# Additional Wetlands Monitoring on Proposed Eskom Nuclear Sites Thyspunt, Bantamsklip and Duynefontein

## Final Report

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**Prepared for**

## Eskom Generation

**Contract No: 4600024472**

**March 2011**

SRK Consulting
Engineers and Scientists

**The Freshwater Consulting Group**

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## Eskom Generation
**Megawatt Park**

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# Executive Summary

This Final Report has been prepared for Eskom (Contract No. 4600024472) to cover additional wetland monitoring at the three proposed Nuclear-1 sites. This is in order to obtain a better understanding of the relationship between groundwater and the wetlands and the potential impacts of development of the site footprints. It is also to provide baseline geohydrological and ecological information that will be used to monitor and evaluate the effectiveness of mitigation measures, in the event that construction of a nuclear power station (NPS) is approved at any of the proposed sites.

The additional work covered in this contract broadly includes the following:

- installation of additional monitoring boreholes and piezometers;
- surveying, verifying and processing of surveyed data;
- monthly and continuous groundwater, surface water and ecological/wetland monitoring;
- wetland mapping and sampling;
- update of numerical flow models;
- quality management (site audits, data verification).

Based on the discussions and data presented in this report the following main conclusions are drawn:

## Duynefontein

Two different wetland types were investigated in detail in this study, the first located in the mobile dunes to the north of the proposed NPS, and the second, comprising an extensive mosaic of wetlands and low lying dunes, located in the south western portion of the site, immediately south of the existing Koeberg NPS. Together, the wetlands are considered to represent natural wetlands on the site, in a relatively unimpacted condition. Although other wetlands do occur elsewhere on the site, these have been created as a result of past excavation, and are either not considered of high importance from a conservation perspective, or are likely to be readily replaceable elsewhere.

Data collected to date indicate the following:

- All of the wetlands investigated are formed where the land surface has been eroded to below the groundwater table; hence the groundwater table is exposed to the atmosphere in these places. In the case of the coastal wetlands in the southwestern portion of the site, additional exposure as a result of artificial excavation or disturbance of dunes may have increased the extent of groundwater exposure, compared to natural conditions. The wetlands in the mobile dunes are part of a dynamic system, and are expected to form and disappear with natural dune migration patterns;

- the direct link between wetlands and groundwater is confirmed by the similarity in chemistry and isotopic signature of the groundwater and water in the wetlands;
- this is further confirmed by the similarity in water level behaviour of the wetlands and the groundwater in relation to dry and wet seasons, as well as rainfall events;
- despite their similar hydrological links, the wetlands in the mobile dunes to the north and those in the southwest have very different levels of biodiversity importance, with the latter supporting a more diverse group of aquatic fauna, while biodiversity in the mobile dune wetland is limited by wetland size and extended hydroperiod;
- The results of the numerical modelling indicate that with dewatering of the whole illustrative NPS footprint (approximately 50 ha), which is a highly unlikely scenario, the dewatering zone (0.1 m drawdown) may extend to a maximum of 2,7 km. However, the wetlands that could be so affected have been identified as artificial wetlands, which probably originally resulted from excavation of borrow pits, during construction of the R27;
- The coastal wetlands in the southwestern portion of the site have been conservatively assessed as having a low (rather than no) sensitivity to potential drawdown. Provided that drawdown is short-term (i.e. over one or two years), and provided that its indirect impacts on wetlands are controlled (e.g. increased invasion of drier areas by alien vegetation), these wetlands are likely to be relatively resilient to drawdown, and aquatic biodiversity should recover quickly once water levels are restored. This assessment is based on the fact that the wetlands are naturally prone to periodic desiccation, and indeed support fauna that occur in these habitats only because there is prolonged annual desiccation. Wetland vegetation would be likely to recover from drawdown desiccation over a slightly longer period (up to five years);
- Seawater intrusion could occur under dewatering conditions in a coastal zone of some 600 m width approximately corresponding to the length of the footprint. Given that the coastal wetlands in the southwestern portion of the site lie some 1 400 m south of the northern boundary of the existing Koeberg NPS, seawater intrusion is unlikely to have any effect on these wetlands, although it might impact on artificial, largely permanently saturated to inundated wetlands located closer to the proposed site (e.g. Wetland P6);
- Given the importance of the wetlands on the site, and in particular, those in the southwestern portion of the site, it is recommended that the vendor should consider measures to reduce the radius of drawdown during construction dewatering, depending on the final footprint location and dewatering design/programme. Such measures could include the use of an impermeable cut-off wall, which may in any case form part of the detailed design for dewatering/groundwater control.

## Bantamsklip

Freshwater ecosystems that are located on or near to this site comprise the hillslope seep and valleybottom wetlands of the ecologically important Groot Hagelkraal River, and the headwater seeps of the Koks River, which drains to the east of the site, and into the Ratels River on the Agulhas Plain.

Data collected to date indicate the following:

- the wetlands are fed by the Hagelkraal River and lose water to the deeper but poorly developed groundwater table of the Bredasdorp Aquifer;
- on the basis of chemical and isotope data, the wetland water and groundwater are similar, thereby supporting the interaction described in bullet point one;
- this is confirmed by the similarity in water level behaviour of the wetland and the groundwater in relation to dry and wet seasons, as well as rainfall events;
- Dewatering of the whole illustrative NPS footprint (approximately 50 ha), which is a highly unlikely scenario, would result in interception of some wetlands (0,1 m drawdown). However, if a smaller part of the footprint is dewatered, say one third (more likely scenario), the wetlands should not be impacted, particulary with groundwater control measures in place, e.g. a cut-off wall;
- seawater intrusion would be expected in the vicinity of the footprint, under dewatering conditions but this would not impact on any wetlands;
- The numerical model indicates that without any drawdown controls such as an impermeable cut-off wall in place, the zone of drawdown of 0,1 m could extend to the wetlands north of the R47, in the event that a third of the NPS footprint is dewatered (most likely scenario).
- Given the importance of the Groot Hagelkraal wetlands on the site, it is recommended that the vendor should consider measures to reduce the radius of drawdown during construction dewatering, depending on the final footprint location and dewatering design/programme. Such measures could include the use of an impermeable cut-off wall, which may in any case form part of the detailed design for dewatering/groundwater control.

## Thyspunt

Monitoring at this site focused on identification and quantification of surface / groundwater links between the mobile Oyster Bay dunefield and the coast, with the specific objective of establishing the extent to which important wetlands such as the Langefonteinvlei and the extensive coastal seeps along the coast are directly or indirectly dependent on groundwater as their main water source. A further objective was to establish the extent to which any of the coastal seeps derive their water from the Langefonteinvlei, and are thus interdependent on the integrity of this system.

The monitoring network established as part of this project thus focused on unpacking the interrelationships between surface and groundwater flows, and wetland function, as related to the Langefonteinvlei and the coastal seeps in particular. The Langefonteinvlei comprises two distinct and topographically separate portions, referred to as the northern and southern portions of the wetland. Despite their spatial separation, these portions are nevertheless hydrologically linked.

The coastal seep wetlands comprise a band of wetland seeps, which occur just upstream of the highwater mark, in numerous places along the rocky shore both within the owner controlled site, and in a broader area along ther coast.

Wetland and borehole monitoring data collected to date indicate the following:

- the Langefonteinvlei is fed by groundwater flowing from the mobile Oyster Bay dune field in the north and the water divide in the northeast, which emerges at the foot of the high dune in the north and northeast of the wetland;

- depending on the height of the water table, groundwater emerges either at the head of the Langefonteinvlei, into one of two narrow eastern wetland extensions or, during drier periods, slightly further west, where the two eastern extensions join the main wetland body;

- a thick layer of fine organic sediment with high water storage capacity provides a high degree of hydrological buffering of the eastern extremities of the wetland, at times when they are not directly fed by groundwater flows;

- from its point of emergence into the wetland, the groundwater flows as braided surface trickles over the humus-rich layer of the wetland, down-slope towards the south and southwest;

- Beneath the southern portion of the Langefonteinvlei, and the western sections of both the southern and the northern portions of the Langefonteinvlei, the groundwater table lies beneath the wetland and is not directly linked to it. In other words, the water in this portion of the wetland is perched above the groundwater table of the Algoa Aquifer;

- the exact zone where the wetlands shift between direct and indirect links to groundwater is likely to vary between wet and dry periods;

- It is postulated that the western extents of both portions of the Langefonteinvlei are determined by a balance between groundwater inflows and outflows such as evapotranspiration and infiltration. In other words, water flows on the surface and in the layer of organic sediment until it is used up by evapotranspiration;

- the humus layer has a high water holding capacity and water stored in this layer preserves the wetlands through drought periods;

- water from the higher-lying northern portion of the wetland flows through the low dune ridge that separates the northern from the southern, smaller portion of the wetland;

- The coastal springs located southwest and west of the Langefonteinvlei, especially the stronger flowing spring THY-WSP4 at White Point, are not fed by water from the Langefonteinvlei. They emerge near the coast, where the bedrock lies close to the surface, and are fed by groundwater draining directly from the Algoa Aquifer and TMG Aquifer to the ocean.

The numerical model used the above interpretation of surface / groundwater interactions to assess the implications of various dewatering scenarios. An important aspect of the model was the conclusion that the southern portion of the Langefonteinvlei, and the western sections of both the southern and the northern portions of the wetland are perched above the groundwater table of the Algoa Aquifer, rather than being linked directly to it. Drawdown caused by abstraction or dewatering extending to below these parts of the wetland is therefore unlikely to have any effect on wetland hydrology or hydroperiod. However, if drawdown extends to the northern and eastern portions of the wetland (highly unlikely with current footprint and groundwater control measures), wetland hydrology would be affected.

In the event that drawdown did result in loss of flows from the eastern and northern portions of the wetland such that wetland hydrology was affected, the impacts could be of high significance, depending on their duration and extent. While it is likely that the thick organic layer that underlies the entire wetland would provide a measure of short-term buffering against loss of water to drawdown, such organic layers are sensitive to desiccation and, once drying commences, it is often irreversible, resulting in changes to the hydric properties of the organic sediments. If such changes took place in the Langefonteinvlei, drawdown impacts would result in an irreversible loss of the *Cladium mariscus* wetland habitat, and moreover, be associated with a high potential for long-term subsurface fires in dessicated organic sediments. Such impacts could also give rise to head-cut erosion of the wetland, by trickle flows of groundwater across the wetland surface.

Taking the above into account, the results of the numerical modelling indicate that:

- The zone of dewatering (0,1 m drawdown) could extend to a maximum of 1,8 km from the footprint boundary when dewatering the entire (approximately 27 ha) footprint. The dewatering would intersect flows in the mobile dune, affecting both wetlands in the Oyster Bay dunefield and the Langefonteinvlei itself. The coastal seeps/springs would not be affected by drawdown, although they could be affected if the direct groundwater pathways presently feeding these seeps are interrupted or diverted by dewatering mechanisms. This effect could be mitigated by re-injection of water at selected boreholes just upstream of these seeps;

- Inclusion of a 95 percent impermeable barrier on the northern and eastern boundaries of the footprint by way of mitigation would prevent any influence on the hydrology of the Langefonteinvlei, either on the eastern zone that is fed by the water table or on the western and southern portions of the wetland, which are perched above the water table. Such a cut-off wall may in any case form part of the detailed design for dewatering/groundwater control.

- the use of an impermeable barrier also significantly reduces the extent of likely interference with flows into the coastal seeps to the west of the footprint; inclusion of a barrier on the western side of the footprint should contain the extent of drawdown still further, and thus reduce the extent of coastal seeps that are likely to be impacted.

- Seawater intrusion as a result of drawdown could affect a 280 m width area along the coastline, which could impact on some of the coastal seeps. The affected seeps would be least resilient against increased salinities, as they would also be most likely to be impacted by loss of groundwater flows as a result of upstream diversion through dewatering;

- containment of the seaward edge of the NPS footprint with an impermeable cut-off wall would reduce the extent of seawater intrusion during dewatering;

- In the event that effective impermeable barriers are installed on all sides of the NPS excavation area then there would be unlikely to be any impacts on the hydrology of the Langefonteinvlei or the wetlands of the Oyster Bay dunefield. However, some degradation, albeit of a limited extent, of coastal seep wetlands is likely, even with the implementation of mitigation measures.

With regard to the “northern access route”, the exceptionally low levels of existing impact to the wetlands and dunes within the mobile dunefield mean that any, even relatively trivial, impacts could result in a significant change in the ecological integrity of the system, and a shift in present ecological status from reference condition to a more impacted level. The impacts which would be associated with the construction and ongoing use of a road across the central, least-impacted portion of the mobile dunes are not trivial, and the implementation of the proposed northern road would be considered to have highly significant negative biodiversity consequences. For this reason, the botanical and wetland ecosystem EIA assessments both strongly recommended that the northern access road should not be considered further.

Based on the above conclusions the following is recommended:

## Recommended design criteria to be incorporated into NPS mitigation design

Guidelines have been drawn-up for each site, on which detailed mitigation design for activities potentially affecting surface / groundwater interactions, and the proposed draw-down phase of construction in particular, can be based. In the event that development authorisation is provided at a particular site, the guidelines, which include, as far as possible, identification of functional thresholds, can be used in impact monitoring and as a guide to intervention thresholds. The guidelines centre around key environmental stressors (namely hydroperiod and water quality), which have been identified as those factors most liable to elicit change in the state of important wetland ecosystems.

All thresholds and ranges have, however, been compiled at a coarse level, on the basis of a single year of surface / groundwater data collection, during a relatively dry year at all three sites. Ongoing monitoring under different climatic and other conditions will be necessary to fine-tune the threshold values provided here, which should be seen as dynamic criteria, subject to ongoing revision that reflects the best available information at any given time. These thresholds should be incorporated into the Environmental Management Programmes for each of the three proposed NPS sites, and included as essential conditions that must be specifically met by mitigation design, in the event that authorisation is obtained for a NPS development at any of the proposed sites.

***Table T-E.1*** provides a summary of key criteria to be utilised in dewatering mitigation design for each of the sites.

**Table T-E.1**
**Criteria to be met in dewatering mitigation design at the proposed NPS sites**

| **Key affected wetland ecosystems** | **Management objectives for wetland** | **Mitigation design criteria** |
|---|---|---|
| | | **DUYNEFONTEIN** |
| **Environmental stressor: Hydroperiod** | | |
| Duneslack wetlands in the south west portion of the site | No change in wetland hydroperiod should take place– that is, no change in length of inundation, timing of inundation periods or depth of inundation, compared to the present situation, and excluding natural climatic variation | **Piezometers:**<br>There should be no change in the seasonal regime of depth to water table as measured by piezometer WP2 and WP3l (>0 to <0,5 mbgl) Soil moisture at WP2 to be below 20 percent moisture for at least 5 months of the year (late summer to autumn), excluding small mapped *Typha capensis* portion.<br>**Plant zonation:**<br>There should be no shift in wetland community dominance or structure<br>**Present ecological state (PES):**<br>There should be no deterioration in PES. |
| Duneslack wetlands in mobile dunes to north of site (Sw7) | | **Boreholes and piezometers:**<br>There should be no change in the seasonal regime of depth to water table as measured by piezometer WP1 and boreholes D-WBMR1, MR2 and MR3.<br>**Present ecological state (PES):**<br>There should be no deterioration in PES. |
| **Environmental stressor: Water quality** | | |
| Duneslack wetlands in the south west portion of the site | No change in the range or seasonality of wetland EC regime | EC should not exceed the pre-impact EC range, with higher salinities occurring in wetlands closer to the coast |
| | | **BANTAMSKLIP** |
| **Environmental stressor : Hydroperiod** | | |
| Groot | No change in wetland | **Piezometers:** |

| Key affected wetland ecosystems | Management objectives for wetland | Mitigation design criteria |
|---|---|---|
| | | |
| **THYSPUNT** | | |
| **Environmental stressor : Hydroperiod** | | |
| Duneslack wetlands on the Oysterbay dunefield | No change in wetland hydroperiod should take place– that is, no change in length of inundation, timing of inundation periods or depth of inundation, compared to the present situation, and excluding natural cycles of dryness or external influences | No change in depth to water table as a result of dewatering activities; borehole depth to water table should not vary in dunefield boreholes to any greater level than that recorded at borehole THY-WBMR5, which is located furthest from the point of drawdown; |
| The Langefontein-vlei | No change in hydroperiod, outside that associated with natural dry/ wet cycles; these should not be extended or exacerbated beyond natural levels. This means that the radius of drawdown from groundwater dewatering at the proposed NPS site should not extend beyond the western edge of the Langefonteinvlei, and should preferably be curtailed some distance considerably further west. This specification provides a measure of built-in resilience, as the actual surface / groundwater interface is located further east, within the wetland | **Boreholes:**<br>No change in depth to water table level at monitoring boreholes THY-WBMR2, WBMR3, WBMR4 and WBMR6, when compared to borehole THY-WBMR5 and each other, outside of the range of between-site water level variation observed during long-term monitoring of these sites<br>**Piezometers:**<br>Depth to water table as measured by piezometer WP1 should lie within 0.2m of the surface for at least 5 months of each year, and during wetter years, should be at or above this level for longer; the water table should not drop below 0,6 mbgl; depth to water table at WP3 and WP5 should always be less than 0,2 mbgl; the gradient of change in water level between WP3 and WP2, WP5 and WP1, and WP2 and WP1, as established over an extended monitoring period, should not alter as a result of drawdown at the NPS<br>**Soil moisture:**<br>The gradient of change in soil moisture content between eastern and western and northern and southern sites, should not change as a result of drawdown activities<br>**Plant zonation:**<br>The western extents of the northern and southern sections of the Langefonteinvlei, as indicated on the basis of wetland plant establishment, should not shift eastward<br>**Present ecological state (PES):**<br>There should be no deterioration in PES. |
| Coastal seep wetlands | Excluding change associated with natural variation or external activities, there should be no medium to long term change (i.e. over periods > 5 years) in hydroperiod for any wetlands; no change at all in hydroperiod for at least 70 percent by length of the coastal area extending between Thyspunt (the coastal | **Piezometers:**<br>Depth to water table as measured by piezometer WP6 should not change: the depth to water table within all permanently saturated zones should never be less than 0,5 m.<br>Soil moisture probes should show no change over time that is not reflected to an equal measure by moisture probes located further west along the gradient of change.<br>**Plant zonation and community composition:**<br>Fixed plant plots should not show shifts in the mapped edge of plant communities<br>**Present ecological state (PES):**<br>There should be no deterioration in PES for coastal seep wetlands |

| **Key affected wetland ecosystems** | **Management objectives for wetland** | **Mitigation design criteria** |
|---|---|---|
| | point) and White Point | along 70 percent of the coast between Thysbaai and White point; PES status should not drop below a Class B for the remaining coastal seep wetlands, even after impact |
| **Environmental stressor : Water quality – namely salinity, measured as EC** | | |
| Coastal seep wetlands | No change in coastal seep EC | EC should not exceed the pre-impact EC range – maximum levels of 400 mS/m should be anticipated, but mitigation design should aim to ensure that Coastal Seep EC lies in the vicinity of 88 mS/m for most of the year |

## **Ongoing wetland / groundwater monitoring**

- Groundwater and freshwater ecology monitoring at all three sites should be continued and extended to obtain data on medium-term (about seven year) climatic cycles. This is being covered under the proposed extension of monitoring by Eskom's Nuclear Sites Department at all three sites to cover SSR, EIA and pre-construction monitoring requirements;

- Carry out more detailed geohydrological drilling and test pumping on the final NPS footprint area at the site chosen for Nuclear-1. From this information detailed designs can be derived for dewatering and groundwater control measures, including the installation of cut-off walls and further monitoring boreholes (this will be the responsibility of the NPS vendor);

- update the appropriate numerical flow model with the new information to assist in the dewatering and groundwater control measures design (this will be the responsibility of the NPS vendor);

- Where natural events (e.g. fires, drought) as well as human activities (e.g. alien vegetation clearing) take place in monitored areas, these should be carefully documented, and used to fine-tune the numerical model with regard to the likely impacts of activities that are independent of the development of an NPS. This is important from the perspective of construction and operational phase monitoring in the event that the NPS is approved at these sites. Without a documented understanding of the indirect hydrological and geohydrological impacts of activites that are not related to the NPS development, it will be difficult in the future to argue that detected changes in surface or groundwater after implementation are not the result of the NPS development. This is of importance in that construction/operation of an NPS is not necessarily the only event that might impact on groundwater levels and wetlands;

- Monitoring of soil moisture at different depths in the wetland profile should be included in the long-term monitoring programme – this component was not previously included in the monitoring programme because the full extent to which the organic soils in the Langefonteinvlei play a role in buffering the system against short-term drought was only highlighted by the results of the past year's detailed monitoring data. It was previously assumed that piezometer data interpreted in conjunction with borehole data would be adequate to allow detailed monitoring of changes in wetland hydrology;

- Data generated during subsequent phases of the pre-construction groundwater and wetland monitoring programme should be used to fine-tune the mitigation criteria recommended by this study. These criteria are based on our present levels of understanding of thresholds in the key drivers of wetland function and condition (water quality hydrology, hydroperiod, soil moisture), beyond which ecological degradation can be expected. Such understanding is likely to improve with a longer dataset that extends over a range of natural conditions at each of the sites. The mitigation criteria recommended in this report should, however, be incorporated into the environmental management programmes for the construction and operational phases of a NPS at any of the sites;

- the findings of this project should be incorporated into the findings of the EIA phase of the Nuclear-1 project, and used, in conjunction with management, mitigation and setback requirements, to fine-tune the least-impacting location of a NPS at each site, from both an environmental and a technical perspective.

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