WATERCOURSE DELINEATION & IMPACT ASSESSMENT

FOR THE PROPOSED CONSTRUCTION OF AN ARTIFICIAL WETLAND AT THE DARVILL WWTW, PIETERMARITZBURG, MSUNDUZI MUNICIPALITY, UMGUNGUNDLOVU DISTRICT, KZN

Report compiled by

Bruce Scott-Shaw
NatureStamp (Pty) Ltd
Tel 078 399 9139
Email bruce@naturestamp.co.za

Report compiled for

Sivest
Sivest Environmental Division
Tel 033 347 1600
Email ShivaniN@sivest.co.za

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ASSESSMENT DETAILS & SPECIALIST DECLARATION

This report has been prepared 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 Regulations and the National Environmental Management Act (NEMA, No. 107 of 1998 as amended 2014). It has been prepared independently of influence or prejudice by any parties. A full declaration of independence has been provided in Annexure E.

The specialist details are as follows –

Table 1 Specialist details

Specialist	Task	Qualification and accreditation	Client	Signature
Bruce Scott-Shaw NatureStamp	Fieldwork and report	MSc, Hydrology	SIVEST	Date: 20/01/2016
Susan Carter-Brown NatureStamp	Review	BSc Honours, Environmental Science	SIVEST	Date: 15/02/2016

<u>Details of Author:</u>

Bruce Scott-Shaw is a hydrologist, whose focus is broadly on hydrological perspectives of land use management and climate change. Throughout his university career he has mastered numerous models and tools relating to hydrology, soil science and GIS. Some of these include ACRU, SWAT, HEC-RAS, ArcMap, Idrisi, SEBAL, MatLab, Loggernet and AutoCAD. He has some basic programming skills on the Java and CR Basic platforms.

<u>Details of Reviewer:</u>

Susan Carter-Brown is the founder of NatureStamp and has been practising as an Environmental Assessment Practitioner for the past 6 years. Susan has attended various courses on wetland assessment (Tools for Wetland Delineation, Pretoria 2010; WET-Health; WET-EcoServices, Rhodes University 2010; WET-Health workshop, WESSA 2011), and conducts specialist watercourse assessments as part of an EIA process for a range of developments. She is a member of the KZN Wetland Forum, IAIA KZN and the South African Wetland Society.

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GLOSSARY

Bar: accumulations of sediment associated with the channel margins or bars forming in meandering rivers where erosion is occurring on the opposite bank to the bar.

Biodiversity: the number and variety of living organisms on earth, the millions of plants, animals, and micro-organisms, the genes they contain, the evolutionary history and potential they encompass, and the ecosystems, ecological processes, and landscapes of which they are integral parts.

Catchment: the area contributing to runoff at a particular point in a river system.

Channel section: a length of river bounded by the banks and the bed.

Delineation (of a wetland or riparian zone): to determine the boundary of a water resource (wetland or riparian area) based on soil and vegetation (wetland) or geomorphological and vegetation (riparian zone) indicators.

Ecosystem Goods and Services: The goods and benefits people obtain from natural ecosystems. Various different types of ecosystems provide a range of ecosystem goods and services. Aquatic ecosystems such as rivers and wetlands provide goods such as forage for livestock grazing or sedges for craft production and services such as pollutant trapping and flood attenuation. They also provide habitat for a range of aquatic biota.

Erosion: is the process by which soil and rock are removed from the Earth's surface by natural processes such as wind or water flow, and then transported and deposited in other locations. While erosion is a natural process, human activities have dramatically increased the rate at which erosion is occurring globally. Erosion gullies are erosive channels formed by the action of concentrated surface runoff.

General Authorisation: is an authorization to use water without a license, provided that the water use is within the limits and conditions set out in the General Authorisation.

Gleying: a soil process resulting from prolonged soil saturation, which is manifested by the presence of neutral grey, bluish or greenish colours in the soil matrix.

Groundwater: subsurface water in the saturated zone below the water table. Habitat: the natural home of species of plants or animals.

High terrace: relict floodplains which have been raised above the level regularly inundated by flooding due to lowering of the river channel (rarely inundated).

Hue (of colour): the dominant spectral colour (e.g. red).

Hydromorphic soil: a soil that, in its undrained condition, is saturated or flooded long enough to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).

Hydrology: the study of the occurrence, distribution and movement of water over, on and under the land surface.

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

Invasive alien species: Invasive alien species means any non-indigenous plant or animal species whose establishment and spread outside of its natural range threatens natural ecosystems, habitats or other species or has the potential to threaten ecosystems, habitats or other species.

Mottles: soils with variegated colour patterns are described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles.

Munsell colour chart: a standardized colour chart, which can be used to describe hue (i.e. its relation to red, yellow, green, blue and purple), value (i.e. its lightness) and chroma (i.e. its 10 10 purity).Munsell colour charts are available which show that portion commonly associated with soils, which is about one fifth of the entire range.

NEMA: National Environmental Management Act, Act 107 of 1998.

Obligate species: species almost always found in wetlands (> 99% of occurrences).

Redoximorphic soil features: physic-chemical changes in the soil due to (1) in the case of gleying, a change from an oxidizing (aerated) to reducing (saturated, anaerobic) environment; or (2) in the case of mottling, due to switching between reducing and oxidizing conditions (especially in seasonally waterlogged wetland soils).

Riparian habitat (as defined by the National Water Act): includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils (deposited by the current river system), 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.

Saturation zone: the zone in which the soils and rock structure are saturated with water.

Scree Pan: a collection of rocks and coarse debris that accumulates at the foot of a steep slope.

Seasonal zone of wetness: the zone of a wetland that lies between the Temporary and Permanent zones and is characterized by saturation for three to ten months of the year, within 50cm of the surface.

Sedges: grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.

Soil horizons: layers of soil that have fairly uniform characteristics and have developed through pedogenic processes; they are bounded by air, hard rock or other horizons (i.e. soil material that has different characteristics).

Soil profile: the vertically sectioned sample through the soil mantle, usually consisting of two or three horizons.

Temporary zone of wetness: the outer zone of a wetland characterized by saturation within 50cm of the soil surface for less than three months of the year.

Terrace: area raised above the level regularly inundated by flooding (infrequently inundated).

LIST OF ABBREVIATIONS

DWA Department of Water Affairs

DWAF Department of Water Affairs & Forestry

DWS Department of Water & Sanitation

ECO Environmental Control Officer

EIA Environmental Impact Assessment

EIS Ecological Importance & Sensitivity

EKZNW Ezemvelo KwaZulu-Natal Wildlife

FEPA Freshwater Ecosystem Priority Area

GIS Geographical Information Systems

GPS Global Positioning System

HGM Hydro-Geomorphic

IAPs Invasive Alien Plants

IHI Index of Habitat Integrity

PES Present Ecological State

NFEPA National Freshwater Ecosystem Priority Areas

1. INTRODUCTION

1.1 Project Background and Description of the Activity

NatureStamp has been contracted to conduct a watercourse delineation and impact assessment for the construction of an artificial wetland between the Darvill Waste Water Treatment Works (WWTW) and the Msunduzi River. The artificial wetland is expected to attenuate high flows originating from the existing storage dam (as indicated in Section 5.2) and would further alleviate excess wastewater from the upgrade of the WWTW. Umgeni Water contracted GroundTruth Water, Wetlands and Environmental Engineering to develop a wetland feasibility plan (Report reference: GTW363-150814-01). This report focuses on Site 1 which was selected as the best site for the constructed wetland.

The wetland will be approximately 9.34ha in extent, and potentially capable of attenuating 140Mℓ. The feasibility plan consists of a 324 m^3 cell wetland with a tower drop inlet, an emergency spillway and an earthen wall. The coordinates for the proposed upgrade of the Darvill constructed wetland are: 29° 36' 12.19'' south and 30°25' 50.72'' east. Further information on the constructed wetland can be found in Annexure F and the reference report by GroundTruth. The location of the proposed development can be seen in Figure 1.

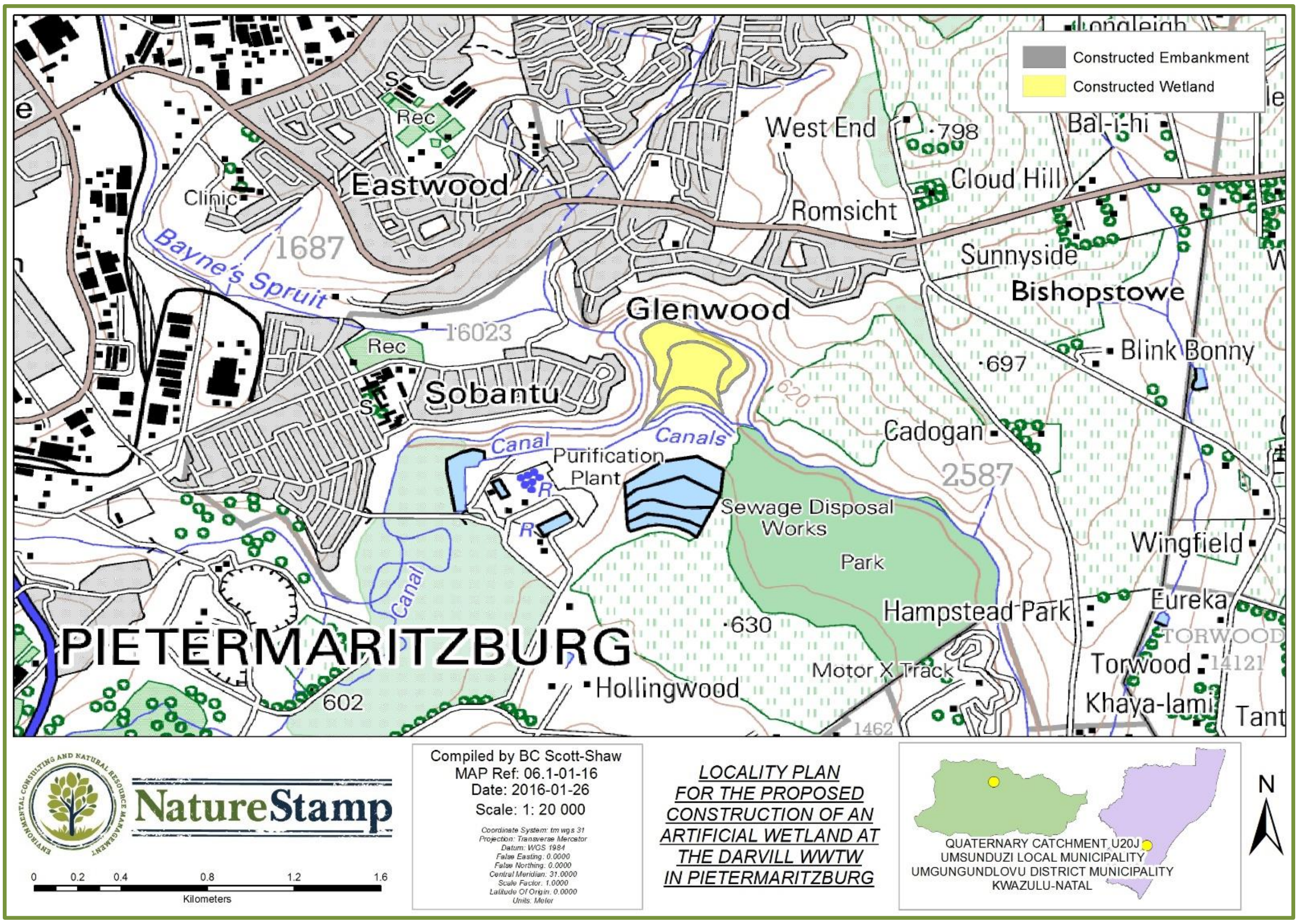

Figure 1 Locality map showing the site for the proposed Darvill Constructed wetlands

Within and surrounding the proposed development, there may be watercourse[1] systems present. Uninformed and poorly planned development activities in the vicinity of watercourses can rapidly degrade these systems. Due to the possibility of negative impacts on nearby watercourses, pre-development assessments are required to gain an understanding of the natural environment and guide the planning and approval process in order that site-specific mitigation measures can be put in place and negative impacts are minimised.

1.2 Terms of reference

NatureStamp has been appointed to conduct a watercourse assessment to determine the presence of watercourse features within 500 meters of the site, the condition/Present Ecological State (PES) and ecological importance & sensitivity of any natural freshwater ecosystems present and to determine any detrimental impacts on the systems that should be avoided and / or mitigated. A water quality assessment was requested to determine the baseline condition of affected watercourse systems for follow-up comparisons.

The terms of reference are as follows:

i. Watercourse Delineation and Assessment

Determine the presence of watercourses within 500m of the proposed development site. Formally assess the condition/PES of the delineated wetland areas present within 500m of the site. This will involve:

- *determining the condition/ PES of the delineated wetlands using the Level 1 WET-Health tool (Macfarlane et al., 2009);*
- *determining the functional importance of the delineated wetlands present using the level 2 WET-EcoServices tool (Kotze et al., 2009); and*
- *determining the ecological importance & sensitivity (EIS) of the delineated wetlands using the Department of Water Affairs and Forestry (DWAF)wetland EIS tool (Duthie, 1999)*

ii. Risk Assessment and Management Plan / Mitigation

The impacts of the proposed development on the delineated watercourse areas would be identified, predicted and described. Measures would be recommended to mitigate impacts.

iii. Watercourse Management and Rehabilitation Plan, including Monitoring Programme

A Watercourse Management and Rehabilitation Plan would be developed to guide the construction and operational phases of the development. It would include a monitoring programme for surface water which established baseline water quality pre-development.

1.3 Classification System for Wetlands and Other Aquatic Systems

Differences in terminology can lead to confusion in the scientific and consulting fields. As such, terminology used in the context of this report need to be defined. The National Water Act (No. 36 of 1998) defines a watercourse, wetland and riparian habitat as follows:

- A **watercourse** means - (a) a river or spring; (b) a natural channel in which water flows regularly or intermittently; (c) a wetland, lake or dam into which, or from which, water flows; and (d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

- A **wetland** means 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

[1] Please note - in the National Water Act (NWA, No. 36 of 1998), the term 'watercourse' means - "*(a) a river or spring; (b) a natural channel in which water flows regularly or intermittently; (c) a wetland, lake or dam into which, or from which, water flows; and (d) an collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse*". In this report, 'watercourse' will be used generally and serves to be all-encompassing of freshwater systems on the site.

land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

- A **riparian habitat** 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.

Any features meeting this criteria within the linear development were delineated and classified using the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland systems hereafter referred to as the "Classification System" (Ollis *et. al*., 2013). A summary of Levels 1 to 4 of the classification system are discussed further below.

Inland wetland systems (non-coastal) are ecosystems that have no existing connection to the ocean which are inundated or saturated with water, either permanently or periodically (Ollis *et. al*., 2013). Inland wetland systems were divided into four levels by the Freshwater Consulting Group in 2009 and revised in 2013. Level 1 describes the connectivity of the system to the ocean, level 2 the regional setting (eco-region), level 3 the landscape setting, level 4A the hydro-geomorphic (HGM) type and level 4B the longitudinal zonation. Further information has been provided in Annexure A.

The level 3 classification has been divided into four landscape units. These are:

a) **Slope** – located on the side of a mountain, hill or valley that is steeper than lowland or upland floodplain zones.
b) **Valley Floor** – gently sloping lowest surface of a valley, excluding mountain headwater zones.
c) **Plain** – extensive area of low relief. Different from valley floors in that they do not lie between two side slopes, characteristic of lowland or upland floodplains**.**
d) **Bench** (hilltop/saddle/shelf) - an area of mostly level or nearly level high ground, including hilltops/crests, saddles and shelves/terraces/ledges.

Level 4 HGM types (which is commonly used to describe a specific wetland type) have been divided into 8 units. These are described as follows:

- **Channel** (river, including the banks) - an open conduit with clearly defined margins that (i) continuously or periodically contains flowing water. Dominant water sources include concentrated surface flow from upstream channels and tributaries, diffuse surface flow or interflow, and/or groundwater flow.
- **Channelled valley-bottom wetland** - a mostly flat valley-bottom wetland dissected by and typically elevated above a channel (see channel). Dominant water inputs to these areas are typically from the channel, either as surface flow resulting from overtopping of the channel bank/s or as interflow, or from adjacent valley-side slopes (as overland flow or interflow).
- **Unchannelled valley-bottom wetland** - a mostly flat valley-bottom wetland area without a major channel running through it, characterised by an absence of distinct channel banks and the prevalence of diffuse flows, even during and after high rainfall events.
- **Floodplain wetland** - the mostly flat or gently sloping wetland area adjacent to and formed by a Lowland or Upland Floodplain river, and subject to periodic inundation by overtopping of the channel bank.
- **Depression** - a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates. Dominant water sources are precipitation, ground water discharge, interflow and (diffuse or concentrated) overland flow.
- **Flat** - a near-level wetland area (i.e. with little or no relief) with little or no gradient, situated on a plain or a bench in terms of landscape setting. The primary source of water is precipitation.
- **Hillslope seep** - a wetland area located on (gentle to steep) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope.
- **Valley head seep** - a gently-sloping, typically concave wetland area located on a valley floor at the head of a drainage line, with water inputs mainly from subsurface flow.

1.4 Relevant Legislation

The following legislation may have reference to the proposed development –

Table 2 Legislation relevant to the Darvill Constructed wetland

National Water Act (No 36 of 1998), Section 21		
Section	**Description**	**Proposed Activity**
c) impeding or diverting the flow	Activities related to this section may influence the flow regime in a watercourse. Structures that impede or divert the flow can partially or fully extend into a river, re-directing the natural flow.	Construction of infrastructure within watercourse.
i) altering the bed, banks, course or characteristics	Changes that affect flood dynamics, such as developments occurring below flood lines altering downstream flood patterns , alteration of the bed and banks is usually needed for construction and infrastructure development near or across a river.	Construction of infrastructure within watercourse.
General Authorisations		
General Notice 1199 as published in the Government Gazette 32805 of 2009	Section 21(c) and (i) water use General Authorisation does not apply to • Any wetland or any water resource within a distance of **500 meters upstream or downstream** from the boundary of any wetland; and • Any estuary or any water resource within a distance of **500 metres upstream** from the salt mixing zone of any estuary.	Development of infrastructure within 500m of a wetland.
Section 28 of the National Environmental Management Act, Act No. 107 of 1998 (NEMA)		
Section 1.	Places an obligation on all individuals to take due care of the environment and to ensure remedial action is instituted to minimize and mitigate environmental impact.	Pre-construction, during construction and operational phase
2014 Environmental Impact Assessment Regulations		
Activity 12 of GNR 983	The development of- (i) canals exceeding 100 square metres in size; (ii) channels exceeding 100 square metres in size; **(iii) bridges exceeding 100 square metres in size;** (iv) dams, where the dam, including infrastructure and water surface area, exceeds 100 square metres in size; (v) weirs, where the weir, including infrastructure and water surface area, exceeds 100 square metres in size; (vi) bulk storm water outlet structures exceeding 100 square metres in size; (vii) marinas exceeding 100 square metres in size; (viii) jetties exceeding 100 square metres in size; (ix) slipways exceeding 100 square metres in size; (x) buildings exceeding 100 square metres in size; (xi) boardwalks exceeding 100 square metres in size; or (xii) infrastructure or structures with a physical footprint of 100 square metres or more; where such development occurs- (a) within a watercourse; (b) in front of a development setback; or (c) if no development setback exists, within 32 metres of a watercourse, measured from the edge of a watercourse; - excluding- (aa) the development of infrastructure or structures within existing ports or harbours that will not increase the development footprint of the port or harbour; (bb) where such development activities are related to the development of a port or harbour, in which case activity 26 in Listing Notice 2 of 2014 applies; (cc) activities listed in activity 14 in Listing Notice 2 of 2014 or activity 14 in Listing Notice 3 of 2014, in which case that activity applies; (dd) where such development occurs within an urban area; or (ee) where such development occurs within existing roads or road reserves.	The construction of watercourse crossings.

Activity 19 of GNR 983	The infilling or depositing of any material of more than 5 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than 5 cubic metres from- (i) a watercourse; (ii) the seashore; or (iii) the littoral active zone, an estuary or a distance of 100 metres inland of the high-water mark of the sea or an estuary, whichever distance is the greater, but excluding where such infilling, depositing , dredging, excavation, removal or moving- (a) will occur behind a development setback; (b) is for maintenance purposes undertaken in accordance with a maintenance management plan; or (c) falls within the ambit of activity 21 in this Notice, in which case that activity applies.	The construction of watercourse crossings.

Laws applicable to the protection of the environment in terms of environmental management include but are not restricted to:

- Atmospheric Pollution Prevention Act, No 45 of 1965;
- Conservation of Agricultural Resources Act, No 43 of 1983;
- Environmental Conservation Act, No 73 of 1989;
- Explosives Act, No. 26 of 1956;
- Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, No 36 of 1947;
- Forest and Veld Conservation Act, Act No 13 of 1941;
- Hazardous Substances Act, No 15 of 1973;
- KwaZulu-Natal Health Act, No 4 of 2000;
- KwaZulu-Natal Planning and Development Act No 5 of 1998 (re: soil conservation);
- Land Survey Act, No 9 of 1921;
- Machinery and Occupational Safety Act, No. 6 of 1983;
- Mines and Works Act, No. 27 of 1956;
- Minerals Act, No 50 of 1991;
- Mineral Development Draft Bill;
- National Environmental Management Act, No. 107 of 1998;
- National Environmental Management: Air Quality Act(AQA), No 39 of 1994;
- National Environmental Management Biodiversity Act, No 10 of 2004;
- National Forests Act, No 84 of 1998;
- National Heritage Resources Act, No. 25 of 1999;
- Natal Nature Conservation Ordinance 15 of 1974;
- National Water Act, No 36 of 1998;
- National Water Act (amendments);
- National Veld and Forest Fire Act, No 101 of 1998;
- Occupational Health and Safety Act, No 85 of 1993;
- Provincial and Local Government Ordinances and Bylaws;
- Soil Conservation Act, Act No 76 of 1969;
- Sub-division of Agricultural Land Act Repeal Act 64 of 1998 (re: soil conservation); and
- Water Services Act No 108 of 1997.

2. STUDY SITE

The site is located within Quaternary Catchment U20J; falling under the uMvoti to Mzimkulu Management Area (WMA) and the uMgeni waterboard (uMgeni Water). The proposed area sits between the Darvill WWTW and the Msunduzi River. The Bayne's Spruit stream meets this system to the west, upstream of the site.

The Bayne's Spruit and the Msunduzi are highly degraded due to the presence of settlements, rubbish dumps and factories that have encroached along the edge and impacted upon of this watercourse. Given the vulnerable state of these watercourse systems, and their associated high population, all catchments areas contributing to this system should be given extra attention and precaution regarding development proposals.

Rainfall in the region occurs in the summer months (mostly December to February), with a mean annual precipitation of 859 mm (observed from rainfall station 0239756 W). The reference potential evaporation (ET_o) is approximately 1667 mm (A-pan equivalent, after Schulze, 2011) and the mean annual evaporation is between 1300 – 1400 mm, which exceeds the annual rainfall. This suggests a high evaporative demand and a water limited system. Summers are warm to hot and winters are cool. The mean annual temperature is approximately 21.5 °C in summer and 13.8 °C in the winter months (Table 3). The underlying geology of the site is sedimentary Ecca Shale and the soils overlain are sandy-clay-loam ranging from Glenrosa to Shortlands form in this particular area.

Table 3 Mean monthly rainfall and temperature observed at Darvill (derived from historical data)

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	Ann
Mean Rainfall (mm)	119	110	98	42	17	7	6	19	37	81	97	108	**859**
Mean Temperature (°C)	21.5	21.6	21.0	18.5	16.0	13.7	13.8	15.3	17.3	18.0	19.2	20.8	**18.1**

Figure 2 The confluence of the Bayne's Spruit and the Msunduzi river upstream of the site

3. METHODOLOGY

A detailed description of the methods has been provided. The regional context and desktop analysis was used as the point of departure. Subsequently, a site visit was undertaken to delineate any wetlands and riparian areas (if present). The site visit was conducted on the 24th of November 2015 to conduct necessary in-field procedures to delineate watercourse systems including: soil sampling, the recording of dominant vegetation and topography/ terrain analysis. The assessment of these systems considered the following tools where relevant:

Table 4 Assessment approach and the recommended tools for rivers and wetlands

Aquatic Component	Method/Technique	Tool Utilized
Rivers	Delineation	*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2005).*
	Classification	*National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis et al, 2014).*
	River condition/Present Ecological State (PES)	DWAF IHI (Index of Habitat Integrity) tool (Kleynhans, 1996) for rivers (riparian habitat only)
	River Ecological Importance & Sensitivity (EIS)	DWAF riverine EIS tool (Kleynhans, 1999)
Wetlands	Delineation	*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2005).*
	Classification	*National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis et al, 2014).*
	Wetland condition/Present Ecological State (PES)	Level 1 WET-Health tool (Macfarlane *et al*., 2009)
	Wetland Functional/Ecosystem Services Assessment	Level 2 WET-EcoServices assessment tool (Kotze *et al*., 2009)
	Wetland Ecological Importance & Sensitivity (EIS)	DWAF wetland EIS tool (Duthie, 1999)

3.1 Regional Context

3.1.1 National Freshwater Ecosystem Priority Areas (NFEPA) Project / Assessment

The 'National Freshwater Ecosystem Priority Areas' (NFEPA) project is a systematic biodiversity planning tool developed by the CSIR (2011) to identify freshwater areas considered the most important for biodiversity conservation. The key objectives of the NFEPA project are to ensure that all ecosystems and species are represented and that key ecological processes remain intact – achieving biodiversity targets within the smallest, most efficient area possible, with attention to connectivity over large areas (CSIR, 2011).

The conservation importance of the Darvill site was determined by consulting the relevant NFEPA layers (NFEPA WMA map, NFEPA wetlands and NFEPA rivers) in a geographical information system.

NFEPA was a three-year partnership project between South African National Biodiversity Institute (SANBI), CSIR, Water Research Commission (WRC), Department of Environmental Affairs (DEA), Department of Water Affairs (DWA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). NFEPA map products provide strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources. These strategic spatial priorities are known as Freshwater Ecosystem Priority Areas, or FEPAs.

FEPAs were determined through a process of systematic biodiversity planning and were identified using a range of criteria for conserving ecosystems and associated biodiversity of rivers, wetlands and estuaries. FEPAs are often tributaries and wetlands that support hard-working large rivers, and are an essential part of an equitable and sustainable water resource strategy. FEPAs need to stay in a good condition to manage and conserve freshwater ecosystems, and to protect water resources for human use. The current and recommended condition for all river FEPAs is A or B ecological category. Wetland FEPAs that are currently in a condition lower than A or B should be rehabilitated to the best attainable ecological condition.

3.1.2 Terrain, Soils, Geology & Vegetation

Contour lines (5 meter) were used to calculate the slope of each of the banks. The soils and geology were obtained from GIS layers obtained from the Soil Science department at the University of KwaZulu-Natal (UKZN). Various vegetation databases were used to determine the likely or expected vegetation types (Mucina & Rutherford, 2006; Scott-Shaw & Escott, 2011).

A number of recognized databases were utilized in achieving a comprehensive review, and allowing any regional or provincial conservation and biodiversity concerns to be highlighted. The Guideline for Biodiversity Impact Assessment (EKZNW, 2013) was followed where applicable. The following databases were interrogated:

- *Ezemvelo KZN wildlife (C-Plan & SEA Database)*

The C-Plan is a systematic conservation-planning package that consists of metadata within a shapefile, used by ArcGIS (or similar tool), which analyses biodiversity features and landscape units. C-Plan is used to identify a national reserve system that will satisfy specified conservation targets for biodiversity features (Lombard *et al*, 2003). These units or measurements are ideal for areas which have not been sampled. The C-Plan is an effective conservation tool when determining priority areas at a regional level and is being used throughout South Africa to identify areas of conservation value. Some of this information extends into the Eastern Cape.

The Strategic Environmental Assessment (SEA, 2000) Plan is a database of the modelled distribution of a selection of red data and endemic species that could, or are likely, to occur in an area.

- *Mucina and Rutherford's Vegetation Assessment*

The South African National Biodiversity Institute (SANBI) developed a database of vegetation types. This database provides information on groups of vegetation at a course scale. It is useful in determining the expected species, conservation status and management practices of an area. However, this database does not provide information on species of conservation concern. This database is used as a step towards grouping vegetation types identified on site.

3.2 Extent, Classification and Habitat Characteristics

The boundary of wetlands and riparian areas occurring on the site 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*' (Department of Water Affairs, 2005). Land cover data, contour data and the latest aerial imagery were examined in a thorough desktop analysis of the site. This provided important background information to the specialists' understanding of the broader context of the landscape (e.g. baseline vegetation, geology and climate). An on-site delineation was undertaken as described below. The field work was undertaken with a wetland functional assessment expert who contributed towards the results and discussion.

3.2.1 Wetland Delineation

The following indicators stipulated in the national delineation guidelines were considered in the field. Not necessarily all of these indicators were used at each site. Mention was made in the results which of these indicators were used:

- **Terrain Unit Indicator** – this relates to the position within the landscape where a wetland may occur. A typical landscape can be divided into five main terrain units, namely the crest (hilltop), scarp (cliff), midslope (often a convex slope), footslope (often a concave slope), and valley bottom. As wetlands occur where there is a prolonged presence of water, the most common place one would expect to find wetlands is on the valley bottom (Rountree *et al,* 2008).

- **Soil Form Indicator** – this identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.

- **Soil Wetness Indicator** - Prolonged saturation of soil results in the development of anaerobic conditions, which has a characteristic effect on soil morphology, causing two important redoximorphic features: mottling and gleying. The hue, value and chroma of soil samples obtained at varying depths can be visually interpreted with the aid of the Munsell Colour Chart and the interface between wetland and non-wetland zones determined.

- **Vegetation Indicator** – Plant species have varying tolerances to different moisture regimes. The presence, composition and distribution of specific hydrophytic plants within a system can be used as an indication of wetness and allow for inference of wetland characteristics.

The area was extensively traversed, auger sample points were taken as required and the exact location of sample points logged using a Garmin GPSMAP 64. At each sampling point the soils were sampled at depths of 0-10 cm and 40-50 cm below surface. The soil value, hue and matrix chroma were recorded for each sample according to the Munsell Soil Colour Chart, and the degree of mottling and/or presence of concretions were recorded. Although the site was transformed, any vegetation of interest was noted for the assessments. If the author was not able to identify any potentially important species, a leaf and bark sample was taken for analysis using a key guide.

3.2.2 Riparian Delineation

Riparian area/zone delineation is similar to wetland delineation in that indicators are used to define the edge of the system. It considers indicators such as topography, vegetation, alluvial soils, and deposition of material to mark the outer edge of the macro-channel and its associated vegetation. The figure below shows the typical morphology of a river channel.

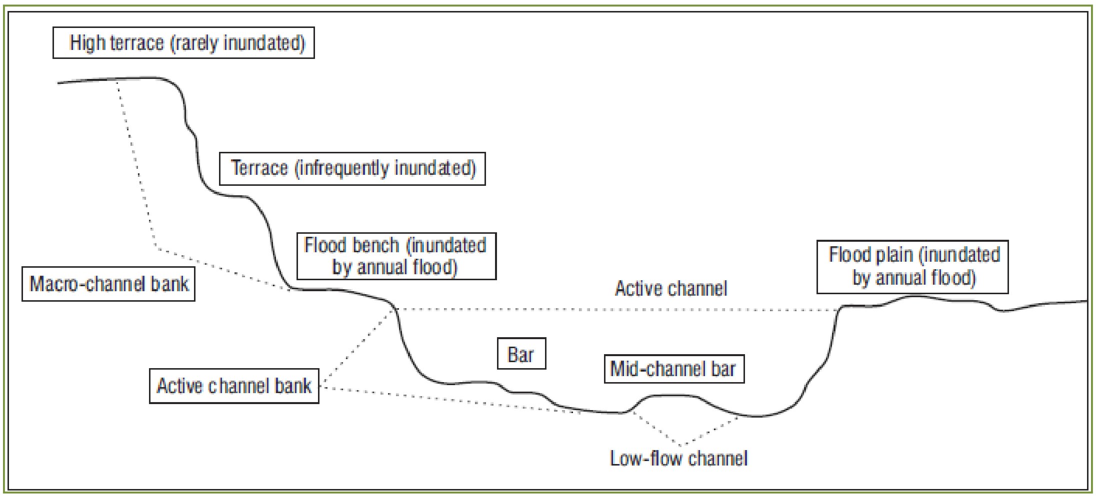

Figure 3 Typical cross-section of a river showing channel morphology 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas – Edition 1' (Department of Water Affairs, 2005)

A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas (DWAF, 2005) was used in the delineation of the riparian zone boundary. Delineated riparian zones were then classified using a HGM classification system based on the system proposed by Ollis *(*2013*)*. According to Cowan *et* al. (2005), riparian ecosystems are separated from other wetland ecosystems on the following three major features:

1. They have linear form as a consequence of their proximity to rivers and form a boundary between the terrestrial and aquatic ecosystems.
2. Energy and materials from the surrounding landscape converge and pass through riparian ecosystems. This amount is greater in terms of unit area than with any other system.
3. Riparian ecosystems are connected hydrologically to both upstream and downstream ecosystems (intermittently).

Figure 4 Soil and water quality sampling technique undertaken at Darvill, showing the analysis of soil colour, depth, structure and texture in the dryland area

3.3 Present Ecological State (PES) Assessment for Riparian Areas

3.3.1 Present Ecological State (adapted from WET-Health, Macfarlane *et al*., 2008)

A WET-Health (Macfarlane *et al*., 2009) Level 1 Rapid Appraisal was used to assess the eco-physical health of any wetlands in the study area. Focusing on geomorphology, hydrology and vegetation, the tool examines the impacts and indicators of change within the system and its catchment by determining the deviation (in terms of structure and function) from the natural reference condition. The outcomes of the appraisal place importance on issues that should be addressed through rehabilitation, mitigation and/or prevention measures. A standardized scoring system allows for consistencies between different systems and reduces user subjectivity.

Scores are allocated according to the magnitude and extent of impact. These scores are integrated to produce an overall score for Present Ecological State (PES) of the system – *namely, natural, largely natural, moderately modified, largely modified, extensively modified,* and *critically modified.*

3.3.2 Index of Habitat Integrity (IHI)

The ecological integrity of a river is defined as its ability to support and maintain a balanced, integrated composition of physico-chemical and habitat characteristics, as well as biotic components on a temporal and spatial scale that are comparable to the natural characteristics of ecosystems of the region (Kemper, 1999). The observed or deduced condition of these criteria as compared to what it could have been under unperturbed conditions is surmised to indicate a change in the habitat integrity. The methodology is based on the qualitative assessment of a number of pre-weighted criteria which indicate the integrity of the in-stream and riparian habitats available for use by riverine biota. Tables 5, 6 & 7 provide the list of criteria and their scores, the impact category and the final scores for the IHI assessment that were used in the calculations.

Table 5 Criteria used in the assessment of the habitat integrity

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment (Gordon *et al*., 1993). Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation (Hilden & Rapport, 1993) is also included.
Channel modification	May be the result of a change in flow, which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included.
Water quality modification	Originates from point and diffuse point sources. Measured directly or agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments (Gordon *et al*., 1992).
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river (Gordon *et al*., 1992). Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

Table 6 Impact classes and their associated scores

Impact category	Description	Score
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
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area is affected. Only small areas are not influenced.	16-20
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.	21-25

Table 7 Description of the IHI categories.

Category	Description	Score (% of total)
A	Unmodified, natural.	100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-99
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions are extensive.	20-39
F	Modifications have reached a critical level and the lotic 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.	0-19

3.4 Functional Assessment of Wetlands

3.4.1 Ecosystem Goods and Services (WET-EcoServices, Kotze et al, 2008)

The WET-EcoServices tool (Kotze *et al.,* 2005) allows measurement of ecosystem goods and services (eco-services) provided by a wetland system. Eco-services refer to the benefits obtained from ecosystems. These benefits may be derived from outputs that can be consumed directly; indirectly (which arise from functions or attributes occurring within the ecosystem), or possible future direct or indirect uses (Howe *et al.,* 1991).

WET-EcoServices provides structured guidelines that allow the importance of the wetland to be scored according to its ability to deliver fifteen different ecosystem services, shown below –

Table 8 Ecosystem services considered in a South African context (WET-EcoServices, Kotze *et al*., 2005)

Direct benefits	Indirect benefits
• **Cultural benefits** Cultural heritage Tourism and recreation Education and research • **Provisioning benefits** Provision of cultivated foods Provision of harvestable resources Provision of water for human use Biodiversity maintenance	• **Regulating and supporting benefits** Flood attenuation Streamflow regulation Carbon storage • **Water quality enhancement benefits** Sediment trapping Phosphate assimilation Nitrate assimilation Toxicant assimilation Erosion control

3.5 Ecological Importance & Sensitivity (EIS) Assessment (Riparian)

The Ecological Importance and Sensitivity (EIS) of riparian areas is an expression of the importance of the aquatic resource for the maintenance of biological diversity and ecological functioning on a local scale to a more broader scale; 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). In this study a qualitative assessment was applied and was partially informed by the present state assessment. This assessment followed the DWA river eco-classification criteria (Module A, Kleynhans & Louw, 2007). The classification provides insights into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition (Kleynhans & Louw, 2007). This further provides the information needed to derive desirable and attainable future ecological objectives for the river (Kleynhans & Louw, 2007).

Table 9 List of the EIS categories used in the assessment tool (Kleynhans & Louw, 2007)

Ecological Importance And Sensitivity Categories	General Description
Very high	Quaternaries/delineations that are considered to be unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.
High	Quaternaries/delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use.
Moderate	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.
Low/marginal	Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.

Table 10 Rating scheme used for the assessment of riparian EIS (Kleynhans & Louw, 2007)

Score	Channel Type	Conservation Context			Vegetation and Habitat Integrity	Connectivity	Threat Status of Vegetation Type
0	Ephemeral Stream	Non-FEPA river	No status	None/Excluded	No natural remaining	None	No Status
1	Stream – non-perennial flow		Upstream management area	Available	Very poor	Very low	Least Threatened
2	Stream – perennial flow		Rehab FEPA		Poor	Low	Vulnerable
3	Minor river – non-perennial flow		Fish Corridor	Earmarked for conservation	Moderately modified	Moderate	Near Threatened
4	Minor river – perennial flow		Fish Support Area		Largely natural	High	Endangered
5	Major river – perennial flow	FEPA river	River FEPA	Protected	Unmodified/natural habitat	Very High	Critically Endangered

3.6 Water Quality Assessment

Water quality samples were taken from strategic locations along the Msunduzi river and the Darvill WWTW treated outlet and sent to the laboratory for analysis. Two sampling points were taken upstream of the proposed development and two samples was taken downstream of this site. Follow-up sampling would need to occur in the same location as the pre-assessment. The developers should use existing water quality sampling along the river if within close proximity of the sites measured in this report. The location of the sampling sites can be seen in Annexure D. As water quality can change significantly over the seasons and after a large rainfall event, the key criteria is the relative difference between the upstream and downstream samples. The baseline physical, chemical and biological water quality characteristics have been provided for reference in the results.

3.7 Determination of Buffer Zones

A buffer zone is designed to act as a barrier between anthropogenic activities and sensitive water resources. This allows for the protection of these water resources against adverse negative impacts (Macfarlane *et al*., 2014). Buffer zones promote the maintenance of basic aquatic processes, the reduction of up-stream impacts and the preservation and provision of aquatic species.

The '*Preliminary Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries'* (Macfarlane *et al*., 2014) was used to determine the buffer zone for wetland types (HGM units) found within the project boundary. As this is a guideline tool, the author applied specialist opinion where relevant given the nature of the development and the environmental setting. The '*Buffer Zone Tool for the Determination of Aquatic Impact Buffers and Additional Setback Requirements for Wetland Ecosystems'*, funded by The Department of Water and Sanitation (DWS) and the Water Research Commission (WRC) was used in this regard (Macfarlane *et al*., 2014). To properly implement this tool the following guidelines are recommended[2]:

1. Define objectives and scope to determine the most appropriate level of the assessment;
2. Map and categorize water resources in the study area (identify water resource type/boundaries);
3. Refer to the DWS management objectives for mapped water resources or develop surrogate objectives (Present Ecological State, social and economic sensitivity);
4. Assess the risks from proposed developments and define mitigation measures necessary to protect mapped water resources in the study area (lateral land-use inputs);
5. Assess risks posed by proposed development on biodiversity and identify management zones for biodiversity protection (presence of biodiversity elements);
6. Delineate and demarcate recommended setback requirements (map setback requirements/zones for biodiversity protection);
7. Document management measures necessary to maintain the effectiveness of setback areas (buffer zone vegetation, soil characteristics, topography and ecological corridor design); and
8. Monitor implementation of buffer zones (determine monitoring objective/buffer zone effectiveness and design a monitoring programme).

3.8 Impact Assessment

The aim of the impact assessment is to identify the likely potential impacts that each phase of a development will have on the receiving environment. If avoidance is not possible, mitigation is required in the form of practical actions (Ramsar Convention, 2008). Mitigation actions can be grouped into the following:

i. **Pre-construction:** This may take the form of changes in the scale of the development (e.g. reduce the size of the development), location of development (e.g. find an alternative area with less impact), and design (e.g. change the structural design to accommodate flows and continuity).
ii. **Construction:** This may take the form of a process change (e.g. changes in construction methods), siting (e.g. locality to sensitive areas), sequencing and phasing (e.g. construction during seasonal periods).
iii. **Operational:** This may take the form of changes in post management (e.g. change management to match unpredicted impacts), monitoring (e.g. frequent checks by an ECO), rehabilitation (e.g. if mitigation actions are not effective).

An assessment of the potential impacts of the Darvill development was guided by the EKZNW handbook for biodiversity impact assessments (2011).

[2] note that some of these objectives were already undertaken for the WET-Health and WET-Ecoservices assessment.

4. LIMITATIONS AND ASSUMPTIONS

In order to apply generalized and often rigid scientific methods or techniques to natural, dynamic environments, a number of assumptions are made. Furthermore, a number of limitations exist when assessing such complex ecological systems. The following constraints may have affected this assessment –

- A Garmin GPSMAP 64 was used in the mapping of waypoints on-site. The accuracy of the GPS is affected by the availability of corresponding satellites and accuracy ranges from 1 to 3 m after post-processing corrections have been applied.

- A Munsell Soil Colour Chart was used to assess soil morphology. This tool requires that a dry sample of soil be assessed. However, due to in-field time constraints, slightly wet soil samples were assessed. Wet samples would have consistently lower values than dry soils; and this is taken into consideration.

- Although the vegetation was taken into account, protected and threatened species, such as bulbs that have not emerged, may not have been identified. If development is to extend into sensitive areas (such as buffer areas), a vegetation survey will be required.

- The soils were very uniform, as such it was sometimes difficult to determine the difference between temporary and dryland wetland/riparian areas.

5. RESULTS AND DISCUSSION

5.1 Regional Context

5.1.1 NFEPA assessment

In accordance with the NFEPA guidelines, the relevant reach of the Bayne's Spruit stream (and its associated riparian area) has not been classified as a river FEPA, which indicates that these river systems are not a national freshwater conservation priority. However, the uMsunduzi River, which has numerous conservation organizations working on it (such as Duzi-Umgeni Conservation Trust, DUCT) has been classified at a Class D (Largely Modified) river.

The NFEPA project highlights the Msunduzi, associated sub-quaternary catchments, associated sub-quaternary catchments and Upstream Management Areas as a Freshwater Ecosystem Priority Areas (FEPAs) and Fish Support Area. As there is much focus on the Msunduzi River, the same considerations should be applied to its tributaries which cumulatively impact on this system. NFEPA wetlands were identified north of the Bayne's Spruit bordering on the edge of the project footprint. These were hence not considered in detail as would not be affected by the development.

5.1.2 Terrain, Soils, geology and vegetation

The terrain, as identified through a desktop analysis had a slope of between 0.2 and 0.25 m/m on either side of the river where the farmlands are situated. The terrain was slightly uneven due to some remnant spoil sites and dumps along the site. Numerous soil profiles were identified throughout the site. All of the non-wetland soils consisted of an Orthic A-horizon underlain by either a yellow a-pedal B-horizon (unconsolidated), lithocutanic material or ecca shale directly. Clovelly soils were the most commonly identified soils. Further information relating to the soil characteristics of each HGM unit has been provided in Table 12.

The vegetation of the area has been identified as Ngongoni veld within the sub-escarpment savannah bioregion (Mucina & Rutherford, 2006). The veld identified on site was in good condition although bush encroachment is evident. The vegetation was further identified as Dry Coast Hinterland Grassland (Scott-Shaw & Escott, 2011). The characteristics of this grassland are described as:

- Undulating plains and hilly landscape mainly associated with drier coast hinterland valleys in the rain-shadow of the rain-bearing frontal weather systems from the east coast.
- Sour sparse wiry grassland dominated by unpalatable Ngongoni grass (*Aristida junciformis*) with this mono-dominance associated with low species diversity.

- In good condition dominated by *Themeda triandra* and *Tristachya leucothrix*.
- Wooded areas are found in valleys at lower altitudes, where this vegetation unit grades into KwaZulu-Natal Hinterland Thornveld and Bisho Thornveld. Termitaria support bush clumps with *Acacia* species, *Cussonia spicata*, *Ehretia rigida*, *Grewia occidentalis* and *Coddia rudis*.

5.2 Extent, Classification and Habitat Characteristics

The current land cover was obtained from various databases and the site visit. Small patches of alien invaders were noted as well as subsistence and commercial farming on the opposite banks. Dumping was observed along the riparian banks. The wetland areas as identified in Figure 6 are intact with numerous sedge species. The dominant species in the riparian areas were a mixture of indigenous and alien tree species. On the southern extent of the banks, natural grasslands were present. Fortunately these areas are less disturbed than than built up areas closer to Pietermaritzburg.

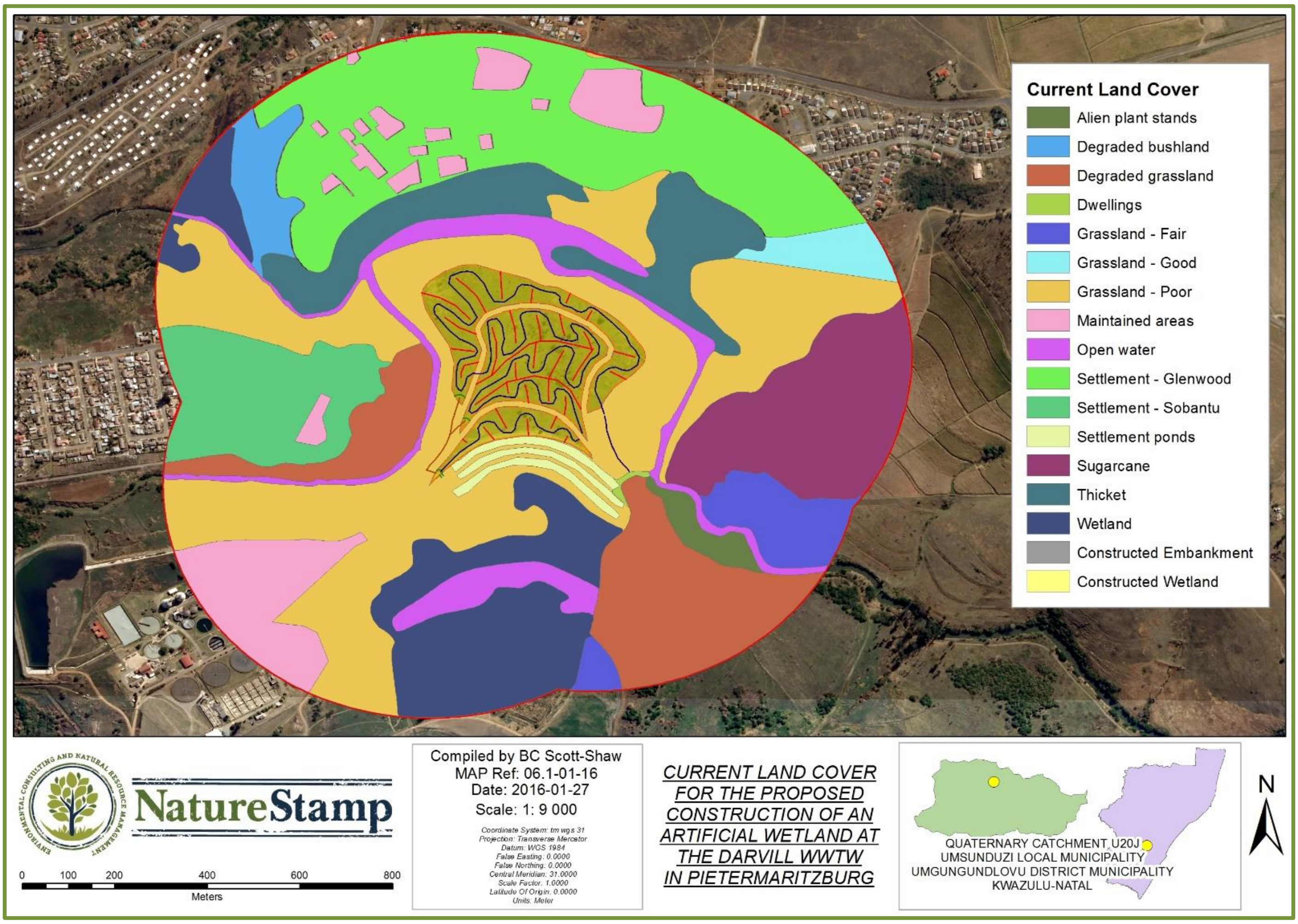

Figure 5 Current land cover found within 500 meters of the proposed constructed wetland

The site consists of areas of hydrological interest and these areas have been tabulated (Table 11) and described in detail. The HGM units are further illustrated in Figure 7. There were no wetlands within the development footprint. Any wetlands that the proposed wetland di not intersect were not assessed for wetland health or functionality as they would not be disturbed by the development. These areas were considered when checking the connectivity of the systems and potential impacts from the roads; as well as to show 'No-Go' areas. Watercourse systems that would be affected by the development were assessed.

The delineation of the wetland and riparian areas identified the following:

- One riverine system (Msunduzi river linked to the Bayne's Spruit stream);
- Riparian habitat associated with the linear system;
- One Hillslope Seepage Wetland on the opposite bank;
- Numerous artificial systems and associated seeps forming part of the WWTW remediation process; and

- One channelled valley bottom wetland linked to the Bayne's Spruit.

Table 11 Description of HGM units near to the development footprint

Feature	Wetland/Riparian/Artificial	Description & Vegetation (after Kotze, 1999)	Soil Characteristics	On-site images
RH	Riparian Habitat	Banks of the Msunduzi river. Dominated by tree and sedge species *(mostly alien invasives). Veld is present on the flood plain side of the bank.*	N/A	
W	Watercourse (Msunduzi River)	A highly modified yet highly important river system that flows through Pietermaritzburg. Many households are dependent on this system.	No mottles Gley-5YR Value – 3 Chroma – 1 Dark Gray Depth sampled: 0-0.5m High Organic matter content in the upper layer	
HS	Hillslope Seepage	Slopes on hillsides, characterized by the colluvial movement of materials. Outflow is usually via a well defined stream channel connecting the area directly to a stream channel.	Mottle % - 2-8% Hue – Gley 2.5YR Value – 5 Chroma – 1 (Reddish Gray) Depth sampled: 0-0.5m	
AC	Artificial Canal	Attenuation canals allowing approximately 2 hours of settling time for treated wastewater before it enters the Msunduzi. The water is chlorinated after flocculation at the the plant.	N/A	
AW	Artificial Wetland	Acts as a back up to the WWTW. When excess waste is present, it is pumped into these tiered wetlands. Some of the waste is also used to irrigate the neighboring turf farm as a form of phyto-remediation. These wetlands are currently supporting numerous wetland fauna and flora.	N/A	

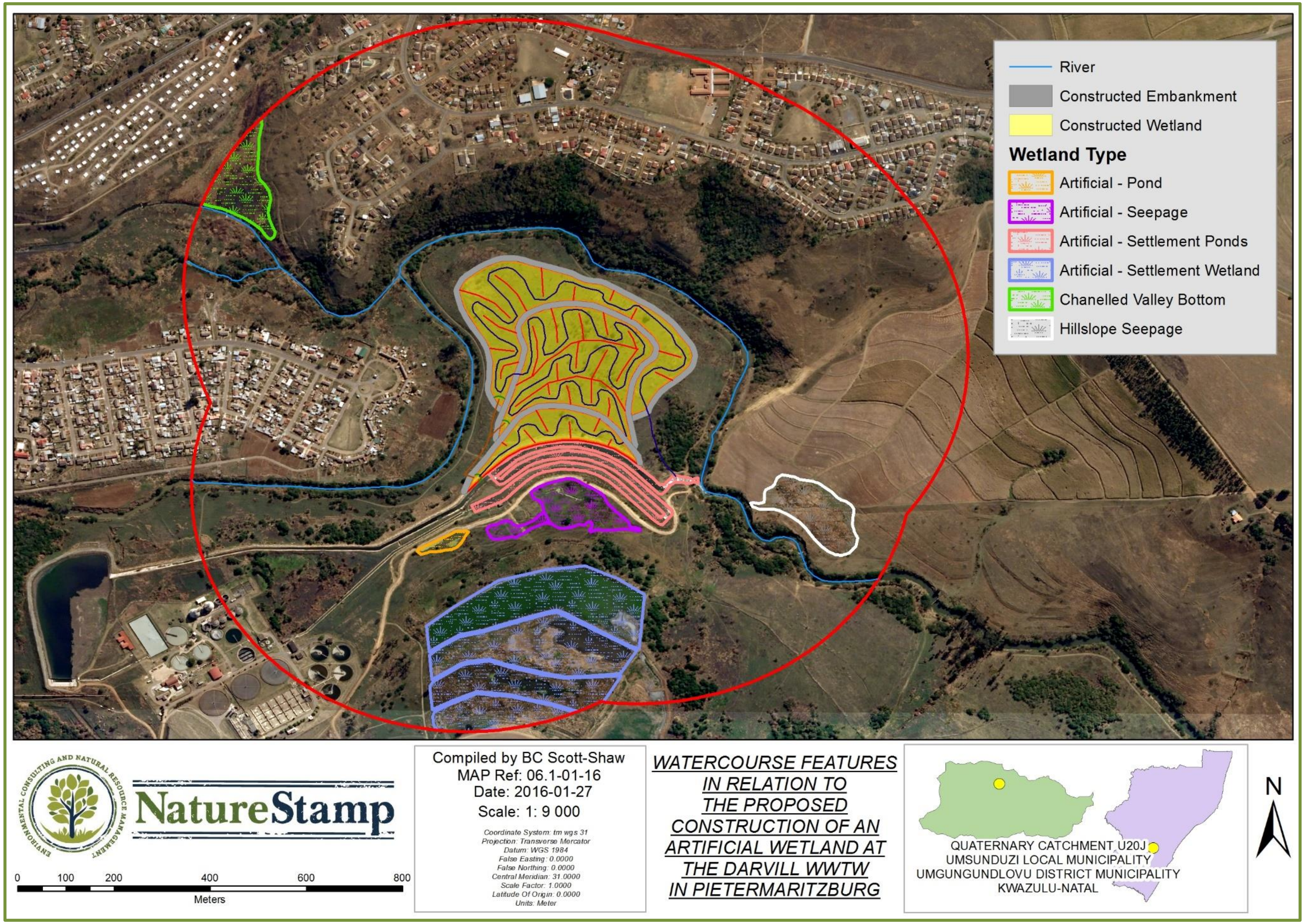

Figure 6 Units identified near the proposed wetland within the project area at Darvill

5.3 Present Ecological State (PES)

5.3.1 Index of Habitat Integrity for riparian areas

The Index of Habitat Integrity tool (Kleynhans, 1996) was used to determine the integrity of the riparian zone only (relevant reach of the Msunduzi). The results have been provided in Tables 12. The results for the system show a PES category of D (44, Table 14): "*Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred*." The key change is the removal of indigenous vegetation due to industry and settlement encroachment, the conversion of riparian edges to dump sites and housing areas. As a result the channel and flow has been altered and drains have been diverting flow away from infrastructure for many years.

Table 12 PES score using the Index of Habitat Integrity tool (Kleynhans, 1999) for the Darvill riparian area

Riparian Zone					
Criterion	**Score**	**Weighting**	**Actual**	**Potential**	
Indigenous vegetation removal	19	13	247	325	
Exotic vegetation encroachment	15	12	180	300	
Bank Erosion	5	14	70	350	
Channel modification	16	12	192	300	
Water abstraction	12	13	156	325	
Inundation	4	11	44	275	
Flow modification	17	12	204	300	
Water quality	22	13	286	325	
Totals			**1379**	**2500**	**55.16**
Category					**44.84**

5.3.2 WET-Health (Macfarlane *et al*., 2008) of wetlands

A WET-Health assessment was undertaken for the wetland systems found within 500m of the development.

- *Hydrology*

The present hydrological state of the HS (seepage wetlands) and the CVB (channelled valley bottom wetland) were given a score of C, meaning that *the impact of the modifications on the hydrological integrity is clearly identifiable, but limited*. The MAP: PET ratio indicates that the wetlands are not dependant on direct precipitation falling onto the wetland, depending on flow from upstream to a greater extent, making them more vulnerable to reduced flows.

The key factors influencing hydrological impacts on the wetlands are the encroachment by humans and animals grazing in the wetland catchment. The largest change from the past is the addition of numerous drains to channel water out of the wetlands away from farmlands. This would have been done in the past to create more arable land. However, it has been intensified in recent years to reduce the flood risk (although is likely to results in the opposite) and create space for development. These are streamflow reduction activities, decreasing water flow into the system. Natural water distribution and retention patterns are altered as a result of impeding structures across the wetland, that is the dirt paths that have resulted in hardened surfaces and therefore greater runoff as the surface roughness is altered.

It is important to note, that while the wetland scores relatively well for Hydrology in this area, there are severe localized impacts in the vicinity of the head roads which are not adequately reflected when combined with the state of the total wetland.

Table 13 The hydrology module for the nearby wetlands

Hydrology module	Channelled Valley Bottom	Hillslope Seepage
Extent of the wetland (ha)	1.6	1.1
MAP:PET	0.5	0.5
Vulnerability factor	0.95	0.95
Combined score for increased and decreased flows	1.3	-0.2
Intensity of impact of factors potentially altering flow patterns	-0.7	-0.8
Magnitude of impact of canalisation and stream modification	1.2	1.2
Magnitude of impact of impeding features	0.8	1.1
Magnitude of impact of altered surface roughness	0.1	0.2
Impact of direct water losses	0.6	0.8
Magnitude of impact of recent deposition, infilling or excavation	0.6	0.9
Combined magnitude of impact of on-site activities	5.6 – Large	5.8 – Large
Combined magnitude score as a result of impacts on hydrological functioning	3.3	3.5
Overall hydrological health	The impact of the modifications on the hydrological integrity is clearly identifiable, but limited.	The impact of the modifications on the hydrological integrity is clearly identifiable, but limited.
Present hydrological state of the HGM unit	**C**	**C**
Trajectory of change of wetland hydrology	(→)	(→)

- *Vegetation*

The present state of wetland vegetation of the channeled wetland was given a symbol B as the vegetation composition has been partly transformed but not that the state of the wetland has been altered. The seepage wetland is completely surrounded by sugarcane which has encroached into the original extent and has resulted in the reduction of characteristic indigenous wetland species. If the current impacts stay at the same rate in the years to come the trajectory of change for the wetland catchment area is estimated to remain stable (→).

Table 14 Vegetation module for the surrounding Darvill wetlands

Vegetation module	Channelled Valley Bottom	Hillslope Seepage
Extent of the HGM unit (ha)	1.6	1.1
Identify and estimate the extent of each disturbance class	Small	Moderate
Magnitude of impact score	1.5	2.9
Present vegetation state	B	C
Trajectory of change to wetland vegetation	(→)	(→)
Overall vegetation health	Although identifiable, the impact of the modifications on the hydrological integrity are small.	Vegetation composition has been moderately altered but introduced alien and/or ruderal species are still clearly less abundant than characteristic indigenous wetland species.
Alien vegetation present (%)	8	18

- *Geomorphology*

The overall geomorphological health of the wetlands were classified as D, which is largely modified: *a large change in geomorphic processes has occurred and the system is appreciably altered*. This was due to the unit having numerous drainage channels, large changes in upstream runoff characteristics and significant infilling from roads, farmlands and houses. The trajectory of change if the impacts progress is likely to remain stable (→). The key concerns lie in the hydrology and geomorphology components.

Note that, although the system scores badly, it is visually in good condition and is in an extremely high pressure system due to significant impacts and alterations.

Table 15 Geomorphology module for the surrounding Darvill wetlands

Geomorphology module	Channelled Valley Bottom	Hillslope Seepage
Extent of the HGM unit (ha)	1.6	1.1
Impacts of channel straightening	0.2	0
Extent of impact of infilling	0.8	0.8
Impacts of changes in runoff characteristics	3.0	3.2
Impacts of erosion	0.1	0.3
Impacts of deposition	0.2	0.2
Present geomorphic state	D	D
Trajectory of change of geomorphic state	(→)	(→)
Overall geomorphological health	**Largely Modified**	**Largely Modified**

- *Overall Health*

The overall health based on the combined impact score is C (Moderate modifications). A moderate change in ecosystem processes and loss of natural habitats is discernable but the natural habitat remains largely intact.

5.4 Functional Assessment of Wetlands (Seepage Wetlands)

For the HGM wetland units identified near the site, streamflow regulation scored highly as the HGMs are linked to sensitive systems and currently regulate flows into these systems. The channeled system, which is less disturbed, generally provides more services than the seepage wetland. Both systems contribute to sediment trapping. There are no dams reducing the input of sediment and little or no wetlands directly linked to these systems. Phosphate trapping was effective with a moderately score of 2.7 and 1.9 respectively as the unit is currently trapping chemicals from the farmlands and settlements. Nitrate removal and toxicant removal effectiveness was 2.5 and between 2.3 and 2.8 as these systems are active in the removal of wastes before it enters the river system.

Biodiversity maintenance noteworthiness was low as the HGM is not rare/uncommon in the area and there are no significant natural features to note. The score for biodiversity integrity shows that the health of the biodiversity is under threat as potential breeding sites or nests. Water supply for human use is low as few households depend on the HGM due to the poor quality and location. The provision of harvestable natural resources is relatively high as the HGM occurs in a poverty stricken and farmlands areas and the HGM could be used to harvest plants for medicinal uses etc. Cultivated food provision is moderate as crops were cultivated within the HGM. The HGM had a moderate cultural significance but a low tourism and recreation score as it is not currently used for any of the above practices and is not located on a tourism route. Education and research also had a low score, as the HGM is not currently used to increase learning and the wetland is not ideal as a reference site. However, there is potential for it to be used with educational tours of the WWTW but a wetland on the south side of the river would be more suitable.

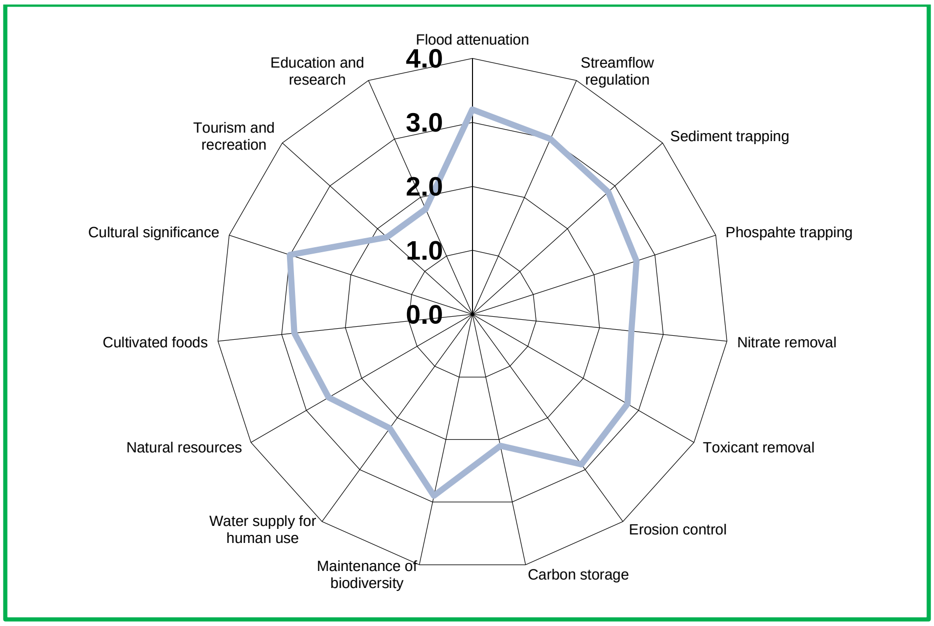

Figure 7 WET-EcoServices of the chanelled valley bottom wetland at Darvill

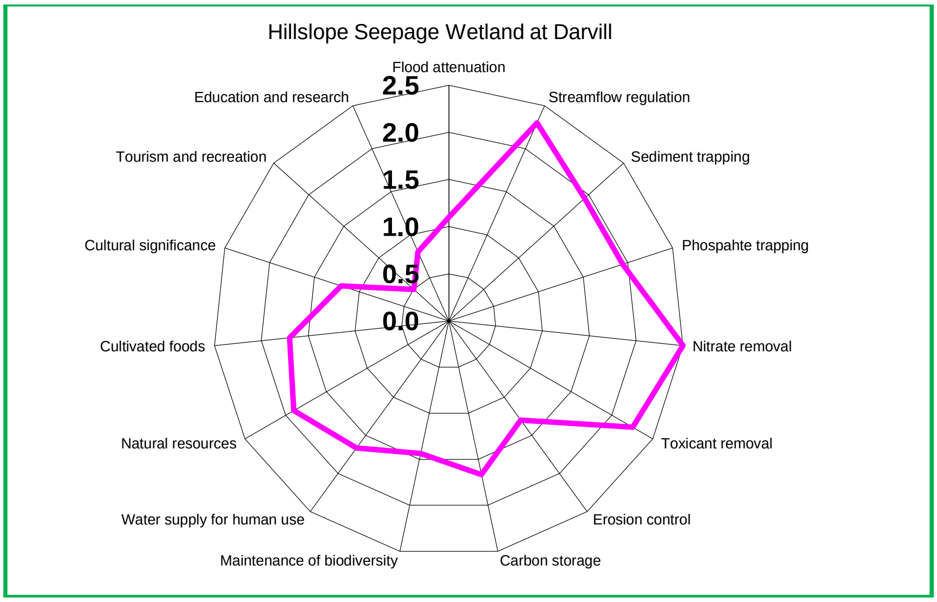

Figure 8 WET-EcoServices of the Hillslope Seep wetlands at Darvill

5.5 Ecological Importance & Sensitivity Assessment

An EIS category was determined for the dominant Darvill riparian areas. The category was calculated to be High: 'Quaternaries/delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use.'

Table 16 EIS category scoring summary for the Msunduzi riparian area

Component	Score (0-5)	Comments/description
Channel Type	5	Major river – perennial flow
Conservation Context	5	River FEPA
Vegetation and Habitat Integrity	1	Very Poor
Connectivity	4	High
Threat Status of Vegetation Type	2	Vulnerable
EIS Rating	**3.4**	**High**

5.6 Water Quality Assessment

The results from the water quality assessment indicate that most of the parameters measured are within the DWS effluent standards. However, the *E. coli* count was unusual. The upstream point had a very high concentration while the downstream point (which has been mixed with the WWTW outlet) was very low. As the outlet is treated it is not likely to have a high count but unlikely to have 0 colonies per 100 ml. This parameter should be used with precaution as the laboratory took a long period to produce the results over the festive season. This preliminary finding suggest a poor quality drinking water upstream of the WWTW as is notorious with this river system. This parameter is known to fluctuate seasonally and, as such, should be considered during and after the development (especially as the measurements were taken in the midst of a severe drought). Presence of ablutions during construction may influence this parameter. The oil and grease component (which is relevant for any development where construction activities occur near water resources) did not meet standard at the upstream and downstream point. In similar vein, the upstream values were much higher than downstream. The treatment chemicals from the WWTW may cause oil & grease to flocculate out of the flowing channel. The oil and grease should not exceed 2.5 $mg.l^{-1}$ or the known level prior to construction. Dissolved manganese is very high from the WWTW outlet and subsequently at the downstream point. Manganese is a common metal found in foods and water and, although not highly toxic, can lead to some health implications. The water should also be monitored for other heavy metals or dangerous chemicals that could be increased during and after construction.

The wetland systems that meets the river to the north of the site was not assessed as they are in an adjacent catchment area to the proposed site.

Table 17 Water quality results from the Msunduzi river, above and below the proposed constructed wetland and at the WWTW outlet

Determinand	Units	Method No	DWS General Effluent Standards	Results		
				Upstream	Downstream	WWTW Outlet
Ammonia	mg N/l	64	<3	0.35	0.63	1.20
Chemical oxygen demand (total)	mg O2/l	3	<75	<20	45	<20
Cyanide*	µg CN/l	-	<20	<20	<20	<20
Dissolved arsenic	µg As/l	83	<20	<1	<1	<1
Dissolved boron	µg B/l	83	<1000	19.0	30	42
Dissolved cadmium	µg Cd/l	83	<5	<1	<1	<1
Dissolved copper	µg Cu/l	83	<10	1.11	1.49	1.15
Dissolved iron	µg Fe/l	83	<300	44	53	26
Dissolved lead	µg Pb/l	83	<10	<1	<1	<1
Dissolved manganese	µg Mn/l	83	<100	1.16	97	204
Dissolved mercury	µg Hg/l	83	<5	<1	<1	<1
Dissolved zinc	µg Zn/l	83	<100	3.79	10.7	17.2
E. coli	colonies per 100ml	31	<1000	6400	2	0
Electrical conductivity at 25°C	mS/m	2	70 - 150	25	47	73
Fluoride	µg F/l	18A	<1000	190	310	560
Free chlorine*	mg Cl2/l	-	<0.25	<0.1	<0.1	<0.1
Hexavalent chromium*	mg Cr/l	-	<0.05	<0.0008	< 0.0008	0.0010
Nitrate/Nitrite	mg N/l	65	<15	1.40	0.97	0.40
Oil & grease*	mg/l	52	<2.5	90	4	<3
Orthophosphate	mg P/l	66	<10	0.002	0.002	1.97
pH at 25°C	pH units	1A	5.5 -9.5	7.6	7.9	7.9
Suspended solids at 105°C	mg/l	5	<25	12	17	11

5.7 Determination of Buffer Zones

Given the nature of the development (the fact that the development will influence the hydrological partitions), no standard buffer was applied to this system. However, a buffer was applied to the watercourse systems for construction activities. The overall recommendation is that the development activities (e.g. concrete mixing, parking of vehicles etc.) should stay out of the buffer areas and out of the floodplain of the river at all possible times.

5.7.1 FEPA Buffer requirements

The FEPA wetlands are strategic spatial priorities for conserving freshwater ecosystems and supporting sustainable use of water resources; the systems need to stay in a good condition to manage and conserve freshwater ecosystems, and to protect water resources for human use. The Implementation Manual for FEPAs (2011) recommends that a generic **100m** buffer around all wetland and river FEPAs be applied to provide functional filtering capacity and adequately protect the system from a water quality perspective. However, the Implementation Manual for FEPAs (2011) also advocates that FEPAs need not be fenced off from human use, but rather that they should be supported by good planning, decision-making and management to ensure that human use does not impact on the condition of the ecosystem. Generic buffers have the potential to be reduced following a site-based assessment and consideration of risk of proposed development and the proposed mitigation measures.

5.7.2 Buffer Tool

The 'Preliminary Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries' (Macfarlane et al., 2014) was considered for the determine the buffer zones for any existing watercourse features (HGM units) found within the project boundary. This tool was used as a guideline for the buffer widths recommended in this report as this is not a typical development that requires operational buffers. The results from this tool suggest that during construction (in this case, the development of a constructed wetland and its associated infrastructure), a **40 m** buffer may be used on the river system. However, as soon as construction is completed, the buffers will not be relevant for the wetland.

5.7.3 Specialist Recommendations

The determination of the buffer zone is largely dependent on the nature of the proposed development. Other factors that need to be considered are the current land use prior to development, the type of watercourses present on the site and the site's physical characteristics. A constructed wetland is considered to be a low risk development (and would likely improve the water quality entering the river and create a habitat for obligate species) and there are no wetlands within the development footprint. However, this development can lead to an increase in pollution and sediment during construction (removal of vegetation, leaks from vehicles and human rubbish). The buffer provides information on areas where the construction activities must avoid. Given the observations made on site as well as the NFEPA guidelines and the buffer tool, it is recommended that a **40 m** buffer be used for NFEPA river systems (these systems are already vulnerable) and the floodplain or flood line be used as the activity buffer for the river. This is most relevant for the construction phase. Encroachment into these areas will cause harm to the watercourse systems. See Annexure D.

Table 18 Final buffer recommendations (specialist buffer widths)

Option	Buffer Recommendation	Msunduzi River (m)
NFEPA Recommendation		100
Buffer Tool	Construction Phase	40
	Operation Phase	N/A
Specialist		**40m / 1:100 Flood Line**

4. POTENTIAL IMPACT PREDICTIONS AND DESCRIPTIONS

The site is in fair condition with natural grassland and woody species being present. There are currently no settlements on the land. The presence of the WWTW has kept people out of the area and the site free from settlements or agriculture. In the context of its surroundings (Figure 9), the site is relatively untouched. Watercourse systems are functional and provide valuable services to the local community and nearby/downstream water users. The water quality of the watercourse systems is poor, even though cattle activity in watercourse systems is fairly low throughout the site.

The grasslands surrounding most of the site are intact with a high basal cover. The hydrological regime of the wetlands and river systems is largely modified, evident with drains along the river banks. The surrounding roads have diverted the original flow paths of some of these systems.

Figure 9 The current state of the edge of Sobantu, approximately 500m from the site along the Bayne's Spruit

4.1 Present Impacts

Within the bridge development footprint, the existing impacts on the watercourses and respective catchment areas include -

- The presence of water demanding alien species that have replaced veld;
- Invasive alien plant invasion in disturbed areas (particularly along servitudes and road edges);
- The clearance of natural habitat for canals and pathways between settlements;
- Concentrated flow paths from drain outlets/dongas along the access roads
- Historical modification of watercourse systems for agriculture and dam/wetland construction; and
- Erosion and sedimentation from construction activities; and
- Rubble dumping and litter around the site (mostly along the river).

In the broader WMA, similar impacts are present as noted for the Darvill site. Additional existing impacts on the watercourses and respective catchment areas include -

- Infrastructure development within wetland systems (wetland encroachment) or river banks – leading to a direct loss of wetland systems and decrease in provision of ecosystem services;
- Cattle grazing in wetlands and the riparian edge – potential for a change in vegetation species composition to occur, soil erosion (cattle path erosion is prevalent in the area) and water pollution;

- Canalisation of streams and rivers – leading to change in the hydrological regime;
- Informal and formal watercourse crossings – leading to the change in hydrological regime;
- Subsistence and commercial farming;
- Industrial waste into the river systems;
- Litter and solid waste disposal – direct water pollution; and
- Poor or absent sanitation – direct water pollution.

In addition to these impacts, there is a high risk of flood damage (crop and livelihood) to the community living within the flood line. With the draining of wetland systems soil sediment levels have increased resulting in a loss of yield.

4.2 Potential impacts during construction

Construction of the wetland will result in a disturbance of the river systems and vegetation habitats during the implementation phase. According to the Hierarchy of Mitigation (Figure 10), *avoidance* and *prevention* of impacts is the aim of integrated environmental management. In the Pre-construction and Planning phase (as discussed by GroundTruth), through an ongoing iterative consideration of alternatives to project location, siting, scale, layout, technology and design, the project team should strive to avoid impacts on the environment altogether. If avoidance of impacts is not possible, impacts should be minimized through mitigation in the form of practical actions.

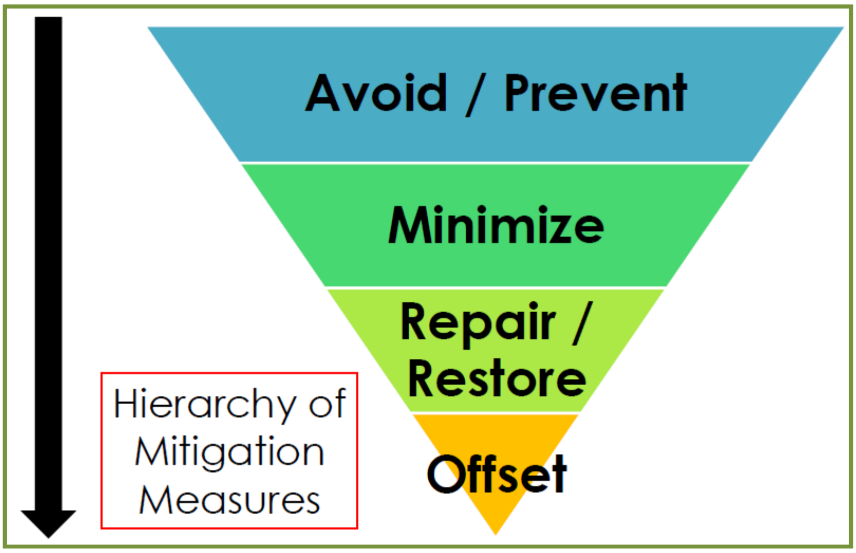

Figure 10 Hierarchy of Mitigation Measures

With a knowledge of the receiving environment and the development in its current format, the following impacts are likely to occur. The impacts identified are those that may alter the Present Ecological State (PES) or the Ecological Importance & Sensitivity (EIS) of the riparian systems.

Construction of the wetland will result in a disturbance of the watercourse system and nearby residents during the implementation phase. These potential impacts include –

- **Soil erosion and sedimentation:** by the removal of topsoil, addition of spoil sites leading to wash and compaction by heavy machinery resulting in an increased runoff;
- **Loss of natural/indigenous vegetation:** change in riparian/wetland vegetation due to the potential disturbance of the wetland and riparian bed and banks. This is likely to result in further alien plant invasion and the removal of indigenous species. This may further enhance erosion potential;
- **Pollution:** an increase in pollution due to heavy machinery, storage of chemicals, ablution facilities and likely spills during construction; and
- **Removal of natural grassland:** The loss of relatively good condition grassland that is a valuable resource for local residents who use it for grazing.

Table 19 Impact Drivers and Description – Construction Phase

ACTIVITY / DRIVER OF IMPACT	IMPACT	DESCRIPTION OF HOW IMPACT OCCURS
Levelling of the plot of the constructed wetland	**Enhanced erosion potential**	As a result of subsequent changes in the hydrological partitions and slight modifications to the slope and soil characteristics (changes to vegetation cover, root content and infiltration rates). This is further described – The potential increase in slope and bank construction will enhance erosion potential (greater energy for sediment wash). The reduction in vegetation cover will open bare soil therefore reducing the surface roughness and increasing the erosive potential to the elements (wind and rain). Sheet wash, rill and gully erosion is likely and may lead to the collapse or slumping of wetland/stream bank areas that would bury marginal wetland habitat. An increase in compaction of the soils along the edge of the plot where heavy machinery traverses would lead to an increase in the runoff.
	Decrease in water quality	As a result of contaminants from heavy machinery (oil, fuel) infiltrating / washed into the system.
	Spread of alien invasives	As these plants colonise stockpiles and spoil sites / spoil sites given their easily dispersed seed.
High activity of heavy machinery and construction staff	**Air pollution affecting wetland fauna**	As a result of excessive air emissions from heavy machinery and generators.
	Noise and disturbance affecting wetland fauna	As a result of excessive air emissions from heavy machinery and generators.
	Decrease in water quality **(impact to aquatic flora and fauna; and water supply)**	As a result of potential leaks of fuel, grease and oil from the heavy machinery. Wash related to the above-mentioned changes during rainfall events will lead to the movement of these substances into the soil and the watercourse systems. As a result of improper storage and handling of hazardous chemicals such as fuel and oil as well as chemicals relating to staff ablution facilities. As a result of any spills, such as concrete, during construction.

4.3 Potential impacts during operation

The majority of the impacts will be during construction. However, some impacts are likely during operation. These include -

- **Increase in population:** a likely increase in people using this route due to the improved infrastructure. This may lead to more people moving to the area (more households) and a greater intensity of the present impacts (this is unlikely as the current wetland is operational but speaks more to developments likely to occur subsequent to this development);
- **Increase in pollution:** an increase in pollution from the wetland surfaces including petro-chemicals and human rubbish. An increase of visitors and vendors during operation may lead to further pollution;
- **Increase in surface runoff:** Increase in impervious surfaces which may promote erosion and flash floods; and
- **Increase in overall edge effects on wetland:** heightened activity in the area
- **Continued alteration of flow pattern:** as a result of concentration of flow around wetland pillars

Table 20 Impact Drivers and Description – Operation Phase

ACTIVITY / DRIVER OF IMPACT	IMPACT	DESCRIPTION OF HOW IMPACT OCCURS
Disturbance of the linear flow channel	**Potential for leaks and contamination of watercourses**	A change in the flow regime due to the construction of supporting structures at the entrance of the wetland. This, as well as rubble, may alter the watercourse bed and flow regimes.
Stormwater runoff along the hardened surfaces of the constructed wetland	**Soil wash**	Disturbance of the soil profile and vegetative cover may prompt a change in flow path, with surface runoff running in rills along the concrete edges.
Foundations and obstructions	**Change in subsurface water movement**	The development of the pathway deeper than the upper soil profile may cause sub-surface water movement to be diverted and potentially concentrated resulting in inundation areas.
Greater human/vehicle movement through the site	**Increase in pollution**	An increase of maintenance vehicles during operation may lead to further pollution such as plastics, cans and glass.

5. RECOMMENDED MITIGATION

Firstly, there should be no development within the designated buffer zones of all watercourses other than the wetland and entrance ways – see Annexure D for map showing the buffer zone. A buffer zone is designed to act as a barrier between anthropogenic activities and sensitive water resources. This allows for the protection of these water resources against adverse negative impacts (Macfarlane et al., 2014). Buffer zones promote the maintenance of basic aquatic processes, the reduction of up-stream impacts and the preservation and provision of aquatic species. All construction activities (e.g. camp and vehicle maintenance) must stay outside of these areas.

Secondly, based on the data, the following are mitigating actions linked to the proposed constructed wetland.

Table 21 Mitigation measures – Construction Phase

IMPACT	MITIGATION
Enhanced erosion potential and compaction	o To minimize the loss and damage to vegetation and to minimize compaction during construction, the construction camp should be kept to a minimum and all activities must be restricted to a demarcated servitude. o To prevent erosion and sedimentation, construction activities should be undertaken during the dry season when flows will be substantially reduced. o The construction camp should be located more than 100m from all watercourses. o All stockpiles and spoil material should be located on even surfaces, and more than 100m from watercourses so as not to cause sediment wash into the system; o Sediment controls measures (e.g. haybales, silt fences, sedimentation ponds, etc) should be put in place should stockpiles show potential to wash away; o The construction area should be clearly identified including access roads, stockpile or excavation areas, storage facilities and parking areas. o Topsoil stripped from the construction footprint must not be spoiled but stockpiled and preserved for use in rehabilitation. Top-soil and sub-soil stockpiles and spoil sites to be placed on opposite sides of the entrance path as this is where they will cause the least impact. o Vehicles should be parked out of the flood line and buffer when not in use in order to prevent compaction of the soil profile. o Topsoil should be replaced in the correct order it was extracted and erosion prevention measures be put in place on areas with a steep gradient (such as geo-textiles). o Any excess subsoil must be removed from the site and spoiled at an agreed spoil site. o Excess flows from open surfaces and increased slope areas need to be controlled by an erosion control measure.

Decrease in water quality	o The EMPr should include a Spill Management Plan for the construction phase that addresses measures to prevent and mitigate the spillage of hazardous materials in the construction site (oil, petrol, diesel, detergents, etc), as even small spills and leakages can have major impacts when incorporated with water. A key issue comprises detergents, which have significant impacts on amphibians and fish; detergents interfere with their membranes, causing mortality. o Regular vehicle and machinery maintenance must be carried out to ensure that accidental spills are avoided. o No washing of construction equipment and vehicles should be allowed from the watercourses. o To prevent spillages, no fuel or oil should be kept onsite or within the demarcated watercourse boundaries. Absorbent materials such as "Drizit" must be readily available in the event of any accidental spills, and all contaminated material including soil must be disposed of at a registered waste disposal site. o In locations were cement is required to be used, cement must be mixed in lined containers to prevent contamination. o All chemicals should be appropriately stored and handled. Storerooms must be more than 100m from watercourse zones and have appropriate concrete flooring and bunding. o Any remnant rubbish, spoil, machinery and contaminants need to be removed from the development area. o Vehicles or machinery must not be serviced or re-fuelled within 100m of the watercourse zones. o Appropriate ablution facilities need to be put in place more than 100m from a watercourse, with no effluent released into the soil or the river. o Rubbish bins need to be placed on site so that no litter or food waste is left around the development.
Spread of alien invasives	o An alien plant removal program should be instituted to eradicate alien plants within the development footprint. Removal would have to coincide with planting of indigenous species to replace alien plants, and ensure a healthy plant cover – especially on embankments. o Wetland vegetation must be planted where any wetland areas were located previously. o Stockpiles and spoil sites must be clearly demarcated and be kept free of weeds and compaction. o Bank areas need to be stabilized before re-vegetation occurs. Bare, exposed areas need to be stabilized by geo-textiles in order to give the vegetation a chance to establish. o All growth forms of Category 1 weeds and invader plants shall actively be removed from all works areas, at all times; o Areas for re-vegetation/alien clearing should be demarcated in order to prevent further disturbance. Furthermore, access roads for machinery should avoid any of the vegetation focus areas and areas with existing natural vegetation. o All Category 2 and 3 weeds and invader plants shall be actively removed all prior to flowering. o All riparian and wetland areas disturbed during the construction phase must be rehabilitated and re-vegetated according to a construction phase rehabilitation plan compiled by an aquatic specialist in conjunction with a vegetation specialist. o Follow up assessments should be undertaken to prevent alien re-growth in alignment with time frames identified by a re-vegetation plan/vegetation specialist.
Air pollution affecting wetland fauna	o All vehicles should be kept up to date with servicing to ensure air emissions are at legislated levels. o There should be no fires burnt within the construction site.
Noise and disturbance affecting wetland fauna	o The wetland system should be demarcated and there should be no access for construction staff into this area during the construction phase. o In the Environmental Awareness briefing, construction staff should be educated on the dynamics of wetland systems, including potential impacts on wetland fauna as a result of noise and activity.

Table 22 Mitigation measures – Operational Phase

IMPACT	MITIGATION
Change in the linear channel flow and channel bed	o Regular maintenance of inlet structures should be undertaken. o The banks of the wetland should be visually inspected every month for signs of excessive loss of riparian vegetation and bank collapse.
Soil wash	o Following completion of the construction activities and replacement of the stockpiled soil, removal of excess soil and re-vegetation of any bare areas must be undertaken. o Compacted soil must be ripped or scarified and seeded with an appropriate vegetation species to stabilize the soil. o If the alien species have become established during the construction period then these must be removed and indigenous species planted.
Change in subsurface water movement	o Inundation areas that occur above confining layers need to be managed. o Precaution should be taken to avoid sub-surface seepage which may contaminate the groundwater reserves.
Increase in pollution or contamination risk	o The EMPr should include a Spill Management Plan for the operation phase that addresses measures to prevent and mitigate the spillage of hazardous materials in the operation site A key issue comprises detergents, which have significant impacts on amphibians and fish; detergents interfere with their membranes, causing mortality. o Regular water quality checks should be done in alignment with existing water quality monitoring strategies.

6. CONCLUSION

The developers of the proposed constructed wetland must note that watercourses are protected by nine Acts and two Ordinances in KwaZulu-Natal[3], which verifies that both national and provincial authorities recognise these systems as highly valuable multiple-use resources and are committed to their conservation. The benefits of wetlands have been well documented. However, it is necessary to take a critical look at the potential gains and losses to the environment. It cannot be assumed that a wetland will directly improve the overall system. As such the following questions should be addressed:

- Is the wetland more beneficial to the ecosystem than the vegetation that will be lost?
- Is this the right setting for a constructed wetland?
- Will the wetland be maintained or will it be left to function more like a storage dam?
- Is there a risk of leaks or berm failure resulting in excess wastewater entering the river system?
- Could the wetland create a suitable habitat for important fauna and flora?

The work undertaken for this report and the wetland creation report indicate that this wetland could suitably address all of these questions. The current vegetation is in poor condition and is not likely to improve. Furthermore, surrounding wetlands have been lost over the years resulting in a shortage of wetland habitat in the area. Given the excess water from the WWTW, the elevation, the fact that the soils are not particularly good for agriculture and the potential to improve water quality which is the biggest problem for the system, this is a suitable area for the wetland. As it will form a part of the WWTW remediation plans, it will have to be well maintained. Given the shallow depth of the wetland and that the water will already be partly treated, the risk of contamination of the river is low. On observation of the artificial wetland above the site, it is clear that the wetland will provide a habitat for important flora and fauna.

The Msunduzi system is classified as FEPA systems and should be given extra protection to minimize the impacts identified. The development proposed for the site will have some impact on these surrounding watercourses during construction. However, the potential for positive impacts of all surrounding systems is large. At all times, disturbance to wetland and river areas should be avoided.

[3] The Lake Areas Development Act, Act No. 39 of 1975; The National Water Act, Act No. 36 of 1998; The Mountain Catchment Areas Act, Act No. 63 of 1976; The Environmental Conservation Act, Act No. 73 of 1976; The National Environmental Management Act, Act No. 107 of 1998; The Conservation of Agricultural Resources Act, Act No. 43 of 1983; The Town Planning Ordinance 27 of 1949; The Physical Planning Act, Act No. 88 of 1967; The Forest Act, Act No. 84 of 1998; The Natal Nature Conservation Ordinance No. 15 of 1974; The KwaZulu Nature Conservation Act, Act No. 8 of 1975

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ANNEXURE A Classification structure for inland systems up to Level 4

WETLAND / AQUATIC ECOSYSTEM CONTEXT		
LEVEL 1: SYSTEM	**LEVEL 2: REGIONAL SETTING**	**LEVEL 3: LANDSCAPE UNIT**
Inland Systems	DWA Level 1 Ecoregions OR NFEPA WetVeg Groups OR Other special framework	Valley Floor
		Slope
		Plain
		Bench (Hilltop / Saddle / Shelf)

FUNCTIONAL UNIT		
LEVEL 4: HYDROGEOMORPHIC (HGM) UNIT		
HGM type	Longitudinal zonation/ Landform / Outflow drainage	Landform / Inflow drainage
A	B	C
River (Channel)	Mountain headwater stream	Active channel
		Riparian zone
	Mountain stream	Active channel
		Riparian zone
	Transitional stream	Active channel
		Riparian zone
	Upper foothill rivers	Active channel
		Riparian zone
	Lower foothill rivers	Active channel
		Riparian zone
	Lowland river	Active channel
		Riparian zone
	Rejuvenated bedrock fall	Active channel
		Riparian zone
	Rejuvenated foothill rivers	Active channel
		Riparian zone
	Upland floodplain rivers	Active channel
		Riparian zone
Channelled valley-bottom wetland	(not applicable)	(not applicable)
Unchannelled valley-bottom wetland	(not applicable)	(not applicable)
Floodplain wetland	Floodplain depression	(not applicable)
	Floodplain flat	(not applicable)
Depression	Exorheic	With channelled inflow
		Without channelled inflow
	Endorheic	With channelled inflow
		Without channelled inflow
	Dammed	With channelled inflow
		Without channelled inflow
Seep	With channelled outflow	(not applicable)
	Without channelled outflow	(not applicable)
Wetland flat	(not applicable)	(not applicable)

Note: 2nd row of Table provides the criterion for distinguishing between wetland units in each column

ANNEXURE B Wetland and soil classification field datasheet example

Sampling Sheet Summary	
Wetland	Darvill
Area (ha)	0.8
Indicator	Soil and vegetation
Connectivity (level 1)	Inland
Eco region (level 2)	South Eastern Uplands
Landscape setting (level 3)	Hillslope Seepage
HGM Type (level 4A)	Endhoreic
Longitudinal zonation (level 4B)	Without channel
Hydrological regime	Frequent Inundation
Soil characteristics	Hue – Gley 2 to 5YR Value – 4 Chroma – 2 (Dark Reddish Gray) Depth sampled: 0-0.5m
Comment	No change in soil characteristics

ANNEXURE C Steps for Riparian delineation

Steps for Riparian Delineation in the field

To delineate riparian areas, use the terrain unit indicator, vegetation indicator species, soil wetness indicator, combined with

- Geomorphology of the banks; and
- Extent of riparian vegetation.

Evidence of alluvial deposits can also be used.

STEPS to delineating the riparian zone:

I. Is the site relatively undisturbed (banks have not been extensively engineered, and the site is predominantly indigenous, naturally occurring vegetation)? If yes, proceed to step II. If no, proceed to step V.

II. Starting at the edge of the channel, use the regional riparian vegetation indicator list, identify the edge of the zone of (obligate) riparian plants.

III. At this point, check:

a. If there are any hydric indicators in the soil (refer to Wetland Delineation component).
b. If you are still in a zone of unconsolidated recent alluvial sediment.

If yes for either **a** or **b**, proceed outwards from the channel to identify the edge of these zones.

Once the answer to **a** and **b** are no, follow the same steps (II and III) using preferential and/or facultative riparian plant species *(Refer to the steps 1 to 12 from the vegetation assessment section below for further detail)*.

Following completion of the above, proceed to step IV.

IV. Examine the geomorphology (shape) of the channel and banks. After moving away from the channel during steps II and III, you should be at or close to the edge of the top of the "macro-channel" bank (in the case of erosive rivers) or the edge of the active floodplain or flood zone (in the case of alluvial depositional rivers). At, or close to, this point you should see an inflection point (change in slope) between the riparian area and the upland (terrestrial) slopes. This can be taken as the edge of the riparian zone.

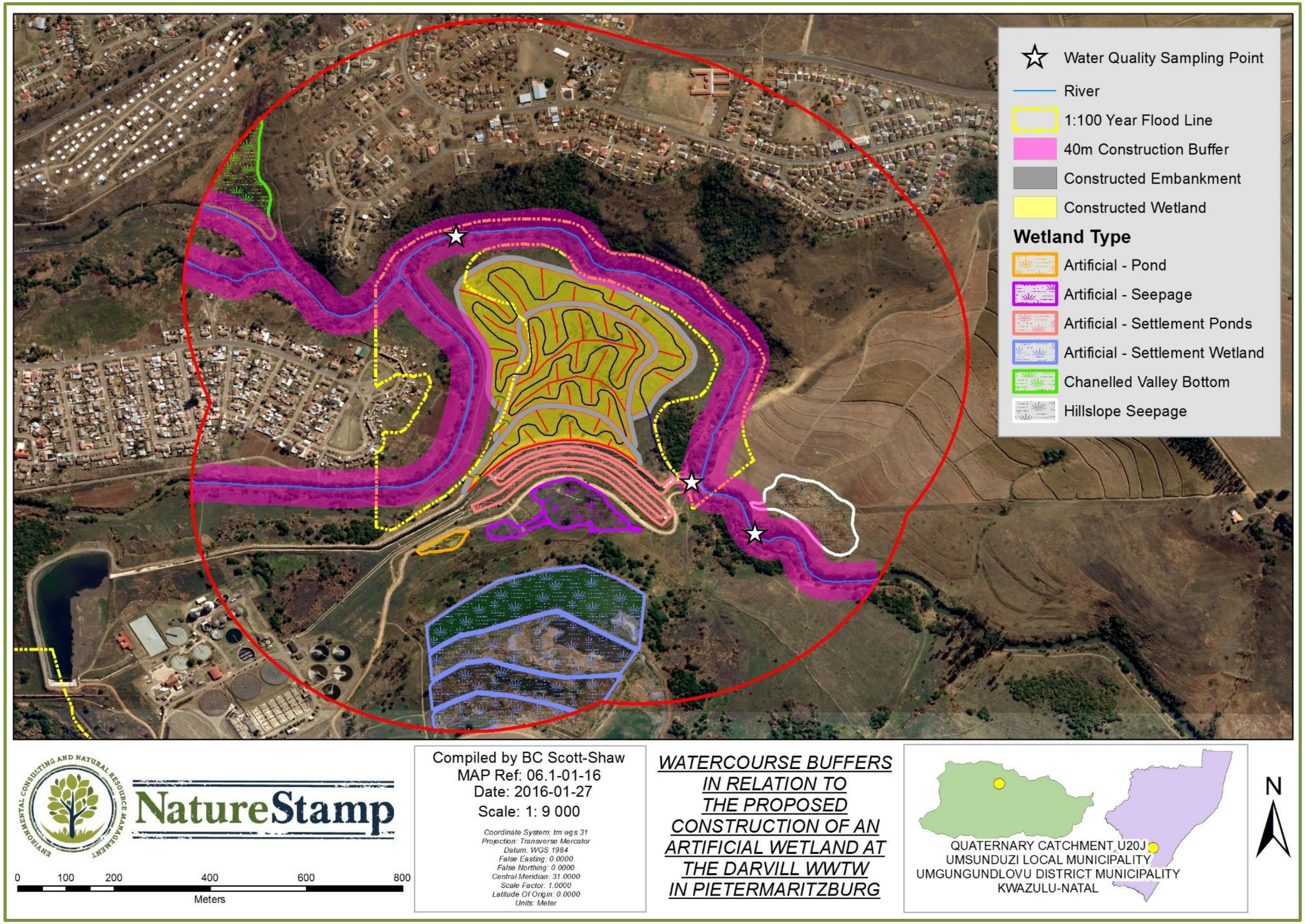
Using Reference Sites:

V. For sites which have been heavily disturbed (i.e. where there is almost no indigenous vegetation remaining, and/or where the banks have been heavily engineered such that it is no longer possible to identify the original morphology of the banks), then a REFERENCE site will need to be located. The Reference site will need to be close by on the same or a similar sized river system, in an area of similar topography. The Reference Site can be used to provide an indication of the likely riparian extent prior to disturbance. Once the reference site is located, proceed with step II.

Where problems may be encountered:

On floodplains, it is important to check whether the floodplain is active (i.e. regularly flooded under the current climatic regime) or a relict floodplain (meaning that the floodplain depositional area formed due to a wetter historical climate and now is no longer regularly flooded). The type of vegetation on the floodplain surface, presence of soil wetness indicators and the presence of ox-bows and other riparian and wetland features would provide the indications of the current levels of flooding/inundation/saturation.

ANNEXURE D Watercourse Buffers for the Msunduzi Constructed wetlands



ANNEXURE E Declaration of Independence

edtea
Department:
Economic Development, Tourism and Environmental Affairs
PROVINCE OF KWAZULU-NATAL

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	DC/
NEAS Reference Number:	
Date Received:	

Application for an environmental authorisation in terms of section 24(2) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) or for a waste management licence in terms of section 20(b) of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008).,

PROJECT TITLE

WATERCOURSE DELINEATION & IMPACT ASSESSMENT

FOR THE PROPOSED CONSTRUCTION OF AN ARTIFICIAL WETLAND AT THE DARVILL WWTW, PIETERMARITZBURG, MSUNDUZI MUNICIPALITY, UMGUNGUNDLOVU DISTRICT, KZN

Specialist:	NatureStamp (Pty) Ltd		
Contact person:	Bruce Scott-Shaw		
Postal address:	PO Box 949, Hilton		
Postal code:	3245	Cell:	078 399 9139
Telephone:	033 343 2049	Fax:	086 776 4889
E-mail:	bruce@naturestamp.co.za		
Professional affiliation(s) (if any)	KZN Wetland Forum		

Project Consultant:			
Contact person:			
Postal address:			
Postal code:		Cell:	
Telephone:		Fax:	
E-mail:			

4.2 The specialist appointed in terms of the Regulations_

I, **Bruce Scott-Shaw** , declare that --

General declaration:

- I act as the independent specialist in this application;
- do not have and will not have any vested interest (either business, financial, personal or other) in the undertaking of the proposed activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I am aware that a person is guilty of an offence in terms of Regulation 48 (1) of the EIA Regulations, 2014, if that person provides incorrect or misleading information. A person who is convicted of an offence in terms of sub-regulation 48(1) (a)-(e) is liable to the penalties as contemplated in section 49B(1) of the National Environmental Management Act, 1998 (Act 107 of 1998).

Signature of the specialist:

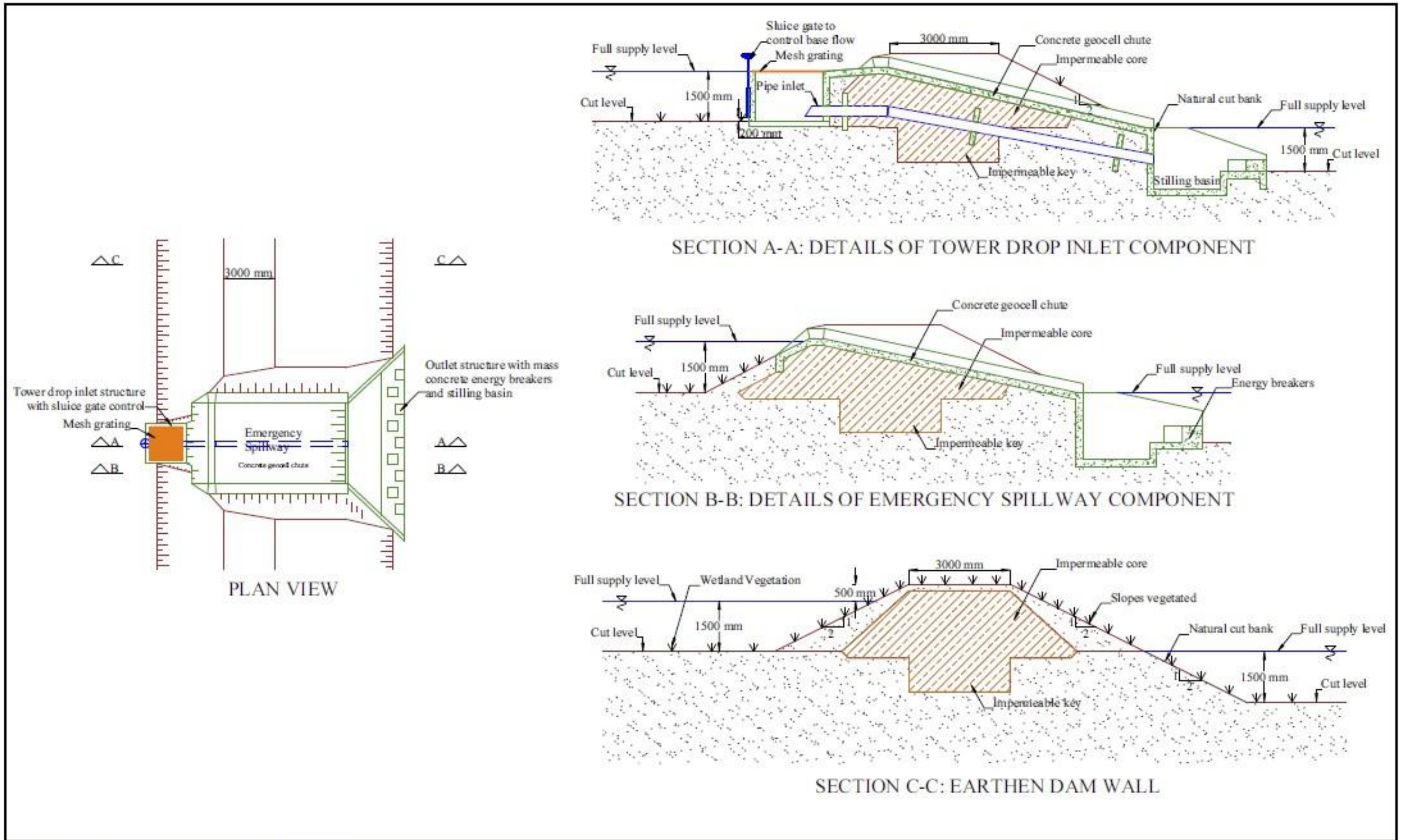
NatureStamp

Name of company (if applicable):

15 January 2016

Date:

ANNEXURE E Constructed Wetland Design



GroundTruth
Water, Wetlands and Environmental Engineering

PROJECT:	DARVILL WETLAND CREATION
DRAWING DESCRIPTION:	PROPOSED WETLAND CELL OUTFLOW MECHANISMS - CONCEPTUAL DRAWINGS

DATE:	SCALE:	DESIGNED BY:	DRAWN BY:	DRAWING No.:	DRAWING CHECKED:
4/07/2014	N.T.S	T. PIKE	R. DOMLEO	GTW363_070714/001	T. PIKE