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5 PROJECT ALTERNATIVES CONSIDERED

5.1 Introduction

The identification, description, evaluation and comparison of alternatives are important for ensuring the objectivity of the assessment process. The aim is to ensure that the selected decision or activity has the lowest negative impacts and the highest positive impacts, while meeting the identified need. The NEMA EIA Regulations of 2006, 2010 and 2014 define alternatives in relation to a proposed activity as "*different means of meeting the general purpose and requirements of the activity", which may include alternatives to the –*

(a) property on which or location where it is proposed to undertake the activity;
(b) type of activity to be undertaken;
(c) design or layout of the activity;
(d) technology to be used in the activity;
(e) operational aspects of the activity;

and includes the option of not implementing the activity".

The "feasibility" and "rationale" of and the need for alternatives must be determined by considering, inter alia,

- the general purpose and requirements of the activity;
- need and desirability;
- opportunity costs;
- the need to avoid negative impact altogether;
- the need to minimise unavoidable negative impacts;
- the need to maximise benefits; and
- the need for equitable distributional consequences.

Every EIA process must therefore identify and investigate alternatives, with feasible and reasonable alternatives to be comparatively assessed. However, if after having identified and investigated alternatives, no feasible and reasonable alternatives are found, no comparative assessment of alternatives, beyond the comparative assessment of the preferred alternative and the option of not proceeding, is required during the EIA phase.

This section describes the alternatives that have been considered during this EIA process. These include the following:

- Site alternatives: location of the power station;
- Activity alternatives: power generation technologies;
- Technology alternatives: nuclear plant types;
- Layout alternatives on each of the sites;
- Constructional and Operational alternatives:
  - Fresh water supply;
  - Management of brine;
  - Outlet of water and chemical effluent;
  - Management of spoil material;
- Off-site access roads to the Thyspunt site;
- On-site access roads at the Thyspunt site; and
- The no-go alternative.

The alternatives that have been considered are listed in this Chapter. An assessment of the potential impacts of the alternatives and recommendations on the preferred alternatives is contained in Chapter 10 of this Revised Draft EIR Version 2.

5.2 Site Alternatives

5.2.1 Background on the site identification and outcome of the Scoping Phase

The consideration of alternative locations for the proposed Nuclear-1 power station was derived from the findings of the Nuclear Site Investigation Programme (NSIP) study undertaken by independent consultants during the 1980s and the findings of the Scoping Phase of this EIA process. Details pertaining to the above-mentioned studies are briefly discussed below. This section also outlines the response of the Department of Environmental Affairs (DEA) to the recommendations made in the Scoping Report. Thereafter, the sites that were considered as feasible and reasonable alternatives for the proposed power station at the end of the Scoping Phase are discussed further.

The Scoping Phase of the EIA process described and discussed the NSIP, which was commissioned by Eskom and aimed at identifying the most suitable sites for location of nuclear power stations in South Africa. The NSIP included a wide range of specialist studies, such as engineering, social science, geology, ecology and town planning. The environmental elements of the work were undertaken by the Environmental Evaluation Units from the University of Cape Town, Port Elizabeth and Rhodes Universities.

The primary objective of the NSIP was to identify sites along the coastline of South Africa, suitable for the construction and operation of future nuclear power stations. The NSIP comprised of three phases: Phases 1 and 2 involved desktop studies, which assessed the general suitability of regions located along the coast. Subsequent to this, five specific sites within the identified regions were earmarked for further detailed investigations. Phase 3 involved field investigations of those sites by various specialists. The field investigations were undertaken in order to determine the suitability and sensitivity of the sites identified and culminated in the identification of five suitable sites, namely:

- Brazil (Northern Cape);
- Schulpfontein (Northern Cape);
- Duynefontein (Western Cape);
- Bantamsklip (Western Cape); and
- Thyspunt (Eastern Cape).

At the commencement of the Scoping Phase of the EIA, in 2006, GIBB assessed these five sites and reviewed the NSIP summary reports, as provided by Eskom, to confirm the continuing validity of the sites as feasible and reasonable alternatives for the Nuclear-1 EIA. Thus, the five sites were taken forward as the starting point in the Scoping process. The process included EIA specialists who undertook baseline investigations and reviewed all previous work undertaken at and in the vicinity of the sites, including the NSIP studies.

5.2.2 The outcome of the Scoping Phase of the EIA process

The EIA team, comprising the lead consultants and specialists, undertook site visits to each of the five sites in order to obtain an overview of the potential environmental risks and key impacts associated with the proposed Nuclear-1 project. Risks and key impacts associated with the construction, operational and decommissioning phases were identified and addressed in consultation with I&APs.

In light of the reasons outlined below, the Brazil and Schulpfontein sites were deemed unsuitable for Nuclear-1 and were therefore excluded from further assessment during this Phase.

Reasons for the exclusion of Brazil and Schulpfontein were as follows:

- Optimal, strategic and cost-effective utilisation of existing infrastructure associated with the Duynefontein, Bantamsklip and Thyspunt sites, with respect to the local integration and exportation of power via existing power corridors;

- Lengthy time delays associated with the authorisation and construction of the new power corridors applicable to the Northern Cape sites, which will prevent Eskom from providing power within the required timeframes;
- Unnecessary environmental impacts associated with the construction of new power corridors given that there is existing infrastructure at or near the other three potential sites; and
- Cost implications associated with the development of new power corridors at the present time.

Despite the exclusion of Brazil and Schulpfontein from the EIA Phase for Nuclear-1, this does not preclude these sites from possible consideration in the future. The three site alternatives taken forward for further assessment in the EIA Phase of this project are Duynefontein, Bantamsklip and Thyspunt.

5.2.3 DEA's response to the proposed exclusion of Brazil and Schulpfontein

The then DEAT provided a formal response to the Nuclear-1 Scoping Report and Plan of Study for EIA on 20 November 2008 **(Appendix B2)**. DEAT accepted the proposed exclusion of the Brazil and Schulpfontein sites for the purposes of the Nuclear-1 EIA and acknowledged that these sites may, however, be subject to future investigations for future nuclear power generation developments. The approach of basing the alternative sites on those identified in the NSIP was also accepted by the DEA (Appendix B).

5.2.4 Coega as an alternative site

During the EIA process (Scoping and EIA commenting periods) I&APs questioned why the Coega Industrial Development Zone (IDZ) has not been considered as an alternative site for Nuclear-1, as it would seem to be an ideal site for a nuclear power station, owing to the fact that the Coega IDZ is attempting to attract large, electricity-intensive industries. It is, furthermore, an already developed ('brownfields') site and may therefore not be subject to the same environmental impacts as undeveloped ('greenfield') sites such as Bantamsklip and Thyspunt.

The background to the investigation of the Coega IDZ and reasons why the IDZ cannot be considered as a reasonable and feasible alternative for Nuclear-1 are as follows:

Technical reasons:

- At the time that the NSIP was developed, criteria that were applied for distances from major metropolitan areas (in this case Port Elizabeth) effectively excluded the Coega site from consideration. A 50 km radius from metropolitan areas was excluded from consideration. The Alexandria area was omitted from consideration after Phase 3A and 3B investigations revealed the following:
  - A power station would have to be founded on at least 20 to 30 metres of unconsolidated sand. Piled foundations would have to be used but these are unacceptable as their seismic design requirements are particularly onerous;
  - According to the Council for Geoscience, which was responsible for the seismic studies for the sites under consideration for Nuclear-1, the presence of the Coega fault, which runs across the southern part of the Algoa basin before extending into Algoa Bay near the Coega harbour, means that the Coega IDZ should be considered carefully before proceeding with geological investigations for nuclear siting; and
  - The confirmation of seismic suitability requires the installation of a network of micro-seismic monitors across the site, and the collection of monitoring data over a period of at least five years. No such monitoring has been performed to date and if it were started now, it would delay the development of Nuclear-1 by at least five years.
  - The proposed EPZ's 800 m and 3 km around Nuclear-1 would respectively sterilise large portions of the Coega IDZ and place development restrictions on

other industrial development in the IDZ, thereby limiting the IDZ's value for industrial development. .

Ecological reasons:

- The region consists of sandy beaches with large wind-driven mobile dunes behind the shoreline. These dune systems comprise the largest mobile dune field in South Africa (larger even than those of the Oyster Bay mobile dune field at Thyspunt). The only rocky outcrops are the cliff faces at Cape Padrone and Woody Cape. The shoreline is easily eroded and unsuitable for the siting of a nuclear power station. In addition the engineering problems associated with the natural movement of the dunes would be considerable;
- The environmental consultants (the University of Cape Town's Environmental Evaluation Unit)) considered the environmental sensitivity of this portion of coastline to be very high. The Alexandria Forest is a unique natural forest occurring only along this stretch of the Eastern Cape coastline and any disturbance to these forests would be highly undesirable; and
- The ecology of the dune fields is also considered to be highly sensitive.

At the time of the Scoping Phase for Nuclear-1, the Coega Development Corporation (CDC) indicated that there was insufficient land available for a nuclear power station. Subsequently, the CDC indicated during the EIA Phase (refer to Appendix D5 containing minutes of CDC meeting of 24 May 2010), that sufficient space is now available for a nuclear power station as several of the Coega IDZ's previous potential tenants have now abandoned their projects. Coega was not considered any further for the ecological and technical reasons mentioned above.

5.2.5 Description of the identified site alternatives

The following section provides a brief description of the three sites deemed suitable for further consideration in the EIA Phase of this EIA process. Please note that a comparative assessment for the sites has been included in Chapter 10.

(a) Site Alternative 1: Duynefontein

The site is located adjacent, and to the north, of the existing Koeberg Nuclear Power Station, which is situated on the Cape West Coast, approximately 27 km north of Cape Town (Error! Reference source not found.**)**. The proposed site falls within the existing Eskom-owned property (which includes the site of the existing Koeberg Nuclear Power Station) as well as the Koeberg Nature Reserve.

The existing infrastructure on the Eskom-owned property includes the following:

- Koeberg has two 900 MW_e Pressurised Water Reactors (PWR) units, with a total output of 1,800 MW_e;
- Associated infrastructure including bulk stores and the road network;
- Transmission lines;
- Nature conservation centre;
- Visitors centre;
- Weather station; and
- Operators Training centre.

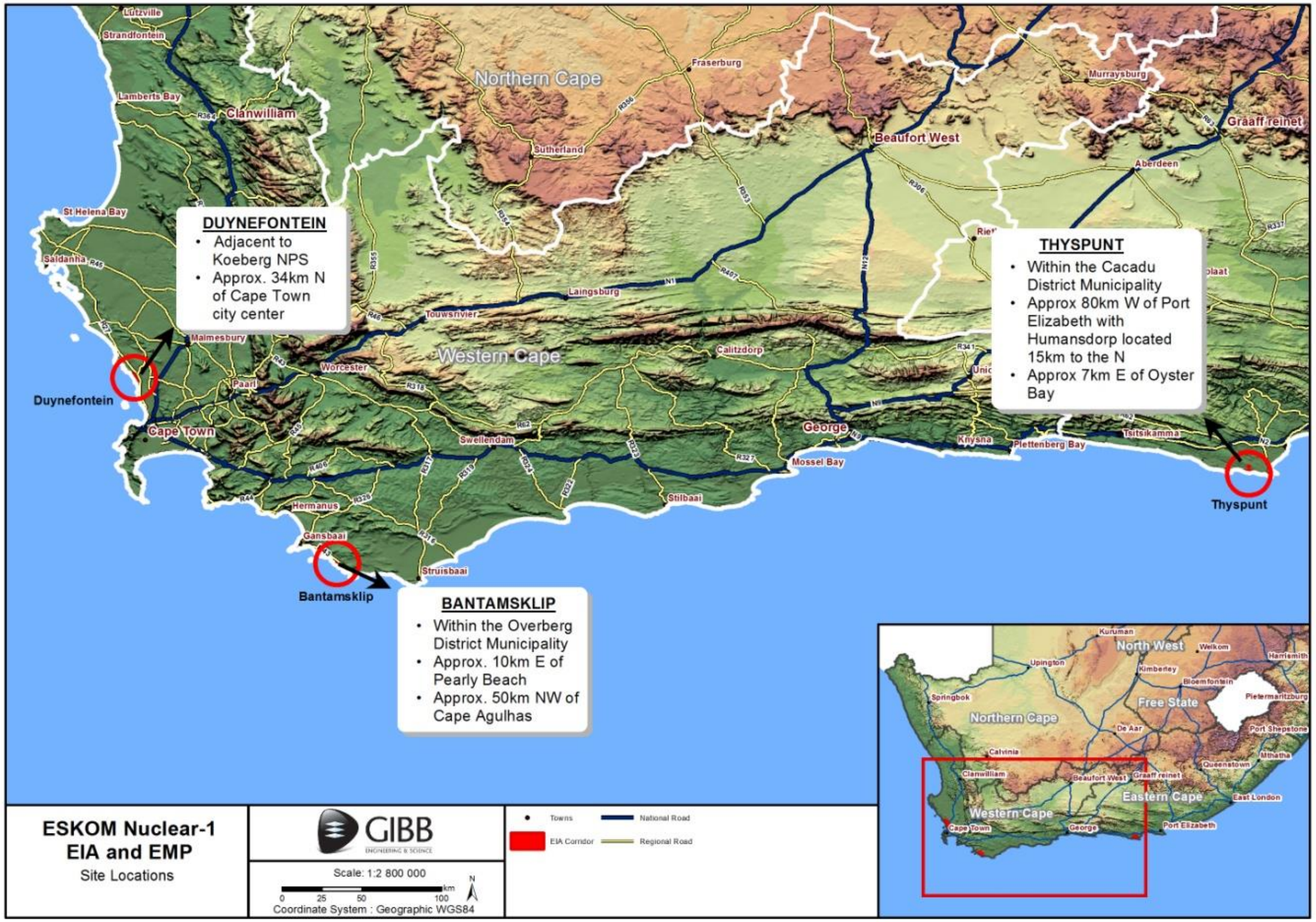

Figure 5-1: Alternative site locations (Duynefontein, Thyspunt and Bantamsklip) deemed suitable for further consideration in the EIA

Establishment of a power station at Duynefontein would increase the existing installed capacity, thus increasing the concentration of power generation in this area for the Western Cape. The site is close to the existing main transmission infrastructure and the power will connect directly to the Cape Peninsula loads with excess power evacuated via the main transmission system to the north.

Figure 5-2: View of Duynefontein looking southeast towards the coast, with the existing Koeberg Nuclear Power Station in the left background

Duynefontein Property Information.

Duynefontein				
Land Description			Title Deed	Total Size (Hectares)
Farm Name	Farm No.	Portion		
Duynefontein	34	0	T21209/1967	1257.3890
Kleine Springfontein	33	6	T21287/1987	54.1648
Kleine Springfontein	33	0	T13256/1975	1399.4196
Total		**6**		**2 928.4019**

(b) Site Alternative 2: Thyspunt

Thyspunt is situated in the Eastern Cape on the coast between the towns of Oyster Bay in the west and St. Francis Bay in the east **(Figure 5-3).**The site for the proposed Nuclear-1 power station is currently vacant. There are a number of houses on the adjacent properties, but these are far outside the proposed Protective Action Zone (PAZ) of 800 m from the proposed nuclear power station. To the north of the sand dunes, which span the northern portion of the site, the dominant land use is dairy farming.

The Thyspunt site will provide a completely new generation pool for the Eskom transmission system to supply both the Eastern Cape loads as well as export excess power to the rest of the network. Besides the advantages of diversity of generation the Thyspunt site will link up to new transmission lines under construction to Port Elizabeth, thus maximising the benefits of the new transmission infrastructure, as well as provide a voltage controllable busbar in the Eastern Cape, which is of significant value to the operation of this network and the transmission system as a whole.

Figure 5-3: View of the Thyspunt site looking east from the vegetated dunes within the proposed power station footprint

Thyspunt Property Information:

THUYSPUNT					
Land Description			Title Deed	Total Size (Hectares)	Notes
Farm Name	Farm No.	Portion			
Buffelsbosch	742	19	T077503/08	15.9201	
Buffelsbosch	742	16	T76184/1990	85.5575	
Langefontein	736	4	T51152/1989	21.4133	
Welgelee	743	4	T28635/1989	222.8280	
Langefontein	736	8	T85804/1993	21.4133	
Buffelsbosch	742	9	T88253/1994	107.0680	Farm 744 is made up of Farms 742/9, 743 and 736/1 – it was noted
Welgelee	743	0	T88253/1994	222.7696	

Langefontein	736	1	T88253/1994	21.4133	at the SG office, but not registered
Welgelegen	735	14	T89489/1993	110.8876	
Welgelegen	735	16	T46702/1994	124.3475	
Welgelegen	735	17	T83908/1994	73.6843	
Buffels Bosch	742	17	T83907/1994	21.4133	
Langefontein	736	3	T60566/1989	21.4133	
Langefontein	736	2	T48531/1992	21.4133	
Langefontein	736	6	T50483/1994	21.4133	
Langefontein	736	7	T89982/1993	21.4133	
Welgelegen	735	2	T72097/1990	385.4066	
Farm	741	0	T39376/1992	35.1921	
Langefontein	736	17 (9)	T023606/11	8.4169	
Farm	809	0	T005384/11	768.3289	
Buffelsbosch	742	Rem	T50050/2010	78.8134	
Ongegunde Vryheid	746	92	T49758/11	188.3111	
Farm	824	0	T39376/1992	0.1023	
Farm	825	0	T39376/1992	0.0058	
Goed Geloof	745	179	T004328/11	48.9146	
Goed Geloof	745	2	T004328/11	146.7748	
Buffelsbosch	742	6	T24590/2011	243.0410	
Goed Geloof	745	210	T019442/11	0.1000	
Goed Geloof	745	209	T11243/2011	0.1000	
Welgelegen	735	9	T000940/11	80.3938	
Buffelsbosch	742	20	T4299/2013	16.8217	
Buffelsbosch	746	18	T14342/2013	21.4133	
Zeekoeirivier	793	0	T31926/2013	119.5515	
Buffelsbosch	742	21	Await TD	17.1353	
Farm	809	36	Await TD	14.9998	
Ongegunde Vryheid	746	23	Await TD	21.4133	
Welgelegen	735	18 (4)	T14342/2013	31.3938	Divided from Farm Welgelegen 735/4
Farm	826	1	Await TD	7.2901	Divided from Farm 826
Buffelsbosch	742	22 (7)	Await TD	32.0347	Divided from Farm Buffelsbosch 742/7 (referring to the northern portion)
Buffelsbosch	742	12	Await TD	32.2794	Divided and the remaining portion is no. 742/22 which is owned by the farmer
Welgelee	743	6 (2)	Await TD	12.2772	Divided from Farm Welglee 743/2
Ongegunde Vryheid	746	5	T37388/2013	34.6031	
Welgelee	743	8 (3)	Await TD	15.2386	Divided from Farm Welglee 743/3
Ongegunde Vryheid	746	11	T31001/2013	36.6296	
Buffelsbosch	742	14	Await TD	301.1563	Divided and the remaining portion is no. 742/25 which is owned by the farmer
Total		**45**		**3828.5080**	

(c) Site Alternative 3: Bantamsklip

Bantamsklip is situated along the Southern Cape coast and is located approximately mid-way between Danger Point and Quoin Point **(Figure 5-4**Error! Reference source not found.**).** The site for the proposed Nuclear-1 forms a part of the total Bantamsklip property. The proposed site is vacant and utilised for activities such as flower harvesting, as well as fishing and illegal harvesting of abalone. Only the Farm Groot Hagelkraal 318 is declared as a private nature reserve (Groot Hagelkraal Private Nature Reserve status), in terms of Section 12(4) of the Western Cape Nature and Conservation Ordinance, 1974 (Ordinance 19 of 1974), and not the entire site.

Bantamsklip Property Information

Bantamsklip				
Land Description			Title Deed	Total Size (Hectares)
Farm Name	Farm No.	Portion		
Hagelkraal	318	Rem	T13021/1992	1320.5774
Buffeljagt	309	3	T78020/1993	362.7053
Luipaards Poort	310	0	T78020/1993	25.5481
Total		45		**1 708.8308**

MOTIVATION FOR EXCLUSION OF BANTAMSKLIP AS A FEASIBLE SITE ALTERNATIVE

An important consideration in the EIA process is ensuring efficacy. By efficacy it is meant that while full disclosure must be ensured, that it is incumbent on the practitioner to ensure that all information provided is relevant to decision-making. Given the public interest in EIAs and Nuclear 1 in particular the temptation is to include information 'just in case' rather than because there is a direct, specific need to provide the information for decision-making purposes. The net effect of providing all information rather than providing information that is directly required for decision-making is to make the documentation cumbersome and difficult to read and to distract stakeholders from the direct purpose of the EIA which is informed decision-making.

With the completion and subsequent approval of the Scoping report in 2008, the intention was to conduct a detailed assessment of three alternative sites for Nuclear 1 namely Duynefontein, Bantamsklip and Thyspunt. All three sites have been investigated in equivalent detail subsequently as part of the assessment phase of the EIA. In those investigations it has become clear that while Bantamsklip remains a viable site for a nuclear power station, it is the least favourable of the three sites for Nuclear 1. Given that the detailed assessment of Bantamsklip has already been presented in the public domain as part of earlier drafts of the Environmental Impact Report, the decision has been made to exclude Bantamsklip from further consideration in this EIR in the interests of brevity.

The three primary reasons for excluding Bantamsklip **at this point** relate to transportation risks, urban planning and the level of assessment available to the Nuclear-1 EIA team on the transmission lines that will be required to evacuate power from the operational power station. In respect of transportation, the route between Cape Town Harbour and Bantamsklip is both longer and topographically more complex, with the need to traverse Sir Lowry's pass being particularly challenging, in comparison to the access routes to the other two sites. This route therefore poses major technical difficulties to heavy load transportation vehicles and thus has a greater associated safety risk (to other road users and transportation staff) than the other routes. There are also significant bridge obstructions and steep grades along this route, which are not present along the routes that would service the other two sites.

The second reason is based on an urban planning perspective. All three sites were considered and investigated by the Urban Town Planners (**Appendix E34**). The sites were ranked and scored in terms of development criteria for a Nuclear Power Station, in which the Bantamsklip site scored the lowest. The scoring is influenced by the limited workforce available in close proximity to the site which is a challenge experienced on the Bantamsklip site as compared to Duynefontein or Thyspunt. This shows that the site is currently not the best choice for Nuclear-1 from an urban planning perspective.

The third reason is because there is a direct obligation (as required by the EIA regulations) to assess the full suite of impacts that would be associated with not just the nuclear power station but associated infrastructure too. A large-scale associated facility is of course the transmission lines that would be needed to supply power during the construction phase, but also to evacuate power from the operational power station. For both Duynefontein and Thyspunt, detailed assessments of the power lines are available to the EIA team but not yet for Bantamsklip. The detailed environmental assessments conducted for Thyspunt and Duynefontein have been taken into consideration with the impact assessment for these sites, giving effect to cumulative impact assessment as shown in Chapter 10. Due to the fact that similar information is not available for Bantamsklip, the EIA team cannot sufficiently assess the cumulative impact for the Bantamsklip site. As such it is simply not possible currently to provide an adequately comparative assessment between the three sites.

The EIA team is confident that excluding Bantamsklip from this EIR does not undermine the obligation to thoroughly investigate alternatives. or disqualify the site for future nuclear use. The inclusion of the Bantamsklip site would add significant further complexity to an already complex EIR without improving decision-making in any material way. The Bantamsklip site will therefore not be further considered in this EIR. Readers interested in the previous assessment of the Bantamsklip site can access the information at http://projects.gibb.co.za/Projects/Eskom-Nuclear-1-Revised-Draft-EIR.

With the above said readers should be cautioned that this does not mean that Bantamsklip can never be considered for a future Nuclear Power Station. The site is not fatally flawed as per the assessments previously conducted; however with the challenges mentioned above Bantamsklip will not be ready to meet the construction timeframe anticipated for Nuclear-1, and as such will not be further considered for this EIA.

Figure 5-4: View of the eastern portion of Bantamsklip looking east

5.3 Activity Alternatives: power generation technologies

5.1.1 Activity Alternative 1: Nuclear generation

The alternative activity type assessment was undertaken during the Scoping Phase and the results thereof are captured in **Chapter 9** of the **Final Scoping Report** (FSR). A brief summary of the findings is provided hereunder, together with additional information of relevance to alternative forms of power generation.

In order for Eskom to achieve its objectives, it requires a reliable source of power generation that will supply a consistent base load power supply that can be efficiently integrated into the existing South African power network. Only certain electricity generation technologies are presently commercially available, although not necessarily financially viable in South Africa, based largely on the availability of resources (fuel) and geographical constraints. The range of viable technologies, which were discussed and compared during the Scoping Phase of the EIA, is listed in **Table 5-1**.

Based on the findings of the Scoping Report, PWR reactor technology was found to be the only feasible and reasonable alternative for this EIA process. Chapter 4 of this EIR has also clearly demonstrated the need and desirability for a nuclear power station based on Generation III PWR nuclear technology.

Table 5-1 Summary of electricity generation technologies that are commercially available but not necessarily financially viable for Eskom

Development Phase	Technology
Proven base load technologies	Conventional coal (pulverised fuel)
	Light Water Reactor nuclear power stations, which include Pressurised Water Reactors and Boiling Water Reactors
	Fast Breeder Reactors
	Heavy Water Reactors
	New coal-based technologies: • Fluidised bed combustion • Supercritical coal stations
	Imported hydro-electric energy
	Combined Cycle Gas Turbine (CCGT)
Proven peak load technologies	Open cycle gas turbine (OCGT)
	Pumped storage schemes
	Hydro-electric generation on the Orange River
Proven (*intermittent*)	Wind and solar
Demonstration	Pebble Bed Modular Reactor (PBMR) (Nuclear) – ***project discontinued***
	Underground Coal Gasification (UCG)
	Concentrated Solar Thermal and its storage capability
Research	Tidal energy and ocean currents

5.1.2 Activity Alternative 2: Wind generation

A significant number of comments have been received during the period of availability of the Draft and Revised Draft EIRs that wind-generated power must be considered as an alternative to a nuclear power station, especially in the Eastern Cape around the Thyspunt site, as EIA processes are currently being undertaken for a number of wind energy facilities in the area and a number of wind energy facilities were under construction. A request was made to provide a comparison of the surface area that would be required for wind powered generation of 4 000 MW, the same capacity as the proposed Nuclear-1 power station. In this regard, it must be stressed that the then DEA's approval of the Final Scoping Report and the Plan of Study for Scoping accepted that power generation alternatives do not need to be investigated in the EIA phase of the project. It has also been made clear in this Revised Draft EIR Version 2 that nuclear power is not being pursued as an alternative to any form of renewable power generation, but that all forms of power generation have an appropriate role in the mix of generation alternatives, the relative contributions of which are to be determined by the Integrated Resource Plan (IRP) 2010. Nevertheless, a brief discussion on the possible implications of wind power as an alternative is provided for comparison below.

The space required for wind farms is dependent on a large number of variables such as wind speed, wind direction, turbine size, terrain (i.e. small hills, valleys), land conditions (i.e. sensitive areas, fauna), surface roughness (it is preferable to avoid trees and bushes, etc.), ground conditions and human settlements. Generally, based on some rules of thumb, a spacing of eight turbine rotor diameters downwind and four turbine diameters across wind can be applied.

If there is a prevailing wind direction where the wind originates from for the majority of the time, wind turbines can be placed four diameters apart (cross wind). However, if the wind direction varies more (as is the case with most coastal areas with pressure system driven winds), then the turbines need to be placed eight rotor diameters apart down wind and cross wind. Areas with a unidirectional or bi-directional wind are generally thermally driven systems typically found in regions such as at Sutherland or on escarpments.

Turbine rotor diameters vary from 80 m to 120 m. In this instance, a 90 m diameter has been used an as example and capacity of 2 MW per turbine has been assumed. If a spacing between turbines of eight rotor diameters by eight rotor diameters is assumed, then an area of 345 600 ha[1] will be required for 13 333 MW of installed capacity. This increased installed capacity will be required due to the fact that wind is not available at all times (a capacity factor[2] of 30 % is assumed)[3]. The effective power produced from 13 333 MW of installed capacity will be 4 000 MW. The actual space that will be used will inevitably be greater than these estimates due to not all pieces of land being suitable for turbine placement.

For comparative purposes, it is estimated that the total area required for Nuclear-1 to generate the same output is approximately 200 - 280 ha, depending on the terrain. This footprint includes the reactor and auxiliary buildings and laydown areas required during construction (including topsoil storage areas).

The actual space that the wind turbines would render unusable for activities such as farming is less than 1 % (around 3 456 ha) of the total affected area. This is the footprint of the turbines (an area of approximately 18 x 18 m per turbine foundation), a clearance area around each turbine (for fires etc.), roads, sub-stations etc. Other potential environmental impacts that typically need to be considered for wind turbines include the footprint of the wind turbines themselves, as well as the footprint of access roads for construction and maintenance, noise of the rotating turbines, visual impacts (which are usually substantial due to the height or the turbines and the movement of the blades) and impacts on birds (usually substantial) and impacts on bats. Traffic impacts during construction would also be substantial due to extra heavy vehicles that would need to be used to transport the large masts and rotor blades

5.1.3 Comparative costs of power generation alternatives

It is not the intention of this EIA process to provide a detailed evaluation of the costs of various alternative forms of electricity generation. However, comparative financial costs of generating electricity from nuclear technologies and various other forms of electricity generation have been reviewed in a number of reports, including the following:

- a joint report (IEA and NEA 2010) by the International Energy Agency (IEA) and the OECD Nuclear Energy Agency (NEA);
- a report (EPRI 2010) commissioned for the South African IRP 2010 process; and
- 2013 reports by the US Energy Information Administration and the UK Department of Energy and Climate Change.

(a) IEA and NEA comparative costs for electricity generation alternatives

The report by the IEA and NEA provides Levelised Cost of Electricity (LCOE) per MWh for almost 200 generating technologies, based on data covering 21 countries (including four major non-OECD countries), and several industrial companies and organisations. The study was carried out with the guidance and support of an ad hoc expert group of officially appointed national experts, industry experts and academics.

The study reaches two important conclusions:

- First, in the low discount rate (5%) scenario, more capital-intensive, low-carbon technologies such as nuclear energy are the most competitive solution compared with coal-fired plants without carbon capture and natural gas-fired combined cycle plants for base load generation. Based on the data available for this study, where coal has a low cost (such as in Australia or certain regions of the United States), both coal plants with and without carbon capture [but not transport or storage] are also globally competitive in the low discount rate case (See Figure 5-5); and

[1] A block of around 60 km x 60km. For comparative purposes, Addo National Park is 164,000 ha (SANParks website) and Baviaanskloof Mega-Reserve is approximately 500,000 ha.

[2] ***The percentage of time that the installation can produce its full output** .**output***.

[3] EPRI (2010) indicates that wind turbines at an unspecified coastal location have a capacity factor of 29.1 to 40.6 %.

- Secondly, in the high discount rate (10%) case, coal without carbon capture equipment, followed by coal with carbon capture equipment, and gas-fired combined cycle turbines (CCGTs), are the cheapest sources of electricity. In the high discount rate case, coal without CC(S) is always cheaper than coal with CC(S), even in low-cost coal regions, at a carbon price of US$ 30 per ton. The results highlight the paramount importance of discount rates and, to a lesser extent, carbon and fuel prices when comparing different technologies.

As an overall conclusion, the study suggests that no single electricity generating technology can be expected to be the cheapest in all situations. The preferred generating technology will depend on a number of key parameters and the specific circumstances of each project. The investors' choice of a specific portfolio of power generation technologies will most likely depend on financing costs, fuel and carbon prices, as well as the specific energy policy context (security of supply, CO_2 emissions reductions and market framework).

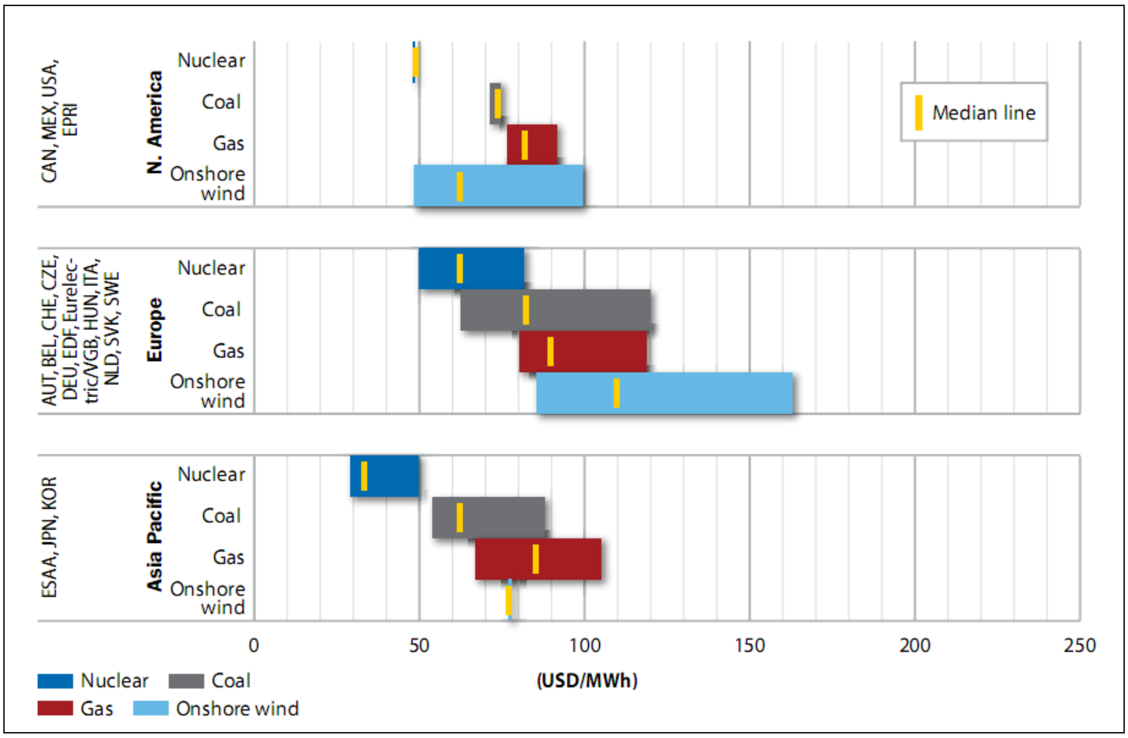

Figure 5-5: Regional ranges of LCOE for nuclear, coal, gas and onshore wind power plants (at 5% discount rate)

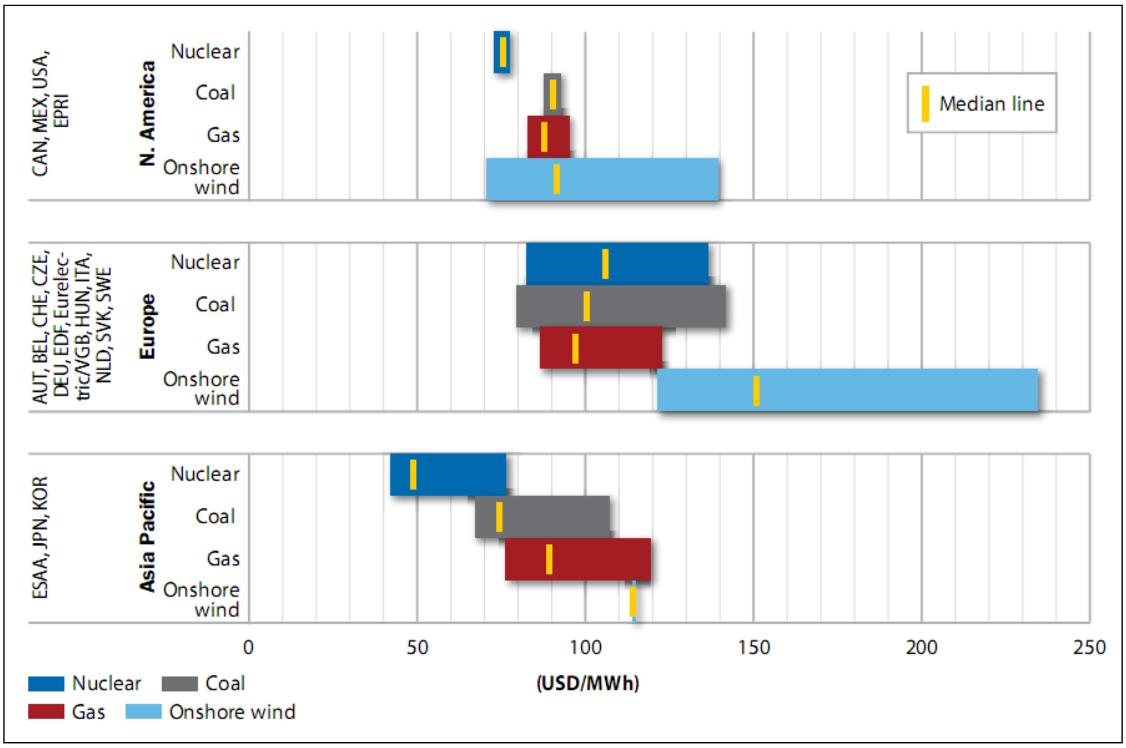

Figure 5-6: Regional ranges of LCOE for nuclear, coal, gas and onshore wind power plants (at 10% discount rate)

It is important to note that the above-mentioned analysis deals only with financial costs of generation alternatives, but does not include externalities such as the environmental costs. Nuclear energy tends to have a high start-up cost with a lower operational cost when compared to coal. Secondly, transport costs also need to be considered by taking into account the location of a proposed power station. If generating electricity in the coastal areas, as is the intention with Nuclear-1, transport costs for coal would be high, whereas transport costs for nuclear fuel would be similar, no matter where the power station is located. The costs of losses in the transmission network for a coal-fired station located in Mpumalanga or Limpopo that provides power to the coastal regions would also need to be considered.

(b) EPRI 2010 study of comparative costs for electricity generation alternatives

Further analysis of the comparative costs of generation technologies is provided by a study commissioned for the IRP 2010. The Electric Power Research Institute (EPRI) produced this report (EPRI 2010) for input into South Africa's IRP 2010. This report provides cost and performance data on renewable resource based technologies such as wind, concentrated solar, solar photovoltaic, biomass, waste, coal, open cycle (natural) gas turbine, combined cycle gas turbine and nuclear technologies expressed in Rand terms per unit of power and unit of energy produced (Table 5-2). Costs are provided for fuel, variable operational & maintenance (O&M) costs, fixed O&M costs and capital costs and lastly total LCOE.

Table 5-2: Summary of the LCOE of generation alternatives in 2020, based on learning rates (Table 17 from Department of Energy 2010c)

		New build options										
		Coal	**Nuclear**	**Solid Waste**	**Biomass**	**Bagasse**	**Gas (CCGT)**	**Concentrated Solar Power (CSP)**	**Pumped storage**	**Peak – OCGT**	**Wind**	**Photovoltaic (Solar)**
	Typical load factor	**85%**	**92%**	**85%**	**85%**	**50%**	**50%**	**40%**	**20%**	**10%**	**30%**	**20%**
Fuel	R/MWh	147	67	0	277	377	597	0	~255[4]	2385	0	0
Variable O&M	R/MWh	44	95	38	31	31	0	0	4	0	0	0
Fixed O&M	R/MWh	61	0	309	117	72	34	10[5]: 188 20[6]: 88	70	80	10: 101 20: 86	10: 121 20: 70
Capital	R/MWh	212	264- 369	713	355	441	748	10: 1178 20: 551	698	2866	10: 560 20: 476	10: 1186 20: 560
LCOE	**R/MWh**	**464**	**426- 531[7]**	**1061**	**779**	**867**	**748**	**10: 1178 20: 551**	**698**	**2866**	**10: 661 20: 562**	**10: 1307 20: 630**

From this table, it is evident that fuel costs for nuclear remain some of the lowest of all the technologies, with the exception of the renewable technologies, for which the fuel costs are zero. Although the variable costs of nuclear remain the highest of the generation alternatives, the LCOE of nuclear compares relatively well with coal and is much lower than other generation alternatives.

It is further shown that OCGT plants have the most expensive LCOE of all generation technologies considered in the South African context. Thereafter follows solar photovoltaic technology (R1307 / MWh at a 10 year learning rate), CSP (R1178 / MWh at a 10 year learning rate) and solid waste (at R1061/ MWh). The LCOE of renewable technologies, including CSP, wind and photovoltaic technologies decrease over time, dropping substantially with a 20-year learning rate, but even considering a 20-year learning rate, they remain more expensive than nuclear, even assuming a 40% CAPEX increase for nuclear.

[4] Assuming sum of fuel and variable O&M costs of coal power to stand for “fuel costs” of pumped storage
[5] 10-year learning rate
[6] 20-year learning rate
[7] With and without 40% CAPEX increase

(c) Generation costs provided by US Energy Information Administration and the UK Department of Energy and Climate Change

The US Energy Information Administration and the UK Department of Energy and Climate Change published LCOE calculations for a range of generation technologies in 2013 (US Energy Information Administration 2013; UK Department of Energy and Climate Change 2013). Care should be exercised when comparing these figures directly, as they are based on different assumptions, but they nevertheless provide an order of magnitude comparison for South African figures from the IRP 2010.

These studies stress the importance of not making direct costs comparisons between dispatchable and non-dispatchable electricity supply[8], the costs of technologies such as wind or solar, which appear to be similar to non-renewables, may in effect be more expensive. This is because non-dispatchable technologies such a wind and solar need other forms of (non-renewable) back-up generation to provide electricity when the renewables cannot provide sufficient capacity. The total cost of some renewables is therefore determined by the cost of the renewables plus the cost of dispatchable backup generation.

Table 5-3: Summary of United Kingdom LCOE of generation alternatives for commissioning in 2020 (UK Department of Energy and Climate Change 2013)

		Coal (Advanced Super-Critical Coal)[9]	Coal (Integrated Gasification Combined Cycle)[10]	Nuclear	Solid Waste	Biomass[11]	Bagasse	Gas (CCGT)	Concentrated Solar Power (CSP)	Pumped storage	Peak – OCGT	Wind	Photovoltaic (Solar)
Minimum LCOE	**£/MWh**	89	106	84	n.a.	105	n.a.	80	n.a.	n.a.	172	85	115
Maximum LCOE	**£/MWh**	133	173	123	n.a.	114	n.a.	83	n.a.	n.a.	200	125	132
Average LCOE	**£/MWh**	109	135	100	n.a.	108	n.a.	82	n.a.	n.a.	185	104	123

[8] See text box
[9] Value for commissioning in 2025. No value is provided in the source document for 2020
[10] Value for commissioning in 2025. No value is provided in the source document for 2020
[11] Value for commissioning in 2016. No value is provided in the source document for 2020

Table 5-4: Summary of United States LCOE of generation alternatives for commissioning in 2020 (US Energy Information Administration 2013)

		Coal (Conventional)	Coal (with Carbon Control and Sequestration	Nuclear	Solid Waste	Biomass	Bagasse	Gas (CCGT) (Conventional CCGT)[12]	Concentrated Solar Power (CSP)	Pumped storage[13]	Peak – OCGT	Wind	Photovoltaic (Solar)
Minimum LCOE	**$/MWh**	89.5	123.9	104.4	n.a.	98	n.a.	62.5	190.2	n.a.	n.a.	73.5	112.5
Maximum LCOE	**$/MWh**	118.3	152.7	115.3	n.a.	130.8	n.a.	78.2	417.6	n.a.	n.a.	99.8	224.4
Average LCOE	**$/MWh**	100.1	135.5	108.4	n.a.	111	n.a.	67.1	261.5	n.a.	n.a.	86.6	144

The LCOE figures quoted above, although highly dependent on exchange rates, indicate that coal-fired electricity and nuclear power have comparable costs in South Africa and the USA, but that nuclear is cheaper than coal in the UK and the USA, particularly if modern coal technologies (e.g. Carbon Sequestration and Control or Integrated Gasification Combined Cycle, which reduce greenhouse gas emissions) are used. Rates for onshore wind power vary between the USA and UK: it is on average marginally cheaper than nuclear and coal in the USA but marginally more expensive than nuclear in the UK. As in South Africa, concentrated solar is shown to be approximately twice as expensive as either nuclear, coal or other renewables in the USA. No LCOE value for concentrated solar is provided for the UK. Photovoltaic (PV) generation is significantly more expensive than coal, nuclear or wind power in South Africa and the USA. However, in the UK, the cost of PV is shown to reduce significantly over time. The average value for PV commissioning in the UK in 2014 is £ 158 / MWh, but reduces to £ 123/ MWh for commissioning in 2020.

(d) Conclusion on activity alternatives

Whilst wind, which has been discussed above, and other renewable technologies have a definite and increasingly important role to play in South Africa's energy supply, they cannot be regarded as reasonable or feasible alternatives within the context of this EIA process. This EIA process is focused on the provision of a base load power station. Only specific technologies, of which nuclear and coal-fired technologies are the most significant ones, can provide reliable base load supply. Chapter 4 of this EIR indicated that the percentage contribution of coal-fired power needs to reduce and that alternatives such as nuclear power, which have low greenhouse gas footprints, need to become more prominent.

Secondly, although renewable technologies use "free fuel" and result in very little operational waste, they may have significant environmental impacts of their own, not only in terms of their physical footprint. Generation infrastructure (turbines) for wind power is widely dispersed and therefore the comparable area of landscape that is affected by wind power vs. a nuclear power plant with the same electrical output is vast (345 600 ha for wind compared to 280 ha for nuclear). Even when it is considered that the actual footprint of wind power is only 1% of the total land area required, this still implies that 4000 MW of effective wind power capacity would have a footprint of around 3 450 ha.

[12] Figures are also provided in the source document for Advanced CCGT with Carbon Control and Sequestration, but are not reflected here.
[13] This source provides LCOEs for "Hydro" projects but it is unclear whether this is for a conventional hydro-electric plant or for a pumped storage project.

Furthermore, when the financial costs of the alternative generation options are compared, it is clear that nuclear power is competitive. It cannot be concluded, based on a comparison of the LCOE of nuclear and the range of other generation technologies per MWh of electricity produced, that a nuclear power station would necessarily result in an excessive increase in electricity costs, as has been argued by some interested and affected parties. The LCOE figures quoted above show that the financial cost of nuclear power per MWh remains competitive with coal-fired and renewable electricity generation. Although nuclear power has a high initial capital cost, its fuel costs and operational costs per MWh are very low compared to most other alternative technologies. A further factor in the apparently reasonable price of renewables that must be considered is that they require expensive dispatchable backup power supply to provide stability of electricity generation, so their actual total costs may be hidden.

Based on the above, it is apparent that nuclear generation remains the most feasible and reasonable alternative for the Nuclear-1 EIA process. Renewable alternatives cannot be considered as technology alternatives in this EIA.

5.4 Nuclear Technology alternatives: nuclear plant types

Table 5-5 indicates the five reactor technologies that Eskom short-listed following the screening phase for the proposed project, which occurred in 2006/7. The table provides a list of the various technologies and the salient features associated with each reactor type.

Table 5-5: Summary of Eskom's short-listed nuclear plant type technologies

REACTOR TYPE	TECHNOLOGY	PLANT/ DESIGN TYPE	SALIENT TECHNICAL FEATURES
Light Water Reactors	**Pressurised Water Reactor**	**AP1000**	**Reactor Thermal Power : 3 400 MWt** **Electrical Power Output: approximately 1140 MWe** **Safety systems such as:** • **Passive core cooling system (PXS)** • **Passive containment cooling system (PCS)** • **Control room emergency habitability systems (VES)** • **Containment isolation** **Efficiency (overall): 33.53%**
		EPR	**Reactor Thermal Power: 4 616 MWt** **Electrical Power Output: approximately 1 650 MWe** **Safety systems such as:** • **Three protective barriers** • **Core Catcher** • **Safety injection system** • **In-containment refuelling water storage system (IRWST)** **Efficiency of 35.75%**

REACTOR TYPE	TECHNOLOGY	PLANT/ DESIGN TYPE	SALIENT TECHNICAL FEATURES
		RSA 1000	**Reactor Thermal Power : 2 895 MWt** **Electrical Power Output: 1 020 MWe** **Safety Aspects:** • **Several interconnecting systems resulting in various complex failure mechanisms** • **Proven technology with more likely design base incident optimized as a result of OE.** • **Operator intervention only necessary after 20 minutes.** **Overall efficiency: ~33%**
	Advanced Boiling Water Reactor	ABWR	**Reactor Thermal Power: 3 992 MWt** **Electrical Power Output: approximately 1 371 MWe** **Safety systems such as:** • **Vessel-mounted recirculation pumps** • **Fine motion control rod drives** • **Advanced digital and multiplexed instrumentation and control system** **Efficiency: Unknown with present data** **Overall efficiency: 34.34%**
Heavy Water Reactors	CANDU	CANDU-6	**Reactor Thermal Power: 2100 MWt** **Electrical Power Output: approximately 700 MWe** **Safety features such as:** • **Defence in depth design approach incorporate tri-level passiveness** • **Preventative boundaries (safety systems are separated physically and functionally) and two independent shutdown systems are built in at different levels** **Efficiency: 33.33%**

At the time of writing, Eskom had not yet chosen a preferred vendor for the supply and installation of PWR technology. The Department of Energy has taken over the nuclear procurement process from Eskom. Thus, the plant types may not be limited to the above-mentioned alternatives. The Department of Energy has not made public which plant types are currently being considered for Nuclear-1. To deal with the potential variations in design Eskom has identified an “envelope” that defines the full range of different plant types, in terms of their footprints and the emissions to air, land and water that they may cause. The envelope represents a “worst case scenario” of potential impacts from a PWR Generation III nuclear power station. The envelope was presented in the form of a “consistent dataset” that was provided to all specialists, to serve as the basis for their assessment **(Appendix C**). Only the key features of the envelope are indicated in **Table 5-56.**

Table 5-6: **Key features of the Nuclear-1 envelope**

	Unit	Envelope
Auxiliary Steam Boiler		
Auxiliary Steam Boiler (x3)	t/h	32
Diesel Storage Tanks (x2)	m³	230
CRF (Main Cooling Water) Chlorine injection		
Normal Operation-Continuous	mg/kg	2.00
Shock (3x/day for 15 min)	mg/kg	4.00
Continuous consumption rate	kg	13 565
Shock consumption rate	kg	848
Total consumption rate	kg	14 413
Civil Works		
(Existing landscape)		
Maximum height above MSL	m	14
Minimum height above MSL	m	6
Sand removal for Construction (**subject to change as it is dependent on the site, terrace elevation and vendor technology)**	m³	15 000 000
Finished Terrace above MSL	m	12- 15
Desalination Plant		
Will the sea water ***used in the desalination plant*** be taken up through the cooling water ***system***?		Not initially. Will later be incorporated when the intake ***system*** is complete.
What input volume of water will be needed and how does it compare to the uptake of cooling water	m³/day	9 000 maximum = 0.14% of intake
Output of ***desalination*** plant (***during*** earth works)	m³/day	3 x 3 000
Output of ***desalination*** plant (***during*** construction)	m³/day	1 x 600
Output of ***desalination*** plant (***during*** operation)	m³/day	2 x 2 000
Brine		
Input	ppm	35 000
Output	ppm	59 000
Diesel Generators		
(Per nuclear unit)		
Emergency Diesel Generators		
Number of generators	each	4
Output Capacity	MW	8
Diesel storage arrangement		Run at rated power for 72 hours
Testing hours per week	hr	2.00
Diesel storage tanks	kl	1 000
Dose Rates		
Radiation Worker		
Normal Operation		
(For Power Station)		
100m	nSv/h	0.30
300m	pSv/h	27.00

	Unit	Envelope
1000m	pSv/h	0.20
Incident Conditions		
100m	nSv/h	2.50
300m	nSv/h	0.20
1000m	pSv/h	1.60
Public Radiation		
(For Power Station)		
Normal Operation	mSv	0.10
Incident and Accident	mSv	10.00
Electrical and thermal characteristics		
(per unit) – *maximum based on EPR design*		
Gross Electrical Output	MWe	1 784
Net Electrical Output	MWe	1 650
House Load	MWe	134
Thermal Output	MWth	4 616
Efficiency	%	35.75%
Availability	%	
18 months	%	91.5%
First 2 years	%	91.5%
Power factor at generation terminals		0.90
Employees on Site		
Please note that this will be the maximum number of employees per group. The peak will not be at the same time for all groups		
Eskom project staff		140
Consultants		40
Vendor staff		2 172
Vendor construction workers		5 000
Eskom operation staff		1 385
Housing		
General Facilities		
Land requirement	ha	44.2
Vendor Staff		
Land requirement	ha	89.5
Total vendor construction staff	ea	2 172
Eskom Project Personnel		
Land requirement	ha	12
Total Eskom project staff	ea	140
Consultants	ea	40
Vendor Construction Workers		
Land requirement		65.7
Workers on site	ea	5 000
% Local	%	25
Workers require housing	ea	3 750
Intake / Outfall Structure		
Intake		
Distance off shore	m	1000 to 2000
Number of Tunnels (for power station)	ea	1 or 2

	Unit	Envelope
Diameter of tunnels	m	5 to 10
Water velocity at intake	m/s	approx 1,0
Water velocity in tunnel	m/s	approx 3,0
Depth of tunnels	m	Approximately 30
Tunnel Spoil		Placed in Rock Retaining Walls and/or ***used as armourstone or gravel in HV yard, if suitable.*** Any additional ***spoil*** will be transported to a suitable approved location off site
Outfall		
Outfall type		Can be off ***shore via pipelines,*** via tunnels or outflow like Koeberg.
Tunnel alternative		
Number of tunnels	ea	***6 to 10***
Diameter of tunnels	m	approximately 3
Distance off shore	m	approximately 500
Depth Of Tunnels	m	approximately 5
Water velocity at the outfall	m/s	approx 5,0
Gas turbines (only at Thyspunt)		
General specifications		
Gross Output Power (2off)	MW	25.30
Gross Efficiency	%	34.00
Fuel mass flow	kg/s	1.74
Noise		
Average sound attenuation @ 1m from the package and 1,5m above ground	dB(A)	85
After additional sound damping	dB(A)	80
Stack		
Gas		Ventilation
Location of release point;	ft	Next to reactor
Height of release above ground;	m	96.00
Vent tip diameter;	m	3.00
Gas exit volume	m³/min	
Exit gas velocity (normal)	m/s	5.80
Exit gas velocity (outage)	m/s	6.35
Exit gas temperature (winter)	°C	Ambient
Exit gas temperature (summer)	°C	Ambient

	Unit	Envelope
Gas Turbine Exhaust Gas		
Exhaust gas mass flow	kg/s	85
Exhaust gas temperature	°C	538
Gas Composition		
N_2	%Vol	74.80
O_2	%Vol	13.90
CO_2	%Vol	4.20
H_2O	%Vol	6.20
Ar	%Vol	0.90
SO_2	%Vol	0.00
Nuclear fuel		
Enrichment of fuel (by weight)	%	4.95
Rods / assembly	each	265
Assemblies / load	each	241
Fuel active height	m	4.20
Fuel assembly pitch	m	0.215
Mass of fuel rod	kg	2.80
Mass of assembly	kg	780
Total assembly mass in reactor	ton	187.98
Duration of fuel in reactor	months	18
Spent fuel over lifecycle (Approx)	ton	1 880
(Approx)	m³	468
Nuclear waste		
Low level waste / year	Steel drums	470
Mass of steel drums (approx)	kg	50-100
Intermediate level waste / year	Concrete	160
Mass of concrete drums (approx)	ton	6.3
Number of trucks to transport the low and intermediate level waste / year	each	The existing Eskom lorry / trailer at Koeberg can take 80 steel drums at a time plus three concrete drums. Transport is done at Eskom and Necsa's convenience to ensure it is optimised for both parties. No transport takes place during school holidays or the rainy season.
Primary energy		
Eskom coal usage	ton/MWh	0.56
Reactor pressure vessel		
Design pressure	bar	167
Design temperature	°C	351
Reactor power	MWth	4616
Coolant Pressure	MPa	15.50
Hot leg temperature	°C	330.00

	Unit	Envelope
Cold leg temperature	°C	295.20
Seismic design		
Peak Ground Acceleration (PGA)		
Horizontal		***0.30***
Vertical		0.2-0.3
Sewer		
People during construction	ea	8 000
Water consumption / person / day	l	120
Sewer plant to treat 70% (rounded)	m³/day	750
Waste water treatment plant		
Potentially active waste (SEK/KER): 6 tanks	m³	750
Potentially active waste TER: 2 tanks	m³	750

The EIA investigations have been based on this “envelope” of characteristics, and any nuclear power station design that conforms to this envelope will, by implication, be acceptable at the recommended site. Should the design of the chosen vendor be significantly different to the envelope of criteria, then that aspect of the design may have to be re-assessed.

5.5 Layout alternatives on each of the sites

Preliminary site ‘envelope’ layouts of the power station footprint were developed by Eskom for each site. These layouts were provided to the EIA Team and were subsequently refined to address some of the issues and concerns that the specialist raised during the specialist integration workshop held on the 25 August 2008, at a second integration meeting with a smaller group of specialists held on the 26 September 2008 (both during the Scoping Phase of the EIA process), as well as a specialist integration workshop held on 24 and 25 November 2009, during the EIA Phase. The proposed positioning of the power station has also been influenced by the sensitivity maps (see end of **Chapter 9**) that were developed with specialist input.

One of the main changes that were made to the layouts was the shifting of the proposed power station from 100 m from the ocean to at least 200 m from the high water mark. This shift was to allow for the maintenance of ecological corridors, whilst also limiting the impact on sensitive dunes and heritage features, across all sites. The setback from the high water mark will also assist in preventing impacts on the station due to a sea level rise associated with climate change. The proposed layouts take account of the environmental sensitivity mapping of the sites and place the power stations in the least environmentally sensitive portions of the sites[14]. The specialists assessed the entire possible footprint area (EIA corridor) and provided recommendations on mitigation measures, areas of high sensitivity and no-go areas.

Figure 3-16 to **Figure 3-21** **in Chapter 3** provide an indication of the proposed layout of the nuclear power stations at the alternative sites. These layouts show an “envelope” layout for a vendor that is yet to be chosen.

[14] It must be noted that the final position of the nuclear power station will be determined following the appointment of the final vendor and the detailed investigations on the inter-site geological conditions. The positions proposed by the specialists and EAP are to be used as a guideline. Should the position have to be shifted significantly outside that proposed in this EIR, a supplementary environmental assessments may need to be undertaken by Eskom.

It is important to note that there are constraints with respect to the Emergency Planning Zones (EPZs) that determine how far a power station position can be moved on the sites in relation to its surroundings. In the case of the alternative sites, there will be a PAZ (refer to Section 3 for an explanation of the EPZ) with a radius of at least 800 m (also referred to as the EZ) from the power station. Thus the power station can be moved no closer than 800 m from the closest road, as no unrestricted public access is allowed within the PAZ. While a single layout has been developed the Thyspunt site, two layouts were initially developed for the Duynefontein as is explained in the section below.

5.1.1 Duynefontein

Eskom had produced two alternative preliminary layouts for the Duynefontein site.

The first alternative extended longitudinally along the coastline, with the second alternative (**Figure 3-18** and **Figure 3-19**) being more compact by having associated infrastructure such as the contractor yards and stockpile areas located inland of the Nuclear island. The second layout was introduced in response to the potentially highly significant impact on botanical processes in the active dunes of the Atlantis corridor dune field[15] as per the 2011 Dune Botany Ecological Assessment. The transverse dune system at Duynefontein is endemic, with this system being poorly represented on the Cape West Coast. However based on further studies and additional field work subsequently conducted at the Duynefontein site (2015 Botanical Dune Report – **Appendix E11**), suggested a reappraisal situation, due to the stabilisation of the mobile dunes in close proximity to the existing KNPS.

Two factors are paramount to this reappraisal: (i) the substantial loss in dune mobility due to development in the south, coupled with increases in vegetal cover have meant the dune can no longer function in its pristine state and (ii) development would be localised to vegetated parts of the dune system, permitting the remaining small mobile system in the north to function in the long term, albeit artificially restricted.

Therefore it is possible to encroach onto the southern portion of the dune system (closer to Nuclear-1 site), with certain provisos in place. However, to maximise the land use and to also be in line with the EIR approach to keep out of the mobile dunes habitat as much as possible, this initial layout will no longer be assessed or considered in this RDEIR Version 2. Therefore the only layout proposed for the Duynefontein site, is the more compact layout as shown in **Figure 3-18** and **Figure 3-19 and Appendix A).**

5.6 Construction and Operational alternatives

5.6.1 Source of water supply

Water supply is required for potable and construction purposes during the NPS construction and for potable, demineralised and fire protection purposes during the NPS operation. The following alternatives for the supply of water during both the construction and operational phases of the project have been explored for the alternative sites (not all alternatives are relevant to each of the sites):

- Use of underground water;
- Municipal water supply;
- Desalination; and
- Obtaining water from local rivers and/ or water transfer schemes.

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[15] It must be noted that from a geomorphological point of view, this habitat is not regarded as sensitive by the Nuclear-1 dune geomorphology specialist.

The result of the investigation into the viability of the proposed alternatives (Fresh Water Supply Study Appendix E8) showed the following in terms of the alternative sources listed above:

(a) Thyspunt

- There is extensive use of groundwater in the surrounding area;
- There are coastal springs at the site;
- The surrounding towns are supplied with water from the Churchill and Impofu dams and from groundwater;
- There is scope for further development of local groundwater resources for construction supply both on-site and in the surrounding area;
- Local and regional surface water resources are under stress and additional draw-off to supply a NPS would exacerbate this situation;
- The main option for surface water supply with least local and regional impact is import of water from the Orange River Scheme;
- Surface water and to a lesser extent groundwater is likely to be adversely affected by climate change; and
- Desalination of sea water is the most viable option for an assured water supply with least environmental impact and would not be affected by climate change.

(b) Duynefontein

- There is extensive use of groundwater in the surrounding area;
- The Aquarius Wellfield was previously developed to supply groundwater to the Koeberg Nuclear Power Station (KNPS) but has not been used recently because of quality constraints. This wellfield requires extensive rehabilitation but could supply the required construction and partial operational demand;
- KNPS is connected to the municipal water supply scheme;
- Additional surface water supply from existing municipal supply sources cannot be guaranteed;
- Surface water and to a lesser extent groundwater is likely to be adversely affected by climate change; and
- Desalination of sea water is the most viable option for an assured water supply with least environmental impact and would not be affected by climate change.

Therefore, based on the above the majority water supply for the construction and operational phases will be obtained from a proposed desalinisation plant. However, Eskom intends to use groundwater resources and supplemental supplies from municipal supply (where available) for a period of approximately one year prior to commissioning of the desalination plant during construction.

The groundwater abstracted as a result of dewatering during the construction phase, will thus occur over a relatively short period of time and would therefore not sustain the water requirements for the duration of the operational phase of the power station. Furthermore, groundwater is used for domestic supply by neighbouring landowners and to avoid impacts on these users, the extraction of groundwater will be kept as limited as possible.

5.6.2 Management of brine

As discussed in Section 5.6.1 water supply can be sourced through desalination of sea water. The desalinisation process results in the creation of brine (concentrated salt) as a waste product, which must be utilised and/or discarded. This section considers two potential alternatives for utilising/discarding the brine emanating from the desalinisation plant during the construction and operational phases of the nuclear power station.

Brine can be disposed either at a disposal site or through an outlet. The following disposal alternatives are possible:

- Disposal of brine at a disposal site; and

- Disposal of brine into the sea during construction and operation.
- Three discharge options for the brine into the sea have been considered, namely –
  - discharging the brine through a pipe located on the upper beach profile;
  - from a pipe located in the surfzone at a depth of 5m; or
  - from a pipe located beyond the surfzone at a depth of 10m.

  The pipe located on the upper beach level will be situated above the maximum wave run-up to prevent damage by wave action as well as scour, burial or blockage of by sand. Disposal of the brine in the turbulent surfzone will also improve mixing and reduce the risk of the brine forming a density current, which will potentially transport the brine offshore along the seabed without undergoing significant additional dilution.

  Discharging the brine at a depth of approximately 5m would still result in the brine being discharged into the surfzone at the alternative sites. The pipe would be buried or extended from a jetty in the surfzone. It is not certain whether this option will increase dilution as current speeds and wave induced turbulence will be reduced with increasing depth.

  A further option preferred) is to discharge the brine beyond the surfzone at a depth of 10m. High initial dilutions could be achieved through discharging the brine upwards from the seabed at high velocities from one or more nozzles.

5.6.3 Outlet of water and chemical effluent

Two alternatives have been considered for the outlet of the water that is used to cool and condense the steam that drives the turbines. These are:

- A near-shore outfall; and
- Offshore outfall tunnel/ pipelines.

Cooling water will be discharged into a cooling water basin, the entrance of which will be provided with screens and a fixed dredging system to remove sedimentation. The cooling water structures will also be designed to ‘no damage’ criteria using appropriate extreme conditions and conventional coastal engineering procedures and will be positioned in a depth (-25 to -35m amsl) where extreme wave conditions do not have a damaging impact on the structure or any of its components. The cooling water outfall design will further aid in the dissipation of warm water via the multiple points of release above the sea bottom at the Duynefontein and Thyspunt sites.

5.6.4 Management of spoil material

The development of the nuclear plant (Nuclear Island and turbine hall), the intake basin and associated tunnels will entail extensive excavations. The extent of the excavations will be determined by the depth of the soil profile overlying the bedrock and will therefore vary between the sites. The quantities of spoil that will be excavated are vast and thus, alternatives for disposal and/or utilisation warrant further consideration. This section discusses seven alternatives for the discard/utilisation of the spoil. It should be noted that a combination of alternatives may be required in order to completely discard the full volume of the spoil material.

The following alternatives have been considered:

- Disposal at sea (including several sub-alternatives related to the distance of disposal offshore and the discharge rate);
- Development of terraces (balancing of cut and fill);
- Development of rock retaining walls;
- Building of dunes;
- Levelling of the HV yard (only applicable at Thyspunt); and

- Commercial uses of the spoil

During the initial planning, it was considered as an alternative to create spoil disposal dumps on land. These dumps would have been up to 40 m tall with bases up to 480 m wide. The development of these spoil dumps has since been rejected as an alternative, due to the large impact on terrestrial ecosystems that their footprint would have caused.

Under the option of disposal at sea, different alternatives in terms of the rate of pumping of the spoil and the distance of disposal from shore, have been investigated in the oceanographic modelling report (Appendix E16). The rates of pumping and the distances of offshore disposal are detailed in **Table 5-7 and Table 5-8**. Temporary pipelines will be installed to transport the spoil offshore.

Table 5-7: Offshore spoil disposal alternatives at Duynefontein

Alternative	Depth	Distance from shore	Sediment volume	Discharge rate
Alternative 1	***Shallow (21 m)***	***2 km***	***6.48 million m^3***	***3.93 m^3/s***
Alternative 2	***Shallow (21 m)***	***2 km***	***6.48 million m^3***	***2.06 m^3/s***
Alternative 3	***Shallow (21 m)***	***2 km***	***3.24 million m^3***	***2.06 m^3/s***
Alternative 4	***Deep (48 m)***	***6.5 km***	***6.48 million m^3***	***3.93 m^3/s***
Alternative 5	***Deep (48 m)***	***6.5 km***	***6.48 million m^3***	***2.06 m^3/s***
Alternative 6	***Deep (48 m)***	***6.5 km***	***3.24 million m^3***	***2.06 m^3/s***

Table 5-8: Offshore spoil disposal alternatives at Thyspunt

Alternative	Depth	Distance from shore	Sediment volume	Discharge rate
Alternative 1	***Shallow (57 m)***	***1.8 km***	***6.37 million m^3***	***3.93 m^3/s***
Alternative 2	***Shallow (57 m)***	***1.8 km***	***6.37 million m^3***	***2.06 m^3/s***
Alternative 3	***Shallow (57 m)***	***1.8 km***	***3.19 million m^3***	***2.06 m^3/s***
Alternative 4	***Deep (84 m)***	***6 km***	***6.37 million m^3***	***3.93 m^3/s***
Alternative 5	***Deep (84 m)***	***6 km***	***6.37 million m^3***	***2.06 m^3/s***
Alternative 6	***Deep (84 m)***	***6 km***	***3.19 million m^3***	***2.06 m^3/s***

The Marine Ecology Assessment (Appendix E15) recommended that deep disposal sites must be used at all sites. It also recommends that the slow discharge rate of 2.06m^3/s must be used at Thyspunt in order to reduce turbidity in the water and therefore reduce the impact on chokka squid.

Eskom will attempt, as far as possible, to balance cut and fill on all of the sites. During the excavation of the power station foundations, significant volumes of sand will be moved around the site and temporary storage sites for spoil will be created (indicated by the “Areas to be rehabilitated” and “potential future development” on **Figure 3-16** to **Figure 3-21**. Once construction is complete, permanent terraces spoil terraces will be created and rehabilitated by placing topsoil on top and seeding with appropriate indigenous plant species.

Therefore a combination of balancing cut and fill and disposal at sea at a deep depth and a slow discharge rate is considered the most viable option for the management of spoil material.

5.7 Off-site access routes to the Thyspunt site

Several alternative off-site access roads to the Thyspunt site have been considered (see Routes 1, 2 and 3 in). These routes are not listed activities for the purpose of this EIA process, as the details of potential road upgrades for these routes are not yet known. Only the on-site infrastructure and on-site access roads (indicated in **Section 5.8**) are listed activities in terms of the EIA regulations. However, the cumulative impacts of these off-site access routes have been assessed.

The off-site routes that have been considered are as follows:

- Route 1: The existing Oyster Bay – Humansdorp dirt road, which is proposed to be upgraded to a tarred road for the project;
- Route 2: The R330, the tarred main link between Humansdorp and St. Francis;
- Route 3: The R102, a dirt road that originates at the N2 Kareedouw interchange and joins Route 1 halfway between Humansdorp and Oyster Bay.

Route 3 has been rejected for technical reasons as the additional distance to the site from the N2 would have been excessive. Both routes 1 and 2 are proposed to be used for the Thyspunt site: Route 1 would be used for heavy vehicle and construction deliveries to minimise the impact of construction traffic on the existing network and Route 2 for passenger vehicles (buses and cars) and ultra-heavy deliveries. Abnormal vehicles will thus need to use Route 2 to access the Thyspunt site (and hence the R330) because the alignment of Route 1 would not accommodate the wide turning circles of the abnormal vehicles. Less than approximately 30 ultra-heavy deliveries would however be made over the nine-year construction phase of the project.

5.8 On-site access routes at the Thyspunt Site

Two alternative access roads are to be provided at the Thyspunt site, namely an eastern and western access road. Initially three alternative routes (including a northern access road) were considered. The Eastern Access Road will be required for heavy vehicle traffic and is essential due to the relatively flat gradient along its alignment and the road geometry, which allows ultra-heavy vehicles to use the road. The Northern and Western Access Routes are alternative alignments that were initially considered for light and heavy delivery vehicles and buses.

In the initial planning stages, Eskom provided what it regarded as feasible engineering solutions for access roads. Several alternatives to the eastern, northern and western access routes were considered. A site visit, which included a team of biophysical specialists, was undertaken in early 2009 in order to optimise these access roads from an environmental perspective and to determine whether any of these access roads could result in environmental fatal flaws.

Error! Reference source not found. **to Figure 5-11** indicate the alternatives to the northern, eastern and western access routes that have been considered.

(a) Eastern Access Road from the R330

This access road turns off the R330 in the vicinity of Sea Vista and proceeds between two dune ridges to the site. The route selection of this road minimises the impact of the road on the wetlands, while respecting a 100 m exclusion zone to the dunes. This road will be designed for the purpose of all access to the site for both construction vehicles and power station personnel. As such, this road will also be designed to carry the ultra-heavy load vehicles to be used for transportation of heavy load plant items such as transformers. The R330 is currently tarred and the road and bridges are of a good standard.

There were three optional alignments from the eastern access road: E1 (southerly), E2 (middle) and E3 (northerly) (**Figure 5-9**). E1 follows approximately the same alignment as that of the existing access road to the "Rebelsrus Nature Reserve" and would have resulted in extreme disruption to these properties. E2 would have bisected a portion of coastal forest and was rejected for this reason. E3 was settled on, in collaboration with all the specialists involved in the site visit, because it avoids the coastal forest and it is far removed from the Rebelsrus landowners. A sub-option (E3A) was also considered. This would have joined E3 but would have joined with the R330 to the north of the St. Francis Links Golf Estate. This option was rejected due to its proximity to the eastern portion of the Oyster Bay Mobile Dunefield, and the complexities of acquiring land in this area.

As indicated in Chapter 10, the impacts of this route on wetlands, botanical resources, faunal habitats and invertebrate habitats are potentially significant. The biophysical specialists have indicated that the impacts will be acceptable, provided that Eskom purchases additional land as an offset to secure the conservation of wetlands (currently in a poor condition) that currently occur immediately to the east of Eskom's property. A detailed "walk-down" assessment of this route will have to be undertaken after authorisation by appropriately qualified and experienced specialists, in order to optimise the alignment of the road.

(b) Western access road

This access road originates near Oyster Bay from the west and turns off the Humansdorp – Oyster Bay gravel road in the vicinity of Oyster Bay, with variant alignments off the public road to the east of Umzamawethu.

Four options for the Western Access Road were initially considered, namely W1, W2, W3 and W4 (**Figure 5-10**). W1 to W3 all originate to the west of Umzamuwethu (between Umzamuwethu and Oyster Bay), whilst W4 originates from the Humansdorp-Oyster Bay road to the east of Umzamuwethu. W4 was initially rejected by the biophysical specialists on the basis of its potential impact on the western portion of the Oyster Bay Mobile Dunefield and associated sensitive ecosystems, its crossing of a drainage line and its length. Of W1 to W3, W1 was preferred by the specialists, as it was considered to have an overall lower potential impact on the biophysical and socio-economic environment than the Northern Access Road.

Subsequently, in recognition of the comments about the western access road received during the 2011 round of public comments on the Revised Draft EIR, new alternative alignments for the Western Access Road were investigated. These alternatives focused on aligning the Western Access Road to the east of Umzamuwethu to prevent the road creating a divide between Umzamawethu and Oyster Bay, since the public participation process highlighted the potential for creating a divide between Oyster Bay and Umzamawethu and because of a concern for the safety of pedestrians, who walk between these communities. Thus, a number of alternative alignments were investigated in late 2012 and the inland alternative furthest from Oyster Bay (IR2) **(Figure 5-11)** has been subsequently recommended in spite of the relatively high biophysical impact associated with this alignment. A detailed environmental assessment of these alignments is in Appendix E32.

The final recommended alignment (IR-2 and IR1/2) is shown by the green line (Option 4) in **Figure 5-12**. Figure 5-11 provides the best compromise of avoidance of social impacts on Umzamawethu and Oyster Bay (e.g. noise, limitation of access and potential traffic safety risks) with minimisation of biological and heritage impacts, as well as avoidance of direct impacts on the mobile portions of the Oyster Bay dune field. This alignment has also been optimised to reduce cut and fill, thereby minimising the road's physical footprint.

(c) Northern "panhandle" access route

The northern access route turns off the Oyster Bay – Humansdorp road (a dirt road) and enters the "panhandle" section of the site, and then runs down the western boundary of the panhandle. It then crosses the mobile dune system south of the panhandle before swinging east and then south again, before entering the EIA corridor.

Two alternatives to the Northern Access Road were considered (Error! Reference source not found.). These included a western option (N1) and an eastern option (N2). N1 was preferred as it crosses a narrower stretch of the Oyster Bay mobile dunefield, and would have resulted in lesser impacts on the wetlands than occur in the dune slack.

The Northern Access Road was rejected during a specialist integration meeting in 2009 due to its high impacts on the Oyster Bay mobile dune field and associated resources like inter-dune wetlands and archaeological sites in the dunes.

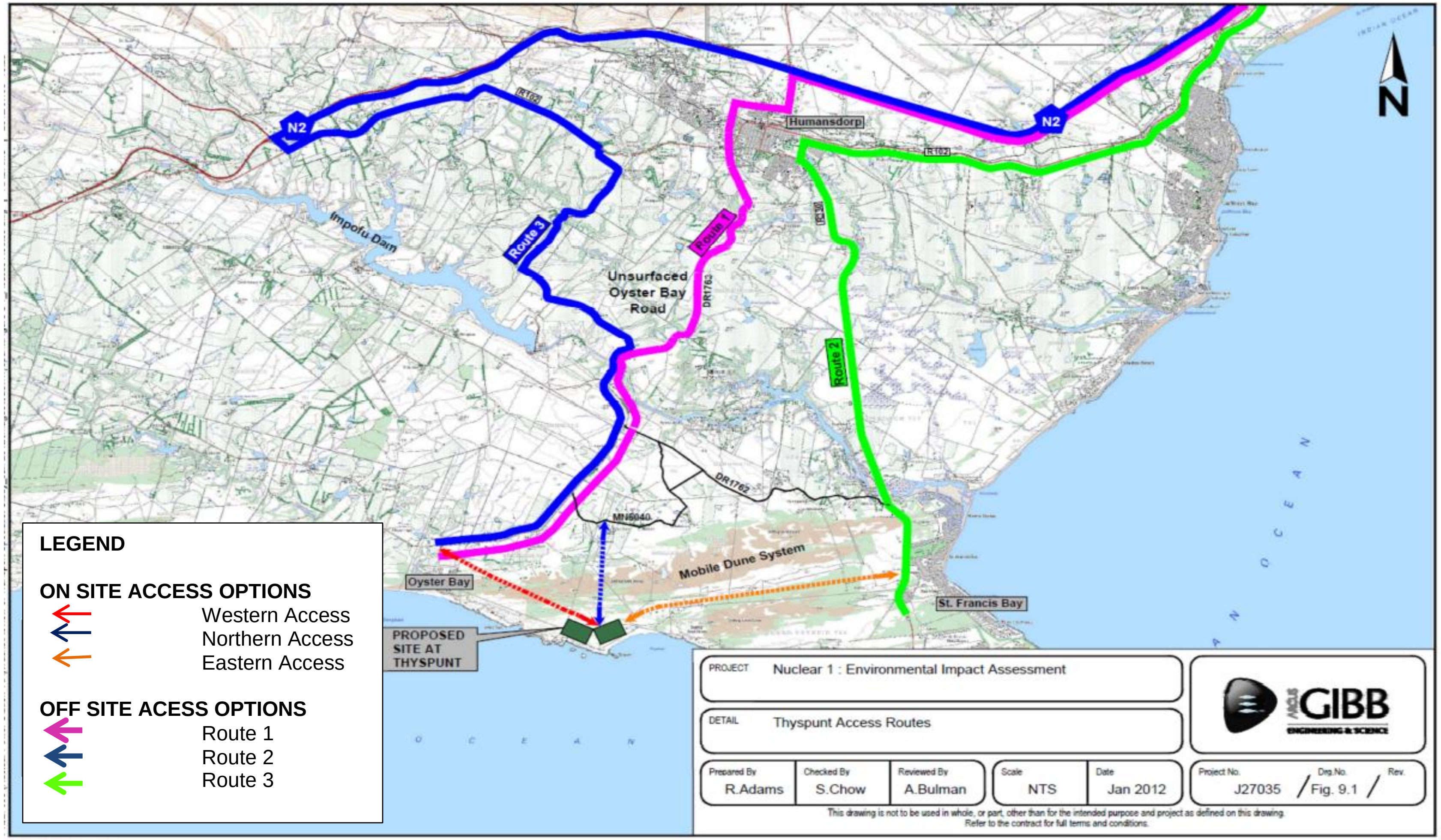


Figure 5-7: Alternative on and off-site access routes to Thyspunt (Not to scale)

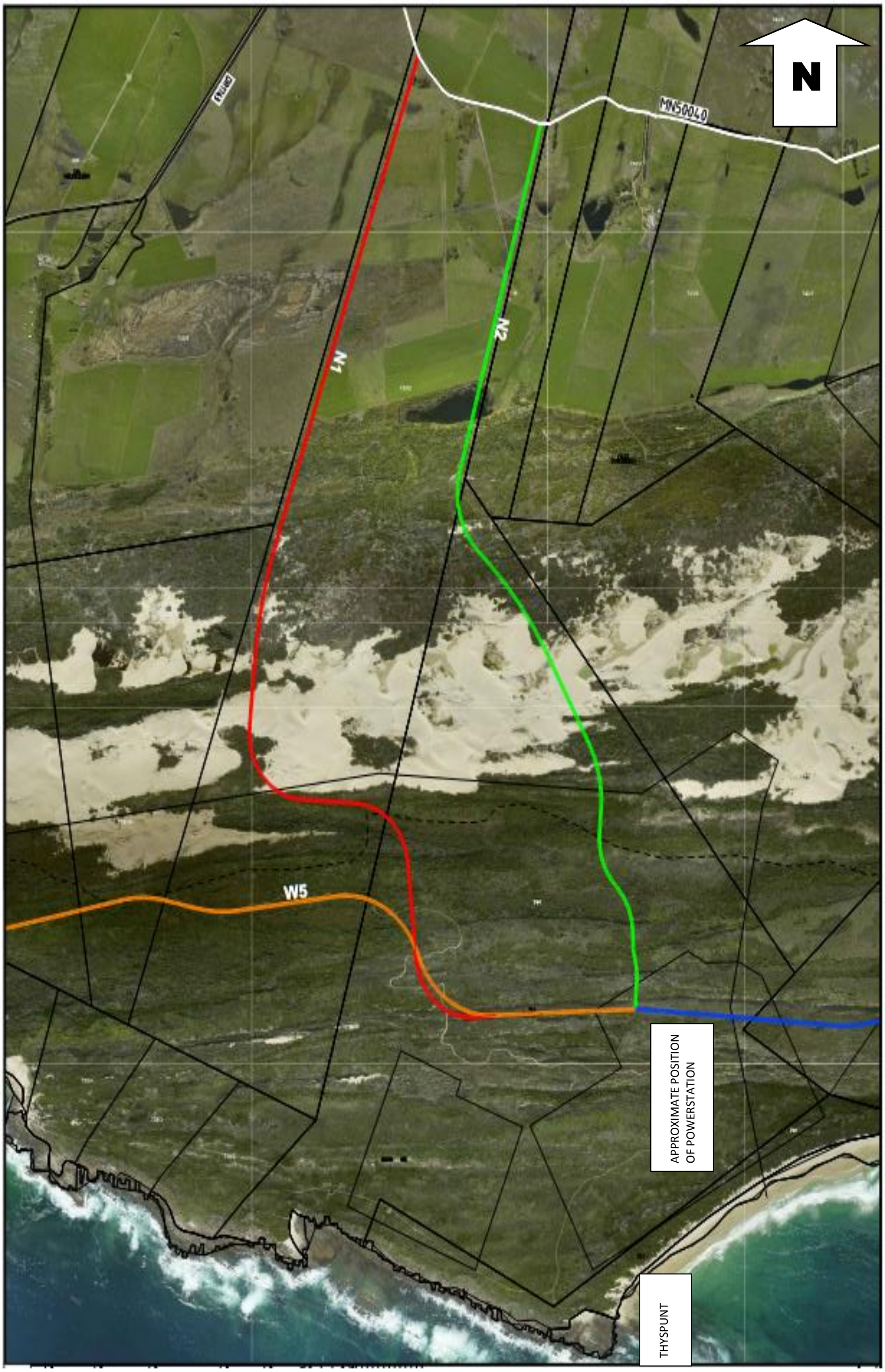


Figure 5-8: Alternative northern on-site access routes to Thyspunt (Not to scale)

Figure 5-9: Alternative eastern on-site access routes to Thyspunt (Not to scale)

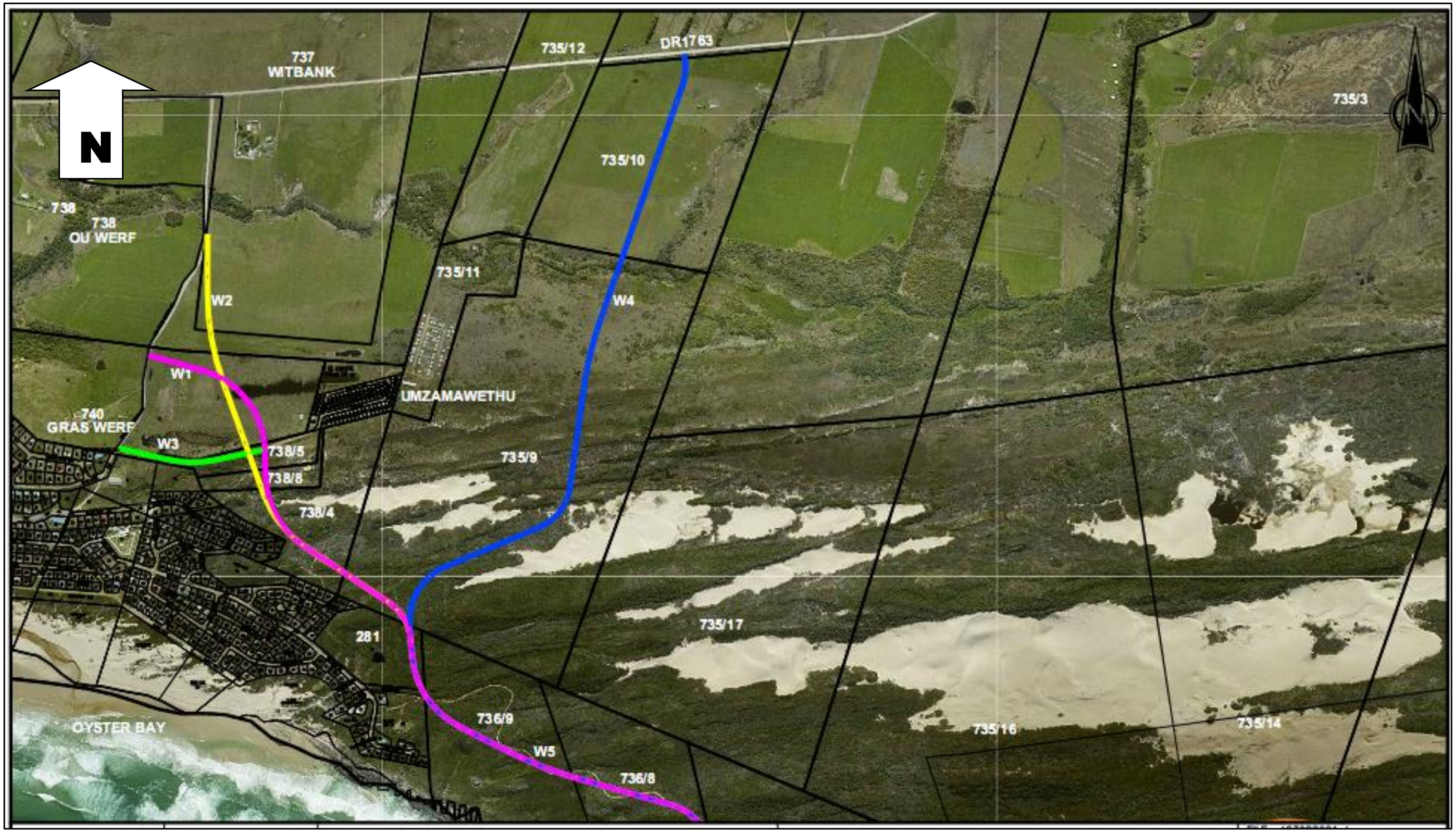
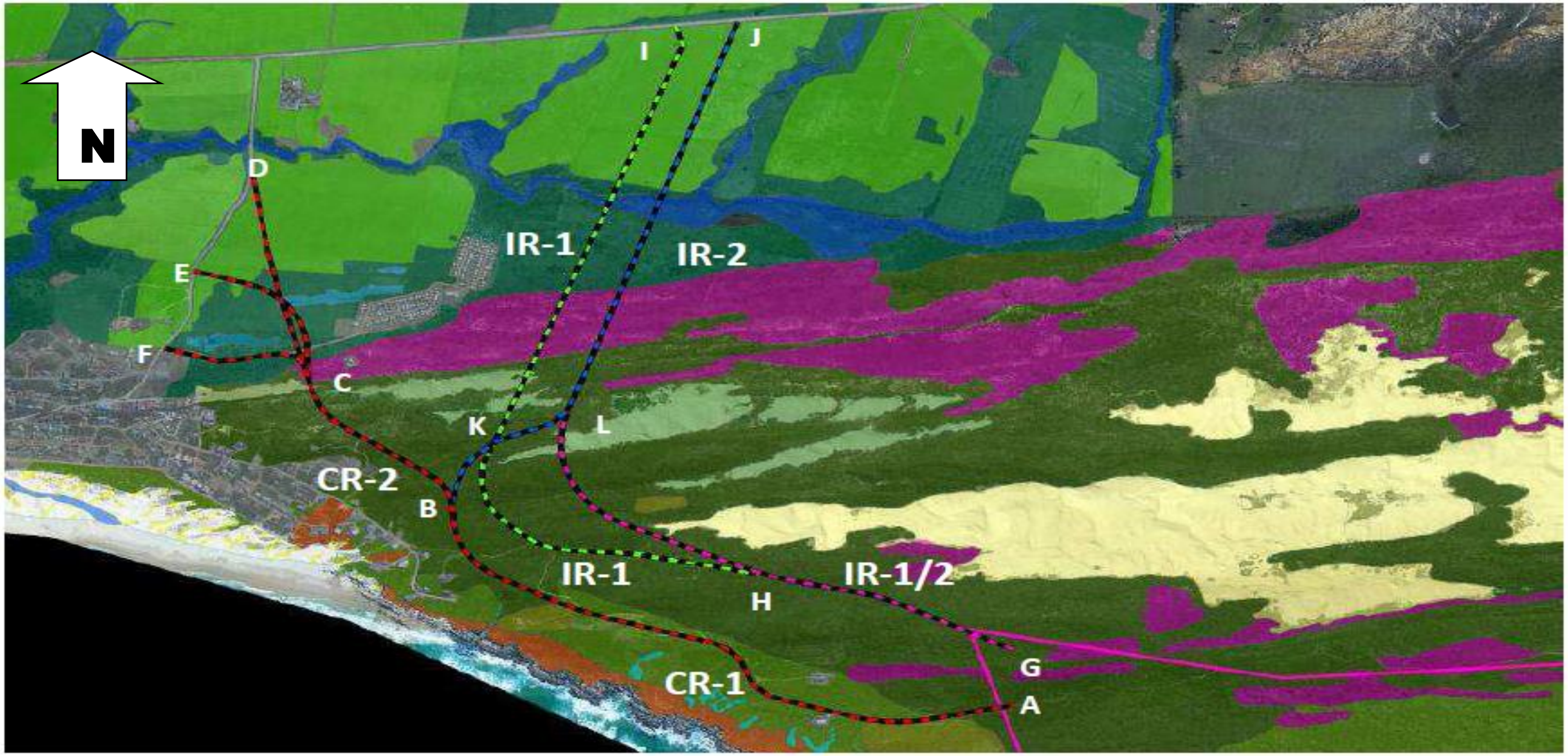


Figure 5-10: Initial alternative on-site western access routes to Thyspunt assessed in 2011 (Not to scale)



1) **Coastal Route** (CR-1 & CR-2): NPS to Humansdorp Road, between Oyster Bay and Umzamawethu; three alternatives at western end: A-B-C-D/E/F
2) **Inland Route 1** (IR-1): NPS to west of Umzamawethu: G-H-I
3) **Inland Route 2** (IR-2): NPS to west of Umzamawethu: G-H-J
4) **Coastal to Inland Route 1, alternative 1** (CR-1 to IR-1): A-B-K-I
5) **Coastal to Inland Route 2, alternative 2** (CR-1 to IR-2): A-B-L-J

Figure 5-11: New alternative on-site western access routes to Thyspunt assessed in 2013 (Not to scale)

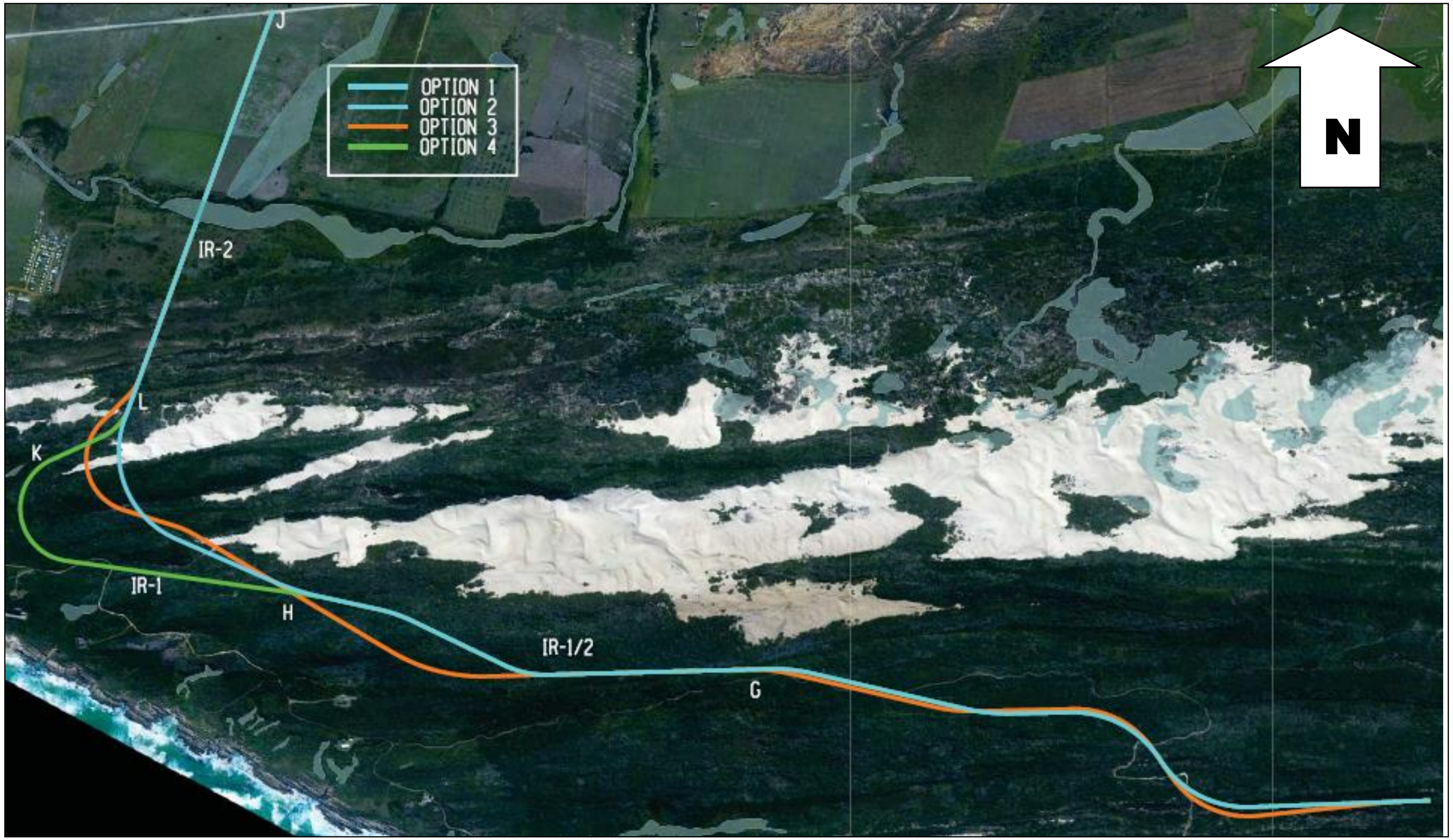


Figure 5-12: Recommended alignment (Option 4) of the on-site western access routes to Thyspunt (Not to scale)

5.9 No-Go (No development) alternative

The No-Go alternative means that the power station would not be constructed. All potential impacts detailed in the remaining part of this EIR, that specifically derive from construction and operation of a nuclear power station would thereby be prevented. These risks need to be thought about at two levels, namely, the risks that are associated specifically with the nuclear power generation and the risks that are associated with the physical alteration of the site proposed for the power station.

Nuclear power generation is not risk free and perhaps the greatest uncertainty with Nuclear Power Stations is radioactive waste disposal. The continued operations of the Koeberg Nuclear Power Station have shown that nuclear power can be operated safely in South Africa, but the question of especially high-hazard radioactive waste and how this can be sustainably and safely neutralized and finally disposed still remains unanswered. It is however recognised that the current interim long term storage solutions over 60 years are international practice. Refer to the detailed specialist study on radioactive waste management in app E33. Of all the benefits of not having another nuclear power station the prevention of the generation of high level radioactive waste must be seen as the most significant which is manageable.

The proposed sites have important environmental value that will be reduced to some extent, at least, by the construction of a Nuclear Power Station.. Obviously that loss of environmental amenity would be prevented in the short term if the Nuclear Power Station were not to be built. The problem, however, is that the decision not to construct the Nuclear Power Station does not, in its own right, guarantee that such environmental amenity would be protected into the future, especially at Thyspunt where there are likely to be significant development demands for the property that would otherwise be used by the power station. The value of the no-go option in respect of environmental amenity can only be realized if other development is effectively managed and in many cases prevented.

The final observation on the no-go option is that it curtails Eskom's ability to respond to growing electricity demand. It would be foolish to suggest that the no-go option will result in rolling blackouts because it will not necessarily mean that at all. . Eskom, or indeed anyone else for that matter, will be extremely hard pressed, however, to find a reliable, alternative manner of generating baseload which is crucial to the sustainability of our national electricity supply, and which does not result in significant greenhouse gas production. Finally, but importantly, the decision not to proceed with the Nuclear Power Station would directly not contribute to the realisation of the IRP2020 requirements.