ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED NUCLEAR POWER STATION ('NUCLEAR-1') AND ASSOCIATED INFRASTRUCTURE

Hydrology Environmental Impact Report

September 2015

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DECLARATION OF INDEPENDENCE

I, Matt Braune as duly authorised representative of SRK Consulting hereby confirm my independence (as well as that of SRK Consulting) *to* as a specialist and declare that neither I nor SRK Consulting have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Arcus GIBB was appointed as environmental assessment practitioner in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for worked performed, specifically in connection with the Environmental Impact Assessment for the proposed conventional nuclear power station ('Nuclear-1'). I further declare that I am confident in the results of the studies undertaken and conclusions drawn as a result of it – as is described in my attached report.

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EXECUTIVE SUMMARY

This Environmental Impact Report (EIR) covers the impacts and mitigation measures associated with the construction and operation of a proposed conventional Nuclear Power Station (NPS) and associated infrastructure at one site in the Eastern Cape and two in the Western Cape. The sites were originally identified as a result of site investigations undertaken since the 1980s and from the EIA Scoping Study. This specialist study covers Hydrology and was carried out by SRK Consulting.

Eskom proposes to construct a NPS of the Pressurised Water Reactor type technology, with a capacity of c.4 000 MWe. The proposed NPS will include nuclear reactor, turbine complex, spent fuel, nuclear fuel storage facilities, waste handling facilities, intake and outfall basin and various auxiliary services infrastructure.

All three proposed sites at Thyspunt, Bantamsklip and Duynefontein are located on the coast.

The study has covered regional aspects based on the surrounding quaternary catchments and a study area of 20 km radius. From the regional assessment it was determined that no potable surface water resources are available at any of the sites. Alternative water supply sources or treatment of sea water must therefore be considered. Desalination is discussed in the Fresh Water Supply specialist study report.

For the currently proposed corridor for nuclear plant and auxiliary buildings of the sites there is a potential flood hazard at low points along the coastal frontage of the corridor in the event of an unusually high water level. A flooding hazard due to ponding also exists at each of the sites at the construction phase, due to the open excavations for the plant foundations.

Potential sea level rise due to global warming has little effect on the NPS and climate change should also have a minor effect on the hydrology of the surface water bodies considering the absence of major watercourse on the sites.

Due to hardening of surfaces at the plant and auxiliary works the stormwater runoff volumes and peaks are expected to increase by about 25 to 40 times when compared to the pre-development conditions. All impacts can, however, be reduced with the implementation of mitigatory measures.

The major characteristics that differentiate the impacts on the environment at the three sites mainly relate to rainfall, the presence of seasonal wetlands and non-perennial watercourses. Thyspunt has the highest rainfall as well as seasonal wetlands and a non-perennial water course. At Duynefontein the impact on the seasonal wetlands is less since the rainfall is the lowest of the three sites. Rainfall at Bantamsklip is higher than Duynefontein, but there are no sensitive environmental features or any ecologically sensitive wetlands. The direct hydrological impacts at all three sites are *low* in significance rating with a *low* consequence.

Should no Nuclear Power Station be built (no go option) at any of the sites, Eskom would sell the Bantamsklip and Thyspunt properties and possibly also superfluous land at Duynefontein. The sites may then be developed for other purposes with less strict controls and regulation than those for Nuclear Installations. This may lead to increased runoff from the developments. If the impacts are then not well managed

they may have negative consequences. However, the impact on the Duynefonetin site would be positive.

The Best Management Practices approach is adopted for the identification of structural and non-structural mitigation measures. The structural mitigation measures include:

- Diversion berms;
- Silt traps;
- Energy dissipation structures; and
- Dirty water containment dams.

The non-structural measures include:

- Drawing-up stormwater control measures maintenance programmes; and
- Production of control measures operational manuals.

There are no fatal flaws at any of the sites regarding surface water impacts.

Existing information should be supplemented on the following aspects:

- Detailed footprint and layout of plant area and ancillary works;
- Locality and extent of possible future residential / commercial developments; and
- Quantification of the rainfall difference due to climate change at each of the sites.

PLEASE NOTE:

This report has been amended as per the recommendations of the Peer Review Report compiled by GCS (Pty) Ltd (Appendix E37 of the Revised Draft EIR Version 2)

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED NUCLEAR POWER STATION ('NUCLEAR-1') AND ASSOCIATED INFRASTRUCTURE

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GLOSSARY

Catchment Management Agency: A water management institution responsible for managing the water resources in terms of the National Water Act, 1998 (Act No. 36 of 1998)

Clean water runoff: Runoff due to rainfall that has no substances that could be harmful to man or the environment.

Contamination: The introduction of any substance into the environment by the action of man.

Dam Break Model: A model simulating the effect of dam failure on the downstream receiving environment.

Design Rainfall Depth: That rainfall frequency/distribution/intensity that should influence civil design and stormwater management to take cognisance of both normal and extreme rainfall events.

Dirty water runoff: The introduction into the environment of any substance by the action of man that is, or results in, significant harmful effects to man or the environment.

Floodline: A line drawn in plan indicating that area which is inundated with flood waters during a flood.

Groundwater: Refers to the water filling the pores and voids in geological formations below the water table.

Hazard: An event that may cause damage to infrastructure, the environment and/or harm to man.

Highest Astronomical Tide: This is the highest level in the ocean that can be predicted to occur under average meteorological conditions and under any combinations of astronomical conditions.

Hydrological Characteristics: Characteristics of surface water features including streams, rivers, dams, wetlands, vlei and lakes defined by the physical parameters that support such features such as:

- catchments and their characteristics;
- meteorological settings;
- groundwater recharge; and
- water quality

Impact:. is any effect on the environment caused by an activity; such effects on the environment include effects on human health and safety, flora, fauna, soil, air, water, climate, landscape, socio-economic environment or the interaction among these factors and cultural heritage or socio-economic conditions resulting from alterations to these factors;

Mean Annual Runoff: This is the expected average runoff from a catchment on a yearly basis due to an average rainfall over the catchment**.**

Plant Workforce: The workforce that will support construction, operation and decommissioning of the proposed development.

Pollution: The introduction into the environment of any substance by the action of man that is, or results in, significant harmful effects to man or the environment.

Probable Maximum Precipitation: The maximum rainfall falling with an expected return period of 10 000 years.

Proposed Project Footprint: That area and the spatial definition of that area, where the project will be superimposed on the natural environment.

Return Period: Estimates of the likelihood of the occurrence of a given duration and intensity of precipitation, for analysis of the potential costs and benefits of building adequate controls. A return period is the frequency with which you would expect, *on average*, a given precipitation event to recur.

Surface Water Resource: All surface water available for beneficial use, including by man, aquatic ecosystems and the greater environment.

Vulnerability: An indication of how sensitive a site and /or the environment is to the hazard causing harm.

ABBREVIATIONS

AMS	Annual Maximum Series
BMPs	Best Management Practices
CN	Curve Number
CV	Coefficient of Variation
DWA	Department of Water Affairs
EIA	Environmental Impact Assessment
HAT	Highest Astronomical Tide
Hwl	High water level
IAEA	International Atomic Energy Agency
ISP	Integrated Strategic Perspective
MAE	Mean Annual Evaporation
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NNR	National Nuclear Regulator
NWA	National Water Act, 1998 (Act No. 38 of 1998)
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SAWS	South African Weather Service
SCS	Soil Conservation Services
SRK	SRK Consulting
WRC	Water Research Commission

1. INTRODUCTION

1.1 Background

The study is based on currently available information and covers the proposed Thyspunt, Duynefontein and Bantamsklip sites. The main objectives are to:

- Define the legislative framework and regulatory guidelines pertaining to surface water issues;
- Determine and quantify potential flood hazards on the sites during construction and operation;
- Identify and rate the impacts of the project on the surrounding environment; and
- Determine, on a conceptual level, what stormwater control and mitigation measures are required to comply with minimum required standards and to mitigate the impact on the environment.

1.1.1 Terms of Reference

The assessment of impacts has broadly been undertaken in accordance with the guidelines provided in the Guidelines Document: EIA Regulations (DEAT, 1998), the National Environmental Management Act (NEMA) principles and Section 24(4) of NEMA (as amended), as appropriate to the specific field of study. In addition, the following General Terms of Reference apply to each of the specialist studies:

- Describe the baseline conditions that exist in the study area and identify any sensitive areas that would need special consideration;
- Ensure that all issues and concerns and potential environmental impacts relevant to the specific specialist study are addressed and recommend the inclusion of any additional issues required in the ToR, based on professional expertise and experience. Also consider comments on the previous specialist studies undertaken for the Nuclear Siting Investigation Programme (NSIP) undertaken during the 1980s - 1990s;
- Provide a brief outline of the approach used in the study. Assumptions, sources of information and the difficulties with predictive models must also be clearly stated;
- Indicate the reliability of information used in the assessment, as well as any constraints / limitations applicable to the report (e.g. any areas of insufficient information or uncertainty);
- Identify the potential sources of risk to the affected environment during the construction and operational phases of the proposed project;
- Identify and list relevant legislative and permit requirements applicable to the potential impacts of the proposed project;
- Include an assessment of the ‘no go’ alternative and identified feasible alternatives;
- Assess and evaluate potential direct and indirect impacts during both the construction and operational phases of the proposed project;

- Identify and assess any cumulative effects arising from the proposed project;
- Undertake field surveys, as appropriate to the requirements of the particular specialist study;
- Identify areas where impacts could combine or interact with impacts likely to be covered by other specialists, resulting in aggravated or enhanced impacts and assess potential effects;
- Apply the precautionary principle in the assessment of impacts, in particular where there is major uncertainty, low levels of confidence in predictions and poor data or information;
- Determine the significance of assessed impacts according to a convention for assigning significance ratings to impacts;
- Recommend practical mitigation measures to minimise or eliminate negative impacts, enhance potential project benefits or to protect public and individual rights to compensation and indicate how these can be implemented in the final design, construction and operation of the proposed project;
- Provide a revised significance rating of assessed impacts after the implementation of mitigation measures;
- Identify ways to ensure that recommended mitigation measures would be implemented, as appropriate; and
- Recommend an appropriate monitoring and review programme in order to track the effectiveness of proposed mitigation measures.

The specific terms of reference for the hydrological specialist study are related to assessing the impact of a nuclear facility on the surface water and vice versa. Within this context, the following specific terms of reference were highlighted:

- Surface water / drainage lines occurrence;
- Surface water characteristics (e.g. perennial–ephemeral, effluent–influent– disconnected);
- Spring occurrence and characteristics;
- Rainfall pattern, frequency, storm events;
- Risk of flooding;
- Water quality;
- Stormwater runoff;
- Flow direction;
- Sediment transport, potential for erosion;
- Importance of streams in regional context and as water supply source;
- Possible use of surface water for water supply during construction and operation;
- Risks of pollution;
- Stormwater catchment hydrology and catchment areas;
- Land use categories percentage distribution per sub catchment;
- Representative cross sections for use in flood routing;
- Watercourse hydraulics and flood line determination;
- Flood peaks;
- Flood levels and flow velocity distributions at recognised water course cross sectional chainages;
- Flood hazard assessments;
- Site-specific stormwater management; and
- Dam breaks modelling.

1.1.2 Description and Background to the Project

This specialist study covers Hydrology and has been undertaken by SRK Consulting to inform the Environmental Impact Assessment (EIA) conducted by Arcus Gibb in support of Eskom's Nuclear-1 project.

This report assesses the impacts and proposes mitigation measures associated with the construction and operation of a conventional Nuclear Power Station (NPS) and associated infrastructure at one site in the Eastern Cape and two in the Western Cape (see **Figure 1.1**). The sites have been identified based on site investigations undertaken since the 1980s (Eskom, 1994 a, b, c), as well as the scoping phase of this EIA.

Eskom proposes to construct an NPS of the Pressurised Water Reactor type technology, with a capacity of c.4 000 MWe. The proposed NPS will include the nuclear reactor and its auxiliaries, turbine complex, spent fuel and nuclear fuel storage facilities, waste handling facilities, intake and outfall basin and various auxiliary service infrastructures. The main infrastructure buildings as listed above will be situated in a corridor area, which is shown schematically on the various site plans in **Section 2**. Other associated buildings such as security, reservoirs, bulk stores, weather station and nature conservation may be located elsewhere within the property boundaries.

Freshwater demands for the proposed plant are estimated to peak at 9 000 m^3/day (see Fresh Water Supply EIR), a requirement that places significant pressure on freshwater resources in certain areas in South Africa that are remote from established regional water schemes (e.g. the Orange River Scheme). The proposed project footprint is expected, on a local scale, to be remote from any water courses. This statement excludes areas where housing will be required for the plant workforce since this will not be on the immediate site but in townships and villages close by.

1.2 Study Approach

1.2.1 Methodology

The approach adopted for this study was to firstly develop baseline information on all surface water related issues that could have a potential impact on the planned sites. The surface water modelling required a model to assess each site during flood conditions, which required a hydrological model to determine the flood peaks and volumes, as well as a hydraulic backwater model to determine the relevant hydraulic characteristics.

There are various approaches for the design flood estimation depending on the data available as well as site conditions. Due to minimal stream flows being available (small catchments, high infiltration rates, and small surface flows) the hydrological model required a rainfall based method for the design flood estimation. A deterministic/probabilistic approach using the design rainfall, rather than a continuous simulation, was adopted to create a design event storm for each of the catchments.

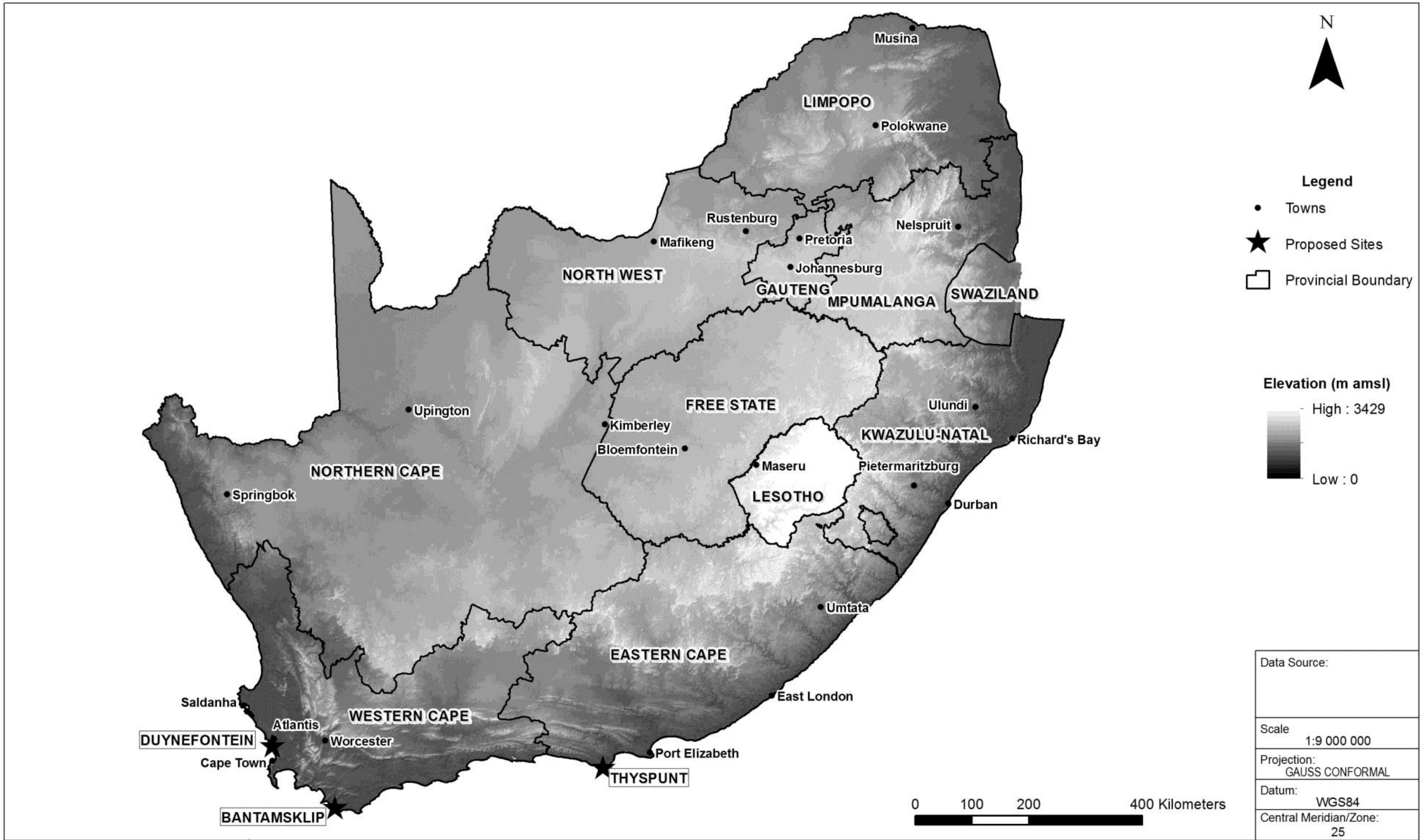
There are also various design event models available for estimating the flood peaks and the appropriate method adopted looks at the areal limitations, input data requirements, assumptions and limitations.

Although alternatives design flood methods were used as an order of magnitude check indicative, the adopted method used for this study is the Soil Conservation Services (SCS-SA) method. This predicts runoff peaks and volumes based on a runoff curve number (CN) giving an indication of the infiltration losses and runoff potential of the catchments.

Several hydraulic models are available on the market internationally. The most well-known, and widely used model is the Hydraulic Engineering Centre's River Analysis System (HECRAS) Model, Version 3.2, developed by the United States Army Corps of Engineers. This model has been used for this study because it uses standard backwater calculations and is adequate to model the natural watercourses which, due to their small size, do not have a large storage potential (hence a one-dimensional model adequately predicts the water levels). The model has been used in the market for over 30 years and has hence been tested sufficiently for all types of water course conditions. The model uses the standard Manning's Equation and energy balance and covers both sub-critical and super-critical flow regimes. The model calculates the high water level in a watercourse based on cross-sections along the watercourse abstracted from the existing survey information at the site. The HECRAS computer software for the hydraulic calculations has been verified and validated over many years by the software vendor, as required by the National Nuclear Regulator (NNR) regulations.

The expected peak flow rates as determined by the SCS-SA model have been used in the HECRAS model, which can now calculate the expected high water level based on these peak flow rates.

Having identified the various possible hazards one can then quantify the impacts in accordance with the Government Notice R.385 of 2006, promulgated in terms of Section 24 of the NEMA.



srk consulting

NUCLEAR-1 ENVIRONMENTAL IMPACT ASSESSMENT FOR A PROPOSD POWER STATION AND ASSOCIATED INFRASTRUCTURE
SPECIALIST STUDY: HYDROLOGY AND HYDRAULICS
LOCATION OF THE PROPOSED NUCLEAR POWER STATION SITES

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Revision: B Date: 31 10 2012

Several mitigation measures were then identified by using the Best Management Practise (BMP) approach to ensure safety of the site and plant area during construction and operation as well as ensuring that the surrounding environment is conserved.

1.2.2 Regulatory Framework and Guidelines

The characterisation of hydrology and hydraulics of the sites, and the potential impacts and the mitigation measures of a nuclear installation(s), need to comply both with national Acts as well as international standards and guidelines.

The National Water Act, 1998 (Act No 36 of 1998, Regulation GN704) directs water management for the mining industry. Currently, these regulations are mainly applicable to the mining industry, but have also been widely used by the Department of Water Affairs (DWA) for industrial sites such as power stations.

The following NNR requirements were taken into account where applicable:

- The establishment of a NNR to regulate nuclear activities and to provide for safety standards and regulatory practices to protect humans and the environment (National Nuclear Act, 1999);
- The Regulations on the Licensing of Sites for New Nuclear Installations - These are the only national regulations specifically relevant to hydrology. The regulations broadly applicable to hydrology are:

  - Regulation 4 (4 & 5) requires that siting factors and criteria ensure that radiological doses and risks from normal operation and postulated events associated with a nuclear installation(s) will be acceptably low, that natural phenomena will be appropriately accounted for in the design of the nuclear installation(s).

  - Regulation 4(2) requires that inputs be given for design, construction and operation to result in extremely low probabilities of release of radioactive fission products.

In view of this, all relevant legislation and guidelines were considered and are summarised in Error! Reference source not found..

Table 1.1: Summary of Legislative Requirements and Regulatory Guidelines Relevant to Stormwater control

Act / Regulation	Relevance and Requirement
National Environmental Management Act, 1998 (Act No. 107 of 1998)	Guidelines on water quality aspects
International Atomic Energy Agency (IAEA) Safety Standards Series, Safety Requirements	Guidelines on the sizing of stormwater control measures: - drainage systems to handle the Probable Maximum Precipitation (PMP)
National Water Act, 1998 (Act No. 36 of 1998) Government Notice GN704 dated 4 June 1999	Regulating the following: - separation of “clean” and “dirty” water on a site. - containment of “dirty “water runoff up to 1:50 year storm event with 0.8 m freeboard

Act / Regulation	Relevance and Requirement
	- prevention of erosion - determination of 1:100 year flood lines.
Department of Water Affairs & Forestry Best Practice Guideline G1- Storm Water Management Plan & A4 – Pollution Control Dams 2006	Best practice guidelines for water resource protection in the South African mining industry (Storm Water Management and Pollution Control Dams)

An overview of the relevancy of the Acts, guidelines and regulations applicable to this project, are provided below.

National Environmental Management Act, 1998 (Act No. 107 of 1998) [NEMA]

This primarily covers the control and management of environmental impacts.

Department of Water Affairs & Forestry Best Practice Guidelines 2006

This primarily covers the stormwater management systems and the dirty water containment dams (pollution control dams) which may be constructed for stormwater control.

National Water Act, 1998 (Act No. 36 of 1998) [NWA]

Surface water management falls under legislation contained in, *inter alia*, the NWA, of which Section 4 deals with prevention of contamination. The person who owns, controls, occupies or uses the land in question is responsible for taking measures to prevent pollution of water resources. If these measures are not taken, the Catchment Management Agency (CMA) concerned may itself do whatever is necessary to prevent the pollution or to remedy its effects, and to recover all reasonable costs from the persons responsible for the pollution. Any structures which may be located where they may have an impact on a water resource are governed by sections of the National Water Act and/or regulations published in terms of the Act.

The measures necessary to prevent pollution can be broadly summarised as:

- Separate “clean” and “dirty water”;
- Water contaminated by activities / infrastructure may not be discharged to surface water resources; and
- Prevention of erosion.

Nuclear Industry Standards/Guidelines

Relevant sections relating to surface water hydrology and hydraulics were considered, using the following documents:

- “Design Basis Floods for Nuclear Power Plants” Regulatory Guide 1.59 (Revision 2: Aug 1977) - US Nuclear Regulatory Commission. This primarily covers the probable maximum flood peak discharge and probable maximum water levels on streams and coastal areas;
- “Flood Protection for Nuclear Power Plants” Regulatory Guide 1.102 (Revision 1: Sep 1976) - US Nuclear Regulatory Commission. This primarily covers the safety of the site against probable maximum peaks and maximum flood levels;

- “Design of Erosion Protection for Long-Term Stabilization” NUREG-1623 (Sep 2002) - US Nuclear Regulatory Commission. This primarily covers erosion protection and cover designs for sites;
- “Flood hazards for Nuclear Power Plants on Coastal and River Sites” NS-G-3.5 (December 2003) - IAEA Safety Standards, Safety Guide. This primarily covers flood hazard evaluation and protection due to storm surges, waves, runoff and other natural events for coastal and river sites;
- “Site Evaluations for Nuclear Installations” NS-R-3 (November 2003) – IAEA Safety Standards, Safety Requirements. This primarily covers evaluation of external events, monitoring of hazards and quality assurance;

1.2.3 Assumptions and Limitations

Available local information was used with the restriction that only short periods of local metrological and oceanographic data are available at the sites. The assessment was based on regional and local data where available and assumptions made as given in **Table 1.2** below.

Table 1.2: Assumptions and Limitations

Item	Assumptions Made
Rainfall data	Used mainly long term South African Weather Service (SAWS) station data in vicinity of site. This data can then be further augmented and checked with local data once available over a period of time. Only weather stations in the vicinity with extended periods of available rainfall information were considered and no priority was given to stations with long wind/ temperature records since the focus of this particular study was on hydrology. Rainfall data taking into account climate change are currently not available. The University of KwaZulu Natal is currently working on a regional study on the effects of climate change. Initial outcomes of this study show that the impact on the larger peak flows is not expected to be significant because we are looking at the extreme events (1:10 000 recurrence interval), but that the impact on base flows could be more significant. Confidence in the impact prediction is lower for the operational phase as a result of extrapolated rainfall data which is not available for the 1:10 000 rainfall event as is required for this type of activity Detailed rainfall comparison was carried out in the Meteorology Study carried out as part of the EIA.
Infiltration data	An SCS soil type "A" (well draining soils) with an Infiltration constant "K "of 5 m/day was used, based on a preliminary assessment on site. This could be further refined if more infiltration data become available.
Tidal and extreme high water level data	Data were obtained from the Oceanographic and Coastal Engineering Study carried out as part of the EIA.
Tsunami data	Information obtained from the Oceanographic and Coastal Engineering Study for the EIR.
Plant layout & infrastructure data	At this stage it has been assumed that the entire plant area (to the extent of the anticipated footprint) will be paved when operational.

1.2.4 Data Collection

An important component of this study is the collection of local and regional data. A problem generally encountered in South Africa is the lack of long-term meteorological and surface runoff data. In view of this, any existing and appropriate short and long-term data have been collected. Extrapolation of the data has then been done using standard statistical methods (Annual Maximum Series (AMS) for various probability distributions) to predict longer term occurrences. A summary of the main data collected is given in **Table 1.3**.

Table 1.3: Summary of Main Data and Data Source

Item	Data Received	Data Source
1	Aerial photography	Eskom
2	Detailed site contours	Eskom
3	Site "foot print" and locality including corridors for most probable location of intake/outfall structures and HV Yard and land possibly to be crossed by transmission lines, access tunnels, roads, services, infrastructure etc.	Eskom – Nuclear-1 Maps 96_10009, 96_00049, 96_0007

Item	Data Received	Data Source
4	Rainfall data	South African Weather Services & daily rainfall data extraction utility, Institute for Commercial Forestry Research (ICFR) and KwaZulu-Natal University (Pietermaritzburg campus) (ICF, 2004).
5	Ground water and geological information	SRK
6	Extreme high water level information	Draft Nuclear EIR, 2009

1.2.5 Impact Assessment Rating Criteria

In accordance with Government Notice R. 385 of 2006, promulgated in terms of Section 24 of the NEMA and the criteria drawn from the IEM Guidelines Series, Guideline 5: Assessment of Alternatives and Impacts, published by the DEAT (April 1998) as well as the Guideline Document on Impact Significance (DEAT 2002), th potential impacts are assessed in terma of the criteria listed in **Table 1.4**.

Table 1.4: Impact Assessment Criteria and Rating Scale

Criteria	Rating Scales	Notes
Nature	Positive	This is an evaluation of the type of effect the construction, operation and management of the proposed NPS development would have on the affected environment.
	Negative	
	Neutral	
Extent	Low	Site-specific, Affects only the development footprint
	Medium	Local (limited to the site and its immediate surroundings, including the surrounding towns and settlements within a 10 km radius);
	High	Regional (beyond a 10 km radius) to national
Duration	Low	0-5 years (i.e. duration of construction phase)
	Medium	6-10 years
	High	More than 10 years to permanent
Intensity	Low	Where the impact affects the environment in such a way that natural, cultural and social functions and processes are minimally affected
	Medium	Where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; and valued, important, sensitive or vulnerable systems or communities are negatively affected
	High	Where natural, cultural or social functions and processes are altered to the extent that the impact will temporarily or permanently cease; and valued, important, sensitive or vulnerable systems or communities are substantially affected.
Potential for impact on irreplaceable	Low	No irreplaceable resources will be impacted.
	Medium	Resources that will be impacted can be

Criteria	Rating Scales	Notes
resources		replaced, with effort.
	High	There is no potential for replacing a particular vulnerable resource that will be impacted.
Consequence (a combination of extent, duration, intensity and the potential for impact on irreplaceable resources).	Low	A combination of any of the following • Intensity, duration, extent and impact on irreplaceable resources are all rated low • Intensity, duration and extent are rated low but impact on irreplaceable resources is rated medium to high • Intensity is low and up to two of the other criteria are rated medium • Intensity is medium and all three other criteria are rated low
	Medium	• Intensity is medium and one other criterium is rated high, with the remainder being rated low. • Intensity is low and at least two other criteria are rated medium or higher. • Intensity is rated medium and at least two of the other criteria are rated medium or higher • Intensity is high and at least two other criteria are medium or higher • Intensity is rated low, but irrepplaceability and duration are rated high
	High	• Intensity and impact on irreplaceable resources are rated high, with any combination of extent and duration • Intensity is rated high, with all of the other criteria being rated medium or higher
Probability (the likelihood of the impact occurring)	Low	It is highly unlikely or less than 50 % likely that an impact will occur.
	Medium	It is between 50 and 70 % certain that the impact will occur.
	High	It is more than 75 % certain that the impact will occur or it is definite that the impact will occur.
Significance (all impacts including potential cumulative impacts)	Low	• Low consequence and low probability • Low consequence and medium probability • Low consequence and high probability
	Low to medium	• Low consequence and high probability • Medium consequence and low probability
	Medium	• Medium consequence and low probability • Medium consequence and medium probability • Medium consequence and high probability • High consequence and low probability
	Medium to high	• High consequence and medium probability
	High	• High consequence and high probability

Only the above-mentioned criteria were taken into account in the assessment of impact significance. In addition, the degree of confidence in the prediction of impacts, the nature of applicable mitigation measures and legal requirements applicable to the impacts have been described.

2 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The hydrological investigation covered the catchments draining through the sites as well as the adjacent catchments potentially affecting the sites. Details are given below.

2.1 Thyspunt

2.1.1 Quaternary and Major Catchments

The site is situated on the coastline between Oyster Bay and Cape St. Francis and the quaternary catchments in the area are as follows:

- Catchment K80F, within which the site is located and drained by the Klipdrif and Slang Rivers to the west of the site;
- Catchment K90D and K90E, to the north and east of the site drained by the Krom River;
- Catchment K90F, north and east of the Krom River catchment drained by the Seekoei River.

The regional water features and the major catchments are presented in **Figure 2.2**.

2.1.2 Surface Water Features

The following general comments relating to surface water features (and their potential use) can be made at this stage:

- The site is located within the Fish to Tsitsikamma Water Management Area and within the Krom-Seekoei sub area as is defined in the Integrated Strategic Perspective (ISP) for the Fish to the Tsitsikamma Water Management Area (DWAF, 2004).
- The total yield from the sub-area was calculated as 47.4 Mm^3/a after transfers and return flows and the total user requirements as 46.2 Mm^3/a. The sub area is therefore approximately in balance. The 1.2 Mm^3 surplus is due to a surplus in the upper Krom River, which indicates additional capacity to the Nelson Mandela Metro.
- The stressed nature of the catchment would require that alternative sources of water are found for both the construction and operation phases. Development opportunities do exist but need to be further investigated with DWA. It should be noted that an NPS is classified as a strategic water user and hence would get preference over any other developments in the catchment.
- The area is characterised by a few dams on the Krom River. The most notable of these dams is the Impofu Dam. The available surface water in this region is allocated to Port Elizabeth and Humansdorp.
- On a local scale, the site has a number of wetland areas, which are fed primarily by groundwater.

2.1.3 Rainfall Details

At present there are no long-term local rainfall data at the site, with the on-site EIR rainfall station only being installed in January 2008.

Daily rainfall data from measuring stations in the vicinity of the site were extracted from the South African Weather Service (SAWS) database as summarised in **Table 2.1**.

Table 2.1: Summary of Rainfall Stations Considered: Thyspunt

Station No.	Years of Record	Distance from Site (km)	Elevation (m amsl)	MAP (mm)
17452 (Humansdorp) -daily records	122 (94% reliability)	17.7	118	687
17723 (Jeffrey's Bay) -daily records	122 (54% reliability)	27.5	44	558
35060 (Emerald Hill) -daily records	118 (35% reliability)	92.9	164	694
17582 (Cape St. Francis) -daily records	121 (76% reliability)	12.0	29	657
Cape St. Francis -hourly records	3 (100% reliability)	12.0	29	595

Station 17452 (Humansdorp) has a long reliable rainfall record (94 per cent) and is located only 18 km from the site and has therefore been selected to be representative of the rainfall in the area. The selected station has 122 years of patched rainfall records, which is still shorter than the prescribed 1 000 years and even 10 000 years rainfall required for determining the estimated runoff flows and volumes (ICFR, 2004).

The extreme runoff flows and volumes for the 1 000 year and 10 000 year rainfall for the site are estimated using the information available for Station 17452 and on the basis of the US Nuclear Regulation Commission guidelines. In view of this the 24 hour rainfall depths were calculated using a statistical approach. A statistical analysis using the Annual Maximum Series (AMS) was undertaken for probability distributions as recommended in Flood Risk Reduction Measures (FRRM). The best fit distribution was found to be the Weibull giving a correlation coefficient R^2 of 0.9874.

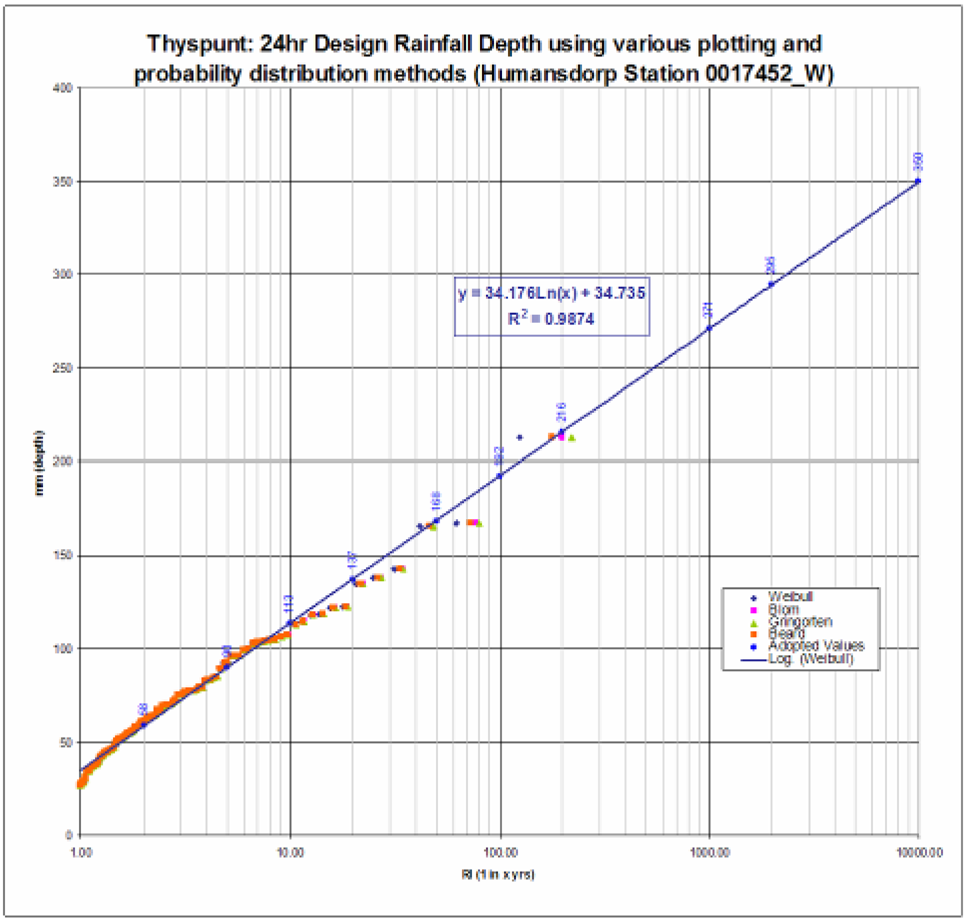
Based on the above, the expected 24 hour design rainfall depths are tabulated in **Table 2.2** and shown graphically in **Figure 2.1.**

Table 2.2: Adopted 24 Hour Design Rainfall Depth: Thyspunt

Recurrence interval (years)	Without Climate Change Assumptions 24 hour storm rainfall (mm) (Adopted MAP = 687)
50	168
100	192
200	216
1 000	271
10 000	350

Climate change has not yet been included as no scientific local information is currently available. This will be quantified when the KwaZulu-Natal University has completed their regional study on climate change.

Figure 2.1: Adopted 24 Hour Design Rainfall Depth: Thyspunt



2.1.4 Extreme High Water Level and Tsunami Data

The specialist oceanographic study (Draft Nuclear EIR, 2009).has been completed, giving an indication of the expected extreme high water level and sea level rise information. **Table 2.3** summarises the extreme high water levels from the ocean at the Thyspunt site. The extreme Tsunami level expected for the site are summarised in **Table 2.4**.

Table 2.3: Extreme High Water Levels: Thyspunt

			No Climate Change		Climate Change	
	Component	**Units**	**Best Fit**	**Upper 95% Confidence**	**Best Fit**	**Upper 95% Confidence**
1: 1 000 000 Return Period	Highest Astronomical Tide (Port Elizabeth)	mamsl	1.28	1.28	1.28	1.28
	Sea level rise	m	0.00	0.00	0.80	0.80
	Wave set-up and run-up	m	8.48	9.36	9.64	10.71
	Positive storm surge	m	1.43	1.75	1.73	2.11
	Extreme high water level	mamsl	11.19	12.39	13.45	14.90

Table 2.4: Tsunami Data: Thyspunt

Tsunami	Units	No Climate Change		Climate Change	
Component		**Best Fit**	**Upper 95% Confidence**	**Best Fit**	**Upper 95% Confidence**
Upper 90th Percentile high tides (Port Elizabeth)	mamsl	0.98	0.98	0.98	0.98
Sea level rise	m	0.00	0.0	0.8	0.8
Positive storm surge (1:10 years)	m	0.74	0.80	0.90	0.97
Tsunami	m	2.91	3.694	3.52	4.40
Wave Set-up and run-up (1:10) years	m	6.59	6.78	7.41	7.62
Extreme high water level	mamsl	11.22	12.20	13.68	14.83

Based on the above table and including climate change it is recommended that the base level of the plant should not be lower than 14.90 mamsl.

2.1.6 Long Term Hydrology Details

Based on information from the Water Resources Study (WR2012, 2012), which was a joint venture with the Water Research Commission on Water Resources in South Africa (2012), the following key long-term hydrology details have been extracted and are summarised in **Table 2.5**.

Table 2.5: Thyspunt Quaternary Catchment Information Summary

ID	Gross area (km^2)	Forest area (km^2)		Irrig. Area (km^2)	Evap zone	MAE (mm)	Rain zone	MAP (mm)	MAR (mm)	MAP – MAR Resp.	Net MAR (m^3x10^6)	Gross MAR (m^3x10^6)	CV
		Forest	Alien										
K80F	221	0	27.3	0	24C	1 400	K8	769	185	5	40.8	40.8	0.530
K90D	215	0	8.6	1.3	24C	1 400	K9B	693	73	6	15.7	15.7	0.898
K90E	176	0	33.9	1.2	24C	1 400	K9C	676	65	6	11.5	11.5	0.775
K90F	250	1.8	0.7	1.2	24C	1 400	K9C	699	73	6	18.3	18.3	0.778

Note: MAE = Mean Annual Evaporation
MAP = Mean Annual Precipitation
MAR = Mean Annual Runoff

The relatively low "Coefficient of Variation" (CV) numbers indicate that primary water courses in the catchment are generally perennial and secondary water courses are generally non-perennial.

Based on the above, catchment K80F can expect a MAR of about 185 mm (the MAP correlates with the information as is supplied in the Climatology Report). This equates to an average of just less than 15.4 mm per month. This average would be higher during the wet season but will be covered in more detail once the monthly water balance for the site has been completed. Due to the high infiltration rate of the sandy soils (approximately 208 mm/hour), no base flow runoff is expected on the site for pre-development. During construction of the foundation when most of the overlying sand is removed, some base flow runoff into the excavation area is expected to occur. Further more detailed studies would be required to quantify this for incorporation into the final design.

2.1.7 Regional Hydrological Modelling

Description of Model

In order to quantify the volume and peak flows emanating from the regional catchments at the site either deterministic and/or empirical methods can be used.

Taking into account the location of the site, i.e. being very close to the ocean, it is difficult to utilize empirical methods as these methods are based on data from regional catchments rather than local catchments in the vicinity of the site. For this reason a deterministic modelling approach has been adopted for natural existing catchment conditions as the size of the proposed footprint is insignificant when compared to the size of the regional catchments.

Based on the size of the catchments it is shown that the Soil Conservation Services (SCS) method is best suited for determining runoff. For this project the SCS-SA model has been used which has been adopted for South African rainfall conditions.

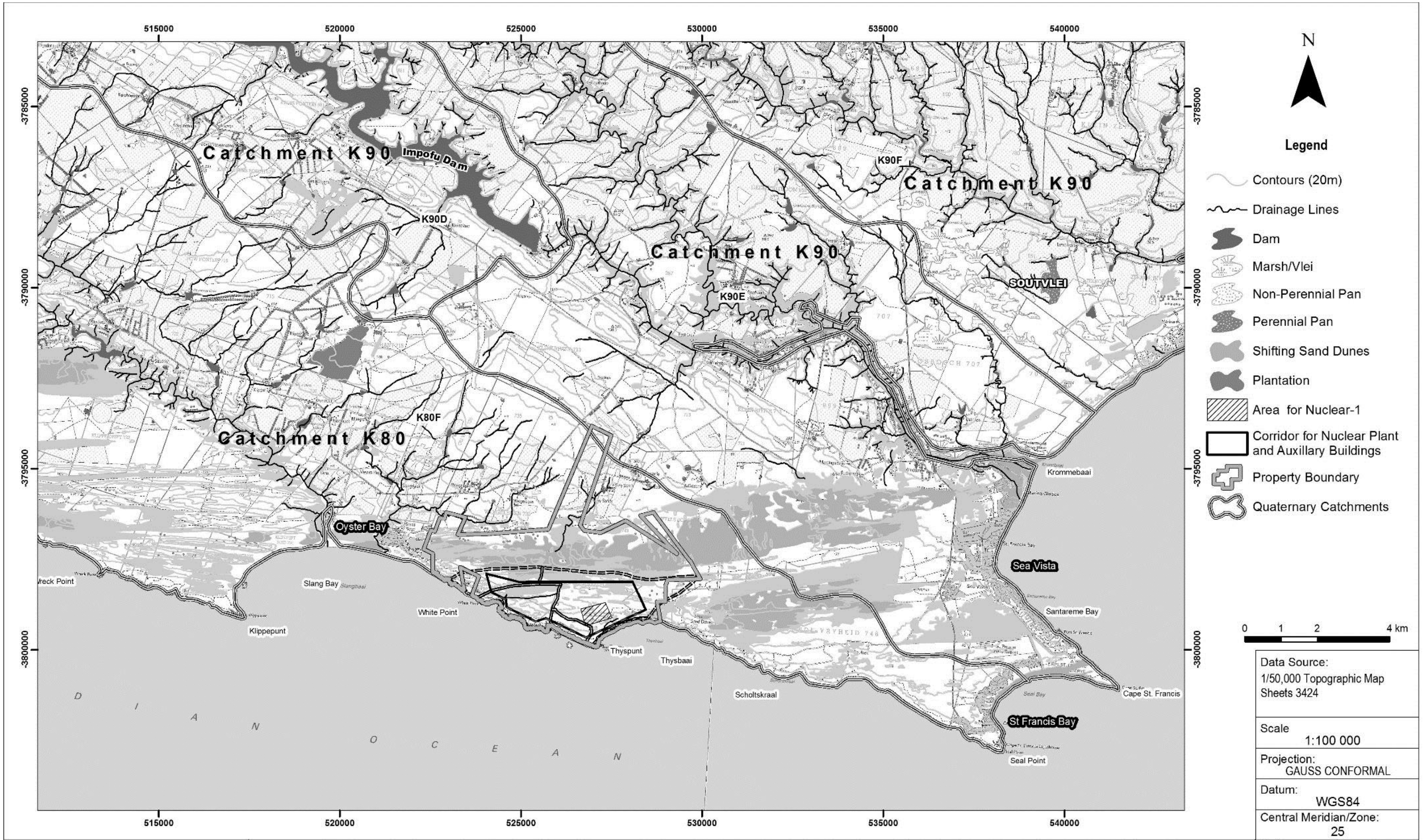
The runoff flows and volumes are based on the US Nuclear Regulation Commission guideline (IAEA, 2003), which recommends the use of statistically-derived floods and the Probable Maximum Flood (PMF) which is based on the Probable Maximum Precipitation (PMP). The US Nuclear Regulation Commission concluded that it is reasonable to use the PMF as the design flood as it provides reasonable assurance of non-exceedance for a 1 000 year period. For a 1 000 year design and a 90% probability of non-concurrence, the design flood would have a recurrence interval (Return Period) of approximately 10 000 years. The regional catchments are shown in **Figure 2.2.**

Input Data

The main input data for the relevant major catchments and water courses modelled are given below in **Table 2.6**.

Table 2.6: Stormwater Model Input Parameters – Major Catchments: Thyspunt

Parameter	Value	Reason
SCS–SA Model		
Return period (Years) 50 100 200 1 000 10 000	24 Hour Rainfall depth (mm) 168 192 216 271 350	As detailed in section 2.1.3
Rainfall distribution	SCS Type II	Coastal region distribution as detailed in SCS manual
Catchment Curve number (CN) Pre-development	27	Sandy soil, SCS type 'A' with high infiltration rate (208 mm/hour)



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SPECIALIST STUDY: HYDROLOGY AND HYDRAULICS
LOCALITY PLAN SHOWING REGIONAL WATER FEATURES AND MAJOR CATCHMENT : THYSPUNT

Date:	Compiled by:
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Peak Flow Estimation

Based on the above approach and model input parameters, the estimated peak flow rates for the site are given in **Table 2.7**.

Table 2.7: Peak flow rates for Thyspunt

Watercourse Reference	Catchment Area (km^2)	Peak Flows (m^3/s)			
		1:100 year	1:200 year	1:1 000 year	1:10 000 year
TP2_RIV1	1.70	0.4	1.0	5.4	16.2
TP4_RIV2	4.50	0.8	2.1	8.7	26.6
TP4_RIV3	0.52	0.1	0.3	1.8	5.2

For the locality of the water courses see **Figure 2.4**.

These peaks are used in the hydraulic model to determine the expected flood levels and flow characteristics along the three watercourses.

2.1.8 Regional Hydraulic Study

In this section the expected high water level in watercourses close to the site are determined for the PMP rainfall event as shown in **Figure 2.4**.

2.1.9 Description of Model

The model and methodology has been discussed in **Subsection 1.2** above. The Manning 'n' is the roughness coefficient (level of resistance to the flow) used in the backwater calculation. A high value indicates dense vegetation (more resistance and increase in water levels) and a low value indicates thin vegetation (less resistance).

The boundary condition is what controls the backwater model. An example would be a known water level, critical depth or slope of the watercourse. In this instance the known downstream water level (Highest Astronomical Tide) were used.

Mixed Flow regime determines both super and sub-critical flow regions and combines the sub and super-critical flows in one backwater model. Super-critical flows are controlled by the upstream water levels and sub-critical controlled by the downstream water levels.

The HECRAS model input parameters are summarised in **Table 2.8**.

Table 2.8: Hydraulic Model Input Parameters: Thyspunt

Parameter	Value	Reason
Mannings 'n'	0.045 – 0.050	Well vegetated river bed & floodplains
Boundary Conditions	1.28 m	Highest Astronomical Tide at river mouth (excludes extreme high water level as presented in the Oceanographic study)
Flow Regime	Mixed	Natural control points

2.1.10 Water Course Definition

There is a small, well-vegetated water course (TP2_RIV1), which drains through the north western corner of the site, along the northern boundary of the site.

There is a low-lying area and watercourse (TP4_RIV2), discharging into the ocean, east of the site. There is also a small tributary (TP4_RIV3) east of the site. This watercourse does not have a large catchment and hence no floodline was determined. The water courses are all well vegetated**.**

2.1.11 Floodline Determination

Floodlines were determined at a few sections along the watercourses for the PMP rainfall. These were the only defined drainage lines based on the site inspection, contours and images which were available at the time. The remaining drainage lines are not well defined and discharge as sheet flow during a storm event, eventually temporarily ponding in the low lying areas. The results are tabulated in **Table 2.9** and also shown in **Figure 2.3**.

Table 2.9: Summary of Flood Levels: Thyspunt

Water course	Water course section	High water level (mamsl)	Flow velocity (m/s)
TP2_RIV1	48	3.6	0.1
	439	11.6	3.6
	647	17.5	4.4
TP4_RIV2	117	3.6	1.0
	264	4.1	0.8
	472	5.6	1.2

On the basis of the results of the evaluation, the following was observed:

The western part of the site:

- The highest water level expected is 18 mamsl. The surrounding area is at an average level of 22 to 32 mams, based on the surrounding contour information.
- The maximum velocity in the upper reaches is 4.4 m/s for the PMP which is some distance away from the infrastucture. The majority of the velocities are much lower along the lower reaches resulting in minimal erosion potential.
- No impact of the watercourse is therefore expected on the site.

The eastern part of the site:

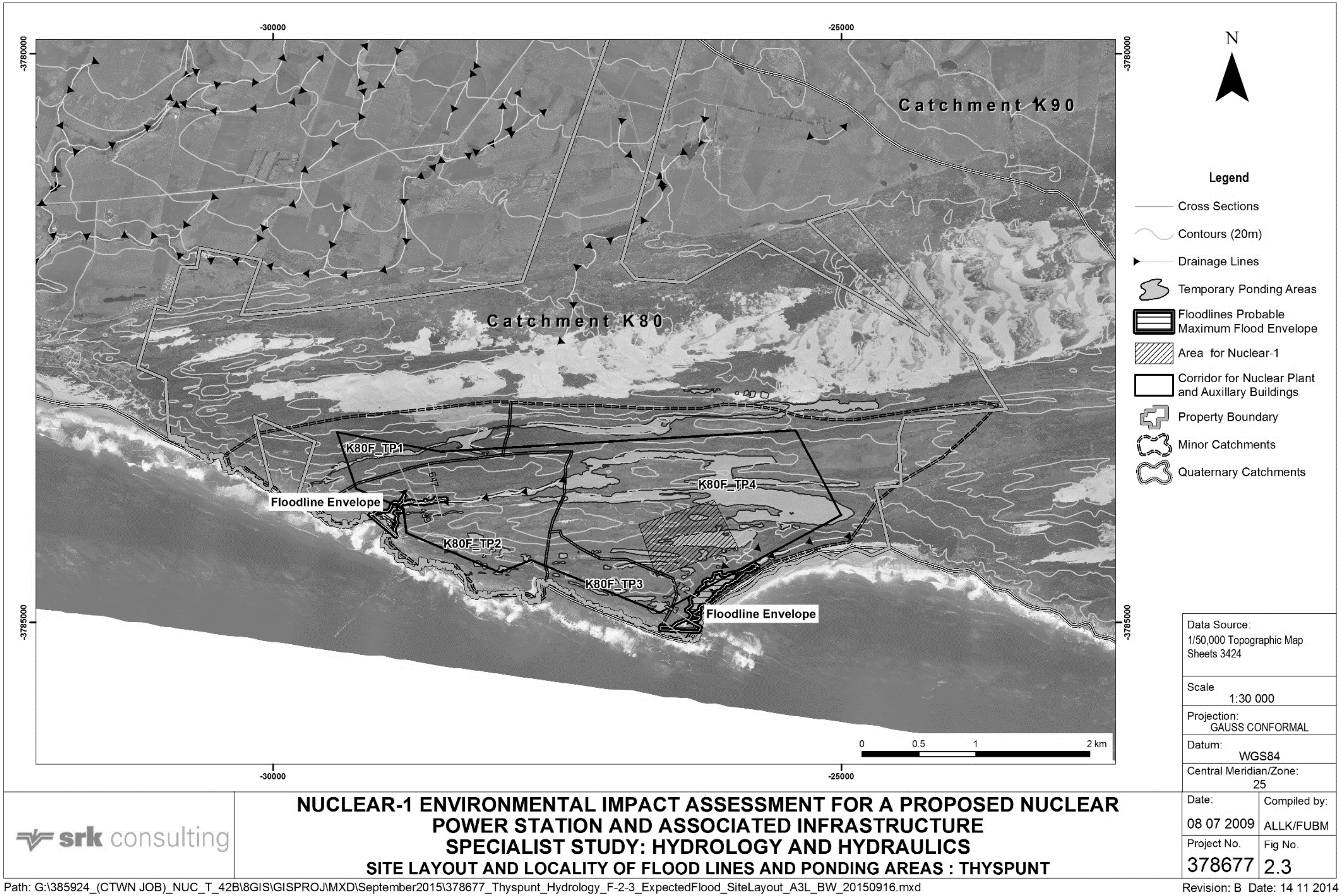
- The highest water level expected is 5.6 mamsl. The surrounding area is at an average level of 7 to 8 mamsl.
- The maximum velocity is 1.2 m/s for the PMP. The majority of the velocities are much lower along the lower reaches resulting in minimal erosion potential.
- No impact of the watercourse is therefore expected on the site.

It should be noted that this excludes the extreme high water level from the ocean, which would flood all the drainage lines up to a level of 14.77 mamsl.

2.1.12 Ponding Areas

In addition to watercourses, possible temporary ponding areas have also been determined. These areas consist primarily of low points with no natural outlet. During a storm event these areas would accumulate excess runoff from the surrounding catchment, which would cause temporary ponds. The expected runoff volumes for the surrounding area have been based on the PMP as determined in **Subsection 2.1.3**.

The expected ponding areas and flood levels are shown in **Figure 2.3**. The current estimates are based on regional infiltration parameters, which based on local groundwater modelling results are expected to be very similar at the site.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-25000
-3780000
-3785000
N
Catchment K90
Catchment K80
K80F_TP1
K80F_TP2
K80F_TP3
K80F_TP4
Floodline Envelope
Floodline Envelope
Legend
Cross Sections
Contours (20m)
Drainage Lines
Temporary Ponding Areas
Floodlines Probable Maximum Flood Envelope
Area for Nuclear-1
Corridor for Nuclear Plant and Auxillary Buildings
Property Boundary
Minor Catchments
Quaternary Catchments
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Date: 08 07 2009
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Project No. 378677
Fig No. 2.3
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SPECIALIST STUDY: HYDROLOGY AND HYDRAULICS
SITE LAYOUT AND LOCALITY OF FLOOD LINES AND PONDING AREAS : THYSPUNT
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2.1.13 Plant Area Specific Stormwater Management

Having quantified and assessed the regional hydrology and hydraulics of the site, the local site stormwater management is now considered.

The site is situated on the coastline between Oyster Bay and Cape St. Francis and is covered mainly by Fynbos and a few wetlands within the valley areas. The wetlands are primarily fed by groundwater as there are no noticeable local water courses. In the event of significant rainfall it is expected that some temporary ponding will occur between the sand dunes, parallel to the coastline. This is mainly based on the contour information which shows that there are several “valley” areas in which stormwater would pond. The anticipated site conditions during various phases of the development are presented below.

During Construction

It is anticipated that during construction a large excavation will be required in order to get to bedrock for the foundations of the reactor(s). It is assumed that the site footprint will have a surface area of approximately 60 ha and the depth would be about 15 m for the conceptual site positions.

During Operation

During operation it is expected that the plant area would cover most of the current footprint and would be mainly paved.

Decommissioning Phase

During this phase it is expected that after removal and dismantling the plant and associated structures, the disturbed area will be rehabilitated with formal environmental and human health risk plans, based on a comprehensive environmental impact assessment in accordance with relevant laws and regulations that would apply at the time of decommissioning.

2.1.14 Stormwater Model and Input Parameters

For this analysis smaller sub-catchments have been defined for each of the sites. This then enables one to determine runoff peaks and volumes at selected outlet points. The following catchments have been defined based on the current detailed topographic information and named as follows:

- K80F_TP2; and
- K80F_TP3.

The respective catchments are shown in **Figure 2.2**. The SCS-SA model has again been used to model the respective catchments for each of the above defined land use conditions.

The chosen stormwater model main input parameter are summarised in **Table 2.10**.

Table 2.10: Stormwater Model Input Parameters: Thyspunt

Parameter	Value		Reason
SWMM model			
Return period (years) 50 100 200 1 000 10 000 1 000 000	24 hour Rainfall Depth without Climate (mm) Change Assumptions 168 192 216 271 350 Not applicable	24 hour Rainfall Depth with Climate Change Assumptions (mm) *Currently unavailable Currently unavailable Currently unavailable Currently unavailable Currently unavailable Not applicable	As detailed in section 2.1.3
Rainfall distribution	SCS Type II	SCS Type II	Coastal region distribution as detailed in SCS manual
Catchment curve Number (CN) - pre-development - construction - operational	27 91 98	27 91 98	Sandy soil, SCS type 'A' with high infiltration rate (200 mm/hour) for pre-development. High runoff potential due to rock and paved areas for construction & operational phases

*these are currently not available and will be quantified when more information becomes available.

2.1.15 Plant area Stormwater Modelling

Based on the defined sub-catchments and stormwater model input parameters, peak flows and volumes could be determined for the following conditions:

- Pre-development;
- During construction; and
- Operational.

The results are summarised in **Table 2.11**.

Table 2.11: Peak Flow Rates & Runoff Volumes: Thyspunt

	Pre-development		During construction		Operational/ closure	
Recurrence interval (years)	Peak flow (m^3/s)	Runoff volume (m^3x10^3)	Peak flow (m^3/s)	Runoff volume (m^3x10^3)	Peak flow (m^3/s)	Runoff volume (m^3x10^3)
1:50	0.15	2.9	18.9	83.0	20.1	95.0
1:100	0.27	7.4	21.9	97.0	23.0	108.9
1:200	0.9	13.7	24.8	110.7	25.8	123.0
1:1 000	4.3	33.9	31.5	142.7	32.4	156.0
1:10 000	12.9	74.6	41.1	189.0	41.9	201.0

On the basis of the above results, the following observations are made:

- During the phase prior to development very low runoff peaks and volumes are expected due to the high infiltration rate.
- During the construction phase a large increase in runoff peaks and volumes is expected due the high runoff potential of the rock floor of the pit, as well as potentially covered side slopes with an impervious layer for erosional stability of the open pit.
- For the operational phase there is little difference when compared with the construction phase as it is assumed that a high proportion of the area would be paved and hence have a high runoff potential.

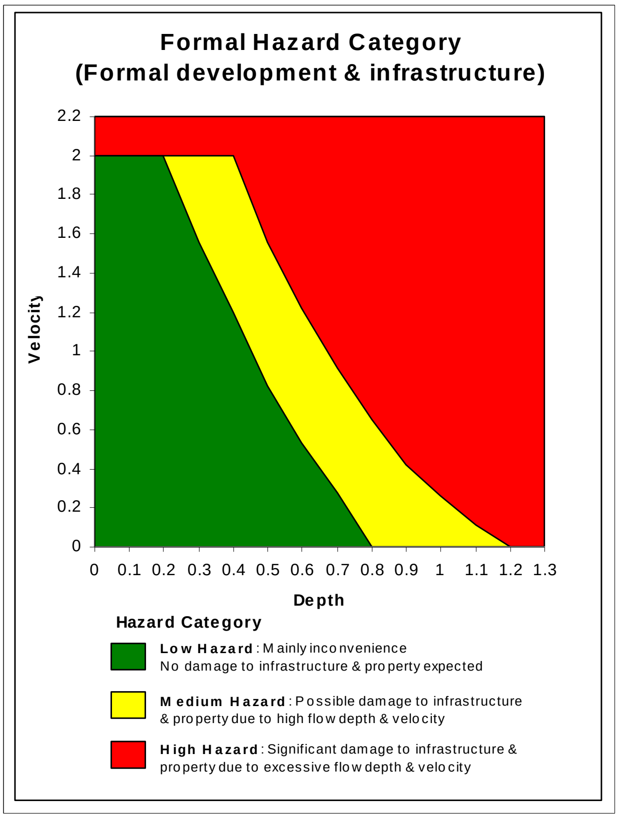
2.1.16 Evaluation of Site Sensitivity (Flood Hazard) and Impacts

Based on the above section the expected stormwater runoff peaks and volumes have been quantified for various development phases for both external catchments as well as the site. This now allows one to evaluate the site sensitivity (flood hazard)and the impact they have on the development as well as surrounding area. The approach followed is that of a quantitative risk assessment whereby the impact is a product of the flood hazard and the vulnerability of the development to the hazard. This impact is then rated in terms of high, medium and low site sensitivity. The impact assessment is carried out for the following development conditions:

- Prior to development;
- Construction; and
- Operation.

The site sensitivity (flood hazard,) based on a flow depth and velocity relationship, is given in **Figure 2.4**.

Figure 2.4: Flood Hazard assessment: Thyspunt



The site sensitivity (flood hazards) are categorised as follows:

- Low sensitivity (LH): Mainly inconvenience, no damage to infrastructure and low safety risk.
- Medium sensitivity (MH): Possible damage to infrastructure and a medium safety risk.
- High sensitivity (HH): Significant damage to infrastructure and high safety risk.

Regional Catchments

The regional catchment assessment is based on the existing topography and natural water features within the regional catchments. The expected hazard categories and locality for pre-development conditions are shown in **Figure 2.5**.

The following observations are made:

- Only water course TP2_Riv1 could present a hazard and possible impact on the site due to the water course being close to the site.
- The extreme high water level is expected to have a high hazard but not to have an impact on the site as the site is above the high water level.

Plant Area Assessment

An impact assessment for the future plant area regarding on-site stormwater control has also been completed for the following three development conditions:

- Pre-development, assuming virgin catchment conditions;
- During construction, assuming that the plant area is initially excavated to rock level at a depth of about 15 m and a stormwater control embankment is in place; and
- Operation, assuming that the plant area is fully developed with all infrastructure completed and area fully paved.

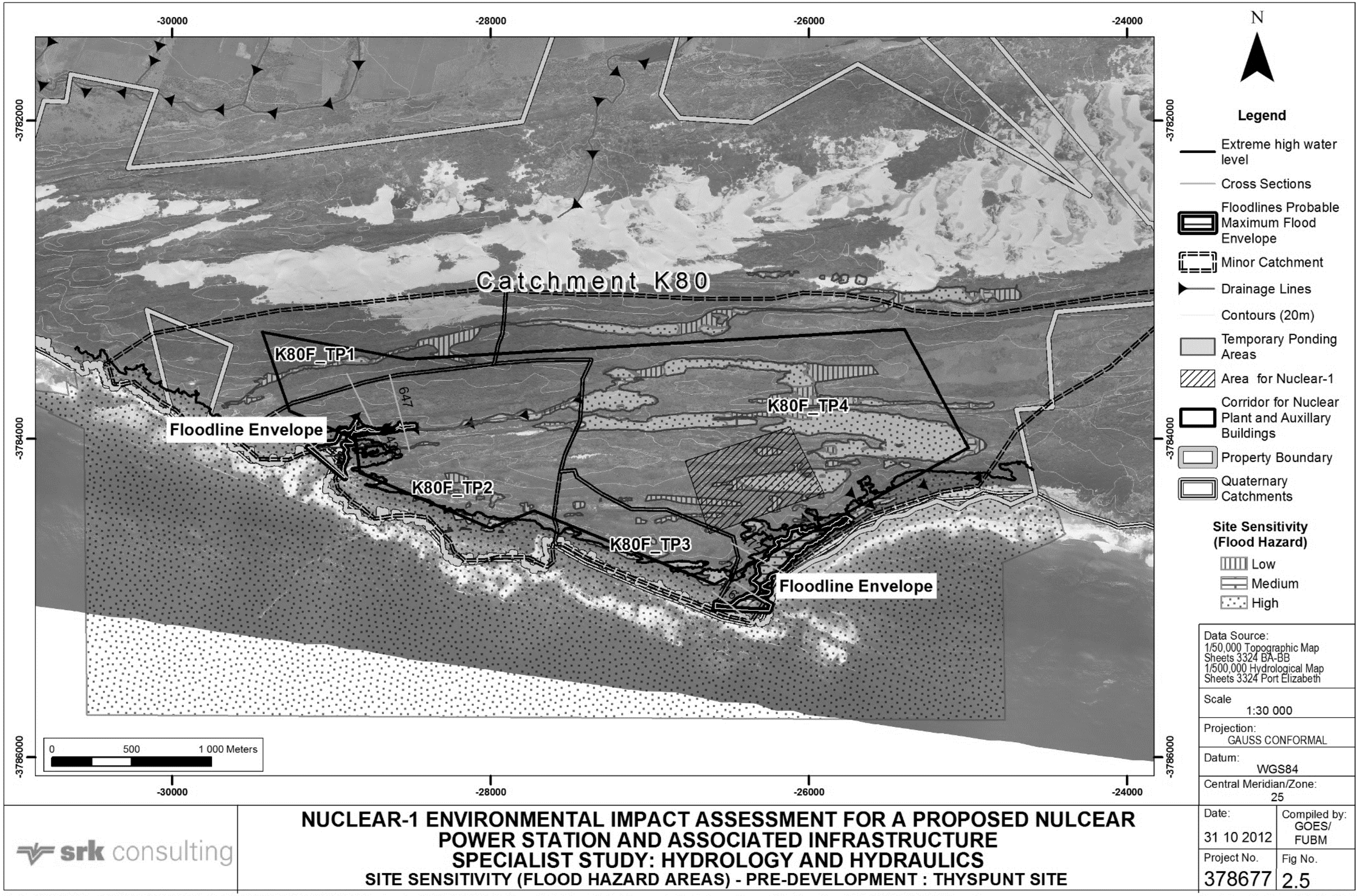
The expected sensitivity (hazards) are summarised in **Table 2.12**, **Table 2.13** and **Table 2.14**, respectively, for the above development conditions, with no mitigation measures in place. The expected sensitivity (hazard) areas for construction/operation phases are shown in **Figure 2.6.**

Table 2.12: Expected Plant Area Impacts (Pre-development): Thyspunt

Hazard Source	Site
	Hazard
Local on site ponding areas	H

Table 2.13: Expected Plant Area Impact (During Construction): Thyspunt

Hazard Source	Site
	Hazard
Runoff into excavation	H



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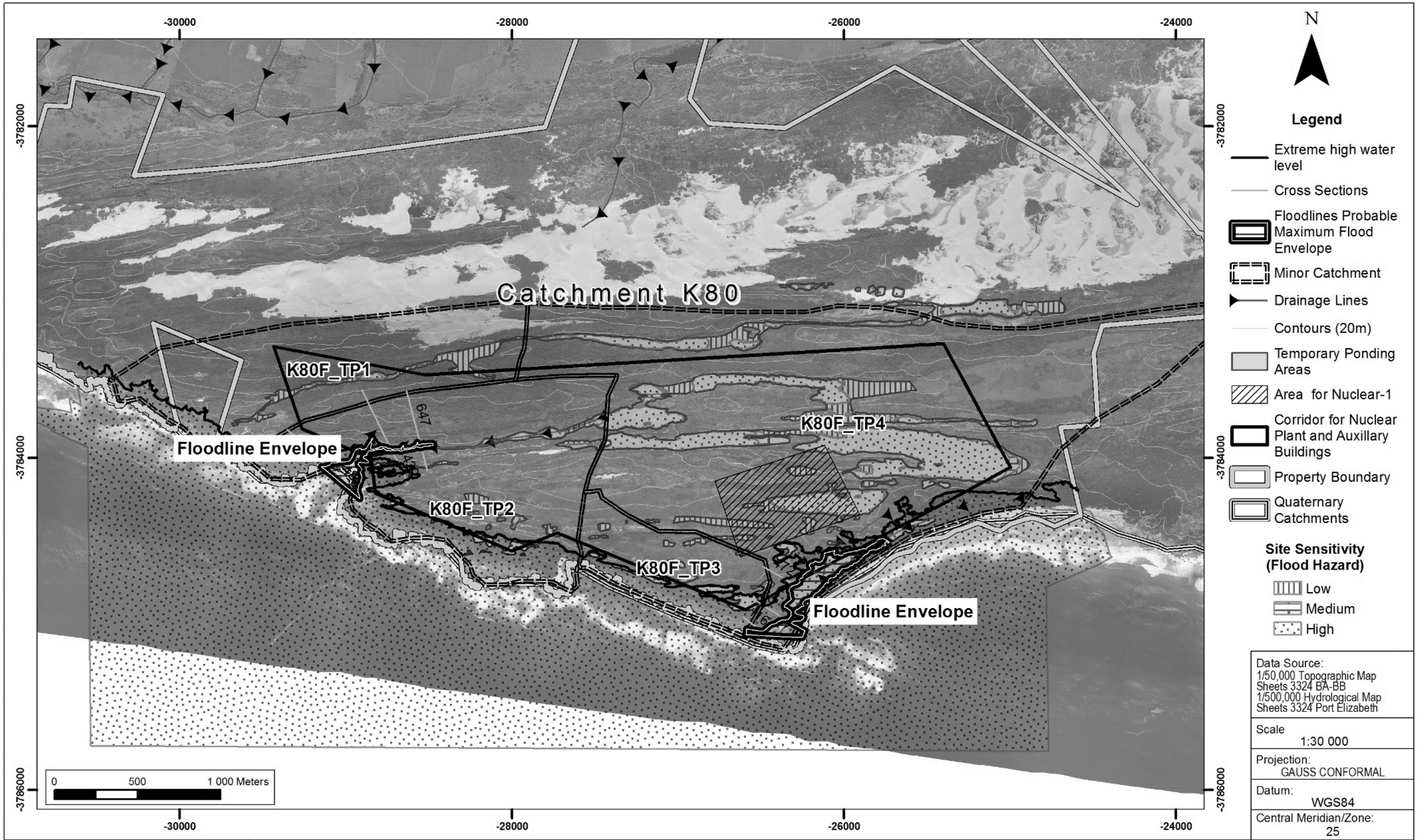

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Datum: WGS84

Central Meridian/Zone: 25

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SPECIALIST STUDY: HYDROLOGY AND HYDRAULICS
SITE SENSITIVITY (FLOOD HAZARD AREAS) - CONSTRUCTION STAGE : THYSPUNT SITE

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Project No. 378677	Fig No. 2.6

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Revision: B Date: 31 10 2012

Table 2.14: Expected Plant Area Impact (Operational/Closure, no mitigation): Thyspunt

Hazard Source	Site
	Hazard
Plant area runoff	H

The following observations are made:

- There is a high sensitivity (hazard) for all the above development conditions should no mitigation measures be implemented on site.
- The main cause of the high sensitivity (hazard) is the consequence of disruption to construction activities as well as interference with the power station operation in the event of a major storm with no flood control measures in place.

2.2 Duynefontein

The proposed site is situated on the coastline approximately 30 km north of Cape Town in the Western Cape.

2.2.1 Quaternary and Major Catchments

The Quaternary catchments in the area are as follows:

- Catchment G21A to the north and drained by the Modder River;
- Catchment G21B where the Duynefontein site is situated and drained by Salt River, south of the existing Koeberg Nuclear Power Station (KNPS); and
- Catchment G21F to the south drained by the Diep River.

2.2.2 Surface Water Features

The following general comments relating to surface water features (and their potential use) can be made at this preliminary stage:

- The area is characterised with a low rainfall (MAP <500 mm) and besides the Salt River, Diep River and minor pans and dams, there are no notable surface water features.
- The drainage lines are non-perennial and flow manifests as sheet flow during major storm events.

2.2.3 Rainfall Details

Daily rainfall data from measuring stations in the vicinity of the site were extracted from the database of the SAWS as summarised in **Table 2.15**.

Table 2.15: Summary of Rainfall Stations Considered: Duynefontein

Station No.	Years of Record	Distance from Site (km)	Elevation (mamsl)	MAP (mm)
21130 (Vanschoorsdrift)	148 (31.9% reliable)	16.2	42	347
41060 (Burgerspost)	150 (32.0% reliable)	21.0	180	584
20649 (Robben Island)	148 (69.1% reliable)	17.7	18	416

From the above the following is noted:

- At the time of this study long-term rainfall records of the rainfall station at the existing Koeberg Power Station were not available as the station has not been commissioned for a long enough time periods. Due to this, the closest station with the longest record was used.
- Station 20649 has the longest reliable record and is only about 18 km away from the site.

Based on the above, station 20649 has been selected to be representative of the rainfall in the area. The selected station has 148 years of patched rainfall records which is shorter than the predicted 1 000 and even 10 000 years rainfall required for determining the estimated runoff flows and volumes for nuclear sites. These extreme runoff flows and volumes are based on the US Nuclear Regulation Commission guidelines (IAEA, 2003). In view of this, 24 hour design rainfall depths were calculated using a statistical approach. A statistical analysis using the Annual Maximum Series (AMS) was undertaken for the following probability distributions:

- Weibull (1939)- normal, Pearson III
- Blom (1958) - normal
- Gringorten (1963) – exponential, EV1 & GEV
- Beard (1962) – Pearson III

The best fit distribution was found to be the Weibull giving a correlation coefficient $R^2 = 0.9549$.

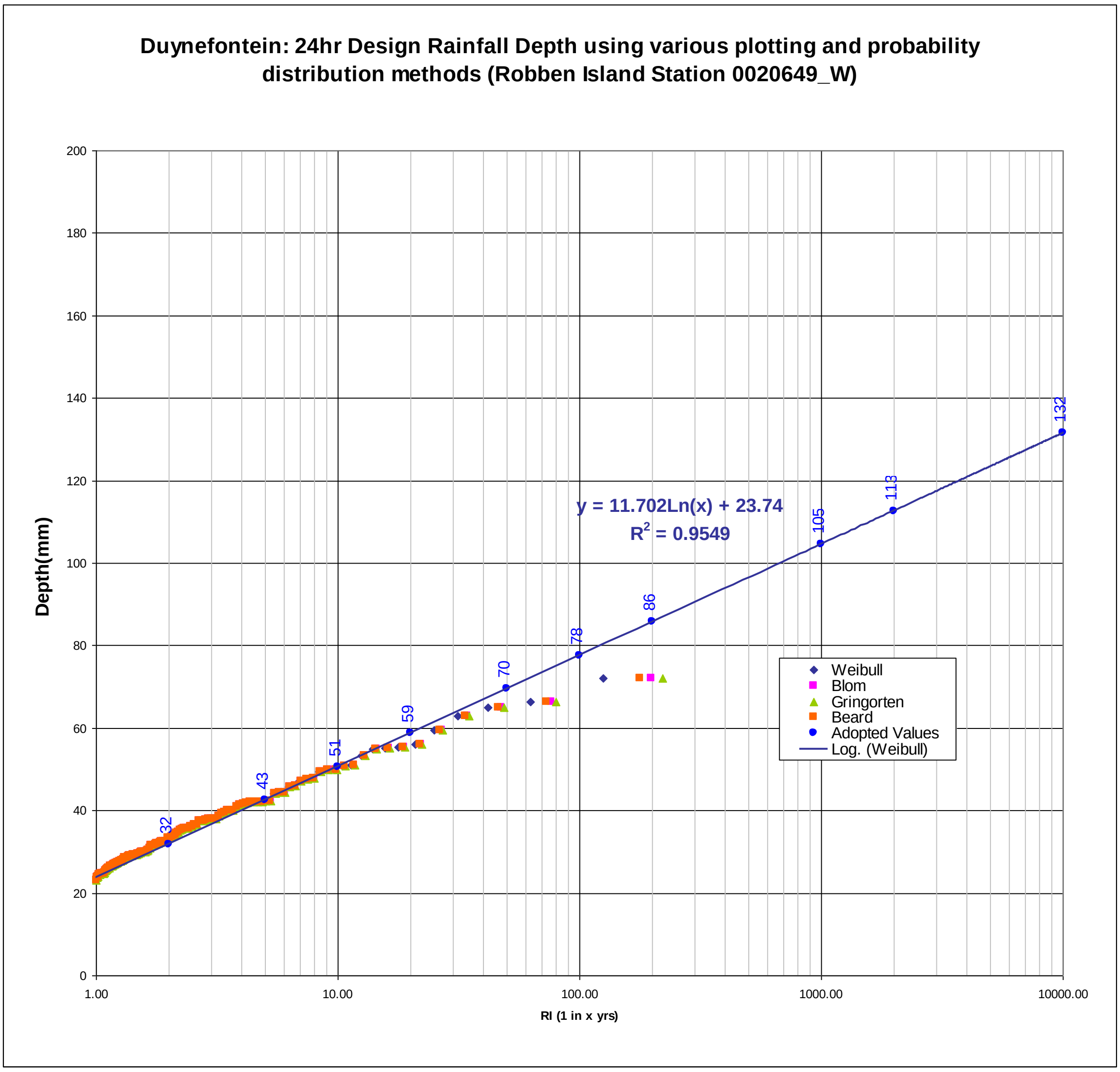
Based on the above the expected 24 hour rainfall depths are tabulated in **Table 2.16** and shown graphically in **Figure 2.7**.

Table 2.16: Adopted 24 Hour Design Rainfall Depths: Duynefontein

Recurrence interval (Years)	24 hour storm rainfall (mm) (Adopted MAP = 416)
50	70
100	78
200	86
1 000	105
10 000	132

Climate change has not yet been included as no scientific local information is currently available. This will be quantified when the KwaZulu-Natal University has completed their regional study on climate change.

Figure 2.7: Adopted 24 Hour Design Rainfall Depth: Duynefontein



Rainfall data taking into account climate change are currently not available. The University of KwaZulu-Natal (Pietermaritzburg) is currently busy with a regional study on the effects of climate change, forecasting c.80 years of rainfall. The impact on the larger peak flows is not expected to be significant, but the impact on base flows could be more significant. This impact would need to be reconsidered once the information from the climate change study becomes available

2.2.4 Extreme High Water Level and Tsunami Data Duynefontein

The specialist oceanographic study (Draft Nuclear EIR, 2009), has been completed giving an indication of the expected extreme high water and sea level rise information. **Table 2.17** below summarises the extreme high water levels and **Table 2.18** summarises the expected tsunami levels from the ocean at the Duynefontein site.

Table 2.17: Extreme High Water Levels: Duynefontein

			No Climate Change		Climate Change	
	Component	**Units**	**Best Fit**	**Upper 95% Confidence**	**Best Fit**	**Upper 95% Confidence**
1: 1 000 000 Return Period	Highest Astronomical Tide (Cape Town)	mamsl	1.20	1.20	1.20	1.20
	Sea level rise	m	0.00	0.00	0.80	0.80
	Wave set-up and run-up	m	3.91	4.25	4.44	4.84
	Positive storm surge	m	1.31	1.67	1.59	2.02
	Extreme high water level	mamsl	6.41	7.11	8.03	8.86

Table 2.18: Tsunami Data: Duynefontein

Tsunami	Units	No Climate Change		Climate Change	
Component		**Best Fit**	**Upper Confidence**	**Best Fit**	**Upper Confidence**
Upper 90th Percentile high tides (Port Elizabeth)	mamsl	0.92	0.92	0.92	0.92
Sea level rise	m	0.00	0.0	0.8	0.8
Positive storm surge (1:10 years)	m	0.59	0.64	0.72	0.77
Tsunami	m	2.91	3.64	3.52	4.4
Wave Set-up and run-up (1:10) years	m	3.15	3.23	3.56	3.65
Extreme high water level	mamsl	7.57	8.43	9.52	10.54

From the above table and including climate change it is recommended that the base level of the plant should not be lower than 10.54 mamsl.

2.2.5 Long Term Hydrology Details

Based on information from the Water Resources Study (WR2012) the following key long term hydrology details have been extracted and are summarised in **Table 2.19.**

Table 2.19: Duynefontein Quaternary Catchment Information Summary

ID	Gross area (km^2)	Forest area (km^2)		Irrig. Area (km^2)	Evap zone	MAE (mm)	Rain zone	MAP (mm)	MAR (mm)	MAP – MAR Resp.	Net MAR (m^{3}x10^6)	Gross MAR (m^{3}x10^6)	CV
		Forest	Alien										
G21A	523	0	135	3.9	23C	1 450	G1D	345	23	4	11.8	11.8	1.372
G21B	304	0.05	67.6	1.3	23C	1 445	G2A	332	25	4	7.7	7.7	1.267
G21F	242	1.3	21.4	8.3	23C	1 430	G2A	362	22	4	5.4	5.4	0.823

The site is located within the Berg River Water Management Area and within the West Coast Rivers sub area as is defined in the Integrated Strategic Perspective (ISP) for the Berg River Water Management Area (DWAF, Berg River Internal Strategic Perspective).

This catchment has negligible yield from surface water and is entirely reliant on groundwater and water transfers. Uncertainties include the groundwater potential as well as the possible impacts of coastal resorts on the primary aquifers (use and pollution). Furthermore, the recharge of these aquifers is low due to the low precipitation in the area. Saline intrusion from over-abstraction near the coast is a potential threat.

The ISP indicated that sufficient quantity of water was available to the Saldahna area to meet existing demands (released from Voëlvlei Dam, DWAF, Berg River Internal Strategic Perspective), but the quality of water (occasionally of high salinity during winter months) supplied out of Misverstand Dam, is the primary concern. Further development in the area will place additional stress on Voëlvlei Dam.

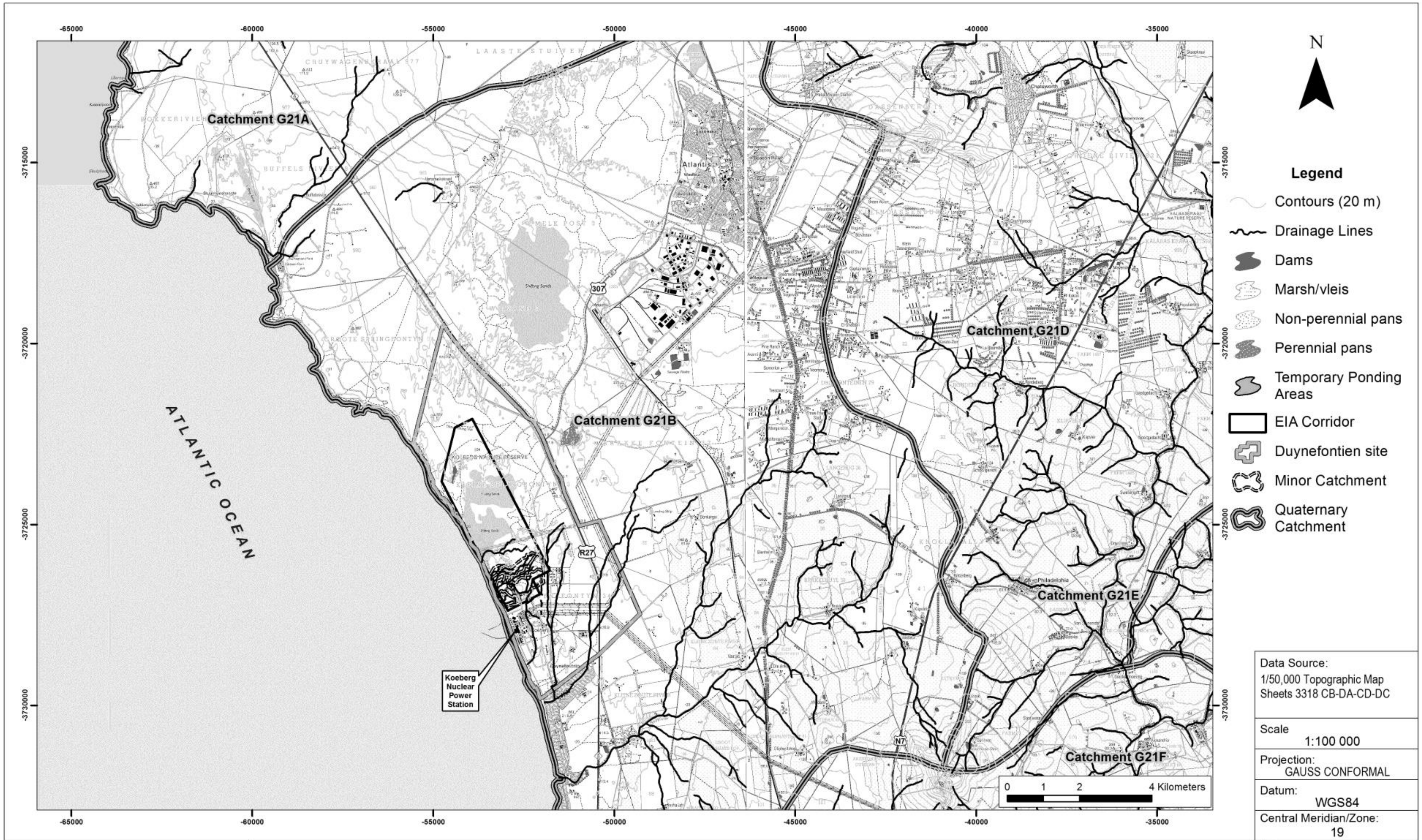
Desalination of sea water is a viable option (see Fresh Water Supply EIR).

The stressed nature of the catchment would require that alternative sources of water be found for the both construction and operation. The suitability in terms of water quality can only then be assessed.

The relatively low "Coefficient of Variation" (CV) numbers indicate that primary water courses in the catchment are generally perennial and secondary water courses are generally non-perennial.

Based on catchment G21B a Mean Annual Runoff (MAR) of about 25 mm is expected. This equates to an average of just over 2 mm per month. This average would be higher during the wet season and expected distribution of MAR will only be available if the monthly water balance for the site is calculated. Due to the high infiltration rate of the sandy soils (approx 200 mm/hour) no base flow runoff is expected on the site for pre-development. During construction of the foundation when most of the overlying sand is removed some base flow runoff is expected into the excavated area**.** Detailed studies would be required to refine this initial estimate.

Figure 2.8 indicates the locality of the regional water features and major catchments.



Data Source: 1/50,000 Topographic Map Sheets 3318 CB-DA-CD-DC

Scale 1:100 000

Projection: GAUSS CONFORMAL

Datum: WGS84

Central Meridian/Zone: 19

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NUCLEAR-1 ENVIRONMENTAL IMPACT ASSESSMENT FOR A PROPOSED NUCLEAR POWER STATION AND ASSOCIATED INFRASTRUCTURE

SPECIALIST STUDY: HYDROLOGY AND HYDRAULICS

LOCALITY PLAN SHOWING REGIONAL WATER FEATURES AND MAJOR CATCHMENTS: DUYNEFONTEIN

Date:	Compiled by:
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Project No.	Fig No.
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Revision: B Date: 14 11 2014

2.2.6 Regional Hydrological Modelling

Surface Water Features

The following general comments relating to surface water features (and their potential use) can be made at this preliminary stage:

- The area is characterised with a low rainfall (MAP less than 500 mm) and besides the Salt River, Diep River and minor pans and dams, there are no notable surface water features.
- The drainage lines are non-perennial and flow as sheet flow during major storm events.

Catchment Characteristics

The catchments are currently all well vegetated. The catchments are expected to have a low runoff coefficient due to sandy soil, dense vegetation and undulating topography creating potential storage areas. This also correlates with the preliminary infiltration rates of on average 5 m per day (208 mm/hour).

2.2.7 Regional Hydraulic Study

There are no expected high water levels in water courses close to the site and surface water drains away from the proposed site. The regional catchments are shown in **Figure 2.8**.

The remainder of the minor catchments (G21B_DF1 to G21B_DF7) drain through the proposed site refer to **Figure 2.9**.

2.2.8 Description of Model

In order to quantify the volume and peak flows emanating from the regional catchments at the site the SCS model has been used.

2.2.9 Water Course Definition

Northern Catchments

Within the catchments (G21B_DF8 & G21_DF9) there are no defined water courses and the surface water drains from east to west, north of the proposed site. The catchments consist of undulating well drained sandy soils and eventually the catchment drains into the Atlantic Ocean during an extreme storm event.

Southern Catchments

The smaller catchment (G21B_DF10) drains the local runoff from the existing KNPS and the adjacent catchment (G21B_DF11) diverts the upstream surface water around the existing KNPS. During an extreme storm event this overland flow would drain south of the existing Koeberg site into the Atlantic Ocean. The most southern catchment (G21B_DF12) has a more defined water course (Salt River) and drains south of the proposed Duynefontein site and the existing KNPS. All the catchments consist of undulating well drained sandy soils eventually draining into the Atlantic Ocean.

(a) Minor catchments draining through the site

The following minor drainage lines (catchments G21B_DF1-G21B_DF7) drain through the proposed site (**Figure 2.9**). The catchments consist of undulating well drained sandy soils eventually draining into the Atlantic Ocean during an extreme storm event.

2.2.10 Floodline Determination

No floodlines were determined due to the locality of the proposed site with respect to the topography and the resultant sub-catchment boundaries. The nearest major water course is the Salt River mouth approximately 5.6 km south of the proposed Duynefontein site.

The following is observed:

- Northern catchments (G21B_DF8 & G21B_DF9):
- No impact of the water course is expected on the site.
- Southern catchments (G21B_DF10 – G21B_DF12):
- No impact of the water course is expected on the site.
- Catchments draining to site (G21B_DF1 – G21B_DF7):
- Potential runoff from (G21B_DF1 – G21B_DF7) catchments would need to be adequately diverted around the site to ensure minimal impact on the environment.

2.2.11 Ponding Areas

In addition to watercourses, possible temporary ponding areas have also been determined. These areas consist primarily of low topography points with no natural outlet. During a storm event these areas would accumulate excess runoff from the surrounding catchment, which would cause temporary ponds/inundation. The expected runoff volumes have been based on the PMP. The expected ponding areas and flood levels in the vicinity of the sites are shown in **Figure 2.9**.

2.2.12 Plant Area Specific Stormwater Management

Having quantified and assessed the regional hydrology and hydraulics one now needs to consider the local on site stormwater management.

2.2.13 Site Description

The majority of the site is covered by fynbos and there are no noticeable local water courses. In the event of significant rainfall it is expected that some temporary ponding will occur between the sand dunes which are aligned parallel to the coastline .The anticipated site conditions during various phases of construction are given below.

During Construction

It is anticipated that during construction a large open excavation will be required in order to access bedrock level for the foundations. The anticipated footprint is expected to have a surface area of about 60 ha and the depth would be about 20 m for the current site position.

During Operation

During operation it is expected that the plant area would cover most of the anticipated footprint.

Decommissioning Phase

During this phase it is expected that after removal and dismantling the plant and associated structures, the disturbed area will be rehabilitated with formal environmental and human health risk plans, based on a comprehensive environmental impact assessment in accordance with relevant laws and regulations that would apply at the time of decommissioning.

2.2.14 Description of Stormwater Model and Input Parameters

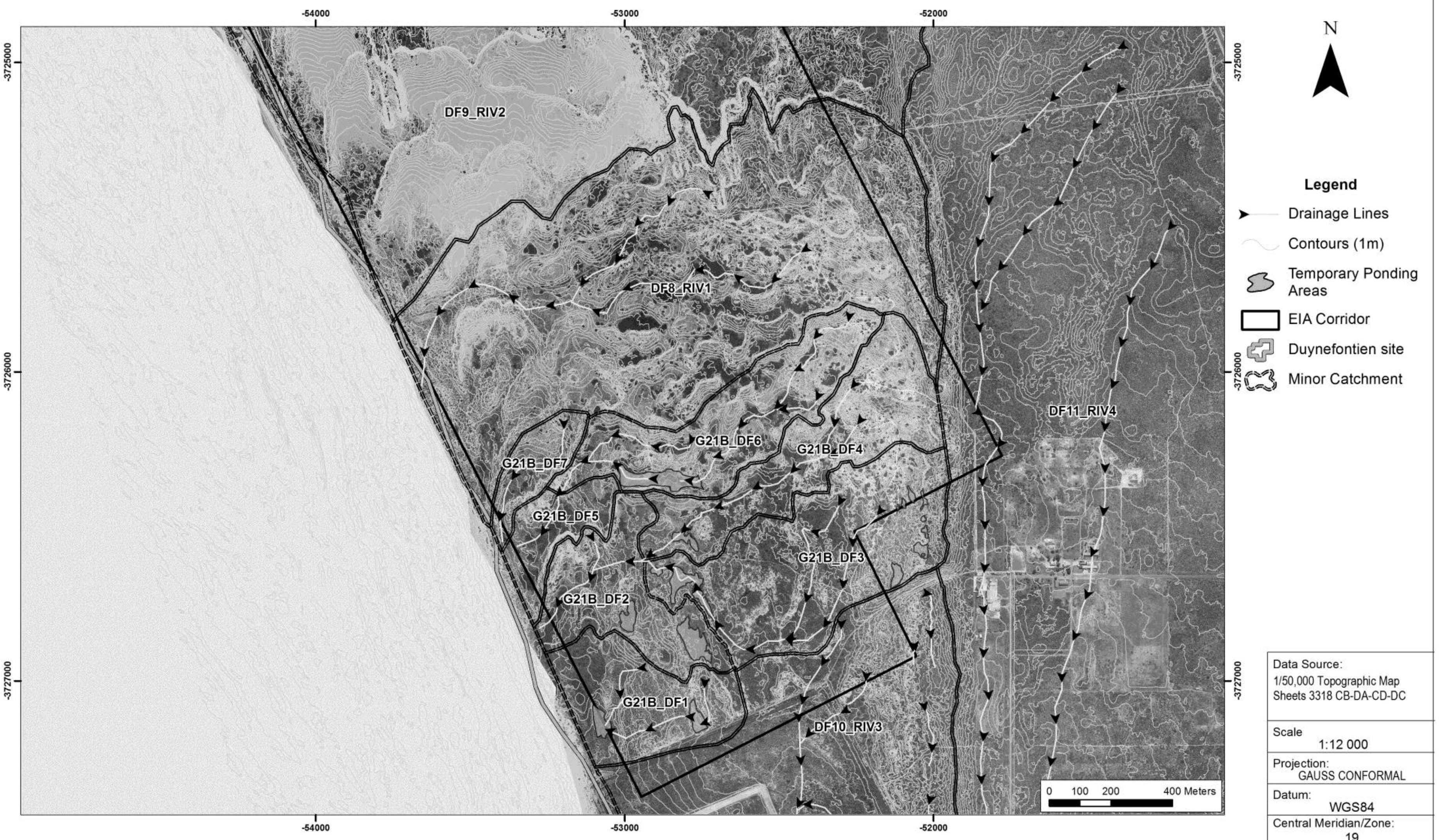
For this analysis smaller sub-catchments have been defined for each of the sites. This then enables one to determine runoff peaks and volumes at selected outlet points. Catchments G21B_DF1 to G21B_DF7 have been defined based on the current detailed topographic information and are shown in **Figure 2.9**.

The SCS-SA model has again been used to model the respective catchments for each of the above defined land use conditions. The chosen stormwater model main input parameters are summarised in **Table 2.20**.

Table 2.20: Stormwater Model (SCS-SA) Input Parameters – Plant Specific Catchments: Duynefontein

Parameter	Value		Reason
SCS-SA Model			
Return Period (Years)	24 hour Rainfall Depth (mm)	24 hour Rainfall Depth with Climate Change Assumptions	As detailed in section 2.2.4
50	70	*Currently unavailable	
100	78	Currently unavailable	
200	86	Currently unavailable	
1 000	105	Currently unavailable	
10 000	132	Currently unavailable	
Rainfall Distribution	SCS Type II	SCS Type II	Coastal Region Distribution as detailed in SCS Manual
Catchment Curve number (CN) - Pre-Development - Construction - Operational	 27 91 98	 27 91 98	Sandy Soil, SCS Type 'A' with high infiltration rate (200 mm/hour) for Pre-Development. High runoff potential due to rock and paved areas for Construction & Operational phases

*these are currently not available and will be quantified when more information becomes available.



Data Source: 1/50,000 Topographic Map Sheets 3318 CB-DA-CD-DC		
Scale 1:12 000		
Projection: GAUSS CONFORMAL		
Datum: WGS84		
Central Meridian/Zone: 19		
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Project No. 385908	Fig No. 2.9	

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SPECIALIST STUDY: HYDROLOGY AND HYDRAULICS
LOCALITY PLAN SHOWING REGIONAL WATER FEATURES AND MAJOR CATCHMENTS: DUYNEFONTEIN

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Revision: B Date: 14 11 2014

2.2.15 Plant Area Stormwater Modelling

Based on the defined sub catchments and above input parameters the peak flows and volumes could be determined for the following conditions:

- Pre development;
- During construction; and
- Operational and closure

The results are summarised in **Table 2.21**.

Table 2.21: Peak Flow Rates & Runoff Volumes: Duynefontein

	Pre-Development		During Construction		Operational/ Closure	
Recurrence Interval (years)	**Peak Flow (m^3/s)**	**Runoff Volume (m^3)**	**Peak Flow (m^3/s)**	**Runoff Volume (m^3)**	**Peak Flow (m^3/s)**	**Runoff Volume (m^3)**
1:50	0.00	10	6.8	29 500	8.4	38 800
1:100	0.00	100	7.8	34 000	9.3	43 600
1:200	0.01	300	8.8	38 500	10.3	48 400
1:1 000	0.04	1 100	11.2	49 400	12.7	59 700
1:10 000	0.27	3 200	14.6	65 100	16.0	75 900

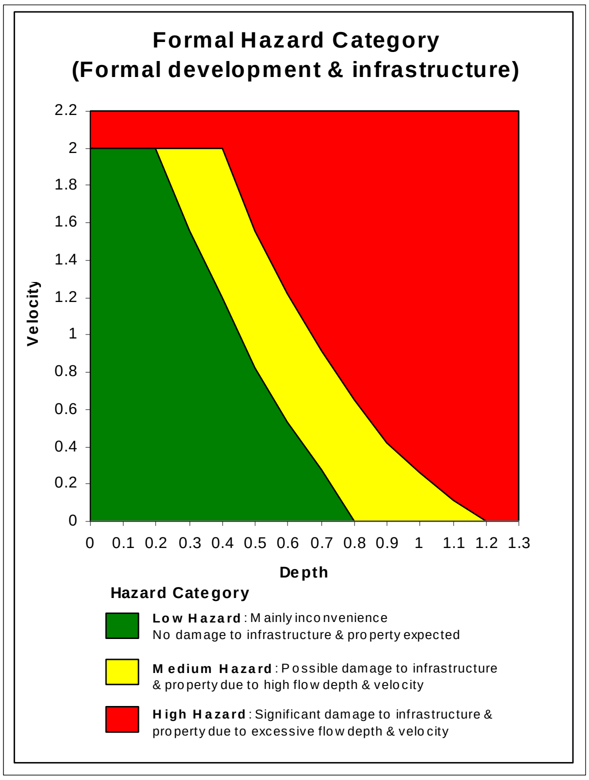
The following observations are made:

- Pre-development runoff flows and volumes are very low due to the high infiltration
- rates of about 200 mm/h;
- During construction runoff flows and volumes are substantially higher due to the site
- being excavated to bedrock (low infiltration rates);
- Operational/closure runoff flows and volumes are slightly higher than the during
- construction values due to the site being paved; and
- There is a major percentage increase in runoff from the site due to the development
- and this would need to be managed at the various discharge points to ensure minimal
- Impact on the environment.

2.2.16 Evaluation of Site Sensitivity (Flood Hazards) and Impacts

Considering that there are water courses and ponding areas in close proximity to the sites a site sensitivity (flood hazard) assessment has been done. The flood hazard, which has been defined using a flow depth and velocity relationship, is portrayed in **Figure 2.10**.

Figure 2.10: Flood Hazard Assessment: Duynefontein

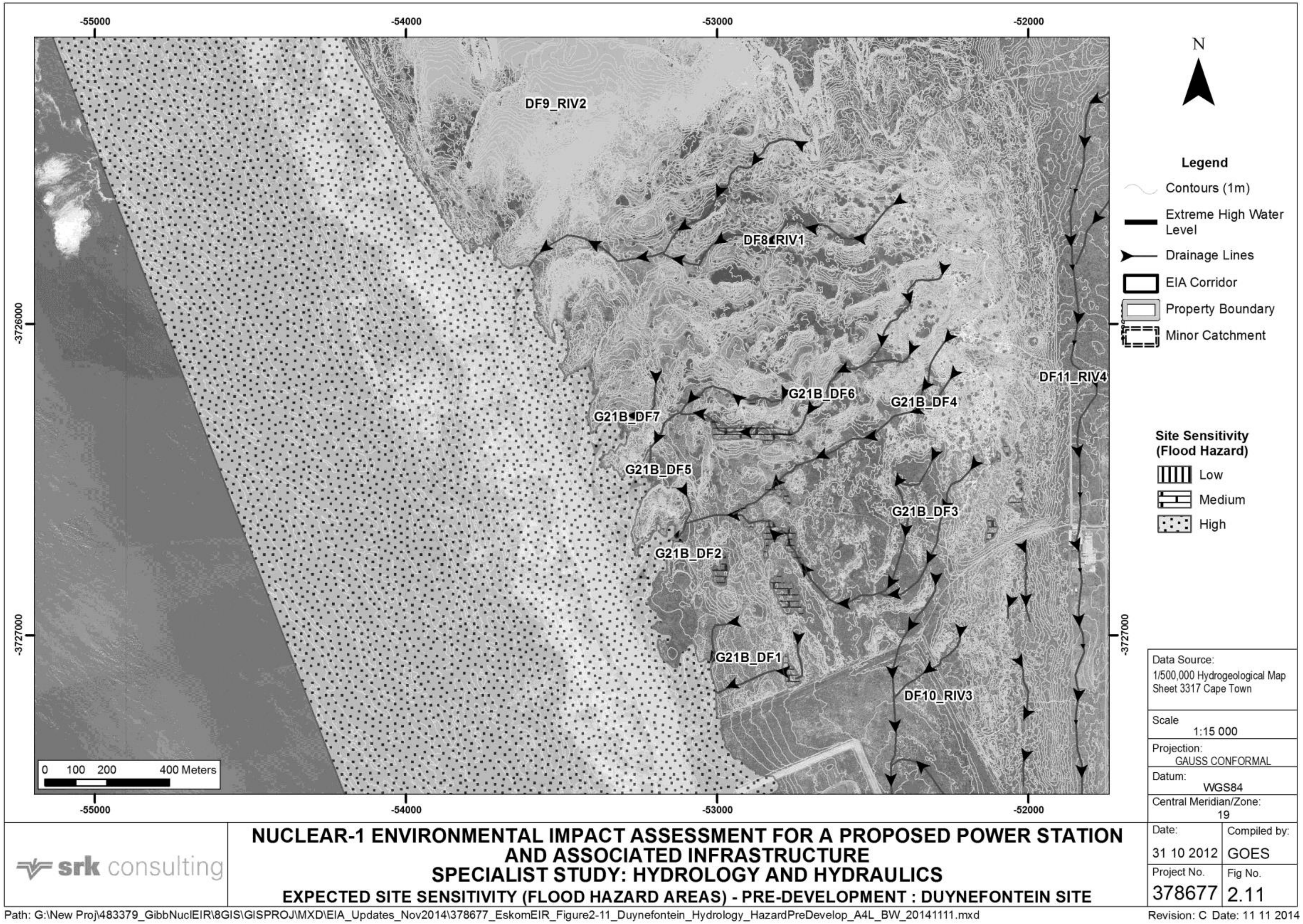


The site sensitivity (flood hazards) are categorised as follows:

- Low sensitivity (LH): Mainly inconvenience, no damage to infrastructure and low safety risk.
- Medium sensitivity (MH): Possible damage to infrastructure and a medium safety risk.
- High sensitivity (HH): Significant damage to infrastructure and high safety risk.

Regional Catchments

The regional catchment assessment has been based on the existing topography and natural water features within the regional catchments. The expected site sensitivity (hazard categories) and locality for the pre-development condition are shown in **Figure 2.11**.


-55000
-54000
-53000
-52000
-3726000
-3727000
DF9_RIV2
DF8_RIV1
DF11_RIV4
G21B_DF6
G21B_DF4
G21B_DF7
G21B_DF5
G21B_DF3
G21B_DF2
G21B_DF1
DF10_RIV3
0 100 200 400 Meters
N
Legend
Contours (1m)
Extreme High Water Level
Drainage Lines
EIA Corridor
Property Boundary
Minor Catchment
Site Sensitivity (Flood Hazard)
Low
Medium
High
Data Source:
1/500,000 Hydrogeological Map Sheet 3317 Cape Town
Scale
1:15 000
Projection:
GAUSS CONFORMAL
Datum:
WGS84
Central Meridian/Zone:
19
Date:
31 10 2012
Compiled by:
GOES
Project No.
378677
Fig No.
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NUCLEAR-1 ENVIRONMENTAL IMPACT ASSESSMENT FOR A PROPOSED POWER STATION AND ASSOCIATED INFRASTRUCTURE
SPECIALIST STUDY: HYDROLOGY AND HYDRAULICS
EXPECTED SITE SENSITIVITY (FLOOD HAZARD AREAS) - PRE-DEVELOPMENT : DUYNEFONTEIN SITE
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The following observations are made:

- Due to the low runoff potential only a low sensitivity(hazard) is expected due to flooding;
- The extreme sea high water level is expected to have a high sensitivity (hazard) but is not expected to impact on the site which is situated above this extreme sea high water level.

Plant Area Assessment

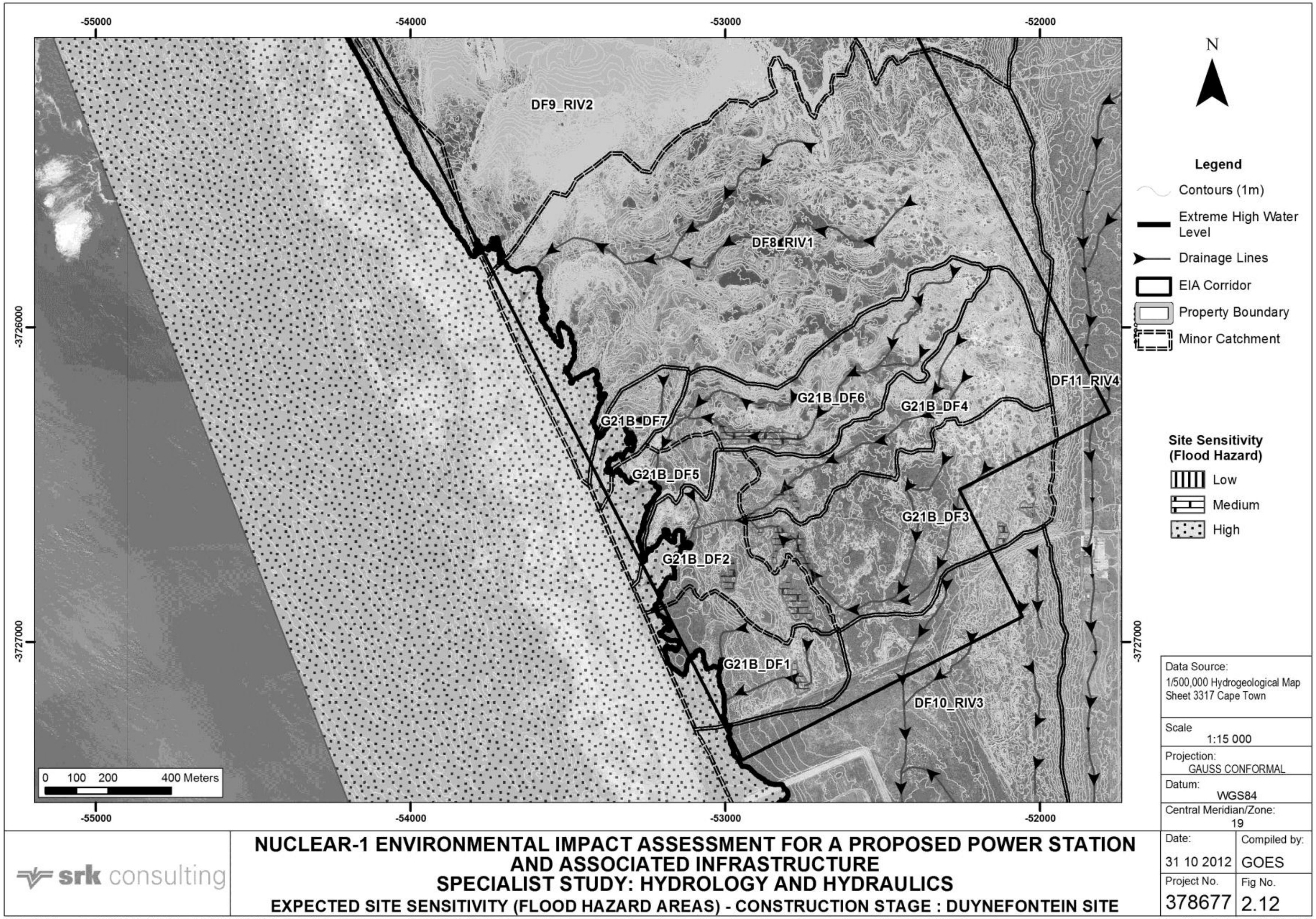
A site sensitivity (hazard) assessment for the potential plant area has also been done for the following three development conditions:

- Pre -development, assuming virgin catchment conditions;
- During construction, assuming that the plant area is initially excavated to rock level at a depth of about 15 m and a stormwater control embankment is in place; and
- Operation, assuming that the plant area is now fully developed with all infrastructure completed and area fully paved.

The expected hazards are summarised in **Table 2.22**, **Table 2.23** and **Table 2.24**, respectively, for the above development conditions. The expected site sensitivity (hazard areas) for construction/development phase are shown in **Figure 2.12**.

Table 2.22: Expected Plant Area Hazard (Pre Development): Duynefontein

Hazard Source	Site
G21B_DF1	MH
G21B_DF2	MH
G21B_DF3	LH
G21B_DF4	LH
G21B_DF5	LH
G21B_DF6	LH
G21B_DF7	LH



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Revision: C Date: 11 11 2014

Table 2.23: Expected Plant Area Hazard (During Construction): Duynefontein

Hazard Source	Site
	Hazard
Runoff into excavation	HH

Table 2.24: Expected Plant Area Impact (Operational/Closure, no mitigation): Duynefontein

Hazard Source	Site
	Hazard
Plant area runoff	HH

The following observations are made:

- There is a high sensitivity (hazard) for the construction and operational/closure phases should no mitigation measures be implemented;
- The main cause of the highsensitivity (hazards) is the disruption to construction activities as well as interference with the power station operation in the event of a major storm with no flood control measures in place.

2.3 Bantamsklip

2.3.1 Description of the Affected Environment

The proposed site is situated on the coastline approximately 8 km east of Pearly Beach in the Western Cape.

No major water structures/features are found upstream from the Bantamsklip site.

2.3.2 Rainfall Details

Daily rainfall data from measuring stations in the vicinity of the site were extracted from the database of the SAWS as summarised in **Table 2.25**.

Table 2.25: Summary of Rainfall Stations Considered: Bantamsklip

Station No.	Years of Record	Distance from Site (km)	Elevation (mamsl)	MAP (mm)
6836 (Stanford)	116 (54.9% reliable)	30.2	15	546
7263 (Boskloof)	122 (51.9% reliable)	35.9	213	447
7050 (Dungheye Park)	114 (45.6% reliable)	39.6	152	483

From the above the following is noted:

- No long term records are available at the Bantamsklip site but gauges were installed in January 2008. These records do not present sufficiently long data records to be included in this study.
- Station 6836 has one of the longest reliable records, similar elevation and is the closest station, about 30 km away from the site.

Based on the above station 6836 has been selected to be representative of the rainfall in the area. The selected station has 116 years of patched rainfall records which is still shorter than the predicted 1 000 and 10 000 years rainfall required for determining the estimated runoff flows and volumes. These extreme runoff flows and volumes are based on the US Nuclear Regulation Commission guidelines (IAEA, 2003). In view of this 24 hour design rainfall depths were calculated using a statistical approach. A statistical analysis using the Annual Maximum Series (AMS) was undertaken for the following probability distributions:

- Weibull (1939) – normal, Pearson III;
- Blom (1958) – normal;
- Gringorten (1963) – exponential, EV1 & GEV;
- Beard – Pearson III.

The best fit distribution was found to be the Weibull giving a correlation coefficient $R^2 = 0.9705$.

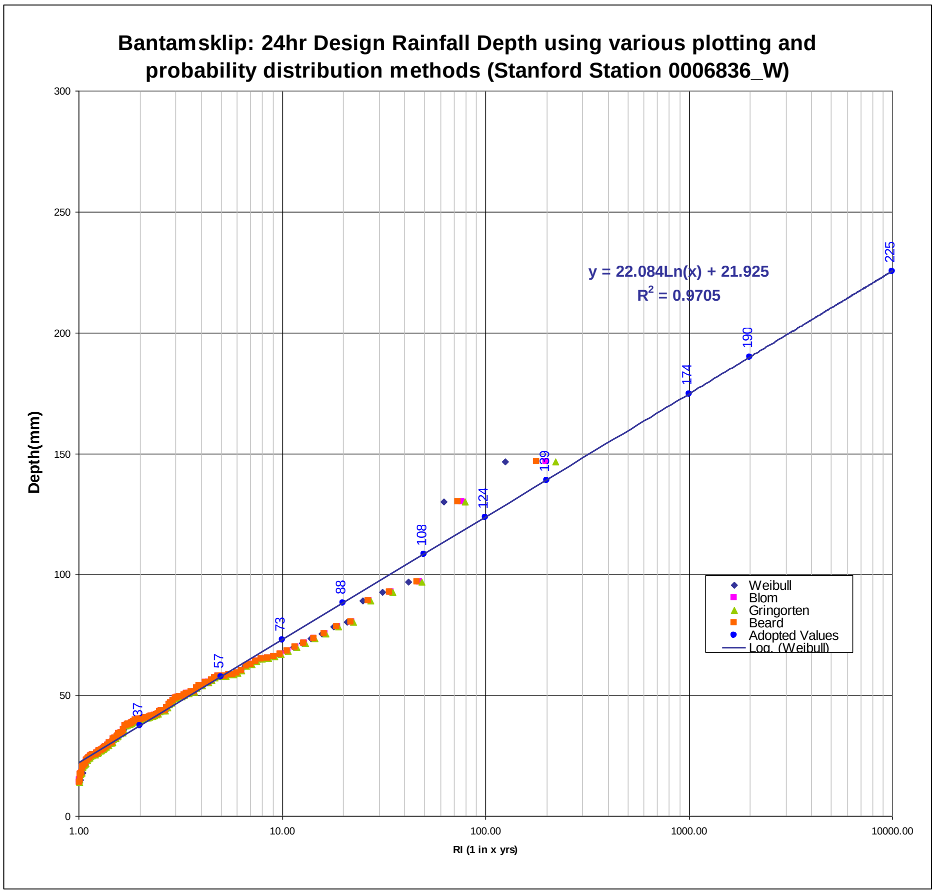
Based on the above, the expected 24 hour rainfall depths are tabulated in **Table 2.26** below and shown graphically in **Figure 2.13**.

Table 2.26: Adopted 24 hour Design Rainfall Depths: Bantamsklip

Recurrence interval (Years)	24 hour storm rainfall (mm) (Adopted MAP = 546)
50	108
100	124
200	139
1 000	174
10 000	225

Climate change has not yet been included as no scientific local information is currently available. This will be quantified when the University of KwaZulu-Natal has completed their regional study on climate change

Figure 2.13: Adopted 24 hour Design Rainfall Depth: Bantamsklip



2.3.3 Extreme high water level and tsunami data

The specialist oceanographic study for Duynefontein has been completed. The study for Bantamsklip has not yet been completed and extreme water levels are assumed to be of a similar nature. Therefore, the Duynefontein values have been used until the detailed oceanographic study for Bantamsklip becomes available. These assumed values are deemed representative and sufficient for this study. **Table 2.27**.

summarises the extreme high water levels from the ocean and **Table 2.28** summarises the tsunami levels .at the Bantamsklip site.

Table 2.27: Extreme High Water Levels: Bantamsklip

			No Climate Change		Climate Change	
	Component	**Units**	**Best Fit**	**Upper 95% Confidence**	**Best Fit**	**Upper 95% Confidence**
1: 1 000 000 Return Period	Highest Astronomical Tide (*Hermanus*)	mamsl	1.28	1.28	1.28	1.28
	Sea level rise	m	0.00	0.00	0.80	0.80
	Wave set-up and run-up	m	*4.25*	*4.67*	*4.81*	*5.30*
	Positive storm surge	m	1.541	1.86	1.83	*2.25*
	Extreme high water level	mamsl	*7.04*	*7.81*	*8.72*	*9.63*

Table 2.28: Tsunami Data: Bantamsklip

Tsunami	Units	No Climate Change		Climate Change	
Component		**Best Fit**	**Upper 95% Confidence**	**Best Fit**	**Upper 95% Confidence**
Upper 90th Percentile high tides (Port Elizabeth)	mamsl	1.04	1.04	1.04	1.04
Sea level rise	m	0.00	0.0	0.8	0.8
Positive storm surge (1:10 years)	m	0.78	0.83	0.94	1.00
Tsunami	m	2.91	3.64.	3.52	4.40
Wave Set-up and run-up (1:10) years	m	3.25	3.35	3.67	3.78
Extreme high water level	mamsl	7.98	8.86	9.97	11.02

Based on the above table and including climate change it is recommended that the base level of the plant should not be lower than 11.02 mamsl.

2.3.5 Long-Term Hydrology details

Based on information from the Water Resources Study (WR2012, 2012), the following key long-term hydrology details have been extracted and are summarised in **Table 2.29**. The regional catchments are shown in **Figure 2.14**.

Table 2.29: Bantamsklip Catchment Information Summary

ID	Gross area (km^2)	Forest area (km^2)		Irrig. Area (km^2)	Evap zone	MAE (mm)	Rain zone	MAP (mm)	MAR (mm)	MAP – MAR Resp.	Net MAR (m^3x10^6)	Gross MAR (m^3x10^6)	CV
		Forest	Alien										
G40M	393	0	230	6.6	23C	1 440	G5B	509	39	5	15.4	15.4	0.718
G50A	243	0	0	0	23C	1 440	G5B	545	37	5	9.1	9.1	0.721
G50B	339	0	227	0.8	23C	1 445	G5B	492	35	5	11.9	11.9	0.719

The relatively low “Coefficient of Variation” (CV) numbers indicate that primary water courses in the catchment are generally perennial and secondary water courses are generally non-perennial.

The proposed site is located within the Breede River Water Management Area and within the Overberg East sub area as is defined in the Integrated Strategic Perspective (ISP) for the Breede River Water Management Area.

The 2000 water requirements in the sub area indicate that the sub area was then in balance (ISP), the main uses being by the towns in the area as well as for rural domestic and stock watering purposes.

Ecological Reserve Requirement in the Overberg West sub area is estimated to be 94 Mm^3/annum of the 480 Mm^3/annum and more detailed studies would be required to confirm these. Various water resources development options exist in the Breede River Water Management Area and the timelines and feasibilities thereof need to be discussed with the DWA. The viability of these options should be measured against the option of desalination of sea water.

The stressed nature of the catchment would require that alternative sources of water are found for both construction and operation. Development opportunities exist but need to be further investigated with the DWA. Water quality needs to be investigated when possible suitable sources are identified.

Based on the above, MAR of about 37 mm is expected for catchment G50A. This equates to an average of just over 3 mm per month. This average would be higher during the wet season but would be covered in more detail once the monthly water balance for the site has been completed. Due to the high infiltration rate of the sandy soils (approx 200 mm/hour) no base flow runoff is expected on the site for pre-development. During construction of the foundation when most of the overlying sand is removed, some base flow runoff is expected into the excavated area. Further more detailed studies would be required to refine this initial estimate.

2.3.6 Regional Hydrological Modelling

Surface Water Features

The following general comments relating to surface water features (and their potential use) can be made at this preliminary stage:

- The area is characterised with a low rainfall (MAP less than 600 mm) and besides the Haelkraal, Koks, Wolfgat and Ratel Rivers, and surrounding marshes, there are no further notable surface water features.

- The drainage lines are non-perennial and flow as sheet flow during major storm events.

Catchment Characteristics

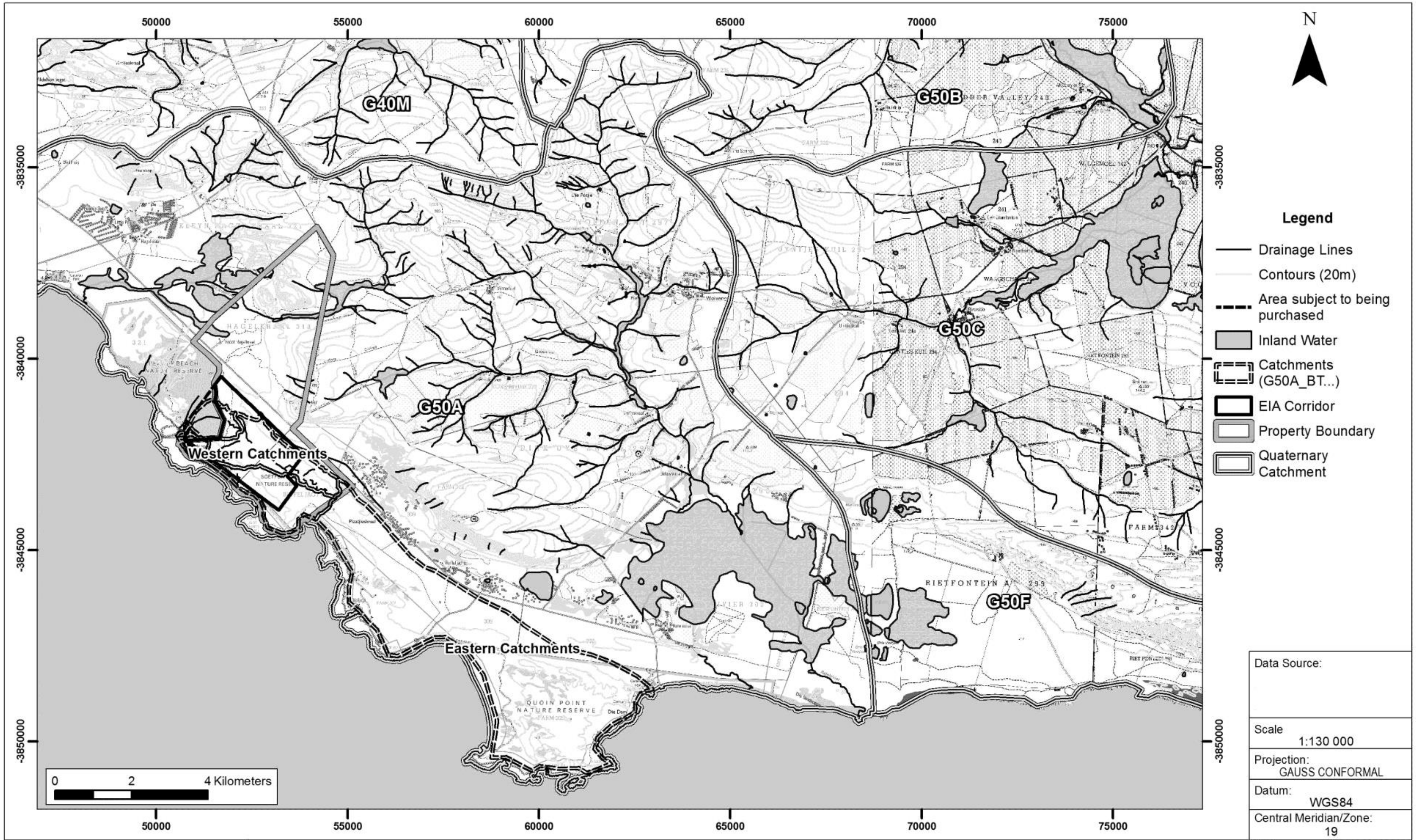
The catchments are currently all well vegetated primarily with fynbos. The catchments are expected to have a low runoff coefficient due to sandy soil, dense vegetation and undulating topography creating potential storage areas. This also correlated with the preliminary infiltration rates of on average 5 m per day (208 mm/hour).

2.3.7 Description of Model

The volume and peak flows emanating from the regional catchments at the site were again determined by the SCS Method using local rainfall conditions.

Input Data

The main input data for the relevant major catchments and water courses modelled are given below in **Table 2.30**.



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NUCLEAR-1 ENVIRONMENTAL IMPACT ASSESSMENT FOR A PROPOSED NULCEAR POWER STATION AND ASSOCIATED INFRASTRUCTURE
SPECIALIST STUDY: HYDROLOGY AND HYDRAULICS
LOCALITY PLAN SHOWING REGIONAL WATER FEATURES AND MAJOR CATCHMENTS : BANTAMSKLIP SITE

Date:	Compiled by:
31 10 2012	GOES/ FUBM
Project No.	Fig No.
378677	2.14

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Revision: C Date: 11 11 2014

Table 2.30: Stormwater Model (SCS-SA) Input Parameters – Major Catchments: Bantamsklip

Parameter	Value		Reason
SCS–SA Model			
Return period (Years) 50 100 200 1 000 10 000	24 hour Rainfall depth (mm) 108 124 139 174 225	24 hour Rainfall depth (mm) Incl Climate Change Assumptions *Currently unavailable Currently unavailable Currently unavailable Currently unavailable Currently unavailable	As detailed in section 2.3.2
Rainfall distribution	SCS Type II	SCS Type II	Coastal region distribution as detailed in SCS Manual
Catchment Curve number (CN) - Pre-development	27	27	Sandy soil, SCS Type 'A' with high infiltration rate (200mm/hour)

*These will be quantified when more information becomes available

Peak Flow Estimation

Based on the above model input parameters the predicted peak flow rates are given in **Table 2.31**.

Table 2.31: Result of Regional Hydrological Modelling: Bantamsklip

Water course Reference	Accumulative Catchment Area (km^2)	Peak Flows (m^3/s)			
		1:100 year	1:200 year	1:1 000 year	1:10 000 year
G50A_BT1	0.04	0.01	0.03	0.11	0.30
G50A_BT2	3.14	0.55	1.01	2.65	6.38
G50A_BT3	2.87	0.52	0.96	2.56	6.21
G50A_BT4	0.04	0.01	0.03	0.12	0.31
G50A_BT5	1.05	0.23	0.44	1.25	3.13
G50A_BT6	0.97	0.22	0.42	1.20	3.00
G50A_BT7	1.39	0.29	0.54	1.49	3.68
G50A_BT8	3.58	0.76	1.44	4.02	9.99
G50A_BT9	54.93	-	-	-	-
G50A_BT10	166.26	-	-	-	-
G50A_BT11	20.62	4.21	7.94	21.89	54.02
G50A_BT12	2.59	0.58	1.13	3.22	8.08

2.3.8 Regional Hydraulic Study

There are no expected high water levels in water courses close to the site and the surface water drains away from the proposed site. The regional catchments have been called “western catchments” and “eastern catchments” for referencing purposes as shown in **Figure 2.14**.

The remainder of the minor catchments (G50A_BT1 and G50A_BT6) drain through the proposed site.

2.3.9 Water Course Definition

Western Catchments

Within these catchments (G50A_BT7 and G50A_BT8) there are no defined water courses and the surface water drains to the north of the proposed site. The catchments consist of undulating well-drained sandy soils eventually draining into the Atlantic Ocean during an extreme storm event. Catchment G50A_BT9 is more defined and drained by the Haelkraal River and also drains into the Atlantic Ocean.

Eastern Catchments

The smaller catchments (G50A_BT11 & G50A_BT12) drain the local runoff in the area. The catchments consist of undulating well drained sandy soils eventually draining into the Atlantic Ocean during an extreme storm event. The larger catchment (G50A_BT10) is drained by the Koks, Wolfgat and Ratel Rivers and also drains into the Atlantic Ocean.

2.3.10 Floodline Determination

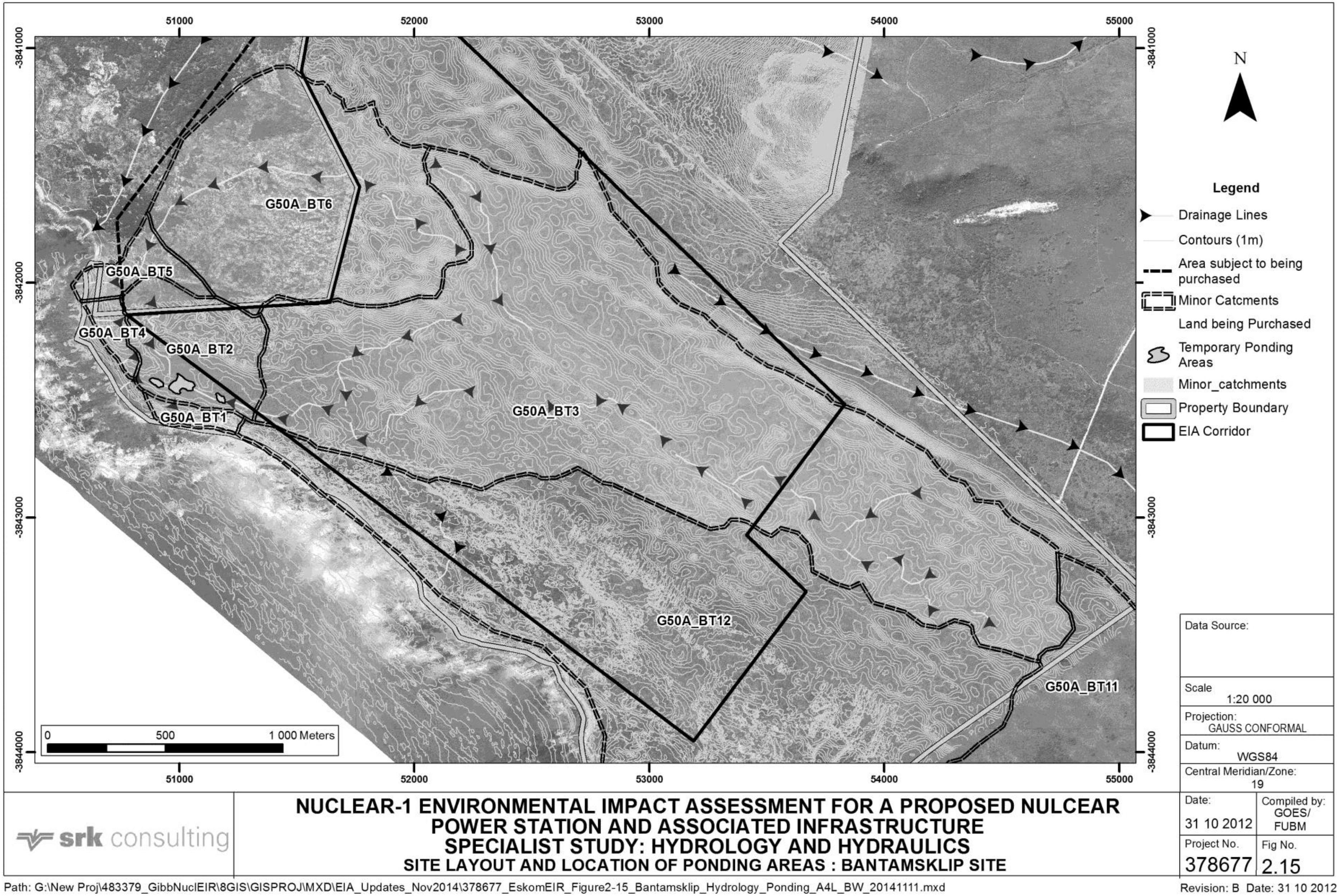
No floodlines were determined due to the locality of the proposed site with respect to the topography and the resultant sub-catchment boundaries. The nearest major water course is the Haelkraal River mouth approximately 5 km north west of the proposed site.

The following is observed:

Western Catchments (G50A_BT7, G50A_BT8 & G50A_BT9):
No impact of the water course is expected.

Eastern Catchments (G50A_BT10, G50A_BT11 & G50A_BT12):
No impact of the water course is expected.

Catchments Draining to Site (G50A_BT1, G50A_BT6):
Potential runoff from these catchments would need to be adequately diverted around the development footprint to ensure minimal impact on the environment.


51000
52000
53000
54000
55000
-3841000
-3842000
-3843000
-3844000
G50A_BT6
G50A_BT5
G50A_BT4
G50A_BT2
G50A_BT1
G50A_BT3
G50A_BT12
G50A_BT11
0
500
1 000 Meters
N
Legend
Drainage Lines
Contours (1m)
Area subject to being purchased
Minor Catcments
Land being Purchased
Temporary Ponding Areas
Minor_catchments
Property Boundary
EIA Corridor
Data Source:
Scale
1:20 000
Projection:
GAUSS CONFORMAL
Datum:
WGS84
Central Meridian/Zone:
19
Date:
31 10 2012
Compiled by:
GOES/
FUBM
Project No.
378677
Fig No.
2.15
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NUCLEAR-1 ENVIRONMENTAL IMPACT ASSESSMENT FOR A PROPOSED NULCEAR POWER STATION AND ASSOCIATED INFRASTRUCTURE
SPECIALIST STUDY: HYDROLOGY AND HYDRAULICS
SITE LAYOUT AND LOCATION OF PONDING AREAS : BANTAMSKLIP SITE
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Revision: B Date: 31 10 2012

2.3.11 Ponding Areas

In addition to water courses, possible temporary ponding areas have been determined. These areas consist primarily of topographical low points with no natural outlet. During a storm event these areas would accumulate excess runoff from the surrounding catchment which would cause temporary ponds/inundation. The expected runoff volumes have been based on the PMP as determined in **Subsection 2.3.2**. The expected ponding areas and flood levels in the vicinity of the sites are shown in **Figure 2.15**.

2.3.12 Plant Area Specific Stormwater Management

Having quantified and assessed the regional hydrology and hydraulics one now needs to consider the local site stormwater management.

2.3.13 Site Description

The majority of the site is covered by fynbos and there are no noticeable local water courses. In the event of significant rainfall it is expected that some temporary ponding will occur between the sand dunes which are aligned parallel to the coastline. The anticipated site conditions during various phases of construction are given below.

During Construction

It is anticipated that during construction a large open excavation will be required in order to access bedrock for the foundations in areas where overburden is thick.

During Operation

During operation it is expected that the anticipated plant area would be mainly paved.

Decommissioned Phase

During this phase it is expected that after removal and dismantling the plant and associated structures, the disturbed area will be rehabilitated with formal environmental and human health risk plans, based on a comprehensive environmental impact assessment in accordance with relevant laws and regulations that would apply at the time of decommissioning.

2.3.14 Description of Stormwater Model and Input Parameters

For this analysis smaller sub-catchments have been defined. This then enables one to determine runoff peaks and volumes at selected outlet points. The following six catchments have been defined based on the current detailed topographic information and named as follows:

G50A_BT1 – G50A_BT6:

- The respective catchments are shown in **Figure 2.15.**
- The SCS-SA model has again been used to model the respective catchments for each of the above defined land use conditions.
- The chosen stormwater model main input parameters are summarised in **Table 2.32**.

Table 2.32: Stormwater Model (SCS-SA) Input Parameters – Plant Specific Catchments: Bantamsklip

Parameter	Value		Reason
SWMM Model			
Return period (Years) 50 100 200 1 000 10 000	24 hour Rainfall depth (mm) 108 124 139 174 225	24 hour Rainfall depth (mm) incl Climate Change Assumptions *Currently unavailable Currently unavailable Currently unavailable Currently unavailable Currently unavailable	As detailed in section 2.3.2
Rainfall distribution	SCS Type II	SCS Type II	Coastal region distribution as detailed in SCS Manual
Catchment curve number (CN) - Pre-development - Construction - Operational	27 91 98	27 91 98	Sandy soil, SCS Type 'A' with high infiltration rate (200 mm/hour) for Pre-Development. High runoff potential due to rock and paved areas for construction & operational phases

*These are currently not available but will be quantified when more information becomes available

2.3.15 Plant Area Stormwater Modelling

Based on the defined sub catchments and above input parameters the peak flows and volumes were determined for the following conditions:

- Pre development;
- During construction;
- Operation and closure

The results are summarised in **Table 2.33**.

Table 2.33: Peak Flow Rates & Runoff Volumes: Bantamsklip

	Pre-Development		During Construction		Operational/ Closure	
Recurrence Interval (years)	**Peak Flow (m^3/s)**	**Runoff Volume (m^3)**	**Peak Flow (m^3/s)**	**Runoff Volume (m^3)**	**Peak Flow (m^3/s)**	**Runoff Volume (m^3)**
1:50	0.10	1 300	11.6	51 100	13.0	61 500
1:100	0.20	2 500	13.6	60 400	15.0	71 100
1:200	0.40	3 900	15.5	69 200	16.8	80 100
1:1 000	1.20	8 400	19.9	89 700	21.1	101 100
1:10 000	3.20	17 400	26.3	119 900	27.3	131 600

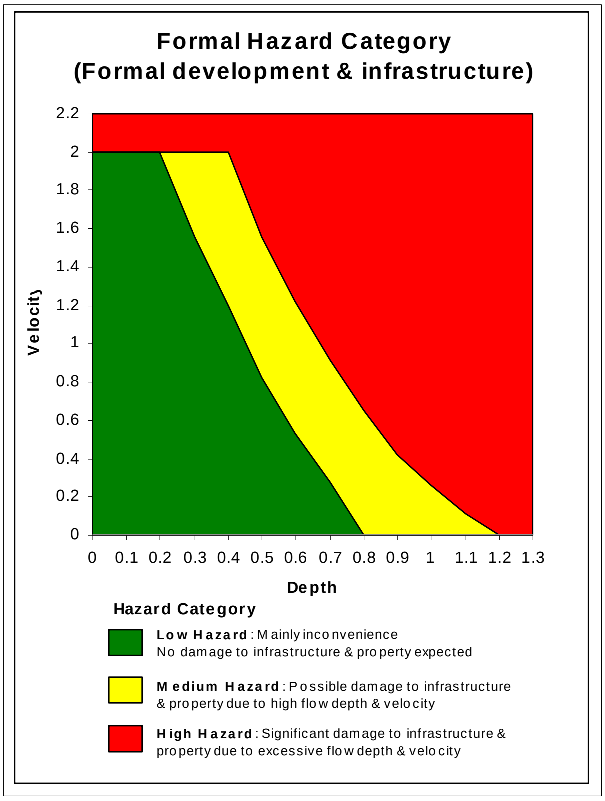
The following observations are made:

- Pre-development runoff flows and volumes are very low due to the high infiltration rates of about 200 mm/h;
- During construction runoff flows and volumes are substantially higher due to the site being excavated to bedrock (low infiltration rates);
- Operational/closure runoff flows and volumes are slightly higher than during
- construction due to the site being paved; and
- There is a major percentage increase in runoff from the site due to the
- development which would need to be managed at the various discharge points
- To ensure minimal impact on the environment.

2.3.16 Evaluation of Site Sensitivity (Flood hazards) and Impacts

Considering that there are water courses and ponding areas in the proximity of the sites a flood hazard assessment has been done. The site sensitivity (flood hazard), which has been defined using a flow depth and velocity relationship, is portrayed in **Figure 2.16.**

Figure 2.16: Flood Hazard Assessment: Bantamsklip



The site sensitivity (flood hazards) are categorised as follows:

- Low sensitivity (LH): Mainly inconvenience, no damage to infrastructure and low safety risk;
- Medium sensitivity (MH): Possible damage to infrastructure and a medium safety risk;
- High sensitivity (HH): Significant damage to infrastructure and high safety risk.

Regional Catchments

The regional catchment assessment has been based on the existing topography and natural water features within the regional catchments. The expected site sensitivity (hazard) categories and locality for the pre-development condition are shown in **Figure 2.17**.

The following observations are made:

- Due to the low runoff potential and predicted low runoff peaks no significant flood hazard (sensitivity) and flood impact is expected.
- The tsunami and HAT are expected to have a high hazard (sensitivity) but are not expected to impact on the site as this will be positioned above these high water levels.

2.3.17 Plant Area Assessment

A sensitivity (hazard) assessment for the potential plant area has also been done for the following three development conditions:

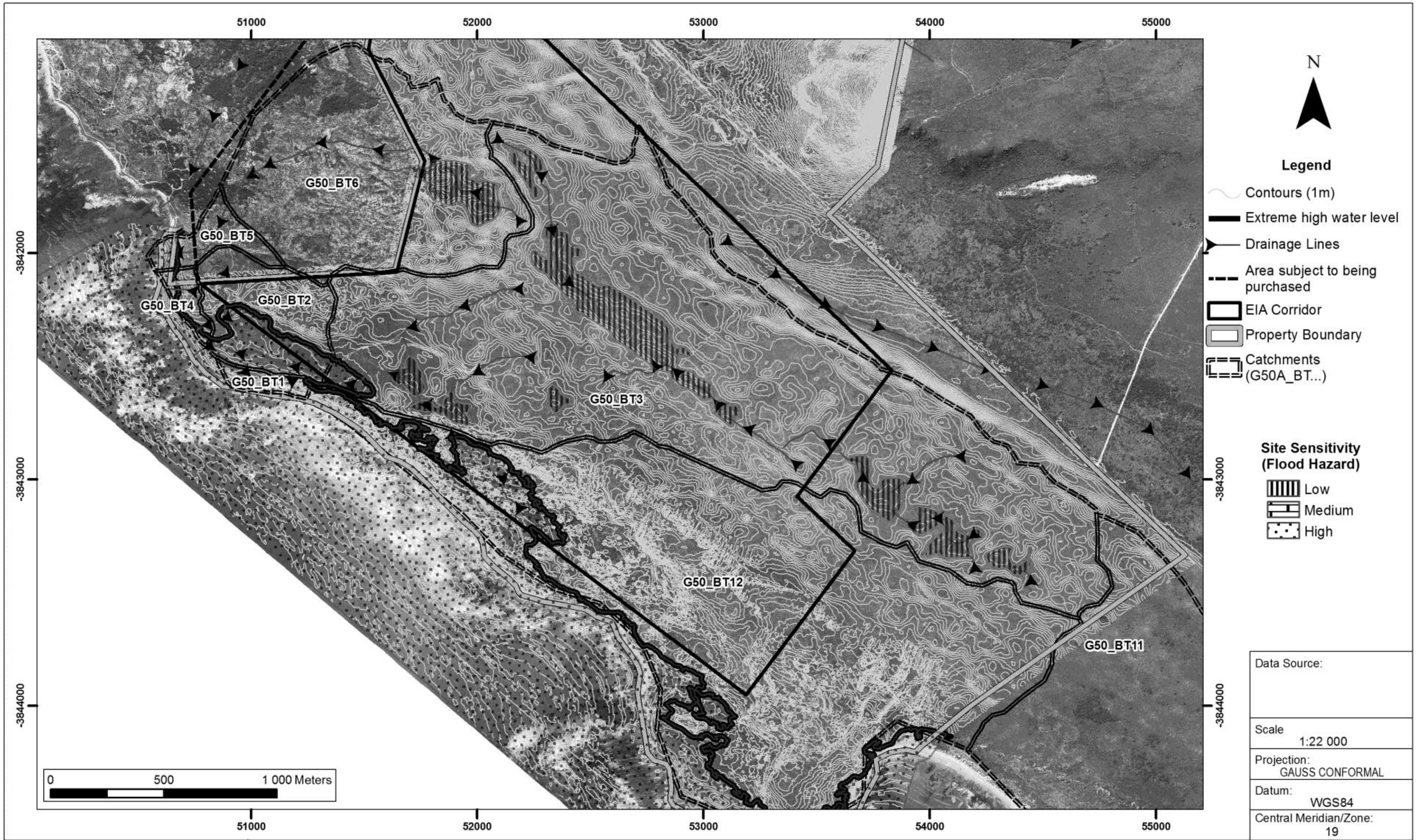
- Pre-development, assuming virgin catchment conditions;
- During construction, assuming that the plant area is initially excavated to rock level at a maximum depth of about 15 m and a stormwater control embankment is in place; and
- Operation, assuming that the plant area is now fully developed with all infrastructure completed and the area fully paved.

The expected sensitivity (hazards) are summarised in **Table 2.34**, **Table 2.35** and **Table 2.36**, respectively, for the above development conditions.

The expected sensitivity (hazard areas) for construction/operation phase is shown in **Figure 2.18**.

Table 2.34: Expected Plant Areas hazards (Pre Development): Bantamsklip

Hazard Source	Site
	Hazard
G50A_BT1	LH
G50A_BT2	MH
G50A_BT3	LH
G50A_BT4	LH
G50A_BT5	LH
G50A_BT6	LH



NUCLEAR-1 ENVIRONMENTAL IMPACT ASSESSMENT FOR A PROPOSED NULCEAR POWER STATION AND ASSOCIATED INFRASTRUCTURE
SPECIALIST STUDY: HYDROLOGY AND HYDRAULICS
EXPECTED SITE SENSITIVIT (FLOOD HAZARD AREAS) - PRE-DEVELOPMENT : BANTAMSKLIP SITE

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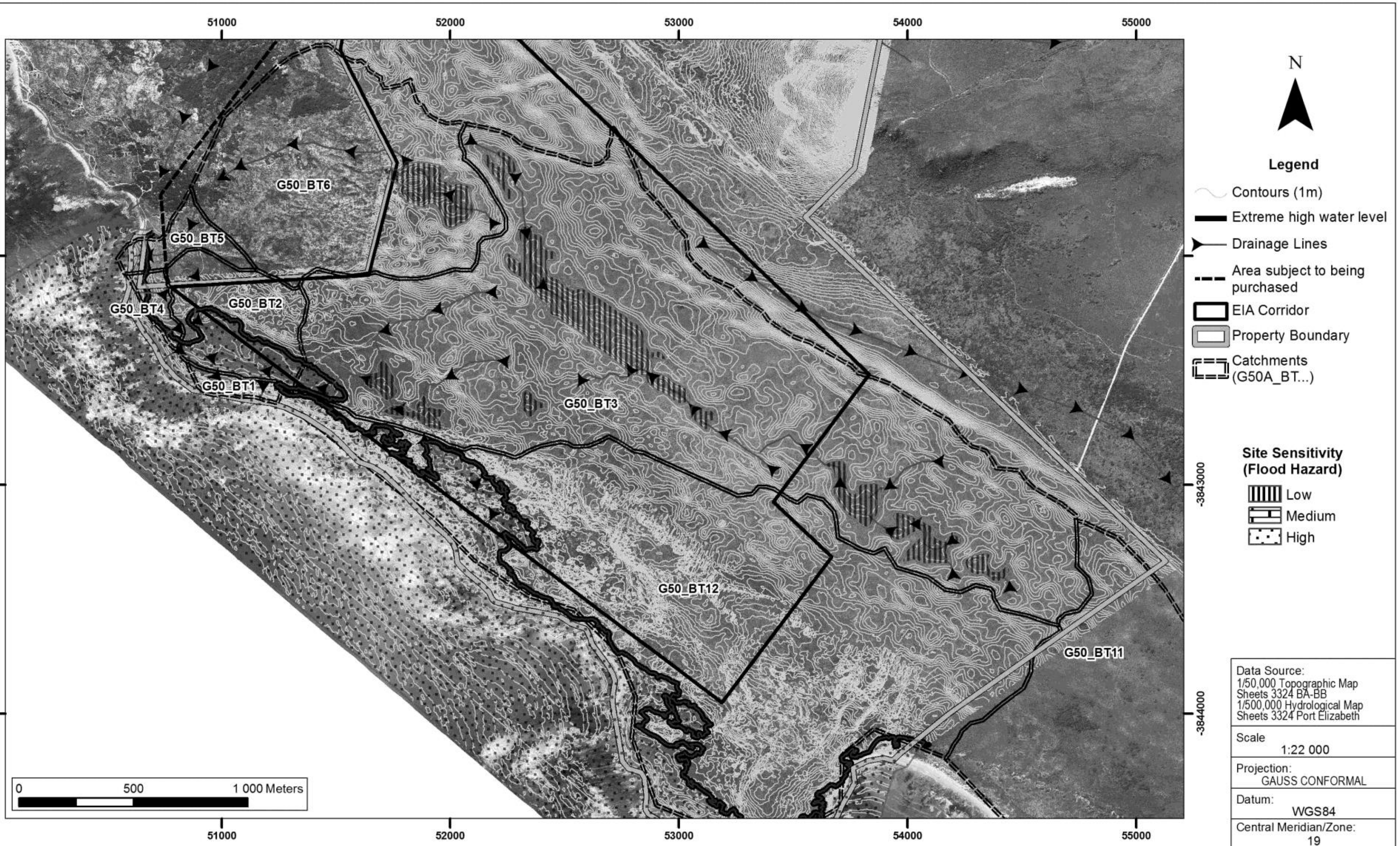
Revision: B Date: 31 10 2012



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Projection: GAUSS CONFORMAL	
Datum: WGS84	
Central Meridian/Zone: 19	
Date: 31 10 2012	Compiled by: GOES/ FUBM
Project No. 378677	Fig No. 2.18

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NUCLEAR-1 ENVIRONMENTAL IMPACT ASSESSMENT FOR A PROPOSED NULCEAR POWER STATION AND ASSOCIATED INFRASTRUCTURE
SPECIALIST STUDY: HYDROLOGY AND HYDRAULICS
EXPECTED SITE SENSITIVIT (FLOOD HAZARD AREAS) - CONSTRUCTION : BANTAMSKLIP SITE

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Revision: B Date: 31 10 2012

Table 2.35: Expected Plant Area Hazards (During Construction): Bantamsklip

Hazard Source	Site
	Hazard
Runoff into excavation	HH

Table 2.36: Expected Plant Area Impact (Operational/Closure, no mitigation): Bantamsklip

Hazard Source	Site
	Hazard
Plant area runoff	HH

The following observations are made:

- There is a high hazard for all the construction and operational/closure conditions should no mitigation measures be implemented.
- The main cause of the high hazards is the consequence of disruption to construction activities as well as interference with the power station operation in the event of a major storm with no flood control measures in place.

3 IMPACT IDENTIFICATION

The identification of impacts of each of the developments have been based on the EIA Regulations (DEAT, Regulation 385, in terms of the National Environmental Act 1998, (Act 107 0f 1998), the NEMA principles and Section 24(4) of the NEMA (as amended).

3.1 Thyspunt

The potential impacts identified linked to the activities for the construction and operational phase are summarised in **Table 3.1** and include direct and cummalitive impacts.

Table 3.1: Thyspunt Impact Identification

Activity	Potential Impact
Direct Impacts	
Construction Phase	
Setting up of construction camps & workshops	Increased runoff due to hardened surface. Increased erosion potential
Constructing access roads	Concentrated and increased runoff, Increased erosion potential
Deposition of excavated soil	Sea level rise
	Increased runoff , changes in flow paths & increased silt deposition
Excavation for foundations	Increased runoff, changes in flow paths & increased silt deposition due to barren soil. Flooding of works,
	Sea level rise
Construction of plant infrastructure	Changes in flow path. Increased risk of pollution
	Sea level rise
Operational Phase	
Plant area platform, paving and ancillary workshops	Increased runoff due to hardened surface into water course and ocean
	Sea level rise
Spillage of pollutants from workshops and pump stations	Contamination of the downstream and surrounding area.
Plant wash down water entering the surface runoff	Contamination of the downstream and surrounding area.
Cumulative Impacts	
Construction Phase	
Establishment of additional road networks	Concentrated flows and redirection of flow paths
Building of houses and commercial centers	Increased hardened surfaces causing concentrated & increased runoff
Spoil heaps	Concentrated flows and redirection of flow paths
Traffic on roads	Potential pollution due to vehicles
Operational Phase	
Power lines and pylons	Increased hardened surfaces at pylon basis causing redirection of flow paths
Traffic on roads	Potential pollution due to vehicles
Residential and commercial activities	Potential pollution due to spillages
	Increased hardened surfaces causing concentrated & increased runoff

3.2 Duynefontein

The potential impacts identified linked to the activities for the construction and operational phase are summarised in **Table 3.2** and include direct and cummalitive impacts.

Table 3.2: Duynefontein Impact Identification

Activity	Potential Impact
Direct Impacts	
Construction Phase	
Setting up of construction camps & workshops	Increased runoff due to hardened surface. Increased erosion potential
Constructing access roads	Concentrated and increased runoff, Increased erosion potential
Deposition of excavated soil	Sea level rise
	Increased runoff , changes in flow paths & increased silt deposition
Excavation for foundations	Increased runoff, changes in flow paths & increased silt deposition due to barren soil. Flooding of works,
	Sea level rise
Construction of plant infrastructure	Changes in flow path. Increased risk of pollution
	Sea level rise
Operational Phase	
Plant area platform, paving and ancillary workshops	Increased runoff due to hardened surface into water course and ocean
	Sea level rise
Spillage of pollutants from workshops and pump stations	Contamination of the downstream and surrounding area.
Plant wash down water entering the surface runoff	Contamination of the downstream and surrounding area.
Cumulative Impacts	
Construction Phase	
Establishment of additional road networks	Concentrated flows and redirection of flow paths
Building of houses and commercial centers	Increased hardened surfaces causing concentrated & increased runoff
Spoil heaps	Concentrated flows and redirection of flow paths
Traffic on roads	Potential pollution due to vehicles
Operational Phase	
Power lines and pylons	Increased hardened surfaces at pylon basis causing redirection of flow paths
Traffic on roads	Potential pollution due to vehicles
Residential and commercial activities	Potential pollution due to spillages
	Increased hardened surfaces causing concentrated & increased runoff

3.3 Bantamsklip

The potential impacts identified linked to the activities for the construction and operational phase are summarised in **Table 3.3** and include direct and cummalitive impacts.

Table 3.3: Bantamsklip Impact Identification

Activity	Potential Impact
Direct Impacts	
Construction Phase	
Setting up of construction camps & workshops	Increased runoff due to hardened surface. Increased erosion potential
Constructing access roads	Concentrated and increased runoff, Increased erosion potential
Deposition of excavated soil	Sea level rise
	Increased runoff , changes in flow paths & increased silt deposition
Excavation for foundations	Increased runoff, changes in flow paths & increased silt deposition due to barren soil. Flooding of works,
	Sea level rise
Construction of plant infrastructure	Changes in flow path. Increased risk of pollution
	Sea level rise
Operational Phase	
Plant area platform, paving and ancillary workshops	Increased runoff due to hardened surface into water course and ocean
	Sea level rise
Spillage of pollutants from workshops and pump stations	Contamination of the downstream and surrounding area.
Plant wash down water entering the surface runoff	Contamination of the downstream and surrounding area.
Cumulative Impacts	
Construction Phase	
Establishment of additional road networks	Concentrated flows and redirection of flow paths
Building of houses and commercial centers	Increased hardened surfaces causing concentrated & increased runoff
Spoil heaps	Concentrated flows and redirection of flow paths
Traffic on roads	Potential pollution due to vehicles
Operational Phase	
Power lines and pylons	Increased hardened surfaces at pylon basis causing redirection of flow paths
Traffic on roads	Potential pollution due to vehicles
Residential and commercial activities	Potential pollution due to spillages
	Increased hardened surfaces causing concentrated & increased runoff

4 ENVIRONMENTAL ASSESSMENT

The identification of impacts of each of the developments have been based on the EIA Regulations (DEAT, Regulation 385, in terms of the National Environmental Act 1998, (Act 107 0f 1998), the NEMA principles and Section 24(4) of the NEMA (as amended). The impacts have been assessed by using the following two categories:

- Direct impacts, impact the NPS will have on the environment;
- Indirect impacts; impacts that the environment will have on the NPS.

The above impacts have then been defined for each of the sites, both with and without mitigation measures. The BMPs approach, whereby the mitigation measures are divided into structural and non-structural BMPs, has also been applied. Structural BMPs are usually defined as “Essential mitigation measures” and Non-structural BMPs are defined as “Optional mitigation measures”.

The impact assessment is based on the standard tables and score values as defined in **Table 4.1**

Construction is scheduled to take five years and the NPS will be in operation for about 60 years. Decommissioning will therefore only occur in more than 65 years’ time. This is too far ahead for any meaningful predictions of likely impacts and mitigating measures.

4.1 Thyspunt

This development is surrounded by several ponding areas and two water courses.

4.1.1 Direct Impacts

The direct impact assessment for the site is summarised in **Table 4.1** with no defined changes regarding surface water features within the development area.

Table 4.1: Summary of Direct Impact Assessment

Impact	Nature	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE
Increased runoff peaks due to hardened surface.	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**
Increased runoff peaks due to hardened surface with mitigation	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**
Increased runoff volume due to hardened surface	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**
Increased runoff volume due to hardened surface with mitigation	Negative	Low	Medium	Low	Low	Low	Low	**Low**
Disruption during construction: Increased erosion potential	Negative	Low	Medium	Low	Low	Low	Low	**Low**
Disruption during construction: Increased erosion potential with mitigation	Negative	Low	Medium	Low	Low	Low	Low	**Low**
Disruption during construction: Flooding of works,	Negative	Low	Medium	Low	Low	Low	Low	**Low**
Disruption during construction: Flooding of works, with mitigation	Negative	Low	Medium	Low	Low	Low	Low	**Low**
Changes in flow paths	Negative	Low	High	High	Low	Medium	Low	**Low - Medium**
Changes in flow paths with mitigation	Negative	Low	High	High	Low	Medium	Low	**Low - Medium**
Disruption during construction: Increased silt deposition due to barren soil.	Negative	Low	Medium	Low	Low	Low	Low	**Low**
Disruption during construction :Increased silt deposition due to barren soil with mitigation	Negative	Low	Medium	Low	Low	Low	Low	**Low**
Pollution of surface waters	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**
Pollution of surface waters with mitigation	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**
Sea level rise	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**
Sea level rise with mitigation	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**

The following observations are made:

- The impacts relating both to the construction and operational phases of the project are directly related to increased run off associated with the hardened surfaces. In turn, this also increases the erosion potential in and around the site.
- During the construction phase, it is predicted with a high level of confidence that the significance of the impact will be low-medium. The implementation of recommended mitigation measures will further reduce the adverse impacts.
- The stormwater can potentially wash pollutants in and around the site to the neighbouring watercourses and the marine environment should mitigation measures not be put into place
- The operational phase (expected to be about 60 years) of the project will be the longest phase of the total project and therefore the probability of having a 1:10 000 year rainfall event is greater than for the construction phase (expected to be about 10 years). This is also illustrated in **Table 4.2** which shows that the probability of occurance of a 1:10 000 year event is only 0,0001 in any one year but is 0,00995 during a period of say 100 years. This trend is also depicted by means of the confidence in the impact prediction, which is lower for the operational phase due to needing to extrapolate rainfall data which is not available for the 1:10 000 rainfall event. The 1:10 000 year event is specifically selected in the case of Nuclear Installations as required by the IAEA Safety Standards Series, Safety Requirements.
- Impacts of low significance are predicted on a regional level

Table 4.2: Probability Analysis

Recurrence Interval vs Probability Analysis

RI		Probability of occurrence in X years						Probability of not occurring in X years			
		1	10	100	1000	10000	1000000	100	1000	10000	1000000
10		0.10000	0.65132	0.99997	1	1	1	0	0	0	0
20		0.050	0.40126	0.99408	1	1	1	0.006	0	0	0
50		0.020	0.18293	0.86738	1	1	1	0.133	0	0	0
100		0.010	0.09562	0.63397	1	1	1	0.366	0	0	0
200		0.005	0.04889	0.39423	0.993	1	1	0.606	0.007	0	0
1000		0.001	0.00996	0.09521	0.632	0.99995	1	0.905	0.368	0	0
10000		0.0001	0.00100	0.00995	0.095	0.632	1	0.990	0.905	0.368	0

4.1.2 Indirect Impacts

An indirect impact is defined as the impact the activity (activities) on the site have on the surrounding environmental but not directly associated with the activities on site. The following Indirect Impacts could be identified at the site during construction:

- Altered flow paths due to excavation of material and temporary dumping;
- Increase in sediment load causing deposition of soil along natural flow paths causing temporary ponding; and

- Increase in runoff peaks and volumes from barren soil causing possible erosion gullies along natural water courses.

Bearing in mind that the site and surrounding areas consists mainly of well drained sand the indirect impacts are expected to be of low significance.

4.1.3 No- go Option

Should it be decided to not construct a nuclear power station at Thyspunt Eskom will sell the land and the stringent controls that would be required and implemented for a nuclear site may not materialise if other types of developments take place. The no go option could then cause a higher negative impact than if a NPS was built.

4.1.4 Potential Impact the Environment May Have on the NPS

Extreme natural hydrological events may have an impact on the NPS. These include tsunamis, high astronomical tides and high rainfall events. The probability of these events are, however, fairly low and the elevation of the NPS would cause the impacts to be of low significance. The impacts on the project are summarised in **Table 4.3**.

Table 4.3: Summary of Impacts of Environment on the NPS

Impact	Nature	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE
Rising Sea Level	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Rising Sea Level with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**
Highest astronomical tide	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Highest astronomical tide with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**
Extreme high water level	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Extreme high water level with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**
Frequent high rainfall events	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Frequent high rainfall events with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**

4.2 Duynefontein

4.2.1 Direct Impacts

The direct impact assessment for this site is summarised in **Table 4.5**.

Table 4.4: Summary of Direct Impacts Assessment

Impact	Nature	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE
Increased runoff peaks due to hardened surface.	Negative	Medium	Medium	High	Low	Medium	Low	**Low - Medium**
Increased runoff peaks due to hardened surface with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**
Increased runoff volume due to hardened surface	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**
Increased runoff volume due to hardened surface with mitigation	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**
Disruption during construction: Increased erosion potential	Negative	Medium	Medium	Low	Low	Medium	Low	**Low - Medium**
Disruption during construction: Increased erosion potential with mitigation	Negative	Low	Medium	Low	Low	Low	Low	**Low**
Disruption during construction: Flooding of works,	Negative	Medium	Medium	Low	Low	Medium	Low	**Low - Medium**
Disruption during construction: Flooding of works, with mitigation	Negative	Low	Medium	Low	Low	Low	Low	**Low**
Changes in flow paths	Negative	Medium	High	High	Low	Medium	Low	**Low - Medium**
Changes in flow paths with mitigation	Negative	Low	High	High	Low	Medium	Low	**Low - Medium**
Disruption during construction: Increased silt deposition due to barren soil.	Negative	Medium	Medium	Low	Low	Medium	Low	**Low - Medium**
Disruption during construction :Increased silt deposition due to barren soil with mitigation	Negative	Low	Medium	Low	Low	Low	Low	**Low**
Pollution of surface waters	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**
Pollution of surface waters with mitigation	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**
Sea level rise	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**
Sea level rise with mitigation	Negative	Low	Medium	High	Low	Medium	Low	**Low - Medium**

The following observations are made:

- The impacts relating both to the construction and operational phases of the project are directly related to increased run off associated with the hardened surfaces. In turn this also increases the erosion potential in and around the site.
- During the construction phase, it is predicted with a high level of confidence that the impact the project will have at this site will be of low-medium significance. The implementation of recommended mitigation measures will further significantly negate the residual adverse impacts.
- Stormwater can potentially wash pollutants in and around the site to the neighbouring watercourses and the ocean, should mitigation measures not be put into place.
- The operational phase (expected to be about 60 years) of the project will be the longest phase of the total project and therefore the probability of having a 1:10 000 year rainfall event is greater than for the construction phase (expected to be about 10 years). This is illustrated in **Table 4.6**, which shows that a 1:10 000 year event has a probability of 0,0001 of occurring in any one year, while there is a probability of 0,0095 of the event occurring in a period of 100 years. This is also reflected in the confidence in the impact prediction, which is lower for the operational phase as a result of extrapolated rainfall data which are not available for the 1:10 000 rainfall event as is required for this type of activity. See **Table 4.5**.
- The impacts are of low significance at a local level, the reason being that this site is isolated and the most significant cumulative impact relates to the commercial and residential activities in the area. Increased runoff from hardened surfaces will impact on surface water bodies and the ocean should mitigation measures not be implemented.
- An insignificant impact is predicted on a regional level due to no significant water resources in close proximity to the proposed NPS.

Table 4.5:Probability Analysis

Recurrence Interval vs Probability Analysis

RI		Probability of occurrence in X years						Probability of not occurring in X years			
		1	10	100	1000	10000	1000000	100	1000	10000	1000000
10		0.10000	0.65132	0.99997	1	1	1	0	0	0	0
20		0.050	0.40126	0.99408	1	1	1	0.006	0	0	0
50		0.020	0.18293	0.86738	1	1	1	0.133	0	0	0
100		0.010	0.09562	0.63397	1	1	1	0.366	0	0	0
200		0.005	0.04889	0.39423	0.993	1	1	0.606	0.007	0	0
1000		0.001	0.00996	0.09521	0.632	0.99995	1	0.905	0.368	0	0
10000		0.0001	0.00100	0.00995	0.095	0.632	1	0.990	0.905	0.368	0

4.2.2 Indirect Impacts

An indirect impact is defined as the impact the activity (activities) on the site has on the surrounding environmental system but not directly associated with the activities on site. The following indirect impacts are identified during construction:

- Altered flow paths due to excavation of material and temporary dumping;
- Increase in sediment load causing deposition of soil along natural flow paths causing temporary ponding;
- Increase in runoff peaks and volumes from barren soil causing possible erosion gullies along surface water courses; and
- Bearing in mind that the site and surrounding areas consist mainly of well drained sand the indirect impacts are expected to be of low significance to insignificant.

4.2.3 Site Sensitivity

In addition to the defined impacts described above the sensitivity of the affected environment also needs to be considered. The site sensitivity can in this context be described as the "ability" of an affected environment to tolerate disturbances, i.e. if the affected environment has a high "ability" and "resilience" to counteract the impacts the sensitivity would be low. No-go option

Should it be decided to not construct an additional nuclear power station at Duynefontein Eskom could sell superfluous land. However, this is unlikely to significantly affect the site and the no go option should then cause a lower impact than if a NPS was built.

4.2.4 Potential Impact the Environment May Have on the NPS

Extreme natural hydrological events may have an impact on the NPS. These include tsunamis, high astronomical tides and frequent high rainfall events. The probability of these events occurring is, however, fairly low but should they occur the consequences could be severe. The impacts on the project are summarised in
Table 4.6.

Table 4.6: Summary of Impacts of Environment on the NPS

Impact	Nature	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE
Rising Sea Level	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Rising Sea Level with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**
Highest astronomical tide	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Highest astronomical tide with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**
Extreme high water level	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Extreme high water level with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**
Frequent high rainfall events	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Frequent high rainfall events with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**

4.3 Bantamsklip

4.3.1 Direct Impacts

The direct impact assessment for the site is summarised in **Table 4.7**.

Table 4.7: Summary of Direct Impact Assessment

Impact	Nature	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE
Increased runoff peaks due to hardened surface.	Negative	Medium	Medium	High	Low	Medium	Low	Low - Medium
Increased runoff peaks due to hardened surface with mitigation	Negative	Low	Low	High	Low	Low	Low	Low
Increased runoff volume due to hardened surface	Negative	Low	Medium	High	Low	Medium	Low	Low - Medium
Increased runoff volume due to hardened surface with mitigation	Negative	Low	Medium	High	Low	Medium	Low	Low - Medium
Disruption during construction: Increased erosion potential	Negative	Medium	Medium	Low	Low	Medium	Low	Low - Medium
Disruption during construction: Increased erosion potential with mitigation	Negative	Low	Medium	Low	Low	Low	Low	Low
Disruption during construction: Flooding of works,	Negative	Medium	Medium	Low	Low	Medium	Low	Low - Medium
Disruption during construction: Flooding of works, with mitigation	Negative	Low	Medium	Low	Low	Low	Low	Low
Changes in flow paths	Negative	Medium	High	High	Low	Medium	Low	Low - Medium
Changes in flow paths with mitigation	Negative	Low	High	High	Low	Medium	Low	Low - Medium
Disruption during construction: Increased silt deposition due to barren soil.	Negative	Medium	Medium	Low	Low	Medium	Low	Low - Medium
Disruption during construction :Increased silt deposition due to barren soil with mitigation	Negative	Low	Medium	Low	Low	Low	Low	Low
Pollution of surface waters	Negative	Low	Medium	High	Low	Medium	Low	Low - Medium
Pollution of surface waters with mitigation	Negative	Low	Medium	High	Low	Medium	Low	Low - Medium
Sea level rise	Negative	Low	Medium	High	Low	Medium	Low	Low - Medium
Sea level rise with mitigation	Negative	Low	Medium	High	Low	Medium	Low	Low - Medium

The following observations are made:

- The impacts relating both to the construction and operational phases of the project are directly related to increased run off associated with the hardened surfaces. In turn this also increases the erosion potential in and around the site.
- During the construction phase, it is predicted with a high level of confidence that the impact of the project will be low. The implementation of recommended mitigation measures will further negate the residual impacts.
- Stormwater can potentially wash pollutants in and around the site to the neighbouring water courses and the marine environment, should mitigation measures not be put in place.
- The operational phase (expected to be about 60 years) of the project will be the longest phase of the total project and therefore the probability of having a 1:10 000 year rainfall event is greater than for the construction phase (expected to be about 10 years). This is illustrated in Table 4.5 above and shows that a 1:10 000 year event has a probability of 0,0001 of occurring in any one year while there is a probability of 0,0095 of the event occurring in a period of 100 years.This is reflected by means of the confidence in the impact prediction, which is lower for the operational phase as a result of extrapolated rainfall data, which are not available for the 1:10 000 rainfall event as is required for this type of activity.
- The impact is low at a local level, the reason being that this site is isolated and the most significant cumulative impact relates to the commercial and residential activities in the area. Increased run off from hardened surfaces will impact on the surface water bodies and the ocean should mitigation measures not be implemented.
- An impact of low significance is predicted on a regional level due to no significant water resources in close proximity to the proposed NPS.

4.3.2 Indirect Impacts

An indirect impact is defined as the impact that the activity has on the surrounding environmental system but not directly associated with the activities on site. The following construction-related indirect impacts have been identified at the site:

- Altered flow paths due to excavation of material and temporary dumping;
- Increase in sediment load causing deposition of soil along natural flow paths causing temporary ponding;
- Increase in runoff peaks and volumes from barren soil causing possible erosion gullies along surface water courses; and
- Bearing in mind that the site and surrounding areas consists mainly of well drained sand the indirect impacts are expected to be of low significance to insignificant.

4.3.3 Site Sensitivity

In addition to the defined impacts described above the sensitivity of the affected environment also needs to be considered. The site sensitivity can in this context be described as the "ability" of an affected environment to tolerate disturbances, i.e. if the affected environment has a high "ability" and "resilience" to counteract the impacts the sensitivity would be low.

4.3.4 No- go Option

Should it be decided to not construct a nuclear power station at Bantamsklip Eskom could potentially sell the land and the stringent controls that would be required and implemented for a nuclear site may not materialise if other types of developments take place if the land is not incorporated with adjacent conservation focussed areas such as Kleyn Kloof Private Nature Reserve. This is, however, not guaranteed.
The no go option could potentially have a higher negative impact than if a NPS was built.

4.3.5 Potential Impact the Environment May Have on the NPS

Extreme natural hydrological events may have an impact on the site. These include tsunamis, HATs and frequent high rainfall events. The probability of these events occurring is, however, fairly low. The impacts on the project are summarised in
Table 4.8

Table 4.8: Summary of Impacts of Environment on the Proposed Site and Project

Impact	Nature	Intensity	Extent	Duration	Impact on irreplaceable resources	Consequence	Probability	SIGNIFICANCE
Rising Sea Level	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Rising Sea Level with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**
Highest astronomical tide	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Highest astronomical tide with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**
Extreme high water level	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Extreme high water level with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**
Frequent high rainfall events	Negative	High	Medium	High	Low	Medium	Low	**Low - Medium**
Frequent high rainfall events with mitigation	Negative	Low	Low	High	Low	Low	Low	**Low**

5 FLOOD CONTROL MITIGATION MEASURES

5.1 Thyspunt

5.1.1 Flood Control Measures

These need to be implemented for the following main reasons:

- To ensure the safety of the site and plant both during construction and the operational phases; and
- To ensure that the surrounding area is not impacted on negatively by the plant during construction, operation and at closure.

Proposed mitigation measures have been designed to a conceptual level so as to comply with required design standards and by applying the BMPs approach as discussed below.

5.1.2 Best Management Practices (BMPs)

An internationally accepted approach is the application of BMPs when considering mitigation measures. The BMPs approach is defined as “A Multi-disciplinary approach in applying appropriate technology to preserve the environment and comply with accepted safety standards”. The BMPs can be applied to the following phases of development:

- **Planning and Design Phase (Pre-Development)**

At the planning and design phase it is important to:

- Plan the final locality and level of the plant area in order to minimise the impact of the flood hazards.
- Take into account the extreme water levels from the ocean – the minimum level of the plant area should be 14.90 mamsl.
- Ensure that the plant footprint should, if possible, not be positioned within a water course area.

- **Construction Phase**

At the construction phase it is important to:

- Separate “clean” stormwater runoff from “dirty” stormwater runoff and minimise the inflow of “clean” stormwater runoff into the construction site. The “clean” stormwater runoff is defined as surface water emanating from “virgin” undeveloped catchments and “dirty” stormwater would emanate from areas with construction activities.
- Ensure that a stormwater diversion embankment is constructed around the perimeter of the site to ensure that both catchment runoff and sea water ingress is prevented. This diversion embankment could possibly be constructed to later be incorporated with the final plant level and platform.

- Ensure that a temporary stormwater collection sump is installed during foundation excavation activities to allow excess runoff to drain to a defined low area (sump) where any transported sediment could be contained and stormwater pumped out. Depending on the nature and content of the sediment this could be pumped to a temporary holding facility and then transported to a waste disposal site. Further details would be obtained from more detailed water quality studies at a later stage. In terms of Regulation 704 (June 1999) of the National Water Act, 1998 (Act No. 36 of 1998) at least the 1:50 year runoff volume with an 800 mm freeboard would need to be contained. The 1:50 year flood event is significant in the design of the pollution mitigation measures while the 1:10 000 flood event parameter is relevant to nuclear safety.

- **Operational Phase**

At the operational phase it is important to:

- Have designed, sized and implemented all required stormwater control and mitigation measures so as to comply with applicable design standards, thereby ensuring the safety of the plant as well as the conservation of the surrounding environment.
- Define any “dirty” stormwater runoff from the plant area and prevent this from leaving the plant area. This must be achieved by implementing “dirty” water collection channels at the perimeter of the plant area. To allow for a sufficient hydraulic gradient and flow velocity, the channels should be positioned so as to drain half the site into the south-western corner and the other half into the south-eastern corner. In terms of IAEA Safety Guide No NS-G-3.5, (IAEA, 2003) the drainage system needs to handle up to the 1:50 year storm event.
- Based on the assumption in the above bullet, and in terms of Regulation 704 (June 1999) of the Water Act (Act 36 of 1998), the entire plant runoff would need to be contained in dirty water containment ponds. This is currently a conservative approach as not all the plant runoff possibly needs to be classified as “dirty” runoff, thereby reducing the amount of storage required. Further details and refinements would be determined from more detailed water quality control studies. In addition to the above, the average monthly operating volume (i.e. that volume accumulating from the plant area due to average monthly rainfall and runoff) would also need to be taken into account. Due to the current uncertainties of the plant size, dirty water areas and imperviousness, a water balance has not yet been carried out. This would be carried out at design phase.

In view of the above the required preliminary total storage volume has been determined for various relevant design standards as given in **Table 5.1**.

Table 5.1: Preliminary Storage Requirement, Dirty Water Containment Ponds

Design standard	Design standard reference	Dirty water storm runoff volume (m^3x10^3)	Average monthly allowance (m^3x10^3)	Total storage volume required (m^3x10^3)
1:10 000 year	IAEA, Safety guide no. NS-G-3.5 (IAEA, 2003).	201	40	241
1:1 000 year	US Nuclear Regulatory commission draft report NUREG/CR-1623 (USNRC, 1977).	156	31	187
1:50 year	Regulation 704 of June 1999) , National Water Act (Act No. 36 of 1998)	95	19	114

The following is noted:

- The 1:1 000 year standard could possibly be applied by considering that over a lifespan of 100 years the probability of the event not occurring is 0.905 for a 1:1 000 year event and 0.990 for a 1:10 000 year event. These are both very low and the 1 000 year standard could possibly be applied.
- The 1:50 year design standard could also possibly be used as this complies with the Regulation 704 of 1999 (Water Act 36 of 1998) and is relevant to pollution prevention mitigation measures.

For practical reasons it is proposed that two containment ponds be positioned at each of the plant areas. A return water system would also be required to pump the stored water back to the plant for possible reuse depending on the quality of the runoff. Further details on this would be determined at design phase.

The proposed mitigation measures are summarised in **Table 5.2**. The BMPs can furthermore be divided into two main categories as follows:

- **Structural BMPs** – includes physical structural control measures; and
- **Non-Structural BMPs** – includes non-structural measures such as policy documents, guidelines, contracts between various parties for the upkeep and maintenance of the structural BMPs.

5.1.3 Required Stormwater Control Measures

Based on the above approach, required conceptual stormwater control measures are now defined as shown in **Figure 5.1** and discussed below.

Figure 5.1: Proposed Stormwater Control Measures and Conceptual Details

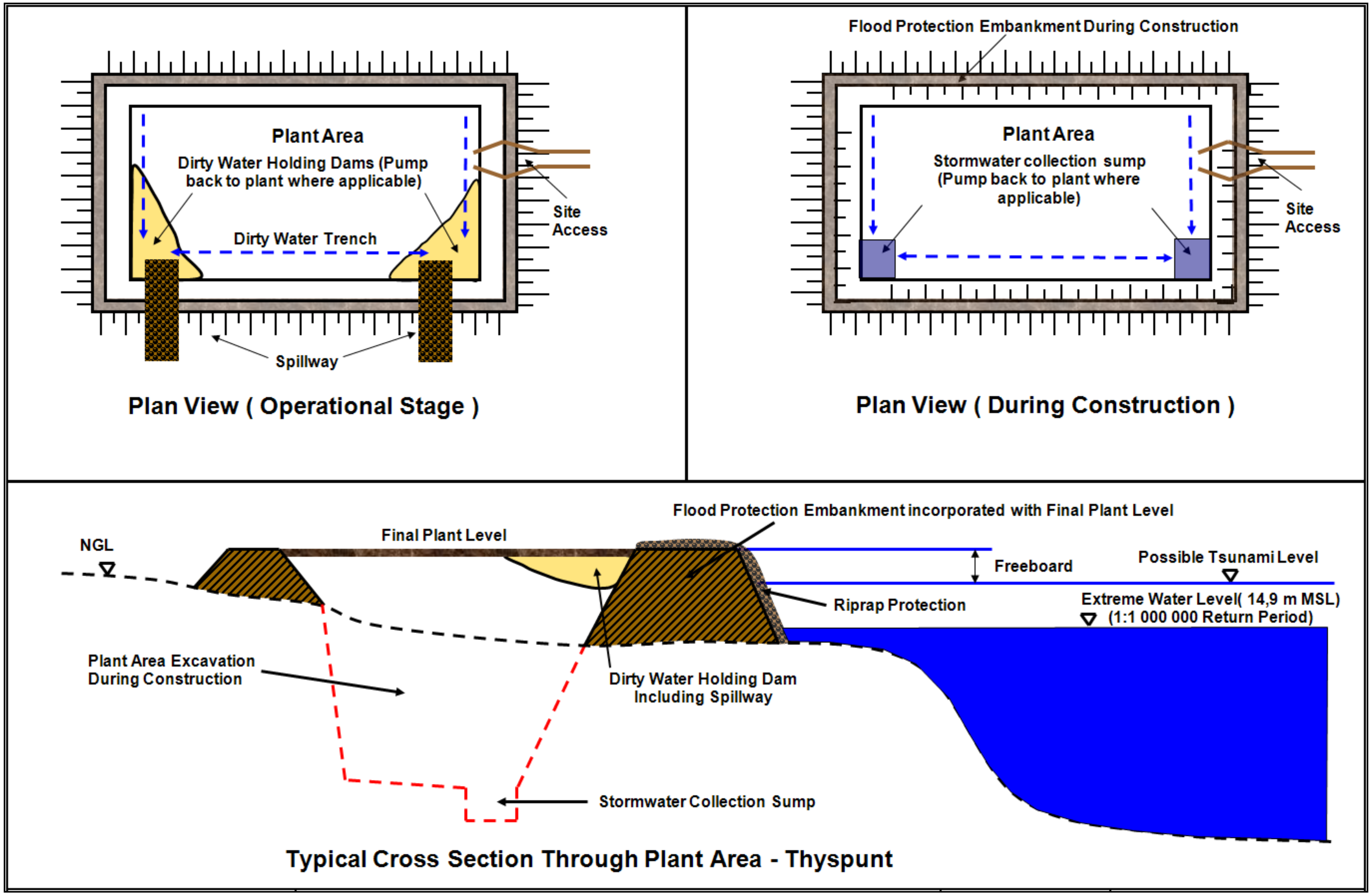


Table 5.2: Proposed Mitigation Measures

Proposed mitigation measure	Design standards	Minimum dimensions (m)*				Reason of mitigation measures
		H	W	D	V ($m^3 x 10^3$)	
Structural measures						
Stormwater diversion embankment ("clean" stormwater)	Pmf (1:10 000 years), hydraulic capacity	-	-	-	-	To divert any possible stormwater runoff from external catchments during construction and operational phases
Dirty water collection channels	Pmf (1:10 000 years) hydraulic capacity	-	-	-	-	To drain any potential polluted runoff from the plant area into the dirty water containment ponds
Dirty water containment ponds total storage	1:1 000 years or (50 year) storage volume	-	-	-	187 (114)	To temporarily store potential polluted runoff over a period of 48hours
Open pit stormwater collection & extraction system	1:1 000 years or (50 year) storage volume	-	-	-	28.5 (16.6)	Temporary storage area for stormwater runoff collection and extraction
Non-structural measures						
Stormwater control measures maintenance program	-	-	-	-	-	Maintenance manual to ensure that all controls are regularly maintained and repaired when required
Stormwater control measures operational manual	-	-	-	-	-	Operational manual to ensure that all controls are operated correctly.

Note: H, W & D denote the height, width and depth of a drainage system. These values will be calculated at design phase.

V denotes the preliminary calculated storage volume required for the dirty water containment pond.

5.2 Duynefontein

5.2.1 Mitigation Measures for Stormwater Control

Flood control measures need to be implemented for the following main reasons:

- To ensure the safety of the site and plant during both the construction and operational phases;
- To ensure that the surrounding area is not impacted on negatively by the plant during construction, operation and at closure.

5.2.2 Best Management Practices (BMPs)

An internationally approved approach is the application of BMPs when considering mitigation measures. The BMPs approach is defined as “A multi-disciplinary approach in applying appropriate technology to preserve the environment and comply with accepted safety standards”. The BMPs can be applied to the following phases of development:

Planning and Design Phase (Pre-Development)

At the planning and design phase it is important to:

- Plan the final locality and level of the plant area in order to minimise the impact of the flood hazards.
- Take into account the extreme water levels from the ocean the minimum level of the plant area to be 10.54 mamsl.
- Position the plant footprint outside of watercourse areas.

Construction Phase

At the construction phase it is important to:

- Separate “clean” stormwater runoff from “dirty” stormwater runoff and minimise the inflow of “clean” stormwater runoff into the construction site. The “clean” stormwater runoff is defined as surface water emanating from “virgin” undeveloped catchments and “dirty” stormwater would emanate from areas with construction activities.
- Construct a stormwater diversion embankment around the perimeter of the site to ensure that both catchment runoff as well as sea water ingress is prevented. The diversion embankment can possibly be constructed later to be incorporated with the final plant level and platform.
- Ensure that a temporary stormwater collection sump is installed during foundation excavation activities to allow excess runoff to drain to a defined low area (sump) where any transported sediment could be contained and stormwater pumped out. Depending on the nature and content of the sediment this could be pumped to a temporary holding facility and then transported to a waste disposal site. Further details would be obtained from more

detailed water quality studies at a later stage. In terms of Regulation 704 (June 1999) of the National Water Act, 1998 (Act No. 36 of 1998) at least the 1:50 year runoff volume with an 800 mm freeboard would need to be contained. The 1:50 year flood event is significant in the design of the pollution mitigation measures while the 1:10 000 flood event parameter is relevant to nuclear safety.

Operational Phase (Post Construction)

At the operational phase it is important to:

- Have designed, sized and implemented all required stormwater control and mitigation measures so as to comply with applicable design standards thereby ensuring the safety of the plant as well as conserving the surrounding environment.
- Define any “dirty” stormwater runoff from the plant area and prevent this from leaving the plant area. This is achieved by implementing “dirty” water collection channels at the perimeter of the plant area. To allow for a sufficient hydraulic gradient and flow velocity the channels should be positioned so as to drain half the site into the south-western corner and the other half into the south-eastern corner. In terms of IAEA Safety Guide No NS-G-3.5 (IAEA, 2003) the drainage system needs to handle up to the 1:10 000 year storm event.
- Based on the assumption in the previous bullet point and in terms of Regulation 704 (1999) of the National Water Act 1998 (Act 36 of 1998) the entire plant runoff would need to be contained in dirty water containment ponds. This is currently a conservative approach as not all the plant runoff possibly needs to be classified as “dirty” runoff, thereby reducing the amount of storage required. Further details and refinements would be determined from the water quality control study. In addition to the above the average monthly operating volume accumulating from the plant area due to average monthly rainfall and runoff would also need to be taken into account. Due to the current uncertainties of the plant size, dirty water areas and imperviousness, a water balance has not yet been carried out. This would be carried out at design phase.

In view of the above the required preliminary total storage volume has been determined for various relevant design standards as given in **Table 5.3**.

Table 5.3: Preliminary Storage Requirement, Dirty Water Containment Ponds

Design Standard	Design Standard Reference	Dirty Water Storm Runoff Volume (m^3)	Average Monthly Allowance (m^3)	Total Storage Volume Required (m^3)
1:10 000 year	IAEA, Safety Guide No. NS-G-3.5	75 900	15 180	91 080
1:1 000 year	US Nuclear Regulatory Commission Draft Report NUREG/CR-1623	59 700	11 940	71 640

1:50 year	Regulation 704, Water Act (Act 36 of 1998)	38 800	7760	46 560

The following is noted:

- A 1:1 000 year standard could possibly be applied by considering that over a life span of say 100 years, the probability of the event not occurring is 0.905 for a 1:1 000 year event and 0.990 for a 1:10 000 year event. These are both very low and the 1:1 000 year standard could possibly be applied.
- The 1:50 year design standard could also be used as this complies with the Regulation 704(1999) of the National Water Act 1998 (Act No. 36 of 19980).

For practical reasons it is proposed that two containment ponds be positioned at each of the plant areas.

A return water system would also be required to pump the stored water back to the plant for possible reuse depending on the quality of the runoff. Further details of this would be determined at design phase.

The proposed mitigation measures are summarised in **Table 5.4**.

The BMPs can furthermore be divided into two main categories as follows:

- **Structural BMPs –** includes physical structural control measures
- **Non-Structural BMPs –** includes non-structural measures such as policy documents, guidelines, contracts between various parties for the upkeep and maintenance of the structural BMPs.

5.2.3 Required Stormwater Control Measures

Based on the above approach, required conceptual stormwater control measures are now defined as shown in **Figure 5.2** and discussed below.

Figure 5.2: Proposed Stormwater Control Measures and Conceptual Details

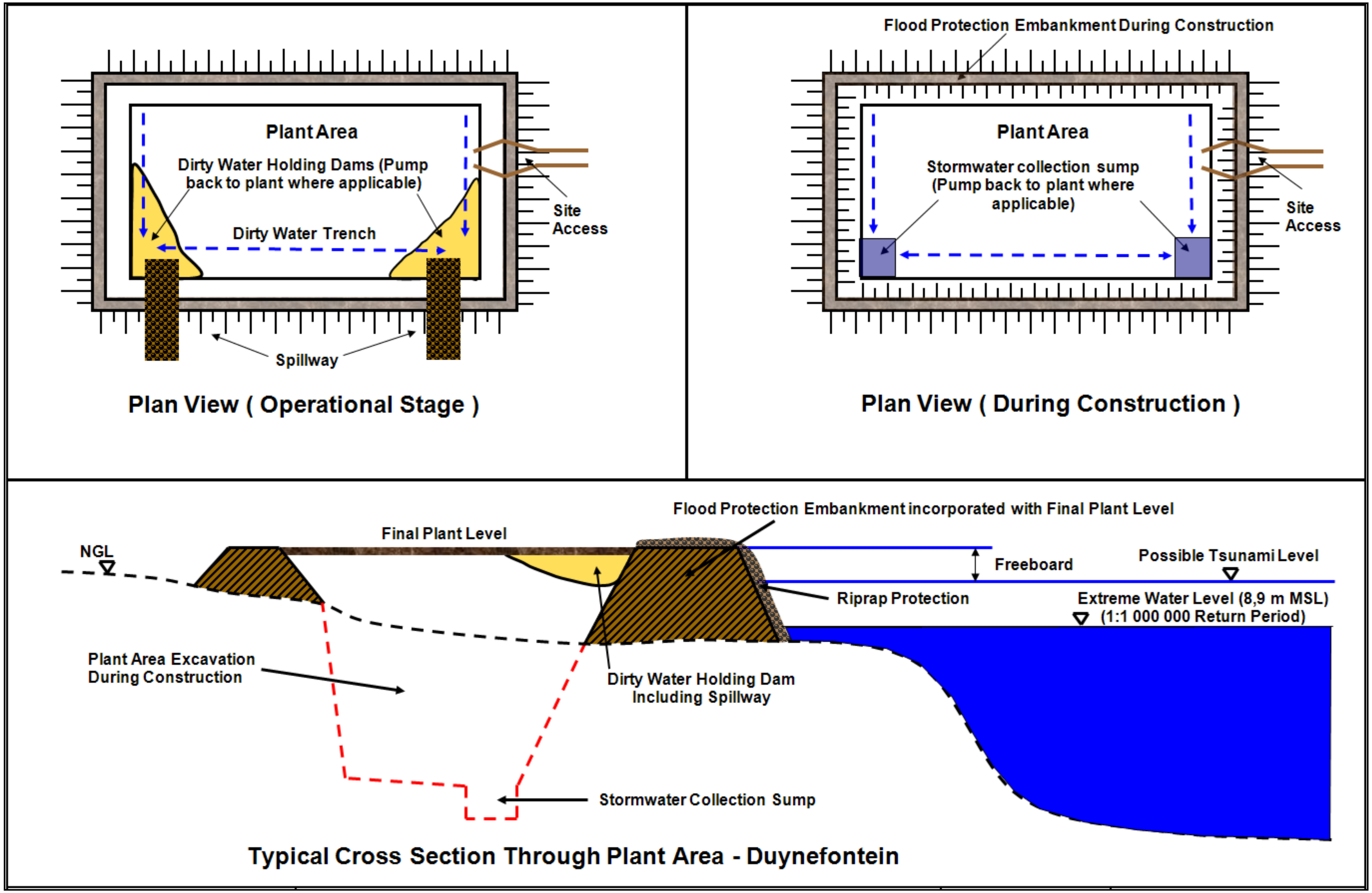


Table 5.4: Proposed Mitigation Measures

Proposed Mitigation Measure	Design Standards	Minimum Dimensions (m)				Reason of Mitigation Measures
		H	W	D	Vx10^3	
Structural Measures						
Stormwater diversion embankment (“clean” stormwater)	PMF (1:10 000 years), hydraulic capacity	-	-	-	-	To divert any possible stormwater runoff from external catchments during construction and operational phases
Dirty water collection channels	PMF (1:10 000 years) hydraulic capacity	-	-	-	-	To drain any potential polluted runoff from the plant area into the dirty water containment ponds
Dirty water containment ponds (x2)	1:1 000 years or 50 year storage volume	-	-	-	72 (46)	To temporarily store potential polluted runoff over a period of 48 hours
Open pit stormwater collection & extraction system	1:1 000 years or 50 year storage volume	-	-	-	9.6 (6.4)	Temporary storage area for stormwater runoff collection and extraction
Non-Structural Measures						
Stormwater control measures maintenance program	-	-	-	-	-	Maintenance manual to ensure that all controls are regularly maintained and repaired when required
Stormwater control measures operational manual	-	-	-	-	-	Operational manual to ensure that all controls are operated correctly.

Note: H, W & D denote the height, width and depth of a drainage system. These values will be calculated at design phase.

V denotes the preliminary calculated storage volume required for the dirty water containment pond.

5.3 Bantamsklip

5.3.1 Mitigation Measures for Stormwater Control

Flood control measures need to be implemented for the following main reasons:

- To ensure the safety of the site and plant both during construction and the operational phases.
- To ensure that the surrounding area is not impacted on negatively by the plant during construction and operation.

Proposed mitigation measures have been designed to a conceptual level so as to comply with required design standards and by applying the BMPs approach as discussed below.

5.3.2 Best Management Practices (BMPs)

An international approved approach is the application of BMPs when considering mitigation measures. The BMPs approach is defined as "A multi-disciplinary approach in applying appropriate technology to preserve the environment and comply with accepted safety standards". The BMPs can be applied to the following phases of development:

Planning and Design Phase (Pre-Development)

At the planning and design phase it is important to:

- Plan the final locality and level of the plant area in order to minimise the impact of the flood hazards.
- Take into account the extreme water levels from the ocean the minimum level of the plant area must be 11.02mamsl.
- Position the plant footprint outside of any watercourse areas.

Construction Phase

At the construction phase it is important to:

- Separate "clean" stormwater runoff from "dirty" stormwater runoff and minimise the inflow of "clean" stormwater runoff into the construction site. The "clean" stormwater runoff is defined as surface water emanating from "virgin" undeveloped catchments and "dirty" stormwater would emanate from areas with construction activities.
- Construct a stormwater diversion embankment around the perimeter of the site to ensure that both catchment runoff as well as sea water ingress is prevented. The diversion embankment could possibly be constructed to later be incorporated with the final plant level and platform.
- Ensure that a temporary stormwater collection sump is installed during foundation excavation activities to allow excess runoff to drain to a defined low area (sump) where any transported sediment could be contained and stormwater pumped out. Depending on the nature and content of the sediment this could be pumped to a temporary holding facility and then transported to a waste disposal site. Further details would be obtained from more detailed water quality studies at a later stage. In

terms of Regulation 704 (June 1999) of the National Water Act, 1998 (Act No. 36 of 1998) at least the 1:50 year runoff volume with an 800 mm freeboard would need to be contained. The 1:50 year flood event is significant in the design of the pollution mitigation measures while the 1:10 000 flood event parameter is relevant to nuclear safety.

Operational Phase

At the operational phase it is important to:

- Have designed, sized and implemented all required stormwater control and mitigation measures to comply with applicable design standards thereby ensuring the safety of the plant as well as conserving the surrounding environment.
- Define any "dirty" stormwater runoff from the plant area and prevent this from leaving the plant area. This is achieved by implementing "dirty" water collection channels at the perimeter of the plant area. To allow for a sufficient hydraulic gradient and flow velocity the channels should be positioned so as to drain half the site into the south-western corner and the other half into the south-eastern corner. In terms of IAEA Safety Guide No NS-G-3.5 (IAEA, 2003), the drainage system needs to handle up to the 1:10 000 year storm event.
- Based on the assumption in bullet point above and in terms of Regulation 704 of the National Water Act 1998 (Act No. 36 of 1998), the entire plant runoff would need to be contained in dirty water containment ponds. This is currently a conservative approach as not all the plant runoff possibly needs to be classified as "dirty" runoff thereby reducing the amount of storage required. Further details and refinements would be determined from the water quality control study. In addition to the above the average monthly operating volume, which accumulates from the plant area due to average monthly rainfall and runoff, would also need to taken into account. This would be determined by carrying out a monthly water balance of the plant area (from past experience it is shown that this adds about 20 per cent to the storm runoff volume). Due to the current uncertainties of the plant size, dirty water areas and imperviousness, a water balance has not yet been carried out.

In view of the above the required preliminary total storage volume has been determined for various relevant design standards as given in **Table 5.5**.

Table 5.5: Preliminary Storage Requirement, Dirty Water Containment Ponds

Design Standard	Design Standard Reference	Dirty Water Storm Runoff Volume (m^3)	Average Monthly Allowance (m^3)	Total Storage Volume Required (m^3)
1:10 000 year	IAEA, Safety Guide No. NS-G-3.5	131 600	26 320	157 920
1:1 000 year	US Nuclear Regulatory Commission Draft Report NUREG/CR-1623	101 100	20 220	121 320
1:50 year	Regulation 704, Water Act (Act 36 of 1998)	61 500	12 300	73 800

Note:

- A 1:1 000 year standard could possibly be applied by considering that over a life span of say 100 years the probability of the event not occurring is 0.905 for a 1: 1 000 year event and 0.990 for a 1:10 000 year event. These are both very low and the 1 000 year standard could possibly be applied.
- The 1:50 year design standard could also possible be used as this complies with Regulation 704 (1999) of the National Water Act 1998 (Act No. 36 of 1998).

For practical reasons it is proposed that two containment ponds be positioned at each of the plant areas.

A return water system would also be required to pump the stored water back to the plant for possible reuse depending on the quality of the runoff. Further details on this would be determined at design phase.
The proposed mitigation measures are summarised in **Table 5.6** and discussed below.

The BMPs can furthermore be divided into two main categories as follows:

- **Structural BMPs** – includes physical structural control measures
- **Non-Structural BMPs** – Includes non- structural measures such as policy documents, guidelines, contracts between various parties for the upkeep and maintenance of the structural BMPs.

5.3.3 Required Stormwater Control Measures

Based on the above approach, required conceptual stormwater control measures are now defined as shown in **Figure 5.3** and discussed over page.

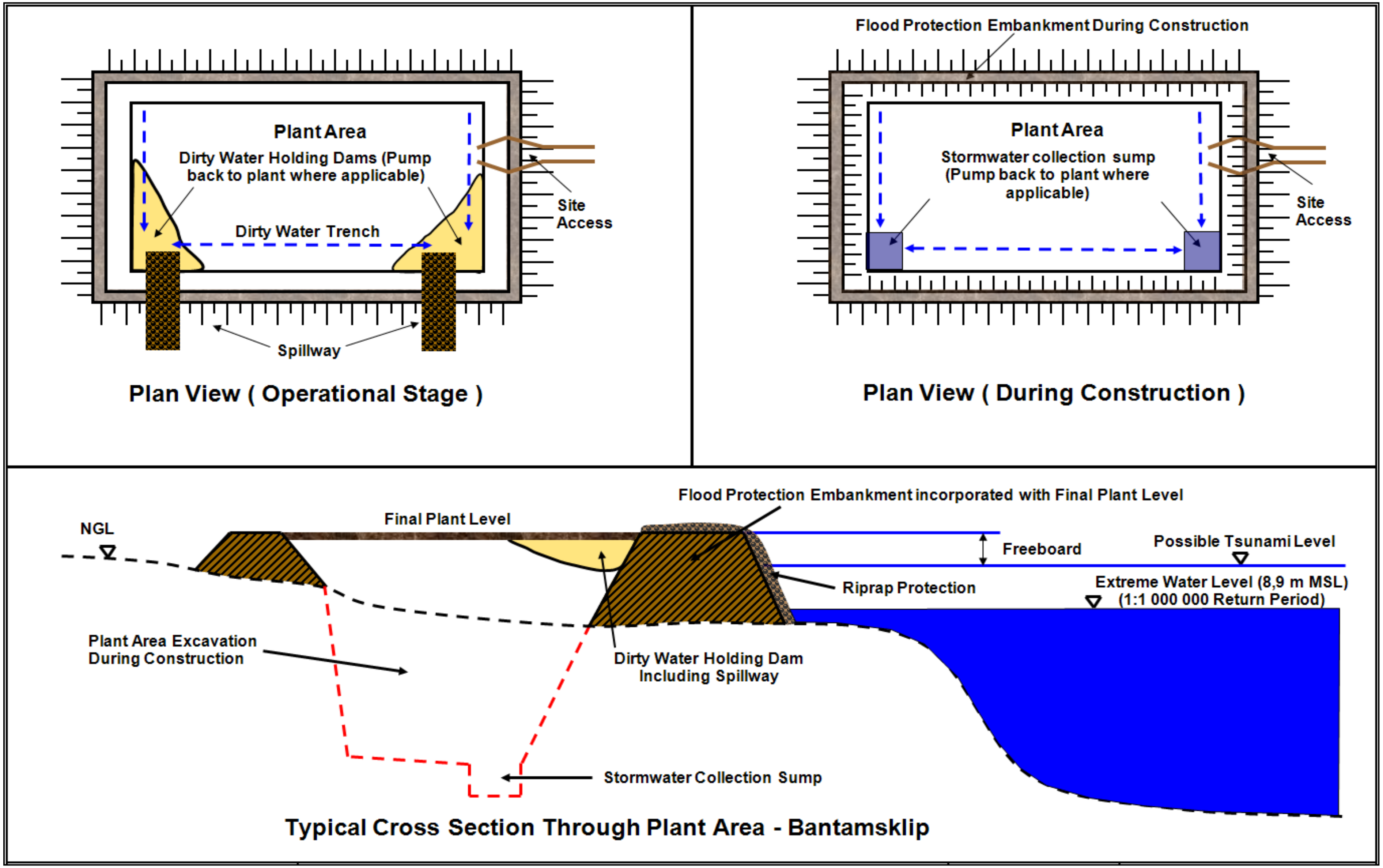
Table 5.6: Summary of Proposed Mitigation Measures (Bantamsklip)

Proposed Mitigation Measure	Design Standards	Minimum Dimensions (m)				Reason of Mitigation Measures
		H	W	D	V (m^3x10^3)	
Structural Measures						
Stormwater diversion embankment ("clean" stormwater)	PMF (1:10 000 years), hydraulic capacity	-	-	-	-	To divert any possible stormwater runoff from external catchments during construction and operational phases
Dirty water collection channels	PMF (1:10 000 years) hydraulic capacity	-	-	-	-	To drain any potential polluted runoff from the plant area into the dirty water containment ponds
Dirty water containment ponds total storage	1:1 000 years or (50 year) storage volume	-	-	-	121 (74)	To temporarily store potential polluted runoff over a period of 48hours
Open pit stormwater collection & extraction system	1:1 000 years or (50 year) storage volume	-	-	-	17.3 (10.6)	Temporary storage area for stormwater runoff collection and extraction
Non-Structural Measures						
Stormwater control measures maintenance program	-	-	-	-	-	Maintenance manual to ensure that all controls are regularly maintained and repaired when required
Stormwater control measures operational manual	-	-	-	-	-	Operational manual to ensure that all controls are operated correctly.

Note: H, W & D denote the height, width and depth of a drainage system. These values will be calculated for the Final EIR.

V denotes the preliminary storage volume required for the dirty water containment pond.

Figure 5.3: Proposed Stormwater Control Measures and Conceptual Details



5.4 Surface water and Mitigation Measures Monitoring Protocol

The objectives of the monitoring programme are:

- To minimise the potential for contamination of soils and water courses through effective soil and stormwater management;
- To minimise the potential for land and water contamination due to substances utilised, stored or removed from site during operational activities; and
- To monitor the effectiveness of management measures and mitigation measures stipulated in the EIR.

5.4.1 Monitoring Points

Since there are no perennial streams on any of the sites and only non-perennial streams on the Thyspunt site, water quality sampling of surface water is restricted to the sensitive wetlands and the surface ponding areas on the other sites and non perennial stream on Thyspunt. Specific monitoring points can only be defined on site. The non-perennial streams should be monitored upstream from the activities and again downstream and at least at two points in the ponding areas on all sites.

Exclusions

- Marine monitoring falls outside of the scope of this EIR; and
- Groundwater and meteorological monitoring are covered in the respective EIRs.

5.4.2 Monitoring Parameters

Determinands of key relevance are detailed in **Table 5.7**.

Table 5.7: Determinands of Key Relevance

Key Determinand	Relevance
Physical Quality	
Electrical conductivity	General Indication of change of water quality
pH	Has a bearing on the solubility of metals that may occur
Turbidity	Indicates the cloudiness of the water
Chemical Quality	
ICP Metal Scan	Excessive amounts can make the water poisonous for marine and aquatic environment
BTEX	Benzene, Toluene, Xylene, Ethyl Benzene (Also known as Volatile Organic Compounds)
Nutrients	stimulate eutrophication if present in excess
Radioactive isotopes	Possible radioactive contamination

5.4.3 Monitoring Frequency

The recommended sampling frequency is detailed in **Table 5.8**.

Table 5.8: Minimum and Recommended Number of Samples

Sampling Point		Minimum per point		Recommended per point	
Name	GPS Coordinates *	Number of samples per year	Sampling Frequency	Number of samples per year	Sampling Frequency
Duynefontein Ponding area		2	When possible in wet season	4	Quarterly (if rained)
Thyspunt Ponding area		2	When possible in wet season	4	Quarterly (if rained)
Thyspunt Non-perennial Streams		4 (2 up stream and 2 downstream of activity)	When possible in wet season	12	Bi-monthly
Bantamsklip		2	When possible in wet season	4	Quarterly (if rained)

* To be determined on site

5.4.4 Wetland Monitoring

Table 5.9 shows recommended wetland monitoring protocols.

Table 5.9: Recommended Wetland Monitoring.

Recommended monitoring programme	Rationale	Frequency and duration of monitoring	Reporting frequency	Management objectives
Monitoring of water depth / depth to water table in key wetlands over time	This will set a pre-construction baseline and allow identification of impacts after construction	Weekly data collected over one year Monthly data collected thereafter – but weekly during dewatering activities. At least two years pre-impact monitoring required Ongoing for first three years of operational phase.	Annual (baseline) Monthly (construction phase)	No change in wetland hydro period with drawdown
Monitoring of water quality – major nutrients; EC	This will allow identification of impacts associated with contaminated seepage from various activities associated with the NPS site, including stormwater runoff	Monthly baseline data collection Weekly data collection during construction phase Monthly data collection for first three years of operational phase	Annual (baseline) Monthly (construction phase)	No change in water quality
Aquatic invertebrates	Selected dune slack wetlands where plant monitoring may be problematic	Bi-annual – ongoing for first five years of operational phase (due to assumed slow response rate).	Annual	No change in habitat quality or loss of wetland extent
Plant zonation	Mapping of plant zonation at selected wetland sites should allow tracking of changes in wetland function associated with diversion of flows, and allow measurement of the efficacy of groundwater infiltration and dispersion mitigation measures	Bi-annual – ongoing for first five years of operational phase (due to assumed slow response rate).	Annual	No change I wetland zonation or shrinkage / expansion of wetland edge
Monitoring of selected radioactive isotopes in coastal seeps and Langefontein – surface water and selected plant tissue	There are no background data for radioactive isotopes for this site, against which to gauge possible future contamination.	Monthly – annual after five years of operational phase	Annual	No change over time from baseline conditions

5.4.5 Physical Monitoring and Maintenance of Stormwater Mitigation Structures

Monitoring and maintenance of mitigating structures is essential to the success thereof. The following key issues are pertinent:

- At all times, bunded areas must be checked and maintained in accordance with appropriate spill control and fire prevention facilities, equipment, signage and personnel training. All contaminated silt removed from stormwater canals must be disposed of at appropriate waste disposal sites;
- Impervious surfaces must be maintained;
- Stormwater canals must be inspected at least on a monthly basis and de-silted when required;
-
- Regular inspections must be carried out to detect leaks and spillages from any chemical/fuel storage facilities; and
- Internal audits must be undertaken on a monthly basis to identify any potential risks and to provide preventative maintenance and risk reduction as may be identified by the audits.

5.4.6 Monitoring Data Management

A data management system is essential for the storing of all monitoring data. This is to allow easy retrieval and options for statistical analysis. Should trends be detected that may indicate that the physical management systems are failing or underperforming, the adequacy of the implemented mitigation measures should be revisited and appropriate amendments made.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The following is concluded for each of the three sites:

Thyspunt

- The MAP at the site is fairly high at 687 mm.
- Due to the high MAP, large runoff volumes and peak flows are expected from the developed site.
- The plant runoff volume is expected to be about 40 times larger than that of the pre-development site.
- There is no spare capacity for water supply from surface water resources in the surrounding quaternary catchments.
- The sea level rise as well as the extreme high water level is not expected to cause any impact on the proposed development as this will be designed for.
- The natural water course near the site is expected to have a low impact on the site.
- Ponding areas on and around the site may have an impact on the construction works.
- Rainfall on the construction site is expected to have an impact on construction works.
- With no mitigation measures put in place there is a chance of pollutants entering the natural environment.
- Due to increased and concentrated stormwater runoff, erosion and sedimentation is possible.
- The direct impacts from the site have, on average, a low to low-medium significance
- The sensitivity of the environment is considered to be low to low-medium.
- Should the no-go option be implemented on this site, Eskom will sell the land and the natural environment may only be preserved until another developer wants to develop the site, with probably less stringent environmental control thereby potentially causing a higher negative impact
- A desalination plant is not expected to have any impact on the surface water.

Duynefontein

- The MAP for this site is fairly low at 416 mm.
- Due to the lower MAP reasonably low runoff volumes are expected.
- The plant runoff volume is expected to be about 25 times larger than that of the pre-development site.
- There is no spare capacity for water supply from surface water resources in the surrounding quaternary catchments.
- The sea level rise as well as the extreme high water level is not expected to cause any impact on the proposed development as this will be designed for.

- There are no natural water courses within the proximity of the site.
- Ponding areas on and around the site may have an impact on the construction works.
- Rainfall on the construction site is expected to have an impact on construction works.
- With no mitigation measures put in place there is a chance of pollutants entering the natural environment.
- Due to increased and concentrated stormwater runoff, erosion and sedimentation is possible.
- The direct impact from the site has, on average, a low to low-medium significance rating.
- The sensitivity of the environment is considered to be low to low-medium.
- Should the no-go option be implemented on this site, superfluous land may be sold. However, this should not have a significant effect on the site and the over impact would be positive.

Bantamsklip

- The MAP at the site is about 546 mm.
- Fairly large runoff volumes are expected at the site.
- The plant runoff volume is expected to be about 25 times larger than that of the pre-development site.
- There is no spare capacity for water supply from surface water resources in the surrounding quaternary catchments.
- The sea level rise as well as the extreme high water level is not expected to cause any impact on the proposed development as this will be designed out.
- There are natural water courses in the vicinity of the site.
- Ponding areas on and around the site may have an impact on the construction works.
- Rainfall on the construction site is expected to have an impact on construction works.
- With no mitigation measures put in place there is a chance of pollutants entering the natural environment.
- Due to increased and concentrated stormwater runoff, erosion and sedimentation is possible.
- The direct impact from the site has, on average, a low to low-medium significance rating.
- The sensitivity of the environment is expected to be low to low-medium.
- Should the no-go option be implemented, Eskom will sell the land and the natural environment may only be preserved until another developer wants to develop the site, with probably less stringent environmental control, thereby potentially causing a higher negative impact

6.2 Recommendations

The following actions are recommended from the study:

- Alternative water supply sources such as a desalination plant should be investigated due to the unavailability or scarcity of surface water resources at all three sites.
- The plant floor level for the Thyspunt site must not be lower than 14.90 mamsl to ensure sufficient safety against flooding.
- The plant floor level for the Duynefontein and Bantamsklip sites must not be lower than 10.54 and 11.02 mamsl respectivelyo ensure sufficient safety against flooding.
- The BMPs approach must be adopted for the selection of structural as well as non-structural mitigation measures.
- Stormwater control mitigation measures must be implemented in the construction, operational and decommissioning phases.
- Effective mitigation measures will mitigate any negative affects on the hydrology of all three sites and therefore the no-go option on all three sites is not considered to have more positive effects.

Structural mitigation measures must include:

- Stormwater diversion berms;
- Silt traps;
- Energy dissipation structures;
- Dirty water containment ponds; and
- Stormwater collection sumps.

Non structural mitigation measures must include:

- Stormwater control measures maintenance programmes; and
- Stormwater control measures operational manuals using a best management practices principle.

A surface water monitoring protocol and programme must address the following:

- The non-perennial streams must be monitored upstream from the activities and again downstream and at least at two points in the ponding areas on all sites; and
- Water quality sampling is to be carried out at all sensitive wetlands and ponding areas within the vicinity of the site.

Existing information should be supplemented during the course of the project on the following aspects:

- Site specific extreme high water level at the Bantamsklip site;
- Estimation of a possible tsunami levels;
- Detailed footprint and layout of proposed plant areas and ancillary works;
- Establishment of possible pollution sources;
- Locality and extent of possible future residential / commercial developments in proximity to the proposed sites; and
- Quantification of the rainfall difference due to climate change at each of the sites.

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