SECTION 5.2: *MONITORING*

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Rev	**Draft**	**Date**	**Description**
0		April 2015	New section. Thyspunt Site Safety Report compiled in support of Eskom's Nuclear Installation Site Licence for the Thyspunt site.
0a		January 2025	Section updated to address NNR and Eskom comments.
0b		March 2026	Section updated to make minor editorial corrections.

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EXECUTIVE SUMMARY

This section of this Site Safety Report (SSR) presents the rationale, scope and content of the various monitoring programmes implemented at the site where a new nuclear installation(s) is planned to be built. It covers monitoring to March 2024 and that which will continue into the future in terms of:

- groundwater;
- surface water;
- meteorology;
- oceanography;
- seismology;
- background radiation.

The relevant guidelines and regulations issued by Eskom, the National Nuclear Regulator and the International Atomic Energy Agency are used to inform the approach to the various monitoring programmes. These are described in terms of parameters, frequency, monitoring stations and purpose but results are only described in the relevant SSR sections.

With respect to the monitoring programmes implemented and operational at the site, the following conclusions are drawn:

- The programmes adequately cover the key activities required to fully describe the physical characteristics of the site to demonstrate compliance with licensing requirements.
- No anomalous or critical data or trends have been detected by the monitoring programmes to date (up to March 2024).
- The monitoring programmes are contributing valuable information for the reduction of uncertainties at the site.
- The adequacy and need for the various monitoring programmes will be assessed on an annual basis.
- Monitoring data will be incorporated into scheduled revisions of this SSR. Any outliers deviating from trends/ranges so far established will be investigated and the results used to modify predictions/designs as necessary and appropriate.
- An adequate management system has been implemented and followed in the operation of the monitoring programmes and acquisition and storage of monitoring data, including establishment of monitoring protocols, to fulfil all quality assurance requirements for a nuclear installation site.

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5.2 MONITORING

5.2.1 Introduction

This section of this Site Safety Report (SSR) presents the rationale, scope and content of the various monitoring programmes implemented at the site where a new nuclear installation(s) is planned to be built. It covers monitoring to March 2024 and that which will continue into the future.

5.2.2 Purpose and Scope

This section covers all the site-specific characteristics and environmental data necessary for this SSR. Only those monitoring activities that are required for the compilation and update of this SSR are covered here. This section therefore does not deal with the *ad hoc* type information gathering exercises that form part of the SSR compilation and update, e.g. population, or monitoring required for the Environmental Impact Assessment process, e.g. ecological indicators. It presents the overall monitoring programme for the site based on the specific monitoring activities discussed in each of the remaining sections of ***Chapter 5*** (Site Characteristics) of this SSR.

5.2.3 Regulatory Framework

The development and implementation of the monitoring programmes covered in this section have been based on the current national legal and regulatory framework (see ***Chapter 2***, Legal and Regulatory Basis) at the time of this SSR development. The Regulations on Licensing of Sites for New Nuclear Installations (Department of Minerals and Energy, 2011), does not contain any specific reference to monitoring. However, the following Regulation has relevance:

- *"Regulation 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;*
  - *f) projections of the above data commensurate with the design life of the nuclear installation(s)."*

In addition, the following requirements documents, national and international guides and position papers have relevance:

- National Nuclear Regulator (NNR), Regulatory Guide RG-0011, Interim Guidance on the Siting of Nuclear Facilities (National Nuclear Regulator, 2016).

- NNR Requirements Document RD-0034, Quality and Safety Management Requirements for Nuclear Installations, applicable sections depending on the safety classification of the particular activity (National Nuclear Regulator, 2008).

- IAEA Safety Standard Series report, Safety Guide No NS-G-3-2, Dispersion of Radioactive Material in Air and Water and Consideration of Population Distribution in Site Evaluations for Nuclear Power Plants (International Atomic Energy Agency, 2002), sections 2 and 3, transport and diffusion of effluents discharged into the atmosphere and hydrosphere, respectively.

5.2.4 Approach

The purpose of the monitoring described herein is to assist in defining the baseline characteristics of the site and to assist in the management of uncertainties. Monitoring of materials and events that could have an impact on the nuclear installation (e.g. degradation, corrosion) and monitoring of parameters for confirmation of estimates of public exposure are not covered here. However, corrosion is covered in ***Sections 5.8*** (Meteorology) and ***5.11*** (Geohydrology).

This section covers all natural site characteristics and presents the monitoring activities that are being carried out for this SSR. The site is a greenfield site where it is proposed to establish a new nuclear installation(s). Collection of data is continuing, and databases are being updated and evaluated on a regular basis. The new information will be taken into account in scheduled updates of this SSR and *ad hoc* submissions to the NNR.

5.2.5 Monitoring Programmes

The monitoring programmes implemented for this site investigation stage are designed to provide adequate and sufficient information about the characteristics of the site for this SSR approval and licensing purposes. The programme is based on measurements of site parameters requiring long-term data sets, i.e. two years or longer, as required by the IAEA (International Atomic Energy Agency, 2002). The main objective of the monitoring is to provide sufficient understanding and assurance on the suitability of the site based on reliable analysis of site parameters relevant for nuclear installation safety through the facility lifetime. It also aims at confirmation of the assumptions used in the conceptual and numerical models for the site, and at managing and obtaining a better understanding of any uncertainties.

A summary of the site monitoring programmes is presented in ***Table 5.2.1*** and

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listed below. More details on the groundwater, surface water, oceanography, meteorology and radionuclides monitored, sampling frequency, sampling and analysis methods, sampling location and density etc. will be addressed as part of the safety case for a construction licence. Compliance with quality requirements is indicated in ***Table 5.2.4***. These programmes are all being carried out by Eskom's contractors. Monitoring stations are shown in ***Drawings 5.2.1*** and ***5.2.2***. The site materials corrosion monitoring programme being carried out by Eskom is not included here as this impacts on investment and operating costs rather than safety. The ambient radiation survey started in the last quarter of 2012 and the preliminary survey as indicated in ***Table-5.2.1*** and ***Table-5.2.2*** was reported in the Report on Background Radiation (Eskom, 2014). This was of a screening nature to obtain an initial radiological profile of the site and the region in which it is located. Specific baseline radioactivity monitoring will be addressed during the next licensing phase.

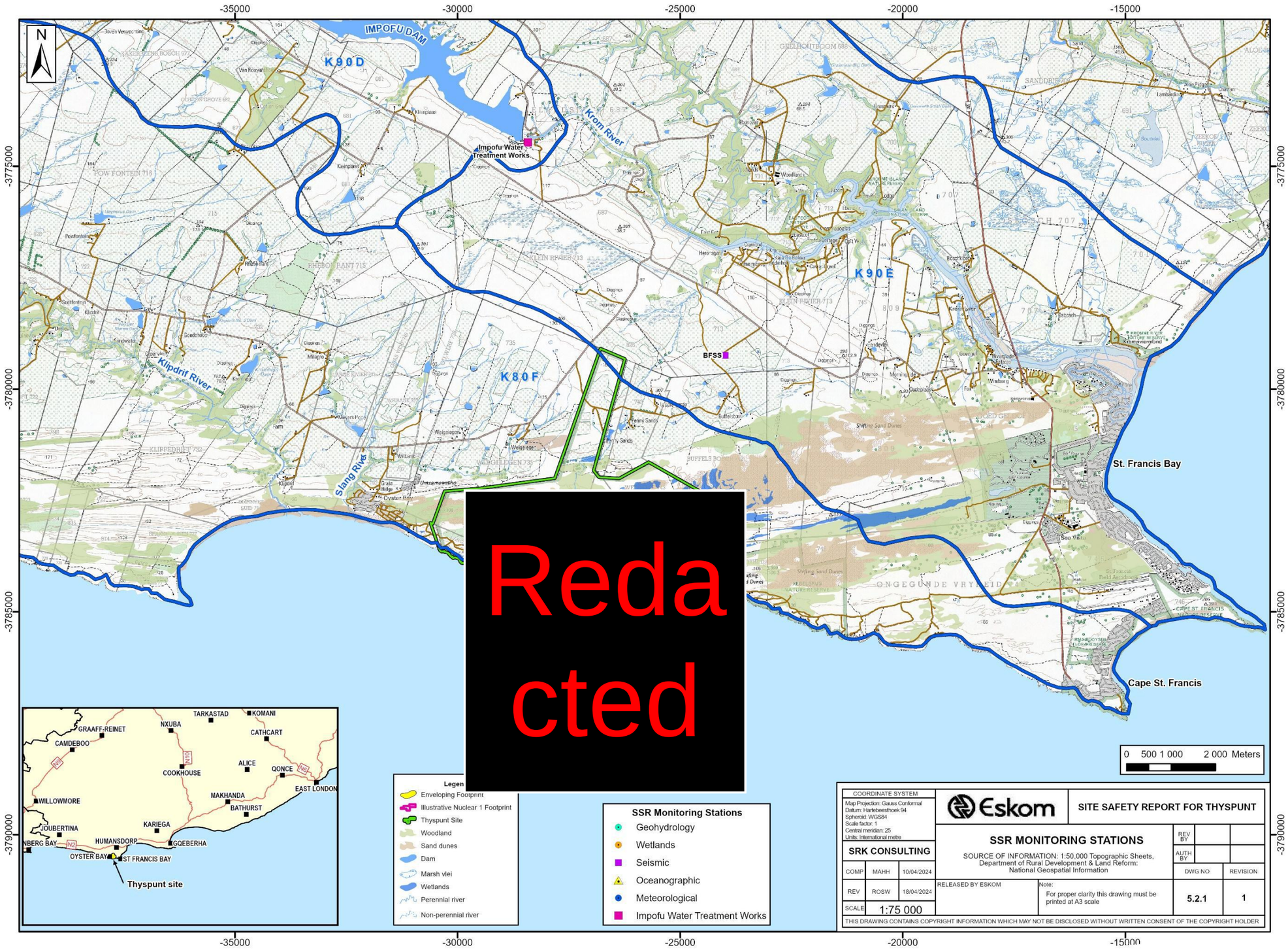
Table 5.2.1
Summary of the Thyspunt SSR Monitoring Programmes

Discipline	Parameters Monitored	Frequency	Monitoring Stations/Method(s)	Purpose
Geohydrology	Groundwater levels Electrical conductivity	Continuous (recorded hourly)	Boreholes	Firm-up predictions on site groundwater level maximum/minimum fluctuations
	Groundwater quality: Macro- chemistry Selected trace elements Selected radionuclides	Hydrocensus and biannually	Boreholes/springs	Establish baseline quality and corrosivity potential
Meteorology	Rainfall Wind velocity and direction Temperature (two levels) Humidity Barometric pressure Solar radiation Corrosion Lightning Visibility	Continuous	10 m tall met mast (approximate 48 m tall met mast, at least three years prior to construction) South Africa Weather Services	Establish site climatological regime. Prediction of extreme weather phenomena.
Hydrology	Rainfall	Continuous	See Meteorology/ Oceanography	Predict run-off and flood levels/risk
	Surface water flows	Continuous	Perennial rivers (DWS stations)	Predict run-off and flood levels/risk
	Surface water quality: Macro-chemistry	May and November of one year	Rivers and wetlands	Baseline quality

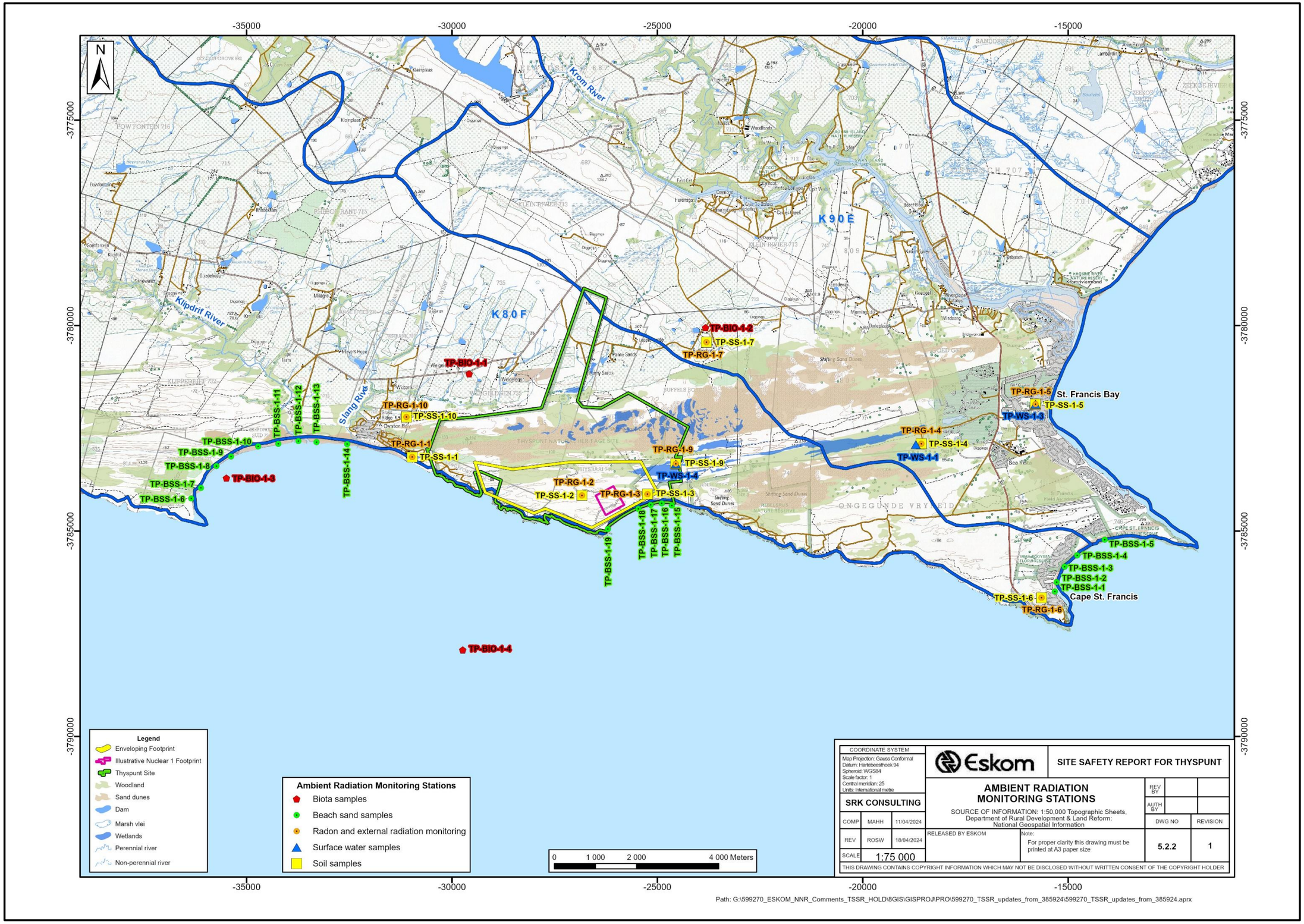
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Discipline	Parameters Monitored	Frequency	Monitoring Stations/Method(s)	Purpose
	Selected trace elements Selected radionuclides			
Oceanography	Waves Currents Water level Water temperature Salinity Turbidity Beach profiles	Continuous Beach profiles measured quarterly then annually	Acoustic Doppler Current Profilers (ACDP) at 10 m and 30 m water depth Temperature sensor Pressure sensor DGPS beach survey	Prediction of maximum wave run-up height. Cooling water intake and outfall suitability.
Seismology	Micro-seismic waves	Continuous (from 2008)	Micro-seismic station	Seismic hazard analysis. Prediction of maximum ground acceleration
Ambient radiation (preliminary survey reported on in (Eskom, 2014)	Radon gas, K-40, U-238, Th-232, Cs-137, C-14, H-3, Sr-90	Over one year. Once-off airborne gamma survey; seasonal water, biota and air sampling	Airborne gamma surveys; soil, water, biota, dairy cow milk and air samples	Determine reference background levels

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Geohydrology

Groundwater forms an important component of the site physical characteristics and occurs at shallow levels in the enveloping footprint area. Groundwater monitoring is therefore a key issue to assist in determination of site suitability. Pre-construction monitoring is focussed on the following and started in February 2008:

- **groundwater levels** – monitored to provide valuable information on seasonal trends and response to extreme weather conditions, e.g. high rainfall events and droughts - Monitoring borehole sites were selected with reference to the likely position of the nuclear installation within the enveloping footprint.
- **wetlands/seeps** – monitored to determine interaction with groundwater and the possible long-term effect (quality, water level/flow rate, as applicable) of site groundwater control measures.
- **groundwater quality** – monitoring of pH, electrical conductivity, macro-chemistry and selected trace elements and radionuclides to provide a baseline data set.

On the basis of the results up to January 2024 and this SSR developed for the site, additional monitoring points will be established to provide a more extensive network and confirmation of the site parameters prior to construction activities. Detailed monitoring data are presented in ***Section 5.11***.

Meteorology

Meteorological monitoring at the site began on 10 January 2008 with the establishment of an on-site meteorological station. It consists of a 10 m mast, fully equipped with instrumentation to measure the following parameters:

- wind vector (speed, direction and standard deviation of horizontal direction, i.e. ‘sigma theta’);
- ambient temperature (at two levels);
- relative humidity;
- solar radiation;
- atmospheric pressure;
- rainfall;
- lightning;
- corrosion;
- visibility.

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The major topographical features at the site run parallel to a northwest to southeast vector. The topography in the immediate vicinity (10 km) and north of the site is characterised by undulating hills with heights reaching less than 200 m above mean sea level (m amsl). Closer to the site, the hills (dunes) run more parallel to the coastline and rise up to maximum heights of about 98 m. Further north (20 km), the topography rises to about 230 m amsl, with a maximum elevation of 310 m amsl occurring in the northwest of the study area.

It is important and necessary to gain a good understanding of atmospheric conditions near the nuclear installation and therefore the location of the onsite weather station was selected in such a manner to be free from influence of any nearby features, including those of natural (e.g. dunes) and man-made origin. Furthermore, since it is important to determine meteorological parameters in free wind flow, the weather station was located on the first dune range from the shoreline, thereby minimising the potential local disturbance that the east-west dune patterns may introduce. The selection of a suitable location for the mast and all instrumentation took a number of factors into account to ensure the quality of the measurements.

The base of the mast is at a height of 51 m amsl. The closest dune higher than this is to the west, at a distance of approximately 520 m, and has a height of about 70 m amsl. Due to the relatively low relief, it is not expected that the prevailing wind speed or direction vary significantly across the region. Therefore, the wind speed and direction at a single location is considered to adequately represent the wind field for the purposes of this SSR. Concurrent measurements are being made at the South African Weather Services station at Cape St. Francis, approximately 9.3 km east of the site. Detailed meteorological monitoring data are presented in ***Section 5.8***.

Measurements at higher levels are required at least one year prior to the start of the plant construction. As a minimum, the height of the measurements must allow the observation of the diffusion conditions at the same level as the highest release points at the nuclear installation. This may be in the form of a tall mast or a Doppler Acoustic Sounding device.

Hydrology

There are no major or perennial water courses crossing the site and the only permanent water bodies at the site comprise wetlands and coastal seeps. SSR monitoring is restricted to the site only, since upstream dams are being monitored by the Nelson Mandela Bay Metropolitan Municipality and regional river flows by the Department of Water and Sanitation (DWS). Climatological, wetlands and tidal monitoring are covered under ***Section 5.8*** (Meteorology), ***Section 5.11*** (Geohydrology) and ***Section 5.9*** (Oceanography), respectively.

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Detailed monitoring data are presented in ***Section 5.10***.

Oceanography

The site is a coastal site bordered by the Indian Ocean. Monitoring of oceanographic parameters is therefore a key element in determining the site suitability. The following oceanographic parameters are being monitored:

- waves;
- currents;
- water level;
- water temperature;
- salinity;
- turbidity;
- beach profiles.

In this regard a comprehensive data collection programme has been implemented at the site. The objective of this programme is to provide baseline data for the evaluation of the nuclear installation safety, the design of coastal structures at the site, and calibrating the numerical models to confirm that models are accurate and can thus be used for prediction of both frequent and rare events. The programme commenced in January 2008 and detailed monitoring data are presented in ***Section 5.9***.

Seismicity

Seismicity is the single most important parameter determining a site's suitability for establishment of a nuclear installation. Seismic monitoring is aimed at reconfirming the suitability of an area for a nuclear installation, mapping seismicity within a selected study area and the identification of active geological features. It is important that sufficient data be gathered that can be used as input for a Seismic Hazard Analysis. The South African National Seismograph Network (SANSN) forms the regional database and consists of the historic database covering the period 1620 to 1970 and an instrumental database spanning the period 1971 to 2010.

A micro-seismic monitoring programme was previously operated on a continuous basis in the proximity of the site for the period 1997 to 2003, by means of a seismograph at Buffelsbos. This seismograph station was decommissioned during September 2003. A total of 26 earthquakes were recorded during the operational period, with only three earthquakes ranging in size from ML (Local Magnitude scale) 1.3 to ML 3.7, recorded within a 100 km radius of the site. This station was re-opened in September 2008 and

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incorporated into the SANSN, but in the subsequent period no significant seismic activity was recorded close to the site, and specifically within the regulatory 8 km boundary around the site. This seismic monitoring station is to continue operating throughout the entire life-cycle of the proposed nuclear installation. The station was sited with respect to suitable bedrock outcrop, low background 'noise', availability of power/cell phone communication and protection. Details on seismic monitoring are presented in ***Section 5.14***.

Background Radiation

A preliminary, background radiological survey/study was reported on in 2014 (Eskom, 2014) and a more detailed pre-operational background radiological survey/study, in accordance with the requirements of RG-0011 (National Nuclear Regulator, 2016), will be conducted two to three years before construction. A summary of the preliminary background radiation monitoring elements and radio-analyses is given in ***Table 5.2.2*** and ***Table 5.2.3***, respectively. Location of the monitoring positions is shown on ***Drawing 5.2.2***.

Table 5.2.2
Main Elements of the Ambient Radiation Monitoring Programme

#	Monitoring element	Frequency of monitoring	Sampling Description	Equipment Type
1	Ambient external radiation	Continuous	Integrated monitoring Ten fixed locations	Thermo-Luminescent Dosimeters (TLD)
		Once per quarter	Large area mobile survey Stationary monitoring at sampling location	Portable Sodium Iodide Multi-Channel Analyser (NaI MCA) equipment
2	Atmospheric radon	Continuous	Integrated monitoring Ten fixed locations integrated	Radon Gas Monitors (RGM)
3	Soil radioactivity	Once per quarter	Ten locations	Necsa radio-analysis
4	Beach sand radioactivity	Once per quarter	≤3 composite samples	Necsa radio-analysis
5	Biota radioactivity	Once per quarter	≤4 land and marine biota samples	Necsa radio-analysis
6	Airborne radioactivity	Long duration sample at one location	Once-off	High volume air sampler

Table 5.2.3
Sample Matrix and Radio-analysis by Necsa

Sample Matrix	Radio-analysis
Biota	Determination of U and Th by neutron activation analysis (NAA)
	Po-210 analysis on *dried* material by radiochemical separation and alpha spectrometry; includes acid digestion step
	Broad energy gamma spectrometry for the analysis, in particular Pb-210, Ra-226, Ra-228, Th-228 and K-40 on *ash* material. *Also (Cs-137 662KeV)*
	Gross alpha/beta analysis to obtain a first order estimate of the total alpha and beta activity of the sample
Soil/Solid	Uranium and thorium by NAA. Uranium is determined as U-238 and thorium as Th-232.
	Low energy gamma analysis for the determination of Pb-210, U-235 and other products in the Th-232 and U-238 decay series.
	Quantitative gamma spectrometry for low level analysis with emphasis on Cs-137- 662KeV
Water	Uranium analysis (elemental)
	Gross alpha/beta analysis to get a first order estimate for the total activity

5.2.6 Reporting

Monthly, quarterly and annual monitoring reports are being produced which will be used in the regular update of this SSR. The monitoring reports that are gathered over the life of the site and used in the development and update of this SSR will be stored in the Nuclear Siting Studies archive and will be available to the regulator on request.

5.2.7 Management of Uncertainties

The key uncertainties pertaining to the site of relevance to site safety and management actions to deal with them are the following:

- seismic hazard - seismic hazard analysis (SHA) entails calculating the level of ground motion expected at a site based on a model of the regional and local seismicity (size and location of earthquakes). The related uncertainty is addressed by conducting a probabilistic SHA. (see ***Section 5.14***).
- capable faults (on-shore and off-shore) - No evidence of capable faults has been found in either the Site Vicinity or Site Area (see ***Section 5.13***).
- length of the monitoring record, which is relatively short for many parameters. However, in the case of e.g. meteorological data, longer term data sets from the Cape St. Francis meteorological station are used to compare and extrapolate trends. In the case of geohydrology and hydrology

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there have been drought periods and high rainfall events during the monitoring period which have enabled ground and surface water level responses to such 'extreme' events to be assessed.

- in the case of oceanography and coastal engineering, longer-term data sets obtained from nearby sites and from computer models have been used to supplement these measurements and to estimate extreme events in ***Chapters 5*** (Site Characteristics) and ***6*** (Evaluation of External Events).

Trends and ranges in recorded monitoring data are discussed in detail in the various sections of ***Chapter 5*** as listed above. Any outliers deviating from these ranges/trends arising during future routine monitoring will be assessed and assumptions, models and contingencies adapted as necessary.

5.2.8 Management System

All monitoring activities have been conducted in accordance with the overall management system for the production and update of this SSR (see ***Chapter 10***, Management System). Appropriate measures have been implemented to ensure the application of national standards and international best practice in the determination of the basis, scope and purpose of monitoring, as well as in the collection, transfer, storage, analysis, interpretation and presentation of monitoring data. Where data sets have been obtained by one organisation and passed on to another for further processing/incorporation into models, validity and accuracy of the data sets has been verified by an accompanying verification and approval certificate and referral to the supplying organisations' project quality plan and method statement.

Prior to the start of the monitoring programmes described herein, the following documents were compiled by the contractor and approved by Eskom to assist in quality assurance and ensure that site work was carried out safely:

- Project Quality Plan;
- Method Statement;
- Risk Assessment;
- Health, Safety and Environmental Management Plan.

Quality data packs accompanying each relevant section of Chapter 5 include:

- calibration sheets for field equipment;
- list of approved suppliers used;

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- certificates of accreditation for laboratories used;
- modelling rationale, benchmarking, validation and verification;
- peer review reports;
- monitoring protocols.

The organisations responsible for the monitoring of field parameters have adhered to all applicable regulatory requirements, in particular the requirements of the NNR requirements document RD-0034 (National Nuclear Regulator, 2008). Monitoring protocols complying with international best practice have been developed and used as part of this SSR management system (see ***Chapter 10*** and the applicable sections of ***Chapter 5*** and the accompanying appendices).

Monitoring protocols specify the purpose of the sampling and minimum standards for sampling rates, data capture, storage, transfer and archiving, which adhere to the minimum requirements for the collection, storage and transfer of data, as defined (National Nuclear Regulator, 2008) or a Nuclear Sites' approved alternative. A summary of activities, links within this SSR and quality requirements is given in ***Table 5.2.4*** below. The relevant safety classifications for the various monitoring disciplines are also listed.

Table 5.2.4
Summary of Activities, Links and Quality Requirements

Programme	Links		Safety Classification	Quality Requirements
	Inputs	Outputs		
Geohydrology	Groundwater levels Groundwater quality Rainfall	Information on groundwater levels and quality will provide essential input into Ecology, Hydrology, Geohydrology, Water Supply and Geotechnical sections (Sections ***5.3***, ***5.10***, ***5.11***, ***5.12*** and ***5.15***), and External Events (***Chapter 6***).	C	Project Quality Plan Method statement Monitoring protocol Calibration of field equipment, e.g. pH, EC and dip meters, data loggers, GPS. Laboratory accreditation

Programme	Links		Safety Classification	Quality Requirements
	Inputs	Outputs		
Meteorology	Rainfall Humidity Wind velocity and direction Temperature at two levels Lightning Visibility, Corrosion	Meteorological data will form input to the Meteorological, Hydrological, Geohydrological and Water Supply sections (***5.8***, ***5.10***, ***5.11*** and ***5.12***) and External Events and PRIPE, (***Chapters 6*** and ***7***).	C	Project Quality Plan Monitoring protocol Method Statement
Oceanography	Coastal accretion/erosion Water temperature Currents Wave height	Oceanographic data will form input to the Oceanography & Coastal Engineering, and Hydrology SSR sections (***5.9, 5.10)*** and External Events (***Chapter 6***)	C Safety level 4 Quality level 3	Project Quality Plan Method statement Monitoring protocol
Hydrology	Maximum wave height SA Weather Service data DWS flow gauging station data Rainfall	Hydrology data will form input to the Hydrology, Geohydrology, Fresh Water Supply sections (***5.10***, ***5.11*** and ***5.12)*** and External Events (***Chapter 6***)	B	Project Quality Plan Method statement Monitoring protocol
Seismology	Seismic event record	Seismic data will form input to ***Section 5.14*** and External Events (***Chapter 6***).	A	Covered by the SSHAC process
Background radiation (2-3 years before construction)	Pre-operational background radiological survey	Background radiological data will form input to Potential Radiological Impact to the Public and the Environment **(Chapter 7)**	L2	Project Quality Plan Method statement Monitoring protocol

Use of up-to-date monitoring and recording systems ensures that all data are readable and will be for the site lifetime.

Electronic records have been stored in a secure central repository with regular off-site back-up procedures. The overall quality management system complied with that set out in ***Chapter 10*** of this SSR. All references cited are saved on the central repository.

5.2.9 Conclusions

With respect to the monitoring programmes implemented and operational at the site, the following conclusions are drawn:

- The programmes adequately cover the key activities required to fully describe the physical characteristics of the site to demonstrate compliance with licensing requirements.
- No anomalous or critical data or trends have been detected by the monitoring programmes to date (up to March 2024).
- The monitoring programmes are contributing valuable information for the reduction of uncertainties at the site.
- The adequacy and need for the various monitoring programmes will be assessed on an annual basis.
- Monitoring data will be incorporated into scheduled revisions of this SSR. Any outliers deviating from trends/ranges so far established will be investigated and the results used to modify predictions/designs as necessary and appropriate.
- An adequate management system has been implemented and followed in the operation of the monitoring programmes and acquisition and storage of monitoring data, including establishment of monitoring protocols, to fulfil all quality assurance requirements for a nuclear installation site.

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5.2.10 References

1. Department of Minerals and Energy, 2011. *The Regulations on Licensing of Sites for New Nuclear Installations. Government Gazette 34735, Notice 914.,* Pretoria: s.n.

2. Eskom, 2014. *Report on the Background Radiation at the Thyspunt Proposed Nuclear Site 441046,* Cape Town: s.n.

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