Project: George Rex Wetland Reserve, Knysna

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EXECUTIVE SUMMARY

A low confidence desktop determination of the George Rex wetland area was undertaken and signed off by the Department of Water Affairs in September 2008, in response to a development application. The recommendation was that only 29% of the wetland area could be developed - this 29% includes the buffer areas around the wetland - and the rest of the site (71%) should be conserved. A Water Use License Application submitted to DWA by Jazz Spirit 130 (Pty) Ltd. to develop 62% of the site and conserve 38%, was therefore declined based on this and other factors.

In 2010 a meeting was held between the applicant and DWS and a 50:50 development conservation ratio considered. It was stated that should the developer want to submit this revised development proposal as part of an Environmental Impact Assessment application, a higher confidence wetland Reserve assessment would need to be conducted at the developer's cost. This document is the outcome of a higher confidence Reserve determination for George Rex wetland.

The earlier Reserve of 2008 was based on preceding specialist detailed studies of the site (Bornman, 2005) and deemed that 71% of the site remained as a functional wetland. Since this time, the Present Ecological State of the site has declined from a C to a C/D condition between 2008 and 2016. The Recommended Ecological Category of a C was set for the site in 2008 and, as many of the more recent impacts are reversible, a C condition remains feasibly attainable and is suggested as the Target Ecological Condition for this site.

Off-site mitigation is not possible within this catchment as the vast majority of wetlands in the catchment and surrounding area have been lost to catchment development or are already protected and in good condition. There are no sites where rehabilitation of wetlands can be undertaken in the immediate catchment to offset losses within the site.

Rehabilitation within the site is however recommended to improve the condition and functionality of the wetlands, as well as to provide a level of protection to the downstream Knysna Estuary against poor effluent discharges from the non-compliant WWTW located adjacent to Erf 12403 (the study site). The hydrological functions of the wetlands – water quality amelioration and stormwater attenuation – are particularly important and rehabilitation interventions should aim to maximize these functions, as well as improve the condition of wetland vegetation generally, and specifically to increase the extent of brackish estuarine wetland patches through improved tidal exchanges. The latter can be achieved by opening the culvert in the southwestern corner of the wetland so as to allow estuarine movement into the wetland.

There appears to be a fluctuation of discharge quality from the WWTW (or Knysna STP) adjacent to Erf 12403. Conditions were poor in the past, e.g. as shown by the 2006 WSP Environmental report, with an improvement due to the upgrade of the WWTW in 2013. However, data from 2013-2016 indicated problematic water quality issues related to final discharge effluent although it was not possible to ascertain whether, or how much of the final effluent from the STP was seeping through the George Rex wetland (i.e. erf 12403 or the study site). Recent events (last quarter of 2016 and early 2017) have indicated issues with the quality of discharge effluents from the WWTW. Under these conditions it is certain that the wetland would be serving a scrubbing function, particularly in terms of nitrogen levels and faecal

coliforms, which would assist in reducing the risk of contaminated water reaching the sensitive Knysna Estuary via the Ashmead Channel.

E.coli counts and nutrient levels (N and orthophosphate-P) outflows to the estuary should not be permitted to exceed guideline levels; meaning that effluent discharge standards should be met. The wetlands should be engineered and rehabilitated to promote diffuse flow through vegetated areas; to remove channelized flows (except for the tidal exchanges as these arise from culverts) and could consider the creation of open water areas within the reedbeds to improve oxidation and water quality enhancement functions of the wetland. Walkways and educational/recreational areas will also further demonstrate the value of improved wetland state.

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Abbreviations

CD: WE	Chief Directorate: Water Ecosystems
CMA	Catchment Management Agency
DEAT	Department of Environmental Affairs
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry (pre-April 2010)
DWS	Department of Water and Sanitation (post May 2014)
EDM	Eden District Municipality
EC	Ecological Category
EFZ	Estuary Functional Zone
EIS	Ecological Importance and Sensitivity
EIA(s)	Environmental Impact Assessment(s)
EWR	Ecological Water Requirement
HGM	Hydrogeomorphic
IECM	Institute for Environmental and Coastal Management
IHI	Index of Habitat Integrity
MSL	metres above sea level
NGL	Natural Groundwater Level
NWA	National Water Act
NWRCS	National Water Resource Classification System
ORDS	Outeniqua Reserve Determination Study
PES	Present Ecological State
PES/EI/ES	Present Ecological State / Ecological Importance / Ecological Sensitivity
RC	Reference Condition
RDM	Resource Directed Measures
REC	Recommended Ecological Category
SC&A	Scherman Colloty & Associates
SQ	Sub-quaternary
STP	Sewage Treatment Plant
TDS	Total Dissolved Solids
TPC	Threshold of Potential Concern
WMA	Water Management Area
WMS	Water Management System
WULA	Water Use License Application
WWTW	Waste Water Treatment Works

Glossary of Terms

Aerobic: Having molecular oxygen (O2) present.

Anaerobic: Not having molecular oxygen (O2) present.

Anthropogenic: Of human creation

Buffers: Strips of land adjacent to water resources that serve as a barrier or zone of diffusion of impact (usually of runoff) between the water resource and an adjacent land use activity. These buffer zones are usually vegetated strips of land that reduce adverse effects of adjacent development on wetland function and condition.

EcoClassification: Process to determine and categorise the ecological state of various biological and physical attributes compared to the reference state. The procedure of EcoClassification describes the health of a water resource and derives and formulates management targets / objectives / specifications for the resource. This provides the context for monitoring the water resource within an adaptive environmental management framework. The classification ranges from A (natural) to F (highly impacted) ecological categories.

EcoRegions: "Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources", and are designed to serve as a spatial framework for the research, assessment, management and monitoring of ecosystems and ecosystem components (US EPA). Several levels or scales of EcoRegions can be delineated (e.g. Level I low resolution/detail; Level III high resolution and detail). In South Africa, EcoRegions form the basis of river health monitoring.

EcoStatus: The overall Present Ecological State (PES) or current state of the resource. It represents the totality of the features and characteristics of a river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services. The EcoStatus value is an integrated ecological state made up of a combination of various PES findings from component Ecostatus assessments (such as for invertebrates, fish, riparian vegetation, geomorphology, hydrology and water quality).

EcoSpecs: Ecological Specifications, or EcoSpecs, are the clear and measurable specification of ecological attributes (e.g. water quality, flow, biological integrity) which serve as the ecological input to Resource Quality Objectives. They are defined during Reserve studies.

Floodplain: Wetland inundated when a generally meandering river overtops its banks during flood events resulting in the wetland soils of the floodplain being saturated for extended periods of time. Meandering usually develops upstream of a local (e.g. resistant dyke) base level, or close to the mouth of the river (upstream of the ultimate base level, the sea). Ox-bows or cut-off meanders - evidence of meandering – are often present on the floodplain.

Groundwater table: The upper limit of the groundwater.

Groundwater: Subsurface water in the zone in which permeable rocks, and often the overlying soil, are saturated under pressure equal to or greater than atmospheric.

HGM unit: A HydroGeomorphic Unit – a single "reach", segment or unit of a particular HGM wetland type.

Hydric soil: Soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (i.e. vegetation adapted to living in anaerobic soils).

Hydrology: The study of water, particularly the factors affecting its movement on land.

Hydrophyte: Any plant that grows in water or on a substratum that is at least periodically deficient in oxygen as a result of soil saturation or flooding; plants typically found in wet habitats.

Infilling: Dumping of soil or solid waste onto the wetland surface. To fill in a wetland (or riparian area) in order to raise the ground level above the flooding or saturated zone; usually for the purposes of construction. Infilling generally has a very high and permanent impact on wetland functioning and is similar to drainage in that the upper soil layers are rendered less wet, usually so much so that the area no longer functions as a wetland.

National Water Resource Classification System: The Water Resource Classification System is a defined set of guidelines and procedures for determining the different classes of water resources (South African National Water Act (Act 36 of 1998) Chapter 3, Part 1, Section 2(a)). The outcome of the Classification Process will be the setting of the class, Reserve and Resource Quality Objectives by the Minister or delegated authority for every significant water resource (river, estuary, wetland and aquifer) under consideration. This class, which will range from Minimally used to Heavily used, essentially describes the desired condition of the resource, and concomitantly, the degree to which it can be utilised.

Offsets: 'Biodiversity offsets are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function and people's use and cultural values associated with biodiversity.' (Business and Biodiversity Offsets Programme, http://www.foresttrends.org/documents/files/doc_3117.pdf, 2009).

Palustrine wetland: All non-tidal wetlands dominated by persistent emergent plants (e.g. reeds) emergent mosses or lichens, or shrubs or trees (see Cowardin et al., 1979).

Peat: A brownish-black organic soil that is formed in acidic, anaerobic wetland conditions. It is composed mainly of partially-decomposed, loosely compacted organic matter with more than 50% carbon. The 50% carbon content is mostly applicable for the sphagnum peat moss peat deposits in the Northern Hemisphere. The South African soil classification uses a > 10% carbon content as a guideline. Inorganic soil particles are blown or washed into peatlands and also form part of the peat.

Permanently wet soil: Soil which is flooded or waterlogged to the soil surface throughout the year, in most years.

Platform: The elevated surface of an infilled area of wetland or riparian zone. Platforms are often constructed using *ex situ* material which is used to increase the ground level height in order to reduce flooding or saturation of the soils. Platforms can then be used for construction of residential or commercial properties, or for cultivation of crops.

Reference State: (Also Reference Condition). The natural or pre-impacted condition of the system. The reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development.

Resource Quality Objectives (RQOs): The RQOs for a water resource are a numerical or descriptive statement of the conditions which should be met in the receiving water resource, in terms of resource quality, in order to ensure that the water resource is protected. They might describe, amongst others, the quantity, pattern and timing of instream flow; water quality; the character and condition of riparian habitat, and the characteristics and condition of the aquatic biota.

Runoff: Total water yield from a catchment including surface and subsurface flow.

Seasonally wet soil: Soil which is flooded or waterlogged to the soil surface for extended periods (>1 month) during the wet season, but is predominantly dry during the dry season.

Temporarily wet soil: The soil close to the soil surface (i.e. within 50 cm) is wet for periods > 2 weeks during the wet season in most years. However, it is seldom flooded or saturated at the surface for longer than a month.

Water regime: When and for how long the soil is flooded or saturated.

Waterlogged: Soil or land saturated with water long enough for anaerobic conditions to develop.

Wetland catchment: The area up-slope of the wetland from which water flows into the wetland and including the wetland itself.

Wetland delineation: The determination and marking of the boundary of a wetland on a map based on soil, vegetation, and/or hydrological indicators (see definition of a wetland). The DWAF (2005) guidelines should be employed to undertake this for field application.

Wetland: Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which under normal circumstances supports or would support vegetation typically adapted to life in saturated soil (National Water Act (NWA), Act No. 36 of 1998).

1. Introduction

Scherman Colloty & Associates cc. (SC&A) was appointed by Jazz Spirit 130 (Pty) Ltd. to undertake a wetland Reserve assessment for the George Rex wetland (Erf 12403) in Knysna. The assessment was requested by the Department of Water and Sanitation (DWS) in response to a development application submitted by Jazz Spririt 130 (Pty) Ltd. A team of specialist experts was assembled to undertake the study.

1.1. Specialist team

Scherman Colloty & Associates cc. is a specialist consulting firm based in Grahamstown in the Eastern Cape. The two partners have more than 35 years combined experience in the environmental management and aquatic assessment fields, with a diverse suite of clients based nationally and internationally.

Dr Patsy Scherman has been actively involved in a number of Reserve Determination and Water Resource Classification projects over the years, having been the project technical team manager or water quality specialist on a number of these projects. The management includes the co-ordination of technical teams, including socio-economics, wetland, groundwater, estuary and river teams. She was team leader of the Outeniqua Reserve Determination Study (ORDS; specifically the Knysna / Swartvlei study area) (2006 – 2010) and the Gouritz Reserve study (2013-2015), and currently heads the Mzimvubu Classification study. She has also developed and managed integrated environmental and water quality monitoring programmes; and conducts water specialist studies for Environmental Impact Assessments (EIAs) and wind and solar power projects. Patsy has provided training and specialist water quality services to the Chief Directorate: Water Ecosystems (CD: WE) of the DWS, for a number of years.

Mark Rountree, of **Fluvius Environmental Consultants,** has 15 years of international specialist consulting experience and an additional 5 years preceding academic research experience of focussed on river morphology, river dynamics and environmental flows studies for rivers, floodplains and wetlands. He was contracted by SC&A to provide specialist wetland Reserve input. Mark's academic training began in South Africa and continued, through an Andrew Mellon research scholarship, at postgraduate level in the United Kingdom. Short courses at Duke (USA) and Monash (Australia) Universities further developed his academic experience, with field training undertaken in Brazil, Peru, Hawaii, Costa Rica, Panama, Australia and the United Kingdom in addition to extensive field experience in South Africa. Mark began consulting independently in 2001, focussing on specialist geomorphological aspects of environmental flow studies in Southern Africa. In 2007 he established Fluvius Environmental Consultants, a specialist river and wetland environmental consultancy based in Cape Town. Mark is a founding member of the South African Wetlands Society and is the current Chairman of the Western Cape Wetlands Forum. Work experience in the wetland arena includes policy, training and development of assessment methods for wetlands for government agencies, and specialist input into EIAs and Water Use authorisations as well as basin-wide wetland assessments. Additionally, from 2009-2012 Mark was the project manager and lead author for the 3 year study on the development of methods and manuals for environmental flow determinations of South African wetlands. His experience of particular relevance to this project is in the Development of Rapid Environmental Flow Methods for Wetlands. This was a 3 year project for the Department of Water Affairs and Forestry (DWAF). Mark was the project manager and lead author of the manual (2009-2012).

Expertise around the Knysna lakes was provided by **Prof Janine Adams** of the Nelson Mandela Metropolitan University and **Lara van Niekerk** of the CSIR. Both have worked extensively on the lake system, and were part of the team undertaking the Outeniqua (Knysna / Swartvlei) Estuary Reserve study completed in 2010.

1.2. Background to the study

Knysna Erf 12403 originated from the development of Hunters Estate Retirement Village in the 1990s. An application for a residential and commercial development (the George Rex development) on an existing wetland alongside the Knysna Estuary (lagoon) was submitted by Jazz Spirit 130 (Pty) Ltd. (the developer) to DWS (then DWA) in 2006. This application was to develop 62% of the site and conserve 38%. The developer approached the DWS regional and Resource Directed Measures (RDM) Reserve office in Pretoria and a low confidence desktop Reserve determination was undertaken for the wetland by Mark Rountree and signed off in September 2008. Current RDM policy recommends that the state of a water resource should be maintained and if possible, improved. The recommendation from this Reserve determination study was that only 29% of the wetland can be developed. This 29% includes the buffer areas around the wetland. The rest of the site (71%) should be conserved. The Water Use License Application (WULA) was therefore declined based on this and other factors.

In 2010 a meeting was held between the applicant and DWS and a 50:50 development conservation ratio considered. It was stated that should the developer want to submit this revised development proposal as part of an Environmental Impact Assessment (EIA) application, a higher confidence wetland Reserve assessment would need to be conducted at the developer's cost (Kloppers; DWA, 2010). The following list of additional tasks would need to be conducted; guided by the 2008 Reserve determination (note that this list was submitted by DWS in 2010 and should not be considered conclusive):

1. Ecological services assessment;
2. Proper conservation areas must be defined and protection clearly described;
3. Buffers around the conservation area are not considered part of the conservation area percentage;
4. Develop a stormwater management plan;
5. Design a wetland rehabilitation plan for the larger catchment area so as to ensure that the functionality lost due to the development of the site is not lost to the town and catchment area; and
6. Mitigation and rehabilitation options should be proposed.

The 2008 Reserve template specified for the George Rex wetland also made the following recommendations for future development options:

- Conserve and rehabilitate the undeveloped area to improve wetland functionality as an off-set area; and
- Develop a wetland monitoring plan, should the WULA be authorized, focussing on ecological responses, changes in functionality and water quality.

As the previous (2008) study was a low confidence Desktop study of the site, and much information and data for the site has subsequently been collected and a number of new specialist studies have been undertaken in the interim, a higher confidence study was recommended for the site. It was at this stage of the process that SC&A joined the team in February 2016 to conduct the higher confidence wetland Reserve assessment for the George Rex wetland, i.e. Erf 12403.

1.3. Scope of study

The tasks required by the DWS in terms of the Wetland Reserve, and the approach followed by the specialist team, are itemized below:

- **Task 1:** Conduct a higher confidence Reserve assessment for the George Rex wetland, resulting in an assessment and possible update of the PES, Ecological Importance and Sensitivity (EIS) and Recommended Ecological Category (REC).
- **Task 2:** Scenario selection and ecological consequences, which will include an evaluation of the likely functions and impacts of the reference recondition, current condition and a number of development options (factoring in the percentage of site developed, canals versus more natural wetlands, etc.) on the Ecological Category of the wetlands of the site under these scenarios, and what possible impacts may be felt in the estuary.
- **Task 3:** Determine the Recommended Ecological Category (REC) in liaison with DWS and the Catchment Management Agency (CMA).
- **Task 4:** Clarify issues such as rehabilitation, buffers and off-sets.
- **Task 5:** Develop a monitoring programme for the wetland, so as to meet Reserve requirements.

The following main points are addressed during the study:

- **Percentage of the site considered wetland:** There have been a number of studies showing different percentages of wetland area of the site. These were assessed and reviewed in order to provide clarification and direction for this study.
- **PES, EIS and importantly, functionality:** The water quality and hydrological functionality particularly were re-assessed.
- Impact of new development scenario(s) on the area and estuary
- Discussion around what % protection is reasonable considering present state and functionality

2. Background to Wetland Reserve studies

As stated in Section 1.2, it was a requirement in 2010 that a higher confidence wetland Reserve assessment would need to be conducted at the developer's cost. This is the focus of this current report. The following section of this report provides some background to the legal definition of wetlands and the purpose and scope of the Reserve and other Resource Directed Measures relating to the protection of water resources.

2.1. What is a wetland

The South African National Water Act (NWA, Act 36 of 1998) defines a wetland as '***land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil***."

Wetlands must have at least one of the following attributes (DWAF, 2005):

- Soil that displays characteristics of prolonged saturation
- Water loving plants (even if occasional)
- High water table that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil.

Although the primary driving force behind all wetlands is water, due to its dynamic nature varying daily, seasonally and annually – it is not always a very useful parameter for accurately identifying the outer boundary of a wetland. Long-term monitoring is needed to accurately characterize the hydrology of a wetland and the extent of its saturation zones. As a result of this dynamic hydrology within and between wetlands, it is difficult to define the minimum frequency and duration of saturation that creates a wetland.

Instead, an approach is commonly followed which identifies the indirect indicators of prolonged saturation by water: wetland plants (hydrophytes) and wetland (hydromorphic) soils. The presence of these distinctive indicators in an area implies that the frequency and duration of saturation is sufficient to classify the area as a wetland. Typically, land that is wet (saturated) within 50cm of the soil surface for more than two weeks of the year, can develop wetland conditions due to the prolonged soil saturation and biochemical and biotic changes that result.

Generally, there are three different zones in a wetland, which are distinguished according to the changing frequency of saturation. These three zones may not be present in all wetlands. The central part of the wetland, which is nearly always saturated, is referred to as the permanent zone of wetness. This is surrounded by the seasonal zone, which is saturated for a significant duration of the rainy season. The temporary zone in turn surrounds the seasonal zone, and is saturated for only a short period of the year but this duration is sufficient, under normal circumstances, for the formation of hydromorphic soils and the establishment of wetland vegetation (DWAF, 2005).

The identification of the edge of a wetland is a process known as wetland delineation. The Department of Water and Sanitation (DWS) has published guidelines for undertaking delineations (DWAF, 2005; DWAF, 2008a). The object of the delineation procedure is to identify the outer edge of the temporary zone. This outer edge marks the boundary between the wetland and adjacent terrestrial areas.

The focus on the upper 50cm of the natural soil level is because this is the general rooting zone of plants. Only wetland plants can endure saturated soil conditions for prolonged periods.

Specific soil forms are usually associated with wetland environments. The permanent zone will always have either Champagne, Katspruit, Willowbrook or Rensburg soil forms present, as defined by the Soil Classification Working Group (1991). Seasonal and temporary zones are associated with a much wider variety of soil forms (DWAF, 2005; DWAF, 2008a). Gleying and soil mottling typically occurs in most wetland soils, but if a soil profile qualifies as Champagne, Rensburg, Willowbrook or Katspruit form, it is not necessary that grey colours be present for the profile or horizon to qualify as hydromorphic as the topsoil horizon may be thicker than 50cm. Topsoils are usually dark in the permanent wetness zone due to the accumulation of organic matter (DWAF, 2005; DWAF, 2008a).

Wetlands are regarded as water resources under the NWA and it is not permissible to develop within wetlands without a water use license. A variety of protection measures may be enforced to safeguard the country's water resources and the ecosystem services and benefits that they provide for society.

2.2. Resource Directed Measured for the protection of water resources

The purpose of the NWA (No. 36 of 1998) is to achieve equity, sustainability and efficiency in the use and protection of South Africa's water resources: - to fulfil the vision of "some, for all, forever".

With the passing of the NWA the approach to water resource management in South Africa underwent a fundamental shift:

- From a focus on increasing supply to a focus on managing demand;
- From reactive to proactive (goal-seeking) resource protection; and
- From viewing the aquatic ecosystem as a competing water user to the recognition that the ecosystem is 'the resource base'. A 'water resource' is now understood to refer to the entire aquatic ecosystem and not merely the water it provides. This has also redefined the concept of 'water resource use', to include not only water but the full range of goods and services that aquatic ecosystems provide.

Under the NWA, all water resources are an indivisible natural asset under the custodianship of national government. Thus there is no longer riparian ownership of water resources. The only right to priority of use is that of the 'Reserve', consisting of a 'Basic Human Needs Reserve' and an 'Ecological Reserve'. The Basic Human Needs Reserve ensures the water that is required by domestic users for drinking, food preparation and personal hygiene. The Ecological Reserve refers to "*the quantity and quality of water required … to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource*" (NWA, 1998).

Within the Department's Water Resource Management cycle **(Figure 2.1)**, a variety of water resource protection mechanisms exist in the form of Resource Directed Measures. Protection measures do not mean that the needs of conservation are placed above those of people - the intention of the Ecological Reserve is to "maintain the ecological functions on which humans depend".

The DWS's Water Resource Management cycle has been designed as an adaptive resource management approach that is strategic (goal-seeking). The management of water resources is driven by the "Vision for the resource" **(Figure 2.1)**, as determined in the DWS National Water Resource Classification System (NWRCS) (DWAF, 2006). Future management of the water resource is set for the resource and its component units, and range from A to D Ecological Categories (defining the Reserve), in order of decreasing levels of protection for, or increasing levels of risk to, aquatic species and habitats. These categories are couched within Water Resource Classes I-III, ranging from minimally to heavily utilized, which defines the future management of the resource so as to balance protection and use.

The Ecological Category and ultimately Water Resource Class of a resource will encompass the Reserve, Classification and associated Resource Quality Objectives that are set to achieve it. Resource Directed Measures are therefore collectively comprised of:

- The National Water Resource Classification System;
- The Reserve; and
- Resource Quality Objectives (RQOs).

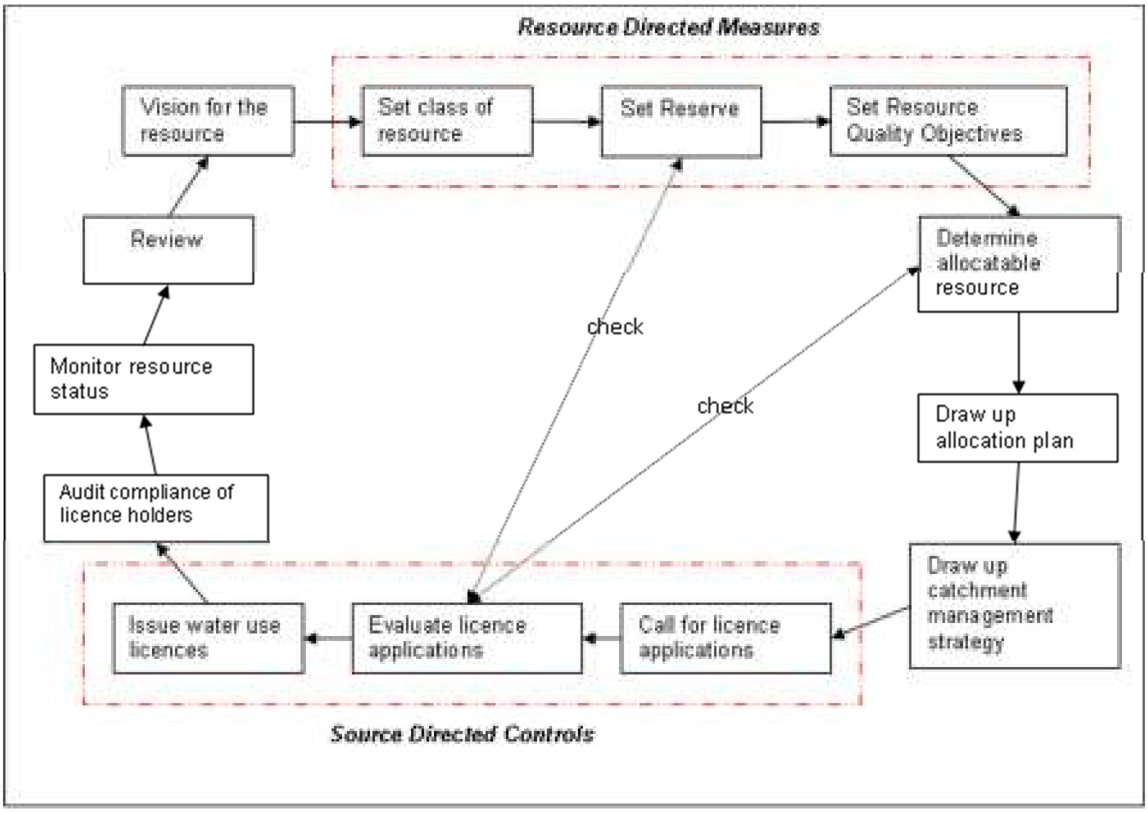

Figure 2.1: The DWS's Water Resource Management cycle.

2.3. Resource Directed Measured for wetland flats

The George Rex Wetland is located on a very shallow gradient slope that was once linked directly with the Knysna Estuary. This type of flat wetland, dependent on a local or regional groundwater table, is not a typical valley bottom, surface water driven wetland type.

For the evaluation of non-consumptive water uses (such as a proposed development) on wetlands of this type, the DWA (2013) recommended that no Ecological (Environmental Flow) Reserve studies be undertaken on the wetland flats in isolation of the underlying groundwater aquifer. Wetlands such as these are maintained by regional groundwater aquifers that permanently or seasonally intersect low points in the landscape, causing the development of hydric soils and wetland conditions to form.

These wetland types have complex hydrology and the connections between the surface wetlands and groundwater aquifer cannot be assessed at a rapid level. Wetland flats can however be used as indicators of the condition of the groundwater resource upon which they are dependent.

For non-consumptive water uses (i.e. Section 21 c and i Water Uses), either generic EcoSpecs (ecological specifications) or more detailed assessments of the Ecostatus and generation of specific EcoSpecs can be undertaken (DWA, 2013). In these cases***, "a rapid, low confidence EcoStatus assessment of the wetland should be undertaken by a wetland specialist"***. The determination of the REC should follow the approach described in Rountree et al. (2013). ***Specific EcoSpecs or Resource Quality Objectives to describe and enable monitoring of the REC*** must be provided by the wetland specialist.

This is the approach that has been followed in this study.

3. The George Rex wetland

George Rex wetland (Erf 12403) is located adjacent to the Knysna Estuary in the K50B quaternary catchment **(Figure 3.1)**. The entire property is elevated 2 to 3m above mean sea level and was historically within the associated floodplain of the estuary. The site is 19.406 Ha in extent (Vreken, email communication, 22 April 2016) and is characterised by fairly flat terrain (<1:100) which drains very slowly in a south and westerly direction into the Knysna estuary. The soil has a medium to low permeability and persistent rainfall will tend to pond on the surface (Outeniqua Geotechnical Services, 2015).

Figure 3.1: The position of Erf 12403 or the George Rex wetland (study site).

There has been a long history of impacts associated with the dumping of sawdust, invasion of alien trees and obstruction of the natural flow of fresh and estuarine water onto the property, as well as elevated nutrient inflows from the adjacent catchment and nearby Waste Water Treatment Works (WWTW). The wetland has thus been highly modified and is impacted as a result of the above-mentioned activities (Grobler and Belcher, 2009; 2010).

4. Extent of the George Rex wetland

There have been several studies attempting to define and confirm the extent of wetlands within the George Rex property. Studies by Bornman (2006) indicated that, based on the analysis of historical aerial photography prior to the main impacts on the site, the entire site was composed of a combination of estuarine, brackish and freshwater wetlands (**Figure 4.1**).

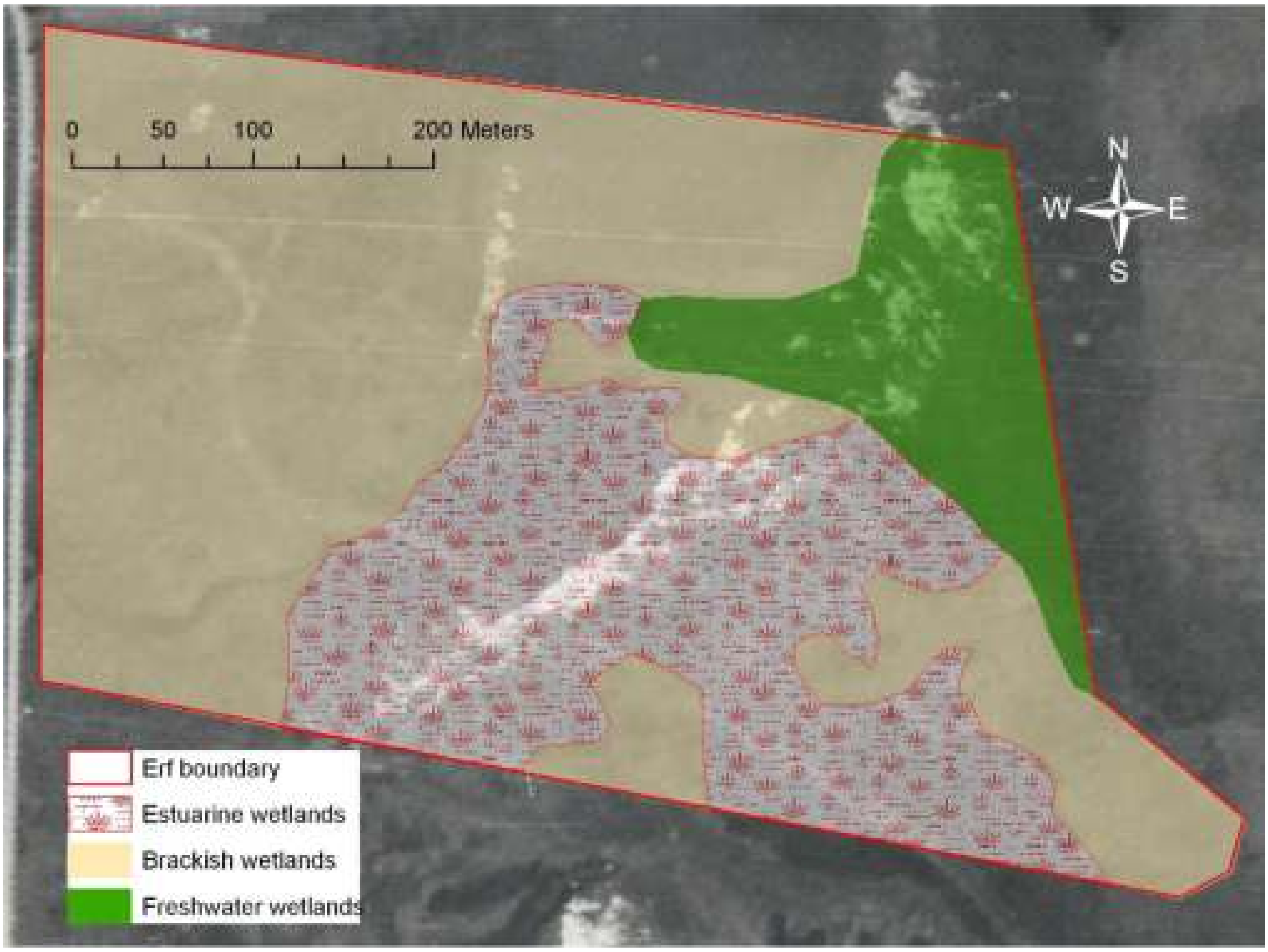

Figure 4.1: Historic vegetation distribution of Erf 12403 superimposed over a 1936 aerial photograph (Bornman, 2006).

By 2003, the proportions of wetland types had changed such that only 0.7 ha of estuarine wetlands remained, with the previously small freshwater wetland area having increased to 13.5 ha (7.3 ha of which were regarded as intact; the rest comprising former estuarine wetlands that become fresh due to salinity decreases). The remainder of the site (5.8 ha) was comprised predominantly of highly degraded areas, with much of the degradation attributable to historic dumping of wood wastes as well as more recent dumping of infill material, and impacts from the adjacent catchment and nearby WWTW. Despite the degraded portions of the site however, the vast majority of the site was still regarded as wetland **(Figure 4.2)**.

Figure 4.2: Distribution of freshwater wetlands in the area. The boundary of Erf 12403 is shown in red (Bornman, 2006). Most of the erf is composed of freshwater wetlands.

These results were corroborated by earlier groundwater studies (Bornman and Adams, 2004) that recorded groundwater at depths between 0.15 and 1.1m below the surface - despite this study being undertaken during drought conditions when the groundwater would be lower than normal.

A further groundwater study (WSP Environmental, 2006) recorded the static groundwater levels **(Table 4.1)** at several locations across the site. Two weeks prior to the sampling taking place, a 50 year rain event occurred. Sampling was postponed for the maximum time possible within the constraints of the project to allow water levels to return to normal levels, but even then the water level recorders showed the water table at or slightly below the surface at all points **(Table 4.1)** except point A2, which was at 51cm below the soil surface. Point A2 is however located within the zone of fill (sawdust fill) at the site **(Figure 4.3)** and thus the water table is much closer to, or potentially above, the natural soil surface. White and yellow points on **Figure 4.3** indicate the position of piezometers and monitoring points on site.

Indications of prolonged wetness in soils within the top 50cm is taken as a sign of wetland conditions in South Africa. During heavy rainfall events, widespread flooding has been observed over a large part of the property. This is because the property is in a naturally low lying area with low flow conditions and surface water stagnation.

Table 4.1: Ground heights and water levels (above mean sea level (amsl) /below mean ground level respectively as indicated (bmgl)). Source: WSP Environmental, 2006.

Piezometer	Ground Height (a.m.s.l)	Watel level (b.m.g.l)	Water level (a.m.s.l)
P1	1.92	0.00	1.92
P2	1.84	0.00	1.84
P3	2.10	0.00	2.10
P4	2.34	0.03	2.31
P5	2.46	0.00	2.46
P6	2.29	0.00	2.29
P7	2.09	0.39	1.70
P8	2.44	0.20	2.24
P9	2.09	0.00	2.09
P10	2.44	0.04	2.40
P11	1.88	0.00	1.88
P12	1.81	0.00	1.81
P13	1.79	0.14	1.65
P14	2.44	0.00	2.44
A2	2.12	0.51	1.61
B1	2.00	0.20	1.80
B2	1.85	0.00	1.85

Figure 4.3: Location of water level sampling points and piezometers (WSP Environmental, 2006).

A more recent Geotechnical study (Outeniqua Geotechnical Services, 2015) indicated that the permanent (fluctuating) water table was only encountered at a depth of 1.4m - 2.0m below natural ground level (NGL). The water table level measurements in test pits indicated slight variations across the site with an average depth of 1.6m below ground surface. However, mottling, a sign of prolonged seasonal soil saturation, typically occurs at much shallower depths than this (ranging from 0.25m to 1.6m below ground level), suggesting that the water table encountered during that study is not indicative of the seasonal water table depth.

In 2014, an additional wetland delineation study was undertaken by EcoRoute Consulting (2014). The findings of that study suggested that, of the 22.49ha site, just 3.35 ha was regarded as wetland, and that this was comprised of the following:

- Permanent wetland - 2.32 ha
- Seasonal Wetland - 0.56 ha
- Water input - 0.006 ha
- Stormwater Channel - 0.46 ha (1.5m wide and 1m deep).

However, in a review of those findings undertaken as part of this study, that delineation was deemed incorrect because, although the practitioner attempted to apply the DWAF (2005) soil and vegetation indicators to delineate the wetland zone, the following critical aspects of the site conditions were not taken in to account:

- Most critically, the extent of the obligate wetland plant Phragmites australis was used as a key indicator of the extent of the wetland, but the practitioner disregarded the effect of mowing which has severely reduced the extent of reeds at the site. The comparison of the 2008 and 2016 site photographs **(Figure 4.4)** demonstrates the tremendous reduction in the extent of reeds that has been effected by regular mowing of the site;
- The practitioner used vegetation as a key indicator of wetland extent, but smaller wetland obligate species at the site were not considered, nor was the fact that most of the vegetation at the site has been altered by former land-use activities;
- A groundwater report (WSP Environmental, 2006) had confirmed that the water table is at least temporarily within 50cm of the soil surface across almost the entire site, and anecdotal evidence from the landowner confirms the occasional flooded/inundated condition of the site;
- They did not consider the historical aerial photographic record, nor previous studies (Bornman and Adams, 2004; Bornman, 2005; 2006) that shows the widespread extent of wetlands prior to surface disturbance of the soils and vegetation. The underlying hydrological drivers (the basis of the wet conditions) are still present at the site, as proven by the high water table across the site recorded in the groundwater studies (WSP Environmental, 2006); and
- The upper soil horizons have been disturbed by dumping, infilling and former agricultural activities and it would be difficult or misleading to base results on these disturbed or artificial upper horizons of the soil. The high organic content does however point to moist local soil conditions.

Given that the primary hydrological driver (groundwater flow from the surrounding catchment combined with a shallow water table due to the proximity to sea level) remains intact, and there is increasing surface flows arising from the upstream catchment (due to increasing catchment development), there seems to be no evidence to support a dramatic decline in the extent of wetlands (areas with the water table at or near the surface, or that are inundated, for at least part of the year). It is the opinion of the authors that the results of the EcoRoute 2014 delineation report are misleading due to inaccurate estimation and reporting of the extent of wetlands, as defined by the National Water Act, at the site.

Figure 4.4: Panoramic view of the site in June 2008 (top), prior to the clearing and mowing of the vegetation at the site, and (bottom) April 2016 after mowing of the site was instituted at the request of the municipality (due to perceived fire risk).

The authors therefore still endorse the findings of Bornman (2006) who recognised that, whilst historically almost the entire site would have been covered by wetland vegetation, under the present day conditions some of these areas have been lost as functional wetlands due to infilling at the site. Based on the findings of Bornman (2006), in 2008 the DWS accepted that 71% of the site was regarded as wetland and the remaining 29% of the site could be regarded as "non-wetland" due to the degraded nature of some portions of the site. Under present conditions, because the hydrological drivers are still operating, if the mowing of the vegetation was stopped, alien vegetation removed and the draining of flows around and across the site reduced through rehabilitation of the excavated canal and drain, then wetland vegetation is likely to re-establish across the majority of the site, as was documented in 2003 **(Figure 4.5)** and observed by this author in 2008 **(Figure 4.4)**.

Given that the site has been determined to be exactly 19.406 ha in extent (Vreken, email communication, 22 April 2016), and the approved extent of functional wetland in 2008 was determined as 71%, then the total area of wetland for the site would equal 13.8 ha (i.e. 71% of 19.4 ha).

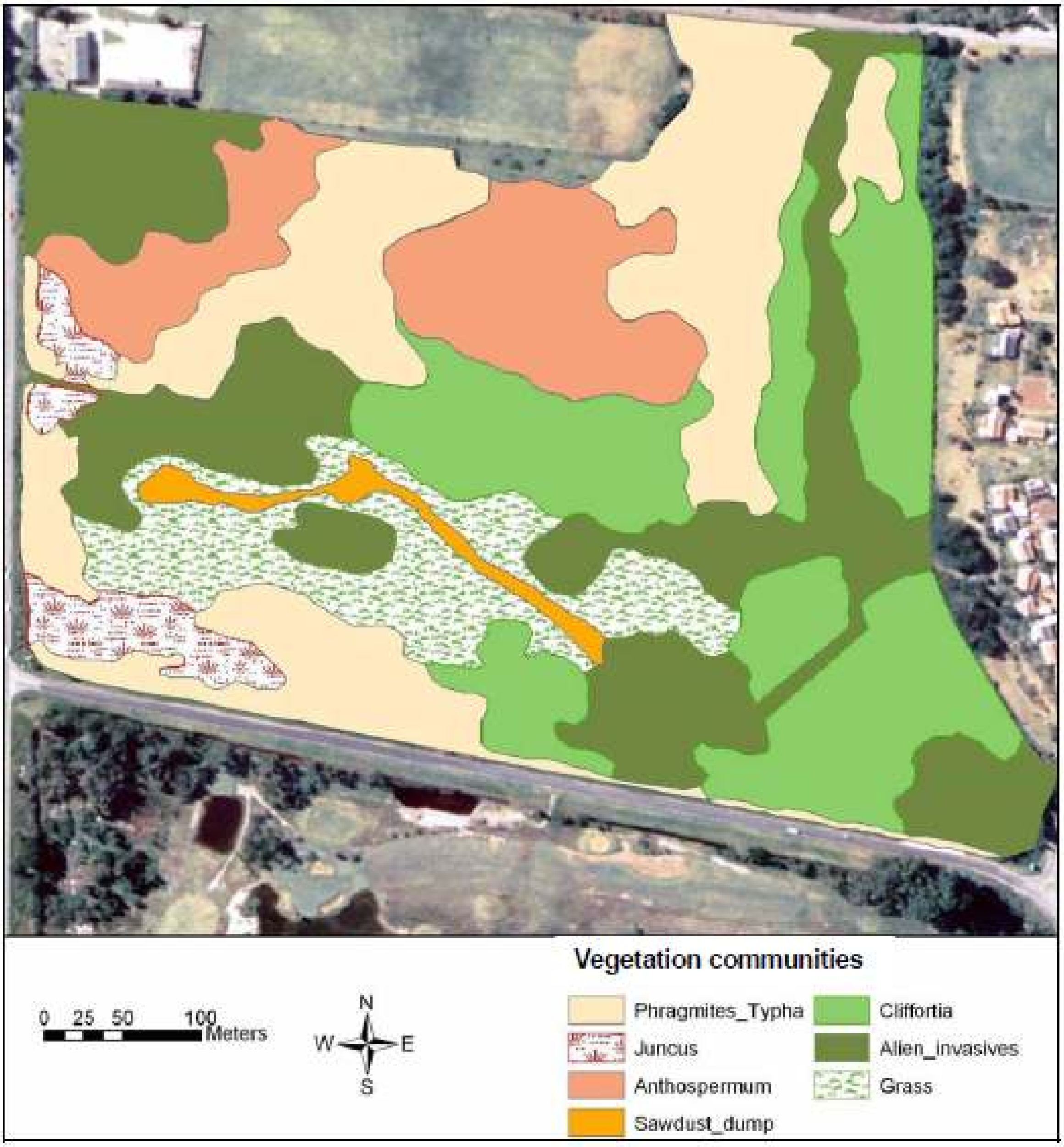

Figure 4.5: Detailed distribution of wetland vegetation and other communities in 2003 at the site. The extensive grass is associated with the sawdust dumping area (Bornman, 2006).

5. EcoStatus of the George Rex wetland

EcoStatus assessment of a water resource involved the determination of several characteristics of the water resource:

1) The current ecological condition or Present Ecological State (PES), which is the condition of the site relative to the natural historic (the so called Reference Condition) of the site;
2) The Importance of the site, which in the case of wetlands refers to the functional, ecological and local socio-economic importance and sensitivity of the wetlands; and
3) Based on the importance and current condition, what the Recommended Ecological Condition (or desired management condition) of the wetland should be.

5.1. Reference Conditions

Under natural (or reference) conditions (before anthropogenic impact), the entire site was composed of wetlands **(Figure 4.1)**, comprising a combination of estuarine, brackish and freshwater wetland habitats (Bornman, 2006) and this historic condition is described in **Section 4** of this report.

Under Reference Conditions (RC), freshwater drained from the higher lying areas to a system of freshwater wetlands at the base of the Knysna Estuary floodplain. These wetlands formed a continuous corridor and drained water to the south, where it eventually entered the Knysna Estuary (Bornman, 2005). Estuarine water entered the property along the southern and south-western boundaries prior to the construction of George Rex Drive, resulting in the mosaic of freshwater, brackish and estuarine wetland vegetation across the site.

5.2. Present Ecological State

The present day freshwater wetlands along the eastern boundary of the property are a remnant of the natural freshwater wetland corridor that existed. Under present day conditions, this proportion of wetland types has changed. The estuarine inflows have declined (reduced by roads and culverts) and brackish/estuarine wetland vegetation is now restricted to the south-western corner of the property **(Figure 5.1)**. In contrast, the extent of freshwater wetlands has expanded due to the increased freshwater inflows to the site as a result of increased impervious surfaces on the roads and adjacent upslope developments. This increased volume of stormwater completely floods the property at times and prompted the authorities to construct an artificial canal that followed the eastern and southern boundaries of the site (Bornman, 2005). This has affected surface water distribution across the site, but no significant changes in the direction of groundwater flow are expected from these small surface canals and berms.

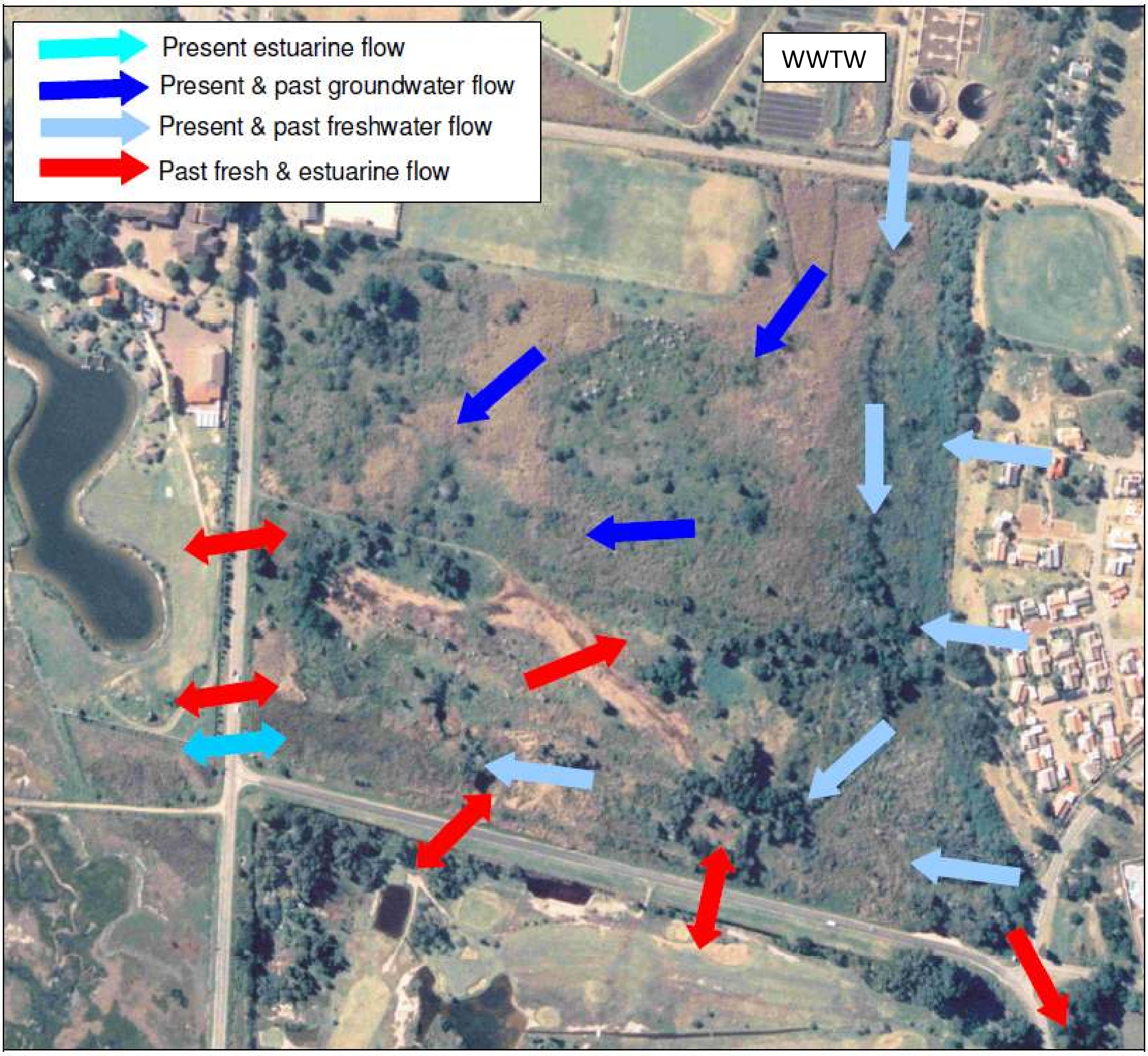

Figure 5.1: Past and present drainage patterns on the study site, Erf 12403 (Bornman, 2005).

The PES of the site was first assessed in 2008 (DWAF, 2008b). At the time, the PES of the wetland was estimated using the vegetation alteration module of the DWS's Wetland Index of Habitat Integrity (IHI) (DWAF, 2007) **(Appendix 1)**. At the time this was the only habitat integrity tool available for the assessment of wetlands. A single module (vegetation condition) was used because the hydrology, geomorphology and water quality parameritization was fixed for floodplain-type wetlands only and the weightings of these assessed parameters were not considered appropriate for the site. The resultant PES from that assessment was determined as a C category (moderately modified), with an overall condition score of 74.5%. A C Ecological Category means that a "*loss and change of natural habitat and biota (has) occurred, but the basic ecosystem functions are still predominantly unchanged*". The main impacts at the site at this time were identified as:

- The dumping of sawdust and soil on the wetland surface;
- Cutting off of saltwater from the estuary (due to the small culvert beneath George Rex Drive) and increased freshwater flows from the upstream catchment (which have caused a change from estuarine/brackish to freshwater wetland vegetation across large parts of the site);

- Increased nutrients arising from seepage from the adjacent sewage works;
- Alien trees which have shaded out the wetland vegetation in places; and
- Small drains which have been constructed to drain the wetland. Although the site was affected by these impacts, the persistent areas of Phragmites reedbeds and patches of estuarine wetland vegetation represented natural vegetation for the site; albeit at different proportions from the historic condition.

In 2016 an updated site assessment and PES estimate was undertaken for the site (this study) **(Appendix 1)**. The condition of the site has deteriorated since 2008 as a result of the following additional impacts:

- The "temporary" soil pile[1] had remained in place and is now densely colonised by large woody invasive alien trees;
- The constructed channel excavated along the side of the site carries surface and shallow subsurface flows arising near the upslope WWTW downstream through the site to the lower Phragmites reedbeds, preventing these flows from spreading laterally across the site;
- The perceived impact of the discharges from the WWTW, although these are difficult to quantify;
- The extent of estuarine vegetation has been reduced from increasingly blocked/overgrown culverts linking the estuary to the site; and
- The most dramatic impact of the site is that the extent of wetland vegetation; specifically the extent of Phragmites reedbeds; has been reduced due to regular mowing of the site **(Figure 4.4, Figure 5.2)**. This vegetation control was undertaken in response to the local municipality's request to control vegetation growth for fire risk and local safety reasons.

The current (2016) condition of the vegetation was assessed using the same tool as the 2008 study. The current PES was estimated to have reduced by half an Ecological Category; from a C (in 2008) down to a ***C/D ecological condition (58.7%) in 2016*** due to the deterioration of the vegetation at the site in response to the impacts listed above[2]. Much of this recent vegetation degradation, attributed to mowing/vegetation clearing of the site, could however be reversed.

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[1] The Knysna Municipality issued a permit (permit no. 12403/P1) to the developers of the property on 19 August 2005 in terms of the Outeniqua Sensitive Coastal Area Extension Regulations, authorising them to stockpile soil at the site.

[2] This score contrasts strongly with the "E" Ecological Condition estimate of EcoRoute (2014), but that assessment was considered misleading, as discussed in Section 4 of this report.

Figure 5.2: Google Earth images from 2003 (A), 2005 (B), 2006 (C), 2010 (D), 2011 (E and F), 2013 (G) and 2016 (H) that show the changing vegetation of the site through this period. In the 2016 image (H), the main vegetation types - reeds (1), mowed grass (2) and invasive alien trees (3) - are indicated.

5.3. Functionality and Importance

In 2008 the Ecological Importance and Sensitivity (EIS) of the wetlands at the George Rex site was estimated as Low to Moderate (DWAF, 2008b). This higher confidence assessment has increased the ecological importance to Moderate. Information has been identified that demonstrates that these wetlands are at least locally important in that the wetlands on the George Rex site historically comprised a combination of estuarine and freshwater wetlands. The brackish and low-lying *Phragmites* reedbeds would have been supratidal, being only inundated during high springwater tides. Maree (2000) indicates that 60% of the supratidal wetlands in Knysna have been lost, whereas Colloty (2000) recorded an 85% loss in supratidal salt marsh. Despite the dominance of the nationally common *Phragmites* reedbeds within this site, they thus represent an area of now very reduced wetland type for the area.

In the 2008 study the Hydrological Functional Importance was estimated as Very High (DWAF, 2008b). This was due to the critical role that the wetland was believed to play ameliorating the impacts from the upstream urban area on the downstream lagoon which it flows into; specifically through:

- Trapping sediment and litter from the upstream urban areas;
- Attenuating the floods from the upstream catchment; and
- Scrubbing nutrients from the high nutrient, *Escherichia coli*-contaminated waters seeping from the adjacent sewage works. In a 2006 study (WSP Environmental, 2006), a plume of elevated Total Coliform values was identified entering the site along the north eastern boundary and extending in a south westerly direction. The elevated microbial activity was associated with subsurface seepage from the sewage works and concentrations of Total Coliforms on the site were high compared to the historical record, with only the lower end of the range equivalent to values measured by an earlier study (Bornman, 2005).

It was believed that if the wetland functioning were to be impaired or further reduced, the downstream impacts (i.e. on the Knysna lagoon estuarine system into which the wetland flows) would have increased. Poor water quality has been one of the impacts that is negatively impacting upon the ecological condition of the nationally important Knysna estuarine system (see **Section 6.2**). Although available water quality data indicated that there has been a significant improvement in the quality of effluent leaving the WWTW or STP since the upgrades of 2013, recent events (i.e. the last quarter of 2016 and early 2017) have suggested a resurgence in poor discharges from the WWTW, intimating that the George Rex wetland would still perform a critical nutrient scrubbing function. Hydrological importance remains Very High due to these factors.

5.4. Recommended Ecological Category

In 2008 the PES and REC for this wetland was set as a C (DWAF, 2008b). Despite the high hydrological importance of the system, and **regional rarity of these wetlands** (most wetlands in the area have been lost to development), much of the degradation of the site at that time (from historic sawdust dumping and hydrological impacts of roads and surrounding developments) would not have been possible to reverse. Achieving a much higher ecological condition was thus not deemed possible within the constraints of the existing impacts on the site due to the developments around the site and within the catchment. In this study, the PES has been shown to have declined since 2008 and is now estimated at a C/D Ecological Condition. It is ***recommended that the REC for the site remains at a C***, primarily because of the important hydrological and water quality functions of the wetland.

6. Water quality functionality of the George Rex wetland

To assess the water quality scrubbing functions assumed to be undertaken by the George Rex wetland, a water quality study of the area was undertaken. As the wetland is upstream of the Knysna Estuary it is important to understand what the water quality inputs are to the estuary / lake system, what the current status of the estuary is and whether it is vulnerable to poor water quality inputs, and what could be coming from the WWTW upstream of George Rex wetland.

6.1. Approach

This task is related to the reassessment of water quality functionality since the 2008 Reserve task (see **Section 5**), and was undertaken as follows:

- Use water quality information from the Outeniqua Reserve Determination Study (ORDS) to understand the water quality state of the Knysna Estuary (DWA, 2009a; b);
- Use information from the PES/EI/ES (Present Ecological State/Ecological Importance/Ecological Sensitivity) project (DWS, 2014a) to provide a desktop assessment of water quality impact ratings for the area. The assessment for the Gouritz Water Management Area (WMA) was undertaken by Southern Waters;
- Gather water quality data for the area. Data sources were DWS's Water Management Systems (WMS) database for water quality monitoring data, and that gathered by the Eden District Municipality (EDM) (Vernon Gibbs-Hall, EDM, pers.comm., April 2016); Quality data were also accessed from the Knysna Municipality regarding the quality of discharge effluent emanating from the Knysna Sewage Treatment Plan (STP) for 2013, i.e. once the STP had been upgraded; and
- Use existing literature (e.g. Bornman and Adams, 2004; Bornman, 2005; WSP Environmental, 2006) to understand the quality of water moving through the wetland area and possibly impacting on the estuary.

6.2. Water quality state of the Knysna Estuary

The geographical boundaries of the Knysna Estuary were defined as follows during the ORDS (2008):

- Downstream boundary: Estuary mouth (33°59′55″ S; 23°00′11″ E);
- Upstream boundary: Extent of tidal influence, ~6.2 km from the mouth (34°04′56″ S; 23°03′35″ E); and
- Lateral boundaries: 5 m contour above Mean Sea Level (MSL) along each bank.

Delineation of the Estuary Functional Zone (EFZ) **(Figure 6.1A)** shows that Erf 12403 (study area) falls almost completely within the EFZ **(Figure 6.1B)**. Allanson & Associates (1995) reported that the area was elevated 1 to 5 m above the mean water level in the adjacent estuary, and according to the contours on the base plan of the area, the entire property is elevated 2 – 3m amsl. The level of George Rex Drive is at +2.35m amsl. Under extreme water level conditions and with the expected sea level rise, it is not impossible that this level will be exceeded in the future (Huizinga, CSIR, pers. comm.; cited in Bornman, 2005).

Figure 6.1: Google Earth images of the Knysna Estuary EFZ (A) and the George Rex wetland opposite "The Moorings" (B) and within the EFZ.

The PES of the Knysna Estuary was set at a B category (78.0%), i.e. largely natural with few modifications, with an overall Estuarine Importance Score of 100, i.e. a Highly Important system. The biotic health of the system (C category) is not as good as the physical habitat and this must be borne in mind in the management of the system. The REC represents the proposed level of protection assigned to an estuary which, in turn, is used to determine the Ecological Reserve. The study concluded that the pressures contributing to the present state of the estuary are human disturbance in and around the estuary, development, and increased eutrophication due to catchment activities, which would include potential impacts from overloaded sewage treatment plants. Although the Knysna Estuary is located in a protected area and should therefore be managed at an A ecological category (i.e. minimally modified), this was not considered possible due to the numerous developments around the lake. The REC was therefore set at the Best Attainable State, i.e. a high B category (DWA, 2009a).

The results of the Reserve study indicated the following trends (DWA, 2009a):

- **The trajectory of change** with further developments in the area, road reclamation, increasing recreational use, and eutrophication issues is negative.

- **Knysna is marine dominated, and fresh water abstraction impacts will be felt in the upper reaches:** The estuary is a very marine dominated system which results in the impact of freshwater abstraction being predominantly felt in the upper reaches of the estuary above the red bridge (see **Figure 6.1**).
- **Tidal prism is the primary reason that the nutrient loading is managed**: The system is very marine dominated with the daily tidal prism approximating the Mean Annual Runoff (MAR) into the system. The estuary is fortunate in that the massive tidal exchange mitigates significantly the elevated anthropogenic nutrient input particularly in the Ashmead Channel area on the eastern side of the lake.
- **Anthropogenic drivers are often more important than flow-related drivers of change**: The degree to which estuary health is impacted upon by non-flow anthropogenic drivers is very significant in the Knysna Estuary. Habitat loss, angling, human disturbance, encroachment and nutrient input are the key issues which need to be managed in the Knysna system. It is of utmost importance that agencies such as SANParks, DWS, Department of Environmental Affairs and Tourism (DEAT) and the Knysna Municipality manage the system to reduce these impacts through effective co-governance.
- **Importance of lateral systems**: While the majority of freshwater entering the Knysna Estuary is from the Knysna and Gouna rivers there are a number of systems, e.g. the Salt River, which enter the main basin of the Estuary. These systems are very important to the functioning of the estuary and must be actively managed from a water quantity and quality perspective. Water quality in the estuary needs to be improved and all point and diffuse sources identified and managed. The lower reaches around the Ashmead channel need specific attention (see **Figure 6.1**).

Non flow-related anthropogenic influences, other than modification of river inflow, that are affecting the abiotic characteristics in the estuary are described below:

- ***Structures (e.g. weirs, bridges, mouth stabilisation):*** Artificial structures such as marinas, bridges and causeways resulted in long-term depositional areas where cohesive sediments and contaminants can accumulate and modify the local habitat.
- ***Discharges into the estuary affecting water quality:*** The Knysna WWTW discharges treated sewage effluent into the Ashmead Channel, increasing inorganic nutrient and organic loading to this part of the estuary. During rains, storm water from the urban areas and informal settlements along the estuary also discharges pollutants into the estuary, e.g. nutrients and toxic substances.
    - The most important source of toxic contaminants into the system was the waste leachate generated by the wood treatment plant (Thesen Island Co.). This industry was relocated in the earlier 1990s to be replaced by the high density Thesen Island Residential Development.
- Human exploitation (consumptive or non-consumptive): None

6.3. Water quality summary: Knysna area

The Knysna River system runs mostly through mountainous terrain with indigenous forests and low impacts overall. Consequently the PES is high throughout the system although forestry and invasion by alien plant species does occur, especially towards the lower part of the catchment towards the estuary. The lower reaches of the river extends into the Knysna lagoon/estuarine system. The estuary is flanked on both banks by a number of up-market residential areas. Recreational and ritual use, as well as heritage and aesthetic value is high.

Main land use and towns in Primary Catchment K are shown below (RHP, 2007; cited in DWA, 2014), while the state of the wastewater treatment works (WWTW) is taken from DWA (2012; cited in DWA, 2014), i.e. the 2012 Green Drop Report for the Western Cape. This information is taken from the Desktop EcoClassification Report for the ORDS (DWA, 2014), with the Knysna catchment area shaded in **Table 6.1** below.

Table 6.1: Land use, main towns and WWTW risks in Primary Catchment K (RHP, 2007, cited in DWA 2014).

Management area	Mossel Bay - George	Wilderness	Knysna-Bloukrans (K50A and K50B)
Main land use	Natural forests and conservation areas, afforestation (pine), dryland and irrigated agriculture (lucerne, pastures), urban, livestock (sheep), tourism	Natural forests and conservation areas, afforestation (pine), irrigated agriculture (lucerne, pastures), urban, tourism	Natural forests and conservation areas, afforestation (pine), irrigated agriculture, urban, livestock (sheep), tourism
Main town	Mossel Bay, Hartenbos, George	Wilderness, Karatara, Sedgefield	Knysna, Plettenberg Bay, Nature's Valley
Risk rating of WWTW (high – critical only)			Knysna 2 WWTW: High risk rating (poor effluent quality; flow exceeds capacity)

Data from the PES/EI/ES study (DWS, 2014a) shows the following water quality impact ratings **(Table 6.2)** for the river sub-quaternary (SQ) catchments in the study area.

Table 6.2: Water quality impact ratings in the sub-quaternary catchments of the study area (DWS 2014a).

SQ name	River / estuary	PES	Physico-chemical modification rating
K50A-09006	Knysna	A	0
K50A-09041	Kruis	A	0
K50A-09069	Knysna	A	0
K50B-09111	Gouna	B	0

Physico-chemical modification (water quality impact) rating = 0, i.e. no discernible impact, or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability. Note that the Sout River (which flows into the Knysna estuary / lake system) was not digitized and is not found on the 1:500000 map provided by DWS for the PES/EI/ES study.

6.4. Water quality input to the lake / estuary system

To evaluate water quality state along the eastern shore of the Knysna estuary / lake, the following information was evaluated, with results of the assessments shown below each point:

- DWS data for the **Sout River inflow to the lake system**, i.e. monitoring point 190523 **(Figure 6.2)**, Eastford south at Knysna/Sedgefield road (N2) on Soutrivier mouth, was evaluated. The data record is 96 points, from 17/6/2008 to 09/09/2013. Note that only pH and *Escherichia coli* were analysed.
    - **Results** show that *E. coli* guidelines for recreational use are exceeded at both the median (232.5 counts/100 mL) and 95th percentiles (2 420 counts/100 mL).
- Data from Eden District Municipality for the **water quality monitoring points around the lake** as shown on **Figure 6.3**. Sampling for *E. coli* has been done on at least a monthly basis since 2009. See **Appendix 2** for recent data (i.e. 2015 to April 2016).

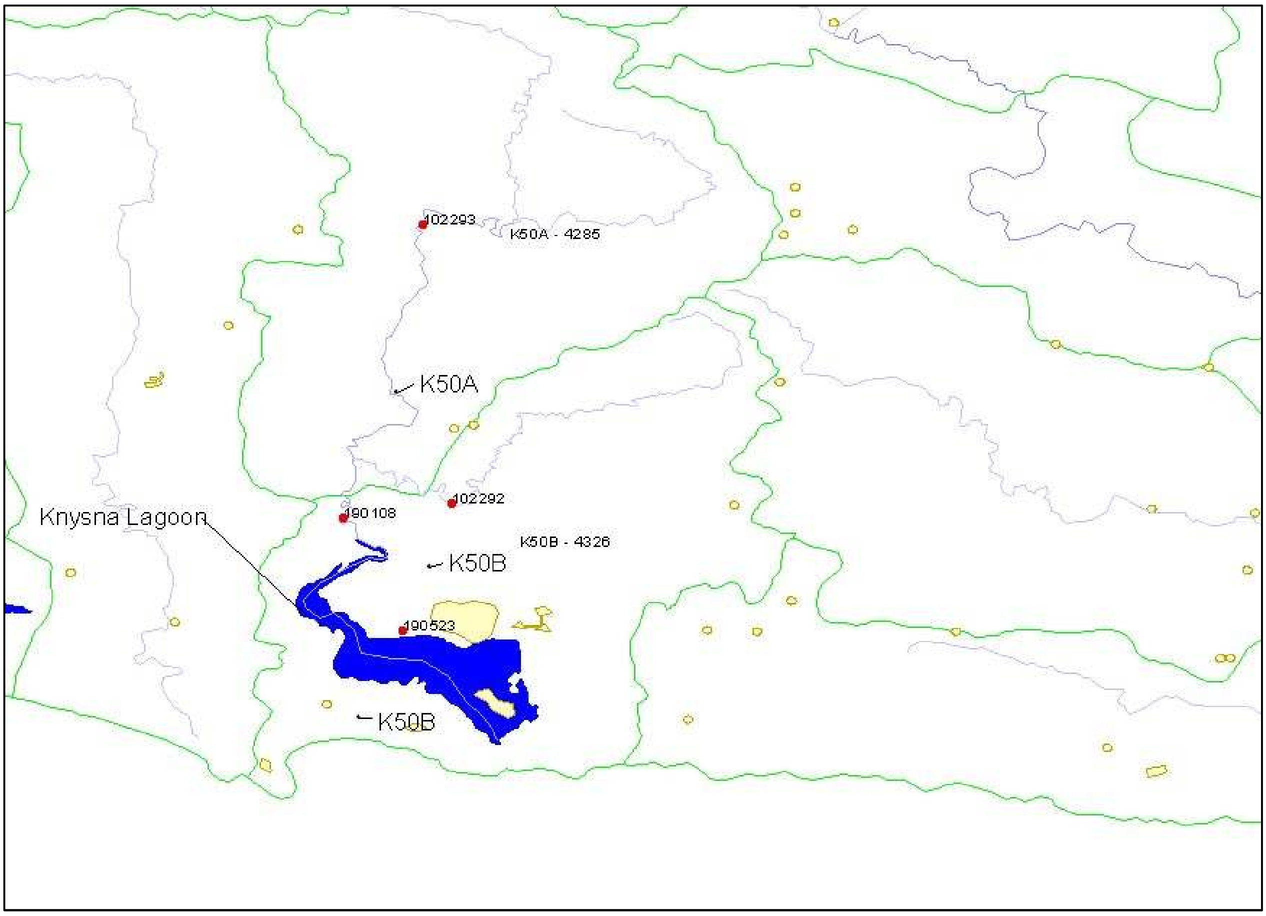


Figure 6.2: **DWS water quality monitoring points in quaternary catchments K50A and K50B.**

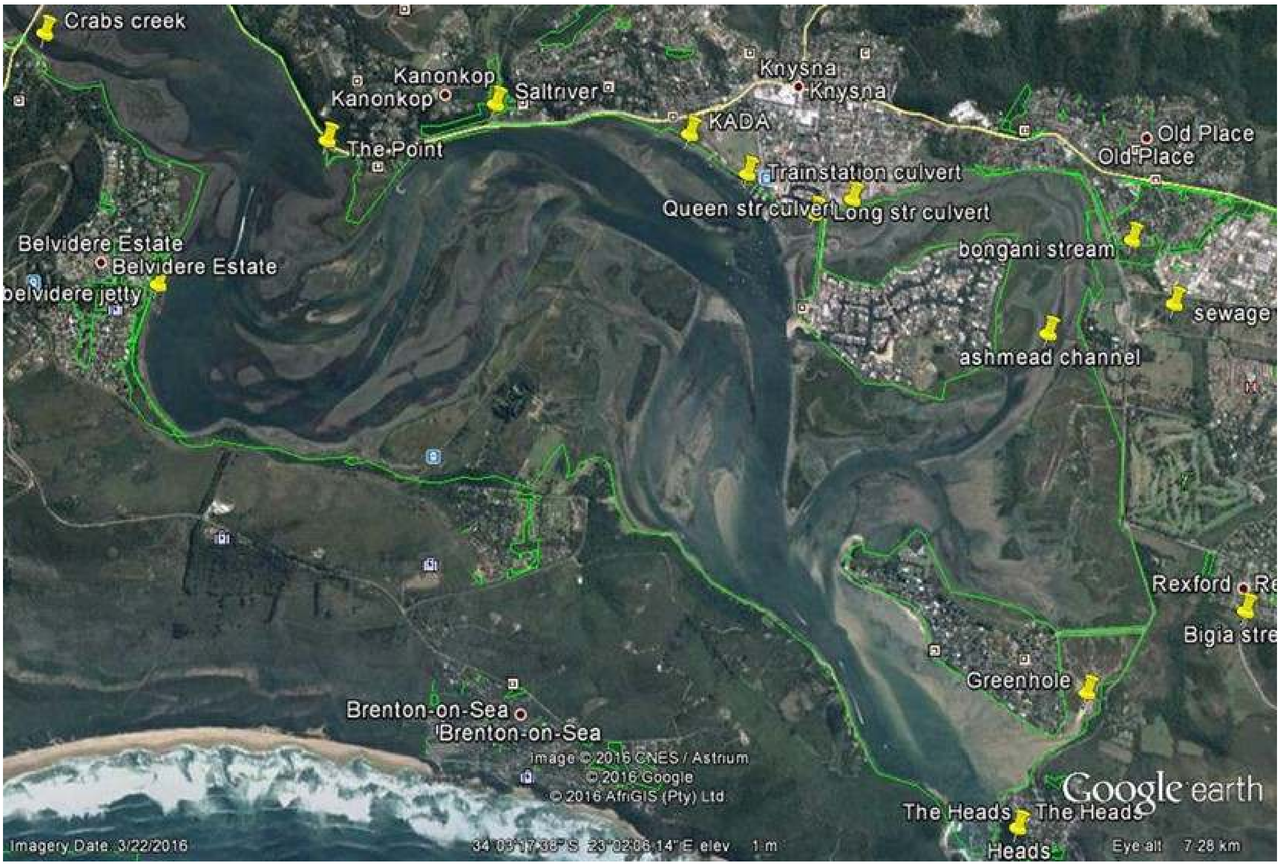


Figure 6.3: Eden DM water quality monitoring points along the Knysna Lake system.

Results are as follows:

The data available for the output from the WWTW for *E. coli* showed highly elevated results for 2012, which is consistent with the Green Drop reports of 2012 and 2014. Monthly *E. coli* reports from the Knysna Municipality website – see **Figure 6.4** for May 2016 - indicate that conditions in the Ashmead Channel downstream of the WWTW are satisfactory at present, although those in the Bongani Stream still exceed guidelines.

[Note that a deterioration in the water quality condition of effluent discharges from the WWTW has been experienced in the last quarter of 2016 and early 2017].

KNYSNA
Municipality Munisipaliteit uMasipala

ESTUARY WATER QUALITY UPDATE

Sample taken on: 13 May 2016
Laboratory report: 18 May 2016

Recent levels of bacteria at the following **2 points** exceed acceptable recreational levels. According to the national Department of Water Affairs guidelines, target water quality for recreational use may not exceed 500 E.coli/100ml.

1.	Bongani:	1300/100ml
2.	Queen Street:	3000/100ml

The following **12 points**, mentioned below, tested under the limit and are therefore safe for public use.

1.	Ashmead:	350/100ml
2.	Belvidere:	1/100ml
3.	Bigai:	82/100ml
4.	Bollard Bay:	0/100ml
5.	Crabs Creek:	4/100ml
6.	Green Hole:	0/100ml
7.	KADA Culvert:	12/100ml
8.	Long Street:	0/100ml
9.	Salt River:	6/100ml
10.	The Heads:	0/100ml
11.	The Point:	1/100ml
12.	Train Station:	53/100ml

Figure 6.4: Monitoring data from the Knysna Municipality website for *E. coli* as compared to marine recreational guidelines (DEA, 2012).

- **Status of the WWTW** located above Erf 12403

The status of this WWTW (i.e. named the Knysna 2 SBR plant) is taken from the 2014 Green Drop report for the Western Cape (DWS, 2014b). The Green Drop programme was introduced as a regulatory tool by the DWS in 2008 to identify and develop the core competencies needed to improve the level of wastewater management in the country.

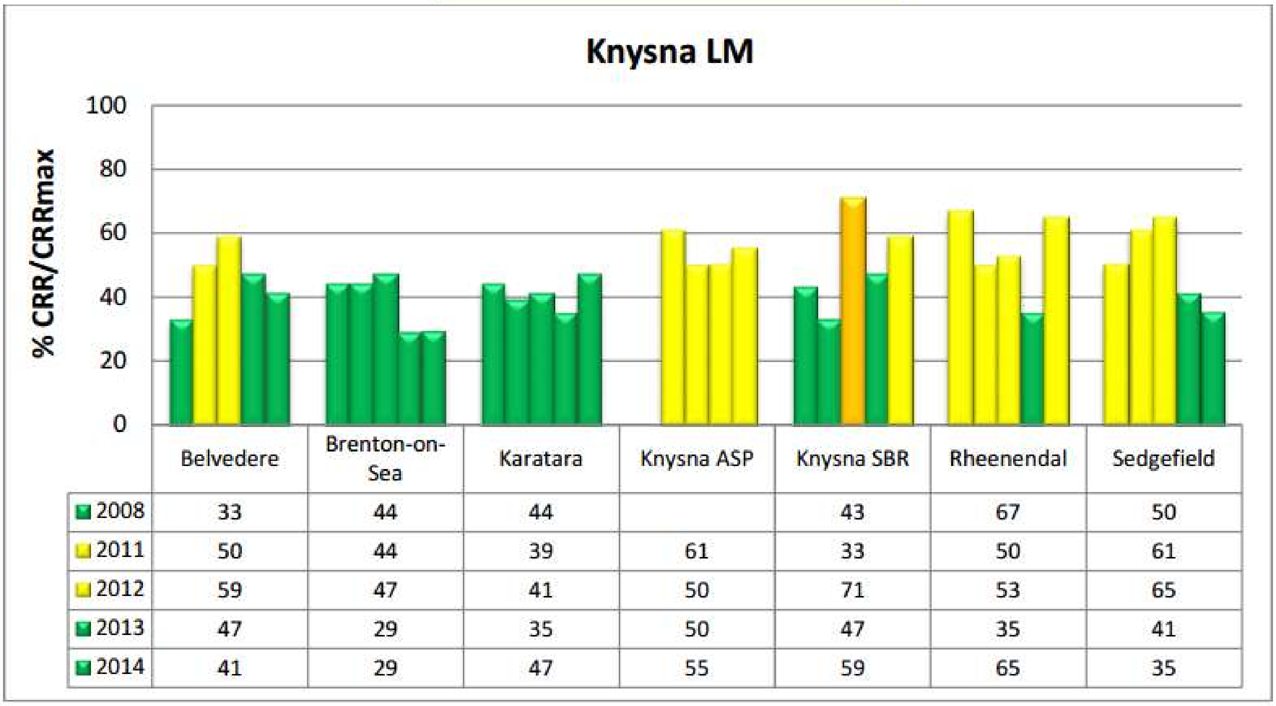
Note the use of the following colour legend when assessing **Figure 6.5**, which shows that Knysna 2 SBR (located above George Rex wetland; see **Figure 6.5**) is in a **Medium Risk category** as at 2014 (which is an improvement from a High Risk plant in the 2012 Green Drop report).

% Deviation = CRR/CRR(max) TREND		
	90 – 100% Critical risk WWTPs	
	70 - <90% High Risk WWTPs	
	50-<70% Medium risk WWTPs	
	<50% Low Risk WWTPs	

%CRR/CRR$_{max}$ = Wastewater Risk Rating

WWTP: Waste Water Treatment Plant; CRR: Cumulative Risk Rating

Risk trend per plant as %CRR/CRR$_{max}$



	Belvedere	Brenton-on-Sea	Karatara	Knysna ASP	Knysna SBR	Rheenendal	Sedgefield
2008	33	44	44		43	67	50
2011	50	44	39	61	33	50	61
2012	59	47	41	50	71	53	65
2013	47	29	35	50	47	35	41
2014	41	29	47	55	59	65	35

Figure 6.5: Risk trend for Knysna Local Municipality WWTWs (DWS, 2014b).

The risk trend shown for the Knysna 2 SBR system (75% effluent compliance, but 0% microbial compliance) for the 2012-2013 monitoring period, showed a lack of flow measuring and the resulting report of a large overloading of the works. The plant achieved a 58.8% Medium Risk rating (DWS, 2014b).

Data accessed from the Knysna Municipality for 2013-2016 indicate an ongoing problem in meeting Electrical Conductivity (EC) standards, with ammonia levels in the discharge effluent becoming increasingly higher since 2014. **Table 6.3** is a summary of the final effluent quality over time for selected variables, as compared to General and Special Limits (or discharge standards). Exceedence of General Limits are shown in red text, and that of Special Limits in blue text. Although no guideline limits were applied to *E. coli* results, levels above 1000 counts/100mL are also shown as red text. Analyses of water samples were conducted by A.L. Abbott & Associates analytical laboratory in Cape Town.

Table 6.3: Water quality data for the Knynsa STP's final effluent.

	Date	EC (mS/m)	NH3-N (mg/L)	NO2/NO3-N (mg/L)	PO4-P (mg/L)	Faecal coliforms* (counts/100mL)	E. coli* (counts/ 100mL)
General Limit		**150**	**6**	**15**	**10**	**1000**	**n/a**
Special Limit		**100**	**2**	**1.5**	**2.5**	**<1**	**n/a**
	2013						
	19/3/2013	700	0.98	3.9	1.4	1736	1
	16/4/2013	164	<0.15	3.2	0.5	36	1
	22/5/2013	159	<0.15	2.2	0.94	<1	<1
	19/6/2013	156	<0.15	2.6	3.6	387	79
	25/7/2013	187	3.4	5.1	3.5	<1	<1
	22/8/2013	195	<0.15	1.8	0.54	137	79
	17/9/2013	190	0.74	3.7	3.7	34	1
	23/10/2013	174	1.8	0.74	3.9	>2419	62
	20/11/2013	144	0.96	<0.2	0.58	31	2
	18/12/2013	162	14.6	0.35	0.57	1120	1120
	2014						
	22/1/2014	159	<0.15	1.6	<0.2	35	816
	18/2/2014	167	19.7	<0.2	0.54	2	2
	18/3/2014	152	2.9	7.4	2.9	365	365
	15/4/2014	171	9.1	0.99	<0.2	37	37
	21/5/2014	167	7.9	6.0	1.4	11	3
	16/7/2014	200	7.8	0.2	0.5	<1	no data
	20/8/2014	215	18.9	0.61	2.5	24	17
	22/10/2014	170	0.3	3.3	0.23	1300	1300
	20/11/2014	162	18.3	0.29	0.37	613	no data
	9/12/2014	173	28.2	<0.2	1.0	1553	1553
	2015						
	22/4/2015	182	32.6	<0.2	0.3	1011	1011
	20/5/2015	214	38.7	4.7	2.7	55	55
	18/6/2015	163	10.8	1.1	0.98	5	5
	22/7/2015	147	12.8	0.62	0.3	<1	<1
	19/8/2015	199	33.4	<0.2	1.0	>2419	>2419
	23/9/2015	142	12.2	4.6	4.3	1046	1046
	21/10/2015	187	22.5	<0.2	0.56	<1	<1
	18/11/2015	155	26.7	<0.2	0.43	2	2
	9/12/2015	185	36.6	<0.2	0.45	>2419	>2419
	2016						
	20/1/2016	188	32.7	<0.2	0.28	>2419	>2419
	17/2/2016	200	41.0	11.0	0.60	>2419	>2419
	16/3/2016	190	39.8	<0.2	0.46	>2419	>2419
	22/4/2016	260	41.7	<0.2	0.37	>2419	>2419
	25/5/2016	580	38.2	<0.2	0.72	>2419	>2419
	22/6/2016	660	50.1	0.44	1.80	27	27

Table 6.3 indicates that although it is not possible to ascertain whether, or how much of the final effluent from the STP may be seeping through the George Rex wetland, the wetland would be serving a **scrubbing function** due to the questionable quality of the effluent, particularly in terms of nitrogen levels and faecal coliforms. The data shows numerous exceedances of General and Special Limits, indicating the poor quality of the discharge.

6.5. Water quality moving through the George Rex wetland

Activities upslope of the site have the potential to impact the quality of the groundwater. Approximately 100m to the north of the site is the WWTW, which consists of a number of lined sludge ponds (see **Figure 3.1, Figure 4.3**). To the north east is a cemetery and to the east the Hunters Estate residential development. Polluted stormwater from the surrounding area therefore has the potential to impact the groundwater quality on the site (WSP Environmental, 2006).

Bornman and Adams (2004) and Bornman (2005) referred to seepage from the northern adjacent WWTW providing a continuous supply of nutrient rich water that led to the establishment of monospecific stands of the common reed, *Phragmites australis* and *Typha capensis* (bulrushes). It is assumed that the *Phragmites* now fulfil an important role in cleaning any polluted and eutrophic groundwater flowing through the property from the sewage works.

Seepage from the WWTW was confirmed at the time by bacterial testing in boreholes manually augered in the wetland during the 2004 survey. *E. coli* counts of up to 756 per 100 ml were recorded on the property, indicating definite faecal pollution. The *E. coli* guideline for full contact recreation (e.g. swimming) is 130 counts / 100ml (DWAF, 1996a). The 2005 study found that the reed beds were successful in reducing the bacterial and nutrient load of the groundwater to acceptable standards.

Fourteen (14) piezometers were installed to determine the microbial and chemical quality of the groundwater for the groundwater study of WSP Environmental in 2006 **(Figure 6.6)**. A line of seven piezometers was installed along the northern boundary of the site and a further five between the northern boundary and the woodwaste pile, with the last piezometer placed directly opposite the WWTW. Water samples were taken and analysed for a suite of chemical and microbial parameters. Chemical results were compared to the DWS Guidelines for Aquatic Ecosystems (DWAF, 1996b), and microbial testing to Recreational Use guidelines (DWAF, 1996a) to determine the potential human health risk that the groundwater features pose to the residents of the proposed development.

The results of the Electrical Conductivity (EC), Total Dissolved Solids (TDS), NH_4 (ammonium) and to a lesser extent the PO_4 (phosphate), indicate the presence of a contaminant plume originating from the WWTW on the north-western section of the site. However, the water table measurements suggest that whilst the chemical data confirm the extent of impact on the groundwater from the sewage works discharges, the volumetric flux of impacted water from the sewage works to groundwater is relatively small. The high phosphate recorded on the eastern boundary of the site coincides with data from Bornman (2005), which indicates a possible source of phosphate entering the site from Hunters Estate (WSP Environmental, 2006).

A plume of elevated Total Coliform values (i.e. elevated above historical records) is evident entering the site along the north-eastern boundary and extending in a south westerly direction. There are three sources of potential microbial contamination on the site, namely sub-surface seepage from the WWTW, the cemetery directly upgradient from the site, and impacted stormwater runoff from the upgradient industrial area and including the adjacent WWTW (see **Figure 6.8**). An evaluation of the chemistry associated with cemeteries suggested that the cemetery is not a significant contaminant source.

Figure 6.6: Position of piezometers (P1-14) for the 2006 groundwater study of WSP Environmental.

Test results indicated the presence of elevated microbial activity associated with subsurface seepage from the WWTW, but presence of elevated faecal coliforms within the central portion of the site indicates that poor stormwater quality entering the site at the north-eastern corner also represents a significant source of microbial contamination. The quality of stormwater runoff from the upgradient areas would be expected to have been particularly poor during the flood event just prior to sampling, and the levels of faecal coliforms reported are thus considered to represent worst case conditions (WSP Environmental, 2006). **Figure 6.7** is a cross-section across the site, showing contaminant areas and the approximate extent of the contaminated plume as in 2006 (WSP Environmental, 2006).

It should be noted that upgrading of the Knysna WWTW was undertaken after the work of 2005 and 2006. A Press Release by the Knysna Municipality regarding the Knysna Estuary Pollution Action Plan in February 2013 referred to the long-awaited upgrading of the WWTW (i.e. the Knysna 2 SBR plant) being near completion. Prof Allanson had visited the works in January 2013 and spoke of the good quality effluent then leaving the plant. The Action Plan addresses three main sources of pollution into the estuary: the sewer network including the WWTW, polluted river systems that run through informal settlements into the estuary, and the stormwater network which has illegal connections to the sewer network. A Stormwater and Sewer Connection Audit was also initiated in 2013.

However, recent data on the quality of the final effluent from the STP **(Table 6.1)** indicate that although there may have been an improvement in the quality of effluent leaving the WWTW or STP after the upgrades of 2013, **there is still a nutrient load leaving the plant**, as well as periodic high faecal coliform levels. It is therefore expected that the George Rex wetland would still be performing a nutrient scrubbing function on any effluent which may seep through the wetland.

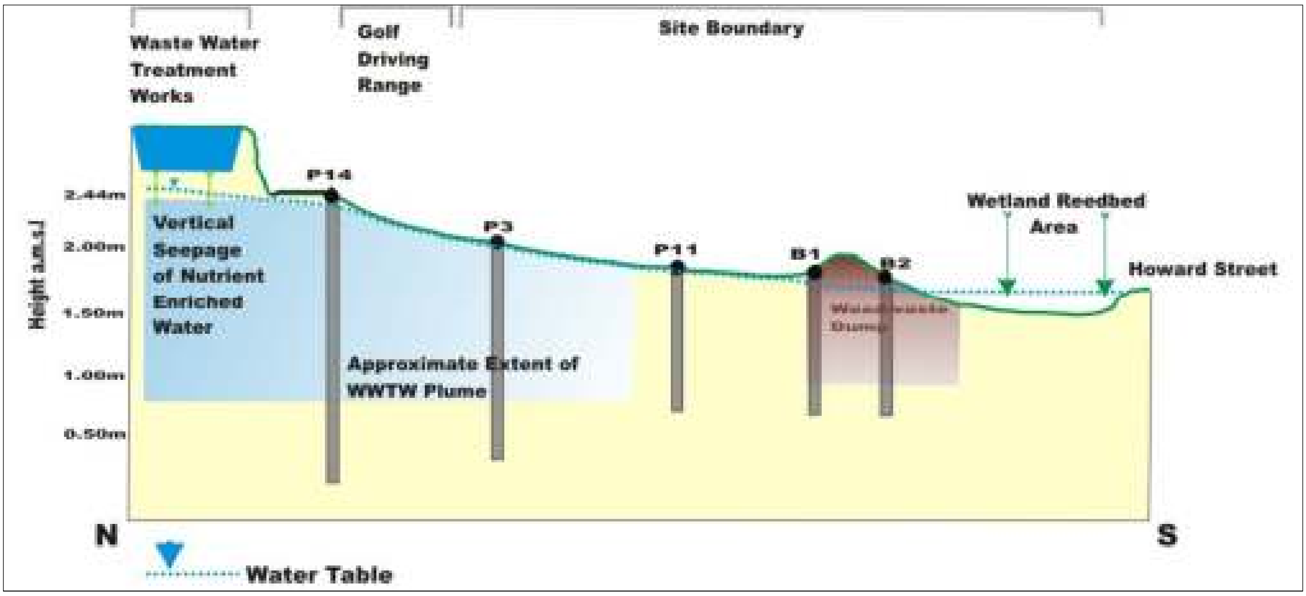


Figure 6.7: **Site cross-section, showing contaminant plume and seepage from the WWTW (WSP Environmental, 2006).**

6.6. Conclusion

There appears to be a fluctuation of discharge quality from the WWTW (or Knysna STP) adjacent to Erf 12403. Conditions were poor in the past, e.g. as shown by the 2006 WSP Environmental report, with an improvement due to the upgrade of the WWTW in 2013. However, data from 2013-2016 indicated problematic water quality issues related to final discharge effluent although it was not possible to ascertain whether, or how much of the final effluent from the STP was seeping through the George Rex wetland (i.e. erf 12403 or the study site). Recent events (last quarter of 2016 and early 2017) have indicated issues with the quality of discharge effluents from the WWTW. Under these conditions it is certain that the wetland would be serving a scrubbing function, particularly in terms of nitrogen levels and faecal coliforms. **Figure 6.8** below shows the wetland in relation to the WWTW and points of contamination, i.e. the Bongani Stream and Ashmead Channel, as well as discharge points from the Knsyna WWTW shown in red text. Activities impacting on water quality, e.g. the WWTW and industrial area, are also shown. The blocked outlet point from Erf 12403 is indicated. It is recommended that this point be opened as part of the proposed development, so as to assist with restoring a link to the estuary and rehabilitation of estuarine wetland area within erf 12403. This restored link, and scrubbing of contaminated water by a functioning wetland, would also assist in reducing the risk of contaminated water reaching the sensitive Knysna Estuary via the Ashmead Channel.

Figure 6.8: Areas of interest in relation to Erf 12403, including activities impacting on water quality.

7. Development options

Where wetlands comprise a large proportion of a potential development site, then typically four options are available to developers. These are:

Option I: Do nothing. Wetlands are protected water resources and development within them requires a Water Use Licence to be granted from the relevant water authority (DWS or the local CMA; in this case the Breede-Gouritz CMA).

Option II: Develop the "non-wetland portion" (for George Rex, this was proposed by DWAF in 2008) of the site only and conserve the remaining wetlands to maintain current functions.

Option III: Develop a larger portion of the site and rehabilitate/engineer the remaining wetland area to improve current condition and/or functions to offset the area losses of wetland. This approach uses the concept of "hectare equivalents" to trade off large poorly functioning wetlands for smaller areas of improved/higher functionality in a way that maintains the function, but not necessarily the extent, of wetland in the landscape. This is an approach to wetland management that has been considered by the DWS in recent years.

Option IV: Develop the site and offset the losses at the site through off-site mitigation. This approach, often undertaken by mines and other similarly large developments, seeks to offset wetland loss/impairment at one site through compensating for the loss of function (and area/condition) of wetlands by rehabilitating wetlands in the same or adjacent catchments. This maintains the functional role and functional extent (measured in hectare equivalents – the area of wetland multiplied by the PES) of wetlands in a catchment.

Option I represents the status quo. Although no development has taken place since 2008, the site had been affected by previous impacts on and around the site, such that the PES had already been reduced to a C in 2008. Subsequent to this, due largely to land use management of the site (vegetation clearing at the request of the local municipality), the PES of the site has continued to decline (from a C in 2008 to a C/D in 2016 – see **Section 5.2** of this report).

Option II considers the scenario proposed in the 2008 Reserve study. Based on previous detailed studies (e.g. Bornman, 2005), the DWS determined that 5.8 ha (29%) of the George Rex wetland site was not functioning as a wetland and that that portion of the property could be available for development. However, in order to offset the loss of any (current or future) functionality from this section of the property, the remaining wetland area would need to be rehabilitated to improve its wetland functionality in order for the DWS to meet the strategic objective for the Knysna lagoon/estuary water resource.

Option III is considered technically viable, and has been evaluated further in **Section 8** of this report. Several proportions of development and protected wetland area have been considered.

Option IV – offsite mitigation – is not possible for the George Rex wetland site as there are no other nearby remaining similar wetlands (Bornman, 2006) that could be feasibly purchased and rehabilitated to offset further loss of wetlands in the catchment.

The evaluation of scenarios has thus only considered Option I, II and variety of scenarios under Option III.

8. Site scenarios and consequences

A variety of future development or site management scenarios have been considered for the George Rex wetland site. These are:

- **Scenario 1**: do nothing
- **Scenario 2:** 71% wetland, 29% developed (2008 Reserve)
- **Scenario 3a:** 80% wetland, 20% developed
- **Scenario 3b**: 60% wetland, 40% developed
- **Scenario 3c**: 50% wetland, 50% developed
- **Scenario 3d**: 30% wetland, 70% developed – this scenario is roughly equivalent to the proposal from EcoRoute (2014) that indicated 12 ha of the 22.49 ha property be developed and 7 ha of the wetlands be rehabilitated. See **Appendix 3** for the current provisional development plan, including the driving range, which fits into this scenario. (If the driving range is included as part of open space, the development fits the 50:50 option, i.e. Scenario 3c).
- **Scenario 3e**: 10% wetland, 90% developed
- **Scenario 3f**: 100% development (0% wetland)
- **Scenario 3g**: Complete rehabilitation of the site (100% of the area is rehabilitated)

Each scenario has been evaluated in terms of its ability to meet the REC for the site, as well as the economic feasibility of implementing the scenario **(Table 8.1)**.

Assumptions in the evaluation of the scenarios were:

- The site is 19.406 Ha in extent, as determined by the town planner (Vreken, email communication, 22 April 2016);
- Of the site, 71% (13.8ha) is considered wetland (as indicated by DWA, 2008);
- The **PES** of the wetland in 2008 was 74.5% (C Ecological Category). Across the 13.8ha of the site that was estimated as being a functional wetland at that time, the condition (PES) multiplied by the extent (ha) of the wetland equates to 10.3 functional equivalent hectares (i.e. 10.3 ha of functional wetland if the wetland condition/function was 100%).
- The **PES** of the wetland in 2016 has since declined to 58.6% (C/D Ecological Category). Using the proportions determined by DWS in 2008, this equates to 8.1 functional equivalent hectares (i.e. 8.1ha of functional wetland if the wetland condition/function was 100%).
- The **REC** is to maintain a C category wetland at the site, and this means that at least 9 functional equivalent hectares must be maintained at the site to achieve a minimum (65%) C condition wetland.
- Despite the recommendations of EcoRoute (2014), it is not considered feasible to rehabilitate completely (i.e. 100%) to pristine conditions due to existing impacts and site and catchment constraints.

Table 8.1: Hectare (ha) equivalents required to maintain the PES condition of the wetland observed in 2008 and 2016, and to achieve a minimum "C" Ecological Category.

Condition	PES (%)	Ha equivalents*
2008	74.5	10.3
2016	58.7	8.1
Minimum "C" (65% PES) to meet the REC	65.0	9.0

*Ha equivalents equate to 100% functionality of wetland

- This study has assumed however that, with suitable rehabilitation interventions, an improvement of the current condition of the wetland could be achieved that would represent a better condition even than of that (74.5%) seen in 2008. This study has assumed that an 80 to 90% restoration of the vegetation and function for the wetland within the site is possible, if the following interventions are implemented:
    - Removal of invasive vegetation;
    - Cease mowing the wetland vegetation;
    - Removal of some of the infill material within selected areas to bring the water table back in line with the original soil level;
    - Replanting of selected wetland species;
    - Increased culvert capacity to increase tidal exchange, and
    - Promotion of diffuse flows (through closure of the excavated canals and berms).

  This is considered feasible given that the conditions observed in 2008 (when PES was at 74.5%) would be further improved upon through increased tidal exchange by reconnecting the wetland to the estuary (see **Figure 6.8**), removal of fill, plugging of drains and canals, removal of invasive vegetation and overall improved vegetation condition and wetland function. Improved management of the adjacent WWTW would also improve positively on the wetland.

The evaluation and consideration of the consequences of the scenarios, specifically the potential of the proposed scenarios to achieve the REC for the wetland, and of the potential economic feasibility, identified **Scenario 3b** as a potential preferred option **(Table 8.2)**. This scenario – representing a 40% development footprint for the site - would be able to achieve a C REC condition and simultaneously provide a slightly larger development footprint than that provided for in the 2008 Reserve. However, this is still a smaller development footprint that the options previously proposed by the developer (EcoRoute, 2014) and the economic viability of this scenario is not known at this stage.

Table 8.2: Development scenarios and their ability to meet the REC

Scenario	Potential to achieve REC (minimum 65%)	Potential to achieve REC (PES of 2008)	Economic feasibility of implementation
Scenario 1: do nothing	This is not achieving the REC. The site conditions have continued to degrade from 2008 to 2016, with the PES declining from a C to a C/D in this time.		Represents current situation.
Scenario 2: 71% wetland, 29% developed (2008 Reserve)	Rehabilitation of wetlands across 51 to 58% of the site will be required to achieve the REC of a low C (65%). This scenario will allow the REC to be achieved.	Rehabilitation of wetlands across 59 to 66% of the site will be required to achieve the REC of a high C (74.5% - the 2008 condition of the site). This scenario will allow the REC to be achieved.	The low development footprint is considered economically unviable by the current developer and this scenario is not considered feasible for the current proposed project.
Scenario 3a: 80% wetland, 20% developed	Rehabilitation of wetlands across 51 to 58% of the site will be required to achieve the REC of a low C (65%). This scenario will allow the REC to be achieved.	Rehabilitation of wetlands across 59 to 66% of the site will be required to achieve the REC of a high C (74.5% - the 2008 condition of the site). This scenario will allow the REC to be achieved.	
Scenario 3b: 60% wetland, 40% developed	Rehabilitation of wetlands across 51 to 58% of the site will be required to achieve the REC of a low C (65%). This scenario will allow the REC to be achieved.	Rehabilitation of wetlands across 59 to 66% of the site will be required to achieve the REC of a high C (74.5% - the 2008 condition of the site). This scenario will probably not be able to achieve this REC due to the reduced extent of wetlands.	**This is the maximum development footprint option that has been identified that will be able to achieve a C Ecological Category for the wetland at the site (albeit a lower C condition from that observed in 2008).**
Scenario 3c: 50% wetland, 50% developed	Rehabilitation of wetlands across 51 to 58% of the site will be required to achieve the REC of a low C (65%). This scenario will not be able to achieve the REC due to the reduced extent of wetlands.	Rehabilitation of wetlands across 59 to 66% of the site will be required to achieve the REC of a high C (74.5% - the 2008 condition of the site). This scenario will not be able to achieve the REC due to the reduced extent of wetlands.	
Scenario 3d: 30% wetland, 70% developed	Rehabilitation of wetlands across 51 to 58% of the site will be required to achieve the REC of a low C (65%). This scenario will not be able to	Rehabilitation of wetlands across 59 to 66% of the site will be required to achieve the REC of a high C (74.5% - the 2008 condition of the site). This scenario will not be able to	This scenario is roughly equivalent to the proposal from EcoRoute (2014) that indicated 12 ha of the 22.49 ha property be developed and 7ha of the wetlands be rehabilitated.

	achieve the REC due to the reduced extent of wetlands.	achieve the REC due to the reduced extent of wetlands.	
Scenario 3e: 10% wetland, 90% developed	This scenario will not be able to achieve the REC due to the critically reduced extent of wetlands.	This scenario will not be able to achieve the REC due to the critically reduced extent of wetlands.	
Scenario 3f: 100% development (0% wetland)	This scenario will not be able to achieve the REC due to the critically reduced extent of wetlands.	This scenario will not be able to achieve the REC due to the critically reduced extent of wetlands.	
Scenario 3g: Complete rehabilitation of the site (100% of the area is rehabilitated)	Rehabilitation of wetlands across 51 to 58% of the site will be required to achieve the REC of a low C (65%). This scenario will allow this REC to be achieved.	Rehabilitation of wetlands across 59 to 66% of the site will be required to achieve the REC of a high C (74.5% - the 2008 condition of the site). This scenario will allow this REC to be achieved.	This is not economically viable for the current proposed project as there will be no development income generated that will be available to fund the required rehabilitation of the site.

9. Buffers and stormwater management

DWA (2013) noted that whilst large buffers are appropriate for surface water inputs, smaller buffers are likely to be sufficient to mitigate runoff from the catchment and adjacent land-use disturbances in wetland flats as the wetlands are driven by groundwater rather than surface runoff. The catchment-wide or regional groundwater inputs thus buffer the smaller surface runoff contributions.

Scenario 3b is the recommended option for considering development for the site. This scenario will allow for 40% of the site to be developed, with the remaining 60% of the site incorporating wetlands (between 51 to 58% of the site will be required to achieve the REC of a low C) and small buffers. Small buffers are required because the wetland is heavily influenced by groundwater (as shown in previous studies – see WSP Environmental, 2006) and, in the brackish/estuarine areas, by tidal flows. Large buffers are not required to attenuate these flows in and out of the wetland.

It is recommended that a portion of the freshwater wetland area within the site be engineered to function as an open water pond. Stormwater from the adjacent catchment can be attenuated within such an area, and ***the open water nature of the pond would aid in water quality improvement through oxidation processes***. Flows across and within the wetland should however all be as diffuse as possible, with the only channelled flows being the tidal inflows from the culverts. Diffuse flows through well vegetated reedbeds within the freshwater wetlands will enhance sediment, litter and nutrient trapping within the wetlands and thus reduce impacts to the downslope brackish and estuarine wetland areas. The inclusion of walkways and incorporation of recreational/educational areas in the design, should also be considered.

10. Conclusions and recommendations

Historically, the entire George Rex wetland site comprised a combination of estuarine, freshwater and brackish wetland types. However, subsequent infilling, draining and surrounding infrastructure developments have reduced the functionality and condition of the wetlands in the area. The earlier Reserve of 2008 was based on preceding specialist detailed studies of the site (Bornman, 2005) and deemed that 71% of the site remained as a functional wetland.

Since this time, the PES of the site has declined from a C to a C/D condition between 2008 and 2016. The REC of a C was set for the site in 2008 and, as many of the more recent impacts are reversible, a C condition remains feasibly attainable and is suggested as the Recommended Ecological Condition (REC) for this site.

Off-site mitigation is not possible within this catchment as the vast majority of wetlands in the catchment and surrounding area have been lost to catchment development or are already protected and in good condition. There are no sites where rehabilitation of wetlands can be undertaken in the immediate catchment to offset losses within the site.

Rehabilitation within the site is however recommended to improve the condition and functionality of the wetlands, as well as to provide a level of protection to the downstream Knysna Estuary against poor effluent discharges from the non-compliant WWTW located adjacent to Erf 12403 (the study site). The hydrological functions of the wetlands – water quality amelioration and stormwater attenuation – are particularly important and rehabilitation interventions should aim to maximize these functions, as well as improve the condition of wetland vegetation generally, and specifically to increase the extent of brackish estuarine wetland patches through improved tidal exchanges. The latter can be achieved by opening the culvert in the southwestern corner of the wetland so as to allow estuarine movement into the wetland.

In an evaluation of potential development and management scenarios for the site, Scenario 3b (allowing for a 40% development footprint) was identified as the scenario with the maximum development footprint that would still allow for a C Ecological Condition to be achieved. Using a hectare equivalent approach, between 51 to 58% of the site will be required to achieve the REC of a low C. Thus the remaining 60% of the site (remaining from the 40% development footprint) would comprise a combination of various wetland types (51-58% of the site) and small buffers. DWA (2013) noted that whilst large buffers are appropriate for surface water inputs, smaller buffers are likely to be sufficient to mitigate runoff from the catchment and adjacent land-use disturbances in wetland flats (wetland types like George Rex) as the wetlands are driven by groundwater rather than surface runoff.

E.coli counts and nutrient levels (N and orthophosphate-P) outflows to the estuary should not be permitted to exceed guideline levels; meaning that effluent discharge standards should be met. The wetlands should be engineered and rehabilitated to promote diffuse flow through vegetated areas; to remove channelized flows (except for the tidal exchanges as these arise from culverts) and could consider the creation of open water areas within the reedbeds to improve oxidation and water quality enhancement functions of the wetland. Walkways and educational/recreational areas will also further demonstrate the value of improved wetland state.

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Appendix 1: PES scores in 2008 and 2016 using the vegetation alteration module of the DWS's Wetland Index of Habitat Integrity

PES score in 2008

VEGETATION ALTERATION - the impacts of landuse activities *within* the wetland on the vegetation of the wetland							
Estimate the impact **RATING** (0-5) and aerial **EXTENT** (0-100 %) of the various landuse activities on the wetland system							
Landuse Activities on the wetland	Ranking	Weighting	Rating (0-5)	Extent (0-100%)	Impact Score	Weighted Impact Score	*Confidence Rating (1-5)*
Mining/Excavation	1	*100*	0	0	0	0	
Infilling/Backfilling	2	*70*	3.5	29	1.015	0.7105	
Vegetation Clearing/Loss/Alteration	3	*60*	1.5	46	0.69	0.414	
Weeds or Invasive plants	4	*50*	3	10	0.3	0.15	
Percentage in Reference State	6	0	0	15	0	0	
VEGETATION ALTERATION SCORE				100		**1.2745**	*Confidence:*
					PES %:	**74.5**	*0.0*
					PES Category:	**C**	

PES score in 2016

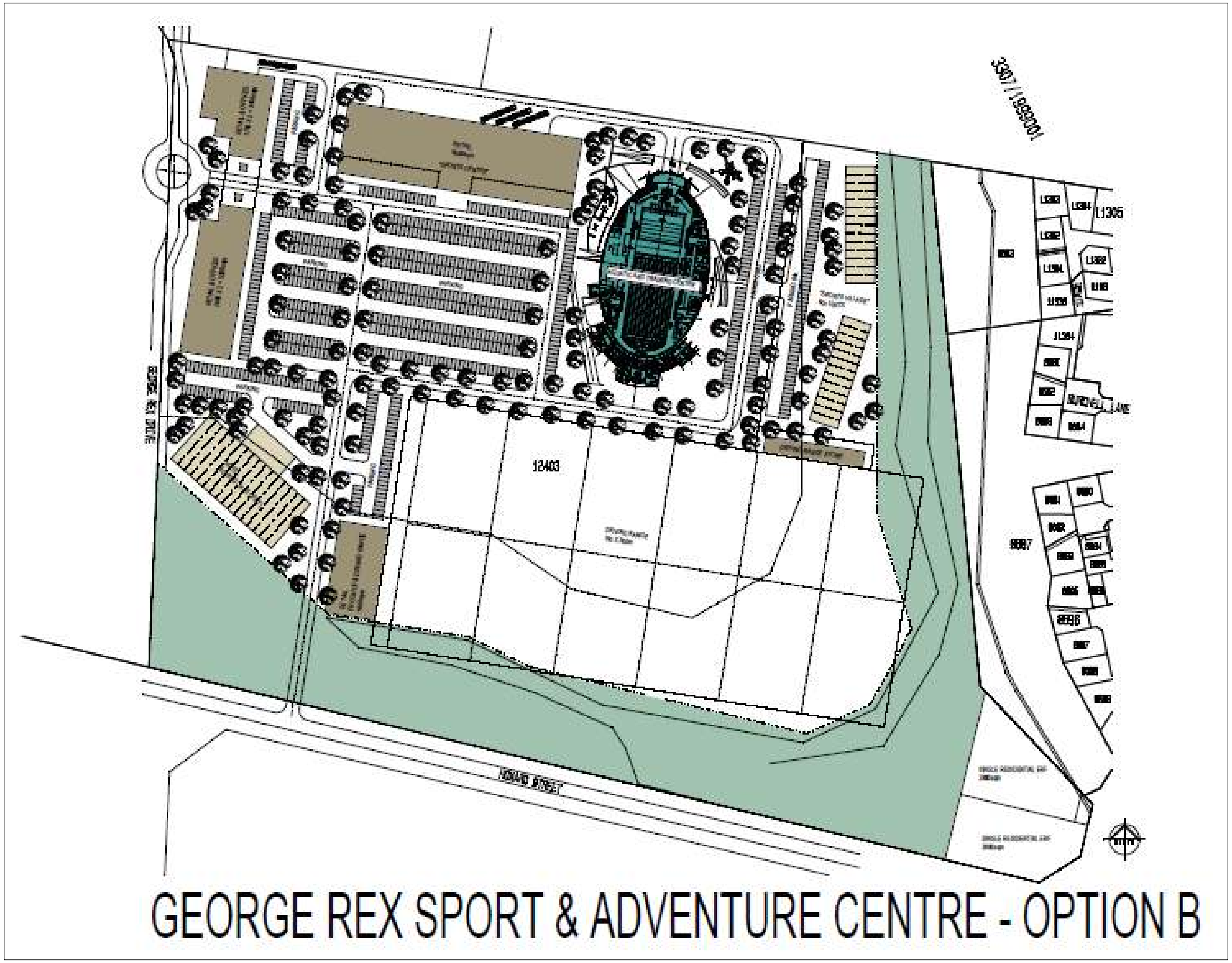
VEGETATION ALTERATION - the impacts of landuse activities *within* the wetland on the vegetation of the wetland							
Estimate the impact **RATING** (0-5) and aerial **EXTENT** (0-100 %) of the various landuse activities on the wetland system							
Landuse Activities on the wetland	Ranking	Weighting	Rating (0-5)	Extent (0-100%)	Impact Score	Weighted Impact Score	*Confidence Rating (1-5)*
Mining/Excavation	1	***100***	0	0	0	0	
Infilling/Backfilling	2	***100***	3	20	0.6	0.6	
Vegetation Clearing/Loss/Alteration	3	***90***	2.5	60	1.5	1.35	
Weeds or Invasive plants	4	***80***	3	5	0.15	0.12	
Percentage in Reference State	6	0	0	15	0	0	
VEGETATION ALTERATION SCORE				100		**2.07**	*Confidence:*
					PES %:	**58.6**	***0.0***
					PES Category:	**C/D**	

Appendix 2: Eden District Municipality data for the Knysna Lakes area for 2015 to April 2016

Escherichia coli (number of colonies per 100ml) levels in water samples collected in selected rivers and inlets discharging into the Knysna Estuary. E.coli is used as a bacterial indicator of faecal pollution by warm-blooded animals. The 400 colonies/100ml limit is obtained from the South African Guidelines for Water Quality for Recreational Use (DWAF 1996) as an indicator of increasing risk of gastrointestinal effects following full-contact recreation. Samples exceeding the 400 (no./100ml limit are indicated in red. Note that the upper limit of detection is 2419 (no./100ml) therefore samples with this value are in all probability higher than this level.

Name of sample site	Land's End Ashmead Channel	Leisure Island (Upper Ashmead)_S4	Thesen Island (Ashmead)Inlet_S5	Thesen Island (Causeway)Main Channel_S7	Bongani Stream	Land's End Shore	Ashmead (Loerie Park)_S6	Bigai / Howard Upstream	Salt River	Waste water treatment plant
13 January 2015 Eden					2419		259	276	74	
10 February 2015 Eden					2419			82	118	
9 March 2015 Eden					2419		2419	250	1414	
13 April 2015 Eden					1986		1203	461	320	
23 April 2015 Deepwater channels (mid-channel sample)	293		629	302			2419			
6 May 2015 Eden					2419		2419	88		
19 May 2015 Eden					2419		866	47	120	
8 June 2015 Eden					1986		7	178	204	
22 June 2015 Eden					2419					
29 June 2015 Eden										
4 August 2015 Eden					2419		86	13	2419	
31 August 2015 Deepwater channels (mid-channel sample)		71	82	85			57			
9 September 2015 Eden					460		3000	120	3000	
15 October 2015					2900		1100	3700	2000	
13 November 2015					350		880	240	1980	
23 November 2015 Deepwater channels	Inconclusive									
01 December 2015					3000		3000	70	40	
14 January 2016					300		300	300	300	
11 February 2016					6600		1440	800	160	
15 March 2016					38		29	27	1	
07 April 2016					14400		7100	3200	8	
No samples	1	1	2	2	17	0	17	16	15	0
No times exceeding 400 (no. /100ml) limit	**0**	**0**	**1**	**0**	**14**	**0**	**11**	**4**	**5**	**0**
% exceeding 400 (no./100 ml) limit	**0%**	**0%**	**50%**	**0%**	**82%**	**n/a**	**65%**	**25%**	**33%**	**n/a**

Appendix 3: Proposed development option for Erf 12403



Appendix 4: Comments and responses report

Page / Section	Report statement	Comments	Changes made?	Author comment
COMMENTS ON DRAFT 1 OF AUGUST 2016				
Andries Fourie, Jazz Spirit, 14 August 2016 (by e-mail)				
	The REC of C was set in 2008 by DWA	Accepted	n/a	This means that the DWS decided to maintain the condition of the wetland in its (then) ecological condition of a "C" – this was estimated at 74.5% of the natural condition/health (relative to natural, which would have been 100% function/health). It is important to note that the Reserve methodology evaluates the deviation of the present state **away from natural**. The aim is therefore not to get everything back to a natural unimpacted state, but merely to show how far the current state is from the natural state. In this instance it was accepted that a Moderately Modified ecological condition (i.e. a C category wetland with 60-80% functionality) would be acceptable into the future.
		Erf 12403 is 19 4069 ha – the Report states that 51%-58% of the property is needed to achieve the REC of a C, so why can we not develop 49% of the property and the 51% remains Wetland. That 9% equates to 17,466m² - my reasoning is based on the fact if we are allowed to develop 40% of the property you must keep in mind close to 50% of that will go towards roads; parking and open space – which again can be designed to improve the Wetland - which we cannot sell/does not contribute to income directly.	n/a	1. This assumption stands if the DWS is prepared to still accept that just 71% of the site is functional wetland. Keep in mind that one groundwater report has shown that the water table remains very high across the site, and that this could be taken to conclude that the drivers of wetland conditions (high water table in this case) persist across the entire site. This is a very important point. If DWS was to decide that the whole site is functional wetland, then no development would be considered. 2. Note that the 51 to 58% range is because every ecological category is a band and not a single number.

Page / Section	Report statement	Comments	Changes made?	Author comment
		Continuation from previous page	n/a	3. Roads, parking etc. would be considered part of the developable portion. 4. Any smaller area of remaining wetland means that even a low C condition for the wetland is not attainable (for the overall site; taking in to account the reduced area). 5. The only option for proposing a smaller area of wetland be left is if the DWS/BGCMA were to accept a lower target condition for the wetland (see also C. Ebersohn's comment on this later). It is an option we could explore with them, if the socio-economic benefits of the development were to outweigh the ecological impacts of further wetland area loss, but the outcome of such a discussion is not certain and would go against the current national policy for managing wetlands. 6. Previous studies indicated low estimates of the wetland area, which do not seem to be substantiated by available scientific evidence, as ○ they contradict earlier detailed studies of Bornman and colleagues, ○ they do not match the evidence of the historical imagery, ○ groundwater monitoring information confirms an at least temporary or seasonally high water table (indicative of wetland conditions) across the entire site, ○ most of the site is within the Estuary Functional Zone, and ○ these low estimates of wetland area do not reflect the definition of wetlands as described in our legislation.

Page / Section	Report statement	Comments	Changes made?	Author comment
		Continuation from previous page	n/a	It seems that the extensive open spaces for parking and swimming arena/golf range shown on some of the plans do not take in to account the rather restricted development footprint issues that constrain development at the site. Perhaps it would be possible to put some of the parking requirements underneath residences/commercial spaces etc.?
		Is there no way something like a Golf Driving range could be developed as part of the Wetland/Scrubbing – function?	n/a	The scrubbing function is largely dependent on vegetation leaf area/biomass – plant productivity to remove elevated nutrients in the water. The saturated soils, frequent flooding and dense (largely tall reeds) vegetation necessary to achieve this do not seem suited to a driving range as no mowing of vegetation would be possible.
Colleen Ebersohn, Eco-Route Consulting, 30 August 2016 (telephonically with Dr Scherman)				
		How can we debate the earlier delineation when considered accurate by some parties?	n/a	We can only comment and compare the results of the various data sources, findings of previous studies and our own field observations (from both 2008 and 2016).
		Prof Fred Ellery said the process to define PES includes a scenario step.	n/a	The scenario steps are considered in detail in the report in steps 7 and 8 (future development options and consequences thereof). *Additional note: The Scenario step is not required to determine the PES as PES determination is undertaken during EcoClassification.*

Page / Section	Report statement	Comments	Changes made?	Author comment
		You did not consider or disputed the groundwater levels of a reputable company, i.e. Outeniqua Geotechnical Services. What evidence do you have for this, e.g. did you go and do more groundwater testing and dig more test pits etc. etc.	n/a	No new test pits were dug. The results of all three water table studies were presented and evaluated in Section 4 of this report (including the Outeniqua study). Water tables fluctuate, but it is the maximum seasonal level that is of critical importance (this would determine the extent of wetland conditions, but also affect foundations/damp issues/drainage of residences built within these areas).
		Where is the scientific data or process to define your C/D for present state.	No	The process for estimating the PES is describe in Section 5.2. The PES output tables from the 2008 and 2016 studies are shown as Appendix 1. The current C/D estimate of condition is in line with the national scoring system (the geo-morphology and some aspects of the hydrology remain intact, some natural vegetation persists and some impacts are recent and easily reversible). The PSP does not agree that this should be classified as an E or F condition wetland (such sites would be like parking lots or open cast mines) as these very low scores represent sites where all wetland function and attributes have been lost. This is not the case for the George Rex site.
		Janet Ebersohn does not agree that the REC should be a C.	No	The REC is indicated as a C because, although the PES is in a C/D condition, the importance of the site (motivations in Section 5.3) and that the degradation from a C to C/D condition is recent and easily reversible dictate that the DWS should aim to manage the wetland in a C condition. As indicated in our correspondence, the client can motivate for a lower REC for the site with DWS, but this would need to be motivated for in terms of critical regional/national socio-economic aspects (such as the concessions for open cast coal mines in that they are critical for energy security for the country).

Page / Section	Report statement	Comments	Changes made?	Author comment
Colleen Ebersohn, Eco-Route Consulting, 9 September 2016 (by e-mail)				
		I had an in depth telephonic discussion with Dr Scherman with regards to the report and the lack of clarity of certain issues (e.g. percentage developable area vs wetland area) and how these figures were calculated, e.g. on what data was it based as it seems that Mark Rountree used the previous Bornman report and discarded the recent Qutiniqua Lab report?	Clarification added to subsequent versions of the report	The Outeniqua results (Outeniqua Geotechnical Services, 2015) were also reviewed in preparing this report. Although the Outeniqua study indicated lower water table depths (1.4m - 2.0m below ground level) than the Bornman and Adams (2004) and WSP Environmental (2006) studies, that study (Outeniqua Geotechnical Services, 2015) indicated that soil mottling, a sign of prolonged seasonal soil saturation, typically occurs at much shallower depths (ranging from 0.25m to 1,6m below ground level). When the effects of infilling (artificial raising of the soil level through dumping/infilling of ex-situ material) are taken into account, it is clear that the seasonal water table is close to the natural (original) soil surface level for much of the site. The extensive reeds that persisted across the site in 2008 are testimony to the availability of near-surface water (Phragmites are obligate wetland plants – they can only survive in wetland soils).
		I am of the opinion that the report findings should be based on recent field data, Mark Rountree should revisit the site and re-investigate the current "in situ" situation. This will be the only way to gain final clarity to the actual extent of the wetland and the possible rehabilitation thereof. Without a report addressing these issues it would be very difficult to move forward with the EIA process.		As previously discussed, the PSP does do not believe more field time or additional specialist studies are required to confirm the two key issues for the site – that of (1) the extent of wetland (which is a fixed attribute of the site) and (2) the condition of the wetland (which is a function of the current condition and functionality). Wetland extent (in the legal sense) does not vary with time; and wetland condition changes slowly, but over years, not days. There are numerous data from many studies available to evaluate these two aspects of the site and we have spent considerable time scrutinizing these reports and data and used these in conjunction with the site observations.

Page / Section	Report statement	Comments	Changes made?	Author comment
		Continuation from previous page	n/a	1. The EXTENT of wetland on a property does not alter with infilling/ draining/ mowing, as the legal definition of wetlands is related to the natural circumstances of the site. A similar example would be the extent of the natural 1:100 year floodline along a river, which the DWS often uses to denote the regulated riparian zone along watercourses. The extent of the wetland is the key issue for this site. The records of maximum water table depths, extent of wetland-dependent plants and historical studies of the site provide objective and irrefutable evidence that wetland conditions existed and persist across much of the site. This information is evaluated in the report. If most of the site was terrestrial and not wetland, then there would be no need for any infilling of the site. That platforming will be necessary is indicative of wetland conditions (high water table and/or occasional flooding) at the site. 2. The CONDITION (also referred to as Present Ecological State) of the wetland is related to the current site conditions, and this can vary over time. The PSP field visit of April 2016, combined with the numerous available specialist reports that have been undertaken in the last decade, as well as the work done for DWS in 2008, provide a great deal of evidence as to the current conditions of the wetland. However, the condition is of the wetland is of secondary importance as it is the actual extent of wetland that is critical for determining the available developable area.

Page / Section	Report statement	Comments	Changes made?	Author comment
COMMENTS ON DRAFT 2 OF SEPTEMBER 2016				
Barbara Weston, DWS Directorate: Reserve Requirements, 6 December 2016				
Editorial changes				Editorial changes, and additions to the text, have been made throughout the document.
Section 1.2, pg 2	Proper conservation areas must be defined and protection clearly described	Add "…defined **and buffer zones delineated**, and protection clearly described."	No	Buffer zones have not yet been determined as, in line with the new approach developed by the Water Research Commission and advocated by the DWS, the widths of buffers is determined by the landuse activity type and range of mitigation actions employed in the development proposal. At this early stage of development planning, this information cannot yet be determined.
Section 1.2, pg 2		Add section on the 2008 Reserve study	Yes	
Section 1.3, pg 3		Change TEC to REC	Yes	
Section 3, pg 7		Maps of the extent of the wetland etc.		A map of the exact extent of wetland at the site is not yet provided as, except for the southwest corner which has a remnant patch of brackish/estuarine wetland remaining in it, the majority of the site is highly impacted by infilling and mowing. The exact footprint of the wetland that is to remain on the site can be moved around to accommodate proposed development so long as the area (the hectare equivalents required to meet the REC) can be met. It would be premature to constrain the proposed development of the site prior to these details being established.
Section 3, pg 7		Links to the estuary	No; not addressed in this section	The historic stronger links to the estuary are discussed in the Reference Conditions description of the report (Section 5.1)

Page / Section	Report statement	Comments	Changes made?	Author comment
Pg 11	In 2014, an additional wetland delineation study was undertaken by EcoRoute Consulting (2014).	Who did this? Why such a small percentage of ha remaining as wetland?	No	The study was undertaken by Janet Ebersohn. Results can be found in the following document: *Ebersohn, J. 2014. Erf 12403 Wetland Assessment Report.*
Section 6.2, pg 21. Section 6.4, pg 24. Section 6.5, pg 28		1. Pg 21: Need to make the link between the impacts on the Knysna Estuary and this proposed additional impact on George Rex wetlands. I don't see the important link of the George Rex wetlands in relation to the estuary. 2. Pg 24: Indicate and mark the Ashmead Channel and Bongani stream and explain in relation to the wetland/estuary. Also indicate the negative trajectory of this wetland. 3. Pg 28: You need to indicate the water quality impact sources on a map or in a figure to orientate the reader. It must be in relation to the wetland to be affected by the development. Emphasize how the maintenance of the wetland can benefit the water quality issues.	Yes	Addressed in Section 6.6. A Google Earth image has been inserted as Figure 6.8 and a concluding section (Section 6.6) added to the water quality chapter.
Figure 6.5	Figure 6.5 is a risk trend diagram for Knynsa LM WWTWs	Indicate with a red line water limit should be across the bar.	No	Not relevant to this type of information.
Chapter 7, pg 31.		1. Indicate that the wetland has been exposed to impacts already before 2008 due to lack of management. 2. Show Option II in a figure.	1. Yes 2. No	1. Text of Option I has been revised. 2. A map has not been included as the development should not yet be constrained on the site. Although the current proposed development option has been mapped, it is overlain on the 2014 (incorrect) wetland delineation. This plan is shown in Appendix 3, but as an interim option for information purposes only.

Page / Section	Report statement	Comments	Changes made?	Author comment
Chapter 8, pg 32; pg 33. Chapter 9, pg 36.		You need to show the recommended scenario i.e. REC=C, in a diagram/google so that one can visually get an idea of what is lost/gained etc. This is missing: - Indicate reference wetland - Development pre-2008 - Decline of wetland - Proposed REC=C delineation This report needs a proper final plan of the scenario, schematically.	No	It is not possible to provide a single diagram of what a C category wetland should look like. The exact footprint of the wetland that is to remain on the site can be moved around to accommodate proposed development so long as the area (the hectare equivalents required to meet the REC) can be met. It would be premature to constrain the proposed development of the site prior to these details being established. It is also not possible to provide additional photographs/maps of what the wetland would have looked like in reference state etc., other than that which is already provided in the report (see Figure 4.1 for the historic vegetation distribution superimposed over a 1936 aerial photograph). Chapter 4 also includes a description of the 2003 wetland, with Figure 4.4 showing the impact of mowing between 2008 and 2016, and Figure 5.2 shows vegetation changes from 2003 to 2016. Note that Appendix 3 shows the current development option on the table. However this should not be considered the final plan as the development can still be optimized in terms of space and design, to meet DWS requirements.
Table 8.2, Scenario II, Economic feasibility column.	The low development footprint is considered economically unviable by the developer and this scenario is not considered feasible from an economic/development perspective.	No. Can't say this, as it is only one use or one type of developer it is unfeasible for. If economic feasibility is to be assessed, would need higher confidence or classification.	Yes	Text adjusted to read as follows: *The low development footprint is considered economically unviable by the current developer and this scenario is not considered feasible for the current proposed project.*
Chapter 9, pg 36		What about combining the benefit of creating a recreational area i.e. walkways, birdwatching?	Yes	Text been adapted accordingly.

Page / Section	Report statement	Comments	Changes made?	Author comment
Chapter 10, pg 37		Need to properly delineate this wetland – related to REC and peg the bufferlines and potentially set TPCs to manage		1. Confirmed with reviewer that the intent of the comment was for a **diagram** of the delineated wetland; and not to redo the delineation. 2. Bufferlines cannot be included until the final footprint of the wetland that is to remain on the site has been determined. The proposed development footprint can be moved around as long as the area or hectare equivalents required to meet the REC, can be met. 3. The PSP contract includes the preparation of a Monitoring Programme, which would include the preparation of TPCs (Thresholds of Probable Concern). This task will be completed once a final development option has been agreed on for the wetland.
Chapter 10, pg 37	DWA (2013) ….. surface water inputs, smaller buffers are likely to be sufficient to mitigate runoff from the catchment …. surface runoff.	What does "smaller buffers" mean?		The smaller buffers are related to a probable 20-30m buffer being adequate for protection, versus a larger 50 – 100m buffer. A tool is used to define the width of the buffer needed, depending on factors such as the wetland, its current state, impacts and surrounding landuse.
Shaddai Daniels, DWS Bellville, 17 January 2017				
		This sub directorate is satisfied with the report and it is of utmost importance that the wetlands remain in a C category as a very minimum requirement in terms of functionality, as indicated in the 2008 reserve. It is also important since it feeds into the estuary which must be managed in a pristine or close to pristine condition.		No action required.

Page / Section	Report statement	Comments	Changes made?	Author comment
		This report together with the other information required in terms of a S21 (c) and (i) application must be submitted for the WULA process and all impacts associated with pre, during and post construction phases must speak to the preferred option (as indicated in the report to be option 3b). Once all of these documents are received and assessed, cumulative impacts will be looked at together with the proposed mitigation measures and these will be conditioned into the license if approved.		No action required.
Breede-Gouritz Catchment Management Agency, 27 January 2017				
		It was indicated that the previous study was a "desktop" low confidence study. For future developments a higher confidence study with some validated observations are required.	No	Much information and data for the site has been collected since the 2008 assessment, and a number of new specialist studies have been undertaken in the interim. The input information available was considered sufficient for a higher confidence study, with the following tasks undertaken to fulfil the requirements of a higher confidence study (as outlined in Chapter 1): 1. Update of the PES, EIS and REC, as required. 2. Scenario selection and ecological consequences

Page / Section	Report statement	Comments	Changes made?	Author comment
		1. Note that a proper diagram with the wetland and proposed development need to be outlined. It is important to indicate sensitive, vulnerable and high functional areas of the wetland. 2. Linkages to the estuary also needs to be indicated.	Yes	1. Appendix 3 shows the current proposed development option, but for information purposes only. This should not be considered the final plan as the development can still be optimized in terms of space and design, to meet DWS requirements. The sensitive and functional areas of the wetland have been clarified in the text (Chapter 4). 2. Figure 6.8 shows the potential link to the estuary in the southwestern corner of the site.
		The Reserve Report should indicate the impacts of the Knysna WWTW on the wetland and estuary. It is important to mention water quality and wastewater inflows. Final effluent discharge volumes will increase in future, so indicated expected impacts on the wetland and estuary.	Yes	Although the text covered this point adequately as is required for a Reserve Report (and not an impact assessment), some clarifications have been added.
		Please look at the water quality of present freshwater systems and its impacts on both the wetland and estuary.	No	This was covered in Chapter 6.
Pg 21		A link between the impacts on the Knysna estuary and the proposed additional impacts on George Rex wetland need to be made.	Yes	Text has been adapted accordingly.
Pg 24		Please indicate Ashmead and Bongani Stream in a figure/map and explain the relations to the wetland and estuary. Also emphasise how the maintenance of the wetland can benefit water quality issues.	Yes	See Figure 6.8 and Section 6.6

Page / Section	Report statement	Comments	Changes made?	Author comment
		Eden District Municipality monitor the Knysna Lake System on a monthly basis. Please provide a table indicating water quality results for the last year.	Yes	The data from Eden DM was sourced from Vernon Gibbs-Hall in April 2016, during preparation of the first version of this report. Data are included as Appendix 2 for the last year of data and for selected sites.
Pg 27		Please provide summary and trend analysis as indicated in Table 6.1.	Yes	A summary has been provided. The value of trend analysis is unclear. The data in the table clearly shows non-compliance with discharge standards, which is an issue to be addressed as part of management the WWTW. The impact of non-compliant discharges on the ecosystem are clear.
Pg 28		Make use of water quality guidelines for aquatic use.	No	Aquatic ecosystem guidelines are resource-based, while the data provided in Table 6.1 (now Table 6.3) is for the final effluent. If aquatic ecosystem guidelines are to be used, they must be applied at a point in the resource downstream of the outlet from the WWTW. Also please note that aquatic ecosystem guidelines do not exist for faecal coliforms or *E.coli* as these are human-health or recreational issues only.
		Please include diagrams and figures in the report as requested by Ms Weston of CD:WE, DWS.	Yes	Ms Weston's comments have been addressed as far as possible. See changes in the text and replies to her comments as shown above in this table.