GEORGE
TEL: +27 (0) 44 873 4923 **FAX:** +27 (0) 44 874 5953
EMAIL: info@sescc.net **WEBSITE:** www.sescc.net
ADDRESS: 102 Merriman Street, George 6530
PO BOX: 9087, George , 6530

CAPE TOWN
TEL: +27 (0) 21 554 5195 **FAX:** +27 (0) 86 575 2869
EMAIL: betsy@sescc.net **WEBSITE:** www.sescc.net
ADDRESS: Tableview, Cape Town, 7441
PO BOX: 443, Milnerton, 7435

AQUATIC BIODIVERSITY IMPACT ASSESSMENT

for the proposed

DEVELOPMENT OF THE REMAINDER OF ERF 464, ADJACENT TO THE GARDEN ROUTE DAM, GEORGE

PREPARED FOR:	George Local Municipality Contact Person: Delia Power 71 York Street George 6530 Tel: 044 801 9111	**PREPARED BY:**	Sharples Environmental Services cc Contact Person: Debbie Fordham 102 Merriman Street George 6530 Email: debbie@sescc.net
			DATE: 20 September 2021

AQUATIC SPECIALISTS

Specialist	Qualifications / Affiliations	Details
Debbie Fordham	MSc - Environmental Science BAH (Hons) - Environmental Science BA – Environmental Science & Geography A member of the South African Wetland Society, Society for Wetland Scientists, the Southern African Association of Geomorphologists, amongst other organisations	Debbie is a qualified aquatic ecologist and environmental scientist. Debbie holds a BA (Environmental Science and Geography), BA (Hons) and M.Sc. in Environmental Science from Rhodes University. She was awarded her Master of Science degree, by thesis, in Wetland Ecology, entitled: The origin and evolution of the Tierkloof Wetland, a peatland dominated by Prionium serratum in the Western Cape. She has specialised in aquatic habitat assessment and has been consulting producing numerous aquatic habitat impact assessment reports. She is well established in her specialist field and has worked in various provinces within South Africa. She is familiar with the latest water resource related legislation and the processes that are required.
Dr Brian Colloty (Review scientist)	(Pr Sci Nat 400268/07) B.Sc. Degree (Botany & Zoology) - NMMU B.Sc. Hon (Zoology) - NMMU M.Sc. (Botany - Rivers) - NMMU PhD (Botany – Estuaries & Mangroves) – NMMU Professional Natural Scientist (Pr.Sci.Nat) in Ecology – The South African Council for Natural Scientific Professions (SACNASP)	Ecologist & Environmental Assessment Practitioner (Pr. Sci. Nat. 400268/07). Member of the South African Wetland Society. 25 years' experience in environmental sensitivity and conservation assessment of aquatic and terrestrial systems inclusive of Index of Habitat Integrity (IHI), WET Tools, Riparian Vegetation Response Assessment Index (VEGRAI) for Reserve Determinations, estuarine and wetland delineation throughout Africa. Countries include Mozambique, Kenya, Namibia, Central African Republic, Zambia, Eritrea, Mauritius, Madagascar, Angola, Ghana, Guinea-Bissau and Sierra Leone. Current projects also span all nine provinces in South Africa.

INDEMNITY AND COPYRIGHT

Report citation:

Sharples Environmental Services cc. 2021. Aquatic Biodiversity Impact Assessment for the development of the Remainder of Erf 464, adjacent to the Garden Route Dam, George.

REPORT REQUIREMENTS

Specialist report requirements in terms of Appendix 6 of the 2014 EIA Regulations (as amended 2017):

1. (1) A specialist report prepared in terms of these Regulations must contain—

(a) details of— (i) the specialist who prepared the report; and

(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;

(b) a declaration that the specialist is independent in a form specified by the competent authority;

(c) an indication of the scope of, and the purpose for which, the report was prepared;

(cA) an indication of the quality and age of base data used for the specialist report;

(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;

(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;

(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;

(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;

(g) an identification of any areas to be avoided, including buffers;

(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;

(i) a description of any assumptions made and any uncertainties or gaps in knowledge;

(j) a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;

(k) any mitigation measures for inclusion in the EMPr;

(l) any conditions for inclusion in the environmental authorisation;

(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;

(n) a reasoned opinion—

(i) whether the proposed activity, activities or portions thereof should be authorised;

(iA) regarding the acceptability of the proposed activity or activities; and

(ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;

(o) a description of any consultation process that was undertaken during the course of preparing the specialist report;

(p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and

(q) any other information requested by the competent authority.

EXECUTIVE SUMMARY

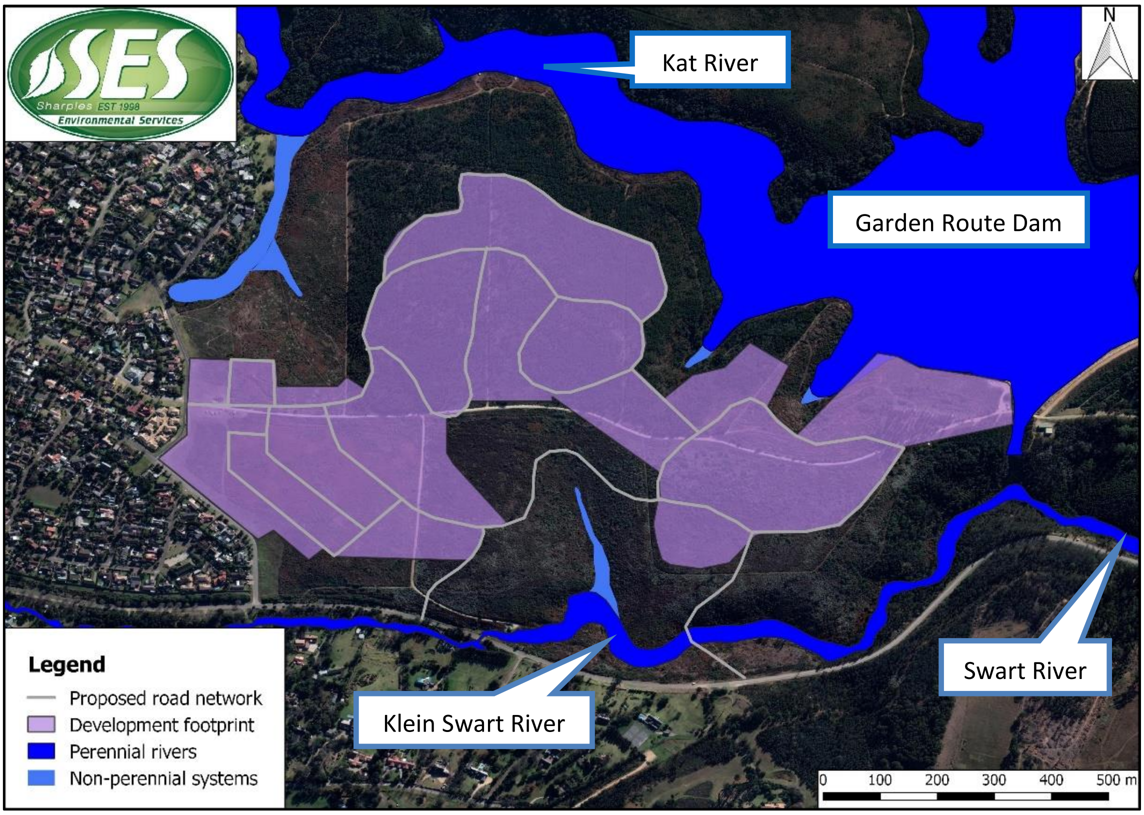
Introduction

The George Municipality is planning to develop a college or university, housing, and recreational open spaces on a remainder of a portion of Erf 464, near the Garden Route Dam in George. The property lies between the dam in the north and east, and the Klein Swart River that flows in an easterly direction on the southern boundary of the property before these systems converge. The site is undeveloped except for gravel roads and bulk infrastructure crossing the proposed development area.

Three alternatives were provided for aquatic impact assessment, namely:

- Alternative 1: the original site layout plan
- Alternative 2 (preferred alternative): the revised development layout plan
- 'No Go' Alternative: no development and the status quo remains

One of the key differences between the revised layout (preferred development alternative) and the original (Alternative 1) is the reduced development footprint and the increase in Open Space area. The map below shows the location of the preferred development layout (Alternative 2) in relation to the existing residential area and nearby water resources.



Historic impacts

Decades ago, the site was cleared for forestry and associated watercourse road crossings. Following this, the Kat and Swart Rivers were dammed and back-flooded to create the Garden Route Dam. In approximately 2006 the plantation was harvested and although indigenous vegetation re-established, the composition was altered, and alien invasive plant species encroached. These past anthropogenic changes to land use and disturbance of land cover in the catchments has significantly impacted the watercourses of the study area. However, despite the modified present ecological state of the aquatic ecosystems, any further impacts upon their characteristics (habitat, biota, geomorphology, and water quality) must be prevented. Therefore, the identified aquatic ecosystems, which may potentially be impacted upon by the project, underwent detailed assessment.

Identified aquatic habitats

Kat River

The Kat River is a perennial stream with its source in the Outeniqua Mountains above the town of George. It flows along the edge of the developed area and then becomes dammed shortly upslope of the confluence with the Swart River to the south. The physical character of the Kat River changes significantly over a relatively short longitudinal distance. There is a steady decrease in the quality of river habitat in a downstream direction. Towards the confluence with the Swart River the channel becomes completely transformed by the impoundment. Additionally, the river and dam receive pollutants from the urban area. Disturbance-tolerant and alien invasive species have largely replaced the more sensitive indigenous species adapted to free-flowing conditions. Therefore, the reach of the Kat River assessed (on the northern boundary of the property and dam edge) obtained a 'D' ecological category score for present ecological state (PES) as it is Largely Modified from the natural condition. There has been a large loss of natural habitat, biota, and basic ecosystem functions. The Kat River was determined to be of High ecological importance and sensitivity (EIS) as it is part of an important corridor network and the provision of water by the dam is an important service to society.

Klein Swart River Wetland

The reach of the Klein Swart River system that will be impacted by the proposal can be classified as a channelled valley bottom wetland. The wetland has been subjected to impacts caused by past forestry activities, infrastructure, and alien invasive plant species infestation. Any proposed development within this catchment will result in further impacts on the watercourse. The PES of the Klein Swart River Wetland is also Largely Modified and received an overall 'D' ecological category. The EIS level and functional importance of the Klein Swart River Wetland was determined to be Moderate. It provides very limited direct human benefits but has moderate significance regarding indirect services. It is recommended that the development proposal incorporate basic measures to make improvements in ecological functioning (such as alien plant eradication, water quality management, and stabilisation of eroded areas).

Drainage Lines

There are three small drainage lines that concentrate runoff from the property into the Kat River and dam, and there is one tributary draining in a southernly direction into the Klein Swart River Wetland. These tributaries are small natural systems with temporary flow. The four drainage systems will have been impacted upon in the past by forestry activities associated with the planation on the property, but they are not currently subjected to anthropogenic impacts. Historically these systems would have been classified as episodic streams which merged with the Swart River before it was dammed, and the drainage lines were flooded.

Hillslope seep and out flowing stream

There is a small hillslope seep located at the head of a drainage line, in the north western portion of the site, that develops into a channel and joins the Kat River. The system receives stormwater from the existing road network and lateral inputs from urban development along the riparian edge. Invasive alien plant species dominate the disturbed site. The PES of the wetland system is defined as Moderately Modified represented by an overall 'C' category and with the adoption of a buffer area the system can be maintained in its present condition. It is recommended that efforts are made to improve the vegetation and water quality components.

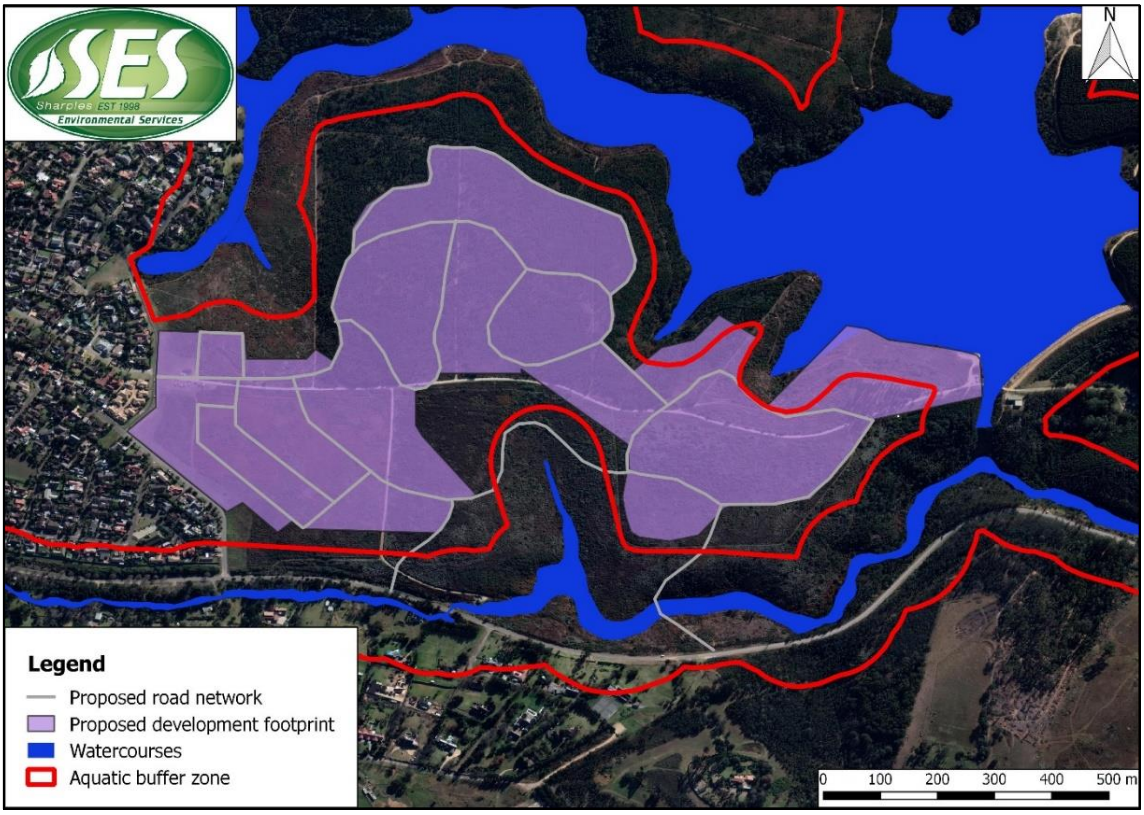
Impact Assessment

The impact significance of the proposed development was determined for each potential impact of the project alternatives. The No Go Alternative was determined to have no impact and is the preferred alternative for aquatic biodiversity. The most severe potential impacts associated with the development will likely be erosion and sedimentation in the operational phase, as a result of new road crossings and increase in hardened surfaces, as well as changes in water quality characteristics from stormwater runoff

Of the alternatives assessed, the original layout (Alternative 1) poses the greatest threat to aquatic biodiversity. Without mitigation, the Alternative 1 layout has unacceptably high impacts upon aquatic habitat. While this impact significance is substantially reduced if mitigation is successfully implemented, the Alternative 2 layout still remained the preferred development alternative. The Alternative 2 layout has been designed to incorporate more of the recommended aquatic buffer areas (excepting the hotel and waterfront areas). While the preferred alternative still has potential to cause medium impacts upon the identified aquatic habitats (even after mitigation) there are no high impacts anticipated. Even with active management, activities and infrastructure in close proximity to watercourses will always pose a threat to their ecological integrity. Therefore, despite the medium risk of water pollution and erosion in the operational phase, the preferred alternative is still deemed acceptable from an aquatic ecological perspective.

Aquatic Buffer Zone

Buffer areas, applied in conjunction with other measures, can be very effective in mitigating impacts from development upon aquatic habitat. The final buffer areas determined for this project are relatively large, beyond 100 m in width in most locations and should be treated as No-Go zones for development (apart from road crossings which cannot be avoided). Only very low impact activities, such as hiking footpaths, cycling tracks, and birdwatching (which do not require hard infrastructure) should be allowed within the buffer zone, but there must be no intrusion into the wetland areas. The map below indicates the minimum recommended buffer area in relation to the preferred alternative (Alternative 2 layout). The hard infrastructure associated with the business zone should be set back from the dam edge and areas surrounding the buffer should be used for low impact activities as a transitional area.



Mitigation (excerpt)

- The stormwater management infrastructure must be designed to ensure the runoff from the development is not highly concentrated before entering the buffer area. The volume and velocity of water must be reduced through discharging the surface flow at multiple locations surrounding the development, preventing erosion. It is therefore recommended that the stormwater management plan be developed with the incorporation of Sustainable Drainage Systems (SUDS). The SUDS systems attempt to maintain or mimic the natural flow systems as well as prevent the wash-off of urban pollutants to receiving waters.
- Sewerage pump stations should not be located within 100 m of a watercourse and man holes should not be placed within the freshwater habitat. Reasonable measures must be taken to provide back-up for mechanical, electrical, operational or process failure and malfunction at pump stations. Emergency power shall be provided that will prevent overflows from occurring during any power outage. In consideration to South Africa's loadshedding events, these measures must be permanently on site at each station. Pump stations will need to be placed within a suitably lined, impermeable concrete bunded area with the capacity to hold untreated waste water in an emergency and provide for sufficient time for maintenance staff to address any faults/ problems. This is to limit the risk of untreated sewage overflowing in the event of any leakage or accidental spillage at the pump station.
- The recommended installation and maintenance of stormwater inlet grates and grease traps/oil separators to prevent pollutants from entering the environment from stormwater. Key maintenance will include litter and sediment clearing and the servicing and maintenance of key collection points like catch pits, detention tanks etc.
- During construction, measures to contain impacts caused during high rainfall events (such as substantial sedimentation and/or erosion) must be planned for and available for use. All bare slopes and surfaces to be exposed to the elements during clearing and earthworks must be protected against erosion using rows of silt fences, sandbags, hay bales and/or earthen berms spaced along contours at regular intervals. Stockpiles must not be located within 50 metres of the wetland, dam, and must avoid the riparian buffer. The furthest threshold must be adhered to. Erosion control measures including silt fences, low soil berms and/or shutter boards must be put in place around the stockpiles to limit sediment runoff from stockpiles. Alternatively, the exposed slopes must drain into small temporary stormwater and silt traps/ponds.
- The extent of infilling within the aquatic habitat for the bridge must be minimised as far as possible, demarcated, and crossings must be constructed perpendicular to the natural direction of flow.
- Promote the use of the open space area (whilst avoiding activities within wetland habitat) for recreational activities. Surrounding the dam buffer area, walkways, picnic benches, or cycling

trails, are potential low impact land uses that are unlikely to impact upon the aquatic habitat. Promoting a sense of ownership from the residents of their open space area will benefit them as well as the environment.

- A monitoring programme shall be in place, not only to ensure compliance with the EMPr throughout the construction phase, but also to monitor any post-construction environmental issues and impacts such as increased surface runoff. The monitoring should be regular and additional visits must be taken when there is potential risk to aquatic habitat. Any construction within wetland habitat, such as bridge and pipeline crossings, must be monitored daily. The ECO may request that the Project Manager suspend part or all the works. The landowners and community could be involved in the long-term monitoring and rehabilitation.
- It is recommended that a wetland rehabilitation plan be developed and implemented to conserve the aquatic habitat in the Klein Swart River and Kat River. It would aim to halt the channel erosion and remove invasive vegetation in a sensitive manner.

Conclusion

The No Go Alternative is preferred from an aquatic perspective as it will not impact upon the watercourses and the PES will be maintained. However, should development be unavoidable, the Alternative 2 scenario (which largely incorporates recommendations of this report) will not cause any unacceptable impacts upon aquatic habitat (with the adoption of the recommended mitigation measures and EMPr).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

CBA- Critical Biodiversity Area

DEA&DP-Western Cape Department of Environmental Affairs and Development Planning

DWAF - (Former National)Department of Water Affairs and Forestry

DWS- Department of Water and Sanitation

ECO- Environmental Control Officer

EIA- Environmental Impact Assessment

EIS- Ecological Importance and Sensitivity

EMP - Estuary Management Plan

EMPr- Environmental Management Programme report

EPL - Ecosystem Protection Level

ETS - Ecosystem Threat Status

ESA- Ecological Support Area

FEPA- Freshwater Ecosystem Priority Area

GPS- Geographic Positioning System

HGM - Hydrogeomorphic (wetland type(s))

NBA - National Biodiversity Assessment

NFEPA- National Freshwater Ecosystem Priority Area

NWA- National Water Act

NWM - National Wetland Map

PES- Present Ecological State

REC- Recommended Ecological Category

SAIIAE - South African Inventory of Inland Aquatic Ecosystems

SANBI - South African National Biodiversity Institute

SES- Sharples Environmental Services

SWSA - Strategic Water Source Areas

WCBSP - Western Cape Biodiversity Spatial Plan

WWTW - Wastewater Treatment Works

GLOSSARY

Alien vegetation: plants that are not indigenous to a particular area.

Aquatic ecosystem: an ecosystem that is permanently or periodically inundated by flowing or standing water, or which has soils that are permanently or periodically saturated within 0.5 m of the soil surface. (Ollis *et al.,* 2013)

Aquatic impact buffer zone: a strip of land with a use, function or zoning specifically designed to protect one area of land against impacts from another. A buffer zone which acts as a barrier between human activities and sensitive water resources thereby protecting them from adverse negative impacts (McCarthy & Bredin 2016)

Artificial: produced by human beings, not naturally occurring.

Biodiversity Corridor: typically linear habitats that differ from a more extensive, surrounding matrix, designed to link one or more patches of habitat to improve species movement and dispersal.

Catchment: the land area from which water runs off into a specified wetland or aquatic ecosystem

Channel: a landform consisting of two distinct banks and a bed that continuously or periodically conveys flowing water.

Channelled valley-bottom wetland: a valley-bottom wetland with a river channel running through it. Channelled valley bottom wetlands are characterised by their position on valley floors and the absence of characteristic floodplain features. Dominant water inputs to these wetlands are from the river channel flowing through the wetland, either as surface flow resulting from flooding or as subsurface flow, and/or from adjacent valley-side slopes (as overland flow or interflow). (Ollis *et al.,* 2013)

Concentrated flow: a flow of water contained within a distinct channel. Rivers are characterised by concentrated flow, either permanently or periodically.

Dam (in-channel): an artificial body of water formed by the unnatural accumulation of water behind an artificial barrier that has been constructed across a river channel or an unchannelled valley-bottom wetland.

Dammed: as relates to a depression, where an artificial barrier across a channel, valley-bottom wetland or seep has led to the unnatural accumulation of water, thus forming a depression with its outflow drainage determined by the nature or operation of the artificial barrier.

Delineation (of a wetland): the determination of the boundary of a wetland based on soil, vegetation and/or hydrological indicators.

Diffuse (surface or subsurface) flow: when water flow is not concentrated within a distinct channel but is rather spread as sheet-flow on the ground surface, or as seepage below the ground surface.

Ecosystem: a biological community of interacting organisms and their physical environment.

Erosion: Physical and chemical processes that remove and transport soil and weathered rock.

Evaporation: the loss of water from a free water surface or from the soil surface by vaporisation.

Excavation: an artificial depression created by digging out material from the ground

Flow regime (as relates to a river): the frequency, timing and duration of flow.

Groundwater: subsurface water in the saturated zone below the water table (i.e. the water table marks the upper surface of groundwater systems).

Hydrogeomorphic: a combination of hydrology (i.e. the nature of the movement of water) and geomorphology (i.e. landform characteristics and processes).

Hydrogeomorphic (HGM) type: one of the seven primary HGM Units of the Ollis *et al.* (2013) Classification System, namely: river, floodplain wetland, channelled valley-bottom wetland, unchannelled valley-bottom wetland, depression, seep or wetland flat.

Hydrogeomorphic (HGM) unit: a type of aquatic ecosystem distinguished on the basis of, (i) landform (which defines the shape and localised setting); (ii) hydrological characteristics (the nature of water movement into, through and out of the ecosystem); and (iii) hydrodynamics.

Hydrological regime: the typical cycle of water movement in an aquatic ecosystem.

Indigenous vegetation: plants that are naturally occurring in a particular area.

Infiltration: downward permeation of water below the ground surface, either into the soil or into the groundwater.

Intermittent (as relates to non-perennial flow regime): water flows for a relatively short time of less than one season's duration (i.e. less than approximately 3 months), at intervals varying from less than a year to several years.

Intermittently inundated: holding surface water for irregular periods of less than one season (i.e. less than approximately 3 months), at intervals varying from less than a year to several years.

Intermittently saturated: with all the spaces between the soil particles filled with water for irregular periods of less than one season (i.e. less than approximately 3 months). This corresponds to the 'temporary (outer) zone' of a wetland, according to the terminology used in the DWAF (2005) wetland delineation manual.

Inundated: covered by water (water is observably present at the surface).

Mountain headwater stream (as relates to river zonation): a very steep-gradient stream dominated by vertical flow over bedrock with waterfalls and plunge pools. Normally first or second order. Reach types include bedrock fall and cascades. Characteristic gradient greater than 0.1.

Mountain stream (as relates to river zonation): steep-gradient stream dominated by bedrock and boulders, locally cobble or coarse gravel in pools. Reach types include cascades, bedrock fall, step-pool, plane bed. Approximate equal distribution of 'vertical' and 'horizontal' flow components.

Natural: existing in, or produced by, nature; not made or caused by humankind.

Non-perennial (as relates to flow regime): does not flow continuously throughout the year, although pools may persist.

Perennial (as relates to flow regime): flows continuously throughout the year, in most years.

Plantation: an area in which trees have been planted, especially for commercial purposes, in contrast to a forest consisting of indigenous or alien invasive trees.

Precipitation: any form of water that falls to or condenses on the ground (including rain, snow, etc).

Present Ecological State: the current state or condition of an environmental resource in terms of its characteristics and reflecting change from its reference condition

Rehabilitation: restoring processes and characteristics that are sympathetic to, and not conflicting with, the natural dynamic of an ecological or physical system.

Riparian zone or **riparian area**: area of land directly adjacent to the active channel of a river, which is influenced by river-induced or river-related processes. The South African National Water Act (Act No. 36 of 1998) defines 'riparian habitat' to include "...the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas."

River: a linear landform with clearly discernable bed and banks, which permanently or periodically carries a concentrated flow of water. A river is taken to include both the active channel and the riparian zone as a unit.

River reach: a length of river characterised by a particular channel pattern and channel morphology, resulting from a uniform set of local constraints on channel form. A river reach is typically hundreds of meters in length.

Seasonally inundated: with surface water present for extended periods during the wet season/s (generally between 3 to 9 months duration) but drying up annually.

Seasonally saturated: of wetland soils, with all the spaces between the particles filled with water for extended periods (generally between 3 to 9 months duration), usually during the wet season/s, but dry for the rest of the year. This corresponds to the 'seasonal zone' of a wetland, according to the terminology used in the DWAF (2005) wetland delineation manual.

Sedges (herbaceous vegetation type): stiff, grass-like plants of the family Cyperaceae, sometimes referred to as 'nutgrasses'. Sedges are distinguished from grasses in that they do not have a leaf sheath (their leaves are attached directly to the culm or stem) or when they do, it is closed around the culm, where grasses have an open leaf sheath.

Seep: a wetland area located on gently to steeply sloping land and dominated by the colluvial (i.e. gravity-driven), unidirectional movement of water and material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically, extend onto a valley floor. Water inputs are primarily via subsurface flows from an up-slope direction

Seepage: percolation of water through a soil layer, as subsurface flow.

Slope: an inclined stretch of ground typically located on the side of a mountain, hill or valley, not forming part of a valley floor. Includes scarp slopes, mid-slopes and foot-slopes.

Strategic Water Source Areas: areas of land that either: (a) supply a disproportionate (i.e. relatively large) volume of mean annual surface water runoff in relation to their size and so are considered nationally important; or (b) have high groundwater recharge and where the groundwater forms a nationally important resource; or (c) areas that meet both criteria (a) and (b). (Le Maitre *et al.,* 2017).

Substratum: the material that constitutes the bottom of an aquatic ecosystem.

Terrestrial: of or on dry land; outside the boundaries of a wetland or other aquatic ecosystem.

Upper foothills (as relates to river zonation): moderately steep, cobble-bed or mixed bedrock-cobble bed channel, with plane bed, pool-riffle or pool-rapid reach types.

Unchannelled valley-bottom wetland: a valley-bottom wetland without a river channel running through it. These wetlands are characterised by their location on valley floors, an absence of distinct channel banks, and the prevalence of diffuse flows (Ollis *et. al.,* 2013).

Valley-bottom wetland: a mostly flat wetland area located along a valley floor, often connected to an upstream or adjoining river channel.

Watercourses: includes both the channel and banks of all rivers, springs, and natural channels in which water flows regularly or intermittently.

Wetland: land that 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 (National Water Act (Act No. 36 of 1998)).

1 INTRODUCTION

Sharples Environmental Services cc (SES) has been appointed by *George Municipality*, to undertake an aquatic habitat impact assessment and water use authorisation application for the proposed development of vacant land (RE/Erf 464), near the Garden Route Dam, in George. The property lies between the dam in the north and east, and the Klein Swart River that flows in an easterly direction on the southern boundary of the property before these systems converge. An artificial spillway for the dam lies within a steep-sided valley at the eastern edge of the study area. There is potential for the water resources within the study area to be negatively impacted upon by the project, and therefore specialist input is required, to inform the environmental and water use authorisation processes.

1.1 Location

The development will be within the urban edge of George, a town in the Garden Route of the Western Cape. The property to be developed is the vacant Erf 464 which is located on the eastern side of the town, adjacent to the Garden Route Dam (Figure 1). The site is bordered by the dam and Kat River to the north and east; the Klein Swart River to the south; and the adjacent neighbourhoods, Eden, and Loerie Park, to the west.

Figure 1: Google satellite imagery showing the location of the study area in relation to George

1.2 Alternatives

The site is currently vacant, with various gravel roads on the site being utilised for recreational activities. This property falls within the urban edge of the George Municipality. It is proposed to construct a tertiary education campus, with associated residential units and open spaces. Figure 2 below is the originally proposed site layout plan for the development, which is assessed as Alternative 1.

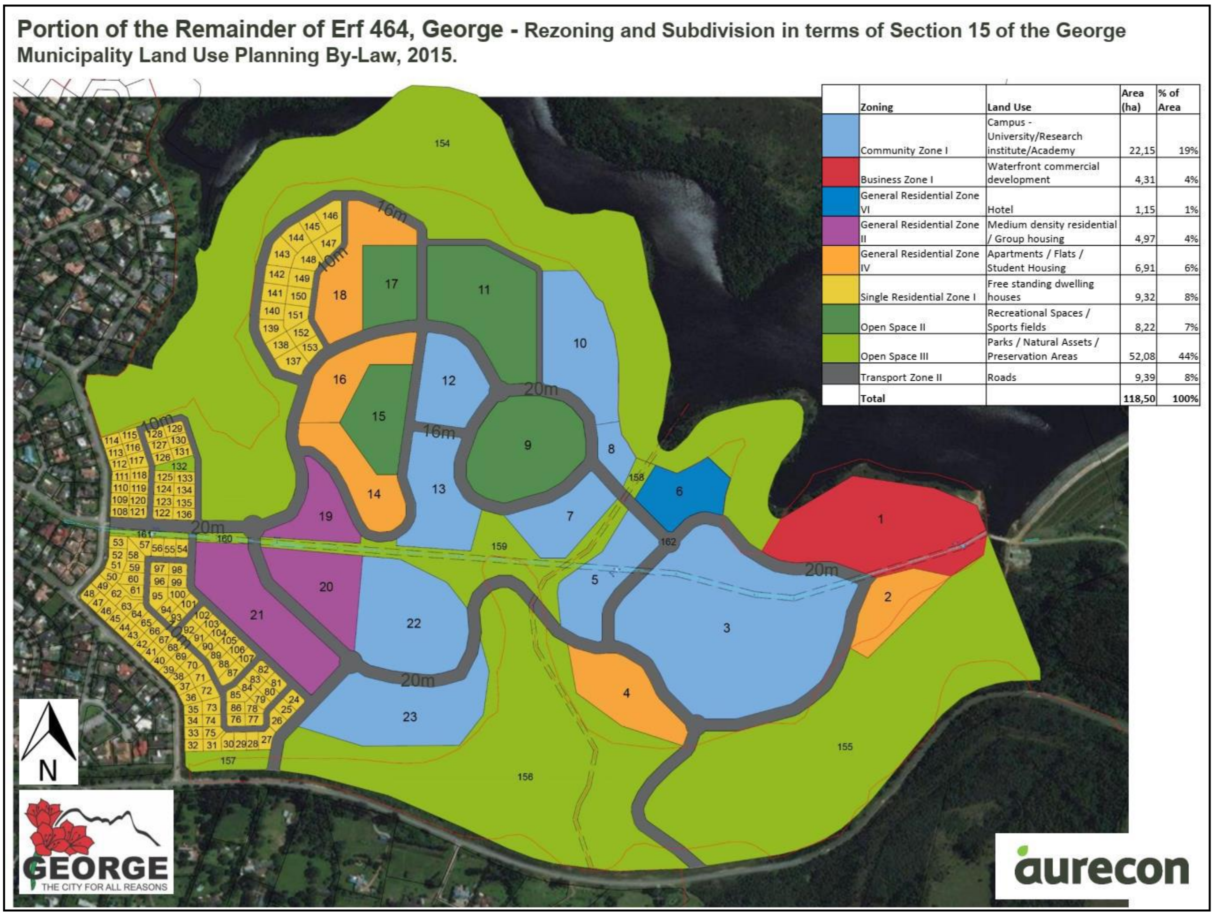


Figure 2: Original proposed layout assessed as Alternative 1

After various feasibility studies, socio-economic analyses, stakeholder workshops and site visits with a range of specialists, a revised site layout plan (Figure 3), was then designed. One of the key differences between this revised alternative layout and the original (Alternative 1) is the reduced development footprint and the increase in Open Space area. The Public Open Spaces account for > 57% of the development proposal.

Additionally, the proposed development footprint has been set back farther from the watercourses (excepting Business Zone 1, a waterfront commercial development, which was previously granted environmental authorisation under the NEMA (2014, as amended)). Retaining an undeveloped area around sensitive natural resources creates a buffer between incompatible land uses. Sensitive areas zoned as Open Space 3 can be conserved and properly managed, whilst still allowing access for passive recreational use. The alternative layout provides for significantly more Open Space zoning. The revised conceptual site layout plan is assessed as Alternative 2 (the preferred alternative).

The “no-action” alternative was also assessed. It implies a continuation of the current situation or the status quo. It provides a baseline against which to assess the relative impacts of other alternatives. It also assumes that regulations such as Duty of Care and alien invasive plant management under CARA (Conservation of Agricultural Resources Act No. 43 of 1983) will be implemented by the landowner. Currently there is a significant level of alien invasive plant infestation on site. The No-Go alternative assessed assumes that alien invasive plants will be appropriated managed.

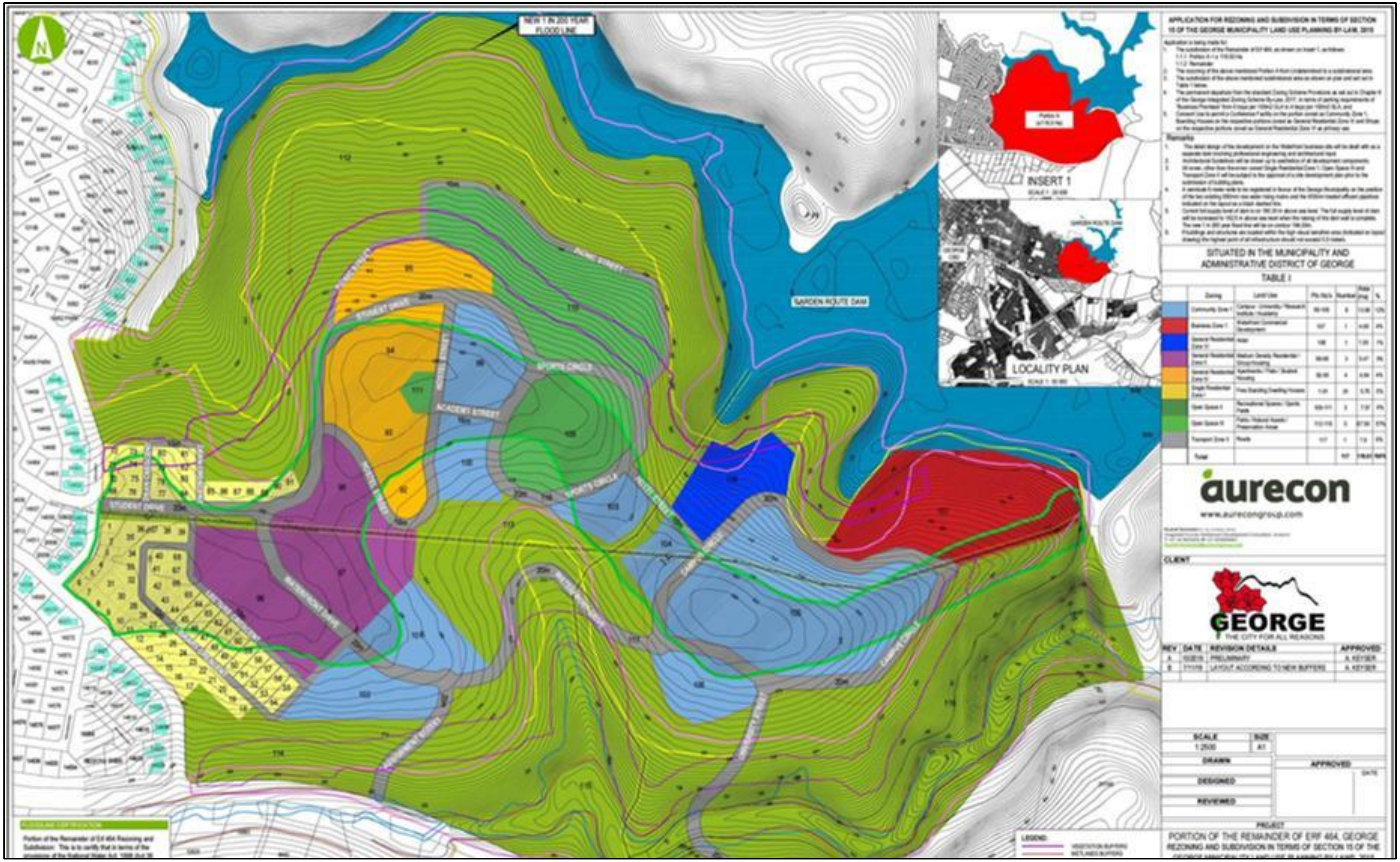


Figure 3: The revised conceptual site layout plan assessed as Alternative 2 (the preferred alternative). Light green areas represent proposed Open Space areas.

1.3 Proposed service infrastructure

The current site is undeveloped except for bulk infrastructure crossing the proposed development area. Currently two (2) existing 600 mm Ø raw water rising mains as well as 450 mm Ø treated effluent pipeline crosses the area. According to the Engineering Services Report, the main access road to the campus after construction will be North from Saasveld Road, whereby the design of the road will be a combination of earthworks, filling and bridges over the existing watercourses on site.

George Municipality has more than one WWTW. The proposed development falls within the Glenwood Pump Station sub-drainage area which drains to the Outeniqua WWTW. Wastewater generated from the proposed development will gravitate to the existing Glenwood PS as well as the proposed Erf 464 pump stations and pump sewage through rising mains and gravity pipelines to the Glenwood PS and from there into the existing system towards the Outeniqua Waste Water Treatment Works, where it will be treated. The WWTW does not currently have capacity to service this development, but is currently being upgraded, and will need to be able to accommodate the wastewater prior to construction.

The two new pump stations are required to drain approximately 70% of the total development with the remainder able to gravitate. According to the Engineering report, sufficient emergency storage will be provided at the pump stations in order to mitigate events such as power outages, blockages and breakdowns. The pump stations will pump wastewater from areas which cannot be served hydraulically by gravity sewers. The design of the proposed sewer pump stations will conform to pump station design pump capacities. Each pump station will be designed to accommodate the flow rate that gravitates towards it. The pump stations will have variable speed pump sets to accommodate the varying nature of the incoming sewer flows. A pump station consists of a sump to receive incoming sewage, and pumps that pump the sewage through a rising main to a wastewater treatment work or into a downstream stilling chamber as well as emergency storage facilities.

The proposed site is currently undeveloped and can be categorised as a “Greenfield Development”. Therefore, the proposed development is expected to increase the amount of stormwater runoff due to additional hard surfaces being constructed. A stormwater management plan has been compiled by Aurecon and outlets can be seen in Figure 4 below.

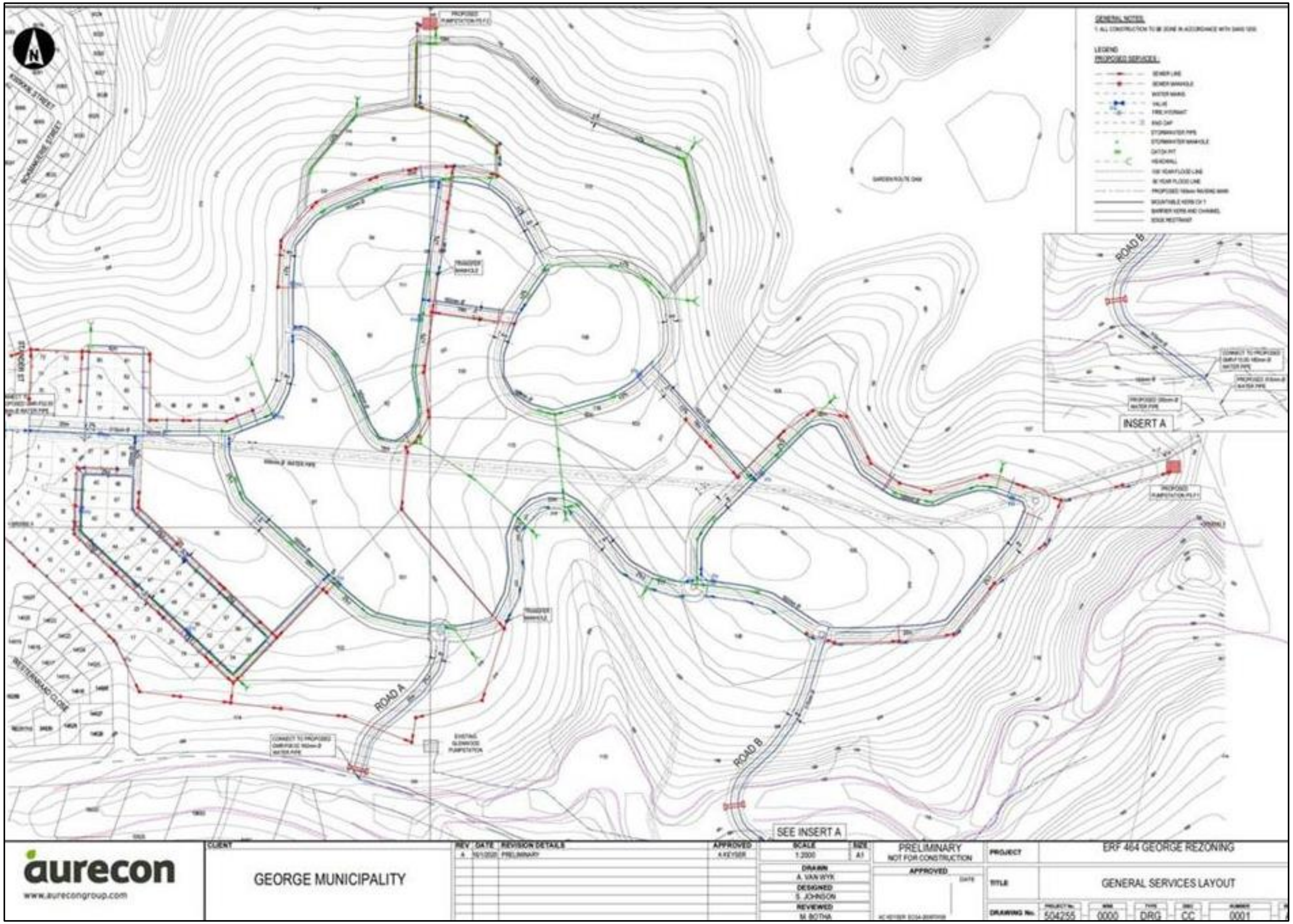


Figure 4: General services layout for the preferred alternative showing road, sewer, and stormwater infrastructure

1.4 Relevant legislation

The protection of water resources is essential for sustainable development and therefore many policies and plans have been developed, and legislation promulgated, to protect these sensitive ecosystems. The proposed project must abide by the relevant legislative requirements. Table 1 below shows an outline of the environmental legislation relevant to the project.

Table 1: Relevant environmental legislation

Legislation	Relevance
South African Constitution 108 of 1996	The constitution includes the right to have the environment protected
National Environmental Management Act 107 of 1998	Outlines principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for coordinating environmental functions exercised by organs of state. In terms of Section 2 and Section 28 of the NEMA, mining companies are responsible for any environmental damage, pollution or ecological degradation caused by their activities “inside and outside the boundaries of the area to which such right, permit or permission relates”.
Environmental Impact Assessment (EIA) Regulations	Regulations have been promulgated in terms of Chapter 5 of NEMA and were published on 4 December 2014 in Government Notice No. R. 32828. In addition, listing notices (GN 983-985) lists activities which are subject to an environmental assessment.
The National Water Act 36 of 1998	Chapter 4 of the National Water Act addresses the use of water and stipulates the various types of licensed and unlicensed entitlements to the use of water. Any uses of water which do not meet the requirements of Schedule 1 or the GAs, require a license which should be obtained from the Department of Water and Sanitation (DWS). According to the Department of Water and Sanitation (DWS), any structures (e.g. pipelines) within a 500 metre radius from the boundary of a wetland constitutes a Section 21(c) and (i) water use and as such requires a water use licence.

General Authorisations (GAs)	The project will require a Water Use Authorisation in terms of Section 21 of the National Water Act (NWA), Act 36 of 1998. Government Notice R509 of 2016 was issued as a revision of the General Authorisations (No. 1191 of 1999) for section 21 (c) and (i) water uses (impeding or diverting flow or changing the bed, banks or characteristics of a watercourse) as defined under the NWA.
National Environmental Management: Biodiversity Act No. 10 of 2004	This is to provide for the management and conservation of South Africa's biodiversity through the protection of species and ecosystems; the sustainable use of indigenous biological resources; the fair and equitable sharing of benefits.

1.5 Scope of Work

The Scope of Work in accordance with the Terms of Reference supplied by Site Plan Consulting are described below:

1.5.1 Phase 1

- Contextualization of each study area in terms of important biophysical characteristics and the latest available aquatic conservation planning information.
- Desktop delineation and illustration of all watercourses within each study area utilising available site-specific data such as aerial photography, contour data and water resource data.
- A risk/screening assessment of these identified watercourses to determine which ones will be impacted upon by the proposed development areas.

1.5.2 Phase 2

- Ground truthing, infield identification, delineation and mapping of any affected aquatic ecosystems in terms of the Department of Water and Sanitation (DWAF 2008) *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas*.
- Classification of the identified aquatic ecosystems in accordance with the, 'National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa' (Ollis *et al.* 2013) and WET-Ecoservices (Kotze *et al.* 2009).
- Description of the identified watercourses with photographic evidence
- Conduct a Present Ecological State (PES), functional importance assessment and Ecological Importance and Sensitivity (EIS) assessment of the delineated wetland habitats, utilising:
  - Level 1 WET-Health tool (Macfarlane *et al.*, 2009) – PES

  - WET-Ecoservices (Kotze *et al.*, 2009) - Functional assessment
- Conduct a Present Ecological State (PES) and present Ecological Importance and Sensitivity (EIS) assessment of the delineated river/riparian habitats, utilising:
  - Qualitative Index of Habitat Integrity (IHI) tool adapted from (Kleynhans, 1996) – PES
  - DWAF (DWS) River EIS tool (Kleynhans, 1999) - EIS
- Indicate the Recommended Ecological Category (REC) of the potentially impacted aquatic ecosystems.
- Identification, prediction and description of potential impacts on aquatic habitat during the construction and operational phases of the project.
- Identify direct, indirect, and cumulative impacts the proposed development will have on aquatic habitats and the significance of these impacts. Rate the significance of the impacts.
- Recommend actions that should be taken to prevent impacts on aquatic habitat, in alignment with the mitigation hierarchy, and any measures necessary to restore disturbed areas or ecological processes.
- Determination of No Go and buffer zones using Macfarlane & Bredin (2016) aquatic buffer tool
- Identify legislation and permit requirements that are relevant to the development proposal from an aquatic perspective.

2 STUDY AREA

The desktop study was informed by the available datasets relevant to water resources, as well as historic and the latest aerial imagery, to develop an understanding of the fluvial processes of the study area. A significant amount of the latest spatial data has been provided through the products of the 2018 National Biodiversity Assessment (NBA). The NBA is the primary tool for monitoring and reporting on the state of biodiversity in South Africa. It is used to inform policies, strategies and actions in a range of sectors for managing and conserving biodiversity more effectively. The desktop study was followed by the detailed site assessment.

2.1 Biophysical characteristics

George receives rainfall throughout the year, with the lowest amount in June and the highest amount in November. The average midday temperatures for the area range from 18.2°C in July to 27.6°C in February (Mucina and Rutherford, 2006). The area is characterised by gently undulating topography on the coastal plateau between the Outeniqua Mountains and the ocean. The topography of the site can be described as a low, flat-topped ridge with gentle to moderately steep sloping sides and featuring indents where the landscape has been eroded into small valleys by drainages. A larger drainage valley lies along the southern boundary and the Garden Route Dam shoreline lies close to the northern boundary. Slopes on the southern edge are steep, while those beyond the northern half are more gradual, except for the drainage valleys, which are relatively steep. The geology comprises mainly of phyllite and quartzite strata of the Kaaimans Group, with quartzitic sandstones of the Table Mountain Group (Cape Supergroup), as well as gneissic granite and granodiorite from George Batholith (Cape Granite), which are highly erodible (Figure 5).

According to Mucina and Rutherford (2012), the vegetation is sensitive in nature; largely mapped as Garden Route Shale Fynbos with a portion in the south classified as Garden Route Granite Fynbos (Figure 6). In the 2016 list of Threatened Ecosystems of the Western Cape (WCBSP), these vegetation units were classified as Endangered and Critically Endangered, respectively. However, in the latest National Biodiversity Assessment (2018) the Ecosystem Threat Status of Garden Route Shale Fynbos has been reduced to Vulnerable.

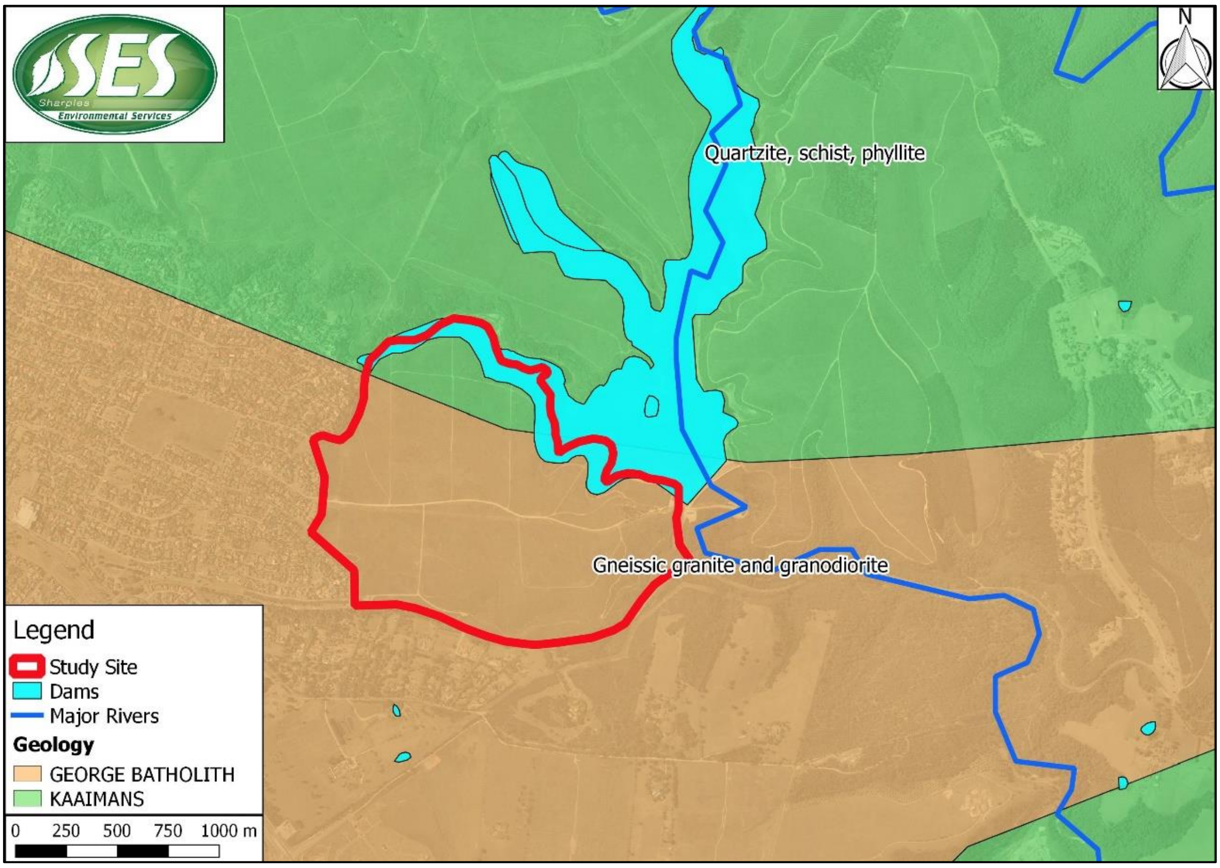


Figure 5: The geology of the area (CGS 2019)

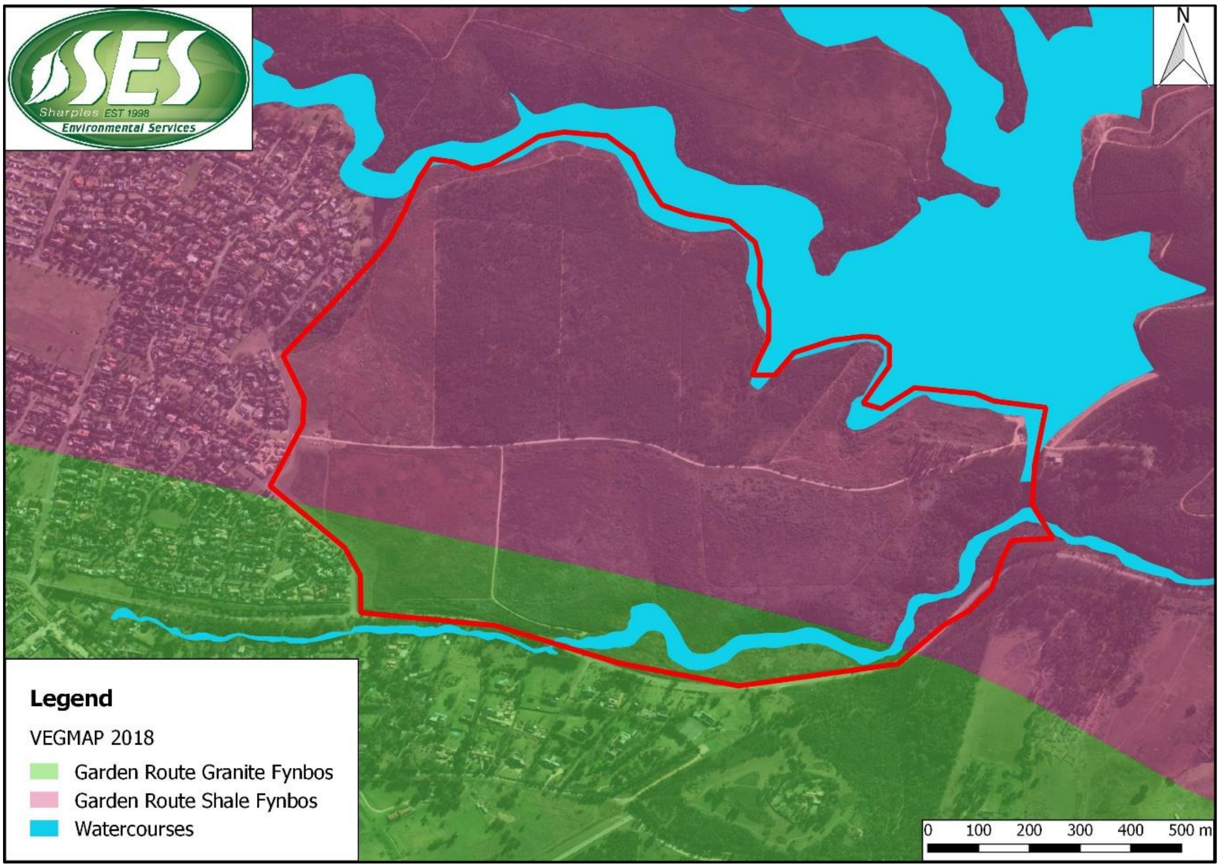


Figure 6: The vegetation types of the study area according to the VEGMAP of the National Biodiversity Assessment (SANBI, 2018)

A botanical assessment for this proposed development has been undertaken by Conservation Management Service (2018) and should be read in conjunction with this report. According to the botanical study, the vegetation of the entire site is disturbed and formerly transformed fynbos and thicket habitat but invasive alien plants are invading the entire study site (Conservation Management Service, 2018). The most important and ecologically concerning invasives are *Acacia mearnsii* (black wattle), *Acacia melanoxylon* (blackwood) and *Solanum mauritianum* (bugweed). Other alien weeds like *Amaranthus* sp., *Conyza bonariensis, Cirsium vulgare* and alien grasses like *Paspalum* sp. and *Cortaderia selloana* (pampas grass) can be found throughout the study area.

A recent fire (October 2018) is estimated to have burnt at least 40% of the study area and both pioneer Fynbos and Pioneer Forest / Thicket have been affected. The high density of alien plants on site and dry conditions prior to the fire, resulted in an extremely hot burn which scorched large areas of topsoil, making these areas susceptible to further alien infestation and erosion (Conservation Management Service, 2018).

2.2 Drainage network

The rivers of this region have their source in the Outeniqua Mountains, and flow south over the narrow coastal plain, to form small estuaries at the coast. The larger rivers are perennial, as they are fed by precipitation and surface runoff during the winter rainfall season, and supplemented by mountain seeps during the lower rainfall periods. These high gradient mountain/ mountain foothill streams are typically dark brown in colour due to the high concentrations of humic compounds in the fynbos vegetation.

The site is within the Quaternary Catchment K30C of the Coastal Gouritz Water Management Area and the South Eastern Coastal Belt Ecoregion (Figure 7). The major river systems in this catchment are the Swart River and Kaaimans River. The Swart River system joins the Kaaimans River downstream before the mouth to the Indian Ocean (Figure 7). Upslope of the dam and Kat River that feeds it, is the George and Outeniqua Strategic Ground Water Area (CSIR, 2018).

Flow related activities, such as abstraction for domestic purposes, alien tree infestation, plantations and dams, are the largest drivers of degradation in watercourses of the area. The Garden Route Dam was identified by the NFEPA (2011) project as a wetland but not allocated FEPA status. In the latest dataset, NWM5, it is more accurately shown as a dam.

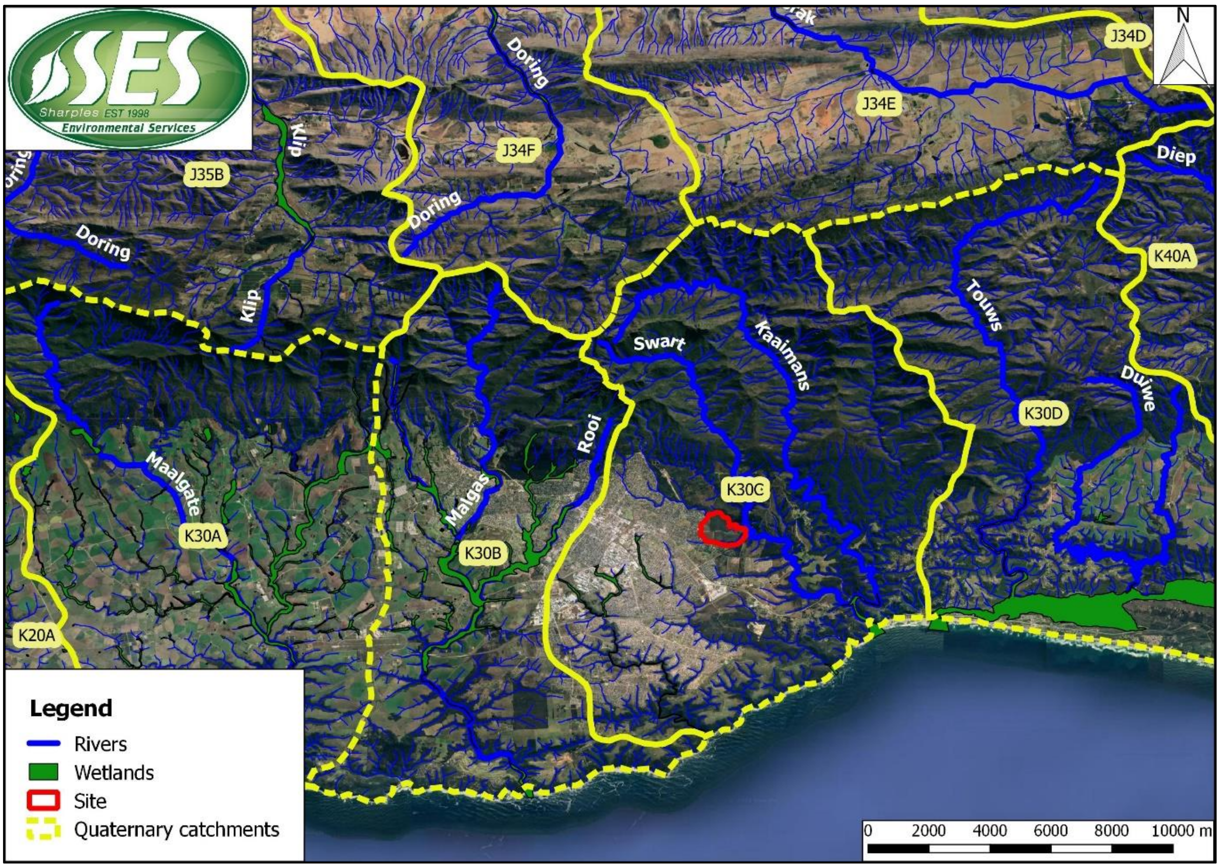


Figure 7: The quaternary catchment K30C and NFEPA identified systems

2.3 South African Inventory of Inland Aquatic Ecosystems (SAIIAE)

The South African National Wetland Map 5 (NWM5) shows no wetland ecosystems identified within the study area (Figure 8). The wetland dataset was produced by the South African Inventory of Inland Aquatic Ecosystems (SAIIAE) during the National Biodiversity Assessment of 2018 (Van Deventer *et al.* 2018). Mapping the locality of wetlands is essential so that they may be classified into the different wetland ecosystem types across the country, which in turn can be used along with other data to identify wetlands of conservation significance. The South African National Wetland Map (NWM) utilises the latest spatial data to portray the extent and ecosystem types of the estuarine and inland wetlands, collectively known as wetlands, and informs decision makers in assessing development applications, land use and conservation planning and policy making.

The NBA 2018 Rivers Map is a GIS layer which summarises the river condition, river ecosystem types, flagship and free-flowing river information (Van Deventer *et al.* 2019). The river lines data set is associated with the National Wetland Map 5 (NWM5) issued with the SAIIAE. The GIS layer of origin is the 1:500 000 rivers data layer that DWAF coded for geomorphological zonations, with added data from the Chief Directorate Surveys and Mapping's (CDSM) 1:50 000 rivers GIS layer, and information generated during the NFEPA project in 2011.

There are no wetlands mapped by the NWM5 within the site (Figure 8). There is a very small artificial depression, mapped outside of the site, on the southern side of the Saasveld Road. This system will not be affected by the development as it is situated on the other side of the valley and road.

The NBA 2018 Rivers data only identifies the perennial Swart River off the eastern property boundary. The other systems depicted in Figure 9 are from the 1:500000 cadastral rivers data. The PES is within the 'D' category meaning that the Swart River has been largely modified in this reach. This can largely be attributed to the dam. The ecosystem threat status is classified as Least Threatened.

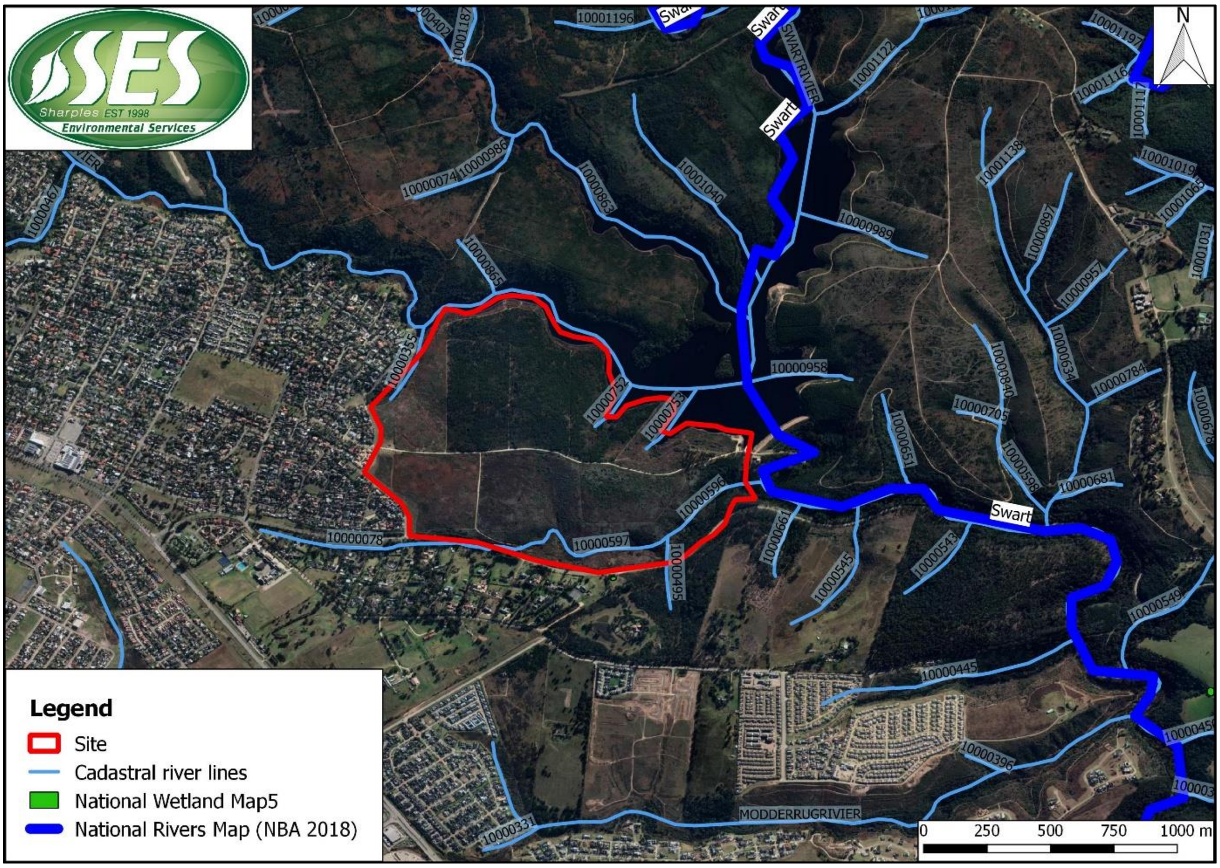


Figure 8: Map showing the wetlands and rivers identified in the South African Inventory of Inland Aquatic Ecosystems (SAIIAE) developed as part of the National Biodiversity Assessment (2018)

2.4 Strategic Water Source Areas

The study area is located within the Outeniqua Strategic Water Source Area for Surface Water (Figure 9). The mountainous area north of the site is mapped as the George and Outeniqua Strategic Water Source Area for Groundwater. Strategic Water Source Areas (SWSA) is where the water that is supplied is considered to be of national importance for water security. Surface water SWSAs are found in areas with high rainfall and produce most of the runoff. Groundwater SWSAs have high groundwater recharge and are located where the groundwater forms a nationally important resource. There are 22 national-level SWSAs for surface water (SWSA-sw) and 37 for groundwater

(SWSA-gw). The SWSA-sw in South Africa, Lesotho and Swaziland occupy 10% of the land area and generate 50% of the mean annual runoff. They support at least 60% of the population, 70% of the national economic activity, and provide about 70% of the water used for irrigation. The SWSA-gw cover 9% of the area of South Africa, account for 15% of the recharge, 46% of the groundwater used by agriculture and 47% of the groundwater used by industry.

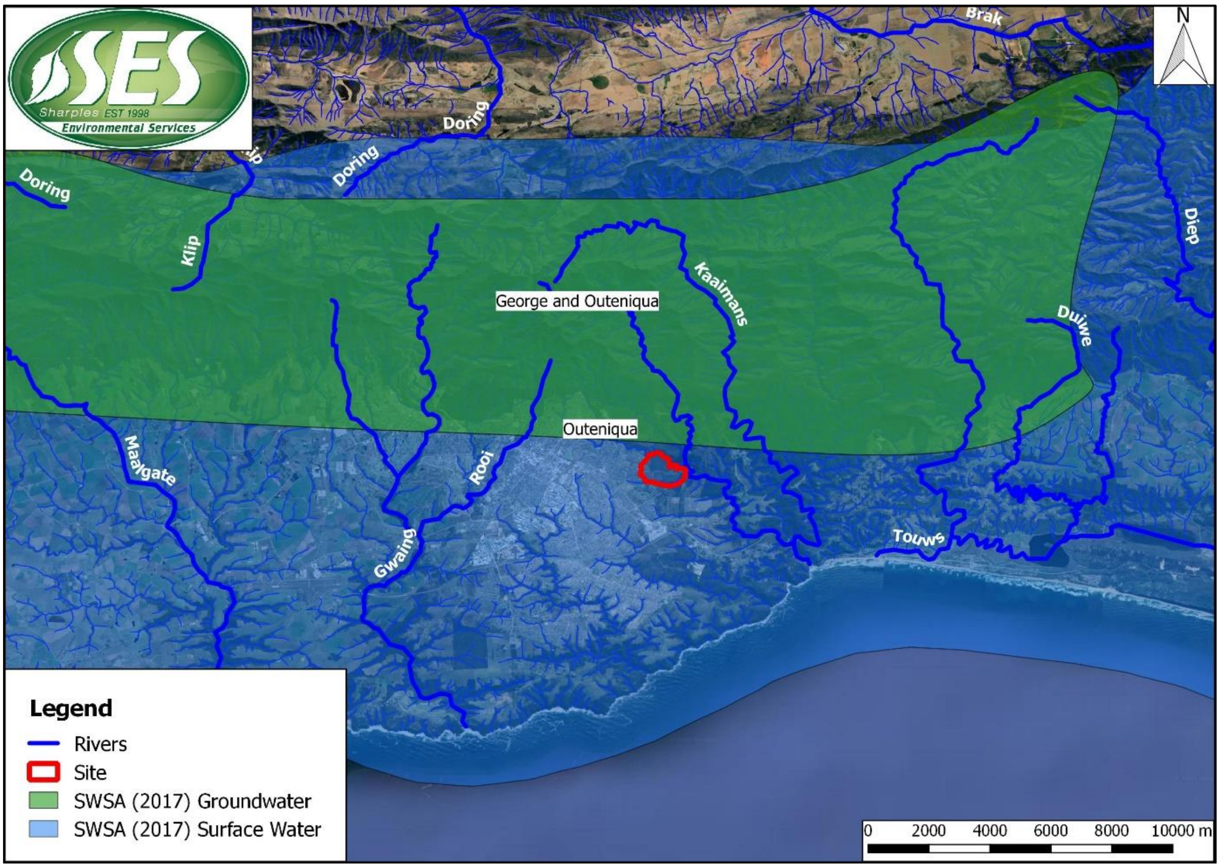


Figure 9: The site in relation to the Strategic Water Source Areas

2.5 Western Cape Biodiversity Spatial Plan

There is CBA aquatic habitat mapped on the site by the Western Cape Biodiversity Spatial Plan (CapeNature, 2017). The WCBSP identifies areas crucial for conserving a representative sample of biodiversity and maintaining ecosystem functioning. The primary purpose of a map of Critical Biodiversity Areas and Ecological Support Areas is to guide decision-making about where best to locate development. Critical Biodiversity Areas (CBA's) are required to meet biodiversity targets. These areas have high biodiversity and ecological value and therefore must be kept in a natural state without further loss of habitat or species. Low-impact, biodiversity sensitive land uses are the only land uses allowed in CBA's. The WCBSP made a distinction between areas likely to be in a natural condition (CBA1) and areas that could be degraded (CBA2). Ecological Support Areas (ESA's) are not essential for meeting biodiversity targets but are important as they support the functioning of CBA's and Protected Areas (PA's). ESA's support landscape connectivity surrounds ecological infrastructure that provide ecosystem services and strengthen resilience to climate change. These areas include Endangered vegetation; water source and recharge areas; and riparian habitat around rivers and wetlands. The WCBSP also made a distinction between ESA's in a functional condition (ESA1) and degraded areas in need of restoration (ESA2).

According to the WCBSP data, there are small pockets of the study area that are classified as Critical Biodiversity Areas, such as a portion of wetland habitat in the south and terrestrial habitat in the eastern area (Figure 10). However, the majority of the site is considered to have potential for restoration or is mapped as an ecological support area. The reasons provided by the WCBSP include Threatened Vertebrate and Water Resource Protection. Additionally, a segment along the dam in the northern part of the site is part of a protected area called the Katrivier Nature Reserve.

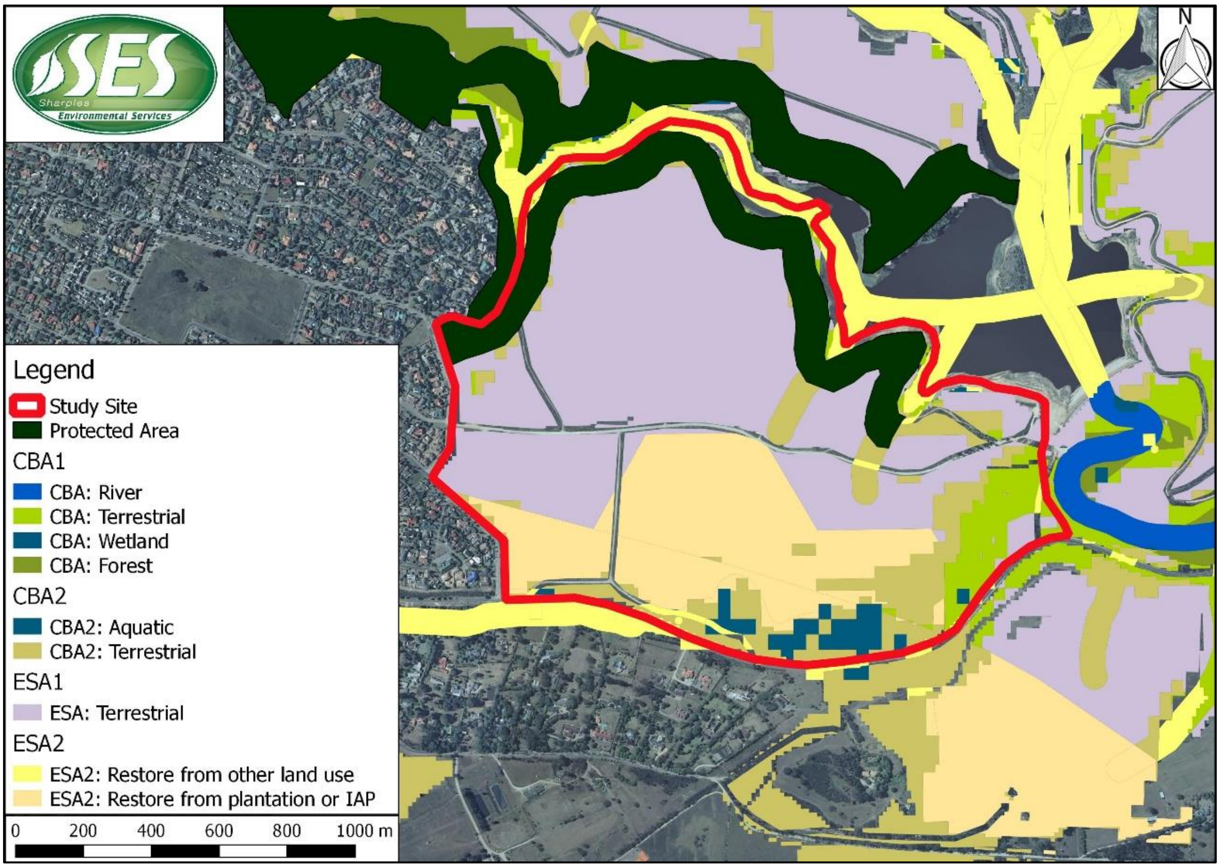


Figure 10: The site in relation to the Western Cape Biodiversity Spatial Plan (CapeNature, 2017)

2.6 Water Quality

The George Municipality Laboratory Services tests the water quality of raw water at the new water works on a weekly basis, in order to treat the water to levels which comply with the SANS 241:1: 2015 Limits for drinking water. The water tested is the raw water sourced from the Garden Route Dam and the purpose of sample analysis is to ensure that the correct treatment is administered to ensure compliance with the standards for water for human consumption. However, for the purpose of the aquatic assessment the variables need to be compared to standards required for healthy aquatic ecosystems (DAFF South African Water Quality Guidelines: Aquatic Ecosystems 1996). Certain constituents, such as ammonia and phosphorous, are valuable indicators for aquatic ecosystem health but are not analysed for domestic water purposes. Thus, some of these constituents are not included in the ongoing municipal tests and additional testing was undertaken for the aquatic assessment. Ideally, for accurate interpretation of the water quality results, daily samples should be taken for at least 4 weeks, to get a good indication of concentrations. A single measurement is of limited use, and shouldn't be used to draw conclusions on the water quality, but the results can provide insight regarding the current impacts.

The once off sampling was conducted by SES to assess against the targets for aquatic ecosystems and provide a snapshot indication of chemical and physical constituents. Three water samples were collected on the 29th of August 2019 from the study area (Figure 11). Two of the samples were sourced from the dam and the other from the Klein Swart River. The results are a snapshot of the conditions at the time of sampling, and will have changed since, but provide an indication of the status quo at the time of initial site assessment in 2018. The water quality results for the sampling points Garden Route Dam and Kat River indicate fair water quality from an aquatic perspective. However, the water quality at the time of sampling in the Klein Swart River to the south of the property, was poor and indicative of potential impacts from urban development.

The TWQR for ammonia is 7 µg/L. The once off sampling effort by SES showed ammonia concentrations of well above the TWQR and the AEV at all the sampling points. The highest ammonia levels were recorded below the Glenwood pump station, where a concentration of 1010 µg/L was measured. This is approximately 10 times the suggested AEV. It is likely that the source of pollution is the Glenwood pump station and/or the associated sewage infrastructure that cross the system a few meters above the sampling point. At the time of sampling, *E.coli* levels downstream of the pump station were more than double the concentration considered safe for intermediate contact recreational (DWAF, 1996a). Nitrogen is also not tested for on a weekly basis by the municipality. The SES sampling concluded that mesotrophic conditions can be expected if the nitrate concentrations are used as indicators. The N:P ratio is indicative of unimpacted natural waters for the sampling points in the Garden Route dam and Kat River. However, the sampling point below the Glenwood pump station has a ratio of approximately 7:1. This indicates a hypertrophic or eutrophic system. These results clearly indicate the potential for pump stations to pollute nearby watercourses and the risk of constructing them in close proximity to aquatic habitat.

Figure 11: Map of the study area showing the three water sampling points of 2018

3 HISTORIC LAND USE

The vacant site proposed for development has historically been subjected to significant land use and cover change. Many of the impacts from past activities are not clearly visible today. Additionally, there is existing infrastructure throughout the site, such as buried water pipelines, which have altered the land surface (microtopography) and vegetation cover, but these impacts are not obvious. Research into the historic land use activities on the site provides context in which to analyse the magnitude of the proposed activities. Decades ago, the site was cleared for forestry and associated roads and watercourse crossings. Following this, the Kat and Swart Rivers were dammed and back-flooded to create the Garden Route Dam. In approximately 2006 the plantation was harvested and although indigenous vegetation re-established, the composition was altered, and alien invasive plant species encroached. Water pipelines, and the sewage pump station, have caused further disturbance to the site and the watercourses crossed. Additionally, the fire regime was altered, and the wild fires of 2018 resulted in sediment runoff and erosion.

3.1 Pre 2006

The town of George was established as a result of the growing demand for timber and the wood used in building, transport, and furniture. Historically, the entire study area was cleared of indigenous vegetation and utilised for commercial forestry (largely pine plantation) for many decades. Figure 12 below shows the forestry activities in the study area and the topography of the site prior to the construction of the Garden Route Dam on the Swart River. Figure 13 shows that the entire site was under pine plantation in the early 2000s. Forestry continued on the site until 2006 when it was harvested but not replanted (Figure 14). The wastewater pump station near the Klein Swart River, as well as a buried pipeline from the dam wall to the west, are both visible in the 2006 imagery.

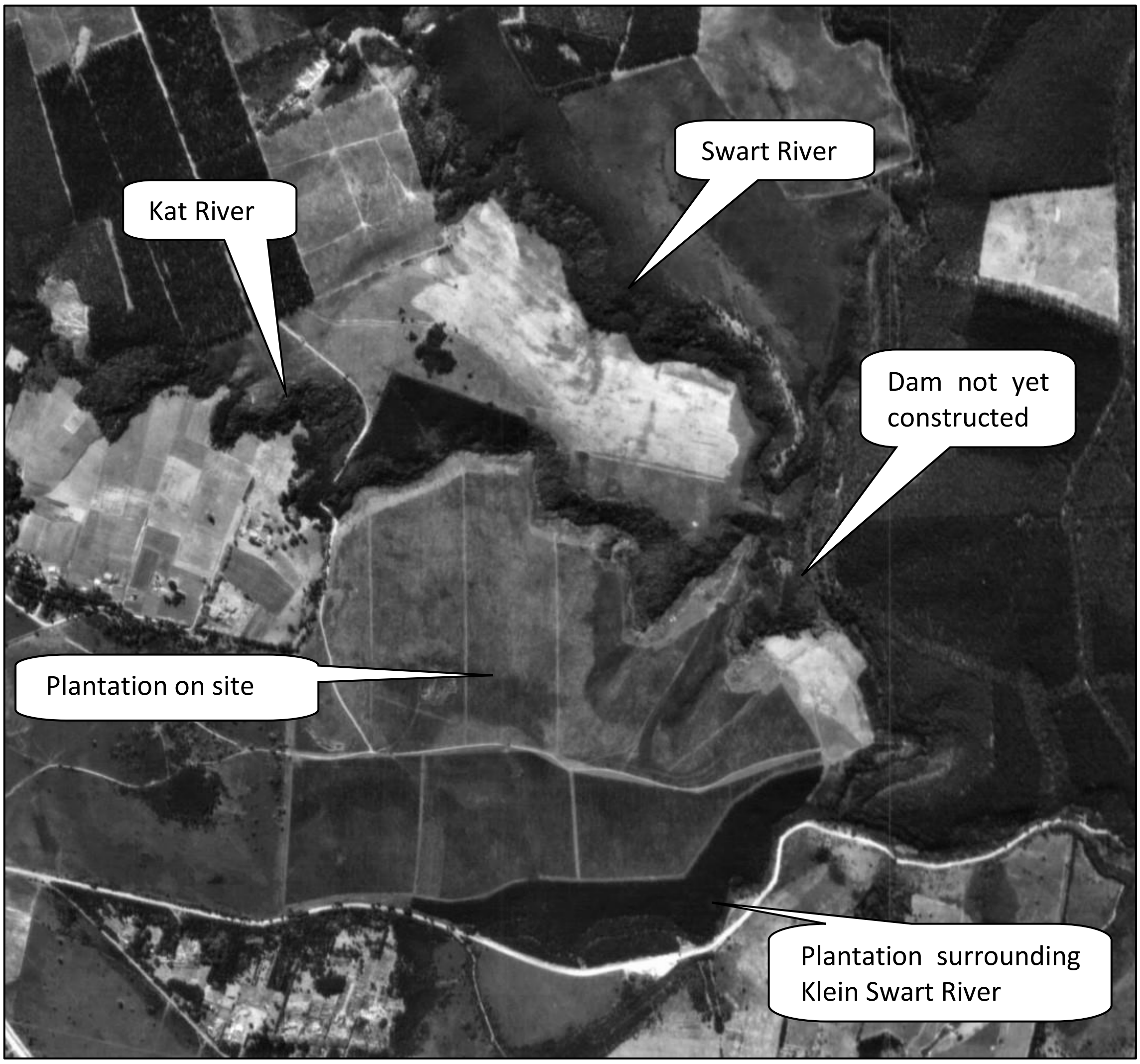


Figure 12: Historical aerial photography of the study area in 1957 (note that the dam was not yet constructed, and the area was used for forestry)

Figure 13: Historic satellite imagery from 2000 showing the plantation land cover of the site (Department of Rural Development and Land Reform, NGI 2000)

Figure 14: Google satellite imagery from 2006 when the plantation was harvested and not replanted. Note the vegetation clearance and soil disturbance within the Klein Swart River

3.2 Post 2006

The land has remained vacant from 2006 and largely used as a recreational area by the residents of George. Around 2009 there is evidence that a pipeline was constructed from the dam towards the Saasveld Road and pump station (Figure 15). The pipeline crosses the Klein Swart River and construction has resulted in vegetation clearance, soil disturbance, and the modification of the channel banks. The 2010 imagery shows the increase in the amount of alien invasive plant species which have established due to previous land disturbance. Additionally, an old forestry road crossing is now visible. In 2011 there is evidence of erosion from the pipeline crossings (Figure 15, 16, and 17).

The 2018 wildfire scar is shown in Figure 18 on the northern half of the study area. The unnaturally intense burn (fueled by the alien invasive trees present) resulted in erosion from surface runoff on bare ground and resultant sedimentation of the Kat River and dam. No new river crossings have been constructed since the pipeline installation and some of the past crossings (such as the old forestry road in the southwestern area) are no longer utilized and vegetation has reestablished. However, an area alongside the middle road has been cleared and excavations have caused soil disturbance. (Figure 29 & 20). This may be for fire management or to maintain the pipeline servitude/ pipe line itself. The soil movement has created a berm on the downslope side of the road with a slight dip between within which rainwater is collected/ retained for a short period of time.

In 2019 the dam level was raised by constructing a new spillway. The dam's full supply level was raised by 2.5 metres, which increased the total storage capacity of the dam by approximately 25%.The new spillway weir height is 182,5m with a storage capacity of 12,5 million cubic metres. This may further reduce the flow volume downstream and backflood more riparian habitat within the Kat and Swart rivers.

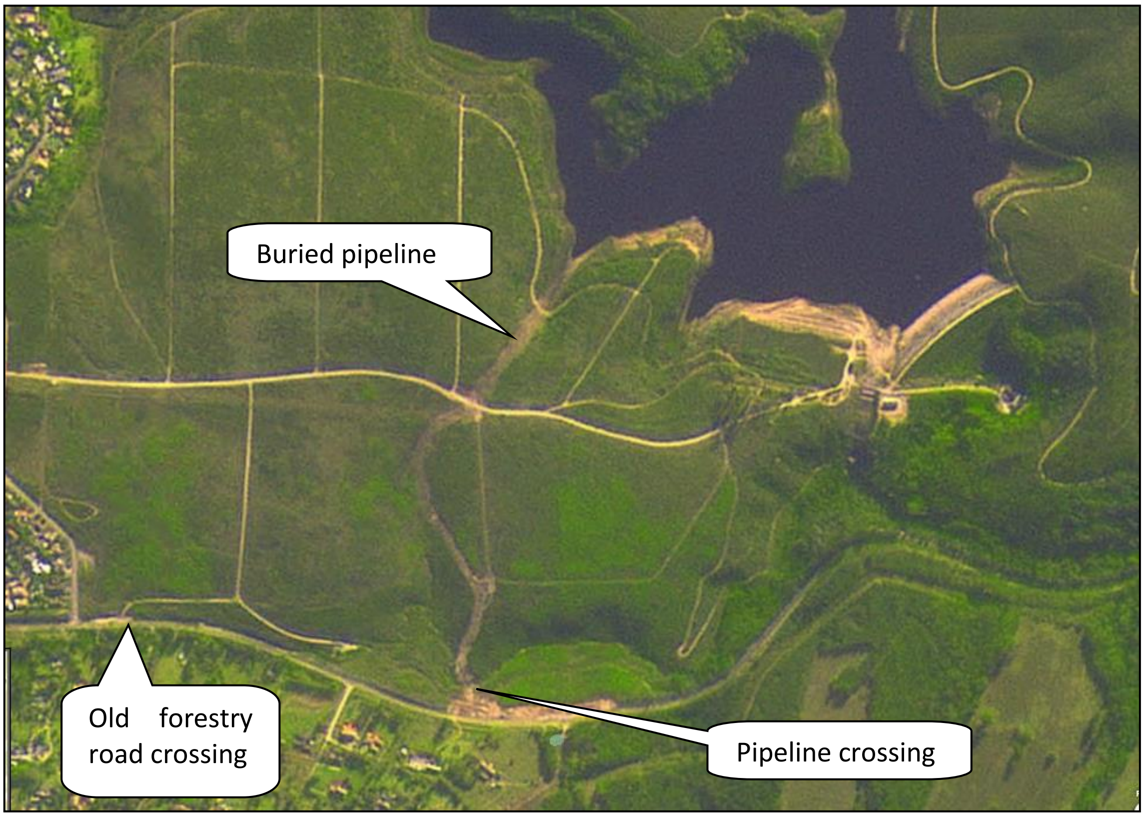


Figure 15: SPOT-5 satellite imagery for 2010 showing the linear disturbance footprint for the water pipeline and its crossing of the Klein Swart River toward the Saasveld Road. Also note the signs of alien invasive tree infestation.

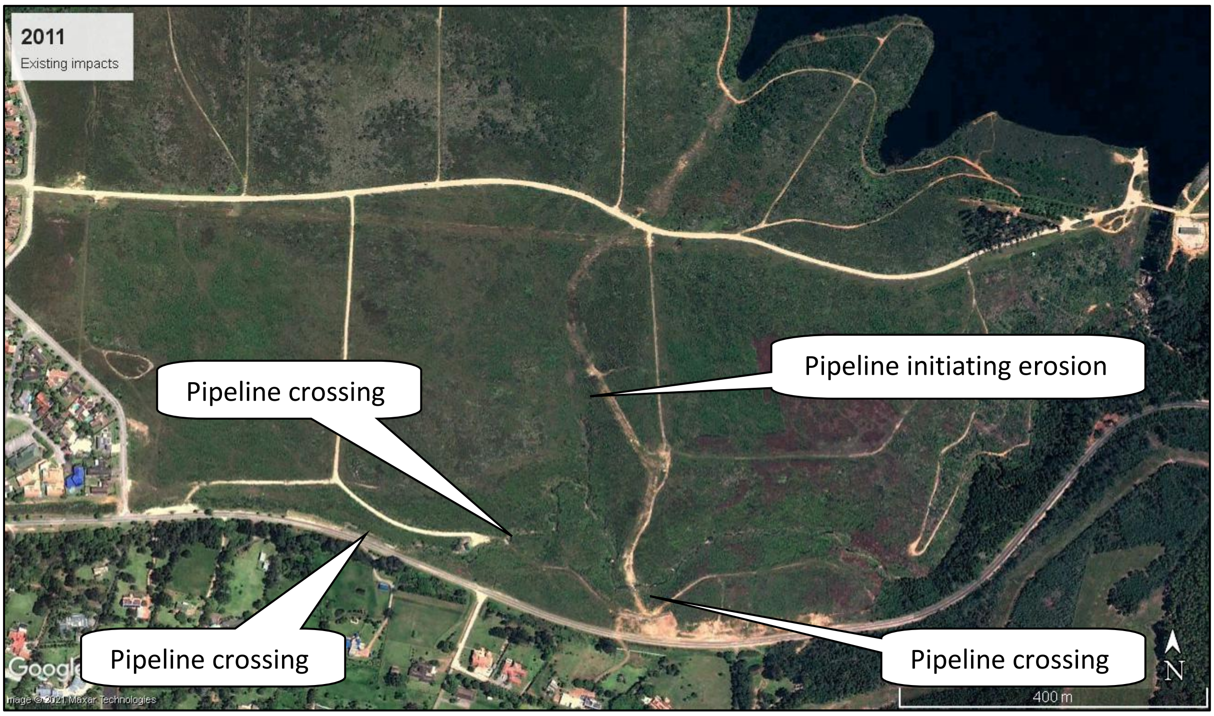


Figure 16: Google imagery from 2011 shows that the installation of the water pipeline has resulted in a linear disturbance which crosses the Klein Swart River towards the Saasveld Road. Note the cleared bare ground and erosion.

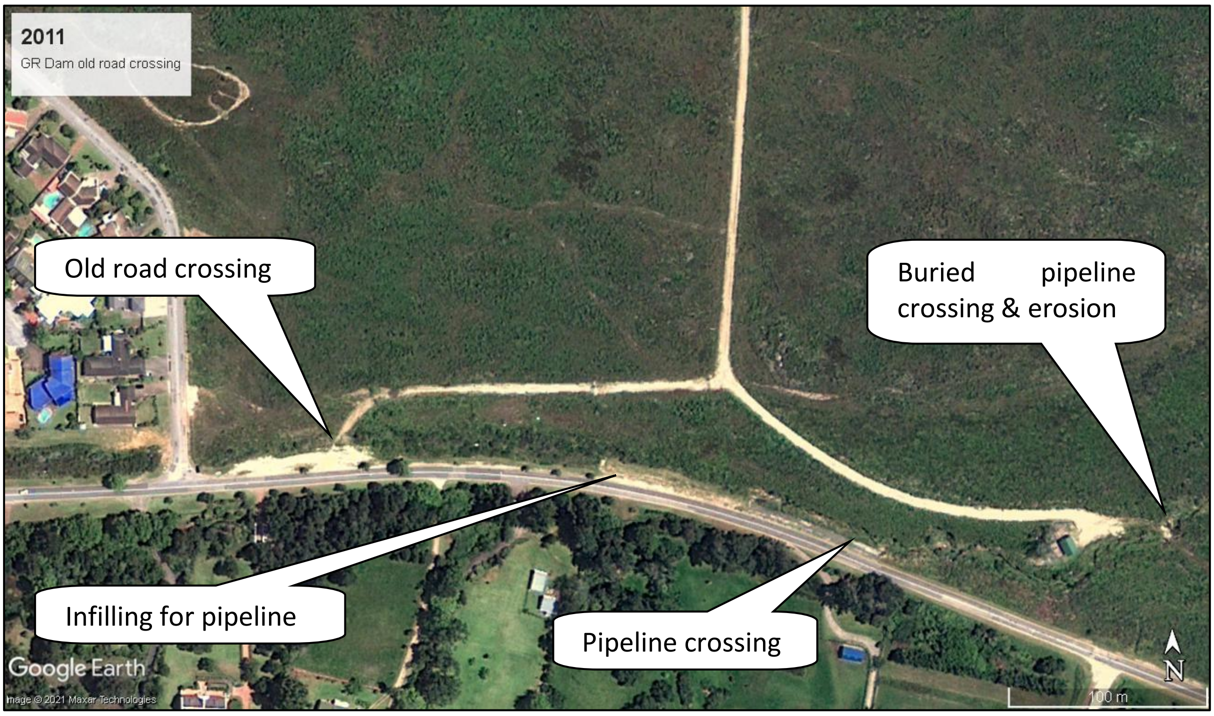


Figure 17: Google imagery from 2011 showing the location of the old forestry road which is no longer clearly visible as well as disturbance from pipeline construction near the Klein Swart River channel. Note the incised channel from the changes to land cover and infrastructure within the system.

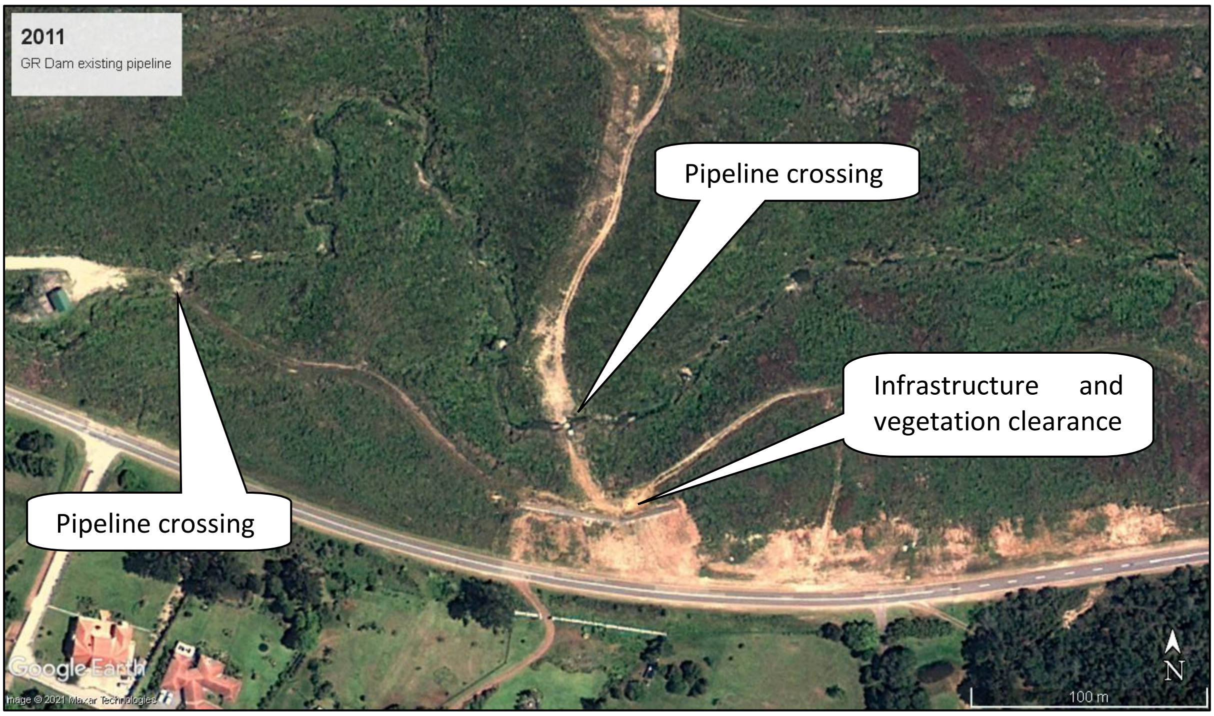


Figure 18: Google imagery from 2011 showing the significant disturbance from pipeline construction and associated infrastructure within the Klein Swart River.

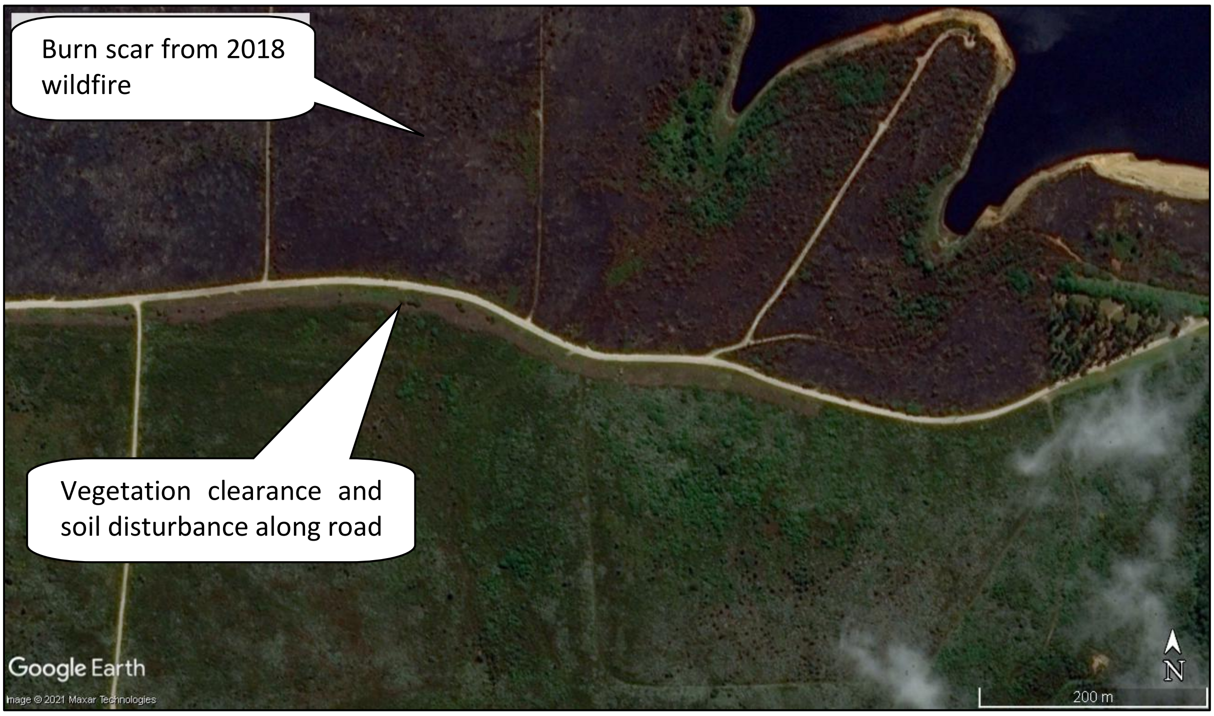


Figure 19: Google imagery from 2018 showing the burn scar from the wildfire and the cleared area alongside the road

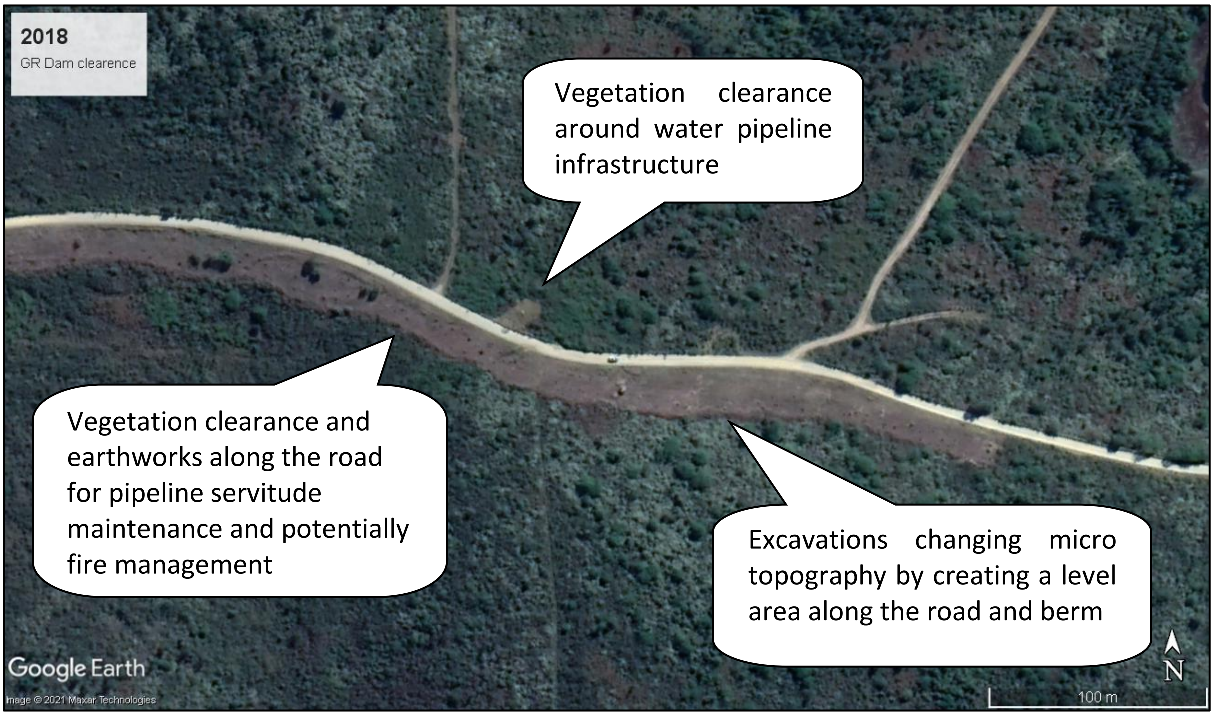


Figure 20: Google imagery from 2018 showing the cleared and excavated area alongside the road

4 APPROACH AND METHODS

4.1 Status quo assessment

- Desktop delineation was conducted in QGIS (v2.19.0) and Google Earth Pro using available imagery and datasets to identify and screen watercourses within a 500m radius (Department of Water and Sanitation, DWS, regulated area) of the proposed project (Table 2).
- Various data sources were consulted to develop an understanding of the biophysical characteristics of the study area and its conservation context (Table 2). The contextualization of the study area was undertaken in terms of important biophysical characteristics and the latest available aquatic conservation planning information in a Geographical Information System (GIS). It is imperative to develop an understanding of the regional drainage setting and longitudinal dynamics of the watercourse. The conservation planning information aids in the determination of importance and sensitivity, management objectives, and the significance of potential impacts.
    - Infield verification and refinement of the location and extent of the watercourses was undertaken to identify the systems that are likely to be impacted by the project and to inform further assessment. The site visits occurred on the 23rd and 24th of June 2021. The infield delineation was conducted in accordance with *A Practical Field Procedure for Identification and Delineation of Wetland and Riparian areas - Edition 1* (DWAF 2005) (Table 4).
    - The delineated aquatic habitats were then each classified separately into HGM units in accordance with the 'National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa' (Ollis *et al.,* 2013) and WET-Ecoservices (Kotze *et al.* 2009) (Table 4). Wetland classification systems are usually based on a selected wetland definition, the most commonly used being that of Cowardin *et al.* (1979), which requires that a wetland meets one or more of the following criteria: (1) it supports hydrophytes at least periodically, (2) the substrate is composed of undrained hydric soil and/or (3), the substrate is non-soil and is saturated or covered by shallow water at some time during the growing season of each year. The Ollis classification system is used to describe the watercourses within this study because the WET-Health 2 and WET-EcoServices 2 assessment tools are based upon this system. It is a six-tiered classification system is based on a top-down, hierarchical classification of aquatic ecosystems, following the functionally-oriented hydrogeomorphic (HGM) approach to classification but incorporating structural attributes at the lower levels of the hierarchy. HGM Units are distinguished primarily on the basis of:

- Landform, which defines the shape and localised setting of the aquatic ecosystem.
- Hydrological characteristics, which describe the nature of water movement into, through and out of the aquatic ecosystem.
- Hydrodynamics, which describe the direction and strength of flow through the aquatic ecosystem

- The following are primary HGM Units which represent the main units of analysis for the classification system: (1) River; (2) Floodplain Wetland; (3) Channelled Valley-Bottom Wetland; (4) Unchannelled Valley-Bottom Wetland; (5) Depression; (6) Seep; and (7) Wetland Flat.
- In practise, many wetlands do not fit comfortably into this classification. In 2019, Grenfell *et al.* developed a Genetic Geomorphic Classification System for Southern African Palustrine Wetlands. The geomorphic classification system has four wetland macrotypes based on sediment source (colluvial, alluvial, Aeolian, and geochemical). These are subdivided into eight wetland types; hillslope seep, floodplain, valley-bottom, plain, blocked-valley, alluvial fan, aeolian depression, and geochemical depression. The classification is based on landscape location, shape, and the occurrence of geomorphic characteristics indicative of process. This classification system supplemented the assessments.

Table 2: Utilised data and associated source relevant to the proposed project

Data	Source
Google Earth Pro™ Imagery	Google Earth Pro™
DWS Eco-regions (GIS data)	DWS (2005)
South African Vegetation Map (GIS Coverage)	Mucina, Rutherford & Powrie (2018)
South African National Wetland Map 5	CSIR (2018)
Artificial Wetlands	CSIR (2018)
National Biodiversity Assessment Threatened Ecosystems (GIS Coverage)	SANBI (2018)
Geology	Surveyor General (2019)
Contours (elevation) - 5m intervals	Surveyor General
NFEPA river and wetland inventories (GIS Coverage)	CSIR (2011)
NEFPA river, wetland and estuarine FEPAs (GIS Coverage)	CSIR (2011)
Western Cape Biodiversity Framework 2017: Critical Biodiversity Areas of the Western Cape.	Pence (2017)

- Determination of the Present Ecological State (PES), functional importance assessment and Ecological Importance and Sensitivity (EIS) assessment of any affected wetland habitats.
- The health/condition or Present Ecological State (PES) of the wetland was assessed using the Level 2 WET-Health assessment tool Version 2 (Macfarlane *et al.* 2008 & 2018), which is based on an understanding of both catchment and on-site impacts and the impact that these aspects have on system hydrology, geomorphology and the structure and composition of wetland vegetation.
- Wetland benefits can be classified into goods/products (directly harvested from wetlands), functions/ services (performed by wetlands), and ecosystem scale attributes. The WET-Ecoservices tool (Kotze *et al.*, 2009, in Press) is utilised to assess the goods and services that the individual wetlands under assessment provide, thereby aiding informed planning and decision-making. The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing).

Importance Category		Description
Very Low	0-0.79	The importance of services supplied is very low relative to that supplied by other wetlands.
Low	0.8 – 1.29	The importance of services supplied is low relative to that supplied by other wetlands.
Moderately-Low	1.3 – 1.69	The importance of services supplied is moderately-low relative to that supplied by other wetlands.
Moderate	1.7 – 2.29	The importance of services supplied is moderate relative to that supplied by other wetlands.
Moderately-High	2.3 – 2.69	The importance of services supplied is moderately-high relative to that supplied by other wetlands.
High	2.7 – 3.19	The importance of services supplied is high relative to that supplied by other wetlands.
Very High	3.2 - 4.0	The importance of services supplied is very high relative to that supplied by other wetlands.

- The Ecological Importance and Sensitivity (EIS) of aquatic habitats is an expression of the importance of the water resource for the maintenance of biological diversity and ecological functioning on local and wider scales; whilst Ecological Sensitivity (or fragility) refers to a system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Kleynhans & Louw, 2007). The Wetland EIS Tool was utilised to determine EIS (Kleynhans, 1999).

- Determination of the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessment of the delineated river/riparian habitats was undertaken utilising:
- Qualitative Index of Habitat Integrity (IHI) tool adapted from (Kleynhans, 1996) – PES
- DWAF (DWS) River EIS tool (Kleynhans, 1999) - EIS
- The PES and EIS results then allowed for the determination of management objectives for the potentially impacted aquatic ecosystems.

4.2 Impact assessment

- The watercourses within the 500m buffer study area that were identified as likely to be impacted by the project were assessed further using the appropriate tools (Table 3).
- The approach adopted is to identify and predict all potential direct and indirect impacts resulting from an activity from planning to rehabilitation. The anticipated impacts of the proposed development on the associated aquatic habitat were identified and evaluated based on a significance rating scale encompassing factors such as extent, magnitude, duration and significance of impacts.
- Impact significance is defined broadly as a measure of the desirability, importance and acceptability of an impact to society (Lawrence, 2007). The degree of significance depends upon three dimensions: the measurable characteristics of the impact (e.g. intensity, extent and duration), the importance societies/communities place on the impact, and the likelihood / probability of the impact occurring.
- Actions are thereafter recommended to prevent and mitigate the identified impacts on aquatic habitat, in alignment with the mitigation hierarchy, as well as any measures necessary to restore disturbed areas or ecological processes.
- Any necessary buffer areas or No-Go areas are visually represented. The buffer zone was determined by a tool developed by Macfarlane and Bredin (2016) called *Buffer zone guidelines for rivers, wetlands and estuaries*, site-based information and professional opinion. The final buffer requirement includes the implementation of practical management considerations/ mitigation measures. The aquatic buffer area was determined utilizing the buffer tool by Macfarlane *et al.* (2016) which produces an output based on potential risk associated with the proposed development type (i.e. 'medium density urban residential development' in this instance) in conjunction with the sensitivity of aquatic resources (i.e. the dam and Klein Swart River). The buffer width was determined to be approximately 100 m and was then refined by the specialist based on additional information. For example, the characteristics of the site which included aspects such as site topography, soil

characteristics, runoff characteristics, vulnerability of the site to erosion, inherent nutrient levels in the landscape, level of domestic use of water resources, natural level of wetness and vegetation characteristics which were estimated either using available desktop information and/or data gathered from the site visit. There are limitations to fixed-width buffers and therefore it was slightly adapted to the specific characteristics of the site, without being reduced in size.

Table 3: Tools utilised for the assessment of water resources impacted by the proposed project.

Method/Tool*	Source	Reference
Delineation of wetland and/or Riparian areas	A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas.	(DWAF 2005)
Classification of wetlands and/ or other aquatic ecosystems	National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa & WET-Ecoservices	(Ollis *et al.*, 2013), Kotze *et al.*, 2009)
Present Ecological State (PES) Assessment (Wetland)	WET-Health Assessment Version 2	(McFarlane *et al.* 2009)
Functional Importance Assessment (Wetland)	WET-Ecoservices Assessment	(Kotze *et al.*, 2009)
Ecological Importance & Sensitivity (EIS) Assessment (wetland)	DWAF Wetland EIS Tool	(Duthie 1999)
Present Ecological State (PES) Assessment (River)	Rapid IHI (Index of Habitat Integrity) tool developed Kleynhans (1996), Modified by DWAF	(Ecoquat)
Ecological Importance & Sensitivity (EIS River)	DWAF EIS tool developed by Kleynhans (1999)	(Kleynhans, 1999)
Aquatic Buffer Zone Determination	Buffer zone guidelines for rivers, wetlands and estuaries	Macfarlane and Bredin (2016)

5 ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations are relevant:

- No georeferenced shapefiles of the layouts were provided and therefore the mapped locations of infrastructure are not exact but informed by the maps provided.
- Although a substantial amount of information has been provided through reports such as the engineering report, there is limited detail regarding stormwater management measures, bridge and road designs at water crossings, pipeline and bridge construction method statements etc. This in turn limits the level of confidence of assessment as it increases the assumptions associated with the project design and potential impacts.
- The aquatic habitat and buffer areas are to be considered No Go zones for development. An additional zone between development and aquatic buffer areas is proposed for low conflict land uses, such as picnic sites and cycling paths (which do not require vegetation clearence or hard infrastructure). While these activities, as well as fence lines etc., are not indicated in the layout or detailed in any reports, it can only be assumed that the above will be implemented and not misconstrued. Buffer areas should not be used for parking areas or sports fields but may be advantageous alongside them.
- Aquatic ecosystems vary both temporally and spatially. Once-off surveys such as this are therefore likely to miss certain ecological information due to seasonality, thus limiting accuracy and confidence. Water quality sampling presents only a ‘snap shot’ indication.
- Infield soil and vegetation sampling was only undertaken within a specific focal area around the proposed development, while the remaining watercourses were delineated at a desktop level with limited accuracy.
- No detailed assessment of aquatic fauna/biota was undertaken.
- The vegetation information provided is based on observation not formal vegetation plots. As such species documented in this report should be considered as a list of dominant and/or indicator wetland/riparian species and only provide a very general indication of the composition of the riverine vegetation communities. Please refer to the botanical assessment for detailed vegetation descriptions.
- It is assumed that all the mitigation measures detailed in this report will be effectively implemented and monitored.
- The author of this report does not have any Engineering qualifications. Therefore, all examples of structures or methods for mitigation are merely a guideline suggestion and are likely to require Engineering input and/or input by the Contractor (in liaison with the ECO) before they are adopted and incorporated into the construction method statement. The

author does not take responsibility for the effectiveness of the implementation of these concepts during construction.

- The aquatic biodiversity assessment does not focus upon the socio-economic impacts of the project (for example, recreational use or changes to water purification methods for potable use or increased demand). These social impacts regarding water consumption, rather than ecology, will be incorporated within the water use authorisation application.
- The report complies with the requirements of Appendix 6 of the EIA Regulations (NEMA 2014, as amended) as the specialist was appointed prior to the 9th of May 2020.
- The assessment has not included any upgrades or alterations to the existing pump station or applied for such activities in the WUL application. If it is determined at a later stage that upgrades are required, it must be assessed accordingly. This study is based on the information that has currently been provided by the client.

- The vegetation information provided is based on observation not formal vegetation plots. As such species documented in this report should be considered as a list of dominant and/or indicator wetland/riparian species and only provide a very general indication of the composition of the riverine vegetation communities.
- This report deals exclusively with a defined area and the extent and nature of freshwater/aquatic habitat and ecosystems in that area.
- While disturbance and transformation of habitats can lead to shifts in the type and extent of aquatic ecosystems, it is important to note that the current extent and classification is reported on here.
- All soil/vegetation/terrain sampling points were recorded using a Garmin Montana Global Positioning System (GPS) and captured using Geographical Information Systems (GIS) for further processing.
- It is assumed that all the mitigation measures detailed in this report will be effectively implemented and monitored.
- The assessment of impacts and recommendation of mitigation measures was informed by the site-specific ecological concerns arising from the field survey and based on the assessor’s working knowledge and experience with similar development projects. The degree of confidence is considered good.

6 RESULTS

The aquatic habitats within a 500 metre radius of the site were identified and mapped on a desktop level utilising available data. Following the desktop findings, the infield site assessments (conducted on the 26th of September 2018 and on the 23rd of the 7th 2020) confirmed the location and extent of these systems. In order to identify the wetland/river types, using Kotze *et al.* (2009) and Ollis *et al.* (2013), a characterisation of hydrogeomorphic (HGM) types was conducted. It was then determined which HGM units are at risk of being impacted upon by the project. There are a number of factors which influence the level of impact, such as type of system, position of the system in relation to the project and position the system is located in the landscape. Factors considered for determining if a system were at risk included if a system's flow (surface or groundwater), water quality, biota or habitat would be negatively altered by the project.

Figure 21 below shows the delineated aquatic habitats in relation to the site, including the Garden Route Dam as a feature on the Kat River. Any development of the vacant land is highly likely to impact the habitat, biota, and water quality of the HGM units 1, 2, 3, and 4, and they were therefore assessed further. These areas should be restored where possible and afforded protection.

Artificial wetland habitat occurs within the study area as a result of changes from the existing infrastructure on the property. A leaking water pipeline has created a small pocket of wetland next to the gravel road. The maintenance activities associated with the pipeline servitude and road culverts have also altered the movement of water through this location and changed soil characteristics. Any wetland characteristics in this small area are not formed under normal circumstances. Additionally, the wetland is not self-sustaining as it is entirely dependent on the water inputs of the broken pipe.

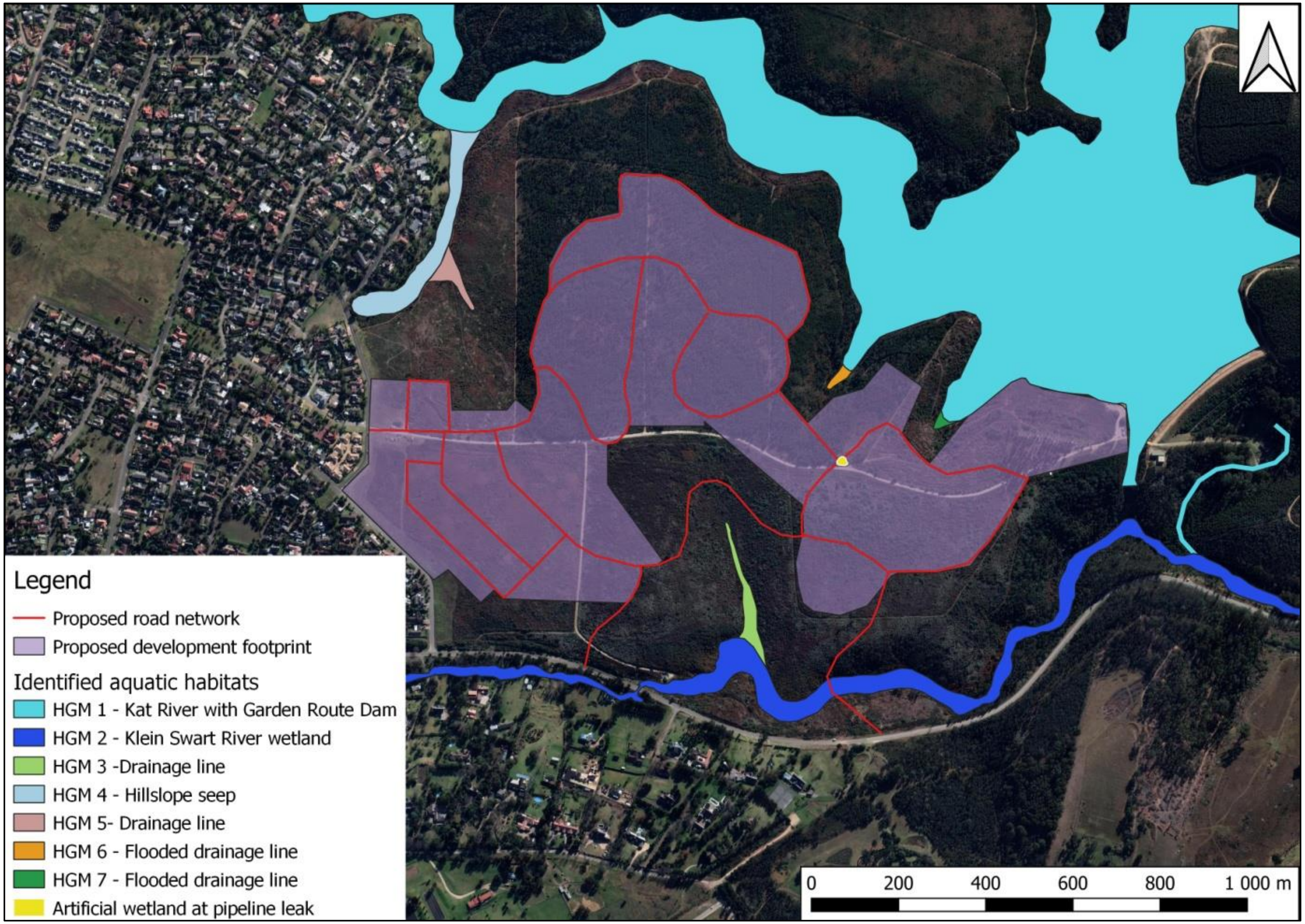


Figure 21: The watercourses potentially impacted by the proposed development

6.1 HGM 1 - Kat River and dam

6.1.1 Kat River

The Kat River is a perennial stream with its source in the Outeniqua Mountains above the town of George (Figure 22). It flows along the edge of the developed area and then becomes dammed shortly upslope of the confluence with the Swart River to the south (Figure 23). The physical character of the river changes significantly over a relatively short longitudinal distance. Consequently, there is a steady decrease in the quality of river habitat in a downstream direction. The development will not affect the upstream areas. Upslope of the urban area, the Kat River has a steep gradient and a substrate dominated by bedrock and boulders. However, as the mountain stream reaches the foothills, flowing along the edge of the town, the slope lessens, and an alluvial channel develops with extensive emergent vegetation. Marginal wetland habitat forms along this reach (Figure 24). Anthropogenic changes such as an increase in hardened surfaces, vegetation clearance, and the introduction of alien invasive plants from forestry, have resulted in channel incision and loss of wetland habitat. Towards the confluence with the Swart River the channel becomes completely transformed by the dam (Figure 25). Vegetation has been cleared and replaced with garden plant species and grass. There is evidence of sediment deposition in the channel due to erosion of the bed and banks and increased inputs from the catchment. The water is receiving pollutants from urban stormwater and household drain pipes.

The reach of the Kat River assessed is largely flooded by the dam but would have a moderately steep gradient and is within the Upper foothills longitudinal zone. It is situated within a semi-confined valley floor and has a narrow channel with limited floodplain development. The substrate is dominated by gravel and coarse sand. The river is relatively well vegetated but largely with alien invasive trees species such as *Acacia mearnsii*. It has been subjected to significant degradation due to land cover and land use changes associated with urban development, plantation, damming, and alien invasive tree infestation. Additionally, the river and dam receive pollutants from the urban area. There are pollutants entering from urban stormwater inflows as well as from malfunctioning service infrastructure. It is important to manage the system wisely due to its value as a corridor network, domestic water provisions, and the important rivers downstream.

Figures 22 to 26 are photographs of the upstream reaches of the Kat River to indicate the longitudinal changes and general characteristics of the system. Figure 27 is a photograph of the affected area of the Kat River and dam taken from the proposed development site. The reach which may be affected by the project is the back-flooded, dammed area. The habitat upstream of the property proposed for development was not assessed in detail.

Figure 22: The pristine upper reaches of the Kat River situated on the mountain foothills above the urban area

Figure 23: Photograph of the upstream reach of the Kat River as it flows alongside the urban area, prior to becoming dammed. The channel is incised and there is alien invasive plant infestation

Figure 24: Photograph of the wetland habitat, dominated by indigenous <u>Cliffortia ondorata</u> within the Kat River system, upstream of the dam. The reach assessed does not have any remaining wetland habitat as it is along the dam edge.

Figure 25: Photograph showing a severely modified reach of the Kat River along the urban edge. This reach is not near the site, but the photograph shows the existing impacts upon the river

6.1.2 Garden Route Dam

The Garden Route Dam provides the city of George its main water supply as well as acts as the recreational centre for the local residents (Figure 26). The dam was constructed in 1979 at the confluence of the Kat River and Swart River. The dam is assessed as part of the Kat River system. While the development property is largely located along the bank of the Kat River, the Swart River is the major system entering the dam, which would in normal circumstances flow unhindered around the eastern edge of the property, toward the coast and join the Kaaimans Estuary. However, the system has been impounded and dam that does not release sufficient flows for the ecological reserve. Excessive damming of rivers affects the flow, which in turn affects water chemistry, sediment transport and average temperatures. Most major manipulations of flow regimes are linked to in-channel large dams. The Garden Route Dam is an example of this, having manipulated the habitat and flow regime of the Kat River, Swart River, and the Kaaimans River downstream.

The change from the natural river form and habitat to a dam has in turn decreased the biodiversity of these rivers. Disturbance-tolerant and alien invasive species have largely replaced the more sensitive indigenous species adapted to free-flowing conditions. Freshwater Biodiversity Information System (FBIS) is a platform for hosting, visualising and sharing freshwater biodiversity information for South African rivers. According to FBIS, there are two fish species occurrence records within the Garden Route Dam. Both species are widespread, non-native species: *Lepomis macrochirus* (bluegill sunfish) and *Micropterus salmoides* (largemouth bass). According to FBIS, there are three fish species occurrence records on the Swart River site (SWAR-00015), downstream of the Garden Route Dam. The species listed are:

- *Galaxias zebratus* (Cape Galaxias) a Regional Endemic
- *Sandelia capensis* (Cape kurper) a Regional Endemic
- *Pseudobarbus afer* (Eastern Cape redfin) a Micro-endemic (Endangered)

Kariba weed (*Salvinia molesta)* was first noticed in the Garden Route Dam in 2013. Nutrients introduced from urban areas increase plant growth. The floating macrophyte can grow so thick that it blocks out sunlight and oxygen, with negative consequences for aquatic biota. The infestation is managed by spraying herbicide and introducing a biological control agent. *Cyrtobagous salviniae* weevils are a tiny beetle released on the dam which feed on the weed.

Figure 26: Photograph of the Garden Route Dam on the Kat River system

6.1.3 Present Ecological State

The reach of the Kat River assessed obtained a 'D' category score for PES as it is largely modified from the natural condition (Table 4). There has been a large loss of natural habitat, biota, and basic ecosystem functions.

Table 4: The Kat River Present Ecological State Assessment and Result

Rapid Habitat Integrity Assessment (Ecoquat Model)			
Determinand	**Score (0-5)**	**% intact**	**Rationale**
Bed modification	4	30	The Kat River has been subjected to significant purposeful and direct bed alterations. The reach upslope of the Garden Route Dam has been subjected to sedimentation, channel straightening, infilling and excavation from urban development. The construction of the dam has transformed the river bed morphology and led to downstream erosion due to sediment starvation and the altered longitudinal profile. Bed modifications have substantially reduced the quality /availability of habitat for biota.
Flow modification	3,5	40	The Garden Route Dam has resulted in significant flow modifications by impounding flows and through water

			abstraction whilst insufficient flows are released for the natural reserve. This has substantially impacted the Swart River and Kaaimans River downstream. Upslope of the dam the urban area and plantations have caused changes in temporal and spatial characteristics of flow. There has been a reduction in habitat types and water availability as a result of the many impacted habitat attributes.
Inundation	4	30	The Garden Route Dam is a significant impoundment that supplies George with water for domestic use. It has caused the inundation of a significant reach of the Kat River destroying riffle, rapid, and riparian zone habitat. It has completely obstructed the movement of aquatic fauna, influences the water quality characteristics, and the movement of sediments.
Bank condition	3	50	The bank condition has been altered by the urban development and plantation impacts as well as erosion due to alien invasive plant species compromising the banks. However, the level of incision in this reach is relatively mild and controlled by the dam spillway, but downslope of the dam the river has eroded to bedrock and unstable banks have resulted. The magnitude of the impact of this upon aquatic habitat is of a lesser degree than other attributes.
Riparian condition	3,5	40	The riparian area of the Kat River above the dam has been significantly encroached into by urban development, plantation and exotic vegetation which have compromised the available habitat extent, diversity and removed the buffering capabilities. However, the remaining habitat is vegetated and not entirely transformed.
Water quality modification	3	50	The reduced water quality of the Kat River is largely due to general misuse and mismanagement. decreased by urban pollutants such as untreated sewage, domestic effluent, polluted runoff and submerged macrophytes.
Average Score	**3,5**	40,0	*Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.*
Ecological Category	**D**	**Poor**	

6.1.4 Ecological Importance and Sensitivity

The Kat River was determined to be of High ecological importance and sensitivity (Table 5). It is part of an important corridor network that should be carefully managed for its conservation value. The reach of the river above the dam is a protected area (although largely unmanaged) but the system is important for the conservation of ecological diversity. Additionally, the provision of water by the dam is a significant service to society.

Table 5: The Kat River EIS assessment and result

Ecological Importance and Sensitivity assessment (Rivers)			
Determinants		**Score (0-4)**	**Rationale**
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	1,5	Although no rare or endangered species were encountered on site there are some species that are vulnerable on a local scale.
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	2,0	Fynbos species: More than one population (or taxon) judged to be unique on a local scale.
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	3,0	A substantial proportion of the biota is expected to be permanently dependent on flowing water for all phases of their life cycle.
	Species/taxon richness (range: 4=very high - 1=low/marginal)	2,0	The system has moderate species/taxon richness rated on a local scale.
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	3,0	Despite the reduction in habitat types due to physical modifications, the system still provides a moderate level of habitat diversity, such as pools, runs, and marginal wetland area.
	Refugia (4=Very high - 1=marginal/low)	3,0	The refuge value is moderate to high as the system does occasionally provide refugia to biota during times of environmental stress, largely due to the remaining diversity of habitat types.
	Sensitivity to flow changes (4=Very high - 1=marginal/low)	2,0	A limited change in flows of the stream does affect habitat types such as the marginal wetland areas and extent of the channel. However, the biota is only susceptible to flow decreases or increases during certain seasons.
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	2,0	The river has some habitat types that are sensitive to water quality change related to flow decreases or increases, but it is also influenced by the seasons.
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	4,0	The river corridor links the Outeniqua Mountains to the coast. It is therefore an important link in terms of connectivity for the survival of biota and is moderately sensitive to modification. However, the garden route dam reduces the connectivity substantially.
	Importance of conservation & natural areas (range, 4=very high - 0=very low)	3,0	As stated above, the river is part of an important corridor network that should be carefully managed for its conservation value. The reach of the river above the dam is a protected area (although unmanaged) but the system is important for the conservation of ecological diversity on a provincial /regional scale.
MEDIAN OF DETERMINANTS		2,50	
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		**HIGH, EC=B**	*Many elements sensitive to changes in water quality/ hydrological regime*

6.1.5 Management objective

The management objective was determined through the recommended ecological category of the wetland. This places it in the REC 'D' category which recommends maintaining the river from its present state. However, it is recommended that the development proposal incorporate basic measures to make improvements in ecological functioning (such as the halting and management of erosion and pollution and alien invasive removal that is in any case mandatory).

6.2 HGM 2 - Klein Swart River Wetland

The reach of the Klein Swart River system that will be impacted by the proposal can be classified as a channelled valley bottom wetland (Figure 27). Historically, it is likely that wetland habitat occupied the entire (although narrow) valley floor but various impacts through time have resulted in the loss of connectivity in wetland habitat along the reach. The channel incision has caused the loss of some marginal wetland habitat due to flow modification. The pockets of wetland habitat that remain consist largely of robust indigenous vegetation such as *Phragmites australis, Typha capensis, Pteridium aquilinum*, *Cyperus sp., Zantedeschia aethiopica, Helichrysum petiolare* (Figure 28). The disturbed areas are however dominated by alien invasive plant species such as *Acacia melanoxylon*, *Acacia mearnsii, Rubus cuneifolius, Arundo donax,* and *Pinus sp.* (please refer to the botanical study for a more detailed species list).

The wetland has been subjected to impacts caused by past forestry activities, infrastructure, and alien invasive plant species infestation. The construction of the road to the south of the wetland has directly destroyed habitat, altered flow movements, and increased sediment inputs. A sewage pump station has been constructed within the wetland habitat, pipelines cross the wetland, and the colour and odour of the water indicated that this effluent is escaping into the system and causing pollution (Figure 29).Additionally, the water quality sample results confirmed the presence of pollutants and *E.coli* This infrastructure has altered the morphology and hydrology of the wetland and resulted in habitat fragmentation within the valley. Any proposed development within this catchment will result in further impacts on the watercourse but there are opportunities to rehabilitate it.

Figure 27: Photograph of the incised wetland channel near the pump station

Figure 28: Photograph showing the wetland in the valley bottom with associated hydrophilic vegetation (largely sedges) in the permanent zone and the encroachment of alien invasive plant species

Figure 29: Photograph of the milky, polluted water flowing within the incised channel in the lower reaches of the wetland

The water quality results indicated that although the dam water only had some variables above the target limits for aquatic ecosystems, there were a significant number of pollutants entering the Klein Swart River (at the time of sampling). The greatly elevated Ammonia and *E.coli* levels downstream of the sewage pump station will have impacted upon the ecological health of that habitat. *E.coli* levels at the pump station point were more than double the concentration considered safe for intermediate contact recreational uses (DWAF, 1996a).

Past and present impacts have resulted in significant wetland habitat loss in large sections of the system. The hydrological regime has deviated greatly from the perceived reference state due to changes in water movement and retention patterns. The geomorphological characteristics have been transformed from the natural condition largely through erosion and sedimentation. Channel incision and straightening resulting in no bank overspill are especially harmful to a system dependent upon over-topping of the channel Although the area is well vegetated with hydrophilic indigenous vegetation, most areas are infested with alien invasive trees. The infestation of alien invasive plants in the catchment has altered the surface runoff and water inputs of the wetland area. Within the wetland, these plants confine flows and smother indigenous vegetation from the periphery. Additionally, the alien species decrease dry season flow which has resulted in terrestrial plant species encroaching into and establishing in the freshwater habitat.

6.2.1 Present Ecological State (PES)

The Present Ecological State (PES) of the Klein Swart River Wetland in the south of the property is defined as Largely Modified represented by an overall 'D' score category for the WET-Health 2 assessment (Table 6). This category is indicative of a system where a large change in ecosystem processes and loss of natural habitat and biota and has occurred. Should development on the property, and cause addition impacts from increased hardened surfaces, concentrated flows and pollutants, there will be a negative trajectory of change in wetland integrity.

Table 6: The WET-Health Version 2 PES scores for the wetland on the Klein Swart River

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	7,7	3,8	3,4	3,0
PES Score (%)	23%	62%	66%	70%
Ecological Category	**E**	**C**	**C**	**C**
Trajectory of change	↓	↓	↓	→
Combined Impact Score	5,6			
Combined PES Score (%)	44%			
Combined Ecological Category	**D**			
Hectare Equivalents	10,7 Ha			
Confidence	Moderate: Field-based 'Level 2' assessment but relatively high probability of connection to regional aquifer			

6.2.2 Ecosystem Services

At a desktop level the functionality of channelled valley-bottom wetlands as a whole tend to contribute less towards flood attenuation and sediment trapping than typical floodplain wetland types but would supply these benefits to a certain extent. Channelled valley bottom wetlands have potential for removal of nutrients and toxicants to some degree, particularly from diffuse water inputs from adjacent hillslopes (Kotze *et al.* 2009).

The indirect goods and services provided by the wetland, such as sediment and nutrient trapping, were assessed as being Moderate to High (Table 7 and Figure 30). However, the wetland has a very low provision of direct ecosystem services apart from the small amount it contributes to the open space recreational setting (such as cycling) on the property. The system is not significant in terms of food or resource provisions, education/research and/or socio-cultural. This is mostly due to the lack of any endangered species, no known traditional practices, and the poor condition of the system.

Table 7: Scores for Klein Swart River Wetland EcoServices Assessment

Swart River Wetland - Ecosystem Services Scores	Overall score (0- 4)
Flood attenuation	1,6
Streamflow regulation	2,2
Sediment trapping	2,7
Phosphate trapping	2,6
Nitrate removal	2,5
Toxicant removal	2,6
Erosion control	1,9
Carbon storage	2,0
Maintenance of biodiversity	1,6
Water supply for human use	1,2
Natural resources	0,2
Cultivated foods	0,0
Cultural significance	0,0
Tourism and recreation	1,9
Education and research	1,3
Threats	3,0
Opportunities	4,0

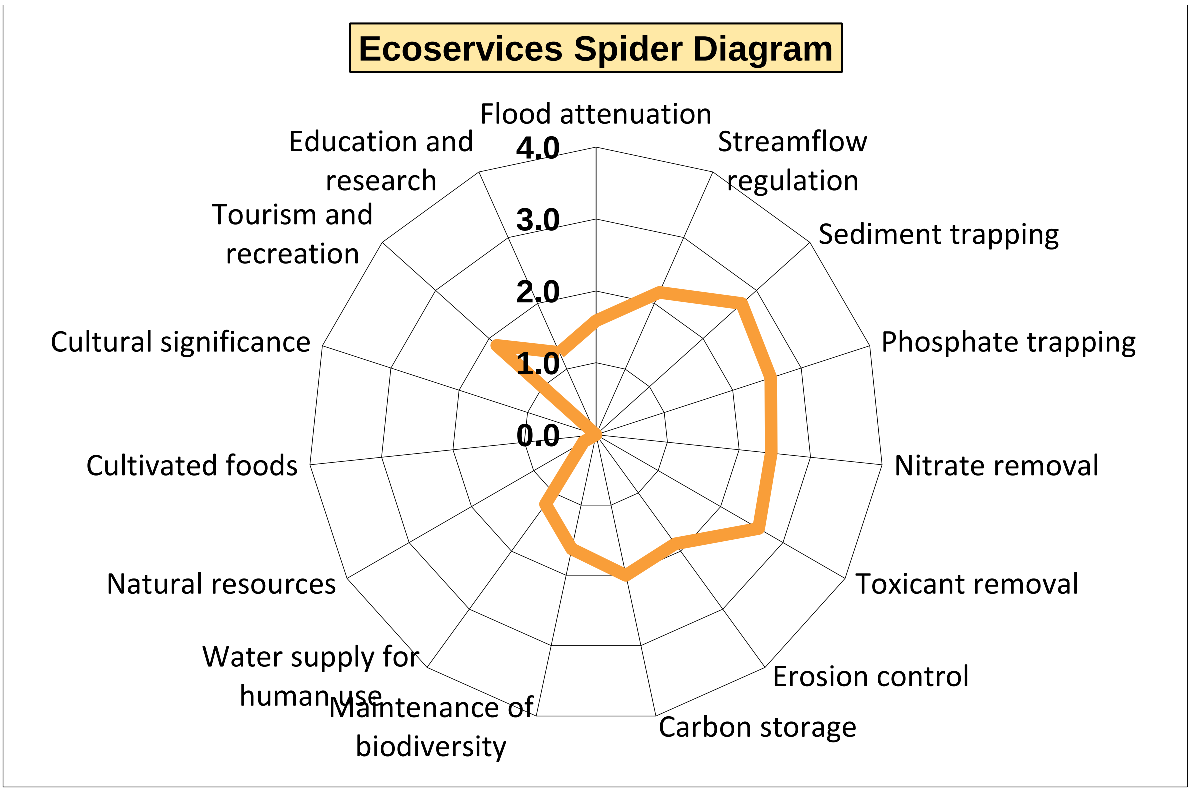


Figure 30: WET-Ecoservices Results

6.2.3 Ecological Importance and Sensitivity (EIS)

The Ecological integrity and sensitivity of the Klein Swart River Wetland was assessed and obtained a Moderate EIS score (Table 8). Similar to the functional assessment above, the results show that the wetland provides very limited direct human benefits yet has moderate significance regarding indirect services. Ecologically, the wetland is not conserved in any way and no red data species, or populations of unique species were observed. However, the wetland is an important piece of the larger river corridor network, influences significant downstream systems, and is moderately sensitive to changes to flow regime and periods of low flows.

Table 8: EIS Scores for the Klein Swart River Wetland

SUMMARY	Swart River Wetland	
	Score (out of 4)	**Rating**
BIODIVERSITY IMPORTANCE	2,33	Moderate
FUNCTIONAL/HYDROLOGICAL IMPORTANCE	1,63	Low
DIRECT BENEFITS TO SOCIETY	1,17	Low
Ecological Importance and Sensitivity (EIS)	**2,33**	**Moderate - High**

6.2.4 Management objective

The management objective was determined through the recommended ecological category of the wetland. It is recommended that the development proposal incorporate basic measures to make improvements in ecological functioning (such as the halting and management of erosion and pollution and alien invasive removal that is in any case mandatory).

6.3 Minor systems

6.3.1 HGM 3 – Non-perennial stream

There are three small drainage lines that concentrate runoff from the property into the Kat River and dam, and there is one tributary draining in a southernly direction into the Klein Swart River Wetland. These tributaries are small natural systems with temporary flow. The systems are of similar ecological integrity as they share biophysical characteristics and have been similarly impacted by land use and cover changes. The tributaries all have narrow, shallow channels that are stable despite being steep longitudinally. No erosion was evident within these catchments. The tributaries are well-vegetated with shrubs such as *Diospyros dichrophylla* and *Searsia glauca,* with an understory dominated by *Helichrysum petiolare*. and *Pteridium aquilinum*. However, there is a moderate level of alien invasive tree infestation (largely *Acacia mearnsii, Acacia melanoxylon* and Pinus sp.). *Rapanea melanophloeos trees* (Cape Beech), a protected species, were observed within the southern tributary riparian zone.

The four drainage systems will have been impacted upon in the past by forestry activities associated with the planation on the property, but they are not currently subjected to anthropogenic impacts and function in a near natural manner. The present ecological state of the small tributary systems was determined to be within the "B" category, indicating that modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is also very small or not evident (Table 9). The proposed development is located within these catchments and will impact these systems.

Table 9: The PES results for the tributary streams

Rapid Habitat Integrity Assessment (Ecoquat Model)			
Determinand	**Score (0-5)**	**% intact**	**Rationale**
Bed modification	0,5	90	The systems are unimpacted by roads, erosion or any impacts causing bed modification. There is no evidence of sedimentation or erosion.
Flow modification	0,5	90	The systems only flow intermittently from surface runoff. These flows have been marginally impacted by altered runoff patterns caused by the gravel roads upslope. The regime has not been impacted by decreased or increased inputs. There have been no significant flow modifications.
Inundation	0	95	There are no inundated areas.
Bank condition	0,5	90	The riparian banks are stable, shallow in depth and not well defined. They are well vegetated with a mix of indigenous species and alien species. There has been no decrease in bank condition in these systems.
Riparian condition	2,5	60	The riparian areas are stable and well vegetated. However, there is a moderate level of alien invasive plant infestation that threatens the habitat integrity.
Water quality modification	0	95	There are no anthropogenic impacts in the systems micro catchments. There is no potential for pollutants to enter the systems. Additionally, there is no erosion to cause sedimentation.
Average Score	**0,7**	86,7	*Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.*
Ecological Category	**B**	**Good**	

The ecological importance and sensitivity category of the tributary network was determined as being 'Moderate' (C category) (Table 10). The systems do not have a high sensitivity as they are only intermittently inundated with no significant diversity of habitat along the reach. However, they act as an important ecological corridor.

Table 10: The EIS results for the tributary stream assessment

Ecological Importance and Sensitivity assessment (Rivers)			
Determinants		**Score (0-4)**	**Rationale**
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	1,0	Although no rare or endangered species were encountered on site there are some species that are vulnerable on a local scale.
	Unique (endemic, isolated, etc.) (range: 4=very high)	1,0	Fynbos species: More than one population (or taxon) judged to be unique on a local scale.
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	1,0	The species associated with these riparian systems are likely very tolerant of increases and decreases in flow as the systems are intermittently inundated. A very low proportion of the biota is expected to be only temporarily dependent on flowing water for the completion of their life cycle. Sporadic and seasonal flow events expected to be sufficient.
	Species/taxon richness (range: 4=very high - 1=low/marginal)	2,0	Despite the presence of alien invasive plants, the untransformed habitat and fynbos vegetation type results in a moderate species/taxon richness
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	2,0	There is a low diversity in aquatic habitat types do to the shallow, straight, and intermittently flowing systems with a uniform substrate material
	Refugia (4=Very high - 1=marginal/low)	2,0	The systems have a limited ability to provide refuge to biota during times of environmental stress. This is due to the limited diversity of habitat and intermittent flow.
	Sensitivity to flow changes (4=Very high - 1=marginal/low)	1,5	These small intermittent rivers, with limited habitat types, are only susceptible to flow decreases or increases during certain seasons.
	Sensitivity to flow related water quality changes (4=Very high)	1,0	These are streams with habitat types rarely sensitive to water quality change related to flow decreases or increases.
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	2,0	The tributaries are a moderately important link in terms of connectivity for the survival of biota upstream and downstream and is moderately sensitive to modification. The network provides a corridor to the Kat River system.
	Importance of conservation & natural areas (range, 4=very high)	2	The tributaries are in a semi natural area which is important for the conservation of ecological diversity on a provincial /regional scale.
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		**MODERATE, EC=C**	*Some elements sensitive to changes in water quality/hydrological regime*

6.3.2 HGM 4 - Hillslope seep and out flowing stream

HGM 4 is a small hillslope seep with an outflowing channel. The seep is located at the head of a drainage line that develops into a channel and joins the Kat River to the north. The system receives stormwater from the existing road off site and lateral inputs from urban development along the riparian edge on the northern side of the channel. Even prior to the development of housing in this area, the wetland will have been subjected to anthropogenic impacts from forestry activities. The channel is slightly incised but well-vegetated. Invasive alien plant species dominate the disturbed site (such as *Acacia mearnsii*, *A. melanoxylon, Solanum mauritianum, Pennisetum clandestimum,* Rubus sp., and *Canna indica)*, however, indigenous plants such as *Pteridium aquilinum* and *Helichrysum petiolare* are present. The project will cause an increase in hardened surface area and removal of vegetation in the catchment which may alter the system's flow regime. The stormwater infrastructure of the development, if poorly designed, will increase and concentrate surface runoff into the system which may cause erosion. The entire project may also negatively affect the water quality of the channel due to increased sediment inputs and potential pollutants.

The Present Ecological State (PES) of the wetland system is defined as moderately modified represented by an overall 'C' category for the WET-Health assessment (Table 11). The wetland is not in a natural state and much of the original wetland cover has been lost. The hydrology score for the wetland has an impact rating of 3.8 (C) indicating that the hydrological processes have been modified by the stormwater outlet of the road and overall increase in hardened surfaces in its catchment. The geomorphological processes remain largely stable and therefore obtained a "B" Category impact score. However, without the adoption of mitigation measures this is likely to decrease. The vegetation element has undergone disturbance resulting in a "C" PES category. A "B" PES was obtained for water quality; however, this is a seasonal system and would likely be lower if perennial due to urban contaminates.

It is anticipated that the health of the wetland is likely to deteriorate in the future due to the likelihood of increased anthropogenic pressures. Due to the small size of the system, and its steep slope, the wetland is vulnerable to perturbations. However, should the design of the development incorporate an appropriate stormwater management plan and strictly avoid the wetland and associated buffer area, to maintain diffuse flows and curb erosion, it is anticipated that the hydrological health of the system will be maintained.

Table 11: Summary of WET-Health Assessment for HGM 4

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	3.8	1.3	1.2	3
PES Score (%)	62%	87%	88%	70%
Ecological Category	**C**	**B**	**B**	**C**
Trajectory of change	↓	↓	→	→
Combined Impact Score	2.2			
Combined PES Score (%)	78%			
Combined Ecological Category	**C**			
Hectare Equivalents	10,7 Ha			
Confidence	85% Field-based assessment			

Seep wetlands are expected to contribute to some surface flow attenuation until soils are saturated, after which, their contribution to flood attenuation is very limited. Seep wetlands are commonly considered to supply a number of water quality enhancement benefits by removing excess nutrients and inorganic pollutants (especially nitrogen) produced by agriculture, industry and domestic waste. (Kotze *et al.*, 2009). The HGM 4 hillslope seep provides limited ecosystem services as it is small and in a modified state. However, it attenuates stormwater runoff from the developed area and road. Additionally, it may trap sediments and nutrients from runoff to a small degree prior to entering the Kat River and dam. With the adoption of a buffer area the system can be maintained in its present condition, however, it is recommended that efforts are made to improve the vegetation component.

6.3.3 HGM 5, 6, & 7 - Drainage lines

HGM 5 is a small drainage basin in the northern area of the site which transports sheetflow down slope toward HGM 4. The valley does not support a flowing stream as it is shallow and gently sloped. Water supply is not sufficient to exceed the threshold which would result in the formation of a clearly defined channel. Surface runoff does however collect toward the base of the slope near the confluence with HGM 4. The HGM 6 and HGM 7 drainage lines have been flooded by the construction of the dam. The recent raising of the dam spillway has resulted in further submergence of the valleys. Any features which are characteristic of non-perennial streams are no longer present. Historically these systems would have been classified as episodic streams which merged with the Swart River before it was dammed and back flooded.

6.3.4 Artificial wetland

Wetland is a term applied to a variety of ecosystems, depending on the definition used. The definition used in this aquatic assessment is sourced from the South African National Water Act (Act No. 36 of 1998) which 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".* The guideline for the delineation of wetlands in South Africa – Practical Field Procedure for The Identification and Delineation of Wetlands and Riparian Areas (Rountree *et al.,* 2008) – uses this definition. There are other definitions which specifically include artificially formed ecosystems. Artificial wetlands are aquatic ecosystems where hydric soil features have developed, or where wetland plants have colonised, in historically non-wetland areas due to human activities.

On the property proposed for development, artificial wetland habitat has formed on the drainage divide, on the northern side of the road (Figure 31 & 32) and south of the road below a culvert outlet. It is clear that a municipal raw water pipeline has a leak in this one location (Figure 33 & 34). The constant inundation of the surrounding terrestrial soils, for a sufficiently long period of time, has resulted in the development of a small artificial 'seep' wetland. It is important to note that the NWA definition of a wetland provides for 'normal circumstances'. The small wetland on the site is entirely artificial and the characteristic soils and vegetation would be terrestrial in nature under normal circumstances. The water is humic stained as it is raw water from the dam, which has dark brown coloured water. Should the pipeline be repaired or decommissioned, this patch of wetland vegetation will slowly cease to exist, and the land would revert back to terrestrial fynbos habitat again.

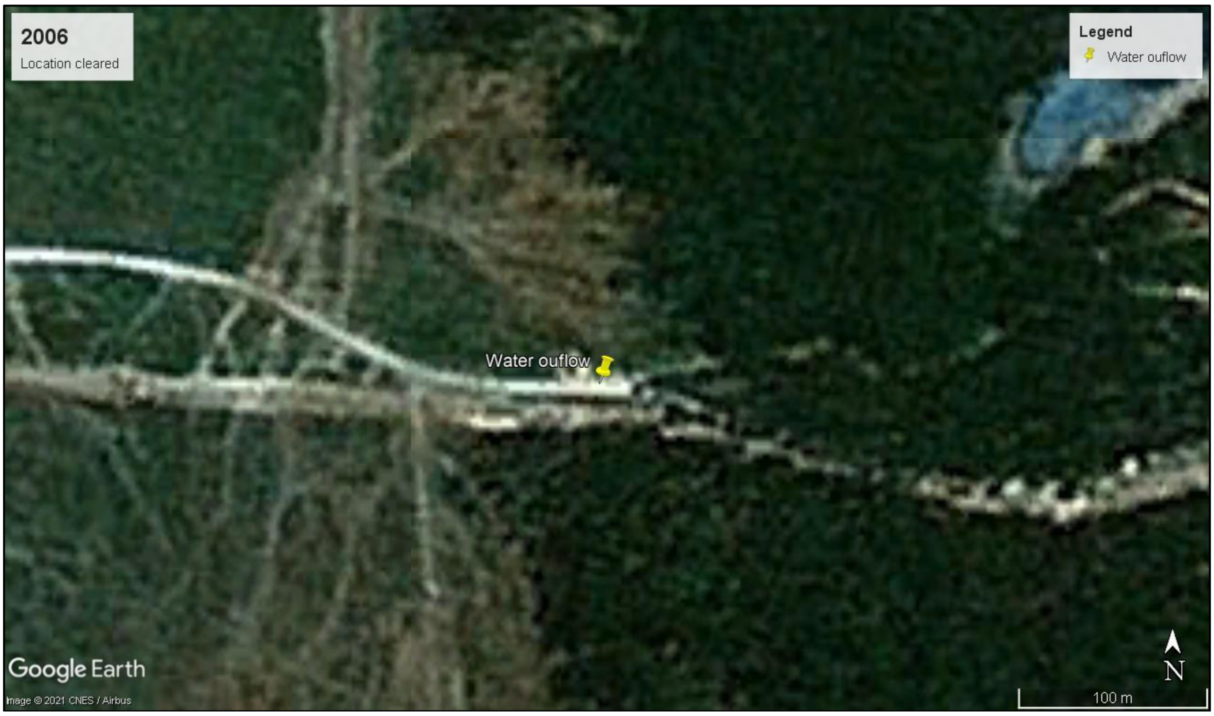


Figure 31: Location of the current pipe leak in relation to historic satellite imagery from 2006 showing the disturbed nature of the area

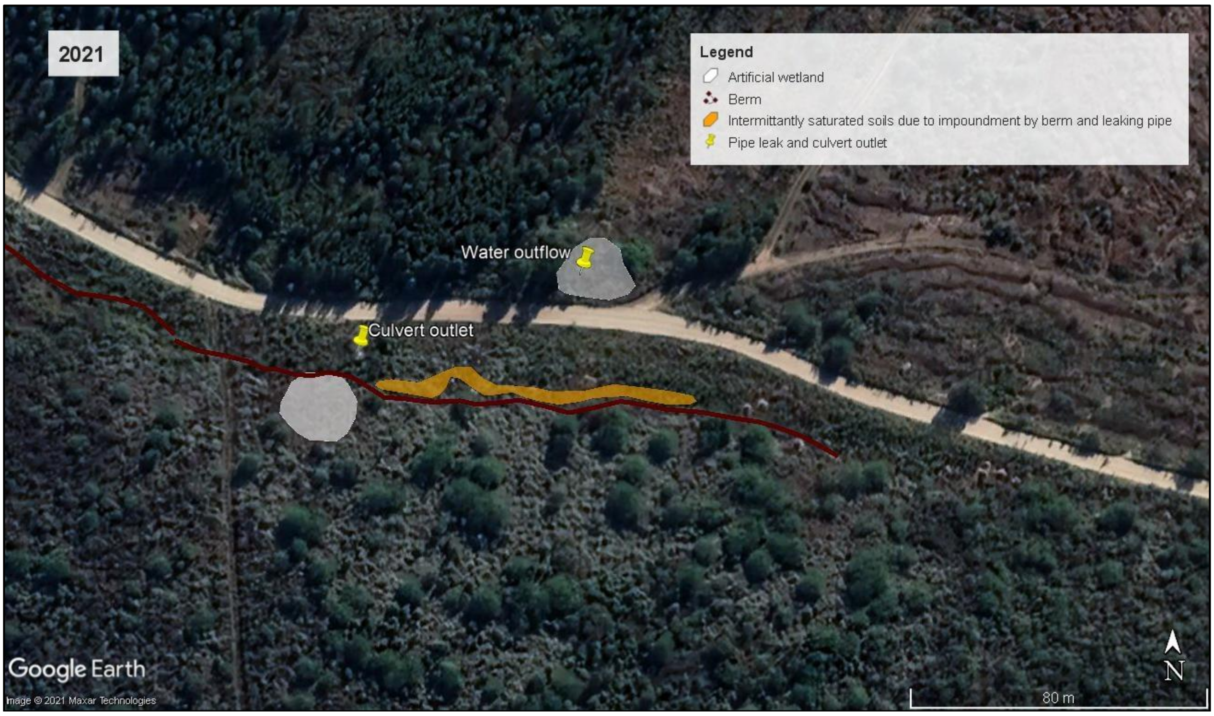


Figure 32: Imagery from 2021 showing the changes to the natural characteristics of the site due to human influences

Figure 33: Photograph of the artificial wetland habitat that has formed due to prolonged inundation from a leaking water pipeline

Figure 34: Photographs showing the source of water inputs from a leaking water pipeline. The water is humic stained as it is raw water from the dam, which has dark brown coloured water.

South African legislation does not distinguish between natural and artificial wetlands. Wetlands that have been artificially created will after a certain number of years have the same legal status as naturally occurring wetlands. This is important as there are instances where artificial (usually constructed wetlands) are created by a change in the landscape and have the capacity to fulfil the same functions as natural wetlands. The protection of these artificial systems can be necessary if the artificial wetlands provide valuable ecosystem services to society. However, to be worthy of such protection, a wetland would need to be somewhat self-sustaining in fulfilling these functions. The artificial wetland on the site is completely dependent on the pipe leaking. It covers a very small area and any ecosystem services supplied are deemed as relatively insignificant. Most importantly, it is not self-sustaining, as the pipeline could be repaired or decommissioned at any time. Therefore, the small pocket of artificial wetland does not warrant further investigation and its loss will not impact aquatic biodiversity. Resources should be focused upon improving the state of the natural watercourses in the area.

7 IDENTIFIED IMPACTS

Aquatic ecosystems are particularly vulnerable to human activities and these activities can often result in irreversible damage or longer term, cumulative changes. The significance of an impact to the environment or ecosystem can only be assessed in terms of the change to ecosystem services, resources and biodiversity value associated with that system or component being assessed. The approach adopted is to identify and predict all potential direct and indirect impacts resulting from an activity from planning to rehabilitation. Thereafter, the impact significance is determined. The direct and indirect impacts associated with the project are grouped into four encapsulating impact categories where associated or interlinked impacts are grouped. Impacts have been separated into construction and operational phases of the project within these categories. There are no impacts associated with the No Go Alternative.

7.1 Disturbance/loss of aquatic vegetation and habitat

The disturbance or loss of aquatic vegetation and habitat refers to the direct physical destruction or disturbance of aquatic habitat caused by vegetation clearing, disturbance of wetland habitat, encroachment and colonisation of habitat by invasive alien plants. The Garden Route Dam has flooded natural riparian habitat along the northern boundary of the study area. Therefore, the large majority of aquatic habitat and vegetation that is at risk would be located to the south, in the Klein Swart watercourse. Adherence to a buffer area (discussed in Section 9.2) will protect aquatic habitat from the majority of potential impacts. However, the construction of road and pipeline crossings is a significant threat to aquatic vegetation and habitat.

7.1.1 Construction Phase

The project will require a large area of vegetation on the property to be cleared resulting in land cover changes in the catchments. The machinery, vehicles and workers (i.e. turning areas and crossings) needed to construct the roads and stormwater infrastructure will transform areas of riparian habitat. The remaining wetland habitat on the Klein Swart watercourse will be either replaced or at least compromised by the construction of infrastructure. Any flow diversion of dewatering activities for construction may result in the desiccation of portions of habitat reliant on permanent saturation. There will be a significant amount of soil disturbance on the hilltop and slopes. The movement of topsoil and incorrectly placed stockpiles could bury aquatic habitat. Due to construction, alien invasive species may encroach further into any disturbed areas and outcompete indigenous vegetation thereby reducing aquatic biodiversity.

7.1.2 Operational Phase

Localised scour around structures or flow impediments may result and alter the natural bank and channel, channel bank stability and floodplain processes. Road and pipeline crossings that concentrate diffuse flows and can also inadvertently trigger gully formation. Roads, pipelines, culverts and bridges create migration barriers to biota, resulting in reach to zone scale instream biological impacts. The stormwater infrastructure of the housing and associated road network will increase and concentrate flows into the watercourses. This may lead to erosion in the systems that compromises remaining habitat.

The bridge design provided by the engineers for the crossing over the Klein Swart River wetland habitat will result in unnecessary vegetation and habitat loss. It is a typical design and does not take the sensitivity or local topography of the site into account. The civil drawing shows a box culvert design with only one culvert opening for flow. This is not appropriate for this wetland system and apart from immediate, direct habitat loss it will also cause impacts to remaining habitat into the operational phase of the project. The pipeline crossing designs have not yet been provided but the route is aligned with the road crossing.

The project will promote the establishment of disturbance-tolerant biota, including colonization by invasive alien species, weeds and pioneer plants within the remaining habitat. Although this impact is initiated during the construction phase it is likely to persist into the operational phase. The development and implementation of a suitable alien invasive plant control and management plan will be essential to managing the potential impact of these plants on watercourses in the long-term.

7.1.3 Decommissioning Phase

Should sewer pipelines or such infrastructure associated with the development be decommissioned in the future, there is potential for disturbance of habitat similar to the construction phase impacts. Earthworks (by machinery and activities requiring labour) and stockpiles, within the aquatic habitat, required to remove old infrastructure may result in trampling and burying of aquatic habitat.

7.2 Sedimentation and erosion

Sedimentation and erosion refers to the alteration in the physical characteristics of wetlands and rivers as a result of increased turbidity and sediment deposition, caused by soil erosion and earthworks that are associated with construction activities, as well as instability and collapse of unstable soils during project operation. These impacts can result in the deterioration of aquatic ecosystem integrity and a reduction/loss of habitat for aquatic dependent flora & fauna. This will mainly affect the health of the Klein Swart River wetland habitat as the dam prevents erosion on aquatic habitat to the north. There may be a lesser ecological impact of sedimentation in the dam, however, any sedimentation could have an indirect negative impact on society. Sediments deposited in the dam can build up and reduce the storage capacity. Additionally, the water abstracted for human consumption may require additional/alternative treatment.

7.2.1 Construction Phase

Vegetation clearing and exposure of bare soils within and upslope of the aquatic habitat during construction will decrease the soil binding capacity and cohesion of the upslope soils and thus increase the risk of erosion and sedimentation downslope. This may cause the burying of aquatic habitat and also cause aquatic faunal fatalities. It may lead to the wetland ceasing to function. Ineffective site stormwater management, particularly in periods of high runoff, can lead to soil erosion from confined flows. Formation of rills and gullies from increased concentrated runoff. This increase in volume and velocity of runoff increases the particle carrying capacity of the water flowing over the surface. This is likely to be one of the most significant impacts upon the wetland. Any development on the steeply sloped areas, including roads, magnifies the potential for the watercourses to be impacted upon.

7.2.2 Operational Phase

Where soil erosion problems and bank stability concerns initiated during the construction phase are not timeously and adequately addressed, these can persist into the operational phase of the development project and continue to have a negative impact on downstream water resources in the study area. The increase in hardened surface by the development will be considerable and, if not mitigated against, will result in further erosion/sedimentation in the wetland. Surface runoff and velocities will be increased, and flows may be concentrated by stormwater infrastructure. The dam wall acts as a local base level that prevents erosion directly upslope but would be affected by sediment inputs through stormwater runoff. Stormwater management during operation will be critical in ensuring that runoff characteristics mimic the natural scenario and do not lead to increased floodpeaks and flow velocities which could lead to increased erosion and sedimentation risks that could potentially affect the downstream watercourses.

7.2.3 Decommissioning Phase

Should sewer pipelines or such infrastructure associated with the development be decommissioned in the future, there is potential for erosion and sedimentation similar to the construction phase impacts. Earthworks by machinery and activities requiring labour, within the aquatic habitat, required to remove old infrastructure may result in soil disturbance.

7.3 Water Pollution

Water and/or soil pollution cause negative changes in the physical, chemical and biological characteristics of water resources (i.e. water quality). This can result in possible deterioration in aquatic ecosystem integrity and a reduction in, or loss of, species of conservation concern (i.e. rare, threatened/endangered species). The result is only disturbance tolerant species remaining. Additionally, litter indirectly decreases the aesthetic value of the aquatic habitats. The dam will mitigate some of the potential impacts of water pollution on the ecosystems downstream by containing the water and diluting concentrations. However, the risk of pollution to both water resources (the dam and the Klein Swart) are significant if not mitigated against. The nutrient enrichment can cause an increase in denitrification rate and biological uptake and processing. Resultant organic loading can reduce biological uptake and processing.

7.3.1 Construction Phase

During construction there are a number of potential pollution inputs into the aquatic systems (such as hydrocarbons and raw cement). These pollutants alter the water quality parameters such as turbidity, nutrient levels, chemical oxygen demand and pH. These alternations impact the species composition of the systems, especially species sensitive to minor changes in these parameters. Sudden drastic changes in water quality can also have chronic effects on aquatic biota in general and result in localised extinctions. Hydrocarbons including petrol/diesel and oils/grease/lubricants associated with construction activities (machinery, maintenance, storage, handling) may potentially enter the system by means of surface runoff or through dumping by construction workers. Raw cement entering the systems through incorrect batching procedure and/or direct disposal. This is especially likely during construction of the bridge within the Klein Swart River. The incorrect positioning and maintenance of the portable chemical toilets and use of the surrounding environment as ablution facilities may result in sewage and chemicals entering the systems.

7.3.2 Operational Phase

The greater the extent of hardened surfaces (e.g. roofs, parking lots etc.), the lower the infiltration of stormwater and therefore the greater the surface runoff and increase in flood peaks. A change in water distribution generally results in altered wetness regimes, which in turn affect the biophysical processes and the vegetation patterns. Urbanization of the catchment and its associated stormwater runoff is a threat to aquatic biodiversity not only because of the increased hydrological disturbance and habitat loss, but also because of an increased delivery of pollutants to streams. These pollutants often do not have a chronic effect on aquatic biota, but their negative and collective effects may be realised over longer periods of time. The most problematic nutrients are nitrogen and phosphorus.

An increase is these two nutrients can typically have a significant and drastic effect on the productivity of watercourse biota particularly plants such as algae which increases abundantly and depletes dissolved oxygen.

Stormwater runoff from urban surfaces may include nutrients, pollutants, raw sewage, and other domestic waste. This waste can lead to eutrophication, excess plant growth causing changes to community dynamics, hypoxia (oxygen depletion) as well as inhibit the growth of bacteria that play an important role in removing nitrogen from water. The increase in vehicles on the property due to the development increases the potential for pollutants to enter the systems. If not prevented, litter, and contaminants, including sand, silt, and dirt particles, will enter storm water runoff and pollute the watercourses. Micro-litter such as cigarette butts may travel through certain stormwater grids and grids may not be regularly cleared. Activities such as car washing, swimming pool backwashing, laundry handwashing etc. all have the potential to enter the stormwater system and pollute the Dam or Klein Swart River system. The business zone (including the Waterfront and Hotel) is likely to include restaurants that increase the risk of oils, grease, fats, and soaps polluting the dam. The close proximity of these areas to the dam increases the probability of pollution.

The establishment of sewer pipes within and/or in close proximity to watercourses always poses a long term threat to the water quality and ecological health of aquatic ecosystems due to the relatively high likelihood that surcharge events will occur at some point in the future. A complete shift in the structure and composition of aquatic biotic communities is the result, as well as a general degradation in water resource quality that could have negative impacts to human users. Over the lifetime of the development, surcharge events and/or pipe leakages will likely occur and as a result some pollution as a result of sewerage infrastructure is inevitable. Mitigation measures must be put in place to reduce the intensity of pollution events and ultimately reduce pollutant loads. It is assumed that all waste water will be disposed of via existing infrastructure and will not be treated on the property. However, should any onsite waste water treatment infrastructure fail, and result in raw sewerage entering any watercourses, it may impact the water quality of the systems. Any water pollution within the rivers will have a significant negative impact as, if not prevented, the pollutants will enter the Garden Route Dam, Klein Swart River and Kaaimans River downstream. However, the existing pollution sources (the Kat River area and pump station in the Klein Swart River) have already reduced ecological health. The existing pump station (to be upgraded) and the two additional pump stations should each have back-up generators installed to deal with loadshedding, as well as unexpected outages.

During maintenance of the development there could be water pollution impacts similar to those encountered in the construction phase.

7.3.3 Decommissioning Phase

Earthworks by machinery and activities requiring labour, within the aquatic habitat, required to remove old infrastructure may result in minor water quality impacts.

7.4 Flow Modification

The changes in the quantity, timing and distribution of water inputs and flows within the watercourse. Possible ecological consequences associated with this impact may include deterioration in freshwater ecosystem integrity, reduction/loss of habitat for aquatic dependent flora & fauna, and a reduction in the supply of ecosystem goods & services. The flow volumes entering the Dam will increase with development but the effect on ecology will be minimal. The dam does not release water and therefore the impoundment will mitigate against flow changes downstream. However, the development runoff will cause a significant change in the flow regime of the wetland habitat in the Klein Swart River. Therefore, altered flow patterns and volumes has a higher potential to impact the ecological state of the Klein Swart River and downstream systems rather than the ecology of the dam. Any infrastructure within the riparian zone is highly likely to change flow distribution.

7.4.1 Construction Phase

Land clearing and earth works upslope of the watercourses will reduce infiltration rates and increase the surface runoff volume and velocity. Such changes in surface roughness and runoff rates may lead to some rill and gully erosion. Altered water inputs from upslope disturbances as well as modified water distribution and retention patterns will ultimately affect the hydrological integrity of water resources. The dam will however act as a type of buffer to changes downstream by regulating flow from the impoundment. The Klein Swart River is proposed to be crossed by roads and pipelines. The construction of such infrastructure will alter the flow pattern through dewatering and diversion activities. This may result in erosion and desiccation of wetland habitat that relies on prolonged flooding. Stormwater runoff outlets, if poorly planned/ designed, may concentrate surface flows and alter the manner in which flow enters the systems.

7.4.2 Operational Phase

Hardened/artificial infrastructure will alter the natural processes of rain water infiltration and surface runoff, promoting increased volumes and velocities of storm water runoff, which can be detrimental to the rivers and wetlands receiving concentrated flows from these areas. According to the SANRAL (2006), urbanisation typically increases the runoff rate by 20 -50%, compared with natural conditions. Increased volumes and velocities of storm water draining from the development and discharging into down-slope watercourses can alter the natural ecology of the systems, increasing the risk of erosion and channel incision/scouring and backflooding. The impact of permanent flow modifications caused by the development is likely to be significant and negative in nature. Figure 35 below is an illustration of the impacts upon wetland habitat under various scenarios indicating the importance of stormwater mitigation.

7.4.3 Decommissioning Phase

Should sewer pipelines or such infrastructure associated with the development be decommissioned in the future, there is potential for slight flow modification similar to the construction phase impacts. Trenches and associated dewatering activities within the aquatic habitat, required to remove old infrastructure, may result in temporary changes in flow patterns.

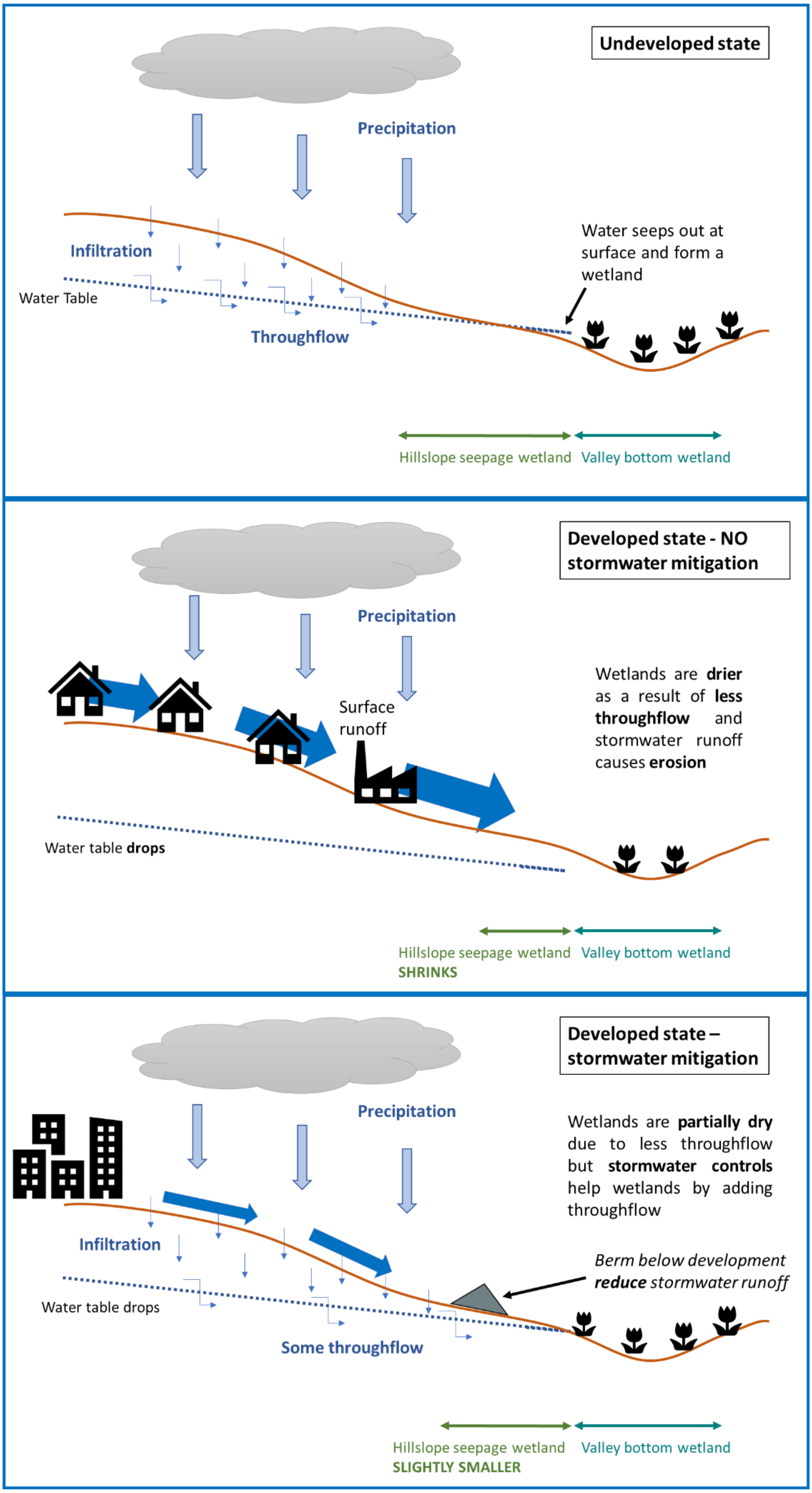


Figure 35: Diagrams indicating the characteristics influencing wetlands that are affected by development

7.5 Cumulative Impacts

Cumulative impacts on the environment can result from broader, long term changes and not only as a result of a single activity. They are rather from the combined effects of many activities overtime. Rivers are longitudinal systems where different reaches interact in a continuum along the length of the river. Activities in the upper reaches influence the processes of the lower reaches and it must therefore be viewed as a whole. Watercourses are set apart from many other ecosystem types by the degree to which they integrate with and are influenced by the surrounding landscape, or catchment. The physical, chemical and biological characteristics of any river are determined almost entirely by the nature of its catchment and the activities, human and natural, that take place in it (Davies and Day 1998). Widespread land use conversion at a catchment scale can dramatically alter the flow rates, water quality and sediment regimes of watercourses.

The catchment has been impacted by human activities for a long period of time (refer to historic imagery), largely for commercial forestry and urban expansion. The cumulative impact of activities in the catchment (such as the construction of the dam, clearance of riparian vegetation, infilling and diversions, urban encroachment into the watercourses, water over-abstraction, and an altered sediment regime), has resulted in wide-spread habitat degradation. The impacts have affected the entire downstream length of the system with a highly modified sediment regime and change in flood peaks all the way down to the Kaaimans River mouth. The riparian areas impacted are classified as Critical Biodiversity Areas and fragments as Ecological Support Areas according to the Western Cape Biodiversity Spatial Plan (CapeNature, 2017). These habitats/ CBAs are required to meet biodiversity targets and they need to be maintained in a natural or near-natural state. Any degradation due to this project will have a negative cumulative impact upon biodiversity conservation targets. The rehabilitation and monitoring of the watercourses may however benefit aquatic biodiversity and the conservation of the watercourses. Rehabilitation may never achieve the pre-impacted ecological state, but it will have positive outcomes to regain some ecosystem services and processes functioning.

The cumulative impact of the project upon aquatic biodiversity is of medium significance. It is important to consider that this property was earmarked for development since 2013 and included in the urban edge of George. Therefore, it is likely that some form of development, whether it be this proposal or another, will occur in this location. The Alternative 2 layout, apart from the encroachment of the hotel and waterfront, will at least not result in any high impacts to aquatic biodiversity (after mitigation).

8 IMPACT SIGNIFICANCE ASSESSMENT

The impact significance of the proposed development was determined for each potential impact of the project alternatives (Tables 12 - 17). The significance weightings (see methodology in Annexure 12) for each potential impact are as follows:

- <30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop the area),
- 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),
- >60 points: High (i.e. where the impact must have an influence on the decision process to develop the area).

The assessment of impacts 'with mitigation' is considered as the best case scenario and assumes that all of the mitigation measures within this report and the EMPr will be successfully implemented. However, assessment under the category 'without mitigation' measures assumes a worst case scenario involving the poor implementation of construction mitigation, bare minimum incorporation of recommended design mitigation, poor operational maintenance, and poor onsite rehabilitation.

It was determined that the most severe potential impacts associated with the development will likely be habitat disturbance/loss and erosion and sedimentation as a result of new road and pipeline crossings, as well as stormwater runoff. The transformed land surface will promote increased volumes and velocities of storm water runoff, which can be detrimental to the watercourses receiving concentrated flows off of the area. Due to the large increase in hardened surfaces, even with the implementation of mitigation measures such as stormwater management, a Low rating cannot be reached for all risks. However, following mitigation, Alternative 2 will not have any unacceptably high impacts.

The original layout (Alternative 1) poses the greatest threat to aquatic biodiversity. Alternative 1 proposes to develop a greater area of the site and the footprint is in closer proximity to the identified watercourses. Therefore, the development of this layout will require a larger area of land to be transformed to hardened surfaces and it will have a higher likelihood of impacting aquatic habitat downslope. Without mitigation, the Alternative 1 layout has unacceptably high impacts upon aquatic habitat. While this impact significance is substantially reduced if mitigation is successfully implemented, the Alternative 2 layout remains the preferred development alternative. The

Alternative 2 layout has been designed to incorporate more of the recommended aquatic buffer areas. The waterfront and hotel remain within the buffer zone in both layouts.

The No Go Alternative was determined to have no/ negligible impact upon aquatic habitat. It is the preferred alternative for aquatic biodiversity. The No Go assumes that sufficient resources will be allocated to continually manage the land and halt existing impacts (such as alien plant infestation and water contamination).

The impacts can be decreased to acceptable levels provided that mitigation measures in the following Section, especially the buffer areas, are implemented and adhered to during the construction and operational phase of the project. Buffer areas, applied in conjunction with other measures, can be very effective measures to mitigate impacts from development upon freshwater habitat.

8.1 Alternative 1 Impact Table

Table 12: Evaluation of potential impacts of Alternative 1 of the Garden Route Dam Erf 464 development on aquatic habitat during construction

	Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance	Reversibility	Mitigation Potential	Irreplaceable Resource Loss
Construction Phase	Loss and disturbance of aquatic vegetation & habitat	Without Mitigation	Regional (3)	Medium (3)	Moderate (6)	Definite (5)	**High (60)**	Partly	High	Yes
		With Mitigation	Local (2)	Short (2)	Moderate (6)	Highly Likely (4)	**Medium (40)**	Barely	Medium	No
	Erosion & sedimentation	Without Mitigation	Regional (3)	Long term (4)	Very High (10)	Highly Likely (4)	**High (68)**	Partly	High	Yes
		With Mitigation	Local (2)	Medium (3)	Moderate (6)	Probable (3)	**Medium (33)**	Barely	Medium	No
	Water Pollution	Without Mitigation	Regional (3)	Short (2)	Very High (10)	Highly Likely (4)	**High (60)**	Partly	High	Yes
		With Mitigation	Regional (3)	Very short (1)	High (8)	Improbable (2)	**Low (24)**	Barely	Low	No
	Flow modification	Without Mitigation	Local (2)	Short (2)	Moderate (6)	Definite (5)	**Medium (50)**	Partly	Medium	Yes
		With Mitigation	Site (1)	Short (2)	Low (4)	Highly Likely (4)	**Low (28)**	Barely	Low	No

Table 13: Evaluation of potential impacts of Alternative 1 of the Garden Route Dam Erf 464 development on aquatic habitat during operation

	Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance	Reversibility	Mitigation Potential	Irreplaceable Resource Loss
Operational Phase	Loss and disturbance of aquatic vegetation & habitat	Without Mitigation	Local (2)	Permanent (5)	Low (4)	Highly Likely (4)	**Medium (44)**	Partly	Medium	No
		With Mitigation	Site (1)	Permanent (5)	Minor (2)	Probable (3)	**Low (24)**	Barely	Low	No
	Erosion & sedimentation	Without Mitigation	Regional (3)	Permanent (5)	High (8)	Highly Likely (4)	**High (64)**	Partly	Medium	Yes
		With Mitigation	Local (2)	Permanent (5)	Moderate (6)	Probable (3)	**Medium (39)**	Barely	Low	No
	Water Pollution	Without Mitigation	Regional (3)	Permanent (5)	High (8)	Highly Likely (4)	**High (64)**	Partly	High	Yes
		With Mitigation	Regional (3)	Permanent (5)	Moderate (6)	Probable (3)	**Medium (42)**	Barely	Low	No
	Flow modification	Without Mitigation	Regional (3)	Permanent (5)	Moderate (6)	Definite (5)	**High (70)**	Partly	Medium	Yes
		With Mitigation	Local (2)	Permanent (5)	Low (4)	Highly Likely (4)	**Medium (44)**	Barely	Low	No

Table 14: Evaluation of potential impacts of Alternative 1 of the decommissioning impacts associated with the proposed Garden Route Dam Erf 464 development

	Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance	Reversibility	Mitigation Potential	Irreplaceable Resource Loss
decommissioning Phase	Loss and disturbance of aquatic vegetation & habitat	Without Mitigation	Local (2)	Short (2)	Low (4)	Probable (3)	**Low (24)**	Barely	Low	No
		With Mitigation	Site only (1)	Very short (1)	Small (0)	Improbable (2)	**Low (4)**	Barely	Low	No
	Erosion & sedimentation	Without Mitigation	Local (2)	Short (2)	Low (4)	Probable (3)	**Low (24)**	Partly	Medium	No
		With Mitigation	Site only (1)	Very short (1)	Small (0)	Improbable (2)	**Low (4)**	Barely	Low	No
	Water Pollution	Without Mitigation	Regional (3)	Short (2)	Low (4)	Probable (3)	**Low (27)**	Partly	High	No
		With Mitigation	Local (2)	Very short (1)	Minor (2)	Improbable (2)	**Low (10)**	Barely	Low	No
	Flow modification	Without Mitigation	Local (2)	Short (2)	Minor (2)	Probable (3)	**Low (18)**	Barely	Low	No
		With Mitigation	Site only (1)	Very short (1)	Small (0)	Probable (3)	**Low (6)**	Barely	Low	No

8.2 Alternative 2 Impact Table

Table 15: Evaluation of potential impacts of Alternative 2 of the Garden Route Dam Erf 464 development on aquatic habitat during construction

	Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance	Reversibility	Mitigation Potential	Irreplaceable Resource Loss
Construction Phase	Loss and disturbance of aquatic vegetation & habitat	Without Mitigation	Local (2)	Medium (3)	Moderate (6)	Definite (5)	**Medium (55)**	Partly	Medium	Yes
		With Mitigation	Site (1)	Short (2)	Low (4)	Highly Likely (4)	**Low (28)**	Barely	Low	No
	Erosion & sedimentation	Without Mitigation	Regional (3)	Long term (4)	High (8)	Highly Likely (4)	**High (60)**	Partly	Medium	Yes
		With Mitigation	Local (2)	Short (2)	Low (4)	Probable (3)	**Low (24)**	Barely	Low	No
	Water Pollution	Without Mitigation	Regional (3)	Short (2)	High (8)	Probable (3)	**Medium (39)**	Partly	High	No
		With Mitigation	Local (2)	Very short (1)	Low (4)	Improbable (2)	**Low (14)**	Barely	Low	No
	Flow modification	Without Mitigation	Local (2)	Short (2)	Low (4)	Definite (5)	**Medium (40)**	Partly	Medium	No
		With Mitigation	Site (1)	Short (2)	Minor (2)	Highly Likely (4)	**Low (20)**	Barely	Low	No

Table 16: Evaluation of potential impacts of Alternative 2 of the Garden Route Dam Erf 464 development on aquatic habitat during operation

	Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance	Reversibility	Mitigation Potential	Irreplaceable Resource Loss
Operational Phase	Loss and disturbance of aquatic vegetation & habitat	Without Mitigation	Local (2)	Permanent (5)	Low (4)	Probable (3)	**Medium (33)**	Partly	High	No
		With Mitigation	Site (1)	Permanent (5)	Minor (2)	Probable (3)	**Low (24)**	Barely	Low	No
	Erosion & sedimentation	Without Mitigation	Regional (3)	Permanent (5)	Moderate (6)	Highly Likely (4)	**Medium (56)**	Partly	Medium	Yes
		With Mitigation	Site (1)	Permanent (5)	Low (4)	Probable (3)	**Medium (30)**	Barely	Low	No
	Water Pollution	Without Mitigation	Regional (3)	Permanent (5)	High (8)	Probable (3)	**Medium (48)**	Partly	High	Yes
		With Mitigation	Local (2)	Permanent (5)	Moderate (6)	Probable (3)	**Medium (39)**	Barely	Low	No
	Flow modification	Without Mitigation	Regional (3)	Permanent (5)	Low (4)	Highly Likely (4)	**Medium (48)**	Partly	Medium	Yes
		With Mitigation	Local (2)	Permanent (5)	Minor (2)	Probable (3)	**Low (27)**	Barely	Low	No

Table 17: Evaluation of potential impacts of Alternative 2 of the decommissioning impacts associated with the proposed Garden Route Dam Erf 464 development

	Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance	Reversibility	Mitigation Potential	Irreplaceable Resource Loss
decommissioning Phase	Loss and disturbance of aquatic vegetation & habitat	Without Mitigation	Local (2)	Short (2)	Low (4)	Probable (3)	**Low (24)**	Barely	Low	No
		With Mitigation	Site only (1)	Very short (1)	Small (0)	Improbable (2)	**Low (4)**	Barely	Low	No
	Erosion & sedimentation	Without Mitigation	Local (2)	Short (2)	Low (4)	Probable (3)	**Low (24)**	Partly	Medium	No
		With Mitigation	Site only (1)	Very short (1)	Small (0)	Improbable (2)	**Low (4)**	Barely	Low	No
	Water Pollution	Without Mitigation	Local (2)	Short (2)	Low (4)	Probable (3)	**Low (24)**	Partly	High	No
		With Mitigation	Site only (1)	Very short (1)	Minor (2)	Improbable (2)	**Low (8)**	Barely	Low	No
	Flow modification	Without Mitigation	Local (2)	Short (2)	Minor (2)	Probable (3)	**Low (18)**	Barely	Low	No
		With Mitigation	Site only (1)	Very short (1)	Small (0)	Improbable (2)	**Low (4)**	Barely	Low	No

9 MITIGATION

The mitigation of negative impacts on biodiversity and ecosystem goods and services is a legal requirement for authorisation purposes and must take on different forms depending on the significance of the impact and the specific area being affected. Mitigation measures related to the impacts associated with the project activities are intended to augment standard/generic mitigation measures included in the project-specific Environmental Management Programme (EMPr). Mitigation requires the adoption of the precautionary principle and proactive planning that is enabled through a mitigation hierarchy (Figure 36). Its application is intended to strive to first avoid disturbance of ecosystems and loss of biodiversity, and where this cannot be avoided altogether, to minimise, rehabilitate, and then finally offset any remaining significant residual negative impacts on biodiversity (DEA 2013).

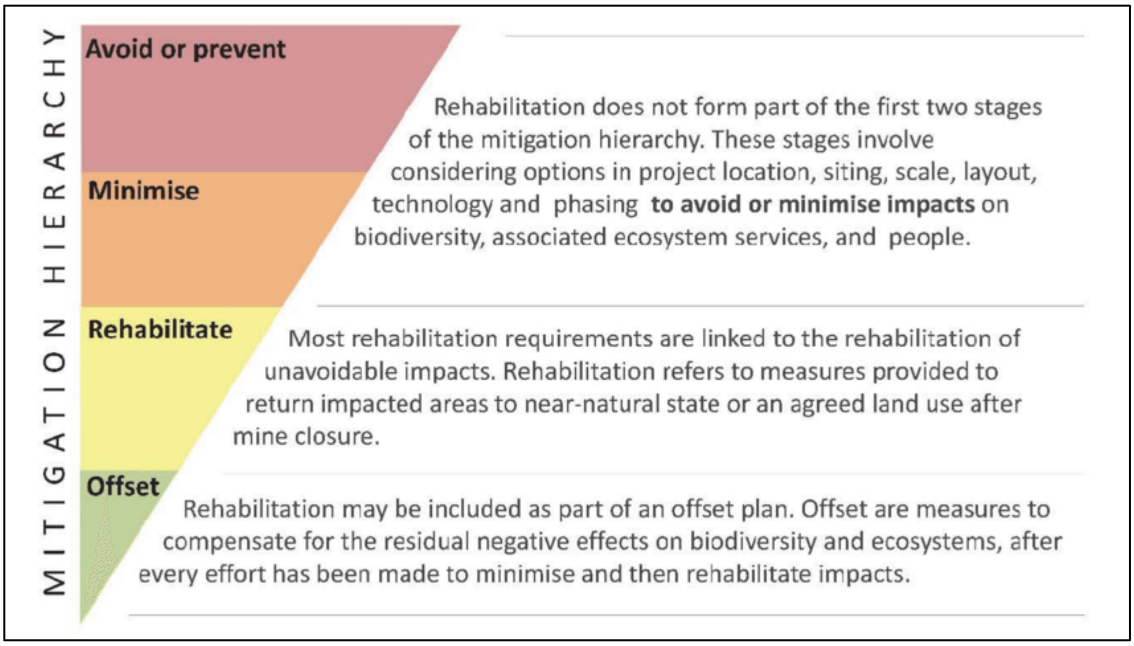


Figure 36: Diagram illustrating the 'mitigation hierarchy' (after DEA et al., 2013)

9.1 Application of the mitigation hierarchy

A stepped approach has therefore been followed in trying to minimize impacts, which includes:

1. attempting to avoid/prevent impacts through appropriate project design and location: *Development set-backs / buffer zones recommended;*
2. employing mitigation measures aimed at minimizing the likelihood and intensity of potential risks/impacts: *Provision of construction and operation phase management and mitigation measures to avoid any unnecessary direct or indirect impacts to watercourses*;

3. addressing residual impacts to areas adjacent to the development site which may be impacts: Recommendation *of the compilation of a watercourse rehabilitation and management plan, and*
4. compensating for any remaining/residual impacts associated with permanent habitat transformation: *Assessment of the need and desirability of wetland offsets (not required for this proposal).*

9.2 Aquatic Buffer Zones

Aquatic buffer zones are designed to act as barriers between human activities and sensitive water resources in order to protect them from adverse negative impacts. Buffer zones associated with water resources have been shown to perform a wide range of functions and have therefore been adopted as a standard measure to protect water resources and associated biodiversity. An aquatic impact buffer zone is defined as a zone of vegetated land designed and managed so that sediment and pollutant transport carried from source areas via diffuse surface runoff is reduced to acceptable levels (Macfarlane and Bredin 2016).

The buffer areas for the project were informed by the buffer zone guidelines and tools developed by Macfarlane and Bredin (2016), however, a fixed-width buffer for the aquatic habitats has various limitations. Therefore, the buffer widths were further refined, utilizing professional knowledge, to best fit the specific characteristics of the area and protect aquatic ecosystems. The final buffer areas determined for this project are relatively large, beyond 100 m in width in most locations, to fulfil the objective of protecting the aquatic habitat (Figure 37). The aquatic buffer areas should be treated as No-Go zones for development and all associated hard infrastructure should be set back (apart from road crossings which cannot avoid the buffer areas). Only very low impact activities, such as narrow, brush-cut pathways, should be allowed within the buffer area.

The Alternative 2 layout does not place the development footprint within the buffer areas (excepting the hotel and waterfront). This significantly reduces the risk of impacting aquatic habitat compared to the original plan. However, there are pump stations and stormwater outlets within the buffer which should be set back as far as possible. It is recommended that the hard infrastructure associated with the business zone (i.e. parking and buildings) be removed from the recommended buffer zone.

The aquatic habitats, especially the Klein Swart River, must be treated as absolute No Go Zones and should be actively managed. The dam itself can be used for recreational activities, such as canoeing, without compromising any aquatic functioning. The large buffer areas must be restricted to very low conflict land uses, such as essential services (stormwater outlets) and recreational areas (cycling tracks). The objective of this space is to prevent inappropriate areas, such as within watercourses, from being utilized and by rather providing a transitional area for interaction with the environment outside of the sensitive areas. It is important that the environment is incorporated into the design and utilised for low impact activities (such as pathways, cycling tracks, picnic areas, etc.) so that the community are afforded the benefits of ecosystem services and take ownership of these habitats.

Although this buffer area from aquatic habitats substantially reduces the extent of the proposed development footprint, it will enhance the overall development through scenic value, educational uses, recreational uses, that can be extended to the whole local community that currently utilise the area and benefit from the freshwater resources. Carefully designed and managed buffer zones can contribute to a highly effective storm water management system. This requires approaches as advocated in the South African Guidelines for Sustainable Drainage Systems (Armitage, *et al.* 2013).

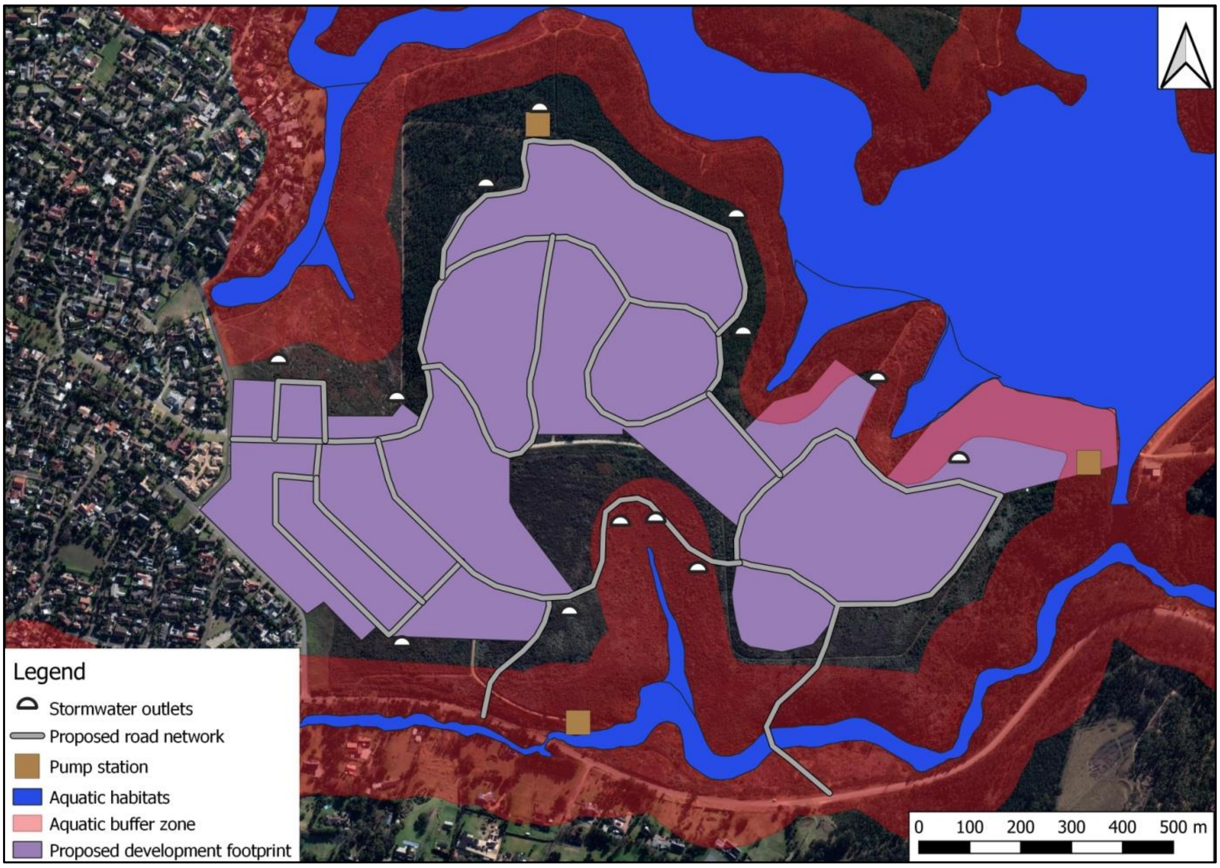


Figure 37: The recommended aquatic buffer zones in relation to the development

Monitoring implementation and management of the final buffer areas should be undertaken throughout the duration of construction activities to ensure that the effectiveness of the final buffer zone areas is maintained, and that management measures are appropriately implemented. Regular inspections during the operational phase should also be undertaken to ensure that functions are not undermined by inappropriate activities. It is also recommended that a stormwater management plan be developed to maintain or mimic the natural runoff as well as prevent the wash-off of pollutants to receiving waters.

9.3 Recommended mitigation measures

Any potential risks must be managed and mitigated to ensure that no deterioration to the water resource takes place. Standard management measures should be implemented to ensure that any on-going activities do not result in a decline in water resource quality. Consideration should also be given to the rehabilitation of watercourses. Mitigation measures related to the impacts associated with the construction activities are intended to augment standard/generic mitigation measures included in the project-specific Environmental Management Programme (EMPr).

In terms of Section 2 and Section 28 of NEMA (National Environmental Management Act, 1998), the landowner is responsible for any environmental damage, pollution or ecological degradation caused by their activities “inside and outside the boundaries of the area to which such right, permit or permission relates”. Therefore, the monitoring of the development activities is essential to ensure the mitigation measures are implemented. Compliance with the mitigation recommendations must be audited by a suitably qualified independent Environmental Control Officer with an appropriately timed audit report. Frequent ECO visits are encouraged especially during work within the watercourses. In the case where there is extensive damage to any aquatic system, where rehabilitation is required, a suitably qualified aquatic specialist must audit the site. Monitoring for non-compliance must be done on a daily basis by the contractors. Photographic records of all incidents and non-compliances must be retained. This is to ensure that the impacts on the aquatic habitat are adequately managed and mitigated against and the successful rehabilitation of any disturbed areas within any system occurs. Annual monitoring of the watercourses affected by the development is recommended in order to ensure that operational impacts are being effectively managed.

The mitigation of impacts must focus on preventing water pollution, maintaining aquatic habitat integrity and managing the runoff generated by the development and introducing it responsibly into the receiving environment. Practical examples of some mitigation measures are shown in Annexure 13 for consideration. The following mitigation measures in Table 18 must be adhered to:

Table 18: Mitigation measures

9.3.1 DESIGN/ PRE-CONSTRUCTION PHASE

9.3.1.1 Stormwater management

The mitigation of impacts must focus on managing the runoff generated by the development and introducing it responsibly into the receiving environment. The stormwater flows must enter the wetland areas in a diffuse flow pattern without pollutants.

When developing a stormwater management plan for the site, it will be critical that due consideration is given to the collection and treatment of stormwater prior to discharge into the natural environment. It is therefore recommended that the stormwater management plan be developed with appropriate ecological input and be developed based on Sustainable Drainage Systems (SUDS). The SUDS systems attempt to maintain or mimic the natural flow systems as well as prevent the wash-off of urban pollutants to receiving waters. To achieve these objectives a detailed Stormwater Management Plan (SWMP) must be prepared at detailed design stage for approval.

Soft infrastructure must be considered where practical. For example, permeable surfaces can be done via permeable concrete block pavers (such as Amorflex), brick pavers, stone chip, and gravel and may contribute to slowing surface flows (especially if maintained). Baffles in the stormwater conduits are effective. Stormwater managed by the development could be discharged into porous channels / swales ('infiltration channels or basins') running near parallel or parallel to contours within and along the edge of the development (Figure 38). This will provide for some filtration and removal of urban pollutants (e.g. oils and hydrocarbons), provide some attenuation by increasing the time runoff takes to reach low points, and reduce the energy of storm water flows within the stormwater system through increased roughness when compared with pipes and concrete V-drains.

Figure 38: Examples of soft infrastructure incorporated into the stormwater management design (porous channels / swales)

Should residual impacts still be anticipated after most stormwater mitigation measures have been considered, it may be necessary to investigate large scale measures, such as an infiltration berm/ trench/swale (along the contour) directly upslope of the riparian zone of the dam. Although construction of such a structure has a large disturbance footprint in close to the dam it may slow surface runoff velocities and trap pollutants prior to the water reaching the dam in the operational phase. It is only recommended if absolutely necessary and only for the dam side of the development.
Frequent, multiple stormwater outlets must be designed to prevent erosion at discharge points. Outlets should be in the form of multiple smaller storm water outlets rather than a few large outlets in order spread out surface flow and avoid flow concentration and erosion as far as possible on the steeper sections of the housing and road networks, it is recommended that the frequency of stormwater outlets is increased to prevent erosion at discharge points.
All erosion protection measures (e.g. Reno-mattresses) must be established to reflect the natural slope of the surface and located at the natural ground level. Structures such as these must be located within the layout footprint and not encroach into the aquatic areas.
Stormwater exit points must include a best management practice approach to trap any additional suspended solids and pollutants originating from the proposed development. Also include the placement of stormwater grates (or similar). The use of grease traps/oil separators to prevent pollutants from entering the environment from stormwater is recommended. To ensure the efficiency of these, they must be regularly maintained. This is especially important due to the proximity of the business and hotel zones.
Inlet protection measures to capture solid waste and debris entrained in storm water entering the storm water management system (inlet protection devices) will be incorporated into the design of the system and could include the use of either curb inlet/inlet drain grates and/or debris baskets/bags. It is also important to note that storm water infrastructure will likely require regular on-going maintenance in the form of silt, debris/litter clearing in order to ensure their optimal functioning. They will therefore be designed to cater for regular maintenance.
For parking lots and driveways - garden beds (landscaped areas) and storm water conveyance channels, the use of concave open-lined swales or bio-retention areas should be used to receive and convey storm water. For these areas no curbs or spaced curbs are recommended so water can move freely from hardened surfaces into the swales or bioretention areas. Equally, if flower/plant beds are to be established adjacent to paved surfaces, then these should be designed to receive storm water from hardened surfaces and should be planted with robust indigenous species that to contribute to storm water management objectives.
Storm water should be harvested onsite from roofed surfaces thus reducing the quantity (volume) of

water received by downstream water resources as surface flow. This water is to be used onsite for non-potable applications or non-potable uses.
Stilling basins will be installed below all outlets and suitable armouring of the downstream area (e.g. using reno-mattresses, rock pack, etc.) must be installed below all storm water outlets prior to flows entering downstream watercourses. The reno-mattresses must extend an appropriate distance downslope to ensure that erosion risks are minimised. The outlet reno-mattresses must be established to reflect the natural slope of the surface it is constructed on and are to be located at the natural ground-level. The outlets and associated outlet protection structures should be aligned parallel to contours wherever possible to reduce the gradient of outflows and remain outside of wetlands and their buffer zones where possible.
9.3.1.2 Roads and watercourse crossings
The typical drawing of the proposed bridge structure presented within the Engineering Report is considered high risk from an aquatic perspective, as the structure is designed so as to replace wetland habitat and confine flow. It must be redesigned or relocated to account for the sensitive aquatic habitats. The bridge designs must be finalised after incorporating the mitigation measures of this report. When designing new roads or road upgrades, proper sizing and installation of stream crossing culverts is critical to ensure long-term sustainability and project success, with culvert failure often leading to access problems and can cause extensive environmental degradation, especially if flows get diverted to unstable slopes.
Bridges over wetland habitat must span the entire width of the freshwater habitat and channel wherever possible. It is recommended that the number of support piers to be located within the riparian zone (wetted zone and supported habitat) be limited in number as far as possible.
The extent of infilling within the aquatic habitat must be minimised as far as possible. This is in alignment with a single span design instead of box culverts.
Roads should follow the natural elevation contours where possible in order to maintain gentle gradients so as to minimise the risk of surface water runoff, high flow velocities and soil erosion.
Bridge and culvert structures must be designed to adequately allow for the natural movement of water from the upstream to the downstream sides of the structure without inhibiting the natural movement of water and may not result in changes to flow volumes and velocities or create artificially inundated areas but allow for the free-flow movement of water.
Use existing roads or upgrade existing tracks to cross wetlands rather than constructing entirely new roads wherever possible. Road design must ensure that flows through the wetlands to be traversed by roads remain unhindered and mimic the natural situation as far as possible. Roads crossing wetlands must be perpendicular to the general water flow direction and cross in a straight line as far

as possible.
The level of piped culverts (if required at all) needs to match the ground level of the wetland/river bed and should not be elevated above the wetland/river at the downstream end so as to cause erosion where water flows incorrectly onto the wetland surface/river bed from height. Crossings that are installed below the natural ground level are to be constructed with an appropriate drop inlet structure on the upstream side to ensure that 'headcut' erosion does not develop as a result of the gradient change from the natural ground level to the invert level of the culvert.
Energy dissipaters should be installed to prevent scour at any culvert outlet. This can be constructed of appropriately sized rock armour and should have a concave cross-section to prevent the scouring of adjacent banks. Coarse bedding material or geotextile wrapped dump rock must be considered for use wherever the roads crosses wetland characterised by diffuse subsurface flows or within the non perennial tributaries.
Appropriate measures to dissipate flow velocity below bridge structures must be considered and designed for pre-construction.
9.3.1.3 Pipelines and pump stations
Avoid multiple watercourse crossings and align pipeline crossings of watercourses with planned road crossings where possible.
Crossings must be constructed perpendicular to the natural direction of flow. Pipeline trenches and sandy bedding material can produce preferential flow paths for water across wetlands that can potentially drain wetland areas. Crossing wetlands perpendicular to the general direction of flow instead of at an angle will reduce this risk.
Pipelines across wetlands should be buried at a sufficient depth below ground level such that the pipelines do not interfere with surface water movement or create obstructions where flows can cause erosion to initiate. Alternatively, pipe bridges must be designed considering the road bridge design recommendations.
Sewerage pump stations should not be located within 100 m of a watercourse and man holes should not be placed within the aquatic habitat. The existing pump station should ideally be relocated out of the Klein Swart River system/ or receive significant upgrades, and although this may not be a realistic/feasible option it merits investigation. Two new pump stations are planned, in addition to the existing Glenwood pump station. The existing pump station is apparently not maintained and is known to overflow into the Klein Swart River. Additional sewage infrastructure within the buffer area adds to this risk. The National Water Act imposes 'duty of care' on all landowners, to ensure that water resources are not polluted. The following Clause in terms of the National Water Act is applicable in this case: 19 (1) "An owner of land, a person in control of land or a person who

occupies or uses the land on which (a) any activity or process is or was performed or undertaken; which causes, has caused or likely to cause pollution of a water resource, must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring". In the context of Eskom loadshedding, and relatively frequent outages in South Africa, it is important that pump stations are well managed and have the appropriate components and back-ups at each one, for all scenarios.
Reasonable measures must be taken to provide back-up for mechanical, electrical, operational or process failure and malfunction at pump stations. At a minimum there should be an alarm system to warn of an electrical failure and sufficient standby equipment to provide for reasonable assurance that the infrastructure can be fully functional within at least 24 hours. Emergency power shall be provided that will prevent overflows from occurring during any power outage. Installing permanent generators at each station is strongly advised.
Pump stations will need to be placed within a suitably lined, impermeable concrete bunded area with the capacity to hold untreated waste water in an emergency and provide for sufficient time for maintenance staff to address any faults/ problems. This is to limit the risk of untreated sewage overflowing in the event of any leakage or accidental spillage at the pump station. The storage area must be lined and bermed to minimise spillage possibilities into the dam or river. This must be done at the existing pump station that is known to overflow into the Klein Swart River.
Signage should be provided at a visible location at the pump stations with emergency telephone contact details provided on the signs so that pump station failure, leakage or electrical power outages affecting the system can be easily reported to the Local Municipality.
9.3.1.4 Water Pollution
It is recommended that baseline water quality measurements are undertaken. There are various existing pollution inputs (such as contaminated stormwater runoff and sewage leakages from pump station overflows) that enter the Kat River alongside the suburb of Denneoord, which feeds into the dam. There is evidence that the sewer infrastructure in the Klein Swart River near the Saasveld Road, whether the pump station or pipelines, is leaking and polluting the aquatic habitat. It is a concern that this impact will continue, or even worsen, if additional inputs are directed to it and the other two due to the development. Therefore, it is recommended that the cause of the water pollution in this catchment be identified and remedied prior to construction of the proposed development.
Water samples should be taken and analysed to determine the pre-development water quality, the effectiveness of remediation prior to commencement, and then in the operational phase of the development. A sampling site downstream on the Swart River may also prove beneficial for water quality monitoring. This comparison data will allow for inferences to be made regarding the actual pollution impact of the development, should it be a concern in the future. A water quality audit

should be undertaken annually in the long-term.
It is important that detailed analysis and discussion of implications of the water quality results be undertaken by a suitable qualified professional. Taking the samples without the appropriate interpretation is insufficient and will not assist management. Records should be maintained of monitoring data and procedures and made available to the public on request.
The recycling/reuse of dirty water is promoted; alternatively, this water will need to be directed into the sewer system.

9.3.1.5 No Go and Buffer Areas

Aquatic buffer zones which are designed to act as barriers between human activities and sensitive water resources in order to protect them from adverse negative impacts. Buffer zones associated with water resources have been shown to perform a wide range of functions and have therefore been adopted as a standard measure to protect water resources and associated biodiversity. An aquatic impact buffer zone is defined as a zone of vegetated land designed and managed so that sediment and pollutant transport carried from source areas via diffuse surface runoff is reduced to acceptable levels (Macfarlane and Bredin 2016). The recommended aquatic buffer areas were determined and presented in Figure 39.

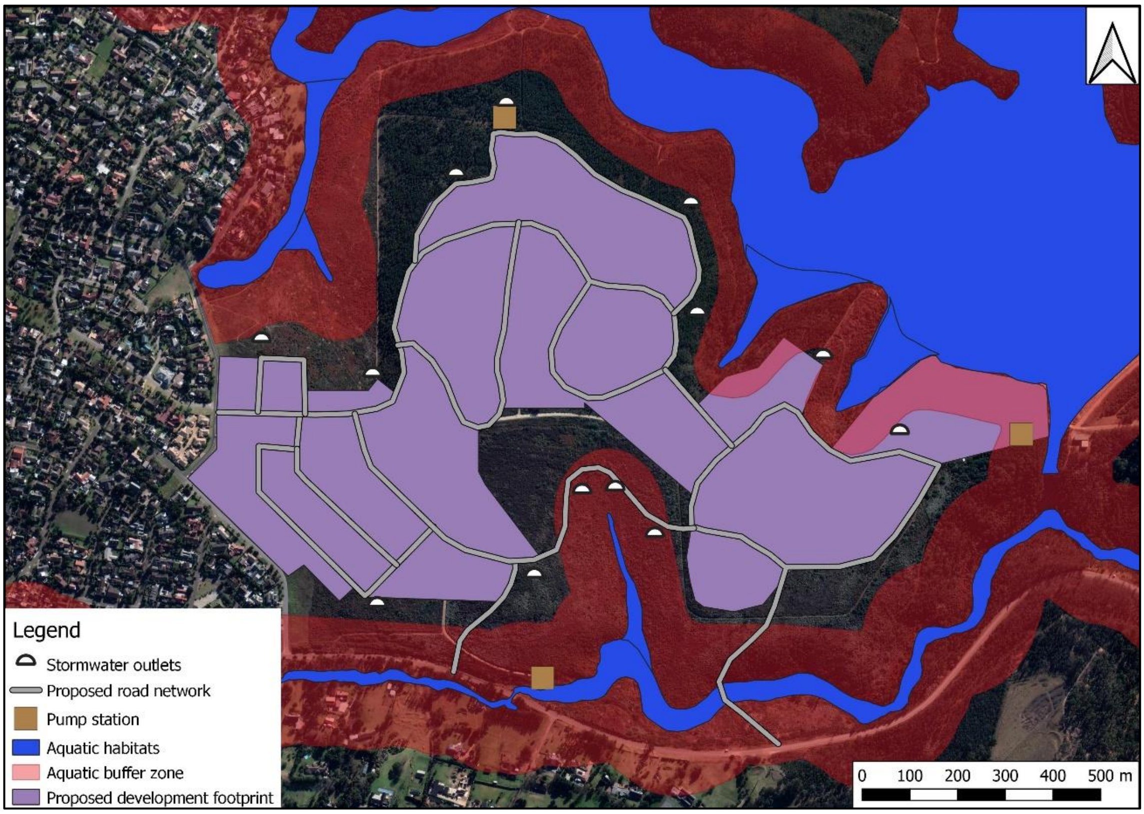
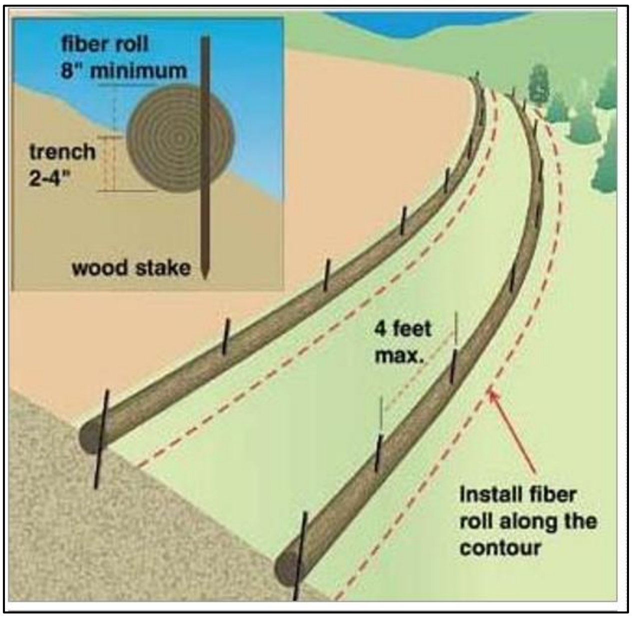


Figure 39: Recommended aquatic No Go areas and low impact land use buffer zone

While the proposed layout (Alternative 2) has avoided the majority of the delineated aquatic habitat,

there are still portions of the development that are encroaching into the sensitive areas and their buffers. Therefore, the layout plan must be amended to account for the buffer areas depicted above.
The buffer area must be considered as a No Go area for development and large infrastructure. An important component of these buffers is that they represent minimum setbacks from the watercourse. Functions such as stormwater attenuation and roads must lie outside of this setback area as far as possible or be designed with consideration to the mitigation measures of this report.

9.3.2 CONSTRUCTION PHASE MITIGATION
9.3.2.1 Road and pipeline crossings
Suitable engineering Method Statements for pipelines/roads crossing wetland and for general activities taking place within wetland must be developed. A copy of the method statement will need to be made available at the construction site offices/site camp at all times. Any direct modification of wetland and river habitat for the installation of culverts and road drainage must be limited to the construction servitude. For roads this should be limited to the road footprint.
The edges of the construction servitude / development zone within the vicinity of the aquatic habitat must be clearly staked-out and demarcated using highly visible material (e.g. danger tape) prior to construction commencing. Removal of vegetation must only be when essential for the continuation of the project. Do not allow any disturbance to the adjoining natural vegetation cover or soils.
Access to and from the development area should be either via existing roads or within the construction servitude. Any contractor found working within No-Go areas must be fined as per fining schedule/system setup for the project.
A maximum construction working servitude width of 10m should be allowed on either side of the bridge. The 10m servitude includes the temporary bypass road required for access.
Contaminated runoff from the pipeline installation site should be prevented from directly entering any of the watercourses. Construction of the pipeline should preferably be done during the drier months when the water quality impacts from the construction activities may impact on the downslope watercourses. Measures to contain impacts caused during high rainfall events (such as substantial sedimentation and/or erosion) must be planned for and available for use.

Diversions must be temporary in nature and no permanent walls, berms or dams may be installed within a watercourse. Sandbags used in any diversion or for any other activity within a watercourse must be in a good condition, so that they do not burst and empty sediment into the watercourse. Upon completion of the construction at the site, the diversions shall be removed to restore natural flow patterns. Under no circumstance shall a new channel or drainage canals be excavated to divert water away from construction activities.
No equipment laydown or storage areas must be located within delineated aquatic buffer zone.
9.3.2.2 Sediment Control
Construction must be carried out during the dry season and contingency plans must be in place for high rainfall events during construction.
Before any work commences, sediment control/silt capture measures (e.g. bidim/silt curtains) must be installed downstream/downslope of the active working areas. Silt fences/curtains must be regularly checked and maintained (de-silted to ensure continued capacity to trap silt) and repaired where necessary. When de-silting takes place the silt must not be returned to the watercourse. An example of fibre rolls and silt fence measures for sediment control on the slopes: 

Excavated rock and sediments from the construction zone, and including any foreign materials, should not be placed within the delineated rivers and riparian areas in order to reduce the possibility of material being washed downstream.
All bare slopes and surfaces to be exposed to the elements during clearing and earthworks must be protected against erosion using rows of silt fences, sandbags, hay bales and/or earthen berms spaced along contours at regular intervals. The spacing interval must be smaller for steeper slopes and if required the ECO should advise in this regard.
Stockpiles must not be located within 50 metres of the wetland, dam, and must avoid the riparian area. The furthest threshold must be adhered to. Erosion control measures including silt fences, low soil berms and/or shutter boards must be put in place around the stockpiles to limit sediment runoff from stockpiles. Alternatively, the exposed slopes must drain into small temporary stormwater and silt traps/ponds.
Any fauna (frogs, snakes, etc.) that are found within the construction area must be moved to the closest point of similar habitat type outside of the areas to be impacted.
9.3.2.3 Monitoring
Regular inspections during the operational phase should also be undertaken to ensure that functions are not undermined by inappropriate activities. Any construction within wetland habitat, such as bridge and pipeline crossings, must be monitored daily.
Access routes/paths through intact indigenous riverine vegetation must be preapproved and signed off by the ECO prior to construction commencing and must take into account the sensitivity of the vegetation occurring at the site

Staff environmental induction must take place prior to construction commencing and any subcontractors utilised must be inducted before starting work onsite. The ECO must monitor the compliance of the Contractors and instruct the Contractors where necessary. The ECO may request that the Project Manager suspend part or all the works.

9.3.3 POST CONSTRUCTION/ REHABILITATION

9.3.3.1 Rehabilitation
Demarcations are to remain until construction and rehabilitation is complete.
For bridge crossings, once the base is cast and the piers are constructed, the excavated riparian zone must be backfilled subsoil and topsoils in the proper order that they were excavated.
All disturbed areas beyond the construction site that are intentionally or accidentally disturbed during the construction phase must be rehabilitated immediately to the satisfaction of the ECO. All disturbed areas must be prepared and then re-vegetated to the satisfaction of the ECO. Erosion control measures such as soil savers, eco-logs, sand bags and biodegradable silt fences must generally be installed prior to re-vegetation.
Erosion features that have developed due to construction within the aquatic habitat due to the project are required to be stabilised. This may also include the need to deactivate any erosion headcuts/rills/gullies that may have developed.
It is recommended that a wetland rehabilitation plan be developed and implemented to conserve the aquatic habitat in the Klein Swart River. Ideally this plan would also extend to the wetland areas upstream of the dam on the Kat River. It would aim to halt the channel erosion and remove invasive vegetation in a sensitive manner. The aim of the rehabilitation is to ensure the necessary procedures are appropriately implemented in the natural environment that may be negatively affected by the development. The plan will promote the re-establishment of the ecological functioning of any area disturbed by construction activities. Also consult WET-RehabEvaluate, WET-RehabMethods (Cowden and Kotze, 2009), and the river rehabilitation manual developed by Day *et al.* 2016, for further information.
The solid domestic waste must be removed and disposed of offsite. All post-construction building material and waste must be cleared in accordance with the EMPr.
Plant indigenous riparian vegetation along degraded unvegetated edges of watercourses, such as along the edge of the dam, to increase vegetation in the riparian zone and remove alien species. This creates a slight buffer between the impacts of the activities and the watercourses. It is recommended that landscaping promote the use of indigenous species common to the region and that as much natural ground cover is established on the site to help with binding soils and

encouraging water infiltration, thus reducing overland flows and the pressure on storm water management infrastructure.
Recovery of disturbed areas should be assessed for the first 6 months. Any areas that are not progressing satisfactorily must be identified and action must be taken to actively re-vegetate these areas. If natural recovery is progressing well, no further intervention may be required.
Where large gaps in the riparian areas have resulted (i.e. where indigenous vegetation has been replaced by dense alien plant infestations), it is recommended that cover components be reinstated appropriately. Only indigenous species are to be considered. For example, disturbed areas in the wetland due to pipeline or bridge crossings could use wetlands plant species such as *Wachendorfia thyrsiflora, Zantedeschia aethiopica,* and *Cyperus textillis* for rehabilitation. No alien trees, plants, or grasses to be planted in aquatic habitats. Monitoring the condition of the re-established vegetation cover will be necessary to assess particular aftercare or plant maintenance requirements.
9.3.3.2 Alien plant management
It is the contractor's responsibility to continuously monitor the area for newly established alien species during the contract and establishment period, which if present must be removed. Removal of these species shall be undertaken in a way which prevents any damage to the remaining indigenous species and inhibits the re-infestation of the cleaned areas. Any use of herbicides in removing alien plant species is required to be investigated by the ECO before use, for the necessity, type proposed to be used, effectiveness and impacts of the product on aquatic biota.
9.3.3.3 Monitoring
A monitoring programme shall be in place, not only to ensure compliance with the EMPr throughout the construction phase, but also to monitor any post-construction environmental issues and impacts such as increased surface runoff. The monitoring should be regular and additional visits must be taken when there is potential risk to aquatic habitat.

9.3.4 OPERATIONAL PHASE
9.3.4.1 Stormwater Management
Stormwater infrastructure must be inspected at least once every year (before the onset of rains) to ensure that it is working efficiently.
The stormwater management infrastructure must be designed to ensure the runoff from the development is not highly concentrated before entering the buffer area. The volume and velocity of water must be reduced through discharging the surface flow at multiple locations surrounding the

development, preventing erosion.
The mitigation of impacts must focus on managing the runoff generated by the development and introducing it responsibly into the receiving environment. The stormwater flows must enter the wetland areas in a diffuse flow pattern without pollutants.
Any evidence of erosion from this stormwater system must be rehabilitated and the volume/velocity of the water reduced through further structures and/or energy dissipaters. These structures must be incorporated within the layout area.
9.3.4.2 Pollution control
The recommended use and maintenance of grease traps/oil separators to prevent pollutants from entering the environment from stormwater.
Key maintenance will include litter and sediment clearing and the servicing and maintenance of key collection points like catch pits, detention tanks etc. Such maintenance should be budgeted for.
Appropriate waste water infrastructure must be designed to prevent any such water from entering the surrounding environment.
Pumps, pipelines and other equipment should be regularly inspected and maintained. Spare parts should be readily available. Downtime should be kept to a minimum in order to prevent spillages and adverse environmental impacts. Flow meters should be kept in working order and calibrated if necessary. It is advisable to develop and maintain contingency plans. The plans should provide for the avoidance and control of spills, leakage or breakdowns so as to prevent pollution of the environment. The preparation of such plans should include: emergency holding procedures, clean-up procedures, action to minimise any adverse effects, methods for disposal of spilled materials, training of personnel in operating procedures to avoid or minimise the likelihood of spills. Other likely incidents which should be anticipated may include disruption of power supplies, human error, disruption caused by acts of nature – such as storms, flooding, fire, pump failure, waste overloading, temporary or permanent loss of trained personnel.
The pipeline should be regularly monitored and maintained to ensure that any problems with the pipeline are rectified before they can impact on any watercourses.
The Department of Water regional office should be notified, as soon as possible, of any significant chemical spill or leakage to the environment where there is the potential to contaminate surface water or groundwater. Stop the existing effluent from entering into the river from the existing pump station. Better management of the system is required to prevent water pollution. Direct discharge of untreated effluent into the river is not permissible.

9.3.4.3 Buffer Area
Maintenance of the aquatic habitat and buffer area must be implemented for it to remain effective. Apart from erosion control and alien invasive plant eradication, the encroachment of any further infrastructure or vehicles must be prevented.
Engage with the community and Home Owners Association to explain the reasons why the buffer and the water resources are protected and what human activities are allowed. The landowners and community could be involved in the monitoring and rehabilitation (under appropriate leadership/management).
Promote the use of the open space area (whilst avoiding the aquatic habitat and riparian area) for recreational activities. Surrounding the dam area, walkways, picnic benches, or cycling trails, are potential low impact land uses that are unlikely to impact upon the freshwater habitat. Promoting a sense of ownership from the residents of their open space area will benefit them as well as the environment.
A section of the Kat River Nature Reserve along the dam falls within the recommended buffer area. Although the reserve is currently poorly managed or utilised, there is potential to expand its protection to the rest of the buffer area and open space of the proposed development area. Corridors such as this are ecologically beneficial.
9.3.5 MONITORING
Monitoring of the project activities is essential to ensure the mitigation measures are implemented. Compliance with the mitigation recommendations must be audited by a suitably qualified independent Environmental Control Officer with an appropriately timed audit report. In the case where there is extensive damage to any aquatic system, where rehabilitation is required, a suitably qualified aquatic specialist must audit the site. Monitoring for non-compliance must be done on a daily basis by the mine operators. Photographic records of all incidents and non-compliances must be retained. This is to ensure that the impacts on the aquatic habitat are avoided and mitigated against and the successful rehabilitation of any disturbed areas within any system occurs.

10 WATER LICENSING REQUIREMENTS

The proposed development requires a Water Use License (WUL) in terms of Chapter 4 and Section 21 (c) and (i) of the National Water Act No. 36 of 1998 and this must be secured prior to the commencement of construction. The following water uses have been identified for the project:

- Section 21 (c): Impeding or diverting the flow of a watercourse
- Section 21 (i): Altering the bed, banks, course or characteristics of a watercourse

These water uses will be associated with the following activities:

- The construction of infrastructure within the regulated area of the identified watercourses
- Waste water pipelines crossing rivers, adjacent to rivers, as well as within 500 m of the boundary of a wetland.
- The construction of road crossing on a watercourse
- Earthworks and storm water runoff and erosion/sediment during construction
- Storm water runoff management during operation

The findings of the Aquatic Risk Matrix Assessment undertaken show that due to development risk being calculated as 'Moderate' (after mitigation) the development cannot be authorised in terms of the GA (General Authorisation) for Section 21 (c) and (i) water use under this scenario and requires a full license application. Also, the GA for Section 21 c and i water use does not apply for "Any water use associated with the construction, installation or maintenance of any sewerage pipeline, pipelines carrying hazardous materials and to raw water (wastewater) and wastewater treatment works" and therefore a full WULA is required. A water use license is currently being applied for through the online eWULAAs system and with the BGCMA.

11 CONCLUSION

An aquatic habitat impact assessment was undertaken for the proposed development of vacant land adjacent to the Garden Route Dam in George. The watercourses within a 500 metre radius of the site were identified and mapped on a desktop level utilising available data. Following this, the infield site assessments confirmed the location and extent of these systems. It was determined that the lower reach of the Kat River, two degraded wetlands, three small drainage lines, and the Klein Swart River wetland, may potentially be impacted upon by development, and were therefore assessed in detail. All of the watercourses in the study area have been significantly modified by human activities, largely for commercial forestry and the construction of the dam. However, due to their ecological importance and provisioning services, it is recommended that management strive to improve their condition and prevent any further degradation.

It was determined that the most severe potential impacts associated with the development will likely be habitat disturbance/loss and erosion and sedimentation as a result of new road and pipeline crossings, as well as stormwater runoff. The transformed land surface will promote increased volumes and velocities of storm water runoff, which can be detrimental to the watercourses receiving concentrated flows off of the area.

As part of mitigation, an aquatic buffer zone was developed around the watercourses in relation to the project footprint. The buffer areas are relatively large, beyond 100 m in width in most locations, and should be treated as No-Go zones for development (apart from road crossings which cannot be avoided). Only low impact activities, such as hiking footpaths, cycling tracks, and birdwatching (which do not require hard infrastructure or vegetation clearing) should be allowed within the buffer zone, but there must strictly be no intrusion into the wetland areas.

Three project alternatives were provided for aquatic impact assessment, namely:

- Alternative 1: the original site layout plan
- Alternative 2 (preferred alternative): the revised development layout plan
- ‘No Go’ Alternative: no development and the status quo remains

The assessment determined that the original layout (Alternative 1) poses the greatest threat to aquatic biodiversity. Alternative 1 proposes to develop a greater area of the site and the footprint is in closer proximity to the identified watercourses (there are large portions encroaching into the buffer). The Alternative 2 revised layout has been designed to incorporate more of the recommended aquatic buffer areas and it is therefore the preferred development alternative.

However, the waterfront/business zone and proposed hotel remain within the buffer zone, in both layouts, and it is recommended that these areas be set back.

The No Go Alternative was determined to have no/ negligible impact upon aquatic habitat and is the preferred alternative for aquatic biodiversity. However, should development be unavoidable, the Alternative 2 layout (after the implementation of mitigation) will not cause any unacceptably high impacts upon aquatic habitat.

12 REFERENCES

ARMITAGE, N., VICE, M., FISHER-JEFFES, L., WINTER, K., SPIEGEL, A., & DUNSTAN, J. 2013. Alternative Technology for Stormwater Management: *The South African Guidelines for Sustainable Drainage Systems.* Report to the Water Research Commission. Pretoria

BROMILOW, C. 2001. Problem Plants of South Africa: a Guide to the Identification and Control of more than 300 invasive plants and other weeds. Briza Publications, Pretoria.

CAPENATURE. 2017 WCBSP George [Vector] 2007.

COWDEN, C. & Kotze, D.C. 2009. WETRehabEvaluate: Guidelines for monitoring and evaluating wetland rehabilitation projects. WRC Report No TT 342/09, Water Research Commission, Pretoria.

CSIR (Council for Scientific and Industrial Research). 2010. National Aquatic Ecosystem Priority Areas (NFEPA). Council for Scientific and Industrial Research, Pretoria, South Africa.

DAY, L., ROWNTREE, M., & KING, H. 2016. The Development of a Comprehensive Manual for River Rehabilitation. WRC Report No TT 646/15. Water Research Commission, Pretoria.

Department of Water and Sanitation (DWS). 2016. General Authorisation in terms of Section 39 of the National Water Act, 1998 (Act No. 36 of 1998) for Water Uses as defined in Section 21 (c) and (i).

Department of Water Affairs (DWA), 2014. Reserve Determination Studies for the Selected Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area: Desktop EcoClassification Report. Prepared by Scherman Colloty & Associates cc. Report no. RDM/WMA16/00/CON/0213.

Department of Water Affairs (DWA), 2010. Resource Directed Measures: Reserve Determination studies for selected surface water, groundwater, estuaries and wetlands in the Outeniqua catchment: Ecological Water Requirements Study – Main Report: Outeniqua Reserve Study (K10-K50, K60G). Report No. RDM/K000/02/CON/0907.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY, 1999a. Resource Directed Measures for Protection of Water Resources. Volume 4. Wetland Ecosystems Version 1.0, Pretoria.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY, 2005. A Practical Field Procedure for Identification and Delineation of Wetland and Riparian areas. Edition 1, September 2005. DWAF, Pretoria.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY, 2007. Internal Guideline: Generic Water Use Authorisation Application Process

Department of Water Affairs (DWA), 2014. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Desktop EcoClassification Report. Prepared by Scherman Colloty & Associates. Report no. RDM/WMA16/00/CON/0213.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY. 2009. DWAF Training Manual: National Water Act Section 21(c) and (i) Water Uses. Version: November 2009.

DRIVER, A., NEL, J.L., SNADDON, K., MURRAY, K., ROUX, D.J., HILL, L., KLEIN SWARTZ, E.R., MANUEL, J. AND FUNKE, N. 2011. *Implementation Manual for Aquatic Ecosystem Priority Areas. Report to the Water Research Commission*. Pretoria

DWAF. 2008. Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas, prepared by M. Rountree, A. L. Batchelor, J. MacKenzie and D. Hoare. Stream Flow Reduction Activities, Department of Water Affairs and Forestry, Pretoria, South Africa

DEPARTMENT OF WATER AFFAIRS AND FORESTRY, 1996. South African Water Quality Guidelines. Volume 7: Aquatic Ecosystems.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY, 1996a. South African Water Quality Guidelines (second edition), Volume 2: Recreational Use.

KLEYNHANS, C.J., 1996. Index of Habitat Integrity (IHI).

KOTZE, D.C., MARNEWECK, G.C., BATCHELOR, A.L., LINDLEY, D.S. AND COLLINS, N.B. 2009. WET-Ecoservices: A technique for rapidly assessing ecosystem services supplied by wetlands.

NAIMAN, R.J., AND H. DECAMPS. 1997. The ecology of interfaces -- riparian zones. Annual Review of Ecology and Systematics 28:621-658

MACFARLANE, D.M. and Bredin, I.P. 2016. Buffer zone guidelines for rivers, wetlands and estuaries. Part 2: Practical Guide. WRC Report No (tbc), Water Research Commission, Pretoria.

MACFARLANE, D.M., KOTZE, D.C., ELLERY, W.N., WALTERS, D., KOOPMAN, V., GOODMAN, P. & GOGE, C. 2008. WET-Health: A technique for rapidly assessing wetland health, Version 2.

MUCINA, L. AND RUTHERFORD, M. C. (EDS) 2006. The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

LAWRENCE, D.P., 2007. Impact significance determination - Designing an approach. Environmental Impact Assessment Review 27: 730 - 754.

ROGERS KH. 1995. Riparian Wetlands. In: Wetlands of South Africa, Cowan GI (ed). Department of Environmental Affairs and Tourism: Pretoria.

Russell, W.B., 2009. WET-Rehab Methods: National guidelines and methods for wetland rehabilitation. WRC Report No. TT 341/09. Water Research Commission, Pretoria.

SOUTH AFRICAN NATIONAL PARKS. 2014. Outeniqua National Park: State of Knowledge. South African National Parks unpublished report.

TURPIE J; Taljaard S; van Niekerk L; Adams J; Wooldridge T; Cyrus D; Clark B; & Forbes N. 2013. The Estuary Health Index: A standardised metric for use in estuary management and the determination of ecological water requirements. WRC Report No 1930/1/12.

VAN GINKEL, C.E., GLEN, R.P., GORDAN-GRAY, K.D., CILLIERS, C.J., MUASYA AND VAN DEVENTER, P.P., 2011. Easy identification of some South African Wetland Plants (Grasses, Resticios, Sedges, Rushes, Bulrushes, Eriocaulons and Yellow-eyed grasses). WRC Report No. TT 459/10.

13 ANNEXURE 13 (METHODOLOGIES)

13.1 Definitions

Wetlands, streams and rivers are defined as follows:

Wetlands are areas that have water on the surface or within the root zone for extended periods throughout the year such that anaerobic soil conditions develop which favour the growth and regeneration of hydrophytic vegetation (plants which are adapted to saturated and anaerobic soil conditions). In terms of Section 1 of the NWA, wetlands are legally defined as: (1) "…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."

Rivers and streams are natural channels that are permanent, seasonal or temporary conduits of freshwater. In terms of ecological habitats, rivers and streams comprise in-stream aquatic habitat and riparian habitat. Generally, riparian zones mark the outer edge of stream and river systems. Streams and rivers are differentiated in terms of channel dimensions and generally fall within the broad category of rivers / riverine ecosystems in this report. • Instream habitat is the aquatic habitat (or alluvial in the case of intermittent / ephemeral watercourses) within the active channel that includes the water column, river bed and the inundated active channel margins, and associated vegetation. In terms of Section 1 of the NWA, instream habitat is legally defined as habitat that includes "…the physical structure of a watercourse and the associated vegetation in relation to the bed of the watercourse."

The riparian zone is habitat comprising bare soil, rock and/or vegetation that is: (i) associated with a watercourse; (ii) commonly characterised by alluvial soils; and (iii) inundated or flooded to an extent and with a frequency sufficient to support vegetation species with a composition and physical structure distinct from those of adjacent land areas (DWAF, 2005). In terms of Section 1 of the NWA, riparian habitat is legally defined as: 'habitat that "…includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas."

13.2 Wetland delineation and HGM type identification

Wetland delineation includes the confirmation of the occurrence of wetland and a determination of the outermost edge of the wetland. The outer boundary of wetlands was identified and delineated according to the Department of Water Affairs wetland delineation manual 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2005a). Wetland indicators were used in the field delineation of the wetlands: position in landscape, vegetation and soil wetness (determined through soil sampling with a soil auger and the examining the degree of mottling).

Four specific wetland indicators were used in the detailed field delineation of wetlands, which include:

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur.
- The Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

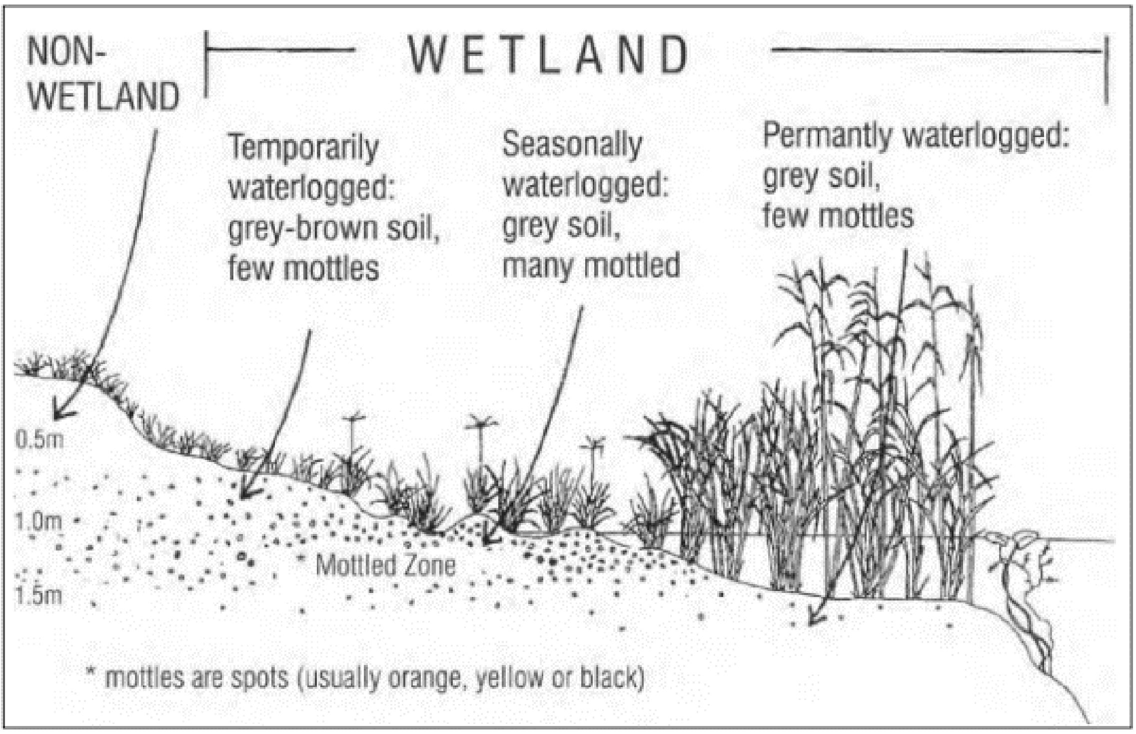


Figure A1: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change as one moves along a gradient of decreasing wetness, from the middle to the edge of the wetland. Source: Donovan Kotze, University of KwaZulu-Natal.

According to the wetland definition used in the National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practice the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps for several centuries).

The permanent, seasonal and temporary wetness zones can be characterised to some extent by the soil wetness indicators that they display (Table A11.1a)

A11.1a: Soil Wetness Indicators in the various wetland zones

TEMPORARY ZONE	SEASONAL ZONE	PERMANENT ZONE
Minimal grey matrix (<10%)	Grey matrix (<10%)	Prominent grey matrix
Few high chroma mottles	Many low chroma mottles present	Few to no high chroma mottles
Short periods of saturation (less than three months per annum)	Significant periods of wetness (at least three months per annum)	Wetness all year round (possible sulphuric odour)

Table A11.1b: Relationship between wetness zones and vegetation types and classification of plants according to occurrence in wetlands

VEGETATION	TEMPORARY WETNESS ZONE	SEASONAL WETNESS ZONE	PERMANENT WETNESS ZONE
Herbaceous	Predominantly grass species; mixture of species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas	Hydrophilic sedges and grasses restricted to wetland areas	Dominated by: (1) emergent plants, including reeds (*Phragmites australis*), a mixture of sedges and bulrushes (Typha capensis), usually >1m tall; or (2) floating or submerged aquatic plants.
Woody	Mixture of woody species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas.	Hydrophilic woody species restricted to wetland areas	Hydrophilic woody species, which are restricted to wetland areas. Morphological adaptations to prolonged wetness (e.g. prop roots).
SYMBOL	**HYDRIC STATUS**	**DESCRIPTION/OCCURRENCE**	
Ow	Obligate wetland species	Almost always grow in wetlands (>90% occurrence)	
Fw/F+	Facultative wetland species	Usually grow in wetlands (67-99% occurrence) but occasionally found in non-wetland areas	
F	Facultative species	Equally likely to grow in wetlands (34-66% occurrence) and non-wetland areas	
Fd/F-	Facultative dryland species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% occurrence)	
D	Dryland species	Almost always grow in drylands	

In order to identify the wetland types, using Kotze *et al.* (2009) and Ollie *et al.* (2013), a characterisation of hydrogeomorphic (HGM) types was conducted. These have been defined based on the geomorphic setting of the wetland in the landscape (e.g. hillslope or valley bottom, whether drainage is open or closed), water source (surface water dominated or sub-surface water dominated), how water flows through the wetland (diffusely or channelled) and how water exits the wetland (Figure A11.1b).

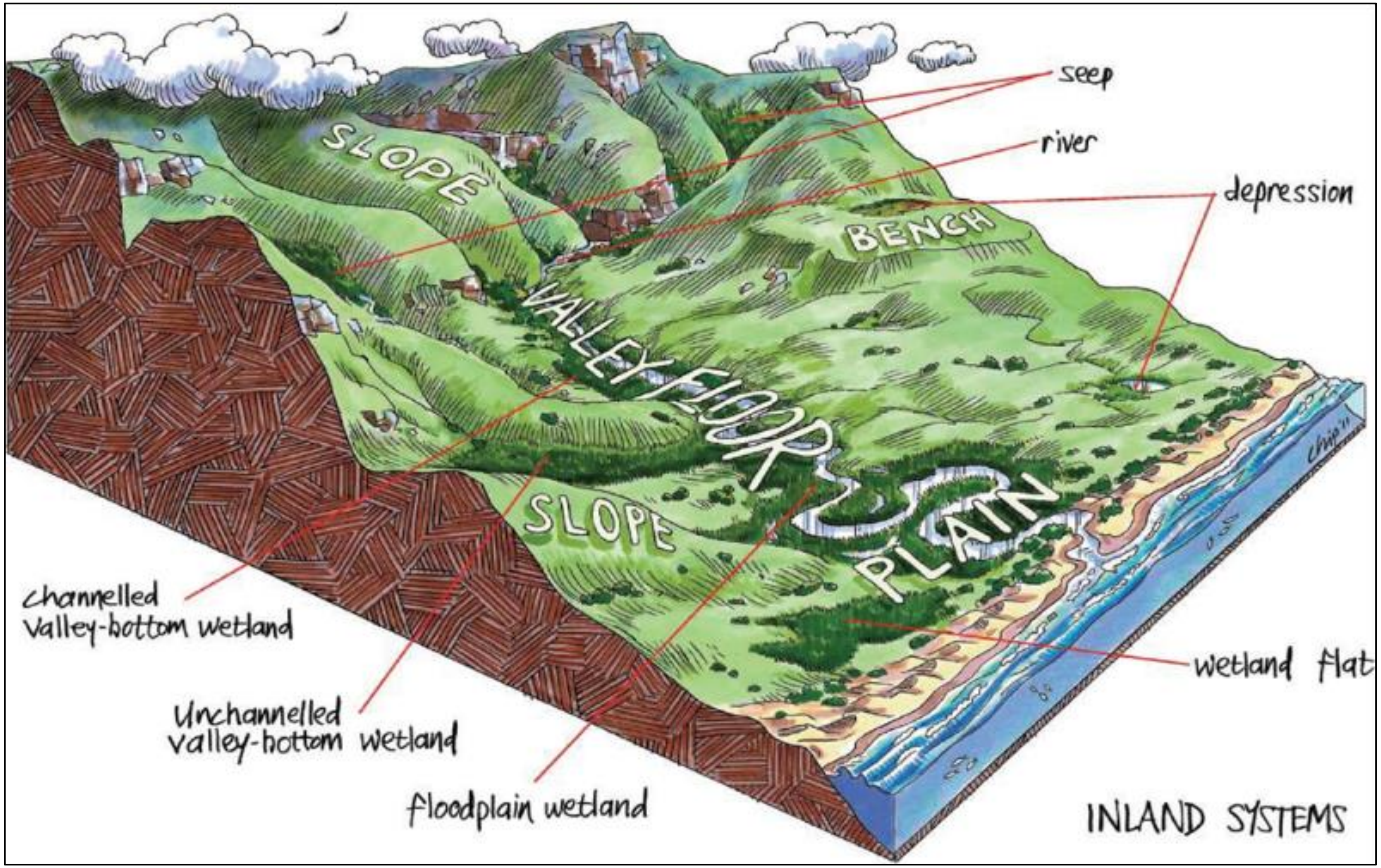


Figure A11.1b: Illustration of wetland types and their typical landscape setting (From Ollie <u>et al.</u> 2013)

13.3 Delineation of Riparian Areas

Riparian zones are described as “the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas” i , Riparian zones can be thus be distinguished from adjacent terrestrial areas through their association with the physical structure (banks) of the river or stream, as well as the distinctive structural and compositional vegetation zones between the riparian and upland terrestrial areas (Figure 8). Unlike wetland areas, riparian zones are usually not saturated for a long enough duration for redoxymorphic features to develop. Riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or stream channel.

Like wetlands, riparian areas can be identified using a set of indicators. The indicators for riparian areas are: - **Landscape position**; - Alluvial soils and recently deposited material; - **Topography** associated with riparian areas; and - **Vegetation** associated with riparian areas. Landscape Position As discussed above, a typical landscape can be divided into 5 main units (Figure 2), namely the: - Crest (hilltop); - Scarp (cliff); - Midslope (often a convex slope); - Footslope (often a concave slope); and - Valley bottom. Amongst these landscape units, riparian areas are only likely to develop on the valley bottom landscape units (i.e. adjacent to the river or stream channels; along the banks comprised of the sediment deposited by the channel). Alluvial soils are soils derived from material deposited by flowing water, especially in the valleys of large rivers. Riparian areas often, but not always, have alluvial soils. Whilst the presence of alluvial soils cannot always be used as a primary indicator to accurately delineate riparian areas, it can be used to confirm the topographical and vegetative indicators. Quaternary alluvial soil deposits are often indicated on geological maps, and whilst the extent of these quaternary alluvial deposits usually far exceeds the extent of the contemporary riparian zone; such indicators are useful in identifying areas of the landscape where wider riparian zones may be expected to occur.

Topography and recently deposited material associated with riparian areas The National Water Act definition of riparian zones refers to the structure of the banks and likely presence of alluvium. A good indicator of the presence of riparian zones is the presence of alluvial deposited material adjacent to the active channel (such as benches and terraces), as well as the wider incised “macro-channels” which are typical of many of southern Africa’s eastern seaboard rivers. Recently deposited alluvial material outside of the main active channel banks can indicate a currently active flooding area; and thus the likely presence of wetlands. Vegetation associated with riparian areas unlike the delineation of wetland areas, where redoxymorphic features in the soil are the primary indicator, the identification of riparian areas relies heavily on vegetative indicators. Using vegetation, the outer boundary of a riparian area can be defined as the point where a distinctive change occurs: - in species composition relative to the adjacent terrestrial area; and - in the physical structure, such as vigour or robustness of growth forms of species similar to that of adjacent terrestrial areas. Growth form refers to the health, compactness, crowding, size, structure and/or numbers of individual plants.

As with the delineation approach for wetlands, the field delineation method for riparian areas focuses on two main indicators of riparian zones: - **Vegetation Indicators**, and - **Topography** of the banks of the river or stream.

Additional verification can be obtained by examining for any recently alluvial deposited material to indicate the extent of flooding and thus obtain at least a minimum riparian zone width. The following procedure should be used for delineation of riparian zones: A good rough indicator of the outer edge of the riparian areas is the edge of the macro channel bank. This is defined as the outer bank of a compound channel, and should not be confused with the active river or stream channel bank. The macro-channel is an incised feature, created by uplift of the subcontinent which caused many rivers to cut down to the underlying geology and creating a sort of “restrictive floodplain” within which one or more active channels flow. Floods seldom have any known influence outside of this incised feature. Within the macro-channel, flood benches may exist between the active channel and the top of the macro channel bank. These depositional features are often covered by alluvial deposits and may have riparian vegetation on them. Going (vertically) up the macro channel bank often represents a dramatic decrease in the frequency, duration and depth of flooding experienced, leading to a corresponding change in vegetation structure and composition.

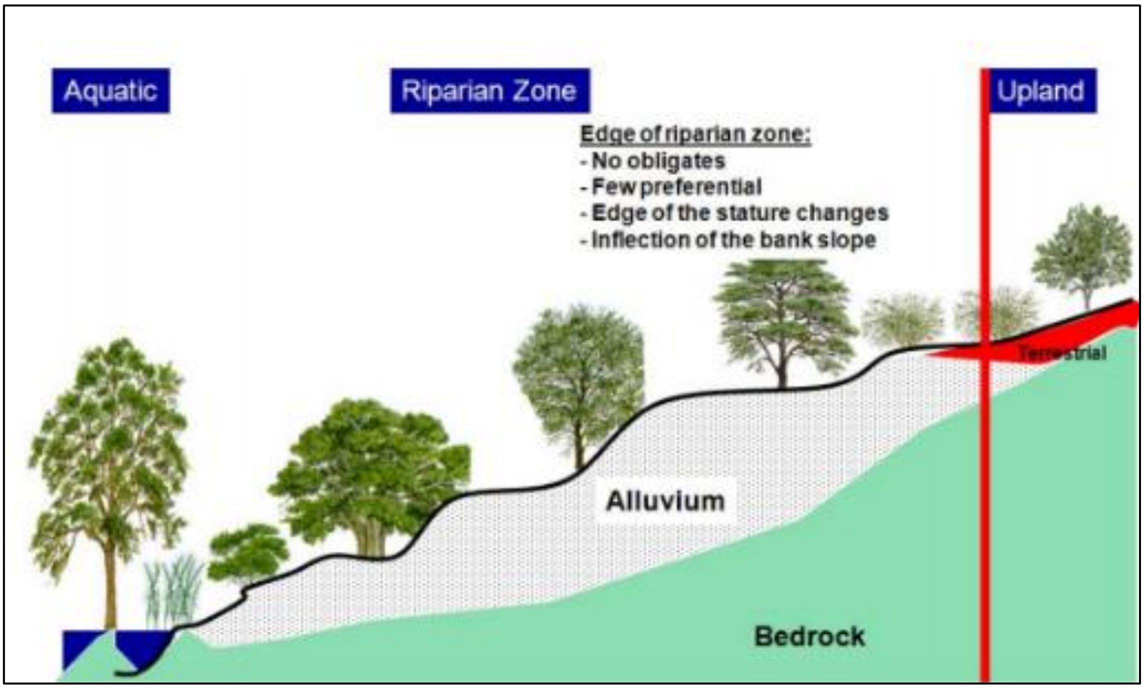


Figure A11.2a: A schematic diagram illustrating the edge of the riparian zone on one bank of a large river. Note the coincidence of the inflection (in slope) on the bank with the change in vegetation structure and composition. The edge of the riparian zone coincides with an inflection point on the bank; where there are not obligates upslope; few preferential. The boundary also coincides with the outer edge of the stature differences (DWAF 2008).

13.4 Present Ecological State (PES) – Wetlands

WET-Health assists in assessing the health of wetlands using indicators based on geomorphology, hydrology and vegetation. For the purposes of rehabilitation planning and assessment, WET-Health helps users understand the condition of the wetland in order to determine whether it is beyond repair, whether it requires rehabilitation intervention, or whether, despite damage, it is perhaps healthy enough not to require intervention. It also helps diagnose the cause of wetland degradation so that rehabilitation workers can design appropriate interventions that treat both the symptoms and causes of degradation. WET-Health is tailored specifically for South African conditions and has wide application, including assessing the Present Ecological State of a wetland. There are two levels of complexity: Level 1 is used for assessment at a broad catchment level and Level 2 provides detail and confidence for individual wetlands based on field assessment of indicators of degradation (e.g. presence of alien plants). A basic tertiary education in agriculture and/or environmental sciences is required to use it effectively. Level 1 was utilised for the assessment.

WET-Health is a tool designed to assess the health or integrity of a wetland. Wetland health is defined as a measure of the deviation of wetland structure and function from the wetland's natural reference condition. This technique attempts to assess hydrological, geomorphological and vegetation health in three separate modules.

Hydrology is defined in this context as the distribution and movement of water through a wetland and its soils. This module focuses on changes in water inputs as a result of changes in catchment activities and characteristics that affect water supply and its timing, as well as on modifications within the wetland that alter the water distribution and retention patterns within the wetland.

Geomorphology is defined in this context as the distribution and retention patterns of sediment within the wetland. This module focuses on evaluating current geomorphic health through the presence of indicators of excessive sediment inputs and/or losses for clastic (minerogenic) and organic sediment (peat).

Vegetation is defined in this context as the vegetation structural and compositional state. This module evaluates changes in vegetation composition and structure as a consequence of current and historic onsite transformation and/or disturbance.

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present State score. The tool attempts to standardise the way that impacts are calculated and presented across each of the modules. This takes the form of assessing the spatial extent of impact of individual activities and then separately assessing the intensity of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall magnitude of impact (Table A11.2a).

Table A11.2a: Guideline for interpreting the magnitude of impacts on integrity (Macfarlane et al., 2008).

IMPACT CATEGORY	DESCRIPTION	SCORE
None	No discernible modification or the modification is such that it has no impact on this component of wetland integrity.	0 – 0.9
Small	Although identifiable, the impact of this modification on this component of wetland integrity is small.	1 – 1.9
Moderate	The impact of this modification on this component of wetland integrity is clearly identifiable, but limited.	2 – 3.9
Large	The modification has a clearly detrimental impact on this component of wetland integrity. Approximately 50% of wetland integrity has been lost.	4 – 5.9
Serious	The modification has a highly detrimental effect on this component of wetland integrity. Much of the wetland integrity has been lost but remaining integrity is still clearly identifiable.	6 – 7.9
Critical	The modification is so great that the ecosystem processes of this component of wetland integrity are almost totally destroyed, and 80% or more of the integrity has been lost.	8 – 10

Impact scores obtained for each of the modules reflect the degree of change from natural reference conditions. Resultant health scores fall into one of six health categories (A-F) on a gradient from “unmodified/natural” (Category A) to “severe/complete deviation from natural” (Category F) as depicted in Table A11.2b, below. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic systems.

Table A11.2b. Health categories used by WET-Health for describing the integrity of wetlands (after Macfarlane et al., 2008).

IMPACT CATEGORY	DESCRIPTION	RANGE	PES CATEGORY
None	Unmodified, natural.	0 – 0.9	**A**
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1 – 1.9	**B**
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2 – 3.9	**C**
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4 – 5.9	**D**
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still	6 – 7.9	**E**
Critical	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8 – 10	**F**

An overall wetland health score was calculated by weighting the scores obtained for each module and combining them to give an overall combined score using the following formula:

Overall health rating = [(Hydrology*3) + (Geomorphology*2) + (Vegetation*2)] / 7

This overall score assists in providing an overall indication of wetland health/functionality which can in turn be used for recommending appropriate management measures.

13.5 Wetland Functional Importance (Goods and Services)

WET-EcoServices is used to assess the goods and services that individual wetlands provide, thereby aiding informed planning and decision making. It is designed for a class of wetlands known as palustrine wetlands (i.e. marshes, floodplains, vleis or seeps). The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing). The first step is to characterise wetlands according to their hydro-geomorphic setting (e.g. floodplain). Ecosystem service delivery is then assessed either at Level 1, based on existing knowledge or at Level 2, based on a field assessment of key descriptors (e.g. flow pattern through the wetland).

The overall goal of WET-EcoServices is to assist decision makers, government officials, planners, consultants and educators in undertaking quick assessments of wetlands, specifically in order to reveal the ecosystem services that they supply. This allows for more informed planning and decision making. WET-EcoServices includes the assessment of several ecosystem services (listed in Table

A11.4a) - that is, the benefits provided to people by the ecosystem.

Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits		Flood attenuation	The spreading out and slowing down of floodwaters in the wetland, thereby reducing the severity of floods downstream
				Streamflow regulation	Sustaining streamflow during low flow periods
			Water quality enhancement benefits	Sediment trapping	The trapping and retention in the wetland of sediment carried by runoff waters
				Phosphate assimilation	Removal by the wetland of phosphates carried by runoff waters
				Nitrate assimilation	Removal by the wetland of nitrates carried by runoff waters
				Toxicant assimilation	Removal by the wetland of toxicants (e.g. metals, biocides and salts) carried by runoff waters
				Erosion control	Controlling of erosion at the wetland site, principally through the protection provided by vegetation.
				Carbon storage	The trapping of carbon by the wetland, principally as soil organic matter
	Direct benefits	**Biodiversity maintenance**[2]			Through the provision of habitat and maintenance of natural process by the wetland, a contribution is made to maintaining biodiversity
		Provisioning benefits		Provision of water for human use	The provision of water extracted directly from the wetland for domestic, agriculture or other purposes
				Provision of harvestable resources	The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.
				Provision of cultivated foods	The provision of areas in the wetland favourable for the cultivation of foods
		Cultural benefits		Cultural heritage	Places of special cultural significance in the wetland, e.g., for baptisms or gathering of culturally significant plants
				Tourism and recreation	Sites of value for tourism and recreation in the wetland, often associated with scenic beauty and abundant birdlife
				Education and research	Sites of value in the wetland for education or research

Table A11.4a: Ecosystem services assessed by WET-Ecoservices

The steps involved in applying WET-EcoServices can be summarised as follows.

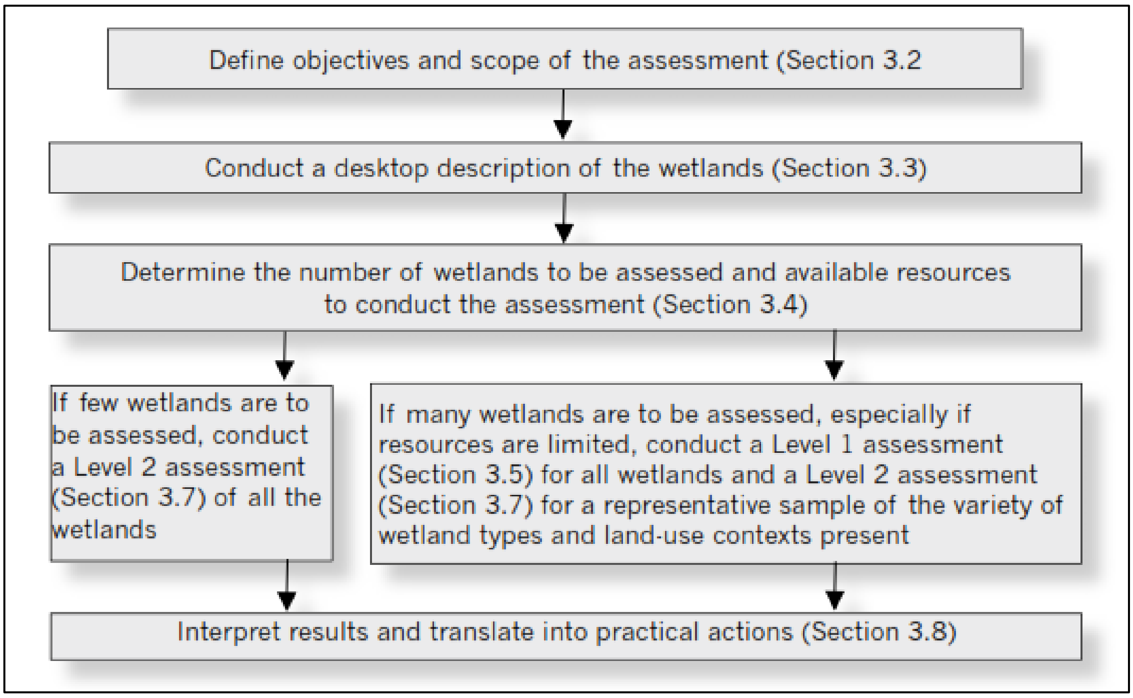


Figure A11.4a: Steps required for Wet-EcoServices. The sections referred to within this figure relate back to the Wetland Management Series: Wet-Ecoservices. WRC Report TT 339/08

13.6 Ecological Importance & Sensitivity (EIS) - Wetlands

The Ecological Importance and Sensitivity was determined by utilising a rapid scoring system. The system has been developed to provide a scoring approach for assessing the Ecological, Hydrological Functions; and Direct Human Benefits of importance and sensitivity of wetlands. These scoring assessments for these three aspects of wetland importance and sensitivity have been based on the requirements of the NWA, the original Ecological Importance and Sensitivity assessments developed for riverine assessments (DWAF, 1999), and the work conducted by Kotze et al (2008) on the assessment of wetland ecological goods and services from the WET-EcoServices tool (Rountree, 2010). An example of the scoring sheet is attached as Table A11.5a. The scores are then placed into a category of very low, low, moderate, high and very high as shown in Table 14.5b.

Table A11.5a: Example of scoring sheet for Ecological Importance and sensitivity

ECOLOGICAL IMPORTANCE AND SENSITIVITY:			
Ecological Importance	Score (0-4)	*Confidence (1-5)*	**Motivation for site**
Biodiversity support			
Presence of Red Data species			
Populations of unique species			
Migration/breeding/feeding sites			
Landscape scale			
Protection status of the wetland			
Protection status of the vegetation type			
Regional context of the ecological integrity			
Size and rarity of the wetland type/s present			
Diversity of habitat types			
Sensitivity of the wetland			
Sensitivity to changes in floods			
Sensitivity to changes in low flows/dry season			
Sensitivity to changes in water quality			
ECOLOGICAL IMPORTANCE & SENSITIVITY			
HYDROLOGICAL/FUNCTIONAL IMPORTANCE			
IMPORTANCE OF DIRECT HUMAN BENEFITS			
OVERALL IMPORTANCE			

Table A11.5b: Category of score for the Ecological Importance and Sensitivity

RATING	EXPLANATION
None, Rating = 0	Rarely sensitive to changes in water quality/hydrological regime
Low, Rating =1	One or a few elements sensitive to changes in water quality/hydrological regime
Moderate, Rating =2	Some elements sensitive to changes in water quality/hydrological regime
High, Rating =3	Many elements sensitive to changes in water quality/ hydrological regime
Very high, Rating =4	Very many elements sensitive to changes in water quality/ hydrological regime

13.7 Present Ecological State (PES) – Riparian

Habitat is one of the most important factors that determine the health of river ecosystems since the availability and diversity of habitats (in-stream and riparian areas) are important determinants of the biota that are present in a river system (Kleynhans, 1996). The 'habitat integrity' of a river refers to the "maintenance of a balanced composition of physic-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region" (Kleynhans, 1996). It is seen as a surrogate for the assessment of biological responses to driver changes.

DWAF have developed a modified IHI, designed to accommodate the time constraints associated with desktop assessments or for instances where a rapid assessment of river conditions is required. The protocol does not distinguish between instream and riparian habitat and addresses six simple metrics to obtain an indication of Present Ecological State (PES). Each of the criteria are rated on a scale of 0 (close to natural) to 5 (critically modified) (Table A11.6a) according to the following metrics:

- Bed modification
- Flow modification
- Inundation
- Bank condition
- Riparian zone condition
- Water quality modification

This assessment was informed by (i) a site visit where potential impacts to each metric were assessed and evaluated and (ii) an understanding of the catchment feeding the river and landuses / activities that could have a detrimental impact on river ecosystems.

Table A11.6a: The rating scale for each of the various metrics in the assessment

RATING SCORE	IMPACT CLASS	DESCRIPTION
0	**None**	*No discernible impact or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.*
0.5 - 1.0	**Low**	*The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.*
1.5 - 2.0	**Moderate**	*The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.*
2.5 - 3.0	**Large**	*The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.*
3.5 - 4.0	**Serious**	*The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.*
4.5 - 5.0	**Critical**	*The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.*

The six metric ratings of the HGM under assessment are then averaged, resulting in one value. This value determines the Habitat Integrity PES category for the HGM (Table A11.6b).

Table A11.6b: The habitat integrity PES categories

PES CATEGORY	DESCRIPTION
A: Natural	Unmodified, natural.
B: Good	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C: Fair	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D: Poor	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E: Seriously modified	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F: Critically modified	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

13.8 Ecological Importance & Sensitivity – Riparian

The ecological importance of a wetland/river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Kleynhans & Louw, 2007; Resh *et al.*, 1988; Milner, 1994). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity (Table A11.7a).

Table A11.7a: Components considered for the assessment of the ecological importance and sensitivity of a riparian system. An example of the scoring has also been provided.

Ecological Importance and Sensitivity assessment (Rivers)		
	Determinants	**Score (0-4)**
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	0,5
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	0,0
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	0,5
	Species/taxon richness (range: 4=very high - 1=low/marginal)	1,5
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	1,0
	Refugia (4=Very high - 1=marginal/low)	1,5
	Sensitivity to flow changes (4=Very high - 1=marginal/low)	1,0
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1,0
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	1,0
	Importance of conservation & natural areas (range, 4=very high - 0=very low)	2
MEDIAN OF DETERMINANTS		1,00
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		**LOW, EC=D**

The scores assigned to the criteria in Table A11.7a were used to rate the overall EIS of each mapped unit according to Table A11.7b, below, which was based on the criteria used by DWS for river eco-classification (Kleynhans & Louw, 2007) and the WET-Health wetland integrity assessment method (Macfarlane *et al.*, 2008).

Table A11.7b: The ratings associated with the assessment of the EIA for riparian areas

RATING	EXPLANATION
None, Rating = 0	Rarely sensitive to changes in water quality/hydrological regime
Low, Rating =1	One or a few elements sensitive to changes in water quality/hydrological regime
Moderate, Rating =2	Some elements sensitive to changes in water quality/hydrological regime
High, Rating =3	Many elements sensitive to changes in water quality/ hydrological regime
Very high, Rating =4	Very many elements sensitive to changes in water quality/ hydrological regime

14 ANNEXURE 14: BEST PRACTICE MATERIALS & METHODS FOR CONSTRUCTION

The following information is a summary of relevant measures described in the documents; *Typical Best Management Practices for construction sites* by Westmoreland Conservation District in 2016 and *WETRehabmethods* (Russel *et al.* 2009). For the SUDS methods please refer to *The South African Guidelines for Sustainable Drainage Systems* (Armitage *et al.* 2013). Please note that these are only examples of mitigation methods and concepts and require Engineering input and/or input from the appointed contractor if they are to be utilized. Any dimensions and details presented are purely theoretical or only to provide guidance.

14.1 Geotexiles

Geotextiles are a range of both woven and non-woven continuous filament needle-punched membranes. They are manufactured out of polypropylene and polyester fibres. Geotextiles are used as:

- *drainage filter material* to allow moisture to seep out of soils and other *in situ* material without the parent material moving through the cloth along with the moisture. An example is the universal use of the cloth as a separation lining between all gabion – soil interfaces. Needle pointed 'Bidim' should be used in preference to woven fabrics for gabion backing

- *a soil-reinforcing membrane* where berms/ embankments need to be built with side slopes steeper than the natural angle of repose of the soil involved.

- *a separation membrane* between ground surfaces and road-building material when constructing a road across unstable surfaces. This could have important application where roads are required to traverse wetland conditions.

The geotextile material is sold in standard rolls of 5 m x 150 m and with various thicknesses/strengths for the various applications required. Joints in geofabric should be made with an overlap of at least 300 mm or a 150 mm double fold over and tied with galvanized wire staples at

300 mm intervals. The joint must always lap away from the direction of flow, otherwise the joint will open.

14.1.1 Geo-cells

These are systems of regular cells that have been formed by the alternate fastening of strips of polyethylene material in order to form a system of square cells when the finished product is stretched out sideways. The cells are filled with either soil, gravel or concrete, in order to either: stabilize steep slopes, when soil (planted to suitable vegetation) or gravel/crushed rock is used line chute spillways or storm water drains, when concrete is used protect foundations from the force of falling water below weirs, when concrete is used protect earthen berms from trampling by animals, when crushed rock or concrete is used stabilize roadway stream crossings, when concrete is used hold soil in place over geomembranes to permit slopes steeper than 1:10 but not steeper than 1:5.

14.1.2 Geojute or hessian

Cloth of woven jute is known in the trade as Geo-jute, Soil saver, etc. It is probably more cost effective to purchase it as plain hessian. Laid on bare soil as a cover to both hold soil in place, reduce the energy of falling raindrops, and to retain moisture on and in the soil, hessian is a useful product to encourage the quick germination and growth of vegetation that has been seeded, especially on sloping land. On steeper slopes it should be used double thickness, anchored at the top by burying 250 mm into the soil, and anchored with short wooden pegs at 1.5-2.0 metres centre to centre down the slope.

14.1.3 Concrete cellular mattresses

Marketed as Armorflex, these interlocking, pre-cast blocks are manufactured by Messrs. Concor Technicrete Building Products. Armorflex mattresses consist of concrete blocks that are machine-pressed to a special inter-locking shape. They inter-lock with each other transversely across the width of the mat. Where the mats are required to protect the underlying soil from high velocities, they can be wired together, across the direction of flow, to provide extra stability. When properly designed and laid Armorflex can provide protection against quite fast flowing water. The velocity that the lining can tolerate is a function of the geometry of the channel and the characteristics of the underlying soil.

14.1.4 Gabions

Gabion work is the technique of building with dry handstone sized rocks packed into specially manufactured wire baskets and mattresses of various standard sizes. The baskets and mattresses are laced together as they are filled, in the construction of, usually, mass gravity weirs, although chutes can also be constructed with them.

14.2 Storm water drains/canals

These are well known to be used to divert runoff from a problem area to a safe disposal point. Storm water drains are designed and surveyed to intercept runoff and carry it in a non-erosive manner to a disposal point. Their gradients are necessarily lower than that of the topography from whence the runoff comes. The runoff will therefore obviously flow slower than previously, and with the drop in velocity, a large portion of the sediment carried in suspension will be deposited in the drain. This will result in the need for regular maintenance. If the sediment is not removed timeously the drain will lose its capacity and overtop during a heavy rainfall event.

14.3 Bio-engineering

Vegetation can be used alone or with engineering structures Bio-engineering is the use of vegetation for controlling runoff, stabilising erosion and trapping sediment. Vegetation may be used alone or supported by engineering structures or soft applications (such as fibre mats to enhance the likelihood of establishment. Furthermore, vegetation may be used to augment hard engineering structures, where the vegetation plays a significant role in the long-term success of the structure.

14.3.1 Contour banks

Contour banks are constructed on a slight gradient, at intervals down the slope, in order to intercept excess runoff and guide it away to a safe disposal point. They are of earthen construction and must be strongly built and with sufficient capacity to withstand storm rainfall runoff events. They are not suitable for land slopes in excess of 8%, and at the upper slope range will in any case not curb erosion sufficiently.

14.3.2 Bench terracing

This involves the wholesale re-construction of the land profile into a series of stepped benches with a lateral gradient towards a suitable discharge point.

14.4 Urban stormwater management

There is seldom a culvert beneath a public road or rail, or issuing from an urban area, that is not characterised by a gully at it’s lower end. This results in large amounts of sediment and increased flood flows being concentrated (and with flow velocities therefore increasing) that will impact negatively on wetlands downstream. In the case of roads and rail, the reason for the gully is that the natural pattern of fairly widespread, shallow, and therefore low velocity overland flow has been intercepted and concentrated at the culvert. Depending on available funds, engineers designing the road or rail are generally forced to reduce the number of culverts in order to stay within their budget.

Install energy dissipaters at the outlets of the culverts. The concentrated, high-velocity runoff can be spread, and it's velocity thereby reduced, by excavating level spreader canals below the outlets, and earthen berms introduced lower down the slope to ensure that the runoff is dispersed as much as possible. The downside of this idea is that the spreader canals will require regular maintenance and cleaning out of sediments and debris.

Adoption of these areas by the local communities, and especially local schools, should bring about a greater awareness of the problem, and inculcate eventually in the minds of the population a more careful approach to managing storm runoff.

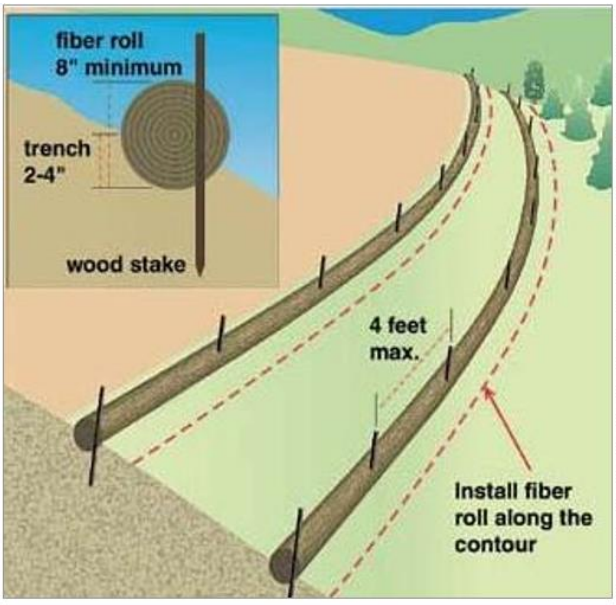
Culvert pipes will concentrate flow and encourage the formation of gullies. Care will have to be taken to dissipate the energy of water exiting from these structures. A better solution, if suitable material is available, would be to construct the bottom of the embankment of permeable rock fill over all or part of its length. Filter fabric layers would be required to separate the rock fill from the soil above and below.

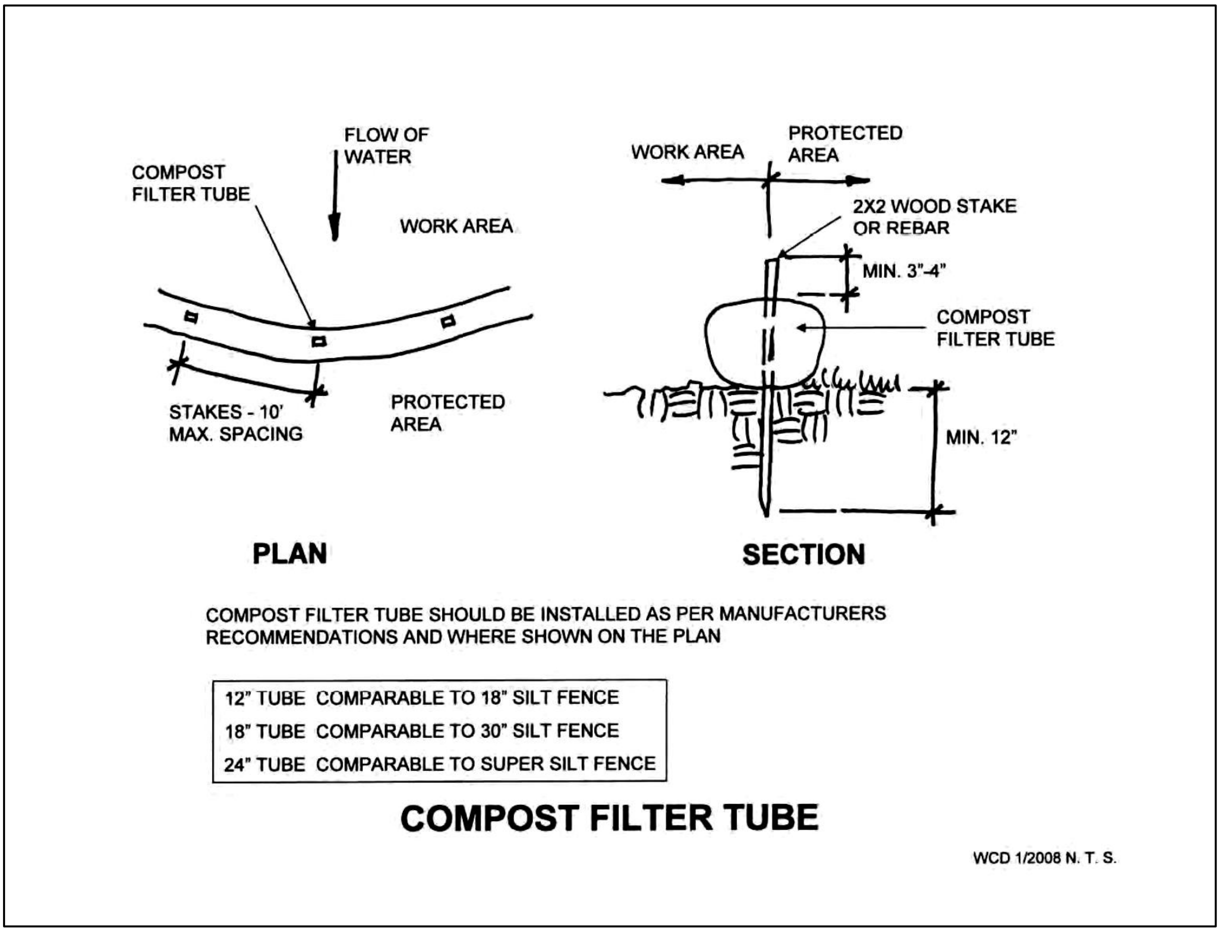
14.5 Compost Filter Tube

Typical Features:

- Can be used in place of silt fence
- Should be laid on the contour
- Stakes should be driven through the tube at least 12" into the existing ground, with 3"- 4" exposed above the tube
- Remove sediment when it reaches 1/3 height of sock
- Once site is stabilized, tube may be cut open and seeded.

<u>Please note that the information is sourced from the above-mentioned documents and is only a guideline example of some of the structures or concepts used in mitigation. Engineering input and/or input by the Contractor in liaison with the ECO is required to determine the correct measure to be adopted and incorporated into the method statement.</u>

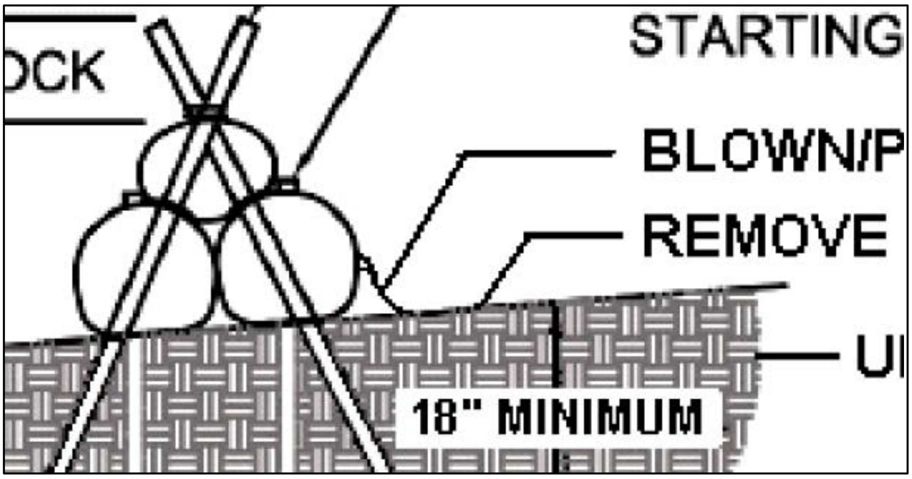

fiber roll
8" minimum
trench
2-4"
wood stake
4 feet
max.
Install fiber
roll along the
contour



14.6 Compost Sock Sediment Trap

Typical Features:

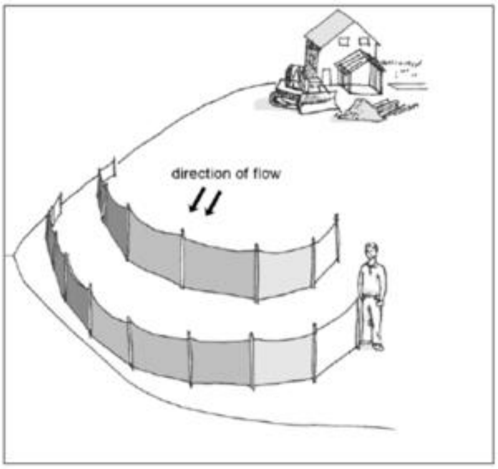
- Sock material and compost material shall meet industry standards
- Shall not exceed 3 socks in height, and shall be stacked in pyramidal form
- Maximum tributary area is 5 acres
- Shall be inspected weekly and after each runoff event
- Remove sediment when it reaches 1/3 height of socks

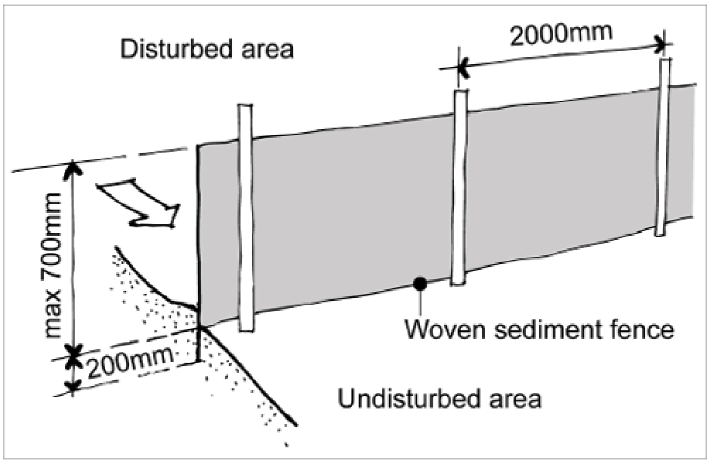


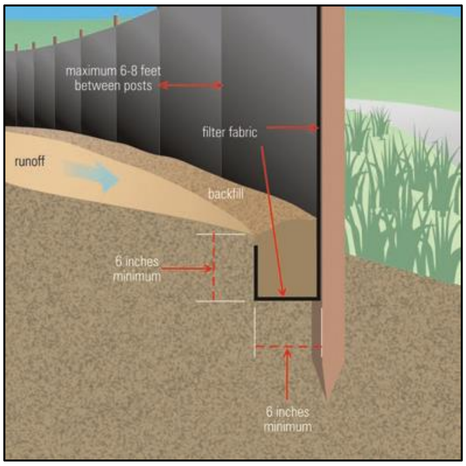
14.7 Silt Fence - Standard

Typical Features:

- Designed to handle sheet flow, not concentrated flow
- 6” x 6” trench should be excavated
- The bottom 12” of the fabric should be placed in the trench in an “L” shape with a 6” horizontal flap and a 6” vertical rise
- Should not be able to lift the bottom of the fence off of the ground
- Multiple rows of silt fence may not be used on a continuous slope
- Should be at least 8’ from toe of slope
- Should be installed at existing level grade
- Both ends of each section must be extended 8’ upslope at 45 degrees
- Sediment must be removed when accumulations reach ½ of the above ground height of the fence
- Any section of fence which has been undermined or over-topped must immediately be replaced with a rock filter outlet



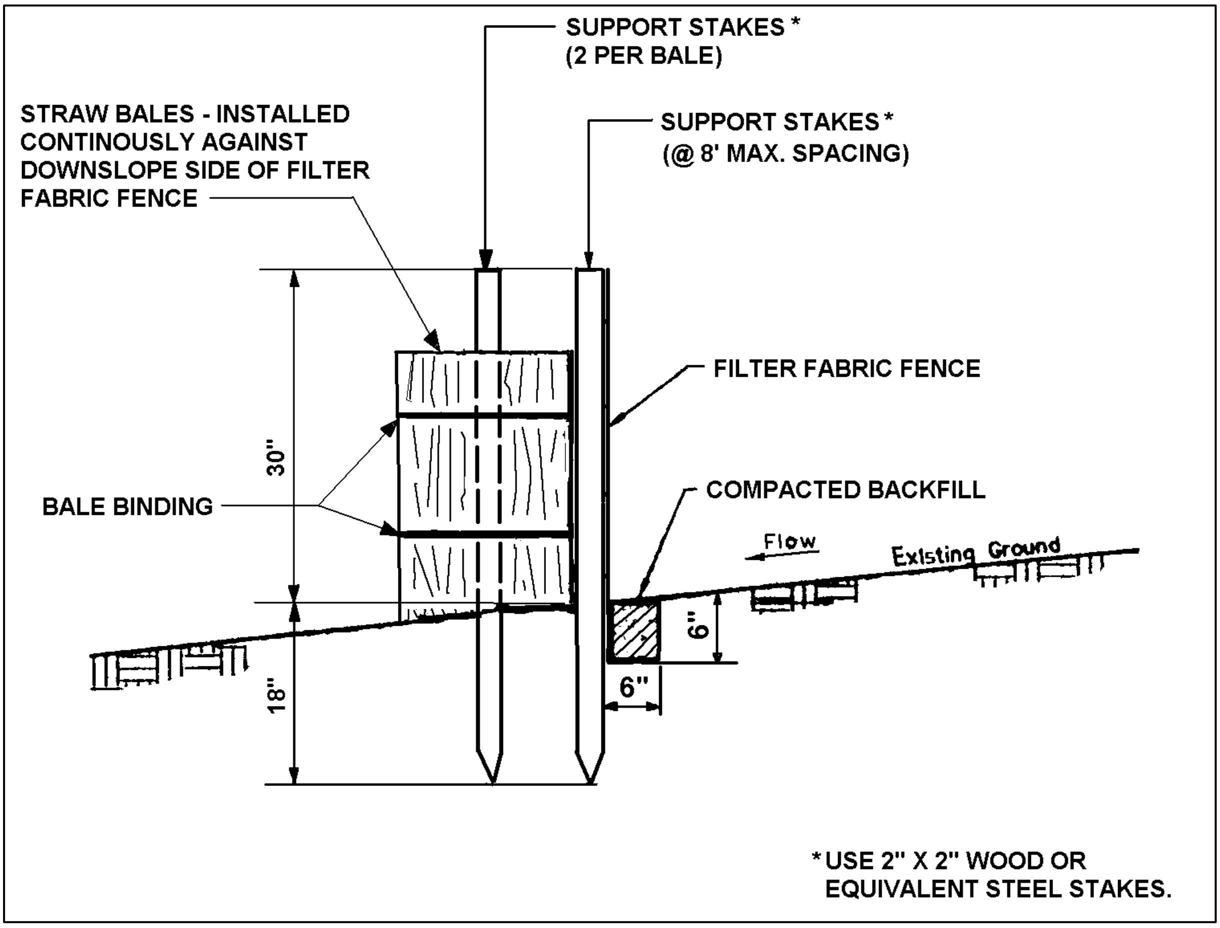




14.8 Silt Fence - Standard Silt Fence with Straw Bales

Typical Features:

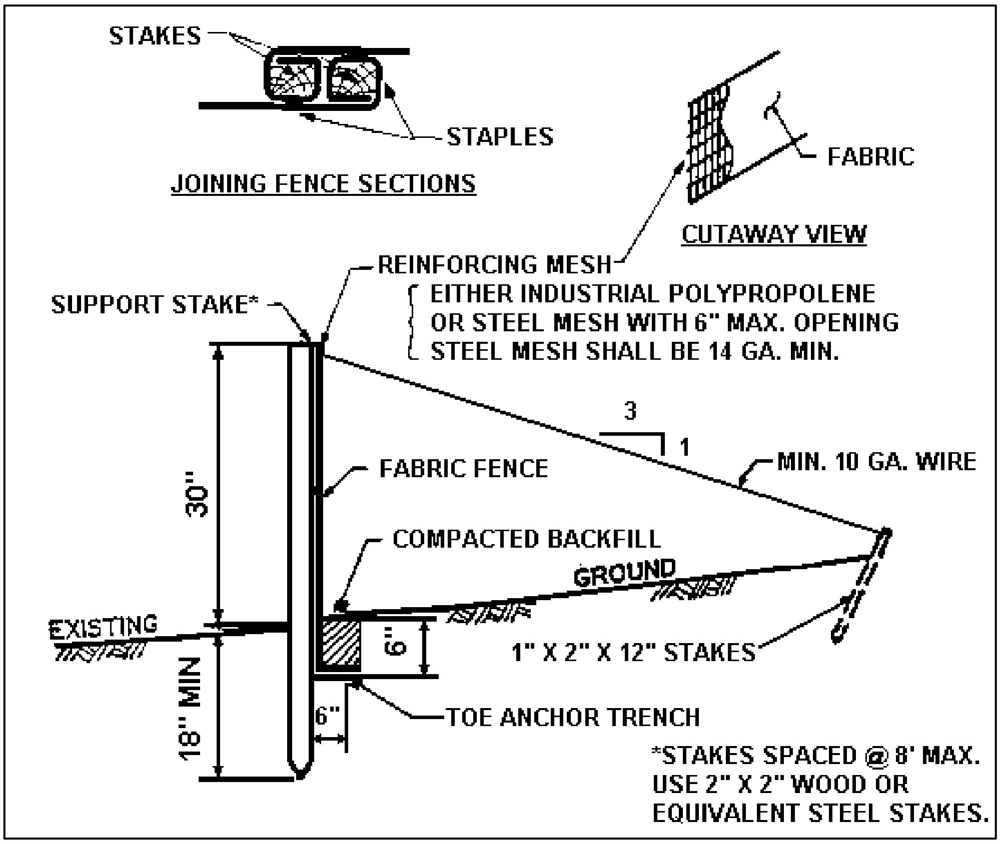
- Designed to handle sheet flow, not concentrated flow
- 6" x 6" trench should be excavated
- The bottom 12" of the fabric should be placed in the trench in an "L" shape with a 6" horizontal flap and a 6" vertical rise
- Should not be able to lift the bottom of the fence off of the ground
- Multiple rows of silt fence may not be used on a continuous slope
- Should be at least 8' from toe of slope
- Should be installed at existing level grade
- Both ends of each section must be extended 8' upslope at 45 degrees to main fence
- Sediment must be removed when accumulations reach ½ of the above ground height of the fence
- Any section of fence which has been undermined or over-topped must immediately be replaced with a rock filter outlet



14.9 Silt Fence - Standard Reinforced 30” Silt Fence

Typical Features:

- Designed to handle sheet flow, not concentrated flow
- 6” x 6” trench should be excavated
- The bottom 12” of the fabric should be placed in the trench in an “L” shape with a 6” horizontal flap and a 6” vertical rise
- Should not be able to lift the bottom of the fence off of the ground
- Multiple rows of silt fence may not be used on a continuous slope
- Should be at least 8’ from toe of slope
- Should be installed at existing level grade
- Both ends of each section must be extended 8’ upslope at 45 degrees
- Fence is reinforced with minimum 10 gauge wire
- Sediment must be removed when accumulations reach ½ of the above ground height of the fence
- Any section of fence which has been undermined or over-topped must be replaced immediately with rock filter outlet


STAKES
STAPLES
JOINING FENCE SECTIONS
FABRIC
CUTAWAY VIEW
REINFORCING MESH
EITHER INDUSTRIAL POLYPROPOLENE
OR STEEL MESH WITH 6" MAX. OPENING
STEEL MESH SHALL BE 14 GA. MIN.
SUPPORT STAKE*
3
1
MIN. 10 GA. WIRE
FABRIC FENCE
30"
COMPACTED BACKFILL
GROUND
EXISTING
6"
1" X 2" X 12" STAKES
18" MIN
6"
TOE ANCHOR TRENCH
*STAKES SPACED @ 8' MAX.
USE 2" X 2" WOOD OR
EQUIVALENT STEEL STAKES.

14.10 Rock Filter

Typical Features:

- Constructed of R-3, R-4 or R-5 rock faced with 2B (AASHTO #57) stone
- Used to filter sediment laden water from concentrated areas but not used in place of sediment traps or basins
- May not be used in lieu of channel liner

14.11 Vegetative Filter Strip

Typical Features:

- Suitability of natural vegetation should be field verified
- Should be well-established perennial grass at a minimum or other dense, meadow vegetation
- Width should be minimum 50 feet in width
- Protect area from compaction
- Protect device from siltation during and after construction
- Woody or brushy vegetation is not acceptable
- Runoff should be in the form of sheet flow

14.12 Rock Energy Dissipater

Typical Features:

- Rock rip-rap sized to dissipate energy from high velocity water discharges from pipes
- Geotextile fabric is placed under the rock to prevent scour of the earth beneath
- Apron dimensions designed for slope and volume (velocity)
- Stabilized surface should extend to natural flow channel
- Sediment deposit indicates serious problem

14.13 Slope Stabilization with Turf Reinforcement Mat

Typical Features:

- Turf reinforcement mat used to stabilize slopes to prevent severe erosion
- Allows seed to germinate easier and grow faster
- Must be installed in the direction of water flow
- Must be stapled to the ground according to manufacturer recommendations
- Colored dots are typically provided on the TRM for installation guidance
- Sections are overlapped and pinned to surface
- Soil contact is very important for TRM to do its job, or soil will erode under TRM
- Does not prevent slumping of soil due to saturation

14.14 Hydromulch

Typical Features:

- Mulch should be applied at recommended rates
- Mulch should be anchored or tackified immediately to prevent being windblown
- Mulch on slopes >8% should be held in place by netting

14.15 Pervious Pavement

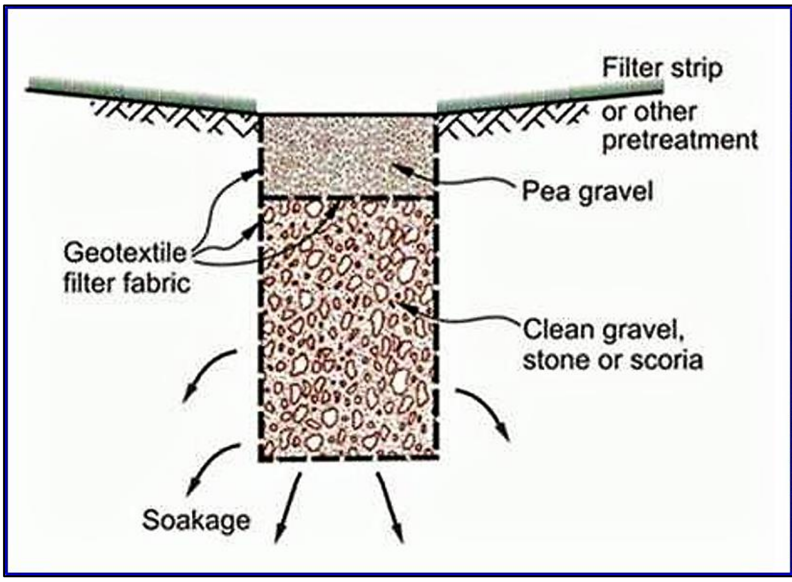
Typical Features:

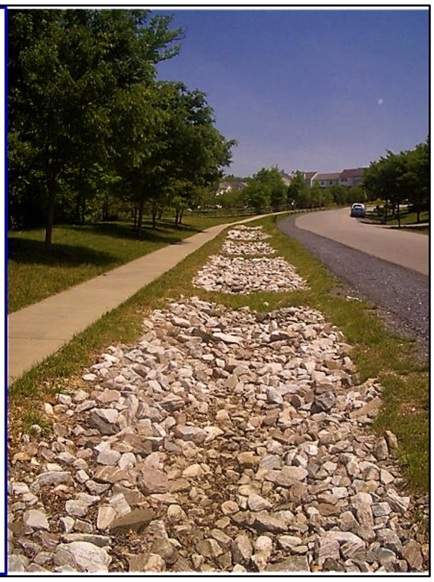
- Protect area from compaction
- Protect from siltation during and after installation
- Level or gently sloping subgrade
- Layer of geotextile fabric beneath porous base
- Porous base, 8” to 12” clean crushed stone
- Paving material meets permeability standards
- Subdrain if needed

14.16 Infiltration Trench

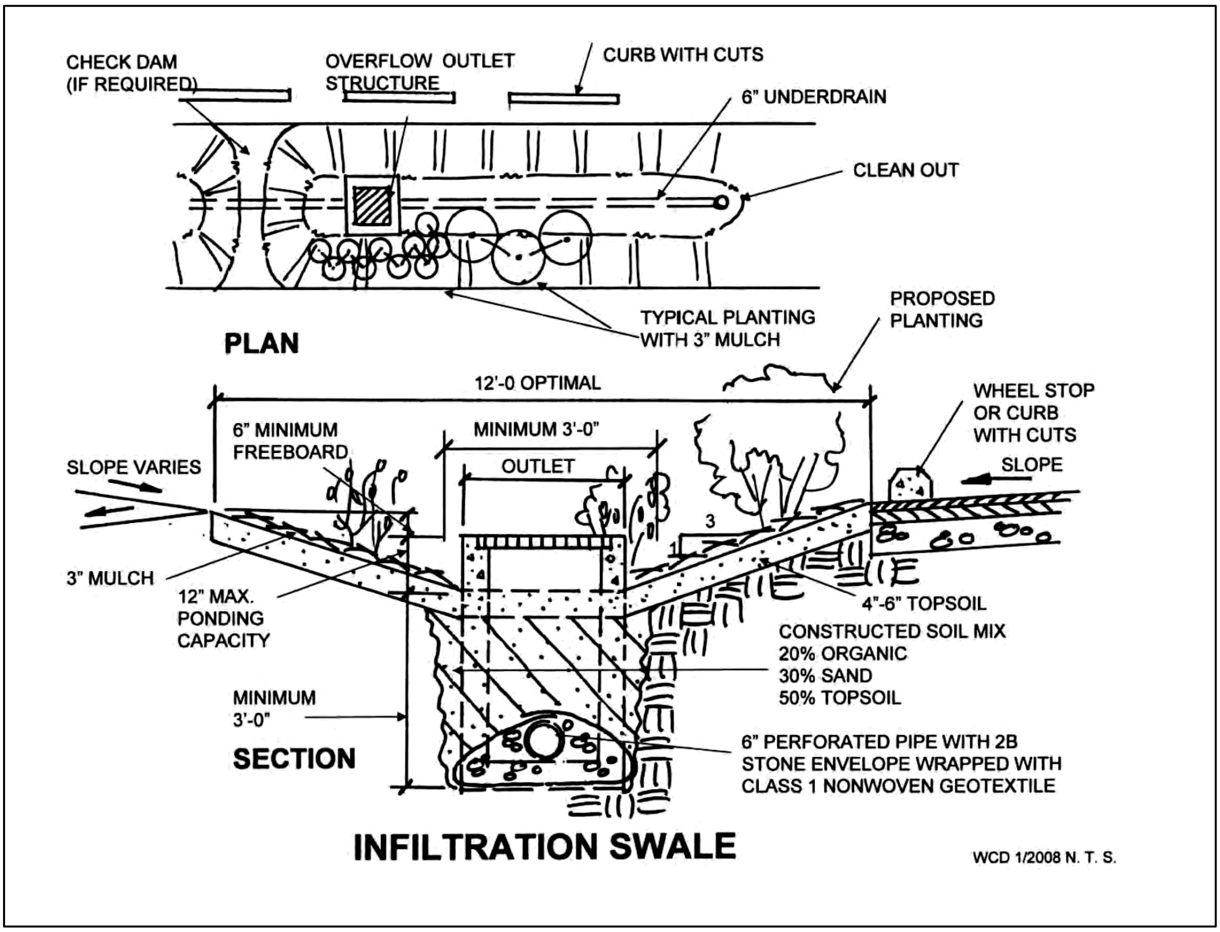
Typical Features:

- Protect area from compaction
- Protect device from siltation during and after construction
- Continuous perforated pipe at minimum slope
- Drainage layer of clean, washed, uniform grade aggregate wrapped in geotextile fabric
- Engineered soil media
- Dense vegetation for stabilization





14.17 Bio-Infiltration or Contour trench/swale

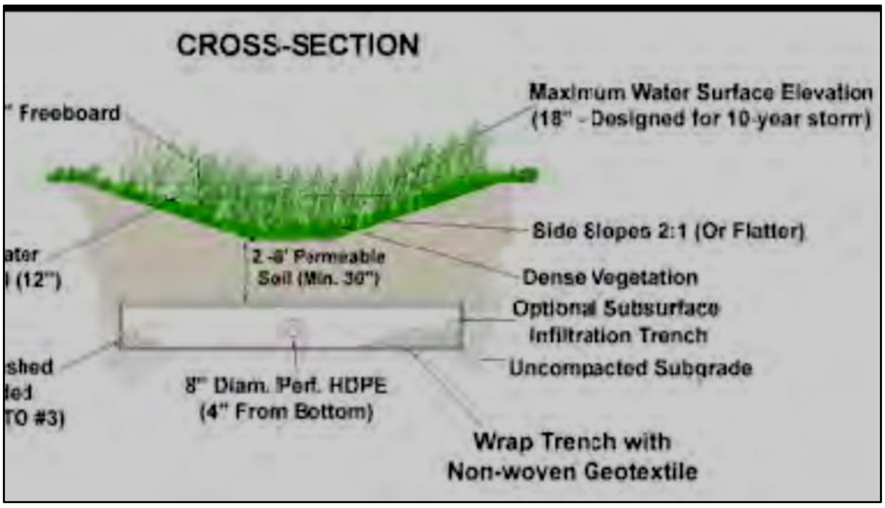


14.18 Vegetated Swale

Typical Features:

- Protect area from compaction
- Protect device from siltation during and after construction

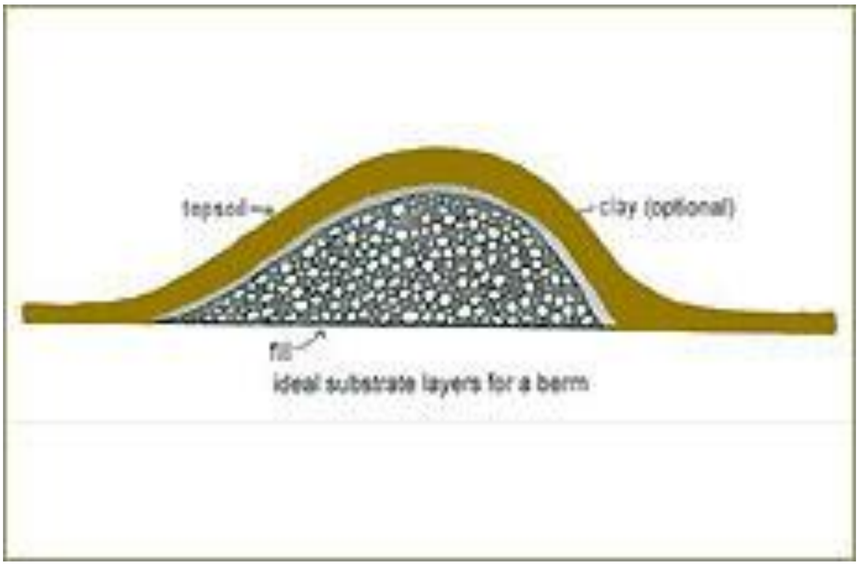
- Planted with dense, low-growing native vegetation tolerant to excessive water drought and salt
- Longitudinal slopes 1% to 6% with 3:1 or gentler side slopes and trapezoidal channel
- Check dams maximize infiltration



14.19 Infiltration Berm

Typical Features:

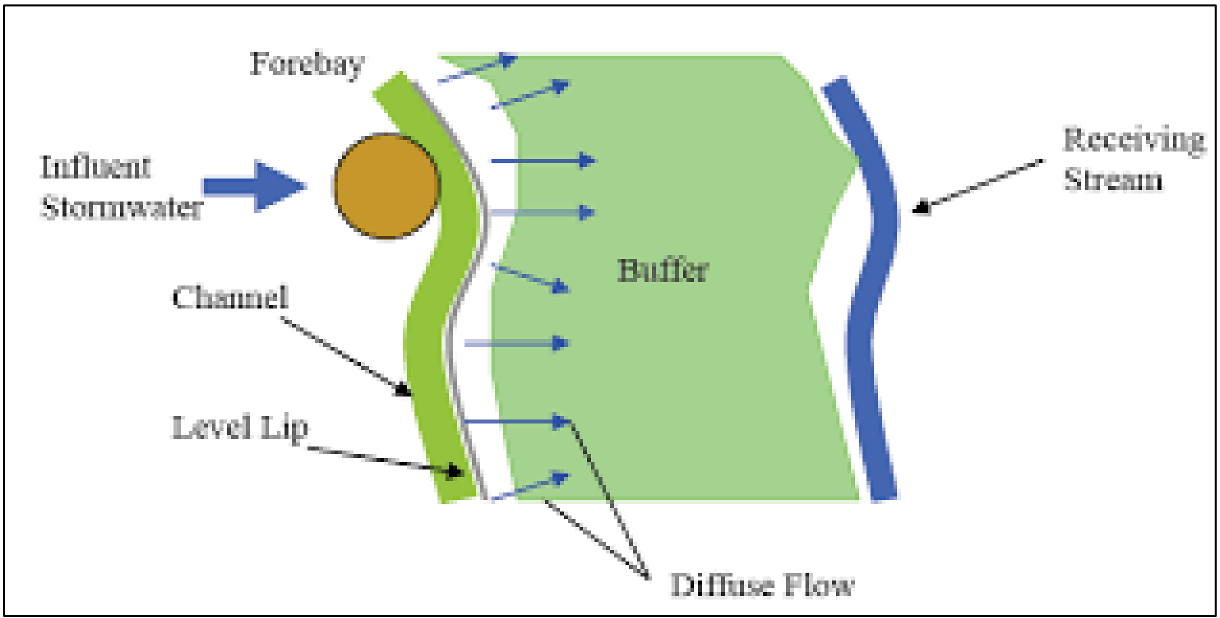
- Protect area from compaction
- Protect device from siltation during and after construction
- Berms should be lopsided with 4:1 side slopes or gentler and no higher than 24 inches
- Planted with turf grass at a minimum or other dense, meadow vegetation, shrubs and trees

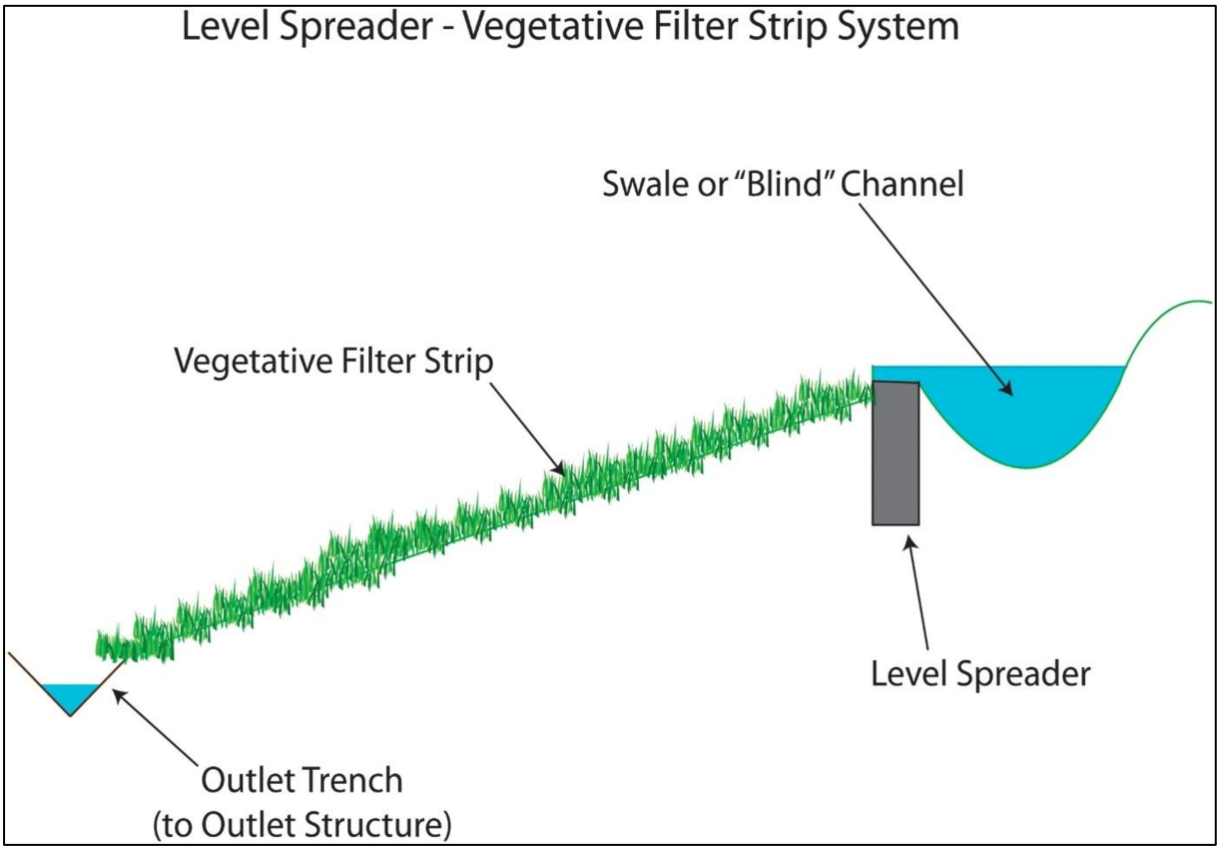


14.20 Level Spreaders

Typical Features:

- A structure designed to uniformly distribute concentrated flow over a large area essentially converting concentrated flow to sheet flow when no alternative exists to convey flow to a surface water or storm sewer
- Should be designed by a professional and included on an approved plan
- Should not exceed a drainage area of 5 acres
- Should be constructed and maintained LEVEL along an existing contour
- Downslope edge should be properly stabilized with TRM or by using a formed concrete curb





15 DIRECT, INDIRECT AND CUMULATIVE IMPACTS METHODOLOGY

Direct, indirect and cumulative impacts should be assessed in terms of the following criteria:

The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.

The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional,

The **duration**, wherein it will be indicated whether:

The lifetime of the impact will be of a very short duration (0-1 years)

The lifetime of the impact will be of short duration (2-5 years)

Medium term (5-15 years)

Long-term (> 15 years) –

Permanent

The **magnitude**, where:

0 is small and will have no effect on the environment,

2 is minor and will not result in an impact on processes,

4 is low and will cause a slight impact on processes,

6 is moderate and will result in processes continuing but in a modified way,

8 is high (processes are altered to the extent that they temporarily cease), and

10 is very high and results in complete destruction of patterns and permanent cessation of processes.

The **probability** of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of:

very improbable (probably will not happen),

improbable (some possibility, but low likelihood),

probable (distinct possibility),

is highly likely (most likely) and;

is definite (impact will occur regardless of any prevention measures).

The **significance**, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high;

The degree to which the impact can be reversed.

The degree to which the impact may cause irreplaceable loss of resources; and

The degree to which the impact can be mitigated.

The significance is calculated by combining the criteria in the following formula, **S = (E+D+M) P**, where:

S = significance weighting

E = extent

D = duration

M = magnitude

P = probability

The significance for each potential impact are as follows:

Low (i.e. where this impact would not have a direct influence on the decision to develop the area),

Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),

High (i.e. where the impact must have an influence on the decision process to develop the area).

16 DECLARATION OF INDEPENDENCE

I, Debbie Fordham, declare that I:

- Act as an independent specialist consultant, in this application, in the field of wetland and riparian ecology;
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed,
- Have, and will have, no vested interest in the proposed activity proceeding.
- Have no, and will not engage in, conflicting interests in the undertaking of the activity;
- Undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2014 (as amended); and
- Will provide the competent authority with access to all the information at my disposal regarding the application, whether such information is favourable to the applicant or not.

The following report has been prepared:

- As per the requirements of Section 32 (3) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) Environmental Impact Assessment Regulations 2014 as per Government Notice No. 38282 Government Gazette, 4th December 2014 (as amended).
- In accordance with Section 13: General Requirements for Environmental Assessment Practitioners (EAPs) and Specialists as well as per Appendix 6 of GNR 982 - Environmental Impact Assessment 2014 Regulations (as amended).
- With consideration to Cape Nature's standard requirements for biodiversity assessments and in accordance with DEA&DP's Guideline on Involving biodiversity specialists in the EIA process
- Independently of influence or prejudice by any parties.

17 SPECIALIST CV

Debra Jane Fordham

Aquatic Ecologist working in George at Sharples Environmental Services cc as a specialist consultant and managing water use licensing applications (WULAs). Debbie holds a M.Sc. degree in Environmental Science from Rhodes University, by thesis, entitled: The geomorphic origin and evolution of the Tierkloof Wetland, a peatland dominated by *Prionium serratum* in the Western Cape.

Debbie has conducted many aquatic habitat assessments and rehabilitation plans of various spatial and temporal scales, in numerous locations within South Africa. These assessments include wetland, river, and estuary health assessments, rehabilitation plans, water quality analysis, monitoring recommendations, and generally compiling reports that clearly convey the findings and contribute to future management. She has also completed Water Use License Applications, Basic Assessment Reports and Environmental Management Plans. Debbie is highly proficient with GIS mapping software and incorporates spatial analysis in all assessments.

Key skills:

- Desktop mapping and infield assessment for wetland/ riparian habitat delineation
- Assessment of wetland and riparian functional importance (EIS) and Present Ecological State (PES) now including the WET-Health V2 tool, amongst others.
- Evaluating impacts to wetland and riparian systems from proposed developments
- Identifying mitigation measures and developing monitoring and rehabilitation plans
- WULA, EIA and BAR Applications
- ArcGIS V10, QGIS 2.18, CoralDraw X4, Strater V3, Statistica V9, MSOffice

Tertiary Education at Rhodes University, South Africa:

M.Sc. Environmental Science

Master of Science degree, by thesis, entitled:

The geomorphic origin, evolution and collapse of a peatland dominated by Prionium serratum: a case study of the Tierkloof Wetland, Western Cape.(Supervised by Prof. Fred Ellery)

BA Honours – Environmental Science

Honours Dissertation: The status and use of Aloe ferox. Mill in the Grahamstown commonage, South Africa. (Supervised by Prof. Sheona Shackleton)

Honours Subjects

- Wetland Ecology
- Environmental Water Quality /Toxicology
- Environmental Impact Assessment (EIA)
- Biodiversity, Non-Timber Forest Products (NTFPs) and Rural Livelihoods
- Statistics

BA Degree – Environmental Science and Geography

Current position: Aquatic Ecologist and WULA Manager

Sharples Environmental Services cc: 2016/08/10 - Present

Debbie fulfils the specific requirements of each project with regards to the relevant aquatic legislation, such as conducting aquatic habitat impact reports and Water Use Licence Applications (WULAs). This mostly requires undertaking ground-truthing, classification, infield identification, delineation, impact assessment and mapping of aquatic ecosystems. SES conduct Present Ecological State (PES), functional importance assessments and Ecological Importance and Sensitivity (EIS) assessments of aquatic ecosystems. She conducts environmental impact and environmental sensitivity (constraints) assessments on aquatic habitats to determine if they are at risk of being impacted upon by proposed development areas during construction and operational phases of development. Including identifying direct, indirect, and cumulative impacts that proposed developments will have on aquatic habitats and the significance of these impacts and recommend actions that should be taken to prevent impacts on aquatic habitats. She also determines and maps No-Go and buffer zones utilising professional knowledge and buffer zone guidelines for rivers, wetlands and estuaries.

Publications and memberships:

Bekker, D. J. & Shackleton, S. 2010. The status and use of *Aloe ferox Mill*. in the Grahamstown commonage. Policy Brief, Rhodes University

Professional Wetland Scientist applicant with SWS

Southern Cape Wetland Society (SCWS)

South African Wetlands Society (SAWS)

Freshwater Ecosystem Network (FEN)

Southern African Association of Geomorphologists (SAAG)

DWAF accredited wetland delineation

Recent Aquatic Impact Assessment Projects:

Installation of A Water Pipeline from An Existing Borehole to The Herbertsdale Reservoir, Mossel Bay Municipality

Unauthorised Clearance of Vegetation and Construction of a Dam on Farm Angeliersbosch Re/157, Prince Albert

Rehabilitation of The Excavation of a Channel Within the Brandwag River, On the Remainder of Farm Bowerf 161, Brandwacht, Mossel Bay

Rehabilitation Plan for activities On A Portion of Remainder Portion 104 Of the Farm Modder Rivier No 209, George

Aquatic Impact Assessment for The Proposed Extension of Walvis Street, Mossel Bay

Rehabilitation Plan for the transformation of agricultural land to commercial land on Farm Re 109/209, George

Aquatic assessment for the proposed Dana Bay Access Road, near Mossel Bay

Invasive Alien Plant Control Plan for New Horizons Mixed-Use Development on Farm Hillview No. 437, Plettenberg Bay

Cemetery expansion on Erf 566 and 480, Melkhoutfontein

The expansion of Goue Akker Cemetery in Beaufort West

Construction of a bulk sewerage pipeline from Green Valley township, Wittedrift, to the Plettenberg Bay WWTW

Periodic Maintenance of Trunk Road 31- Barrydale To Ladismith (Km 30.89 To Km 76.06), Western Cape Province

Expansion of the Gansbaai Sand en Klip Quarry

Seven Oaks Residential Development, Wittedrift, Plettenberg Bay

Gran Sasso Quarry water abstraction and proposed construction of a road crossing a watercourse, Tygervalley, Cape Town

Maintenance of Trunk Road 33/4 and Trunk Road 34/2, though Meiringspoort, Western Cape Province

Proposed Waste Water Treatment Works, Irrigation Activities & Effluent Discharge by Parmalat SA (Pty) Ltd, Bonnievale

Development of Remainder of Erf 562 Kurland, Plettenberg Bay

Ladismith Cheese Water Use Application

Construction of A 22kv Overhead Powerline, near Humansdorp, Eastern Cape

Development of Herold's Bay Country Estate on A Portion of Portion 7 Of Farm Buffelsfontein No. 204, Herold's Bay

Groot Witpan and Konga Pan salt mining, Northern Cape

Gemsbok Horn salt pan mine prospecting

Hartenbos Estuary Habitat Integrity Assessment with Fish Survey and water quality analysis

The proposed Aalwyndal Precinct Plan Development: Biodiversity Component

Tweekuilen Estuary Habitat Integrity Assessment with Fish Survey

Residential Development on Portion 3 of Kraaibosch 195, George

End