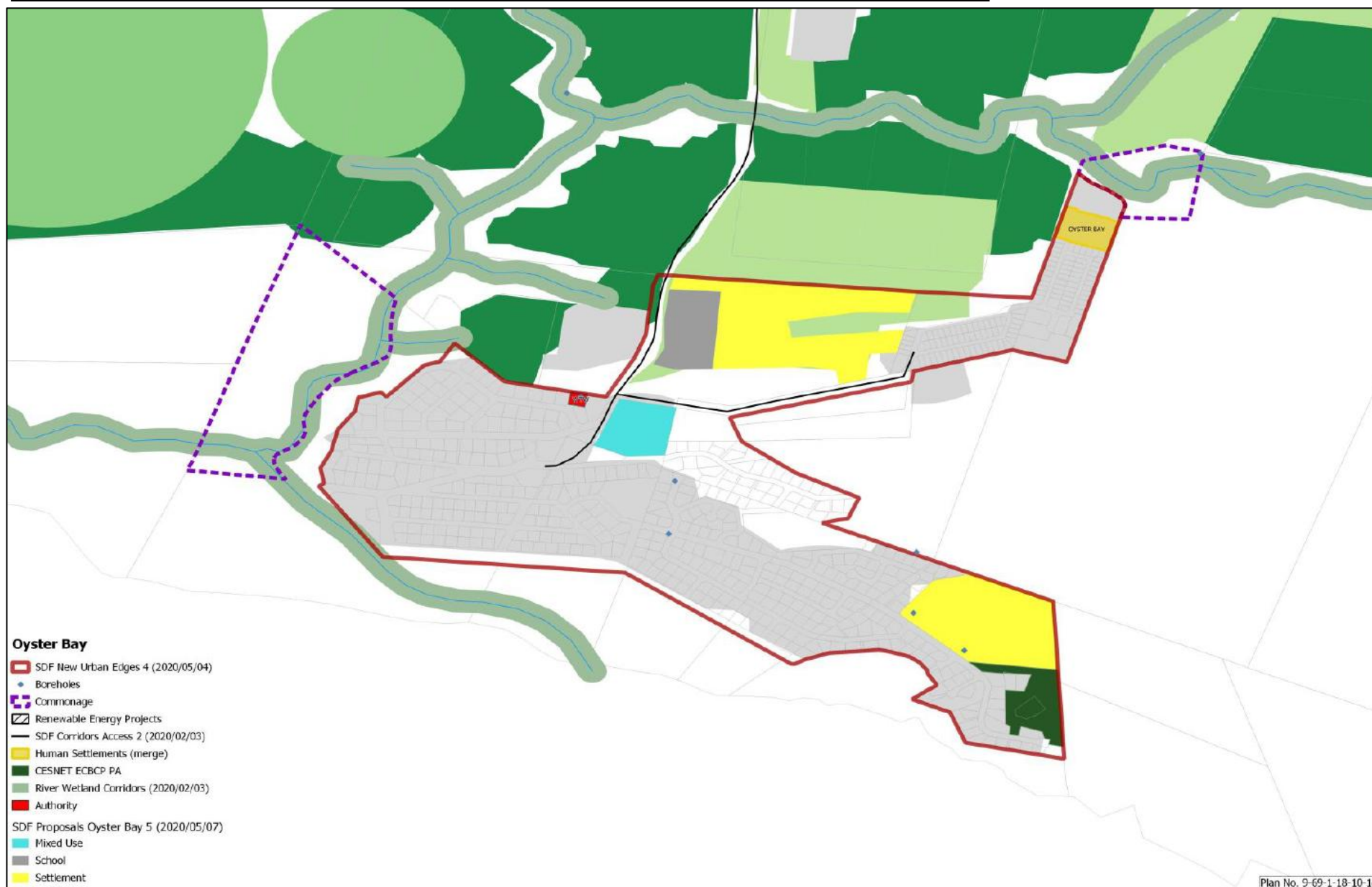


Figure 37: Oyster Bay Framework Plan

b) Koukamma Spatial Development Framework (2023) [68]

Koukamma Local Municipality is situated in the Sarah Baartman District Municipality. Kareedouw is the administrative centre and accommodates approximately 12 per cent of the municipality's total population.

According to the SDF [68] the spatial vision for Koukamma is as follows:

“Koukamma is a municipal area that is integrated into the broader national and regional spatial framework and that protects and makes available resources equitably to support social and economic growth and development within the well-connected settlements and rural area.”

The provision of adequate housing facilities for the population of the municipal area is one of the key principles and priorities of the SDF. The focus is to upgrade and formalise existing informal areas and to encourage the eradication of informal housing and/or shacks.

The SDF proposes densification and compaction of existing urban areas in an attempt to direct development pressures towards intensification within existing built-up areas. Existing built-up areas should therefore be used in the most efficient way to accommodate society's needs for further development before consideration is given to the release of greenfield or new urban areas. Proposed urban edges around settlements enable the protection of valuable resources and facilitate compaction for efficient urban form.

As the municipal economy is dependent on its natural resource base, i.e. extensive areas of significant biodiversity and higher-potential agricultural land, its needs to be utilised in an environmentally sustainable manner. Broad-based agrarian transformation leading to sustainable livelihoods, increased rural economic development and improved land reform are therefore encouraged.

The SDF emphasises the economic advantages and prospects of establishing small scale farming projects as it can make a significant contribution to local economic development for rural communities and create opportunities for prospective farmers. Small-scale farming can be established near settlements and along logistics routes.

The character of the unique natural, cultural and working landscape, townscapes and seascapes should be safeguarded to ensure the area remains a well-established tourism and recreation destination. New tourist and resort facilities could be established in the rural area.

Appropriate use of the coastline must be ensured, i.e. balancing conservation with development and ensuring that no new coastal developments are undertaken unless these adjoin an existing development.

Existing and potential farming and forestry areas should be safeguarded as productive landscapes, primary economic assets and a food security resource.

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Limited non-agricultural and service-related industries can be accommodated in the rural area, provided it is entirely self-sufficient, i.e. the extension of the municipal reticulation network is not required.

In general, the provision of community facilities and associated services to rural communities should take place in existing settlements.

The composite spatial framework integrates the various spatial strategies and policies to reflect the spatial intentions of the municipality (refer to Figure 38).

c) Measures to Control Development around the Nuclear Installation(s)

Development in the vicinity of the nuclear installation(s) should be controlled and/or monitored in consultation with the relevant provincial and/or local municipal authorities. This is to ensure that no change of land use occurs within the vicinity which may give rise to activities that may pose an external threat to the nuclear installation(s), e.g. a restriction on the location of hazardous industries, or those which may have a detrimental impact on emergency planning. These requirements need to be incorporated into SDFs and strategic planning directives. In this regard, and as highlighted above, a number of measures have already been incorporated into the Kouga SDF.

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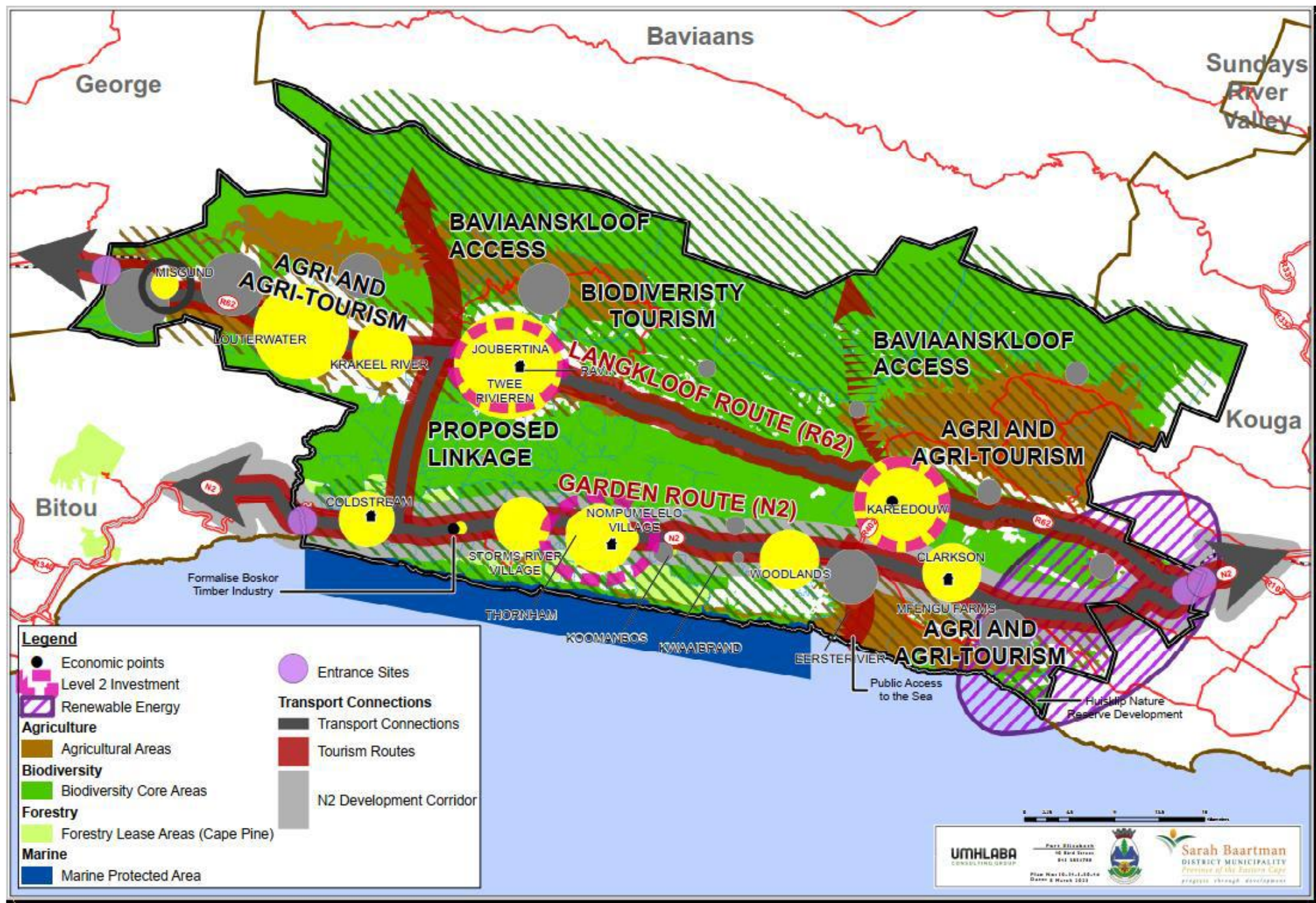


Figure 38: Koukamma Spatial Development Framework

6. OPERATING EXPERIENCE

6.1 Koeberg Nuclear Power Station

Eskom is the holder of the Nuclear Installation Licence (NIL-01 variation 22) [31] for the Koeberg Nuclear Power Station (Koeberg), which consists of two 930 MWe pressurised water reactor units.

The plant started commercial operation in 1984, and the original safety studies assumed a 40-year operational life. Unit 1 reached 40 years of commercial operation in July 2024 while Unit 2 reached 40 years in November 2025. Both units have received the Nuclear Installation License to extend their life by another 20 years. Koeberg has been producing clean, safe electricity for more than 40 years, conforming to industry standards, utilising internationally benchmarked management systems, and employing suitably qualified and authorised personnel.

Jellyfish is known to cause blocking of power station cooling systems when they reach high densities. Four notable jellyfish ingress events have been recorded since KNPS commenced operation in the 1980s with the most prominent events being in February 1997, June 1999, May 2005 and March 2020. In all four cases, massive ingress of jellyfish into the inlet basin significantly affected normal operations of the nuclear installation.

Experience at KNPS has demonstrated that during ingress of jellyfish into the inlet basin, a percentage of jellyfish is removed from both the rake and drum screens and diverted to the wash water waste sump, while the remainder of the jellyfish adhere to the screens (particularly the drum screen). In past events, the drum screen became saturated with jellyfish which necessitated the use of high-pressure firehoses to clean the drum screen.

The occurrence, distribution and density of jellyfish in and near the vicinity of the water intakes is monitored to ascertain the potential risk to nuclear installation safety posed by clogging of intakes. This serves to provide an early warning system of possible jellyfish ingress. A range of mitigation equipment is strategically stored on site, ready to be deployed in the event of jellyfish ingress. These include oil booms, a skimmer pontoon, bubble curtains, high pressure hose, etc. The successful mitigation of jellyfish ingress into the intake basin is dependent on the integrity, availability, and reliability of equipment used during such an event.

6.2 Fukushima Daiichi

On 11 March 2011, a 9-magnitude earthquake, followed by a 15 m tsunami, heavily damaged the nuclear power reactors at Japan's Fukushima Daiichi facility [32]. Following this accident, regulators required significant enhancements to nuclear power plants. These included: adding capabilities to maintain key plant safety functions following a large-scale natural disaster; new equipment to better handle potential reactor core damage events; strengthening emergency preparedness capabilities and in the case of site evaluations, updating evaluations on the potential impact from seismic and flooding events. Internationally licensees (operators) were requested to reanalyse potential

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flooding and seismic effects based on advances in the knowledge and understanding of seismic and flooding hazards. These re-evaluations used updated information and methodologies to inform plant operators of potential impacts to their sites. As such Eskom has changed the approach used for the tsunami hazard analysis (THA) and the seismic hazard analysis for the site.

Other changes to requirements included consideration of the credible combinations of natural and human induced external events that could affect the safety of nuclear installations on the same site or on adjacent and nearby sites.

From the lessons learned from the Fukushima accident and other related accidents taken into consideration during siting investigations, the following are of particular relevance:

- LOOP together with the failure of on-site backup systems can have severe consequences.
- Flooding from the sea was found to be a significant hazard that has to be taken into account in the design of the nuclear installation(s), i.e. the terrace will need to be positioned above the design-basis flood level, or a protective revetment will need to be designed in front of the terrace.
- Loss of ultimate heat sink (i.e. loss of sea water cooling) can lead to loss of the decay heat removal system.
- Inoperable communication and transport networks around the nuclear installation site may jeopardise the implementation of safety related measures by operators and the emergency planning organisation by making escape routes impassable and isolating the plant site in a possible emergency, with consequent difficulties in communication and supply.

Eskom has considered hazards from extreme events as part of the site assessment and has not identified any hazard that could preclude the location of the NPP at the Duynefontyn site. Gen III reactors will incorporate further safety enhancements and additional resilience against severe external hazards. Eskom is committed to learning from events and experience such as Fukushima, as well as capturing wider learning from non-nuclear industries.

7. CONCLUSION ON ADEQUACY OF SITE INVESTIGATION

The Thyspunt nuclear site has been extensively investigated with regard to all the site characteristics that could be significant to safety of the proposed nuclear installation. Characteristics of the natural environment in the site region that might be affected by potential radiological events in normal operational states and in accident conditions were also investigated.

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Possible natural phenomena and human-induced situations and activities in the region of the site have been identified and evaluated according to their significance for the safe operation of the nuclear installation.

Pre-historical, historical, and instrumentally recorded information and records, as applicable, of the occurrences and severity of important natural phenomena or human-induced situations and activities have been collected for the region and have been carefully analysed for reliability, accuracy, and completeness.

Appropriate methods following international codes and standards and safety were adopted for establishing the hazards that are associated with major external phenomena, for example, a state-of-the-art methodology, the senior seismic hazard analysis committee (SSHAC) Level 3 process was followed to determine the seismic hazard for the site.

The size of the region to which a method for establishing the hazards associated with major external phenomena was applied, was large enough to include all the features and areas that could be of significance in the determination of the natural and human-induced phenomena under consideration and for the characteristics of the event.

In the evaluation of the site to determine its potential radiological impact on the region for normal operational states and accident conditions that could warrant emergency response actions, appropriate estimates of expected or potential releases of radioactive material were derived, with account taken of the enveloping characteristics of proposed facilities to be constructed on the site and its safety features.

The direct and indirect pathways by which radioactive material could potentially reach and affect people and the environment were investigated and evaluated, taking into account specific regional and site characteristics [10].

8. SITE DEVELOPMENT CONSIDERATIONS

8.1 Nuclear Developmental Stages

The site will be developed in various stages in accordance with the NNR Position Paper 0009 (PP-0009) (refer to Table 13) [24].

Table 13: NNR Licensing Stages

Stage	Activity	Nuclear Authorisation
1(a)	Site establishment	Permit
1(b)	Early site activities	NISL / NIL to site
1(c)	Early construction activities	NIL to site via Licence Change Request (LCR)
2(a)	Design (Optional)	Authorisation to Design/Design Certification

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Stage	Activity	Nuclear Authorisation
2(b)	Manufacturing (Long Lead Items)	Authorisation to Manufacture
3(a)	Construction	NIL to Construct a Nuclear Installation LCR
3(b)	Fuel to/on Site	NIL via LCR
3(c)	Fuel Loading and Commissioning	NIL via LCR
4	Plant Operation	NIL via LCR
5	Decontamination and Decommissioning	NIL via LCR

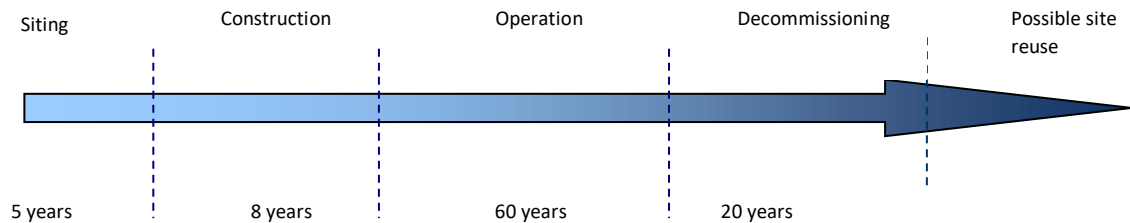


Figure 39: Theoretical Planned Site Lifecycle Phases (Adapted from [63])

Most existing nuclear power plants were initially licensed for 40 years. The design that Eskom seeks to procure has a lifespan of 60 years which can be extended to ~ 80 years. The number and design of the reactors to be built are still to be determined, but they will be of the Pressurised Water Reactor type.

9. DEVELOPMENTAL CONSTRAINTS

On the basis of the available information about the site characteristics and preliminary design considerations, a provisional enveloping footprint area has been selected (shown in Figure 16). This is the area within which the reactor and other buildings will be established. As no vendor has yet been appointed, detailed design of the site layout as well as the number and dimensions of plant facilities remain preliminary and conceptual and will only be finalised in the next licensing stage.

Nonetheless information exists, assumptions can be made, and principles stated with respect to site specific developmental constraints and the principles that will inform the development of the site. These are described in the subsequent sections. It should be noted that these may change due to changes in site data, regulatory requirements or shifts in international practice.

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9.1 Environmental Constraints

Environmental authorisation was granted to Eskom for the proposed construction, operation and decommissioning of the nuclear power station (Nuclear-1) to be located at the Duynefontyn site [2]. Eskom will apply for environmental authorisation for the proposed construction, operation and decommissioning of a nuclear power station (Nuclear-2) at the Thyspunt site. Environmental constraints identified will be managed in accordance with the Environmental Management Plan in accordance with the National Environmental Management Act requirements.

9.2 Physical Constraints

The following physical constraints will need to be taken into account when defining the nuclear power plant terraces.

- The terraces supporting NPPs should be located in that part of the environmental footprint which has the lowest dunes. This in turn, results in the smallest quantity of sand which needs to be excavated and removed. Any changes in this position will have severe consequences with respect to excavation of the NPP foundations.
- The volumes of sand and rock which will need to be excavated, stockpiled, backfilled and spoiled will vary depending on the exact terrace location, dimensions and the below grade level of the selected power plant design.
- At the NPP terrace locations the upper section of the bedrock will be weathered and will need to be prepared such that a competent load bearing bedrock is exposed. Once competent rock is exposed, the foundation may need to be built up with a soil cement sub-foundation to the underside of the nuclear island, as was done for KNPS.
- The oceanography studies undertaken to date suggest a maximum design basis wave height in the order of +14.85 m amsl at an exceedance frequency of $1\text{E-}07\text{ y}^{-1}$. This elevation results from a combination of tide and storm conditions, run-up, climate change and tsunami. In order to provide a margin against the design basis tsunami, the terrace elevation for NPPs should be greater than +15 m amsl. Additional tsunami hazard studies will be performed prior to construction to further confirm the required design for the site.
- The water table mirrors the site topography, steadily rising towards the north-west. The NPP terraces should be located such that there is a minimum margin of at least 2.0 m between top of terrace and the water table. This depth to groundwater will be greater than 2.0 m over most of the site with only the North Eastern corner experiencing the minimum depth.
- As the elevation of the terrace increases so does the power demand for pumping cooling water through the turbines. Hence, it is desirable to optimise as far as possible the terrace elevation against the electrical house load. It is anticipated that the cooling water requirement will be in the order of $184\text{ m}^3/\text{s}$ for 4 000 MWe, and $76\text{ m}^3/\text{s}$ is

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required for 1 650 MWe and this volume will need to be pumped over the 60 year life of the NPP(s). This in turn, implies a loss of power output and a portion of the capital expenditure which cannot be recovered.

10. CONCEPTS ADOPTED FOR SITE DEVELOPMENT

The concepts discussed in this section are preliminary and conceptual and will be influenced by the licensing and regulatory requirements that will need to be adhered to, as well as the site development and contracting approaches to be adopted by Eskom.

10.1 Access Roads

The Thyspunt site does not currently have formal access routes, and the construction of a new access road will be required. On receipt of an Environment Authorisation (EA) and when a decision is made to build, the identified access roads will be constructed in accordance with NEMA requirements and constraints identified during the EIA.

The following four grade-separated interchanges along the N2 highway give access to the site:

- the link to the R102 road at Mondplaas;
- the turn-off to Jeffreys Bay;
- the link to R330 road just north of Humansdorp;
- the link to R62 road at Dieprivier, as illustrated in Figure 41.

10.2 Site Access

As illustrated by Figure 41, the site can be accessed from the east, north or from the west. The western and eastern accesses were the preferred access alternatives previously recommended, however, due to the significant impact of these access roads on the surrounding environment and the land required for these accesses, it is recommended that only the eastern access off the R330 be constructed as a formal paved access road (refer to Figure 41). The western access road should be constructed as a low order gravel access road that will serve primarily as an emergency access.

Approach Routes – Construction Phase

The following access routes from Humansdorp to the Thyspunt site and possible alternatives were evaluated (refer to Figure 41):

- Oyster Bay Road;
- R330;
- Humansdorp Industrial Bypass.

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10.3 Emergency Evacuation Routes

Two access roads are also required for the safe and quick evacuation of all personnel in the unlikely event of an emergency. Further arrangements with regard to emergency evacuation will be put in place with the local authorities and disaster management structures once a firm decision is made to build the nuclear power station.

10.4 Transportation of Abnormal/Heavy Haul Loads

Most major components for a nuclear power plant are manufactured overseas and imported by sea, and many of these components are abnormally large in comparison to normal road freight. Delivery to the site by abnormal load vehicles will therefore be required. Most of the heavy equipment from abroad will therefore be transported by ship to the Port of Gqeberha as it is the closest harbour to Thyspunt that has the capacity for heavy loads. The proposed route follows Buffelsfontein Road (M9) and Seaview Road from Gqeberha harbour up to the N2, then via the N2 up to the interchange east of Jeffreys Bay, then along the R102 up to Humansdorp, then via Main Street to Park Street, then via the R330 up to the Eastern Access and then to the site (refer to Figure 41).

The following possible mitigation measures will be required along the abnormal load route:

- The railway crossing along the exit of Gqeberha requires an upgrade for the haul vehicles.
- The overhead electric powerlines should be raised to accommodate the height clearance required.
- Overhead bridges – Transport vehicles will have to make use of on and off ramps at interchanges to avoid overhead bridges. Ramps and detour routes will have to be constructed where required.
- Under bridges – Propping will be required at most bridges to ensure stability during transportation. Strengthening and bracing will also be required at the Van Staden's bridge. Upgrades to intersections and roundabouts will be required.
- It is recommended that the abnormal load trips occur during the off-peak hours in the evening, between 21h00 and 5h00 to reduce the impact on the traffic.

During previous studies concerns were raised about the use of Main Street in Humansdorp and other possible routes to bypass the town were investigated. Due to possible challenges with intersection upgrades and adjustments required along Main Street to accommodate the abnormal loads, the Alternative (A) route was recommended. It is a direct link between Voortrekker Road (MR389) and St. Francis Bay Road MR381 (R330) intersecting just north of Kwanomzamo. This is the shortest route for an eastern bypass, approximately 850 metres long and is the most practical for construction (refer to Figure 41).

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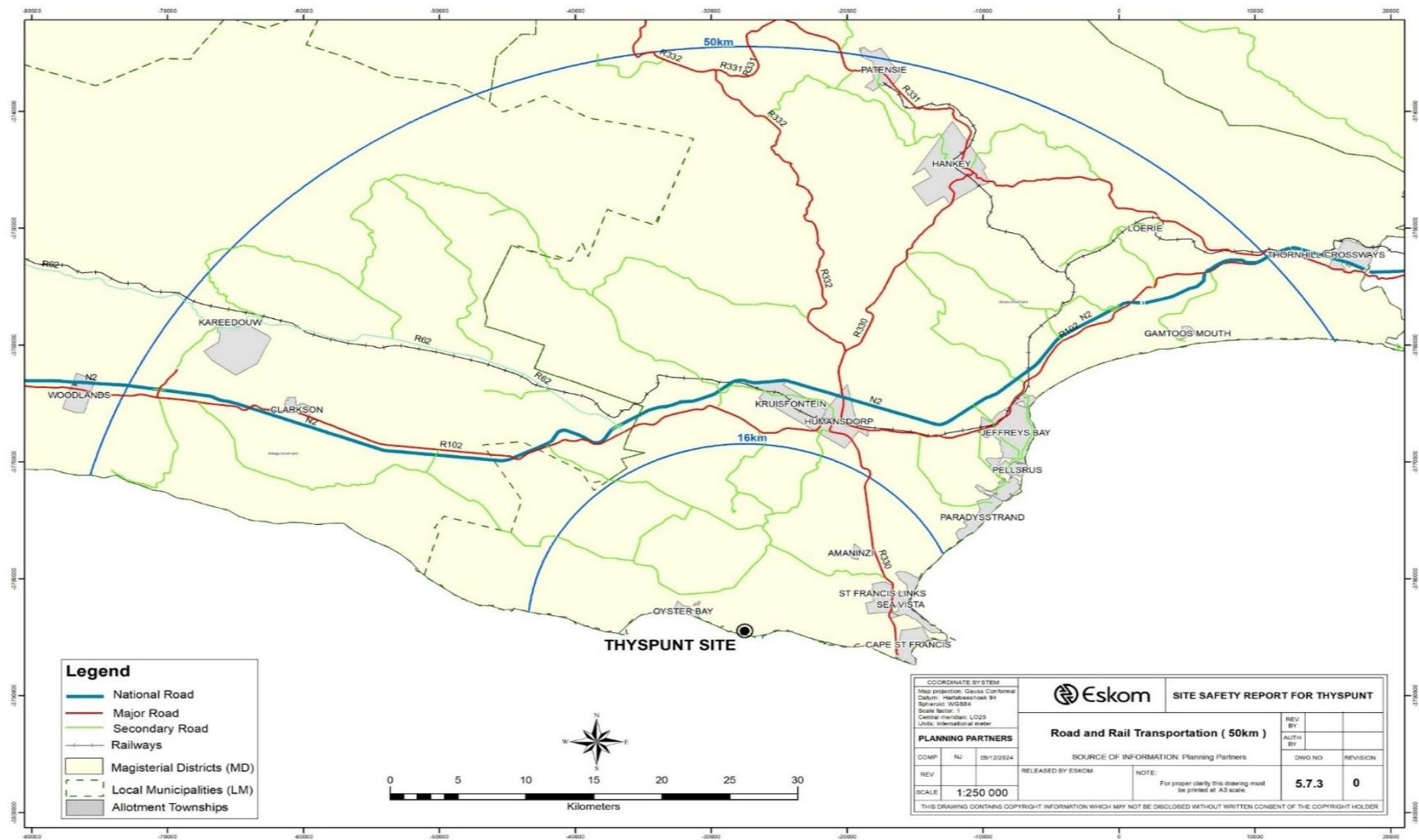


Figure 40: Road and Rail Transportation (50 km)

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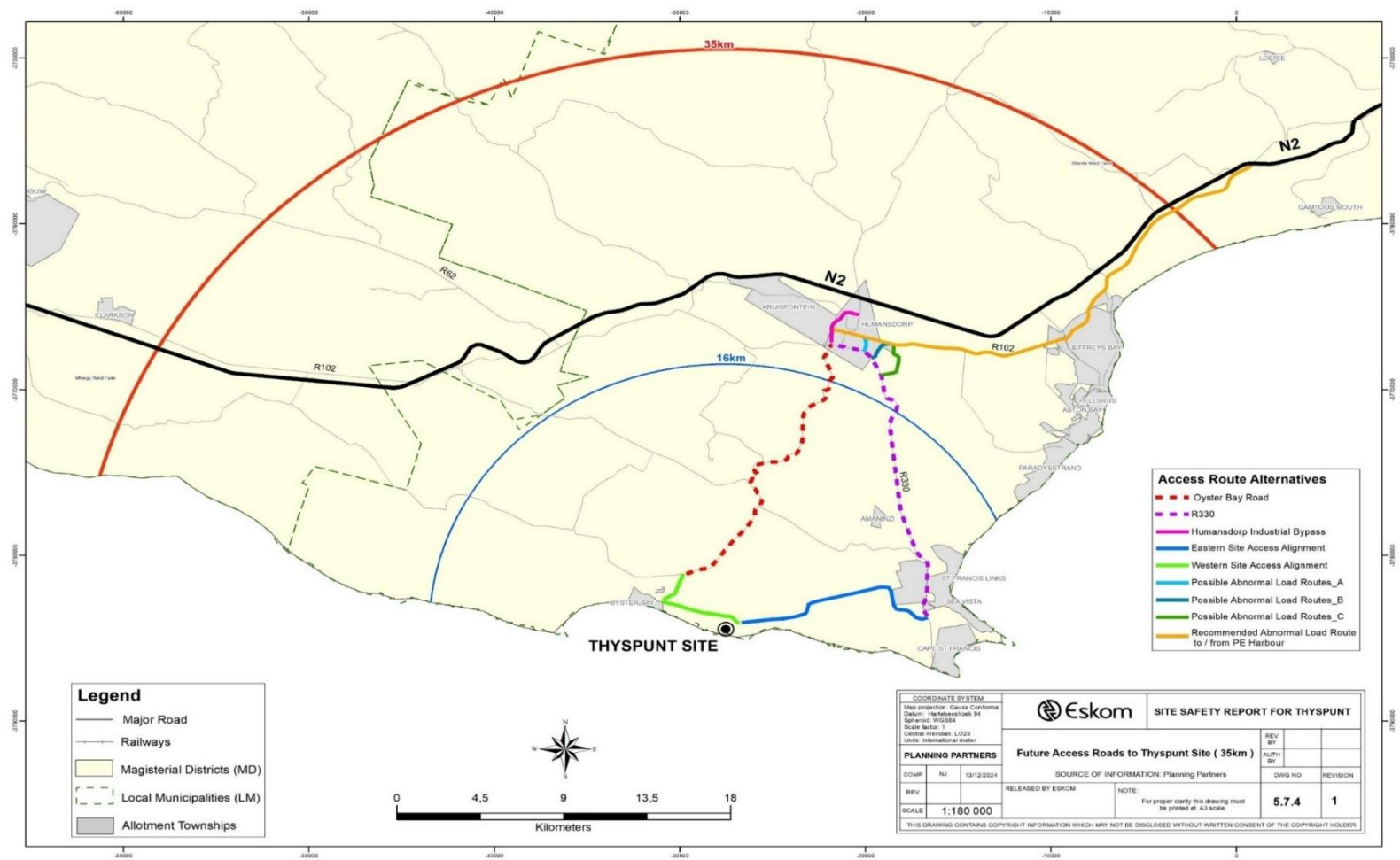


Figure 41: Future Access Roads to Thyspunt Site (35 km)

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10.5 Bulk Earthworks

Once the earthmoving machinery has been transported to the site, small scale earthworks will be undertaken to provide platforms for temporary Eskom Offices, a Visitors' Centre, Fitness for Duty Building, temporary desalination plant, potable water storage tanks, portable toilets, central conservancy tanks for waste water, parking and a contractor's yard.

Areas will be identified for

- a mulch stockpile
- a helipad
- a topsoil stockpile

Thereafter, earthworks will proceed on the NPP terrace as well as terraces for other buildings. Excavated material will be used for compacted fill in other terraces. Once the NPP terrace has been prepared to its finished elevation, preparatory work for the excavation can begin. These works will include some form of dewatering which may not affect the wetlands. These works are likely to extend for a period in the order of 8 months prior to the start of excavation.

Contractors' yards will be constructed from the sands on the site with the aim of achieving a balanced cut and fill and so limit as far as possible the need for disposal of spoil.

The elevations of the NPP terraces should be located at elevations which achieve a balance between mitigating against flooding from the sea, achieving at least 2 m height above the ground water table, minimising the quantity of sand spoil and the cooling water pumping requirements over the life of the power station.

A wearing course of imported material will be constructed on all terraces which will accommodate construction traffic and support an applied pressure of 150 kPa for laydown areas. The terraces will be profiled to ensure that rainwater will flow to the stormwater drainage system which will be installed as part of the earthworks. Primary access roads will be provided on the terraces but access to the contractors' yards from the primary roads will be provided by the vendor. Note should be taken that there will be some weathering of the surface during construction and this will be monitored and repaired where necessary by the vendor. Also included in the construction of the terraces will be the potable and fire water ring mains, electrical ring main which feeds inter alia, the site lighting, stormwater and sewer networks.

Edges of terraces will be indicated properly for safety, including, if necessary, railings or fences. A site security fence will surround the construction site and will be constructed once the earthworks are completed.

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Rock which is removed from the cooling water inlet tunnel and the excavation for the Nuclear and Conventional Islands may be used as fill material or transported to the local quarry for crushing and use in other applications.

10.6 Potable Water Ring Main

A potable water ring main will be established. During the initial stages of construction, the potable water requirements are envisaged to be 104 l/s. This water can be supplied from a number of sources as construction proceeds. Initially potable water will be supplied from existing boreholes on site, but this water may need to be treated. The water will be stored in elevated water tanks. As the site readiness activities increase so the water demand will be satisfied by increased numbers of water storage tanks located on relatively high parts of the construction site. The tanks will supply sufficient pressure for drinking water, the filling of toilet systems and other low-pressure requirements to temporary and permanent buildings as these are developed. Where required, pressurised pump systems can be added for additional pressure.

As the bulk earthworks for the various terraces are completed, water ring mains will be installed. Water will be supplied from the desalination plant (which will have been completed by this time) to storage reservoirs which in turn, feed the ring mains. Draw-off points will be provided in the ring main as required on site.

Water will be stored at various locations around the construction site to meet balancing requirements and cater for emergencies (e.g. firefighting) or planned shut-downs. The balancing volume is required to cater for peak outflows, while a near constant inlet flow is being received. A storage capacity of 48 hours of annual average daily demand is suggested, although there may be situations where 24 hours will suffice.

The nominal capacity for elevated storage, based on a typical period involved in power failures, will be based on 2 to 4 hours of instantaneous peak demand. The nominal capacity of the duty pump should be equivalent to the sum of the instantaneous peak demands.

10.7 Stormwater System

As noted under the bulk earthworks, the stormwater systems for the terraces will be included in the terrace construction.

The rain water will be collected via a system of roads, stormwater pipes, and open channels. Open channels are the preferred option primarily from construction cost and maintenance perspectives.

Prior to discharge into the environment, the stormwater will pass through environmental ponds / sediment collection structures designed to collect all types of solid material conveyed in the water and oil/grease traps should pollution be a possibility. Thereafter, it

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will be discharged into the open vegetation from the various terraces with energy dissipation structures being used to prevent erosion at the exit points.

Stormwater will be considered for discharge into the cooling water intake basin once operating.

Research indicates that the extended duration flows typically experienced in retention ponds negatively impact receiving streams / wetlands, particularly when the streams and wetlands are subject to erosive flows for long periods. Standing water also serves as a habitat for mosquitoes associated with diseases. Hence, the use of retention ponds will need special attention if they are considered for use on the site.

10.8 Sewer System

During the initial stages of the construction use will be made of chemical toilets provided and serviced by an independent service provider. Conservancy tanks will be provided as central collection points for sewerage. From these tanks the sewerage will be transported to the local municipality for treatment.

Once the temporary sewerage treatment plant (STP) has been commissioned and the sewer piping network installed, treatment of the waste will be done on the site. The temporary STP may need to be moved into its final position once the terrace construction has been completed. The STP will be modular to cater for variations in flow rate over the life of the NPP. The STP will not interface with the nuclear island and all waste generated which is potentially contaminated will be treated separately inside the nuclear island.

There may be more than one collection point for the sewer system, but these will be limited as far as possible to limit the number of pump stations constructed. These pumps will then pump sewerage to the STP.

10.9 Electrical Ring Main

The construction supply system will consist of a 11 kV cable network fed from a substation/switching station. The substation will initially be fed by a 22 kV line from the existing reticulation network in the area. The supply will be supplemented with a 132 kV line during the course of the construction period. The 132 kV supply will be stepped down to 11 kV.

The 11 kV cable network will be used to supply mini substations located at various supply points on the site. The 11 kV will be stepped down to supply 400 V 3-phase to the vendor. 400 V is the South African standard voltage for 3 phase industrial supplies. The 11 kV cable network can also supply 11 kV directly to the vendor if required.

The location of plant, for example sub-switching stations, mini substations shall be decided upon considering the following factors:

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- Vehicular and pedestrian traffic.
- Environmental impact.
- Water run-off.
- Pollution.
- Accessibility for ease of operation and maintenance, and
- Location of other underground services, for example telecoms lines, water etc.

10.10 External Lighting

During pre-construction the main areas of concern for lighting are the Eastern Access Road, Contractors Facility, Electrical Substation Yard and Eskom Site Office Facilities.

Most of the exterior luminaries whether or not they are pole-mounted or surface-mounted onto buildings shall have photocell lighting control, which means that the lamps stay on from dusk till dawn for security purposes.

The smaller roads and building facades around the site shall be adequately lit to enable cars and pedestrians to manoeuvre around the site. Lighting levels shall not be excessive. Extensive use of floodlights and surface mounted bulkhead lights with sharp cut-off angles and excessive upward light distribution shall not be encouraged.

High-mast lighting is provisionally envisaged at various locations on the site.

10.11 Telecommunications

The systems, buildings and towers to accommodate the site telecommunications will be constructed and commissioned as the earthworks are completed for the terraces.

11. SAFETY CASE ELEMENTS

The Thyspunt site investigations have been conducted with Nuclear Professional diligence within a structured management environment, collected comprehensive information about the characteristics of the site, defined site specific design parameters and demonstrated site suitability in accordance with Eskom's requirements whilst also fulfilling the relevant national nuclear regulators safety requirements, i.e. National Nuclear Regulator (NNR) Act and the Regulations on Licensing of Sites for New Nuclear Installations.

11.1 Safety Analysis

Evaluation and screening of external events at the Thyspunt site do not preclude the site from the establishment of a nuclear installation. External events evaluated were either:

- screened out from being considered further as a design basis;

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- screened out conditional on the basis that the status be confirmed when the specific design is selected; or
- will be compensated for by means of:
 - design features of the envisaged nuclear installation(s); or
 - site protection measures.

The radiological dose assessment performed has shown that the representative person total annual dose is conservatively estimated to be less than 0.2 millisievert per year. It can therefore be concluded that the new nuclear installation(s) on site with a maximum generating capacity of 33 000 MWth will comply with the NNR regulatory public dose limit and site dose constraint values of 1 millisievert per year and 0.25 millisievert per year respectively.

A screening radiological risk assessment was carried out for non-human biota assuming simultaneous operational discharges from the NNPS and KNPS out using the ERICA Tool. The ERICA Tool is a software designed to demonstrate and evaluate the impact of radiation to the local ecosystem (plants and animals). The assessment shows that plants or animals assessed in the area would not be harmed from radiation. All species evaluated fall below the screening limit of 10 µGy/h meaning there is no significant impact expected on animals or plants.

The Level 3 Probabilistic Safety Assessment study performed for the site concluded that the annual expected station risks due to reactor accidents and external hazard induced reactor accidents for a 6-unit EPR reactor installation or an 8-unit AP1000 reactor installation for the population within a 50 km radius around the site is deemed to be well within the NNR risk limits with reasonable margins.

11.2 Management System

A comprehensive and integrated system for managing safety and quality was established to control the effectiveness of the execution of the site investigations and assessments and engineering activities performed in the different stages of the site evaluation.

The management system covers the organisation, planning, work control, personnel qualification and training, verification, and documentation, therefore ensuring that the required quality of work was achieved. Records are kept of the work carried out in the activities for site evaluation for the full life cycle of the nuclear installation(s).

A quality assurance programme was implemented for all activities that could influence safety or the derivation of parameters for the design basis for the site. The quality assurance programme was graded in accordance with the importance to safety of the individual siting activities under consideration.

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The Eskom siting team had the overall responsibility for implementing siting activities. The siting team consist of a number of scientists/experts who were suitably qualified and experienced in the relevant disciplines required for siting. This team specified the work to be done and has overseen the investigations and acceptance reviews of the siting reports that document the siting investigation results.

Due to the wide range of subject areas and to provide the range of technical expertise required for the characterisation of the site and development of the safety case, the siting team was augmented by procuring the services of specialist consultants. Contracts were entered into with a number of established South African consultants. All contracted resources were approved nuclear service providers and were appointed for specific work on the basis of their respective qualifications and experience. Consultants were qualified in accordance with Eskom quality and safety management requirements as well as that of the NNR's RD-0034 (*Quality and Safety Management Requirements for Nuclear Installations*) [22], pertaining to the nuclear safety level of the service/product they provided. Consultants implemented RD-0034 and ISO 9001:2008 [11] and later ISO 9001:2015 [14] compliant management systems. The management systems provide the framework for the promotion, monitoring, maintenance, and enhancement of a strong safety culture, ensuring a common understanding of the key aspects of the safety culture. Adherence to local statutory requirements and compliance to specific national regulations and regulatory requirements from the NNR were verified. In particular, implementation of the RD-0034 requirements and the requirements of RG-0016 (*Requirements for Authorisation Submissions involving Computer Software and Evaluation Models for Safety Calculations*) [30] by the performers of the relevant tasks were recorded and acceptance reviews were performed by Eskom.

11.3 Operational Support Programme

For the purpose of the NISL application, the operational support programme to be implemented is only briefly described. The operational support programme will be explained in much more detail in the PID to be developed as part of the NIL application.

The operational support programme (OSP) is a suite of safety programmes, plans, and procedures that are used to control the operation of the plant so that the plant safety parameters are respected, and assumptions made in the safety analyses remain valid. The OSP documents and programmes shall be developed in accordance with the safety case requirements for each licensing stage of the NISL application and shall take into account the selected vendor and the nuclear power plant type, once established. The OSP shall address the following areas:

- OSP requirements description document;
- OSP development programme;

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- The operating technical specifications (OTS);
- Maintenance programme;
- In-service testing (IST);
- In-service inspection (ISI) programme;
- Configuration management programme;
- Emergency planning development programme;
- Environmental surveillance programme;
- Meteorology monitoring programme;
- Maintenance and update of the site safety report;
- Radiation protection programme;
- Spent nuclear fuel and radiological waste disposal programme;
- Plant operating experience and corrective action programme;
- Physical security plan;
- Operating procedures (normal, incidents, accidents);
- Severe accident mitigation design alternatives.

Some of the documents related to the disciplines listed above may only be completed once the technology or vendor has been selected as this may affect the systems, structures, and components of the plant and their functionality. The personnel required to compile and review these documents shall be adequately trained and authorised for their area of expertise in accordance with the relevant Eskom training procedures.

11.4 Compliance with Safety Standards

11.4.1 Regulatory Framework

The legal basis for obtaining an NISL is given in the NNR Act (Act No. 47 of 1999) [36] as amended, specifically sections:

- 2(1) Subject to subsection (2), this Act applies to, (a) the siting, design, construction, operation, decontamination, decommissioning and closure of any nuclear installation.
- 5(b) grants the NNR the power to, amongst others, exercise regulatory control related to safety over the siting, design, construction, operation, manufacture of component parts, decontamination, decommissioning, and closure of nuclear installations through the issuing of nuclear authorisations.

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- 20(1) states that: “*No person may site, construct, operate, decontaminate, or decommission a nuclear installation, except under the authority of a nuclear installation licence*”. In terms of the provisions of this section, the siting, construction, operation, decontamination, or decommissioning of any nuclear installation must be authorised by way of a nuclear licence granted by the NNR.
- 21(1) requires that any person wishing to site, construct, operate, decontaminate, or decommission a nuclear installation may apply in the prescribed format to the chief executive officer of the NNR for a nuclear installation licence and must furnish such information as required by the NNR board of directors.
- 23(2) states that the Chief Executive Officer may, subject to subsection (3), impose (and amend) conditions of authorisation which are necessary to ensure the protection of persons, property, and the environment against nuclear damage, or to provide for rehabilitation of the site.
- National Nuclear Regulator Amendment Act, Act No. 26 of 2024, published in Republic of South Africa Government Gazette, No. 51804, 20 December 2024 [38].

Other regulatory requirements applicable to siting of nuclear facilities are:

- R.388 (*Regulation on Safety Standards and Regulatory Practices*) [4].
- R.927 (*Regulation on Licensing of Sites for New Nuclear Installations*) [1].
- Regulation GN1219 (*Regulations on the Format for the Application for a Nuclear Installation Licence or a Certificate of Registration or a Certificate of Exemption*) [5].
- RD-0024 (*Requirements on Risk Assessment and Compliance with Principal Safety Criteria for Nuclear Installations*) [21].
- RD-0034 (*Quality and Safety Management Requirements for Nuclear Installations*) [22].
- RG-0011 (*Interim Guidance for the Siting of Nuclear Facilities*) [29].
- RG-0016 (*Guidance on the Verification and Validation of Evaluation and Calculation Models Used in Safety and Design Analyses*) [30].
- PP-0009 (*Authorisations for Nuclear Installations*) [24].
- PP-0014 (*Consideration of External Events or Nuclear Installations*) [26].
- PP-0015 (*Emergency Plan Technical Basis for New Nuclear Installations*) [25].

Other regulations taken into consideration include:

- Occupational Health and Safety Act (OHSA), 1993 (Act No. 85 of 1993) [33].
- Environmental requirements in terms of the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) [34].

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11.4.2 Compliance with regulatory requirements

Results from the siting investigations were assessed against the national nuclear regulatory requirements, in particular:

- R.388 [4]:
 - The dose constraints applicable to the average member of the critical group within the exposed population will be well below the regulatory dose constraint requirement of 0.25 millisievert per year, and the annual effective dose limit for members of the public from all authorised actions will not exceed the 1 millisievert limit.
 - A safety culture was fostered and maintained to encourage a questioning and learning attitude to nuclear safety.
 - Management systems (quality management programmes) were established.
- R.927 [1]:
 - New nuclear installation(s), reflects through their design, construction and operation, an acceptably low probability of postulated events that could result in the release of quantities of radiological material.
 - The site location and the engineered safety features of all nuclear installations, included as safety measures against the hazardous consequences of postulated events, ensure an acceptably low risk of public exposure.
 - The site is such that radiological dose and risk from normal operation and postulated events associated with all nuclear installations in the vicinity will be acceptably low.
 - Natural phenomena and potential man-made hazards are appropriately accounted for.
 - Adequate emergency plans and nuclear security measures can be developed.
 - The cumulative radiological impact all nuclear installations and actions, in the vicinity, is quantified.
- RG-0011 [29]:
 - Assurance is provided that the nuclear safety criteria (pertaining to dose and risk), relating to the safety of the public, can be complied with given the characteristics of the site and its environs, and preliminary information on the design and operation of the facilities.
 - The site characteristics do not preclude the designs of the technologies proposed for construction on the site.

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- It is feasible to develop and implement emergency and security plans, given the characteristics of the site and its environs.
 - It will be feasible to make arrangements for controlling developments in the vicinity.
- RD-0024 [21]:
 - Risk to the public due to accident conditions was identified.
 - Dose to the public due to normal operations was identified.
- RD-0034 [22] that requires that Eskom and its consultants implement integrated management systems for the management of siting investigations and the resultant reporting of the results thereby ensuring a defensible product is delivered.
- RG-0016 [30] requires that all calculation models and/or evaluation models used in the site safety analyses are verified and validated, thereby ensuring robustness of all models and accuracy of the results.

11.4.3 International Standards, Experience, and Best Practice

The Thyspunt site investigation studies took into account relevant international safety standards and recommendations, as well as lessons learned and best practice from countries with experience in the field of site evaluation and development of new nuclear installations. The main sources considered are listed in Appendix A.

12. NUCLEAR AND RADIOLOGICAL EMERGENCY PREPAREDNESS AND RESPONSE PLAN

12.1 Proposed Emergency Planning

It is a licensing requirement that the licensee of an operational nuclear facility or an applicant to construct a new nuclear facility demonstrates that emergency preparedness and response plan is feasible. The primary objectives of a nuclear and radiological emergency plan are to:

- 1) Prevent deterministic health effects (death and injury) by:
 - a) taking action before or shortly after a major (core damage) release or exposure from a reactor accident;
 - b) keeping the public and emergency worker doses below the threshold for deterministic health effects.
- 2) Reduce the risk of stochastic effects on health (primarily cancer and severe hereditary effects) by:
 - a) implementing protective action in accordance with the IAEA guidance;

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- b) keeping emergency worker dose below the regulatory worker dose limit.

Prevention of deterministic health effects can be achieved by taking protective actions shortly after or before the release. These actions must be based on plant condition and revised based on the environmental measurements. Similarly, prevention of risk of stochastic health effects is reduced by taking actions based on ambient dose rates and analysis of environmental samples.

For construction of a new nuclear power station (NPS), assessment of the feasibility of the emergency planning (EP) was done as part of the environmental impact assessment (EIA) of the project and also as part of the site safety analysis which culminated in the environmental impact report (EIR) and site safety report (SSR) respectively. The feasibility assessment of the EP is a component of a comprehensive safety assessment that grows in detail during multiple nuclear licensing stages. It culminates in the final emergency plan which is based on the detailed design and completed construction of the NPS prior to initial operation which will be submitted to NNR for acceptance.

The EP includes arrangements based on criteria set in advance to determine when to take different protective actions and what capability is required to protect and inform personnel at the scene and the public. The arrangements are based on emergency planning zones (EPZs) which represent the areas in which planning for specific protective actions are based on projected health risks posed by those accidents that could, under severe conditions, release radioactivity to the environment. Protective actions include measures to limit the exposure of the public to radioactive contamination through external radiation exposure, inhalation of airborne radioactivity, and ingestion of contaminated foodstuff. For nuclear emergencies, two sets of requirements have to be fulfilled;

- Functional (response) requirements; and
- Infrastructure (preparedness) requirements.

Functional response requirements refer to the “capability” to perform an activity. The “capability” includes having in place the necessary authority and responsibility, organisation, personnel, procedures, facilities, equipment, and training to effectively perform the task or function when needed during an emergency. It also includes having in place the necessary infrastructure needed during an emergency response. Infrastructure in this context means transport and communications networks, industrial activities and in general all resources that one may need for a rapid and free movement of members of the public out of the affected area in the shortest period possible. The specific requirements that the applicant must comply with to demonstrate the feasibility EP programme are summarised in the NNR siting regulations R.927 [1] and PP-0015 [25].

As stated in the siting regulations, the identification and determination of EPZs consider the characteristics of the site, reactor design information, estimation of source terms (the quantity, composition, time, and duration of the radioactivity release) for each of the

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accidents considered. Calculation of the projected off-site doses arising from the release is based on site-specific or generic information and the latest meteorological and population data of that region. Radiological health impact analysis will take into consideration the age of the exposed group.

12.2 The basis of feasibility of an emergency preparedness and response plan

The basis/measure of feasibility of an emergency plan is the capability of the emergency response organisation such as provincial and national disaster management's ability to respond within the prescribed period to prevent undue health effects as a result of exposure to radiation. This means that there should be no adverse site conditions which could hinder the sheltering or evacuation of the population in the region or the ingress or egress of external services needed to deal with an emergency. The size of the population in the EPZ should not exceed the threshold level which impedes viability of emergency planning and response plan. Other important factors that are taken into consideration in determining the feasibility of emergency planning are:

- Distance of the site from population centres;
- Special groups of the population who are difficult to evacuate or shelter, such as people in hospitals, old age homes, schools, or prisons;
- Particular geographical features such as islands, mountains, and rivers which may have an effect on the migration of the plume and evacuation efforts and subsequently on the consequence of a radiological accident;
- Characteristics of local public transport and communications networks;
- Industrial facilities which may entail potentially hazardous activities;
- Agricultural activities that are sensitive to possible discharges of radionuclides;
- Possible concurrent external events; and
- Weather conditions at the time of an emergency.

Various layers of defence are included in the design of an NPS to prevent accidents. Such a design concept which features a number of layers of safety is referred to as defence in depth. Only when the most extreme accident conditions occur resulting in failure of multiple layers of defence, could there be a release of radioactivity to the outside environment. The last layer of defence to protect people is the emergency plan.

The input data into the design of the emergency preparedness and response plan are the postulated severe accidents of that particular reactor design combined with lessons learnt from real-life accidents that have occurred in the world such as the Three Mile Island (TMI), Chernobyl, and Fukushima nuclear accidents, as well as nuclear accidents originating from non-nuclear power plants.

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12.3 Emergency Planning Zones

It is an international norm that three EPZs made up of three circles of different radii centred from the reactor, are established. In determining the EPZ, the following criteria should be used in the definition of the required zones (refer to Figure 42):

- EZ: Effective dose (projected) of 100 mSv in the first 7 days;
- LPZ: Effective dose (projected) of 100 mSv per annum; and
- Overall EPZ: Effective dose (projected) of 1 mSv per annum

The radii of different EPZs are calculated by using the radioactive source term from a postulated severe accident, referred to as the reference accident case to avert radiological health risk. The reference accident is determined by evaluating all accidents that scoped the highest percentage of severe accidents and the corresponding highest percentage of risk. Therefore, since accidents with the highest probability do not necessarily translate into accidents with the highest risk, an extensive study is conducted to find the point where severity of an accident balances with the risk. In most Generation II PWRs, the reference accident has been found to scope 98% of severe accidents with frequency of one in a million years (10^{-6} per annum) and scoped 72% of the risk.

To evaluate and select the acceptability of the technology, a similar criterion will be used in conjunction with the plant parameter envelope (PPE). The assessment will not only be based on price/affordability and design criteria but will also ensure that the magnitude of EPZs is adequate so that the operation of the reactor does not pose undue risk to members of the public. The intention for the parameters is to achieve the following objectives:

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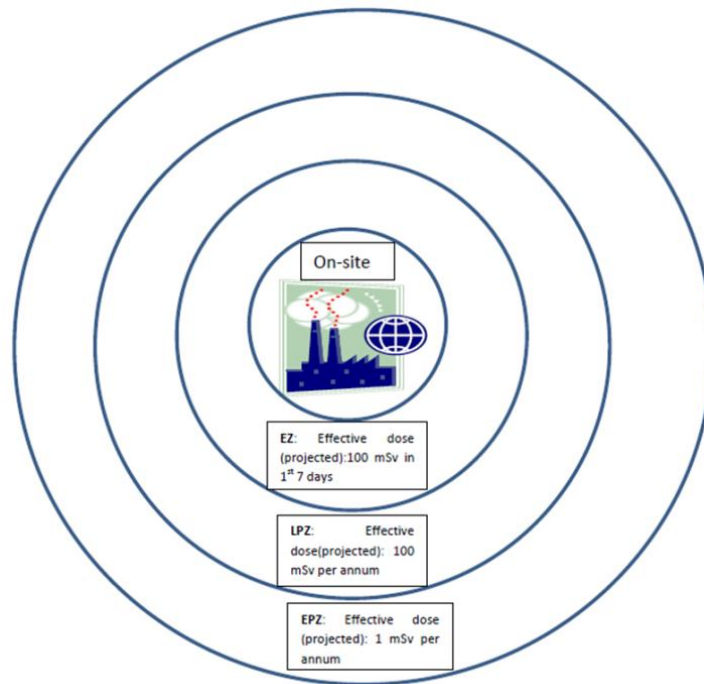


Figure 42: Relationship among Various Zones around the Nuclear Power Plant
(in accordance with PP-0015) [25]

- Minimal emergency protection action beyond 800 m from the reactor should the accident result in early releases of radioactivity to the atmosphere from the reactor containment building;
- No delayed action such as temporary transfer of people at any time beyond approximately 3 km from the reactor;
- No long-term action involving permanent (longer than 1 year) resettlement of the public at any distance beyond 800 m from the reactor;
- Restriction on the consumption of foodstuff and crops should be limited in terms of timescales and ground area in order to limit the economic impact.

To evaluate the acceptability of the proposed EPR and AP1000 technologies, a PRA / PSA using site characteristics and relevant source term information to determine the risks to the public and workers on the Thyspunt site resulting from a potential release as a consequence of a severe accident was conducted. The conclusions from this study are as follows:

- The annual expected station risks due to reactor accidents for the population within a 50 km radius around the site was deemed to be well within the NNR risk limits.
- The safety criteria as well as the bias against larger accidents has been satisfied for the limited scope PSA.

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- Although the study was limited in scope and not all data site-specific, it is considered adequate for the site licensing stage as long as the selected reactor designs have the same or similar features as the EPR and/or AP1000. Where site-specific input data was not available, conservative assumptions were made.

12.4 Urgent Protective Countermeasures

The implementation of the urgent protective measures is based on the generic intervention levels (GILs), which are levels for the implementation of that countermeasure. These are summarised in Table 14 alongside their respective protective action. It is important to mention that the GILs values tabulated below are not unique to South Africa's nuclear regulatory requirements; they were derived by the International Atomic Energy Agency (IAEA) and are used worldwide.

Table 14: Protective actions and their corresponding generic intervention levels

Protective Action	Generic Intervention Level	Exposure Duration	Objective for EPZ Distance, km
Sheltering	10 mSv	2 days	0.8
Evacuation	50 mSv	7 days	0.8
Iodine prophylaxis	100 mGy	—	0.8
Temporary relocation	30 mSv during initial 30 days and 10 mSv in subsequent 30 days		3
Permanent resettlement	1 000 mSv	Lifetime	0.8
Food banning/replacement			40

12.5 Taking Credit for the Effectiveness of Protective Countermeasures

It has been proven that when protective countermeasures are implemented in time, there is a reduction in the dose to which members of the public are exposed to. Dose reduction depends on the intervention adopted and the time it was implemented after notification of an emergency.

To ensure that the PSA results are a conservative representation of the on- and off-site radiological consequences resulting from an accidental release, the following assumptions were considered:

- No credit was taken for on-site mitigative actions which will be documented in severe accident management guidelines in the operational stage.
- No emergency plan countermeasures (sheltering, evacuation, and iodine prophylaxis), other than a food ban, have been assumed.

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12.6 Control of Foodstuff: Generic Action Levels

Control of food and water may have to be instituted to prevent members of the public from consuming contaminated foodstuff. The circumstances that influence the decision whether to institute such countermeasures, may be divided into three categories: availability of alternative supplies; where alternative supplies are scarce; and for distribution in international trade. Control or withdrawal of foodstuff from consumption is implemented when the radioactivity of a certain group of isotopes in a certain category of food stuff has reached a pre-determined level of radioactivity; and this radioactivity level is known as the generic action level (GAL). The generic action levels that have been established for use by national authorities when alternative supplies of food are available are listed in Table 15. As stated, the GAL values depend upon the type of foodstuff and the type of contaminating radionuclide. The radionuclides in question are those most likely to be of concern in foods following an accident. In situations where extensive restrictions on food supplies could result in nutritional deficiencies or, in the extreme, starvation, case-by-case evaluations will be required. In most such situations, relocation will be indicated and alternative food made available. However, when this is not possible, the radiation hazard must be considered realistically in comparison to competing health hazards, and higher action levels should invariably be adopted. Following any event that may contaminate foodstuffs, a variety of countermeasures may be instituted at various stages in production and marketing. These should be implemented to ensure that, to the maximum extent practicable, foodstuffs are maintained below the action levels. The generic action levels for foodstuffs will also satisfy the requirements for distribution of foodstuffs in international trade for consumption in countries unaffected by an accident.

The results show that emergency actions for the two reference reactor technologies would be limited. No off-site short-term emergency interventions would be required beyond the owner controlled boundary of the NPS. However, the final emergency plan will be based on EPZs agreed to by the NNR.

The feasibility of an emergency plan that can be extended even beyond the calculated EPZs, depends on acceptable site aspects such as the absence of adverse conditions which could hinder the ingress or egress of external services that may be needed to deal with an emergency. These aspects are discussed in the next section.

Table 15: Generic action levels for foodstuff

Foodstuff destined for general consumption		
Isotope Group	Radionuclide	Generic Action Level (GAL) [kBq/kg]
1	¹³⁴ Cs, ¹³⁷ Cs, ¹⁰³ Ru, ¹⁰⁶ Ru, ⁸⁹ Sr, ¹³¹ I	1
2	⁹⁰ Sr	0.1
3	²⁴¹ Am, ²³⁸ Pu, ²³⁹ Pu, ²⁴⁰ Pu, ²⁴² Pu	0.01

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Foodstuff destined for general consumption		
Isotope Group	Radionuclide	Generic Action Level (GAL) [kBq/kg]
Milk, Infant food, and water		
4	¹³⁴ Cs, ¹³⁷ Cs, ¹⁰³ Ru, ¹⁰⁶ Ru, ⁸⁹ Sr	1
5	⁹⁰ Sr, ¹³¹ I	0.1
6	²⁴¹ Am, ²³⁸ Pu, ²³⁹ Pu, ²⁴⁰ Pu, ²⁴² Pu	0.001

12.7 Classification of nuclear emergencies

There are progressive stages of response to a nuclear emergency plan, depending on the seriousness of the potential consequences of an accident. These are:

- **Unusual Event:** An abnormal occurrence that indicates an unplanned deviation from normal operations, the actual or potential consequences of which require notification of the emergency controller and activation of the appropriate components of the nuclear emergency plan.
- **Alert:** A situation exists that could develop into a site or general emergency and therefore requires notification of all emergency personnel in order to obtain a state of readiness to respond.
- **Site Emergency:** An emergency condition exists that poses a serious radiological hazard on site but poses no serious radiological hazard beyond the public exclusion boundary.
- **General Emergency:** An emergency condition exists that poses, or potentially poses, a serious radiological hazard beyond the public exclusion boundary.

An analysis to demonstrate the viability of an emergency plan should take into account the characteristics of the site relevant to the design assessment, risk and dose calculation, external events, meteorological data, land-use, population demographics, regional development, and projection of the above data commensurate with the design life of the nuclear installation.

13. RADIOACTIVE WASTE MANAGEMENT AND DECOMMISSIONING STRATEGY

13.1. Provisions for the Management and Disposal of Radioactive Waste

Radioactive waste will be managed in accordance with the Radioactive Waste Management Policy and Strategy for the Republic of South Africa of 2005 [3].

The NNR regulates all nuclear activities and the management of radioactive waste in terms of its mandate set forth in the National Nuclear Regulator Act (1999) [36] as amended. In terms of the Nuclear Energy Act (1999) [35] as amended, the authority over radioactive waste and irradiated fuel waste is the Minister of Energy.

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The quantity of waste will depend on the operating procedures in force at the power station. The proposed power station, similar to the KNPS, will produce levels of low-level waste (LLW), intermediate-level waste (ILW), and high-level waste (HLW). LLW and ILW contain radioisotopes that decay relatively quickly in nuclear terms (30 to 300 years, respectively).

13.2. Vaalputs Radioactive Waste Disposal Site

In accordance with the National Radioactive Waste Management Policy and Strategy, Vaalputs Radioactive Waste Disposal Site, located in the Northern Cape, is the designated facility for the disposal of L&ILW in South Africa. Vaalputs has been designed and permitted with sufficient capacity for handling the L&ILW from KNPS and any new nuclear power station(s). Disposal at the site is carried out in terms of a nuclear authorisation granted by the NNR under the National Nuclear Regulator Act, 1999 (Act No. 47 of 1999) [36] as amended.

Historically, the South African Nuclear Energy Corporation (NECSA) was charged with and operating the Vaalputs radioactive waste disposal facility.

The role of NECSA has been transferred to the National Radioactive Waste Disposal Institute established as an independent entity by statute under the provision of section 55(2) of the Nuclear Energy Act (No. 46 of 1999) [35] and the National Radioactive Waste Disposal Institute Act, (No. 53 2008) [37] to provide professional Nuclear Waste Management and Disposal Services in South Africa on behalf of the state.

13.3. Decommissioning Strategy

When the nuclear power station has reached the end of its viable lifetime approximately 60 years after commissioning, it will be decommissioned. According to RD-0026 [23], decommissioning is defined as an administrative and technical action taken to allow the removal of all the regulatory controls from a facility (except for a repository which is not closed and not decommissioned). For nuclear facilities, decommissioning is the final phase in its lifecycle after siting, design, construction, commissioning, and operation. It is a complex process involving operations such as detailed radiation surveys, decontamination, and dismantling of plant, equipment and facilities, demolition of buildings and structures, site remediation, as well as the management of resulting waste and other materials. All activities take place under a regulatory framework prescribed and authorised by NNR (refer to RD-0026 [23]) that takes into account the importance of the health and safety of the operating staff, the general public and protection of the environment.

A decommissioning strategy developed in accordance with Regulation R.388 [4] and RD-0026 [23] will be submitted to the NNR as part of the conceptual decommissioning plan at the design phase and will be updated throughout the operation of the authorised action of the plant as a basis of a detailed decommissioning plan.

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The decommissioning plan for the proposed nuclear installation(s) is likely to be similar to the plan for Koeberg Nuclear Power Station. This plan provides for the following key phases of decommissioning.

Phase 1: Preparations

This phase will be initiated seven years prior to shutdown of the nuclear power station. It includes a detailed list of preparatory functions (e.g. development of a decommissioning project team organisation), investigations and studies (e.g. environmental impact assessment, cost effective feasibility study, compilation of quantities of radioactive material to be secured, control mechanisms, and waste characterisation, including a quantitative estimate of the type, amount, and location of important radionuclides at the end of operating life, etc.), procedures and technical specifications (e.g. final shutdown and defueling sequencing, procedures for occupational exposure control, control and release of liquid and gaseous effluent, processing of radioactive waste, site security, emergency programmes, and industrial safety), and temporary construction facilities to support dismantling activities (e.g. centralised processing areas to facilitate equipment removal and component preparation for off-site disposal, upgrading of roads to facilitate hauling and transportation, fabricate shielding in support of removal and transportation activities, construction of contamination control envelopes, and the procurement of specialised tooling.)

Phase 2: Plant shutdown and defueling

Decisions are made about the final shutdown dates of the units (namely after the winter peaks or at the optimum fuel utilisation stage) and the detailed final plant shutdown and defueling plan is implemented.

Phase 3: Implement the used fuel pool cooling separation plan

Once the fuel has been transferred to the spent fuel pool, the spent fuel pool separation plan is implemented to establish an independent spent fuel pool cooling system.

Phase 4: Decommissioning operations

This phase includes the following tasks:

- Demolition of conventional island and auxiliaries;
- Safe enclosure preparation; and
- Electromechanical dismantling.

Phase 5: Used fuel removal and electromechanical dismantling of the fuel building and auxiliaries

After 10 years of decay in the used fuel pool, the last full load of fuel would have sufficiently cooled down to be removed from the pools. The used fuel is then relocated to dual-

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purpose casks (storage and transport) for transfer to the national repository. Once the used fuel pools have been emptied, the plant can be decontaminated and decommissioned in accordance with the plan.

Phase 6: Demolition of remaining structures and site rehabilitation

The dismantling of the non-essential structures at the site will commence once fuel transfer operations are complete. Site areas affected by the dismantling activities are cleaned and the plant area graded as required to prevent pounding and inhibit the floating of sub-surface materials.

The exact contents of the decommissioning plan are unknown at this stage, and it would only be finalised once an application is made for the decommissioning of the nuclear installation.

14. TRANSPORTATION OF RADIOACTIVE WASTE AND RADIOACTIVE MATERIAL

South Africa is a member state of the International Atomic Energy Agency (IAEA) and therefore subscribes to the transport regulations set out by the IAEA (refer [18]) for the safe transport of radioactive materials such as nuclear fuel, low and intermediate level radioactive waste, and mineral concentrates. These requirements have been incorporated into South African regulations (refer to RG-0007 [27], and RG-0008 [28]). Authorisation from the NNR must therefore be obtained before any radioactive material is transported. These include the application for a nuclear vessel licence to transport nuclear fuel from the manufacturer to a harbour near the nuclear power station.

The purpose of adopting the IAEA transport regulations and incorporating them into South Africa's regulations is to "*...protect persons, property, and the environment from the effects of radiation during the transportation of radioactive material...*". This is achieved by making recommendations with regards to the methods of containment, shielding, and prevention.

The nuclear fuel will be transported by sea (shipment) in specially designed robust steel containers to the nearest harbour like in the case of abnormal and heavy haul loads in accordance with the IAEA regulations and NNR regulatory requirements which set the basis for nuclear fuel cycle material transport. The NNR oversees that these regulations are complied with by conducting regular inspections and audits. Internationally, there have been no serious incidents in the history of nuclear material transport, mainly due to the effort and expense which goes into ensuring safety.

Radioactive waste (low and intermediate level) that will be generated by the nuclear power station will be transported to Vaalputs Radioactive Waste Disposal Site. It is proposed to be transported via the N7 to Vaalputs.

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15. CONCLUSION

This document provides members of the public with a broad overview of the project; the regulations that Eskom must comply with before an authorisation for nuclear site licence (NISL) and NIL can be obtained (given that these are two separate processes). As alluded to earlier, the NIL represents the primary authorisation for the construction, operation, maintenance, decontamination, and decommissioning of the nuclear installation based on a specific technology design. The associated PID for this NIL application will be developed once an application for an NIL is made.

Every effort has been made to provide the public with all pertinent information on the nature of the NISL authorisation applied for and the associated hazards. In particular, clear evidence has been provided that all hazards that could result in ionising radiation have been identified and that these can be kept ALARA. It can therefore be concluded that the Thyspunt site has been adequately characterised as a suitable site to locate a new nuclear installation(s).

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APPENDIX A: INTERNATIONAL GUIDES, CODES AND STANDARDS

International guides, codes and standards considered in the development of the Thyspunt Site Safety Report that fed into this document are listed below.

International Atomic Energy Agency (IAEA) guides, codes, and standards

- Fundamental Safety Principles, Safety Fundamentals No. SF-1.
- Site Evaluation for Nuclear Installations, Safety Standard Series No. SSR-1.
- Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluation for Nuclear Power Plants, Safety Standard Series No. NS-G-3.2.
- Design of Nuclear Installations Against External Event Excluding Earthquakes. Safety Standard Series, Safety Standard Series No. SSG-68.
- Meteorological and Hydrological Hazards in Evaluation for Nuclear Power Installations. Safety Standard Series No. SSG-18.
- Hazards Associated with Human Induced External Events in Site Evaluation for Nuclear Installations. Safety Standard Series No. SSG-79.
- Seismic Design for Nuclear Installations, Safety Standard Series No. SSG-67.
- Seismic Hazards in Site Evaluation for Nuclear Installations. Safety Standard Series No. SSG-9.
- Volcanic Hazard in Site Evaluation for Nuclear Installations, Safety Standard Series No. SSG-21.
- Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants. Safety Standard Series No. NS-G-3.6.
- Managing Siting Activities for Nuclear Power Plants. Technical Report No. NG-T-3.7.
- Site Survey and Site Selection for Nuclear Installations. Safety Standard Series No. SSG-35.

United States Nuclear Regulatory Commission (USNRC)

- USNRC 10 Code of Federal Regulations Chapter 1, Part 100, Reactor Site Criteria.
- USNRC 10 Code of Federal Regulations Part 52 (10 CFR 52) Process for Early Site Permits, Standard Design Certification and Combined Construction and Operating Licence.
- USNRC Regulatory Guide 4.7 on General Site Suitability Criteria for Nuclear Power Stations.

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- USNRC Regulatory Guide 1.208 Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion.
- USNRC Regulatory Guide 1.132. Site Investigations for Foundations of Nuclear Power Plants.
- USNRC NUREG-0800 Standard Review Plan for the Review of Safety Analysis Report (SAR) for Nuclear Power Plants.
- USNRC NUREG/CR-6966 Tsunami Hazard Assessment at Nuclear Power Plant Sites in the United States of America.
- USNRC Regulatory Guide 1.27 Ultimate Heat Sink for Nuclear Power Plants.
- USNRC Regulatory Guide 1.59 Design Basis Floods for Nuclear Power Plants.
- USNRC Regulatory Guide 1.70 Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants.
- USNRC Regulatory Guide 1.206 Combined Licence Applications for Nuclear Power Plants.
- USNRC Regulatory Guide 1.102 Flood Protection for Nuclear Power Plants.

Electric Power Research Institute (EPRI)

- Site Selection and Evaluation Criteria for New Nuclear Energy Generation Facilities.

International Organisation for Standardisation (ISO)

- ISO 9001-2008, Quality Management Systems – Requirements
- ISO 14001: 2005, Environmental Management Systems – Requirements.
- ISO 9225:1992 Corrosion of Metals and Alloys – Corrosivity of Atmospheres – Measurement of Pollution.
- ISO 9224:1992 Corrosion of Metals and Alloys – Corrosivity of Atmospheres – Guiding Values for the Corrosivity Categories.
- ISO 17025:2005. General Requirements for Competence of Testing and Calibration Laboratories.
- ISO 9001-2015, Quality Management Systems – Requirements.

International Commission on Radiological Protection (ICRP)

- Assessing Dose of the Representative Person for the Purpose of Radiation Protection of the Public: ICRP Publication 101, Part1 (ICRP, 2005).

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- General Principles for the Radiation Protection. Annals of the ICRP. Publication 75 (ICRP, 2006).
- The 2007 Recommendations of the International Commission on Radiological Protection. Annals of the ICRP, Publication 103.
- The concept and use of Reference Animals and Plants, ICRP Publication 108.
- Age Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients. Publication 72 Volume 26.

American Nuclear Standards Institute (ANSI)

- Criteria for Investigations of Nuclear Facility Sites for Seismic Hazard Assessments. Standard ANSI/ANS-2.27-2008.

American Society of Civil Engineers (ASCE)

- Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities. ASCE/SEI 43-05.

South African National Standards (SANS)

- SANS 241:2006. South African Standard Code of Practice for the General Procedures and Loadings to be adopted in the Design of Buildings.

European Utility Requirements (EUR) Organisation

- European Utility Requirements for Light Water Reactor (LWR) Nuclear Power Plants.

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